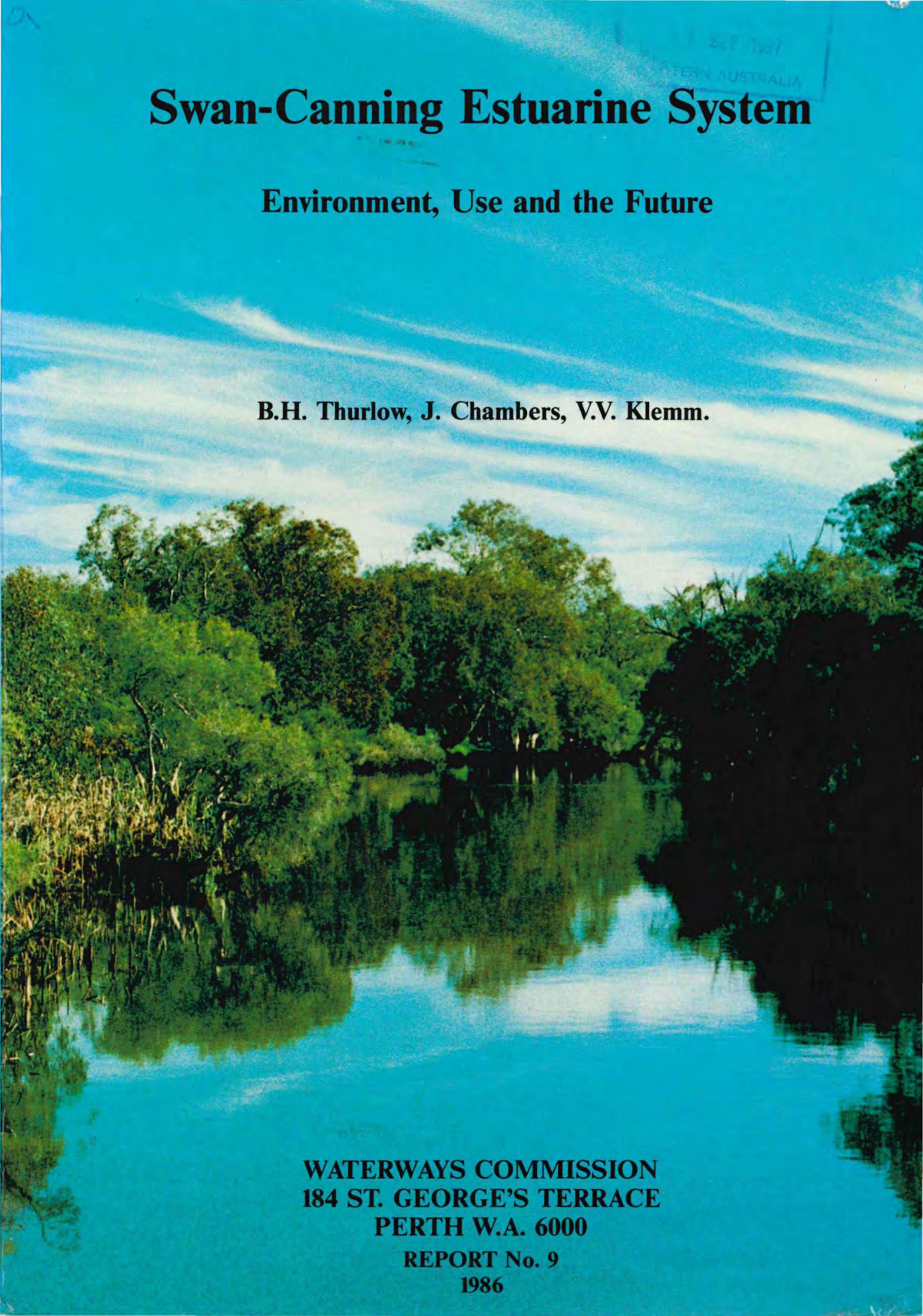
# Swan-Canning Estuarine System

## Environment, Use and the Future

B.H. Thurlow, J. Chambers, V.V. Klemm.



WATERWAYS COMMISSION
184 ST. GEORGE'S TERRACE
PERTH W.A. 6000
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# SWAN-CANNING ESTUARINE SYSTEM:

# ENVIRONMENT, USE AND THE FUTURE


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This project is a compilation of the works and knowledge of many individuals. It was initiated by Mr. R. Atkins and Mr. C. Liddle of the Waterways Commission. The report is co-authored by Ms J. Chambers (Chapters 4 and 5) and Ms V. Klemm (Chapter 6). Photography is the work of Mr B. Utley, map drafting Ms L. Sisco (Small) and manuscript preparation Ms L. Hunter.

Appreciation is expressed to authors of past studies and papers for their indirect contribution. Similarly recognition is given to all those currently working in educational institutions, government agencies and local government who willingly gave of their time and knowledge.

Public input to the project has been an important facet and it is necessary to thank all recreation clubs, organisations and users for their input. Similarly to all those people who have submitted public submissions.

**B.H. THURLOW**
**PROJECT OFFICER**

# ERRATA

## TEXT

### Pg 83

Third paragraph. Reference to the Appendix should read Appendix 2.

### Pg 91

Last line. Reference to the Appendix should read Appendix 3.

### Pg 115

Section 2.3.3. The first sentence should read: "The potential for inorganic nitrogen (nitrate plus ammonium) levels to cause nuisance characteristics of eutrophication is secondary to phosphorus".

### Pg 117

The footnote that should appear at the bottom of this page appears on Pg 119.

### Pg 160

Section 1.7, 3rd sentence should read: "Moreover all future river crossings and major roads located on river foreshores should be the subject of appropriate environmental studies".

### Pg 215

Table listing approximate areas of private ownership. The area from Gilbert Fraser Oval to Pt. Direction is not in private ownership but has a small strip of Crown land foreshore in front of a number of lots in this region. The area is currently the subject of rezoning.

### Pg 288

Net fishing in the river by the general public is now only permitted between midnight Monday and midnight Thursday. No net fishing is permitted upstream of Plain Street, Perth on the Swan and Helena River, upstream of Second Avenue, Shelley and Sulman Avenue, Salter's Point on the Canning and downstream of Point Walter and Point Resolution on the Swan River. There are also points near jetties etc. where net fishing is also restricted. Readers are referred to the Department of Fisheries for more exact information.

**Pg 302**

Section 3.3.2, 1st sentence should read: "Analysis of age of respondents revealed an over-sampling in the 15-44 age group and an under-sampling in the 45+ age category recorded at any site, compared with the resident Perth population".

**Pg 304**

Section 3.3.5, 4th sentence should read: "This is a popular wind surfing site and results suggest that people are more likely to undertake this activity alone compared with other activities".

**Pg 310**

Section 4.1.2, 4th paragraph should read: "The Study Group (Roger et al., 1984) commented that dredging has the potential to cause major changes to the composition of the aquatic fauna to the detriment of the current recreational and commercial fishery".

**MAPS**

Map No 85001-1-1/2/3/4 should read Blackwall Reach.

Map No 85001-1-1 A small portion of MRS Parks and Reserves boundary is unmarked near the Claremont/Peppermint Grove boundary.

Activities Map. The text describing development sites and club facilities can be found on pages 229 and 278 respectively.

**Pg 121**

Table 11; Drain 15 Turbidity should read: 24.5.

**Pg 122**

Table 12; Drain 1 Total Phosphorus should read: 0.12 and Chloride should read: 1752.

Drain 8 Total Phosphorus should read: 0.54 and Chloride should read: 400.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| BMA | Building Management Authority |
| CALM | Conservation and Land Management |
| CPFSG | Central Perth Foreshore Study Group |
| D of AG | Department of Agriculture |
| DCE | Department of Conservation and Environment |
| DSR | Department of Sport and Recreation |
| DYSR | Department of Youth, Sport and Recreation |
| EPA | Environmental Protection Authority |
| ERMP | Environmental Review and Management Programme |
| FAWPC | Foreshore and Waterways Protection Council |
| GCL | Government Chemical Laboratories |
| LGA | Local Government Authority |
| M&H | Marine and Harbours Department |
| MRD | Main Roads Department |
| MRPA | Metropolitan Region Planning Authority |
| MRS | Metropolitan Region Scheme |
| MWA | Metropolitan Water Authority |
| NOI | Notice of Intent |
| NPA | National Parks Authority |
| PER | Public Environmental Report |
| PHD | Public Health Department (State Health Laboratories) |
| PWD | Public Works Department |
| RAOU | Royal Australian Onnithologists Union |
| SECWA | State Energy Commission of Western Australia |
| SPC | State Planning Commission |
| SRMA | Swan River Management Authority |
| Water Authority)<br>WAWA ) | Water Authority of Western Australia |
| WAWRC | Western Australian Water Resources Council |
| WWC | Waterways Commission |

## MAPS

A folio of 12 information sheets covering the entire study area accompanies this report. Each sheet has four A3 maps detailing four aspects of the river environment:

| | |
|---|---|
| Metropolitan Region Scheme Parks and Recreation Reserves Details : | MRS Parks and Reserves boundaries, roads, bridges, description of area. |
| Activities Details : | Recreation reserves, recreation facilities, system 6 reserves, development sites, historic sites. |
| Industrial Details: | Water quality sampling points, industrial licences, dredging, reclamation, drains, 1 : 100 year flood line. |
| Vegetation Details: | Peripheral vegetation and seagrass areas. |

NB: Where information is limited maps have been combined ie Information Sheet 9 Map Numbers 9 and 13.

# CHAPTER 1 : INTRODUCTION

## 1.0 INTRODUCTION

The Swan River and its tributaries have and continue to play an integral role in the development of metropolitan Perth and the lifestyle of its residents. Individual perceptions of the river vary. To some it is a barrier, to others it is the greatest scenic attribute Perth has. Preservation and management of the river environment is therefore an important and diverse issue.

Past concern initiated the establishment of the first managing body. Today Perth has one of the cleanest rivers of any city in the world. This makes it a relatively unique resource. However, effort and attention should not be reduced merely because everything appears to be in order. Management is an ongoing task; to be updated as new information is available; to be re-appraised in light of changing attitudes and behaviour.

Prevention of possible problems should be at source. This requires that management and planning extends far beyond the land/water interface. Catchment management is essential. The primary responsibility of the river managing authority must therefore be co-ordination of other managing bodies indirectly involved with river management and dissemination of information upon which these authorities can base their decisions thus ensuring the integrity of the river environment is maintained.

For the Waterways Commission and Swan River Management Authority to fulfil these obligations requires as complete knowledge as possible of the functioning of the river environment, its current use and potential problems. The river environment is a naturally evolving system, however, this process is considerably hastened by man's activities. The location of metropolitan Perth to the river increases the pressure for change. The way in which the man-made environment can fit in with the natural environment without dominating it needs to be examined.

Changing public attitudes require that greater emphasis be placed on the conservation and preservation of natural resources. These attitudes should be reflected in management decisions.

This report is a collation of information on the river environment; some previously published, some new works. It is not purely a collection of facts but an overview of future planning and mangement of the river system. It precedes the development of a management programme for the area.

The following aspects have been addressed during the course of the study; the physical environment, and tenure, land use, Local Government, flora and fauna, commerce and industry, transport, utility services, water quality and pollution, dredging and reclamation works, erosion, recreation resources, access to the river, the human environment and social needs of the community.

Naturally this work is not definitive as there will always be a need for updating and expansion of certain details. Future research should emphasise its application to management of this resource.

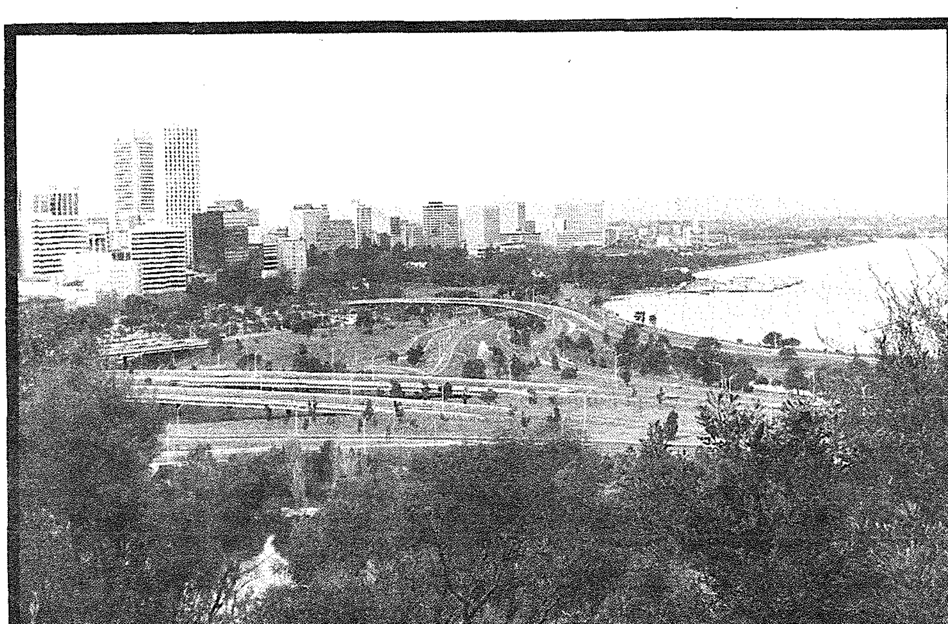


PLATE 1: City river interface

## CHAPTER 2 : MANAGEMENT

### 1.0 PAST MANAGEMENT OF THE ESTUARINE SYSTEM

The first move to establish some centralised control of the Swan River Estuarine System came in 1943 when the then Director of Works, Mr. R.J. Dumas, with the Commodore of the Royal Perth Yacht Club and four other members formed the Swan River Reference Committee. It was purely an advisory body constituted to co-ordinate the activities of a multitude of Authorities and Departments interested in some way with river usage, works and cleanliness of the foreshores.

Over the years the Committee was gradually enlarged until it finally comprised fifteen members who acted in a voluntary capacity and devoted much personal time in dealing with problems associated with the beaches.

Although this Committee had no statutory authority, it achieved much, in particular eliminating many points of pollution and contamination.

The original Swan River Conservation Act was passed in 1958 and provided for a Board of seventeen members. Legislation was based largely on the experiences of the original Committee.

At the time of its introduction the legislation was the first of its type in Australia and was framed on broad lines to give the Board wide powers - subject to the Minister and subject to appeals to the Minister and Courts. The Board exercised the role of a watchdog and co-ordinator in addition to its major work of monitoring river purity and foreshore cleanliness.

Many factors highlighted the need for a single controlling Authority with statutory powers and a responsibility for river purity, beauty and orderly development. They were the increase in population in the Metropolitan area, the Metropolitan Region Planning Authority's proposals for the Metropolitan Region Scheme, the expanding demand for water space for aquatic activities, the need for additional foreshore areas for public recreation and the upsurge in industrial activity.

### 2.0 THE WATERWAYS CONSERVATION ACT 1976 AMENDED

On 23rd March 1977, the Swan River Conservation Act 1958 Amended and was repealed. The Waterways Conservation Act 1976 now governs management of the Swan-Canning Estuarine System.

The Waterways Commission was established to administer the Act and three management Authorities established to manage the three proclaimed management areas, one of which is the Swan River Management Area.

## 2.1 Role of the Waterways Commission

The basic role of the Waterways Commission is outlined in Sections 23, 24 and 25 of the Act.

Section 23 : The duties of the Commission are:

- To preserve and enhance the quality of the environment and amenities of the waters and of the associated land to which the powers of the Commission apply.

- To control and wherever practicable prevent any act capable of causing pollution of these waters or that land.

- Provide advice and disseminate knowledge on the conservation and good management of river, inlets, and estuaries and of associated land.

- As far as is practicable consult and make arrangements and agreements with relevant local government authorities, residents and other persons affected by the operation of the Act.

Section 24:

In performing its functions the Commission shall have regard to:

- The interests of navigation, fisheries, agriculture, water supply, recreation and leisure time occupation for the benefit of the public, the natural beauty and amenity of the area, and the preservation of the public rights of access.

- The rights acquired by persons, whether as owners or occupiers, in relation to boat houses, jetties and other structures then in being, being rights and exercise of which is not likely to impair the environment.

Under Section 25 of the Act the Commission has all powers, rights and privileges as may be reasonably necessary to enable it to carry out its duties.

## 2.2 Swan River Management Authority

The area of water and foreshore under the control of the Swan River Management Authority (SRMA) was proclaimed in the Government Gazette 9th September 1977.

For the purposes of the Waterways Conservation Act the area comprising the waters to which the Swan River Conservation Act 1958-1975 formerly applied and the foreshores of these waters are known as the Swan River Management Area.

The boundaries of the waters and associated land comprised in the management area are marked in red on Swan River Management Authority Plans A, B and C held at the offices of the Waterways Commission, Perth.

The waters of the management area include the waters upstream of Fremantle Traffic Bridge to the confluence of Wooroloo Brook on the Swan River, the lower diversion dam on the Helena River and the point where Brookton Highway crosses the Canning River.

It is the general duty of the Authority to conserve and manage the area of the waters and associated land placed under its control. The Authority also has the responsibility for the initial preparation and constant review of the proposals for any management programme related to its area. Under its powers the Authority is also entitled to make and enforce by-laws pursuant to this Act. Sections 26, 27 and 28 of the Act outline the duties, functions and powers of the Management Authority. Map 1 shows this study area.

## 2.2.1 Staffing

Staffing of the Commission is illustrated below in Figure 1. Consultants are employed on a contractual basis if further technical advice is required by the Commission in the performance of its functions.

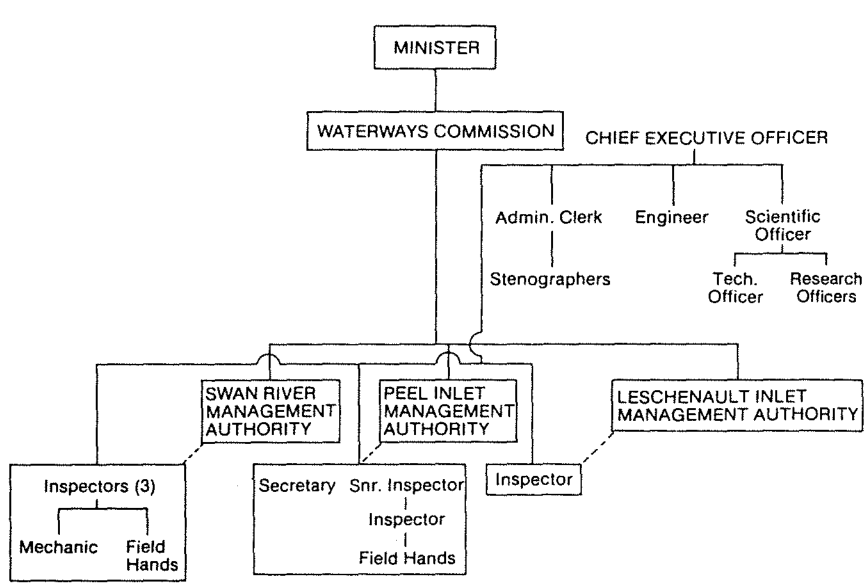
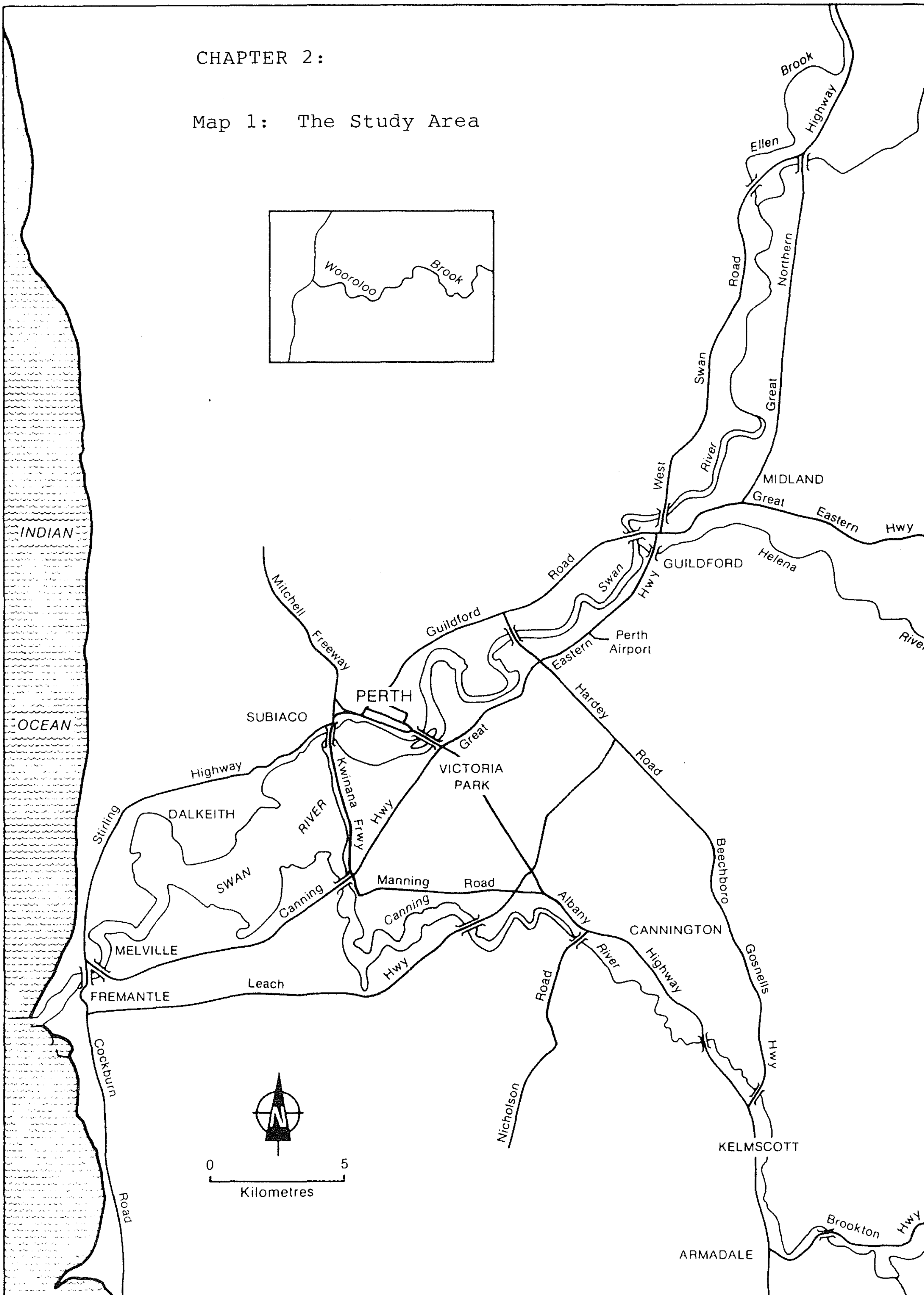



FIGURE 1: Staffing

CHAPTER 2:

Map 1: The Study Area



### 2.2.2 Membership

The Authority is composed of 12 members. The original composition in 1976 was:

| | No Members |
|---|---|
| Local Government Association | 2 |
| Perth City Council | 1 |
| Harbours and Rivers PWD | 1 |
| Harbour and Light Department | 1 |
| Community Interest | 6 |
| Chairman nominated by the Minister | 1 |
| | 12 |

Other persons were co-opted from Government Chemical Laboratories, Metropolitan Water Authority, Fisheries and Wildlife and Town Planning as representatives on the various Committees. Since then the composition has been modified to cope with the changing roles of government agencies.

The four Committees are Biological, Industrial, Planning and Works and Structures.

Officers of the Commission also attend meetings but do not have the power to vote.

Attempts are made to ensure that the Chairman of the Authority does not represent the view of another government authority.

### 2.2.3 Regulations

In accordance with the Act regulations, known as the Waterways Conservation Regulations 1981, were established by the Governor in the Government Gazette on the 14th July 1981. These Regulations deal with:

-Conflict of powers
-Management programmes
-General offences
-Licences
-Inspectors and honorary wardens
-Administration

### 2.2.4 Management Programme

Under Section 35 of the Act the Waterways Commission is required to prepare detailed documented programmes for its management areas. The programme should be developed in consultation with the Management Authority, Local Government and other public authorities.

A management programme may include a working plan to be carried out for the improvement, development and maintenance of the waters and associated land, the prevention and control of fires and public utilisation of the area, the study, care and restoration of the natural environment, the conservation of indigenous flora and fauna and other such matters as the Management Authority and Commission recommend and the Minister approves.

## 3.0 ADDITIONAL MANAGING AUTHORITIES

In addition to the Swan River Management Authority, other government agencies, departments and local government are involved directly or indirectly in the management of that estuarine system. These are as follows:

### 3.1 Department of Marine and Harbours

The Department of Marine and Harbours (formerly the Department of Harbour and Light) is responsible for boating and navigation on the Swan/Canning Estuarine System. Acts administered by the Department and relating to the river environment are:

- W.A. Marine Act 1982 Amended.
- Shipping and Pilotage Act 1967 Amended.
- Jetties Act 1926 Amended.

Regulations persuant to these Acts are contained in the Navigable Waters Regulations Amended. Regulations pertain to:

- Control of speed on the river.
- Gazettal of swimming areas, waterski areas etc.
- Organisation of regattas.
- Control of persons in charge of vessels.
- Use of public jetties.
- Silencers on boats.
- Closure of navigable waters for safety or in cases of emergency.

The Department is also responsible for the construction, provision and maintenance of facilities and services, both on land and water, that are desirable to meet the needs of both recreational and commercial boating. Approval is required from Marine and Harbours, The Local Government Authority and SRMA for the siting and location of these facilities. Funding is generally on a fifty-fifty contribution basis from Marine and Harbours and the Local Government Authority.

Licensing of 'linear and drive" vessels is also the responsibility of Marine and Harbours. However, issuing must have the approval of the public or Local Government Authority having responsibility for the management of land above high water mark in the area where the vessel is intended to be operated. Similarly liaison occurs with the SRMA, Health Department, Licensing Board of Western Australia and occasionally clubs or organisations located in the area, depending upon the type of operation proposed.

Mooring licences are also controlled by the Department, being granted by the Minister with that person able to use waters specified in the licence for the purpose of mooring vessels (Marine Act Section 65 1). To date, no public mooring areas have been declared within the management area and mooring of vessels on the river remains free of charge.

Management, use, maintenance, and preservation of all jetties is the responsibility of the Department of Marine and Harbours. Licences are issued by the Minister for Transport on such terms and conditions as considered fit to any person for the erection or construction of a jetty or for the maintenance and use of any jetty. Section 17 of the Waterways Conservation Regulations 1981 pertains to the issue of jetty licences and states that the Minister administering the Jetties Act shall not issue a licence under the Jetties Act until he has received and considered the recommendations of the Commission under the scheme of Regulation 17. It follows that the actual decision to issue an effective licence is ultimately left to the Minister responsible for the Jetties Act.

The Department has Inspectors responsible for the administration of its regulations, however, staffing resources are limited.

## 3.2 State Planning Commission

In December 1985 the Metropolitan Region Planning Authority and the Department of Town Planning were amalgamated to form the State Planning Commission. Acts administered by the Commission include the Metropolitan Region Scheme and the Town Planning and Development Act.

The Metropolitan Region Scheme (MRS) Act is the principle Act affecting planning in the Perth region and became law in 1959. In 1960 the Metropolitan Region Planning Authority (MRPA) was formed. The Metropolitan Region Scheme was proclaimed soon after on 30th October 1963.

Since that time, the scheme has been under continual review. The Minister for Planning recently announced that there is to be a wide ranging review of the long term planning framework for the Perth region.

The original scheme of 1963 included a Parks and Recreation Reserve encompassing most of the river foreshore from Fremantle to Seaforth on the Canning River, and to Guildford on the Swan River. A small portion of the Helena River foreshore is also reserved for Parks and Recreation. These reserves are indicated on the attached maps.

Declaration of these boundaries in 1963 meant that certain foreshore areas were, and still are in private ownership. Consequently rationalisation of these boundaries and acquisition of these properties have been an ongoing responsibility of the MRPA.

The aim of the Parks and Recreation Reserves along the foreshore is to establish a linear parkland along the rivers foreshores. Expansion of the Metropolitan area has meant that a review of MRS boundaries and possible extension of these along the Upper Swan and its tributaries is necessary.

Land that has been selected (under the MRS) as likely to be required for public purposes is known as "reserve land" or "regional reservation". Generally nobody may build or carry out any development on reserve land (apart from putting up a boundary fence) without applying to the MRPA for permission. The SPC may agree to development on reserve land subject to conditions limiting the period of approval or relating to the type of buildings that may be erected. Where reserve land abuts the rivers the SPC approaches the Waterways Commission for its opinion on the matter and these guidelines are incorporated into the SPC's judgements.

Where land was already developed and which subsequently became a regional reserve under the scheme, the continued use of the land has generally been permitted.

It should be noted that the regional plan is a general planning document only. Local Government plans are broken down into small component parts.

The main objectives of the SPC regarding the environment are:

- To protect the environment and enhance the amenity of the existing urban areas.

- To maintain the open character of the hills escarpment as a back-drop to the City.

- To protect the quality of the Metropolitan Region's water supply.

- To control urban development on land subject to flooding.

- To ensure adequate provision of useful open spaces and to encourage or promote their development or a wide range of recreational and community use or for natural landscape preservation.

Since its establishment, the SPC has acquired considerable land for Parks and Recreation Reserves. However, while the SPC maintains that it should not be reponsible for the ongoing management of Parks and Recreation Reserves, it nevertheless finds itself becoming more and more involved. The SPC sees the Department of Conservation and Land Management as possibly being capable of managing and developing the SPC's large land holdings.

## 3.3 Water Authority of Western Australia

In 1985 the Metropolitan Water Authority and the Public Works Department (Water Resources Division) were amalgamated to form the Water Authority of Western Australia.

Although the Authority is mainly concerned with the provision, monitoring and maintenance of fresh water and resources, there are certain activities it undertakes which affect the river environment. These are:

- Connection and maintenance of drains to the rivers and tributaries.

- Installation of sewerage facilities thus reducing potential contamination of the river and underground aquifers.

- Licensing and control of discharges to drain and sewer.

- Provision of water supply and hill storage facilities.

- Monitoring of stream flow.

The Authority also undertakes hydrological studies. For example determination of Swan/Canning and Avon River flood levels; assessment of the impact of land fill on the flood plain; assessment of the impact of roads and bridges etc on river hydrology; impact of planning schemes on river hydrology.

Acts administered by the Water Authority:

- Metropolitan Water Authority Act 1982.
- Metropolitan Water Supply, Sewerage and Drainage Act 1909-1981.
- Land Drainage Act 1925 Amended.
- Right in Water and Irrigation Act 1914 Amended.

### 3.4 Local Government Authorities

In 1977 opposition of a number of Local Government Authorities bordering the river resulted in the boundary of the SRMA being limited to those illustrated on plans A, B, and C previously described. As a consequence, the Authority is limited under the co-operation provisions of the Act relating to usage of and improvements to foreshore recreational facilities. However, in recent years, the Authority and Commission staff have become more involved, not only in advising Local Government on the impact of land use on the river environment but also assisting with planning projects. The most recent example being Garvey Park, Belmont.

Principally the SRMA should encourage Local Government to ensure that their decisions are based on the fullest available information on the potential environmental impact. When information is inadequate, it should be sought.

Each Local Government Authority within the Metropolitan region must prepare a detailed Town Planning Scheme consistent with the proposals shown in the region scheme (Section 34 MRS Act). Similarly by-laws must also be consistent with the MRS.

There are twenty Local Government Authorities with boundaries adjacent to or including the river environment. These are:

City of Armadale
Town of Bassendean
City of Bayswater
City of Belmont
City of Canning
Town of Claremont
Town of East Fremantle
City of Fremantle
City of Gosnells
Shire of Kalamunda
City of Melville
Town of Mosman Park
Shire of Mundaring
City of Nedlands
City of Perth
Shire of Peppermint Grove
Shire of Swan
City of South Perth
City of Stirling
City of Subiaco

Where the Waterways Conservation Act is in conflict with the powers conferred on a Local Government Authority by the Local Government Act 1960 or any other

Act, if in the opinion of the Commission the matter relates entirely to the waters comprised within a management area, the provisions of the Waterways Conservation Act shall prevail. Alternatively where the matter in question relates to associated land or land to which Section 31 and 32 of the Act applies and the Commission agrees with the Local Government Authority that it is not likely to affect such waters, then the Waterways Conservation Act shall not apply.

However, where the matter in question in the opinion of the Commission may indirectly affect such waters, the Local Government Authority shall consult with the Commission. Regulations made under the Waterways Conservation Act may outline the types of matters that are to be taken as falling within the categories referred to above and as to the manner in which and circumstances where such matters shall be brought to the notice of the Commission.

## 3.5 Department of Fisheries

The Department of Fisheries (previously the Department of Fisheries and Wildlife) is responsible for rules and regulations pertaining to the taking of fish* from the river system.

Legislation governing fishing in Western Australia include:

- The Fisheries Act.
- Regulations made under the Fisheries Act.
- Proclamations and notices issued under the Fisheries Act and published in the Government Gazette.

An Officer from the Department of Fisheries is a member of the Biological Technical Committee.

## 3.6 Health Department

The Health Department is responsible for bacteriological water quality analyses and its possible impact on human use of the river and environs. Standards for pesticide and heavy metal levels in food and drugs are also the Department's responsiblity.

* Term includes all or any of the varieties of marine or fresh water fishes and crustacea and marine animals.

The principle Act is the Health Act 1911-1979 Amended. Food and Hygiene Regulations are also applicable and may be administered by the Health Department or Local Government Authority. These Regulations regulate licensing of commercial food outlets.

Discharge of effluent wastes and control of tips sites are also regulated under the Health Act.

### 3.7 Department of Lands

The Department of Lands administers the Land Act 1933. Where the Waterways Conservation Act is in conflict with certain sections of the Land Act, then the Waterways Conservation Act shall not apply.

The Lands Department is responsible for the creation of reserves under Land Act (further discussed in Chapter 10) and also for the administration of property titles.

### 3.8 Conservation and Land Management Department

This Department was created in 1985 from the amalgamation of the Forests Department, National Parks Authority and Wildlife Division of the former Department of Fisheries and Wildlife. Reserves may be created and vested in this Department for example, Pelican Point Reserve and Alfred Cove Wildlife Reserve. The Authority seeks the advice of this Department where reserve land abuts the river.

### 3.9 Department of Conservation and Environment

This Department services the EPA under the provision of the Environmental Protection Act 1971-1980 as amended. Where the Waterways Conservation Act is in conflict with the EPA Act the provisions of the Waterways Conservation Act shall not apply. The Department also administers functions and powers provided in the Clean Air Act and the Noise Abatement Act 1972-1981 (as amended).

## 4.0 COMMUNITY GROUPS

In addition to Government Authorities, there are community groups interested in the development and management of the riverine system. Contact and liaison with these groups should be an important part of working management. The call for public submissions as part of this study project indicate the importance of this aspect. Although some of the comments received may be idealistic, they provide managers with ideas and options that may not have been previously considered. They also give an insite to community attitudes. It is the role of Management to bring these ideas to a rational basis.

## CHAPTER 3 : PHYSICAL CHARACTERISTICS

### 1.0 INTRODUCTION

Considerable information has been documented on the physical characteristics of the Swan-Canning Estuarine System. It is not the function of this report to detail this work and the reader is referred to Riggert (1978), Seddon (1972) and Spencer (1956) for more comprehensive studies.

### 1.1 Origin of the River

The Swan-Canning Estuarine System is a typical estuary of the south-west region of Western Australia and flows through the Perth metropolitan region. It has a scoured channel, which after expanding into broad waters, discharges into the sea at Fremantle through a long narrow inlet channel.

The river system is characterised by a seasonal pattern of river flow, which makes parts of the river fresh in winter and brackish or marine in summer.

The estuarine system receives water from both the Avon and Swan Coastal Catchments which total approximately 119,000km$^2$ and 20,000km$^2$ respectively. The Avon River, which becomes the Swan at the confluence of Wooroloo Brook, has its main source at Wickepin some 370m above sea level on the Darling Plateau flowing nearly 300km through the Darling Range down to the coastal plain.

The descent from near Toodyay to the plain is a gorge falling 127m in 80km, which rejuvenates the stream before it reaches the plain. The estuarine section of the Swan River extends to around Middle Swan Bridge, approximately 50km from the ocean and to Kent Street Weir on the Canning River.

The major tributaries of the Swan-Canning Estuarine System are the Dale River at the head waters, the Mortlock River below Northam Weir and Toodyay Brook and Brockman River which flow in upstream of the coastal plain. Ellen Brook, the Helena, Canning/Southern Rivers feed directly into the Swan River on the coastal plain. Several smaller brooks such as Wooroloo, Susannah and Jane Brooks on the Swan and Bickley on the Canning contribute "fresh water" from surrounding wetlands during the winter months.

## 1.2 Climate

Perth is situated at 31° 57' latitude (S) and 115° 52' longnitude (E). The climate of the region is described as Mediterranean. Average summer temperatures are 29°C maximum and 17.3°C minimum with predominantly easterly winds with a south-west afternoon seabreeze. In the winter the average maximum temperature is 17.8°C with a 9.3°C minimum. Winds are predominantly north-west to south-west during this period.

The average rainfall for the metropolitan region is 872mm with the majority of rain falling between May and August inclusive.

## 1.3 Hydrology

The volume of river inflow into the system is the principal factor determining the hydrological status of the estuary. Consequently the hydrological condition of the estuary changes seasonally.

Under winter conditions the upper estuary is fresh throughout. In comparison the lower estuary surface chlorinity varies from 1661 mg/L in a wet year to greater than 19,300 mg/L in a dry year. Deep water in the lower estuary maintains a chlorinity similar to sea water (19,370 mg/L) as the density of sea water is so much greater than that of fresh water that the two will not mix unless some force is applied. This stratified condition is termed a 'halocline'. The deep water is isolated because of this condition with very little light penetrating for plant photosynthesis and consequently deoxygenation occurs due to biological activity.

In spring, as runoff decreases, intrusion of sea water into the estuary by the tides displaces the fresh water (because of the greater density) and subsequent wind stress mixes the two bodies. In full summer conditions when there is no effective river runoff the lower estuary is marine throughout with a gradient along the upper estuary. Evaporation from the surface may still further increase chlorinity and estuary water is sometimes greater than the sea.

Tidal movements may also cause hydrological change. Spencer (1956) reports that falling barometric pressures and the characteristic gales of such periods result in each flood phase being greater than that of the preceeding ebb, so that over a period of several days there is a marked increase in the mean water level, due to the entry of sea water from the marine end of the system. Rising barometric pressure results in the ebb phase of each tidal cycle once again becoming dominant, so that the water level falls steadily as water moves out of the system.

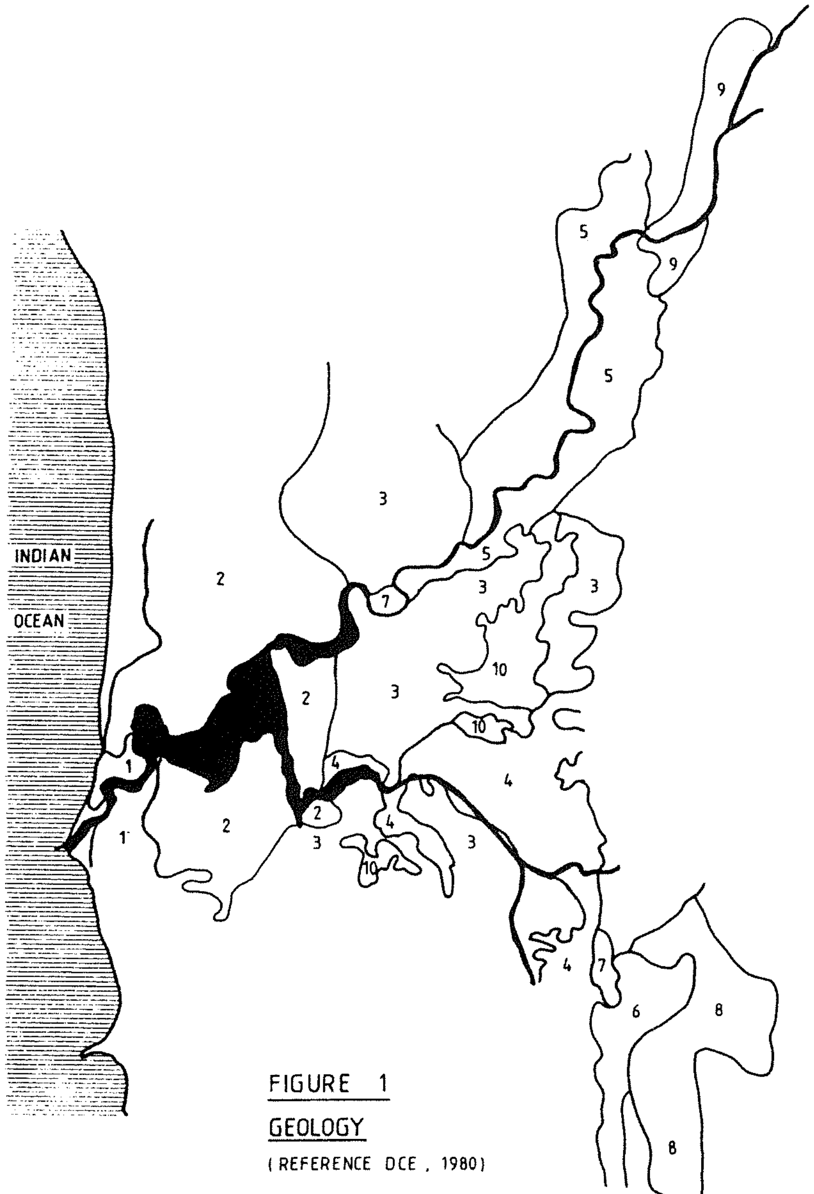



FIGURE 1
GEOLOGY
(REFERENCE DCE, 1980)

LEGEND - GEOLOGY

| | |
|---|---|
| 1 | BLACKWALL REACH TAMALA LIMESTONE, EOLIANITE, MINOR MARINE LIMESTONE & SOME SAND |
| 2 | UPSTREAM TO RIVERTON BRIDGE & MT. LAWLEY - SAFETY BAY SAND, CALCAREOUS SAND DUNES (ALSO ELLAM STREET) |
| 3 | BASSENDEAN SAND WHITE & GREY QUARTZ SAND |
| 4 | GUILDFORD FORMATION, SANDY CLAYS TO CLAYEY SANDS, INCLUDES OTHER ALLUVIUM & COLLUVIUM |
| 5 | DEMONSTRATED ORE RESERVES OF 4 |
| 6 | MIGMATITES |
| 7 | YOGANUP FORMATION, FOSSIL SHORELINE SANDS, SOME CONTAIN HEAVY MINERALS |
| 8 | GENEISSES INCLUDES METASEDIMENT |
| 9 | METAMORPHIC BELTS 'C' CHITTERING, SCHISTS |
| 10 | WETLAND DEPOSITS SWAMP ESTUARINAL, LAGOONAL. |

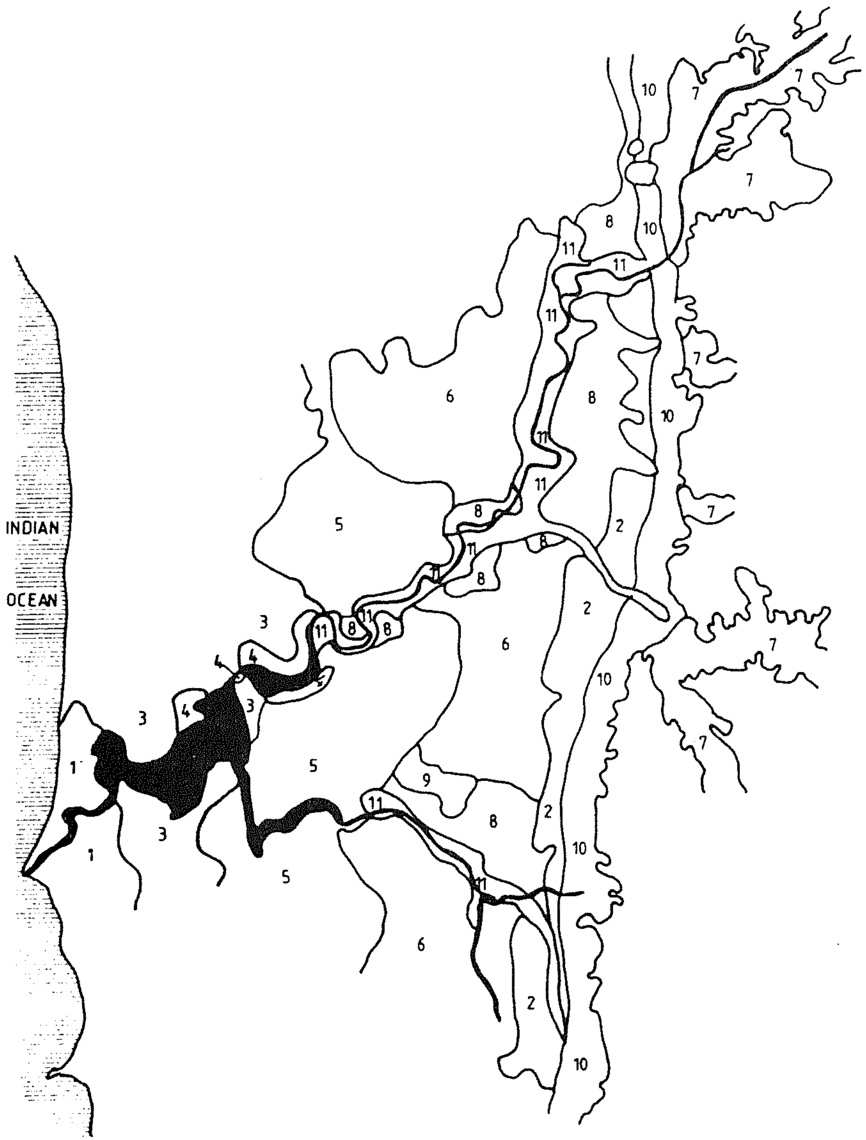



FIGURE 2

LANDFORMS & SOILS

(REFERENCE DCE, 1980)

LEGEND - LANDFORMS & SOILS

| | |
|---|---|
| 1 | CT. COTTESLOE: LOW HILLY LANDSCAPE WITH SHALLOW BROWN SANDS OVER LIMESTONE, MUCH EXPOSED LIMESTONE |
| 2 | F. FORRESTFIELD: LATERITISED FOOTHILLS OF THE DARLING SCARP DOMINATED BY GRAVELLING & SANDY SOILS |
| 3 | K. KARRAKATTA: UNDULATING LANDSCAPE WITH DEEP YELLOW SANDS OVER LIMESTONE. |
| 4 | V. VASSE: POORLY DRAINED PLAINS WITH VARIABLE UNDIFFENTIATED ESTUARINE & MARINE DEPOSITS |
| 5 | B. BASSENDEAN: SAND PLAINS WITH LOW DUNES & OCCASSIONAL SWAMPS; IRON OR HUMAS PRODZOLS: AREAS OF COMPLEX STEEP DUNES |
| 6 | SR. SOUTHERN RIVER: SANDPLAINS WITH LOW DUNES & MANY INTERVENING SWAMPS; IRON OR HUMAS PRODZOLS, PEATS & CLAYS |
| 7 | H. HELENA: VERY DEEPLY INCISED VALLEYS WITH STEEP ROCKY SLOPES & SOME SHALLOW RED OR YELLOW EARTH |
| 8 | GF. GUILDFORD: FLAT PLAIN WITH MEDIUM TEXTURED DEPOSITS; YELLOW DUPLEX SOILS |
| 9 | Ca. CANNINGTON: POORLY DRAINED PLAINS WITH CALCAREOUS SUBSTRATE; YELLOW DUPLEX SOILS WITH MINOR AREAS OF RED & BLACK CLAYS OVER LIMESTONE |
| 10 | DS. DARLING SCARP: VERY STEEP SLOPES WITH SHALLOW RED & YELLOW EARTH & MUCH ROCK OUTCROP |
| 11 | Sw. SWAN: ALLUVIAL TERRACES WITH RED EARTHS & DUPLEX SOILS. |

The time and duration of these phases and the actual chlorinities experienced depend on the time of onset, duration and intensity of rainfall in the catchment.

## 1.4 Water Temperature

Water temperatures change seasonally, vertically and locally. Winter surface temperatures range from 13.2°C to 15.8°C and summer values from 23.2°C to 25.6°C. Factors affecting temperature are inflowing 'fresh' or marine water, depth, atmosphere temperature and mixing of fresh and marine waters. More detailed analysis are presented in Chapter 6 on Water Quality.

## 1.5 Tides

The Swan-Canning Estuarine System experiences approximately a 0.5 metre tidal range at both Fremantle and Barrack Street. The upper limit of the tidal action on the Swan River is near Middle Swan Bridge and Kent Street Weir on the Canning River.

## 1.6 Geology and Landform

Figures 1 and 2 illustrate the general landforms and geology of the study area and associated lands. A more comprehensive discussion may be found in the Atlas of Natural Resources, Darling System (DCE, 1980). Vegetation and land use are illustrated in Figures 3 and 4 respectively.

A basic understanding of landform and geology are essential because of the manner in which they affect, contribute and influence the river environment. Soil type for example influences erosion, sedimentation, background heavy metal levels, pollution potential, ground water movement and drainage patterns.

## 1.7 Sediments

The bed substratum grades from coarse, mainly quartz sand in the upper reaches of the river to dark grey mud downstream to Heirisson Island. From Salter Point to Kent Street Weir on the Canning River extensive shallow mud and sand flats prevail. The shallows in Perth Water are of a sandy medium with marginal sand flats and spits occurring in the Melville Water area. The basin substratum consists of fine grey mud. In addition, extensive fossil shell beds are found in much of Perth and Melville Waters.

Substrates in the lower estuary range from a fine, dark grey mud in the Blackwall Reach channel to coarse shell and pebble beds in the Rocky Bay channel; elsewhere sand flats and sills predominate (Chalmer et. al., 1976).

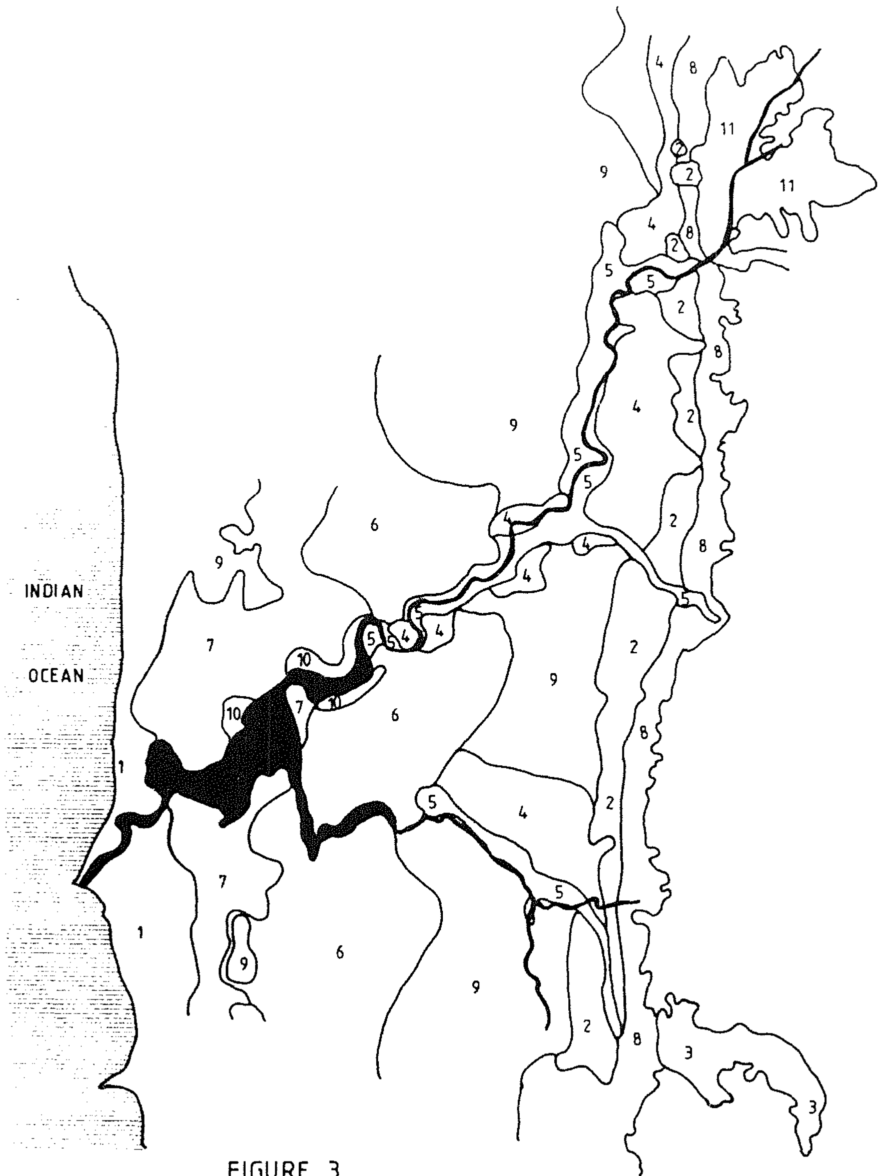



FIGURE 3

VEGETATION

(REFERENCE DCE, 1980)

## LEGEND - VEGETATION

| | |
|---|---|
| 1 | COTTESLOE COMPLEX - CENTRAL & SOUTH. MOSAIC OF WOODLAND E.GOM PHOCEPHALA & OPEN FOREST OF E. GOMPHOCEPHALA - E. MARGINATA - E. CALOPHYLLIA; CLOSED HEALTH ON THE LIMESTONE OUTCROPS |
| 2 | FORRESTFIELD COMPLEX - VEGETATION RANGES FROM OPEN FOREST OF E. CALOPHYLLA - E. WANDOO - E. MARGINATA TO OPEN FOREST OF E. MARGINATA - E. CALOPHYLLA - C. FRASERANA BANKSIA SPP. FRINGED WOODLAND OF E. RUDIS IN THE GULLIES THAT DISSECT THIS LANDFORM |
| 3 | HELENA COMPLEX IN MEDIUM TO HIGH RAINFALL: VEGETATION RANGES FROM OPEN FOREST OF E. MARGINATA - E. CALOPHYLLA - E. PATENS THROUGH HEATH & HERBLAND TO LICHENS ON GRANITE ROCK |
| 4 | GUILDFORD COMPLEX - A MIXTURE OF OPEN FOREST TO TALL OPEN FOREST OF E. MARGINATA & WOODLAND OF E. WANDOO, E. MARGINATA & WOODLAND OF E. WANDOO (WITH RARE OCCURENCES OF E. LANE-POOLEI). MINOR COMPONENTS INCLUDE E. RUDIS - M. RHYSHIOPHYLLA |
| 5 | SWAN COMPLEX - FINGED WOODLAND OF E. RUDIS - MIRHAPHIOPHYLLA WITH LOCALISED OCCURENCE OF LOW OPEN FOREST OF E. OBESA & M. CUTICULARIS |
| 6 | BASSENDEAN COMPLEX - CENTRAL & SOUTH: VEGETATION RANGES FROM WOODLANDS OF E. MARGINATA - C. FRASERENA - BANKSIA SPP TO LOW WOODLAND OF MELALEUCA SPP, SEDGELANDS ON THE MASTER SITES. THIS AREA INCLUDES THE TRANSITION OF E. MARGINATA TO E. TODTIANA IN THE VICINITY OF PERTH. |
| 7 | KARRAKATTA COMPLEX - NORTH - TRANSITION VEGETATION COMPLEX - A TRANSITION COMPLEX OF LOW OPEN FOREST & LOW WOODLANDS OF BANKSIA SPP. E. TODTIANA ON THE ON THE TRANSITION ZONE OF A SERIES OF HIGH SAND DUNES BETWEEN BASSENDEAN NORTH & KARRAKATTA NORTH. |
| 8 | DARLING SCARP COMPLEX - VEGETATION RANGES FROM LOW OPEN WOODLAND TO LICHENS ACCORDING TO DEPTH OF SOILS. WOODLAND COMPONENTS CHIEFLY E. WANDOO, WITH E. LAELIAE IN THE NORTH. E. HAEMATOXYLEN IN THE SOUTH, & E. CALOPHYLLA THROUGHOUT THE REGION. |
| 9 | SOUTHERN RIVER COMPLEX - OPEN WOODLAND OF E. CALOPHYLLA - E. MARGINATA - BANKSIA SPP. WITH FRINGING WOODLAND OF E. RUDIS - M. RHAPHIOPHYLLA ALONG CREEK BEDS |
| 10 | VASSE COMPLEX - MIXTURE OF THE CLOSED SCRUB OF MELALEUCA SPP, FRINGING WOODLAND OF E. RUDIS - MELALEUCA SPP. & OPEN FOREST OF E. GOMPHOCEPHALA, E. MARGINATA, E. CALOPHYLLA |
| 11 | HELENA COMPLEX IS LOW TO MEDIUM RAINFALL VEGETATION RANGES FROM OPEN FOREST OF E. MARGINATA - E. CALOPHYLLA, E. PATENS THROUGH HEATH & HERBLAND TO LICHENS ON GRANITE ROCK. |

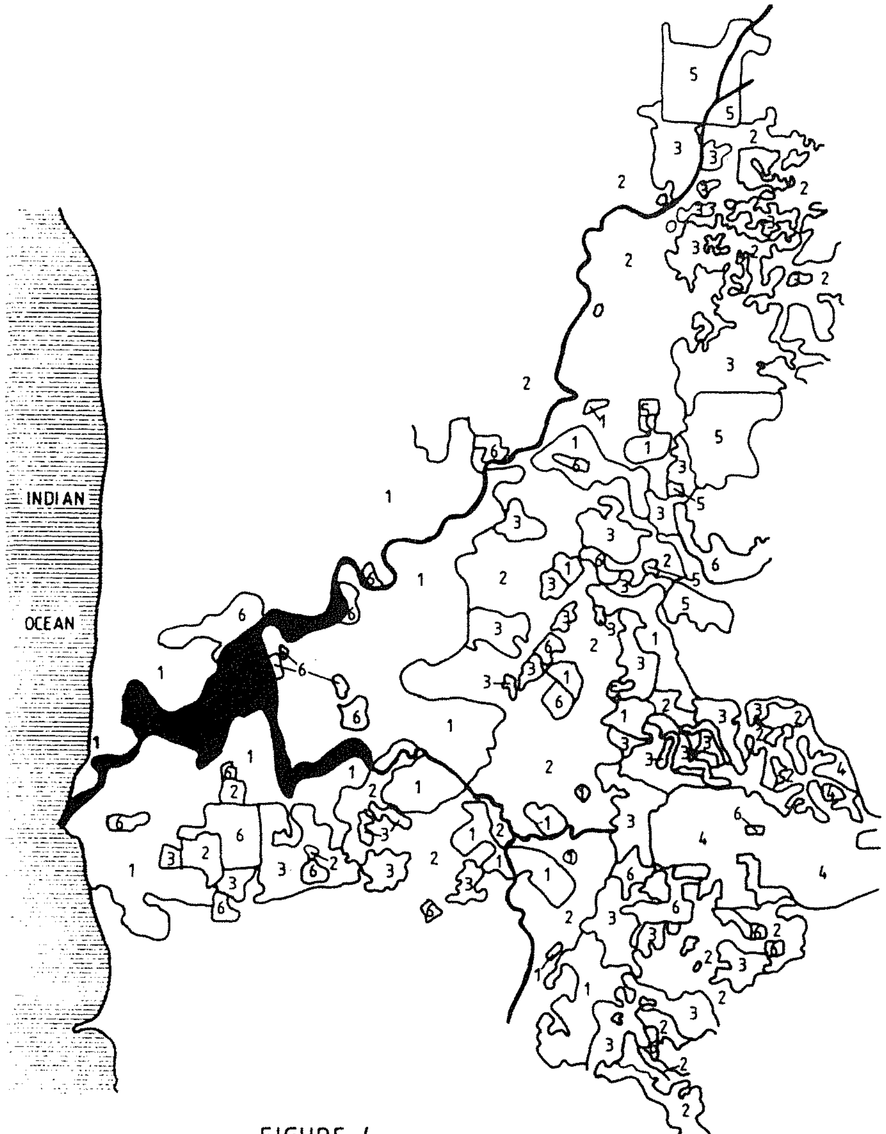



FIGURE 4

LAND USE

(REFERENCE DCE, 1980)

LEGEND - LAND USE

| | |
|---|---|
| 1 | SIGNIFICANT POPULATED PLACES > 1000 |
| 2 | CLEARED LAND: LESS THAN 15% NATURAL VEGETATION |
| 3 | UNCLEARED LAND: 15% OR GREATER NATURAL VEGETATION |
| 4 | STATE FORESTS: INCLUDING TIMBER RESERVES |
| 5 | NATIONAL PARKS: ADMINISTERED BY THE NATIONAL PARKS BOARD |
| 6 | RESERVES FOR SUCH PURPOSES AS:<br>CONSERVATION OF FLORA & FAUNA<br>RECREATION & CAMPING<br>PARKLANDS<br>WATER SUPPLY<br>RE-AFFORESTATION<br>OTHER NATIONAL PARKS NOT ADMINISTERED BY THE NATIONAL PARKS BOARD |

Various substrates provide important habitats to the flora and fauna of the estuarine system and these are discussed in Chapter 4 and 5 respectively and the impact of changes to the substrate as a result of dredging are discussed in Chapter 8.

## 2.0 THE AVON RIVER CATCHMENT

The Avon River is the major source of "fresh water" to the study area and consequently it is impossible to undertake a review of the Swan-Canning Estuarine System without assessing, however limited, the status of the Avon River and its catchment.

### 2.1 Salinity

Prior to European settlement of Western Australia the region was covered with deep-rooted perennial vegetation. Clearing of the land for agriculture has lead to changes in the water balance of the landscape resulting in potential salinity problems.

Before clearing, the native vegetation produced a mulch of organic material on the soil. Root micro-organisms and animal activity kept the surface soil friable and permeable and the roots explored the subsoil to a great depth in search of water. Malcolm (1980) states that as a result conditions of low runoff; low excess percolation; salt storage in soils; salt storage in ground water prevailed. Removal of the native vegetation and its subsequent replacement with annual crops and pastures causes the potential salt problems to develop. Important changes take place in both the surface and subsoil. According to Malcolm (1980), the following changes occur:

- More runoff
- More excess percolation
- Salt moves with percolating water
- Increased winter water logging
- Seepages and perched water tables
- Increased water pressure

Increased ground water levels in turn re-distribute soil solutes, leaching some to the streams thereby increasing stream salinity (Hurle and Johnston, 1979 as cited by Stokes, 1980). However, by maintaining high levels of evapo-transpiration in areas of high salt storage discharge of saline ground water will be minimised.

Mulcahy (1973 as cited by Kendrick, 1976) reports that the extension of agriculture eastward from the Meckering Line has increased the frequency of saline lake discharge into rivers including the Avon, thus further raising their salinity load.

Sadler and Williams (1980) discussing salinity management in Western Australia, report that as early as 1908 engineers concluded they had induced a salinity rise in the Helena River by clearing native vegetation to increase streamflow. Pines were replanted on this cleared land in an attempt to rectify the problem and this became the first recorded remedial measure responding to stream salinity in south-western Australia.

Data recorded by PWD (1984) indicate that two stream sites of the Avon system have a trend towards increasing salinity through time. These are gauging sites 616179 and 616001. The latter site is Wooroloo Brook (Karls Ranch) with a long term average Total Soluble Salt (TSS) value of 1790 mg/L (990 mg/L chlorinity). Brockman River at Glen Darron is the other site, recording a long term average TSS value of 1460 mg/L (808 mg/L chlorinity). For comparison a five year mean of SRMA chlorinity data 1979-1984 recorded at Walyunga is 3397 mg/L*.

Kendrick (1976) reviewing the fauna of the Avon River suggests that raised salinites have been the principal cause of the decline of the mollusc Westralunio carteri since the 1940's. In contrast evidence suggests that the mollusc Anticorbula amara has extended its range upstream from the Swan Estuary in response to the increased salinity of the river environment.

Although to date the salinity of waters entering the Swan-Canning Estuarine System have not changed significantly, the potential exists if the problems of dry land salinity and leaching of soil solutes into streams continue. Catchment management initiatives must be based on an understanding of the relationship between salt storage characteristics, the hydrologic regime and the land use of the catchment area.

## 2.2 The Avon River Training Scheme

In an attempt to overcome the incidence of flooding of the Avon River, particularly at Northam, a proposal to train the river was presented to the State Government in the early 1950's by the concerned parties. It was envisaged that by promoting an increased rate of water runoff, there would be less likelihood of flooding. To achieve this increased rate of runoff, it was proposed that the river bed be cleared of debris, widened where necessary and also straightened where feasible. The programme was started in 1956 and the majority of work was completed by 1970.

* Waters of 277 mg/L chlorinity are considered fresh water for drinking and waters with a chlorinity greater than 831 mg/L are rejected as drinking water.

According to Kendrick (1976) over its 20 years of operation, no official evaluation of the "training scheme" has been released but it is clear that one negative consequence has been the creation of a large body of unstable sand in the channel between York and Toodyay. Further without some new initiative, it seems that the obliteration of most, if not all of the pools in this area is only a matter of time. Notwithstanding this, Kendrick (1976) comments that although no data are available on which to base precise comparisons, there can be little doubt that the near total clearing of the catchment has substantially increased the concentration and probably also the volume of surface runoff after rain. These factors have probably intensified the erosion of sediments, particularly from higher land, and contributed significantly to the accumulation of sand in the bed. The continual access of livestock to the banks, channel and tributaries is also likely to have aggravated this process.

## 2.3 Eutrophication

An increase in the amount of nutrients entering a water body if not too great may be a good thing but in excess the results can be disastrous. Kendrick (1976) comments that contamination of ground and surface water by animal wastes is an acknowledged pollution hazard in some parts of the world where intensive livestock farming is widespread.

Such events point to a second major threat to the biota of the Avon (salinity being the first). The sudden re-activation of animal wastes by summer or autumn rains can lead to crises of deoxygenation and eutrophication in the river pools, which are the dry season refuges of fauna. The normal soaking rains of the winter wet season do not usually overload rivers with organic debris from adjacent paddocks. In contrast, however, the high intensity of the summer thunderstorm produces, literally, a sheet of runoff carrying the more abundant debris into the rivers, where the higher summer temperatures cause rapid decomposition, a drastic fall in oxygen levels and there is no following runoff giving overflow and dilution (Morrissy, 1978).

Consequently, the traditional practice of permitting livestock generous access to the pools, channel and banks of the Avon and its tributaries should now be re-appraised in light of its apparent significant impact on the river environment (Kendrick, 1976).

## 2.4 Addressing the Problems

Recognition of the Avon's "problems" by the associated Local Government Authorities has resulted in the establishment of the Avon River Steering Committee. The aims of the Committee are as follows:

1. To restore the natural functioning balance to the Avon River System for social, economic and environmental reasons.

2. To reduce the rate of water discharged into the river system by actively encouraging all recognised methods of soil conservation on rural land and to extend these concepts to the beds of the rivers.

3. To encourage improvement of the quality of water flowing into the river system.

4. To collect, collate and make available to the public all existing information on the river system.

5. To seek financial and scientific assistance with which to further these aims.

To date the impact of problems on the Swan-Canning Estuarine System associated with the Avon River and its catchment has been limited. However, because of the Avon's "fresh water" contribution to the system it is impossible to treat each as a separate entity and for this reason the Commission is assisting the Avon River Steering Committee with its work.

## 3.0 FLOODING

Flooding of land adjacent to the river is a natural occurrence. European man has interferred with this regime by:

- Blasting of the rockbar at the estuary mouth.
- Damming of the Helena and Canning Rivers.
- Dredging of the upper reaches of the river.
- Filling of the flood plain, floodway and walling of the river.
- Development of structures over the river such as bridges.

The first three points have all, to some extent, reduced the incidence of flooding. The last two points, however, may confine river flow holding back flood waters forcing them out over low lying lands upstream of the point of confinement.

### 3.1 The Need for Legislative Control

The need for legislation to effectively control filling of the flood plain has been recognised and in 1984, an amendment to the Land Drainage Act went before

Parliament. After public submissions on the amendment (including one from the Waterways Commission) revision of the legislation was undertaken. However, it is not anticipated that this revised legislation will be presented to Parliament until after June, 1986.

Without the amendments the only institutional arrangements presently available to the State to control development on flood plains are through the Planning Authorities such as the Town Planning Board, MRPA and Local Authorities. Where subdivisions or building proposals relate to land known to be flood prone, these Authorities refer them to the Public Works Department (now Water Authority of W.A.).

Any condition or restrictions recommended by the Water Authority are imposed at the discretion of the Authorities. This method of control has been moderately successful because of the goodwill of the bodies concerned.

There have been instances, however, where Local Authorities have sanctioned, or themselves been party to injudicious filling on flood plains. Furthermore, planning bodies have expressed concern about their liability in the event of a challenge to their Authority to refuse building applications or to impose costly or unpopular conditions on the basis of what is seen by some as an obscure flood risk.

## 3.2 Scope of the Legislation

The proposed Amended Land Drainage Act (not revised form) establishes the right of the Minister for Works to determine the site, nature and dimensions of permissible developments on all areas of flood prone land. It is envisaged that in most instances these controls will be administered by the planning bodies, including the Waterways Commission, by virtue of delegated powers.

Adoption of the 1 in 100 year, or the one percent flood is in accordance with criteria recommended by the Australian Water Resources Council. This level flood is the standard used almost exclusively for flood management of urban lands. This line is marked on the accompanying maps.

The Bill provides for the delineation of that portion of flood prone lands which is necessary to carry the waters of the flood. This is referred to as the floodway. The remainder of flood prone lands although inundated during a flood do not contribute to the conveyance of flood waters.

Within the floodway development which would obstruct the flow of waters is not permitted. It is proposed that land use within the floodway will be restricted to playing fields, parklands and non-obstructive boating facilities. On the balance of flood prone lands buildings would normally be approved provided they were built above the flood level and the foundations were adequately protected against erosion.

Provision is made in the Bill for the Minister to exercise control of development within declared flood prone areas.

The Minister may delegate to river Management Authorities (including the Waterways Commission) his power to approve developments within floodways. His power to control developments on the remainder of the flood plain may be delegated to Local Authorities.

## 3.3 Assessment of the Legislation

In its assessment of the proposed Amended Land Drainage Act the Commission resolved that:

- Delegation of power in management areas should be obligatory.

- Management Authorities would expect to be consulted in decisions related to development of flood prone land.

- Local Authorities should be obliged to accept the Water Authority's advice.

- Local Authority Town Planning Schemes should incorporate controls for the development of flood prone land as advised by the Water Authority.

- The Waterways Commission should be represented on Committee's of Inquiry.

- The Commission should be consulted on matters affecting the quality of waters discharging into waters under the jurisdiction of the Waterways Conservation Act.

- It is desirable to adjust management area boundaries to include flood prone land.

## 3.4 Determination of Flood Prone Areas

In 1977, the Public Works Department determined the 'floodway' of the Canning and Swan River and these are illustrated on the attached maps. The term 'floodway' is defined as that part of the river cross-section upon which no obstruction such as filling, embankments, structures and high fences should be permitted. This section of the river is required if the 100 year flood is to flow unimpeded.

It is important to note that development and filling of flood plain land beyond the recommended limits means a larger area of land inconvenienced upstream as a result of higher flood levels. If filling of a flood plain beyond recommended limits can be justified, the Public Works Department (1978) comments that flood levels and constraints on developments upstream would require modification.

In determining both the 'floodway' and 'limit of development' lines the Public Works Department (1978) attempted to keep existing development outside these lines. However, this was not possible with a few developments adversely situated on the flood plain. Many of these buildings are outhouses or are associated with water based sports. The fact that these are liable to damage during major floods should be recognised.

Filling of some flood plains has taken place since the study in 1977. The effect of this encroachment beyond the recommended limits requires examination in the light of potential increased flood levels upstream. A study to this end is currently being undertaken by the Water Authority.

Determination of the Swan River 'floodway' involved projection of the one percent flood or 1 in 100 year flood event. This was based on 9 years of recording at the Walyunga gauging station and other past flood events such as these experienced in 1926 and 1955. A "lumped" model was used for analysis.

Determination of Canning flood levels were based on historic floods recorded prior to damming of Canning River and storage capacity of the dam. Flooding will occur as a result of overflows from the dam and local drainage. Consequently the impact of a 1 in 100 year flood during summer will be negligible because of low dam levels. The greatest potential impact will be at the end of winter when dam levels are maximum. Occurrence of a 1 in 100 year flood at this time would result in a constant flow of water over the dam wall for a significant period of time.

Discussion with Professor C.A. Parker (pers. comm., 1985) indicated that flood levels determined by Public Works Department may be significant under estimates. It is suggested that the almost total clearing of natural vegetation within the Avon catchment has significantly reduced infiltration of water into the soil, producing an increased amount of runoff into streams which in turn increases the amount of water reaching the Swan River from this source.

However, D. Vodanovic (Water Authority, pers. comm., 1985) indicated that although this assumption is basically correct, recent flood studies of the upper Swan and lower Avon Rivers by Binnee and Partners have correlated well with the original 1977 Public Works Department study. Moreover, the study conducted by Binnee and Partners used the Flaute model which incorporates details on the catchment, unlike the Public Works Department study which 'lumped' all details, so aspects such as extensive vegetation clearing have been considered. A variation of 2-3% was recorded between the two studies suggesting flood levels determined by Public Works Department are realistic (D. Vodanovic, pers. comm., 1985).

A comprehensive study planned of the Avon River catchment, in which the Waterways Commission is to be involved, will need to address this matter in more detail.

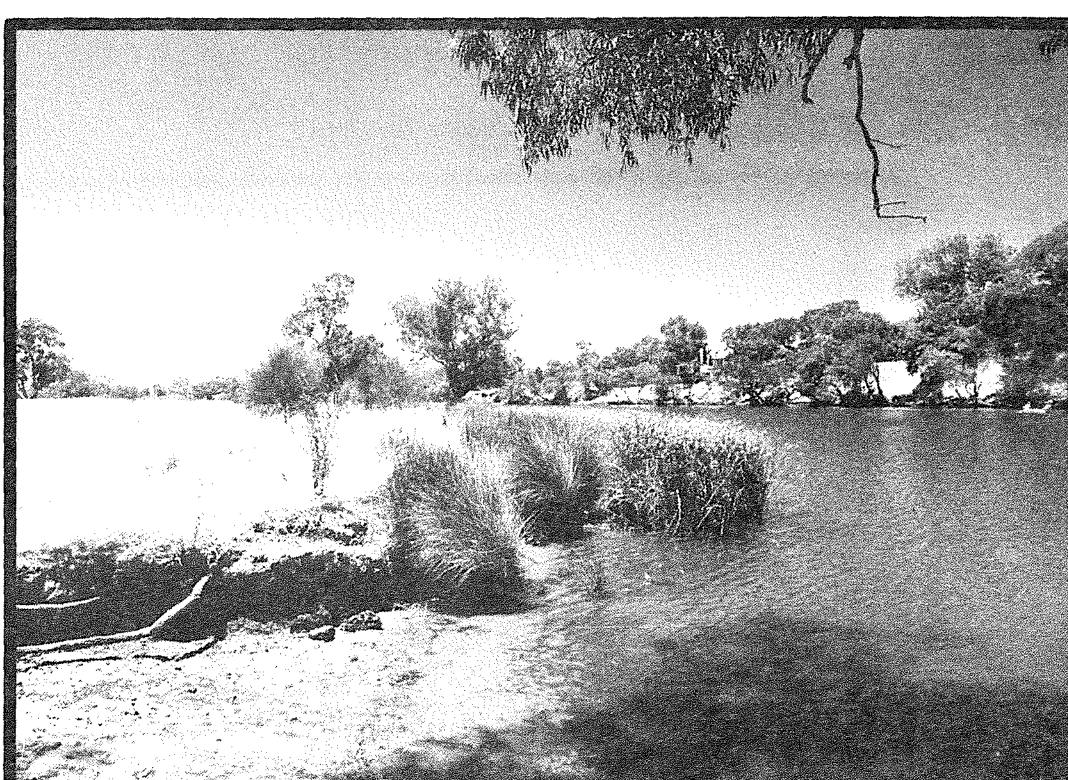


PLATE 2: Flood prone land Ashfield Flats (looking upstream)

PLATE 3: Attadale foreshore prior to reclamation looking east

PLATE 4: Landfill Attadale 1963

# CHAPTER 4 : FLORA

## 1.0 INTRODUCTION

The flora of the Swan River estuary includes both the aquatic plants such as algae, seagrasses and other submerged angiosperms, and the vegetation which fringes the estuary shoreline - the marshes and fringing forests.

Apart from its aesthetic value, the flora plays a vital role in the estuarine ecosystem. The plant communities are highly productive despite the severe environmental conditions associated with the estuary and support a diverse and productive fauna. The flora not only provides a food source for the fauna but also a habitat in which to live; as shown by the importance of seagrass meadows as nursery areas for fish and peripheral vegetation to water as a habitat for water birds.

The flora also interacts with the physical environment, stabilising sediments, contributing to the estuary's efficiency as a waterway and performing important functions in oxygen and nutrient dynamics in the system.

The estuarine flora is a valuable resource and yet it is vulnerable to clearing or dredging and other activities by man which can degrade or destroy it. Conservation of the flora and the fauna it supports, requires careful management and knowledge of the estuarine ecosystem and the factors which affect it.

In this report a description will be given of the estuarine flora, its dynamics, importance and the types of activities by which man may damage the flora.

## PART 1 AQUATIC FLORA

## 2.0 MACROALGAE

Sixty six species of macroalgae have been identified in the Swan River estuary. Although this number is small compared to the 600 or so species identified for our coastal waters, it is a large number for an estuarine system and indicates both a strong marine influence in the estuary and a lack of pollution. The major study of macro-algae distribution was undertaken by Allender (1970). Sample sites are illustrated in Figure 1.

The distribution of these algae, both in time and space, is largely controlled by the hydrology of the estuary. Two seasonal phases of salinity and temperature can be recognised; the summer-autumn phase

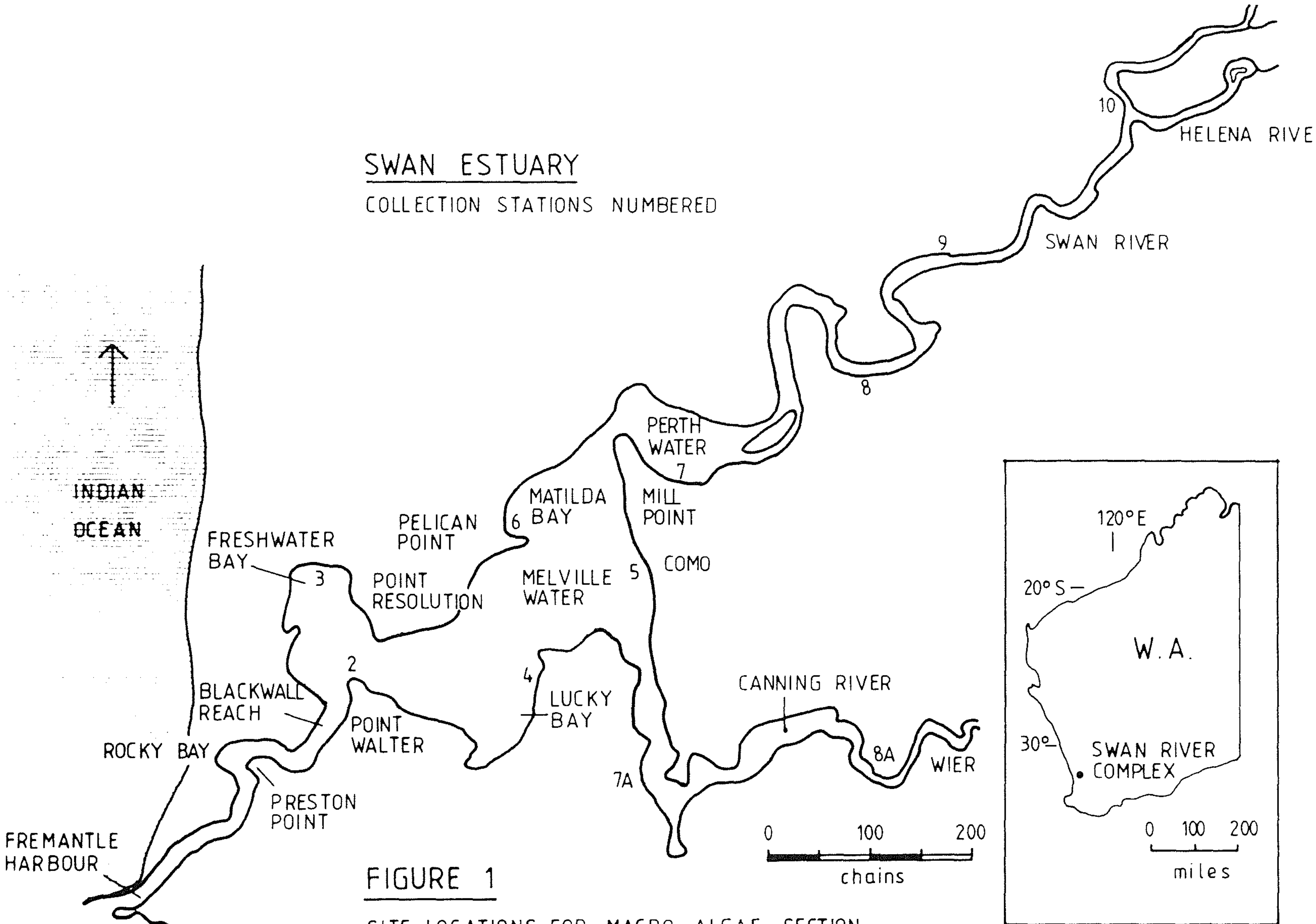



FIGURE 1

SITE LOCATIONS FOR MACRO-ALGAE SECTION
(FROM ALLENDER 1970)

which has marine-dominated salinities to Perth water, with salinities decreasing and water temperature increasing further upstream, and the winter-spring phase during which fresh water runoff from winter rainfall causes a halocline of cool fresh water to 2-5 metres depth with salt water beneath. High turbidity is also associated with this phase.

Over half of the algal species in the estuary occur throughout the year (perennial), while the rest occur only in the summer-autumn phase. Many of the perennial species exist in a smaller or fragmentary form during winter when the physical environment is unfavourable for growth.

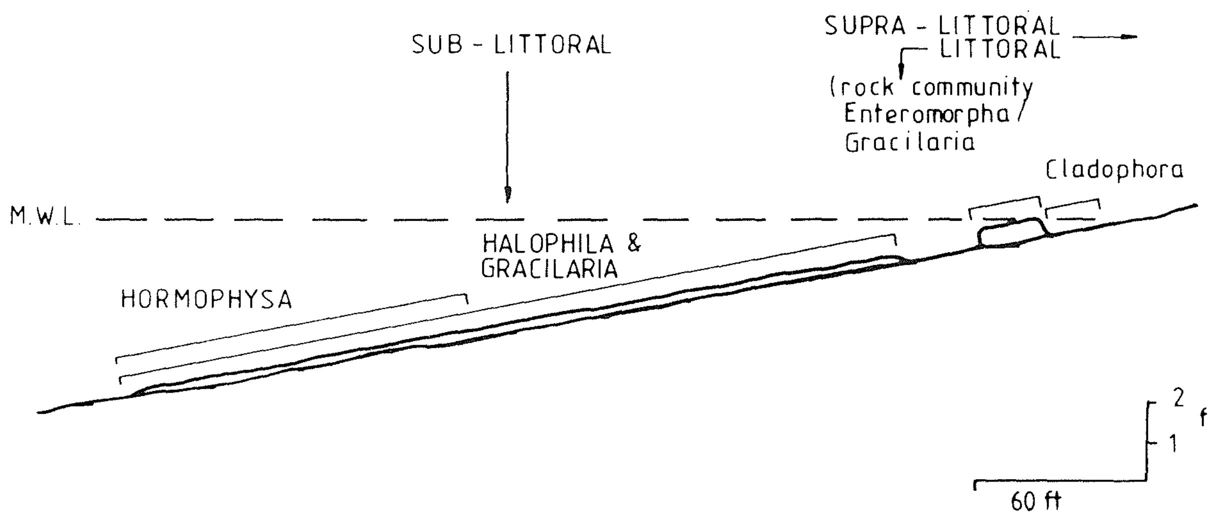
Algae may attach to a number of substrates or float freely in the water. In a survey of 46 species, Allender (1970) found that 60% of the species could be found attached to plants (epiphytism) while 90% could attach to other substrates especially rock, piles, mussels and other shells. Only 30% of species ever attach to bare sand and only eight species were found to be free-floating. Those algae which attach to substrates are limited in their distribution to areas where these sites are available. The most common plants subject to epiphyte-attachment are the seagrass Halophila ovalis and the red algae Gracillaria verrucosa, both plants being very abundant in the estuary.

## 2.1 Macroalgae Distribution

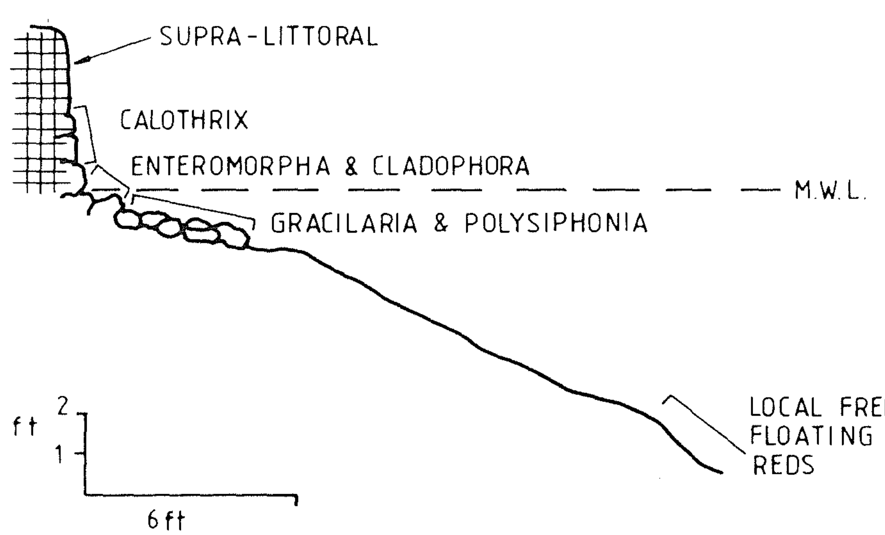
The estuarine algae are similar to those occurring in the marine environment adjacent to the estuary. However, with increasing distance from the mouth of the estuary, the total number of algal species and their vertical distribution through the water column becomes smaller, whereas the proportion of Chlorophyta (green algae) and perennial species increases.

The reduction in total number of species upstream is related to the salinity of the water, fresh water tends to be detrimental to the growth and metabolism of marine macroalgae. Similarly the decreased vertical distribution upstream may be because algal species which usually live in deep water e.g. Monospora australis, Gelidium pusillum and Polysiphonia subtilissima cannot tolerate continuous exposure to low salinities. The depth to which algae can grow ranges from 3-4 metres near the mouth of the estuary at Freshwater Bay to only 6-24 centimetres at the junction of the Swan and Helena Rivers. Almost all of the benthic algae occur in shallow water (Allender 1981).

## A. SAND FORMATION




## B. ROCK FORMATION




## FIGURE 2

SCHEMATIC REPRESENTATION OF TYPICAL SAND / MUD & ROCK SHORELINE PROFILES FROM ALLENDER (1970)

### 2.1.1 Vertical Distribution

Two formations of algae are found in the estuary depending on the type of substrate present, sand/mud or rock (Figure 2).

**Sand/Mud Formations**

In sandy areas no algae occurs in the supra-littoral zone due to instability of the substrate. However in the littoral zone occasional free-floating algae or loosely attached Cladophora sp. may be found. In the sub-littoral zone where Halophila occurs, epiphytic algae are common both on Halophila and associated macroalgae, Gracillaria. Hormophysa triquetra is also an important species in this zone, especially in Melville Water.

In deeper or sheltered areas the red algae Gracillaria verrucosa and Griffithsia corallina are often found. Algae are rare above Perth Water, apart from Gracillaria.

**Rock Formations**

Where rocky shores occur, algae such as Calothrix parietina can attach to rocks in the supra-littoral zone. In winter, however, Calothrix is replaced by Enteromorpha sp., Ulvaria oxysperma and Bangia fuscopurpurea. In the lower estuary these algal associations form a band 0.3-0.5 metres high diminishing to 0.2 metres at their northern limit in Perth Water.

Due to the small tidal amplitude of the Swan River, the littoral zone is narrow. In the lower estuary it is represented by a 0.15-0.30 metre band of an Enteromorpha association. In Melville and Perth Waters, Cladophora sp. becomes co-dominant with this association. There is no algal development in the littoral zone above Perth Water.

In the sub-littoral an association of Polysiphonia macrocarpa and Vaucheria sp. occurs, extending up to the lower part of the littoral. In the upper sub-littoral, Gracillaria is dominant throughout most of the estuary, although plants become smaller and sparser in deeper water and upstream of Perth Water to Garratt Road Bridge. Further upstream the blue-green algae, Lyngbea lutea is dominant. Downstream of Preston Point the Gracillaria association is replaced by Ulva lactuca, Grateloupia filicira and Colpomenia peregrina.

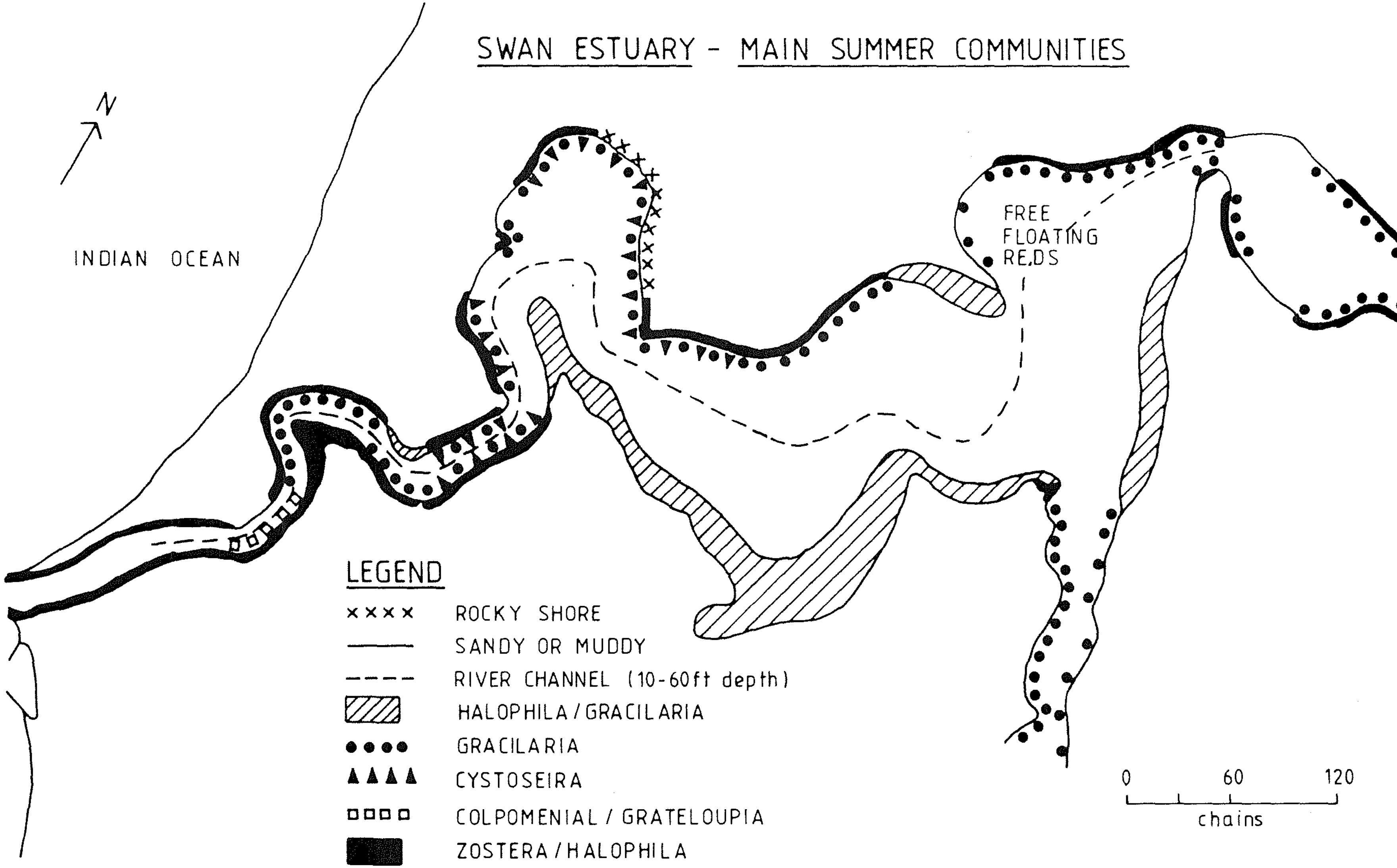



FIGURE 3

DISTRIBUTION OF ROCK OR SAND/MUD FORMATIONS & MAJOR SUMMER COMMUNITIES IN THE SWAN RIVER ESTUARY.
( FROM ALLENDER 1970 )

At greater depths than the Gracillaria association in the mid-estuary Cystoseira trinodis occurs to 3-4 metres in depth together with smaller algae and numerous epiphytes. The distribution of both rock and sand/mud formations is shown in Figure 3.

### 2.1.2 Distribution Along the Estuary

The distribution of algae along the estuary is largely controlled by salinity. Allender (1970) recognised four major groups and these are shown in Figure 4.

1. **Lower Estuary Group**

   Nine species of marine algae reach no further up the estuary than Preston Point. These species mainly occur in late summer to early winter (peak of the marine phase in the estuary) and this grouping occurs in waters of an average annual salinity of 25 ppt or more.

2. **Mid-Estuary Transition Group**

   From Preston Point to Melville Water there is a gradual reduction in species number. This grouping corresponds to a salinity of 23 ppt or more.

3. **Mid-Estuary Cut-off Group**

   The greatest single reduction in species numbers occurs from Melville Water and Matilda Bay into Perth Water. This area is the upper limit of 14 algal species and corresponds to an average salinity of 22 ppt.

4. **Upper Estuary Transition Group**

   The remaining algal species gradually phase out upstream from the Perth Water with a few species of mainly fresh or brackish water affinities appearing e.g. Rhizoclonium kerneri. The grouping corresponds with an average salinity of 4 ppt or more.

Further information on the species studied by Allender (1970) is given in Appendix 1 including taxonomic affinity, rare species, substrate type, vertical distribution and seasonality of the species. A number of very general trends can be derived from this table.

Algae in the upper estuary are from the Cyanophyta and Chlorophyta only, most species are rare and occur predominantly in winter. Algae in mid-estuary are perennial or are found in the summer to winter phase, all phyla except the Phaeophyta (brown algae) are represented. In the lower estuary algae vary widely in their characteristics, similarly those algae which can

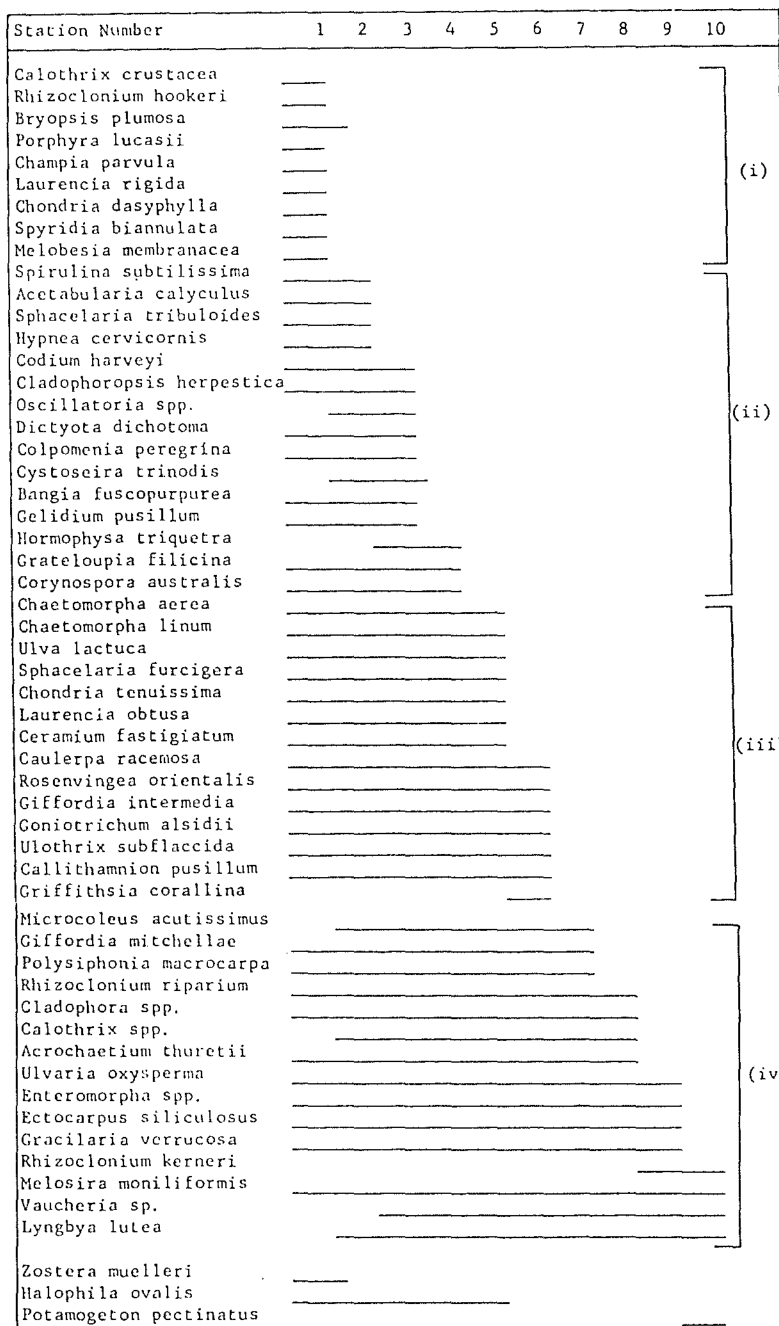



FIGURE 4: Maximum upstream distribution of the algae and seagrasses in the Swan estuary. The stations are shown in Figure 1. For explanation of groupings, see text. From Allender (1970)

survive in both the lower and mid-estuary. Those restricted to the mouth of the estuary are all Rhodophyta and occur during the summer to winter phase. Those species found throughout the estuary had very general characteristics but were mostly perennial and did not include the Phaeophyta.

## 2.2 Seasonality

An examination of the seasonality of algal species of the estuary shows that most are present in autumn, with lowest numbers in spring. The poorest algal development is between winter and spring. This is because time is required for the species to react to the winter runoff conditions and so the phase is slightly behind the beginning of winter conditions.

The largest seasonal difference between numbers of species is near the mouth of the estuary where the greatest number of species occurs. Many of these species are strictly marine and are largely eliminated by fresh water conditions of winter/spring.

In mid-estuary the most conspicuous seasonal floristic changes include the presence of blue-greens, Bangia and Ulvaria and the rise in importance of the diatom Melosira in early winter. Species of other families especially Phaeophyta decline during this time.

Significant changes occur in biomass from winter to summer. During late spring a few species have bloom conditions which persist into summer. However, the total number of species remains low, building up more slowly through summer to early winter. The bloom algae are those of the more ubiquitous and perennial species such as those of Cladophora, Enteromorpha, Polysiphonia, Gracillaria, Ectocarpus and Ulva.

Unfortunately there has been no quantitative work to date on the biomass and productivity of the macroalgae in the Swan River estuary.

## 3.0 MICROSCOPIC ALGAE

The microscopic flora of the estuary can be divided into three main groups depending on their habitat. These include planktonic (free floating, commonly called phytoplankton) epiphytic (attaching to plants) and benthic (found in the sediment) forms. The micro-flora is dominated by diatoms (Bacillariophyta) of which 363 taxa belonging to 79 genera have been recorded (John 1984). The remaining micro-flora is made up of Dinoflagellates and microscopic forms of the other groups of algae (e.g. Chlorophyta).

Of the 363 taxa of diatoms in the estuary, 134 are fresh water species with limited intrusion into brackish water, 125 are marine with limited intrusion into fresh or brackish water and 93 are brackish water species. Eleven taxa can occur over a broad range of salinities.

The fresh water species are mostly restricted to the upper estuary but can be found in the lower estuary in winter, while the marine species are confined to the lower estuary except during the summer-autumn phase when they move into the upper estuary as salinities increase.

## 3.1 Phytoplankton

The planktonic flora of the Swan River estuary is dominated by diatoms. Winter is characterised by diatom blooms, spring by phytoflagellates (a term used to describe any microscopic algae with flagellae) and summer and autumn by diatoms and phytoflagellates.

### 3.1.1 Seasonality and Distribution of Phytoplankton Communities

**Winter:** Under the influence of winter fresh water runoff, the upper estuary tends to be dominated by pseudoplankton (epiphytic and benthic algae detached and suspended by increased flow conditions) such as the genera Synedra, Melosira, Suriella and Eunotia. These pseudoplankton constitute 20 to 80% of the planktonic diatoms. The most common euplankton (true planktonic forms) were from the genera Nitzschia, Cyclotella and Thalassiasira.

In the lower estuary during the early part of winter (June, July) the planktonic community could be described as a mixture of the species prevalent in the upper estuary transported downstream, as well as marine species such as Coscinodiscus, Lithodesmium, Chaetoceros, Rhizosolenia and Skeletonema costatum.

**Spring:** The spring planktonic community is dominated by phytoflagellate blooms, in both the upper and lower estuary. In early spring phytoplankton biomass is low as the estuary is still under the influence of fresh water runoff. Sparse diatom populations of predominantly pseudoplankton (almost 90%) occur in the upper estuary and are similar to the winter communities. In the lower estuary, blooms of the dinoflagellate Prorocentrum minimum are common.

In October the phytoflagellate Chlamydomonas globosa has been observed to bloom in the upper estuary and planktonic diatoms are very sparse. In the lower estuary the diatom S. costatum dominates the community replacing the dinoflagellates, and spreads to the upper estuary in later spring. In the lower estuary Rhizosolenia setigera becomes the dominant phytoplankton. In mid-estuary a community of intermediate composition occurs.

**Summer:** In early summer S. costatum dominates the upper estuary in association with various other diatoms. In mid summer S. costatum is restricted to the very upper reaches of the estuary with dinoflagellate blooms of Prorocentrum and Peridinium sp. and various diatoms occuring in the upper estuary.

In mid-estuary the community is dominated by the diatoms Cerataulina daemon and Lithodesmium undulatum, while in the lower estuary species of Chaetoceros, Rhizolenia, Coscinodiscus and Actinocyclus dominate. This reflects the very high species diversity present in summer.

In late summer S. costatum once again becomes established as the dominant planktonic species, while the upper estuary is dominated by pseudoplankton with occasional blooms of S. costatum and dinoflagellates Prorocentrum and Cymnodinium sp.

**Autumn:** In autumn an increasing number of marine species become established in the upper estuary and the communities are more homogeneous throughout the estuary. S. costatum commonly dominates communities. Coscinodiscus sp. becomes common in mid-spring and becomes dominant in late spring together with large numbers of dinoflagellates such as Dinophysis, Peridinium sp. in the lower estuary.

### 3.1.2 Productivity

While salinity preference and tolerance are important factors in controlling the distribution of phytoplankton, diatom populations and planktonic blooms are regulated by the availability of soluble nitrogen and phosphorus, supplied mainly by riverine input. For this reason the upper estuary has a higher phytoplankton biomass than the lower estuary. The highest biomass is associated with phytoflagellate blooms in spring, while the shift in diatoms to non-diatom blooms is associated with a low N : P ratio. Nitrogen appears to limit phytoplankton biomass in the lower estuary during the summer-autumn phase (John 1984).

Levels of phytoplankton biomass in the estuary are low but this belies their importance, as they are capable of extremely high growth rates, with turnover times of less than one day under optimal conditions.

No measurements of the productivity of phytoplankton have been carried out in the Swan River estuary. However, results by a considerable number of researchers (cited Hillman 1984) on other estuaries indicate that phytoplankton productivity is in the range of 750-1250 g D.W. $m^{-2}$ $a^{-1}$.

## 3.2 Epiphytic Microalgae

The distribution of epiphytic microalgae is generally reflected in the distribution of angiosperms and macroalgae on which they grow. During winter most of the macrophytes in the littoral and sublittoral zones are denuded by fresh water flushing, especially in the upper estuary. Hence few sites are available to epiphytic microalgae.

### 3.2.1 Important Macrophytes for Epiphytic Microalgae

In general the upper estuary has a much lower macrophyte abundance than the lower estuary, as most of the red and brown algae and the seagrasses occur in the lower estuary. Macroalgae which are important to the epiphytic community include the red algae Gracillaria verrucosa, Gelidium pusillum Lawrencia rigida, Champia parvula Polysiphonia sp. and Ceranium sp. and the brown algae Cystoseira trinodis, Ectocarpus siliculosus and Spacelaria furcigera.

In spring, many green algae are present in large numbers in the mid-estuary and become important to the epiphyte community. These include Ulva lactuca, Ulvaria oxysperma, Enteromorpha sp. Rhizoclonium sp. and Chaetomorpha sp. By summer/autumn various macroalgae occur throughout the estuary and in the upper estuary the red algae Comsopogon and the angiosperm Potamogeton pectinatus are abundant. Vaucheria, Ulothrix and Lyngbea sp. are also common algae for epiphyte attachment in the upper estuary.

### 3.2.2 Seasonality and Distribution of Epiphyte Communities

The most dominant and widely occurring epiphytic diatom in the estuary is Melosira moniliformis. Other very common epiphytic diatoms are Synedra fasciculota and Amphora vertricosa.

In the upper estuary fresh water flushing during winter has an adverse effect on epiphytic diatoms, resulting in an increase in pseudoplankton. However, the dominant epiphyte in winter is Melosira moniliformis. This species is replaced by Synedra fasciculata in spring together with other species of Synedra and Amphora. In summer Cocconeis placentula is dominant with Amphora sp., S. fasciculota and M. moniliformis, the latter becoming dominant again in autumn. In summer-autumn, a few marine species are also found in the community.

In the lower estuary a number of Cocconeis sp. are dominant in winter being replaced in spring by Melosira moniliforms. In summer the epiphyte community is characterised by a high species diversity predominantly of the genera Cocconeis, Licmophora, Grammatophora, Achnanthes and Melosira. Species diversity falls slightly in autumn, the most common genera being Licnophora, Grammatophora and Striatella.

The productivity of these epiphytic algae has not been studied but is likely to be related to macrophyte substrate availability. In which case biomass and productivity would probably be lowest in winter and highest in the summer.

## 3.3 Benthic Microalgae

The benthic flora in the estuary is also dominated by diatoms. These algae may be episammic (attached to sediment particles), epipelic (able to swim between the sediment particles) or periphytic (algae commonly planktonic or epiphytic found on/or in the sediment). This section will deal predominantly with those microalgae which are not commonly found in planktonic or epiphytic habitats. The predominant benthic genera are Navicula, Nitzchia, Achnanthes, Amphora, Diploneis, Rhopalodia, Gyrosigma, Pleurosigma and Paralia.

### 3.3.1 Seasonality and Distribution of Benthic Communities

**Winter:** In early winter the upper estuary shows high species diversity, not being dominated by any single species, but in late winter incoming fresh water removes much of the benthic flora leaving only small populations dominated by Nitzchia puncata. In the lower estuary Paralia sulcata is the dominant species.

**Spring:** In the upper estuary marked changes occur throughout spring. In early spring Navicula tripuncata is the dominant diatom together with various Nitzchia sp. In mid-spring quite a high diversity of species occurs, becoming dominated by Gyrosigma spenceri and Diplonis smithii and various Achnanthes sp. by late spring.

Paralia sulcata dominates the lower estuary benthic flora throughout spring, although the species associated with it vary.

**Summer:** In the upper estuary Nitzchia and Navicula sp. dominate in early and mid-summer while Achnanthes becomes dominant in late summer. In the lower estuary Paralia sulcata becomes even more dominant in the summer (70 - 90% of the community) in association with *Opephora martyi*, *Plagiogramma appendiculatum* and various *Navicula* sp.

**Autumn:** *Navicula ilopangoensis*, *Rhopolodia gibberula* and *Achnanthes* sp. dominate the upper estuary, however, *Paralia sulcata* and *Opephora martyi* first noted in summer become more frequent throughout autumn. These are both marine species. A similar community to that seen in summer is found in the lower estuary, still dominated by *Paralia sulcata*.

With the increase in rainfall and flushing *Nitzchia puncata* and *Cyclotella* sp. quickly become dominant again in the upper estuary.

On the whole the benthic flora is more stable than the epiphytic and planktonic flora. The upper estuary communities change more frequently than in the lower estuary especially in shallow areas. The upper estuary also has a high percentage of planktonic species.

### 3.3.2 Productivity

Functional chlorophyll (representing live benthic microalgae) has been found to depths of 18cm in the sediment of the Swan River. The photic zone (the depth of sediment in which there is enough light to allow photosynthesis), however, is probably only 4-6mm deep in coarse sand and less than 1mm in fine sand or mud. At Pelican Point, biomass estimates of 60mg Chlorophyll a $m^{-2}$ have been made for the top 5mm of the sediment. The photic zone in that area is probably only 2mm deep and hence only 15-20mg Chl.A $m^{-2}$ is actually contributing to productivity by photosynthesis. However, certain species of benthic microalgae are also able to live heterotrophically in the absence of light.

Crude productivity estimates using a Clark electrode suggest carbon fixation rates for benthic microalgae at Pelican Point are in the range of 60-150g C $m^{-2}$ $yr^{-1}$. In areas of fine mud biomass estimates are much lower as the photic zone is much smaller. Near Heirisson Island only 13 $mgCm^{-2}$ was found in the top 5mm and hence productivity levels could be much lower than at Pelican Point. However, assuming a productivity of only 10$gCm^{-2}$ $yr^{-1}$ this would mean in the area of the Swan Estuary to the Causeway, in water of less than two metres depth (8$km^2$), benthic microalgae would fix 80 000kg of carbon per year. (Masini pers. comm. 1985).

Apart from their importance to the food chain, benthic algae are also important in the nutrient cycling of the estuary. Through photosynthesis, they preserve an oxic layer between the sediment and the water which is important in many nutrient transformations.

# 4.0 AQUATIC MACROPHYTES

## 4.1 Seagrasses

Seagrasses are marine flowering plants (Angiosperms) that grow under completely submerged conditions thus differing from other aquatic angiosperms. In the Swan River estuary the main seagrass is Halophila ovalis. This seagrass has leaves shaped like small paddles, hence it is sometimes called 'paddleweed'.

### 4.1.1 Distribution

The seagrass Halophila ovalis is widely distributed in the Swan River estuary and occupies about 20% of the lower estuary, while a small amount of Zostera mucronata occurs near the mouth of the estuary (Figure 5).

The main beds of seagrass occur in the shallow waters of Freshwater Bay, Melville Water and Lucky Bay with the largest densest bed occurring in the latter. The total area occupied by Halophila is in excess of 550 ha, with its distribution ending abruptly at the Narrows and Canning Bridges. Over 90% of the seagrass is found within the 2 metre bathymetry mark (relative to an arbitrarily selected low water mark at Fremantle) and since average daily tides are between 0.5-1.2 metres, this means Halophila does not grow where the water is regularly deeper than three metres. The exception to this is a small area near the estuarine mouth where it occurs at depths up to 4m in clear water (Hillman 1984).

### 4.1.2 Productivity

Study of seasonal changes in biomass and productivity show Halophila grows fastest in the summer months and reaches maximum biomass by autumn. There is virtually no growth during winter. Annual productivity of a typical seagrass bed is approximately 1500g d.w. $m^{-2}$. This means that Halophila yearly contributes at least 25% as much new plant material to the estuary as phytoplankton (Hillman 1984).

## 4.2 Fresh/Brackish Water Macrophytes

The dominant macrophyte in the Upper Swan, beyond Middle Swan Bridge is the flowering plant Potamogeton pectinatus. This plant forms dense beds in slow-moving waters of the Swan River. Other macrophytes found in association with P. pectinatus include Najas marina, Chara spp., Nitella spp. and occasional stands of Vallisneria gigantea.

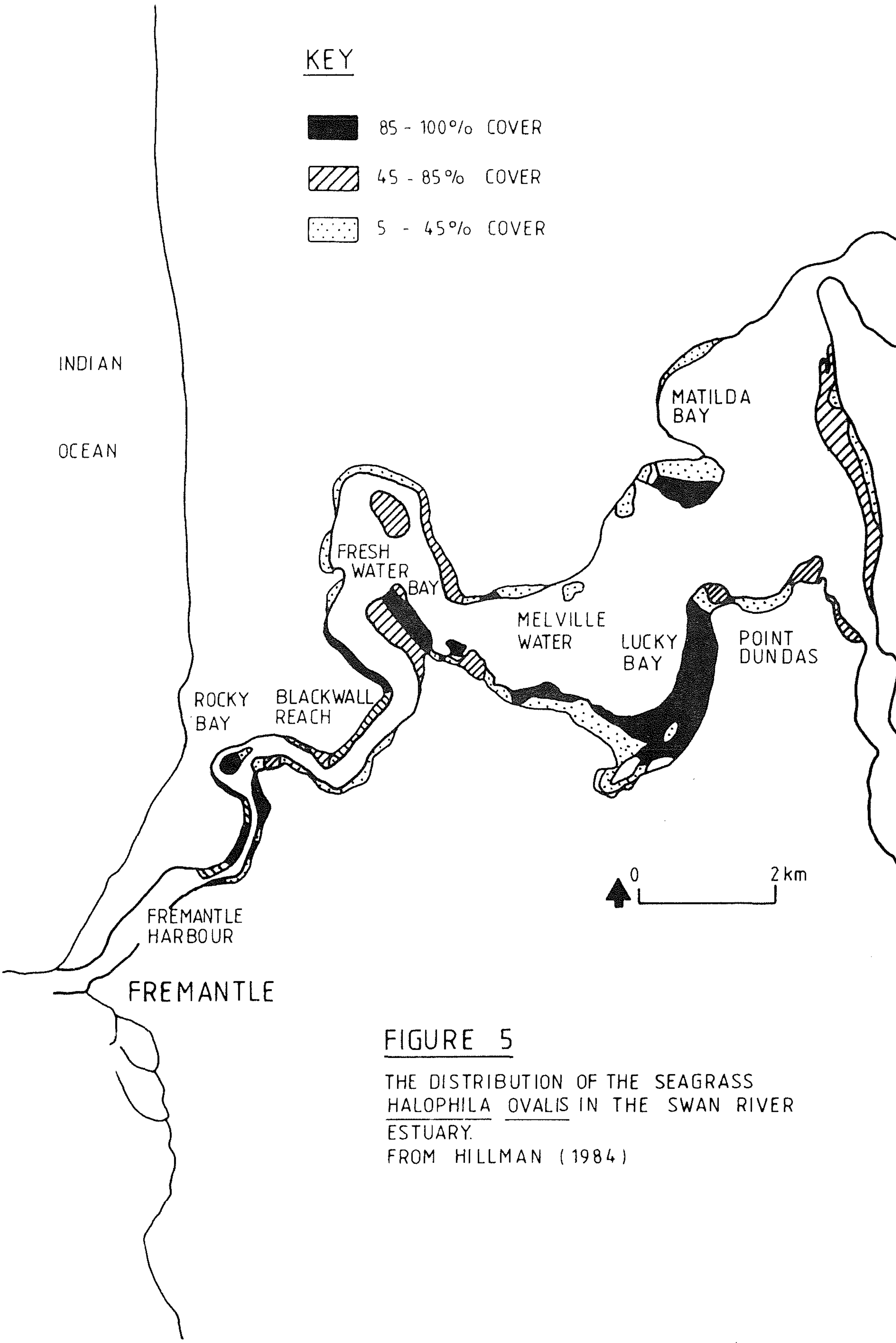



FIGURE 5

THE DISTRIBUTION OF THE SEAGRASS *HALOPHILA OVALIS* IN THE SWAN RIVER ESTUARY.
FROM HILLMAN (1984)

Chara and Nitella are superficially similar to flowering plants but are in fact a form of algae, commonly called Stoneworts (Charophyta). The remaining species mentioned are flowering plants. Najas marina (Prickly Naiad) is an annual plant disappearing in the winter months while Vallisneria gigantea and Potamogeton pectinatus survive the winter, although often these plants die back to a root stock. Maximum growth of these plants occurs at water temperatures of 25°C.

In the Canning River there are less fresh water macrophytes because the river is very shallow. However, there are large areas of Hydrilla verticillata (Water Thyme) and occasional stands of Triglochin procera and Nymphaea spp. (water lily).

## 5.0 UTILISATION OF AQUATIC PLANTS BY FAUNA

### 5.1 The Importance of Aquatic Plants in the Estuarine Food Webs

In the transfer of plant material to animals, two basic types of food chain are recognised; the grazing food chain and the detrital food chain. In the grazing food chain plants are eaten by herbivorous animals, which are eaten by carnivorous animals which in turn are eaten by larger carnivores and so on. This is the dominant food chain in the open ocean.

The detrital food chain involves the breaking down of dead plant material by bacteria and fungi which are eaten by protozoans ('large' microscopic animals). The protozoans are eaten by tiny invertebrate animals which feed larger carnivores and so on. Seagrass communities and mangrove swamps are typical examples of ecosystems based on detrital food chains.

In the Swan River estuary the typical phytoplankton based grazing food chain certainly exists but a large proportion of phytoplankton productivity is utilised via detrital food chains. Detrital food chains are the dominant pathway for seagrasses and macroalgae in the estuary; of the one hundred and ten species of fish recorded (Chubb et al 1979) only three are known to graze macroalgae, while Halophila is not grazed at all except by accident. It must be noted however that the two food chains are closely inter-connected. Most fish are broadly omnivorous or carnivorous and a large fish may eat both detrivorous invertebrates and planktivorous fish. Thus both types of food chain make up the ecosystems food web.

Determination of the relative importance of different aquatic plants in the estuarine food web has been carried out by Hillman (1984). Conservative estimates suggest 15-20% of the food web is based on seagrass material and 80% on phytoplankton, which agrees quite well with the relative contributions of seagrass and phytoplankton as primary producers. Studies by Hillman (1984) also show that most fish and crustacea in the estuary derive between 5-50% of their food from seagrass while certain species feed solely on phytoplankton (e.g. anchovy, pilchard). The importance of macroalgae to the food web has not been determined, however, they are not comparable to Halophila in terms of abundance and probably form only a minor part of the estuarine food web.

The role of brackish and fresh water species has similarly not been investigated, however, the fruits of Potamogeton pectinatus and the stolons of Vallisneria gigantea are eaten by water birds.

## 5.2 The Importance of Aquatic Plants for Shelter & Nursery Habitats

The majority of the important commercial and amateur fish species use the estuary as a nursery habitat, the adult fish returning to the ocean (see chapter on Fauna). In the Swan River estuary it has been found that the shallow areas covered by Halophila are the most important nursery habitats for these juvenile fish. This is largely because of the large numbers of small invertebrate animals which form a principle part of their diet occur predominantly in the shallows (Thompson 1957, Wallace 1975). The density of these invertebrates is up to ten times greater in the shallows than in the deeper waters (Wallace 1977) and hence the popularity of the areas of seagrass as feeding sites.

As seagrasses are firmly rooted in the sediment and are highly productive they can form vast underwater meadows providing a relatively sheltered and stable environment for fauna. The dense seagrass canopies soften water movement, provide cover from predators and supply a large surface area for the many species of plants and animals which spend most of their life attached to substrates. The tiny algae and animals attached to seagrass leaves are also grazed by other small fish and crustacea. Further, seagrasses serve to oxygenate the water during the day and are capable of stabilising bottom sediments.

# 6.0 HUMAN ACTIVITIES WHICH AFFECT THE AQUATIC FLORA

The growth of aquatic plants is affected by many environmental factors including salinity, temperature, light penetration through the water, nutrients, wave and current action and sedimentation. When the natural regime of these factors is disturbed by man's intervention, plants have to adapt to a new environment or they exhibit decreased productivity or are killed depending on the magnitude of change in the environment.

The natural variation in environment from the estuarine mouth to the upper parts of the Swan and Canning Rivers is also reflected in the distribution of different plants, each species colonising that part of the estuary most suited to its requirements. Long term changes in the environmental regime of the estuary would therefore change the distribution of plant communities. In this section the environmental disturbance caused by man's activities and its effect on the aquatic flora is summarised.

## 6.1 Dredging

Dredging involves the excavation of sediments at one location and their disposal at another location. In the process a quantity of fine particulate material is often put into suspension. Dredging has a disruptive effect on the biota in the area and their physical environment, both in the short and long term.

### 6.1.1 Short Term Effects

The immediate effect of dredging is the physical destruction of the benthic flora and habitats within the dredging and disposal sites. One of the main short term effects is the suspension of fine particulate matter which increases turbidity and reduces the penetration of light through the water column. At about 5% no production can occur and prolonged exposure will cause the death of benthic plant communities. This is especially true during the saline phase of the estuary (summer-autumn) when there is little flushing to remove the suspended sediment. Where water flow is weak sediment particles settle on the plants, further reducing light availability. If turbidity is very high sedimentation can occur at a faster rate than the vegetation can grow and communities can be smothered.

Reduced light penetration similarly affects phytoplankton, reducing productivity. However, as phytoplankton are found near the surface of the water, this effect is less severe than for benthic plants. However, phytoplankton are often caught up in the flocculation of fine suspended particles to form larger ones and they are subsequently sedimented to the bottom of the water column.

Other short term effects which affect the aquatic flora include:

(a) The possible formation of foam on the surface of the water which reduces light penetration and the exchange of gases to the environment.

(b) Deoxygenation of the water can occur as anaerobic (deoxygenated) sediments are exposed by dredging. Once exposed, these sediments immediately take up oxygen from the water. Deoxygenation can also be caused by an increased bacterial activity and biological oxygen demand as a result of resuspended organic matter.

In shallow wind-swept, well-flushed areas oxygen depletion would be minimal but in still, deep areas or below a halocline it may be severe. Oxygen is required for respiration both in plants and animals. For example, it has been demonstrated that Halophila ovalis fails to recover after 24 hours of anaerobiosis.

(c) Nutrient release from the disturbed sediments may result in increased productivity of phytoplankton and benthic plant communities if turbidity does not limit photosynthesis. In the short term this may produce an unstable community of high biomass and diversity.

(d) The release of herbicides, dissolved heavy metals, hydrogen sulphide and other toxic substances from the sediments may have deleterious effects on the plant community. Generally toxic substances change community structure by removing susceptible species, possibly reducing species diversity. (Mollett unpubl., Hodgkin unpubl.).

### 6.1.2 Long Term Effects

Many long term effects are inter-related and largely irreversible. The main purpose of dredging is to increase the depth of the water column. As the majority of plants occur in shallow areas (2 metres deep) dredging below this depth reduces the area of estuary available to colonisation by aquatic plants. Communities found in areas greater than 2 metres tend to be less abundant due to light penetration limitations. Further, the sites of dredging and disposal will be prone to erosion as the unconsolidated sediments are less stable than the present sediments. Dredging or subsequent erosion and deposition tends to sort sediment particles, changing the composition of both chemical and physical components of the sediment. This will determine what plant species can colonise the area depending on the preference of plant species for certain sediment types.

The alternation of the physical dimensions of the estuary can lead to changes in natural flow patterns, circulation and tidal exchange with the sea which in turn, may change the salinity regime in the area. This can induce changes in the species, abundance and distibution of flora in that area.

Finally, although released nutrients may provide short term increases in biomass and species diversity, in the long term disturbed areas tend to contain communities of lower species diversity (Mollett unpubl., Hodgkin unpubl.).

## 6.2 Boating

At present boating does not significantly affect the aquatic flora. Yachting is confined to deep water areas where there is little flora and small power boats are not in sufficient number to cause much damage. It would take a large increase in the number of small power boats utilising the shallows to cause concern (Hillman pers. comm., 1985) Halophila ovalis is shallow rooted and has brittle rhizomes which are easily broken and is, therefore, easily torn up by strong wave action.

The creation of jetties and boat moorings is another threat to the flora. The increased usage, shading of plants and turbidity created in these areas destroys seagrass beds. The jetties do provide attachment for macroalgae, but macroalgae are less important to the estuarine ecoystem.

## 6.3 Pollution

An increase in nutrients or toxic substances in the estuary will cause degradation of the aquatic flora.

Seagrasses draw their nutrients from both the sediment and the water and hence are able to grow in very nutrient poor waters. Increases in the nutrient supply do not cause increased seagrass growth but rather increases in phytoplankton, micro and macroalgae growth. Resulting phytoplankton blooms can cause a decreased amount of light reaching the seagrasses, while increased epiphyte growth may further shade seagrass leaves. This can cause destruction of seagrass beds, especially in deeper areas where seagrasses are at the limit of the photic zone (Hillman 1984).

John (1984) considers nitrogen to be the nutrient most limiting to the growth of phytoplankton to the Swan River estuary and this can also be assumed for macroalgae since their nutritional requirements are similar. Hence increases in nitrogen could cause blooms of these plants.

Many ecologically desirable plants e.g. phytoplankton, are very susceptible to toxic substances such as heavy metals, pest and herbicides. An increase in these substances would select for the more tolerant species causing degradation of the plant community.

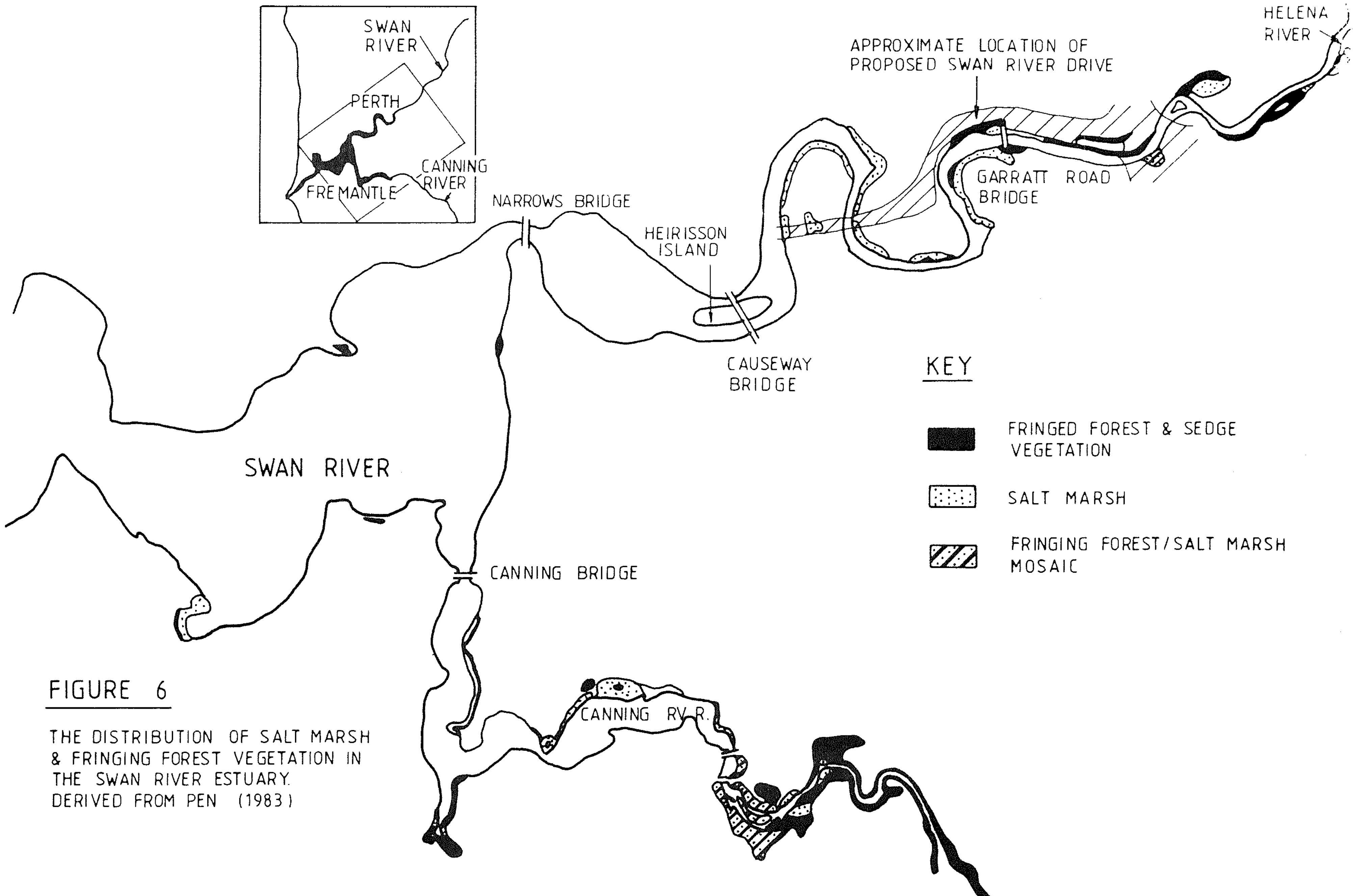



FIGURE 6

THE DISTRIBUTION OF SALT MARSH & FRINGING FOREST VEGETATION IN THE SWAN RIVER ESTUARY. DERIVED FROM PEN (1983)

## 6.4 Catchment Modification

Damming of rivers reduces the fresh water flushing of the estuary, especially during winter. The resulting change in the salinity regime would change the spatial and seasonal distribution of the aquatic flora as described in this section. Many brackish fresh water species may also suffer severe reductions in their populations.

# PART 2 FRINGING VEGETATION

The fringing vegetation of the Swan River estuary has markedly declined in area since 1829 with the beginning of British colonisation. Clearing, initially for agriculture and later for urban development, has left only a few scattered remnants of the original fringing vegetation in the estuarine basin and has degraded the peripheral vegetation of the upstream areas of the Swan and Canning Rivers (Figure 6).

The remaining areas of fringing vegetation play a vital role in the maintenance of the estuarine ecosystem, particularly as a habitat for water birds. The vegetation supports an ecosystem which provides food and shelter for many different kinds of birds and other small animals.

Despite its diminished size the fringing vegetation displays a wide diversity of plants. These form a variety of communities that have adapted to the different environments found on the estuarine shores (Figure 7). Two main types of vegetation can be recognised, however, salt marsh and fringing forest. This vegetation has been described in detail by Pen (1981, 1983).

## 7.0 SALT MARSH VEGETATION

Salt marshes are typically flat areas adjacent to the estuary, which are subject to tidal inundation. When the tide recedes, the water remaining on the marsh can become highly saline due to evaporation. Vegetation in these areas is dominated by salt-tolerant plants such as the samphires (*Sarcocornia* and *Halosarcia* sp.) and in areas which are slightly less saline, rushes such as *Juncus* and *Bulboschoenus* can grow.

The salt marsh vegetation can be divided into different complexes and communities on the basis of the dominant species in them (Figure 7). A brief summary will be given here on each of these vegetation units starting with the complex associated with highest salinities (*Halosarcia*) to that of the lowest salinities (*Juncus*).

The *Halosarcia* complex occurs adjacent to the estuary in the supra-littoral zone, often near *Sarcocornia* complex (see below). This complex tolerates periodically extremely high salinities (up to twice that of seawater) during summer, to very low salinities (near that of fresh water) in winter. *Halosarcia* associates with a tiny ephermeral herbaceous plant (*Angianthus* sp.) to form a community often backed by *Melaleuca* and/or *Casuarina*, and also with the heath-like shrub *Frankenia pauciflora* in one location close to tidal pools.

The *Sarcocornia blackiana* community is recognised only by the unusual abundance of this species. It occurs in a similar environment to *Halosarcia* but possibly on slightly higher ground.

PLATE 5: Successful replanting of *Juncus* has restored foreshore vegetation to disturbed river banks

FIGURE 7: Common species in the different plant complexes and communities along the Swan and Canning Rivers. From Pen (1983)

## SALT MARSH VEGETATION

### Halosarcia Complex

Halosarcia indica subsp. bidens and/or
Halosarcia halocnemoides

Halosarcia Typical Community
    As above
Halosarcia-Frankenia Community
    As above and
    Frankenia pauciflora
Halosarcia-Angianthus Community
    As above and
    Angianthus preissianus,
    Angianthus micrpodioides

Sarcocornia blackiana Community
    Sarcocornia blackiana Community
    Polypogon monspeliensis

### Sarcocornia Complex

Sarcocornia quinqueflora,
Suaeda australis,
Samolus repens

Sarcocornia Typical Community
    As above
Sarcocornia-Bulboschoenus Community
    As above and
    Bulboschoenus caldwellii
Bulboschoenus Predominant Community
    Bulboschoenus caldwellii
Sarcocornia-Triglochin-Isolepis marginata Community
    As above and
    Triglochin mucronata,
    Isolepis marginata

### Juncus Complex

Juncus kraussii

Juncus Typical Community
    As above
    Juncus-Sarcocornia Sub-community
        Juncus kraussii,
        S. quinqueflora

S. australis

Juncus-Samolus Sub-community

Juncus kraussii,
Samolus repens

Juncus-Melaleuca Community

Juncus kraussii and
Melaleuca cuticularis,
M. hamulosa or
M. rhaphiophylla

**Casuarina-Melaleuca Complex**

Casuarina obesa and/or
Melaleuca rhaphiophylla
J. kraussii

Casuarina-Melaleuca Typical Community

As above and
Bulboschoenus caldwellii,
S. repens,
Myoporum caprarioides

Casuarina-Melaleuca-Baumea Community

As above and
Baumea juncea

Melaleuca-Typha Community

Melaleuca rhaphiophylla,
J. kraussii,
Typha orientalis

Casuarina-Bulboschoenus Community

C. obesa,
B. caldwellii,
J. kraussii

**Melaleuca-Juncus Complex**

M. rhaphiophylla
J. kraussii

Melaleuca-Juncus Community

As above

**Eucalyptus-Melaleuca (River Bank) Complex**

Eucalyptus rudis
Melaleuca rhaphiophylla,
Rumex crispus,
Paspalum dilatatum

Eucalyptus-Melaleuca-Juncus pallidus Community

As above and
Juncus pallidus,
Centella cordifolia
Paspalum distichum
P. dilatatum
Typha orientalis

Eucalyptus-Melaleuca-Aster Community

As above and
Aster subulatus

Eucalyptus-Melaleuca Typical Community

As above
Eucalyptus-Melaleuca-Typha
Sub-community
Typha orientalis
Eucalyptus-Melaleuca - Typical
Sub-community

**Melaleuca (Swamp) Complex**

M. rhaphiophylla,
E. rudis,
P. dilatatum,
Agonis lineanifolia,
Lepidosperma longitudinale

Melaleuca Community

As above and
Cynodon dactylon,
Baumea jucea and/or
J. kraussii
Melaleuca-Agonis Community
As above and
Agonis linearifolia
Melaleuca-Melaleuca preissiana Community
As above and
Melaleuca preissiana,
Eucalyptus calophylla,
Oxylobium linearifolium

Schoenoplectus validus Community

Schoenoplectus validus

Baumea juncea Community

Baumea juncea

Typha orientalis Community

Typha orientalis

Schoenus Complex

Schoenus subfasicularis

Schoenus Community

As above

Eucalyptus rudis Woodland

Dominant species -
E. rudis
Other (understorey) species:

* Stenotaphrum secundatum
* Rumex crispus

* Pennistum clandestinum
Cynodon dactylon
* Conyza bonoriensis
* Sonchus asper
Paspalum dilatatum
* Watsonia bulbilifera
Acacia saligna
* Lolium multiflorum
* Lolium rigidum
Iridaceae sp.
* Avena barbata
* Stachys avensis
* Erharta erecta
Briza maxima
* Lotus uliginosus
* Raphanus raphanistrum
* Oxalis pes-caprae
* Fumaria officinale
* Homeria collina
* Hyperchoeris radiata
* Erodium cicutarium
* Arctotheca calendula
* Sonchus oleraceus
Salvia sp.

<u>Weed Community</u>
Common Species:
Paspalum dilatatum
* Conyza bonariensis
Acacia saligna
* Cortaderia selloana
* Stenotaphrum secundatum
* Rumex crispus
* Ricinus communis
Pteridium aquilinum
* Rubus selmerii
* Arundo donax
* Pennistum clandestinum
* Zantedeschia aethiopica
Cynodon dactylon

* Denotes exotic species

The <u>Sarcocornia</u> complex occurs along tidal flats somewhat sheltered from the river by <u>Casuarina obesa</u> and/or <u>Juncus kraussii</u> on low river bank levees. The complex rarely abuts onto the rivers. There are various forms of this complex including <u>Sarcocornia</u> typical community which is associated with high soil salinities and <u>Sarcocornia/Bulboschoenus</u> community which occurs where soil salinities are at a minimum for this complex. <u>Sarcocornia/Bulboschoenus</u> community is often found in salt marshes dissected by drains or which are close to drainage outlets. While Bulboschoenus predominant community is dominated completely by B. caldwellii and is found landward of the Juncus complex and around tidal pools. A final community Sarcocornia/Triglochin/Isolepsis is found at the highest land surface elevation associated with this complex.

The Juncus complex is found fringing the rivers and tidal creeks and replaces the Sarcocornia complex where salinities decrease. It is mainly seen as a stand of Juncus kraussii but may form communities with Samolus repens, Sarcocornia quinqueflora and Melaleuca.

## 8.0 FRINGING FOREST & SEDGE-LIKE VEGETATION

Like the salt marsh vegetation, the fringing forest and sedge-like vegetation can also be divided into different complexes and communities which are associated with a range of salinities (Figure 7).

The Casuarina/Melaleuca complex is found at the highest salinities associated with fringing forest. The complex fringes rivers on land having a slightly higher elevation and lower salinities than the Sarcocornia and Juncus complexes. Often salt marshes are found landward of this complex. The Casuarina/Melaleuca typical community is distinguished particularly by the shrub Myoporum caprarioides. Where fresh water intrudes as a result of drains a Melaleuca/Typha community forms, characterised by an absence of Casuarina obesa and an abundance of Typha orientalis. The Casuarina/Bulboschoenus community is believed by Backshall (1977) to be a consequence of the destruction of Juncus kraussii at the shoreline enabling B. caldwellii to colonise under the Casuarina.

The Melaleuca Juncus complex is typically found fringing the river, with a band of Juncus complex separating it from the waters edge. The complex is commonly found at elevations equal to that of the Juncus complex but where soil water salinity is considerably less due to fresh water flushing.

The Eucalyptus/Melaleuca (river bank) complex occurs along the upper part of estuaries where fresh water conditions are experienced. Eucalyptus/Melaleuca co-dominates with Juncus pallidus in non-tidal stationary (lentic) areas, with Aster subulatus, and also occurs with Typha and 'weed' species to form three separate communities.

The Melaleuca (swamp) complex is found in swampy areas and is the most extreme fresh water associated complex found along the rivers. The Melaleuca community is very similar in form to the Melaleuca/Juncus complex and is often found fringing landward of it. The Melaleuca/Agonis community is associated with large scale flushing during winter as a result of drains natural creeks and fresh water ground flow. The Melaleuca preissiana community is found in one location (Clontarf) fringing between a Melaleuca community and pasture on higher ground.

The Schoenoplectus validus community is a completely emergent strip, one to three metres wide, parallel to and about one to two metres from the river bank. It is often associated with fresh water drains, particularly those entering more saline waters. Occasionally Bulboschoenus caldwellii is found fringing with it, but mostly it occurs as a monospecific stand.

Baumea juncea forms a community in lentic waters and is only found in a few locations such as Alfred Cove and Salter Point.

Typha orientalis is found in areas subject to fresh water flushing, being virtually always associated with the existence of a nearby drain, although it can tolerate relatively high summer salinities.

The Schoenus complex occurs on dry sandy beach ridges and is associated with the highest land surface elevation on which peripheral estuarine vegetation can be found. It is sometimes found in close proximity to the Halosarcia complex but there is little floristic similarity.

Eucalyptus rudis woodland and weed community are both the result of man's interference with the natural vegetation and will be discussed in a later section.

## 9.0 VEGETATION DISTRIBUTION & DYNAMICS

Peripheral estuarine vegetation is a mosaic of the Sarcocornia/Halosarcia, Casuarina/Melaleuca and Melaleuca/Juncus complexes. This mosaic is found on the Swan River between Alfred Cove and Bayswater.

Further upstream a transition from estuarine to fresh water riverine vegetation of the Eucalyptus/Melaleuca (river bank) complex begins, ending at Middle Swan Bridge. From thereon up the river, riverine vegetation is continuous.

Along the Canning River there is no transition as Kent Street Weir forms an upper limit to the estuary and, therefore, to estuarine vegetation. However, field observations show that this transition zone probably did exist between Kent Street Weir and Nicholson Road Bridge. For a detailed distribution of complexes and communities see accompanying maps.

Apart from the distribution of complexes and communities along the estuary, several complexes and/or communities may be distributed spatially along a river bank. For example, over a gradient of increasing elevation and decreasing salinity away from the river shore, a zonation may occur of Sarcocornia/Halosarcia Casuarina/Melaleuca - Melaleuca/Juncus - Eucalyptus/ melaleuca. Over time or due to environmental changes one or more of these vegetation units may replace another. This is a natural process called succession. A general dynamic trend of estuarine vegetation is towards fringing forests. Some of the possible dynamic relationships between different vegetation units are summarised in Figure 8.

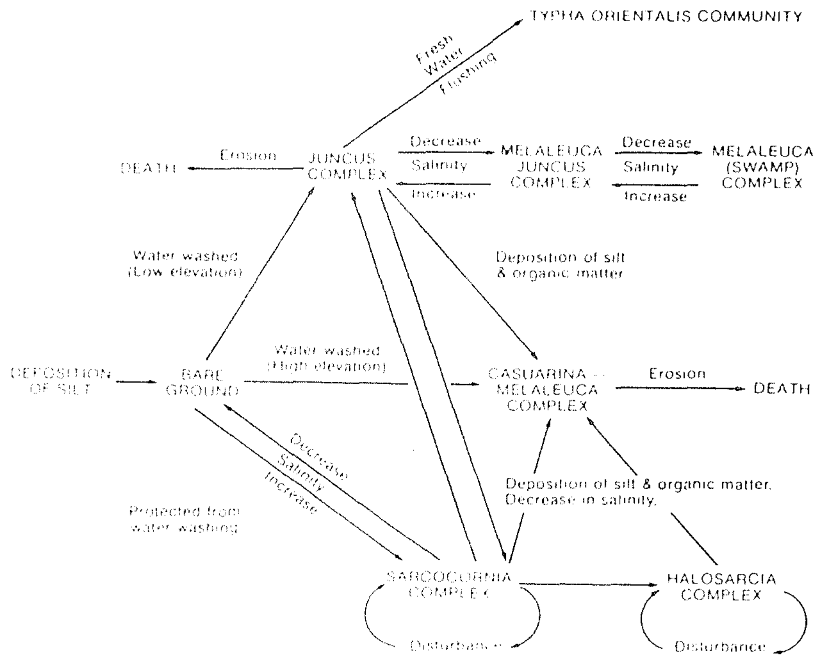
## 10.0 THE EFFECT OF MAN ON THE FRINGING VEGETATION

### 10.1 Changes in Salinity

Although vegetation naturally progresses along a line of succession, many vegetation changes are responses to environmental changes induced by man. For example, in salt marsh areas, drains may cause a localised decrease in salinity promoting a succession from Sarcocornia to Juncus communities. This is evident at Clontarf on the Canning River. Increased fresh water flushing, due to clearing or drainage may also cause fringing forest of Melaleuca/Juncus and Melaleuca swamp communities to invade the rivershore belt of Juncus. This has occurred at Clontarf and Bullcreek.

Drains sited in fringing vegetation can even lead to the succession of fringing forest by salt marsh, which requires considerable environmental change. Where drains have been put through fringing forest vegetation, fresh water is directed straight out into the river rather than flushing through the vegetation. The cessation of flushing allows the intrusion of saline river water into these areas, increasing salinity and causing succession to favour Juncus and Sarcocornia salt marsh complexes. This has occurred on the western bank of the Maylands peninsula, causing the destruction of perhaps the largest stand of Melaleuca/Juncus fringing forest in the estuary.

A

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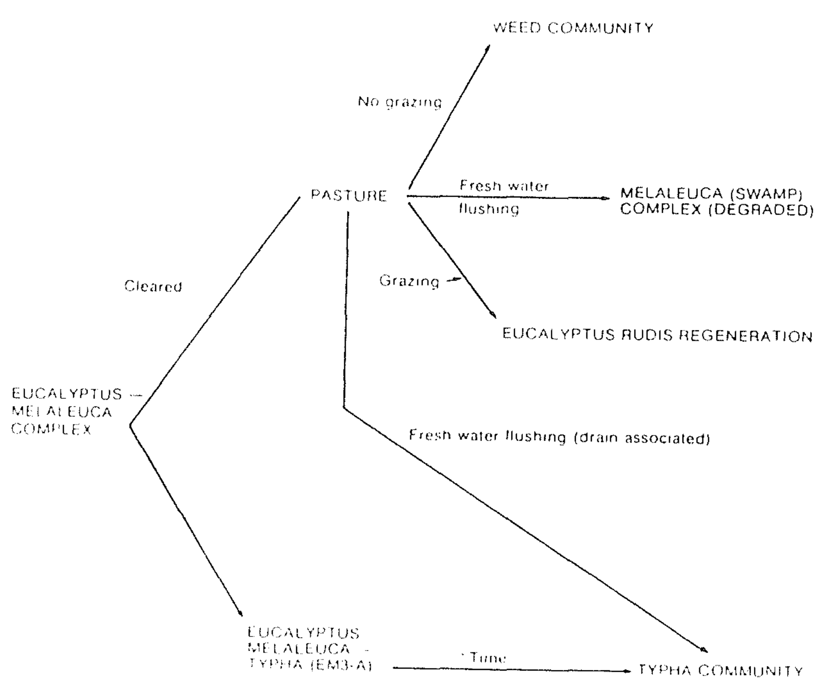



FIGURE 8: Possible dynamic relationships between:

a) Estuarine vegetation.
b) Fresh water riverine vegetation.
(From Pen 1983).

Increasing salinity has also caused changes in the fringing forest vegetation of the Upper Swan. The naturally fresh water in this part of the river has become increasingly saline due to clearing upstream of the Swan River Management area. This has caused an invasion by salt-tolerant species (especially Casuarina obesa) into the Eucalyptus/Melaleuca river bank community if salinities continue to increase the Eucalyptus/Melaleuca community will probably be succeeded by Casuarina/Melaleuca complex, which would be more suitable to the new salinity regime.

Apart from causing changes in the environment, man can also have a more direct effect on the vegetation, causing destruction of fringing vegetation, erosion and allowing the introduction of weed and exotic species into plant communities.

## 10.2 Salt Marsh Degradation

Halosarcia and Sarcocornia complexes are capable of maintaining themselves despite severe disturbance by man. The high salinties associated with these complexes preclude the establishment of weeds and exotic species allowing regeneration to occur. Many of the dominant plant species in these complexes are able to regenerate well within ten years of being cleared and the few exotic ephemerals which may establish tend to compliment rather than degrade these complexes.

However, at the southern tip of the Maylands peninsula a Halosarcia/Frankenia community occurs in an area which has not suffered any past disturbance. In an adjacent area a similar Halosarcia complex occurs which has a history of continued disturbance, but here there is no Frankenia pauciflora. Pen (1983) believes this may be because Frankenia cannot regenerate under conditions of severe disturbance and if so, F. pauciflora can be considered a diminishing species along the estuary and the Halosarcia complex is actually a degraded form of the Halosarcia/Frankenia community.

Despite the resilience of the salt marsh communities, many of them are being destroyed or are under threat. Perhaps the most severely degraded vegetation is at Burswood Island. Land reclamation has destroyed the salt marsh vegetation in the centre of the island and vehicular traffic has prevented rushes and samphires from colonising much of the tidal flat. The Swan River Management Authority has had some success regenerating the shoreline using Juncus kraussii.

Some peripheral vegetation at Maylands and most of the vegetation at Bayswater and Redcliffe is under threat by the planned Swan River Drive Highway.

The reclamation of Burswood Island and the planned highway could cause a large scale decrease in the distribution of the Halosarcia complex throughout the estuarine system. This would leave only significant stands at Alfred Cove, Ashfield Flats and Maylands. The Maylands stand, which is the rare Halosarcia/Frankenia community is not reserved under Parks and Recreation at present and is therefore threatened by future development, although it is an area recommended by System 6 as a regional park. The stand at Ashfield Flats is severely disturbed.

The Halosarcia complex is one of the stages of succession and if no significant stand exists to provide a source of seed the vegetation system will be disturbed, resulting in further degradation of communities.

Salt marshes on the southern side of Garratt Road Bridge and Ashfield Flats are subject to landfill. Ashfield, Bayswater and Maylands salt marshes are also common areas for trail bike riding. This creates large areas of bare ground which either become pools (which are suitable for mosquito breeding) or are colonised by weed species. Trail bike riding also occurs in areas along the Canning River but is becoming more controlled. Vehicular traffic is a problem, however, particularly near salt marshes at Ferndale, Kent Street and Wilson (Brock and Pen 1984).

At Ashfield, trampling of the vegetation and fire have damaged the stands of rushes at the shoreline, allowing boat wash to cause erosion of the banks.

## 10.3 Weeds and Exotic Species

The invasion of weeds and exotic species occurs when the change in environmental conditions is rapid (for example, after fire or clearing) and the opportunistic 'weed' species colonise the disturbed area before the indigenous successional species can establish. Degradation of this nature is widespread and in many cases no indigenous species remain in the understorey of plant communities, particularly the Melaleuca swamp community.

The introduction of Typha orientalis along the estuary is probably the most significant change to have occurred. This species rapidly establishes in areas where man-made drainage disturbs the natural environment and tends to have greatest success near and in stationary waters. Large areas of salt marsh have been lost to the invasion of Typha.

Typha has also caused the displacement of understorey species associated with fringing forest. Typha is not a serious problem in Melaleuca/Juncus and

Casuarina/Melaleuca complexes, where it is found only in areas of localised flushing, but invasion of the Eucalyptus/Melaleuca river bank complex is more widespread and complete. Where Typha invades new development of the upper storey cannot occur and hence in time, as the present trees age and die, it is probable that this degraded community will be succeeded by Typha.

Bulboschoenus caldwellii is another species which establishes in areas of fresh water flushing from drains.

This species tolerates much higher salinities than Typha and is common in the Sarcocornia complex, while Typha tends to invade salt marsh communities with a lower range of summer salinities.

Apart from Typha and Bulboschoenus, a number of other weed species are quick to establish in areas of disturbance. Pen (1983) gives a list of typical weed species found in the Swan River estuary.

## 10.4 Clearing for Pasture and Parkland Development

Along the upper sections of the Swan and Canning Rivers, clearing of the understorey of the Melaleuca swamp and Eucalyptus/Melaleuca complexes has caused severe degradation. Trees have been left intact and occasionally strips of vegetation have been left to support the river bank but the natural understorey, which was probably dominated by Astartea fasicularis and Agonis linearfolia, is no longer present in most locations.

Along the majority of the Canning River above Kent Street Weir, this understorey is now composed of numerous exotic species including blackberry (Rubus pruticosus), castor oil bush (Ricinus communis), giant reed (Arundo donax), arum lily (Zantesdeschia aethiopica) and many other grass and weed species. Although not an introduced species the Port Jackson Wattle (Acacia saligna) has also become common along the river bank. Certain sections of the river have little if any understorey, couch being the dominant species (Cynodon dactylon and Paspalum distichum).

In upstream sections of the Swan River, clearing has similarly denuded the understorey with predominantly Aster subulatus, Atriplex hastata, Rumex crispus, Senecio quadridentatus and various grass species (mostly Cynodon dactylon) dominating the flora beneath Eucalyptus and Melaleuca trees. Trampling by stock has left several areas of bare ground along the river bank, which are now subject to erosion by water flow.

Severe mechanical disturbance associated with parks and pasture keeps the understorey depauperate in species. While pasture lands are grazed at low to moderate levels continued regeneration of trees is possible, but once grazing pressure is removed, weeds establish preventing regeneration of the natural vegetation. Similarly in maintained parkland, activities prevent tree and other natural vegetation regenerating. Therefore, the present tree populations in these areas will become increasingly aged and eventually die, leaving the weed understorey.

### 10.5 Deposition and Erosion

The fringing vegetation of the Swan River estuary is a dynamic system, constantly changing with changes in environmental conditions. Two physical factors which are important to these dynamics are the deposition of silt (siltation) to form new areas of ground and erosion. At present, these processes are not permitted to occur freely as siltation is hazardous to boating and erosion destroys property. Therefore, accretion will only occur in areas of existing vegetation and, as a result, the peripheral vegetation will progress towards fringing forest. No new areas will form on which salt marsh communities can establish and no areas of fringing forest will be eroded. The distribution of salt marsh will decrease and the system will become 'top heavy' with stabilised fringing forest, creating an unbalanced system.

## 11.0 MANAGEMENT AND CONSERVATION OF THE PERIPHERAL VEGETATION

### 11.1 Conservation

The System 6 report recommends various areas for reserves along the Swan and Canning Rivers. These include:

a) Alfred Cove - it is recommended that the existing foreshore reserve C35066 for Conservation of Flora and Fauna which is vested in the W.A. Wildlife Authority be extended to include an area of tidal flats which are of great importance to the wading bird community of the Swan River estuary.

b) Pelican Point and South Perth Foreshore - Although the fringing vegetation at these sites is very disturbed, they and the tidal flats adjacent to them represent the remaining significant wading bird habitats. It was recommended that the South Perth foreshore become a regional park and the tidal flats along it be declared a Class A reserve for conservation of Flora and Fauna and that the reserve be vested in the W.A. Wildlife Authority. Similar recommendations were made for Pelican Point except that part of the foreshore was also recommended as a flora and fauna reserve.

c) It is proposed that Mt. Henry and the foreshore from Salter Point to Clontarf be made regional parks and that an area of Bull Creek be made a Class C reserve for flora and fauna.

d) Canning River (Riverton Bridge to Nicholson Road Bridge) - The peripheral vegetation between Riverton Bridge and the footbridge was recommended as a Class A reserve for flora and fauna. Between the footbridge and Nicholson Road a reserve for Parkland was recommended.

e) The remainder of the Canning River past the Swan River Management area was to be reserved for parks and recreation.

f) The Swan River foreshore at Maylands, the salt marshes at Maylands and Belmont and the predominantly salt marsh backwater at South Guildford were all recommended as regional parks.

g) Finally the Swan River foreshores from Guildford to Walyunga be made a regional park.

Perhaps the most floristically important areas of the Swan River estuary are on the Canning River between Riverton and Nicholson Road Bridges and Ashfield Flats (Pen pers. comm. 1985). At present the Canning River area is predominantly in a Parks and Recreation Reserve under the Metropolitan Region Scheme while the majority of Ashfield Flats is designated as regional open space with a small area of fringing forest to the south-west being designated as a flora and fauna reserve under Town Planning Scheme 3.

Many other areas, as well as these are important to birds and other fauna as noted above. At Bull Creek an isolated patch of <u>Eucalyptus</u> - <u>Melaleuca</u> with its natural understorey still survives. Conservation of these areas is important if we are to preserve the natural flora and fauna of the Swan River Estuary.

## 11.2 Management

To prevent further degradation of the peripheral vegetation proper management is required. Pen (1981, 1983) gives a number of management recommendations arising from his study:

a) Pioneer species _Atriplex hastata_, _A. hypoleuca_, _Carpobrotus edulis_, _Suaeda australis_ and _Sarcocornia quinqueflora_ would be useful for foreshore regeneration. _Casuarina obesa_ is also useful for regeneration along the estuary.

b) Regeneration will be more successful if attention is paid to the zonation of the existing vegetation. It will provide information on what species are needed and where to plant them.

c) Drains should bypass salt marsh vegetation so as not to reduce salinities in the area and empty into fresh water associated vegetation to allow flushing. Degradation will still occur but the complexes will not be destroyed.

d) Drains should not be emptied into stationary bodies of water since they support the most vigorous growth of _Typha_. This may help to contain the _Typha_ invasion.

e) To prevent erosion of drainage channels constructed to combat the mosquito problem, _Juncus kraussii_ should be planted along drain margins.

f) Public and stock access to areas of natural vegetation should be discouraged to prevent further degradation.

g) Erosion and deposition are necessary to maintain the dynamic relationships of the river vegetation system.

h) Native species should be used in regeneration. Pen (1983) provides a list of suitable plants.

i) It is a policy of the M.R.P.A. to lease riverside public land to neighbouring land owners for grazing where appropriate. Generally only cattle are permitted as they do little damage to the land. This practice should be continued and extended where possible to allow _E. rudis_ regeneration although cattle should be excluded from the waters edge where they could damage peripheral vegetation and cause erosion. Dense stands of _E. rudis_ should be thinned to allow normal growth.

# CHAPTER 5 : FAUNA

## 1.0 INTRODUCTION

A wide diversity of animal life is found in the Swan River estuary. Apart from the fish and crustacea exploited by both amateur and professional fishermen, the estuary supports numerous aquatic verterbrates, invertebrates, insects and birds.

Many of these animals are permanent inhabitants of the estuary while others are migrants which utilise the estuary as a nesting or nursery site, drawn by the abundant food available in the estuary. Estuaries in general are highly productive but certain areas are particularly important to the aquatic fauna - the shallow banks covered by seagrasses, foreshores and areas of peripheral vegetation. Here, where the flora is most abundant, the fauna form complex highly productive food webs.

To conserve this valuable resource, management of the estuarine environment is required. Habitats and food sources need to be protected, which ultimately means the conservation of the aquatic flora, and the complex interaction of the food web need to be left undisturbed.

Not all faunal species are regarded as an asset and in fact certain insect species, for example the mosquito, form a nuisance and their populations need to be controlled. Where this is necessary control measures need to take account not only for their effectiveness on the target species but also their effect on the other fauna in that environment.

In this report a description is given of the estuarine fauna, their distribution, feeding habits, habitat and human activities which effect them. A review of the mosquito nuisance and its control is also be given.

## 2.0 AQUATIC INVERTEBRATE FAUNA

There is a wide range of invertebrates in the Swan River estuary including crustaceans, molluscs, annelids, coelenterates, echinoderms, foraminiferans, platyhelminths and bryozoans. These groups can be divided further, for example within the crustacea there are;

barnacles
ostracods - Tiny benthic or pelagic animals
copepods - zooplankton

and another group including;

decapods - prawns crabs etc
amphipods )
isopods ) Tiny benthic or occasionally pelagic
tanaids ) animals

Within the molluscs there are bivalves, gastropods (snails and sea-slugs) and chitons. Within the annelids there are the polychaetes (bristle worms) and leeches. The coelentrates are represented by jellyfish, corals and anemones. Echinoderms are represented by sea urchins and starfish. Foraminferans are skeleton-producing protozoans, platyhelminthes are flat worms and bryozoans are plant-like animals. Another animal in the estuary often grouped with the invertebrates but actually possessing a rudimentary backbone for part of its life cycle, is the prochordate sea-squirt. Illustrations of some of these invertebrates are given in Figure 1.

## 2.1 Crustaceans

Perhaps the most obvious invertebrates in the estuary are the large decapods. These include the Western king prawn (Penaeus latisulcatus), the greasyback, school or common river prawn (Metapeneas dalli) and the blue manna crab (Portunus pelagicus). The Western king prawn and the blue manna crab are basically marine but use the estuary as a nursery habitat for juveniles. They are common in the estuary during summer although the crab may remain in the estuary all year at times of reduced winter flushing, particularly in areas of the lower estuary which can remain marine. Osmotically, blue manna crabs are unable to survive sustained exposure to waters of less than 10% (Meagher 1971). The greasyback prawn is capable of reproducing and living entirely within the estuarine system and hence must be able to adjust to a wide range of salinities. These three species are commonly found on shallow banks where potential food is more abundant, however, the blue manna crab can be found in deep water in the lower estuary. Both prawns and the blue manna crab are important to commercial and amateur fishermen.

Other decapods found in the estuary include the crabs Halicarcinus australis, H. bedfordii and Heteropanope serratifrons which are commonly found amongst mussels on piles (Wallace 1977). H. australis is found throughout the estuary (Ashman et al., 1969) whereas the other two may be restricted to the lower to mid estuary. Four species of palaemonid shrimps have been recorded from the estuary. Macrobrachium intermedium occupies beds of the seagrass Zostera mucronata from Fremantle to Freshwater Bay while Palaemonetes affinis is present in low numbers in the rocky area of the channel of the lower estuary and in Fremantle Harbour. Neither of these species are found in the estuary during winter, however, they may be during summer when

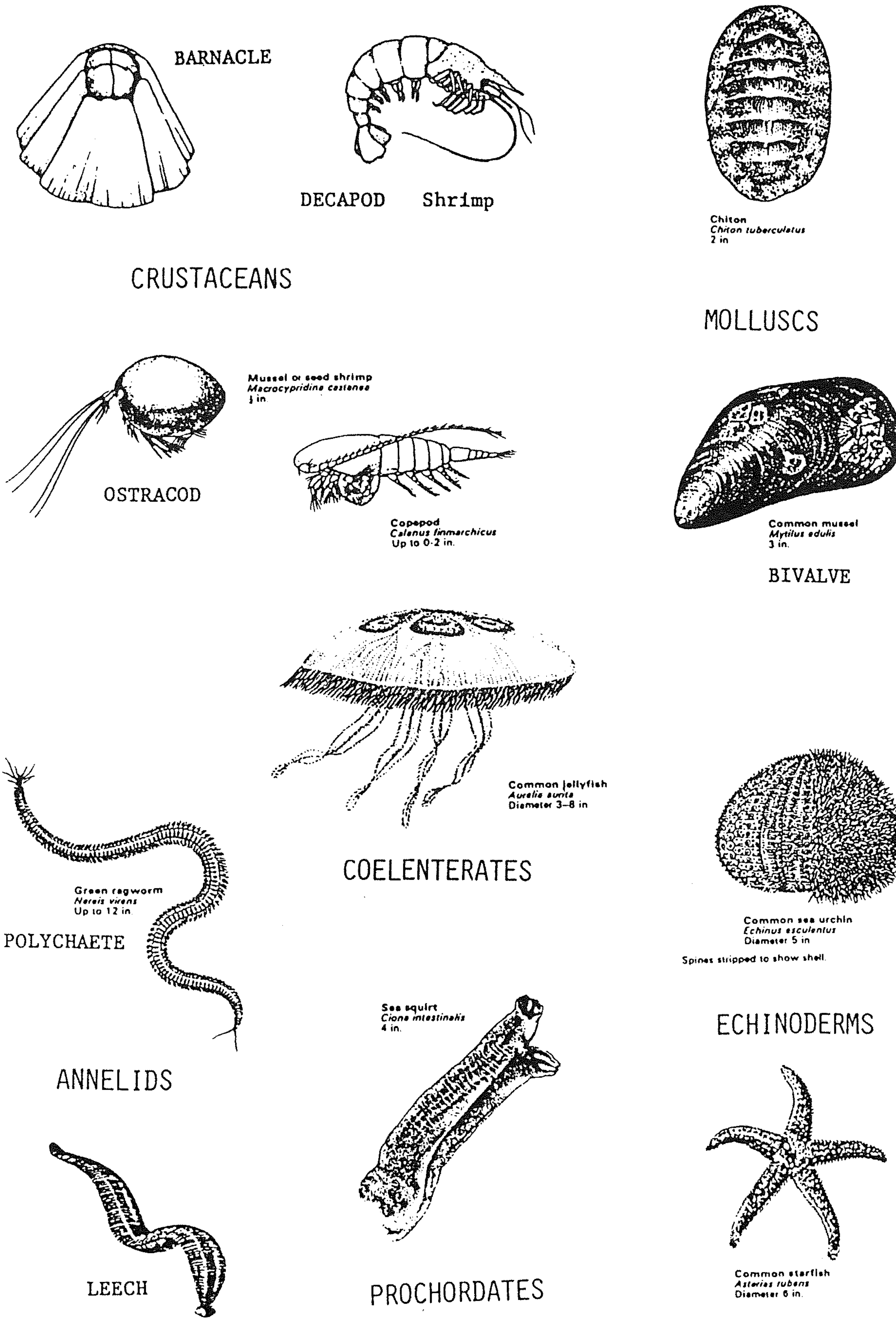



FIGURE 1: A selection of the kind of Invertebrates found in the Swan River Estuary

salinities in the estuary approximate those of seawater. Palaemonetes australis is found throughout the estuary down to Point Walter. It can tolerate a wide range of salinities from fresh water to salinities greater than seawater, although it is not found in marine habitats. Palaemonetes atrinubes is the final palaemonid species and is present in the lower estuary from Canning Bridge and Pelican Rocks to Point Walter during summer. In winter it is absent from the shallows and probably seeks deeper more saline waters of the channels. P. atrinubes inhabits shallow water over a substrate of mud or detritus and, unlike P. australis, is often found swimming above the substrate during the day (Boulton 1981).

The remaining crustaceans are much smaller than the decapods. The barnacle Balanus amphitrite is common up to Heirisson Island on rocks and piles. This marine animal is killed each year by fresh water flushing in winter, except at the mouth of the estuary. Larvae from the mouth travel up the estuary each summer and recolonise previously inhabited areas where they grow quickly. Serventy (1955) also noted another species of barnacle Balanus nigrescens.

Amphipods and isopods are common among mussel masses and may also be found free swimming or amongst plants. Amphipods common in the estuary include Melita matilda, M. spp., Paracorophium excavatum, Corophium minor, Talorchestia spp., and Caprella spp. Tanaids found in the estuary include Apseudes spp., and Paratanais spp., while isopods include Sphaeroma quoyana which tunnels into sandstone rock in the Freshwater Bay area and jetty piles (Serventy 1955) and Syncassidina aestuaria which is often found among mussels on piles (Wallace 1977).

Ashman et al., (1969) found that four of the six amphipods they studied were permanent inhabitants of the estuary. These included the two Melita sp. P. excavatum and C. minor. The Talorchestia sp. and another unidentified species were restricted to the lower estuary during the summer marine phase. The four permanent species were able to tolerate a wide range of salinities from 5% to 34%. However C. minor is restricted to below Heirisson Island. This may be because it is tubiculous (lives in tubes) on algae and appears to have a specific association with the marine algae Cystophyllum muricatum which occurs only in marine areas. It is also found in tubes on substrate and hence its preference for a particular substrate may restrict its distribution.

Ostracods and copepods are less than 1mm in length and hence have been missed in some invertebrate studies (Wallace 1977). No ostracod species have yet been identified for the Swan River estuary although they have been noted (Rippingale 1981). However, a few species of copepod are known. The copepods Sulcanus conflictus and Gladioferans imparipes feed predominately on phytoplankton and dominate the zooplankton population in spring and autumn. In summer S. conflictus dominates as it is omnivorous and is able to feed on juvenile G. imparipes (Rippingale and Hodgkin 1974). S conflictus also dominates saline pools (up to 15%) in the upper estuary in summer. Halicyclops and harpacticoid copepods are also found in these pools. (Rippingale 1981). Two other copepods found in the estuary, Oithonia nana and Acartia clausi, are marine species and are restricted to the lower estuary.

## 2.2 Molluscs

In a study by Chalmer et al. (1976) 97 mollusc species were identified in the Swan River estuary including 51 species of bivalves, 44 species of gastropods and 2 species of chiton. These species were divided into four groups:

i) Species of marine affinity with no more than temporary sporadic estuarine representation - 64 species (66%).

ii) Species of marine affinity, with more or less continuous estuarine representation - 25 species (26%).

iii) Species of exclusively estuarine affinity, having neither marine nor fresh water representation, about 7 species (7%).

iv) Species of fresh water affinity, with limited estuarine and no marine representation - one species (1%).

The lower estuary is dominated by molluscs of marine affinity. The temporary marine inhabitants live only in the lower estuary during the summer-autumn marine phase. Of the continuous marine inhabitants no more then six are capable of surviving continously in the middle estuary and only four have shown incursions into the upper estuary during years of low winter flow; the rest are restricted to the lower estuary. Three bivalves (Spisula trigonella, Tellina deltoidalis, Theora lubrica) and three gastropods (Batillaria australis, Nassarius pauperatus and N. burchardi) make up the group of marine species able to live continously above the lower estuary and are much more abundant in the estuary than in marine habitats. It is thought that S. trigonella, T. lubrica and N. burchardi are recent invaders of the estuary, as the earliest records of these species are since the 1960's.

The two chitons found in the estuary are both only temporary inhabitants of the lower estuary. They are known only from channel dredgings around Rocky Bay and all specimens collected were small and uncommon.

The seven exclusively estuarine species include the bivalves Xenostrobus securis, Arthritica semen, Anticorbula amara and the gastropods Tatea preissi, Potamopyrgus spp., Assiminea sp. and Hydrococcus graniformis. These characterise the middle and upper estuaries. The first four are believed to invade the lower estuary during strong winter flooding, while Potamopyrgus and Assiminea sp. are only known from the upper estuary. H. graniformis has not been recorded since 1840 and is now possibly extinct in the Swan.

In the upper estuary, the increase in salinity due to clearing for agriculture in the upper catchment may have changed the mollusc distribution within historic time. The one truly fresh water species, the snail Plotiopsis australis has become less common and more scattered in distribution while the estuarine species A. amara has become more common. It is thought that Potamopyrgus spp. was also once more widely distributed (Kendrick 1976).

The majority of molluscs attach to rocks or are found on the surface of rocky, sandy or muddy substrates. For example the edible mussel Mytilus edulis planulatus attaches to rocks and jetty piles up to Blackwall Reach, from here a smaller mussel Xenostrobous securis is found in this habitat. Molluscs are also known to bury themselves deeply into the substrate e.g. the bivalve Sanguinolaria biradiata.

## 2.3 Annelids

The Annelids are predominantly represented by polychaete worms. Only one unidentified species of leech and another of an oligochaete worm have been found and these were restricted to the upper estuary, (Ashman et al 1969).

Of the twelve species identified from the Swan River Estuary it is thought only six are permanent residents (Hodgkin unpubl.).

The large polychaetes Marphysa sanguinea, Australonereis ehlersi and Scoloplos simplex are common in shallow water but are not found in deep water in any quantity (Wallace 1977). M. sanguinea is used for bait by fishermen. These three species and other smaller forms (Capitella capitata, Ceratonereis erythraeensis, Nereis oxypoda, two Prionospio spp., an unidentified Cirratulid spp., Haploscoloplos kerguelensis, Diopatra spp.) all bury in sandy to muddy substrates to 10-20cm depth, although some are also found amongst mussels on piles.

The only polychaetes found in deep water in any quantity are the Prionospio species, one of these being found only in deep water (sp. 2). Deep water areas are typified by a gelatinous black mud which is very impoverished in oxygen and food. C. capitata, which can survive under low oxygen concentrations, is not found in the deep water areas, reflecting their poor suitability for invertebrate inhabitation. A sedentary worm, Mercierella enigmatica secrets masses of calcareous tubes on rocks and timber at low water.

All of the species above are distributed throughout the estuary at least to Garratt Road Bridge with the exceptions of A. ehlersi, Nereis oxypoda, Prionospio sp. 2, the Cirratulid species and Diopatra sp. which are found only up to Melville Water in marine conditions. C. erythaeensis and H. kerguelensis are both considered to be marine invaders but can tolerate salinities as low as 7°/₀₀ and 14°/₀₀ respectively. M. sanguinea is a permanent resident of the estuary and burrows deeply into the mud in winter possibly to avoid low salinities (Ashman et al., 1969).

## 2.4 Coelenterates

There are two species of jellyfish in the Swan River estuary, the transparent Aurelia aurita and the brown spotted Phyllorhiza punctata. A. aurita is able to survive in quite low salinities but P. punctata is less tolerant of low salinity and varies greatly in abundance from year to year (Hodgkin unpubl.). It is most common in summer when salinities are highest. Occasionally the box jellyfish (Carybdia rastoni) is brought into the estuary by tidal movement and wind (Riggert 1978).

An anemone Radianthus concinnata was dredged from 4-8 metres depth in Rocky Bay in 1973. A living colony of a small semi-colonial, ahermatypic coral (Culicia sp. c.f. C. tenella) was dredged from a shingle substrate in the channel of the lower estuary near Minim Cove in 1974. An unidentified seapen has been collected from the lower estuary (Chalmer et al., 1976). Wallace (1977) also records an unidentified anemone found in Alfred Cove and the Canning River in deep water. All of the identified species and the seapen are of marine affinity.

## 2.5 Echinoderms

Starfishes and sea-urchins are occasionally found in the estuary, although most of them are of marine origin.

Sea-urchins, which are temporary inhabitants of the estuary, include Breynia which was collected at Lucky Bay after several dry winters in 1961, and Peronella lesueuri which was found in deep water of Blackwall Reach also after dry winters. The sea-urchin Temnopleurus michaelseni is a permanent resident of the lower estuary as far up as Bicton. It also prefers deeper water.

The starfish Anthenea australiae and Astropecten triseriatus are temporary inhabitants of the lower estuary distributed as far as Peppermint Grove and Bicton respectively (Riggert 1978). While the brittlestars Amphiura spp., Ophiactis spp. and Amphipholis squamata may be continuous residents of the lower estuary. These species were collected from the channel below Blackwall Reach.

## 2.6 Other Invertebrate Groups

The Foraminiferans are a group of skeleton-producing protozoans. In the deeper areas at the Narrows and Melville water one species Ammonia becarii makes up more than 50% of the fauna. This species is highly tolerant of fluctuations in temperature and salinity. Another group of foraminifera, the miliolids are not tolerant of salinity fluctuation and make up the majority of the fauna below Blackwall Reach and extend just into Melville water. The number of foraminifera decreases markedly upstream (Quilty unpubl. cited Riggert 1978).

One unidentified Platyhelminth or flatworm has been recorded in the lower estuary (Ashman et al., 1969).

Two species of Bryozoans can be observed in the estuary. The marine Membranipora sp. encrust the edible mussel Mytilus edulis in the lower estuary while the more estuarine species Conopeum sp. encrusts on the smaller mussel Xenostrobus securis as far up as Guildford (Riggert 1978).

A member of the prochordates, the sea squirt is also found in the lower estuary (Serventy 1955).

## 2.7 Zooplankton

Zooplankton is made up of a wide range of invertebrates. Copepod crustaceans are planktonic throughout life but occasionally amphipods and ostracods may be found in the water column. Bacteria and protozoans may also be planktonic. Finally the larvae of crabs (Halicarcinus sp.) molluscs and worms are planktonic for a few days or weeks before settling on the bottom and are common in the zooplankton at times (Hodgkin unpubl.).

## 2.8 Distribution and Abundance

The Swan River supports a rich invertebrate fauna. This is characterised by a low faunal diversity and high abundance of a few species. Wallace (1977) recorded a highest density for a single species of 36 500 individuals per square metre of the small polychaete Capitella capitata in the sand flats of Alfred Cove. This area also had the highest density for total individuals of all invertebrate species: 76 500 ± 6 500$m^{-2}$. Densities were lower at other sites but single species often recorded densities of up to 10 000 $m^{-2}$.

Most invertebrate species are of marine affinity and hence species diversity decreases upstream, particularly in winter.

Habitat selection by invertebrates is influenced by sediment particle size, water depth and oxygen conditions of the sediment. Most species prefer sandy, shallow, well aerated conditions as found in foreshore areas. Few species inhabit the fine, oxygen-depleted muds of the deeper water.

Planktonic species of invertebrates generally feed on phytoplankton or smaller zooplankton. Benthic species are often detrivores, feeding on the protozoans and bacteria associated with the decay of seagrasses and algae, hence the high proportion of invertebrates found in seagrass beds.

Invertebrates are a very important part of the estuarine ecosystem and are the food of most estuarine fish and wading birds. The few species which are adapted to life in brackish waters are very successful and their mechanisms of adaptation are of great scientific interest.

# 3.0 FISH OF THE SWAN RIVER MANAGEMENT AREA

A total of 122 fish species, representing 62 families, have been recorded from the Swan River Management Area showing that relatively diverse and abundant fish fauna is present in the estuary (Chubb 1984). These fish can be divided into three types; lampreys, elasmobranchs and teleost fish. The teleost fish, which make up the majority of the fish fauna (116 species) can be further divided on the basis of how they utilise the estuary. Some fish are found only in fresh water areas of the estuary, some are able to carry out their whole life cycle within the estuary, while others use the estuary predominantly as a nursery area, spending the rest of the time in the marine environment. Finally, some fish are purely marine but visit the estuary to feed when salinities approximate seawater. Information on the life cycle, feeding habits, habitat, estuarine distribution, abundance and importance to recreational and commercial fisheries of all of these fish is summarised in Appendix 2.

## 3.1 Lampreys and Elasmobranchs

The pouch or wide-mouthed lamprey Geotria australis has been found in the Swan-Avon system and in particular in the Canning River. Lampreys are primitive jawless fishes who parasitise other fish by attachment of their sucker-like mouths. The larval stage of this lamprey has only once been found in the river and adults are only found occasionally. It is possible that the high summer temperatures (28 - 30°C) in the Swan are lethal to the larvae of this lamprey (Macey and Potter 1978).

The elasmobranchs, or cartilaginous fishes, is the group comprising sharks and rays. They are represented by five species in the Swan River estuary each belonging to a different family. However, four of these have been recorded only once in W.A. Museum records. The fifth species, the Swan River whaler, Carcharhinus leucas has been caught at intervals by professional fishermen and a few amateurs during spring and summer. The Swan River whaler can tolerate salinities from fresh to 50°/₀₀ and is thought to use the estuary as a nursery ground, although there is a lack of records for this species in nearby marine habitats. Larger sharks have been sighted in the Swan River estuary and attacks have been recorded but there have been no positive identifications of the species responsible (Chubb 1984).

## 3.2 Freshwater Teleost Fish

There are only four indigenous species of fresh water fish in the Swan River system. These include the western minnow (Galaxias occidentalis), the fresh water cobbler (Tandanus bostocki), the nightfish (Bostockia porosa) and the western pygmy perch (Edelia vittata).

However, changed river conditions brought about by damming have allowed a number of introduced species such as the goldfish (Carassius avratus), brown and rainbow trouts (Salmo trutta and S. gairdneri) and redfin perch (Perca fluviatilis), to thrive in the upper reaches of the Canning River. The mosquito fish (Gambusia affinis), originally introduced to control mosquito breeding, is also common in fresh water areas. Several other fresh water species have been introduced into the Swan and Canning Rivers but have been less successful than those mentioned. However, the success of the introduced teleosts has probably contributed to the paucity of indigenous species (Chubb et al., 1979).

The majority of these fish are found in the upper estuary only when salinities are below 6‰. The long-headed goby (Favonigobius suppositus) can be present in small numbers at similar salinities. The life history of this species is not fully known however and it is not possible to say whether it is a fresh water or estuarine species (Chubb 1984).

## 3.3 Estuarine Teleost Fish

All species within this group are capable of reproducing and living entirely within the estuarine system and, therefore, must be able to cope with seasonal variations in salinity. A typical life-cycle for these fish is shown in Fig. 2.

Some species are also capable of living entirely in marine environments e.g. cobbler (Cnidoglanis macrocephalus), the southern anchovy (Engraulis australis), gobbleguts (Apogon rueppelii) and flathead (Platycephalus endrachiensis). However Kowarsky (1975) found differences between meristic characteristics of the estuarine and marine populations of cobbler suggesting that these species have discrete marine and estuarine populations.

Other species in this group such as black bream (Acanthopagrus butcheri), Perth herring (Nematalosa vlaminghi) and yellow-tailed trumpeter (Amniotaba caudavittatus) are capable of making marine excursions from the estuary mainly in response to winter flood conditions.

Certain species have developed specialised breeding habits to cope with the extreme habitats of the estuary. These fish produce relatively few eggs but take better care of them than most fish. Hardyheads (Allanetta mugiloides and Antherinsoma species) attach their eggs to seagrass fronds. Gobies (Favonigobius species and Pseudogobius olorum) build nests under stones and other objects. Cobbler is also thought to build nests (Lenanton 1978).

## 3.4 Estuarine-Marine Teleost Fish

The shallow banks of the Swan River estuary particularly those covered by the seagrass Halophila ovalis provide a relatively protected environment containing abundant food resources. This makes the estuary an excellent nursery for the juvenile forms of a number of marine fishes. Species in this category usually reproduce in the ocean and utilise the estuary as a nursery habitat during the summer months, when salinities approximate seawater.

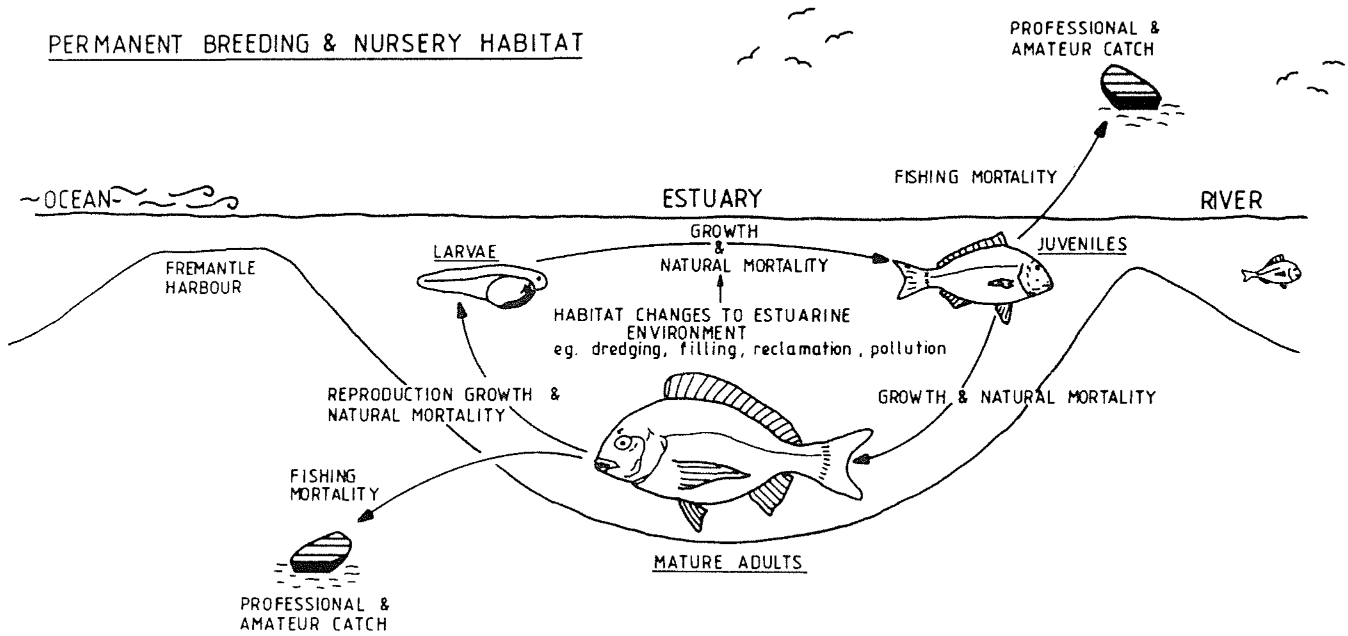



FIGURE 2

TYPICAL LIFE CYCLE OF AN ESTUARINE TELEOST FISH
( FROM LENANTON 1978 )

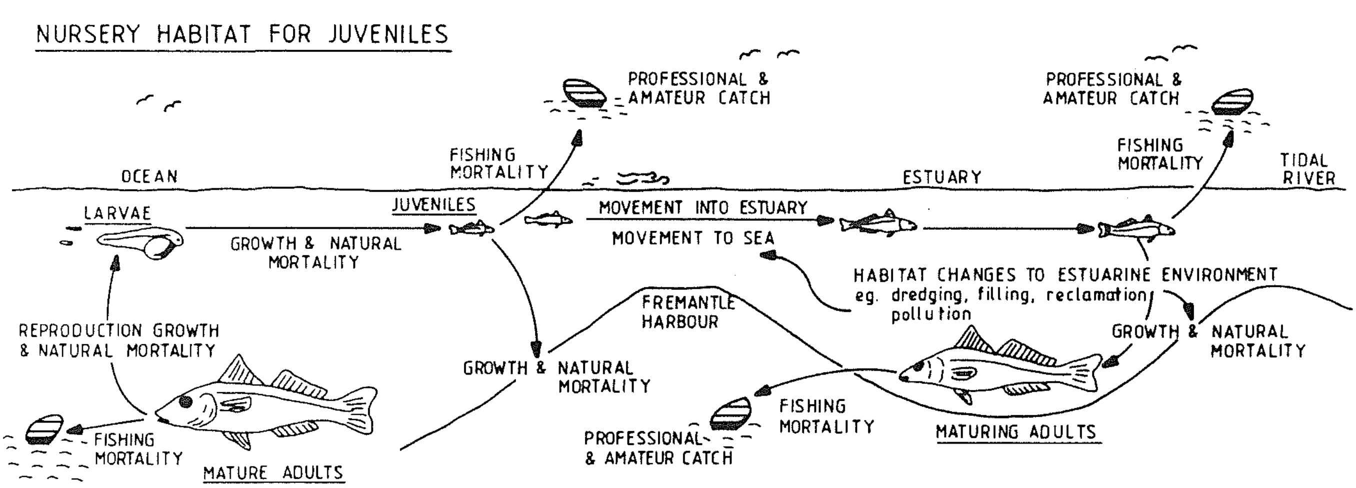



FIGURE 3

TYPICAL LIFE CYCLE OF AN ESTUARINE - MARINE TELEOST FISH
( FROM LENANTON 1978 )

There are a number of marine species which not only utilise the estuary as a nursery ground but also as an adult feeding ground. The sea and yelloweye mullets (Mugil cephalus and Aldrichetta forsteri), mulloway (Argyrosomus hololepidotus), tailor (Pomatomus saltatrix) and probably the small-toothed flounder (Pseudorhombus jenynsii) and common blowfish (Torquigener pleurogramma) fall into this category. The young stay in the estuary throughout their first year but the adults of, for example mulloway and tailor, tend to occur seasonally.

Fishes in this group include the bulk of the most important commercial and amateur fishing species, particularly those listed above. The blowfish is becoming an increasing nuisance for anglers (Riggert 1978). The life cycle pattern for this group (Figure 3) represents a year of reasonable winter flushing. In drier years, species such as the trumpeter whiting (Sillago maculata), tailor and mulloway, which have little tolerance to variation in salinity may remain in the lower estuary all year conversely, if winter flooding is high these species may be forced out of the estuary for long periods. Other species more tolerant of salinity changes such as the sea and yelloweye mullet are more commonly found in the lower estuary throughout the year (Lenanton 1978).

## 3.5 Marine Teleost Fish

The majority of species found in the Swan River estuary fall into this group. They are species which are often represented by older individuals that enter the lower reaches of the estuary for a restricted period; typically during the summer-autumn marine phase. They are able to tolerate only minor deviations from marine salinities (35°/₀₀). These fish form only a minor part in the estuarine fishery being more commonly caught in the marine environment. However, in abnormally dry years they may remain in the estuary for several months. A typical life-cycle for these fish is shown in Fig. 4.

An interesting group of the marine fish are the tropical fish including the flutemouth (Fistviaria commersoni), pennant trevally (Alectis cillaris), black-spot goatfish (Parapeneus fraterculus) goby (Priolepis nuchifasciatus), lined pufferfish (Arothron hispidua) and the silver toadfish (Lagocephalus sceleratus). These coral reef species are transported as larva in a plume of tropical water, called the Leeuwin current, which projects south along the Western Australian coast during winter. Thus warmer water species may temporarily extend their range into colder water by living in the shallower areas of estuaries, where summer temperatures are considerably higher than

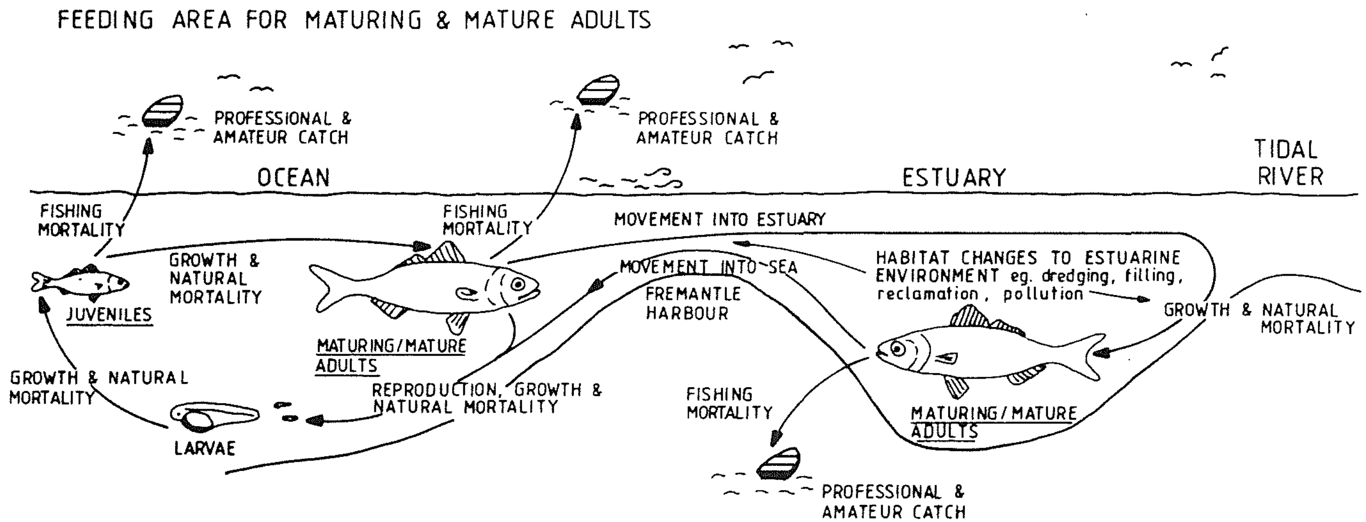



FIGURE 4

TYPICAL LIFE CYCLE OF A MARINE TELEOST FISH WHICH VISITS THE ESTUARY
( FROM LENANTON 1978 )

those of the nearby ocean. However winter water temperatures in the Swan River estuary are lower than those in the ocean, which probably affects the survival of these species (Chubb 1984).

## 3.6 Feeding Characteristics

Loneragan (1981) found that of the 38 shallow water fish in his study placed in feeding groups, 30 species and 49.5% of the total number of fish were carnivores. The detritivore group was the second most important (33.5%) followed by herbivores (11.4%) and lastly omnivores (5.6%). However, when the total catch was considered in terms of the biomass of fish caught the detrivores became the most important feeding type (64.5%), followed by omnivores (17.7%), carnivores (16.1%) and herbivores (1.7%). The change in relative proportions of the feeding groups was due to the large biomass of the detrivores, Perth herring and sea mullet and the omnivores, yellow-tailed perch, black bream and yellow-eye mullet.

Fish that live predominantly in the water column are able to eat phytoplankton, zooplankton and other smaller fish. Table 1 shows that of the 22 most abundant fish in the estuary, all of the pelagic forms were carnivores and a study of the Appendix also suggests that this is the dominant feeding type of pelagic fish. Demersal (bottom-living) species show a wider variety of feeding characteristics, although carnivorous species are still dominant. Demersal fish are able to eat benthic macro and micro-algae, seagrass, detritus, benthic invertebrates and other smaller fish. Few fish actually eat living plants, but often feed on decaying plant material complete with its attached fauna of protozoans and bacteria. This detritus is also a common food for benthic invertebrates which are an important part of many fishes' diet, especially the juvenile forms of estuarine-marine fish. Other larger demersal carnivores may in turn eat these juvenile fish. A simplified food chain for the estuarine environment is given in Figure 5.

Detritus, which is an important basis of this food chain is most commonly derived from seagrasses and their attached epiphytes, which are found in shallow areas of the estuary. The abundance of detritus and hence benthic invertebrates which feed on detritus in the shallows make these important areas for fish. Far fewer species are found in deeper areas where food is more scarce.

A full description of the feeding habits of various important commercial and recreational fishery species is given in Thompson (1957) and Wallace (1975).

MOST ABUNDANT FISH IN THE SWAN RIVER ESTUARY

| | RANK BY NUMBER | BIOMASS % CATCH OR RANK | FEEDING TYPE | LIFE CYCLE | HABIT | FISHING |
|---|---|---|---|---|---|---|
| 6+<2m Sc Perth Herring | 1 | 55.0 (1) | D | E | | C |
| 5+<&>2m Sc 6 - lined trumpeter | 2 | 1.7 (8) | H | E-M | D | RC |
| <2m Sc Hardyhead - A. presbyteroides | 3 | (13) | C | E-M | P | - |
| <2m Sc Ogilby's hardyhead | 4 | 4.2 (7) | C | E-M | P | - |
| <2m Sc Hardyhead - A. wallacei | 5 | (15) | C | E | P | - |
| <&>2m Sc Souhtern anchovy | 6 | 1.1 (9) | C | E(M) | P | RC |
| <&>2m Sc Common blowfish or food fish | 7 | 7.1 (4) | C | E-M | D | R |
| <&>2m So Gobbleguts | 8 | (12) | C | E | D | - |
| <2m So Long-finned goby | 9 | (17) | C | E | D | - |
| <2m Sc Sea mullet | 10 | 9.0 (2) | D | E-M | D | CR |
| <2m Sc Yelloweye mullet | 11 | 4.5 (6) | O | E-M | D | CR |
| <2m Sc Blue-spot goby | 14 | (23) | C | E | D | - |
| <&>2m Sc Yellow-tailed perch | 15 | 7.7 (3) | O | E | D | RC |
| 4+<2m Sc Elongate hardyhead | 12 | (19) | C | E | P | - |
| <2m Sc Hardyhead - A. mugiloides | 13 | (21) | C | E | P | - |
| <&>2m Sc Trumpeter whiting | 16 | (11) | C | E-M | D | RC |
| <&>2m So Silver belly/roach | 17 | (14) | ? | E-M | D | C |
| <&>2m So Black bream | 18 | 5.4 (5) | O | E | D | RC |
| <&>2m Sc Tailor | 19 | (16) | C | E-M | P | RC |
| <&>2m Sc Sandy sprat/whitebait | 20 | (25) | C | E-M | P | C |
| <2m So Bridled goby | 21 | (22) | C | E | D | - |
| <&>2m So Cobbler | 33 | (18) | C | E(M) | D | RC |

TABLE 1: Characteristics of the most abundant fish in the estuary and their importance for fishing (see Appendix 2 for key)

Based on data from Lenanton (1978)
Chubb et al (1979)
Loneragan (1981)
Chubb et al (1984)

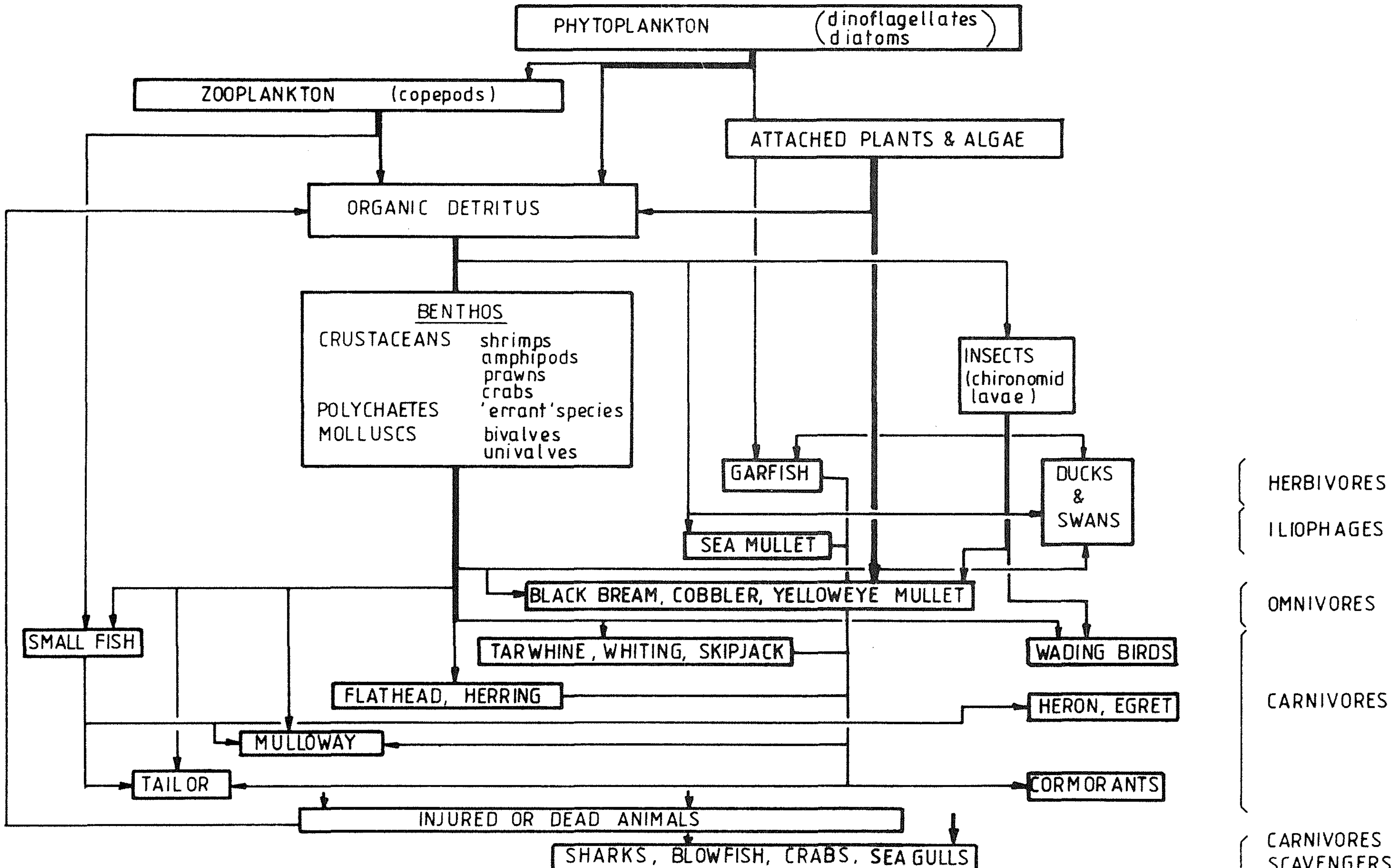



FIGURE 5

SIMPLIFIED CONCEPT FOR THE FLOOD CHAIN IN THE SOUTH-WESTERN AUSTRALIAN ESTUARINE ENVIRONMENT (FROM LENANTON 1978)

## 3.7 Abundance

Table 1 lists the 22 most abundant species in the Swan River Estuary. These species represent those that were caught in beach seine, otter trawl - gill nets between February 1977 and June 1980 and numbered more than 1000 individuals over that time (Chubb 1984).

The most common species in the estuary is the Perth herring (Nematalosa vlaminghi). Other common species include the sea and yellow-eye mullets, the six-lined trumpeter (Pelates sexlineatus) the hardyheads, the southern anchovy, various gobies, the common blowfish, gobbleguts and the yellow-tailed perch (Amniataba caudauiltatus).

Loneragan (1981) found that of those fish caught in beach seines (i.e. in water less than 2m deep) Perth herring was also the most abundant species and contributed the highest biomass (55% of the total catch). Sea mullet, yellow-tailed perch, blowfish and black bream dominated the rest of the catch in terms of biomass. Hence a small number of species accounted for a large proportion of the total catch.

The abundant species were divided fairly evenly between purely estuarine forms (12 species) and estuarine-marine forms (10 species) which use the estuary predominantly as a nursery ground. No fish of the marine group were represented. All of the abundant species have been caught in the lower middle and upper estuary and half of them are to be found in both shallow (less than 2m deep) and deep water. However, many important species are found predominantly in the shallows e.g. Perth herring, sea and yellow-eye mullet.

Most of these species live on the bottom of the estuary (demersal - 14 species) while eight species are found throughout the water column (pelagic).

Thirteen of the 22 most abundant species are important to commercial and/or the recreational fishery.

Data for the freshwater regions of the estuary are scarce. However, McDermott (1981) found that the most abundant species above Kent Street Weir on the Canning River was the mosquito fish (Gambusia affinis). The second most abundant species the long-headed goby (Favonigobius suppositus) followed by the hardyhead (Atherinosoma wallacei). Other species were the long-finned goby, blue-spot goby and the sea mullet. The western minnow (Galaxias accidentalis) was also found in the upper regions of the Canning River at Thornlie.

Of the 122 species of fish in the estuary listed by Chubb (1984), 64 species might be considered rare (less than 10 individuals caught over the study period). The majority of these species are marine visitors (49 species), while 31 of these marine species were known only from marine records. Of the remaining rare species five were fresh water fish, five were estuarine-marine and five had no data available on their life cycle. The large proportion of rare species in the Swan River estuary may be related to the relatively deep and wide nature of the entrance channel. This may facilitate the entry of marine species (Loneragan 1981).

Members of the whiting (Sillaginidae) and garfish (Hemiramphidae) families are less abundant in the Swan River estuary than in either the Peel-Harvey or Blackwood River estuaries (Chubb et al 1979).

## 3.8 Distribution

Many studies of fish in estuaries have found that the highest number of individuals, species and diversity are found where salinities are highest and decrease with increasing distance upstream. This is not the case in the Swan River estuary. The mean number of species was found to increase from 7.9 species at Stirling Bridge to 11.7 at Perth water and then decline to 5.7 at Sandy Beach with increasing upstream (Loneragan 1981). Along the Canning River they decreased from 9.1 species at Mount Henry to 4.9 at Kent Street Weir (McDermott 1981). Highest numbers of individuals and species then were found in the middle estuary, particularly at Perth Water and Alfred Cove.

Both Perth Water and Alfred Cove are shallow regions with some deeper water and are away from the greatest tidal action and the major channel for river flow during the winter flush. The high diversity of these middle estuary sites is related to the large proportion and abundance of estuarine species in the Swan River. During the summer months both the estuarine-marine and estuarine species contribute to the diversity of the middle estuary. During winter, the reduced salinities and higher flow velocities associated with the fresh water flush cause some marine-estuarine species to leave the middle estuary. Possibly the estuarine species move away from areas of greatest flow (i.e. the upper estuary) and move into quieter waters such as Perth Water and Alfred Cove. Thus the diversity in the quieter waters would be maintained or only partially decreased compared with a large decrease in the upper and lower estuaries.

A description of the distribution of the most abundant species of fish in the Swan River estuary is given in Table 2.

DISTRIBUTION OF THE MOST ABUNDANT FISH IN THE ESTUARY

| FISH | DISTRIBUTION IN ESTUARY | COMMENTS |
|---|---|---|
| Perth herring | M/U | In estuary all year, most common between Guildford and Alfred Cove and between Kent Street and Shelley Basin |
| Six-lined trumpeter | L | Found in summer, uses the estuary as a nursery ground |
| Hardyheads | L | P. ogilby; is found in the estuary only during summer and A. elongata is more restricted to Perth water and Alfred Cove than A. mugiloides. All these species have similar habitat requirements and diets and so each species has a different distribution so as not to compete for space. |
| A. presbytoides | L | |
| P. ogilbyi | L/M | |
| A. mugiloides | M | |
| A. elongata | M | |
| A. wallacei | U | |
| Southern anchovy | M/U | Only found in open water of the upper estuary e.g. Joel Terrace and Shelley Basin |
| Blowfish | L | Most recorded are at Stirling Bridge, with a maximum upstream limit of Alfred Cove |
| Gobbleguts | L/M | |
| Gobies | | |
| F. lateralis | L/M/U | |
| P. olorum | M/U | |
| Mullet | | |
| M. cephalus | L/M/U | |
| A. forsteri | L/M | |
| Yellow-tailed grunter | U | Upstream of Joel Terrace on the Swan and throughout Canning River |

TABLE 2: Distribution of the most abundant fish in the estuary. Data from Lenanton (1981). (See Appendix 2 for key)

Data from Loneragan (1981)

## 4.0 HUMAN ACTIVITIES WHICH AFFECT THE AQUATIC FAUNA

Activities such as dredging, damming of rivers and pollution of the estuary affect the fauna in two ways. Firstly, they may have a direct effect on the fauna and secondly, they affect the flora (see chapter on Flora) on which the fauna depends as a food source. The direct effect of these activities on the invertebrate and fish fauna of the estuary will be discussed here.

### 4.1 Dredging

The most obvious effect of dredging is to destroy the fauna in the immediate vicinity. The resulting deeper water is also less suitable for flora and invertebrates, as discussed in previously, creating a decreased diversity and abundance of species. This in turn reduces the nursery areas available for juvenile fish.

Short term effects of dredging include:

1. Deoxygenation of the water which can be severe in the immediate vicinity of dredging. If the estuary is not well mixed and a halocline exists, deoxygenation will be greater below the halocline. Oxygen levels of less than 3 $mgL^{-1}$ can kill fish (Perkins 1974).

2. Suspension of fine particulate matter presents a more serious problem. Apart from its affect upon the flora, suspended material clogs the feeding mechanisms of animals which filter their food from the water column (e.g. many zooplankton, benthic invertebrates and some fish). Fish generally tend to avoid turbid areas (Lenanton 1978), but turbidity may cause clogging of gills and have an adverse effect on spawning, egg and larvae development.

3. Release of pesticides, nutrients, heavy metals and other toxic substances from the sediments is detrimental to the aquatic fauna.

In the long term dredging causes changes in the bottom contours of the estuary, an increase in water depth and changes the composition of the sediment. These changes affect the re-establishment of the invertebrate community in the area. In some cases the community can recover to pre-dredge status within two years (Walpole Inlet - Lenanton unpubl.) whereas in other cases, for example at Pelican Rocks in the Swan estuary recovery is not yet complete after 20 years. Invertebrates will recolonise more quickly if the new substrate is of a coarse nature, water depth is less than two metres, and the bottom is level without deep enclosed holes which fill with fine sediment and are not readily flushed, causing oxygen depletion (Wallace 1977).

## 4.2 Modifications to the Estuarine Catchment

Clearing in the upper catchment encourages soil erosion and leaching, leading to increased sediment loads with similar effects to those caused by suspended particulate matter as a result of dredging. Increased sediment loads also provide opportunities for increased loads of adsorbed nutrients, pesticides and heavy metals to be transported downstream and deposited in the estuary sediments. Clearing in the Swan-Avon catchment has also increased the salinity of runoff water which affects the fresh water component of the fauna (Kendrick 1976). Freshwater invertebrate and fish populations are becoming more restricted in their distribution as salinity increases while more estuarine forms invade their previous habitat.

## 4.3 Pollution

The addition of pesticides, heavy metals and nutrients to the estuary or their release from the sediments has a number of detrimental effects on the invertebrate and fish fauna.

Dissolved pollutants are rapidly taken up into the biological food web where they accumulate with increasing steps along the food chain. Pollutants may also be taken up directly from the sediments by rooted angiosperms or detritus feeders such as Perth herring, sea mullet and many benthic invertebrates. Not all these pollutants are accumulated but may be recycled back to the sediment by faecal pellets and dead organisms. Accumulation of pesticides and heavy metals can occur until toxic doses are reached. The susceptibility of fish and invertebrates depends on the tolerance of each species. Finally, both pesticides and heavy metals may be a potential health hazard to people who consume contaminated animals (Perkins 1974).

Studies by Marks et al., (1980) of the relationship between concentration of heavy metals in muscle tissues and body weight of fish from the Swan-Avon Estuary indicated that the mean concentration of all heavy metals in fish heavier than 50g were below the levels given by the NHMRC and in the Western Australian Drug and Food Regulations. Notwithstanding that the metal levels in the muscle tissue of fish from the Swan Avon are low, there are some indications that the concentrations may be related to feeding habit with highest mean concentrations found in sediment ingesting organisms.

Chegwidden (1980) conducted a preliminary investigation of heavy metals using one non-edible species of mussel in the Swan River. It was found that mussels contained no excessive levels of copper, cadmium, nickel and chromium in the river system. Mean zinc levels for mussels from the Swan River were 53 μg/g (W/W) and for the Canning River were 50 μg/g (W/W). Both exceeded the local public health standard of 40 μg/g (W/W). Only individual 20 mussels were used in this study, therefore, more intensive research is required to validate these findings. A further study is to be conducted in the near future of heavy metal accumulation in edible mussels throughout the Swan Estuary.

Excessive nutrients in estuarine waters can lead to eutrophication which may affect the aquatic fauna in a number of ways. Changes to the ecology can favour certain species over others, production of physiological stress of animals can occur due to localised over-supply or depletion of dissolved oxygen and animals may be killed due to blooms of toxic blue-green algae (Lenanton 1978).

## 4.4 Fishing

Despite increasing fishing pressure on the estuary, the abundance of estuarine fish does not appear to have declined over recent years (Lenanton 1978). This is because the majority of commercial and recreational fish and crustacean species are recruited from the ocean each year and the abundance in the estuary one year has little influence on the abundance in the next year. However, it is important to remember that many of these species utilise other estuaries of temperate Western Australia. Thus intense pressure applied simultaneously to fish populations in all these estuaries may well cause serious problems to fish stocks.

More important than fishing levels in the estuary is the protection of the estuarine environment to allow maximum utilisation of the area for crustaceans and fish.

# 5.0 BIRDS OF THE SWAN RIVER MANAGEMENT AREA

The Swan River estuary provides a variety of habitats for many different kinds of water birds. The shallow tidal flats provide abundant food for wading birds while the deeper areas of the tidal flats are utilised by ducks and swans. Many species forage from the estuary for fish while others inhabit the few remaining areas of rushes and sedges. Each of these four main groups will be discussed in turn. A list of the species of birds which are common inhabitants of the Swan River Estuary is given in Appendix 2.

## 5.1 Wading Birds

Wading birds can be divided into two groups; trans-equatorial migrants and Australian resident species. The trans-equatorial migrants breed in the northern hemisphere and spend the non-breeding season in Australia during our summer. During the four to five months which they spend in Australia they build up large energy reserves (in the form of fat tissue) which are expended on the return flight to the northern hemisphere. The gonads presumably are also built up to a reproductive condition. It is, therefore, important that during this period there should be a large amount of food available and that there should be little disturbance of their normal feeding activities (Lane 1970 unpubl.) Most migrants arrive in September/October and depart in March/April. However, non-breeding young birds may remain over the year. Of the Australian resident species some breed locally but most make regular movements within Australia.

Research by the RAOU indicates that the Swan estuary is an important and complex wader site. It is better considered as part of the Swan Coastal Plain System, since many of the waders move regularly between the estuary and lakes such as Forestdale and Yangebup. The estuary is especially important for migratory waders when they first arrive in spring. At this time the lakes are too full to provide a suitable habitat and the waders remain on the estuary.

Twenty-eight species of wading birds have been recorded on the Swan River of which twenty-two are trans-equatorial migrants and six are Australian residents. The most abundant species is the Red-necked stint (Calidris ruficollis). At times up to 4000 of these may be found on the tidal flats of the Swan estuary (Lane 1976). Other common waders are the Curlew sandpiper (Calidris ferruginea), Red Knot (Calidris canutus), Grey plover (Pluvialis squatarola), Red-capped plover (Charadrius ruficappilus) and the Black-winged stilt (Himantopus himantopus) of which only the latter two are residents.

Several of the waders encountered on the estuary are common in the south-west (Common sandpiper Tringa hypoleucos, Terek sandpiper Xenus cinereus, Hooded Plover Charadrius cucullatius, Eastern Golden Plover Pluvialis dominica and Grey Plover) but of these, only the Hooded Plover is uncommon within its total range. For migratory species, the south-west region is further than their main populations travel and is generally deficient in habitat.

### 5.1.1 Distribution

Dredging and reclamation has left only three significant remaining habitats for wading birds at Alfred Cove/Point Waylen, Pelican Point and the South Perth foreshore. Forty hectares of tidal flat along the South Perth foreshore have been proclaimed an aquatic reserve vested in the W.A. Wildlife Authority with a further 120 ha at Alfred Cove/Point Waylen and 20 ha at Pelican Point similarly reserved (Riggert 1978). Further conservation of these areas was recommended by System Six (see Flora section) as each of these three areas complement each other, depending on tides and weather (DCE 1983).

Some concern has been expressed by the RAOU that these System Six recommendations in relation to vesting have not yet been carried out.

Other areas of use by wading birds are the areas of mud flats between Heirisson Island and Ivy Street, Redcliffe and also along the Canning River at Adenia Road Lagoon, Watts Road swamp and on the mud flats near Riverton Bridge.

### 5.1.2 Feeding and Habitat

Waders feed almost exclusively on the invertebrate life (molluscs, polychaete worms, crustaceans, insect larvae etc) found on the tidal flats and salt marshes. Although they may also eat aquatic plants and insects.

The waders can be divided into two groups, on the basis of their feeding type, into short-beaked and long-beaked species. Optimum conditions for feeding for short-beaked waders (Grey Plover, Sharptailed Curlew, Common Sandpiper, Little Stint and Red-capped dotterel) optimum conditions for feeding are damp sand with water at 0-2.5cm depth. Long-beaked waders (Red neck avocet, Banded and white-headed stilts, Bar and Black-tailed godwits and Greenshanks) normally feed in water 2-15cm deep.

This difference in feeding habit affects the distribution of waders. For example short-beaked waders are generally found in shallower near-shore areas and among reed beds which provide abundant insect life, only venturing out on to the tidal flats at exceptionally low tides. When the flats are exposed thousands of short-beaked waders may be seen feeding over them (Lane 1970 unpubl.). The long-beaked waders are common on the tidal flats at normally low tides and among the salt marshes.

Waders are generally very shy, easily disturbed and, being gregarious, usually gather in large flocks with many species often feeding together.

## 5.2 Ducks and Swans

There are nine species of ducks and one species of swan recorded for the Swan River estuary. The most common of these being the Black swan (Cygnus atratus), the Black duck (Anas superciliosa), Grey teal (Anas gibberfrons) and the Mountain duck (Tadoma tadornoides).

The majority of these birds prefer fresh water lakes and swamps but may be found on the estuary during summer when many of these areas dry out. The Black duck and Grey teal are known to breed at Alfred Cove and Pelican Point with congregations of several hundred occurring in autumn but most other species are only occasional visitors.

### 5.2.1 Feeding and Distribution

Ducks and swans are principally herbivores feeding on algae and aquatic plants sifted from the sediment in shallow water. The Black duck and Grey teal are also known to strip the seeds from fringing rushes and sedges. Ducks may supplement their diet with various invertebrates found in the reed beds and these animals are the main food source for the Blue shoveller and Musk duck.

Black swans, Grey teal and Mountain ducks are common at Alfred Cove/Point Waylen where they feed in the salt marshes and Halophila beds. Ducks are also found at South Perth foreshore, Pelican Point and the salt marshes between Heirisson Island and Redcliffe. Ducks and swans are seen on the Canning River especially at Riverton Bridge, Fern Road Lagoon and Nicholson Road Billabong.

## 5.3 Birds of the Fringing Vegetation

This group includes birds which nest and shelter entirely in rushes and sedges and those which nest in trees along the river banks. These birds, especially the former, are the most threatened on the Swan River since their normal habitat has been severely reduced.

### 5.3.1 Feeding and Distribution

Rails, crakes, waterhens, warblers and grassbirds nest in very dense stands of sedges and rushes. The buff-banded rail (Rallus phillipensis), spotless crake (Porzana tabuensis), spotted crake (Porzana fluminea) and the black-tailed native hen (Tribonyx ventralis) have been recorded at Alfred Cove coming onto the tidal flats in the late afternoon where they feed until dawn. Many of these birds have been recorded along the Canning River where there are still dense stands of vegetation (Brock & Pen 1984) and a few sightings have been made on the salt marshes of the Upper Swan (Blair & Blatchford 1978). The birds eat a variety of foods ranging from plants and seeds to invertebrates and frogs.

The second group includes herons, egrets and ibis. The sacred ibis (Threskiornis moluccs) and the nankeen night-heron (Nycticorax caledanicus) have breeding colonies at Perth Zoo and feed on the mudflats at South Perth. The white-faced heron (Ardea novaehollandiae) and great egret (Egretta alba) have been recorded at Alfred Cove. Once again the fringing vegetation of the Canning River and Upper Swan are important habitats for these birds, where they nest in trees, bushes or rushes and feed on a variety of insects, aquatic invertebrates, fish, frogs and occassionally snakes.

## 5.4 Estuarine Fish-Eating Birds

Darters, grebes, pelicans, cormorants and terns all forage the deeper waters of the estuary mainly for fish. Unlike the birds of the fringing vegetation, these birds continue to have a viable habitat. A few species are from marine environments (e.g. pied cormorant - Phalacrocorax varius), some breed within the estuary (e.g. Australian pelican - Pelecanus conspicillatus and some of the terns), while others breed in fresh water lakes and feed on the estuary (e.g. some of the cormorants and grebes). Gulls are common on the estuary and are included in this group, but are predominantly scavengers.

The most common species in this group would be the silver gull (Larus novaehollandiae), Little black cormorant (Phalacrocorax sulcirostris) and the crested tern (Sterna bergii). Many fish-eating species nest on bare ground and are common on sand bars, especially at Alfred Cove.

## 5.5 Other Birds

Within the Swan River management area are a large number of forest, woodland and urban birds, particularly in the fringing vegetation along the Upper Swan and Canning Rivers. A list and description of some of these birds is given by Brock and Pen (1984).

## 5.6 Protection of Birds in the Swan River Management Area

Birds on the Swan River are protected by the Wildlife Conservation Act and a number of trans-equatorial migrant species are also protected under the Australia-Japan Migratory Birds Treaty. A similar treaty is presently being drawn up between Australia and China.

The Australia-Japan Migratory Birds Treaty was brought into force in 1974, and under the agreement both countries will take special protective measures for the preservation of species of migratory birds, and birds in danger of extinction, and their environment.

At least 25 species of birds present in the Swan River management area are covered by this agreement. These species are shown in Appendix 3.

## 6.0 HUMAN ACTIVITIES WHICH AFFECT BIRDS

### 6.1 Reclamation

Reclamation of foreshore areas has meant the loss of many habitats for water birds of the Swan River management area. Also draining of swamps and lakes in other metropolitan areas has further reduced nesting and feeding areas for water birds. Any further loss of habitats along the estuary would place even greater pressure on other areas of the river and lakes and swamps around the metropolitan region.

### 6.2 Dredging

Removal of shallows, especially tidal flats, by dredging reduces the available feeding grounds for birds which rely on the aquatic plants, invertebrates and fish found in these areas. The resultant increase in turbidity disadvantages birds which fish by sight e.g. cormorants. Degradation of aquatic communities and release of toxic substances often associated with dredging (see chapter on Flora) will also affect birds as they are dependent on the aquatic food chain.

### 6.3 Mosquito Control

The spraying of pesticides to control mosquito populations in salt marshes may impair and contaminate food chains on which water birds depend. Insect larvae and crustaceans are killed by pesticides such as Abate removing them from the food chain. The use of Dibrom is preferable for water birds, as although it has a high toxicity it has a very short life (probably less than 24 hours) and, as it is oil-based, it does not sink to the bottom where crustacea live. Mosquito larvae, however, are killed as they rise to the surface (SWANS 1976).

The RAOU claims there is a need for an evaluation of current midge control method needs to be carried out. Particular reference should be made to the Block-winged Stilts and their reaction to or ingestion of pesticides.

## 6.4 Boating and Human Access to Foreshores

Boating in areas of water bird usage and access for people to the foreshore results in disturbance of the bird populations. Public submissions supported restricting boating within and adjacent to mudflat areas, reducing the problems of disturbance by landing parties and erosion by wash from speed boats. Water birds are generally very shy and will fly off when approached. A few species such as the red-necked Avocet, white-headed stilt and red-capped dotterel will settle somewhere else in the area but many migratory birds will leave the area to find less disturbed locations.

Dogs are also a problem, chasing birds and destroying nests by digging in the sand (Lane 1970 unpubl.). This view is supported by the RAOU who comment that harrassment by dogs is a major problem particularly at Como and Alfred Cove. It is suggested that education and low enforcement seem an appropriate remedy.

Disturbance of water birds is particularly important for trans-equatorial migrants. A high level of disturbance results in a high level of energy expenditure by the birds concerned. The resulting decrease in fat production reduces the likelihood of a successful migratory flight to the summer breeding grounds.

Thus it is important to keep people away from important water bird areas such as Alfred Cove, Pelican Point, South Perth foreshore and some areas of wetland along the Canning River. However, the RAOU commented in its public submission that, provided they were correctly sited, the development of interpretative trails at Alfred Cove and Pelican Point may be possible. This would enable people to see the birds without disturbing them.

Fishing and bait digging within these water bird areas was also considered by the RAOU to be detrimental.

# 7.0 MOSQUITOES IN THE SWAN RIVER MANAGEMENT AREA

## 7.1 Problem Species

Mosquitoes are a major nuisance to people residing near or visiting certain areas of the Swan River estuary. Apart from the nuisance effects which may disturb outdoor and indoor activities, they are also carriers of disease. There are twelve species of mosquito in the Perth Metropolitan area. These include:

<u>Aedes vigilax</u>
<u>Aedes camptorhynchus</u>
<u>Aedes alboannulatus</u>

Aedes notoscriptus
Culex annulirostris
Culex australicus
Culex molestus
Culex fatigans
Culex globocoxitus
Culiseta altra
Mansonia linearlis (= Coquillettidia linealis)
Anopheles annulipes

By far the most serious mosquito nuisance associated with the Swan River wetlands is attributed to *Aedes vigilax* and/or *Aedes camptorhynchus*. Both these species breed in salt marshes on tidal flats throughout the year, although the extent and rate of breeding is dependent on tidal and climatic conditions. Best breeding conditions occur during summer.

Both species have eggs which can withstand desiccation for long periods, hatching when conditions are suitable. Both are vicious biters throughout the day and are particularly aggressive at dusk and dawn. *Aedes vigilax* is known to migrate as far as 15 to 30km from its breeding ground and is the most common mosquito along the Canning river, while it and *A. camptorhynchus* are common at Alfred Cove and between Maylands and Guildford (Blair 1979, Brock and Pen 1984).

*Culex annulirostris* is the second most common mosquito along the Canning as far as Kent Street Weir and is the main nuisance on the Canning in Gosnells. This species breeds in fresh water overgrown with vegetation. It may also occasionally breed in brackish water. It bites predominantly at dusk and probably travels at least 6km from breeding areas.

*Culex fatigans* and *Mansonia linearlis* are also common in the Canning River up to Kent Street Weir, the latter also being important up to Gosnells. *Culex fatigans* is the common domestic mosquito and breeds in polluted water close to human habitation (e.g. septic tanks, sewer outfalls, ground pools, drains, tins and tyres). It bites at night, may travel up to 3km from breeding areas and is common in autumn. *Mansonia linearlis* requires fresh waters supporting aquatic plants on which they attach their eggs. It is a vicious biter during the day and especially around sunset.

The remaining important species *Aedes alboannulatus* breeds in clear water especially during autumn and winter and hence may cause a periodic nuisance in the upper reaches of the Canning River. It bites during the day and evening but does not enter domestic environments far removed from the wetland (Brock and Pen 1984).

The other species listed above are relatively insignificant and in fact Culex globocoxitus and C. australicus rarely if ever, bite man (Irving-Bell and Liehne 1978).

Two main types of habitats support mosquito breeding on the Swan River estuary. Firstly, the salt marshes along the Canning River at Alfred Cove and between Maylands and Guildford are able to support prolific summer breeding of Aedes vigilax and/or Aedes camptorhynchus. Secondly, the fresh water flood plains and river margins of the upper estuary provide breeding grounds for the fresh water species C. annulirostris, M. linearlis and A. alboannulatus. The remaining mosquito C. fatigans breeds near residential areas.

The production of plague proportions of Aedes vigilax is dependent on:

a) Frequency of tidal flooding.

b) Size of available breeding area.

c) Ambient air and water temperature. This species prefers warm sunlit pools and develops optimally at 31-35°C with no breeding occurring over 40°C. (Blair 1977).

All other species (except Culex fatigans) breed in more stable and continuous conditions. The size of their population is determined by the abundance of the breeding habitat, which in most areas is insufficient to support plague populations. These species also take longer to complete their growth cycle and are less prolific.

## 7.2 Control of Mosquito Populations

Control of mosquito populations can be divided into three categories; chemical, physical and biological. Chemical control is by the use of insecticides and larvicides. Physical control aims at modifying the environment to remove or reduce the standing surface water required for mosquito breeding. Biological control is the introduction of a parasite, predator or pathogen to reduce the pest population. Mosquito control in Swan River Management Area has evolved to use all three methods.

### 7.2.1 Chemical Control

Chemical control is currently undertaken with organophosphate insecticides directed against both larvae and adults. The use of 'Abate' against mosquito larvae is the present recommended method of chemical control. Breeding sites are identified and treated wherever necessary. Tidal pools need continual monitoring as tides rinse pools free of the insecticide. 'Abate' shows quite high specificity in its toxicity towards dipterous insects (e.g. mosquitoes, midges, houseflies). Toxicity is low for mammals, birds and fish but certain crustacea, aquatic insects and aquatic larvae of other insects common to the mosquito larval habitat are susceptible and such organisms are often components of the water fowl food system. 'Abate' has a relatively low effective, residual longevity, but as the mosquito life cycle is short (6.4 days from egg to adult) spraying is often frequently required.

When mosquito populations are in pest proportions fogging with 'Dibrom' (Naled) is carried out to treat adults. This is not a long term solution as it will ultimately lead to insecticidal resistant mosquitoes (Shell Chemicals 1979 cited in Brock and Pen 1984).

Both forms of chemical control can lead to damage of wetland vegetation. During larvaciding, fogging and monitoring for breeding, vehicles may be driven over tidal flats which will lead to the eventual destruction

of plants in the area. Continued chemical control of these areas will lead to degradation of salt marsh communities.

Spraying of 'Abate' is carried out along the Canning River to Kent Street Weir by the Town of Canning and at Alfred Cove by the City of Melville. The City of Gosnells receives very few complaints regarding mosquitoes. When they are received, specific breeding sources are located and treated with kerosene. There is some opposition to the use of chemicals in their area. The Town of Armadale also receives few complaints (less than two per year) and occasional instances of larvaciding with 'Abate' are carried out. The Town of Bassendean sprays with 'Abate' especially in the area of Ashfield Flats, as does the Belmont City Council just near Garratt Road Bridge, predominantly during summer to keep down populations of *Aedes vigilax*. The City of Bayswater has few complaints about mosquitoes and has no mosquito control programme.

### 7.2.2 Physical Control

Physical control usually involves the regulation of water movement (through the construction of water control works), drainage (through ditching or channelling), flooding (by diking) or landfill reclamation, of permanently or temporarily inundated land (Blair 1979).

In the past land reclamation has removed many potential breeding sites for mosquitoes. In such cases land reclamation was, and still is, generally intended to provide land for urban development; elimination of mosquito breeding areas was not its primary function. Today with dwindling wetland resources, such practices are not encouraged.

In the Town of Canning drains were established on tidal flats at Ferndale, Kent Street and Bannister Creek. This has caused the pools of water at these sites to drain more quickly than normal, leaving insufficient time for mosquitoes to breed. The drains have caused localised degradation of the vegetation (see Flora section) but provide an excellent environment for the young stages of certain fish species and the mosquito fish Gambusia affinis. It has not however enabled Gambusia to enter the pools where breeding occurs, (Brock and Pen 1984).

### 7.2.3 Biological Control

In about 1934 the mosquito fish Gambusia affinis was introduced into the Swan River estuary. This fish feeds on mosquito larvae and other insects. Although its effectiveness as a control of mosquito populations has never been quantified, Blair (1979) believes it contributes significantly to a reduction in mosquito numbers.

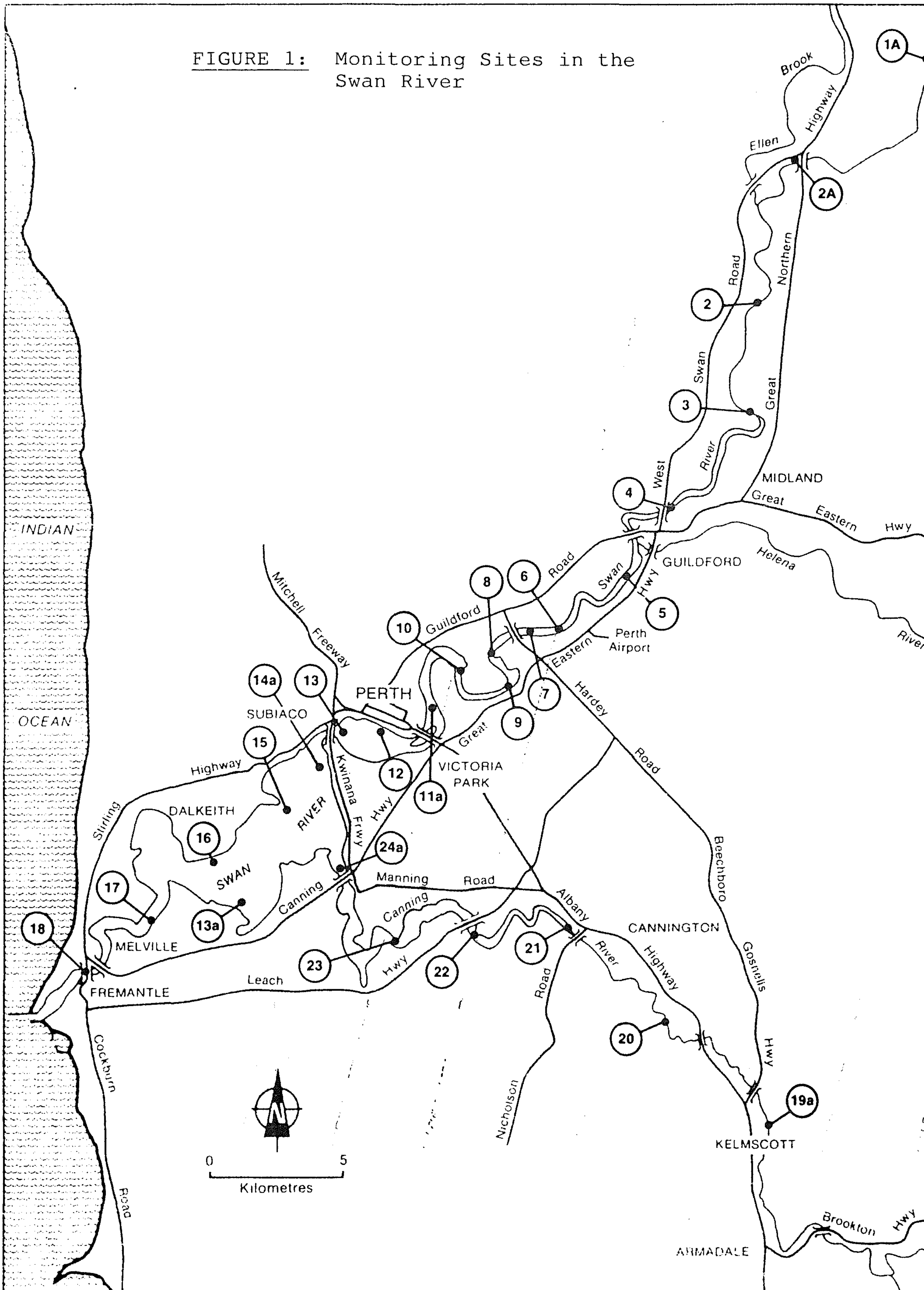
Gambusia is common in the upper Canning River but dense vegetation often prevents it access to mosquito breeding areas. In summer many pools in which Aedes vigilax breeds are too hot and saline to support Gambusia (Meagher and Le Provost 1975, Blair 1979). Brock and Pen (1984) found Gambusia in insufficient numbers to make an impact on Aedes vigilax larval populations on the Canning River salt marshes. Gambusia is thought to have a detrimental effect on native fish populations. (Blair 1979).

The City of Canning is currently evaluating another biological mosquito larvicide in the form of a recently isolated strain of the bacterium Bacillus thuringienses. It attacks the gut of mosquito and blackfly larvae resulting in death within 30 minutes of application. It is completely harmless to all other animals except certain Chironomids (e.g. larval stages of midges).

Other biological controls of mosquitoes are reviewed by Blair (1979).

Non-biting midges (Chironomids) do not appear to pose a nuisance in the environs of the Swan River estuary but rather are common near freshwater swamps.

FIGURE 1: Monitoring Sites in the Swan River



## CHAPTER 6 : WATER QUALITY AND POLLUTION

### 1.0 INTRODUCTION

This report assesses the water quality of the Swan-Canning Estuarine System and its tributaries (streams and drains). It reviews the potential and existing water quality problems associated with the growth of an industrial city.

Water quality assessment criteria are based on Schedules 7(2) and 7(3) developed by the E.P.A. for Marine and Estuarine Waters of Western Australia (DCE, 1981).

### 1.1 Water Quality Monitoring

Water quality monitoring has been conducted on this estuary since 1944, with regular monitoring adopted in 1962 (previously sampling was irregular).

Initially river sampling sites were selected at swimming areas, public utilities and areas suspected of pollution problems. Further surveying of the upper reaches of the estuary showed that normal drainage from low lying land, grazing paddocks, industrial and stormwater drains were contributing to chemical and bacteriological problems in the system. As a consequence the sampling programme was modified in 1958 to include the entire estuarine system (Shewchuk, 1982). Figure 1 and Table 1 illustrates the currently monitored river sites in the Swan-Canning Estuary.

Increasing industrialisation in the Perth Metropolitan area has resulted in increased discharges to the river. Consequently the sampling of 37 major drains discharging to the estuary was initiated in 1979 (Figure 2 & Section 2.4).

Monitoring of the estuary and its contributing drains is conducted quarterly with a four month interval at the end of each year. This enables sampling on different months each successive year.

Public submissions expressed the need for the following monitoring programmes:

1. A water quality monitoring programme should occur on a regular basis at a number of locations on all waterways.

2. The quality and quantity of effluent discharged into the river should be controlled.

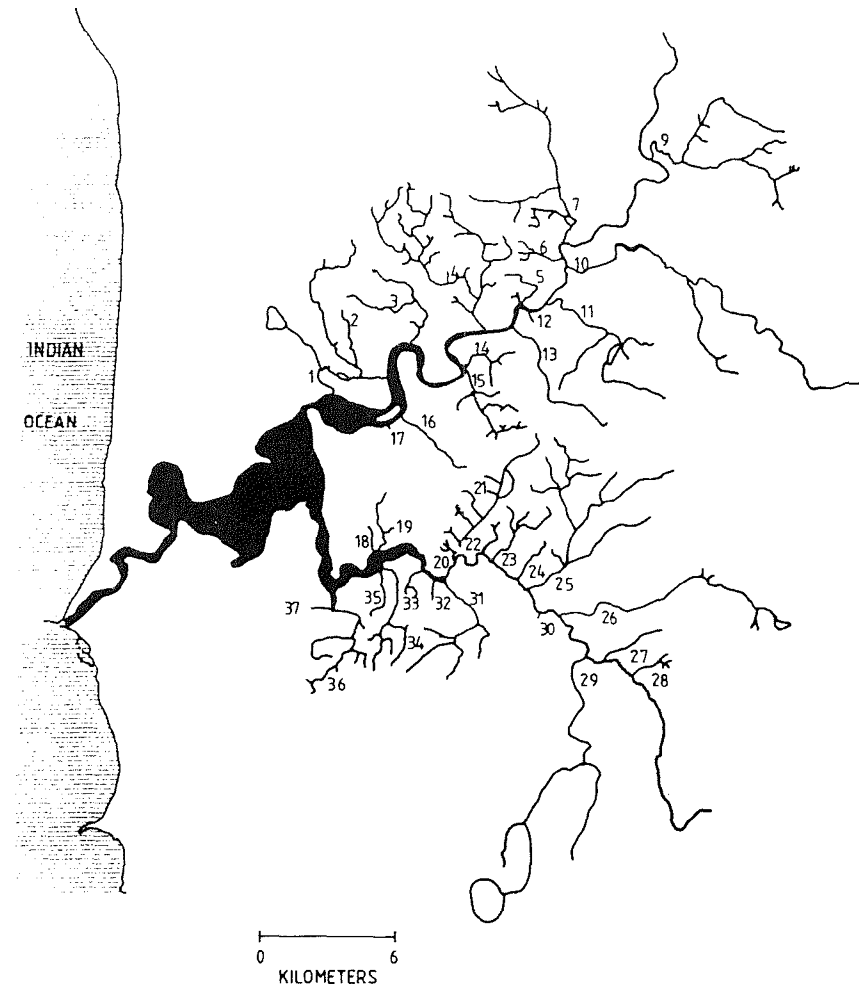
## CURRENTLY SAMPLED DRAINS

### CODE

| | |
|---|---|
| D1 | SPRING ST |
| D2 | CLAISEBROOK |
| D3 | PENINSULAR RD. - MAIN DRAIN |
| D4 | KING WILLIAM ST. DRAIN |
| D5 | KITCHENER RD. - MAIN DRAIN |
| D6 | BROOK ST. - MAIN DRAIN |
| D7 | BENNETT BROOK |
| D8 | ELLEN BROOK |
| D9 | JANE BROOK |
| D10 | HELENA RIVER |
| D11 | AIRPORT - NORTH DRAIN |
| D12 | AIRPORT - MIDDLE DRAIN |
| D13 | AIRPORT - SOUTH DRAIN |
| D14 | BELMONT CREEK |
| D15 | BELMONT - MAIN DRAIN |
| D16 | PERTH CITY COUNCIL - CAUSEWAY |
| D17 | PERTH CITY COUNCIL - McCALLUM PARK |
| D18 | MANNING - MAIN DRAIN |
| D19 | COLLIER PINES - MAIN DRAIN |
| D20 | WILSON - MAIN DRAIN |
| D21 | MILLS - MAIN DRAIN |
| D22 | WHARF ST. - MAIN DRAIN |
| D23 | COCKRAM - MAIN DRAIN |
| D24 | LACEY ST. - MAIN DRAIN |
| D25 | YULE BROOK |
| D26 | BICKLEY BROOK |
| D27 | HELM ST. - MAIN DRAIN |
| D28 | ELLIS BROOK |
| D29 | SOUTHERN RIVER |
| D30 | THORNLIE GOLF DRAIN |
| D31 | BANNISTER CREEK - MAIN DRAIN |
| D32 | RILEY RD. - MAIN DRAIN |
| D33 | MARJORIE RD - MAIN DRAIN |
| D34 | MODILLION AVE - MAIN DRAIN |
| D35 | SIXTH AVENUE - MAIN DRAIN |
| D36 | BULLCREEK - MAIN DRAIN |
| D37 | BRENTWOOD - MAIN DRAIN |

FIGURE 2

CURRENTLY SAMPLED DRAINS



| SITE NUMBER | SITE NAME |
|---|---|
| 1 | Walyunga |
| 2 | Barrett Street |
| 2A | Upper Swan Bridge |
| 3 | Middle Swan Bridge |
| 4 | Meadow Street Bridge |
| 5 | Kingsley Road |
| 6 | Forbes Street |
| 7 | Milne Street, Bayswater |
| 8 | Maylands Swimming Pool |
| 9 | Sandringham Hotel |
| 10 | Maylands |
| 11 | Nile Street, East Perth |
| 12 | Perth Water |
| 13 | Narrows Bridge |
| 13A | Lucky Bay |
| 14A | Pelican Rocks |
| 15 | Pelican Point |
| 16 | Armstrong Spit |
| 17 | Blackwall Reach |
| 18 | Fremantle Traffic Bridge |
| 19A | MacKenzie Grove |
| 20 | Herbert Street |
| 21 | Nicholson Road Bridge |
| 22 | Riverton Bridge |
| 23 | Salter Point |
| 24 | Canning Bridge |

**TABLE 1:** River Site Names for Sampling Points on the Swan-Canning Estuary

These are currently covered by the existing monitoring programme.

## 1.2 Sampling

Samples are collected in plastic bottles and stored on ice until delivery to Government Chemical Laboratories and the State Health Department Laboratories. The former analyses for nutrient, physico-chemical, chlorophyll 'a', pesticide and heavy metal components while the latter analyses bacteriological levels of the water. Biological (algae) sampling and analysis is undertaken by Government Chemical Laboratories and the Waterways Commission. This Commission also provides field assistance during quarterly sampling runs.

Table 2 lists the parameters sampled under the Commission's water quality monitoring programme. The parameters of Orthophosphate, Kjeldahl-Nitrogen, Colour & *Salmonella* spp. were excluded from this report. These parameters (with the exception of colour) have been incorporated into the sampling programme fairly recently and consequently show no apparent trends.

**Nutrients**

Orthophosphorus (inorganic phosphorus)
Total Phosphorus (inorganic & organic phosphorus)
Kjeldhal Nitrogen (organic nitrogen & ammonium)
Ammonium-Nitrogen
Nitrate-Nitrogen

**Physico-Chemical**

Temperature
Chloride ion
pH
Dissolved oxygen (saturation & concentration)
Biochemical oxygen demand
Turbidity
Colour

**Phytoplankton**

Chlorophyll 'a'
Species Representation

**Bacteriological**

Faecal *Escherichia coli*
Faecal *Streptococci*
*Salmonella* spp.

**TABLE 2:** Parameters sampled under Waterways Commission Monitoring Programme

## 1.3 Data Manipulation

Sites represented in Figure 1 were pooled into the divisions in Figure 3 for physico-chemical nutrients and chlorophyll 'a'. These results were then averaged to produce summer (November-April) and winter (May-October) mean representative values. Summer represents the period of low rainfall and winter high rainfall. Heavy metal, pesticide and bacteriological data were averaged to produce summer and winter mean values.

Data used covers the period November 1979 to April 1985. The unavailability of profile (depth) data limits manipulations to surface values only. However, a comprehensive analysis of profiles is currently under way and some inferences from this have been made.

Limits of detection (when standard methods can not reliably detect below a certain level) exist for Biochemical Oxygen Demand (BOD), Ammonium-Nitrogen, Nitrate-Nitrogen, Total Phosphorus, Chlorophyll 'a' and Heavy Metals. These data have been excluded from statistical analysis and are presented as the percentage of recordings below the limit of detection for the relevant parameter.

Instantaneous quarterly loading data (g $hr^{-1}$) for nutrients and heavy metals in drain discharges were calculated using mean flow rates and nutrient levels.

### 1.3.1 Limitations of Available Data

Quarterly data gives an indication of long-term rather than short-term trends in water quality. Biological response to substances, particularly nutrients, can be of the order of hours, days and weeks which can only be determined by more intensive sampling. However the cost of this is considerable. The Commission undertakes limited intensive programmes as resources permit.

## 1.4 Assumptions

Determining the fate of drain inputs and the origin of river values requires a lot of detailed information. Assuming nett seaward flow it is expected that a high input would directly affect the river value downstream of that point. This change depends on the input size, the river's flow rate and sedimentation effects (Taylor 1980).

The assumptions made in this report reflect those used by Taylor (1980) and are listed below:

1. Flow rates were average values.

2. The rivers had a nett seaward flow.

3. Sedimentation was limited.

4. Drain inputs were thoroughly mixed with river water.

5. Quarterly sampling recordings represent instantaneous values. The assumption that these values represent a constant environment between sampling dates.

6. Localised affects of discharges are limited.

7. Drain flow rates are constant.

# 2.0 PHYSICAL & EUTROPHIC CHARACTERISTICS

## 2.1 Division of the Estuary

A seven part division of the Swan-Canning Estuary was based on Chalmers et al. (1976). Modifications were made by combining some of the zones used. Figure 3 represents these divisions.

The first division (Zone 1) represents the drainage from the Hills Catchment to the Swan Estuary. The Upper Estuary Swan represents the upper reaches of marine tidal intrusion and is separated into two zones. Zone 3 represents the area of the estuary with a history of pollution problems. This section also receives the majority of industrial and urban drainage released into the system. Zone 2 is relatively free of pollution problems and receives limited discharges.

The Middle Estuary Swan is a river basin extending from Heirisson Island to Blackwall Reach. This area is marine dominated. The Lower Estuary Swan-Canning extends from Blackwall Reach to Fremantle Traffic Bridge and is a narrow, winding channel connecting the estuarine lagoon with the ocean.

The MacKenzie Grove Catchment (Zone 6) depicts the area below the Canning Dam which drains through urban and semi-rural areas. The Upper Estuary Canning is the fresh water region of the Canning River. Kent Street Weir acts as a barrier to the penetration of marine water so the area upstream remains fresh throughout the year. The Middle Estuary Canning is under tidal influence. This area is comparable to the Upper Estuary Swan.

## 2.2 Physical Characteristics of the Estuary

### 2.2.1 Chlorinity

Characteristic of South Western Australian Estuaries, the Swan Estuary exhibits a salt wedge effect resulting in intense season chlorinity gradients. A salt wedge is identified as the movement of tidal marine water upstream and its penetration is dependent on freshwater inflow. The salt-wedge in the Swan Estuarine System advances and retreats along the bottom as tides flood and ebb (Jack, 1977) and is capable of penetrating upstream to Middle Swan Bridge.

Chlorinity levels range from close to seawater (19,370 mg/L chloride) in summer to freshwater (140 mg/L chloride) in winter (Table 3). The depth of dominance

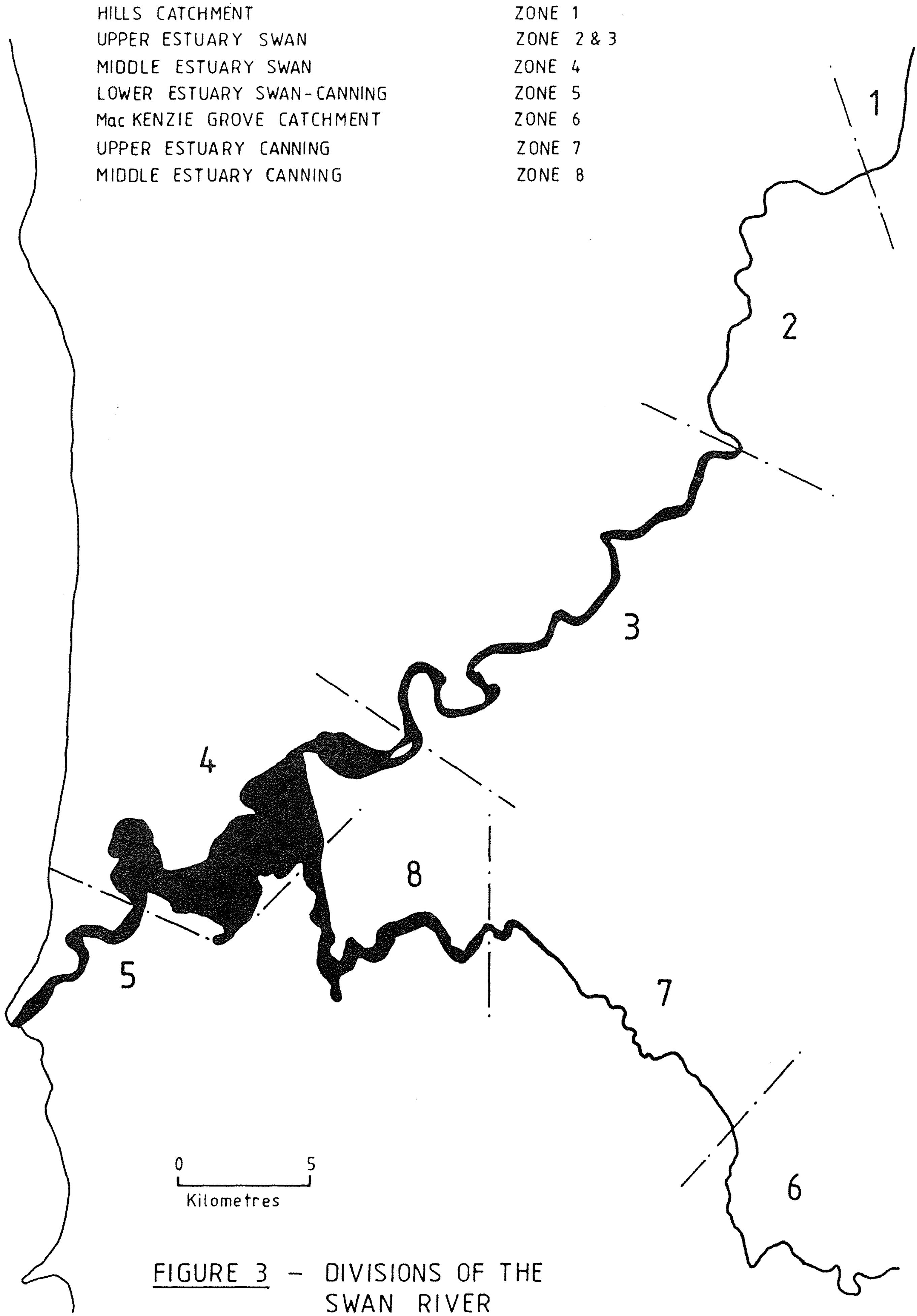



FIGURE 3 – DIVISIONS OF THE SWAN RIVER

of fresh and marine water is dependent on freshwater inflow to the system. The salt-wedge in the downstream area of the Swan River is most noticeable during late winter when the input of freshwater is capable of displacing the marine surface water to a depth of 4 metres. Upstream areas exhibit little stratification and generally have uniform chlorinities. A detailed assessment of the salt-wedge characteristics of the Swan-Canning Estuary is presented in Chapter 3 (Physical Characteristics).

Chloride levels place considerable stresses on the biota and limit the distribution of species within the estuary. The chloride ion levels in the fresher section of the Swan River (Hills Catchment) are higher than the similar MacKenzie Grove section of the Canning. These higher chloride levels may be attributed to replacement of deep-rooted native vegetation by shallow-rooted agricultural species in the farming catchment of the Avon River. Replacement of native plants raises ground water levels which redistributes soil solutes. Leaching of some of the redistributed ions into streams increases the salinity (Stokes, 1980). Similar salinity problems do not occur in foothills catchment of the Canning River because the area of catchment is considerably smaller and much of the catchment is forests, orchards or semi-rural.

### 2.2.2 Temperature

Temperature affects biological and biochemical processes occurring within an estuarine system. "Sudden or prolonged temperature changes can have a pronounced affect on the flora and fauna of a river." (Shewchuk, 1982). Temperatures in the estuary range from 13.8°C (Winter) to 25.6°C (Summer). (Table 3)

### 2.2.3 Biochemical Oxygen Demand

The Biochemical Oxygen Demand indicates the presence of organic material requiring oxygen for decomposition. This oxygen is obtained from dissolved oxygen in the water and is replenished from the air or plant photosynthesis. If the rate of consumption is greater than the rate of replenishment the level of dissolved oxygen will fall, consequently affecting aquatic life.

The criteria available for BOD levels are set out in Table 4 and suggest that levels below 5 mg/L represent a 'clean' and reasonably healthy environment. Levels above this may indicate the degradation of algal blooms or organic inputs from stormwater and industrial sources and reflect an environment not suitable for the maintenance of aquatic life (particularly as a consequence of low dissolved oxygen levels).

| | CHLORIDE ION MG/L | | TEMPERATURE °C | | BOD MG/L mg | | DO SATURATED % | | DO CONCENTRATION MG/L | | TURBIDITY NTU | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SUMMER | WINTER | SUMMER | WINTER | SUMMER | WINTER | SUMMER | WINTER | SUMMER | WINTER | SUMMER | WINTER |
| Upper Estuary Swan Zone 2 | 3289 | 2263 | 23.8 | 13.8 | 2.7 (35) | 3.0 (56) | 75 | 79 | 6.4 | 8.1 | 2.0 | 35.6 |
| Upper Estuary Swan Zone 3 | 9692 | 3786 | 25.6 | 16.8 | 4.16 (4) | 3.72 (53) | 102 | 80 | 7.7 | 7.8 | 3.0 | 27.0 |
| Middle Estuary Swan | 17695 | 7681 | 23.4 | 15.3 | 2.4 (40) | 2.4 (50) | 95 | 85 | 6.7 | 8.0 | 1.8 | 16.9 |
| Lower Estuary Swan-Canning | 19214 | 13990 | 22.4 | 15.8 | 2.6 (36) | 2.1 (67) | 91 | 93 | 6.5 | 8.0 | 0.8 | 4.3 |
| Upper Estuary Canning | 228 | 198 | 21.5 | 13.9 | 2.5 (64) | 3.2 (72) | 48 | 61 | 4.3 | 6.3 | 4.4 | 10.3 |
| Middle Estuary Canning | 14842 | 3944 | 23.2 | 14.5 | 2.4 (30) | 2.2 (44) | 79 | 70 | 5.8 | 6.9 | 2.0 | 6.4 |

TABLE 3: Physico-chemical characteristics of the Swan-Canning Estuary (November 1979 - April 1985). Numbers in brackets represent the percentage of recordings below the detectable limit - BOD 2.0 mg/L

| Classification | BOD mg/L |
|---|---|
| Very Clean | 1 |
| Clean | 2 |
| Fairly Clean | 3 |
| Doubtful | 5 |
| Bad | 10 |

**TABLE 4** : BOD Criteria for Water Quality (Govt. Chem. Labs, 1983)

On the most part the Swan Estuarine System is healthy and significant discharges of organic material do not occur. (Table 3)

The upper area of the Swan River receives the majority of urban stormwater and industrial discharges to the river and exhibits frequent algal blooms. As a consequence BOD levels in this area are high (approaching 5 mg/L). Levels exceeding the upper level of detection (10 mg/L) were recorded only twice during the study period, both in Zone 3 of Upper Estuary Swan (such high readings are associated with large algal bloom decomposition).

### 2.2.4 Dissolved Oxygen

Dissolved oxygen levels are influenced by BOD (as discussed previously), chlorinity, temperature, rate of photosynthesis, rate of respiration, and atmospheric diffusion. Dissolved oxygen levels of 100% saturation reflect a clean river system, while levels below this may suggest the bacteriological decomposition of organic matter, high respiration rates when there is no photosynthesis (e.g. overnight). Higher readings indicate high rates of photosynthesis (e.g. during algal bloom). Typically seawater with 100% saturation contains 6.6 mg/L (Winter) to 9.0 mg/L (Summer) dissolved oxygen. A saturation level below 60% (4.5 mg/L) can have deleterious affects on aquatic life.

Increased temperature and chloride levels result in decreased oxygen solubility reducing the 100% saturation and therefore DO levels. The interplay of temperature and chlorinity on oxygen levels varies seasonally. Govt. Chem. Labs (1983) suggest that for aquatic life to survive and reproduce, levels of oxygen should not fall below 4.5 mg/L for even short periods of time. In view of this, the oxygen characteristics of the estuary are sufficient for the maintenance of aquatic life.

The Canning Upper Estuary exhibits low dissolved oxygen (Table 3) conditions (most prevalent during Summer) which pose a threat to aquatic life. The sedimentation of organic material, its decomposition, turbidity and the low rate of oxygen replenishment all contribute to reduced oxygen levels. Turbidity has its affect by decreasing light penetration and, therefore, reducing photosynthesis. It is the process of photosynthesis that helps to replenish the levels of oxygen dissolved in water.

The replenishment rate of oxygen is dependent on the rates of photosynthesis, respiration and oxygen exchange at the atmosphere-water interface. In some instances, low levels of oxygen can cause the release from sediments of nutrients, pesticides, heavy metals, etc.

### 2.2.5 Turbidity

Turbidity is an indication of the presence of suspended matter such as clay, silt, fine organic and inorganic matter, plankton and other microscopic organisms. High turbidity readings indicate a low level of light penetration. These reduced light levels may limit growth of algae and other aquatic plants. Extreme levels may also result in the coating of fish gills with particulate material, leading to death through lack of oxygen.

Lowest recordings are evident during summer when the estuary is dominated by tidal marine water, which carries low amounts of suspended material. Winter turbidity values are high resulting from land drainage to the estuary (Table 3).

Turbidity and colour levels observed in the Swan-Canning Estuary are typical of south-west rivers and predominantly result from dissolved tannins and suspended particulate material.

### 2.2.6 pH

pH is a measure of alkalinity and acidity. It is measured on a scale of 0-14, where 7 is neutral, <7 is acidic and > 7 is alkaline (or basic). Changes in pH can have deleterious affects on aquatic life (Hart, 1974), particularly bacteria and microorganisms which act to purify the river. These may be inhibited or killed by such changes. pH changes can be reduced by the discharge of industrial effluents and by algal blooms. The pH range for this estuarine system is 6.0 to 9.0 which is indicative of no acidic or alkaline effluents significantly altering the pH of the river.

## 2.3 Eutrophic Characteristics of the Swan-Canning Estuary

Nutrients (phosphorus and nitrogen) and chlorophyll 'a' levels signify the eutrophic status of an estuary or water body. Eutrophication is "the nutrient enrichment of waters which results in stimulation of an array of symptomatic changes. Among these are increased production of algae and macrophytes, deterioration of fisheries, deterioration of water quality and other changes which are found to be undesirable and interfere with water uses" (Govt. Chem. Labs, 1983). This phenomenon of eutrophication is generally associated with an increase in algal concentrations as a result of increased nutrient levels, in particular phosphorus and nitrogen.

### 2.3.1 Nutrients - Sources and Sinks

Nutrients entering an estuarine system can be removed from the water column by three processes: 1. Flushed out of the system. 2. Algal uptake for growth. 3. Precipitation and incorporation into sediments. Nutrients can subsequently be released from the sediments and taken up by algae which 'bloom'. On decomposition of a bloom nutrients are returned to the water column or sediments.

Sources of nutrients to the Swan-Canning Estuary include, decomposing matter, leaching from foreshore sanitary landfill sites, stormwater, industrial discharges, animal wastes, detergents, fertilisers, leaching from legume and native pastures, and sewage (some of these will be covered separately). As many of these are non-point source, tracing the origin of such nutrients is difficult.

Nutrient loading from these sources varies seasonally with premium loading during winter.

The Vollenweider classification of water-bodies using phosphate, inorganic nitrogen and chlorophyll 'a' enables the determination of the degree of enrichment that has occurred. Under this classification system, waters with low nutrient levels and, consequently, low plant growth are termed oligotrophic. Eutrophic waters can be defined as having high nutrient levels and increased plant growth.

### 2.3.2 Phosphorus

Phosphorus is generally considered the more important nutrient with regard to the control of plant growth in an estuarine environment. Natural levels of phosphorus are low (0.01 mg/L - Govt. Chem. Labs, 1983) and are generally limiting to plant growth. The measurement of thics nutrient allows an assessment of possible nutrient enrichment (Table 5).

Average five year seasonal phosphorus levels in the Swan-Canning Estuary range from 0.05-0.83 mg/L (Table 6) classifying the estuary as Eutropolytrophic-Polytrophic. Phosphorus levels, therefore, are rarely limiting for plant growth and create a high potential for extensive algae and macrophyte bloom development.

Comparison of these data with a previous study by Shewchuk (1982) suggests an increasing phosphorus input to the estuarine system since 1975. This reflects the increasing use of phosphorus in both rural and urban areas of the catchment.

| **Water States** | **Phosphorus (mg/L)** | **Inorganic Nitrogen (mg/L)** |
|---|---|---|
| Ultra-oligotrophic | <0.005 | <0.20 |
| Oligo-mesotrophic | 0.005-0.01 | 0.20-0.40 |
| Meso-eutrophic | 0.01-0.03 | 0.30-0.65 |
| Eutro-polytrophic | 0.03-0.10 | 0.50-1.50 |
| Polytrophic | >0.10 | >1.50 |

**TABLE 5** Phosphorus and Inorganic Nitrogen Criteria for Determining the Eutrophic Status of an Estuary (Government Chemical Laboratories, 1983)

### 2.3.3 Nitrogen

The potential for inorganic nitrogen (nitrate plus ammonium) levels to cause nuisance characteristics of eutrophication is phosphorus. The criteria presented in Table 5 list the trophic status of water. Application to available data (Table 6) indicate that during Summer the majority of the estuary has limiting inorganic nitrogen levels; Swan Upper Estuary - Zone 2 & Canning Upper Estuary have classifications of Eutropolytrophic & Polytrophic respectively signifying favourable levels for phytoplankton growth.

During Winter the estuary is considered to be Eutro-polytrophic.

| Division | Total Phosphorus mg/L | | Inorganic Nitrogen mg/L | | Chlorophyll 'a' ug/L | |
|---|---|---|---|---|---|---|
| | **Summer** | **Winter** | **Summer** | **Winter** | **Summer** | **Winter** |
| Upper Estuary Swan - Zone 2 | 0.05 | 0.148 | 0.179 (35) | 1.063 | 14 (6) | 8 |
| Upper Estuary Swan - Zone 3 | 0.16 | 0.191 | 0.145 (42) | 0.965 (3) | 40 | 14 (5) |
| Middle Estuary Swan | 0.095 | 0.278 | 0.079 (64) | 1.044 (46) | 6 (7) | 7 (9) |
| Lower Estuary Swan-Canning | 0.07 | 0.067 | 0.076 (23) | 0.43 (17) | 6 (15) | 8 (3) |
| Upper Estuary Canning | 0.83 | 0.513 | 0.668 (0) | 1.135 (11) | 7 | 3 (7) |
| Middle Estuary Canning | 0.19 | 0.250 | 0.143 (35) | 0.990 (30) | 6 (7) | 6 |

**TABLE 6 :** Seasonal mean Total Phosphorus, Inorganic Nitrogen, and Chlorophyll 'a' levels for the Swan-Canning Estuary. Numbers in brackets represent the perentage of recordings below the detectable limit, i.e.

| | |
|---|---|
| Total Phosphorus | 0.01 mg/L |
| Inorganic Nitrogen | 0.02 mg/L |
| Chlorophyll 'a' | 2 ug/L |

### 2.3.4 Chlorophyll "a"

The nutrients nitrogen and phosphorus indicate the potential for excessive plant growth, chlorophyll 'a' levels measure phytoplankton standing crop (biomass). One of the nuisance properties of eutrophic waters is the intensity and frequency of algal blooms (represented by high chlorophyll 'a' values). An algal bloom "may be observed as cloudiness, colour (often green) or a floating algal scum" (Cunningham 1984).

Large algal blooms increase turbidity through increased cell numbers suspended in the water column. In turn, this can affect light penetration which ultimately affects the rate of photosynthesis of bottom dwelling macro-algae and other aquatic plants reducing their growth. Photosynthesis can increase the concentration of oxygen dissolved in the water column, in some instances waters become supersaturated. As extensive algal blooms decompose (known as a 'crash' when conditions become unfavourable for continued growth) oxygen is removed from the water through the action of micro-organisms. Toxic substances may also be released from the dead cells. The affect of this on other aquatic life can be substantial, including large fish kills.

The criteria available for chlorophyll 'a' levels are presented in Table 7. Throughout the year and the majority of the Swan-Canning estuary chlorophyll 'a' levels classify the system as Mesotrophic, ie < 20 µg/L (Table 5). (The overlap evident between Mesotrophic and Eutrophic suggests that the estuary could also be classified as Eutrophic.) Swan Upper Estuary - Zone 3 exhibits Summer concentrations indicative of algal blooms (this area has a history of such blooms).

| **Water State** | | **Chlorophyll 'a' µg/L** |
|---|---|---|
| Oligotrophic | 0-4 | 0.3-2.5 |
| Mesotrophic | | 1-15 |
| Eutrophic | 10-100 | 5-140 |

**TABLE 7:** Chlorophyll 'a' Criteria for Eutrophication Level Determination. (Government Chemical Laboratories, 1983)

## 2.4 Coastal Plain and Hills Catchments Discharges Physical and Nutrient Status

Coastal plain drains* include creeks, brooks, rivers and urban drains, while the Hills Catchment input is derived from agricultural land drainage upstream of Walyunga. Their impact on the river varies with the characteristics of the drainage catchment (Table 8), type and amount of discharge and the diluting capacity of the estuary.

### 2.4.1 Nutrients

Nutrient levels in discharge waters may be derived from industrial discharges, seepage from septic tanks, illegal dumping of material (sewage, refuse, etc), stormwater runoff carrying garden fertilisers or land drainage. Determination of the exact point of entry

| DRAIN | DRAIN NAME | AREA OF DRAINAGE INCLUDES |
|---|---|---|
| 1 | Spring Street | Lake Monger, Freeway runoff, market areas, sewered area, central business district. |
| 2 | Claisebrook | Industrial, intensive residential, restaurant area, sewered. |
| 3 | Peninsula Rd | Residential, sewered, central business district. |
| 4 | King William St | Industrial, residential, some sewered areas. |
| 5 | Kitchener Rd | Industrial (very ligh), residential, some sewered areas, disused fertiliser factory. |
| 6 | Brook Street | Residential, sewered. |
| 7 | Bennett Brook | Mussel pool, some vineyards, wetlands, rural, some residential, partially sewered. |
| 8 | Ellen Brook | Light agriculture & animal husbandry. Airforce treated sewerage. |
| 9 | Jane Brook | Semi-rural, unsewered, Redhill tip. |
| 10 | Helena River | Semi-rural, sprawling residential, partially sewered, stock holding areas, old abbatoir. |
| 11 | Airport north | Industrial (Forrestfield marshalling yards), Skirts airport to the north, partially sewered. |
| 12 | Airport middle | Direct from Airport, light stock area. |
| 13 | Airport south | Industrial (Forrestfield marshalling yards), chlorinated sewage from Airport, Skirts Airport to the south. |
| 14 | Belmont Creek | Residential, industrial (particularly fast foods), passes rubbish tip, sewered. |
| 15 | Belmont | Industry, residential, mostly sewered. |
| 16 | PCC _ Causeway | Industrial, residential, sewered, stormwater. |
| 17 | PCC - McCallum | Residential, ground water & stormwater flow, sewered. |
| 18 | Manning | Residential, sewered, rubbish tip. |
| 19 | Collier Pines | Residential, sewered. |
| 20 | Wilson | Residential, partially sewered. |
| 21 | Mills | Residential, industry (intensive), partially sewered. |
| 22 | Wharf Street | Residential, industrial, partially sewered. |
| 23 | Cockram | Residential, industrial, unsewered. |
| 24 | Lacey Street | Residential, unsewered. |
| 25 | Yule Brook | Residential, rural (horse pastures), industrial (light), majority unsewered. |
| 26 | Bickley Brook | Residential, semi-rural, industrial, limited area sewered. |
| 27 | Helm Street | Residential, rural, mostly unsewered, stormwater. |
| 28 | Ellis Brook | Residential (light), rural (paddocks & orchards), unsewered. |
| 29 | Southern River | Residential, rural, residential area sewered, Forrestdale Lake, Westfield Treatment Plant (now closed). |
| 30 | Thornlie Golf | Residential, partially sewered. |
| 31 | Bannister Creek | Residential (some), industrial, partially sewered. |
| 32 | Riley Road | Residential (light), sewered. |
| 33 | Marjorie Road | Residential, unsewered. |
| 34 | Modillion Ave | Residential, unsewered. |
| 35 | Sixth Ave | Residential, unsewered. |
| 36 | Bull Creek | Residential, small wetland, mostly sewered, large ground water flow. |
| 37 | Brentwood | Residential, mostly sewered, ground water from Freeway (very acid) |
| | Hills Catchment | Hills and agricultural drainage upstream of Walyunga |
| | Coastal Plain Catchment | Below Canning Dam and upstream of MacKenzie Grove draining through urban and semi-rural areas. |

TABLE 8: Area Types and Deep Sewage Status of Areas Drained by SRMA Sampled Drains

of nutrients to drains is often difficult. The potential for eutrophication in the estuary is, therefore, increased as a consequence of greater nutrient availability.

Drain loading to the estuary during summer is more important than other sources (Table 9) when the influence from non-urban sources (Hills Catchment & MacKenzie Grove Catchment) is reduced. Drain contribution during this season is dominated by King William Street Drain and Southern River inputs (Table 9). The remaining drains discharge less significant levels of nutrients (all releasing < 10% of the seasonal total).

| | **NUTRIENT LOADS ($g\ hr^{-1}$)** | | | |
|---|---|---|---|---|
| | **INORGANIC NITROGEN** | | **TOTAL PHOSPHORUS** | |
| | **SUMMER** | **WINTER** | **SUMMER** | **WINTER** |
| Swan Drains | 1 541 | 11 295 | 471 | 5 150 |
| Walyunga | 99 | 14 806 | 14 | 8 884 |
| Canning Drains | 1 384 | 18 244 | 1 098 | 5 955 |
| Mackenzie Grove | 88 | 1 866 | 18 | 366 |

**TABLE 9:** Comparison of River and Drain Mean Loads ($g\ hr^{-1}$) for the Swan-Canning Estuary

* The input via Mackenzie Grove to the estuary includes the foothills below Canning Dam, that passing through Walyunga is termed Hills Catchment, and the 37 drains sampled represent Coastal Plain drainage which includes both urban and rural.

The Hills Catchment contribution of nutrients dominates loading to the estuary in winter. At this time the flow rate through Walyunga (representing the Hills Catchment input) is twenty-two (22) times the largest drain flow and, as anticipated and evidenced, introduces the majority of nutrients from a single source to the estuary (Table 10).

| **Drain** | **Inorganic Nitrogen % of Discharges** | | **Total Phosphorus % of Discharges** | |
|---|---|---|---|---|
| | **Summer** | **Winter** | **Summer** | **Winter** |
| King William Street | 22 | 4 | 16 | 5 |
| Southern River | 21 | 20 | 56 | 20 |
| Hills Catchment | 3 | 32 | 0.8 | 44 |
| MacKenzie Grove Catchment | 3 | 4 | 1 | 2 |

**TABLE 10** The Percentage Contribution of loading from the main drainage sources.

Loading to both the Swan and Canning Rivers is dominated by urban drainage during summer. In winter the situation in the two rivers differs with hills drainage exceeding urban drain input to the Swan River and urban drainage continuing to dominate the Canning River (Table 9).

The impact of these nutrient discharges on the estuary is influenced by algal uptake, sedimentation and dilution. The potential problems associated with algal blooms are increased by these releases.

### 2.4.2 Physical Parameters

Tables 11 and 12 present the seasonal physical and nutrient data for the thirty-seven sampled drains, the Hills Catchment and the Coastal Plain Catchment.

Although some drains exhibit high BOD (Mills, Cockram & Lacey Street), low Dissolved Oxygen (Bennett Bk, Ellen Bk and Southern River) and high turbidity (King William Street, Kitchener Road and Brentwood) there appears to be limited changes to the receiving waters of the estuary. Localised variations at the point of discharge are expected, however, such sampling is not conducted on the Swan-Canning Estuary.

TABLE 11: Coastal Plain & Hills Drainage Mean Summer Physical & Nutrient Data (November 1979 - April 1985)

| DRAIN NUMBERS | TEMPERATURE (°C) | TURBIDITY (NTU) | DO % | DO CONCENTRATED (mg/L) | BOD | INORGANIC NITROGEN (mg/L) | TOTAL PHOSPHORUS (mg/L) | CHLORIDE (mg/L) |
|---|---|---|---|---|---|---|---|---|
| 1 | 23.3 | 12.5 | 71 | 5.7 | 2.7 (4) | 0.75 | 0.15 | 6825 |
| 2 | 22.2 | 5.2 | 56 | 7.5 | 2.8 | 0.35 | 0.08 | 159 |
| 3 | 22.2 | 5.3 | 83 | 7.3 | 2.6 (54) | 0.85 | 0.03 | 482 |
| 4 | 18.8 | 68.5 | 78 | 7.1 | 2.1 (45) | 1.22 | 0.46 | 127 |
| 5 | 23.6 | 36.8 | 98 | 8.4 | 2.6 (36) | 1.37 | 0.17 | 122 |
| 6 | 22.2 | 4.2 | 83 | 7.3 | 2.8 (18) | 1.16 | 0.20 | 119 |
| 7 | 20.1 | 7.7 | 23 | 2.1 | 2.4 (45) | 1.03 | 0.16 | 101 |
| 8 | 21.6 | 4.1 | 33 | 2.9 | 2.6 (28) | 0.14 | 0.44 | 394 |
| 9 | 18.9 | 2.9 | 87 | 8.2 | 2.2 (50) | 0.07 | 0.02 | 302 |
| 10 | 19 | 3.5 | 65 | 6.0 | 2.6 | 0.07 | 0.05 | 396 |
| 11 | 23.1 | 2.8 | 77 | 6.3 | 4.8 (20) | 0.10 | 0.08 | 198 |
| 12 | 23.4 | 2.2 | 90 | 7.9 | 4.0 (9) | 0.21 | 0.16 | 202 |
| 13 | 23.8 | 6.0 | 80 | 6.8 | 2.4 (9) | 0.3 | 0.05 | 146 |
| 14 | 23.9 | 2.9 | 90 | 7.6 | 4.9 | 0.51 | 0.20 | 179 |
| 15 | 24.5 | 245 | 96 | 8.2 | 2.4 (36) | 0.66 | 0.11 | 132 |
| 16 | 22.1 | 36.3 | 53 | 4.6 | - (100) | 3.30 | 0.07 | 582 |
| 17 | 21.4 | 1.3 | 70 | 6.3 | 2.0 (90) | 2.39 | 0.11 | 101 |
| 18 | 26.9 | 18 | 113 | 9.1 | 2.6 (27) | 0.26 | 0.03 | 158 |
| 19 | 24.9 | 12.3 | 89 | 7.4 | 3.2 (22) | 0.35 | 0.04 | 81 |
| 20 | 23.6 | 8.5 | 50 | 4.3 | 3.1 (54) | 1.40 | 0.37 | 112 |
| 21 | 24.9 | 3.7 | 98 | 8.2 | 5.5 | 0.92 | 0.33 | 108 |
| 22 | No Summer Flow | | | | | | | |
| 23 | 24 | 7.9 | 74 | 6.3 | 5.2 (18) | 0.52 (9) | 0.80 | 224 |
| 24 | 23.3 | 4.6 | 120 | 10.1 | 5.5 (20) | 0.67 | 0.40 | 364 |
| 25 | 22.2 | 4.4 | 84 | 7.4 | 2.5 (18) | 0.10 (27) | 0.08 | 142 |
| 26 | 23.6 | 4.7 | 120 | 10.2 | 2.5 (33) | 0.47 (33) | 0.06 | 930 |
| 27 | 24 | 4.2 | 158 | 13.6 | 3.0 (50) | 0.61 | 0.08 | 348 |
| 28 | 19.9 | 1.5 | 90 | 8.3 | - (100) | 0.10 | 0.02 | 190 |
| 29 | 20.7 | 4.9 | 34 | 3.1 | 2.0 (73) | 1.71 | 2.36 | 211 |
| 30 | 22.5 | 4.6 | 52 | 4.6 | 2.0 (82) | 0.8 | 0.11 | 434 |
| 31 | 20.6 | 32.4 | 38.8 | 3.6 | 2.4 (82) | 0.43 | 0.14 | 151 |
| 32 | 22.3 | 1. 7 | 57 | 5.0 | 2.4 (73) | 0.63 (9) | 0.17 | 89 |
| 33 | 21.3 | 10.2 | 70 | 6.2 | 2.2 (27) | 0.45 (9) | 0.78 | 148 |
| 34 | 21.8 | 8.9 | 67 | 6.0 | 2.8 (75) | 0.35 (9) | 0.11 | 200 |
| 35 | 21.4 | 7.4 | 64 | 5.7 | 2.3 (64) | 0.88 | 0.12 | 860 |
| 36 | 19.6 | 7.2 | 66 | 6.1 | 2.0 (73) | 0.66 (9) | 0.03 | 75 |
| 37 | 21.2 | 92.5 | 60 | 5.5 | 2.1 (82) | 0.53 | 0.03 | 85 |
| Hills Catchment | 23.2 | 1.4 | 90 | 7.5 | 2.7 (27) | 0.205 (18) | 0.03 | 3838 |
| Coastal Plain Catchment | 20.1 | 8.1 | 77 | 7.1 | 2.0 (82) | 0.199 (9) | 0.04 (9) | 182 |

Note: Numbers in brackets are the percentage of recordings below the detectable limit. (November 1979 - April 1985)

TABLE 12: Coastal Plain and Hills Drainage Mean Winter Physical and Nutrient Data (November 1979 - April 1985)

| DRAIN NUMBERS | TEMPERATURE (°C) | TURBIDITY (NTU) | DO % | DO CONCENTRATED (mg/L) | BOD | INORGANIC NITROGEN (mg/L) | TOTAL PHOSPHORUS (mg/L) | CHLORIDE (mg/L) |
|---|---|---|---|---|---|---|---|---|
| 1 | 17.6 | 22.2 | 75 | 6.4 | 2.6 (33) | 0.97 | 1752 | |
| 2 | 18.0 | 6.3 | 64 | 6.1 | 4.5 (11) | 1.41 | 0.11 | 108 |
| 3 | 18.9 | 3.6 | 80 | 7.8 | 3.6 (89) | 0.86 | 0.04 | 457 |
| 4 | 16.0 | 59.7 | 67 | 6.8 | 3.8 (67) | 1.40 | 0.75 | 115 |
| 5 | 17.6 | 97.5 | 71 | 6.7 | 2.8 (67) | 2.50 | 0.49 | 122 |
| 6 | 17.2 | 4.4 | 83 | 8.1 | 4.8 (88) | 1.02 | 0.09 | 111 |
| 7 | 14.4 | 5.4 | 42 | 4.4 | 3.0 (67) | 0.98 | 0.25 | 128 |
| 8 | 14.2 | 4.8 | 51 | 5.2 | 5.4 (88) | 0.54 | 400 | |
| 9 | 14.4 | 3.8 | 88 | 9.0 | 4.0 (86) | 0.67 | 0.47 | 256 |
| 10 | 14.6 | 5.1 | 57 | 5.8 | 2.8 (75) | 0.46 | 0.10 | 286 |
| 11 | 16.2 | 7.3 | 74 | 7.3 | 3.2 (75) | 0.27 | 0.14 | 155 |
| 12 | 17.1 | 17.4 | 84 | 8.2 | 4.7 (11) | 0.67 | 0.18 | 118 |
| 13 | 17.6 | 7.4 | 79 | 7.7 | 3.0 (44) | 1.0 | 0.08 | 175 |
| 14 | 17.7 | 5.9 | 88 | 8.4 | 2.2 (11) | 1.55 | 0.25 | 127 |
| 15 | 18.5 | 17.2 | 80 | 7.6 | 3.2 (56) | 1.09 | 0.28 | 122 |
| 16 | 19.8 | 5.5 | 56 | 5.2 | 2.7 (62) | 1.95 | 0.10 | 190 |
| 17 | 19.8 | 3.0 | 68 | 6.3 | 4.2 (75) | 2.17 | 0.14 | 99 |
| 18 | 20.4 | 3.6 | 87 | 7.9 | 2.1 (75) | 0.75 | 0.06 | 1268 |
| 19 | 19.0 | 11.8 | 85 | 8.0 | 3.0 (38) | 0.63 | 0.04 | 140 |
| 20 | 19.7 | 2.9 | 66 | 6.1 | 3.6 (50) | 2.24 | 1.07 | 88 |
| 21 | 19.2 | 6.3 | 81 | 7.6 | 3.1 (11) | 1.03 | 0.43 | 88 |
| 22 | 18.8 | 2.3 | 100 | 9.4 | 3.2 (40) | 1.84 | 0.12 | 279 |
| 23 | 17.9 | 3.4 | 105 | 10.1 | 2.3 (22) | 1.65 | 0.68 | 218 |
| 24 | 18.4 | 6.5 | 138 | 12.9 | 3.1 (11) | 1.82 | 0.33 | 278 |
| 25 | 15.4 | 20.3 | 96 | 9.7 | 2.5 (22) | 0.75 | 0.12 | 141 |
| 26 | 16.4 | 31.1 | 112 | 10.8 | 2.9 (88) | 0.94 | 0.10 | 215 |
| 27 | 17.5 | 34.5 | 138 | 13.4 | 3.0 (62) | 2.44 | 0.13 | 205 |
| 28 | 14.9 | 30.2 | 90 | 9.2 | 2.2 (62) | 0.6 | 0.07 | 121 |
| 29 | 15.1 | 14.8 | 51 | 5.2 | 2.5 (62) | 2.85 | 1.28 | 174 |
| 30 | 16.0 | 19.6 | 63 | 6.2 | 3.6 (67) | 1.13 | 0.27 | 291 |
| 31 | 15.0 | 27.8 | 51 | 5.1 | 3.2 (45) | 1.28 | 0.24 | 123 |
| 32 | 18.5 | 5.0 | 63 | 6.0 | 2.0 (88) | 1.20 | 0.27 | 78 |
| 33 | 16.7 | 3.0 | 67 | 6.6 | 2.3 (75) | 1.08 | 0.78 | 100 |
| 34 | 16.2 | 5.5 | 56 | 7.3 | 2.0 (88) | 0.63 | 0.15 | 72 |
| 35 | 18.6 | 8.3 | 61 | 5.8 | - (100) | 1.39 (11) | 0.20 | 67 |
| 36 | 15.9 | 11.6 | 64 | 6.4 | 2.3 (89) | 0.87 | 0.04 | 67 |
| 37 | 16.9 | 95.0 | 57 | 5.6 | 3.2 (75) | 0.48 | 0.04 | 77 |
| Hills Catchment | 13.2 | 34.6 | 90 | 9.3 | 2.6 (56) | 0.20 (22) | 0.12 | 2388 |
| Coastal Plain Catchment | 13.7 | 12.3 | 90 | 9.5 | 2.1 (56) | 0.76 (11) | 0.039 | 147 |

Note: Numbers in brackets represent the percentage of recordings which are below the limit of detection. (November 1979 - April 1985)

Chloride levels in all drains approximate that of freshwater and so may result in localised dilution of receiving waters during summer. However, during winter the river inputs mask this affect by reducing the chlorinity of the entire upper estuary. Temperature ranges in the drains are similar to ranges observed in the receiving waters.

## 3.0 POLLUTION : SOURCES AND CONSEQUENCES

Increasing urbanisation of the Perth Metropolitan Region has resulted in increased discharge to the Swan-Canning Estuary. Concurrent to this the potential for major pollution problems has increased. Furthermore, greater useage of the estuary for recreation, sporting, fishing and other activities has exemplified pollution potential from sources other than industry. The aim here is to outline existing, potential and future pollution problems of the estuary.

### 3.1 Pesticides

Pesticides are used for the control of a large variety of organisms which are considered pests. These include insects (insecticides), weeds (herbicides) and fungi (fungicides). All pesticides are subject to chemical modification in the environment. Organophosphate insecticides are decomposed rapidly while organochlorine insecticides break down slowly (Connell, 1974). Consequently the latter are the most persistent of pesticides in the aquatic environment (McEwen and Stephenson, 1979). Persistence of a pesticide depends on:

1. The nature of the pesticide (type) and,
2. The nature of the water (chemical composition, pH, temperature, suspended matter and efficiency of detoxification processes of an organism).

Chlorinated hydrocarbons (insecticides) are highly soluble in animal and plant fats but weakly soluble in water. Due to their persistence in the environment, chlorinated hydrocarbons can be accumulated at all trophic levels. Once ingested an organism cannot eliminate them from its system, and they are therefore accumulated. If consumed they will be passed on to the next trophic level. The extent of residues in an organism is a function of the level and duration of exposure, the species exposed, route of exposure, nature of the pesticide and the ability of an organism to metabolise and/or excrete the compound. These compounds may cause reduced fecundity, lesions, general environmental stress or even death.

### 3.1.1 Sampling

Water sampling is conducted on a quarterly basis at the Causeway and Fremantle Traffic Bridge sites. The Government Chemical Laboratories analyse the samples for common organochlorine and organo-phosphorus pesticides. Those with detectible levels include aldrin, chlordane, DDT and metabolites, dieldrin, heptachlor and lindane - all are organochlorine insecticides.

The limit of detection for common organochlorine pesticides from June 1975 has been 0.001 µg/L. Prior to this limits between 0.01 and 0.001 µg/L were obtained. The limit of detection for parathion, as a reference organophosphorus pesticide, has been 0.01 µg/L. Fenchlorphos (0.1 µg/L at Causeway 17/12/1974) has been the only organophosphorus pesticide detected. This occurred following the fogging of the WACA ground with fenchlorphos for fly control prior to a test match. (Hughes, 2/7/85 pers. comm.).

Herbicides and fungicides are not analysed for under WWC water quality monitoring because:

1. They are generally not persistent.
2. They generally remain in the soil where they are broken down.
3. They have a low toxicity.
4. The initial study on pesticides by the Government Chemical Laboratories was concerned with the persistence and also the widespread use of organochlorines and organophosphates. Levels in the Swan Estuary could then be used as a reference for other areas of the State.

### 3.1.2 Sources and Uses in W.A.

Pesticides may enter the Swan Estuary via soil runoff (organochlorines are bound tightly to soil particles and consequently levels in runoff water are low) or accidental spillage (Section 9).

Table 13 gives the urban and agricultural uses of the six detectible insecticides. The use of organochlorine insecticides has been restricted in recent years. For example, dieldrin is no longer registered for any agricultural use. The last recorded use of dieldrin in agriculture, as a soil pretreatment for potatoes was in July 1982. Dieldrin is now registered only for termite control by subsurface injection (Rutherford 14/4/83 pers. comm.). The changing pattern of use of

| PESTICIDE | AGRICULTURAL USE | METROPOLITAN AREA USE |
|---|---|---|
| Aldrin | None | Termite control for new and established housing |
| Chlordane | None | Used for beetle control on bowling greens |
| DDT & Metabolites | Wheatbelt (cereals, lupins) for control of webb worm orchard industry - particularly apple trees. Small amounts used on linseed and rape crops. Some vegetable crops | Used on fruit trees |
| Dieldrin | None | Termite control for new and established housing |
| Heptachlor | Control black beetle in potatoe crops. Control curculio beetle on apple tree bark | Used for beetle control on bowling greens |
| Lindane | Small use as seed dressing in conjunction with fungicides for long term storage of seeds | Used in the preparation of skins and hides |

TABLE 13: Pesticide Use in W.A.

Person Communication
Michael Cussons Public Health Dept.
16th July 1985

Peter Rutherford Agric. Dept.
19th July 1985

organochlorine pesticides is reflected by the detection of heptachlor and chlordane and absence of lindane in recent samples.

### 3.1.3 **Residues in the Swan Estuary**

Pesticide criteria is set out in Table 14. These standards can be used as general indicators of pesticide contamination. Seasonal means (Table 15) and the graphical representation (Figures 5 to 11) indicate peak pesticide levels occur during winter when high surface runoff leads to increased loads to the river. Seasonal means indicate that no significant deviation above the set standard for each pesticide occurs.

| **INSECTICIDE** | **RECOMMENDED LEVEL µg/L** |
|---|---|
| Aldrin | 0.003 |
| Chlordane | 0.004 |
| DDT & metabolites | 0.001 |
| Dieldrin | 0.003 |
| Heptachlor | 0.001 |
| Lindane | 0.004 |

**TABLE 14 :** Pesticide Criteria for the Maintenance and Preservation of Aquatic Ecosystems (DCE, 1981)

| | **CAUSEWAY** | | **FREMANTLE TRAFFIC** | |
|---|---|---|---|---|
| | **SUMMER** | **WINTER** | **SUMMER** | **WINTER** |
| Aldrin | 0.001 | 0.003 | 0.001 | 0.003 |
| Chlordane | 0.001 | 0.001 | 0.001 | 0.001 |
| DDT & Metabolites | 0.002 | 0.002 | 0.002 | 0.004 |
| Dieldrin | 0.005 | 0.005 | 0.003 | 0.005 |
| Lindane | 0.001 | 0.001 | 0.001 | 0.001 |
| Hoptachlor | 0.001 | 0.003 | 0.001 | 0.003 |

**TABLE 15:** Seasonal Means (µg/L) of Pesticide Levels in the Swan Estuary (May 1974 - March 1985)

FIGURES 5 - 10

SEASONAL MEAN INSECTICIDE LEVELS IN THE SWAN RIVER

—— CAUSEWAY

- - - FREMANTLE

—·— CRITERIA

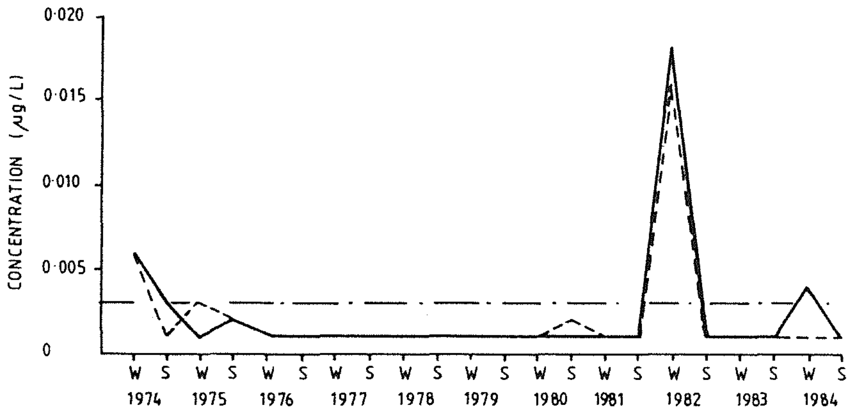



FIGURE 5 - ALDRIN LEVEL

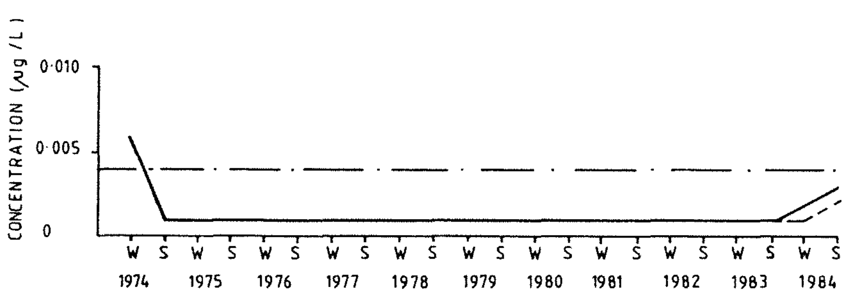



FIGURE 6 CHLORDANE LEVEL

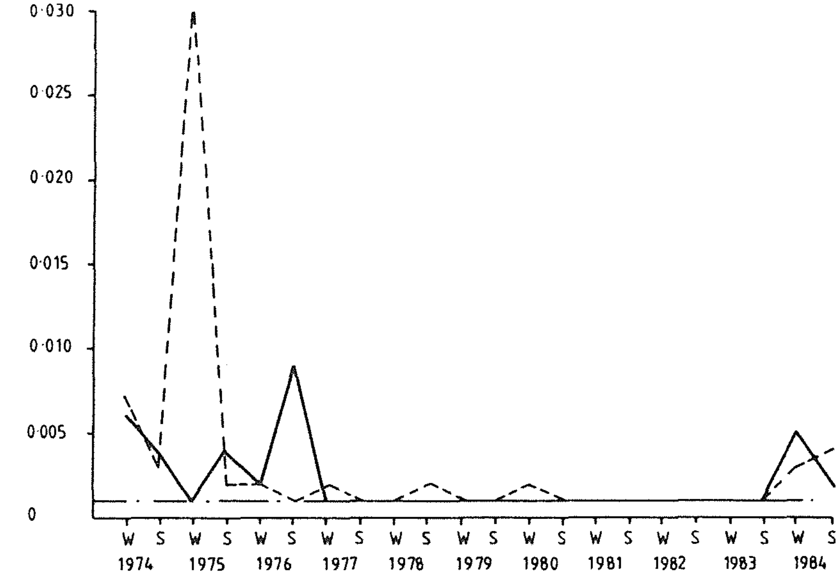



FIGURE 7 - DDT & METABOLITES LEVELS

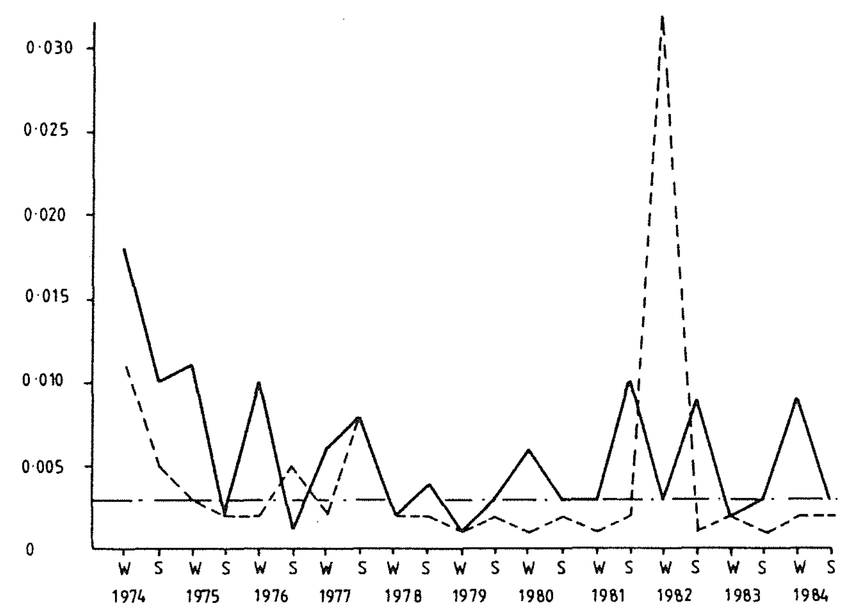



FIGURE 8 - DIELDRIN LEVELS

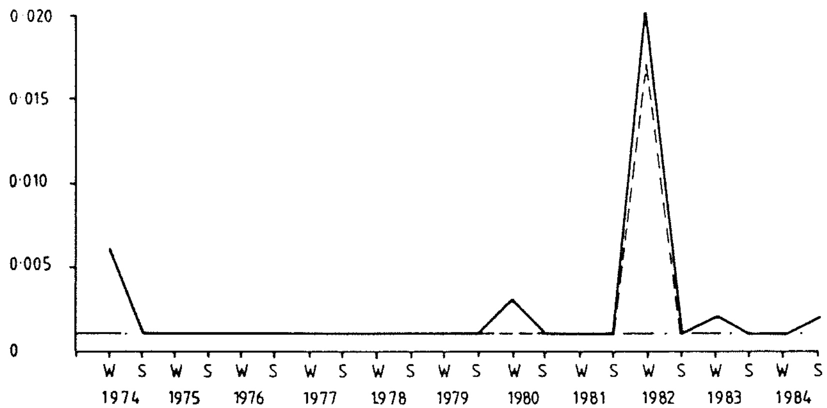



FIGURE 9 - HEPTACHLOR LEVELS

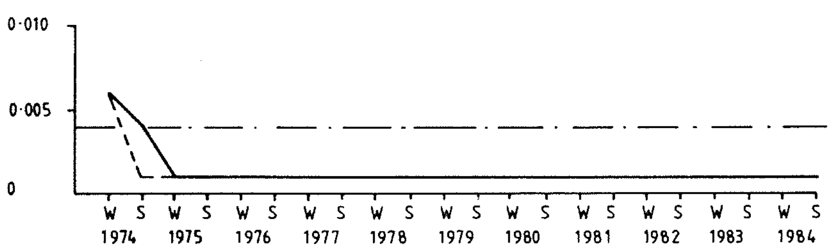



FIGURE 10 - LINDANE LEVELS

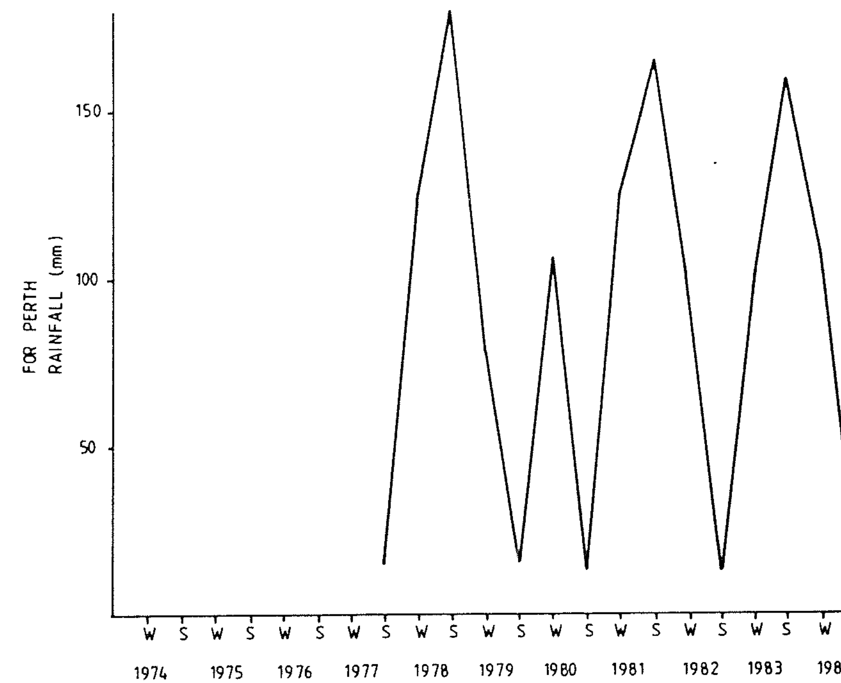



FIGURE 11 - RAINFALL FOR PERTH

Levels present in the Swan Estuary are similar to those found in the Preston River (Atkins 1982). This report found no measurable accumulation of pesticides in fish flesh and sediments in Leschenault Inlet. Accumulation of pesticides in fish flesh and sediments are not expected to be a problem. However, a study of pesticide levels in the Swan-Canning Estuary sediment and biota is required before this can be concluded.

## 3.2 Heavy Metals

Heavy metal contamination of the environment can originate from the following sources:

1. Mining effluents from industrial processing of metals and ores (not applicable to the Swan River).

2. Industrial effluents resulting from the use of metal and metal components in processing.

3. Leaching of metals from garbage and solid waste dumps into stormwater drains.

4. Runoff from rural soil enriched with heavy metals by the application of plant nutrients and crop protective measures.

5. Geological weathering which is the source of background levels (Government Chemical Laboratories 1983).

As with pesticides, heavy metals create problems in aquatic environments as once ingested, organisms cannot eliminate them from their systems. These metals can be accumulated in aquatic organisms up to 9100 times the surrounding concentration levels. Once assimilated heavy metals are incorporated into all trophic levels of food webs. Accumulation of heavy metals may be evident in liver, gills and pancreas of organisms and may lead to acute or chronic effects. These include lesions, reduced fecundity and general environmental stress in organisms. (Chegwidden 1980 b).

### 3.2.1 Sampling

In 1979, a 9 month study was undertaken by the Government Chemical Laboratories & SRMA (Taylor, 1980) to determine heavy metal levels in the Swan-Canning Estuary. This study used the 37 drain locations and four river sites (sites 3, 18, 22 and the Causeway) listed in Section 1.2. The recommendations "that samples for analysis be taken from only those drains with significant inputs of Cr, Cu and Zn" was implemented in the 1982/83 study. Furthermore, the number of river sites was increased from 4 to 11. Table 16 lists the sample sites used in the second heavy metal study.

| **River Sites** | **Drain Sites** |
|---|---|
| 3. Middle Swan Bridge | 1. Spring Street |
| 7. Milne Street | 2. Claisebrook |
| 10. Maylands Causeway | 4. King William Street |
| 13. Narrows Bridge | 15. Belmont |
| Chidley Point | 21. Mills |
| 20. Herbert Street | 22. Wharf Street |
| 22. Riverton Bridge | 26. Bickley Brook |
| 24. Canning Bridge | 29. Southern River |
| **Rural Inputs** | 30. Thornlie Golf |
| 1. Walyunga | 31. Bannister Creek |
| 19. MacKenzie Grove | |

**TABLE 16 :** Sampling Sites used in the 1982/83 Heavy Metal Study.

Heavy metals sampled include cadmium, chromium, cobalt, copper, lead, nickel and zinc. In the 1979 study mercury was also sampled, however, levels well below the recommended criteria (Table 17) justified its deletion in 1982/83. Table 18 indicates possible origins of heavy metals found in the Swan Estuary.

| **Heavy Metal** | **Maximum Recommended mg/L** |
|---|---|
| Cadmium (Cd) | 0.003 |
| Chromium (Cr) | 0.002 |
| Copper (Cu) | 0.005 |
| Mercury (Hg) | 0.00014 |
| Lead (Pb) | 0.008 |
| Nickel (Ni) | 0.020 |
| Zinc (Zn) | 0.020 |

**TABLE 17 :** Heavy Metal Criteria for the Maintenance and Preservation of Aquatic Ecosystems (DCE, 1981)

| Metal | Sources |
|---|---|
| Cadmium | Fertiliser manufacture |
| Chromium | Metal platters, air-conditioner waste |
| Cobalt | Fertiliser manufacture |
| Copper | Copper pipes used in water supply |
| Lead | Fertiliser manufacture (acid production) motor vehicles |
| Nickel | Metal platters |
| Zinc | Fertiliser manufacture, galvanized piping, fertilisers and air-conditioner waste |

**TABLE 18 :** Sources of Heavy Metals to the Swan Estuary

### 3.2.2 Estuary Levels

Taylor (1980) found that levels of copper and zinc exceeded the criteria on one or more occasions, as does the more recent data (1982/83). However, the seasonal mean levels (Table 19) of these two metals show no significant deviation above the set standard. Taylor considered that the heavy metal status of the estuary was satisfactory, with the possible exception of zinc.

| | Copper (mg/L) | | Zinc (mg/L) | |
|---|---|---|---|---|
| | Summer | Winter | Summer | Winter |
| Middle Swan Bridge | 0.003 | 0.006 | 0.010 | 0.014 |
| Milne Street | 0.006 | 0.012 | 0.022 | 0.037 |
| Maylands | 0.004 | 0.012 | 0.013 | 0.034 |
| Causeway | 0.005 | 0.006 | 0.016 | 0.024 |
| Narrows Bridge | 0.005 | 0.006 | 0.021 | 0.022 |
| Chidley Point | 0.004 | 0.004 | 0.013 | 0.009 |
| Herbert Street | 0.003 | 0.004 | 0.010 | 0.013 |
| Riverton Bridge | 0.003 | 0.004 | 0.013 | 0.020 |
| Canning Bridge | 0.005 | 0.004 | 0.009 | 0.011 |

**TABLE 19 :** Seasonal Means for Copper and Zinc in River Sites (November 1979 - April 1985)

TABLE 20 : Seasonal Means for those Drains with Recordings Exceeding the Criteria for Heavy Metals (November 1979 - April 1985)

| | CADMIUM | | CHROMIUM | | COPPER | | LEAD | | NICKEL | | ZINC | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | W | S | W | S | W | S | W | S | W | S | W |
| Spring St | | | 0.06 | 0.07 | 0.013 | 0.006 | 0.004 | 0.010 | | | 0.069 | 0.007 |
| Claisebrook | | | | | 0.009 | 0.007 | 0.004 | 0.010 | | | 0.076 | 0.115 |
| King William Street | 0.005 | 0.001 | 0.005 | 0.001 | 0.019 | 0.014 | 0.010 | 0.008 | 0.028 | 0.014 | 1.27 | 0.556 |
| Kitchener Rd | 0.002 | 0.02 | | 0.004 | 0.025 | 3.89 | 0.004 | 0.027 | 0.006 | 0.057 | 1.17 | 9.74 |
| Belmont | 0.002 | 0.02 | | 0.004 | 0.015 | 3.89 | 0.004 | 0.027 | 0.006 | 0.057 | 1.17 | 9.74 |
| Mills St | | | | | 0.004 | 0.004 | | 0.007 | | | 6.50 | 2.0 |
| Wharf St | | | | | 0.006 | 0.010 | | | | | 0.15 | 0.20 |
| Bickley Bk | | | | | | 0.007 | | | | | | 0.018 |
| Southern R | | | | | 0.004 | 0.004 | | | | | 0.012 | 0.016 |
| Thornlie Golf | | | | | 0.004 | 0.004 | | | | | 0.009 | 0.016 |
| Bannister Ck | | | | | 0.009 | 0.007 | | | | | 0.029 | 0.030 |

All values are presented in mg/L

| | CADMIUM | | CHROMIUM | | COPPER | | LEAD | | NICKEL | | ZINC | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | W | S | W | S | W | S | W | S | W | S | W |
| Spring Street | | | 285 | 19 | 2.5 | 1.6 | 0.76 | 2.7 | | | 13.1 | 1.9 |
| Claisebrook | | | | | 3.6 | 5.8 | 1.6 | 8.4 | | | 30.2 | 96 |
| King William Street | 2.2 | 1.8 | 2.2 | 1.8 | 8.5 | 25 | 4.5 | 14.3 | 12.5 | 25 | 569 | 994 |
| Kitchener Rd | .004 | 2 | | 0.4 | .03 | 385 | .008 | 2.7 | .012 | 5.6 | 2.3 | 964 |
| Belmont | | | | 0.4 | 1.5 | | 2.6 | | | | 722 | 738 |
| Mills Street | | | | 1.2 | 4.6 | | | | | | 19.2 | 93 |
| Wharf Street | | | | | 0.4 | | | | | | | 1.4 |
| Bickley Brook | | | | | 3.5 | | | | | | | 8.9 |
| Southern River | | | | 2.2 | 8.6 | | | | | | 6.7 | 34.5 |
| Thornlie Golf | | | | 0.2 | 1 | | | | | | 0.5 | 4.0 |
| Bannister Creek | | | | 0.7 | 2.2 | | | | | | 2.2 | 9.6 |
| Hills Catchment | | | | .88 | | 296 | | | | | 5.26 | 2147 |
| Coastal Plain Catchment | | | | .89 | | 18.8 | | | | | 4.0 | 93.8 |

TABLE 21: Loads ($g/hr^{-}$) for Swan Drains (Drains with no data indicate levels below the detectable limit) (November 1979 - April 1985)

### 3.2.3 Drain Levels

The criteria for all metals is exceeded on one or more occasions at each site. However, on a seasonal mean basis the majority of discharges are within the criteria for each metal (Table 20).

Spring Street, Claisebrook, King William Street, Kitchener Road and Belmont drains exceeded the criteria for several metals during the 1982/83 study. Copper and zinc mean levels exceeded the criteria in the majority of drains.

Loading data (Table 21) indicate that inputs of cadmium, chromium, lead and nickel are relatively minor compared with copper and zinc. The major drainage source of heavy metals are: 1. Chromium - Spring Street; 2. Copper - Kitchener Road and Hills Catchment; 3. Zinc - King William Street, Kitchener Road, Belmont and Hills Catchment.

Table 22 shows that drain inputs to the Swan River are larger than those to the Cannning River. The input of copper and zinc to the Swan River from industrial/urban discharges is greater than rural catchment discharge in summer. However, during winter rural sources of these two metals exceed the urban load. The higher winter rural release is due to heavy metals used in fertilizers being washed off the land and into streams, ultimately reaching the estuary. Discharges to the Canning River show less marked seasonal variation.

Careful monitoring of drain discharges is required to ensure that heavy metal loading to the estuary does not increase.

| Metal | | Swan Drains | Walyunga | Canning Drains | MacKenzie Grove |
|---|---|---|---|---|---|
| Cu | S | 15 | 1.3 | 4.3 | 1.2 |
| | W | 418 | 431 | 20.3 | 33.8 |
| Zn | S | 1 336.6 | 8 | 38.6 | 5.3 |
| | W | 2 793.9 | 3 126 | 151.4 | 169 |

**TABLE 22 :** Total drain and rural inputs (g/hr) to the Swan and Canning Rivers 1982/83.

### 3.2.4 Heavy Metals in Air Conditioning Waste

Heavy metals (particularly chromium and zinc) are used predominantly as base chemicals to combat corrosion and algal growth in the water cooling pipes of large air conditioning units. In Perth most bleed-off and sludge cleanout from air conditioning units in the central city area are discharged into stormwater drains connected to the Swan River.

The SRMA has no set policy regarding the discharge of air conditioning wastes to stormwater drains. The Water Authority does not allow this effluent to be discharged into the sewage because it kills the bacteria in the system. However, the use of pre-treatment plants to reduce the heavy metal concentration to $< 1$ mg/L would allow discharges to be diverted to the sewage system.

The Waterways Commission is currently assessing the use of chromium and zinc in air conditioning units and their impact on the estuary.

### 3.2.5 Heavy Metals in the Sediments of the Swan River Estuary

Physical factors, such as tide and wind induced currents, commercial shipping and pleasure craft, have the potential to cause sediment resuspension and metal mobilisation at the water - sediment interface. According to Chegwidden (1980 a) "about 30-90% of total metals could be classified as 'environmentally active' depending on the metal, chemical and physical nature of the sediments and the amount of organic matter present".

The Chegwidden (1980 b) study found that sediments near Claisebrook and King William Street drain outfalls had high metal levels. Results indicated that these metals (particularly zinc) were not tightly bound to the sediments and consequently were readily available to the biota. Generally, surface sediments in the Swan Estuary have satisfactory levels of heavy metals, however, it is suggested that deeper sediments are acting as a reservoir.

The study by Chegwidden (1980 a) on sediments near slipping facilities found elevated levels of both copper and zinc in these areas. Chromium and tin were also found to be higher than background levels. The SRMA policy for new slipping facilities states:

> 'When hardstanding areas are created for use for vessels removed from the water via a hoist, then an intercepting drain should be constructed so as to prevent material from the boat on the hardstand washing back into the river. The intercepting drain is to be covered with a mesh, which will

pick up all of the larger pieces of material and the smaller particles will pass into a fine particle trap into a settling tank. The settling tank will be constructed in such a way that it can be periodically cleaned out'.

A further study of heavy metals in the sediments is currently being conducted by the Department of Geology, UWA.

### 3.2.6 Heavy Metal and Aquatic Fauna

Detritus feeders, including polychaete worms, prawns and fish such as mullet, may ingest heavy metals with the organic matter they feed on. These metals may then be incorporated into all trophic levels.

Chegwidden (1980 b) conducted a preliminary investigation of heavy metals using one species of mussel in the Swan River. It was found that mussels contained no excessive levels of copper, cadmium, nickel and chromium in the river system. Mean zinc values for mussels from the Swan River were 53 µg/g (W/W) and for the Canning River were 50 µg/g (W/W). Both exceeded the local public health standard of 40 µg/g (W/W). Only 20 mussels were used in this study, therefore, more intensive research is required to support these findings.

A study is to be conducted on heavy metal accumulation in edible mussels throughout the Swan Estuary. The aim of this research is to determine the contamination levels and also the effects of drains as an environmental pollution source to mussels. Remedial measures to reduce heavy metal impact on aquatic life can not be established until the effects on biota have been determined.

### 3.3 Bacteriological

Bacteriological sampling is conducted quarterly by both the Swan River Management Authority and the Public Health Department, usually within one week of each other. Three types of bacteria are tested; Escherichia coli (E. coli), Streptococci and Salmonella. These bacteria are used as indicators of pathogenic organisms. Both E. coli and Streptococcus are found in the gut of warm-blooded animals and are indicative of faecal or sanitary pollution. Streptococci are found to have greater resistance to natural and man-made purification processes than E. coli. This increased resistance may be an indication of faecal pollution at points distant from the source of discharge.

E. coli and Streptococci are maintained in a freshwater environment with a constant temperature of approximately 37°C (mammals). When introduced to the river system they are subjected to thermal and osmotic stresses resulting in reduced growth rate and death. The impact of large numbers of micro-organisms introduced into the system is, therefore, reduced. Reduction of potential health problems by accidental ingestion is further lessened by the capability of the water body to dilute the micro-organisms.

As no criteria for Streptococci levels are available they were excluded from this report.

E. coli data were divided into the four classification groupings (Table 23). The percentage of recordings falling within these categories were determined as an indication of a site's status (Tables 24 and 25).

| **Mean probable number (cells/100 ml)** | **Classification** |
|---|---|
| 0- 110 | Good |
| 110- 350 | Satisfactory |
| 350-1100 | Requires investigation |
| 1100 + | Unsatisfactory |

**TABLE 23 :** Criteria for water quality with regard to E. coli (Riggert, 1978)

### 3.3.1 E. Coli in the Estuary

Unsatisfactory levels of coliforms occur during winter months as a consequence of agricultural land drainage, transporting animal faeces, and urban drainage to the system. Similar levels are not evident during summer because inputs are low and point source pollution is not significant (Table 24).

### 3.3.2 E. coli Levels in Discharges to the Estuary

High coliform levels (Table 25) recorded in drains with largely sewered catchments (Spring Street, Claisebrook, Brook Street, Airport Middle) are due to urban runoff from gardens, roads, parks, etc. Frequently stormwater carries animal faeces into the river contributing to coliform counts.

TABLE 24: Coliform Classifications of Swan Estuary River Sites (November 1979 - April 1985)

| | Percentage of Recordings | | | |
|---|---|---|---|---|
| | GOOD | SATISFACTORY | REQUIRES INVESTIGATION | UNSATISFACTORY |
| Walyunga | Good 79% | 5 | 5 | 10 |
| Upper Swan Bridge | 36 | 14 | 43 | 7 |
| Barrett Street | 41 | 18 | 27 | 14 |
| Middle Swan Bridge | 35 | 35 | 13 | 17 |
| Meadow Street Bridge | 48 | 17 | 22 | 13 |
| Kingsley Street | 56 | 22 | 9 | 13 |
| Forbes Street | 74 | 4 | 13 | 9 |
| Milne Street | 70 | 9 | 13 | 9 |
| Maylands Swimming Pool | 70 | 13 | 13 | 4 |
| Sandringham Hotel | 74 | 4 | 9 | 13 |
| Maylands | 83 | 4 | 4 | 9 |
| Causeway - Milne Street | 87 | 0 | 4 | 9 |
| Hill Street Perth | 78 | 4 | 13 | 4 |
| Narrows Bridge | 70 | 13 | 9 | 9 |
| Lucky Bay | 88 | 0 | 12 | 0 |
| Pelican Rocks | 91 | 0 | 4 | 4 |
| Pelican Point | 83 | 4 | 4 | 9 |
| Armstrong Spit | 91 | 0 | 9 | 0 |
| Blackwall Reach | 87 | 9 | 4 | 0 |
| Fremantle Traffic | 74 | 17 | 9 | 0 |
| MacKenzie | 36 | 45 | 4 | 14 |
| Herbert Street | 50 | 36 | 4 | 9 |
| Nicholson Road | 45 | 27 | 9 | 18 |
| Riverton Bridge | 43 | 28 | 19 | 10 |
| Salter Point | 78 | 9 | 4 | 9 |
| Canning Bridge | 87 | 4 | 9 | 0 |

TABLE 25: Coliform Classifications of Swan Estuary Drains (November 1979 - April 1985)

| | Percentage of Recordings | | | |
|---|---|---|---|---|
| | GOOD | SATISFACTORY | REQUIRES INVESTIGATION | UNSATISFACTORY |
| Spring Street | 9 | 13 | 17 | 61 |
| Claisebrook | 0 | 0 | 13 | 87 |
| Peninsular Road | 41 | 27 | 23 | 9 |
| King William Street | 87 | 9 | 0 | 4 |
| Kitchener Road | 50 | 23 | 4 | 23 |
| Brook Street | 28 | 14 | 33 | 24 |
| Bennett Brook | 32 | 59 | 4 | 4 |
| Ellen Brook | 6 | 29 | 59 | 6 |
| Jane Brook | 33 | 33 | 33 | 0 |
| Helena Road | 36 | 28 | 7 | 13 |
| Airport North | 60 | 20 | 7 | 13 |
| Airport Middle | 38 | 14 | 10 | 38 |
| Airport South | 43 | 22 | 13 | 22 |
| Belmont Creek | 28 | 33 | 14 | 24 |
| Belmont M.D. | 56 | 26 | 9 | 9 |
| PCC - Causeway | 53 | 18 | 12 | 18 |
| PCC McCallum Park | 76 | 14 | 0 | 10 |
| Manning M.D. | 68 | 14 | 0 | 18 |
| Collier Pines | 84 | 5 | 10 | 0 |
| Wilson M.D. | 81 | 5 | 0 | 14 |
| Mills M.D. | 23 | 23 | 14 | 41 |
| Wharf Street | 30 | 50 | 10 | 10 |
| Cockram M.D. | 24 | 19 | 10 | 48 |
| Lacey Street | 24 | 5 | 43 | 28 |
| Yule Brook | 27 | 23 | 32 | 18 |
| Bickley Brook | 21 | 43 | 7 | 28 |
| Helm Street | 10 | 20 | 30 | 40 |
| Ellis Brook | 56 | 22 | 11 | 11 |
| Southern River | 45 | 32 | 9 | 14 |
| Thornlie Golf | 41 | 23 | 23 | 14 |
| Bannister Creek | 14 | 18 | 45 | 23 |
| Riley Road | 57 | 14 | 10 | 19 |
| Marjorie Road | 38 | 28 | 14 | 19 |
| Modillion Avenue | 30 | 30 | 25 | 15 |
| Sixth Avenue | 73 | 9 | 14 | 4 |
| Bull Creek | 54 | 27 | 9 | 9 |
| Brentwood | 76 | 10 | 14 | 0 |

High coliform levels from largely unsewered areas (Mills, Cockram, Lacey Street, Yule Brook, Helm Street, Bannister Creek, Ellen Brook) can be attributed to urban runoff as well as seepage from septic tanks. These sources of coliforms in drain discharges are not easily traceable.

Health risks created by the ingestion of faecal coliforms are low in the Swan Estuary. Some areas of the river system experience high levels of contamination during winter when agricultural and stormwater runoff is high. However, water contact activities are lowest during this period, reducing the probability of users ingesting these organisms.

## 3.4 Industrial Discharges and Licences

A number of industries in the Perth Metropolitan area use the Swan River Estuary as a discharge point for treated waste waters. These industrial discharges are monitored by the Swan River Management Authority and Water Authority of W.A. Each industry discharging effluent into the Swan River must apply to the SRMA for a disposal licence. If approved, the licence will contain a set of specific conditions relative to that industry. Conditions include time and place of discharge, nature and composition, temperature, the rate and volume of discharge (including maximum), and monitoring conditions.

In 1984-85, twenty one industries were licenced by the SRMA to discharge either directly or indirectly into the Swan River. Table 26 shows the range of industries licensed by the SRMA, the location of the discharges to the river and the contaminants that are controlled by licence conditions.

Industrial waste discharges are treated to reduce oil, grease, surfactants, suspended material and other pollutants to acceptable levels before discharge to drains and the river. Sampling for these parameters gives an indication of the effectiveness of treatment and potential pollution problems. Surveillance is maintained by sampling industry discharges, the main stormwater drains at three monthly intervals and periodic inspections. When pollution is detected it is traced back to its source and appropriate action taken. The Authority works closely with Water Authority of W.A. and Local Government.

Careful monitoring of industrial discharge helps to ensure that the water quality of the Swan Estuary is maintained. Without this power to control industrial discharge the water quality of the system would suffer.

TABLE 26: Industries currently discharging into the Swan-Canning Estuary

| INDUSTRY TYPE | DISCHARGE POINT TO RIVER | DISCHARGE |
|---|---|---|
| Swimming pool | Bicton | Treated filter backwash water |
| Machine Workshop | South Guildford | Suspended solids, Oil and grease, Coolant water |
| Aerated waters and cordial manufacturers | Cannington | Total solids, Oil and grease, pH, surfactants |
| Laundry | Direct to river North Fremantle | BOD, Suspended solids, Total solids, Oil and grease, pH |
| Plaster & Plasterboard manufacturers | Cannington | Suspended solids, pH |
| Sugar Refining | Direct to river Mosman Park | Cooling water |
| Rail car Maintenance Depot | Claisebrook drain East Perth | BOD, Suspended solids, Oil and grease |
| Wool Scouring | Direct to River North Fremantle | BOD, Suspended solids |
| Monumental masons | Bayswater | Suspended solids |
| Brewing | Cannington | BOD, Suspended solids, nutrients |
| Cement and Lime Manufacture | Rivervale | Lime seepage (pH) |
| Plaster Manufacture | Bayswater | BOD, Suspended solids, Oils and grease |
| Soft drink manufacture and bottle washing | Bayswater | BOD, suspended solids |
| Fertiliser manufacturers | Bayswater | Nutrients |
| Fibre Cement Product manufacturers | Cannington | Dissolved solids, pH |
| Brick manufacturers | Midland | Suspended solids, Oil & grease |

On the whole licencees comply with conditions set out, while upper limits are exceeded by certain industries on occasions. The degree of monitoring varies greatly in terms of what is measured, frequency and reporting. The Authority is currently reviewing the licensing of industries with the aim of rationalising conditions between industries and improving the quality of these discharges.

## 3.5 Accidental Spillages

Several land spills of acids, pesticides, petrol and oil have occurred in recent years (Table 27). Since nearly half of Perth's stormwater drainage system discharges into the Swan River, there is a high risk of spillages entering the system. The impact of a spillage depends on its toxicity, the volume spilt and the location of spill to the river (the dilution and flushing capability of the area of water will affect the impact).

Spillages directly to the river could occur at refuelling facilities (yacht clubs, marinas, Barrack Street Jetty, etc), the airport drainage system (which combats spillage with a large oil and grease trapping system) and the sullage pumpout facility at Barrack Street Jetty.

The affects on the biota (particularly prawns and fish) may be lethal or sublethal depending on the nature of the spillage. There may also be serious ecological damage to the river system, such as reduced oxygenation of water due to floating petrol or oil.

Recent development of emergency procedures by the Fire Brigade and Police Department mean that the SRMA is contacted when any spillage occurs in the metropolitan area.

Authorities that may be involved in cleanup operations include: SRMA, W.A. Fire Brigade, Police Department, Department of Conservation and Environment, State Emergency Services, Water Authority of WA, Local Government, Health Department of WA, and Mines Department.

## 3.6 Sewage

Treated sewage has not been discharged into the Swan River since 1936 when it was diverted from the filter beds on Burswood Island to the Subiaco Treatment Plant (Swan River Reference Committee, 1955). Problems of direct sewage discharge now only arise from illegal dumping into stormwater drains and sewage pump station failure (Chapter 7). Untreated and treated (depending on the degree of treatment) sewage can cause many water quality problems including increased nutrient levels,

| DATE | SITE OF SPILL | SPILL TYPE AND AMOUNT | ACTION TAKEN |
|---|---|---|---|
| 30-31.1.80 | Barrack Street Jetty | Diesel 30 000 L | Cleared using oil pollution equipment |
| 16.11.82 | Precision Marine | Oil 20-30 gallons | Washed into harbour on ebb tide |
| 22.12.82 | Barrack Street | Diesel oil 10-15 L | Allowed to disperse and evaporate because of small size |
| 27.7.83 | Royal Freshwater Bay Yacht Club | Diesel fuel | Leak in fuel system repaired |
| 24.9.83 | Cale Street East Perth | Oil | Appeared to be from bilge discharge. Allowed to disperse |
| 10.5.84 | Westrail | Diesel 600 L | Contained before reaching river |
| 17.5.84 | Garratt Road & Guildford Road | Petrol 4000 L | Contained before reaching river |
| 29.5.84 | Welshpool | Diesel/oil spill | Contained in ponds on site |
| 25.2.85 | Garratt Road | Hoegrass (pesticides) 150 L | Contained in stormwater before reaching river |
| 29.3.85 | Kitchener Street & Burswood Road Rivervale | HCl 15-40 L | Diluted in ornamental ponds then discharged to Swan River |
| 23.4.85 | Garratt Road & Guildford | Petrol 10700 L | Contained before reaching river. Minor leakage to wetland |

TABLE 27: Accidental Spillages with the Potential to enter the River System (WWC Files) (November 1979 - April 1985)

increased BOD resulting in decreased dissolved oxygen (DO) levels leading to fish kills, odour problems, floating material and bacterial contamination. Leaching of nutrients and bacteria from septic tank systems also pose problems to water quality although sources are not easily traceable.

The correct siting of ablution facilities in parks and reserves along the foreshore and extending reticulated sewerage to septic tank areas will minimise septic tank seepage to the estuary. A precedent has been set for the connection of such buildings to sewer. The majority of the general boating public do not have any form of sullage holding facilities on their boats and one can only assume that waste waters are discharged directly into the river. As a consequence nutrient enrichment and health problems may be exacerbated. At present the Waste Disposal from Marine Craft Steering Committee (convened by the Health Department of WA) is reviewing waste disposal from boats including legislative control.

### 3.7 Dewatering

Dewatering occurs at many building sites throughout the metropolitan area and this water is often discharged into the urban drainage system. Potential effects of this water on the river system involve increased turbidity, localised pH changes and siltation around the river outlet pipe resulting in habitat changes. The Waterways Commission is currently studying the possible effects of such discharges on water quality and aquatic life in the Swan Estuary.

### 3.8 Factory Breakdown

Toxic substances may enter the river drainage system in the event of factory breakdown. The impact of the discharge will depend on the chemical and volume involved, proximity to the river and location of the spill on the river.

### 3.9 Algal Pollution

The algal community of the Swan-Canning Estuary is diverse (429 spp of macro and micro algae - see Chapter 4). This diversity is indicative of a 'healthy' environment. Frequently, however, blooms of algae occur during spring and autumn. These blooms may be extensive over a large area, or found in isolated pockets.

Available data (WWC files) indicates that blooms of Chlamydomonas occur in spring/summer, Euglena in summer, Cryptomonas and dinoflagellates in autumn. In spring Chlamydomonas blooms are generally confined to the lower reaches of the estuary. As salinities in the upper reaches increase so the bloom moves upstream with optimum salinity. Euglena and Cryptomonas are fresh water species and are limited by salinity. Therefore, algal blooms are also dependent on salinity as well as nutrients, light, etc.

The recording of algal blooms depends upon reporting by field staff and the general public. Blooms of vibrant colour (eg Chlamydomonas or Euglena-bright green) are more readily observed than a brownish coloured bloom (eg Cryptomonas-brown), so bloom data is biased toward the most obvious blooms. There has been more frequent reports of blooms upstream of the Causeway where brackish water creates the most optimal conditions for many algae. Information available is limited as no monitoring programme for bloom conditions has been implemented.

### 3.10 Fish Kills

The death of large numbers of fish may be associated with oxygen depletion, temperature, ammonia toxicity, and other toxins (D'Adamo & Lukatelich, 1985) such as those emitted by dinoflagellates. Over the past five years the SRMA has received only five complaints concerning fish kills in the Swan-Canning Estuary. The number of fish observed range from a few up to 400-500 (Middle Swan : 2/3/83). The causes of fish deaths in this estuary appear to be associated with illegal and legal netting and the decomposition of algal blooms. However, it is not always possible to ascertain the cause of death.

### 3.11 Aquatic Weeds

The Australian landscape is littered with examples of exotic plants that have been introduced to the environment and then become weeds. Aquatic plants capable of reaching nuisance levels usually require slow-moving or still water and a plentiful nutrient supply (Lee, 1979). The APB has declared ten (10) aquatic weeds as noxious in WA. These are:

Alligator Weed : Alternanthera philoxeroides
Arrowhead : Sagittoria montevidensis
Elodea : Elodea canadensis
Lagarosiphon : Logarosiphon major
Leafy Elodea : Egeria densa
Parrot's Feather (Brazillian Water Milfoil) :
Myriophyllum aquaticum

Sagittaria : Sagittaria graminea
Salvinia : Salvina molesta
Water Hyacinth : Eichhornia crassipes
Water Lettuce : Pistia stratiotes

Salvinia and Parrot's Feather are the only weeds recorded in the estuary (SRMA files and APB). These plants are restricted to the fresher upper reaches of the estuary (particularly the Canning River which has high nutrient levels) and drains as they cannot tolerate saline conditions. Salvinia in the Canning River has been eradicated by allowing marine water upstream of the Kent Street Weir and the use of herbicides and mechanical removal. The SRMA policy on the spraying of aquatic weeds prefers winter as chemicals will be diluted minimising the impact on non-target organisms.

### 3.12 Boating and Motor Vehicles as Sources of Oil and Petrol

Stormwater runoff from roads and discharges from boat engines introduce oil and petrol to the estuary. These create a film on the water resulting in oxygen depletion increasing oxygen demand and the tainting or coating of organisms. Although the contribution of oil and petrol from roads may not be as large as industrial discharges, increased road development around the estuary foreshore in the future will raise the potential of this becoming a major pollution source.

Petrol, oil and diesel from recreational vessels can accumulate in heavy use areas. Problems will be amplified in areas of reduced flushing or poorer water quality of the upper reaches.

Increased facilities for boating (such as launching ramps, refuelling facilities, marinas etc.) now and in the future will affect the amount of oil and petrol polluting the estuarine system.

### 3.13 Drainage and Filling of Wetlands

Wetlands serve an important function by storing nutrients and regulating their passage into the estuary. Wetlands also have the ability to remove contaminants (various hydrocarbons and heavy metals) from estuarine waters (AMSA, nd). For this and other reasons management opposes the filling and drainage of wetlands on the foreshore.

### 3.14 Landfill and Tipsites

All sanitary landfill sites on the foreshore of the river system have been closed down although dry industrial waste sites are still operating (ie builders' rubble).

The potential impact of leachate discharge on the river environment is nutrient enrichment toxic substances. The composition and pathway of the leachate discharge means that in isolation the impact from a landfill site is only moderately significant. However, the cumulative affect of nutrient input from urban drainage and other landfill sites increases potential problems, particularly during periods of no river flow (summer). Leaching will be greatest on porous mediums such as Bassendean soils. The impact of leaching of toxic substances usually associated with sanitary landfill has not been investigated. However, leaching of phosphate and ammonia detected from Belmont Rubbish Tip supports the assumption that other polluting substances are entering the river from these sites (SRMA, 1982).

## 3.15 Recreation Facilities

The development of recreation facilities adjacent to or on the river provide the potential for changes in water quality. The fertilisation and reticulation of lawn areas, particularly on porous soils, can lead to nutrient enrichment of adjacent waters. Ablution facilities also provide the possibility of nutrient leaching. As these are usually sited near swimming or water ski areas, algal blooms or excessive weed accumulation are undesirable.

Yacht clubs encounter problems of petrol, oil and diesel accumulation in mooring areas. These products enter the river from bilges or spillage during refuelling (Section 3.5 and 3.12). Heavy metals from antifouling chemicals are known to accumulate in sediments (Section 3.2) and nutrient enrichment can arise as a consequence of sullage removal (Section 3.6).

## 3.16 Canals

Canal developments have the potential to create water quality problems because they are artificial waterbodies and are generally not as thoroughly flushed as the main waterbody.

Changes in salinity and pH, lack of flushing producing a stagnant water body, and increased nutrient input from high density developments are all problems associated with canal waterways. Urban drainage from residential development discharging directly into the canals will increase the problem. For this reason the Canal Steering Committee (Anon, 1984) recommended that no waste water discharge be allowed into these waterways.

The EPA (1982) reporting on canal development at Mandurah suggested that nutrient input into canals may increase due to runoff from garden areas. Moreover, building and dredging of the canal can also result in the release of nutrients.

Problems associated with recreational boating may also increase in these areas because residents are more likely to own boats and use them more frequently.

## 4.0 The Future

The maintenance of water quality and control of pollution problems is dependent upon continuing management.

### 4.1 Current and Future Research

1. The Waterways Commission is currently assessing the use of chromium and zinc in air conditioning units.

2. A study of heavy metals in the sediments of Perth Water is currently underway at the Department of Geology, UWA. This study will contribute to the assessment of metal accumulation in the estuary.

3. A study is to be conducted on heavy metal accumulation in edible mussels throughout the Swan Estuary. The aim of this research is to determine bioaccumulation in the estuary.

4. The Commission is currently reviewing licensed industries with the aim to rationalise industrial discharge conditions and improving the quality of these discharges.

### 4.2 Recommendations

1. Changes in benthic communities as a result of water quality conditions is difficult to determine. The use of biological sampling as a complementary monitoring programme to quarterly sampling is recommended. A preliminary study into the cost-effectiveness of such a sampling regime is recommended.

2. Sediments act as a sink for many compounds (pesticides, heavy metals, nutrients, etc). A comprehensive investigation into levels of pesticides, heavy metal and nutrient accumulation is recommended for the entire estuarine system.

3. Intensive sampling of King William Street, Southern River and Walyunga be conducted to determine the annual nutrient load contributions of each of these major nutrient sources.

4. Implement an additional pesticide sampling site - Walyunga. The rural load of pesticides can then be determined.

5. Industrial discharge turbidity measures to be supplemented with suspended solids levels.

6. Cartage of toxic chemicals (e.g. petrol, pesticides) be improved to reduce the possibility of accidental spillages. Legislation of this type is supported by the Commission.

PLATE 6: Milyu Aquatic Reserve abuts the Kwinana Freeway

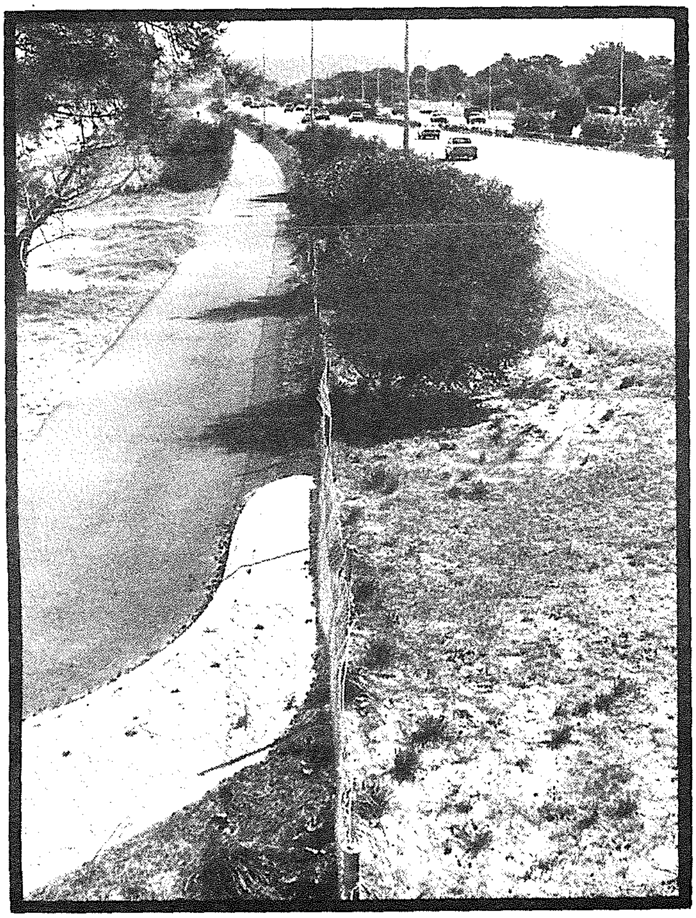


PLATE 7: Commercial Fishing

PLATE 8: Drain sampling

PLATE 9: As a result of industrial monitoring and licensing discharges of this nature no longer occur (photo Guildford, 1960)

# CHAPTER 7 : TRANSPORT NETWORKS AND UTILITY SERVICES

## 1.0 TRANSPORT NETWORKS

The Metropolitan Region Scheme (MRS) as gazetted in 1963 dictates much of the transport network planning for the metropolitan area. In additon to this, amendments and modifications to the scheme have occurred which have/will also affect the river environment.

Ever since its conception in the 1950's, the proposed transport network of the MRS has been publicly questioned due to its impact to date (and potential impact if it continues to follow the same path) on the river foreshore, in particular the inner city area, from both a physical and aesthetic view point.

Of particular concern to the SRMA is the view of some government department representatives that reference to road links in the MRS was and is ample justification to proceed without further investigation. Certainly such a view is not held by the SRMA. First because the Authority was not in existence at the time the scheme was gazetted and second, because man's knowledge of the natural functioning of the river environment and impact of man's activities has increased.

It is anticipated that the present review of the MRS and Corridor Plans will give the Waterways Commission and SRMA the opportunity to have our City planners seriously consider the impact that the proposed transport network will have on the river environment.

### 1.1 Past Development

Past development of roads adjacent to and bridges over the river system have in some cases required reclamation of the river. The Narrows Bridge and interchange resulted in 29 hectares reclaimed from the river for the approach roads to the Narrows Bridge and a further eight hectares for the interchange area. Prior to this project Perth Water was 356 hectares in area (MRD, 1984).

The Narrows Bridge was the keystone to development. However, its development was not without controversy. The Swan River Conservation Board (1969) comments that an Amendment was approved by Parliament restricting the permissable area to be reclaimed to two acres without Parliamentary sanction, and then only with approval from the Board. This Amendment was introduced following a public outcry when river reclamation was undertaken in Perth Water to provide for construction of the Narrows Bridge interchange.

The Main Roads Department states that "... as is the case in all great public works, none of these early steps were free from criticism and controversy. It seemed that everyone wanted a bridge, but not this one or if this one, not in this location" (MRD, 1984).

Similarly the extension of the Kwinana Freeway southwards from Canning Highway between 1979 and 1982 involved controversy because of its location on the Canning River foreshore and the necessity for further reclamation.

Effort has been made by the MRD to assist public access to the river following the construction of Kwinana Freeway with the construction of 5 footbridges along this section. A curved bridge was also built at Cloisters Avenue to provide access to a boat launching area on the river foreshore. Approximately 3 to 5 cars and trailers may be accommodated at this point but manoeuvreability is limited.

## 1.2 Future Road and Bridge Developments

According to the MRD (1984) one improvement of growing importance is the provision of additional capacity at the Narrows Bridge to meet predicted traffic growth. It is suggested the most practical and appropriate solution would be to widen the existing bridge. Such a project could provide sufficient width across the Swan River to enable the existing roads to function without the existing constriction at the bridge site. This solution should cope with increasing traffic for many years.

Considerable progress has been made with the development of the road system in the 'controlled access highway' reserves provided in the Metropolitan Region Scheme and it is expected that this progress will be continued.

In the short term the MRD will undertake the following projects within the Authority's study area:

- Work will continue on the Beechboro-Gosnells Highway to complete the link across the Swan River, including interchanges at Great Eastern Highway and Guildford Road, during 1987.

- Redcliffe-Bushmead Highway will be completed between Great Eastern Highway and Roe Highway in 1986 and assist bypassing traffic on the Guildford-Midland Road.

The question must be raised as to whether this will increase the pressure to develop the Redcliffe-Bushmead bridge and thus Swan River Drive or whether the capacity of Great Eastern Highway will be sufficient for traffic wishing to connect to Beechboro Gosnells Highway north from Roe Highway and visa versa.

- Work will accelerate in 1986/87 on the construction of the Burswood Bridge to provide a connection between Great Eastern Highway and the Hamilton Interchange.

  Once again the question must be asked whether this connection will increase the pressure for development of Swan River Drive to complete the scheme. If both Swan River Drive and the Burswood Bridge are completed a total 60 hectares of Burswood Island will be used for road interchange.

  Hipkins (1985) in a recent address to the Australian Institute of Urban Studies further questions whether the development of the Burswod Bridge will result in the original plan showing a connection from the bridge to Riverside Drive being resurrected. If so such a connection would undoubtedly require filling of the river; cause severe disruption to Trinity College; restrict access and eliminate carparking at Gloucester Park. The proposed roads would bisect East Perth and effectively cut it off from the river.

  Hipkins (1985) comments that the thought of constructing any roads that conceivably direct traffic along river foreshores and to Riverside Drive and the face of the City should be abandoned forever. Furthermore Riverside Drive is a city access road and should not have the function of accommodating regional traffic.

  The amenity of the foreshore is of prime consideration and regional traffic is incompatible.

  With the completion of these, and other projects not associated with the Authority's study area, the MRD anticipates that work could continue to further the development of a primary road network as shown in the Main Roads Department. Projects within the study area would include:

- Continuation of Roe Highway from Welshpool through to South Street. This would involve bridging of the Canning River between Beckenham and Langford.

- The progressive development of the North Perimeter Highway from Great Northern Highway through to the Mitchell Freeway will involve bridging of the Swan River. This connecting road will be in addition to Middle Swan Road and Bridge which will remain a service road.

### 1.3 Proposed Road and Bridge Developments

The MRD comments that a number of road proposals have proved to be extremely contentious in the past and are currently the subject of consideration by Government or are awaiting completion of planning studies. Comment is made by the MRD (1984) that whether projects are included and if so their extent in such cases will of course depend upon the outcome of the studies.

#### 1.3.1 Midland Western Link Road

A recent study of the Midland Western Link Road proposed various options to connect Eden Hill via Morley Drive or Walter Road to Midland via Morrison Road. All options put forward impinge to some degree on Bennett Brook in addition to crossing the Swan River. The former area has been identified as a System Six Reserve (M41). Burrel an William 1978) recommending in the Eastern Corridor Study that Bennett Brook should be considered as a linear parkland connecting Whiteman.

Development of the Midland Western Link Road is not expected before 2001, or more possibly 2010 and even then only if the increase in traffic warrants its construction. At present the EPA is reviewing the proposals. When the MRPA has this information and all public submissions on the project a decision will be made whether the amendment should be incorporated into the MRS. Because it would involve a major amendment to the scheme Government approval will be required (Ray Karvinen, MRPA pers. comm. 1985).

#### 1.3.2 Spencer-Chapman Road Link

The proposal in Amendment 250/31 and retained in Amendment 300/33 of the MRS is to bridge Manning Road over Leach Highway to Chapman Road and thence across the Canning River to Spencer Road. Currently the MRD is preparing an ERMP on the impact of the road crossing through the Canning Wetlands which will be reviewed by the EPA. The general area is indicated on the attached maps. The area is also a System 6 Reserve (M68) and the report comments that

> "the conservation value of any reserve would be significantly decreased by road developments." (DCE, 1983).

The initial proposal presented by the MRPA (1978) drew objections from persons and bodies who considered that the proposed crossing of the Canning River was unacceptable for environmental reasons. It is interesting to note that many of the submissions were from individuals living throughout the Metropolitan Region who were not directly affected by the proposals, but described their interest as 'concerned citizens' or 'voters'. Many claims were made regarding the ecological disruption and in particular the loss of both migrant and resident bird species.

It is inevitable that there will be complete physical modification of the environment along the alignment proposed, and some disruption immediately adjacent to it especially during the construction phase. Development of the road will result in the river foreshore being physically threatened at the following two locations:

(i) At Mason Street/Wharf Street where the edge of the proposed carriageway ranges from 30 to 40 metres from the rivers edge.

(ii) In the vicinity of the proposed bridge crossing near Liege Street where a small section of river foreshore (east and west bank), would be modified.

The variety of generalised comments clearly indicate a fear that the Canning River environment would suffer an amenity or aesthetic loss. More specifically, people are concerned with anticipated increases in noise levels and pollution from exhaust emissions that could have a deleterious effect both on the river environment itself (to users and wildlife) and on adjacent residents. Visual intrusion of the carriageways and bridge into what has long been a quiet, semi-rural river environment is also of concern. The latter point can to some extent be reduced. Unfortunately little can be done to reduce the impact of vehicle noise and this will most certainly result in a change in character of the local environment and will include a loss of tranquility and quiet rural character. Even though there would be an increase in overall public open space available (6ha at this location) the quality of the visitors experience would not be enhanced because of noise and visual pollution to the environment (MRPA, 1978).

Hipkins (1985) suggests that the concept to run a freeway down the Armadale railway line should be considered.

1.3.3 **Swan River Drive**

The construction of this controlled access highway involves the construction of two bridges over the Swan River. The MRD comments that it is unlikely to be constructed for many years. The approximate alignment of the road is illustrated on the attached maps.

Pen (1983) comments that the construction of the planned Swan River Drive will cause the destruction of some vegetation at Maylands and most of the vegetation at Bayswater, and Redcliffe. Of particular concern is the destruction of the Halosarcia complex that would result if Swan River Drive was constructed. It is suggested by Pen (1983) that the:

> " Large scale decrease in the distribution of the Halosarcia complex (H) may have serious consequences. H is one of the stages of succession, and if no significant stands exist to provide a source of seed, one of the links in the successional chain will be weakened or even broken. The efficiency of the vegetation system will be decreased and the subsequent communities will be of a degraded form".

The reservation of land for Swan River Drive and the uncertainty of the road's development must also be taken into account when planning for future development of the area. The City of Stirling is presented with this problem with regards Maylands Peninsula. Two management plans must be prepared, one making allowance for the road and the other without. Consequently, only points common to both plans can be undertaken until a definite decision is made on Swan River Drive.

Again Hipkins (1985) suggests using the railway alignment up the Guidford line in place of Swan River Drive. A freeway along the Guildford railway line would eliminate at least one if not two bridges to cross the river as well as avoid environmental disturbance to sensitive river areas.

1.3.4 **The High Road - Manning Road Link**

This link road was shown in the Stage 'A' Report (MRPA, 1978) as an option for investigation. However the SPC has since resolved for environmental reasons to take no further action to keep open this option between High Road and Manning Road.

Public submissions expressed concern about this proposal, particularly the chance that it may in the future be reconsidered.

## 1.4 Structures

Where bridges are to cross the river the SRMA assesses and advises on the following aspects:

- Height of the bridge and location of arches should not interfere with navigation.

- Provision for cycleway/footpaths either side of the river and under the bridge should be considered.

- Provision for access for SRMA maintenance vehicles should be provided.

- The concept of fishing platforms on new bridges is supported provided there is no fishing from navigation arches.

- Separate walkway/cycleway on bridges is also supported.

- The design of the structure should cause minimum impedence during times of flood.

In addition to the obvious structures of bridges there are also the problems of drainage associated with transport networks. The Kwinana Freeway foreshore is a clearly visible example of structures required for road drainage. These structures must be located so as to prevent scouring and accretion of the river foreshore. In the case of the Freeway, groynes have been established and attempts made to camoflauge the drainage outlets.

Road runoff also presents a potential pollution source to the river. This was further discussed in Chapter 6.

## 1.5 Public Reactions

The comment is made by the MRPA (1978) that there have been no attitude surveys to establish that there is a large body of opinion in favour of river foreshore roads. Equally there is no evidence that there is a total or even majority opposition. However, public reaction recorded by the media and public submissions to the MRPA and SRMA indicate when connecting roads impinge upon an environmentally sensitive area or run along the river foreshores (reducing access, or destroying the aesthetics of the area) a strong "anti" reaction will be observed. Moreover a survey assessing attitudes to conservation and environment in WA concluded:

> "Most people are happy to see conservation groups operating because they believe strongly in the need for conservation but were not willing or able to do much about it themselves" (Newman and Cameron, 1982).

All these factors must be carefully considered when assessing public reaction to road projects planned along river foreshores.

Public submission comments pertaining to transport are contained in Chapter 17, 1.6.

### 1.7 The Future

In 1977 Forbes and Fitzhardinge produced the Swan and Canning River's Activity Study. Addressing the issue of transport networks they concluded that the proposed Swan River Drive and upgrading of Riverside Drive should be abandoned and deleted from the MRS. Moreover all future river crossing and major needs located on river foreshores should be the subject of appropriate environmental studies.

Nine years later the questions are still the same and major roads are still proposed along or crossing the river environment. In fact new road developments appear to indicate that road networks are proceeding towards the ultimate plan first proposed by Stephenson and Hepburn (1955) in the 50's, with the additional links and feeder roads proposed in the MRS eventually being needed. Moreover as Hipkins (1985) points out, if the land has already been acquired, they will almost certainly become a reality.

If Perth is proceeding towards a metropolitan plan that includes Swan River Drive, the Spencer Chapman Link, the Midland Western Link and an upgrading of Riverside Drive then proposed development of other foreshore areas must be assessed with these factors in mind.

If these roads do not proceed then it may be feasible to permit small areas of foreshore to be modified for man's use. However, if the roads are constructed in the future (be it 10, 20 and 30 years), and in the mean time the few remaining foreshore areas have been modified what will be left?

## 2.0 UTILITY SERVICES

### 2.1 Water Supply

Provision of Perth's water supplies is the responsibility of the Water Authority of Western Australia (previously the Metropolitan Water Authority and the Public Works Department).

### 2.1.1 **New Facilities**

Options for increasing ground water recharge or augmenting the metropolitan water supply using tributaries of the Swan-Canning Estuarine System are being assessed. Table 1 summarises the planning information currently available for streams which have potential for development as future sources of water supply to the metropolitan area. Planning for the Canning River Schemes is fairly well advanced, however, the Avon Scheme is as yet only at the conceptual stage.

According to the Water Authority, further investigations are necessary to determine whether these schemes are feasible and, in this regard, the only studies currently in progress relate to Jane, Susannah and Ellen Brooks. These are preliminary studies only and much further work will be required before the feasibility of these sources can be confirmed. None of the potential sources is expected to be developed during the next sixteen years, based on the current long range projections of water consumption.

It is unlikely that any further development would occur on the lower diversion dam or Mundaring Weir. Increasing the height of the wall of the diversion dam would cause upstream flooding. The only possibility would be to increase the size of the pumps pumping from the lower diversion dam. Both Mundaring Weir and the lower diversion dam are fully integrated with the rest of the metropolitan water supply. Water may be transferred from Mundaring Weir to other dams or water may be pumped to the lower diversion dam for transfer to the Weir so the need to "upgrade" the Helena water catchment system is reduced.

The estimated utilisation of annual stream flow of the Helena River by the Public Works Department is 70-80% in the long term and 80-90% in the last few dry years, because Mundaring Weir has not overflowed.

From the point of view of the Waterways Commission, it is important to note that before any of these resources are developed, it will be necessary to submit the scheme to the Environmental Protection Authority for its approval. In any submission to the E.P.A., the effects of the proposed development on the flow regime downstream of the head works would be fully investigated.

Given the importance of the river environment to the people of Perth an E.R.M.P. should also assess the recreational opportunities provided by or lost through development of the water source.

### 2.1.2 Irrigation

Release of water for irrigation purposes occurs on both the Helena and Canning Rivers. Irrigators using the Helena River may request the release of impounded waters from the lower diversion dam provided water is still available. The water is then released until the irrigator's pools fill up. Water is not flushed all the way through to the Swan River, so for much of the summer, the lower Helena River is dry. The Public Works Department (now Water Authority) ceases pumping from the diversion dam to the Weir in October and does not re-commence until after the "clean-up" in late March, and the first rains have fallen.

Release of waters from the Canning Scheme usually occurs between about November and April each year at the request of irrigators under the Rights in Water and Irrigation Act, 1914 Amended. Water is released west of Butcher Road, Roleystone to downstream users.

### 2.1.3 Dams

Damming of both the Helena and Canning Rivers has reduced the flushing effect of river flow. Most certainly the incidence of flooding has also been reduced. Hodgkin (n. d.) reports that any damage to W.A. estuaries from this cause seems to be minimal so far. It can, however, be very destructive resulting in changes in flora and fauna composition and loss of habitats such as wetland areas. Periodic release of water from the two dams on the Swan-Canning Estuarine System maintains fresh water flushing of the upper reaches of the Canning and Helena Rivers. However, Chubb et al., (1979) comment that there are certain factors which have almost certainly contributed to the relatively small populations of indigenous fresh water fish species. Damming of the Helena and Canning Rivers is one and extensive 'drying-up' and increased ionic concentration of runoff from surrounding agricultural land experienced by the Avon River is another.

Provision of Perth's water supplies has also had secondary benefits on the environment and the people of Perth. Maintenance of the vegetation cover in the catchment area has meant that the problems of salination are considerably less than those of the Avon River.

Furthermore, the Water Authority has provided considerable recreational facilities at the many dam sites for the general public. However, because of potential water quality problems recreational use of the catchment area and waterbody itself is restricted. Calls for dams to be made available for water oriented recreation have been made in the past. The Water

Resources Council of W.A. closely reviewed the question of recreation on reservoirs and their catchment areas. However, it ruled out water sports such as boating and swimming on dams serving the metropolitan area (WAWRC, 1985).

## 2.2 Electricity and Gas Supply

### 2.2.1 Power Supply

The location of the metropolitan region to the river system requires that electricity and gas supplies must cross the river at particular locations. Forbes and Fitzhardinge (1977) suggested in their study that in the upper reaches power lines should be confined to 'crossing corridors' associated to road and rail bridges. Down river of Nicholson Road Bridge on the Canning River and the Causeway, on the Swan River overhead power lines should be prohibited from crossing the river. This view is supported by the SRMA.

### 2.2.2 Gas Supply

Since the Forbes and Fitzhardinge (1977) study the provision of gas supplies has meant the location of considerably more of these services on the river. New underground crossings are located at Viveash on the Swan River, Langford on the Canning and Bellevue on the Helena. The SRMA has required stabilisation and rehabilitation of the area after installation using natural techniques. However artificial stabilisation has been required in some instances. The former should always be attempted first, particularly as these pipelines are located in the upper reaches of the river where man-made modifications are fewer.

A more contentious issue has been the location of the Caversham-East Perth Lateral Dampier-Perth Natural Gas Pipeline Project along the river foreshore from Garratt Road, Bayswater to the East Perth gasworks. The SRMA supported the location, given the alternatives, provided that:

- The pipeline was located at the base of the escarpment, and not near the water's edge
- The preferred route was pegged, inspected and approved prior to earthworks commencing
- A rehabilitation programme was undertaken whereby native vegetation was encouraged and all exotic vegetation removed.

In its report and recommendations on the proposed pipeline project the EPA (1984) stated that:

> 'In accepting the preferred route, the EPA nevertheless recommends that river foreshores should not in general be used for siting utilities and that this proposal should not be used as a precedent.'

The EPA recommends that the SECWA report back to it six months, twelve months, and eighteen months after completion of construction of the pipeline with an assessment of the results of rehabilitation and environmental management. Attention should be paid to this matter by all parties as much of the area has been designated System 6 Reserves.

### 2.2.3 Power Station

The location of the East Perth power station and associated facilities on the foreshore presents a visually undesirable picture. Plans to revitalise the East Perth area as part of the Burswood Bridge-Northern Perimeter Bypass have reviewed options for future use of these buildings. The option to develop it as a community use centre, retaining public foreshore access is favoured by the Waterways Commission.

## 2.3 Sewerage and Drainage

The provision of sewerage and drainage facilities is of concern to the SRMA because of potential water quality problems associated with each service.

### 2.3.1 Septic Systems

In Perth over 100,000 households are serviced by private septic tanks. The effluent from these tanks is discharged into the sandy soils and is a potential source of pollutants for the shallow groundwater and river environment.

Estimates by Whelan et al. (1979) indicate that about 400 tonnes of phosphorus in solution is being discharged annually from septic tanks in the Perth area constituting an important potential source of phosphorus for urban water bodies. Similar estimates indicate that 2,200 tonnes of inorganic nitrogen is being discharged annually into soak well and leach drains, oxidising into nitrate and moving into the groundwater.

Given the potential impact of sewage leachate on the river environment the SRMA requires that buildings on the foreshore (or over the river) be connected to sewer, wherever possible. High density developments should not be permitted on the foreshore unless connected to sewer. If septic tanks must be installed then they should be sited so as to minimise any pollution of the river or tributaries.

### 2.3.2 Installation of Sewage Systems

The Water Authority is currently sewering in and adjacent to Underground Water Pollution Control Areas to reduce the risk of groundwater pollution from septic tanks and industrial waste. Infill services planned by the Water Authority for the five year period 1983-88 included areas of Midland, Bassendean, Morley, Balga, Eden Hills and Balcatta in the northern suburbs and Belmont, Applecross, Bateman, Booragoon, Cannington, Thornlie, Gosnells, Westfield, Redcliffe, South Guildford, Maddington, Kewdale, Victoria Park, Willetton and Rockingham in the south (MWA, 1983).

The installation of sewage systems requiress the location of pumping stations at various locations, some of which are located on the river foreshore. The Authority has in the past stated its objection to location of these structures on the foreshore as it sees it as undesirable to have any form of sewage entering the river, as would occur in the case of a system breakdown.

To reduce the potential impact the SRMA has required as part of the conditions for development of these structures:

- An approved alarm system be provided so that pump failures and overflow conditions are monitored.

- Full details of sewage overflow, if any, be supplied to the SRMA on a regular basis.

- The aesthetics of the structure to be approved by the Authority.

### 2.3.3 Drainage

The Water Authority's drainage system serves catchment areas as a whole by providing an outlet drain to dispose of surplus water collected by local govenment authority systems.

The fact that so much of the metropolitan region's drainage system is connected to the river makes it possible for many potential pollutants to be discharged into the river.

## 2.4 Sanitary Landfill

Nutrient enrichment of river water due to leachate discharge from tip sites (old and new) is a potential problem. In 1981, the SRMA and PHD lobbied successfully for the closure of these sites and all proposed sites to be relocated away from the foreshore. Dry industrial waste sites are still operating, e.g. Maylands Peninsula.

Pollution from sanitary landfill sites results from rain infiltrating the refuse, leaching pollutants through to the groundwater. There is also the added danger of leachate entering the river via direct groundwater run-off (Smith, 1985). Leachate production is dependent on the type and stage of decomposition of the waste, and the general degradation process (Smith, 1985). Consequently leachate may still be entering the river many years after the closure of the refuse site. Potential leachate problems are greatest on porous mediums such as the Bassendean soils which form many of the foreshore areas.

The composition and pathway of the leachate discharge means that in isolation the impact from landfill is only moderately significant. However, the cumulative effect of nutrient input from urban drainage and other landfill sites increase potential problems, particularly during periods of no river flow (summer).

To date the impact of leaching of toxic substances usually associated with sanitary landfill sites has not been investigated. However, leaching of phosphate and ammonia detected from Belmont Rubbish tip supports the assumption that other polluting substances are entering the river from these sites (SRMA, 1982).

The use of foreshore areas for sanitary landfill has in some cases restricted current and future use of these sites. The City of Bayswater is currently reviewing the feasibility of using leachate recycling measures to enable irrigation of the area without unduly affecting the water quality of the river.

At Ray Marshall Park, Guildford, Blackadder Creek has been relocated so that minimum drainage occurs through the tip site.

The establishment of the Casino on Burswood Island has also involved studies to assess the possible impact of the development on leachate movement and water quality.

Plans by SPC to redevelop the old Belmont Tip site will also have to address the problem of leachate.

Certainly even though sanitary landfill sites have been closed the problems associated with them still require further study and ongoing management programmes for these areas.

PLATE 10: Earthworks for the Redcliffe Bridge, due for completion 1986/87

PLATE 11: Earth works for Burswood Bridge

TABLE 1: Potential Sources of Water Supply to the Metropolitan Area

| NAME OF SOURCE | DEVELOPMENT CONCEPT | ESTIMATED UTILISATION OF ANNUAL STREAMFLOW | YEAR OF DEVELOPMENT (Indicative only) |
|---|---|---|---|
| AVON RIVER SCHEMES | | | |
| Jane Brook | Pipehead | 30 - 50% | )Subject to findings |
| Susannah Brook | Pipehead | 30 - 50% | )of feasibility and |
| Ellen Brook | Pipehead | 30 - 50% | )development |
| Wooroloo Brook | Dam | Approx. 75% | )programme studies-over |
| Brockman River | Pipehead | 30 - 50% | )a period of years |
| Red Swamp Brook | Pipehead | 30 - 50% | )commencing sometime |
| Julimar Brook | Pipehead | 30 - 50% | )after 2007/08 |
| CANNING RIVER SCHEMES | | | |
| Lower Canning River (At Araluen) | Pumpback | 50% | 2001/02 |
| South Canning | Upper Dam | * | 2004/05 |

NOTE: * An upper dam reduces the probability of the existing dam overflowing. This means that the streamflow utilisation ratio for Canning Dam would increase by approximately 10%.

Information, courtesy MWA (1984).

# CHAPTER 8 : DREDGING AND RECLAMATION

## 1.0 DREDGING

Dredging involves the removal of sediments in the river. Where hydrological processes have resulted in the accumulation of sediments reducing river depth maintenance dredging may be required. Alternatively dredging may be necessary for a new project. Removal of these sediments has disruptive affects on both the physical environment and the flora and fauna inhabiting the sediments and waters. The attached maps indicate dredged areas of the river.

### 1.1 Effects of Dredging in Estuaries

The impact of any dredging project on an estuary will depend on numerous, often inter-related factors, which are unique for each situation. EMAC (1976) assessing proposed dredging in the Blackwood River Estuary listed the following possible affects.

(a) Destruction of existing flora and fauna, especially marginal vegetation and aquatic macrophytes.

(b) Alteration of the physical dimensions of the estuary.

(c) Changes in dynamics of river discharge and tidal exchange with the sea.

(d) Changes in the salinity regime consequent upon (b) and (c).

(e) Destruction of habitats (especially marginal and shallow water habitats) and creation of new ones.

(f) Sorting of dredged material with consequent physical and chemical changes in composition of surface sediments, their granulometric composition and organic content.

(g) Suspension of fine particulate matter with direct effects on both fauna and flora.

(h) Turbidity of the water with reduced light penetration.

(i) Deoxygenation of the water as a result of resuspension of organic matter, resulting in increased bacterial activity and biochemical oxygen demand (BOD) and in reduced photosynthesis because of the turbidity.

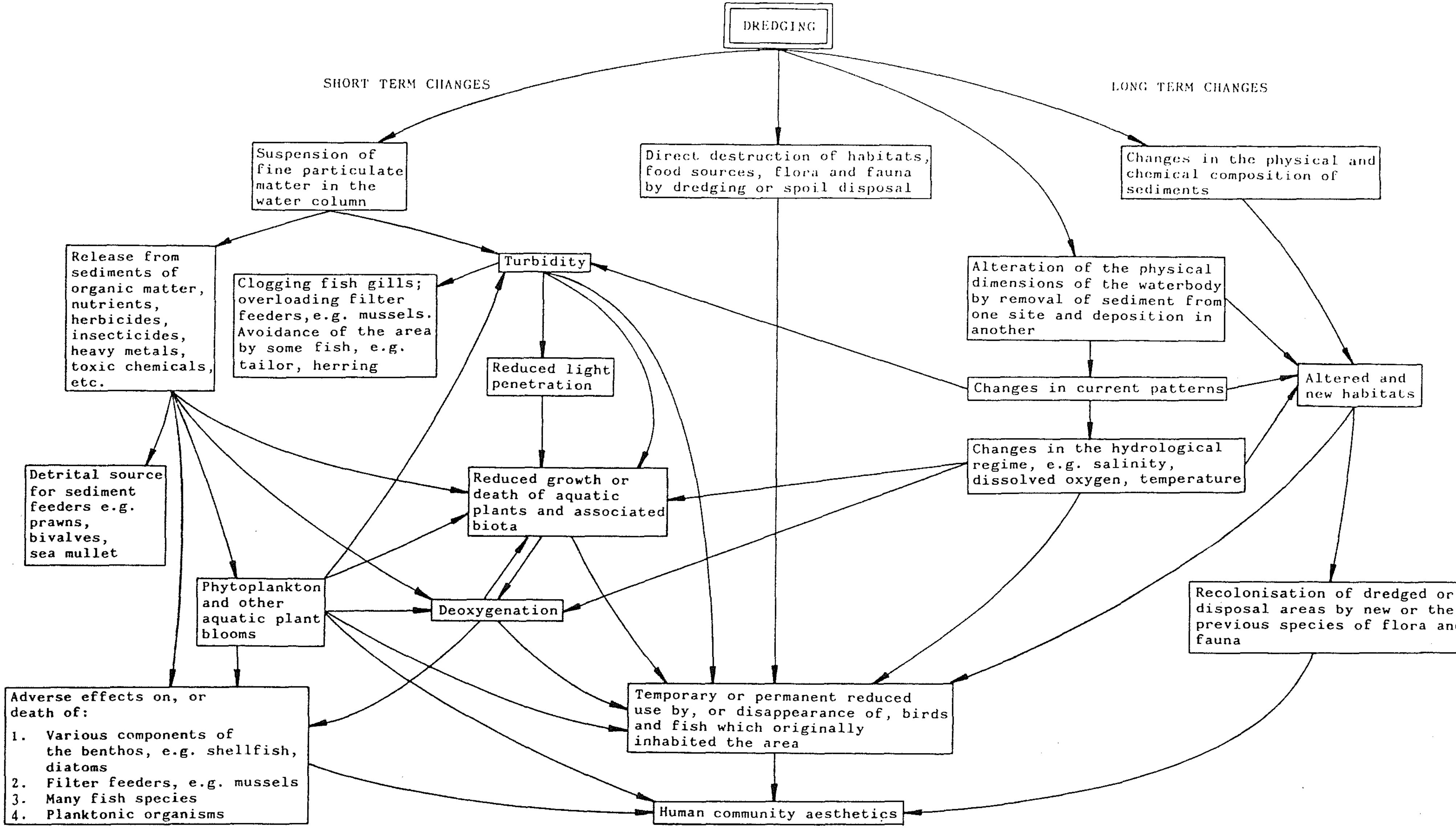



FIGURE 1: Possible Impacts of Dredging on the Estuarine Environment

(j) Nutrient release from suspended sediments.

(k) Changes in water chemistry, e.g. release of herbicides, insecticides, dissolved heavy metals, hydrogen sulphide and other toxic substances.

The environmental effects of dredging may be divided into two groups; short term and long term.

Short term effects are limited to the period of dredging and for some time thereafter. These effects are often seen in the temporary disappearance of an organism from the community, and result mostly from the turbid plume or cloud of suspended sediments in the water and removal or alteration of the habitat. Points (g) to (k) inclusive are considered short term.

Long term effects are difficult to identify and not able to be readily quantified. They may be seen in the death of an organism or its permanent disappearance from the area due to insurmountable disruption of the habitat. Long term effects may also result in decreased rates of growth, reproductive impairment and behavioural abnormalities in the organisms of the area surrounding dredging or disposal operations. Points (a) to (f) inclusive are considered long term.

Figure 1 summarises relationships between the short and long term changes in the estuarine environment which may be caused by dredging.

Further, there will be a gradient of disturbance decreasing with increased distance away from the dredged area. Some organisms are more resilient, or less affected by the more pervasive effects of dredging. Species diversity and productivity will be less affected with increasing distance from the dredging site. Filter-feeding animals, mussels and barnacles can be expected to be the worst affected and burrowing worms and molluscs will probably be less affected, while some species may benefit from the particulate organic matter (EMAC, 1976).

### 1.1.1 Importance of River Shallows

The most commonly dredged areas are the river shallows. Rogers et al. (1984) comment that of the 17.6% shallow banks between the Fremantle Traffic Bridge and the Narrows and Canning Bridges 8% have been deepened by dredging. Intensive dredging has also been carried out between the Causeway and Maylands peninsula.

Many shallow banks are covered by seagrass meadows and loss of these areas will result in the elimination of other biotic elements which use the grasses as a habitat, notably the epiphytic algae which are themselves important primary producers and a variety of invertebrate fauna (EMAC, 1976). Not so widely known is that shallow areas other than seagrass banks are also important feeding grounds for fish, other aquatic fauna and birds. The loss of any shallow banks will reduce the estuary's capability to sustain fish and bird life.

Hillman (1985) states that at peak biomass, the entire area of Halophila ovalis in the estuary represented approximately 350 tonnes dry weight of plant material, 4 200 kg of nitrogen and 630 kg of phosphorus. This was approximately ten times more carbon an twice as much nitrogen and phosphorus as contained in phytoplankton, the other major primary producer of the open water. Thus shallow waters containing seagrass were up to five times more productive then waters with only phytoplankton.

Comments by the Department of Fisheries and Wildlife (pers. com. 1982) state that shallow banks are extremely important for the majority of fishes in the river system; and different groups of fishes prefer different areas of the system. Removal of these shallow banks means that there is a reduction in the area available for the species which need to use such areas. This could well result in reduced estuarine population of, for example, school prawns and fish which are constantly in demand by professional and amateur fishermen. Thus, with respect to the effect of dredging proposals on fish and crustacea of the river system, the point that should be clearly understood is that the impact of individual operations, both past and present, should not be viewed in isolation, but collectively as they affect the entire assemblage of fishes of the river system. Moreover, the tidal area of the river system should be viewed as a single ecological system or unit, and not as being composed of a number of independent units. Therefore, it is neither possible, or desirable to indicate which areas should or should not be dredged.

More recently, submissions to Rogers et al. (1984) claimed that fish productivity in the estuary had declined significantly over the last two or three decades. These claims could not be easily supported. However, because the fishery is heavily reliant on the detrital food chain and the benthic invertebrate community (particularly amphipods) appears to play an important role in transferring seagrass carbon to upper trophic levels (Hillman, 1985), dredging has the potential to cause major changes in the composition of aquatic fauna. This would be to the detriment of the current recreational and commercial fishery resulting in a significant decline of fish abundance (Rogers et al., 1984).

Based on the above information high priority should be given for preservation of all shallow areas.

## 1.2 Re-Establishment of Dredged Areas

Recovery following dredging depends largely on the composition and thickness of sediment uncovered during the dredging process and that deposited, either immediately as spoil or as settled particles from a turbid plume. If there is any substantial change in sediment composition, the relative and absolute abundance of species may change considerably. On the other hand, if sediment composition is virtually unaltered, resettlement may occur by migration of the adult stages of active species, e.g. fish and crabs, and by hydrodynamic distribution of free-swimming or free-floating larval stages. A muddy bottom is likely to support a low diversity of fauna, but on a sandy mud the benthic fauna may be expected to recover at a greater rate (EMAC, 1976).

### 1.2.1 Benthic Invertebrates

In the immediate vicinity of a dredging operation, all elements of this fauna are likely to be adversely affected through the accumulation of suspended sedi ment. It is probable that species composition will differ from that before dredging. Worms, molluscs, small crustaceans and insect larvae are essential elements in the food chain, and food for most estuarine fish and birds. Usage of the dredged area by fish will largely depend on re-establishment of the invertebrate fauna as a food source.

Re-colonization by this fauna depends on water depth, sediment composition, duration of the disturbance, degree of alteration to water currents and regrowth of the aquatic flora.

Past studies of Pelican Rocks (a shallow area of Melville Waters adjacent to the Kwinana Freeway, South Perth) indicate that faunal recovery following dredging was found to be incomplete after a period of twenty years. Only two species out of eight probably common to the area prior to dredging had recolonised holes left after dredging in which fine sediment replaced sand (Wallace, 1977).

However, Wallace (1977) comments that re-establishment of benthic invertebrates can be more successful if the resultant substrate is of a coarser nature and the bottom is level, without deep enclosed holes. Notwithstanding this, any new substrate in more than 2 metres of water will have a less diverse and less abundant fauna than is present in existing shallow areas.

### 1.2.2 Free-Swimming and Planktonic Communities

Use of a dredged area by fish and plankton depends mainly on the re-establishment of an acceptable physical environment (i.e. low turbidity, good light penetration, good oxygen supply) and appropriate food source (e.g. invertebrate and detritus).

### 1.2.3 Aquatic Plants

Seagrass meadows and other plants grow mainly where there is adequate light penetration in shallow waters, and hence are often destroyed by dredging. In the Swan River, regrowth of the dominant seagrass Halophila ovalis depends on the success of vegetative regeneration from rhizomes in an area with an adequate supply of light, usually at a water depth of less than two metres.

Seagrass meadows are important feeding grounds for waterfowl and fish and also provide a habitat for invertebrate fauna which are a food source for many estuarine creatures.

### 1.2.4 Waterbirds

Long term affects on waterbirds depends on how the bottom contours are altered, since waders require shallow intertidal flats and waterfowl such as ducks and swans use water less than one metre deep. The presence of a suitable food source such as shallow banks with seagrass meadows and invertebrate fauna are important in attracting waterbirds. These are the same habitats on which most fish species depend; the deeper water is much less productive for both plant and animal food (EMAC, 1976).

## 1.3 Methods of Spoil Disposal

### 1.3.1 Sidecasting

The easiest and cheapest method of disposal is sidecasting, whereby spoil is deposited back into the waterway at a location where it is unlikely to be transported back to the original area. In essence the disposal site should be deeper than the dredged area. This method has an adverse effect on the estuarine habitat.

In the past it was thought that dumping of spoil in the deeper areas did not adversely affect the flora and fauna of the region, however, recent qualitative studies of Preston Point area revealed that re-establishment of flora and fauna in the deeper areas after spoil dumping (4-5 years ago) had been sparse. Lack of re-colonisation can be attributed to the strong tidal action in the area, consequent instability of bottom sediments producing a substrate unsuitable for many benthic organisms.

### 1.3.2 Reclamation

Another spoil disposal method involves the filling of low lying land (usually wetlands) with dredged material, provided the dredge material is suitable for fill.

Wetlands and low lying areas are important 'filter' areas, fauna habitats, breeding grounds for insects that are an important food source for various bird species. These areas also play an important role in water balance and drainage and in the maintenance of the quality of surface and ground waters. They also have the capacity to store nutrients and regulate their passage into the estuary as well as removing contaminants such as hydrocarbons and heavy metals (AMSA, n.d.). Use of these areas for deposit of dredged material would result in the loss of an already reduced and valuable foreshore environment.

### 1.3.3 Holding in Temporary Bunded Areas and Cartage Away to Disposal Sites

This method involves the pumping of spoil into temporary bunded land areas (or ponds) adjacent to the dredge site. Spoil is then allowed to settle out of suspension and carted away to an approved disposal site. Water overflow from these ponds is returned to the river and localised turbidity may result due to the fine material suspended in the water. Short term problems may also arise due to the disruption of existing recreation areas or the effects of noise and odour on adjacent residential areas.

The long term impact on the estuarine environment and surrounding areas, however, is negligible and for this reason this method of spoil disposal is favoured by the SRMA.

### 1.3.4 Ocean Disposal

Ocean disposal requires dredge spoil to be collected on dump barges and dumped in the ocean. The cost of employing this method can be excessive depending on the

### ASSESS THE PROPOSAL

- . Determine whether dredging is new or maintenance.
- . In the Swan and Canning Rivers only maintenance dredging is appropriate. Dredging shallow banks is not recommended.
- . Specify the method of dredging.
- . Name the contractor and dredge operator.
- . A licence to dredge must be obtained from all management authorities. Dredging for an extractive industry also requires permission from the Departments of Mines, and Lands and Surveys.
- . Define boundaries and depths of dredging.
- . Determine availability of monitoring results.
- . Determine whether dredging can be stopped in the event of unforeseen damage occurring, and who pays to correct the damage.

### ASSESS THE CHARACTERISTICS OF THE ENVIRONMENT

#### 1. Ecological Aspects

- . Evaluate the effect of this proposal with all existing proposals and in the control of previously altered habitats.
- . Determine the likelihood of occurrence and severity of each long and short term change shown in Figure 1 on the environmental effects of dredging.
- . Determine if up-to-date lists of flora and fauna in and around the waterway and spoil disposal site exist.
- . Establish the productivity of the dredge area or spoil disposal site for shellfish or any other commercial fishery.

#### 2. Physical Aspects

- . Analyse the sand budget of the system.
- . Study the hydrological consequences of larger-scale dredging.
- . Determine water characteristics (e.g. temperature, pH, salinity, dissolved oxygen content, nutrients).
- . Determine sediment characteristics (e.g. geology, topography, geochemistry).

#### 3. Dredging Material

- . Establish the history and present status of the area.
- . Determine;
  - physical properties (e.g. total amount and particle size expected suspended time and density),
  - biochemical properties (e.g. B.O.D., nutrients, toxins),
  - chemical properties,
  - biological properties (e.g. microbial content, accumulation and bio-transformation ability, tainting of fish and shellfish).

### SPOIL DISPOSAL

- . Spoil from dredging should not be;
  - dumped in the river system.
  - used for the reclaiming of "wetlands" adjacent to the river.
  - placed on a foreshore as a method of beach renourishment, unless it can be shown that material so placed will not eventually be eroded and deposited back into the river.
- . Spoil from dredging should be removed from the system and disposed of away from the system by either trucking away to land or barging to sea.

FIGURE 2: Points for Consideration in the Assessment of a Dredging Proposal

distance away from a suitable ocean dumping ground. Further, Commonwealth approval may also be required for permission to dump at sea.

## 1.4 Policy Statement

Analysis of the preceding information by the SRMA and its Committees resulted in the development of the following policy. New evidence regarding the impact of dumping dredge spoil into the deeps reinforces the stand taken by the Authority.

**Dredging Policy Adopted by the Swan River Management Authority Members, 19th November, 1981**

1. "Dredging in the river system *A should only be permitted in order to maintain existing navigational channels and boat harbours. Other dredging shall only be undertaken with the approval of the Authority on the advice of the Engineering Division, Department of Marine and Harbours.

2. Spoil from dredging should not be:

   a) Dumped in the river system.

   b) Used for the reclaiming of "wetlands" adjacent to the river.

   c) Placed on a foreshore as a method of beach renourishment, unless it can be shown that material so placed will not eventually be eroded and deposited back into the river.

3. Spoil from dredging should be removed from the river system and disposed of away from the system by either trucking away to land or by barging to sea. *B

*A The river system includes the foreshore areas where dumping of spoil could have adverse affects in eventually finding its way back into the area of the river from which it was removed.

*B Barging to sea could involve Commonwealth Government approvals".

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The cost to organisations requiring to dredge in the river should not be the responsibility of the Authority and should be considered by applicants as part of the organisation's overall planning and management of its assets.

## 1.5 Guidelines for Assessing Dredging Proposals

Each proposal must be assessed individually by the SRMA and costs in terms of damage to the environment evaluated against the reason for dredging. Figure 2 suggests points for consideration by the proponent and SRMA before a dredging proposal is approved.
Dredging modifies the environment, and consequently has some impact on it. The magnitude of this impact depends on the size of the dredging operation, the habitats disturbed, and spoil disposal.

Before approving a proposal, the need for dredging should be demonstrated and the environmental impact assessed. These should be weighed against ecoystem damage in the context of maintenance of the whole estuarine ecosystem.

## 2.0 RECLAMATION OF FORESHORE AREAS

Much of the foreshore land was wetland before settlement by European man and subsequent reclamation and clearing of these areas. Wetland areas can be defined as any lowland covered by shallow and sometimes temporary or intermittent waters, including marshes, swamps, bogs, wet meadows, pot holes, sloughs and river bottoms. Small shallow lakes and ponds are usually included in this group as well as water-logged soils (Riggert, 1974).

A study of the Swan Coastal Plain revealed that 75% of an original 265 275 ha of wetland had been reclaimed (Riggert, 1974). More specifically Rogers et al. (1984) state that more than 50% of foreshore vegetation of the Swan-Canning Estuarine System has been removed through land reclamation and foreshore development since 1942. The attached maps indicate reclaimed areas of the river foreshore.

Pen (1983) comments that until the 1880's water-logged soil or saline areas were unsuitable for agriculture or pasture development and consequently vegetation remained relatively intact. However, demands for city and urban development saw the initiation of a programme to reclaim many of these areas. Up to 1942 only two significant areas of peripheral vegetation had been destroyed, at Mill Point and between Mounts Bay and Crawley. However, since this date much has been destroyed by reclamation carried out to provide sanitary landfill sites, eradicate mosquito breeding areas, provide recreation areas and make lands available for city expansion and some has been destroyed by further clearing.

Between 1950 and 1971, 247.3 ha of foreshore tidal flat and flood plain land had been reclaimed along the rivers by using public refuse (PHD, 1974 as cited by

Pen, 1983). The reclamation of Burswood Island began in the late 1930's (soon after the removal of the sewage filter beds), using slag, dredging material, flyash demolition refuse and sanitary land fill.

## 2.1 Wetlands

When discussing the impact of reclamation on the river system, it is imperative to review the importance of wetlands; reasons for their reclamation; methods of reclamation and guidelines for protection and management of wetlands. Chapter 7 detailed impact of reclamation by sanitary landfill on the river environment and Chapter 3 looked at the consequences of reclamation on river hydrology and flooding.

### 2.1.2 Importance of Wetlands

Area for area wetlands exceed all other land types in wildlife production, providing a breeding ground for small animals (micro and macro invertebrates) and habitat for birds.

Wetlands play an important role in water balance and drainage and in the maintenance of the quality of surface and ground waters. Further they serve an important function by storing nutrients and regulating their passage into the estuary. Wetlands also have the ability to remove contaminants (various hydrocarbons and heavy metals) from estuarine waters (AMSA, n.d.).

The EPA comments that wetlands are among the scarcest resources in Western Australia (DCE, 1977). Consequently SRMA decisions should reflect this fact.

### 2.1.3 Reasons for Reclamation

The greatest threats to wetlands in Western Australia are:

1. Drainage and filling.

2. Pollution.

3. Erosion.

4. Water level changes.

5. Salination.

6. Aesthetic disruption.

7. Aquatic (declared) weeds (DCE, 1977).

### 2.1.4 Guidelines for the Protection and Management of Wetlands

Given the importance of wetlands to the river environment the following aspects should be considered when developing management strategies remembering that prevention is better than cure. Source (DCE, 1980).

- Future wetland preservation is not only dependent upon protection from physical destruction, but also protection of the quality and quantity of the water supply feeding the area.

- Where the wetland has the potential to improve its contribution for wildlife, or for recreation, it should be preserved and managed toward fulfilling this potential.

- Wetland conservation areas should include the water, fringing vegetation and a buffer zone of at least 20-30 metres.

- Residential or tourist developments which depend entirely on destructive filling of wetlands should be opposed.

- Future town planning should prevent inappropriate developments in flood-prone areas by rezoning.

- If a wetland is a known major mosquito breeding site, then this should be taken into account before locating residential development in close proximity to it.

- Industrial development relying on reclamation of a wetland area should be avoided, unless the value to the community of the industry in question outweighs the biological, recreational, social and other values of the wetland.

- The use of wetlands, especially river foreshores as sanitary landfill sites should be strictly avoided.

- Disposal of unwanted dredge "spoil", in deeper parts of the estuary on shallow banks or in estuarine wetlands, should not be allowed.

- Dredging of artificial canals for residential development of estuarine wetlands should not be allowed without a thorough investigation of the environmental consequences.

- Canal estates should not be permitted in areas where their development would lead to loss of valuable, productive wetlands whose continued existence would be of greater long term benefit to the community (in terms of recreation, aesthetic value, fisheries, etc.) than the development.

- Measures to alleviate effects of non-point source pollution are vital if water quality is to be maintained.

- High density developments should be deep-sewered and wastes diverted away from wetland areas, to prevent pollution by nutrients, bacteria, viruses and chemicals.

- Septic tanks and leach drains should be situated at least 2m above the expected highest level of the water table to minimise the leaching or flushing of pollutants from ground water. Septic tanks should never be located in areas of high water table and must conform with public health regulations.

- Septic tanks and leach drains should be set back a sufficient distance from the wetland to minimise the transport of pollutants (in the soil or in the ground water flow) to the waterbody. It is recommended that a minimum setback of 100 metres from any wetland be adopted (greater for high density developments).

- Open areas between leach drains and the waterbody should be well vegetated, as plants draw nutrients from the ground water system, thus reducing the levels of such pollutants reaching the wetland.

- Point sources of pollution should be discouraged in areas of high water table or high potential runoff. They should be sited on flat or gently undulating land away from creeks, streams or other wetlands.

- In the upper catchment pollution from agricultural runoff to wetlands should aim at reducing the amount of nutrients, pesticides, weedicides, herbicides and sediments reaching the waterbody.

- Although the ecological effects of insecticides and herbicides on the aquatic systems are still poorly documented there is increasing evidence to justify the concern that ecological changes do occur, particularly from their indiscriminate use.

- The forms of recreation compatible with the type of wetland and its alternative beneficial uses should be carefully considered.

- Recreation activity in and around the wetland should be restricted to passive, low impact forms compatible with the value of the wetland.

- Segregation of sports or activities which generate noise or cause other forms of disturbance should be considered.

- Formal development of foreshore areas should be maintained with minimum use of fertiliser and irrigation water which would add to nutrient loading.

- The pollution potential of urban stormwater runoff should be reduced by controlling the source of pollutants, reducing peak flow, removing large debris from stormwater and/or diverting stormwater runoff away from wetlands.

- Measures recommended to control eutrophication by reducing input to waterbodies include diverting nutrients, removing nutrients from discharge, using non-phosphate detergents and improving agricultural practices.

- Soil erosion in the wetland catchment, which could carry sediments and pollutants into the water body and alter drainage patterns should be controlled. Methods include redirection or detention of water, restrict clearing of vegetation, modification of slope, recontouring of eroded channels, restricting activities in areas prone to erosion.

- The possible effects of siltation and salination of water resources and of surface waters flowing into reserves should be considered before vacant Crown land is released for agriculture. The anticipated social and economic benefits of the proposed development should be weighed against the value of the water resource to the community before allowing the release.

- The effects of clearing on the water table should be assessed prior to release of further areas of vacant Crown land for agricultural or other development.

- Land use planning should take into account the potential salination consequences of clearing of vegetation to ensure minimal release of salt into catchment areas.

- As a general guide, clearing of native vegetation should be avoided in catchment areas, particularly in deep lateritic zones, where salt storage is high.

- The aesthetic environment of an area to be developed should be preserved to the greatest degree possible by integrating all facets of the development with the natural environment.

- Wetlands which are known to be significant mosquito breeding sites, (samphire-heath tidal flats associated with the Swan-Canning Estuarine System) should be evaluated to determine their worth as wetland environments, so that conservation needs can be balanced against the need for mosquito control.

- The potential of a wetland as a mosquito breeding area should be taken into account before consideration of locating residential development in proximity to it.

## 2.2 River Reclamation

The importance of the river shallows is well documented in the fauna section of this report. In the past, however, these areas have been dredged and/or reclaimed. Given their importance and past reclamation of these areas, Section 60 was incorporated into the Waterways Conservation Act to ensure that reclamation works cannot occur in the river without the Commission's approval. Areas of more than one hectare require approval of both Houses of Parliament.

PLATE 12: Flat open spaces, such as Burke Drive Attadale, are the result of reclamation by sanitary landfill

# CHAPTER 9 : FORESHORE WORKS AND MAINTENANCE

## 1.0 EROSION

Numerous factors influence and contribute to erosion of the river banks. These may be natural or man-induced. Where natural factors are such that they contribute to the natural sloughing of the river bank the impact of man-induced factors will be far greater.

### 1.1 Natural Factors

- **Water Velocity:** When the velocity of flowing water increases, the carrying power of the water body increases resulting in a greater probability of erosion.

- **Flooding of the River:** Flooding may raise the height of the river above any natural protection measures such as vegetation or bank slope. Flood waters are also likely to be of a higher velocity than normal river flow resulting in scouring of the river bank.

- **Tides:** The small tidal range of the study area means that any wave action is almost constantly centred on the same point of the bank, particularly in the upper reaches.

- **Meanders:** Banks on the outside of a meander are more vulnerable to erosion; conversely banks situated on the inside of a meander represent a depositional zone.

- **Slope of the Bank:** A sloping bank will be less inclined to erode than steep banks of similar texture as waves can ride up the slope dissipating wave strength.

- **Foreshore Vegetation:** Submerged and partially submerged vegetation such as Juncus reeds absorb and dissipate wave action. Further up the bank the root system of trees holds together the soil of the river bank. However, if erosion bares the roots and weakens the ground, the tree will topple into the water leaving the bank bare and severe erosion will occur.

- **Soil Type and Geological Age:** Banks of a coarse sandy texture are more susceptible to erosion than those of silt and clay. The natural forces of deposition and erosion will be very active where land forms are young in geological time.

- **Wind:** Waves generated by wind contribute to erosion through their constant pounding on the river bank. Storm events bring high water levels, gale strength winds and higher than normal wave action exacerbating the problem.

  Wave size is dependent on wind speed and width of "fetch" consequently wind erosion is usually minimal within a river but prevalent within the open waters of an estuary.

- **Snagging:** Retention of vegetatin within the river may have both a negative and positive effect on erosion vegetation which has fallen into the river may contribute to erosion by changing the pattern of water flow focussing it onto the river bank. Similarly it may stabilise erosion by acting as a silt trap.

  Desnagging, although necessary for safety navigation is also likely to increase erosion by removing the foreshore protection and increasing the velocity of flow.

## 1.2 Man-induced Factors

### 1.2.1 Boating

#### 1.2.1.1 Hull Design, Speed and Loading

The size of wash produced by power boats depends upon hull design, speed, loading of the boat and engine power.

The types of power boats that most frequently use Perth's river system are:

(A) **Displacement Hull:** A displacement hull will always produce a wash whether it be "pushing" or "pulling" water and generally the size of the wash increases with speed up to a point where it begins to decrease. The wash produced by these power boats is usually the lowest of all types when travelling below the 8 knot speed limit for the upper reaches of the Swan and Canning Rivers.

(B) **V Planing Hull:** The majority of boats using the rivers are of this type. These boats are low powered and produce a medium wash at speeds of less than 8 knots. However, a planing hull, which displaces little water at speed will create a minimal wash. Planing speed for this type of boat and about 4.5 metres in length is approximately 8 knots when empty. Unfortunately once loaded with equipment and passengers, the planing speed increases taking it above the permitted 8 knot speed limit for the upper reaches.

(C) **Deep V Planing Hull:** These boats are high powered and generally have a planing speed of about 10 knots when empty. However, because they must travel within the 8 knot speed restriction, these boats produce the greatest wash of all three types listed here.

As mentioned previously, loading of the boat can significantly increase the wash produced by power boats. The greater the load and further to the back of the boat, the lower the boat will sit in the water. Consequently a greater wash will be produced by all boats travelling within the 8 knot speed limit.

Heavily loaded planing boats do not have the opportunity of reducing their boat wash because they are required to travel within the 8 knot speed limit.

Towing of water skiers also increases the planing speed of a boat.

#### 1.2.1.2 Level of Use

The level of use of the river for power boating also has an impact on the erosion of the foreshore. Frequent use will increase the pressure on the resource and chance of erosion. Places where use is focused into a particular area such as launching ramps and designated water ski areas will be more prone to erosion.

#### 1.2.1.3 Speed Limits

Speed limits for the various sections of the study area are illustrated on the attached maps. It is important to note that speed limits introduced by the Department of Marine and Harbours are for safety purposes not purely erosion control.

Experiments during the 70's reducing the speed limit in the upper reaches of the river to 5 knots for erosion control proved unsuccessful as at this speed rear steerage boats are difficult to steer and manoeuvre.

Similarly, the chance of reducing boat wash and erosion in the upper reaches by allowing boats to travel at their planing speed must be traded for the safety of all river users.

### 1.2.1.4 Propeller Action

The majority of power boats using the rivers have exposed propellers. Dick (1978) suggests that minor erosion of the river bed may occur from the churning effect of propellers in shallow waters. However, the wash produced by boats in motion is a far greater erosive problem. The main consequence of propeller action is more likely to be resuspension of sediments which could adversely effect aquatic flora and fauna of the river. This was discussed more fully in Chapters 4, 5 and 8.

### 1.2.1.5 Water Skiing

Although ski boats reach planing speeds and boat wash is consequently reduced, it is probable that if "weak" banks are located near popular ski areas, then some additional erosion must result from extra wave activity (Anon, 1977). Type of skiing and turning of the boat can also increase boat wash generated by ski boats.

As it can be seen the various hull shapes, speed and loading of different boats produce a vast variety of wash characteristics for different boats in different situations, making regulation of boat wash extremely difficult.

Power boating and erosion are here to stay and planning for the river must take this into account. Erosion control methods used along river banks and verges must ensure that the very characteristics and qualities which have made them attractive are respected and preserved.

Where waters are difficult for power boat navigation (upstream of Middle Swan Bridge and Riverton Bridge) the question must be asked whether the many impacts of power boating and its users are compatible with the character and other "uses" presently made of these upstream areas or whether the area should remain "closed" to these types of boats.

As Dick (1978) states:

> "Management of rivers should not involve random patchwork repair programmes or simply supplying more and more access points when others become over-crowded, but should involve the careful prediction of future problem areas, the direction

of access to areas which can withstand future people and boating pressures as well as active measures to exclude or minimise human erosive forces from other more fragile areas".

### 1.2.2 Structures

The development of structures on or over the river can contribute to both erosion and accretion of the river banks and bed. For this reason it is imperative that approval of structures be undertaken by a managing body familiar with river hydrology and potential changes to river currents that these developments may induce. Structures such as bridges, jetties, stormwater drains, groynes, launching ramps and foreshore erosion control measures themselves all need to be correctly sited and installed so that problems of erosion, accretion and undermining of the structure are not accelerated.

### 1.2.3 Reclamation

Reclamation of foreshore areas may also include problems of erosion as the natural flow pattern of the river is interfered with. In many cases a normally stable gently sloping foreshore has had fill desposited and retained by a river wall. The purpose is to gain land area for a roadway, foot path, grass area etc. Consequently the objective is not so much to prevent erosion, but to maintain an artificial encroachment of land onto the river.

Because the wall in most places is an artificial barrier to wave action, it is undermined. (A log wall will absorb wave energy and a sandstone track wall will reflect wave energy).

Where walling is needed to provide level ground close to the river edge, these should be located, if possible, inshore of high water mark. They will then not be undermined, as many have been with the beach providing a buffer between the river and wall, for dissipation of wave energy. Moreover, a natural beach is likely to be a stable beach, whereas a beach formed by reclamation is likely to suffer erosion.

### 1.2.4 Passage of People

Launching and retrieving of boats not only has a direct effect on foreshore erosion in the form of wash produced while in motion but also indirectly in the many types of human activities associated with boat usage.

In cases where no launch ramp is availble, small boat users and sailboarders may be inclined to launch their craft over the banks. (NB Under the Waterways Conservation Regulations the launching of boats from trailers other than in specified areas is illegal. Launching of boats by hand over the bank is permitted.) This results in the trampling of vegetation and, in sandy, steep situations causes collapse of the banks. Consequently gaps appear in the mesh of reeds lining the foreshores which then become attractive to other river users.

Continued boat launching together with other human and natural forces act to erode these gaps until they enlarge into small embayments. Examples of indiscriminate launching can be found adjacent to Ascot Inn, along Melville Beach Parade, and All Saints Church, Upper Swan. At these sites sailboarders, water skiers and canoeists have been observed launching and retrieving their craft directly over the banks.

Beaching of boats on the foreshore also contributes to erosion both directly and indirectly. Many boat owners combine the days outing with a picnic on the foreshore. Inappropriate choice of site for these picnics can (and does) result in damage to foreshore vegetation when the boat is pulled up onto the beach. Ideally picnic sites should be established at sites along the river least likely to suffer from erosion. Alternatively public jetties may be appropriate in some situations. Boat owners should be encouraged to use these sites rather than tie up to a tree on the river bank and clamber up the bank.

Probably the greatest impact comes from members of boating parties trampling across foreshore vegetation and up banks to reach the foreshore proper. Examples of this can be found at Goodwood Parade and the upper reaches of the study area such as Middle and Upper Swan Bridges where canoes are frequently launched during winter months.

### 1.2.5 Stock Access

In many areas of the upper reaches of the rivers, land owners have land titles giving them riparian rights to allow stock access to the river and banks.

Concentration and persistent access of stock to the area does contribute to erosion. An example of this may be seen at Midland Abattoir where stock holding yards are adjacent to the Helena River bank and considerable erosion has occurred.

The Town of Bassendean has introduced by-laws restricting stock access to the river and a healthy growth of reeds and rushes can be seen in the area, compared with properties with the Shire of Swan.

In its administration of the Waterways Conservation Act, the Commission must be mindful of the interests of agriculture. However, as the metropolitan area expands and rural lands are subdivided, the SRMA should aim to limit stock access to the river, not only as a means of erosion control but also to reduce the incidence of localised eutrophication of the water body. The SRMA has instructed its Inspectors to prosecute persons who allow their livestock to cause erosion damage to the bank.

### 1.2.6 Worm Digging

In the past, digging for worms by fishermen has contributed to undermining of banks and foreshore walling aggravating erosion processes. For this reason, the SRMA has incorporated into its regulations a section dealing with this matter.

Provided people do not disturb the bed, banks, or foreshore of any waters so as to endanger the stability of any part of the banks, foreshore or vegetation, they may still dig for worms in the river. Should the person contravene this regulations they are liable to a fine of $200.

Areas where this activity may need to be restricted in the future are proposed aquatic reserves.

## 1.3 Erosion Works

In an assessment of erosion by the Swan River Conservation Board during the 1970's, it was noted that eroded spots were generally started by human activity. Some of these were attributable to worm diggers, passage along the banks of people and the bare earth being exposed to wash prior to regrowth of vegetation and, in some cases in the upper reaches to cattle drinking and grazing (Roberts, 1977). However, boat wash and flooding aggravated these initially small problems resulting in more serious problems.

A more recent study was undertaken by Officers of the S.R.M.A. in March 1984. Information has been recorded highlighting erosion areas and priority of works and this is updated as new situations arise. Projects include foreshore maintenance, experimental works, monitoring of erosion problems, new armouring works and land-oriented works. Under the terms of the Act, the

S.R.M.A. can carry out the first four points with referral to the M.R.P.A. Measures involving land orientated works requires Local Authority permission.

Particular sites and events around the river have been the subject of complaints about erosion and boat wash. These include:

- **Avon Descent:** Speed limits of craft competing in this event are not restricted and occasional complaints arise as a result. However, flood factors contribute far more to damage of the banks then a one off event such as the Avon Descent.

- **Middle Swan Bridge Upstream:** Recent complaints have surfaced about erosion upstream of Middle Swan Bridge. The S.R.M.A. does not desnag this area of the river as it feels the area should be left for non-motorised craft users. Consequently use by motorised craft is limited due to the hazard of navigation, and it is unlikely that much of the erosion occurring here is the result of power boat activity. It is more likely the result of natural factors such as vegetation snags in the river altering the direction of stream flow or flood events scouring the banks. To date, the Authority has not received any complaints from land owners concerned with erosion of their property. It would appear that they accept these events as "natural".

  There does appear to be a need for a study to be carried out to determine the number of motorised craft travelling upstream of Middle Swan Bridge. If figures indicate "heavy" usage then restricting use of these areas to power boats may have to be considered. One of the actions suggested in the Swan Valley Policy (Govt. of W.A., 1985) is to encourage the use of non-motorised craft on this section of the river. The SRMA supports this move.

- **Rottnest Island Ferries:** Public submissions to the project and a recent assessment of the problem of foreshore degradation south of Blackwall Reach by marina owners based in the area have highlighted the problem of boat wash from these craft, particularly the Sea Raider. The Authority has suggested that the best way of controlling damage to the foreshore by boat wash is to base the Rottnest Ferries at Fremantle. However, the economic impact to operators of these vessels and loss of a tourist facility would need to be addressed first.

- **Success Hill Bassendean and Guildford Bridge:** Concern has been expressed by the Local Authority and members of the public about this section of the river bank. This locality is steep and erosion has occurred over many years and the costs of rectifying the situation would be extremely high. Presently the S.R.M.A. is monitoring the river bed and banks at Success Hill in an attempt to arrive at a long term solution for their stabilisation.

- **Walyunga National Park:** Erosion of the river banks adjacent to the picnic area is considerable and is an example of what flooding can do to the stability of the river bank. The Waterways Commission Engineer has prepared plans to control and rectify this erosion.

There are many more sites around the study area where erosion control measures are required. Without a basic knowledge of the factors contributing to the problem it is difficult for the Authority to ascertain a suitable solution. Consequently there are occasions when a thorough investigation of the problem is required before any works are undertaken.

In the past, various methods have been used by property owners to combat erosion. These usually presented a poor, cheap and unaesthetic appearance. Treatments recommended by Government Departments were often costly and beyond the range of most people (Roberts, 1977).

The requirement is for something reasonably inexpensive but at the same time effective and aesthetic. Tree planting is one measure that the S.R.M.A. will assist with provided land owners take means to keep stock away from the trees.

Funding of erosion control measures is financed by the Authority. Such works are generally limited to public property because the high financial cost of projects makes it impossible to address all problems occurring within such an extensive management area.

In the past two years, a number of C.E.P. projects have enabled the S.R.M.A. to carry out extensive erosion control works. The most recent example is gabion walling adjacent to the Narrows Bridge, Mounts Bay.

River maintenance in the Swan and Canning Rivers has in recent years been carried out by the construction section of Marine and Harbours to the approval of the S.R.M.A.

TABLE 1: EROSION CONTROL METHODS

| LOCATION | METHOD | OBJECTIVE |
|---|---|---|
| Narrows Bridge, Matilda Bay | Rock filled gabion | Stabilise wall against wave action, flooding. Stop undermining of the wall and subsidence of the bank. Provide a stable base for cycleway. |
| Blackwall Reach Parade, Bicton | Vertical limestone walling | Protect drainage works. |
| Sandy Beach Reserve, Bassendean | Beach renourishment and timber retaining walls | Provide a beach at a popular swimming place using coarse sand less likely to be carried away. Retaining walls to protect tree roots to stop individual trees being undermined and falling into the river. |
| Burswood Island, Belmont | *Juncus* rush replanting | Dissipate wave action from ski boats. |
| Fremantle Traffic Bridge | Rock armouring | Protect foreshore from boat wash and strong wave action experienced in this part of the river. |
| Mill Point, South Perth | Vertical walling and groyne | Protect drains from erosion and provide a means of camoflouge. |
| The Esplanade, Mount Pleasant | Baffle board and rush replanting | To protect and maintain sandy beach. |
| Ron Courtney Island, Redcliffe | New channel cut and island created | To reduce the sharp bend in the river at White Cliffs by cutting a new channel, altering river flow and natural meander. |

Under the Waterways Conservation Act, approval must be given by S.R.M.A. for foreshore works. In this way, the S.R.M.A. can ensure that the most appropriate treatment is used, it is installed correctly and an element of uniformity is maintained around the river.

Where a land owner or lessee interferes with, or destroys foreshore vegetation, the Authority may issue an infringement notice requiring the foreshore to be "made good" to its approval. Accepting the desire of individual owners to develop their own land in a character they desire the Authority should impress upon land owners that the best way of achieving river bank stability is through maintenance and regeneration of the natural vegetation.

## 1.4 Erosion Control Methods

In choosing erosion control methods consideration must be given to appearance, significance of erosion, what the erosion affects and how. If feasible, the Authority will attempt to stabilise river bank erosion using natural vegetation and retain the natural appearance of the river.

Erosion control takes many forms which are divided into four categories:

- Limiting human and animal access to the affected area.
- Stabilising with vegetation.
- Beach renourishment.
- Provision of structures specifically designed to correct the situation.

Any combination of these factors may be used.

Table 1 illustrated examples used around the river.

## 1.5 Retaining Wall

Under Regulation 15 of the Waterways Conservation Regulations (1981) a licence is necessary to construct a retaining wall. However, there is no provision to license retaining walls as there is with jetties. A retaining wall must not be removed without first obtaining the written permission of the Commission or SRMA. The Commission may also by notice in writing require the person having control of the retaining wall to carry out such maintenance it considers appropriate.

Chapter 18, 8.0 details the Commissions policies.

## 1.6 Public Submissions

General comments dealing with erosion are contained in Chapter 17, 1.8.

## 2.0 FORESHORE MAINTENANCE

Routine beach cleaning, removal of sunken boats, rubbish and algae removal continues to be the major work-load of the SRMA. The extent of the management area limits the frequency of this work with beach cleaning focusing on the most popular reserve areas during the summer months.

Complaints received by the SRMA most frequently pertain to litter on the foreshore and adjacent swimming areas, or odour from decomposing algae.

| Year | Weight (Tonnes) |
|---|---|
| 1980/81 | 670 |
| 1981/82 | 548 |
| 1982/83 | 578 |
| 1983/84 | 680 |
| 1984/85 | 709 |

**TABLE 2:** Macroalgal material collected and removed from Swan River foreshores, front end loader operations.

In addition to macroalgal cleaning the Authority also removed approximately 215 tonnes of rubbish from the beaches in 1984/85. This figure is inflated during the prawning season when large amounts of blowfish are left on the foreshore by prawners. During December 1985 approximately 92 tonnes of blowfish were removed. The Authority must rely on the use of Local Government tip sites for disposal of this material.

At the request of CALM the Authority has discontinued its regular weed-clearing operations at Milyu Nature Reserve (Kwinana Freeway, South Perth) as these small deposits of decomposing aquatic plants provide ideal conditions for a variety of aquatic invertebrates which are an important food supply for the wading birds.

The Authority also undertakes regular inspections of popular swimming areas and underwater hazards are frequently removed. However, vandalism and the public's enthusiasm for disposing of their rubbish in the river make it difficult to ensure the safety of swimmers in these areas.

Field staff also assist with the removal of abandoned boats, securing of boats with broken moorings and pumping out of craft to prevent them sinking at their moorings. During 1984/85 field staff pumped out 83 boats.

Maintaining access to the river for SRMA maintenance vehicles is essential to ensure the efficiency of these operations.

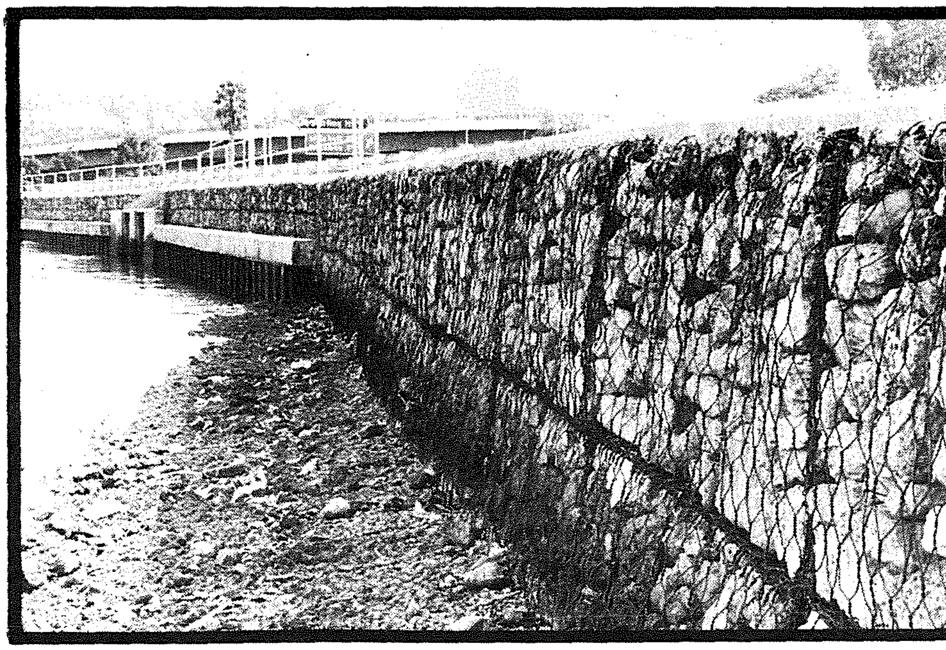

PLATE 13: Perpendicular Gabion Walling, Perth Water

PLATE 14: Foreshore works to protect vegetation, Bassendean

## CHAPTER 10 : LAND USE AND OWNERSHIP

### 1.0 THE PLANNING PROCESS

#### 1.1 Metropolitan Region Scheme

The Metropolitan Region Scheme, as mentioned in Chapter 2, is the major planning document for the metropolitan area. The State Planning Commission is the controlling body and in essence aims, as part of its responsibilities, to reserve and acquire the floodplain, the embankment and special natural features of all rivers, creeks and streams of significance within the region.

Rationalisation of MRS boundaries as declared in 1963 is an ongoing process and current areas of study are listed in Section 2.3.3 of this chapter.

#### 1.2 Corridor Plan

The Corridor Plan for Perth although not in itself a statutory plan is the adopted regional growth strategy. The plan proposes regional de-centralisation of some control area functions to sub-regional centres at Fremantle, Midland, Armadale, Rockingham and Joondalup.

The primary objectives of the Corridor Plan for Perth are to ensure:

- Maximum economic efficiency in future development of the Perth Metropolitan Region.
- An enhanced urban environment.
- The preservation of the essential character of non-urban areas (MRPA, 1970 as cited by Taylor and Burrell, 1978).

Both the Corridor Plan and MRS Scheme are currently under major review.

#### 1.3 Subdivision and Foreshore Reserves

When an area of land abutting a river, stream or creek of any significance is to be subdivided the SPC requires the subdivider to survey off approximately 30 metres of foreshore. Generally this land is required to be vested in the Crown under Section 20A of the Town Planning and Development Act. If the subdivider's title goes to the middle of the river they will probably give up more than 30 metres as the requirement is 30 metres from the river bank. If land is shown on a diagram of survey and the diagram of survey is approved by the inspector of surveys then under Section 20A at this point in time land shown in this way is automatically transferred to the Crown.

In most areas the subdivider cedes the foreshore free of cost as a condition of subdivision. However it does not mean that foreshore land cannot be purchased by the SPC.

It has been the Town Planning Board's policy for more than 20 years to request 30 metres of land free of cost in every subdivision abutting any river or stream of significance.

## 1.4 Local Government

Where the MRS is a general planning document, Local Government Town Planning Schemes detail land use of the area. Development of land within a MRS reserve or abutting a reserve must be referred to the SPC by the LGA.

Local Government Town Planning Schemes are reviewed every five years. During the course of this study many of the 20 Local Government Authorities were reviewing their schemes. One aspect that appears common in many of the inner city areas is the allowance of higher density housing although not necessarily abutting foreshore reserves.

It does suggest that recreation areas may be used more frequently and in greater numbers. For this reason high density housing is probably best located away from foreshore areas important expressly for conservation of flora and fauna.

Adequate off street parking should also be one of the conditions of development so that street and verge parking is available to foreshore users.

The SRMA has the opportunity to review Town Planning Schemes prior to their approval and it should make better use of this opportunity, concerning itself with the potential impacts of these zonings rather than tackling the problem after a development is proposed. Similarly Local Government Authorities should be mindful of the impact zoning may have on the river/foreshore environment.

The boundaries of the City of Perth and Town of East Fremantle protrude into the river. Consensus on developments usually occurs between the three bodies (i.e. SPC, LGA and SRMA). However under the terms of the Waterways Conservation Act this Act is deemed to apply in matters affecting the water environment.

Since initiation of many foreshore projects remains the responsibility of Local Government it is important that liaison be maintained between the SRMA and Local Government. Principally the SRMA should encourage Local Government to ensure that their decisions are based on the fullest available information on the potential environmental impact. When information is inadequate it should be sought.

### 1.4.1 Attitudes of Local Government

As part of the study each of the twenty Local Government Authorities was requested to provide information of its Town Planning Scheme, in relation to the foreshore environment; programmes or policies on foreshore development; problems (environmental or recreational) which occur in foreshore areas and adjacent waterways.

Town of Armadale - The boundary for the Town of Armadale starts just north of McKenzie Grove and extends upstream beyond the SRMA's boundary at Brookton Highway on the Canning River.

The majority of foreshore land is zoned Special Rural Zone under the Armadale Town Planning Scheme with a limited amount of land zoned urban around Kelmscott. The former zoning permits Council to restrict over grazing and enforce tree planting etc. Council is keen to preserve the foreshore areas by maintaining this non-urban low density zoning. Occasionally Council will allow other uses, such as restaurants, but each application will be judged on its suitability in that particular environmental setting.

There is very limited Region Open Space (ROS) along this section of the river with the majority of land being in private ownership. Access to the river is via unconstructed roads, along Water Authority pipelines and the very limited amount of Crown land.

Around Roleystone, Council has increased the distance septic tanks must be from the river because of its concern for pollution of the waterways.

Town of Bassendean - Although foreshore land within the Town of Bassendean reserved under the MRS much of it still remains in private ownership. The land uses along this section of river are mainly single residential and public recreation, with the mental health services, Pyrton Centre being the only other use.

Five large areas are available for recreation. These are Ashfield Flats, Sandy Beach Reserve, Point Reserve, Pickering Park and Success Hill. The latter four have recently been upgraded by the Council.

Much of the foreshore land is also in the floodplain zone and many of the land owners expressed concern at the Land Drainage Amendment (see Chapter 3).

The Council has a by-law which requires that any paddock or stable used for the purpose of keeping horses be located not less than 15 metres away from any water courses.

Septic tank sewerage extends along Ashfield Parade; from Sandy Beach to Pickering Park and south of Success Hill to the Railway Bridge.

Spraying for insect pests occurs along all drains from Guildford Road to the river.

The main environmental issues raised by residents are damage to the foreshore caused by fishermen digging for worms; erosion of banks caused by wash from power boats; the speed of boats using the river; and the problem of mosquitoes in low lying areas adjacent to the river.

<u>City of Bayswater</u> - Land uses within the foreshore area ROS reserves, private residences or proposed road reserve. Should Swan River Drive be completed then access to this section of river would be severely if not totally restricted.

Aspects of interest include:

- The production of leachate within the tip site and consequent discharge into the river.

  Council is currently preparing a management programme for the foreshore area generally centred around the disused Bayswater Refuse Disposal Site. A small wetlands concentration set aside as a bird sanctuary (King William Street) is also included. It is intended the results of this project will form the basis for consideration of any environmental factors in the future development of this area.

- The swamp area adjacent to the tip sites is an important bird nesting and refuge area. The swamp experiences algal blooms during summer and as the result of an outbreak of botulism a pump has been installed to maintain the water level 'drowning' the paper barks. The swamp is adjacent to King William Street drain, overflowing into the drain in winter.

- Sewerage systems along the foreshore areas are septic or leachate drains. The soil type immediately on the banks is clay with Bassendean sands further back.

- The foreshore banks are experiencing severe erosion problems, with very few rushes, Causurinas or Melaleucas remaining along the river's edge. Accelerated erosion may be attributed to boat traffic and a prevailing onshore winds. Formal access to the river within the City of Bayswater is via Hine's Reserve.

- Also proposed for the Bayswater foreshore is the north west shelf gas pipeline. This will also reduce access to the river.

City of Belmont - As the foreshore area is within MRS Parks and Reserves boundaries applications for development are automatically referred to the SPC. Consequently Council does not have a policy on foreshore development. Three bridges are proposed for the Belmont-Redcliffe foreshore and if these all proceed access to the foreshore would be restricted. The SPC is involved in the necessary redevelopment of Redcliffe due to road development.

The Belmont area contains many stables and the foreshore and rivers are used for training of horses.

Garvey Park is being upgraded in conjunction with the SPC and SRMA. The old Belmont tip site is also planned for redevelopment. The SPC is calling for submissions on the area.

City of Canning - Land use within the City of Canning is predominantly Parks and Reserves for land abutting the river. Some wetland areas adjacent to reserved areas are in private ownership e.g. Watts Road Lake.

The City of Canning has been heavily involved in developing a management programme for the Canning River Wetlands. Recreation areas are currently being developed. The Council is keen to see dredging of the river below Shelley Bridge to permit better access to recreation club facilities planned for the foreshore adjacent to Centenary Avenue.

Proposals exist for the development of the Spencer-Chapman Road Link, which would cut through the upstream section of the Canning River wetlands.

Town of Claremont - Land uses within the Town of Claremont are private residential, school uses (private) and parks and reserves.

Vehicle traffic is restricted to only persons whose property backs onto the river and then access is only permitted on special occasions.

Public access is available along much of the foreshore. Unlike other yacht clubs, Claremont Yacht Club is owned in fee simple right to the water's edge although there are no physical barriers to prevent people walking along the foreshore.

Town of East Fremantle - The Council's boundaries extend to the centre of the river unlike most other Local Government Authorities.

Council expressed concern at the movement of sand within its waters and considers that action should be taken to assess and rectify this problem.

Council considers there is a definite need for more ocean ramps for small boat owners. Estimates are that 99% of boat users at Preston Point ramp head out to sea. Council supplies 79 trailer and 30 car bays at this ramp.

Council is of the opinion that parking and launching facilities for boat owners should be shared by all Local Government Authorities with river or ocean boundaries. Council should not be placed in a position where all its foreshore areas are developed to cater for the needs of boat owners.

All foreshore areas are recreation or road reserves with no housing fronting onto the river. Council is conscious that public access to the foreshore (in front of all club facilities) must be maintained. Consequently all leases to clubs on the foreshore stipulate this. Land at Preston Point adjacent to Swan Yacht Club has been vested with the club for development of a junior yacht club facility.

Council is aware of the need to keep all relevant authorities abreast of plans and requests for development of the foreshore. Any plans should stipulate that they are subject to approval from relevant authorities.

A by-law also exists stating that Council may permit a horse or donkey to be bought into the area subject to Council approved conditions.

City of Fremantle - Land use of the river foreshore within the City of Fremantle include container storage, boat building and marinas, private residential and industrial.

The escarpment in the northern foreshore area restricts any access to the river. The City of Fremantle had no plans for changes to its foreshore use when contacted and no set policy on its foreshore area.

The area between the two bridges on the northern side is classified as "Public Purposes" under City of Fremantle Town Planning Scheme No. 2. This is to be superseded by its now Town Planning Scheme, adopted by Council but not yet approved by the SPC. The land in this area will be zoned "Development". At this time Council does not have a policy on this zoning. Various plans have been floated for the area under this new scheme including a marine development.

City of Gosnells - The City has both urban and rural land within its boundaries, giving it a larger range of land uses. Land uses include private housing, office, orchards, parks and reserves and special uses such as Eventide Men's Home. Much of the river abuts a thin foreshore reserve up to the confluence of the Southern River. Any change required from urban deferred or rural zone land requires SPC approval.

- Many foreshore properties have riparian rights with approximately 75-80 having pumping rights to the Canning River.

- The lack of sewerage in certain sectors restricts the density of housing, however, in other areas in the Maddington/Thornlie region land classifications may change from 25 to 40 unit/ha.

The Gosnells Council is involved with a study of recreation facilities available in its boundaries including reviewing the river foreshores. In the past various plans have been put forward by community organisations for foreshore developments, one of these, the cycleway has been completed.

Shire of Kalamunda - Although the Kalamunda Shire abuts the Helena River, this land is owned by the SPC. Management is also carried out by SPC, consequently the Shire of Kalamunda does not have a policy on its river foreshores.

City of Melville - The foreshore areas of Blackwall Reach Parade, Melville Beach Road, Canning Beach Road and the Esplanade are road reserves. It has been suggested that areas not required for road purposes be reclassified for parks and reserves. Although Council sees the need for more boating facilities, such as ramps and parking space at some of its recreation reserves, it also feels that areas may become too congested with all the different 'activities' taking place.

There are no fixed plans for development of the Burke Drive area. To date tree planting has been unsuccessful in this region.

Barriers have been constructed along many of the foreshore areas to restrict car access and consequent destruction of foreshore vegetation.

Council is currently developing a management plan for the Melville Beach Road area. This is necessary due to its popularity as a windsurfing site, and conflict between users and residents.

Town of Mosman Park - Any foreshore developments within the Town of Mosman Park will be oriented towards providing a park type setting for family groups and not facilities for "fad" recreatonal pursuits.

Most of the foreshore from Johnston Street to the railway is in public ownership with the exception of Chine Street to Bateman Street where some owners have title to high water mark.

Like the Shire of Peppermint Grove the Town of Mosman Park considers that the siting of the Johnston Street boat ramp is inappropriate, particularly because of the lack of parking for cars and trailers. The Council would even be prepared to site the ramp elsewhere if possible.

The noise from using this boat ramp early in the morning brings complaints from residents.

Parking congestion also constitutes a problem in areas adjacent to the foreshore. Although the Council does provide limited parking off Johnston Parade the road divides the parking area and the foreshore.

Shire of Mundaring - The Shire of Mundaring encompasses most of the Helena River. All the land along the Helena River is classified rural under the Shire's Town Planning Scheme, except for land upstream of the bird sanctuary. This is classified as SPC Parks and Reserves land or Water Authority water supply catchment.

Each subdivision proposal is assessed by Council on its own merits. There is no minimum size for subdivision lots. Assessment is made on its usefulness as rural land and the aesthetic value of the area. It would be unlikely that 1 ha or 2 ha subdivision would be approved.

The Shire of Mundaring does not have any foreshore reserves under its jurisdiction.

An area east of Roe Highway along Helena Valley Road has been classified Special Rural Zoning partly due to the condition of the land after it was used as animal holding paddocks.

The Council has in the past requested that land in the water catchment be classified as Special Rural so that land clearing and intensive animal farming that may be detrimental to the water supply would be restricted. This request has been refused.

City of Nedlands - Land uses along the City's foreshore include private housing, restaurants, special uses (Sunset Hospital), parks and reserves. Recreation uses are yacht clubs, football clubs, golf driving ranges as well as informal park areas.

A plan to upgrade the area between Broadway and Iris Avenue has recently been rejected by local residents. This particular stretch of foreshore is 'walled' making access to the water difficult. Point Resolution is a System Six area and Council has expressed concern about the need to control access by directing foot traffic via specific routes.

Essentially the strip of foreshore downstream of Iris Avenue is to be retained as a natural strip of land i.e. no cycleways etc. Foreshore markers have been installed along the area to deliniate between public and private land. The reserve extends in many cases to the foot of the cliff with the cliff escarpment forming the boundary. The cliff face is to be treated carefully with no retaining walls etc. The Council has experienced problems of these marker pegs being moved or removed.

Shire of Peppermint Grove - The Shire was particularly keen to express its concern that in the past it was not fully consulted about the decision to redevelop river facilities adjacent to its reserve. It feels that any developments that take place on the water require facilities located on the adjacent foreshore e.g. sewage, electricity, parking for patrons etc. These are provided either by the Local Government Authority or go through land vested in the Local Government Authority. If these facilities are not available or are inadequate then the development should not be considered. To ascertain if they are adequate the LGA should be approached for its opinion.

The Shire of Peppermint Grove attempts to provide a foreshore that is available for the general public. It sees commercial enterprises on its foreshore as inappropriate. The area is attractive to young family groups in particular because of the shallow water, sheltered position, the natural vegetation and the well shaded and grassed area.

Parking and traffic control are the main problems which concern the Shire. Very little parking is available and the majority occurs on-road. This causes problems for residents when inconsiderate people block driveways etc. On Saturday afternoon the area adjacent to Royal Fresh Water Bay Yacht Club is crowded with non-members of the public using Mosman Park foreshore.

Located off Johnston Street the boundary line between Mosman Park and Peppermint Grove, is the Johnston Street launching ramp. there is no parking available for boats and trailers and the ramp itself becomes silted up. Peppermint Grove Shire no longer maintains the ramp as it considers it was inappropriately sited. Furthermore, the Shire feels there is no suitable area for a boat ramp within Peppermint Grove, particularly because of the parking problem.

The Shire would be keen to take over the old tearooms jetty to provide a place for fisherpeople to use and for the public to moor their boats during the day only. It would be prepared to maintain the jetty and be responsible for its upkeep.

The Shire does not encounter vandalism problems with the fossil site, possibly because it is well hidden from the roadway.

The siting of the Scotch College boatshed does not cause problems as students are always supervised and the building is well maintained.

The Council is looking at ways of controlling traffic speed by use of roundabouts etc.

Litter, noise, parking, speed and safety are the main concerns.

The area is purely a public reserve and no commercial development should be approved which could jeopardise public enjoyment.

If a commercial development was approved in the waters adjacent to the foreshore without prior consultation and approved with the Council, then the Council would be prepared to offer a legal challenge if the integrity of the reserve was threatened in any way.

<u>Perth City Council</u> - All the foreshore is accessible to the public with the exception of the light industrial area south of Bunbury Railway Bridge and the old Swan Brewery site. The W.A. Government has now purchased the latter site and plans are being considered for its redevelopment.

The Council has been studying the central city foreshore since 1984 with the view to making the area more usable and available to the general public. Plans for the area have recently been released in the 'Central Perth Policy Document' (CPFSG, 1986).

The Northern City by-pass road is proposed to cross the river in the vicinity of Claisebrook and Burswood Island. The idea of a connecting road from the Causeway (City side) to the bridge at Claisebrook has been refloated (initially presented in the Stephenson Hepburn Study, 1955). It is felt that this road would encourage people to use the Causeway to reach the freeway entrance rather than joining the freeway via Great Eastern Highway. This road follows the foreshore and is likely to require filling of the river. Council is opposed to the development of this road.

City of South Perth - Land uses abutting the river within the City of South Perth are Parks and Reserves, private housing and freeway purposes.

The development of the freeway from Mill Point to Mt. Henry has reduced access to the river at this point.

As well as foreshore land vested with Council, Council also owns a large area of land abutting Sir James Mitchell Park.

Currently Sir James Mitchell Park is being redeveloped in a multi-million dollar project. Landscaping, lakes, walk trails, ablution and carparking are included in the plan.

Council has received complaints in connection with the Salter Point/Clontarf foreshore. The causes of complaint were (a) the nuisance being created by large numbers of mosquitoes; and (b) the high incidence of snake (dugite). movement into properties and homes. The problems are compounded by the recommendations of the System Six Report which declare this a reserve. Guidance has been sought from DCE as to the long term management of the area. Currently the City is preparing a management programme for the area.

City of Stirling - Nearly 75% of the 240 ha of Maylands Peninsula are owned or vested in the City of Stirling. The majority of this is zoned recreation. With such a large area 'available' for recreation it would appear that Maylands Peninsula has regional significance and potential as a recreation area, particularly in relation to its proximity to Burswood Island and Belmont. Any large scale plans for the area by City of Stirling must be considered in relation to plans for these two adjacent areas. Repetition of the same facilities in all three areas will result in each reserve sharing the same 'user catchment' and thus not effectively using the resources to their maximum. It would be more effective if all three have different facilities and are therefore used by three different types of users.

The main problem associated with 'development' of Maylands Peninsula is the proposal for the Swan River Drive Freeway to cut across the northern end of the Peninsula, plans for this road system are long term. However, until the City of Stirling knows whether it is going ahead or not, definite plans for the Peninsula cannot be made and acted upon. The Council is firmly opposed to the development of this roadway. The only advantage to this road system is that it may encourage more people to the area warranting further development of MRS Open Space. However, unless access is provided on and off the Freeway it will not enhance access to the area.

* The hundred year flood line and the 'limit of development' as indicated by PWD reports also determine what 'development' may take place on the Peninsula. For any large scale projects significant amounts of fill will have to be used. If the area was required for housing clean fill would have to be used. Alternatively, if the land was to be used for recreation inorganic fill could be used. At present the clay pit area is zoned residential.

* At present deep sewerage is not available and the Water Authority does not have plans in the near future to install such facilities. Only when deep sewerage 'comes through the area' or a developer proposing housing on such a large scale for it to be financial feasible to install deep sewerage will further housing go ahead.

Two clay pits are situated in the centre of the peninsula. The pits are still currently in use and are being excavated to make them self draining when completed.

Inorganic fill is being used to fill an area to the west of the pits.

Access to the area is available via Peninsula Road only, as Swan View Terrace and Caledonian Avenue are no through roads terminating at Guildford Road.

<u>Shire of Swan</u> - Land use with the Shire of Swan is both urban and rural. Rural land uses are dominated in the Swan Valley by viticulture. Council, together with the W.A. Government have moved to ensure that the vineyards remain a feature of this area. Other land uses of foreshores within the Shire and private residential, stock grazing, industry (Midland Brick and stock holding areas adjacent to Midland Abattoir) and park and reserves.

Council has plans for walkways from Ray Marshall Park to Reg Bond Reserve and a loop network around Kings Meadow Reserve. Upgrading of Middle Swan Bridge Reserve to provide facilities for recreational canoeists is also a priority.

A large area of land in the Upper Swan region has recently been divided in lots for residential purposes with 586 ha abutting the river acquired bt the SPC as a condition of subdivision. This subdivision is known as Brigadoon Estate.

At this stage both Marshall Park and Reg Bond Reserve are to be left as "undeveloped" reserves.

City of Stirling - Only a small area of foreshore is under the control of the City of Subiaco. This is an area from Qantas Boat Ramp to the City's Western boundary. Although Council does not have a set policy on foreshore development, it is firmly against the "commercialisation" of the area. It has had various proposals from hire operators to use this area but all have been refused. It is, however, likely to give approval for a "one-off" event, such as the World Windsurfing Championships.

The reserve area is backed by "Bruce Truss land". This land was vested with the City of Subiaco so that the public would always have access to the foreshore.

The reserve has been "developed" to a level that Council considers appropriate with landscaping, grassed areas, carparking and ablution block.

The remainder of the area within the City's boundaries, Matilda Bay Reserve is vested with the National Parks Authority as an A Class Reserve for recreation. It is unlikely that the area will be further developed with regard to buildings on the reserve. The lease for the restaurant in fact stipulates that no more restaurants will be built on the reserve. The NPA has power to lease the reserve for 21 years. As the reserve was vested in 1957 it has two more years before the lease expires.

## 2.0 LAND OWNERSHIP

Within the study area foreshore land is either privately or publicly owned.

### 2.1 Private Ownership

Where foreshore land is privately owned titles may be;

- Freehold straight line boundaries.

- Freehold high water mark boundaries*.

- Freehold centre of the river boundaries or perhaps even encompass the entire river bed and foreshore either side.

In the past titles of the latter type were created to give land owner's riparian rights to use the water, particularly for stock watering. Consequently these titles occur in the 'fresh water' regions of the system. They were not designed to restrict the general community's access to and use of the river environment.

However under the terms of the Land Act owners may restrict public access to their property. Legislation contained in other Acts (e.g. Rights in Water and Irrigation) contradicts this restricting the land owners right to interfere with waters used by other people. For example land owners fence across the river on the upper reaches of the Swan to restrict stock movement consequently restricting canoe access. Agreement has however been reached whereby land owners remove fences during winter months to enable access to canoeists and Avon River Descent participants.

Where land owners have high water mark boundaries, provided there is no attempt to restrict the natural movement of the river, riparian rights are retained and public access to the property may be restricted. However, these rights are legally removed if owners change the natural flow of the waters - perhaps by erecting a retaining wall where land has eroded away and filling in behind the wall. Reclaimed land under these conditions becomes vacant Crown land. Cases of this type have occurred on the Murray River, Western Australia.

In situations where the river bed is dry during the summer the Department of Land Titles generally accepts that public access is allowable via the river bed as the ownership titles was initially intended to give water rights for stock not restrict community access (B. Cribb, Department of Land and Survey, pers. com. 1985).

The Lands Department and SPC now attempt to excise the waterbody and a major foreshore reserve as one of the conditions of subdivision bringing the public greater access to the river environment. This is not restriced to just the study area but other waterbodies throughout the State.

* Under the terms of the Land Act 1933 Amended <u>High Water Mark</u> when applied to tidal waters, means ordinary high water at spring tides, and when applied to other waters means the ordinary high water mark at winter level.

## 2.2 Public Ownership

Land which is in public ownership may be in one of the following categories. However, it does not necessarily mean it is available for public access and/or recreation use.

- Vacant Crown land.
- Reserved land under the Lands Act 1933 Amended.
- National Parks.
- State Planning Commission owned land.
- Water catchment reserved land.
- Main Roads Department owned land.

Vacant Crown land is owned by the Crown but has not been vested with any particular managing body for a particular function. This land is administered by the Department of Lands and Surveys.

Land may be reserved under the Lands Act 1933 Amended for a variety of functions. The land is then vested in an appropriate managing authority, body or person subject to conditions or limitations to ensure that the land is used for the purpose. Alternatively power may be conferred upon the managing authority to lease for the specified purpose the whole or any part of the land. If the land is not immediately required for the purpose for which it was created a lease may be granted with special conditions for a period not exceeding 10 years.

It should also be noted that nothing shall prevent the survey and declaration of any necessary roads and reserves through any reserve provided that the total area shall not be reduced by more then one twentieth (Section 31 [4]).

Under the Lands Act reserves may be created for the following functions. A full list may be found in Section 29 (1) of the Act.

- Use and requirements of the Government or Crown instrumentality.

- Railways, roads.

- Drainage, sewers.

- Quays, landing places, ferries and bridges.

- State forest, conservation of timber and indigenous flora and fauna, reservoirs.

- Recreational use by inhabitants.

- Camping grounds, public baths, and other edifices for public use or purposes.

- Clubs and club premises.

Consequently an inventory of reserves abutting the river does not give a true indication of publicly available foreshore land.

Reserves may be set aside by the Department of Lands and Surveys or the Minister for Lands. According to the areas function and importance, it may be reserved as an A, B or C Class reserve.

**Class A**

Creation of these reserves is either by the Minister or the Lands Department. Under the terms of the Act they must remain dedicated to their declared purpose until an Act of Parliament in which such lands are specified is enacted.

**Class B**

These reserves are similarly created by notice in the Gazette and may be amended by the Minister for Lands. However, the Minister must report to both Houses of Parliament explaining reasons for cancellation and the new purpose which the land will be used for.

**Class C**

All other reserves may be classified as C and amendment may be by the Department itself.

Any lands may be declared national parks under the National Park Act. Walyunga National Park is the only park within the study area. Reserves classified under the Land Act were also vested with the National Park Authority. These are now administered by the Department of Conservation and Land Management who succeeded the N.P.A.

The SPC is able to acquire land reserved under the MRS Scheme. This land may be vested with other authorities for management. Alternatively the SPC may choose to manage these areas, however, its resources are limited.

Dams on both the Helena and Canning Rivers mean that large tracts of land are reserved as water catchment reserves. These lands may be reserved under the following Acts:

Rights in Water & Irrigation Act.
MWSS & SD Act.
Country Water Supply Sewage and Drainage Act.

Under these Acts public use of these areas is restricted.

Land acquired for future major road developments is usually Main Roads Department owned land. Once again use of this land is restricted pending these road development. Also use of land reserved, although not purchased, for road development is restricted. For example large areas of Maylands Peninsula are reserved for Swan River Drive although the MRD has indicated that it will not need this road network for at least 20 years, if ever. However, in the meantime planning restrictions restrict use of the land.

## 2.3 Foreshore Ownership Status

The Waterways Commission has maps detailing land ownership of the study area which are updated as deemed necessary. These maps are not included in the report because of the problem in providing accurate upto date information.

Essentially most of the foreshore downstream of the Causeway and Canning Bridge is in public ownership. This public land is likely to be in the form of road reserves, Crown land (vested or unvested) or SPC owned; Crown land is the most predominant in this region. Areas further upstream are less likely to be in public ownership and once outside MRS Parks and Recreation boundaries there is very limited SPC owned land as this organisation is limited in its purchase of land outside these reserve boundaries.

| **Approximate Areas of Private Ownership** | **Suburb** |
|---|---|
| Gilbert Fraser Oval to Pt. Direction | North Fremantle |
| Point Roe | Mosman Park |
| Chine Street to Bateman Street | Chidley Point |
| Jutland Parade | Nedlands |
| Parts of the Town of Claremont foreshore | Claremont |
| Dalkeith Foreshore | Dalkeith |
| Dee Street to Ardross Street | Applecross |
| Banks Reserve to Bardon Park | Mt. Lawley |
| Wall Street to Kelvin Street | Maylands |
| Sandy Beach to Success Hill | Bassendean |
| Fauntleroy Avenue | Redcliffe |
| Helena River, Upstream Swan Street | Hazelmere |
| St. Vincents Hospital to Woodbridge | Guildford |
| Lilac Hill Park Upstream to Ellen Brook | Caversham/Upper Swan |
| Reg Bond Reserve to Vine Street | Herne Hill |
| North of Barratt Street to Walyunga National Park | Upper Swan |
| Mt. Henry to Redmond Street | Manning |
| Castledare | Wilson |
| Watts Road | Wilson |
| Few areas on the N.E. side of Canning River | Gosnells |
| Kelmscott Region Upstream | Kelmscott |

### 2.3.1 State Planning Commission Owned Land

The SPC owns many large tracts of land along the foreshore areas, either as a direct result of acquisition or as a condition of subdivision. The majority of these are upstream of the Causeway or Riverton Bridge. This is in part due to the developed nature of the lower reaches prior to the introduction of the MRS Scheme in 1963.

Large areas of SPC owned land are located around the Maylands areas. Much of the old Belmont Tip Site is SPC owned, as is Garvey Park, Redcliffe. The majority of Ashfield Flats is also SPC owned. Land either side of the Helena River at its confluence is in the same category. The SPC has acquired the majority of land on the Helena that lies within the MRS Parks and Recreation boundaries. A combination of SPC and Crown land extends from Ellen Brook to Upper Swan Bridge on the western bank.

The majority of land from Riverton Bridge to the Southern River is SPC land with areas of Crown land abutting the river bank.

As a condition of subdivision the SPC has acquired approximately 570 ha of land adjoining Walyunga National Park and abutting the Swan River. It is probably at this stage that this land will become an extension of the national park.

### 2.3.2 Other Areas of Publicly Owned Land

In the upper reaches of the Swan River a narrow pathway exists from Marshall Park, Midland to Reg Bond, Viveash. Similarly a pathway of publicly owned land runs from approximately Vine Street to north of Barratt Street, Herne Hill.

Much of the Crown owned land has been vested with the corresponding Local Government Authority. However some Local Governments do own land adjacent to the river bank or adjoining Crown land abutting the river bank. Instances of this nature occur at Tompkins Park, Alfred Cove; Sir James Mitchell Park, South Perth; Maylands Peninsula, City of Stirling; and Garratt Road Bridge, Bayswater.

The MRD has also acquired land in preparation for future road developments. These are located at Redcliffe for the new Tonkin Highway Crossing; small parts from west of Garratt Bridge (in preparation for Swan River Drive); and Fauntleroy Avenue to Great Eastern Highway for the proposed Redcliffe to Bushmead Highway.

The preceding discussion of land ownership has been given to highlight the restrictions to public use of the foreshore area. Large tracts of land in public ownership provide opportunities for the development of regional resources, whether for purely conservation purposes and/or recreation. Management should aim at "linking" these areas. This may be by boat, car, cycle or footpaths. Areas do not have to be linked by all methods but a range of opportunities should be provided. Accurate public information maps are an essential part of this 'linking' process.

The SRMA should develop an order of priority list of areas requiring rationalisation and/or extension of MRS Parks and Recreation boundaries, giving reasons for its choices. This will assist the SPC in its decision-making process.

Where private ownership of land restricts "land linking" of the area it is Management's responsibility to provide/seek/examine alternative options. One approach should be to examine "linking" the river areas with other recreation resources in the area i.e. Whiteman Park to the Swan River via Bennett Brook.

### 2.3.3 MRS Parks & Reserve Boundaries Currently Under Review (Reference E. Rossen, SPC)

1. Bennett Brook Amendment Proposal - Linking the Swan River with Whiteman Park (including Lilac Hill Park).

2. Guildford Amendment and Proposal - Rationalisation of boundaries between Success Hill water pipe crossover and West Swan Road Bridge (Barker's Bridge).

3. Chidley Point Amendment - The area from Chine Street to Bateman Street is currently being studied.

4. Claremont Amendment - The whole of the foreshore area within the Town of Claremont boundaries is currently under processing.

5. Alfred Cove Amendment - A possible amendment is being considered for this area.

6. Maylands Amendment - Rationalisation of the MRS boundary which extends into the river at this point is in process.

7. Maddington Amendment - Rationalisation of boundary to include SPC owned land around Herbert Street, Maddington.

# 3.0 LAND USE

## 3.1 South-East Corridor

### 3.1.1 Catchment

The scattered and diverse nature of the different soils and topography has resulted in a sporadic pattern of agricultural development in this corridor.

Some areas exhibit signs of salinity which may be accentuated by clearing (MRPA, 1978). Little virgin forest remains due to clearance for agriculture. The variable Southern River soils, west of Gosnells and Kelmscott, at Forrestdale and again west of Serpentine contain larger areas of uncleared land.

The escarpment and the deeply incised valley of the Wungong, Canning and Serpentine contain low open woodland or open forest depending on soil depth.

Where the natural vegetation has been cleared it has been replaced by agriculture, market gardens and urban development and to a lesser extent by vines and orchards.

Poultry and egg production, horse training and agistment; goat, donkey, pigs and dog breeding are all undertaken within the region, as is bee keeping.

Forestry is not a main use within the Corridor although to the east stretch the State Forests and water catchments, orchard production, particularly stone fruit production is prevalent in the region.

Existing quarries in the study area are situated mainly on rural zoned land. These include builder's sand, brick clay, brick shale, granite/diorite, gravel laterite koalin.

In the past significant wetland areas existed on the coastal plain although many of these have been filled and drained since European settlement.

Industrial areas are located in Canning Vale and Maddington discharging water into drainage channels entering the river.

Other river systems in the area include Bickley Brook and Southern River/Wungong River which are major tributaries of the Canning River.

Urban housing extends to Gosnells with rural wedges separating the surburbs of Gosnells.

### 3.1.2 River Land Use

Parks and recreation reserves and other foreshore reserves are almost continuous on each bank of the Canning River throughout its course to Seaforth.

More specifically from Canning Bridge to Riverton Bridge on the southern shore a narrow strip of reserve runs almost the entire length, most of which is in public ownership. Roadways and urban housing abut these foreshore areas.

On the northern shore close to Castledare a few tracts of remnant foreshore vegetation exist. Pen (pers. com. 1985) comments that this area contains the only remaining area of fringing forest vegetation in a relatively pristine condition left on the Swan-Canning Estuary.

Above Riverton Bridge to Nicholson Road Bridge the Canning River wetlands are located.

At this point extending upstream main drains and storm drains discharge into the river, as illustrated in Figure 2 and Table 8, Chapter 6.

In the past the Canning and its tributaries consisted of an almost continuous pattern of orchards, market gardens and vineyards. Today many of these are only part-time operations, playing an ecological role in retaining a low density of human occupation along the stream systems (MRPA, 1978). Many land owners do however maintain and exercise their riparian rights to draw water from the river, mostly for irrigation purposes.

## 3.2 Eastern Corridor and Swan Valley

### 3.2.1 Catchment

The Eastern Corridor is large, and contains within it areas of quite different character in terms of land use and hence lifestyles.

The Swan River and Helena Rivers abut predominately suburban areas upstream to the Midland-Guildford environs. This area is of important historical value. In the Eastern Hills from Darlington to Mt. Helena there is a wide range of lot sizes and land use. Most residents use their land for residential purposes, with only a few earning a significant income from it. There are orchards, poultry farms, nurseries, cut flower businesses, horse-studs and horse-riding schools, as well as business like furniture making or car repairs.

The larger portion of residents of the areas between the urban sectors are not using their land to earn an income but rather as spacious residential blocks (Taylor and Burrell, 1978).

The Swan Valley is one of the most important agricultural, recreational and tourist assests of the Perth Metropolitan area. It contains highly productive soils and clay resources and produces high quality table grapes, wines and dried fruits.

The Valley is a prominent tourist attraction with outstanding potential for future development. Similarly, the viticulture industry has the potential for expansion.

There is pressure for the Valley to be subdivided into hobby farms and rural homesites which do not fully utilise the high quality soils and which reduce tourism potential. These pressures and others have gradually eroded the agricultural base, landscape and rural character of the Valley, to the detriment of the table grape, wine and tourist industries (Govt. of W.A., 1985).

### 3.2.2 River Land Use

Land use of the river foreshore environment has historically been 'controlled' by the comparative shallowness of the waterways making them more suitable for conservation and recreation than for shipping. Consequently the larger industries normally associated with harbours and water transport did not develop on the Swan-Canning foreshores.

Many of the foreshore industries that did occur have gone, as have the transport network of barges that used to ply the waters between Guildford and Fremantle. Industries still existing include Swan Portland Cement, Rivervale; CSR Sugar Refinery, Point Roe; Midland Brick, Middle Swan Bridge; boat building and repair, Fremantle.

In contrast tourist and recreational use (public and private) has grown over the last thirty years. Many facilities such as marinas, club houses and commercial boating operations are located on the foreshore edge. Detailed information of these facilities is given in Chapters 14 and 15.

As the urban core of the metropolitan region is the oldest and most settled part it is not surprising that the most well established and highly popular regional recreational facilities are located within this area.

Boat building/repair and cargo storage dominate the Fremantle area. Travelling upstream a combination of public open space, boating facilities and urban housing is apparent in this urban core.

Modification of the Mosman Park region is apparent due to quarrying for limestone in the past. The location of the Kwinana Freeway dominates the river from Mill Point to Mt. Henry.

Many of the existing foreshore reserves are the result of filling of low lying wetlands. Few of these wetland areas remain on the river foreshore, Alfred Cove and Canning River wetlands being the main exceptions.

From Walyunga National Park to Upper Swan Bridge land use is essentially rural and conservation oriented. Subdivision for Brigadoon Estate will see a more denser hobby farm environment.

Vineyards dominate the region from Upper Swan Bridge to Middle Swan Bridge, and as part of the Government's Swan Valley Policy will remain so.

Urban land use and its associated pressures increase from Middle Swan Bridge downstream to the Causeway, with many main drains and storm drains discharging into this stretch. Recreational facilities are interspersed along the river's length however private ownership of some sections makes a linear parkway system impossible.

Like the rest of the study area the Helena River system has been dramatically altered by man's activities. These include quarrying for clay and sand, disposal of effluent, stock-holding activities, rubbish dumping, the building of road and railway bridges and the construction of the Mundaring Weir and lower diversion dam.

The study area, downstream of the lower diversion dam has few facilities, much of it is in private ownership. Along its length is the Victor Road picnic area, the Bushmead Rifle Range, Rosehill Golf Course, the Pexton Memorial Playing Fields of Guildford Grammar and Kings Meadow polo grounds.

## 3.3 Involvement in Land Use

The SRMA has in recent years become more involved in land use planning. This is an essential part of effective management of an estuarine system.

Knowledge of land use is necessary not only to eliminate or reduce the direct environmental impact on the river, but also to provide an understanding of possible non-point source pollutants. Impact of land use extends far beyond the foreshore reserves.

Management's understanding and control of land use should extend to the origin of the river's water source.

### 3.4 Land Use Planning Studies

Many land use planning studies of the metropolitan region encompassing the river environment have been undertaken. The most broad based of these studies are the corridor studies of the South-East Corridor and Eastern Corridor which deal extensively with the 'non-urban' river regions. Although not statutory plans they are the adopted regional growth strategy of the SPC.

Another important document is the Swan Valley Policy, a recently released document outlining the Government's commitment to retaining the valley as an agricultural, recreational and tourist asset. Similarly recommendations by the System Six Tourism and Recreation Committee (DCE, 1981) pertain to this study.

Recommendations from these reports applicable to this review are listed below.

#### 3.4.1 South-East Corridor : Stage A Report (MRPA, 1978)

There are few proposals for the Canning River compared with the Upper Swan region. This is in part due to the size of the river itself and consequent potential as a recreational resource, and the fact that SRMA's management area only extends to the Brookton Highway, which is essentially still urban land.

- On the coastal plain, the important landscape areas are associated with the river systems and wetlands. Consequently parks and recreation reservations are recommended for the Canning River adjacent to proposed new sections of Albany Highway at Kenwick and Gosnells.
- Continuation of the 100m foreshore reservations adjusted to local characteristics is recommended for Southern River in new urban areas.
- The valleys of the Canning and the Wungong Rivers are of more than local scenic significance and planning should take this into account.
- Rural wedges should be maintained in the Corridor, i.e. between Gosnells, Kelmscott and Armadale respectively.

  The major impact of developments proposed within the South-East Corridor will occur if the Spencer-Chapman link is persued (See Chapter 7 for further details).

### 3.4.2 Eastern Corridor (Taylor and Burrell, 1978)

- The recreational potential of the Eastern Corridor can best be realised by a basic structure of reserved lands which form a network linking together both the development elements and the varied environments which exist.

River parklands and recreation links proposed are:

- Swan River and adjacent flood plain as a national park - Guildford to Northam.
- Bennett Brook as a river parkland link between Whiteman Park and the Swan River.
- Helena River as a river parkland recreational strip of varying width and activity between the Darling Scarp and the Swan River.
- Helena River Valley as a National Park upstream of the Darling Scarp.
- Lower Helena Catchment Area be reserved as such in the Metropolitan Region Scheme. This provides a continuous link through to Mundaring catchment and the State Forests.
- Woodbridge and Blackadder Creek as linear parklands linking together the Swan River, Marshall Park future open space at Midvale (Stratton Estate), Wexcombe open space (reserved for Recreation), Jane Brook and John Forrest National Park.
- The three disused railway reserves to provide cycleways and bridle trails as part of the system.
- Jane Brook as a river parkland and recreation strip between the Swan River and John Forrest National Park.

The recreation links proposed are not merely local cycleways. They are in the main either district cycleways and bridge trails using the three disused railway reserves or recreation links along creeks and rivers forming the district drainage pattern.

The Primary east-west link through the length of the Corridor will provide for the route of the proposed Hills Parkway, with other movement systems such as bicycleways, horse trails, and walking paths co-existant within the reserve.

At nodal points throughout its length particularly where joined by the proposed secondary system, activity points for both car travellers and others should be located with appropriate facilities. These include:

- Helena Valley (113) ha adjoining the Helena River's southern bank and including the unmade section of Helena Valley Road. It also includes the undeveloped land adjoining the east of Ridge Hill Road, thus completing the link to the disused railway line that runs along the north eastern boundary of Bushmead Rifle Range.
- Reserve and protect the Helena River.
- A flow of water be provided to flush pools along the Helena river.
- Protection of river bank vegetation in stock-holding areas.
- The steep slopes of the Helena River Valley present some measure of scenic grandeur, and their preservation is important in overall landscape planning for the Region. The principles to be adopted in policies and programmes should thus be to ensure a full range of landscape scale, contrasts of texture and use, and that opportunities to enjoy them all are retained.

3.4.3 **Swan Valley Policy (Govt. of W.A., 1985)**

- To promote the development of tourism to its fullest potential, whilst retaining the unique character and special appeal of the Valley and its adjacent areas.
- To conserve and enhance the Swan Valley's unique resources, particularly its rural character and amenity, its built and natural environment, and its clay deposits.
- Institute an investigation to identify land adjacent to water courses which is suitable for inclusion in the Parks and Recreation Reservation in the Metropolitan Region Scheme.
- Develop a Swan Valley Management Plan for the Swan River, Ellen Brook, Susanah Brook, Jane Brook, Bennett Brook and the lower Helena River and their foreshores and floodplains.
- Devise landscape and design criteria in consultation with the Shire of Swan to minimise the impact of regional roads on the environment.

- Locate future regional roads on routes which will not further fragment the Valley and which minimise adverse environmental impacts.

The SRMA has indicated its support for aspects of the Swan Valley Policy pertaining to the Swan River and its tributaries and is liaising with the SPC on this project of development of the Swan River Management Programme.

### 3.4.4 System 6 Tourism and Recreation Committee

- Further recreation reserves should be set aside to take account of future recreational needs associated with population growth;

    - Around major lakes and estuaries.

    - Along rivers and streams, particularly in the vicinity of the escarpment.

    - On sections of wetland reserved primarily for conservation.

- It was recommended that lakes and estuaries with large areas of reasonably deep water should be made available for aquatic recreation if this does not adversely effect an area of value to conservation, the activities permitted should be appropriate to the depth of water, area of water and demand for recreation on that water body. Access to deep water and back-up facilities should be as required for the purpose.

  Where a long term demand can be foreseen and natural conditions are suitable, man-made lakes created by excavation and impounding of water and worked out mining pits should be rehabilitated as lakes for aquatic recreation.

- Management plans for the Waterways Commission's three gazetted management areas should aim to co-ordinate the activities of the various authorities concerned with the waterway and utilise the concept of multiple use of resources in the co-ordination of recreational use of the waterways. This would incorporate establishing the compatibility of various recreational activities, and there would be a need to establish priority uses for various areas.

- Historic sites be managed in conjunction with recreational facilities such as picnic and camping areas, in order to fully utilise their recreational value.

- The very high value for public recreation of small caves in the urban area and fringes be emphasised to local management authorities. Every effort be made to prevent unnecessary destruction of caves and to secure reservation wherever possible.

- The viability of providing pathway systems such as cycle, walking and horse-riding within linear parks be examined.

    - Linear parks could follow rivers or disused road and railway reserves (suitable rivers could include the upper Swan and Canning Rivers and their tributaries).

    - Local Authorities could be involved in the development and management of pathway systems but the initial viability study should be undertaken by the MRPA.

- Recreation areas be allocated primarily on the basis of their suitability for recreational use rather than a 'left-over' after subdivision for urban development.

- Only uses which should be made of the river foreshores and river are those which depend directly on such a location. For example, such uses as ovals, shopper or commuter carparks, major transport routes and utilities and rubbish disposal sites should not be located on foreshores. Specific example of inappropriate foreshore roads include an expanded Riverside Drive, proposed road extensions between Riverton Bridge and Nicholson Road Bridge on the Canning River and the planned Swan River Drive Freeway from Burswood to Redcliffe.

- Where freeways already exist along foreshores the degree of access to the shore and the facilities provided should be reviewed.

- Where possible land should be acquired to form a broad continuous foreshore reserve, to enable the foreshores to function as a continuous linear park.

High priority should be given to the provision of continuous access along the river foreshores. Where appropriate, foot, bicycle and bridle ways should be provided.

There is a need to maintain the present diversity of recreational opportunity and landscape characteristics of the rivers and foreshores.

Local Authorities should endeavour to retain such diversity when developing foreshore reserves and facilities.

- Consideration be given to the provision of additional up-river canoe-launching stages and associated carparking areas. In addition, fences across the upper reaches of the Swan and Canning Rivers should be removed, as they are a danger to canoeists.

- The Swan River Management Authority construct and maintain public jetties for fishing and other purposes.

- All new bridges across the Swan and Canning Rivers include fishing platforms and cycle/pedestrian paths.

- The construction of wining and dining establishments be encouraged on selected locations on foreshores.

- The river from Riverton Bridge to Nicholson Road Bridge and adjoining land held by the MRPA be classified as an A Class reserve for the purpose of Recreation and Conservation of Flora and Fauna. Only non-motorised boats be allowed to operate on this section of the river. Wherever possible further land upstream be obtained for the purpose of recreation.

## 4.0 FORESHORE DEVELOPMENT

### 4.1 Approval Process

Any foreshore development application must receive statutory approval. The first approach is to the appropriate Local Government Authority.

If the application pertains to land within or abutting MRS reserved land, under the terms of the MRS Act it is referred to the State Planning Commission (which has taken on the responsibility of administering this Act).

Should the application require subdivision of land it will under the terms of the Town Planning and Development Act require SPC approval as this Department now administers this Act.

In addition, the Local Government Authority is in all probability likely to refer applicants to the SPC which may impinge on the river environment. The decision for referral may be due to the possibility that the land is in the future likely to be reserved for 'parks and recreation' or that the land may be within the flood plain zone.

Special situations may also exist whereby SPC approval is required. For example, at present developments within the Swan Valley must be referred to the Swan Valley Policy Group Committee.

Prior to giving approval to projects the SPC seeks the advice of other specialised Departments*. These include Water Authority (floodplain management), Department of Conservation and Environment, SRMA and M&H. These referrals are for advice only and development applications would be required to gain statutory approval from the SRMA if the project interferred with river banks, bed or proposed discharges to the river. Given this advice the SPC may then approve or not approve the project. If approval is given various conditions may be placed on the project as a result of this inter-departmental advice.

### 4.1.1 Environmental Protection Authority (EPA)

Proposed land use projects coming to the notice of DCE via SPC referrals or other channels may in the Department's opinion require a more comprehensive environmental study. The proponent as a result may be asked to furnish a:

(a) Notice of Intent - This is a confidential document to the EPA, prepared by the proponent detailing the proposed development. If the project is unlikely to raise much public interest or cause environmental problems it may be approved by the EPA. However if it does not meet these criteria a further review will be requested.

(b) Environment Review and Management Programme - This report details the project and addresses the environmental problems and management considerations of the project. ERMP's are released for public submission.

(c) Public Environment Report - This is a mini ERMP. PER's are released for public submission.

In addition any person or body may refer in writing to the EPA any matter which gives rise to concern as to the possible cause of pollution**. The Authority shall consider this matter and may report and make recommendations to the Minister.

* The SPC is required under the Waterways Conservation Act to refer it to the SRMA.

** Pollution under the EPA Act 1971-80 means only direct or indirect alteration of the environment to its detriment or degradation.

When assessing ERMP's or PER's the SRMA and other managing authorities must be prepared to say no to projects based on their land capability assessment rather than gain a few minor battles while the whole project still goes ahead although unsuitable.

## 4.2 Redevelopment or Upgrading Proposals

Since the initiation of this study, various projects have been proposed or undertaken. Many of these have been the result of CEP projects. The following are an outline of some of these projects to give the reader an idea of the possible look of the river in the future and public reaction to the project. Most of these projects are numbered on the attached maps (Activities details).

i Upgrading of Preston Point Boat Ramp. The Preston Point area has been upgraded providing an extension of carpark facilities and the construction of launching ramp and boarding jetties at the existing launching facilities.

ii Development of Reserve A7800 to provide the public controlled access to this steeply contoured site yet at the same time retain the natural beauty of the area. A walkway and fishing platform has been provided.

iii Dual Use Path - The Town of Mosman Park has initiated the development of a dual use path along to the cliff edge adjacent to McCabe Street. Landscaping of the region has also taken place.

iv The City of Melville has initiated the development of a management programme for Melville Beach Parade. (Francis Road to Dee Road, Applecross. This plan is aimed at alleviating some of the problems residents have experienced in recent months as a result of the extreme popularity of the area for wind surfing.

v Majestic Hotel Site Redevelopment - The Bond Corporation proposed the development of a mooring area abutting Point Dundas. The SRMA in its assessment of the ERMP opposed the development.

vi A government agreement acquiring the Bristle Clay Pits for public purposes (in the long term) together with other land adjacent to Garratt Road Bridge previously purchased by SPC has provided the opportunity for the redevelopment of the site. The SPC has called for submissions and these are currently being assessed.

vii A combined project between the Shire of Belmont, SRMA and SPC using funds from the Federal Government's Natural Enhancement Scheme will see the redevelopment of Garvey Park, Redcliffe during 1985/86. Approximately $750 000 funding has been provided with the aim of providing a foreshore park comparable with parts of Kings Park.

viii Ashfield Flats Canal Development - A proposed canal development of the Ashfield Flats area was floated by the Bassendean Council in 1984/85 using both SPC owned land and private land. Public reaction recorded by the SRMA was on the whole negative. A study of the financial feasibility of the project appears to have rejected the project at this stage. Should a project of this nature be persued then it would be required to follow the Steering Committee's Recommendations for Canal Developments 1984.

ix Walkway - Shire of Swan Project - The Shire of Swan in its submission to the study indicated its intention to develop walkways along the river foreshore extending from Kings Meadow Reserve to Fishmarket Reserve, and Ray Marshall Park to Reg Bond Reserve. Funds have not permitted the Shire to fulfil these plans to date.

x Old Tip Site - The City of Bayswater has conducted an investigation into the potential of leachate entering the river as a consequence of redevelopment of the site. Currently options for development are being studied (including a golf course) and methods of reducing leachate entering the river are being reviewed.

xi Sir James Mitchell Park - This site, extending from Ellam Street in the east to South Perth Esplanade in the west, is in the process of being upgraded to provide parking, ablution facilities, walkways, landscaped gardens and lakes.

xii The Central Perth Foreshore Study - The City of Perth, together with the SRMA and SPC has undertaken an investigation of the central city foreshore with the view to providing better access and 'linking' the city to the river environment. The City of Perth called a moratorium on development on the foreshore until the completion of the study. Recently the Council announced that two restaurants would be developed in the area. The first at Point Fraser (Causeway carpark) and the second, part of the Perth Rowing Club Premises adjacent to Barrack Square.

xiii Burswood Island - Many changes have occurred, or are proposed for the Burswood Island area. These include Casino and Hotel development, 18 hole public golf course, sculpture garden. The completion of the Burswood Bridge will also pass through the 'island'. This is due for completion in 1990 approximately.

xiv East Perth Urban Lands Council - In 1985 the Government initiated the East Perth Land Use and Landscape Committee to evaluate ideas to revitalise the area. Six proposals were released for public comment late last year. These included such ideas as a 'Powerhouse Pier', a medium density village and a plan to recapture the original Swan River landscape. The SRMA submitted a submission on these proposals.

xv Maylands Peninsula - The peninsula is a large tract of land of which a considerable proportion (~ 75%) is in some form of government ownership. In 1984 the City of Stirling was undertaking a study of land use options for the region. Since then redevelopment of the police barracks have occurred and the SPC has undertaken a land use study of a small area on the east bank. Upgrading of the SPC owned Maylands Slipyards has also occurred.

xvi Brigadoon Estate - The development of Brigadoon Estate in the Upper Swan Valley will result in some 570 hectares of land abutting the Swan River to be handed over as a condition of subdivision. It is likely that this land will become an extension of Walyunga National Park.

xvii Midland Western Link Road - A road has been proposed to connect Lockridge/Eden Hill to Midland via Ellen Brook and the Swan River. This project is still under review by the SPC (See Chapter 7 for futher details).

xviii Canning River Wetlands - The City of Canning has undertaken extensive studies of the wetlands and is currently in the process of developing a management programme for the region.

xix Chapman-Spencer Road Link - This proposed road link will cut through the Canning River Wetlands and is opposed by many conservation groups. Chapter 7 details the current situation.

xx In 1985 the Government purchased the old Brewery site on Mounts Bay Road. Public submissions have been called for by the Government to determine the future status of the site. To some people the site is of historic significance, to others it is purely an eyesore. Contraversy will still remain even when a final decision on the site is announced.

xxi Cycleway - In 1985 the City of Belmont proposed the development of a cycleway from Goodwood Parade to the Sandringham Hotel site via the river foreshore.

xxiii Bicton Quarantine Station - The Bicton Quarintine Station is to be subdivided for housing with the lower slopes available for public open space.

xxiv Mosman Park Foreshore - The area of Buckland Hill and land adjacent to McCabe Street has been proposed for redevelopment. Much of this land is defined in System 6 reserves and it is therefore important to incorporate these aspects into planning for the area.

The preceding information has been provided to give the reader an idea of the number of proposals for development and/or upgrading of the river foreshore (these are by no means all). Many of these projects are initiated by Local Government whose officers have little experience in estuarine management or ability to assess the possible impact of land use projects on the river environment. It is essential that the SRMA assist these organisations with the collection of information on which to make land use decisions.

The range of projects around the region indicate the need for some form of co-ordination of planning to ensure that projects are not only physically but also visually acceptable to the river environment.

Too often the comment is made that the river enhances the City. Surely some thought should be given to ensure that foreshore developments do not belittle the river environment ensuring they are in harmony with adjoining properties. Methods of achieving this need to be assessed. The Institute of Landscape Architects in their submission suggested the development of a landscape master plan for the study area. Alternatively Nedlands Council has incorporated a clause in its Town Planning Scheme requiring buildings on the foreshore to be aesthetically pleasing (see Chapter 12). Certainly the use of landscape architects on many of these projects is desirable.

# CHAPTER 11 : TRENDS IN GROWTH AND RECREATION PARTICIPATION FOR THE METROPOLITAN REGION

## 1.0 FACTORS AFFECTING RECREATION DEMAND AND PARTICIPATION

Mercer (1981) comments that recreation planning and research over the last two decades has proceeded on the assumption of unrestrained growth and expansion of all facets of recreation. However, the energy crisis, technological change, the slow down in population increase, growing structural unemployment and the ageing of the population have all force a rethink of this basic assumption.

Factors which may affect the overall pattern of recreational demand and participation are:

- Population growth, size, composition (age and sex structure), spatial distribution and expansion.
- Variation in wealth and income.
- Educational attainment.
- Place of residence.
- Occupation.
- Available leisure time.
- The relative buoyancy of the economy.
- The energy situation.
- Opportunities provided for involvement.
- Substitution effects e.g. power boating for yachting, coastal marinas for river marinas.
- Changing tastes, preferences and development of new activities.

Mercer (1981) comments that age is the single most important variable influencing participation in outdoor pursuits.

Other factors influencing leisure choices at the individual scale range from personality and gender, family and peer group pressure, through to educational, financial and class background to such variables as residential history. Also less easily quantified but nonetheless highly significant are the influence of media, experience in childhood, the content of school curricula, residential locale and the role of family and peers (Mercer, 1981).

## 1.1 Population Structure and Changes

The spatial distribution of the population and the size and demographic structure of that population contribute to a particular profile of recreational demand. The latter point is of particular significance for planning and management of recreation resources. Prediction of trends are extremely difficult.

The general consensus of opinion is that throughout Australia the median age of the population is likely to increase for the rest of this century and the needs, preferences and habits of these people will demand priority, in nearly every economic and social decision (Mercer, 1981). The Town Planning Department (1983) reports that there could be significant "bulges" of certain age groups with certain recreation needs, such as young people, the unemployed and the elderly. For example, in general terms planners can in the future expect increased levels of participation in relatively sedentary activities such as fishing, photography, picnicking, pleasure driving and short walks in the country and a <u>relative</u> decline in participation in active sports like water skiing, surfing, kayaking, yachting and extended wilderness travel (Mercer, 1981).

In August 1983, the estimated metropolitan population was 940 000 and although the rate of growth, per force, remains a matter for speculation, forecasts estimate that the region population will reach about 1 400 000 by 2001 (TPD, 1983). The 1981 Census indicated that 71% of the State's population resided in the Metropolitan Region with population growth exerting pressures on facilities and sites, there is a need for forward planning to effectively manage and conserve limited natural resources, to minimise energy usage and to provide for specialised recreation needs (TPD, 1983).

## 1.2 Other Factors

Leisure patterns are closely related to the wealth and income profile of a given country or region. The timing of recreation usage surveys will also reflect the economic status of the region (Mercer, 1981).

Three scenarios were put forward by the Town Planning Department (1983) to estimate the possible impact of technological change and economic climate on the wealth, income and recreation participation of individuals. However, it is reasonable to assume that a return to something approaching full employment is going to be a priority of Governments in the future.

Jobless Growth Scenario envisages widespread structural unemployment in Perth due to the rapid and unregulated introduction of technology. The economy would continue to grow but by production increases rather than expansion of the work force; so raising the spectre of jobless growth.

Shared Work Scenario envisages that the burden of low employment growth will be shared. There would be more leisure time but disposable incomes will not grow.

Full Employment Scenario would be characterised by low employment levels.

One trend that seems likely to gather momentum is the shift away from full-time employment towards part-time and casual work. This would lead to implications for recreation and education where increased leisure but limited incomes would make new demands on facilities, (TPD, 1983).

Opportunities to recreate locally and to "escape" from the urban environment will also be required. General urban growth, population pressure and sedentary work life of a service-oriented workforce could increase demand for recreation entailing physical exercise and appreciation of natural open space areas (TPD, 1983).

It is also suggested that for local residents, recreation nearer to the home base will be more likely than long distance trips if travel costs rise and real incomes fall. Provision of public transport and low energy forms of transportation (bicycle) need to be considered.

There has also been a corresponding increase in the amount of leisure time for some sections of the work force, due to shorter working weeks, longer annual holidays, flexitime, nine day fortnight work arrangements, public holidays, shift work etc. Over the past five years, unemployment has resulted in 'enforced' leisure time for many people in the community. More recently however unemployment figures have shown signs of improvement but an economic decline could exacerbate unemployment or under employment.

This situation could result in more time but less money for leisure (TPD, 1983). It is suggested that recreational opportunities which are less expensive and more accessible by location and public transport will be needed.

In conclusion the Town Planning Department (1983) reports that demand for recreation of various types and various levels would continue to grow with outdoor recreation focusing on:

- Short car trips to areas of natural attraction.

- Leisure activities such as picnicking, walking, etc in parks, forests, on river foreshores and natural open areas.

- Recreation of the challenging type such as boating and off-road vehicle uses.

- A need for affordable and convenient public transport to recreation sites away from the local neighbourhood.

- Low cost activities without the need for expensive equipment.

- Recreational resorts for home tourism and out of state tourism which would be based on natural attractions such as the ocean, lakes and rivers.

- Home based recreation with a possible effect on size of dwellings and size of building blocks.

Provision of these pursuits will exert pressure on existing resources and increase pressure for development of new places for outdoor recreation.

It is reported (TPD, 1983) that at a regional level, catchment areas, wetlands, marinas, beaches, parks, forests, the Darling Scarp, rivers and areas, for riding, bicycling and walking will be utilised. Careful management is essential to assess the environmental impact on open space areas accessible to the public which may be damaged as a result of use. For example tighter controls over use of the environment by off-road vehicles, power boats or horse riders may be necessary. Mercer (1981) suggests that young people of today will probably develop a higher level of tolerance towards controls and regulations of behaviour in the outdoor environment.

Multi-use of open space and compatibility between those uses is an important consideration for planners and managers of these resources. Maintenance of the physical, environmental and social carrying capacity of an area is also a fundamental requirement.

Aspects deemed necessary by the Town Planning Department (1983) for this regional approach to provision of recreation resources are:

- An open space management body responsible for the acquisition, construction and continued management of parks and recreation will be necessary.
- Methods of allowing the public to use land for various leisure pursuits without the need for aquisition will need to be resolved.
- A need for policies enabling State Forests and Water Catchment areas to be used for active and passive recreation to be resolved.
- Re-assessment of the role of Local Government Authorities and other open space management bodies.

## 2.0 TOURISM*

Tourism plays an important role in the Australian economy constituting about 5% of the G.N.P. (1981 Figures) and ranking about 9th or 10th. The Federal Government has encouraged and supported the promotion of Australia as a major tourist destination. Similarly the Western Australian Government has placed more emphasis on tourism, particularly in association with the staging of the America's Cup. Hitchen (1985) comments that tourism is now Australia's biggest industry and Western Australia's second biggest.

### 2.1 The Tourism Product

Helber (1985) introduces the concept of the tourism product stating that in one sense it is an invisible or intangible commodity in the form of a collection of experiences and reactions that each visitor has during their stay at a particular place. In another sense, the product is an amalgam of the area's physical features, facilities and services that combine to present a special setting and character for the visitor's enjoyment. With tourism, there is no single product as such, but instead a combination of tangible and intangible elements which dictate the degree of user satisfaction and enjoyment.

The key element in achieving product excellence are:

1) The product must have special and unique qualities in order to attract large numbers of people to experience an area first hand.

* A tourist is a person who travels at least 40 km away from their place of residence, stays at least overnight and their trip may be for any purpose.

2) The product must have a high degree of authenticity and realism. Helber (1985) comments that the industry in general is being eroded by cheap duplications and improper imitations of Mediterranean villages, South Pacific paradises. The product must be real, and it should convey a sense of place - in W.A. it should be a W.A. product that reflects the local heritage, local life styles, and the natural physical environment.

3) The product must be marketable and acceptable to the public.

4) Some form of control is necessary to ensure that the unique qualities are not lost or destroyed through over exploitation. The product should enhance and perpetrate the natural and inherent attributes of the area. Tourist facilities should complement, not detract from, a sites natural environment. An area's heritage should not be commercially exploited in a negative way for the benefit of the visitor.

It is appropriate to include the following comment by Helber (1985).

"If developed properly, the tourism industry can be a very effective means of heritage and environmental conservation. But unfortunately, in too many instances, the industry has actually done the opposite. Its rapid expansion and development has badly disfigured scenic environments, destroyed the charm and special character of local areas, overwhelmed small communities and hordes of outsiders have contributed to the expansion of crime and other social problems".

Consequently attitudes and behaviour similar to those indicated by Hitchen (1985) are to be encouraged.

"Our natural environment is more than 90 percent of the product we offer visitors; we are aware of the importance of the environment, we are not about to facilitate its destruction or deterioration, and we support to the full sensible measures designed to preserve it" (Hitchen, 1985).

## 2.2 Marketing

According to the Western Australian Tourism Commission the Swan River plays an important role as a marketing tool. Publicity information always includes siting of Perth City on the foreshore of the picturesque Swan River. Perth has the advantage that it is generally free of air and water pollution - "an environmental condition which is deteriorating many of the more traditional tourist destinations in Europe, Asia and North America at an alarming rate" (Helber, 1985). It is essential that Perth, and more particularly the Swan and Canning Rivers tourist attractions remain attractive to visitors. If Perth is marketed as having a clean, picturesque river then it is up to all authorities involved with river management and tourism to ensure that this product is supplied. Major roadways adjacent to the river, tall buildings on the foreshore, loss of access to the river and diminishing river flora and fauna will all reduce our tourism product. Without careful, planning tourist development could very well be tourisms own downfall.

## 2.3 Tourist Services

Commercial enterprises using the Swan and Canning Estuarine System are not limited to use by tourists, Perth residents also use the majority of these services. Commercial operations on the river are licenced by the Department of Marine and Harbours. These are listed in Chapter 16. Some of the facilities promoted by the Tourist Commission are:

* The Swan Valley.
* River cruises and ferry trips up and downstream.
* Rottnest Island trips.
* Drive tours around the river.

A clean, picturesque and safe environment is very important for these services to succeed - visual access is all important with other facilities such as restaurants also relying on visual access to the river.

## 2.4 The Role of the Swan River Management Authority in Tourism

The SRMA, SPC, Department of Marine and Harbours and Local Government Authorities liaise on the approval of facilities on or adjacent to the river. If these are to be promoted as tourist facilities then the SRMA should consider:

* That the Swan River is promoted as a clean and picturesque river and is an important tourist product.

* Whether the development will detract from this "picture".

* Whether the product is marketable (the Tourism Commission would be able to assist with this assessment).

* The special qualities and authenticity of the product in relation to the river environment.

* Is there sufficient "controls" to ensure that the natural and inherent qualities of the river environment are not lost or destroyed through over-exploitation of the resource.

* That opportunities of Perth residents are not adversely affected through the development of this tourism product. (In essence much of what is developed with tourism in mind can and is being enjoyed by the Perth population as a whole).

Both Federal and State Governments are promoting tourism and it is anticipated that tourism numbers will increase in the future, particularly during the staging of the America's Cup. River managers must ensure that the tourist receives the marketed "product". Similarly incorrect marketing of the product shall not force river managers into approving unsuitable developments.

## 2.5 Past Tourism Studies

WAIT-AID Ltd and Shankland Cox Associates (1977) were commissioned in 1976 to examine and evaluate the natural and man-made resources as they affect tourism and recreation at the regional scale and the opportunities and constraints these resources presented for tourism development potential. Conclusions from the study included:

* Multiple use to be obtained of limited water supplies to help relieve pressures from overcrowding on the Swan River. It was recommended that one of the water supply dams be opened up for recreation. Precedents have been set for this both in Australia and overseas.

* The Swan River is already overcrowded and further filling or dredging to allow more intensive use would have a severe impact on wildlife.

* While there are good reasons for severely limiting additional boating areas and facilities on the rivers (in the interest of human safety and wildlife protection), additional facilities could readily be accommodated along the coast.

* Scenic roads where upgrading should be resisted are ... Riverside Drive at the foot of Perth City and the proposed up-river freeway from Perth (Swan River Drive).

* The Rivervale industrial area, across the river from the city centre and on the main road to the airport, is visually intrusive and should be phased out, particularly as it does not conform with MRPA Scheme zoning.

* To preserve the city's special relationship with the river it is desirable that the long term carparks at the foot of the city centre be camouflaged with landscape roofs.

* Riverside Drive should not be upgraded beyond four lanes.

* Pollution-free water is not only required for preservation of wildlife, but also for its visual amenity value, particularly the Swan River as it passes through central Perth.

## 3.0 AMERICA'S CUP PREDICTIONS

The America's Cup Challenge series will be held between October 1986 to March 1987 inclusive. Successful defence of the Cup will see the event staged every three years.

Increased boat numbers and boating participation to some degree will effect the Swan-Canning Estuarine System. Already applications for hire facilities, marinas and foreshore redevelopment projects have been received by the SRMA and other government departments stating that the objective is to capitalise on tourism and increased boat ownership and participation generated by the America's Cup.

Bowden (1984) prepared forecasts for the America's Cup co-ordinating committee on predictions of W.A. boat numbers to the end of the decade. Points raised in the report were:

- "The overall population of registerable boats is expected to increase from 65 000 in mid 1983 to 87 000 in mid 1990".

- "The number of larger boats (8m and over) is expected to increase from 2 500 to 3 500 over the same period" and at least 800-900 new pen or mooring places will have to be found by the end of the decade to cater for the needs of domestic owners alone. The proposed marinas at Fremantle and Sorrento should help in meeting this demand".

- "Forecasts incorporate an assessment of net 10% stimulus from the America's Cup win and defence".

- "The dominant socio-economic variable in explaining the growth of boats per 1 000 population is a corresponding growth in female labour force participation".

- "The possibility that inadequate boating facilities such as the poor supply of launching ramps, could exert a depressing effect upon the boating population".

- "With the decisions on new marinas at Fremantle and Sorrento already announced, the most pressing outstanding problem facing the industry is viewed by participants" [in the questionnaire] "as the inadequate supply of ocean launching facilities for smaller boats".

Four general themes arose from the questionnaire distributed to boat brokers and sales establishments concerning the stimulus of the America's Cup win on the boating industry itself.

- "Existing launching facilities were grossly overcrowded and/or at inconvenient locations.

- The inequity of building expensive marina facilities for permanent use by only a small section of the boating population.

- The inequity resulting from the lack of return from small boat owners' registration fees and road tax.

- Shortage of launching ramps constituted an impediment to sales effort and a brake on the growth of the small boating industry in W.A.".

Availability of information such as this facilitates the SRMA in its decision making process and it is essential that co-operation between planners for the Cup and managers of the environment be maintained to ensure the integrity of the river environment, particularly in light of the Premier's statement to the Daily News (12th June, 1984) stating that the Swan River's capacity to absorb additional moorings was taxed to the limit and;

> "If we want to save the Swan, offshore facilities are something we can look at".

# CHAPTER 12 : THE ROLE OF WATER IN THE LANDSCAPE

## 1.0 INTODUCTION

The aesthetic importance of the river environment must not be overlooked. Perth City and its location to the Swan River is a successful marketing tool for the Tourist Commission in promoting Perth to overseas visitors. West Australian's are generally very proud of their river system.

But as Digby (1985) states:

"The visual environment affects the greatest number of people and generates the most significant popular response, which includes 'opposition'".

Similarly, Litton et al. (1974) comment that:

"As society becomes more concerned over the scarcity of natural places which are untrampled or undeveloped it is evident that elements which are man-made will be more severely criticised for their degrading presence".

### 1.1 The Waterscape : Importance and Implications for Planning

Besides its necessity for various water sports, why are waterscapes so especially favoured by people?

The popularity of our metropolitan water supply dams as recreation areas (where water sports are not permitted), indicates that the recreational value of waterscapes extends far beyond fishing, boating and other traditional uses.

Kaplan (1977) comments that river environments are by their nature preferred by people because they often provide both a sense of orderliness and a sense of involvement and mystery. Water also contributes to a sense of spaciousness. With the addition of islands, or rocks, or even tree stumps this sense is further enhanced. The water itself provides a continuing, unifying theme to the landscape and one that calls attention to itself.

The river has many qualities that are likely to enhance enjoyment. Movement and stillness of the water can command attention and as it readily changes from one texture to another, it accentuates these characteristics. The banks themselves provide interest and potential diversity with the texture of the river edges also enhancing the attractiveness of waterscapes. As Digby (1985) comments, it is the diversity and combination of physical components that make the place so pleasant for walking, driving, picnicking, photography, painting or just enjoying the view of the combinations of topography, geology, vegetation, buildings and engineering structures, all intimately and intricately related to the panorama of water, sky and bush.

Kaplan (1977) suggests that the river involves an even greater variety of uses (or users) than are usually considered in managing for multiple use. For many the river is a resource to be treasured even from afar. Knowing that it is there, that it is available, constitutes a use-by-proxy. If it were taken away or changed in major ways such 'use' would be violated and the loss to these uncounted many would be real indeed. The beauty and tranquility afforded by the river is there for all to enjoy.

In managing for this multitude of 'uses' the SRMA must be sure that a variety of 'users' are considered in management decisions. To blatantly dismiss augments of aesthetics would be irresponsible. The diversity in environment and population cannot help but require a diversity of approaches if managers are to maximise both impact and satisfaction. The implications for design and management are several. On the one hand, there is room for greater appreciation of -- as well as understanding of -- the scenic factor in such environments. At the same time, there is a pressing need to engage the participation of the many interested individuals whose quiet but often intense concerns have previously been overlooked in the decision-making process (Kaplan, 1977).

## 1.2 Public Perception of the Landscape

Correy (1982, as cited by Digby, 1985) conducted a community preference survey to find out which views of Sydney Harbour people liked or disliked (and why).

It was found that people responded differently in their 'liking' for different views and that there is considerable disagreement among people on the visual value of many elements within a particular landscape.

Some of the conclusions from the study were:

- Most 'disagreements' occurred where scenes showed man-made objects, especially dominant buildings.

- Views of predominantly natural landscapes provided least 'disagreement'.

- No clear-cut opposites, such as 'natural landscape' as against a 'man-made landscape'; which could clearly point to either end of a 'liking' scale, showed up a being significant.

Unfortunately these results indicate it is not possible to have a 'workable' scenic assessment method. However, as Digby (1985) points out the principles of wise planning which include proper selection of site, an understanding of the environment, awareness of other peoples' expectations of their neighbourhood and their proprietary interest in it are just some of the considerations outside the obvious one of financial viability and engineering sufficiency which can be used in planning for the river environment.

## 1.3 Aspects to Consider

Points that the SRMA may consider in its planning decisions are listed below and are based mainly on the work of Litton et al. (1974).

- Design is most strongly expressed when its forms are straight forward and simple. However, problems arise when the visual expression for one element is at visual odds with a different element. Consequently planners must learn to identify areas which must be preserved and those which warrant conservation from those which will need to be altered to accommodate a growing population with growing industrial and service requirements.

- Man-made elements can present excellent and satisfying visual images when the forms adopted are properly limited to the scale and functional requirements of the problem in question and when the accommodation of these forms on the land is done with a minimum of disruption and devastation.

- Structures such as powerlines, canals and freeway systems are visually strong enough to form subdivisions or boundaries in the landscape unit which deflect attention and interest from the most striking or pleasant landscapes.

- When water is a linear boundary at the interface careful planning is necessary to avoid making a free and strong landscape element into a functional fragment (ie Perth Water facing the City).

- If a water or landscape element is to be seen in clear relationship to its surroundings, it is necessary that the nature of its illumination be an important consideration in siting and design.

- When the water element is urbanised it may be concealed or lost in the complexity of urban developments.

- When considering foreshore development selection of view opportunities should be a priority so that undesirable perspectives may be excluded and views of natural features improved.

- Information and access roads should be moved somewhat out of the public eye so that the visual emphasis is placed on the best values of the landscape with its scenic water resources.

- Mass elements, positive or negative, are distinctive because they represent a visible intrusion. The greater the contrast exhibited by the mass element, the more vivid it appears relative to its background, the greater the attraction, the greater the potential degradation by competition.

- Fill structures which project into the water have little to commend them under the best of circumstances but intrusion of such elements into significant view lines can be controlled. Attention to avoiding the most blatant and obvious geometric form could improve their visual relationship to their setting.

- The most perfectly geometric forms are likely to offer the greatest contrast when seen against the natural, usually irregular background of the environment. Busy forms, elaborate decorative detail, or poor visual linkages with the landscape are all capable of generating a degree of contrast which is intrusive. Irregular mass elements may be more easily concealed against a complex background, particularly if the colours and materials chosen blend with that background.

- If man-made point elements are necessary to fulfil functional requirements then rational organisation of these elements will be visually necessary.

- Contrast between the object and background may be reduced in a number of ways. Changing colour by painting; reducing gloss or reflectivity; planting trees to place the offending object in shadow; reducing movement and activity near the point; softening highly visible angularities or structural complexity in favour of less visually exciting outlines. Equally effective but less common possibilities for enhancement by contrast reduction involve removing elements from ridgeline positions to reduce the contrast of silhouette; preventing mirror reflections;

adopting structural forms characteristic of local terrain, or rocks; reducing artificial lighting; keeping clearing or necessary grading to a minimum.

- In the case of new construction, necessary groupings should be designed so that a sense of organisation commensurate with the intended function and its setting is a recognisable visible attribute.

- In cases where the natural qualities of landscape and water are judged to be primary, it is important that planners design and locate necessary utility services, access points and construction to minimise impact.

- Freak architectural styles should be used less in natural surroundings such as the upper reaches of the river than in the competitive city. Some activities do require developments that may be popular with a majority of the public but they add little to the basic qualities which attract people in the first place. If such amenities are more desired than scenery, they should be located in places of low natural scenic value or in places where comparable scenic advantage can be created by design. Only a forthright stand on this point will prevent the eventual reduction of natural values.

- To create a shelf, plateau or space near the water, which is cut off from land by the structure (such as concrete promenades) which only succeed in dividing the landscape into separate bits are not likely to prove as successful as alternatives which provide visual continuity.

- When road construction is contemplated or has occurred adjacent to scenic water resources, screening which permits minimum disturbance by sight or sound should be a fundamental design requirement.

## 1.4 Local Government Initiative

Recognition of the visual amenity of the estuary and foreshores has resulted in some Local Governments incorporating sections into their Town Planning Schemes dealing with this aspect.

The City of Nedlands Town Planning Scheme No. 2 (gazetted 18th April, 1985) is the most specific and is listed (in part only) below.

Section 5.10 Controlled Development Area

5.10.1 Any development within the areas bounded by;

(a) Reserve 17391, The Esplanade, Broadway, lots on the north side of Elizabeth Street and Bruce Street.

(b) Victoria Avenue, the City boundary, the Metropolitan Region Recreation reserve abutting the Swan River and Reserve 16668.

(c) Jutland Parade, Iris Avenue, the Metropolitan Region reserve abutting the Swan River and Point Resolution Reserve.

shall require the Council's special approval.

5.10.2 ... in determining an application for approval of development in a Controlled Development Area:

(a) The Council shall consider the effect of the development on the amenity of the surrounding area, the visual effect of the development as perceived from the Swan River and the effect on the amenity of the parks and recreation reserves in that area in accordance with Council policy from time to time determined for each Controlled Development Area.

..........

(c) The Council may refuse development approval or impose conditions on a development approval where it considers that the amenity of the area may be detrimentally affected by the proposal.

## 1.5 Management

The visual impact of developments on or adjacent to the river environment (and ocean environment) receive considerable attention particularly in the media. Consequently the activities of planners are carried out in an area of conflicting values. Neither the SRMA, SPC or Local Government are immune to these situations. Essentially there is no right or wrong, though at public enquiries an issue may often be argued in these terms because:

1. Those who can attribute a monetory or employment value think they have a superior case.

2. Those who cannot, think they have superior ideals.

Barkham (1973) comments that this kind of battle will continue to be fought over issues of development in the same way and by the same groups of people until values change in response to pressures from the total environment of people.

Techniques may be used to minimise impact of developments but also as Wilkinson (1971) reports:

"There is a need to resolve the disparity between property rights and the landscape in the interests of the present and future".

Property owners should be mindful that their property rights are held in trust and that every legitimate use of the land has spillover effects on the rights of others that limit its scope and use (Wilkinson, 1971).

Criticism has in the past been levelled at environmental planners and managers for rejecting developments on aesthetic grounds, however, man-made structures are usually the most compelling objects in sight when they are set in the natural landscape. For this reason planners and managers must practice constant restraint if visual distractions and degrading clutter are to be minimised in the estuarine landscape.

As Litton et al. (1974) comment:

"The best weapon is the force of example. If public agencies which have a responsibility for preservation and utilisation of the natural and scenic resources demonstrate sensitivity and restraint, the education value will more than justify the care and effort required. Cost is secondary, restraint is not related to dollar values".

One strategy suggested by the W.A. Institute of Landscape Architects in its submission was the development of a landscape masterplan for the river foreshores.

Aspects to consider are:

- The linking of developed nodal areas to other more natural areas.

- Integration of flat open spaces into the landscape.

- Integration of foreshore walling and erosion techniques into the landscape.

- Landscaping of freeway foreshores.

- Protection and preservation of the vineyard areas.

- Bridge design to integrate into the environment.
- Enhancement by management and maintenance of foreshore reserves.
- Restricting stock access in upper reaches.
- Ensure that vegetation is preserved when locating pathway systems.
- Co-ordination in type of materials used for foreshore facilities.

# CHAPTER 13 : ACCESS

## 1.0 FACTORS RESTRICTING ACCESS

The right of the community to 'use' the foreshore and river is undisputable. It is a public resource. Allowing the community right of access to all areas of the river and foreshore to participate in any activities of their choice at any time would be irresponsible management. Besides the various Acts and Regulations instituted by the various managing bodies, controlling use of the waterways and its foreshore there are other factors affecting access to the river environment.

Access to the river and foreshore is restricted by natural features such as water depth, cadastral boundaries, inaccessible terrain, flooding and wetland or drainage systems. Altering any of these would, to varying degrees, interfere with the natural integrity of the river system. Man-made features which restrict public access include land ownership, land use, structures over the river and transport networks.

### 1.1 Land Ownership

As discussed earlier in Chapter 10 there are a number of cases within the management area where land titles extend to highwater mark. If so, land owners may desire to restrict public access across their land provided they do not restrict the natural water movement by doing so.

In a few cases land titles extend to the centre of the river and under the Transfer of Land Act owners may restrict public usage of the area. However, their right to interfere with water used by other people is restricted by other Acts, such as Right in Water and Irrigation and Navigable Waters Regulations.

Such situations have presented problems for planners, particularly recently, with the develoment of dual-use paths around the river. Where the SPC has been unable to acquire the MRS Parks and Recreation Reserves land from the owner, pathways have stopped one side of the property and continued on the other. There are also situations where the SPC has acquired the Parks and Recreation Reserve and the adjacent land owner has developed it to appear like private property.

There is a need for MRS boundaries to be extended and rationalised throughout the management area and also tributaries of the river system. In this way, public access can be ensured as the metropolitan area spreads, deferred rural land subdivided and foreshore reserves ceded to the SPC as a condition of subdivision.

It has been suggested both in public submissions and past reports that the problem of private land ownership of the foreshore may be rectified by allowing public access to private land similar to the situation that exists in England. Unfortunately in addition to getting landowners to agree there are legal problems of compensation and insurance in case of accident. That is not to say these problems cannot be overcome. However, as this is a statewide problem it needs to be addressed on a State basis. In the interim individual agreements between property owners and government agencies may be appropriate provided the rights of both are ensured.

### 1.2 Land Use

Land use of foreshore land (other than privately owned land) and gazettal of specific areas in the river restricts general access to the area. When a lease is granted for use of the river environment it is important to ensure that public access is not restricted except where the safety of the public may be at risk. Many leases to recreation clubs ensure the right of public access through the lease area.

### 1.3 Structures

The building of structures over the river such as power lines, water pipes and bridges, has restricted access not only to the foreshore but also boat traffic past these structures. The height of these structures restrict the size of vessels able to pass underneath.

It is essential that approval for any new structures or upgrading of existing ones take account of access by foot, cycle, vehicle and boat. The SRMA has recommended to the MRD that fishing platforms be incorporated into new bridge structures where feasible, enhancing public access to the river.

Recent development of some structures has assisted access to and across the river. Mt. Henry Bridge, Canning River provides a separate dual-use path. Also a jetty built during bridge construction has remained for public use.

TABLE 1: MODES OF ACCESS TO THE RIVER AND POSSIBLE CONSEQUENCES

| TYPE | ENVIRONMENTAL IMPACT | SAFETY ISSUES | CONFLICT BETWEEN USES |
|---|---|---|---|
| Foot | - Destruction of peripherial vegetation.<br>- Disturbance of sensitive fauna.<br>- Formed paths create artificial barriers for flora and fauna.<br>- Erosion.<br>- Soil compaction | | |
| Cycle | - Formed paths create artificial barriers for flora and fauna.<br>- Creation of pathways requires modification of natural foreshore if terrain unsuitable. | - Closeness to foreshore.<br>- Protruding limbs of trees.<br>- Width.<br>- Right of way.<br>- Walkers supposed to have preference but not really practical.<br>- Promenade cycleways can require railings to ensure people do not crash over the bank. | - Paths create barrier to other users using the foreshore if incorrectly sited. |
| Motor Vehicle | Potential of:<br>- Runoff from roadways, carparks to contribute to water quality problems.<br>- Noise.<br>- Destruction of flora and fauna habitat if)on unformed roadways.<br>- Erosion. ) | | - Noise<br>- Incorrect siting reduces or eliminates available foreshore reserve. |
| Trail Bikes and off-Road Vehicles | - Noise.<br>- Erosion.<br>- Destruction of vegetation. | - Disregard of road rules | - Noise, dust. |
| Horse | - Localised eutrophication of water body.<br>- Erosion.<br>- Destruction of peripheral vegetation | | - Nuisance factor. |

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| TYPE | ENVIRONMENTAL IMPACT | SAFETY ISSUES | CONFLICT BETWEEN USE |
|---|---|---|---|
| Canoe | - Need for launching areas as contribute to erosion and destruction of peripheral vegetation. | - All require knowledge of navigable water regulations for the area. | |
| Rowing | As above | " | |
| Windsurfing | - Most popular sights adjacent to aquatic reserve and access needs to be limited to reduce disturbance of migratory birds. | " | - Yachting. |
| Yachting/Sailing | - Launching of boats over bank can cause destruction of peripheral vegetation. | " | - Other boating. |
| Motorised Craft | - Potential pollution problems due to oil spills.<br>- Launching of boats can lead to destruction of peripheral vegetation.<br>- Noise disturb fauna. | - Speed | - Swimmers.<br>- Noise.<br>- Boat wash create problems for other users of smaller craft. |

## 1.4 Roadways

The development and impact of roadways on the river environment was discussed more fully in Chapter 7. Historical development in many cases has dictated the siting of riverside roads, although road systems such as Mounts Bay Freeway Interchange and Kwinana Freeway have been planning initiatives.

Transport networks may enhance or reduce access to the river and foreshore. Development of minor roads along the foreshore provide our car oriented society with scenic river drives. However, too close alignment reduces or eliminates the foreshore available for other forms of recreation.

Alternatively major roadways such as Riverside Drive and Kwinana Freeway have reduced access to the river by alienating the environment from the public. The Central Perth Foreshore Study conducted by the City of Perth aims to try to overcome this alienation of the foreshore in its future planning for the area (CPFSG, 1985).

There is no place for extensive road networks running parallel to the river foreshore, particularly if the work requires reclamation of the river or foreshore wetlands.

## 1.5 Alienation of the River

In addition to physical inaccessibility to the foreshore or river there is the problem of alienation. Examples around the river include:

- Busy roads directly behind the foreshore reserve making the environment undesirable for use because of noise, safety, petrol fumes.

- Land owners with public foreshore adjacent to their property developing it to appear as if it is private property.

- Walling of the foreshore.

- Development of foreshore reserves. For example carparks situated between the foreshore and play equipment or picnic areas. Cycleways running along the bank of the river so dividing other users from the water. Land leased to clubs for recreational use may also give the impression that public access is restricted.

The smaller the foreshore reserve the greater the impact of incorrect design development.

## 2.0 PROBLEMS ASSOCIATED WITH MODES OF ACCESS

Access to the river environment needs to be controlled in some way. Reasons being environmental impact, safety issues and conflict between various uses of the river environment. Whatever the reason for controlling access it should be noted that no one mode is preferential to another unless level and frequency of use and nature and fragility of the environment is assessed. Table 1 illustrates some of the problems experienced.

## 3.0 ACCESS FOR THE DISABLED

In recent years the rights of the disabled and problems of access they experience have come to the forefront of planning. In 1977 the Australia Standards for the Disabled were developed and more recently in 1985 the Uniform Building By-laws were established.

It is the responsibility of all departments involved in approving plans and overseeing the development of public foreshore facilities to ensure that consideration is given to improving access for the disabled. The disabled have the right to experience positive recreation pursuits; to experience the normal range of individual experiences; to experience independence and self reliance; and to have atypical needs met. It should also be recognised that the needs of these members of the community may be as great, if not greater than those of the abled community (Master, 1980).

Areas of concern are generally parking, kerbs, pathways, ramps, steps, entrances, passageways, toilets, utilities (telephones, drink fountains, picnic tables etc.) and signs. Local Government is aware of these needs and addresses many of these aspects when designing public facilities. Modification of existing facilities is however more difficult

The river environment also requires that the problem of access to and from the water be considered. The SRMA in reviewing this problem assessed the possiblity of installing hydraulic hoist structures. It was concluded that the problems of vandalism would unfortunately render these structures inoperable too often. Consequently the Authority favours ramps to enable access to the water. A ramp has been installed at Garvey Park, Belmont and feedback on the success and popularity will be required before further structures are installed.

New devices will almost certainly provide new options to the Authority and other bodies to alleviate the problems of access to the river environment for the disabled. Management needs to keep abreast of these situations.

If the Authority is to provide facilities for the disabled it is essential that they are promoted to these people so that maximum use is made of them. In 1983, DYSR produced a booklet detailing recreation facilities accessible to the disabled. It would be wise if information is forwarded to DSR as facilities are improved. Table 2 indicates the facilities and problems experienced by the disabled when using the river environment.

PLATE 15: Access to the foreshore has been restricted due to the Kwinana Freeway

TABLE 2: ACCESS TO RIVERSIDE RECREATION FACILITIES FOR THE DISABLED

| FACILITIES | LOCATION | FEATURES |
|---|---|---|
| USABLE | | |
| Beaches/Changerooms | Como Beach/Jetty Kwinana Freeway, Como | Kerbside parking, kerbs ramped. Accessible toilets but no doors, jetty accessible, park in Melville Parade. Assistance required on steep walk bridge over freeway. Playground and equipment. |
| PARTIALLY USABLE | | |
| Claremont Yacht Club (Inc) | 4 Victoria Avenue, Claremont | No kerbs in parking area, gain entry by following path around side of club house away from waterside. Ramp up main office and duties office. Club house and toilets therein accessible. |
| Beaton Park | Esplanade, Dalkeith | Kerbside parking; rough area, no toilets. |
| Children's Park | Warell Road, Nedlands | Kerbside parking, 7.5cm kerb, no toilets. |
| Beaches/ Changerooms | Matilda Bay Reserve Hackett Drive, Crawley | 15 cm kerbs. The reserve is bordered by handrails which have gaps for access. Toilets inaccessible. |
| McCallum Park | Canning Highway, South Perth | Kerbside parking, toilets inaccessible. |

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(Contd).

| FACILITIES | LOCATION | FEATURES |
|---|---|---|
| Pickering Park | Bassendean Parade, Bassendean | Kerbside parking, grassed area. |
| Point Reserve | Surrey Street, Bassendean | Gravel parking area and path system, toilets uphill but accessible. Children's playground and river foreshore. |
| Sandy Beach Reserve | West Road, Bassendean | Open parking, toilets inaccessible. River foreshor shady trees. |
| Success Hill Reserve | Seventh Avenue, Bassendean | Grass parking area, toilets inaccessible, bitumen and grass path system. |
| Kings Meadow Oval | Hill Street, Guildford | Hard packed earth parking area, no kerbs, toilets inaccessible. |
| Maylands Water Playground | Clarkson Road, Maylands | Steps to toilet and shop, there are very steep ramp 10cm kerb, no marked bays, double gates. |
| Point Walter | Honour Avenue, Point Walter, Bicton | 10cm kerbs, jetty inaccessible, toilets inaccessible, access to playground via grassed area. |
| Ascot Water Playground | Mathieson Road, Redcliffe | 15cm kerbs but ramped, cement path system throughout. |
| MTT Ferry & foreshore | South Perth Esplanade, South Perth | Kerbside parking, ramped kerb, toilets inaccessible. |
| Sir James Mitchell Park | Mill Point Road, South Perth | Surf Cat hire. |

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(Contd). .

| FACILITIES | LOCATION | FEATURES |
|---|---|---|
| Clydesdale Park | Mill Point Road, South Perth | Parking on grass, toilets inaccessible. Playground equipment. |
| Swan View Playground | Swan View Terrace, South Perth | Kerbside parking, standard kerbs, no toilets. |
| NOT USABLE | | |
| Beaches/Changerooms | Nedlands foreshore | Inaccessible. |
| Nedlands Yacht Club | Foreshore, Nedlands | Steps to club house. |
| Park | Point Resolution Reserve, Jutland Parade Dalkeith | No toilets, 15cm kerbs. |
| Bicton Baths/Blackwall Reach Jetty | Cr. Blackwall Reach Parade and Braton Street, Bicton | Difficult access. |
| Deep Water Point Reserve | The Esplanade, Mt. Pleasant | Access to playground and boat ramp. Hall, jetty and toilets inaccessible. |
| The Strand Toilets and parking area | The Strand, Applecross | Parking area surrounded by logs stopping access. Jetty accessible. |
| Garvey Park - Ascot Kayak Club | Fauntleroy Avenue, Redcliff | Steps to club house, uneven gravel path system. |
| Riverton Jetty Park | Fern Road, Riverton. | Loose earth parking, no paths, toilets inaccessible and NB currently being upgraded features include ramped kerbing, ramp to water, pathways. |

Ref DYSR (1983)

# CHAPTER 14 : RECREATION FACILITIES AND USE

## 1.0 INTRODUCTION

This chapter details the recreation reserves, facilities and activities that occur within the study area. Much of the information is based on studies undertaken by the Waterways Commission in 1984-85. These data are presented more fully in a technical report entitled "Swan River Recreation Study : Technical Report" (Thurlow, 1986).

Location of reserves and facilities are marked on the accompanying maps.

### 1.1 Provision of Recreational Opportunities

According to Ohmann (1974), the time to match potential recreation uses with each other and with the resource is in the planning stage when management objectives are being defined. Moreover anticipated future demand dictates that managers will soon be expected to provide the appropriate recreation opportunities in the most appropriate areas and not (as may have often been the case in the past) provide for demands where users have "created" them through customs or tradition (Ohmann, 1974).

It is Management's responsibility to ensure that through planning, improper matching of use and resource can be avoided and minimum hardening of sites required to withstand recreation impact.

With a resource such as the Swan-Canning Estuarine System and its proximity to metropolitan Perth, management should look at defining management objectives on a regional basis thus providing more recreational opportunities within the continuum of recreational demands and avoiding more resource conflicts.

Furthermore as Ohmann (1974) comments it should be recognised that each public agency and the private sector cannot (or need not) provide all types of recreational opportunities. Interagency regional planning could result in each public agency, and the private sector, providing the kind of recreation that best meet the agency mission and best "fits" the nature of the resource under the agency's jurisdiction.

## 2.0 FACILITIES

The provision of recreation facilities around the foreshore may be privately or publicly funded. In the public sector much of the responsibility has fallen to individual Local Government Authorities. As Local Government funding is from local residents rates pressure may be applied to provide, or not provide, facilities in certain areas. Additional funding may be provided directly by State Government or via Government Departments. Federal funding in the form of employment and natural enhancement scheme programmes has more recently assisted Local Government.

Provision of these facilities requires a co-ordinated approach to ensure they are sited in the most appropriate location. Each Local Government Authority must not feel obligated to provide every recreational opportunity and facility within its boundaries. The river is a limited resource and facilities cannot continue to be expanded without detracting from the visual and physical environment. This applies particularly to carparks. Rather than a vast majority of a reserve ending up as bituminised carpark it may be more appropriate to permit parking on grass verges etc. during peak periods.

Given that recreational activities may occur both in ocean and river waters opportunities available at both locations should be considered in plans for any future development.

The approval process for over-the-water structures permits control over the type of materials used in construction as well as design features. However facilitiies such as ablution blocks, cycleways, carparking etc. are mostly Local Government responsibility, with the State Planning Commission overseeing plans for land within or abutting MRS Reserves. There is a need for co-ordination of design techniques between and within Local Government.

All facilities should be in harmony with the environment, ensuring they do not dominate its aesthetic qualities. Facilities in National Parks, both here and overseas, often feature designs and construction techniques which are both practical and visually pleasing.

### 2.1 Site Planning

Site planning is essential if users are to get the most from their visit and environmental impact is to be minimal. If sites are not planned correctly their level of use will not justify the money spent on installation and maintenance of facilities perhaps affecting future decisions for new facilities elsewhere. Moreover people will seek out areas more suitable to their needs. Unfortunately these are likely to be less environmentally suitable resulting in more damage to the area.

Too often sites are upgraded according to established patterns of use, however, these are not always the most desirable. In the past the majority of reserves have not been planned but rather just 'grown' and been 'hardened' later with carparks, roads, foreshore walling to control environmental impact. To gain the most from these areas they must be properly planned even if it means removing and/or relocating existing facilities. It is management's responsibility to direct use into the most appropriate areas and not perpetuate past planning mistakes.

Planners should seek the help of existing users, establishing their needs, requirements and any problems that exist within the current site.

Too often simple planning mistakes occur. These include:

- Dividing roads between ablution facilities and/or picnic areas.

- Carparks on the foreshore leaving little recreation area between it and the river forcing users down banks onto more sensitive areas.

- Children's play equipment separated by roads.

- Pathways cutting through recreation reserves.

- Facilities becoming focal features of an area rather then blending in with the surrounds.

- Inconsistency with construction materials and techniques used.

## 2.2 Site Hardening

Sites can be hardened to provide the recreational opportunities called for by the management objectives for that area. In general research should focus on developing techniques of hardening sites so that:

- A minimum of energy (money) is required.

- Any change in the character of the area is acceptable to users.

- The resource is protected and the technique is aesthetically acceptable. (Peterson and Lime, 1979).

Around the river environment these techniques may include erosion control measures, access points to the river, pathway systems and parking facilities.

## 2.3 Boating Facilities

### 2.3.1 Responsibility for Provision of Public Boating Facilities

Responsibility for initiating and planning public recreational boating facilities rests with Local Government. Government funding is provided for approved ramp projects, usually up to 50% of the cost of marine works.

According to P.A. Australia (1981) a more acceptable alternative would be a central authority to establish the overall requirements for recreational boating, together with an indicative cost for each facility. This information, plus a knowledge of the level of funds which the Government is prepared to commit would allow realistic priorities to be set. The control authority would then approach each Shire and enlist their interests. It was also suggested in the report (P.A. Australia, 1981) that the installation of pens, jetties, repair and service facilities, storage areas, etc. be funded by others, preferably the user.

Provision of facilities for recreation clubs and private marina owners essentially remain the responsibility of the leasees, although in some cases government funded projects have assisted with some works used in part by recreation clubs (e.g. jetty and ramps at Garvey Park). These facilities are still available for use by the general public.

### 2.3.2 Gazetted Water Areas

Water areas are gazetted by the Department of Marine and Harbours. These are introduced to restrict use of a certain area to a particular user group to ensure the safety of all users, reduce the conflict between various activities while still providing a range of recreational opportunities around the river.

Gazettal of areas should also take into account the impact of the activity on the river environment and adjacent resident population (i.e. noise and water skiing), not purely provision of a safe area for a particular activity.

The following is a list of gazetted water areas within the study areas. These areas are also marked on the accompanying maps.

### 2.3.2.1 Swimming Areas

The Department of Marine and Harbours defines and sets aside the following areas of navigable waters as areas which shall not be used for any purpose other than swimming:

1. **Swan River**

    a) Point Walter : All water contained within an area commencing at the Point Walter Jetty and extending for 122 metres upstream and for a distance 28 metres into the water.

    b) Swan River - Matilda Bay : All the water contained within an area commencing at a point on the foreshore 183 metres north west of the public launching ramp, extending north west along the foreshore for 220 metres and extending offshore for 85 metres as depicted by piles and signs.

    c) Perth Water : All that water contained within an area commencing at a point on the South Perth foreshore 97 metres north of the Mends Street Jetty; thence extending 22 metres in an easterly direction at right angles to the foreshore; thence 175 metres in a northerly direction parallel to the foreshore; thence 22 metres in a westerly direction to the foreshore.

    d) Belmont : All that area of water within 65 metres of the foreshore and between a point situated 100 metres upstream of the Belmont Swimming Jetties (springs) to a point 100 metres downstream of those jetties.

    e) Ascot : All that area of water within 45 metres of the foreshore and between a point situated 100 metres upstream of the Ascot Swimming Jetties to a point 100 metres downstream of those jetties.

2. **Canning River**

    All water contained within an area commencing at the Deep Water Point Swimming Jetty and extending 188 metres downstream and for a distance of 38 metres into the water.

2.3.2.2 **Speedboat Areas**

The Department of Marine and Harbours defines and sets aside the following area of navigable waters for the purpose of racing of speed boats and orders that bathing shall be prohibited therein:

**Swan River**

All that portion of the Swan River contained within an area commencing at a point on Heirisson Island 375 metres upstream from the north end of the southern Causeway span; thence in an easterly direction to a point on the Victoria Park foreshore 580 metres upstream from the south end of the southern Causeway span; thence in a northerly direction along the foreshore for 1220 metres; thence in a westerly direction for 120 metres towards the centre of the river; thence in a southerly direction to the north eastern extremity of Heirisson Island. Provided that this course shall be used only on Saturdays and Sundays during the conduct of events approved by the Department.

2.3.2.3 **Water Skiing Areas**

Water skiers are confined to the "Swan River areas' on Saturdays and Sundays and public holidays. At all times water skiing is permitted on all waters of the Swan River downstream of the Narrows Bridge with the exception of gazetted speed limit areas and subject to the provisions of the Navigable Waters Regulations.

1. **Bamboos**

   From the prolongation of Osborne Parade 305 metres from shore in the easterly direction in a direct line to the south east end of the Claremont Jetty, thence in a southerly direction for 675 metres and then 305 metres in a westerly direction to meet the shore at the foot of Forrest Street. Deep water take-off only.

2. **White Beach**

   Within a line extending 460 metres in a westerly direction from the prolongation of Jutland Parade, Dalkeith; thence 800 metres in a north-north westerly direction to the beacon on Karrakatta Bank; thence in a east-north easterly direction to the shore but so that no boat or skier shall approach within 90 metres of the shore other than in an area extending 305 metres along the foreshore from the said prolongation of Jutland Parade which shall be the take-off area.

3. **Chidley Point**

Between all that area of water within 305 metres of the shore for a distance of 610 metres to the north-west of Chidley Point; thence in the same direction for a further 230 metres tapering to 230 metres of the shore at the north-westerly extremity of the area, but so that no boat or skier shall approach within 60 metres of the shore except at Chidley Point.

4. **Point Walter**

All the waters of the Swan River contained within an area bounded on the north by an imaginary line drawn from Bricklanding Pile to North Point Walter Spit thence to the extremity of Point Walter Spit and bounded on the south by the foreshore between the extremity of Point Walter Spit and a limit of ski area sign situated on the foreshore 536 metres south-east of the Point Walter Jetty but so that no boat skier shall approach within 60 metres of the Point Walter Jetty nor within 76 metres of the foreshore between the jetty and further limit of ski area sign situated 285 metres south-east of the jetty.

5. **Waylen Bay**

Within a line extending 475 metres from Heathcote Point, Applecross, in a north-easterly direction, thence in a north-westerly direction for 230 metres; thence south-westerly for 1070 metres and southerly to the shore, but so that no boat or skier shall approach within 90 metres of the shore except within an area on the foreshore extending for 150 metres in a south-westerly direction from Heathcote Point as a take-off area, between the hours of 8 a.m. and 2 p.m. on Saturdays and Sundays.

6. **Freeway**

Within a line extending from the groyne at Mill Point, South Perth in a westerly direction for 455 metres; thence in a south-westerly direction for 1525 metres to the Pelican Rocks Beacon; thence in a north easterly direction or 1370 metres to a point on the foreshore, being the prolongation of Judd Street, South Perth, so that no water skier shall approach within 45 metres of the foreshore except at the take-off area.

7. **Commercial Skiing**

Within a radius of 340 metres from a point on the foreshore 70 metres downstream from the Queen Street Jetty, South Perth. This site is reserved for commercial ski schools only.

8. **Association HQ**

Between a line drawn from the south western extremity of Heirisson Island to a point on the South Perth foreshore 600 metres west of the prolongation of Ellam Street, South Perth and a line drawn from a point on Heirisson Island 375 metres upstream from the north end of the southern Causeway span to a point on the Victoria Park foreshore 580 metres upstream from the south end of the southern Causeway span. This area is set aside for the teaching and training of competition skiing by members of the Western Australian Water Ski Association.

9. **Belmont**

Between a line from a spit post at or about the centre of Belmont Park Racecourse due east to the bank and a line between the two chimneys of the Swan Portland Cement Works on the southern bank and the chimneys of the brickworks on the northern bank. This area shall not be used for water skiing between the hours of 2 p.m. and 5 p.m. on those Sunday afternoons that the Maylands Yacht Club is conducting races.

10. **Canning River**

i) **On Saturdays, Sundays and Public Holidays Whilst Rowing Regattas are not in Progress**

All the waters of the Canning River between a line drawn 100 metres upstream and parallel to Canning Bridge and a line drawn 100 metres downstream and parallel to a line joining Fifth Avenue at Rossmoyne and Salters Point but so that no boat or skier shall approach within 60 metres of the foreshore on the west bank between Canning Bridge and Deep Water Point or between Queens Road and the junction of Bull Creek or within 60 metres of the southern foreshore at Rossmoyne between the junction of Bull Creek and the Point a 100 metres downstream of Fifth Avenue, or within 60 metres of the northern foreshore of Aquinas Bay from the foot of Sulman Avenue to a sign on the foreshore on the eastern side of Mt Henry.

No water ski take-off or landing shall be permitted from the Manning foreshore between a point 100 metres upstream on this foreshore being 73 metres south of the prolongation of the southern side of Edgewater Road and extending for 100 metres in a southernly direction along the foreshore.

All water skiing within this area shall be in an anti-clockwise direction and no person shall engage in water skiing except between the hours of 9.00 a.m. and sunset.

It shall also be a condition of water skiing in this area that water ski boats shall observe the signs on the spans of the Mt Henry Bridge and that no boat being within 300 metres of either side of the Mt Henry Bridge shall turn across the directional line of traffic.

ii) **On Saturdays, Sundays and Public Holidays Whilst Authorised Rowing Regattas are in Progress**

That portion of the area defined in paragraph (i) between Canning Bridge and Mt Henry Bridge shall not be used for water skiers except during those hours between 9.00 a.m. and sunset which do not conflict with the holding of rowing regattas the hours which have been duly authorised by the Department of Marine and Harbours.

iii) **On Mondays to Fridays (Not Including Public Holidays)**

All the waters of the Canning River between a line drawn from Deep Water Point due east to the Manning foreshore to a line joining Fifth Avenue at Rossmoyne and Salters Point but so that no boat or skier shall approach within 60 metres of the foreshore on the west bank between Queens Road and the junction of Bull Creek or within 60 metres of the southern foreshore at Rossmoyne between the junction of Bull Creek and the Point 100 metres downstream of Fifth Avenue, or within 60 metres of the northern foreshore of Aquinas Bay from the foot of Sulman Avenue to a sign on the foreshore of the eastern side of Mt Henry.

No water ski take-off or landing shall be permitted on the Manning foreshore except from a point on the foreshore being 73 metres south of the prolongation of the southern side of Edgewater Road and extending for 100 metres in a southerly direction along the foreshore.

All water skiing in this area shall be in an anti-clockwise direction and no person shall engage in water skiing except between the hours of 9.00 a.m. and sunset.

It shall be a condition of water skiing in this area that water ski boats shall observe the signs on the spans of the Mt Henry Bridge and that no boats being within 300 metres of either side of the Mt Henry Bridge shall turn across the directional line of traffic.

The area north of the line drawn from Deep Water Point of the Garratt Road Bridge and extending upstream to a position 235 metres downstream to the Ascot Swimming Jetties. This area is set aside for the training of members of Barefoot Division of W.A. Water Ski Association only and is not to be used for public water skiing.

11. **Bayswater**

All the waters from a position 580 metres upstream of the Garratt Road Bridge and extending upstream to a position 235 metres downstream to the Ascot Swimming Jetties. This area is set aside for the training of members of the Barefoot Division of the W.A. Water Ski Association only and is not to be used for public water skiing.

### 2.3.3 Launching Ramps

In August 1983 the following public boat launching areas were authorized under Section 8 (e) of the Waterways Commission Regulations 1981. Consultation occurred with all Local Government Authorities before compilation of this list. Launching of craft by trailer in locations other than these (or club facilities) is illegal under the Waterways Conservation Regulations. Table 1 lists these areas.

**TABLE 1:** Public Boat Launching Areas

| **RAMP NAME/LOCATION** | **FACILITY** |
|---|---|
| Preston Point, East Fremantle | Two lane concrete ramp suitable for T/S Swing Keel. 79 trailer parking bays. Jetties for boarding craft. Additional car only bays. |
| Point Walter, Bicton | Two double concrete ramps. One set aside for ski craft. |
| Deep Water Point, Mt. Pleasant | One two lane concrete ramp. Approximately 35 parking bays. Used mainly by ski craft. Additional parking on grassed areas. |
| Cloister's Avenue, Manning | Single lane gravel ramp. Parking limited. Road access to ramp difficult. |
| Goodwood Parade, Rivervale | Single lane concrete ramp. Approximately 30 parking bays. Used mainly by ski craft. Shortage of bays. |
| Katanning to Constance Streets, Bayswater | Two lane concrete ramp. Unformed parking area. All weather ramp, draft 1.4 metres. |
| Clarkson Reserve, Maylands | One lane concrete ramp, 57 parking bays. All weather ramp. |
| Matilda Bay, Crawley | Two lane all weather concrete ramp suitable for T/S Swing Keel. 25 parking bays with additional parking on adjacent grassed area. |
| Qantas Ramp, Nedlands | Two lane concrete ramp. Limited parking because of popularity of site to wind surfers, approximately 25 bays. Shallow water and sand drift limit size of craft capable of being launched here. |

| | |
|---|---|
| Johnson Street, Mosman Park | Two lane concrete ramp. No parking, poorly maintained. Not suitable for expansion. |
| Salter's Point (off Salter's Point Parade), Manning | No formal area, suitable small craft only. |
| Riverton Bridge (off Riverton Drive Downstream), Riverton | No formal area, suitable small craft only. |
| Como Foreshore (south of Mill Point), Como | No formal area used mostly by ski craft. |
| Forbes Street, Redcliffe | No formal area. |
| Swan Street, Guildford | Single concrete ramp, recently upgraded, parking. Furthest launch ramp upstream on the Swan River (2 metres). |
| Stirling Bridge (north side, downstream) | No formal area. |
| Kent Street (north side Cannington only) | No formal area, suitable for small craft only. |
| Coode Street, South Perth | Single concrete ramp. Too steep, surface needs repairing. Informal parking but will change as area upgraded. |

It remains the responsibility of Local Government Authorities to ensure that launch ramps are suitable for use, particularly removing the build-up of sand. Similarly Local Government should notify the Authority if it wishes these areas closed to boat launching.

P.A. Australia (1981) reports that the majority of boaters (70-80%) use ramps almost exclusively and asign little or no priority to mooring and berthing facilities. This result has implications on the manner in which funds for facilities might be allocated.

Moreover results indicated that many ramps are either poorly maintained or require modification to make them more acceptable to the boating public. P.A. Australia (1981), therefore, recommended that a high priority be given to bringing existing ramps to an acceptable standard.

Results also confirmed a strong consensus that power boats launching into the river and heading out to sea were a major cause of congestion on the Swan River. Weekend observations at Preston Point Ramp, East Fremantle confirmed that over 90% of boats launched during this time headed directly out to sea. Similarly many of the boats launched early in the morning at other sites headed downstream (and presumably out to sea). These results suggest that rather than establish additional launching facilities within the river management should aim at attracting these boaters away from the river by providing suitable ocean launching facilities. In the short term education programmes and incentives may be needed to change established habits and get these boaters to use new ocean facilities.

Incorrect location of boat ramps can lead to problems of erosion and accretion. Similarly prevailing winds can make launching difficult. Location of boat ramps without trailer parking as at Johnson Street, Mosman Park is foolish planning. Boat ramps located adjacent to residential areas also lead to complaints of noise.

Observations of users have revealed that many people occupy the ramp before they are ready to launch their boat thus delaying other people. Once boats are launched there is a need at some locations for boarding jetties to allow passengers to embark e.g. Preston Point.

SRMA policies for boat ramps are covered in Chapter 18, 6.0.

### 2.3.4 Jetties

A licence under the Jetties Act is deemed to be a licence under the Waterways Conservation Act by virtue of Regulation 17 of the Waterways Regulations. It is a requirement imposed by Regulation 17 (4) that the Minister responsible for the Jetties Act shall not issue a licence under the Act <u>until</u> he has received and considered the <u>recommendations of the Commission</u>.

Therefore under the scheme of Regulation 17, it follows that the actual decision to issue an effective licence is ultimately left to the Minister responsible for the Jetties Act.

SRMA policies on jetties are listed in Chapter 18 3.0 and 5.0. Essentially existing jetties will be licenced if in good order. Similarly jetties will be transferred if in good order provided the new owner resides either in front of or diagonally to the jetty. Applications to construct private jetties will not be approved if they abut public reserves or road reserves.

Applications to construct public jetties may be approved if the structure is vested with the Local Government Authority and the applicant takes responsibility for its maintenance. This maintains public access to the structure and the water.

The SRMA would not recommend any new jetty downstream of the Narrows Bridge or the Canning Bridge unless there were real extenuating circumstances.

Jetties, with the exception of those belonging to private houses are marked on the accompanying maps.

Jetties may be public or private facilities. It is Crown Law opinion that as the public have right of access to navigable waters for fishing, navigation and ancillary purposes a jetty licensee could therefore be restrained from interferring with these rights (by i.e. denying public access to 'private' structures). The extent of these rights would have to be determined by a court hearing a dispute between a licensee and a member of the public who considered their rights were infringed upon by construction and denial of public access to the structure.

Table 2 lists publicly owned jetties.

**TABLE 2:** Public Jetties

| **AREA** | **NO** | **SPECIFIC FUNCTION*** |
|---|---|---|
| Riverside Road, East Fremantle | 3 | Temporary mooring, loading, unloading |
| Riverside Road, (Preston Point Ramp) | 1 | Boarding jetty for boat users |
| East Fremantle | 1 | |
| Braunton Street, Bicton | 2 | Swimming area |
| Pt. Walter, Bicton | 1 | Temporary mooring, loading, unloading |
| Green Place Reserve Chidley Point | 1 | Temporary mooring, loading, unloading |
| Johnson Parade, Mosman Park | 1 | Diving Platform |
| Jetty Road, Claremont | 1 | Temporary mooring, loading, unloading |

| | | |
|---|---|---|
| Jeff Joseph Reserve, Applecross | 1 | Temporary mooring, loading, unloading |
| Mt. Henry Bridge, Mt. Pleasant | 1 | Acces to river |
| Riverton Drive, Bullcreek | 1 | Temporary mooring, loading, unloading |
| Matilda Bay Crawley | 2 | Swimming area |
| Old Power Station, East Perth | 1 | |
| Queen Street, South Perth | 1 | |
| Cracknell Park, Rivervale | 1 | Old Swimming Jetties |
| Bath Street, Maylands | 2 | Swimming Jetties |
| Garratt Road, Bayswater | 2 | Swimming Jetties |
| Garvey Park, Redcliffe | 1 | Access to the river and kayak club use |
| Point Reserve, Bassendean | 2 | Swimming area |
| Kings Meadow Oval, Guildford | 2 | Swimming area |
| Success Hill reserve, Bassendean | 1 | Public access |
| Marshall Park, West Midland | 2 | Swimming area |
| Reg Bond Reserve, Viveash | 1 | Public access |
| Caversham Avenue, Caversham | 1 | Public access |

* The majority of jetties are used for fishing, although they were not specifically built for that purpose.

2.3.5 **Boatsheds**

It is the SRMA's policy to oppose the establishment of private boatsheds on the river. The policy is listed in detail Chapter 18, 4.0. Reasons for this attitude include:

- Poor record of maintenance of structures.
- Visual impact.
- Reducing public access to the foreshore.
- Reduction of water space available for other recreationists.
- Many of the old boatsheds abutted public reserves.
- Marinas and mooring areas provide similar services to boat owners taking up less space, providing more opportunities for a greater number of people.

2.3.6 **River Mooring**

The situation on establishment of moorings within the study area has recently changed. Currently there are to be no new moorings unless written approval has been given by the Department of Marine and Harbours. Prior to this it was possible to put a mooring down anywhere in the river as long as it did not interfere with navigation, established racing areas or use of gazetted areas. It is Marine and Harbours intention to eventually have an inventory of moorings within the river. There is still no fee payable to have a mooring in the river. Consequently the demand for moorings does not reflect the demand for wet pens within the river. This free service also means that on occasions boat owners do not maintain their craft very well allowing their boats to become derelict, eventually sinking at their moorings, leading to court action and eventual removal by the SRMA.

Similarly because boats are on moorings they are more exposed to storm conditions, often breaking their moorings, damaging other craft, being washed up on the foreshore or sinking at their moorings. The SRMA and Marine and Harbours assist in rescuing these craft, the cost of which is often not recovered from boat owners.

Table 3 lists river mooring areas.

**TABLE 3:** River Mooring

| AREA | OCCUPIED MOORINGS | UNOCCUPIED MOORINGS |
|---|---|---|
| Fremantle Bridge (north side) | 7 | 1 |
| Stirling Bridge (north side) | 30 | 8 |
| Stirling Bridge (south side) | 3 | 10 |
| Preston Point (downstream) | 25 | 6 |
| Preston Point (upstream) | 39 | 6 |
| Blackwall Reach (Bicton jetties to Kent Street) | 95 | 53 |
| Blackwall Reach (Kent Street to Pt. Walter) | 30 | 11 |
| Chidley Point to Mosman Bay | 35 | 36 |
| The Esplanade, Freshwater Bay | 57 | 17 |
| Freshwater Bay, Claremont | 18 | 9 |
| Waratah Place, Nedlands | 1 | 12 |
| Armstrong Spit (west) | 1 | 1 |
| Armstrong Spit (east) | 29 | 18 |
| Nedlands Baths | 18 | 11 |
| Matilda Bay (downstream) | 1 | 11 |
| Matilda Bay (Mounts Bay Road) | 42 | 37 |
| Burke Drive (Ardross) | 2 | 1 |
| Canning Beach Road, Applecross | 116 | 50 |
| The Esplanade, Mt. Pleasant (north) | 16 | 19 |
| The Esplanade, Mt. Pleasant (south) | 5 | 8 |

| | | |
|---|---|---|
| Bull Creek, Rossmoyne | 21 | 25 |
| Riverton Drive, Rossmoyne | 1 | 5 |
| Riverton Drive, Shelley | 3 | 4 |
| Total | 633 | 387 |

i.e. 1020 moorings in total with 62% occupation.

Source : WWC.

Kinhill Stearn (1984) report that in January, 1983 there were 515 boats downstream of the Narrows Bridge and Bull Creek moored outside constructed mooring areas.

The SRMA supports the registration of moorings in the river.

### 2.3.7 Marinas

Marinas within the study area are either privately owned or attached to yacht clubs. Section 2.3.9 indicates the size and location of club facilities, commercial facilities are listed in Chapter 15, 9.0.

Potential environmental problems associated with these facilities include:

- The need for dredging or reclamation of the river to construct the facility.
- Diesel spills and accumulation of these product across the water.
- Sullage discharge from boats.
- Shading of flora.
- Heavy metals from antifouling chemicals accumulating in sediments.

Establishment of marinas also requires that subsidiary services are provided. These may include fuel supply, rubbish disposal, slipping facilities, repair and maintenance, chandler and perhaps even security.

Ongoing maintenance of these facilities is also required if they are not to become degraded structures visually intruding on the waterscape. Renewal of jetty licences should be subject to an acceptable standard of maintenance (not purely structural) of the facility.

Maintenance dredging is the responsibility of the water leasee and applications to dredge should comply with the SRMA Dredging Policy.

It is the policy of the SRMA that no more marinas should be constructed in the Swan or Canning Rivers (Chapter 18, 9.3.1). The Authority supports the Government's policy of creating ocean marinas.

Opportunity for expansion of existing marinas within the study area is also limited because of adjoining land and water use.

In the words of Digby (1985):

> "There is little hope of accommodating all of the boats likely to be built for capital city users. Also no person can assume the right to a place on the water".

Hence the cost of keeping a boat in a wet berth should reflect this privelege.

Digby (1985) goes on to suggest the development and implementation of a regional waterway plan as a means of 'halting' further intrusive developments. Given that there is little free foreshore within the Swan-Canning Estuary suitable for marina development such a plan should include ocean facilities so that the provision of these facilities is rationalised and co-ordinated throughout the metropolitan region.

Aspects Digby (1985) suggests should be considered in the development of a regional plan include:

- Sites should be large enough to accommodate a substantial area of landscaping and tree-planting to provide a contrast to berthed boats and marina quays.

- Sites should avoid massive earthworks and changes to topography.

- Public access should be maintained.

- Provision of large areas of hard-standing facilities which can be set well back from the waterline.

- In the interest of conserving water surface it might be appropriate to subsidise hard-standing at the expense of wet berths.

- Use or appropriate colours for marine buildings the range varying with the environment.

TABLE 4: Club and School Facilities

| GROUP | LOCATION | ACTIVITY | COMMENT |
|---|---|---|---|
| Claremont Yacht Club | Jetty Road, Claremont | Yachting, power boating, wind surfing | Freehold title. Only clubhouse and slipways are adequate to meet club needs. |
| East Fremantle Yacht Club | Jerrat Road, East Fremantle | Yachting, Power boating | Mooring, carparking, trailer storage and hardstanding inadequate. |
| Maylands Yacht Club | East Steet, Maylands | Wind surfing, yachting | Clubrooms inadequate. |
| Mounts Bay Sailing Club | Hackett Drive, Crawley | Power boating, wind surfing, yachting | Carparking, boat storage inadequate. |
| Nedlands Yacht Club | The Esplanade, Nedlands | Wind surfing, yachting, sail training | Hardstanding boat storage inadequate. |
| Perth Dinghy Sailing Club | Hackett Drive, Crawley | Yachting | Rescue craft and jetty needed. |
| Perth Flying Squadron | The Esplanade, Nedlands | Power boating, yachting | Slipway, parking trailer storage, clubhouse, hardstanding, ramps inadequate. Extension to jetty planned. |
| Royal Freshwater Bay Yacht Club | Keane's Point, Peppermint Grove | Yachting | Carparking inadequate. |
| Royal Perth Yacht Club | Hackett Drive, Crawley | Power boating, yachting | Dinghy storage jetties, carparking, inadequate. |

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|---|---|---|---|
| Shelley Sailing Club | Riverton Drive, Shelley | Wind surfing, yachting | Adequate |
| South Perth Yacht Club | Coffee Point, South Perth | Power boating, wind surfing, yachting | Only storage sheds and slipway adequate. Plans to upgrade clubhouse, pens, carparking. |
| Swan Yacht Club | Preston Point, East Fremantle | Line fishing, power boating, prawning and crabbing, yachting | Jetties recently rebuilt. Carparking, mooring, slipways, trailer storage, jetties and ramps inadequate. |
| West Australian Water Ski Ass'n | Burswood Island, Rivervale | Water skiing | Proposal for upgrading. |
| Ascot Kayak Club | Garvey Park, Redcliffe | Canoeing | Boat storage inadequate. |
| Swan Canoe Club | Mosman Bay, Mosman | Canoeing | Storage sheds and clubhouse inadequate. |
| Darling Range Canoe Club | Hester Park, Lynwood | Canoeing | |
| 1st Waylen Bay Sea Scouts | Melville Beach Road, Melville | Yachting, canoeing | Ramps inadequate. |
| 1st Canning Sea Scouts | Centenary Avenue, Wilson | Canoeing, rowing, yachting | |
| 1st Mosman Bay Sea Scouts | Johnston Street, Mosman Bay | Canoeing, power boating, rowing, swimming, wind surfing, yachting | Clubrooms and storage sheds inadequate. |

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|---|---|---|---|
| Bassendean Sea Scouts | Pickering Park, Bassendean | Canoeing, power boating, rowing, swimming, yachting | All facilities need upgrading, plans for new hall and storage sheds. |
| Bayswater Sea Scouts | Garratt Road Bridge, Bayswater | Canoeing, power boating, rowing, yachting | Clubrooms and storage shed inadequate. |
| Mt. Lawley Sea Scouts | Banks Reserve, Mt. Lawley | Sea scouting | |
| 3rd East Fremantle Sea Scouts | Riverside Road, East Fremantle | Yachting, canoeing, power boating, rowing, swimming | Need to update existing facilities slipway, trailer storage, hardstanding, storage sheds, jetties, ramps. |
| 1st Fremantle Sea Scouts | Riverside Road, East Fremantle | Power boating, canoeing, rowing, swimming, yachting | Jetties and storage inadequate. |
| 1st Deepwater Point Sea Scouts | The Esplanade, Mt. Pleasant | Canoeing, yachting | |
| Pelican Point Sea Scouts | Hackett Drive, Crawley | Sea scouting | |
| 1st Salter's Point Sea Scouts | Salter's Point Road, Salter's Point | Sea scouting | |
| Amateur Rowing Ass'n of W.A. | Canning Bridge, Applecross | Rowing | All facilities inadequate. |
| Perth and Collegions Rowing Club | Canning Bridge, Applecross | Rowing | All facilities inadequate. |

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|---|---|---|---|
| Australian Native Association Rowing Clubs (ANA) | Canning Bridge, Applecross | Rowing | Would like to move to bigger facilities. Feasibility study. |
| Swan River Rowing Club | Canning Bridge, Applecross | Rowing | Planning new facilities, perhaps relocation. |
| W.A. Rowing Club | Riverside Drive, Perth | Rowing | Upgrading of site, possible restaurant. |
| University Rowing Club | Hackett Drive, Crawley | Rowing | Parking, trailer storage and jetties inadequate. |
| WAIT Rowing Club | Elderfield Road, Waterford | Rowing | Trailer storage areas inadequate. |
| Guildford Grammar School | Off Terrace Rd., Guildford | Rowing, canoeing | Parking, storage areas, inadequate. |
| Christchurch Grammar School | Off Terrace Road., Guildford | Rowing, canoeing | Parking, storage areas, inadequate. |
| Christchurch Grammar School | Forrest Street, Peppermint Grove | Rowing | Storage sheds, launching ramps inadequate. |
| Fremantle Rowing Club | Riverside Road, East Fremantle | Rowing | Extension to club facilities for storage, ablution block etc needed. |

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|---|---|---|---|
| Scotch College | Keane's Point, Peppermint Grove | Rowing | |
| Hale School | Hackett Drive, Crawley | Rowing | Adequate |
| Trinity College | Causeway, Perth | Rowing | Adequate |
| Wesley College | Coode Street, South Perth | Rowing | Adequate |
| Aquinas College | Private Access, Mt. Henry | Rowing, power boating, yachting, swimming | Storage, slipway inadequate. |
| Victoria Park Angling Club | Riverside Road, East Fremantle | Line fishing | Clubhouse, inadequate. |
| East Side Angling Club | Riverside Road, East Fremantle | Line fishing | Adequate |
| Stirling Go-Boat Club | Heirrison Island Perth | Speed boating | |
| W.A. Speed Boat Club | Burswood Island, Rivervale | Speed boating | Recent plans to upgrade and combine water ski and power boat clubs. |
| Education Department | Riverside Road, East Fremantle | | |

- Use of floating pontoons against long-legged piles for structures.

- Implementation of a sustained maintenance programme.

### 2.3.8 Club and School Facilities

Many of the facilities around the foreshore are for the use of club and school groups. Table 4 provides a list of facilities and their location. These facilities are also marked on the accompanying maps.

Other clubs known to use the river but do not have facilities on the foreshore are:

Fremantle Amateur Angling Club
Melville Amatuer Angling Club
Pastime Angling Club
Swan River Angling Club
Railway Institute Angling Club
Amateur Swimming Association
Je T'aime Skiers
Scarboro Water Skiers
University Water Ski Club
Barefoot Water Ski Club
Tertiary Education Canoe Club
Hartley T14 Trailerised Sailing Club

### 2.3.9 Club Water Lease Areas

| CLUB/FACILITY | APPROX NO HECTARES |
|---|---|
| Claremont Yacht Club | 4.8 |
| East Fremantle Yacht Club | 2.5 |
| Maylands Yacht Club | 1.2 |
| Mounts Bay Sailing Club | 10.3 |
| Nedlands Yacht Club | 11.8 |
| Perth Flying Squadron | 3.7 |
| Royal Fresh Water Bay Yacht Club | 8.9 |
| Royal Perth Yacht Club | 4.4 |
| South Perth Yacht Club | 14.8 |
| Swan Yacht Club | 2.2 |
| Education Department, South Fremantle | 0.1 |
| 1st Fremantle Sea Scout | 0.2 |
| Christ Church Grammar | 0.3 |
| East Side Angling Club | 0.4 |
| East Fremanlte Town Council Jetties (currently being negotiated | Not available |
| Total | 65.6 |

1.64% of total lower river basin in club water lease. Source; Department of Marine and Harbours maps, June 1986.

### 2.3.10 Wet Pens

| SITE | | NO |
|---|---|---|
| Recreation Clubs | | |
| Claremont Yacht Club | | 167 |
| East Fremantle Yacht Club | | 99 |
| Mounts Bay Sailing Club | | 30 |
| Nedlands Yacht Club | | 10 |
| Perth Flying Squadron | | 147 |
| Royal Fresh Water Bay Yacht Club | | 263 |
| Royal Perth Yacht Club | | 330 |
| South Perth Yacht Club | | 320 |
| Swan Yacht Club | | 219 |
| East Side Angling Club | | 20 |
| Maylands Yacht Club | | 5 |
| | Sub Total | 1 608 |
| Commercial | | |
| Nedlands Baths Marina | | 43 |
| Pier 21 Marina | | 102 |
| Aquarama | | 208 |
| | Sub Total | 353 |
| | Total | 1 961 |

## 2.4 Other Facilities

### 2.4.1 Recreation Reserves

A variety of recreation reserves exist within the study area. These may have developed by:

- User activity in the area and consequent hardening of the site to reduce impact.
- Sanitary or dredge spoil disposal in fill areas.
- Acquirement by SPC and consequent SPC or LGA development and management.

- Road reserves not required by the MRD and currently being maintained by the LGA as recreation reserves.

- Crown land unvested.

Various facilities are provided at individual reserves and it is necessary that the public be aware of the range of areas available for use. Dissemination of such information can act as an efficient management tool, directing users away from crowded or overused sites.

Table 5 lists the recreation areas available around the river. Areas are listed in order of lower estuary, southern side upstream to Causeway, downstream, northern side; Canning River; upper Swan River. The Table is at the end of this Chapter.

### 2.4.2 Dual-Use Paths - Cycleways

Provision of formal walking and/or cycle paths has gathered momentum over the last five years. This may be attributed to the establishment of Bikeplan and the promotion by Department of Sport and Recreation. The former is a government instrumentality responsible for developing an "Around the River Ride" and planning or cycling facilities throughout Western Australia. The latter promotes greater involvement in recreation and leisure through its "Life Be In It" campaign, with individual campaigns focussing on cycling.

Funding for cycleways and dual-use paths is usually the responsibility of Local Government with Bikeplan assisting in some problem areas. Community employment programmes, wage pause and other Federal Government employment initiatives have provided Local Government with further funding assistance.

A plan was produced in 1985 detailing proposed cycle facilities around the river (Perth Bikeplan Study Team, 1985).

Basically the plan involved the following:

- A loop network from Fremantle to Heirisson Island via Canning Bridge using existing pathways and road links. Plans are for establishment of cycleways to reduce road links both in the long and short term.

- A loop network from Canning Bridge to Riverton Bridge including a crossing at Mt Henry Bridge. This would include a new facility from Mt Henry Bridge to Shelley Bridge on the northern foreshore.

- Provision of a track from Riverton Bridge to Seaforth following the southern foreshore of the Canning River. A path already exists between Nicholson Road Bridge to the confluence of Southern River.

- A loop network from Heirisson Island to new Beechboro/Gosnells Bridge following the shoreline of the river. Essentially most of this will require new works.

- Continuation of the pathway along the eastern foreshore of the river from the new Beechboro/Gosnells Bridge to Middle Swan Bridge, including a branch along the northern foreshore of the Helena, terminating at Midland. Most of this will require new works.

- Continuation of the cycleway from Beechboro/Gosnells Bridge along the western foreshore to Bennett Brook, following the Brook along its eastern foreshore to Whiteman Park. All of this will require new works.

Recent development of some pathway systems has cause concern to the Authority and as a consequent a policy has been developed and a submission made to Perth Bikeplan.

In principle the Swan River Management Authority supports the development of pathways around the river foreshores suitable for bicycle usage. However, correct design and location of the facility is imperative, if the integrity of the river is to be preserved and foreshore reserves are to be maintained as viable environmental and working recreation units.

The Authority does not agree with the point made by Bikeplan that "existing dual-use paths which serve a significant transportation function should be upgraded as necessary and reclassified as cyclepaths". It is the SRMA's opinion that as the river is a major recreational resource for the Perth population all 'cycling' facilities constructed or planned for the river foreshores should be promoted as either footpaths or dual-use paths - for shared use by pedestrians and low speed cyclists. The river environment is available for everyone and priority should not be used as a transport network for cyclists in preference to other users. This is particularly important where facilities are located on the riverside edge of the foreshore recreation reserve forcing other users to cross the path to gain access to the water.

The siting of pathways on the toe of the river bank should be avoided as this type of structure requires either filling or walling of the foreshore to provide a stabilised area. These shallow banks are an important habitat for flora and fauna of the river. Authorities developing the facility opt for this technique when the terrain is steep and it is all to easy to do a little "cut and fill" to locate the cycleway on the toe of the bank.

The SRMA is having to use engineering techniques to stabilise eroded banks and to 'canalise' the foreshore bank. To create an artificial environment unnecessarily for the location of a pathway system should not be permitted.

Pathway facilities should be carefully sited, particularly through recreation reserves (as opposed to strip road reserves) so that there is no reduction in access to the river for the rest of the public who wish to use the river for various recreation purposes. Careful observation of existing patterns of use of the area (both weekday and weekend) prior to pathway development will ensure correct siting. The ability of the foreshore reserve to function as a recreation or environmental unit should be broken up by a pathway system. Alternatively design and siting of the pathway may be used to direct use away from environmentally sensitivie areas.

Where there is a need to cross wetlands, small lagoons and back waters, board walks should be considered as an alternative to filling and culverting. This is particularly relevant in the upper reaches of the Swan and Canning Rivers where small tributaries are common.

The upper reaches of the river are also more prone to winter flooding. The Authority considers that when building pathways in these areas it should be accepted that the facility is not going to be usable all year round. If possible, the pathway should be sited to avoid frequently flooded areas. Filling the site to place the pathway above common flood levels would not be considered.

If participation in cycling continues to grow then sign posting may be necessary at entry points into major foreshore reserves to remind cyclists they are entering a popular reserve and pedestrians <u>do</u> have right of way.

**Policy Statement**

Swan River Management Authority
Policy Statement
Cyclepaths, Dual-Use Paths - Swan and Canning River Foreshores
19th March, 1985

The Authority is in agreement with cycle tracks along the foreshores of the waterways subject to the following:

a) The cyclepath should not be on the river bank as this would reduce the access for the rest of the public who wish to use the river for various recreation purposes.

b) The cyclepath should not divide the reserve but should be designed in such a way that it is on the roadside of any carparking facilities.

c) The cyclepath should be sited at least a minimum of 10 metres away from the river's edge. However, the Authority would prefer to see the cyclepath towards the back of the reserve similar to the Matilda Bay cyclepath.

d) Where there is only a narrow reserve, less than 10 metres, there should not be any cyclepath. The cyclepath should be incorporated into the roadway and given the appropriate status. Alternatively the cyclepath could detour away from the river to other areas of scenic, historic or scientific interests.

e) The cyclepath should only be brought closer to the river at selected points. These could incorporate rest areas for walkers and cyclists.

The Authority accepts that exceptions to the rule exist such as Mounts Bay Road where the cyclepath is adjacent to an extremely busy road.

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The above mentioned policy statement has been distributed to individual Local Government Authorities. Some responses have questioned point (d). However, because of the importance of these strip areas due to their location and use by certain recreationists the Authority has decided to retain this point.

Siting of the pathway along these strips of reserve reduces the area available to other users, forcing them further down the river bank thus endangering the stability of the bank and vegetation.

Also where other river users must sit behind the pathway their visual access to the river is impaired. This should not be so, as both the cyclist and walker have the advantage of height, and thus ability to see over users seated on the foreshore.

Various construction techniques have been used in the development of pathway systems around the river. These include concrete, asphalt, compacted limestone, brick paving and compacted soil surfaces. There is a need for co-ordination of these techniques so that pathways do not change at each Local Government boundary, but rather are in tune with the natural environment.

In conclusion, it is obvious that all Authorities should carefully consider the location of pathway systems prior to their installation, to ensure that other users are not disadvantaged and the foreshore environment is not impaired.

It is the exact location of these facilities that is of concern to the SRMA i.e. their proximity to the river, topography of land, installation techniques used etc. In places the natural terrain, in the SRMA's opinion is unsuitable for a cycleway system.

The SRMA is concerned by the attitude of some agencies who consider that where pathways have been diverted away from the river, (because the terrain or natural conditions of the environment are not suitable) that this is only a temporary measure to be rectified by modifications to the river environment at some later date.

### 2.4.3 Heritage Trails

'Heritage trails' are routes designed to enhance the community's awareness, understanding and enjoyment of part of Western Australia's natural and/or cultural heritage. Administration is undertaken by the Western Australian Heritage Committee. The project is part of Western Australia's Commonwealth/State Bicentennial Commemorative Programme. Chapter 16 discusses these facilities in more detail.

It is anticipated that more trails will be established within the study area in the coming year as trails are selected to feature significant landforms, flora, fauna, aboriginal sites or tracks, historic buildings, structrues or routes.

A booklet is available detailing "Guidelines for the Development of Heritage Trails" (Western Australia Heritage Committee, 1985). These guidelines are in harmony with preservation of the environment while permitting public access. Consequently the majority are applicable to the development of many pathway systems around the river.

Liaison between the Heritage Committee, CALM, DCE and the SRMA is still advisable to ensure drainage, placement and surfacing of the trail is appropriate.

### 2.4.4 Fishing

#### 2.4.4.1 Locations

The major angling sites on the estuary are the jetties and walled foreshore areas, especially between the Causewaya nd Narrows Bridge, on the South Perth foreshore and between the Causewaya long Riverside Drive and Mounts Bay Road to Crawley on the northern foreshore. Virtually all jetties and traffic bridges (not closed to line fishing) on the estuary provide a focus for fishing parties. The rocky cliffs of Blackwall Reach, Point Walter are also a popular location.

Prawning and crabbing locations include Matilda Bay; Mounts Bay Road; Como foreshore from Mill Point to Mount Henrry; The Esplanade; Mt Pleasant; Canning Beach Road; The Strand and Melville Beach Road, Applecross; Point Walter, Bicton and Pelican Point, Nedlands.

Worm digging is also an activity associated with fishing and can contribute to ban erosion. Areas where this activity occurs include Pelican Point, Alfred Cove and Heirisson Island. Worm diggers should be encouraged to dig for worms offshore so as not endangering the stability of the bank, and return sport to the water. In aquatic reserve areas such as Pelican Point it may be necessary to limit this activity if the birds or tidal flats are excessively disturbed.

Net fishing by recreational will be banned in the whole of the Swan-Canning Estuary from 1st July 1986. The ban will not apply to nets used to catch crabs or prawns.

#### 2.4.4.2 Facilities

Many recreational fishermen are dependent on the provision of public facilities such as bridges, jetties and groynes. Access to foreshore banks is also necessary. Because of the limit needs of this group of users their requirements have often been overlooked in many of the foreshore developments of the past. Submissons to the Fishery Working Group (Roger et al., 1984) were critical of the lack of shoreline facilities available to recreational fishermen. For many anglers the lack of access limiting their fishing operations to shoreline fishing. Similar comments were recorded in the recreation studies conducted by the Waterways Commission (Thurlow, 1986).

## 3.0 USAGE

Recreational use of the river is by far the biggest single use replacing past uses of transport, industry and commerce. Recreation can take many forms. People's visits and use of the river environment are a combination of activities, although one may be more dominant than the others. For example the main aim may be to water ski but the day's activities are likely to also include picnicking, walking, swimming and relaxing.

In many recreation studies activities are divided into passive and active. However, until level, frequency, pattern and impact of use are established, it is misleading to arbitrarily catergorise activities in this manner, suggesting that certain activities will always be suitable in sensitive environments.

When considering the impact of various activities on the environment the pattern, level and frequency of use must be assessed. If the impact is unacceptable steps should be taken to control or eliminate the problem. Providing alternative or substitute sites or activites is one means that may be feasible. For example providing marinas and small boat launching sites on the coast is likely to reduce the pressure on Swan River.

As Moeller and Echelberger (1977) state:

> "The supply of substitutable facilities within a particular region will influence consumption at individual facilities within that region".

Notwithstanding this recreational participation is influenced by trends which may last, only one or two seasons - possibly they may last indefinitely. In catering for new activities it is advisable to install temporary facilities (or non at all) until the permanence and impact of the activity can be determined further.

People's satisfaction with their recreation experience are difficult to determine, varying between individuals, groups and communities. It is, therefore, difficult for management to determine measures which will satisfy all users. It is often argued by proponents of developments that the proposed facility will satisfy demand as well as increasing opportunities and access to the river environment. However, as Stankey (1982) points out:

> "There is increasing evidence that growth in use does not necessarily reflect increased satisfaction. The 'growth is good' argument ignores problems of inter-personal definitions of quality, it fails to account for the fact that expanded growth might be occurring at the expense of certain opportunities, and it does not recognise that while participation might grow in absolute terms, there could still be declining per capita satisfaction".

It is, therefore, best to supply a range of opportunities throughout the river environment. Management should also consider what recreational opportunities are available elsewhere within the Metropolian region.

### 3.1 Pattern of Use

Seasonal use of the river is associated with acceptable day and water temperatures with the river experiencing greatest use between the months October to April inclusive.

Power boating organised by yacht clubs is a prominent feature of winter usage of the lower estuary. Canoeing in the upper reaches also occurs during the winter months. Greatest use of Walyunga National Park is also recorded during the winter months from April to September. Wind surfing activities, although less during winter months still hold a prominent place.

Summer activities include water skiing, sailing, power boating, picnicking, swimming, wind surfing, cycling and fishing, with the flottila of yachts on Melville Water on Saturday afternoon being visually the most dominant.

Weekly use shows a dominance of activities on weekends, although many foreshore areas are used as lunch spots midweek. Swimming classes and group outings have been observed. Weekday use by school rowing clubs also occurs. Twilight and afternoon sailings bring a number of yachts onto the river midweek. Cyclists can also be observed midweek on their way to and from work, school etc. In general most activities occur weekday but at a significantly lower level.

Daily use generally starts early morning with the commercial and recreational fishermen. Rowing clubs also take advantage of calm early morning conditions. Water skiers are usually on the water as early as regulations permit and decline as waters become too choppy.

Walkers, cyclists and joggers also use the foreshore early morning and evening when conditions are cooler and/or activities can be fitted in with work schedules.

Use on Sundays sees groups arrive pre and post lunchtime. However, maximum Saturday use does not occur until after 'the shops have closed'.

The appearance of the yachts on the river is dictated by start times ranging from 2 p.m. to 3.30 p.m. on Saturday and anything from 9.00 a.m. for junior members on Sundays.

Use by the majority of wind surfers is dictated by the presence of suitable breezes. The ease with which these craft are set up and launched also means that some users are able to fit in an afterwork sail.

On weekends the number of users usually starts to taper off around 4.00 p.m. However, a particularly hot night will see many carpark areas full as Perth residents take advantage of cooler conditions and have picnic teas on the river foreshore.

Any time from 6 o'clock onwards sees the arrival of the fishermen again and when the prawns are running prawning parties arrive enmasse. Although weekend use is greatest for number of people fishing and prawning, weekday figures are significant compared with water skiers, power boaters etc. This is because it is an afterwork activity.

The occurrence of an unusual event (organised or climatic) is likely to alter the general pattern of use. For example events such as the Head of the River or 'Avon Descent' have been observed to alter these patterns.

Commercial use of the river is dictated by time tables of the operators, MTT ferries running daily and approximtely every 20 minutes peak time. Rottnest ferries, wine cruises and MTT scenic cruises leave daily during summer. Evening cruises are less frequent. Some craft are also available for charter so their patterns of use fluctuate.

## 3.2 Club Use

### 3.2.1 Fishing Clubs

Eleven angling clubs were sent questionnaires, nine of these were returned, including one from the Australian Anglers Association W.A. Division (Inc.). The Association has 7 200 members on a statewide basis. 529 belonged to the remaining responding clubs. The Association estimates a participation rate of 25% with a mode of 75% for other respondent clubs.

Activities which club members participate in are line fishing, prawning and crabbing. Popular areas used by anglers are Garratt Road Bridge, the Narrows, Causeway, Brewery, Mosman Jetty, Canning Bridge, Blackwall Reach, Guildford, Shelley and Goodwood Parade.

Most clubs do not have any facilities available to them relying on public facilities such as jetties, boat ramps, carparks etc. for member's use. The greatest use of the river is made from November to June inclusive.

Water safety issues of concern to clubs were:

- General inconsideration by users (66%).
- Boat wash creating problems for small craft (56%).
- Inadequate policing of the waterways (56%).

Special problems of netting, navigation, conflict with water skiers and littering were also highlighted.

Angling club responses to matters of concern include:

- Crowding on the foreshore and parking areas (89%).
- Inadequate recreation facilities available on the river (66%).
- Public access is being reduced to foreshore areas (55%).
- Erosion of foreshores and river bank (55%).
- Boating congestion on the river (55%).

Aspects of management raised by the angling clubs were:

- Maximum safe use of the river.
- Stop foreshore development.
- Provide additional facilities.

- Keep larger boats out of the river.

- Emphasis on recreation activities using the natural environment.

- Ban netting.

- Maintain pollution free waters.

One aspect to note is that unfortunately many of the popular fishing areas coincide with power boating and water ski areas.

### 3.2.2 Canoeing Clubs

Questionnaires were sent out to five canoeing clubs with three responding, including the Amateur Canoe Association. The Association has 500 members with respondent clubs having 171, the former estimating an 80% participation rate and clubs a 30% rate. Canoeing is the only activity organised by the clubs with the greatest use of the river occurring January to June inclusive.

Areas used by clubs are Garratt Road to Barker's Bridge, Freshwater Bay to Stirling Bridge and the Upper Canning.

Water safety issues of most concern to respondents include:

- General inconsideration by users (100%).

- Boat wash causing problems for small craft (100%).

- Speeding in restricted areas (100%).

Matters of concern to respondents were:

- Erosion of foreshore and river banks (100%).

- Boating congestion on the river (66%).

- Inadequate recreation facilities available outside the river that could be used by recreationists (66%).

- Natural heritage areas are being destroyed (66%).

Management issues raised by respondents were:

- More areas should be made available for passive recreation.

- Reduce erosion.

- Balance between users.

- Favour non-polluting craft.

It was suggested that clubs should share foreshore facilities.

### 3.2.3 Rowing Clubs

Questionnaires were sent to fifteen rowing clubs, fourteen of these responded including the Rowing Association. Membership through individual clubs totalled 1 451. The Association claimed 1 400 members. Club sizes ranged from 30 - 200 with a participation ranging from rates of 30 - 100%. A mode of 90% participation was recorded.

Areas used for rowing are Canning Bridge, Stirling Bridge, Perth Water and upstream of Garratt Road.

All clubs are involved with rowing although some of the school clubs also participate in canoeing and swimming activities.

School groups make the greatest use of the river between October to March inclusive. Other clubs extend this use through to September with the months from February to September being dominant.

Water safety issues of concern to respondents were:

- Boat wash creating problems for small craft (100%).

- General inconsideration by other users (71%).

- 'Inexperienced' people in charge of craft (57%).

- Poor knowledge of navigable waters regulations (57%).

Special problems particularly experienced by rowers led to many 'extra' comments suggesting the need for separate rowing areas. These calls resulted from conflict with power boats, partly due to rowing courses being located near ski areas.

Matters of concern to respondents included:

- Safety of members at risk due to other river users contravening boating rules and regulations (78%).

- Boating congestion on the river (50%).

- Some recreation activities are being developed at the expense of others (50%).

Aims of management were viewed by respondents as:

- Allowing all users to have the opportunity to engage in their particular activity with minimum interference from other users, while not unduly affecting the environment.
- Safety.
- Education.
- Organise events.
- Policing of regulations.
- Restricting larger craft to ocean moorings.
- Communicate with users on changes to regulations etc. via a newsletter.
- Maintain public access.

### 3.2.4 Sea Scout Clubs

Of the thirteen sea scout groups contacted eight responses were received. Membership numbers in responding clubs range from 23 to 120 with a total of 583 members recorded. Participation rates range from 25% to 100%. Areas of the river used are predominantly adjacent to club facilities.

Greatest use of the river is made between October and April inclusive.

Activities which the clubs participate in include canoeing, yachting, power boating, rowing, swimming, wind surfing, rafting and kayaking. The range of activities enables the young members to experience most water sports and attain some degree of competency.

Water safety issues that concerned the clubs included:

- Poor knowledge of navigable waters regulation (87%).
- General inconsideration by other users (87%).
- 'Inexperienced' people in charge of boats and sail craft (87%).
- Boat wash creating problems for small craft (87%).

- Speeding in restricted areas (75%).

- Inadequate policing of the waterways (75%).

- Dangerous alcohol included situations (50%).

Matters of most concern to clubs included:

- Safety of members at risk (75%).

- Some recreation activities being developed at the expense of others (78%).

- Boating congestion (62%).

- Development occurring with little regard for the natural environment (62%).

Opinions on the aim of management included:

- Giving all users a fair go.

- Control of speeding.

- Ecological preservation.

- Less commercial development.

- Reducing litter and pollution.

- Upgrading foreshore access.

### 3.2.5 Swimming Clubs

A questionnaire was sent to the Western Australian Swimming Association which has 7 000 members. Only a small minority participate in 'Swim Thru's' organised by the Association. Greatest use of the river is made from December to March inclusive. Situations that endanger the safety of members using the river are:

- Poor knowledge of navigable waters regulations.

- General inconsideration by users.

- Speeding in restricted areas.

- Boat wash creating problems for swimmers.

Aspects of concern to the Association included:

- Boating congestion on the river.

- Safety of members at risk due to other users contravening boating rules and regulations.

Aims of management include top priority to preservaton of environment but allow a range of recreational activities.

### 3.2.6 Water Skiing Clubs

Ten water ski organisations were sent questionnaires with six of these returned. Individual club membership totalled 288 with participation rates ranging from 25 to 100%. Club sizes ranged from 27 to 100. Greatest use extends from September to April inclusive.

Water safety issues of concern included:

- General inconsideration by users (83%).
- Inadequate policing of the waterways (83%).
- Poor knowledge of regulations (66%).

Matters of concern included:

- Boating congestion on the river (83%).
- Safety of members of risk due to other contravening boating rules and regulations (83%).
- Crowding on foreshore and parking areas (66%).
- Some recreation activities are being developed at the expense of others (50%).

Aims of management included:

- Maintaining a clean river and foreshore.
- Desnagging upper reaches.
- Liaison with Department of Marine and Harbours.
- Public education programme.
- Encourage users to respect other users rights.
- More areas are needed for water skiing.
- Preservation of the environment while allowing for a range of activities.

Areas used by clubs include Deep Water Point, Narrows Bridge to Royal Perth Yacht Club, Heirisson Island, Ascot Barefoot Area, Lilac Hill Park.

### 3.2.7 Yacht Clubs and Associations

Twelve yacht clubs and nine yachting associations were forwarded questionnaires. All yacht clubs responded as did six associations, including the Yachting Associaton of W.A. Individual club membership totalled 9 877, including family groups. Participation rates ranged from 30 to 75% depending on time of year and activity offered.

Yachting is the predominant activity from October to April and power boating during the winter months. Considerably more members participate in the former.

Activities which the clubs participate in are power boating, wind surfing, yachting, sail training, line fishing, prawning and crabbing.

Water safety issues of concern included:

- 'Inexperienced' people in charge of craft (78%).
- Poor knowledge of navigable waters regulations (61%).
- Boat wash causing problems for small craft (50%).

Matters of concern to respondents included:

- Boating congestion on the river (89%).
- Safety of members at risk due to other river users contravening boating rules and regulations (89%).
- Crowding on foreshore and parking areas (50%).

Aims of management pertained to:

- Environmental preservation.
- Erosion control.
- Safety.
- Greater public awareness.

Most of the associations suggested the need for more public education programmes for river users.

Areas used by the clubs are most of Melville Water (depth permitting), Shelley on the Canning River and upstream of Bunbury Rail Bridge on the Swan.

### 3.2.8 Aggregate Analysis

The two most frequently indicated water safety issues were:

1. General inconsideration by other users.

2. Boat wash creating problems for small craft or skiers.

Activities particularly affected by this latter point were rowing, canoeing, swimming and sea scouts.

The lowest scoring category was; 'dangerous alcohol induced situations' - 24%. However, when it is considered that one in every four clubs/associations considers that the safety of members is placed at risk due to this factor the problem is significant.

The two main issues of concern to respondents were:

1. Boating congestion on the river (75%) with 90% of these respondents indicating this factor would affect them more in the future.

2. Safety of members at risk due to other river users contravening boating rules and regulations (75%), with 87% of these respondents indicating this factor would affect them more in the future.

Safety of members was ranked first by five (5) activities. These were:

Yachting
Water Skiing
Sea Scouts
Rowing
Swimming

Boating congestion was ranked first by three (3) activities and second by a further three (3) activities. Activities are:

| | |
|---|---|
| Yachting | 1 |
| Water Skiing | 1 |
| Swimming | 1 |
| Canoeing | 2 |
| Sea Scouts | 2 |
| Rowing | 2 |

The remaining activity - angling - is probably not so highly ranked because the majority of angler's fish from the foreshore and consequently are not subject to the same problems.

The 'second level' of concern dealt with:

1. Erosion of the foreshore and river bank.

2. Crowding on the foreshore and parking areas.

3. Some recreation activities are being developed at the expense of others.

Weighting of data to give each activity equal priority changed the order of priority little. In addition, approximately 80% of responses indicated that these issues would affect river users more in the future.

Angling activities received a one (1) ranking on four matters. These were:

1. Commercial operations on the river reduce the recreational opportunities available to the general public.

2. Crowding on the foreshore and parking areas.

3. Inadequate recreation facilities available on the river.

4. Public access is being reduced to foreshore areas.

Anglers are basically opportunistic users of foreshore facilities, i.e. few man-made facilities are needed and most of these are public facilities such as jetties, banks, bridges, and carparks. Data indicate that if these facilities are not maintained, renewed or increased, or public land is developed restricting public access then it is the anglers (and other similar users) who 'miss out'. Anglers have the advantage that they can blend in with many other activities but the disadvantage that they can also lose many opportunities when other user facilities are developed.

The main aspects raised by respondents regarding the aim of the SRMA are presented below. Certain issues are under the jurisdiction of other Government Authorities. However, as the SRMA liaises with these authorities, all aspects have been included. Certainly all data will assist administering authorities in their management of the study area. It should be remembered that this question was open-ended and consequently respondents were not prompted into answering in a particular manner.

**Respondents' Perceptions of Aims of SRMA in Managing Swan-Canning Estuarine System:**

| **Environmental Issues** | **Total** | **%** |
|---|---|---|
| Preserve and enhance the natural environment | 21 | 36 |
| Maintain water quality | 14 | 24 |
| Retain foreshores for public open space, restrict access, ensure foreshores not commercially developed | 11 | 19 |
| Maintenance of foreshore/clearing up of litter | 6 | 10 |
| Erosion Control | 3 | 5 |
| **Recreation Opportunities** | | |
| To regulate and encourage provision of adequate facilities and provide access for as many users as possible | 27 | 46 |
| Maintain a balance between all types of users (foreshore and aquatic) ensuring the needs of passive users are represented | 10 | 17 |
| **Water Safety Issues** | | |
| Policing of waterways, safety of users, increase public awareness of regulations, encourage respect for other users, and co-ordinate formal use | 25 | 42 |
| Total | 117 | |

**Respondents' Perceptions of Aims of SRMA in Managing Swan-Canning Estuarine System**

| **Categories of Response** | | |
|---|---|---|
| Environmental Issues | 55 | 47 |
| Recreation Opportunities | 37 | 32 |
| Water Safety Issues | 25 | 21 |
| Total | 117 | 100 |

## 3.3 General Public use and Attitudes

The WWC and SRMA conducted a survey of visitors to the Swan-Canning Estuarine System. This involved an on-site survey of recreationists over the weekend of 19th and 20th January 1985 at 11 sites within the management area. Methods used were:

1. Distribution of a self-administered questionnaire to visitors on-site and collected on-site.

2. Completion of record and observation sheets by staff.

The total number of questionnaires hand-out was 750 and 94% of these were returned.

The following results are taken from this study. Results are represented in full in the Swan River Recreation Study Technical Report (Thurlow, 1986).

### 3.3.1 Mode of Travel

As anticipated the majority of respondents travelled to their chosen site by private vehicle (88%). The next two highest categories were "walked" (5%) and "cycled" (4%). The results have obvious implications for management; provision of carparking facilities or encouragement of the latter modes of travel through provision of appropriate facilities.

Counts taken at Sir James Mitchell Park suggest that a far greater number of respondents were involved in cycling but unfortunately were not sampled because they did not stop at the site. Further results do not indicate whether cyclists rode from home or drove to the river and then used the cycleways. A trend towards the latter would suggest the need for carparking facilities for these users. Alternatively a trend towards the former could ease the burden of provision of carparking facilities on the foreshore.

### 3.3.2 Age Structure of Users

Analysis of age of respondents revealed an over-sampling in the 15-44 age group and an under-sampling in the 45th age category record at any site, compared with the resident Perth population.

Participation in wind surfing, water skiing, beach combing, sunbathing decreased with age. A slight decrease was also recorded for cycling. Alternatively a slight increase was recorded for people yachting/sailing. Similarly participation in BBQ/picnicking, enjoying the view, power boating, relaxing, walking also increased with age.

A slightly larger percentage of older people ranked BBQ/picnicking, enjoying the view, power boating, relaxing and walking as their 'most important' activities than people in the younger age group. In comparison 'most important' activities decreased for socialising, water skiing and wind surfing with a corresponding increase in age.

Age structure data and recreation preference of various age groups are testimony that responsible planning should provide for a variety of opportunities around the river to cater for various groups. Given that the Perth population is anticipated to be dominated by an older population structure in the future an increase in activities now favoured by the older age categories can be expected.

### 3.3.3 Place of Residence

Ninety percent of respondents came from the Perth Metropolitan area indicating the importance of the river as a regional resource. However, it should be remembered that the sample caters for reserves users only, not people using facilities which are promoted to the tourist.

Results tentatively suggest that reserves in the upper estuary are more likely to be used by a higher percentage of local users. Consequently if a large reserve area is developed in the upper reaches promotion of the facility will be required to encourage full use.

Given that the river environment is a major recreational resource to the people of Perth, decision makers should ensure that development of the resource does not deny access and/or the opportunities sought and participated in by Perth residents.

### 3.3.4 Pattern of River Use

Over 80% of respondents had visited the site before and 98.5% of these stated they would visit the site again.

Nearly 60% of respondents stated that they had visited the site less than 3 weeks ago with a major portion (37.5%) visiting the area the previous weekend. Just over 21% of respondents reported that their last visit to the site had been over 12 weeks ago.

Approximately 35% of respondents had visited some part of the river four or more times in the last month suggesting a weekly ritual for many users.

Sites recording the highest number of 'one week ago' visitors were Claughton Reserve (54%), Goodwood Parade (53%), Qantas Ramp (44%) and Deep Water Point (30%).

These sites have either boat launching facilities, are designated water ski areas or suitable for wind surfing. Consequently people involved in these activities are likely to use the same site because their chosen activity limits the area of river available to them. It is also probable that participation rates for these people will e higher because of the financial investment in equipment and consequent dedication to their activity.

Results also indicate that young people (15 - 24 age category) are more likely to make weekly visits to the river than older people. The fact that younger people may undertake their chosen activity alone and are, therefore, independent possibly contributes to these data. They are also less likely to have as strong commitments to family, home and work than older people.

The more frequent visits the greater the probability that these results are representative of river users in general.

### 3.3.5 Companions

Respondents generally visited the area with family or friends or a combination of the two. Very few people visited the site alone. The greatest proportion of people visiting an area alone came from Qantas Ramp (27%). This is a popular wind surfing site and results would that people are more likely to undertake this activity alone compared with other activities.

Family groups predominantly used the following sites: Point Reserve (57%), Riverton Bridge (59%) and Upper Canning (65%). In contrast Goodwood Parade reported 64% of respondents came with friends.

At sites experiencing many users visiting the area alone, a greater demand will be placed on facilities such as carparking.

### 3.3.6 Activities

As anticipated respondents participated in a range of activities during their visit to the river. The mean number of activities people participated in was 3.3.

| **Top Ten Ranked Activities** | **%** | **Ten 'Most Important' Activities** | **%** |
|---|---|---|---|
| Relaxing | 63 | Relaxing | 68 |
| Enjoying the View | 52 | Socialising | 30 |
| Socialising | 42 | Enjoying the View | 26 |
| BBQ/Picnic | 35 | BBQ/Picnic | 25 |
| Sunbathing | 21 | Wind Surfing | 21 |
| Wind Surfing | 17 | Swimming/Paddling | 17 |
| Walking | 16 | Walking/Water Skiing | 14 |

| | | | |
|---|---|---|---|
| Swimming/Paddling | 15 | Yachting | 13 |
| Power Boating | 13 | Sunbathing | 10 |
| Water Skiing | 11 | Power Boating | 7 |

In addition to being involved in activities such as picnicking, relaxing, socialising etc. some sites also recorded a high percentage of respondents involved in other more water-dependent activities.

| **Site** | **Activity** | **% of Cases** |
|---|---|---|
| Point Walter | Power Boating | 18.5 |
| Matilda Bay | Wind Surfing | 29.5 |
| Sir James Mitchell Park | Yachting/Sailing | 48.8 |
| Deep Water Point | Water Skiing | 47.4 |
| Goodwood Parade | Water Skiing | 58.1 |
| Claughton Reserve | Power Boating | 38.3 |
| Qantas Ramp | Wind Surfing | 64.6 |

These results indicate that subsidary activities such as picnics, relaxing, walking etc are an important part of the overall (days outings) recreation experience.

### 3.3.7 Appealing and Least Appealing Aspects of the Visit

The 'appealing aspects' and 'least appealing aspects' of a person's visit can provide management with an insight into the type of environment and atmosphere that is desired by the recreationist. It is also likely that these can be applied to other recreation areas.

| **Ten Most Appealing Aspects of Visits** | **%** | **Ten Least Appealing Aspects of Visits** | **%** |
|---|---|---|---|
| Picturesque View | 39 | Litter | 32 |
| Shade and grassed areas | 35 | Lack of parking/ramps | 21 |
| Uncrowded relaxed quiet foreshore | 34 | Crowded | 16 |
| Calm Safe Water | 23 | Grass growth/driving on grass | 14 |
| Close to home convenience | 11 | Jelly Fish | 13 |
| Access (including cycleways) | 10 | Dogs | 13 |
| Clean and well kept | 10 | BBQ/tables etc | 11 |
| Observing water skiers, boats etc | 10 | More boat ramps etc | 7 |
| Wind for sailing | 10 | Poor observance of rules | 6 |
| Toilet facilities | 8 | | |

Comparison between people perceiving the same area as crowded revealed that only at two sites did the 'crowded' number exceed the 'uncrowded' number. These sites were Goodwood Parade, a popular water ski area and Qantas Ramp, a popular wind surfing area. Deep

Water Point recorded on equal number of respondents in each category. These data raise the issue of user safety.

Given that respondents perceive a crowding problem it is possible that they will:

- 'Demand' alternative areas of the river be made available for their chosen activity. In which case because of development of the river environment to date it is highly likely that these alternative areas will be less suitable for environmental reasons, safety reasons, or impact on other activities/users.

- 'Demand' alternative water bodies within the metropolitan area be made available.

- 'Discover' less densely used areas of the river where planning or management has not occurred to date and where the impact of such uncontrolled activity could be detrimental to the environment.

- Users may become impatient and more aggressive with other visitors and managers as they have to wait their turn, jostle for parking etc.

Management decisions should plan for the most appropriate use to ensure the natural integrity and relaxed atmosphere people are seeking is preserved.

Areas where perception of crowding was greatest were water ski and wind surfing sites and consequently the issue of safety is raised.

### 3.3.8 Aspects of River and Foreshore Reserves Respondents would like to see Changed

Sixty percent of respondents reported they would like to see some aspect of the river and/or foreshore reserves changed. Development and maintenance of foreshore reserves involved the greatest criticism.

Assuming that the number of responses received are the minimum number of respondents sharing that view it is significant that 16% of <u>all</u> respondents sampled commented on poor water colour or weed in the water; 14% complained about rubbish in the water or pollution of the water in general; 10% reported that there was little observance of river regulations and/or this aspect needed more effective policing; 9% wanted more trailer/ramp setting up areas and 7% wanted better parking for boat trailers. Further, nearly 21% stated that they would like to see more BBQ's seats, taps, toilets and ablution facilities maintained to a higher standard. Planning and management for the river and foreshores must address these factors.

Public perception of water quality, including general comments made to staff and Authority members (such as "the river's polluted", "a little bit more [pollution] won't matter") indicate the need for the Commission to promote the quality of our rivers and estuaries and the importance of conservation by all members of the community.

It is desirable that a range of reserve and recreation facilities are provided around the river. However, the question must be raised as to what is a sufficient level of development for an area. There are obviously going to be times when demand will exceed supply. People visiting all areas of the river should not expect to have an unlimited array of facilities available. There is no ideal reserve development, some people prefer everything laid on, some people enjoy roughing it. It is reasonable, however, to expect with Perth's climate that some form of shade and grassed or sand area be available on the foreshore.

However, this should blend with not dominate the natural vegetation of the area. Vegetation and landscaping of the area should include indigenous species and regeneration of existing species should be encouraged.

Provision of boating facilities was commented on by approximately 28% of respondents. Aspects concerning trailer parking and setting-up areas were most frequently raised. These data indicate the inadequacy of these facilities at some sites according to today's level of use and the need for careful planning in the future. However, the question must be asked whether further facilities will alleviate problems or exacerbate ones of crowding, safety and more people using the same area. Re-directing use to other less densely used areas through education may be one option.

Observations of usage of Preston Point Ramp, East Fremantle, indicated that over 90% of users head out to sea. Use of river facilities to such a large extent suggests inadequate coastal facilities and inappropriate use of the river resource.

Responses concerning water safety mainly focused on non-observance of navigable water regulations and the need for education programmes for boat users. At present private boat users do not require any knowledge of these regulations to use a boat on the Swan-Canning Estuarine System.

The call for more effective policing of boating areas came mainly from Deep Water Point and Goodwood Parade respondents, both popular water ski areas.

### 3.3.9 Behaviour

Respondents were asked to indicate if they had experienced any offensive behaviour by other groups during their visit. Sites recording the largest number of complaints were Point Walter (20), Sir James Mitchell Park (17), Goodwood Parade (12), Matilda Bay (11) and Deep Water Point (11).

Generally, problems associated with the behaviour of users reinforce the least appealing aspects of respondents' visits. Aspects such as 'fast driving' can probably be overcome by incorporating traffic control mechanisms into design plans for reserves. However, reducing the incidence of other factors relies on public education programmes aimed at reducing incidents which may endanger the safety of users.

### 3.4 School Use

The Education Department of Western Australia runs a sailing school for public schools operating from Mounts Bay Sailing Club, Crawley each weekday of school terms.

Instruction is given to 22-25 classes each week with approximately 45 classes using the facility each term.

Activities taught by the school are sailing and sail boarding. Students are instructed and tested in water safety, river regulations and boat handling. Testing is both of a written and practical nature.

The areas of the river used for board sailing extend from Mounts Bay Sailing Club to Pelican Point out to Knots Spit. Sailing courses extend to Mounts Bay Road Boatshed; the Narrows; Como foreshore; Canning Bridge and Waylen Bay. Each class generally undertakes 1-2 trips to each location depending on wind conditions.

Use is also made of the river environment by school groups other then those listed in 2.3.8 or using the sailing school.

Many take advantage of hire and drive operations existing on the river, particularly surfcat and wind surfer hire. In addition many schools have canoes and kayaks which they use on the river. Similarly the Department of Sport and Recreation hires out these types of equipment.

School use provides a platform for educating users about water safety and river regulations as well as permitting many young people to experience a variety of recreation activities.

4.0 **ACTIVITIES**

4.1 **Foreshore Activites**

4.1.1 **Cycling**

The Perth Bikeplan Study Team (1985) suggest that transportation cycling accounts for nearly 80 percent of cycling activity with around 5.5 percent of all trips in the Perth Metropolitan area being bicycle transportation trips and a further 1.5 percent bicycle recreation trips.

Observations taken by the Waterways Commission (Thurlow, 1986) indicated that up to 100 cyclists and pedestrians per hour passed through Sir James Mitchell Park on Sunday 20/1/85.

The Central Perth Foreshore Study Group (1985) reported on a Sunday between 7 a.m. and 7 p.m. (November 1984) 180 pedestrians and 470 cyclists passed south to north over the Causeway; 360 pedestrians and 1 380 cyclists (average) along Riverside Drive in the vicinity of Victoria Avenue and 120 pedestrians and 520 cyclists north to south over the Narrrows Bridge.

Provision of these dual-use pathways requires that additional facilities also be available. These include drinking water, shade areas, toilet facilities, lock-up storage facilities for cycles, parking for cars, and possibly cycle hire facilities. In many instances these are already provided at reserves around the river although new ones may be required in 'remoter' regions.

These factors should be considered during the initial planning of any pathway system.

The Central Perth Foreshore Study Group (1985) suggests that the high cycle figures recorded along Riverside Drive are likely to be due to the cycle hire facility in Carpark 4, Fraser Point. If cycle hire facilities are to be provided it is suggested that these facilities be sited close to parking areas which have limited weekend use rather than adding a new group of users to an already heavily used area. Development of hire facilities must take into account present use of the area, facilities provided and whether hirers will be drawn from the population already using the area or if more people will be attracted to the area adding to the demand on existing facilities.

Linking up river pathway systems with other areas of interest (scenic, historical or scientific) would add further variety to people's visit.

### 4.1.2 Fishing

Fishing is a popular activity on the river having experienced considerable growth in recent years. Numerous people can now be observed fishing at various locations around the river. Forbes and Fitzhardinge (1977) suggested that up to 600 people were involved in fishing over the course of a summer's weekend. Observation by the SRMA in the summer of 1985 did not support this figure. However, observations in 1986 when prawns were 'running' easily supported this figure with prawning parties often being made up of 10 or more people.

In 1983-84 the Department of Fisheries and Wildlife conducted an investigation into recreational and commercial fishing in the Swan-Canning Estuary highlighting use, concerns, problems and conflict between commercial and recreational fishermen (Roger et al., 1984).

Those involved in fishing were particularly concerned with man-made changes to the river and foreshore vegetation and the possible impact on the fish fauna. It has been calculated that of the 17.6% of shallow banks, between the Fremantle Traffic Bridge and the Narrows and Canning bridges, 8% has been deepened by dredging. Intensive dredging has also been carried out between the Causeway and Maylands Peninsula. In addition reclamation has also destroyed much of the fringing vegetation and some areas of river shallows. These areas can be seen on the attached maps.

The study group (Roger et al., 1984) commented that dredging has the aquatic fauna to the detriment of the current recreational and commercial fishery. Moreover Rogers et al. (1984) believed that the shallow seagrass areas of the Swan River are very important in supporting the variety and abundance of fish found within the estuary. Their removal would seriously affect the value of the estuary for recreational and commercial fishing and result in a significant decline of fish abundance. High priority should be provided for their preservation.

People involved in fishing also raised concern about the impact oil pollutants from outboard motors and their mechanical action on seagrass and algae. Rogers et al. (1984) believed that whilst these factors may be of some concern in restricted parts of the estuary, tidal interchange and wind driven surface water movement within the estuary minimise their impact.

Similarly the influx of nutrients and herbicides provide a long term threat to the stability of the estuary as a fish habitat unless monitored and controlled.

Submissions to this report and the Fishery Working Group questioned the effects of noise on fish behaviour. No data were available to assess this claim but Rogers et al. (1984) report that it is possible that schools of sea mullet and Perth herring in particular, spend less time at any one location in the estuary perhaps moving more frequently in response to noise.

It is claimed that fish productivity in the estuary has declined significantly over the last two or three decades, partly due to environmental changes and partly to over-fishing of the resource. The Working Group (Rogers et al., 1984) did not believe that fish stocks other than bream and yellow tail trumpeter are likely to be at risk to the point where stock recruitment failure occurs. The reduction in catch rates experienced by anglers is likely to be due to the total available catch being spread over a greater number of people, reducing average catches. Moreover as new recruits enter the fishery, catch success will improve or decline as the abundance of resident fish falls as a result of fishing and natural mortality (Rogers et al., 1984).

Consequently the only means of improving the catch success of anglers is to reduce the level of total fishing pressure being applied if it becomes feasible.

Calls to ban commercial net fishing within the estuary were received in submissions to the Working Group (Rogers et al., 1984) and this report. The Working Group reports that exploitation of predatory fish by anglers as fishing pressure continues to increase is likely to lead to lower natural mortality of their prey and perhaps greater abundance of species such as mullet and Perth herring. Consequently it was recommended that the commercial net fishery within the estuary should be sustained at a low level to provide for the proper utilisation of the mullets and Perth herring provided commercial fishing can be sufficiently separated in space and time from other people using the estuary.

### 4.1.3 Barbecuing and Picnicking

Results from the on-site survey indicated a high level of participation in this activity. It is often only one of a range of activities users participate in.

Local Government is usually responsible for provision and maintenance of these facilities. Results indicated that users would like to see more facilities of this nature available on the foreshore. People involved in this activity also commented on the provision and maintenance of shade and grass areas, seating and tables on the foreshore.

Observations at upstream locations indicate that these facilities are often under-utilised compared with downstream locations. Advising the public what facilities are available may lead to a more balanced pattern of use.

### 4.1.4 Miscellaneous

Other activities occur on the foreshore and although not totally dependent on the foreshore are considerably enhanced by the location.

Activities include:

- Pleasure driving
- Enjoying the view and watching other activities
- Walking
- Exercising dogs and horses
- Photography
- Bird watching
- Games and using play equipment

Although not dominant uses of the foreshore the needs, opportunities and impact of these users need to be considered by Management.

## 4.2 Offshore Activites

### 4.2.1 Houseboats

The SRMA has received occasional requests for houseboats to be used on the river, both on a commercial and private basis.

Commercial houseboats are controlled by the Department of Marine and Harbours under the W.A. Marine (Hire and Drive Vessels) Regulations 1983.

The definition of a houseboat means "any vessel or pontoon that is held or let;

a) as a place of habitation whether such use be temporary, intermitent or permanent.

b) as a place for accommodating or receiving persons for purposes of shelter, recreation, entertainment or refreshment; or

c) as club or business premises,

but does not include a vessel being temporarily used for any of the purposes in sub-paragraphs (a), (b) or (c) of this paragraph if the vessel is normally employed in carrying goods or passengers, or both, for reward or plying for hire for the carriage of goods or passengers, or both".

Private houseboats are not controlled directly under any specific legislation. However, regulations restricting sullage disposal from craft, mooring at public jetties and provision of facilities required by houseboat owners discourage their use on the river system.

The need for legislation to control private houseboats would probably be best met by the Department of Marine and Harbours. However, such legislation would need to ensure that boat owners spending a night on their boat prior to a yacht race or trip to Rottnest etc. were not severely disadvantaged.

As well as problems of conflict with other users and competition for the river resource the facilities required for houseboats make this activity unfeasible and undesirable.

Facilities required for houseboats include approved berthing areas providing for:

- The taking on of stores.
- The taking on of water.
- Rubbish disposal facilities.
- Sullage and sewage disposal facilities.
- Parking space for vehicles.
- Fuel supplies.
- Electricity outlets.

Research by the SRMA led to development of the following policy on houseboats:

**Policy on Houseboats**

Houseboats should not be permitted to be located on the Swan-Canning Estuarine System.

Houseboats are not compatible with other river users for the following reasons:

- The waterways are central to the Perth Metropolitan region and area easily accessible to the one million inhabitants of the region.

- Considerable pressure is already placed on the waterways and the foreshore environment by these people.

- The waterways main use is as a recreational resource enjoyed in both the physical and aesthetic sense.

- The waterways are under pressure from recreationists for its use and some persons may claim that it is at saturation point now.

- Houseboats moored permanently will take up recreational water which should be available to all users.

- People do not have to live on the river, there is no shortage of land.

- The navigable water above the Causeway and Mt Henry Bridge is limited. The former is also subject to flooding, during which time it would be dangerous for any vessel particularly houseboats.

- Downstream of these bridges there are only a limited number of mooring areas suitable for all weather conditions. There is already keen competition for these areas by yacht clubs, private boating enthusiasts, wind surfers, swimmers etc.

### 4.2.2 Swimming

Swimming within the river is not as popular as it has been in the past. This can be partly attributed to the closure of many of the old swimming baths. Gazetted swimming areas are listed in Section 2.3.2.

Swimming classes are still held around the river during summer holidays.

Popular swimming areas included Point Walter, Mosman Bay, Freshwater Bay, Matilda Bay, Success Hill and Governor Stirling Jetties, Midland. In addition, children can be observed at many upriver locations where swimming areas are not gazetted. In these areas where the river is quite narrow, the possibility of accidents with boats is increased. One such area is Success Hill where children leap from the overhead water pipe, ferry drivers having to wait on occasions until children clear the area before they can proceed.

Complaints of boats, particularly wind surfers entering gazetted swimming areas at Point Walter and Matilda Bay were also common. The Department of Marine and Harbours have amended the swimming area at Matilda Bay to permit wind surfers to take off from the foreshore without going through the swimming areas.

Comments in the onsite survey suggest that people are concerned about the water quality in the upstream areas, sometimes restricting their children from swimming in these areas. Problems such as sore ears, eyes and throats associated with the old swimming baths have also contributed to this attitude. Water quality of the river is discussed in Chapter 6, however, in general water quality sampling results, indicate that during summer the Swan River is suitabe for bathing, well flushed areas of the lower estuary being the most acceptable.

### 4.2.3 Boating

#### 4.2.3.1 Boat Ownership

Any motorised craft, including auxillary yachts are required to be registered with the Department of Marine and Harbours.

On the 30th April 1985, there were 69 625 registered craft; 42 827 of which were currently licensed. The Department of Marine and Harbours proposes that 50 824 of the 69 625 are active boats. This figure is derived from boat registrations over the past three years. Data, therefore, indicate that upto 16% of active boats may not currently be licensed. Approximately 64% of registered craft or licensed craft are from within the metropolitan area.

**TABLE 6:** Boating Registration W.A.

| SIZE | | REGISTERED CRAFT N | % | LICENSED CRAFT N | % |
|---|---|---|---|---|---|
| <5 | metres | 48 483 | 70 | 28 026 | 65 |
| 5-5.9 | metres | 12 239 | 18 | 8 818 | 20 |
| 6-6.9 | metres | 4 105 | 6 | 2 789 | 7 |
| 7-9.9 | metres | 3 416 | 5 | 2 329 | 6 |
| <10 | metres | 1 382 | 2 | 865 | 2 |
| | | 69 625 | | 42 827 | |

Source Department Marine and Harbours 30th April 1985.

Table 6 indicates that a very small percentage of registered private boats are over 8 metres in length (less than 8%). These data suggest that provision of public funded boating facilities throughout the State should concentrate on meeting the needs of the small boat owner.

Very few boats less than 7 metres would have wet pen or moorings on the river. The majority of craft of this length are trailable. P.A. Australia (1983) found that 75% of respondents stored their boats at home which supports the theory that many boat owners have trailable craft.

**TABLE 7:** Number of Boats Registered with Member Clubs of Y.A.W.A. 1983-84 Census

| | **W.A.** | **STUDY AREA** |
|---|---|---|
| Total Boats | 5 438 | 3 256 |
| Power Yachts | 2 144 | 1 151 |

Table 7 indicates a little over 2 000 sail craft are associated with yacht clubs based within the study area. It would appear that overall sail craft users are a minority group compared with power boat enthusiasts. Information is not available, however, on the number of registered power boats using the river as opposed to ocean waters. Observations at Preston Point boat ramp on a Saturday and Sunday morning in summer revealed that over 90% of people launching between 7.00 a.m. and 9.00 a.m. headed down river and presumably out to sea.

4.2.3.2 **Boating Predictions**

P.A. Australia (1981) reported that since 1979, the rate of growth had slowed down and showed signs of developing into an "S" curve configuration indicating the onset of saturation. Factors against further growth were the "fuel crisis", the general economic downturn, increased boat prices. Mr. M. Law, Secretary of the Boating Industry Association of W.A. (Pers. comm.) suggested in July 1984 that predicted growth rates for boat ownership had proved inaccurate because of the present economic situation. On a more positive note a newspaper article in the West Australian, Friday 31st August, 1984 reported that "trailer-sailers 5-7 metres overall and twin diesel cruisers of 10 metres plus are the most sought after types of boat at present; according to brokers and dealers in Perth and Fremantle and it seems that the America's Cup Victory, on top of Jon Sanders double circum-navigation, has made many more people sea conscious".

In addition factors supporting further growth in 1981 were (P.A. Australia, 1981):

a) An ageing population with increased per capita ownership.

b) Shorter working hours.

c) Cheapness of boating compared with other forms of entertainment.

d) Advent of lighter, more fuel efficient craft.

Forecasts by Bowden (1984) excluding the effect of the America's Cup are an increase from 65 122 registerable boats mid 1983 to 79 716 in 1990. A 10% stimulus is anticipated from the Cup Defence.

#### 4.2.3.3 **Motorised Boating**

It is estimated that between 500-700 motorised craft using the river on an average Sunday afternoon, participating in various activities.

**Power boating** covers speed boating and pleasure cruising.

Speed boating is a club activity and is restricted to the Heirisson Island area (Section 2.3.2). Unfortunately no response to the club questionnaire was received for clubs involved in this activity. This area of the river is also available for the Water Ski Association of W.A.

Facilities available on shore are limited. Applications have been received for upgrading of the area for use by these two club groups.

Erosion is associated with this activity although rush replanting on Heirisson and Burswood Island foreshore has been successful in dissipating boat wash. The present location of the speed boating area has meant that the problem of noise normally associated with motorised boating has not been prevalent. Whether this will change with the location of the Burswood Hotel is unknown.

Level of participation is difficult to ascertain as people launch at one location and visit a number of river locations during their cruise. Observations indicate that many people take the opportunity to cruise to up-river locations. In part this is due to the scenic qualities of the region and in part due to the current use of downstream areas (i.e. approximately 1 500 yachts using the lower estuary on a Saturday afternoon in summer).

Problems associated with pleasure cruising are lack of parking and boat launching areas. This may be attributed in part to improper use of river facilities i.e. Preston Point ramp is used predominantly by ocean-going craft.

Pleasure cruising is also associated with erosion and noise pollution, particularly in upstream areas. Complaints and public submissions suggest that power boating be banned upstream of Garratt Road Bridge, in one case; and upstream of Middle Swan Birdge in other submissions.

Pleasure cruising appears to be an extended family group activity. Boat owners are usually in the 35 plus age category.

**Water skiing** is restricted to those areas listed in Section 2.3.2. Participation is by club groups and casual users. Many of the club groups compete with casual users for the same areas. Only the Water Ski Association has facilities on the river foreshore (Burswood Island).

Results from the recreation study indicated a frequent level of participation in this activity by users. Water skiing appears to be predominantly undertaken by boat owners in the 20-35 age category with their immediate family and friends.

Complaints of poor knowledge of boating regulations by some water skiers eminated from water skiers in the Deep Water Point and Goodwood Parade water ski areas. Club membership provides an opportunity for educating users about those rules and regulations.

There was also a strong consensus that more water ski areas are required around the river.

The Barefoot Water Ski Association indicated that it would like to exchange its present area for an area at Lilac Hill Park. However, it is the SRMA's opinion that there should not be any barefoot water skiing in the Lilac Hill area of the river as it is considered that the banks of the river could be damaged by boat wash if all craft could travel at unrestricted speeds.

The area of the river in question is not suitable as a permanent site for barefoot wate skiing. It is really only suitable for canoes and small boats. There is also the potential for conflict between barefoot water skiers and other users of the river because the river is narrow at this point.

The SRMA is also concerned that, while it has allowed barefoot water skiing to take place in the past, it considers that a more permanent use of the area would cause more erosion to the banks.

The area of the river at present is quiet and peaceful and this could be disturbed by the loud noise of ski boats.

Complaints of noise generated from ski boats is common. This aspect is addressed in Section 4.2.4.2.

**Jet skiing** is not a common activity on the river. Craft are under the same restrictions as power boats. One problem associated with this activity is that craft are unstable under the 8 knot speed limit. Therefore there are few areas within the river where these craft may operate without exceeding the speed limit. Applications for jet ski hire and drive operations have been refused to date by M&H and LGA's because of problems of speed, safety and noise.

**Parasailing** occurs infrequently on the Swan-Canning estuary. This activity is subject to the same restrictions as water skiing.

One commercial operation is licensed under the Hire and Drive Regulations to operate from Mill Point ski area.

As participation in this activity is limited, conflict with water skiing is minimal. Only if this activity were to experience a sudden increase in popularity would further restrictions be necessary.

**Boat fishing** is also a minor activity on the river, with most boat fishing occurring on the ocean. Preston Point ramp is used by a large number of ocean-going fishermen.

#### 4.2.3.4 Non-Motorised Boating

The majority of regular boating on the river is non-motorised and club oriented.

**Canoeing and kayaking** occurs mainly in the upstream sections of the river during winter months. Most observed paddling was club oriented. Sea scouts and school groups also participate in these activities. Favoured areas are adjacent to club facilities and Riverton Bridge to Canning Bridge.

It is impossible to estimate the number of casual users in this activity as the SRMA's recreation studies focussed on summer use. It is known, however, that participation rises considerably prior to the staging of the Avon River Descent. Areas used for training for this event are Walyunga National Park downstream to Middle Swan Bridge.

The biggest problem encountered by paddlers is boatwash from other craft and it has been suggested that a separate area be set aside for these activities. The SRMA considers that the section of river from Middle Swan to Upper Swan Bridge is ideal for this.

**Rowing** is essentially a competitive club activity Participants require calm, safe water. Unfortunately the main rowing course is located adjacent to a water ski area creating problems for rowers.

Numbers participating in rowing are approximately 1 400.

As with canoeing and kayaking boat wash creates considerable problems for rowers. Areas used by rowers are Canning Bridge, Perth Water, Crawley Bay and Guildford. The Rowing Assocition sees the need for a new rowing facility upstream of Garratt Road Bridge.

In the long term it may be necessary to look at development of an artificial waterway suitable for rowing, kayaking and water skiing. It would need to be available on a time share basis and used for staging of State, National and International Events.

**Wind surfing** or board sailing is a comparatively new activity on the river. The recent staging of the World Championships has served to increase its popularity.

Wind surfing is both a club and casual users activity. Areas popular for casual use are Qantas Ramp, Nedlands, Matilda Bay, Nedlands and Melville Beach Parade, Melville. Authorities responsible for management of these areas have all encountered problems with the change in patronage to the area. City of Subiaco has recently upgraded parking to provide more bays and the Department of Marine and Harbours has changed the swimming area at Crawley Bay to permit wind surfers to "legally" take off from the foreshore. The City of Melville is in the process of developing a management programme for the area to ensure that opportunities are available for wind surfers, residents and other users of the area.

It is estimated that between 300-400 casual wind surfers use the river on a Sunday afternoon (winds permitting). The rise in popularity is reflected in the number of Hire and Drive operations licensed to hire sail boards (see Chapter 15). Most of these are licensed to hire from shops rather than the foreshore as this would only add to congestion at popular areas.

Survey results indicate that wind surfers experienced problems of lack of parking and crowding. The latter aspect raises the problem of safety.

Questionnaire results indicated that participation in wind surfing was male oriented and popular amongst the 15-24 age category. Users were also likely to undertake this activity alone, consequently placing greater pressure on foreshore facilities.

Wind surfers were also found to participate frequently in their chosen activity (8-12 times in the last month), therefore, popular sites are likely to experience greater pressure that sites used for other activities.

There is a need to ensure that wind surfers are recognised by other users as a class of their own.

The cost, ease of transport and setting up, and fact that wind surfing is a one person activity all contribute to its popularity. It is unlikely that this activity has reached its peak.

**Yachting/Sailing** is mostly a club activity, dominating Saturday afternoon use of the lower estuary. It is estimated that 1 500 yachts are on the river on an average summer Saturday.

Congestion and safety were the two main problems highlighted by yacht clubs. Not only has participation in yachting grown in the last 30 years but also the size of craft has also increased. One of the reasons for establishing Fremantle Sailing Club was to attract larger ocean going craft outside the estuary.

Sailing by users other than club members is restricted to finding suitable mooring facilities or having craft that can be launched easily from existing boat ramps.

A letter to the SRMA from the Hartley TS 16 Association of W.A. indicated that the only launching ramps suitable for access to the lower estuary for these yachts are Point Walter and Matilda Bay. Upgrading of other ramps may be necessary to improve access for trailable yachts.

"Surfcating" and "catamarans" are also popular trailable sail craft although it is anticipated that their popularity has declined with the advent of wind surfers. Hire surfcats as Sir James Mitchell Park are very popular during the summer months. Approximately 50% of respondents interviewed at Sir James Mitchell Park used these hire facilities. These boats are often as close to yachting as many people experience. Hire opportunities should remain as long as popularity persists.

Attitudes expressed in the SRMA's recreation studies indicated that yachting unfairly dominated river usage, with other user groups being discriminated against. Management needs to ensure that it considers the needs and opportunities of other classes of users in its decision making process.

Research data also indicated that many yacht clubs could increase membership numbers if facilities were expanded. Questions of congestion and conflict with other activities must be seriously addressed before such expansion can be contemplated.

### 4.2.4 Boating Problems

In addition to the problems of safety (Section 4.3) and erosion (Chapter 9), other problems occur with boating (both motorised and non-motorised craft). These include effluent disposal from craft, noise pollution and abatement, dredging and desnagging of the river and generalised pollution.

#### 4.2.4.1 Effluent Disposal from Crafts

Under Section 48 of the Waterways Conservation Act 1976 (amended) a person is guilty of an offence if they knowingly permit any poisonous, noxious or polluting matter to be discharged or deposited on or in any waters or land under the jurisdiction of the Waterways Commission. Persons doing so are liable to a fine of $200. These rules may be applied to the deliberate discharge of sullage from boats.

Currently vessels on the Swan which have toilets or shower facilities are likely to have systems flushing straight out or be emptied by in-board pumps. Burke (1979) comments that the use of sea toilets probably has an insignificant effect on the ocean, and consequently there would be little reason to prohibit their use outside the estuary. However, as pointed out in Chapter 6 on Water Quality, discharge of sewage and refuse may lead to localised if not general pollution without some form of control.

In 1980 pumpout facilities were installed at Barrack Street Jetty. Up till this date all effluent was flushed out either into the river or ocean. The facility was initially planned for both public and commercial use, however, limited public use is made of the facility. SRMA draft by-laws are currently being developed which will require all commercial vessels that have berths at Barrack Street Jetty to discharge sullage into this pumpout facility. Further, a mutual agreement between the SRMA and Marine and Harbours requires, as one of the commercial licensing conditions, small hire vessels (such as power boats and yachts) used in the estuary be fitted with a Porta Potti system.

The Waste Disposal from Marine Craft Steering Committee, convened by the Health Department of Western Australia, is currently reviewing waste disposal from boats including legislative control. The Committee has approached the America's Cup Funding Committee for assistance to install and operate a pumpout facility in Fremantle. It is essential that such facilities are connected to a sewer with the capacity to dispose of these volumes. The Committee is also reviewing the possibility of all craft built in the future to have holding tanks capable of being emptied by land-based pumps.

A recent application for a packet licence was granted by the Licensing Court of Western Australia provided the vessel did not operate on the Swan and Canning Rivers because the owner was not willing to install sullage tanks. The upholding of the Commission's policies by other agencies is evidence of responsible management.

Education of the public to accept the need for preventing discharges of this nature entering the river must be the primary aim of the Authority because of the difficulty in administering this by-law. Burke (1979) suggested that penalties for non-compliance should be advertised and high enough to act as a deterrent, rather than a punishment.

#### 4.2.4.2 Noise Pollution and Abatement

Noise is a form of pollution, affecting the quality of people's lives. The major burden can often fall upon people who are not directly party to any benefits.

Randle (1982) assessed noise levels, relating to water skiing and other boating activities during the time that boats were in operation on the Swan-Canning Estuarine System. Considerable noise can be generated by these activities and consequently may affect the public living nearby where these activities occur. Areas investigated were; Deep Water Point, Mt Pleasant, White Beach, Dalkeith, Bamboos, Claremont. Results indicated the Mt Pleasant area was exposed to higher levels of noise from ski boats. The general conclusion from Randle's (1982) survey of residents near these ski areas was that the majority of residents were not greatly annoyed by ski-boat noise. For the most part residential areas are well located away from the water ski areas, therefore, the noise was not too loud.

Unfortunately the same cannot be said for other areas of the river. Two public submissions to this study related to noise problems, one of these from the Health Department of Western Australia*. The Health Department indicated that over recent years the Noise Abatement Section had received complaints against the

* Now incorporated into the Department of Conservation and Environment.

noise generated by craft on the river. The majority of these centering around water ski boats. The particular areas that have generated complaints are Chidley Point and Deep Water Point. Other areas have also generated isolated complaints to the Health Department.

Isolated complaints have also been noted in relation to the Rottnest Island Ferries and river cruise vessels. One recent complaint resulted in modification to the vessel to reduce the noise generated. However, this is one of the few complaints that has been successfully attended to.

Under the terms of the Waterways Conservation Act "pollution" is not interpreted to include noise pollution. Consequently the SRMA is unable to act on these complaints other than referring them to the Health Department. Moreover, Local Government Authorities, Marine and Harbours or Health Department have little success in handling these matters under present legislation. However, under the Navigable Water Regulations the Department of Marine and Harbours may require boats to be fitted with efficient silencers (Section 15).

Attempts to reduce the noise impact include restricting the times when ski boats may operate. However, a few boat owners have been observed to ignore these regulations. The fact that skiing occurs most frequently on the weekends when most people are home exacerbates the problem. Similarly wind direction, cummulative effect of the number of boats and topographical features also increase the problem. Moreover individual acceptance of noise makes recommended standards for noise limitation difficult - what is acceptable to one person may be unacceptable to another.

To date legislation seems unsatisfactory to address the problem. While the Swan-Canning Estuarine System provides a recreational facility for a considerable number of people the use of this facility can also interfere with the comfort and response of other persons in their own homes.

At the very least any future decisions regarding location of water ski sites should include an assessment of the noise problems.

Recently the SRMA requested the Noise Abatement Advisory Committee to review the problem with the view to introducing more effective legislation similar to that operating in the Eastern States. The review is currently underway.

#### 4.2.4.3 Dredging and Desnagging

The impact of dredging on the estuarine environment has been discussed in Chapter 8. Reasons for dredging are usually deepening of navigation channels, mooring and marina areas, and increased recreation water for deeper draft vessels.

Demands for dredging to increase the amount of deep water available have been made in the past. However, the majority of these have been resisted on the following basis:

a) Anticipated impact on the estuarine environment.

b) Given the increasing number of boats using the river the amount of water made available by dredging will probably only provide a temporary solution to boating congestion but still have a considerable impact on the estuarine environment.

Desnagging the river of tree branches and other obstacles is undertaken by the SRMA. Above Middle Swan Bridge on the Swan and Riverton Bridge on the Canning, no desnagging occurs. Consequently these waters are hazardous to motorised craft, often resulting in damaged propellers. Because of this restriction to motorised craft the water is ideal for canoeing and other non-motorised boating activities. Demands have come from various sectors to desnag these areas particularly above Middle Swan. However, the SRMA has resisted this pressure and will continue to do so. It is the SRMA's opinion that the area should be available only to non-motorised craft. Certainly recreation studies by the Waterways Commission indicate the need for areas of the river set aside specifically for non-motorised craft use. If motorised craft are permitted into the area they will dominate the waterway spoiling the experience for other users as well as jeopardising their safety.

If control is not placed on dredging and desnagging of the river then the quality of the estuarine environment and recreational opportunities available to other users will decline.

#### 4.2.4.4 Pollution

Petrol, oil and diesel from recreational vessels can accumulate in heavy use areas. These problems will be amplified in areas of reduced flushing or poorer water quality areas of the upper reaches. These products enter the river from bilges or spillage during refueling. Heavy metals from anti-fouling chemicals are known to accumulate in sediments. It is the sublethal effects on fauna that are of concern and need to be monitored.

Management should aim to reduce the chances and impact of such incidents.

## 4.3 Safety

### 4.3.1 Speed Limits

Control and setting of speed limits on the river are the responsibility of the Department of Marine and Harbours. Essentially speed limits are set for one of three reasons:

Safety issues
Damage to boats and pens
Erosion

Also special restrictions exist during yacht racing times e.g. upstream of Bunbury Rail Bridge:

The following is a list of restrictions within the study area:

1. Limits the speed of motor boats to that of four (4) knots within the following areas:

   **Canning River**

   All waters of the Canning River upstream of the Riverton Bridge.

2. Limits the speed of motor boats to that of five (5) knots in the following areas.

   **Swan River**

   i) From a point 100 metres downstream of the Point Reserve Swimming Jetties to the Bassendean Road Bridge.

   ii) From a point 100 metres downstream of the Governor Stirling Jetties to a point 100 metres upstream of those jetties.

   iii) From a point 100 metres upstream of Caversham House for Navigable waters upstream of that point.

3. Limits the speed of motor boats to that of eight (8) knots and prohibits water skiing within these following areas:

   **Swan River**

   i) Between the Fremantle Traffic Bridge and a line drawn from Point Roe in a southerly direction to the Bicton Jetty.

ii) Between a line drawn from Point Roe in a 128° direction to the Bicton Swimming Jetties and a line drawn from Chidley Point in a 128° direction to the foreshore at Bicton. Provided that this speed restriction will apply on Saturdays, Sundays and public holidays only between the 1st October and the following 30th April.

iii) Within the area of water of the Swan River from the Bunbury Railway Bridge upstream to Punt Road, Rivervale, provided that the following condition shall apply - that the speed restriction will apply only between the hours of 12 noon and 5 p.m. on those Sunday afternoons that the Maylands Yacht Club is conducting races.

iv) Between the upstream limit of the water ski area commencing 580 metres upstream of the Garratt Road Bridge.

v) From a position 235 metres downstream of the Ascot Swimming Jetties to a position 100 metres downstream of the Point Reserve Jetties, but excluding the gazetted swimming area at Ascot.

vi) From the Bassendean Road Bridge to a point 100 metres downstream to the Governor Stirling Jetties.

vii) From 100 metres upstream of the Governor Stirling Jetties to approximately 100 metres upstream of Caversham House.

**Canning River**

i) Between Canning Bridge and a line drawn between Point Heathcote and the other end of Como Jetty.

ii) Within Bull Creek from its junction with the Canning River.

iii) Between 1 p.m. and 6 p.m. on Saturdays, sunrise to 9 a.m. on Sundays and 2 p.m. and 5 p.m. on those public holidays while authorised rowing regattas are in progress. All the waters of the Canning River between Canning Bridge and Mt Henry Bridge.

Provided that this speed restriction shall not apply to vessels used by officials of the W.A. Rowing Association and used in the conduct of the rowing regattas.

iv) On Mondays to Fridays (not including public holidays) all the waters of the Canning River north of a line drawn due east from Deep Water Point to the Manning foreshore and extending to Canning Bridge. Provided that this speed restriction shall not apply to vessels used by officials of the W.A. Rowing Association and used in the conduct of rowing training.

4. Limits the speed of motor boats to have of <u>twelve (12) knots</u> within the following area. From a point 200 metres downstream to the Belmont Swimming Jetties (springs) to the upstream limit of the "A" Class Reserve at Maylands but excluding the gazetted swimming area at Belmont.

### 4.3.2 Aspects of Water Safety

Responses to the club questionnaire and on-site recreation survey conducted by the Waterways Commission give an insight into water safety issues and user awareness of them.

The two most frequent water safety issues indicated by clubs were:

- General inconsideration by other users.
- Boat wash creating problems for small craft or skiers. Activities particularly affected by this point were rowing, canoeing, swimming and sea scouts.

The lowest scoring category was; 'dangerous alcohol induced situations' - 24%. However, when it is considered that one in every four clubs/association considers that the safety of members is placed at risk due to this factor the problem is significant. The two most frequently indicated matters of concern to club respondents were:

- Boating congestion on the river (75%) with 90% of these respondents indicating this factor would affect them more in the future.
- Safety of members at risk due to other river users contravening boating rules and regulations (75%), with 87% of these respondents indicating this factor would affect them more in the future. Ten percent of respondents to the on-site questionnaire similarly reported that there was little observance of river regulations and/or this aspect required more effective policing. (The

difference in percentage in the two questionnaires may have attributed to the fact that on-site respondents were unprompted and not all were involved in boating).

Moreover the main problems experienced by the Department of Marine and Harbours Inspectors are:

- Speeding in the upper reaches.
- Skiing outside a designated area.
- No observer while skiing.
- Speeding in 8 knot areas.

(Pers. comm. H. Smith 8/3/85)

All these data indicate that planning and management decisions should aim at reducing boating congestion and eliminating safety problems. Projects that aggrevate either problem should be carefully considered. New developmental proposals should be made to address the problem of how the proposal will reduce or aggravate any of these points of concern, or how these problems will be managed.

The National Safety Council of W.A. in its submission to this report commented that research by the Water Safety Division found a steady growth in craft numbers using the rivers. The Council considered boating safety in general to be an increasing problem but mainly on the ocean. As more people take to the rivers (resulting in crowding) the boat population grows on the ocean. However, incidents to date on the Swan-Canning waterways such as engine failure, boat fires and collisions have usually been of minor consequence. Notwithstanding this the Council sees alcohol and boating as a problem that will have to be addressed by the State Authorities very soon.

The Council is opposed to a licence scheme for boat operators, preferring to see the Australian Yachting Federation Training Scheme endorsed by Local Authorities as a minimum level of competence for boat operators.

### 4.3.3 Foreshore Facilities and Water Safety

One aspect associated with provision of access that has been drawn to the SRMA's attenion is safety of those using foreshore reserves and adjacent waters, particularly swimming areas. The Coroner's decision on a case pertaining to the river suggested that "those responsible for the control of areas where people, particularly children, are encouraged to congregate should endeavour to ensure that such places are safe for those who can be reasonably contemplated to use them. Depending on the circumstances the safeguards to be taken may include removal of the hazard, security fencing or the posting of warning notices. Moreover, although it may be impractical to erect warning signs it does not diminish the managing authorities' responsibilities. Alternatively, an awareness programme directed at the general public advising the dangers which might exist in such places should be considered".

4.4 **Special Events**

Under Section 51 (c) of the Navigable Waters Regulations.

> "A person shall not organise, promote or conduct a race, display or regatta for vessels of any description or exhibition of any form of aquatic sport, including water skiing, in any navigable wates, unless permission, therefore, has first been granted by the Department (of Marine and Harbours)".

The W.A. Aquatic Council assists the Department with organisation of these events. Members represent the following activities:

Yachting
Power boating
Water skiing
Canoeing
Rowing
Swimming
Scouting

The Aquatic Council produces a summer and winter programme of organised activities on the waterways with many events occurring annually. One off events are usually slotted into these programmes.

As well as permission from the Department of Marine and Harbours, organisers may require permission from the SRMA. Also if a foreshore area is to be used permission is required from the Authority with which the reserve is vested, usually Local Government or SPC.

The continuing need for organisation of events to occur is obvious. However, some criticism was recorded by respondents to the SRMA's recreation studies indicating that there is not sufficient 'control' to ensure no interference occurs during the running of the event. Similarly when an organised event is cancelled sufficient notification is not given to other user groups.

## 5.0 MANAGEMENT

### 5.1 Recreation Use and Environmental Constraints

Recreational use results in changes to the character and environmental status of an area. Appropriate location of an appropriate use minimises this impact. Management, in addressing the capacity of an area to withstand various recreational uses should consider the following site factors raised by Chubb and Ashton (1969, as cited by Ohmann, 1974).

a) Geology and soil : As they affect drainage and vegetation i.e. the more fertile soils are able to withstand high levels of use and better maintain a satisfactory ground cover than less fertile soils.

b) Topography and aspect : As they affect slope and thus soil erosion and micro-climatic influence on the flora and fauna.

c) Vegetation : Its ability to tolerate varying intensities and types of recreational use.

d) Climate : As it influences length of season available for a given recreational use.

e) Water : Availability for domestic, irrigation and recreation use.

f) Flora and fauna : Especially where they are the basis for the recreational use of an area.

These factors all play an important role in determining the ability of a site to withstand recreation pressure. Resource managers must also know what the results of varying intensities of recreational use will be. If the environmental impact of recreational use is unacceptable management must review its options for controlling use. Techniques of controlling recreational impact are modification of behaviour and site hardening. The problem is that control techniques (particuarly site hardening) often alter the character of the area beyond the limits of acceptable change for the recreationist. This is particularly prevalent amongst established users and/or residents of the area who see changes to "their" environment unacceptable.

### 5.2 User Conflict

In addition to environmental impact recreation use may result in conflict between various users groups. This may be due to the presence of one group of users reducing the recreational experience sought by another user group. Alternatively it may be that the activities cannot use the same piece of land without endangering the safety of users.

In matching recreational users managers should be aware that recreationists who appear superficially similar may not have identical recreational needs or perceptions of the environment (they may not perceive environmental degradation the same either) (Ohmann, 1974).

## 5.3 Modifying Behaviour

Peterson and Lime (1979) list five methods managers can institute to change the behaviour of recreationists. These are regulation, licensing, manipulation of fees, site design, delivery of services, and information and training.

**Regulation** is the direct prescription, by means of rules or laws of the behaviour that is or is not allowed. Regulation is usually negative in that it generally defines what may not be done. In some instances regulation may be necessary and appropriate, in others it may be too obtrusive. The effect is always strongly dependent on enforcement and enforceability. Improved enforcement of existing rules is often an effective way to change behaviour.

**Licensing** is the conditional granting of priveleges that would otherwise be illegal and is an important technique for controlling behaviour. It can be used to impose qualifications, to restrict the rate or place of entry into a recreation area and to limit the kinds of activities permitted or to specify when and where they will take place.

**Fees** traditionally are imposed by public agencies for generating revenue and paying for services. They can and do influence behaviour strongly, and their effects should be assessed carefully. Where geographic and temporal re-distribution of use would relieve congestion, manipulation of fees is worth considering as an unobstrusive or indirect alternative to use rationing.

**Site modification and delivery of services** can change behaviour either by imposing constraints or by offering incentives. Managers can also control the kind of use an area gets by manipulating the facilities and services provided.

**Information and training** along with provision of technical services, may be useful in indirectly changing or persuading the recreationist to act acceptably. Warning signs will tend to discourage use by people who lack skills or equipment. Brochures, films and advertising can teach principles of environmental protection. Publications describing area and facilities that are consistent with their desires, skills and equipment.

When new techniques are tried, their effects on behaviour should be closely monitored so that changes can be made as needed, and principles and guidelines for future actions can be developed.

## 5.4 Public Education Programmes

Public education programmes are an important management tool that to date the SRMA has use infrequently due to both lack of finance and staff to implement them.

Tasks such as brochure production or lectures to the public are undertaken by staff and Authority members as much as current work loads permit. Unlike National Park Rangers it is not the role of SRMA Inspectors to implement public education programmes.

Techniques that could be employed include:

Television
Newspapers
Radio announcements
Brochures
Lectures
Newsletters
Publication of policies/management decisions
Management in the public eye

In essence they are all aimed at bringing about a change of attitude and behaviour towards the environment and fellow users through greater awareness of the current situation.

In many cases existing legislation allows for control of these situations, however, it is far better to educate than penalise all the public by introducing laws for the minority group of offenders. Education is an ongoing task necessary for each new generation of users. Programmes should not only be aimed at the general public but other managing authorities not so well versed with the implications their decisions and actions may have on the river environment.

It is important that Management monitor the impact of these programmes.

Aspects that may be considered for programmes include:

- In the long term development of a resource centre promoting the programmes of all managing authorities. The centre would aim programmes at school level; adult level and tourist level.

- Increasing public awareness of the fragility of the environment and the impact of various recreational pursuits.

- Making users aware of the areas available for recreation and the types of recreaton activities suitable in the area. To some extent this would help re-distribute use around the river.

- Compilation of Hire and Drive operations around the river so people are aware of these facilities.

- SRMA policies and decisions available to the public and other agencies.

- Greater awareness of water quality of the river.

- Newsletter to clubs on changes in management (public submission idea).

- Guided walks through bird areas. (public submission idea).

- Broadsheets advertising boating rules and regulations to be located at public reserves.

- Liaise with the public on decision making and feedback on these decisions.

- A number of managing agencies producing one brochure that promotes various aspects of river management.

- Information packs to teachers.

Current information programmes include:

Swan and Canning Rivers Boating Guide -M&H.
Seagrass maps - WWC
Function of the Waterways Commission - WWC.
Avon River - WWC
Canoeing Guides - DSR
Around the River Ride - DSR
Heritage Trails - W.A. Heritage Committee
Walks and Talks in Kings Park - Kings Park Board
Boating Safety - Wind Surfing - National Safety Council
Anit-litter Campaign - Keep Australia Beautiful Campaign
Fishing Regulations - Department of Fisheries

TABLE 5 : RECREACTION AREAS

| LOCATION | MAP LOC NO | RESERVE STATUS | VESTED PURPOSE | VESTED BODY | SIZE Ha. | FACILITIES | USAGE | ACCESS |
|---|---|---|---|---|---|---|---|---|
| J. Dolan Reserve, East Frem. | 85001-1-2 | 6226<br>6227 | Pub. Rec. | Town of East Frem. | | Toilet block, 6 car-parking, 4 shelter/ picnic tables. Walk-way other side of road. | Picnicking | Car and foot access possible. Walling of foreshore restricts water contact. |
| Preston Point Reserve, East Frem. | 85001-1-2 | 31403<br>31404 | Parks, launching ramp and parking | Town of East Frem. | 1.4<br>1.5 | Four lane boat ramp, 79 trailer parking, 30 car-parking, toilet block, kiosk, play equipment, seating, jetties, path-way system, shelter/ picnic tables, BBQ. | Popular launch ramp, most head out to sea. Walking, cycling, picnicking. | By boat and car. Beach area shell base, gently sloping. |
| Norm McKenzie Reserve and W. Wayman Reserve | 85001-1-2 | A28785 | Pub. Rec. | Town of East Frem. | .7702 | Shelter/picnic area, play equipment, walkway. | Cycling, walking limited use. Used by sea scout group occasionally. | Limited boat access due to surrounding marina development. |
| Riverside Rd. to Petra St. | 85001-1-2 (unmarked) | A 7800 | Rec. | Town of East Frem. | 7.5 | Walking track, fishing platform, recreation clubs (FSS, EFYC). | Walking, fishing, club use. | Divided by Jerrat Drive. Foreshore side very steep with walking track through this section. |
| Durdham Pk. Bicton (off Durdham Court) | 85001-1-2 | 33997 | Pub. Rec. and parking | City of Melville | .9300 | Carparking, swimming jetties, boat mooring, toilet facilities, shelter, (NB Purchase of quarantine station require plan for entire area to make the most of link with river) | Parking area for water polo club, rigging area small yachts, wind-surfing, swimming. | Sandy beach to water. Moored boats restricts use. Carpark too close to foreshore. Over-head powerline restrict rigging of yachts. |
| Blackwall Reach Pd. to Point Walter Reserve | 85001-1-2 | Road Reserve used for rec. | | Maintained by City of Melville | 900m length by 2-5m wide | Dual-use path, mooring, jetty and sandy beach eastern end. | Walking, cycling, beachcombing, few picnics, access to moored boats. | Steep embankment, must cross path to get to river. Mooring of boats restricts other uses. |

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|---|---|---|---|---|---|---|---|---|
| Point Walter Reserve | 85001-1-2 | A 4813 | Rec. | City of Melville | 67.6 | Dual-use path, 6 car parks holding app. 45-60 boat trailers and 80 cars, 2 double launching ramps, kiosk, BBQ, tree shade, shelters, 2 toilet blocks, 2 areas of play equipment, sandy beach front. Jetty, water ski and swimming areas. | Fishing, prawning, walking, cycling, swimming, water-skiing, wind-surfing, sailing, picnicking, power-boating. | Readily accessible by boat and road. |
| Attadale Reserve (Troy Pk - includes entire length of Burke Dr. to Alfred Cove not quite to waterline) | 85001-1-2 | A24063 | Rec. | City of Melville | 29.0 | Gazette, dual-use path, sports field, off street parking; seating, shade and shelter limited. Flat grassed park land used as golf driving range and dog exercise area. | Golf, walking, cycling, exercising dogs, organised club sports. | Boat access difficult due to mud flats. |
| Alfred Cove Nature Reserve | 85001-1-2 | 35066 | Con. Flora and Fauna | CALM | 7.2716 | Dual-use path adjacent to or through the reserve. | Walking, cycling, exercising dogs, prawning, worm digging. | Unrestricted at present may change when becomes aquatic reserve. |
| Tompkins Park | 85001-1-2 | 35486 | Rec. | City of Melville | 3.3 | Dual-use path and sports fields. | Walking, cycling. | Foot and boat access limited because of mud flats and rush vegetation. |
| Melville Beach Parade | 85001-1-2 | Road Reserve used for recreation | | Maintained by City of Melville | 1.5km by 5-39m wide | Dual-use path, play equipment, wind-surf hire in off peak periods, carparking, limited shelter, grassed area, fresh water. | Windsurfing, small boat use, prawning in season, cycling, walking. | Over fence to fore-shore, gently sloping beach. |
| Jeff Joseph Reserve, The Strand, Applecross | 85001-2-2 (Unnamed) | 27327 | Rec. and Parks | City of Melville | 4.2 | Toilet block, carpark, dual-use path; tennis court, jetty, water-ski area. | Prawning, wind-surfing, pic-nicking, walking, cycling. | Foot and boat in places. Foreshore vegetation acts as a deterent in some places. |

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|---|---|---|---|---|---|---|---|---|
| Pt. Heathcote Reserve | 85001-2-2 | 32738 | Rec. | City of Melville | .6475 | Waterski area, dual-use path. | Waterskiing, prawning. | Foot access via pathway behind SPYC or WBSS. |
| Canning Beach Road | 85001-2-2 | Road Reserve used for rec. | | City of Melville | 1km by 3-6m wide | Seating, shade, grassed area, dual-use path, mooring offshore, jetty at Raffles Hotel. | Prawning, walking, cycling, small boat launching, windsurfing, access to moored boats, picnicking for lunch. | Foot and car access. Boat access through mooring areas. |
| Freeway foreshore Como. Canning Bridge to Mill Point | 85001-2-2<br>85001-6-2<br>(marked but unnamed) | 26085<br>26086<br><br>33804<br>33803 | Scout Hall.<br>Scout and ped. access<br>Rec.<br>Cons. of flora and fauna | Scout Assn.<br>"<br><br>City of SP<br>CALM | <br><br><br>13.8549<br>4.4244 | Dual-use path, shelter, play equipment, club use by Como S.S. Sandy beach area. Milyu Nature Reserve. Waterski area and carpark Mill Point. | | |
| South Perth Foreshore | 85001-6-2 | 28779<br>28778 | Pub. rec. parking | City of SP<br>" | 2.0000<br>.0582 | Jetty, parking, dual-use path, commercial waterski area. | Skiing, fishing, walking, cycling. | Foreshore walling makes access difficult in upstream areas. |
| Sir James Mitchell Park | 85001-6-2<br>85001-7-2 | 35465<br>24112<br>Local Auth. owned land | Rec.<br>Rec. boat shed | City of SP<br>" | 14.035<br>.0463 | In process of being upgraded. Jetty, ferry, surfcat and board hire, parking, water, pathway system, rowing club facilities lakes, launch ramp. | Cycling, walking, fishing, picnicking, surfcat hire, windsurfing, powerboating. | Boat access limited by depth, foot and car access easy. Foreshore walling limits access to the water. |
| McCallum Park | 85001-7-2 | 21889<br>Local Auth. owned land | Rec. | PCC | 8.0589 | Tennis club, play equipment, shade, grassed areas, dual-use path, parking. | Fishing, cycling, walking, special uses such as circus use. | Access to water difficult because of foreshore walling. |
| Heirisson Island | 85001-7-2 | A23063 | Pub. Rec. | PCC | 28.56 | Dual-use paths, ablution block seating, shade, jetty. | Fishing, cycling, walkway. | Access by foot or boat. No car access. |

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|---|---|---|---|---|---|---|---|---|
| Langley Park and foreshoe areas | 85001-7-2<br>85001-6-2 | A12510<br>A13375 | Gardens and rec.<br>Roads, parks, pub. rec. | PCC<br>PCC | 11.6878<br>9.8500 | Dual-use paths, car-parking, sports field, helipad, restaurant (in future) rowing club, berth facilities for charter craft, sullage pumpout facilities, Water Police. Shade, shelter and grassed areas. Small sandy beach downstream of Barrack Street Jetty. Cycle hire. | Fishing, walking, cycling, commercial charter use (wine cruises, MTT ferry etc.), rowing. | Foot access restricted by Riverside Drive. Boat access limited by water depth. Foreshore walling restricts river access. |
| Narrows Interchange | 85001-6-2 | 36167 | Rec. & park | PCC | 2.0466 | Dual-use path, toilet block, sandy beach, parking off Mounts Bay Road. | Fishing under bridge, walking, cycling. | Vehicle and boat access difficult. Foreshore walling restricts access to water. |
| Mounts Bay Road Fishing Spots | 85001-6-2 | 22013<br>22012<br>36167 | P&R<br>P&R<br>Rec. & park | PCC<br>"<br>" | .1265<br>1.6187<br>2.0466 | Dual-use paths. Parking for app. 20 cars each location. 2 sets of steps to each location. Toilet block reserve behind old Brewery remnant of jetty Brewery site. | Cycling, walking, fishing, picnicking and lunching. | Access difficult because of busy road. Limited water contact. |
| Matilda Bay Road Fishing Spots | 85001-6-2 | A17375 | Rec. | NPA | 25.0445 | Dual-use path, swimming area, windsurfing take off point, parking (limited mid week by University use) BBQ, shelter, shade, grassed area, jetties, mooring area, restaurant, kiosk, club facilities. 3 toilet blocks. Boat ramp with parking for 30-35 trailers, telephone, wildlife sanctuary. Sandy beach area, mooring area. | Swimming, wind-surfing, power-boating, pic-nicking, cycling, walking, bird watching. | No dogs allowed. Foot, boat and car access good. |

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| J.H. Abrahams Reserve | 85001-6-2 | A34322 | Rec. | City of Subiaco | 3.1216 | Boat ramp with parking for 3 trailers and 80 cars, lighted cycleway, play equipment, toilet block, sandy beach, BBQ's, seating and grassed areas. (Extra parking University grounds on weekends). | Windsurfing, cycling, walking, sailing, picnicking. | Shallow water limits boat usage. Good water contact for most part. |
| The Esplanade & Beaton Park, Nedlands | 85001-1-2 | A29174<br>A17391<br>27111<br><br>A22527 | Pub. rec.<br>Rec.<br>Cons. Hist. Build.<br>Rec. | City of Ned.<br>"<br>"<br><br>" | 2.1170<br>22.1692<br>.1568<br><br>3.8560 | Restaurants, private marina, boat hire, sports fields and clubs, parking, play equipment, limited shade, dual-use path, viewing area on escarpment, Gallop House open for inspection. Golf driving range. Steps down to river, mooring area upstream location, jetty western end. | Walking, cycling, club use, lunching, golf. | Access to water limited due to foreshore walling. |
| Point Resolution Reserve Nedlands | 85001-1-2 | A 1624 | Rec. | City of Nedlands | 3.5017 | Parking, scenic lookout, walk trails to beach but no formal paths. Tables and water at northern end of reserve. | Lookout, lunching, walking, waterskiing. | Foot access down bank. Water contact good. |
| Bishop Road Reserve | 85001-1-2 | A 1627 | Rec. | Not vested | 0.6804 | Grassed shade area. Parking. Waterski area. | Swimming, exercising dogs, lookout, waterskiing area. | Foot access via path, boat access to waterski area. |
| Claremont Foreshore (McNeil Street to Watkins Rd.) | 85001-1-2<br>85001-6-2 | 24523<br>25344<br>35609<br>A 2025<br>B 5659<br>A 885<br>A23209 | Rec.<br>Rec.<br>Pub. Rec.<br>Rec.<br>Museum<br>Pic. ground<br>Rec. | Claremont<br>Not vested<br>Not vested<br>Claremont<br>Claremont<br>Claremont<br>Nedlands | 3.5410<br>.0266<br>.0301<br>.2974<br>.1391<br>.7891<br>.2534 | Jetty, toilets, drinking water, bit of beach at Jetty Road. Museum, toilet block, palm trees, grass, BBQ's, water, benches, play equipment, Chester Road area. Waterski area eastern end of bay. | Walking, fishing, boating, waterskiing, picnicking, small boat hire. | Some parts are private land. |

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|---|---|---|---|---|---|---|---|---|
| Peppermint Grove, Freshwater Bay | 85001-1-2 | A17113 Location 2539 and 6959 | Rec. | Parks vested with RFBYC rest not vested but maintained by Shire. | 3.2476 | Pathway system, club facilities, 2 toilet blocks north and southern ends, shallow water, good beach area, shade and grassed areas, street parking, remnants of tearooms, mooring areas, kiosk adjacent. | Swimming, wind-surfing, canoeing, walking, rowing, fishing, pic-nicking. | Vehicle access limited as compete with yacht club use. Boat access and water contact good. |
| Mosman Bay Reserve | 85001-1-2 | 23939 | Parks, Gardens and Rec. | Mosman Park Council | .4153 | Boat ramp (no trailer parking), BBQ's, jetty, toilets, parking for 70 cars, footpath from hilltop to river, tea-rooms removed. | Swimming, boating, windsurfing, pic-nicking, swimming classes, fishing. | Good water contact area. |
| Mosman Bay Lookout | 85001-1-2 | 8369 | Rec | Mosman Park Council | 5.1420 | Walkway, seating, parking app. 15 cars. | Picnics, lookout, walking. | No water contact. |
| Chidley Point Reserve (off Caporn Street) | 85001-1-2 | A 3346 | Pub. Utility | Mosman Park Council | 4.5032 | Waterski area, parking 50-70 cars, pathway down to river, toilet block, BBQ's. Sandy beach, few rocks. | Waterskiing, fishing, pic-nicking, scenic lookout. | Foot access, no car access, good water contact. |
| McCabe Street Reserve and Rocky Bay | 85001-1-2 | A 7077<br>31156<br>31157<br>A 1631<br>24242 | Rec.<br>Rec.<br>Parklands<br>Rec.<br>Rec. | Not vested<br>Mosman Council<br>"<br>"<br>" | 2.2257<br>2 7063<br>2.2156<br>5691<br>3.9457 | Tennis clubs, BBQ's, cycleway, pathway system. | Walking, cycling. | No water contact. Car access difficult |
| Foreshore abutting Gilbert Fraser Oval, North Frem. | 85001-1-2 | 36420 Unvested Crown land | Park & Rec. | City of Frem. | 1.4699 | Sandy beach, shelters, dual-use path, launching area under Stirling Bridge, mooring area. | Walking, cycling, swimming, boat launching. | Difficult to find location. |
| CANNING RIVER | | | | | | | | |
| The Esplanade Mt Pleasant | 85001-2-2 | 26811 Unvested Crown land<br>26758 Road Reserve used for recreation. | Rec.<br>Rowing Assn. | City of Melville<br>Rowing Assn. | .3943<br>.2868 | Dual-use pathway. Waterski area, jetty, seating, shade areas, small sandy beach area, verge parking. | Waterskiing, prawning, cycling, walking, fishing. | |

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| Bateman Park | 85001-2-2 | 29130 | Pub. Rec. | City of Melville | 2.000 | | | Water contact and boat access difficult because of mud flats. |
| Eastern Corner Bull Creek | 85001-2-2 | 29130 | Pub. Rec. | City Canning | 5.4018 | | | As above. |
| Bull Creek Road along Riverton Drive to Shelley Bridge | 85001-2-2 | 26292 | P&R | City Canning | 15.9592 | Dual-use paths, sandy beach areas, jetty Bull Creek play equipment, Shelley Sailing Club, Street parking. | Windsurfing, sailing, picnicking. | |
| Riverton Bridge (north and south) | 85001-2-2 | 24973 | Rec. | Not vested | .1991 | Canoe and paddle boat hire, kiosk, toilet block, play equipment. Parking 30 cars. | Fishing, canoeing, picnicking, cycling, walking. | |
| | | 28964 | Rec. | City Canning | .5059 | | | |
| | | 29689 | Pub. Rec. | City Canning | .3541 | | | |
| | | Unvested Crown land | | | | | | |
| Canning Wetlands | 85001-2-2<br>85001-3-2 | SPC owned land | Parks and Reserves | | Unknown | Darling Range Canoe Club, BBQ's, no formal carparking, toilets, grassed area, dual-use path. | Canoeing, picnicking, small boat use, walking, cycling. | Boat access difficult due to depth and snags. |
| | | 7773 | P&R | City Canning | 17.8303 | | | |
| | | 20265 | Pub. Utility | Not vested | 4.5147 | | | |
| | | 25474 | Rec. | Not vested | .2985 | | | |
| | | 24717 | Rec. | Not vested | .3893 | | | |
| | | 26103 | Pub. Rec. | Canning | 6.3545 | | | |
| | | 1289<br>38831 | Landing places | | 1.007 | | | |
| | | 28740 | Pub. Rec. | Not vested | .2656 | | | |
| | | 38680 | Pub. Rec. | City Canning | 1.0519 | | | |
| | | | Pub. Rec. | " | .3343 | | | |
| | | 38829 | Rec. | " | 1.2028 | | | |
| | | 27604 | Pub. Rec. | " | 1.5136 | | | |
| Nicholson Bridge to intersection of Connemara Drive and Jacqueline Drive, Thornlie (both sides of river) | 85001-3-2<br>85001-4-2 | SPC owned land | Parks and Reserves | | | Dual-use path | Walking, cycling, canoeing. | As above<br>Car access also difficult. |
| | | 32677 | Pub. Rec. | City Gosnells | 2.2985 | | | |
| | | 34179 | " | " | .6985 | | | |
| | | 34180 | " | " | .4795 | | | |
| | | 36197 | " | " | 2.2027 | | | |
| | | 29744 | " | " | .0637 | | | |
| | | 30574 | " | " | .4244 | | | |
| | | 30692 | Rec. | Not vested | .2491 | Darling Range Canoe Club, BBQ's, no formal carparking, toilets, grassed area, dual-use path. | Canoeing, picnicking, small boat use, walking, cycling. | Boat access difficult due to depth and snags. |
| | | 28739 | " | " | 1.1842 | | | |
| | | 27505 | " | " | 1.0472 | | | |
| | | 33961 | Pub. Rec. | City Gosnells | .3949 | | | |
| | | 32093 | " | " | 12.0090 | | | |
| | | 33061 | " | " | .3426 | | | |
| Hester Park | | 29223 | " | Not vested | .1781 | | | |

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|---|---|---|---|---|---|---|---|---|
| Homestead Park Thornlie | 85001-4-2 | 26227<br><br>32093 | Community centre and park<br>Pub. Rec. | City Gosnells<br><br>" | 6.5104<br><br>12.0090 | Community centre, dual-use path, play equipment, BBQ's. | Informal recreation, picnicking. | |
| Centenary Park | 85001-2-2 | 36622<br>36970<br>36621<br>SPC owned land | P&R<br>Pub. Rec.<br>P&R<br>Parks and Reserves | MRPA<br>City Canning<br>MRPA | .8527<br>.3592<br>.7819 | Canning Sea Scouts. | Club use, canoeing, sailing. | Now divided by Centenary Avenue. Boat access limited due to river depth. |
| Salter's Point | 85001--2-2 | 23967<br>28747 | Rec.<br>Pub. Rec. | City of SP<br>" | 7.4960<br>.3602 | WAIT Rowing Club, Salter's Point Sea Scouts. | Walking, canoeing, rowing. | |
| Freeway Foreshore Roebuck Rd to Canning Bridge | 85001-2-2 | Unvested Crown land<br>A21288 | Parklands | Unvested | 2.1291 | Boat ramp, dual-use path, parking up to 6 cars and trailers. | Boating, rowing, prawning, cycling, walking. | Road and foot access difficult due to freeway. |
| UPPER SWAN RIVER | | | | | | | | |
| Charles Patterson Park, Perth | 85001-7-2 | 27743 | Rec. and Riverside Improvements | PPC | 2.7333 | Dual-use path | Walking, cycling. | Car access difficult. |
| Burswood Island | 85001-7-2 | Unvested Crown land | | | | Waterski and powerboat clubs, golf course, waterski area. | Waterskiing, powerboating. | Car, foot and boat access difficult. |
| Banks Reserve Mt Lawley | 85001-7-2 | Local Auth. land and unvested Crown land | | PCC<br>SPC | | Mt Lawley Sea Scouts, dual-use path, jetty. | Walking, cycling, fishing. | Public does not really know this area exists. |
| Bardon Park Maylands | 85001-7-2 | 24209<br>30675 | Rec.<br>" | City Stirling<br>" | 5.0968<br>.2673 | BBQ's, toilet block, picnic area, play equipment. | Picnicking. | |
| Clarkson Reserve, Maylands Peninsula | 85001-702 | A33966 | Pub. Rec. | City Stirling | 57.6407 | Boat ramp, toilets, car and trailer parking. | Boating, windsurfing, picnicking, fishing. | |

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|---|---|---|---|---|---|---|---|---|
| Goodwood Parade, Belmont | 85001-7-2 | Unvested Crown land | | | | Boat ramp, toilet block, BBQ's, shelter areas, waterski area. | Waterskiing, fishing. | |
| Cracknell Park | 85001-7-2 | Local Auth. owned land | | Belmont | | Fishing jetties, toilet block, grassed areas. | Fishing, swimming. | No link with reserve and river. |
| Maylands Swimming Jetties | 85001-7-2 | 33131 | Pub. Rec. | City Stirling | 1.0729 | Swimming jetties, toilets, shade, tables. | Swimming, picnicking, fishing. | Unknown area to many. |
| Garratt Road Reserve | 85001-7-2 | Local Auth. owned land<br>30931 | <br>Rec. | City of Bays.<br>" | <br>.1343 | Jetties, swimming area, picnic area, sandy beach, toilet block, paddle boat hire, Bayswater Sea Scouts. | Swimming, picnicking, fishing, boat hire, canoeing. | Difficult car access. |
| Ascot Inn | 85001-7-2 | 28420 | Rec. | Not vested. | .3675 | Jetties, grass area, Ascot Inn Hotel. Very limited parking. | Boating. | Good boat access. |
| Claughton Reserve, Bayswater | 85001-8-2 | Road Reserve | | | | Boat ramp, toilet block, BBQ's, shade, grassed area, no formal parking area. | Boating, fishing, picnicking. | Unknown area to many. |
| Garvey Park and Ron Courtney Island | 85001-8-2 | 36440<br>36441<br>37397<br>26219<br>SPC owned land | Rec.<br>"<br>Club Premises<br>Pub. Rec.<br>Parks and Reserves | SRMA<br>City Belmont<br>"<br>" | 1.8080<br>2.7101<br>.1474<br>.1083 | Ascot Kayak Club, carparking, kiosk, toilet block, dual-use path, horse exercise area, walk trails through lakes, jetty, disabled access ramp to the water, picnic area, tables, BBQ's. | Canoeing, picnicking, exercising horses, fishing. | Foreshore walking has reduced water contact. |
| Sandy Beach Reserve | 85001-8-2 | A18092 | Rec. and Parklands | Town of Bassendean | .3093 | Toilet block, parking, play equipment, BBQ's. | Swimming, fishing, picnicking. | Reserve divided by road and parking. |
| Pickering Park | 85001-8-2 | A18091 | Rec. and Parklands | Town of Bassendean | 1.9197 | Bassendean Sea Scouts, play equipment. | Boat launching, canoeing, sailing. | |
| Point Reserve | 85001-8-2 | A 9100<br>A 9099 | Rec.<br>Rec. | Town of Bass.<br>" | .6526<br>.2251 | Toilet block, play equipment, swimming area, and jetties, carparking 35 cars, shade area. | Swimming, picnicking, fishing. | |

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|---|---|---|---|---|---|---|---|---|
| King Meadow Reserve | 85001-8-2 | 253 | Rec. | Not vested | 4.7550 | Jetties, BBQ's, football oval and facilities. | Swimming, fishing, picnicking, football. | Difficult to locate by car. |
| Success Hill Reserve | 85001-8-2 | A16456 | P&R | Town of Bass. | 5.4632 | Jetty, toilets, walkway, waterfall, grassed parkland, BBQ's | Swimming, fishing, picnicking, bosting. | Parking a long distane from river. |
| Fishmarket Reserve, Guildford | 85001-8-2 | SPC owned land 6446 | Parks and Reserves Municipal purposes | Not vested | 1.1129 | Launch ramp, parking, picnic area. | Boating, fishing, picnicking. | |
| Governor Stirling Jetties Marshall Park | 85001-10-2 | 24092 | School Site | Not vested | 12.6444 | Swimming jetties and area, toilet block | Swimming and fishing. | Local use. |
| Reg Bond Reserve | 85001-10-2 | A28804 | Pub. Rec. | Shire Swan | 3.0554 | Jetty. | Very limited usage, some boaters stop to have picnic. | Unknown to many. |
| Middle Swan Bridge | 85001-10-2 | | | | | Toilet block, canoe launching area, parking, BBQ's. | Picnicking, boating, canoeing. | |
| Walyunga National Park | 85001-13-1/2 | National Park | | CALM | | Toilet block, walkways, BBQ's, picnic area, parking (NB entrance fee). | Picnicking, canoeing, walking. | |

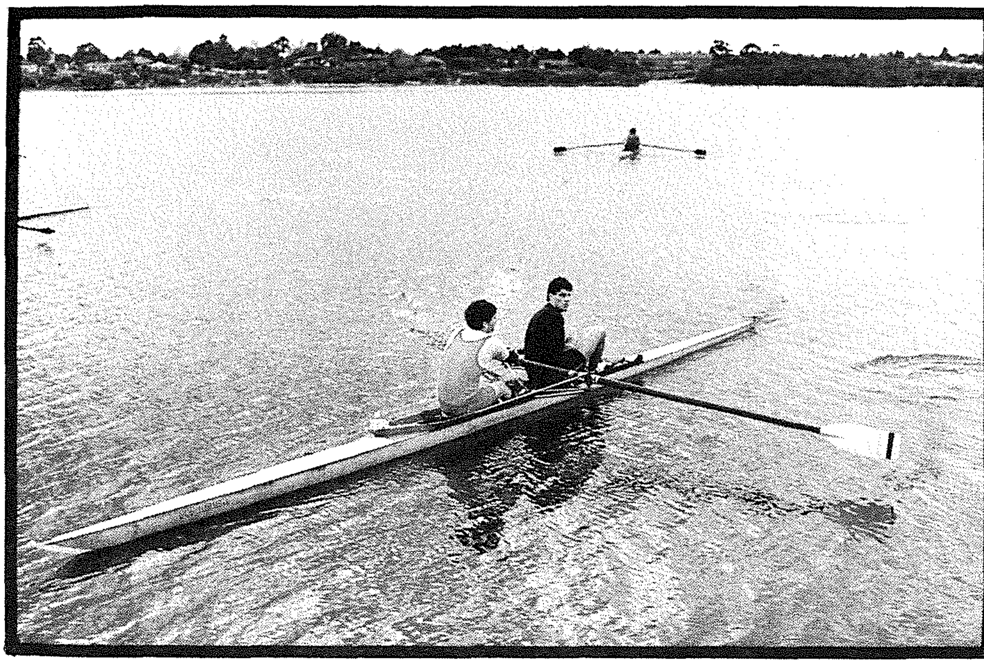
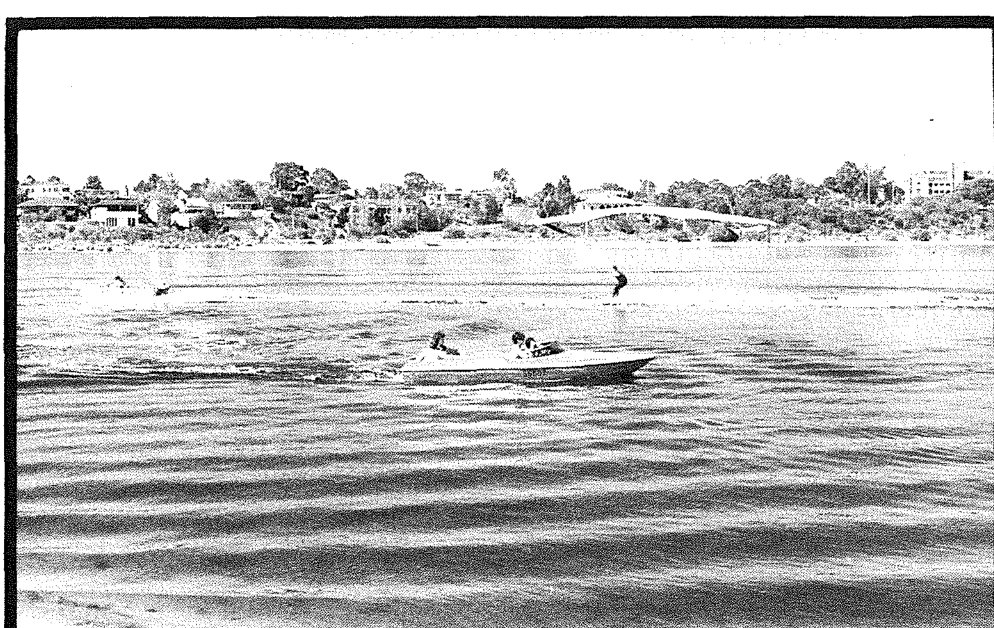


PLATE 16: Rowing

PLATE 17: Waterskiing



# CHAPTER 15 : COMMERCIAL USE

## 1.0 INTRODUCTION

A wide range of commercial operations are located on the river foreshore or within its waters. Types of operations include boat building yards, restaurants, wine cruises, canoe hire, transport ferries and commercial fishing. Many of these facilities cater not only for the tourist industry but also the metropolitan region leisure industry.

Before an commercial venture can operate licensed approval is required from a variety of departments. These may include:

Marine and Harbours
SRMA
Health Department
Licensing Court
Local Government Authority
State Planning Commission
Lands and Surveys (Reserves Section)

Consequently approval by one does not imply that the project has been given the 'go-ahead'. Each department is responsible for approving aspects within its charter and not the overall impact of the project on the river environment.

## 2.0 LICENSING OF COMMERCIAL BOATING OPERATIONS

The Department of Marine and Harbours 'controls' commercial boating operations on the Swan and Canning Rivers. It has the power to survey vessels under Division 5 of the Western Australian Marine Act 1982. The Department is also empowered under Section 54 of the Western Australian Marine Act 1982, and consequent W.A. Marine (Hire and Drive Vessels) Regulation 1983 to license Hire and Drive Operations.

In the former case M&H does not license the operation say of a ferry but rather surveys the vessel for a particular use. It does not have the authority to direct where a particular vessel can operate or indeed control the number of vessels in the same business ie 'wine ferry'. There is a need for an authority to control where commercial vessels can go or what their function is.

The power of M&H regarding Hire and Drive Operations is more specific, giving the Department the authority to control the type, location and time of operation.

In general depending on the type of commercial operation proposed, consultation occurs between M&H and interested Authorities, inclduing the SRMA; the Local Government Authority in which the land is vested and; the SPC if the reserve is within or abutting MRS boundaries before licenses are issued. Advice may also be necessary if the likey impacts of the operation are to be fully assessed.

2.1 **Licensing of Commercial Hire and Drive Operations**

Before issuing a license Marine and Harbours reviews the interaction between the hire operations and current patterns of use of the area in question, particularly weekend use. Approval for hire operations is also dependent on Local Government Authorities giving permission for the use of their foreshores for such operations. In this regard other criteria are considered by them which includes parking, toilet facilities and other associated services. Some Councils refuse to allow any commercial activities from their foreshore. The majority of Councils judge each application on individual merit. Aspects usually considered are:

- Value to community (ratepayers or non-ratepayers).
- Environmental impact (including noise).
- Compatibility with existing use.

To alleviate the situation of Councils refusal, for example Marine and Habours instituted trailerised sailboard hire from premises in 1982 throughout the State. Certain conditions apply to these operations some of which are that the sailboards are not to be used in ocean waters and that the hire operator does not direct the hirer to a specific point on the river.

The areas at which, and times when hire facilities operate have been selected to ensure that the safety of users is ensured and boating congestion is kept minimal. The SRMA would not support licensing of commercial operations if they were to aggravate the problems mentioned in Chapter 14, 3.1. The Authority would support the view of Marine and Harbours to limit commercial operations on the river particularly over the weekend and in densely used areas.

2.1.1 **Local Government Attitudes to Commercial Recreation Enterprises Operating from Foreshore Reserves as at May, 1985)**

**Not Applicable**

Three not applicable;

Armadale
Kalamunda

Mundaring

as waters are unsuitable for hire craft.

**Merit**

**Bassendean Town Council**

Reviews each application on its merits. Council has never been asked to approve a permanent operation. Because of the small number of applications it does not need a policy.

**Bayswater City Council**

Reviews each application on its merits. One operation on trial basis and to be reviewed for next summer. As only 500 metres of the 3½ km foreshore is accessible to the public they are limited in the facilities that can be provided. Proposed Swan River Drive restricts use. Low level use preferred.

**Belmont City Council**

Reviews each application on its merits and would refer the matter to MRPA as within MRS boundaries.

**Canning City Council**

Reviews each application on its merits after preliminary approval from Marine and Harbours. Aspects to consider must be conducive to shallow water, not interfere with Shelley Sailing Club, gazetted ski areas or TS Canning and Sea Scouts.

**Claremont Town Council**

Reviews each application on its merits and confers with other organisations involved with management or using the area.

**East Fremantle Town Council**

Reviews each application on its merits. Main applicant itinerant vendors. Refusal because not compatible with Preston Point Boat Ramp.

**Fremantle City Council**

Each application on its merits referred to MRPA and Marine and Harbours.

**Gosnells City Council**

Much of the water is not suitable for hire craft but each would be judged on its merits. Currently undertaking a recreation study of the City of Gosnells which includes the Canning River.

**Melville City Council**

Recently amended its policy from "NO" to review each application on its merits (March, 1985). Must have approval from Marine and Harbours first. Assess:

Value to the community (ratepayer and general public).

Environmental impact (including noise).

Viability.

Compatibility.

**Peppermint Grove Shire Council**

Reviews each application on its merits.

**South Perth City Council**

Each assessed on its merits but the Council would not like to see all the area taken over by commercial use. Surfcat operators have an area gazetted for use, it is an annual agreement and a fee is charged.

**Swan Shire Council**

Judges each application on its merits. Council receives few requests and therefore does not need a set policy.

**Policy**

**Mosman Park Town Council**

The Council recently changed its policy to "No commercial operations on any foreshore areas".

**Nedlands City Council**

Restricts commercial use of its foreshore area and generally will not agree to such ventures. This policy is due to the limited water access to the foreshore via dredge channels and any sailing craft will aggravate the congestion problem.

### Perth City Council

Council has a moratorium on use of the foreshore between the Causeway and the Narrows Bridge while the CATAC study is being undertaken. In the past many applications were refused as Council thought that alienation of P.O.S. for commercial use was generally undesirable. Previously each application had been judged on its merits and its interaction with other activities.

### City of Stirling

Council has a policy of no commercial hire operators to use the Maylands foreshore. At present Ed Sail operates from the area but strictly on a lessons only basis.

As stated in Chapter 14, it is important for those responsible for approving commercial operations to consider whether it will add to existing pressures of use in the region, subtract from the 'experience ' of current users and residents, or harmonise with the existing situation.

### 2.1.2 Hire Craft

Crafts available for hire within the river include canoes, paddle boats, surfcats, parasailing, yachts, windsurfers and powerboats. These operate from various locations around the river, probably the most well known of these are the surfcats operating at Coode Street Jetty.

Hire craft provide the opportunity for many people to participate in these activities on a casual basis without the need for purchasing their own craft. Similarly school and club groups use these facilities as a means of enducation and allowing members to participate in alternative activities.

Many of these hire facilities operate from popular reserves; in part the reserves are popular because of the hire facility and in part the hire facility has been located there by the proprietor to capture a ready market.

One public submission questions whether it is 'legally' right to use A class reserves, set aside for the enjoyment of the public, for commercial gain.

Once again those agencies responsible for approval of such operations should ensure they will not impinge on existing use and that existing facilities are adequate for anticipated increases in visitors to the site.

Cost of licensing these operations should reflect the cost to these agencies in administering the facility and maintaining the reserve where the activity occurs e.g. foreshore maintenance, litter control, safety patrols. Table 1 is a list of Hire and Drive Operations.

## 2.2 MTT River Use

The MTT offers both a transport and cruise service. The transport service runs between Barrack Street and Mill Street, South Perth, and six trips per week to Coode Street, South Perth. Cruise services include the Contessa which operates from Barrack Street to Tranby House, Ascot and back from August to the long weekend in June. A down river service operates on Sundays and public holidays to Fremantle.

Problems are associated with the lack of toilets at Barrack Street Jetty, occassional interference from sailcraft using Perth Water and the depth of water between Barrack Street and the Causeway. Ferries are hitting bottom on very low tides and dredging of the channel is required.

The MTT does not have any plans for increasing its services.

Patronage:

| | 1983 | 1984 ending 30th June |
|---|---|---|
| MTT Ferry Passengers Single Journey | 440 390 | 438 753 |
| Charter Boat | 34 300 | 30 202 |
| Cruises upstream, downstream | 14 100 | 11 662 |
| | 488 790 | 480 617 |

Data indicate that patronage remained approximately the same from 1983 to 1984. However, comparison of 1985 and 1984 data indicate a decline in passenger usage to the begining of March (10%).

| | | |
|---|---|---|
| 1984 | 5th March | 292 000 |
| 1985 | 9th March | 262 000 |

Information source: Alan Treloar
Paul Paleano MTT

## 2.3 Ferries and Charter Vessels

In addition to ferries operated by the MTT the following ferries operate from Barrack Street Jetty.

| **VESSEL** | **CARRYING CAPACITY OF NO. OF PASSENGERS** | **DESTINATION** |
|---|---|---|
| Temeraire II | 700 | Rottnest Island |
| Captain Cook | 250 | Rottnest Island and River Cruise |
| Katameraire | 150 | Rottnest Island |
| Rottnest Islander II | 850 | Rottnest Island |
| Sea Raider | 250 | Rottnest Island |
| Lady Houghton | 120 | Upstream |
| Miss Sandalford | 130 | Upstream |
| River Princess | 108 | Upstream |
| Golden Swan | 210 | Fremantle/Charter |
| Foxy Lady | 40 | Fremantle |
| Jolly Jumbuck | 100 | Fremantle |
| Entertainer | 120 | Downstream |

(Ref: CPFSG, 1985)

The most popular months are November to January inclusive. The months June to August, inclusive are the lowest use periods with some charter vessels not operating during these months.

During the summer months three vessels go daily to Rottnest, 2-3 travel daily upstream and one daily downstream and three nights per week (usually Wednesday, Friday and Saturday) downstream. Charter operations are most popular between October to March, particularly pre-Christmas. Up to 5-6 vessels operate charter cruises, some operating seven days per week, day and night.

During winter months one boat operates daily to Rottnest and one daily upstream. No night work occurs during the months of June/July.

Vessels are booked to capacity during summer and estimates are of a 25% capacity during winter months.

Problems associated with charter vessels are the lack of comfort facilities for patrons at Barrack Street Jetty, pumpout facilities and permanent berthing facilities are only located at Barrack Street Jetty, complaints of noise problems and boat wash damaging boats and causing erosion, depth of navigation channels, Perth water and upstream. Problems associated with boating in general were listed in Chapter 14.

These vessels are an important part of the leisure facilities available for tourists and metorpolitan residents.

Additional vessels have been surveyed by M&H which may operate sporadically within the Swan-Canning Estuary.

### 2.4 Complaints

Complaints arise from the use of ferries on the river. These relate to noise and boat wash. Noise problems were discussed in more detail in Chapter 14, 4.2.4.2. However, these are isolated incidents compared with complaints about ski boat noise.

Complaints about boat wash focused on cruise craft using upstream areas of the Swan and, Rottnest transport craft using the low reaches. These craft were said to contribute to increased erosion, have a detrimental effect on fish movement, damage moored craft and boating facilities and endanger the safety of other users. (NB: In the upstream areas complaints were not restricted to commercial craft).

Submissions to this report went as far as to suggest Rottnest craft terminate their journey at Fremantle or alternatively further speed limits be imposed on these craft travelling from Fremantle to Barrack Street Jetty. The "Searaider" was particularly singled out.

However, these craft make considerable contributions to leisure opportunities available to metropolitan residents and tourists. Use of techniques designed to modify their impact are advisable before relocation or termination of these operations is considered. Other problems associated with boating were discussed in Chapter 14, 4.2.4.

## 3.0 RESTAURANTS

Applications to develop eating establishments on the foreshore or over the river are relatively common. Aspects which must be considered prior to approval should include:

- Local community attitude.

- Aesthetics (visual, natural environment and local history).

- Local Government Authority attitude.

- Access.

- Utilities and services (e.g. parking and sewerage).

- Maintenance.

- Involvement of jetties and Jetties Act.

- Hydrology.

- Navigation.

- Impingement on foreshore reserves.

At present a large discrepancy exists between 'rates' payable for over the water structures as opposed to land based structures. One example investigated by the Commission revealed a nearly 900% difference. Rates payable on jetty licences are controlled by the Department of Marine and Harbours and average around $10 000 to $15 000 compared with land based facilities which are subject to rates and conditions of the Local Government Authority. As parking rubbish collection and other service facilities must pass through or be located on Local Authority land a more equitable system would seem appropriate. This matter should be addressed as soon as possible.

Restaurants may be located on the river, adjacent to or in close proximity to take advantage of the views. Examples are given in the Table below. As well as these restaurants, some of the Yacht Clubs also have eating facilities incorporated into their clubhouses.

| **SITUATION** | **RESTAURANT** |
|---|---|
| Over the River | The Jetty Restaurant<br>Oyster Beds<br>Pier 21 |
| Foreshore | Mulberry Farm<br>Tawarri Lodge<br>Matilda Bay<br>Pirates Den<br>Ascot Inn<br>Sandringham Hotel<br>Raffles |

| | |
|---|---|
| | White House<br>Pavillion in the Park |
| Away from the river but taking advantage of the view | Kings Park Restaurant<br>Hi-lite 33<br>A Room with a View<br>Merlin Centre<br>Parmelia<br>Nedlands Park Hotel |

This list illustrates that location of restaurants over the water or on the foreshore is not necessary to take advantage of the river view. Similarly it also indicates that the designs and orientation of some of these eating establishments do not take full advantage of their privileged position.

In the past other sites have been proposed, rejected or in some cases to date the situation still remains unresolved. Sites include Peppermint Grove Tearooms, Mosman Bay Tearooms, Minim Cove, Point Walter, W.A. Rowing Club Boatshed. Recently applications have to be made concerning Mosman Bay Tearooms and it is likely that this will be resolved soon.

More recently the City of Perth called for submissions from persons interested in developing a restaurant and associated facilities on the Swan River near the Council's No. 4 Carpark, Riverside Drive. Given that so few appropriately located sites are available, this approach should ensure that the most suitable applicant with the most suitable design will develop the site.

**Policy Statement**

**Policy for Restaurants on the River**

The Authority believes that structures should not be built on or over the Swan and Canning Rivers unless they are necessary to enable public use and enjoyment of the river.

A proliferation of restaurants along the river would be undesirable. However, there could be some further opportunities for people to eat in riverine surroundings.

The establishment should not encroach on the river.

The Authority respects the Local Authority's desires to accord with the wishes of the communities they represent and to keep their waterfront areas in an attractive condition, including preservation of vistas and access along the waterfront. Therefore, most suitable sites for restaurants are those that have already been modified.

## 4.0 OTHER OPERATIONS

Commercial enterprises operating on the river and foreshore (associated with the river) are:

Boat building
Cycle hire
Marinas
Itinerant vendors

### 4.1 Boat Building

Boat building and maintenance occurs in the north Fremantle region of the lower Swan River. Maylands slipyard is located on Maylands Peninsula but is, however, a boat building yard for the general public to use. Problems associated with these facilities include:

- Aesthetically unpleasing.
- They are seen as taking opportunities away from the public.
- Expansion of these facilities (often necessary for the company) may intrude on recreation areas or as in the case of north Fremantle intrude on residential areas.
- Abandonment of boats by boat builders as occurs at Maylands slipyard.
- Standard problems of pollution control and facility maintenance that occur with marinas.
- Public access.

It is logical, however, that some form of boat building and maintenance facilities remain within the river. They should, however, be well maintained and concentrated in these two areas only. Expansion into other areas is seen as undesirable.

### 4.2 Cycle Hire

The popularity of cycling and provision of dual-use paths has resulted in one cycle hire facility operating from City of Perth No. 4 carpark, Fraser Point. Its popularity is reflected in the high number of cyclists using this route on the weekends. Once again provision of ablution, parking facilities etc at the site should be reviewed before approval and the cost should reflect part of Local Government's cost of maintaining the site.

## 4.3 Marinas

Three commercial marinas operate within the river, these being Pier 21, Nedlands Bath Marina and Aquarama. Problems associated with these facilities are similar to those of club marinas and may include:

- Pollution control.
- Maintenance of jetties and onshore structures.
- Expansion of facility, (which may be necessary for commercial viability), intruding into public use areas.
- Public access through the area.

### 4.3.1 Commercial Wet Pens

| Site | No |
|---|---|
| Nedlands Baths Marina | 43 |
| Pier 21 | 102 |
| Aquarama | 208 |

Commercial marinas provide a facility for boat owners who are not and/or do not wish to become members of clubs. There is a place for commercial marinas on the river. However, as the foreshore available for any type of river facility is limited, the needs of this class of user may best be met by development of substitutable facilities on the coast. In this way river oriented craft can use marinas in the river and ocean oriented (types to Rottnest etc.) craft can best be stored at coastal marinas.

As the Government is commited to the establishment of commercially viable coastal marinas the price structure of both coastal and river marinas should be such to encourage boat owners to move to coastal facilities.

## 4.4 Itinerant Vendors

Control of itinerant vendors are the responsibility of Local Government Authorities. The only point to make is that these vendors keep to existing parking by-laws and do not cause congestion in areas they service.

# 5.0 COMMERCIAL FISHING

(Reference : Rogers et al. 1984).

The commercial fishery within the Swan-Canning estuary has been managed as a restricted entry fishery since 1969. Access to this fishery has been controlled by limiting the number of licenses issued by the Department of Fisheries and not permitting the transfer of fishing rights to other persons.

The major species caught by professional fishermen are sea mullet, yelloweye mullet, Perth herring, cobbler and crabs.

The major form of fishing undertaken by these fishermen is net fishing, using set and hauled gill nets principally for sea mullet, yelloweye mullet and Perth herring on the shallow banks of the estuary open to net fishing. Sunk tangle or monofilament set nets for crabs and cobbler are used seasonally in deeper water. Several fishermen also use wire traps to specifically take cobbler.

Commercial fishing usually occurs at night or early morning during the week to avoid other river users.

Species, such as yelloweye mullet and Perth herring, not normally caught by anglers, are mostly sold as bait fish. Cobblers, crabs, sea mullet and minor species catches of tailor, flathead, mulloway, western sand whiting, flathead and blackbream are sold as food fish directly to retail outlets.

In the last five years, commercial landings of fish from the estuary have declined to about half the level of the early 1970's.

In 1984 the Rogers et al. report was released examining the future management of the estuary for recreational and commercial fishing. At the time of the study the number of licensed commercial fishermen was 19, although not all pursued fishing on a full-time basis.

Following public review of the Swan-Canning Estuary Fishery Working Groups report (Rogers et. al., 1984), the public was advised on 29th June 1985 of the following changes to the commercial fishery.

- Commercial net fishing will continue but the number of commercial licenses will be reduced to 12 by retirements and withdrawal from the industry.

- Weekend net fishing in Swan-Canning estuary is now prohibited from 8 a.m. Saturday until 6 p.m. Sunday from October to March inclusive. The rest of the year the weekend closure will operate from 9 a.m. Saturday until 6 p.m. Sunday. This closure will affect both commercial and recreational net fishermen immediately. All waters of the Swan estuary above Heirrison Island, including

Guildford water, will also be permanently closed to net fishing. These closures will not affect recreational fishermen using hand trawl prawn nets, clip nets, hand scoop nets and drop nets to catch prawns and crabs.

Those involved in commercial fishing, like amateurs are concerned with the impact other users have on fish populations.

Aspects highlighted by the Swan River Professional Fishermen's Association include location of waterski areas, loss of foreshore vegetation, impact of dredging, recreational boating contributing to erosion and water quality problems and the need to restrict motorised craft in shallow areas, particularly aquatic reserves.

## 6.0 CANAL* DEVELOPMENTS

In April 1980, Cabinet requested the establishment of a Steering Committee to develop recommendations for the development of canal estates. Until this time, guidelines for canal development had been looked at in isolation by respective Authorities and no overall and co-ordinated planning existed for these types of developments.

In March 1981, the Steering Committee on Canal Developments released its "Recommendations for the Development of Canal Estates". Amended editions were produced in March 1982 and June 1984. These recommendations have been adopted by Cabinet and are recognised as government policy. Copies of the report are available from the Waterways Commission.

The procedure for approval to develop a canal estate are illustrated in Figure 1. It is essential that all relevant Authorities assess the proposal before the Local Government Authorities formally initiates zoning for canal estates.

* A canal or canal waterway is "any artificial channel, lake, harbour or embayment for use or intended for use for navigational, ornamental and recreational pruposes, or any of these purposes". The term includes any access channel, any addition to or alteration of any canal within the meaning of this definition and any system of canals within the meaning of this definition provided in any development of land (Steering Committee on Canal Developments 1984).

To date the Swan River Management Authority does not have a written policy on canal developments within the Swan River Management area. If the Authority was to receive an application for a canal development project it would recommend to the proposer to follow the procedure set out in Figure 1.

Many problems are associated with canal developments but perhaps the most important point to make is that a development of this nature on the Swan/Canning Estuary may set a precedent for other development proposals. Moreover, areas suitable in size for such developments are those in upstream areas as yet unmodified by man. As these areas are more prone to water quality fluctuations and problems, canal developments would seem inadvisable. Factors to consider in association with canal developments are as follows:

- Physical destruction of wetlands.
- Water quality factors related to dredging, flushing, effluent and other forms of urban runoff.
- Flooding and siltation.
- Insects; loss of breeding grounds, nuisance factor.
- Stabilising of canal banks.
- Effect of canal development on flora and fauna. (Aquatic and terrestrial).
- Increased erosion due to boating activities.
- Special requirements for sewage and drainage.
- Responsibility for maintenance of the canal, including water quality assessment.
- Access to the canals.
- Development of canal estates may have the potential to degrade existing environmental resources (EPA, 1982).
- Canal estates promote expectations of high environmental quality within the development with good water quality etc.
- Occupants will have expectations of access to high quality environments nearby (EPA, 1982).
- Monitoring of ground water discharging into canals.

The actual dredging of the canals can also have marked effects. These may be noise and other disturbance to existing communities, disturbance to wildlife, loss of plant and animal communities, increased water turbidity, reduced photosynthesis by aquatic plants, release of suspended sediments into the channel and deposition of suspended sediments elsewhere, release of nutrients, changes in water circulation patterns, disturbance of vegetation on the foreshore and conservation areas and, possibly dust from spoil heaps and filled areas.

Of particular importance to the SRMA is the care and maintenance of canal waterways. This aspect is addressed in the Steering Committee's recommendations (1984). It is stated that since canals are created for the benefit of canal residents in much the same way as roads in conventional residential estates then maintenance should be the responsibility of canal residents or the Local Government Authority to which they pay rates.

Maintenance of canals includes clearing of debris, pollution control and water quality testing, dredging and the operation of mechanical circulation equipment. Private shores and retaining walls are to be the financial responsibility of the land owner. Similarly jetties and structures within the canals are to be maintained by their owners.

Without the above requirements the care and maintenance of canal waterways would become the responsibility of one or more of the Government Authorities. Consequently the financial responsibility for an essentially "private" waterway would have to be borne by the tax payer.

## 7.0 VENDING ON THE RIVER

Over the last year the SRMA received a considerable number of applications for an "icecream boat" to operate on the river. Marine and Harbours have the capacity to survey these vessels however, they are unable to control the type of vending operation, their jurisdiction extending only over the seaworthiness and safety aspects of the boat in question. Similarly the Health Department is only concerned with the health aspects not the suitability of the operation in this estuarine environment. Moreover, any vessel can pick up and put down at a public jetty.

It appears that a gap exists in current legislation in that no authority has control over the types of vending operations allowable on the river. This is of concern to the SRMA who sees the need for a review of current legislation.

**Policy Statement**

The Swan River Management Authority's policy is to oppose vending on the river as it is not an appropriate use. River congestion is getting to the point where activities not essential for river use should not be allowed. This kind of commercial activity is undesirable, the river should be kept specifically for marine activities.

8.0 **ADVERTISING ON THE SWAN RIVER**

Advertising on the river takes various forms such as sponsorship on club yachts, boat hire sail advertising, slogans painted on river craft to the most recent suggestion of floating pontoons advertising products. Complaints have arisen over certain types of advertising. Crown Law has advised the SRMA that it has the power to control these operations.

**Policy Statement**

**Floating Advertising Bill Boards on the Swan-Canning Rivers**

The Authority is opposed to the development of advertising from boats on the river because:

1. It is not an appropriate use.
2. It is visual pollution and does not enhance the river.
3. It is further distraction to drivers when the road is adjacent to the river.
4. It distracts from the natural beauty and amenity of the river.

9.0 **COMMERCIAL WATER LEASE AREAS**

Many of these commercial ventures on the river involve permanent facilities over the water or on the foreshore. Water leases (river bed leases) are held by the following organisations:

| **Site/Facility** | **Approx. No Hectares** |
|---|---|
| Nedlands Baths Marina/Jetty Restaurant | 0.3 |
| Northbridge Holdings (Pier 21) | 1.6 |
| Sesal (Aquarama Marina) | 1.6 |
| Maylands Slipyard | 0.2 |
| Oyster Beds Restaurant | 0.3 |
| Cloughs (Engineering) | 0.5 |

| | |
|---|---|
| Oakhill Nominees | 0.2 |
| Dalden Properties (Mosman Bay) | 1.7 |
| Leeuwin | 1.0 |
| Corkhill Nominees (Precision Mouldings) | 0.9 |
| | 8.3 |

0.2% of area of lower basin

Source: Department of M&H map, June 1986.

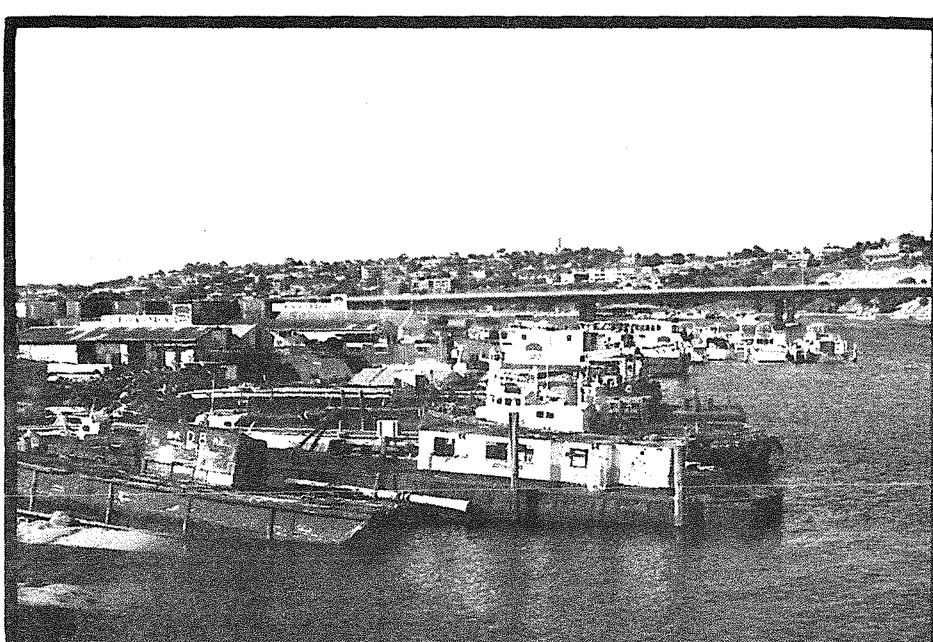


PLATE 18: Boat building and repair, North Fremantle

**TABLE 1:** Hire and Drive Operations Swan-Canning Estuary

| NAME | DESCRIPTION | AREA/CONDITIONS |
|---|---|---|
| Yachtvac | Yachts | -Nedlands and Claremont Yacht Clubs, Mounts Bay Sailing Club, Perth Dinghy Sailing Club, Pelican Point, Chester Road, Claremont<br>-Operation must not take up more than 200 metres of shore |
| Rent-a-launch | 1 ski boat | Swan and Canning River for commercial ski purposes |
| Rent-a-launch | Diesel motors Canoes | Swan River general |
| Carry-on-camping | Trailerised Canoes | Protected waters no more than 0.5km off-shore of river |
| WA Paddle Boat Co | 12 paddle boats | Peppermint Grove Reserve, Keanes Point |
| Pier 21 Marina | Houseboat | Swan River |
| G. Elston | Sailboards | Swan River |
| Freedom Yacht Hire | Yachts | Swan River |
| Australian Sailboard Centre | Sailboards | Hire from the shop used anywhere |
| M. Abbott | Canoe Sailboards | Mason's Landing, Cannington |
| P. Seton-Stewart | Sailing vessels | Claremont Jetty |
| P. Flint | Ski boat | Commercial ski boat area, Narrows Bridge |

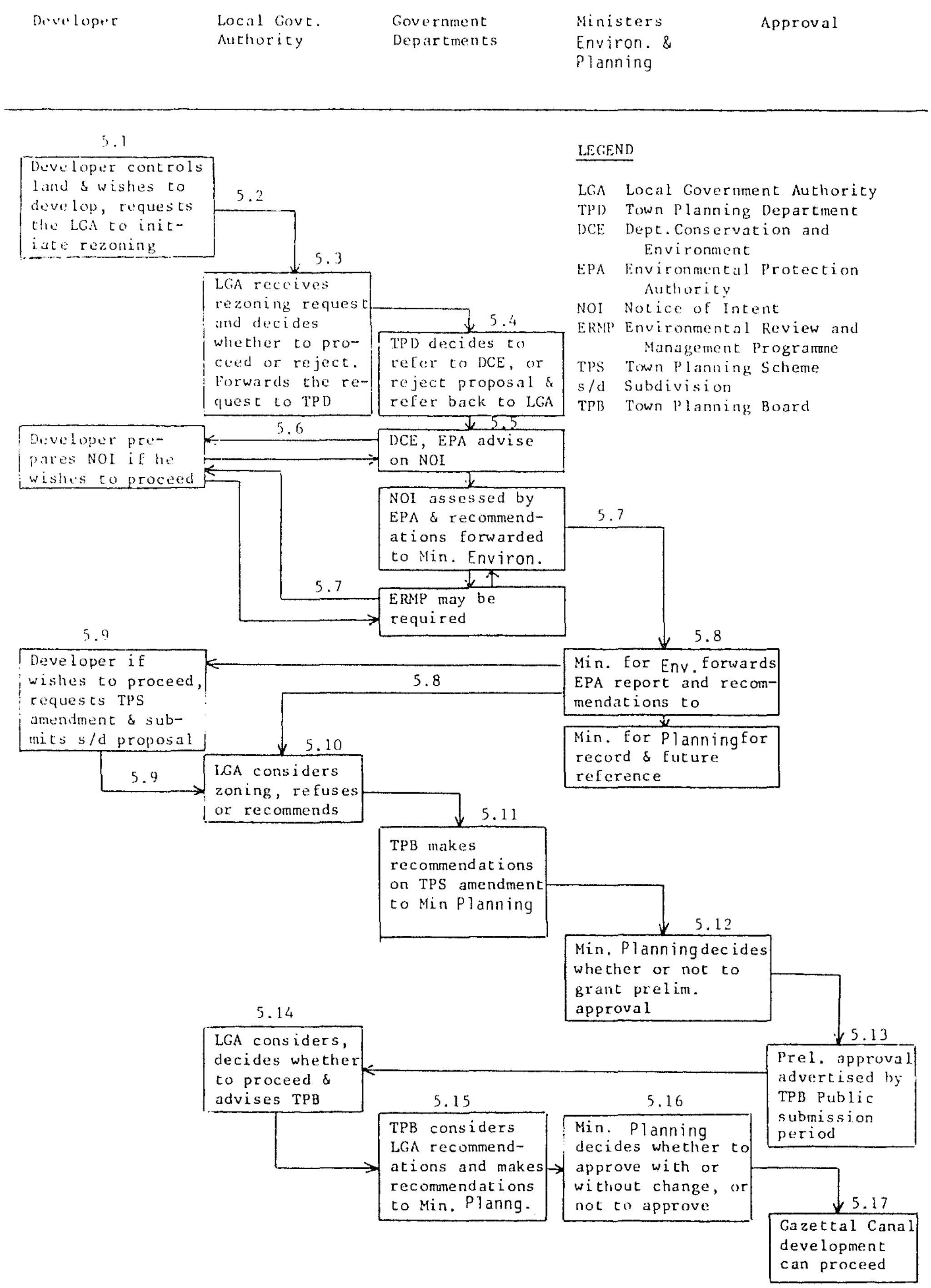
| | | |
|---|---|---|
| Perth Ski Club | Ski boat | Commercial ski boat area, Narrows Bridge |
| Court Marine | Sailboards | Hired from shop, used anywhere |
| Sampson Sail and Wind-surfing | Sailboards | Hired from shop, used anywhere |
| M. Taylor | Trailerised sailboards | Hired from shop, used anywhere |
| M.J. Sail-boards | Trailerised sailboards | Hired from shop, used anywhere |
| G. Morcel | Yachts | Upstream of Stirling Bridge, downstream of Causeway and Canning Bridge |
| Down Under Water Sports | Ski boat | Commercial ski boat area, Narrows Bridge |
| R. Thompson | Parasailing | Narrows ski area, Swan River |
| H. Janney | Sailboards | Hired from shop, used anywhere |
| Main Sail Surfcat Hire | Canoes<br>Sailboards<br>Surfcats | Perth Waters, Swan River |
| Funcats | Surfcats<br>Sailboards | Perth Water, Swan River |
| Shelley Riverton Canoe Hire | Canoes | Riverton Bridge, Canning River |
| Ed Sail | Dinghies Sailboards | Luckey Bay, Swan River |
| Hire-a-cat | Surfcats | Coode Street, South Perth, Swan River |
| M. Timmis | Aqua Bike | Riverton Bridge, Canning River |
| City of Fremantle | Canoes | These three operations are hired from the operator and may be used in any calm waters |
| Shire of Swan | Canoes | |
| Canning Recreation Association | Canoes | |

| | | |
|---|---|---|
| Avon River Raft | Rubber Raft | Avon and Swan Rivers |

Vending Boats

| | | |
|---|---|---|
| P. Odore | Icecream vending boat | )Swan and Canning |
| W. Roes | " | )Rivers |
| P. Carmen | " | ) |

FIG. 1 PROCEDURE FOR APPROVAL TO DEVELOP A CANAL ESTATE



# CHAPTER 16 : HISTORIC SITES

## 1.0 INTRODUCTION

Many sites of significance exist within the management area all having the potential to bring people into contact with the river environment either physically and/or visually - all being worthy of acknowledgement and preservation and requiring ongoing management.

Heightening public awareness by listing of these sites on registers such as the National Estate Register is one means of management. Another is the development of 'trails' as is currently being undertaken by the Western Australian Heritage Commission. These trails are designed to bring more people into contact with the heritage of Western Australia but also protect this heritage by:

- Increasing community awareness and respect through education.

- Channelling public awareness through efficient trail design, therefore, limiting impact to relatively small areas, discouraging random wandering, and avoiding fragile environments (whether natural or built).

  (Western Australian Heritage Committee, 1985).

Such facilities can be very effective 'management tools' if designed correctly enhancing the public's enjoyment of the area. Co-ordination of these projects is necessary and this has been recognised with the establishment of the Heritage Trails Secretariat within the Western Australian Heritage Committee.

### 1.1 Aboriginal Sites

Information received from the Western Australian Museum, Department of Aboriginal Sites indicated that there are over twenty aboriginal sites within the study area. It is most likely, however, that other sites exist which have not yet been registered by the Department.

It was suggested that the Swan River Management Programme refer in general to the existence of aboriginal sites and further consultation should occur in relation to any specific development proposals particular in up river locations.

Known sites and corresponding location numbers for the attached maps are listed in Table 1.

## 1.2 Historic Value

Resources of historical value are divided into three areas:

1. Listings on the National Estate Register and/or those classified or registered by the National Trust of W.A.

2. River wrecks of the Swan and Canning Rivers.

3. 'Heritage Trails'.

Items are listed in Table 1.

### 1.2.1 Classified or Registered Resources

The Register of National Estate is an inventory of places that have aesthetic, historic, scientific or social significance or other special value for future generations as well as for the present community. There are no legal constraints on owners of private property, or on State or Local Government property caused by the entry of that property in the register of the National Estate. In essence the Register is an alerting and educational inventory compiled on the single criterion of national estate significance, and which has implications for protection where actions by the Commonwealth are concerned.

The Heritage Commission has no power to direct private owners or State or Local Governments with respect to their actions that might affect a place in the Register, nor does registration mean that the Heritage Commission may acquire property. The entry of a place in the Register has no legal effect on the status of a place with respect to public access.

The legal implications of registration are directed only at the actions of Federal Government Ministers, Departments and Authorities. These persons and bodies are required to seek prudent and feasible alternatives to any action which might adversely affect a place which is in the Register.

Resources are also classified by the National Trust of Western Australia according to their significance. Classifications are architectural/technical accomplishment; demonstration of a way of life (custom process or function); historical significance (of development or cultural phases, important figures); environmental importance (townscape or landscape value; high degree of unity; setting); scarcity value (a particularly fine or unique example). Items classified by the National Trust are often of a more local value than those appearing on the Register of National Estate. Unfortunately items classified by the National Trust do not have any legal status.

### 1.2.2 River Wrecks

In 1981 the Maritime Archaelogical Association of Western Australia compiled a list of river wrecks within the Swan and Canning Rivers. Again these do not have any legal protection against further destruction. Readers are referred to Scrimshaw (1981) for further details of these boats. All wrecks listed are thought to be built pre 1945.

### 1.2.3 Heritage Trails

'Heritage Trails' are routes designed to enhance the community's awareness, understanding and enjoyment of part of Western Australia's natural and/or cultural heritage. They feature significant landforms, flora, fauna, aboriginal sites or tracks, historic buildings, structures, or routes, or any combination of these.

The project is co-ordinated by the Western Australian Heritage Committee. At present the following trails exist or have been suggested. The locations of existing trails are illustrated on the accompanying maps.

**Swan Valley Heritage Trail** - Retraces the latter part of Stirling's expedition and looks at the development of the Swan Valley.

**Kalamunda (Piesse Brook) National Park Bushwalk** - This walk follows Piesse Brook, joins Bibbulmum Track and features views of the Helena River Valley.

**Peppermint Grove Foreshore Nature Trail** - Is a network of paths featuring natural coastal plain closed scrub and one of Australia's few Pleistocene deposits.

**Hills Creek Trail, Walyunga National Park** - Follows the Swan River banks past former aboriginal campsite and workshop, then up through the hills.

**Canning River Cycleway** - Cycleway following the Canning River from Nicholson Road to Burslem Drive, Thornlie.

**Around the River Ride** - Circuit around Swan River from Mill Street carpark on cycleways and roads with seven suggested start/finish points.

**A Walk Through Claremont** - Features a historic walk around the area and along the foreshore.

**Swan River Canoeing Guide** - Features a canoe guide from Upper Swan Bridge downstream to Middle Swan Bridge.

**Canning River Canoe Guide** - Features suitable areas along the river for canoeing.

**Canning Historical Drive** - Follows the road and river through the City of Canning featuring historical points of interest.

**Bayswater Nature Trail**

A trail was proposed by the City of Bayswater along the foreshore adjacent to the King William Street wetland area.

**Canning River Regional Park** - Trails are proposed within this regional park as funding is available.

**Four Season Trail** - Alternative trails proposed along the Perth foreshore to those featured in and around the River Ride.

## 1.3 Conservation and Scientific Value

The following area is a list of sites which have been particularly singled out by the System Six Report (DCE, 1983) as worthy of conservation. These are already marked on the accompanying maps.

<u>M13 Whiteman Park (Mussel Pool)</u> : Conservation value as it contains a rich diversity of flora and fauna including:

- 5 native species of mammal
- 70 species of bird
- 25 species of reptile including a northerly occurrence of a sub-species of goanna
- 2 species of native fish in the creek

Is of regional significance due to conservation/recreation, and proximity to Perth.

<u>M17 Ellen Brook and Twin Swamps Wildlife Sanctuaries, Upper Swan</u> : Preservation of the short-necked tortoise. Present low numbers is cause for concern about the future of the species. Also high in aquatic plants and contains some five rare plants, (including one which is not known to occur elsewhere) and a variety of invertebrate and fish.

<u>M18 Walyunga National Park</u> : High conservation and recreation values - needs to be increased in size.

<u>M19 Swan River - Guildford to Walyunga National Park</u> : Open space of regional significance because of its high conservation and recreation potential.

M20 Jane Brook : Growth and regeneration of flora.

M33 Helena River - Guildford to Darlington : The area contributes to open space of regional significance because of its conservation and recreation resources and its proximity to the Perth urban area, and its place in forming a link between other areas of regional open space - the Helena Valley and the Swan Valley.

M41 Bennett Brook : Conservation and recreation value of the area is high, given its proximity to the rapidly expanding and densely populated suburb of Lockridge. Preservation of the area would help improve the quality of the water from the Bennett Brook Catchment entering the Swan River.

M44 Swan River, Backwater, South Guildford : The area provides a good refuge for many species of birds including swamphen, reed warbler and sacred kingfishers.

M50 Swan River Foreshore, Maylands : As well as having high conservation value, the area is also significant for fauna.

M51 Swan River Saltmarshes, Belmont and Maylands : These saltmarshes, trees and adjoining extensive wading areas make up one of the few undisturbed areas along the river which support a wide variety of water birds.

M54 Foreshore Reserve, Peppermint Grove : This area is significant for its vegetation structure and has apparently remained unburnt for some time producing specimens of Rottnest cypress, wattles, parrot bush, chenille honeymyrtle and cockies' tongues which are outstanding for their fully developed character. The area is also important geologically, as it contains one of Australia's few Pleistocene deposits.

M56 Foreshore Reserves, Mosman Park : Although much of the vegetation has been disturbed, there is enough natural vegetation remaining which is worth conserving. There is also some quandong and snakebush, which do not occur anywhere else along the Swan River.

M57 Minim Cove Foreshore, Mosman Park : The cliffs expose a rich fossiliferous shell bed that was probably deposited towards the latter part of the Pleistocene era. The bed is one of the best preserved and most informative deposits of its age in Western Australia and is located conveniently close to Perth.

M58 Blackwall Reach Foreshore, Bicton : Blackwall Reach contains the only relatively untouched area of river limestone left in the region.

M59 Point Resolution Foreshore, Dalkeith : The shoreline is sandy and rocky and is banked by a short steep slope with picturesque coastal limestone pinnacles and rocks. Parrot bush is the dominant vegetation with some speciments of the relatively uncommon Grevillea crithmifolia.

M60 Aquatic Reserve, South Perth : The area is one of only three significant wading bird habitats remaining on the Swan River. The migratory waders feed almost exclusively on the invertebrate life which the tidal flats and marshes provide. The three areas complement each other, depending on tides and weather.

M61 Aquatic Reserve, Attadale : This area comprises the tidal flats and saltmarsh areas of Point Waylen and Alfred Cove in Attadale and is another of the only three significant wading bird habitats remaining on the Swan River.

There is an unmodified fossil deposit of sea-shells which is of considerable scientific interest at this site.

M62 Pelican Point, Crawley : The area is the final one of the three significant wading bird habitats remaining on the Swan River. The three areas complement each other depending on tides and weather.

M65 Point Heathcote Foreshore, Applecross : The area consists of rocky headland of coastal limestone carrying a number of native shrubs and contributes to open space of regional significance extending along the Swan River.

M66 Mount Henry, Manning : Mount Henry occupies a prominent headland with limestone outcrops. The area supports over a hundred native species of vegetation in all.

M67 Canning River Foreshore, Salter Point to Clontarf : In the centre of Salter Point at the south end of the reserve there is a lagoon which is connected to the river by a narrow channel. The lagoon is unique on the Swan-Canning Estuarine System and although the remaining vegetation is limited in extent, it contains an interesting complex of species. The area contributes significantly to the appearance of the river and the vegetation protects the bank.

M68 Canning River, Riverton Bridge to Nicholson Road Bridge : The section downstream from the Kent Street Weir consists of the best estuarine vegetation of all Canning and Swan Rivers. The area is inhabitated by about 85 bird species of which 60 are likely to nest there. In the upstream section from the Weir, the vegetation is mainly confined to trees along the river banks including flooded gum and swamp paperbark.

M74 Gull Creek : The area forms a natural pocket within the surrounding urban areas and contains a number of species of native flora which are of high conservation value.

One of Western Australia's largest and rarest dragonflies, *Petalura hesperia* has been collected from the swampy ground alongside Bull Creek.

M75 Upper Canning and Southern Rivers : The Canning River is well fringed with flooded gums and paperbark along the west bank between Nicholson Road Bridge and Royal Street and the east bank is fairly thickly fringed near where Yule and Bickley Brooks join the Canning. Native species have almost entirely been lost from the ground flora.

TABLE 1: Historic Sites

| MAP NO | CODE NO | SITE NAME | LOCATION | COMMENTS |
|---|---|---|---|---|
| 85001-1-2 | 1 | Aboriginal tool making site | Minim Cove, Mosman Bay | At least 10 000 years old discovered 1970's |
| 85001-8-2 | 2 | Aboriginal archaelogical site | Bennett Brook | |
| 85001-8-2 | 3 | Home of the "Waugal" | Mouth of Bennett Brook | Mythological serpent |
| 85001-12-2 | 4 | Archaelogical site | Upper Swan Bridge | Classified National Estate Register |
| 85001-13-2 | 5 | Walyunga National Park | Upper Swan | Former aboriginal campsite |
| 85001-1-2 | 6 | Thomas Carroll, House | Riverside Road, East Fremantle | Built 1900, two-storey limestone iron home. Registered National Trust |
| 85001-1-2 | 7 | "Hillcrest" | North Fremantle | Built in the 1890's home of Francis Pearse, Facade classified by the National Trust |
| 85001-1-2 | 8 | Majestic Hotel Site | Pt. Dundas, Applecross | Original section constructed in 1890's for a former Governor but never used as such |
| 85001-6-2 | 9 | House No. 4 | Richardson Avenue, Claremont | Built in the 1890's, classified by the National Trust |
| 85001-6-2 | 10 | House No. 14 | Chester Street, Claremont | Built around 1890 - 1900's, classified by the National Trust |
| 85001-6-2 | 11 | "The Mansions" | Corner Victoria Avenue, Jetty Road, Claremont | Built 1897, classified by the National Trust for its architectural and environmental importance |

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| MAP NO | CODE NO | SITE NAME | LOCATION | COMMENTS |
|---|---|---|---|---|
| 85001-6-2 | 12 | "Riverside" | Victoria Avenue, Claremont | Built 1890 registered with the National Trust |
| 85001-6-2 | 13 | Claremont Museum | Freshwater Bay, Claremont | This old limestone building was a former school. Built 1853 and classified by the National Trust |
| 85001-1-2 | 14 | Gallop House | Nedlands | Built in 1877 as a farmhouse for the Gallop family. Classified by the National Trust |
| 85001-6-2 | 15 | Nedlands Baths | Nedlands | A restaurant and marina now occupy the site of the old Nedlands Baths, established 1901 and registered with the National Trust |
| 85001-6-2 | 16 | "Crawley House" | Hackett Drive, Crawley | Former Shenton House built 1880's and registered with the National Trust |
| 85001-6-2 | 17 | Matilda Bay Reserve | Crawley | On the National Estate Register |
| 85001-6-2 | 18 | Swan Brewery Site and old stables | Mounts Bay | Use of site dates back to the 1830's but has been a brewery since 1890's. Classified by the National Trust of W.A. |
| 85001-6-2 | 19 | The Old Mill (formerly Shenton's Mill) | Mill Point, South Perth | Built in 1837 to ground grain into flour. Classified by the National Trust. Also on National Estate Register |

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| MAP NO | CODE NO | SITE NAME | LOCATION | COMMENTS |
|---|---|---|---|---|
| 85001-6-2 | 20 | Western Australian Rowing Club | Riverside Drive, Perth | Built 1905, classified by the National Trust. Also on National Estate Register |
| 85001-2-2 | 21 | Canning River Wetlands | Kewdale Railway Crossing to Riverton Bridge on the Canning River | Classified by the National Trust |
| 85001-3-2 | 22 | Woodloes Homestead | Woodloes Street, Cannington | Built about 1871, registered by the National Trust |
| 85001-2-2 | 23 | Convict Fence | Shelley Foreshore and Canning River | Fence built by convict labour 1866-1892 to stop the river channel from silting up |
| 85001-7-2 | 24 | Tranby House | Maylands | Built about 1836. Classified and owned by National Trust. Traditional English home. Also on National Trust Register |
| 85001-7-2 | 25 | Halliday House | Halliday Street, Bayswater | Built about 1880's classified by the National Trust |
| 85001-8-2 | 26 | House No. 7 | Daylesford Road, Bayswater | Built 1890's. Registered by the National Trust |
| 85001-8-2 | 27 | Earlsferry House | Nurstead Avenue, Bassendean | Built 1890's. Registered by the National Trust |

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| MAP NO | CODE NO | SITE NAME | LOCATION | COMMENTS |
|---|---|---|---|---|
| 8500-8-2 | 28 | Fisherman's Cottage | Surrey Road, Bassendean | Former fisherman's cottage. Registered by the National Trust |
| 85001-8-2 | 29 | Success Hill | Success Hill, Bassendean | The spring at the base of this hill was used by Stirling in 1827 as a source of drinking water |
| 85001-8-2 | 30 | Guildford Bridge Site | James Street, Guildford | Site of ferry stop until 1885 when the first bridge was constructed |
| 85001-9-1 | 31 | Midland Railway Institute and Technical School | Montreal Road, Hazelmere | Parts. Registered and classified with the National Trust and on National Estate Programme |
| 85001-8-2 | 32 | Meadow Street Conservation Area | Meadow Street, Guildford | Classified as an historic precinct by the National Trust. Also on National Estate Register |
| 85001-9-1 | 33 | Clayton Farm | Clayton Road, Helena Valley | Established 1861 and registered with the National Trust |
| 85001-8-2 | 34 | Historic Guildford | Guildford | Region contains some 19 resources classified or registered with the National Trust for a variety of attributes. Many of the buildings date back to the 1840's and 50's. Majority on National Estate Register |

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| MAP NO | CODE NO | SITE NAME | LOCATION | COMMENTS |
|---|---|---|---|---|
| 85001-5-2 | 35 | Woodbridge Homestead | Guildford | Built 1885. Owned and classified by the National Trust. Also on National Estate Register |
| 85001-10-2 | 36 | Mussel Pool | Whiteman Park | Formerly owned by Mr. Whiteman, who together with his associates, created this environment and collected the historical pieces of form machinery and equipment. Now owned by SPC |
| 85001-10-2 | 37 | "St. Winnols" | Caversham Avenue | Built 1898 and registered with the National Trust |
| 85001-10-2 | 38 | Swan Valley Vineyards | Swan Valley | The 1860's were marked by the growth of the Swan Valley vineyards. Notable among pioneer wine makers were Dr. John Ferguson, who established Houghton Cellors in 1859, William Harris of "Rainworth", Dr. Alfred Waylen of "Garden Hill" and Thomas Waters of "Olive Farm", South Guildford. In the early 20th Century the wine industry was to become the main agricultural enterprise of the Swan Valley |
| 85001-10-2 | 39 | Sandalford | Caversham | Granted to John Septimus Roe, W.A.'s first Surveyor General in 1829 |

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| MAP NO | CODE NO | SITE NAME | LOCATION | COMMENTS |
|---|---|---|---|---|
| 85001-10-2 | 40 | "Mandalay" | Middle Swan Road | Built 1880's. Registered with the National Trust for its architectural and historical importance |
| 85001-10-2 | 41 | "Rainworth" House and cottage | Middle Swan | Mud brick cottage was constructed 1830-1840's. Two-storey Edwardian house was erected in 1904. On National Estate Register |
| 85001-10-2 | 42 | Chaplain's House | Yule Avenue, Middle Swan | Built 1850's. Registered with the National Trust |
| 85001-10-2 | 43 | Swanleigh Hostel | Yule Avenue, Middle Swan | Established 1874 and registered with the National Trust |
| 85001-10-2 | 44 | St. Mary's Church and graveyard | Middle Swan | Constructed in 1868-69 to a Gothic Revival design by Richard Roach Jewell. Graveyard dated 1840. Classified by the National Trust and on National Estate Register |
| 85001-10-2 | 45 | Strelley Farm Buildings | Dale Road, Middle Swan | Established 1859. Classified by the National Trust and on National Estate Register |

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| MAP NO | CODE NO | SITE NAME | LOCATION | COMMENTS |
|---|---|---|---|---|
| 85001-10-2 | 46 | Houghton Homestead and Winery | Dale Road Middle Swan | Constructed in 1834 and 1859 respectively. Classified by the National Trust and on National Estate Register |
| 85001-10-2 | 47 | "Oakover House" | Dale Road, Middle Swan | Established 1860 with barn and stables in 1840 and 1880's respectively. Classified by the National Trust and on National Estate Register |
| 85001-11-2 | 48 | St. Leonard's | West Swan | Constructed about 1842 on National Trust Register |
| 85001-11-2 | 49 | Haddrills House | Henley Brook | Probably built by Richard Edwards in the 1830's this house was owned by William Haddrill. Classified with the National Trust and on National Estate Register |
| 85001-11-2 | 50 | Susannah Smither's Grove | West Swan Road | Classified with the National Trust. Dated 1840. Also on National Estate Register |
| 85001-11-2 | 51 | Spring Park Farm | Henley Farm | Farm buildings constructed in the early 1850's. James Minchin the original owner was speared to death in 1837. Buildings classified with the National Trust and on National Estate Register |

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| MAP NO | CODE NO | SITE NAME | LOCATION | COMMENTS |
|---|---|---|---|---|
| 85001-11-2 | 52 | Minchin's House | West Swan | Rammed earth construction house built in the 1830's |
| 85001-11-2 | 53 | Richard Edward's House | Henley Brook | Mud brick house owned and built by Richard Edwards in the 1850's, registered with the National Trust |
| 85001-11-2 | 54 | Henley Park | Hernley Street, Henley Brook | Built in the 1880's and registered with the National Trust |
| 85001-11-2 | 55 | "Millendon" | Olive Road, Millendon | Established 1834, classified by the National Trust. Also on National Estate Register |
| 85001-11-21 | 56 | All Saints Church and graveyard | Upper Swan | Located on the site used by Stirling as a camp in 1827 on National Estate Register |
| 85001-11-2 | 57 | Ellen Brook | Upper Swan | On National Estate Register |
| 85001-12-2 | 58 | Ellen Brook Reserve and Twin Swamps Reserve | Upper Swan | On National Estate Register |
| 85001-12-2 | 59 | Belhus | Upper Swan | Granted in G. Leake in 1829, and leased by William Cruse until 1865. It was purchased by the Barrett Leonard family in 1897. On National Estate Register |
| 85001-12-2 | 60 | Belvoir | Great Northam Highway Millendon | Established 1879, classified by the National Trust and on National Estate Register |

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| MAP NO | CODE NO | SITE NAME | LOCATION | COMMENTS |
|---|---|---|---|---|
| 85001-12-2 | 61 | Nolan House | Great Northern Highway | Established 1870, registered by the National Trust |
| 85001-12-2 | 62 | Upper Swan Bridge Site | Upper Swan | The original bridge was built in 1851 and was one of the first public works carried out by convicts |
| 85001-13-2 | 63 | Walyunga National Park | Walyunga | On National Estate Register |
| 85001-1-2 | 64 | Carnac | Fremantle | River wreck, built 1929 |
| 85001-1-2 | 65 | Priestman Grab Crane | Fremantle | River wreck, built 1945 |
| 85001-1-2 | 66 | Eva | Fremantle | River wreck, built 1897 |
| 85001-1-2 | 67 | Mayfield | Rocky Bay | River wreck, built 1899 |
| 85001-1-2 | 68 | Unidentified possibly "City of Perth" | Rocky Bay | River wreck, possibly built 1872 |
| 85001-1-2 | 69 | A.L.C. 40 | Bicton | River wreck, steel barge unknown date |
| 85001-1-2 | 70 | Shell Barge | Upstream Pt. Roe | River wreck, as yet unidentified |
| 85001-1-2 | 71 | Blackwall Reach Barge | Blackwall Reach | River wreck, 60 ton steel barge, unknown date |

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| MAP NO | CODE NO | SITE NAME | LOCATION | COMMENTS |
|---|---|---|---|---|
| 85001-1-2 | 72 | Point Roe Box Barges | Bicton | River wreck, unknown date |
| 85001-1-2 | 73 | Mosman Bay Barge | Mosman Bay | River wreck, wooden vessel, unknown date |
| 85001-1-2 | 74 | Unidentified | Melville Waters between Pt. Dundas and Pelican Point | River wreck, located on Admiralty Chart of 1896 |
| 85001-2-2 | 75 | Unidentified | Pt. Heathcote | River wreck, unknown date |
| 85001-7-2 | 76 | Swan Portland Dredge | Goodwood Parade | River wreck, built pre 1936 |
| 85001-7-2 | 77 | Daisy | Belmont | River wreck, built pre 1920 |
| 85001-7-2 | 78 | Trixen | Maylands | Salvage wreck, built 1904 |
| 85001-8-2 | 79 | Ashfield Pontoons | Ashfield | River wreck, built around 1942 |
| 85001-2-2 | 80 | Lady Ord | Coffee Point | River wreck, built 1878 |
| 85001-2-2 | 81 | Helena Harley | Coffee Point | River wreck, built 1897 |
| 85001-2-2 | 82 | Mayflower | Bull Creek | River wreck, built 1904 |
| 85001-2-2 | 83 | Unidentified | Bull Creek | River wreck, possibly barge used to build the convict fence between 1866-1892 |

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| MAP NO | CODE NO | SITE NAME | LOCATION | COMMENTS |
|---|---|---|---|---|
| 85001-2-2 | 84 | Python | Shelley | River wreck, built 1907 |
| 85001-8-2 | 85 | Swan Valley Heritage Trail | Success Hill, All Saints Church, Guildford | Retraces the latter part of Stirling's expedition and looks at the development of the Swan Valley |
| 85001-9-1 | 86 | Kalamunda (Piesse Brook) National Park Bushwalk | Kalamunda, Helena Valley Region | This walk follows Piesse Brook, joins Bibbulmum Track and features views of the Helena River Valley |
| 85001-1-2 | 87 | Peppermint Grove Foreshore Nature Trail | Peppermint Grove | Is a network of paths featuring natural coastal plain closed scrub and one of Australia's few Pleistocene deposits |
| 85001-13-2 | 88 | Hills Creek Trail, Walyunga National Park | Walyunga | Follows the Swan River banks past former aboriginal campsite and workshop, then up through the hills |
| 85001-3-2 | 89 | Canning River Cycleway | Thornlie | Cycleway following the Canning River from Nicholson Road to Burslem Drive, Thornlie |
| 85001-6-2 | 90 | Around the River Ride | Perth to Fremantle | Circuit around Swan River from Mill Street carpark on cycleways and roads with seven suggested start/finish points |
| 85001-6-2 | 91 | A Walk through Claremont | Claremont | Features a historic walk around the area and along the foreshore |

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| | | | | |
|---|---|---|---|---|
| 85001-10-2 | 92 | Swan River Canoeing Guide | Upper reaches of the Swan River | Features a canoe trail from Upper Swan Bridge downstream to Middle Swan Bridge |
| 85001-2-2 | 93 | Canning River Canoeing Guide | Canning River | Features suitable areas along the river for canoeing |
| 85001-2-2 | 94 | Canning Historical Drive | City of Canning | Follows the road and river through the City of Canning featuring historical points of interest |

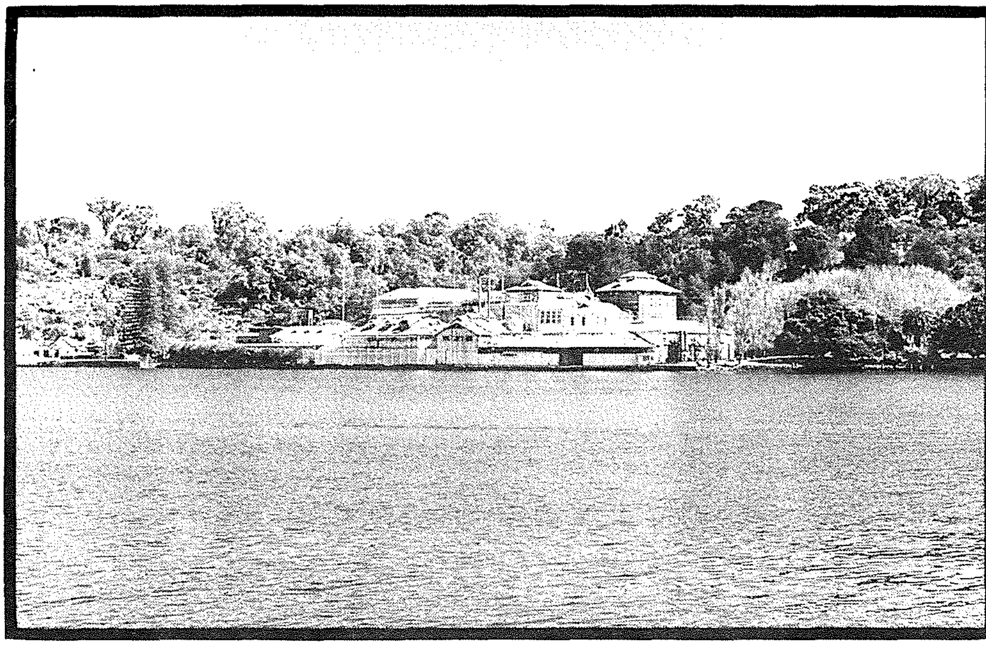

PLATE 19: Redevelopment of the Swan River Brewery, Mounts Bay Road is in progress

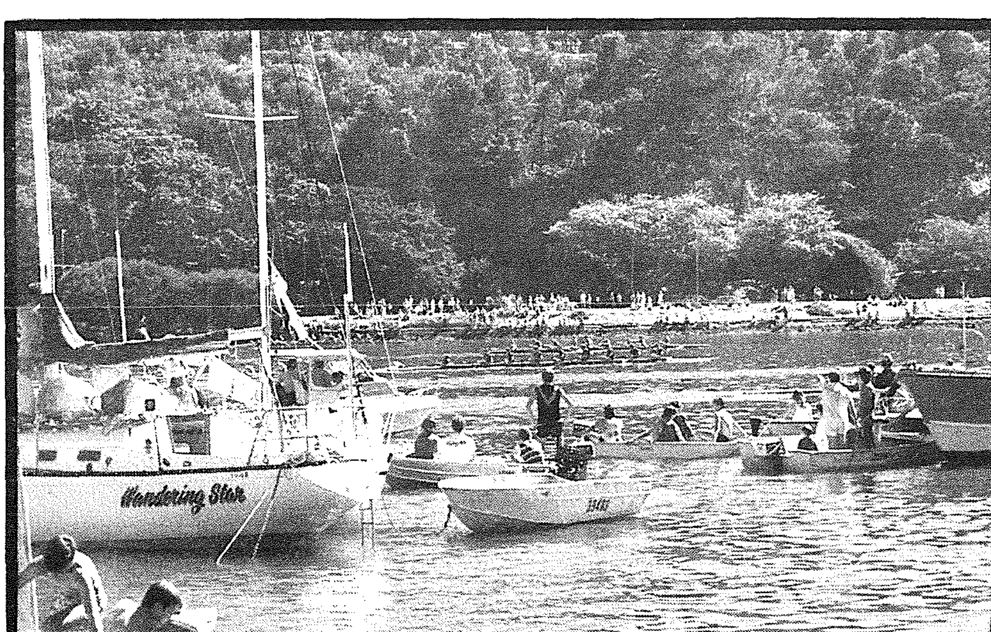


PLATE: 20: Special events, such as the Head-of-the-River are scheduled by the W.A. Aquatic Council

# CHAPTER 17 : PUBLIC COMMENT

## 1.0 INTRODUCTION

In addition to the club and on-site questionnaires public comment was sought by:

1. Invitation to prepare a submission.

2. Newspaper article inviting submissions.

As complaints were received at the office on various topics complainants were also invited to make written comment that would be incorporated into this report.

The following organisations were invited to prepare submissions:

| | **Reply Received** |
|---|---|
| ACHPER | |
| Boating Industry Association of W.A. | |
| Conservation Council of Western Australia | |
| Disabled Sports | |
| Foreshores and Waterways Protection Council | * |
| Landscape Architects Association of W.A. | * |
| National Safety Council | * |
| Royal Australian Institute of Parks and Recreation (W.A. Region) | |
| Royal Australian Ornithologists Union | * |
| Swan River Professional Fisherman's Association | * |
| W.A. Committee on Access for the Disabled | |

It was anticipated that by approaching the Conservation Council of Western Australia they could contact and co-ordinate replies from member groups.

Submissions from Newspaper Article/Phoned Submissions:

F.M. Robinson
The Tree Society
City of Canning
Shire of Swan
W. Hosja
Perth Flying Squadron
R. Bodycoat, I. Hocking, C. Staples
Health Department of Western Australia
C. Wilde
N. McAllister
G. Doig
Bassendean Preservation Group (Late Submission)
Mrs Joyce
M. Hutchinson
E. Watson

Comments have been divided into the following categories and a precis of public comments is presented below:

| | |
|---|---|
| Management Objectives | Litter |
| Management Authorities | Utility Services |
| Land Ownership | Water Quality |
| Land Use | Boating |
| Flora and Fauna | Safety & Education |
| Transport | Historic Sites |
| Dredging and Reclamation | Recreation General |
| Erosion | Proposed Developments |
| Noise Pollution | Access |
| Hydrology | Amenity |
| Legislation | |

## 1.1 Management Objectives

Management should endeavour to preserve the estuary for people by restoring the natural ecology as much as possible with priority to the needs of passive recreation such as walking by the river, swimming, picnicking, cycling, prawning, crabbing, fishing, canoeing and bird-watching.

Proper management will need a major and committed reversal of present damaging practices which have developed unwittingly as a matter of convenience and the principle should apply that the estuary, as a still-water area highly vulnerable to ecological damage, should not be damaged to allow activities which can be carried out elsewhere.

Recognise and maintain the river as a viable linear park system which should cater for a variety of biological and social needs. Need to ensure that problems are clarified if there is to be adequate resolution of conflicts.

Recognitiion of river system as an integral and unique component of the Metropolitan Region and "blue lung" of the City, which should be maintained as a viable landscape unit.

Water areas are priceless assets which must be managed and conserved with great sensitivity for the use and enjoyment of the present and future generations.

Management plans will need to be flexible enough to include changing social attitudes.

Foreshores should become part of the local, district, regional and natural park system, linking recreation reserves and parkland to form a linear unit.

1.2 **Management Authorities**

The formation of a competent management authority properly legislated and funded.

That one governing body should have overall control rather than a complex admixture of various departments and instrumentalities and a large number of local councils.

There is a need for new legislation to over-ride all the myriad bodies that at present enable "buck-passing" to be carried on whenever problems occur either on the rivers or areas adjacent to them.

That developments and activities on foreshore land and the adjacent waterways be required to be approved by a single controlling authority, namely the Waterways Commission, which before reaching its decisions shall obtain the approval of the relevant local authority and relevant state government instrumentalities.

City of Canning has taken an active interest in the value of the Canning River as a waterway capable of serving the residents of the City and the surrounding region from an environmental aspect and an important resource for public recreation.

Further research and investigation should be carried out into the overlapping responsibilities and jurisdiction of the MRPA, local authorities, SRMA and other government departments and instrumentalities in the control and management of waterways foreshores.

1.3 **Land Ownership**

There should be no further alienation of river foreshore for private use.

Review ownership policies of urban and rural foreshore to ensure public access.

The Swan and Canning Rivers are owned by the Crown as Crown Land on behalf of the present and future citizens of Western Australia and should remain as Crown Land to be classified as inalienable "A" Class Reserve accessible to boats, windsurfers and swimmers, etc.

There should be no new private ownership of the estuarine foreshores and any sale or transfer of land with a privately owned river frontage and any application for a building permit on such land should be approved only if river frontage to a depth of 7 or 10 metres from the river is surrendered without compensation, with a view to eventual resumption of all privately owned river frontages. The foreshores can then be used for POS, footpaths, promenades and cyleways, for the benefit of the public rather than a few private individuals.

All foreshores should be Crown Land except where circumstances necessitate an alternative land tenure or lease system to secure public use and access of the foreshore and river.

That all water areas and foreshores of the Swan and Canning Rivers be retained as Public Open Space and that investigation be made of means of increasing the legal protection of these areas to ensure that developments cannot proceed without parliamentary and local community approval.

That all leases and freehold rights over river front land be re-examined and that those which extend to the foreshore or into the river itself be modified progressively to remove the right to private ownership or control of areas of the river and its foreshores.

A policy be established to provide that eventually no private ownership of land be allowed within a minimum of 15 metres of the river's edge (subject to the topography of the land in question, e.g. areas where there are cliffs may require special provision); that there be an embargo on all development on such land) and a provision that when land is transferred this portion revert to public ownership.

That the present law requiring the ceding of a margin of land on the river's edge upon subdivision be extended to apply also to rezoning, strata title development and other development of all kinds.

That areas of the rivers and their foreshores should not be allowed to come under the control of private owners or elite groups.

Land on the foreshores of the Swan and Canning Rivers which is currently controlled by State or Commonwealth Government Departments or Instrumentalities, and to which public access is restricted, be identified and a timetable set for its acquisition for public open space, the demolition of inappropriate buildings and facilities and restoration to a condition as close as possible to its natural condition.

The rivers and their foreshores belong or should belong to the people of Western Australia.

To secure all foreshores and rivers in public ownership for the purpose of recreation (active and passive), tourism and conservation of riverine environments.

## 1.4 Land Use

The natural resource must be considered when making land use decisions, i.e. recreation, conservational/preservational, transport, sanitary land fill, etc.

The Waterways Commission and the Government should not permit any private or public development of these estuaries, or the higher reaches of the waterways, except to the limited extent necessary for public wharves or bridges.

Any proposed development of the rivers for private profit, such as the proposed Bond Corporation Marina at Point Dundas and any proposed subdivision close to the foreshore involving use of the waterways through a canal or keys system should be completely forbidden.

All commercial activities on or using foreshores or rivers should be licensed and, where appropriate, management, amenity and environmental conditions imposed.

Planning of areas adjacent to river foreshores should have due regard to engineering, environmental and planning aspects, in particular access to the foreshore at the initial planning stage.

Foreshores not set aside for conservation or environmental purposes should, where appropriate, be developed for recreational purposes.

Erection of structures should be limited to the provision of facilities for public need only, such as bridges, jetties and navigation beacons.

The principles of FAWPC imply that canal type developments are inappropriate.

The intrusion of commercial operators who absorb choice areas of the river front for profit (particularly Claremont and Peppermint Grove (areas) using land classified as "A" Class Reserves should not be allowed.

Legality of using a "A" Class Reserve for commercial use questioned.

That no leases over such land be allowed other than those approved by an overall managing body and can be held in to be in the public interest.

That owners of land adjacent to the foreshore not be permitted to interfere with, dump rubbish on, develop gardens on or in any other way alter the nature of foreshore land adjacent to their properties or acquire any easements or rights over such foreshore areas.

That facilities on the rivers and their foreshores should be restricted to those for which the water is an essential element.

Provide guidelines on shoreline development which will ensure that the physical and visual integrity of the riverscape is not compromised.

Further research and investigation should be carried out into the use of river foreshores and rivers for having restaurants and other commercial and intensive recreational uses.

## 1.5 Flora and Fauna

The natural ecology of the estuary depends on fertile, undisturbed shallows as the sanctuary and breeding and feeding areas for the whole range of marine and bird life inhabiting it.

Foreshore clearing should cease and sections of shore areas now left bare by development should be planted with Casurina to provide shade for people and the shallows.

Restoration of areas of rushes should be attempted.

Waters of aquatic reserves should be limited to slow moving boats propelled by oar or paddle. Also need for similar areas upstream of Mt. Henry.

Where power boats are operating in deeper water the propellors destroy surface-living frog and fish eggs.

The intense power boat activity at Deep Water Point forms a turbulence and noise barrier to fish life to move up and downstream.

Petroleum fuel contaminates of water surface with a film of oil drifting ashore and rotting the roots of riverside rushes.

To preserve and restore the ecology of the upper reaches of the estuary, a speed limit of eight knots should apply up river from both the Causeway and Canning Bridge.

The major areas of concern to the RAOU are Alfred Cove, Como foreshore and Pelican Point which supports migratory waders during the summer months.

Environmental engineering works should be undertaken, where appropriate, to control mosquito breeding, however, in certain selected areas and in extreme cases, chemical control may be appropriate.

Fishing management schemes should be implemented to ensure conservation of resources and where appropriate, selective stocking of suitable species undertaken.

Objection to residents who poison or cut down trees that they consider block their views of the river.

Objection to Councils that spray for mosquito control which has an effect on the food chain.

The Waterways Commission should be involved in management plans for System 6 reserves.

The preservation of the environment, ecology, natural features, flora and fauna of the Swan and Canning Rivers and their foreshores, and where appropriate, their rehabilitation and regeneration, be an absolute priority and that this value should be uppermost when human use is being considered.

The initiative taken by the System Six report in recommending tenure for land below the high water mark to be managed as wildlife reserves is commended (M60, M61, M62). Clear tenure can lead to appropriate by-laws, education programmes and law enforcement. The threat of development proposals detrimental to waders and other wildlife is also reduced. Some concern is expressed that these System Six recommendations in relation to vesting have not yet been carried out.

Disturbance of the waders is considered to be a major problem. When waders are constantly disturbed they may be weakened, particularly early in the wader season when the birds have just completed their flight from the Northern Hemisphere. In addition, birds that are constantly disturbed may not return.

The existing laws prohibit dogs on the land abutting the proposed aquatic reserves, denying access by dogs to the mudflats for some distance at all three sites. However, harrassment by dogs is a major problem. At Como Foreshore it is common practice for people to let their dog loose while they run along the foreshore and Alfred Cove often has stray dogs roaming the mudflats. Education and law enforcement seem an appropriate remedy.

Until land tenure is granted fishing and bait digging activities are probably legal but detrimental to the sites. Pelican Point is often used as a fishing spot (especially in the evenings) and bait digging is common at Alfred Cove.

Alfred Cove and Pelican Point both lend themselves to the development of interpretative trails which would enable people to see the birds without disturbing them. Alfred Cove has become a popular bird watching site.

Midge control on the Alfred Cove mudflats is undertaken by the City of Melville. An evaluation of the effects of the current midge control method needs to be carried out. Particular reference should be made to the Black-winged Stilts and their reaction to or ingestion of pesticides. Any proposal that considers draining or filling Alfred Cove should be studied critically as RAOU data clearly illustrates the importance of this area for a remarkable diversity of birds.

All three areas are invaded to some degree by species of exotic plants. Alfred Cove in particular has pampas grass, pepper trees and caster oil bushes which threaten to infest areas of remnant native vegetation. The prevention of fire is important if native plants are to resist invading exotic plants. Uncommon birds such as the Buff-banded Rail have a small breeding population at Alfred Cove and these birds require healthy beds of native rushes for their survival.

Boating within and adjacent to mudflat areas should not be allowed. This would prevent problems of disturbance by landing parties and erosion by wash from speed boats.

To provide management prescriptions covering the rehabilitation of degraded areas.

Ensure that continued preservation of these unique portions of the riverscape which are in a relatively undisturbed or natural state.

Steps should be taken to preserve the ecology of the rivers for all time.

Identify key areas of ecological importance and the systems which are in immediate danger of destruction or serious degradation and protect immediately.

Implement a long term management programme which protects and stabilises the ecological system of the Swan and Canning Rivers upstream to the confluence of Wooroloo Brook, the lower Diversion Dam on the Helena River and the Brookton Road Bridge on the Canning River.

City of Canning commissioned a preliminary appraisal of the environmental impact of raising and maintaining a static water level in the Canning River as well as an ecological investigation to evaluate, both the efficiency of various options for mosquito control and their effect on the wetland environment.

The location of Canning River Wetland Reserve between the Riverton Bridge and Nicholson Road Bridge within the boundaries of the City and the high ecological value of this area has caused Council to look at ways of establishing a management structure to preserve the ecology and natural environment of this part of the Canning River. The City is acting in conjunction with the M.R.P.A. and interested community groups to produce a management plan which will take into account the study.

Sensitive environmental and conservation areas on foreshores should be fenced and access restricted.

### 1.6 **Transport**

No further riverside roads should be built, except possibly the Maylands area.

No more freeways or major arterial roads be constructed along the foreshores of the Swan and Canning Rivers.

Expression of concern over possible road link between Centenary Avenue and Riverton Bridge via the Canning River foreshore and/or Bridge Street and Fern Roads, Wilson. Acquired from submitor in 1962/63 M.R.P.A. to provide the general public with freedom of access to the river and foreshore and therefore should not go into forming a road.

Engineering works such as bridges should be built so as not to restrict the continuous use of the river by boats, particularly those involved in the tourist industry.

Objection to Burswood and Swan River Freeway Bridge across to Burswood, a proposed freeway interchange (60 ha) on the peninsula, including more bridges across the river for Swan River Drive, in addition to the new Beechboro/Gosnells Highway Bridge.

Canning River Foreshore area on eastern bank of Canning River between Shelley Bridge and High Road, where a proposed road would spoil foreshores and a bridge would go across the river to High Road.

Objection to Spencer/Chapman Road Link. A new bridge across the river near Mason's Landing as well as the road across the wetlands.

### 1.7 **Dredging and Reclamation**

Filling of foreshores and flood prone areas should be restricted to legitimate developments submitted with a foreshore management plan and in accordance with Council's policies.

Future management should prohibit further dredging and river reclamation unless an essential need can be established.

No further dredging operations should be allowed unless it is for maintenance of existing navigation channels. All future passenger vehicles should comply with existing levels in the river bed.

Halpern Glick Pty Ltd, Canning Water Study outlines the proposals which have been considered not to adversely affect the ecology of the basin and at the same time increase its value as a recreational asset. Scope for controlled dredging operations within this section of the Canning River which can maintain its ecological value as well as allow the waters to be used by recreational craft.

Consider the proposal to dredge adjacent to Centenary Park Reserve, Wilson where scouting, navel cadet activities are already taking place and a site for future yacht club has been located.

Because of the silting up of the Rocky Bay area it is suggested that no more dredging be permitted unless the spoil is removed out to sea.

A survey should be carried out to verify water depths to compare those with the last survey done by P.W.D.

An estimate of the cost of redredging the existing channel through Leeuwin Sand Bank should be made, as at low tide the larger ferries do not use this channel.

Observance that a great deterioration in abundance of fauna since the channel was dredged and the spoil deposited in the deeper areas.

## 1.8 Erosion

Mis-management, lack of control and continual undermining of the river banks, particularly Redcliffe.

No further stone or concrete walls should be built unless there is a demonstrable, practical need.

The claim that planing hulls travelling at speed do not create a wash must be rejected as the wash eventually reaches the shore as a considerable swell.

Further research and investigation should be carried out into the impact of boating on river banks and foreshores.

1.9 **Noise Pollution**

Noise complaints associated with river based activities particularly waterski - boat. Areas are Chidley Point and Deep Water Point although other isolated complaints, plus Rottnest Island Ferries and river cruise vessels.

Noise interfers with the comfort and repose of other persons in their homes.

1.10 **Hydrology**

Adoption of the P.W.D. policy on flood plain and floodways.

1.11 **Legislation**

The Jetties Act be repealed and that necessary provisions which are not obsolete be incorporated in a new piece of legislation.

1.12 **Litter**

People contribute to the litter problem by throwing objects into the river for pets to retrieve.

Persons using the foreshore still discard litter into the water and a campaign should be aimed at these people. Rubbish removal should occur more frequently. People should not leave garden cuttings on the foreshore to be washed into the river.

1.13 **Utility Services**

Any services or utilities proposed to traverse any waterways should have due consideration to location, visibility and environmental aspect. Generally, and where practical, services and utilities should be located underground.

1.14 **Water Quality**

Maintain water quality standards to ensure survival of the estuarine fauna and flora.

Set up a water quality monitoring programme.

1.15 **Boating**

The decision to designate Deep Water Point as a waterski area gave no consideration to the needs of ecology or passive recreation.

Unfortunately there is insufficient patrolling of areas where breaches occur. There is an urgent need for frequent and strong surveillance until deliberate offenders suffer a change of attitude. They all have the opportunity to use their boats on the ocean at speed without damaging the vulnerable still water area. The cost of increased surveillance should not be linked to boat license revenue but rather against general revenue.

It needs to be recognised that there are limitations to the number of water craft which the rivers can accommodate.

There is no need for power boats to travel at high speed in the estuary (limit 5 knots) as the ocean is available.

The increase in the number of power boats and their ability to intrude into shallow water at speed is damaging the ecology and detracting from the enjoyment of the river by people engaged in passive activities.

Wash and propellor turbulence damages the marine life and its environment and interferes with people using the shallow water for other activities.

The concentration of power boats on the Canning River at Deep Water Point is the greatest problem with power boats operating at speed in water shallower than two metres.

The impact of power boats is exacerbated by the assertive and intrusive attitude of some owners who exceed speed limits and move into shallow water.

The effect of the wake created by these large powered craft is causing an alarming amount of damage to property, particularly when the river is calm. A wake of approximately .75 - 1 metre is created straining jetties and brattice work. Consequently, maintenance and replacement of facilities is greater than anticipated.

All large Rottnest Island Ferries should terminate their journey at the Inner Harbour. Failing that, a further speed limit should be imposed on these large powered craft which would have the effect of diminishing the wake, and resultant damage to the foreshore and jetties.

Motor boat use of waterways should be managed to be consistent with the aims of conservation of environmental areas.

Jetties, ramps and beaching areas should be strategically located to provide a service to the public and to protect conservation areas.

Snags and other obstacles should be cleared from waterways to enhance the recreational ability of rivers.

No power boats upstream of Riverton Bridge.

Observations of members suggests that only about 50 percent of power boats observe the eight-knot speed limit between Canning Bridge, the South of Perth Yacht Club and Como Jetty.

Intrusion of power boats into the shallow water on river banks is of concern. Apart from the risk to people, the damaging effect of high speed propellers in shallow water is obvious (8). It is only reasonable that power boats should be restricted from operating in water less than two metres deep, except in designated launching areas.

High speed power boating and water-skiing should be re-located in Freshwater Bay where a much bigger and deeper area of water is available compared with the Canning River. The water sking area could include Karrakatta Bank where the water is relatively deeper than other river banks and less vulnerable to damage.

Conflict with other users should not be raised as an argument against the logical proposal to site the high speed boat traffic in deep water over a wide area. Competition by various interests will exist for use of the river in all its areas and it will be encumbent on all parties to achieve working relationships and it will be essential for them to initiate and abide by agreed or legislated controls.

There is a need to confine water scooters to navigable water and to existing speed limits.

A major source of damage to the river ecology and discomfort to river users is the continued passage of Rottnest Ferries between Perth and Fremantle. In parts of the river, ferry propellors churn up bottom mud and their size and speed creates wash which sweeps across damaging river banks and shallows. The wash also affects moored boats and penned boats at various locations. These vessels should be based at Fremantle and leave for Rottnest from Fremantle. Continued daily passage of these ferries cannot be justified if there is an earnest endeavour to attempt planned, logical management of the estuary.

It will also be necessary to prevent wash damage from large power boats travelling at speed through Melville Water and the lower reaches of the estuary on the way to and from the ocean.

There should be scope for sailboarding without affecting the natural ecology or other river users. Sailboards pose problems because they can operate in shallow water and also sails slapping on the water disturb fish life. Further, many sailboarders are young and inexperienced. A publicity programme is required to acquaint sailboarders with basic river ecology, the needs and rights of other river users and their risk relationship with other craft.

Similarly, catamarans and sailboards operating in Perth Water disturb the bottom, as do aluminium dinghies speeding around the area. A compromise would be to designate the shore area now in use west of Coode Street Jetty as a launching area for both types of craft with a sailing area limited by a line some distance east of the jetty across to a point on Langley Park foreshore so a closed area of shallows to the east could be protected.

Concern expressed over the increasing number of large powered craft being used on the Swan River, and driven at high speeds adjacent to the north shore of Melville Water, particularly the Rottnest Ferries (Sea Raider).

### 1.16 Safety and Education

The safety of junior sailers is of concern when large ferries or high powered large craft pass extremely close to them and they are hit by the wake. The problem is exacerbated by follow-up waves.

The people of Western Australia be made aware that use of the rivers by watercraft is reaching a point where safety is becoming a problem sufficiently serious to occasion warnings by the National Safety Council; that there be no more jetty, marina, yacht/boat club or launching ramp development in the Swan and Canning Rivers. (It would suit the many boat owners who only use the rivers to gain access to the ocean if further marina and launching ramp facilities were constructed on the ocean, provided they do not adversely affect the environment nor infringe the rights of access and use of local residents and beach users).

Because of the public nuisance effects of noise pollution and environmental damage caused by the wash of power boats moving at high speed there be imposed tight restrictions on the movement of private power boats on the upper reaches of the Swan and Canning Rivers and that these restrictions be rigidly enforced.

Research by the National Safety Council has found a steady growth in craft numbers using the rivers. To date, incidents on these waterways are usually minor events, engine failure the most common. Boat fires (about five per year) usually occur in pens or at anchor and present the greatest hazard to human life. Collisions are quite rare and then of minor nature. Though difficult to quantify, we see alcohol and boating as a problem that will have to be addressed by the State Authorities very soon.

Educational programmes for the pleasure boat owner are conducted all year by the National Safety Council. Special causes for Government bodies, commercial operators and aquatic sports clubs are also designed to meet special needs. The Water Safety Division staff are Australian Yachting Federation accredited examiners in TL3 power boat training. Examiners have qualified fifty instructors throughout Western Australia who in turn conduct practical training afloat for the boating public. "Training Trainers" has been under way for five years.

Boating safety is an increasing problem but mainly on the ocean. As more people take to the rivers (crowding) the boat population grows on the ocean. Sailboards have not presented a problem to date.

The National Safety Council is opposed to a <u>licence scheme</u> for boat operators. Five years ago the National Safety Council joined the Australian Yachting Federation Training Programme which provides training skills for all classes of boat power/sail. It is a voluntary programme which the National Safety Council would like to see endorsed by local authorities as a minimum level of competence for boat operators. The course involves practical and theory work.

### 1.17 Historic Sites

Development of the Swan Brewery site has been a continuous element in the social and industrial history of the City since the inception of white settlement. The brewery occupies a unique, highly visible and important site and is, therefore, a landmark. It provides a reference element in important vistas and provides a portal to the City and the Narrows. It also provides a unique vantage point for the enjoyment of the river and the City.

The scale and character of the brewery's principle elements have a congruous relationship with the Swan River, foreshore and Kings Park escarpment.

The brewery and its environmental precinct is a fine grouping of built and natural elements which forms one of Perth's notable pieces of urban landscape.

The chief visual elements of architectural significance in the whole complex are those unique buildings following the Victorian industrial tradition, i.e. the 1897 and 1920 Towers and the envelope that surrounds them, the 1920 Brew House, the 1923 and 1933 Celler Blocks, and the Victorian Stables on the opposite side of Mounts Bay Road. The visibility and importance of the site, the quayside, the large volumes and character of the main buildings and the proximity of Kings Park provide a unique opportunity to conserve and recycle this noteworthy landscape.

The following factors should govern future uses of the brewery and its site:

- The history of the site and its immediate environs.

- Sympathy for the nature of the principal brewery buildings.

- Congruence of the development of the site and its context.

- The proximity and close associations with the river.

- The physical relationship to Kings Park.

- Public accessibility along the foreshore.

Economic factors ought only to be addressed once the principles of character, use and ownership are determined.

Having regard to the six factors listed above it is considered that the site and its prinicple buildings could be suitable for:

- Depicting the history and significance of the site and its environs from earliest times until now.

- A museum of the breweries of Perth.

- A museum of the river.

- Associated public facilities such as quayside, entertainment and eating, movement and parking/mooring facilities (for river traffic, road traffic, cycles and pedestrians) and access between Kings Park and the foreshore.

Public uses such as these would not preclude private uses of the site providing that the overall character of development was not impaired.

1.18 **Recreation General**

Ban on unleashed dogs on beaches and made compulsory for owners to remove faeces deposited by their pets.

Dogs should not be permitted to swim at public swimming areas.

The cycleway around Cranford Avenue Bull Creek should be extended. The foreshore in the area has been alienated from the public by private citizen's fencing down to the foreshore.

The cycleway should be sited with a natural fringe between it and the river's edge.

Provision of parking close enough to picnic areas will need to be resolved.

Active use of waterways for recreation purposes should be encouraged in an orderly and proper manner where amenity and environmental problems will not occur.

- Restrict car access around the river.

- No carparking on the periphery of Ferndale Crescent.

- No horse riding as it is incompatible with the environment.

- Discourage non-aquatic sporting activities.

That to preserve the character of the foreshore of the Swan and Canning Rivers there be no development permitted for activities other than those which rely on the water for their practice or enjoyment.

While recognising the need for carparks, care be taken to keep them small, scatter them widely and site them in such a way that they are unobtrusive and do not impinge upon river and foreshore use; that any structures erected for/by public utilities in the vicinity of the rivers be designed to harmonise with their environment, and that existing structures be re-assessed and progressively modified where necessary to bring them into harmony with the environment.

That while the current enthusiasm for the construction of cyclepaths is to be commended, care should be taken to ensure that it can be tempered by concern for the needs of other foreshore users; that cyclepaths be sited appropriately and not necessarily right on the margin of the river but that they go inland over high headlands to give a variety of gradients and views; and that they be constructed of materials which harmonise with the river environment.

## 1.19 Proposed Development and/or Objections To Them

Objection to Majestic Hotel Site - A proposed marina "re-nourishment" of beaches and foreshore (i.e. filling).

Objection to Swan Brewery Site - Proposed development.

Shire of Swan wishes to develop part of a River Walk Trail:

- One section Kings Meadow Polo Grounds to Fish Market Reserve.
- West Midland Swimming Pool to Reg Bond Reserve.

- Access from Beverley Terrace to the river foreshore.

    - Constructed from gravel insitu soils.
    - Interpretative signs relating environmental historical aspects of the areas through which the trail passes.

Objection to Ashfield Flats - A proposed canal-type development on the flood plain of the river using land designated public open space.

America's Cup fever appears to have infected the developer community and the present State Government at all levels. This condition is in danger of leading to 'white elephant' type development, rushed decisions on the basis of inadequate information and the adoption of the first proposal advanced when review and careful reflection might well reveal other possible solutions which could prove to be cheaper, more convenient and environmentally less destructive.

Foreshore development which is non-profit water-oriented development, or water-based non-damaging sports and activities, affords breaks in the concrete 'choke', or possible realignment of Riverside Drive and down-grading of Mounts Bay Road has merit.

Non-merit in increasing ferry traffic, boat harbours and marinas which would effect the ecology, hotels with restaurant facilities which would increase parking problems or shore-based leisure premises leading to parking problems and creating an eyesore.

No development which could be placed elsewhere should be allowed on the central city foreshore and should be maintained as beautiful open space.

The proposed marina near Pt. Dundas should be prevented as the dredging operations would remove one of the best prawning areas in the Melville Water area of the Swan River. The erection of the marina would create another eyesore and alienate public from direct water contact.

Proposed extensions to the SPYC Marina should be prohibited as this area is now grossly overcrowded.

1.20 **Access**

Assess the existing impact and rectify existing problems immediately through the control of access.

Regulate the access of government public works and management authorities.

Identify the carrying capacity and treat accordingly.

Continuous access be provided along the river foreshore. Access might be handled as per British model where access is available through private land.

No alienation of water frontage Crown Land or public land owned by a municipality or other division of the government should be allowed.

Where there are no riverside roads, access should be for people on foot or bicycle for preference, except a few areas for people prawning, picnicking or crabbing on the foreshore.

That existing access on foot to the rivers be preserved and that, where foreshore areas have been alienated from public access on foot, this access should be progressively restored as the opportunity arises. (This clause particularly applies to some earlier developments and subdivisions, such as those in the Mosman, Claremont and Dalkeith areas.

Maximise public contact (both physical and visual) with the riverscape without detracting or endangering its viability as a natural system.

Maintain <u>controlled</u> access to the riverscape.

1.21 **Amenity**

Study of visual catchment. Definition of focal points. These to be an integral part of the management plan.

Swan River Foreshore at the Swan Brewery site is spoilt while the building between the road and the river still remains standing.

That it be recognised that the rivers are valuable because of their natural beauty which can be enhanced by appropriate development but that if ill-considered, development ruins this visual resource and destroys Perth's most valuable asset.

The scale of the river be preserved by the acceptance for buildings erected in its vicinity of a system of height restrictions providing for specified maximum heights at specified distances from the river; and that ideally we should move towards a position where there is some overall aesthetic control over buildings on both private and public land which impinge visually upon the river environment.

# CHAPTER 18 : POLICIES

## PART 1 WATERWAYS COMMISSION POLICIES

### 1.0 WATERWAYS COMMISSION - PHILOSOPHIES

It is the "General Policy" of the Waterways Commission:

- To retain the integrity of the waterways and related foreshore environments under the Commission's authority in physical character, aesthetic appeal and functional relationships.
- To protect and improve the indigenous flora and fauna, provide recreation facilities for the public and formulate a basis of control to ensure the users do not destroy or over-exploit the waterways, the facilities provided or the indigenous flora and fauna and to inform and educate the public as to the true value of this natural resource.

### 1.1 Research

To carry out research so that meaningful planning and management can be achieved.

### 1.2 Planning

To determine and guide proposals which will enhance the waterways and foreshores, allowing development in accordance with the requirements of the public, while retaining the basic characteristics of the waterways as described in the "General Policy" of the Waterways Commission.

### 1.3 Management and Restoration

To establish a programme of work which will benefit the waterways and waterway users and provide a working knowledge of the waterways which will evolve into a system for maintaining them in natural state as far as desirable.

- Prepare a work schedule for a regular maintenance programme for the waterways and foreshores.
- Determine on an annual basis, restoration projects which will contribute to preserving the natural character of the waterways.

1.4 **Emergency Procedures**

To establish systems of action to promptly locate, control and correct sources of contamination and erosion within the waterways, their tributaries, drains and foreshore areas.

1.5 **Preservation**

To identify and protect those areas which are sensitive, unique or uncommon within the waterway system and to undertake future planning for these areas to ensure their preservation.

1.6 **Education**

To develop a programme of education which will create respect for the understanding of the waterways.

1.7 **Regulatory**

Cause to be enacted such regulations and by-laws as are necessary to achieve these general aims.

2.0 **FORESHORE RESERVES**

This is a general policy statement on foreshore reserves to guide the Waterways Commission and Management Authorities (here after referred to as "the Commission") in management planning and usage of the foreshores along waterways within the management areas.

It is the duty of the Commission to conserve and manage the rivers, inlets and estuaries under the jurisdiction of the Waterways Conservation Act (1976 - 1982). Part of this function is to preserve or enhance the quality of the environment and amenities of the waters and associated land.

2.1 **General Objectives**

Fundamentally, the foreshore reserve exists because there is a waterway.

The general objective is to maintain the natural character of the waterways except where it is appropriate to enhance the amenities provided by the rivers.

Where it is appropriate to maintain the natural condition of the waterways natural processes such as floods, erosion and accretion will change the banks.

In order to enable these natural processes to occur without damage or loss of property and provide for public access and utilisation, foreshore land is being reserved.

The Town Planning Board policy (5th April 1982) is to require provision of a foreshore reserve when a subdivision includes land abutting a waterway.

In its submissions to the Board for the reservation of foreshore land the Commission should advise on the appropriate width and use, and in doing so, highlight the distinguishing features.

2.2 **Purpose**

The purpose for which the foreshore is reserved should be identified. This will influence the determination of the reserve width and justifies the reservation.

2.2.1 **Flood Storage**

Flood prone land adjacent to the waterways is for the storage of flood waters and providing a means for their escape preventing more severe flooding.

Filling and/or development of flood prone land may interfere with flood waters to the detriment of other land owners.

To maintain the characteristics of flood prone land there is a case for reservation.

2.2.2 **Environmental Protection - Flora and Fauna**

The general purpose of a foreshore reserve is to provide a buffer so that activities which may be carried out on adjacent land do not disturb the environment of the waterways. Where adjacent land activities may have a major effect on the waterway environment (traffic, buildings, industry) the reserve may need to allow for a vegetation buffer.

Foreshore vegetation is an integral part of the aquatic ecosystem, particularly important to this ecosystem are the estuarine wetlands. It is appropriate to reserve areas for the protection of plant and animal communities associated with waterways.

2.2.3 **Recreation**

Reserves along the State's major waterways are of regional significance and cannot be considered exclusively as local open space. These waterways attract people from areas far removed from the local area, who come into the area with the express purpose of using the waterways.

Recreation on these foreshore reserves should be water oriented (fishing, swimming, boating, walking). Active recreation pursuits such as sports that are not water oriented should be located away from the foreshores.

### 2.2.4 Public Access to the Waterways

One of the primary purposes or reserves is to enable people to utilise the amenities of the waters. In some cases facilities such as jetties, launching ramps and swimming areas may be appropriate.

### 2.2.5 Bank Maintenance

The reserve should be adequate to allow natural processes such as erosion and accretion to take place without interfering with land use adjacent to the waterways.

### 2.2.6 Other

There may be other purposes for which foreshore land should be reserved.

Not all of these uses will be compatible. Management plans for some foreshores will be necessary to designate and control the use of the various purposes of the foreshore reserve.

### 2.2.7 Criteria for Width

The topography is a prime consideration together with the intended use/s. The width of any reserve may be variable. Reserves with eroding banks should allow for the loss of land to attain a stable shoreline without compromising other uses.

The required width of a foreshore reserve varies according to the size of the waterway.

Generally a reserve of 50m minimum is required along the estuarine lagoons and rivers. Further upstream where rivers become much narrower and public usage is more limited (pedestrian traffic and canoeing) a 10m reserve providing this access and a vegetation easement may be all that is necessary. These widths are a guide only and will vary according to individual circumstances.

### 2.2.8 Public Access

In general the provision of access to foreshore reserves by cul-de-sac roads or loop roads is acceptable and prevents the use of foreshore roads as main traffic carriers.

Cul-de-sacs with parking will concentrate foreshore activities to areas where facilities can be provided to cater for the public. This strategy does not commit the entire reserve to a high level of costly management. Access to the reserve is achieved with a varying degree of difficulty.

There will be situations where a subdivision should be separated from a public reserve by a road to prevent incursion by residents. Owners of land abutting narrow reserves tend to encroach on them with unauthorised developments and thereby cause the general public to think the foreshore is privately owned and not for its enjoyment.

## 3.0 PRIVATE JETTIES

### 3.1 Existing Private Jetties

3.1.1 Located abutting private property which has a waterside boundary.

**Policy**

Owners of this class of jetty to enjoy continued use subject to compliance with all the requirements of the licence granted under the Jetties Act.

3.1.2 Located abutting a public reserve or a road reserve.

**Policy**

Owners of this class of jetty to enjoy continued use subject to compliance with all the requirements of the licence granted under the Jetties Act.

### 3.2 Transfer of Private Jetties

3.2.1 Located abutting private property which has a waterside boundary.

**Policy**

Recommend approval for the transfer provided that the jetty is in good order as required by the licence at the time of the application for transfer to the new owner and to the satisfaction of the management authority.

3.2.2 Located abutting a public reserve or a road reserve.

**Policy**

Recommend approval for the transfer provided that the jetty is in good order as required by the licence at the time of the application for transfer to the new owner to the satisfaction of the management authority.

3.2.3 **Special Conditions**

1. Swan/Canning River Management Area - the new owner to reside either in front of or diagonally to the jetty.

2. Leschenault and Peel Inlet Management Area - transfers of jetty licences will not be recommended where the applicant does not own property in the locality adjacent or near to the jetty - e.g. Mandurah townsite structures - Mandurah property owner, Riverview structure - Riverview property owners etc.

### 3.3 Applications to Construct Private Jetties

3.3.1 Located on private property which has a waterside boundary.

**Policy**

These applications may be recommended for approval provided that:

- The design of the jetty shall comply with the minimum standards for such structures as set by the Manager Engineering, Department of Marine and Harbours.
- The owner of the private property produces a copy of his title verifying the waterside boundary.
- It will not interfere with navigation or current recreational use of the adjacent waters.
- Its length is not in excess of six (6) metres measured from H.W.M. and width not in excess of 1.5 metres.

### 3.3.2 Special Conditions

Swan River Management Area -

The Swan River Management Authority would not recommend any new jetties downstream of the "Narrows Bridge" or the "Canning Bridge" unless there are real extenuating circumstances.

The Swan and Canning Rivers and their foreshores in the metropolitan area are within the SPC's "Metropolitan Region Scheme". An application to construct a jetty must also be made to that Authority.

3.3.3 Located abutting a public reserve or road reserve.

**Policy**

All applications for permanent structures of this nature be refused.

3.3.4 **Special Conditions**

A Management Authority may under special circumstances recommend approval for a temporary jetty abutting a reserve (e.g. a floating jetty was recommended for approval in Fremantle abutting the road reserve opposite the "Captain Fremantle" for use by an America's Cup syndicate conditional to it being removed after the race).

## 4.0 PRIVATE BOATSHEDS OR BOATHOUSES

### 4.1 Existing Private Boatsheds or Boathouses

4.1.1 Located abutting private property which has a waterside boundary

**Policy**

Owners of a boatshed or boathouse to continue to enjoy continued use subject to compliance with all requirements of the licence granted under the Jetties Act.

4.1.2 Located abutting a public reserve or road reserve.

**Policy**

Owners of a boatshed or boat house to continue to enjoy continued use subject to compliance with all requirements of the licence granted under the Jetties Act.

### 4.2 Transfer of Private Boathsheds or Boathouses

4.2.1 Located abutting private property which has a waterside boundary.

**Policy**

Recommend approval for the transfer provided that the boatshed or boathouse is in good order as required by the licence at the time of the application for transfer to the new owner and to the satisfaction of the management authority.

4.2.2 Located abutting a public reserve, road reserve or public jetty or wharf.

**Policy**

Recommend approval for the transfer provided that the boatshed or boathouse is in good order as required by the licence at the time of the application for transfer to the new owner and to the satisfaction of management authorities.

4.2.3 **Special Conditions**

1. Swan/Canning River Management Area - the new owner to reside either in front of or diagonally to the structure.

2. Leschenault and Peel Inlet Management Area transfers of licences will not be recommended where the applicant does not own property in the locality adjacent or near to the jetty - e.g. Mandurah townsite structures - Mandurah property owner, Riverview structure - Riverview property owners etc.

4.3 **Application to Construct Boatsheds or Boathouses**

**Policy**

All applications will be refused.

5.0 **PUBLIC JETTIES - OWNED BY COMMERCIAL ENTERPRISE AND LOCAL GOVERNMENT**

5.1 **Existing Public Jetties**

5.1.1 Located abutting privately owned property.

**Policy**

The owners of the jetty to continue to enjoy continued use subject to compliance with all requirements of the licence granted under the Jetties Act.

5.1.2 Located abutting a public reserve or road reserve.

**Policy**

The owners of the jetty to continue to enjoy continued use subject to compliance with all the requirements of the licence granted under the Jetties Act.

5.2 **Transfer of Public Jetties**

5.2.1 Located abutting privately owned land.

**Policy**

Recommended approval for the transfer provided that the jetty is in good order as required by the licence at the time of application for transfer to the new owner and to the satisfaction of the management authority.

5.2.2 Located abutting a public reserve or road reserve.

**Policy**

Recommend approval for the transfer provided that the jetty is in good order as required by the licence at the time of application for the transfer to the new owner and to the satisfaction of the management authority.

5.3 **Application for New Public Jetties by Commercial Enterprise or Local Government Authorities**

5.3.1 Located abutting land zoned commercial which has a waterside boundary.

**Policy**

These applications may be recommended for approval provided that:

- The design of the jetty shall comply with the minimum standards for such structures set by the Manager Engineering Department of Marine and Harbours.

- The owner of the public jetty produces a copy of the title verifying the waterside boundary.

- It will not interfere with navigation of the adjacent waters.

5.3.2 Located abutting a public reserve or road reserve.

**Policy**

These applications may be recommended for approval provided that:

- The design of the jetty shall comply with the standards set by.

- It will not intefere with navigation of the adjacent waters.

- If that jetty application is submitted by a commercial enterprise then an agreement must be made with the local government authority containing at least the following:

    i) The local government authority accepting the jetty and applying for the jetty licence.

    ii) The commercial enterprise to pay all costs relating to the cost of the jetty.

iii) The commercial enterpise's acceptance of all maintenance costs of the jetty.

iv) The jetty being available for use by the public.

### 5.3.3 Special Conditions

**Swan River Management Area**

The Swan and Canning Rivers and their foreshores in the metropolitan area are within the M.R.P.A's "Metropolitan Region Scheme". An application to construct a jetty must also be made to that Authority.

The Swan River Management Authority would not recommend any new jetty downstream of the Narrows Bridge or the Canning Bridge unless there were real extenuating circumstances.

## 6.0 LAUNCHING RAMPS AND SLIPWAYS

### 6.1 Existing Launching Ramps and Slipways

6.1.1 Located abutting private land which has a waterside boundary.

**Policy**

Owners of the launching ramps and slipways to enjoy continued use subject to compliance with all the requirements of the licence granted under the Jetties Act.

6.1.2 Located abutting a public reserve or road reserve.

**Policy**

Owners of the launching ramps or slipways to enjoy continued use subject to compliance with all the requirements of the licence granted under the Jetties Act.

### 6.2 Transfer of a Private Launching Ramp or Slipway

6.2.1. Located abutting private property which has a waterside boundary.

**Policy**

Recommend approval for the transfer provided that the launching ramp or slipway is in good order as required by the licence at the time of the application to transfer to the new owner and to the satisfaction of the management authority.

6.2.2. Located abutting a public reserve or a road reserve.

**Policy**

Reccommend approval for the transfer provided that the launching ramp or slipway is in good order as required by the licence at the time of the application to transfer to the new owner and to the satisfaction of the management authority.

6.2.3 **Special Conditions**

The Swan River Management Authority requires launching ramps and slipways to be of good engineering design and unless they are in first-class condition they will not be recommended for approval for the transfer.

Swan/Canning River Management Area - the new owner to reside either in front or diagonally to the structure.

Leschenault and Peel Inlet Management Area - transfers of licences will not be recommended where the applicant does not own property in the locality adjacent or near to the jetty - e.g. Mandurah townsite structures - Mandurah property owner, Riverview structure - Riverview property owners etc.

6.3 **Application to Construct a Launching Ramp or Slipway**

6.3.1 Located abutting private land which has a waterside boundary.

**Policy**

These applications may be recommended for approval provided that:

- The design of the launching ramp or slipway shall comply with minimum design standards for such structures set by Manager Engineering, Department of Marine and Harbours.
- The owner of the land produces a copy of the title verifying the waterside boundary.
- The structure will not interfere with navigation of the adjacent waters.

6.3.2 Located abutting a public or road reserve.

**Policy**

These applications will not be recommended for approval.

7.0 **BRIDGES**

7.1 **Existing Bridges**

7.1.1 Having waterside boundaries on both sides of the river.

**Policy**

Owners of a bridge to enjoy continued use subject to maintaining it to a standard set by the Manager Engineering, Department of Marine and Harbours.

7.1.2 Public bridges owned by MRD, Local Government Authorities, MWA or Westrail

**Policy**

Owners of a bridge to enjoy continued use subject to maintaining it to a standard set by the Manager Engineering, Department of Marine and Harbours.

7.2 **Application for Transfer of Private Bridge**

**Policy**

Approval may be given for the transfer provided that the bridge is in good order as required by the standards set by the Manager Engineering, Department of Marine and Harbours.

7.3 **Application to Construct a Bridge**

7.3.1 Located on private land which has waterside boundaries on both sides of the river.

**Policy**

Approved to construct a bridge may be given provided that:

- The design of the bridge shall comply with the minimum design standards for such structures set by the Manager Engineering, Department of Marine and Harbours.

- The owner of the land produces a copy of the title verifying the waterside boundaries both sides of the river.

- The structure will not interfere with navigation of the waters.

- The design of the bridge is such that it gives the minimum interference to flood waters.

7.3.2 **Public Bridges**

**Policy**

Approval to construct a bridge may be given provided that:

- The design of the bridge shall comply with the minimum design standards for such structures set by the Manager Engineering, Department of Marine and Harbours.

- The design of the bridge is such that it gives minimum interference to flood waters.

- There is access along the foreshore beneath the bridge.

- Fishing platforms, pedestrian and cycleways should be included where practicable.

## 8.0 RETAINING WALLS (REGULATION 15 WATERWAYS CONSERVATION REGULATIONS 1981)

**Notes**

1. A licence is necessary to construct a retaining wall.

2. There is no provision to licence retaining walls.

3. A retaining wall must not be removed without first obtaining the written permission of the Commission or relevant Management Authority.

4. The Commission may by notice in writing require the person having control of the retaining wall to carry out such maintenance it considers appropriate.

### 8.1 Existing Retaining Walls

8.1.1 Located on private land which has a waterside boundary.

**Policy**

The owner of a retaining wall to enjoy continued use subject to monitoring it in accordance with the provisions of Regulation 15 of the Waterways Conservaton Regulations 1981.

8.1.2 Located abutting public land - M.R.D. - L.G.A.

**Policy**

The owner of a retaining wall to enjoy continued use subject to maintaining it in accordance with the provisions of Regulation 15 of the Waterways Conservation Regulations, 1981.

8.2 **Transfer of Retaining Walls**

The Waterways Conservation Regulations 1981 do not contain any provision relating to the transfer of retaining walls.

8.3 **Applications for Retaining Walls**

8.3.1 Located on private land which has a waterside boundary.

**Policy**

A licence to construct a retaining wall (Form 4, Schedule 1 of the Waterways Conservation Regulations 1981) may be issued subject to:

- The design of the retaining wall shall comply with the minimum design standards for such structures set by the Manager Engineering, Department of Marine and Harbours.

- The design of the retaining wall shall in the opinion of the Management Authority be in harmony with the area where it is proposed.

- That the construction of a retaining wall is essential to provide stability to the bank.

- The owner produces a certificate of title verifying that the private land has a waterside boundary.

- The retaining wall shall not enter into the waterway beyond the waterside boundary of land except:

  i) Where a vertical wall is proposed and the waterside boundary of the land is shown on the diagram and the title is an irregular line. The wall may be constructed on a fair average straight alignment.

  ii) Where a sloping or battered wall is proposed the point at which the wall meets the line of the mean summer tide as determined by the relevant authority, shall not project beyond the boundary of the land except where a fair average line is approved as in (i) above.

iii) In the event of a dispute between the Commission and the owner as to the location on ground of the waterside boundary of the land, a licenced Surveyor shall be appointed at the cost to the owner to determine and peg the boundary.

8.3.2 Located on public land abutting the water.

**Policy**

- A licence to construct a retaining wall (Form 4, Schedule 1 of the Waterways Conservation Regulations 1981) may be issued provided that:

- The design of the retaining wall shall comply with the minimum design standards set by the Manager Engineering, Department of Marine and Harbours.

- The design of the retaining wall shall in the opinion of the Management Authority be in harmony with the area where it is proposed.

- That the construction of a retaining wall is essential to provide stability to the bank.

- The retaining wall shall not extend beyond the waterside boundary of the land except:

  i) Where a vertical wall is proposed and the waterside boundary of the land is shown in the diagram and the title is an irregular line the wall may be constructed on a fair average straight alignment.

  ii) Where a sloping or battered wall is proposed the point at which the wall meets the line of the mean summer tide as determined by the relevant authority shall not project beyond the boundary of the land except where a fair average line is approved as in (i) above.

  iii) In the event of a dispute between the Commission and the owner as to the location on ground of the waterside boundary of the land, a licenced surveyor shall be appointed at the cost of the owner to determine and peg the boundary.

9.0 **MARINAS AND BOAT PENS WITH WATER LEASE AND JETTY LICENCE**

9.1 **Existing Marinas and Boat Pens**

Owners of these marinas to enjoy continued use subject to compliance with all the requirements of the licence granted under the Jetties Act.

Extension of pens or re-arrangement of pens may be recommended provided that:

i) The extension of pens or re-arrangement of pens must be within the existing water lease.

ii) The design of the pens shall comply with the minimum design standards for such structures set by the Manager Engineering, Department of Marine and Harbours.

9.2 **Application to Transfer a Marina**

**Policy**

Approval may be recommended to transfer a marina provided it is in good order as required by the standards set by the Manager Engineering, Department of Marine and Harbours.

9.3 **Application to Construct a Marina Located on Privately Owned or Leased Land with a Waterside Boundary**

**Policy**

There is sufficient water area available without interference to navigation, swimming areas, water skiing areas or wildlife reserves.

The design of the marina and pens shall comply with the minimum design standards for such structures set by the Manager Engineering, Department of Marine and Harbours.

9.3.1 **Special Conditions**

**Swan River Management Area**

The Swan River Management Authority considers that no more marinas should be constructed in the Swan or Canning Rivers.

10.0 **RESTAURANTS AND TEAROOMS**

10.1 **Existing Restaurants and Tearooms**

10.1.1 Located on or adjacent to a foreshore where the natural landscape has already been substantially modified abutting either public land or privately owned land.

**Policy**

Owners of these restaurants to enjoy continued use subject to compliance with the provisions of the Jetties Act.

10.2 **Transfer of Restaurants or Tearooms**

10.2.1 Located on or adjacent to a foreshore where the natural landscape has already been substantially modified.

**Policy**

Approval may be recommended to transfer a restaurant/ tearoom provided it is in good order in accordance with standards set by the Manager Engineering, Department of Marine and Harbours.

10.3 **Application to Construct a Restaurant or Tearoom**

10.3.1 Located on or adjacent to a foreshore where the natural landscape has already been substantially modified.

**Policy**

Approval may be recommended to construct a restaurant/ tearoom provided, the design standards for such structures set by the Manager Engineering, Department of Marine and Harbours.

10.3.2 **Special Conditions**

**Swan River Management Area**

The Swan River Management Authority believes that structures should not be built on or over the Swan or Canning Rivers unless they are necessary to enable public use and enjoyment of the river.

A proliferation of restaurants along the river would be undesirable. However, there could be some further opportunities for people to eat in riverine surroundings.

The establishments should not encroach on the river.

The Authority respects the Local Authorities' desires to accord with the wishes of the Communities they represent and to keep their waterfront areas in an attractive condition, including preservation of vistas and access along the waterfront. Therefore most suitable sites for restaurants are those that have already been modified.

PART II **SWAN RIVER MANAGEMENT AUTHORITY POLICIES**

11.0 **DREDGING POLICY - SWAN RIVER MANAGEMENT AUTHORITY**

- Dredging in the river system *A should only be permitted in order to maintain existing navigational channels and boat harbours. Other dredging shall only be undertaken with the approval of the Authority on the advice of the Manager Engineering Department of Marine and Harbours.

- Spoil from dredging should not be:

  i) Dumped in the river system.

  ii) Used for the reclaiming of "wetlands" adjacent to the river.

  iii) Placed on a foreshore as a method of beach renourishment, unless it can be shown that material so placed will not eventually be eroded and deposited back into the river.

- Spoil from dredging should be removed from the river system and disposed of away from the system by either trucking away to land or by barging to sea. *B

*A The river system includes the foreshore areas where dumping of spoil could have adverse effects in eventually finding its way back into the area of the river from which it was removed.

*B Barging to sea could involve Commonwealth Government approvals.

12.0 **POLICY ON STORMWATER DISPOSAL - SWAN RIVER MANAGEMENT AUTHORITY**

Stormwater from residential buildings, commercial buildings, industrial sites and adjacent carparks servicing such buildings constructed adjacent to the river, is to be disposed of on site unless special approval has been obtained from the Swan River Management Authority.

13.0 **POLICY ON DEVELOPMENTAL PROJECTS - SWAN RIVER MANAGEMENT AUTHORITY**

If the work is not commenced and completed within the period of one year commencing from the date shown on the letter of approval, application for renewal of the approval will be mandatory and if this renewal is granted the Authority reserves the right to vary the conditions of approval.

## 14.0 OIL SPILLAGE, INDUSTRIAL PREMISES - SWAN RIVER MANAGEMENT AUTHORITY

### Special Note

There have been a number of occasions when there have been spillages of oil in industrial premises and the oil has escaped from them into stormwater drains.

### Policy

It is recommended that all Local Government Authorities, when issuing permits to build in unsewered areas, ensure that adequate measures are taken to prevent polluting materials, such as oils, from entering stormwater drains or percolating through the ground into stormwater drains.

## 15.0 POLICY ON SLIPPING FACILITIES - SWAN RIVER MANAGEMENT AUTHORITY

When hardstanding areas are created for use for vessels removed from the water via a hoist, then an intercepting drain should be constructed so as to prevent material from the boat on the hardstand washing back into the river.

The intercepting drain is to be covered with a mesh, which will pick up all of the larger pieces of material and the smaller particles will pass into a fine particle trap into a settling tank.

The settling tank will be constructed in such a way that it can be periodically cleaned out.

(Policy only to relate to new installations).

## 16.0 POLICY ON RUBBISH DISPOSAL SITES ADJACENT TO THE SWAN AND CANNING RIVER - SWAN RIVER MANAGEMENT AUTHORITY

No new tips should be approved adjacent to the rivers or to streams which feed into them.

This Authority is opposed to the initiation of rubbish dumping on sites adjacent to the rivers which are already gazetted but not currently in use.

This Authority is opposed to any expansion to the existing rubbish tip sites adjacent to the rivers and considers that the existing sites be closed as soon as practicable.

## 17.0 POLICY ON HOUSEBOATS - SWAN RIVER MANAGEMENT AUTHORITY

### Special Note

The definition of a houseboat means "any vessel or pontoon that is held or let"

(a) As a place of habitation where such use be as temporary, intermittent or permanent.

(b) As a place for accommodating or receiving persons for purposes of shelter, recreation, entertainment or refreshment.

(c) As club or business premises.

Does not include a vessel being temporarily used for any of the purposes in subparagraphs (a), (b) or (c) of this paragraph if the vessel is normally employed in carrying goods or passengers, or both, for reward or plying for hire for the carriage of goods or passengers, or both.

### Policy

Houseboats should not be permitted to be located on the Swan-Canning Estuarine System. Houseboats are not compatible with other river users for the following reasons:

- The waterways are central to the Perth metropolitan region and are easily accessible to the 900 000 inhabitants of the metropolitan area.
- Considerable pressure is already placed on the waterways and the foreshore environment.
- Its main use is an active recreational resource both aesthetically and physically.
- The waterways are under pressure from recreationists for its use and some persons may claim that it is at a saturation point now.
- Houseboats moored permanently will take up recreational water which should be available to all users.
- People don't have to live on the river - there is no shortage of land.
- The navigable water above the Causeway is limited and is also subject to flooding, during which time it would be dangerous for any vessel particularly houseboats.

- Downstream of these bridges there are only a limited number of mooring areas suitable for all weather conditions. There is already keen competition for these areas by Yacht Clubs, private boating enthusiasts, windsurfers, swimmers etc.

## 18.0 VENDING ON THE RIVER - SWAN RIVER MANAGEMENT AUTHORITY

The Authority's policy is to oppose vending on the river as it is not an appropriate use. River congestion is getting to the point where activities not essential for river use should not be allowed. This kind of commercial activity is undesirable, the river should be kept specifically for marine activities.

## 19.0 POLICY ON CYCLEPATHS DUAL-USE PATHS - SWAN AND CANNING RIVER FORESHORES - SWAN RIVER MANAGEMENT AUTHORITY

The Authority is in agreement with cycletracks along the foreshores of the waterways subject to the following:

(a) The cyclepath should not be on the riverbank as this would reduce the access for the rest of the public who wish to use the river for various recreation purposes.

(b) The cyclepath should not divide the reserve but should be designed in such a way that is is on the roadside of any carparking facilities.

(c) The cyclepath should be sited at least a minimum of 10 metres away from the river's edge. However, the authority would prefer to see the cyclepath towards the back of the reserve similar to the Matilda Bay cyclepath.

(d) Where there is only a very narrow reserve, less than 10 metres, there shoud not be any cyclepath. The cyclepath should be incorporated into the roadway and given the appropriate status. Alternatively the cyclepath could detour away from the river to other areas of scenic, historic or scientific interest.

(e) The cyclepath should only be brought closer to the river at selected points. These could incorporate rest areas for walkers and cyclists.

The Authority accepts that exceptions to the rule exist such as Mounts Bay Road where the cyclepath is adjacent to an extremely busy road.

20.0 **AQUATIC CLUB - POLICY**

20.1 **New Clubs**

- Applications will be received from newly formed Yacht Clubs for approval to establish a yacht club adjacent to the waters subject to:

  i) The Club is legally constituted and has a membership of at least fifty members.

  ii) It is financially sound and can show proof to the satisfaction of the Commission of the means by which proposed improvements can be financed.

- Each application must give details as follows:

  i) The location and ownership of the land they require for their shorebased facilities.

  ii) The water area which is considered necessary for their operations both immediate and for future expansion.

  iii) A sketch plan showing proposed initial layout, coloured red with possible future extensions coloured blue.

  iv) Any other information the Commission may require before considering the application.

- The relevant Management Authority will consider such applications and after receiving the advice of the Authority the Commission may, at its discretion, grant or refuse approval. Such approval will be subject to the terms and conditions as set out in Section 20.2.

20.2 **Established Yacht Clubs**

- The approval given to a yacht club to operate in accordance with the requirements of this section will not in any way invalidate the terms of the Waterways Conservation Act, 1976, and the Waterways Conservation Regulations.

20.2.1 - Maintenance of buildings, boat pens, jetties, slipways etc. All fixed structures i.e. club house jetties, mooring pens, launching ramps, slipways etc., must be maintained in good order and condition.

Inspections will be carried out at regular intervals and where maintenance is found to be deficient the club will be notified accordingly and must comply with any instructions given by the Management Authority.

- General tidiness and disposal of wastes and rubbish. The premises must, at all times, be kept in a tidy condition. Large containers of ample capacity for dry rubbish must be placed on shore and each jetty and arrangements made with the Local Authority for these to be emptied at regular intervals. Suitable containers for receipt of liquid wastes i.e. sump oil, must also be provided and arrangements made for regular removal of these wastes.

  Where it is found that rubbish, litter or waste oils are being discharged into the waters the Authority may take legal action under Section 22 and 23 of the Waterways Conservation Regulations.

## 20.3 Construction Works

20.3.1 New Works

Before proceeding with any new construction within their boundaries, clubs must submit plans and specifications of their proposals in duplicate to the appropriate Management Authority. The Commission may at its discretion approve, amend or reject the proposals. Where the plans have been amended or rejected, the Commission will provide the Club with its reasons for either amending or rejecting the proposals.

Construction work on the proposals must commence within six months of receipt of approval from the Commission, otherwise the approval will lapse and the club must re-apply for approval.

20.3.2 Additions to Existing Structures

Any additions, alterations or new works, except general maintenance, must be approved by the Commission. Applications for approval must be accompanied by adequate plans and specifications showing existing work coloured blue and proposed new work coloured red. Where the club has received approval for other works which have not been commenced, these should be shown coloured green.

20.3.3 The club will be responsible for ensuring that all construction debris is removed from the site and that no timber offcuts or other materials be dropped into the waters during the construction period.

20.4 **General**

- Club houses and other auxiliary buildings; these must comply with the local building by-laws and must be aesthetically pleasing when viewed from the waters and shall be not less than 30 metres from High Water Mark.

- Jetties, slipways and launching ramps; these may be constructed of timber, concrete or steel or any combination of these materials subject to their design meeting engineering requirements as to strength and durability. Discarded tyres may be used as fenders provided they are reasonably uniform in size and are painted white.

- Public Access; where the lease of the land area granted by an appropriate Authority for the purpose of establishing a club extends to High Water Mark, the public must, at all times, be permitted to traverse this section and no fences are to be constructed by the club concerned which will deny such access.

- Where, if at any time in the future, legislation is passed requiring certain types of private boats to be fitted with holding tanks for the receipt of domestic wastes, clubs will be required to provide, at their cost, suitable pumping out equipment and disposal to sewer or septic tank installation as approved by the Commission.

21.0 **POLICY ON MAINTENANCE OF MARINA AREAS**

21.1 **Tyres**

Tyres may be used as buffers on jetties provided the following conditions are adhered to:

i) The size is uniform.

ii) The tyres are painted white.

iii) They must be fixed to the jetty in conformity with a manner approved by the Authority.

iv) Sections of tyres - also to be of uniform size and painted white - may be fixed vertically to outside pen piles to be used as buffers when boats are manoeuvring. No other materials to be used for this purpose unless approved by this Authority.

v) Tyres must be used in no other form and for no other purpose.

(The requirement is necessary as inspections have revealed that this aspect of pen systems is generally untidy and in some instances most unattractive as a result of the disorderly use of a number of unsuitable materials).

21.2 **Renewal of Substantial Structures**

Any proposal to alter or add to existing structures must be the subject of an application to the Authority.

Minor replacements may be referred to the office by telephone, an inspector will then make an examination who will report to the Chairman who will make a decision.

It is stressed that all other renewals must be the subject of a formal application to the Authority.

21.3 **Maintenance Work**

All maintenance work must be carried out as and when necessary. This requirement is to ensure that such work is not left until pointed out by the Works and Structures Committee during its annual onsite inspection.

21.4 **Maintenance Dredging and Dispoal of Fill**

Any dredging or draglining carried out within the mooring area must be the subject of an application to the Authority.

Such projects could have a bearing on river training.

21.5 **Underground Waste Tanks**

It is required that all Yacht Clubs and similar establishments shall install an underground tank (or tanks - depending on the extent of the pen system), with a minimum nominal capacity of 100 gallons each tank, with fittings to enable pumping out for cartage to an approved waste disposal area. Alternative suggestions will be considered.

Evidence exists that in some instances sump oil, etc., is reaching the river and in the main, facilities are not available for orderly disposal.

21.6 **Disposal of Rubbish**

The Authority insists that large containers be placed on the shore and on each jetty, or, if it is more convenient, at various points in the jetty system for disposal of rubbish including bottles and cans. The containers must be of a size capable of coping with the amount of litter deposited so that this does not overflow. Quite frequently rubbish can be observed floating away from pen systems, indicating that boat owners are throwing rubbish into the water, or rubbish containers are not carefully serviced.

It must be stressed that under the Waterways Conservation Act 1976, it is an offence to litter or pollute the waters of the river in any way and if necessary legal action can be taken by the Authority.

The Authority does not wish to lay down the method of collection or disposal and would welcome suggestions for consideration.

### 21.7 Responsibility for Removal of Debris During Construction Works

Yacht Clubs or the owners or lessees of other establishments will be held responsible for ensuring that any debris, surplus materials or obstacles resulting from any works carried out within their lease, are completely removed from the water area.

(This is to ensure that material is not left in a position from which it can be washed or pushed into the water to become a floating hazard).

With the increased use of the river and the rapid development being carried out near the foreshores, this problem is one of paramount importance. The Authority's staff does not have the time to keep a constant watch on construction activities with a view to clearing debris etc., and the onus must therefore be placed upon the organisation requiring the work.

It must be re-iterated that under the Waterways Conservation Act 1976, it is an offence to allow debris or polluting matter of any description to enter the waters.

### 21.8 Pumping of Bilges at Yacht Clubs/Marinas

This Authority has received a number of complaints regarding oil being pumped from the bilges of boats moored in yacht club pens. This is a serious problem, not only does the river become polluted but it also causes unsightly marks on other boats.

## 22.0 DEVELOPMENT APPLICATIONS

### 22.1 Submission of Plans

When applying for permission to undertake projects, reasonably detailed plans and specifications must be submitted in duplicate and where such undertakings involve structures in or over the water, the allocated mooring area must be clearly defined on the drawings.

To facilitate processing of plans it is essential that existing work, for which approval has been given but which has not been commenced, and proposed work be clearly indicated by the use of the following colours:

| | | |
|---|---|---|
| i) | Existing work | Blue |
| ii) | Work approved but not commenced | Green |
| iii) | proposed work | Red |

22.2 **Submission of Applications**

In the case of Yacht Clubs, all applications must be channelled through the Club Committee for submission to the Authority, which cannot accept approaches from individual members.

By this method the club is kept fully informed and each request can be fitted into the overall picture. It will be realised that confusion would result if the Authority dealt with members without the knowledge of Club Officials.

22.3 **Approval for Work**

All approvals issued are valid for one year after which time they lapse. Therefore, if a project cannot be completed within this time, a written application for an extension must be made in sufficient time to allow processing before the approval expires, otherwise, a completely new submission must be submitted.

If, subsequent to the issue of an approval for any work, it is decided not to proceed, the Authority must be informed so that the project may be deleted from the Approval List.

23.0 **PRECEDENTS**

In addition to the preceeding policies of the Waterways Commission and Swan River Management Authority the following guidelines/precedents have been set.

23.1 **Bridges**

The following aspects should be considered in the overall design of the structure:

a) The height of the bridge and location of arches should not interfere with navigation.

b) Provision for cycleway/footpath either side of the river and under the bridge.

c) Provision for access for SRMA maintenance vehicles.

d) The concept of fishing platforms on new bridges is supported provided there is no fishing from navigational arches.

e) Separate walkway/cycleways on bridges.

f) The structure causes minimum impedence during times of flood.

23.2 **Sewage Reticulation Areas**

The Swan River Management Authority has stated in the past that it is undesirable to have any form of sewage entering the river, therefore, these structures are undesirable. Where there is no other option the following design requirements are necessary:

a) An approved alarm system be provided so that pump failures and overflow conditions are monitored.

b) Full details of sewage overflow, if any, be supplied to the SRMA on a regular basis.

c) A sump failure indicator light be fitted to the top of the electrical control console.

d) The aesthetics of the structure be approved by the Authority.

23.3 **Swimming of Horses in the River**

In August 1981 the SRMA recommended to Local Government that if they did not approve of horses swimming within their boundaries they should pass by-laws preventing horses being on the foreshore of the river.

The Authority itself supported the swimming of horses at Ascot in Belmont and also at a ramp sited on the Swan River opposite the Guildford Grammar School boat ramp as evidence revealed that the swimming of horses at these two sites was not detrimental to users.

23.4 **Livestock**

Inspectors to prosecute persons who allow their livestock to cause erosion damage to the bank.

23.5 **Vegetation**

The Authority supports the removal of bamboo and pampus grass. Where removal of exotic weeds by spraying is requried it is preferable that this occurs in winter when chemicals entering the river will be diluted and impact on the river minimal.

23.6 **Structures Protruding into the River**

1. Where groynes have to be constructed they should be done in such a way as to be used by fishermen.

2. Structures should not be built on or over the river unless they are specifically for the purpose of enabling or enhancing public use or enjoyment of the river.

23.7 **Buildings on the Foreshore or Over the Rivers**

Design of these buildings should require:

i) Connection to sewer.

ii) Stormwater disposal fo on-site.

iii) Debris from the area should not be allowed to enter the river.

23.8 **Floating Advertising Bill Boards on the Swan/Canning Rivers**

The Authority is opposed to the development and advertising from boats on the river because:

1. It is not an appropriate use.

2. It is visual pollution and does not enhance the river.

3. It is further distraction to drivers when the road is adjacent to the river.

4. It distracts from the natural beauty and amenity of the river.

23.9 **Water Skiing in the Upper Swan**

It is the Authority's opinion that there should not be any barefoot water skiing in the Lilac Hill area of the river as it is considered that the banks of the river could be damaged by boat wash if <u>all</u> craft could travel at unrestricted speeds.

The area of the river in question is not suitable as a permanent site for barefoot water skiing. It is really only suitable for canoes and small boats. There is also the potential for conflict between barefoot water skiers and other users of the river because the river is narrow at this point.

The Authority is also concerned that, while it did allow barefoot water skiing to take place before, it considers that a more permanent use of the area would cause erosion to the banks.

The area of the river at present is quiet and peaceful and this could be distrubed by the loud noise of ski boats.

23.10 **Yacht Clubs/Marinas**

Standard interceptor drains be constructed at yacht clubs, marinas and boat building yards to prevent material from boats being washing back into the river.

23.11 **Foreshore Development**

Wherever foreshore development takes place the foreshore must be rehabilitated to the satisfaction of the Authority.

The structure should be sited as to prevent scouring of the surrounding area due to runoff.

23.12 **Mooring**

The Authority supports the registration of mooring in the river.

23.13 **Boating**

The Authority is of the opinion that provision will have to eventually be made for pumpout facilities for private craft.

23.14 **Sewerage**

The Authority considers that septic tanks should be sited to minimise any pollution of the river and its tributaries.

23.15 **Local Government Authorities**

Revision of District Planning Schemes should include liaison with the SRMA to determine what matters need to be addressed with regards to the river environment.

23.16 **Location of Rottnest Ferries Shore Based Facilities**

Only essential facilities should be constructed to enable embarkation and disembarkation of passengers. Private offices proposed at Barrack Street Jetty are not, in the Authority's opinion, a proper use for buildings on or over jetties. On the other hand essential ticket selling facilities would be a proper use.

23.17 **Restaurants**

Regarding restaurants it may be advisable to identify some suitable sites and call for expressions of interest.

23.18 **Transport Networks**

The Authority is concerned with the view of some departments that reference to road links in the metropolitan scheme was ample justification to proceed without further investigation.

# CHAPTER 19 : MANAGEMENT OBJECTIVES

## 1.0 THE NEED FOR MANAGEMENT

Management arises from something people do, or might do, to cause unacceptable consequences to the resource, to the user, or sometimes to the Manager (Peterson and Lime, 1979). Without some form of control over use the various qualities that people seek from a resource would be destroyed. Unfortunately if an area is run as common property (as the river is) each person will seek to maximise their gain and mutual "ruin" is inevitable (Hardin 1968). Within the river environment this "ruin" might take the form of:

- Degradation or destruction of the environment.
- Creating hazardous and/or unsafe conditions for users.
- Conflict between various user groups.

Legislation, policies and regional planning of the resource is essential. Unfortunately all too often these policies and legislation are termed "RED TAPE" and considered by some to hold up progress. However short cuts through the system will only reduce the quality and opportunities available in the long term. As Wilkinson (1971) reports:

> "The province of Government is not to limit change, but rather to limit its consequences in such a way that the community as a whole is in control of its own destiny".

## 2.0 MANAGEMENT OBJECTIVES

Past management of many resources has been the result of catering for demand. However, as Ohmann (1974) comments, in the future, as the population grows and more pressure is placed on resources, Management will be expected to provde the most appropriate opportunities in the most appropriate areas and not provide for demands where users have "created" them through custom or tradition.

On that note the following objectives are presented as a guideline for future management of the Swan-Canning Estuarine System.

1. Maintain the Swan-Canning Estuarine System as a functional (natural) ecosystem, preserving the indigenous flora and fauna of the river and adjacent lands.

2. Uphold international agreements on protection of flora and fauna.

3. Participation in the management of the river catchment in so far as it affects the waterways.

4. Protect and maintain the river environment as a community asset, controlling the level of its modification, so that a range of community use, interests and opportunities can take place.

5. Resolve conflicts arising from the interaction between the environment, development and the community, promoting harmonious use of the waterways.

6. Co-ordinate other bodies with an interest/involvement in the river environment.

7. Incorporate community attitudes, needs and perceptions into management.

8. Preserve and enhance the public's right of access and use where appropriate.

9. Provide a range of recreational opportunities for a range of users at a level appropriate to:

   - Minimising the impact of use on the environment.

   - Maintaining user safety.

   - Minimising conflict between user groups.

10. Maintain and enhance the environment/water quality by:

    - Minimising the impact of pollution from facilities, development and use.

    - Encouraging good management practice.

11. Monitor the environment (water quality flora and fauna etc.) to improve understanding on which advice, planning and informed decisions can be based.

12. Inform and educate the public and other managing and land use planning organisations as to the value of the waterways and the need for good management practice of the waterways and catchment.

13. Observe the rights and desires of land owners adjacent to the river as far as is practicable while achieving the above objectives.

14. Provide the legislation, a management body and the financial funding to achieve these objectives (in the long term).

Under current legislation the Waterways Commission and the Swan River Management Authority are limited in achieving these objectives and must rely on other managing authorities to uphold their policies. This may be achieved by effective liaison between all bodies with an interest/involvement in the river environment.

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# APPENDICES

| NAME | STATION NO | AREA OF ESTUARY | FREQUENCY | HABITAT | WATER DEPTH | SEASON |
|---|---|---|---|---|---|---|
| CYANOPHYTA | | | | | | |
| Oscillatoria amphibia | 8A | Upper estuary 2 | Rare | Encrusts wood piles | Littoral | |
| O. laetivirens | 2 | Lower estuary 4 | Rare | Sheltered lands. Sandy shores not forming | Upper littoral | Winter |
| | 2 | Lower 4 | | Halophila ovalis | Sub-littoral | Late summer |
| O. nigroviridis | 8A | Upper 2 | Rare | Wooden piles | Littoral | Winter |
| Lyngbya lutea | | Most abundant upper estuary but widely distributed 1-2 | Common | Epiphytic on other algae wooden piles | Littoral | All seasons |
| Spirulina subtilissma | | Lower estuary 4 | Rare | Mixed with other b/g on sand | | Mid winter |
| Microcoleus acutissimus | | Throughout 1 | Common | Wooden piles | sub-littoral | Late summer & winter |
| Calothrix confervicola | 2 | Lower estuary 4 | Rare | Epiphyte on Grateloupia (algae) | Sub-littoral | Late summer |
| C. crustacea | | Mid-estuary 3 | | Grows on wood rocks mussels | Upper-littoral | Summer & mid-winter |
| C. parietina | 8A | Upper 2 | Rare | Wooden piles | Upper-littoral | Late winter |
| CHLOROPHYTA | | | | | | |
| Ulothrix subfaccida | Form 1 7A-6 | Mid-estuary | Rare | Epiphyte on Gracillaria stat 6 - free floating | Sub-littoral | Late winter |
| | Form 2 1 | Lower estuary 5 | Rare | Epiphyte on Grateloupio | Sub-littoral | Summer & winter |
| Ulvaria oxysperma | | Upper estuary mostly 2 | | Wooden piles at winter high water levels | | All except summer |
| Ulva lactuca | | Restricted to estuary. Lower, mouth by late winter 4 | | Rock, piles, mussels sm ones epiphytic on algae | Lower littoral & upper sub-littoral | All seasons |
| Enteromorpha ahlneriana | | Wide occurrence 1 | | Any surface Wood, piles, mussels, epiphyte on algae sea- | Upper littoral to littoral or to sub-littoral in lower estuary | Prolific in winter. Rare in summer |
| E. compressa | 10 | Upper estuary 2 | Rare | grasses, (free floating | | Winter |
| E. flexuosa | Up to 7 | Lower/mid 5 | Most common Enteromorpha | in summer) | | All year Max in summer |
| Chaetomorpha aerea | Up to 5 late Summer only | Lower 4 | | Variety of substrates (free floating) | Sub-littoral | Rare in winter |
| Chaetomorpha linum | 2 | Lower 4 | | Free-floating | | Absent in winter |



..../2

| NAME | STATION NO | AREA OF ESTUARY | FREQUENCY | HABITAT | WATER DEPTH | SEASON |
|---|---|---|---|---|---|---|
| CHLOROPHYTA (Contd). | | | | | | |
| Cladophora albida | To 8 & 7A summer only | Widespread 1 | | | Littoral | |
| C. fasicularis | 2 | Lower 4 | Rare | Grows on shells | Shallow | In winter |
| C. flexuosa | Up to 6 & 7A | Lower & mid 5 | | Mainly on rocks also epiphyte (free floating) | Sub-littoral | All year |
| C. glomerata | 4 & 5 | Mid 3 | | Grows on rocks | Littoral-sub lit | Winter |
| C. harveyi | 4 & 6 | Mid 3 | Rare | | | Summer |
| C. laetevirens | 1 & 3 | Lower 4 | | | Littoral & upper sub-littoral | Summer |
| Rhizoclonium hookeri | 1 | Lower 4 | | | | Winter |
| R. riparium | Up to 8 & 7A | Common throughout 1 | | Free-floating. May attach to rock wood | Littoral/upper sub-littoral | All year |
| R. kerneri | 8, 9, 10 | Upper 2 | | | | All year |
| Bryopsis plumosa | 1 | Lower 4 | | Usually on rocks Sometimes epiphyte | Sub-littoral to 6-9 ft | Late summer to early winter |
| Caulerpa racemosa | 6 | Mid Matilda Bay 1951 3 | Not seen in recent years | On mud | Sub-littoral 15 ft | |
| Codium harveyi | To 3 in summer | Lower 4 | | Rocks | Sub-littoral 6-12 ft | P esp summer |
| Cladophoropsis herpestica | 3 | Mid 3 | | small rock encrusting mats | Sub-littoral 6-12 ft | Cooler seasons |
| Acetabularia calyculus | | Mid 3 | | On rocks | Sub-littoral 3-4 ft | Summer collection |
| BACILLARIOPHYTA | | | | | | |
| Melosira moniliformis | To 10 in autumn early winter | Throughout 1 | Most unbiquitous & abundant diatom | All substrates epiphytic, (free-floating) | Lower littoral/ sub-littoral | All seasons esp summer (R) |
| Also Achnanthes, Amphora cocconeis, Grammatophora Lichmophora & Synedra. Mostly epiphytic on larger benthic algae | | | | | | |
| XANTHOPHYTA | | | | | | |
| Vaucheria sp. | | Throughout 1 | | Rock or wood-encrusting mats | Upper sub-littoral | All year |

| NAME | STATION NO | AREA OF ESTUARY | FREQUENCY | HABITAT | WATER DEPTH | SEASON |
|---|---|---|---|---|---|---|
| PHAEOPHYTA | | | | | | |
| Giffordia intermedia | Up to 6 | Lower/mud 5 | | Mostly epiphytic | | Summer, Autumn, Winter |
| G. mitchellae | 7 | Lower/mid 5 | | Variety of epiphytic and other strates | Lower littoral upper sub-lit | Summer to early winter |
| Ectocarpus siliculosus | 7 sometimes further | Lower/mid 5 | | Variety of substrates Sometime free-floating in shallow sheltered areas | Lower littoral & sub-lit | Winter has poor growth |
| Sphacelaria furcigera | | Lower/mid 5 | | Epiphytic on Cystoseira | Littoral | Poor in winter |
| S. tribuloides | ~2 | | | Rocks & shells | Shallow sub-lit 2ft | Summer collection |
| Dictyota dichotoma | | Lower 4 | | Rocks | Sub-littoral | Summer |
| Rosevingea orientalis | | Mid/lower 5 | Widespread | Rock | Lower littoral, sub-littoral 9ft max | Summer, Autumn |
| Colpomenia peregrina | | Lower/mid 5 | | Mussels & rocks | Most shallow sub-littoral at up to 12ft | Except late winter |
| Cystoseira trinodis | Site 6 | Mid Restricted to Freshwater Bay area 3 | | Rocks | Sub-littoral | Defoliated in winter |
| Hormophysa triquetra | | Mid 3 | | 2 forms are on shells, rocks other on sand | Sub-lit to 5ft | Defoliated in winter. No sign of sand form |
| RHODOPHYTA | | | | | | |
| Goniotrichum alsidii | | Lower/mid 5 | | Usually epiphytic on other algae | Littoral, sub-littoral | Late summer, winter |
| Bangia fuscopurpurea | | Lower 4 | | Concrete piles | Upper littoral | Winter/ spring |
| Porphyra lucasii | 1 | Lower 4 | Occasional | Rocks Smaller plants epiphytic | Littoral sub-littoral | Winter |
| Acrochaetium thuretii | Up to 8 | Widely distributed 1 | | Epiphytic on Gracillaria other algae and seagrasses | Lower littoral sub-littoral | Prolific in summer all year |

| NAME | STATION NO | AREA OF ESTUARY | FREQUENCY | HABITAT | WATER DEPTH | SEASON |
|---|---|---|---|---|---|---|
| RHODOPHYTA Contd). | | | | | | |
| Geliduim pusillum | | Lower/mid 5 | | Usually on rocks | Sub-littoral | Perennial |
| Melobesia membranacea | | Mouth of estuary 6 | | Grows only on Halophila ovalis | Sub-littoral | Late spring early winter |
| Grateloupia filicina | | Lower/mid 5 | | Usually rock | Upper sub-littoral | All year |
| Hypnea cervicornis | | Lower 4 | | Rock | Sub-littoral | Summer & autumn |
| Gracillaria verrucosa | | Widespread 1 | Most abundant & widespread estuarine flora | Variety of substrates rocks/mussels also free-floating | Sub-littoral to upper sub-littoral | All year |
| Champia parvula | | Mouth of estuary 6 | | Epiphytic on algae & sea-grass | Sub-littoral | Summer & autumn |
| Callothamnion pusillum | | Lower/mid estuary 5 | | On mussels & sea-grass | Littoral & sub-littoral | All year, poor in winter |
| Corynospora australis | | Lower (mid estuary deep water) 5 | Occasional | Rock, epiphytic on algae | Lower, littoral & sub-littoral | Mainly summer |
| Ceramium fastigiatum | | Lower/mid 5 | | Epiphyte on algae & seagrass & free-floating | Littoral, sub-littoral | Summer & Autumn |
| Griffithsia corallina | | Mid 3 | | Free-floating, observed on rocks mussels | Sub-littoral to 9ft | Summer & autumn |
| Spyridia biannulata | | At mouth 6 | Rare | Rocks | Sub-littoral | Summer & early winter |
| Chondria dasyphylla | | Near mouth 6 | Occasional | Rocks | Upper sub-littoral | Summer to winter |
| C. tenuissima | | Lower/mid 5 | | Rock & epiphytic of Halophila | Sub-littoral | Mid Summer to winter |
| Laurencia obtusa | | Lower/mid 5 | Occasional | Epiphytic on Halophila | Littoral/upper sub-littoral | Autumn & winter |
| L. rigida | | At mouth 6 | Rare | Rocks | Sub-littoral | Summer to winter |
| Polysiphonia macrocarpa | | Throughout most of estuary 1 | Rare | Epiphytic on algae & seagrass | Littoral and upper sub-littoral | Absent late winter |

# APPENDIX 2

# CHAPTER 5

KEY

Life Cycle

| | | |
|---|---|---|
| FW | - | Freshwater species |
| E/FW | - | Freshwater species; can tolerate brackish water |
| E | - | Estuarine; can spend whole life cycle in estuary |
| E(-M) | - | Estuarine; can spend whole life cycle in estuarine and/or marine environments |
| E-M | - | Estuarine-marine; predominantly species which utilize the estuary as a nursery habitat |
| E-M(N) | - | Estuarine-marine species; known to use the estuary as a nursery habitat |
| M | - | Marine; occasionally enters estuary to feed |

Feeding Type

| | | |
|---|---|---|
| P | - | parasite (on other fish) |
| C | - | carnivore |
| H | - | herbivore |
| O | - | omnivore |

Habitat

| | | |
|---|---|---|
| P | - | Pelagic; lives in the water column |
| D | - | Demersal; lives on the bottom of the estuary |
| <2m | - | found in shallow water less than 2 metres deep |
| >2m | - | found in deep water greater than 2 metres deep |
| <&>2m | - | found in both deep and shallow water |
| P(GN) | - | pelagic; based on data that caught only in gill net |
| (<2m BS) | - | found in shallow water; based on data that caught only in a beach seine |
| (D<&>2m BSOT) | - | demersal, found in both deep and shallow water; based on data that caught both in beach seine and otter trawl |
| (D >2m OT) | - | demersal, found in deep water; based on data that only caught in otter trawl |
| Sc | - | schooling fish |
| So | - | solitary fish |

Estuarine Distribution

In what areas fish was caught from the estuary

| | | |
|---|---|---|
| L | - | lower estuary |
| M | - | middle estuary |
| U | - | upper estuary |

Abundance

| | | | | | | |
|---|---|---|---|---|---|---|
| ++++++ | - | 100,000 | - | 999,999 | individuals | |
| +++++ | - | 10,000 | - | 99,999 | " | caught in the Swan-Avon System |
| ++++ | - | 1,000 | - | 9,999 | " | Feb. 1977 - June 1980 using |
| +++ | - | 100 | - | 999 | " | beach seine, otter trawl & gill nets |
| ++ | - | 10 | - | 99 | " | |
| + | - | 1 | - | 9 | " | |
| MR | - | species only known from museum records (Chubb 1984) | | | | |

Rank of 1 - 50 is the abundance of fish caught in beach seines August 1979- Feb 1981 (Longregan 1981)

Commercial/Recreational Fishing

| | | |
|---|---|---|
| C | - | important commercial fishing species |
| R | - | important recreational fishing species (angling) |
| - | - | not an important species to fisherman (Chubb 1984, Lenanton 1978) |

| Family/Species Name | Common Name | Life Cycle | Feeding Habit | Habitat | Estuarine Distribution | Abundance | Comm & Recreat$^{n}$ Fishing |
|---|---|---|---|---|---|---|---|
| AGNATHA (lampreys) | | | | | | | |
| GEOTRIIDAE | | | | | | | |
| *Geotria australis* GRAY, 1851 | Pouched/wide mouthed lamprey | E/FW | P | | U | + MR | - |
| ELASMOBRANCHS(cartilaginous fishes) | | | | | | | |
| HETERODONTIDAE | | | | | | | |
| *Heterodontus portusjacksoni* (MEYER, 1793) | Port Jackson shark | M | | | U | + MR | - |
| CARCHARHINIDAE | | | | | | | |
| *Carcharhinus leucas* (MULLER & HENLE, 1841) | Swan River whaler | E-M(N) | C | P | M | ++ | - |
| SPHYRNIDAE | | | | | | | |
| *Sphyrna zygaena* (LINNAEUS, 1758) | Hammerhead shark | M | C | P | M | + MR | - |
| RHINOBATIDAE | | | | | | | |
| *Aptychotremata vincentiana* (HAACKE, 1885) | Shovelnose ray/guitar fish | M | | D | M | + MR | - |
| MYLIOBATIDAE | | | | | | | |
| *Myliobatis australis* (MACLEAY, 1881) | Eagle ray | M | | D | M | + MR | - |
| TELEOSTS (bony fishes) | | | | | | | |
| ELOPIDAE | | | | | | | |
| *Elops machnata* (FORSSKAL, 1775) | Giant herring | E-M(N) | | P(GN) | M/U | ++ | - |
| MURAENIDAE | | | | | | | |
| *Gymnothorax woodwardi* (McCULLOCH, 1912) | Woodward's reef eel | M | | | L/M | + MR | - |
| OPHICHTHYIDAE | | | | | | | |
| *Calamuraena calamus* (GUNTHER, 1870) | Fringed-lipped snake eel | M | | | M | + MR | - |
| *Ophisurus serpens* (LINNAEUS, 1758) | Serpent eel | M | | | L/M | + MR | - |
| CLUPEIDAE | | | | | | | |
| *Amblygaster postera* (WHITLEY, 1931) | Scaly mackerel | M | | P >2m Sc | L/M | +++ | C |
| *Hyperlophus vittatus* (CASTLENAU, 1875) | Sandy sprat (white bait) | E-M(N) | C | P >&<2m Sc | L/M/U | 20 ++++ | C |
| *Nematalosa vlaminghi* (MUNRO, 1956) | Perth herring | E | D | D <2m Sc | L/M/U | 1 ++++++ | C |
| *Spratelloides robustus* (OGILBY, 1897) | Blue sprat | M | | P >&<2m Sc | L | +++ | C |
| *Sardinops neopilchardus* | Pilchard (mulie) | M | C | P >2m Sc | | 23 | C |
| ENGRAULIDAE | | | | | | | |
| *Engraulis australis* (SHAW, 1790) | Southern anchovy | E(-M) | C | P >&<2m Sc | L/M/U | 6 +++++ | R,C |
| GALAXIIDAE | | | | | | | |
| *Galaxias occidentalis* (OGILBY, 1899) | Western minnow | FW | | (<2m BS) | U | 34 ++ | - |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SPHYRAENIDAE | | | | | | | | | |
| *Sphyraena obtusata* | Striped sea-pike | M | | ( <2m BS) | L | | + | | - |
| ODACIDAE | | | | | | | | | |
| *Neoodax balteatus* | Rock whiting | M | | ( <2m BS) | L | 50 | + | | - |
| *Neoodax semifasciatus* | Blue rock/weedy whiting | M | | ( <2m BS) | L/M | 26 | +++ | | - |
| *Olisthops cyanomelas* | Herring cale | | | | L | | + | MR | - |
| BLENNIDAE | | | | | | | | | |
| *Omobranchus germaini* | Germain's blenny | M tropical | | | L | | + | MR | - |
| *Pictiblennius tasmanianus* | Blenny | M | | | L/M | | ++ | MR | - |
| CLINIDAE | | | | | | | | | |
| *Cristiceps australis* | Crested weedfish | | | (<2m BS) | L | | + | | - |
| CALLIONYMIDAE | | | | | | | | | |
| *Callionymus goodladi* | Goodlad's dragonet | | | (D <&>2m BSOT) | L/M | | ++ | | - |
| *Callionymus papilio* | Painted dragonet | | | (D <&>2m BSOT) | L | | + | | - |
| *Dactylopus dactylopus* | Fingered dragonet | | | | L | | + | MR | - |
| GOBIIDAE | | | | | | | | | |
| *Amoya bifrenatus* | Bridled goby | E | C | D <2m So | L/M/U | 21 | ++++ | | - |
| *Callogobius mucosus* | Sculptured goby | | | (D <&>2m BSOT) | L/M | | ++ | | - |
| *Favonigobius lateralis* | Long-finned goby | E | C | D <2m So | L/M/U | 9 | +++++ | | - |
| *Favonigobius suppositus* | Long-headed goby | E/FW | C | (D <&>2m BSOT) | M/U | 29 | +++ | | - |
| *Priolepis nuchifasciatus* | Goby (tropical) | M tropical | | | L | | + | MR | - |
| *Pseudogobius olorum* | Blue-spot goby | E | C | D <2m So | L/M/U | 14 | +++++ | | - |
| *Tridentiger trigonocephalus* | Japanese goby | E | | (D <&>2m BSOT) | L/M | | +++ | | - |
| SCOMBRIDAE | | | | | | | | | |
| *Scomber australasicus* | Common or slimy mackerel | M | | P >2m So | | | | | R |
| *Thunnus albacares* | Yellow-finned tuna | M | C | P | M | | + | | |
| BOTHIDAE | | | | | | | | | |
| *Pseudorhombus jenynsii* (BLEEKER, 1855) | Small-toothed flounder | E-M | C | D <&>2m So) | L/M | 45 | +++ | | R,C |
| PLEURONECTIDAE | | | | | | | | | |
| *Ammotretis elongatus* (McCULLOCH, 1914) | Elongate flounder | M | | (D <&>2m BSOT) | L | | + | | - |
| CYNOGLOSSIDAE | | | | | | | | | |
| *Cynoglossus maculipinnis* (RENDAHL, 1921) | Tongue sole | M | | (D <&>2m BSOT) | L/M | | ++ | | - |
| MONACANTHIDAE | | | | | | | | | |
| *Bigener brownii* (RICHARDSON, 1844-8) | Spiny-tailed leatherjacket | E-M(N) | C | (D <&>2m BSOT) | L | 44 | ++ | | - |
| *Brachaluteres jacksonianus* (QUOY & GAIMARD, 1824) | Pygmy leatherjacket | | | (D <&>2m BSOT) | L/M | | + | | - |
| *Chaetoderma penicilligera* (CUVIER, 1817) | Weedy leatherjacket | | | (D <&>2m BSOT) | L | | + | MR | - |
| *Eubalichthys mosaicus* (RAMSAY & OGILBY, 1886) | Mosaic leatherjacket | | | (D <&>2m BSOT) | L/M/U | | + | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Pseudocaranx wrighti* (WHITLEY, 1931) | Fan trevally | | | (D >2m OT) | L/M | | ++ | - |
| *Seriola hippos* (GUNTHER, 1876) | Samson fish | M | C | P | M | | + MR | - |
| *Trachurus mccullochi* (NICHOLS, 1920) | Yellow-tailed scad/ jack mackerel | E-M(N) | | D >2m Sc | L/M/U | 35 | +++ | R |
| ARRIPIDAE | | | | | | | | |
| *Arripis georgianus* (VALENCIENNES, 1831) | Herring/tommy rough/Aust herring | M | C | P <&> 2m Sc | L/M/U | 48 | +++ | R,C |
| *Arripis trutta ceper* (WHITLEY, 1951) | Australian salmon | M | | P >2m Sc | L | | + MR | R,C |
| LUTJANIDAE | | | | | | | | |
| *Caesioscorpis theagenes* (WHITLEY, 1945) | Southern fusilier | | | (<2m BS) | L | | + | - |
| NEMIPTERIDAE | | | | | | | | |
| *Pentapodus vitta* (QUOY & GAIMARD, 1824) | Butter fish | M | | | L | | + MR | - |
| GERREIDAE | | | | | | | | |
| *Gerres subfasciatus* (CUVIER, 1830) | Silver belly/roach | E-M(N) | | D <&>2m So | L/M/U | 17 | ++++ | C |
| SPARIDAE | | | | | | | | |
| *Acanthopagrus butcheri* (MUNRO, 1949) | Black bream | E | O | D <&>2m So | L/M/U | 18 | ++++ | R,C |
| *Chrysophyrya unicolor* (QUOY & GAIMARD, 1824) | Pink Snapper | E-M | | | L | | + MR | - |
| *Rhabdosargus sarba* (FORSSKAL, 1775) | Tarwhine/silver bream | E-M(N) | O | D <&>2m So | L/M/U | 24 | +++ | R,C |
| SCIAENIDAE | | | | | | | | |
| *Argyrosomus hololepidotus* (LACEPEDE, 1802) | Mulloway | E-M(N) | | D <&>2m So& Sc | L/M/U | | +++ | R,C |
| MULLIDAE | | | | | | | | |
| *Upeneus tragula* (RICHARDSON, 1846) | Bar-tailed goatfish | | | (D<&>2m BSOT) | L | 47 | + | - |
| *Parupeneus fraterculus* (VALENCIENNES, 1831) | Black-spot goatfish | M tropical | | (<2m BS) | L | 47 | + | - |
| *Upeneichthys lineatus* (BLOCH & SCHNEIDER, 1801) | Blue-spotted goatfish | | | (<2m BS) | L | 47 | + | - |
| PEMPHERIDAE | | | | | | | | |
| *Pempheris klunzingeri* McCULLOCH, 1911) | Rough bullseye | M | | | L | | + MR | - |
| KYPHOSIDAE | | | | | | | | |
| *Kyphosus sydneyanus* (GUNTHER, 1886) | Buffalo bream/drummer | M | | (<2m BS) | L | | + | - |
| SCORPIDIDAE | | | | | | | | |
| *Microcanthus strigatus* (CUVIER, 1831) | Stripey | M | | (<2m BS) | L/M | 43 | ++ | - |
| *Neatypus obliquus* (WAITE, 1905) | Footballer sweep | M | | | U | 46 | + MR | - |
| ENOPLOSIDAE | | | | | | | | |
| *Enoplosus armatus* (SHAW, 1790) | Old wife | M | | (<2m BS) | L | | + | - |
| CHEILODACTYLIDAE | | | | | | | | |
| *Cheilodactylus gibbosus* (RICHARDSON, 1841) | Crested morwong | M | | | L/M/U | | + MR | - |
| MUGILIDAE | | | | | | | | |
| *Aldrichetta forsteri* VALENCIENNES, 1836) | Yellow-eye mullet | E-M(N) | O | D <2m Sc | L/M/U | 11 | +++++ | R,C |
| *Mugil cephalus* (LINNAEUS, 1758) | Sea mullet | E-M(N) | D | D <2m Sc | L/M/U | 10 | +++++ | R,C |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| GONORHYNCHIDAE | | | | | | | | | |
| *Gonorhynchus greyi* (RICHARDSON, 1845) | Sand fish/beaked salmon | M | | | L | | + | MR | - |
| CYPRINIDAE | | | | | | | | | |
| *Carassius auratus* (LINNAEUS, 1758) | Goldfish/golden carp | FW | | P (GN) | U | 49 | + | | - |
| PLOTOSIDAE | | | | | | | | | |
| *Cnidoglanis macrocephalus* (VALENCIENNES, 1840) | Cobbler/estuary catfish | E(-M) | C | D >&<2m So | L/M/U | 33 | ++++ | | R,C |
| *Paraplotosus albilabris* (VALENCIENNES, 1840) | White-lipped catfish | | | | L | | ++ | MR | - |
| *Tandanus bostocki* (WHITLEY, 1944) | Freshwater cobbler | FW | | | U | | + | MR | - |
| ANTENNARIIDAE | | | | | | | | | |
| *Histrio histrio* (LINNAEUS, 1758) | Sargassum fish | M | | | L | | + | MR | - |
| BYTHITIDAE | | | | | | | | | |
| *Dipuluscaecus* (WAITE, 1905) | Orange eelpout | M | | | L/M | | ++ | MR | - |
| HEMIRAMPHIDAE | | | | | | | | | |
| *Hyporhamphus melanochir* (VALENCIENNES, 1846) | Sea garfish | E-M(N) | | P >&<2m Sc | M | | + | | R,C |
| *Hyporhamphus regularis regularis* (GUNTHER, 1866) | Western river garfish | E | H | P >&<2m Sc | L/M/U | 37 | ++ | | R |
| POECILIIDAE | | | | | | | | | |
| *Gambusia affinis* (BAIRD & GIRARD, 1853) | Mosquito fish | FW | C | (<2m BS) | M/U | 25 | +++ | | - |
| ATHERINIDAE | | | | | | | | | |
| *Allanetta mugiloides* (McCULLOCH, 1913) | Hardyhead | E | C | (BS)<2m | L/MU | 13 | ++++ | | - |
| *Atherinosoma elongata* (KLUNZINGER, 1879) | Elongate hardyhead | E | C | P <2m Sc | | 12 | ++++ | | - |
| *Atherinosoma presbyteroides* (RICHARDSON, 1843) | Hardyhead | E-M | C | P <2m Sc | | 3 | +++++ | | - |
| *Atherinosoma wallacei* (PRINCE,IVANTSOFF&POTTER1982) | Hardyhead | E | C | P <2m Sc | | 5 | +++++ | | - |
| *Pranesus ogilbyi* (WHITLEY, 1930) | Ogilby's hardyhead | E-M | C | (BS)<2m | | 4 | +++++ | | - |
| MONOCENTRIDAE | | | | | | | | | |
| *Cleidopus gloriamaris* (DE VIS, 1882) | Knight fish | | | | M | | + | MR | - |
| VELIFERIDAE | | | | | | | | | |
| *Metavelifer multiradiatus* (REGAN, 1907) | Veilfin | | | | L | | + | MR | - |
| FISTULARIIDAE | | | | | | | | | |
| *Fistularia commersoni* (RUPPELL, 1835) | Flutemouth | M tropical | | (<2m BS) | L | | + | | - |
| SYNGNATHIDAE | | | | | | | | | |
| *Hippocampus angustus* (GUNTHER, 1870) | Seahorse | M | | (D <&>2m BSOT) | L/M | | + | | - |
| *Hippocampus breviceps* (PETERS, 1869) | Short-snouted seahorse | | | (<2m BS) | L | | + | | - |
| *Histiogamphelus gallinaceus* (HALE, 1941) | Cocks-comb pipefish | | | (<2m BS) | L | | + | | - |
| *Lissocampus sp.* | Pipefish | | | (<2m BS) | L | | + | | - |
| *Stigmatophora argus* (RICHARDSON, 1840) | Spotted pipefish | M | | (<2m BS) | L/M | 31 | ++ | | - |
| *Urocampus carinirostris* (CASTELNAU, 1872) | Hairy pipefish | M | | (D <&>2m BSOT) | L/M/U | 30 | ++ | | - |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SCORPAENIDAE | | | | | | | | | |
| *Gymnapistes marmoratus* (CUVIER, 1829) | Devilfish | E-M(N) | C | (D <&>2m BSOT) | L/M | 38 | ++ | | - |
| TRIGLIDAE | | | | | | | | | |
| *Chelidonichthys kumu* (LESSON, 1830) | Red gurnard | M | | | L/M | | + | MR | - |
| *Pterygotrigla polyommata* (RICHARDSON, 1839) | Sharp-beaked gurnard | M | | | L/M | | + | MR | - |
| PLATYCEPHALIDAE | | | | | | | | | |
| *Platycephalus endrachtensis* (QUOY & GAIMARD, 1824) | Flathead | E(-M) | C | D <&>2m So | L/M/U | 27 | +++ | | R,C |
| *Platycephalus inops* (JENYNS, 1840) | Long-headed flathead | M | | | L | | + | MR | - |
| *Platycephalus isacanthus* (CUVIER, 1829) | Flathead | M | | | L | | + | MR | - |
| *Platycephalus laevigatus* (CUVIER, 1829) | Rock flathead | M | | (D <&>2m BSOT) | L | | + | | - |
| PEGASIDAE | | | | | | | | | |
| *Parapegusus natans* (LINNAEUS, 1766) | Sea moth | M | | | L/M | | + | MR | - |
| PERCICHTHYIDAE | | | | | | | | | |
| *Bostockia porosa* (CASTELNAU, 1873) | Night fish | FW | | P (GN) | U | | + | | - |
| TERAPONIDAE | | | | | | | | | |
| *Amniataba caudavittatus* (RICHARDSON, 1845) | Yellow-tailed perch/trumpeter | E | O | D <&>2m Sc | L/M/U | 15 | +++++ | | R,C |
| *Pelates sexlineatus* (QUOY & GAIMARD, 1824) | Striped perch/6-lined trumpeter | E-M(N) | H | D <&>2m Sc | L/M/U | 2 | +++++ | | R |
| *Pelsartia humeralis* (OGILBY, 1899) | Sea trumpeter | M | | | L | | + | | ? |
| KUHLIIDAE | | | | | | | | | |
| *Edelia vittata* (CASTLENAU, 1873) | Western pygmy perch | FW | | (<2m BS) | U | 39 | + | | - |
| APOGONIDAE | | | | | | | | | |
| *Apogon rueppellii* (GUNTHER, 1859) | Gobbleguts | E(-M) | C | D <&>2m So | L/M/U | 8 | +++++ | | - |
| *Siphamia cephalotes* (CASTLENAU, 1875) | Woods siphon-fish | M | | | L | | + | | - |
| SILLAGINIDAE | | | | | | | | | |
| *Sillaginodes punctatus* (CUVIER, 1829) | King George Whiting | E-M(N) | C | D <&>2m Sc | L/M | 28 | ++ | | R,C |
| *Sillago bassensis* (CUVIER, 1829) | School whiting | M | | D <2m Sc | M | | + | | R,C |
| *Sillago maculata* (QUOY & GAIMARD, 1824) | Trumpeter whiting | E-M(N) | C | D <&>2m Sc | L/M/U | 16 | ++++ | | R,C |
| *Sillago schomburgkii* (PETERS, 1865) | Western sand/yellow-finned whiting | E-M(N) | C | D <&>2m Sc | L/M | 22 | +++ | | R,C |
| POMATOMIDAE | | | | | | | | | |
| *Pomatomus saltatrix* (LINNAEUS, 1766) | Tailor | E-M(N) | C | P <&>2m Sc | L/M/U | 19 | ++++ | | R,C |
| RACHYCENTRIDAE | | | | | | | | | |
| *Rachycentron canadus* (LINNAEUS, 1766) | Black kingfish/cobia | M | C | P | L/M | | + | MR | - |
| CARANGIDAE | | | | | | | | | |
| *Alectis ciliaris* (BLOCH, 1787) | Pennant trevally | M tropical | | | L | | + | MR | - |
| *Caranx georgianus* (CUVIER, 1833) | Skipjack trevally | M | C | D >2m Sc | L/M | 40 | +++ | | R,C |
| *Pseudocaranx dentex* (BLOCH & SCHNEIDER, 1801) | Skipjack trevally | | | (D >2m OT) | L/M | | ++ | | - |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Meuschenia freycineti* (QUOY & GAIMARD, 1824) | Six-spined leatherjacket | | C | (D <&>2m BSOT) | L/M/U | 41 | +++ | | - |
| *Monacanthus chinensis* (OSBECK, 1765) | Fan-bellied leatherjacket | | C | (D <&>2m BSOT) | L/M | 42 | ++ | | - |
| *Penicipelta vittiger* (CASTELNAU, 1873) | Tooth-brush leatherjacket | | | (D <&>2m BSOT) | L/M | | + | | - |
| *Scobinichthys granulatus* (SHAW, 1790) | Rough leatherjacket | | C | (D <&>2m BSOT) | L/M | 36 | ++ | | - |
| OSTRACIONTIDAE | | | | | | | | | |
| *Anoplocapros lenticularis* (RICHARDSON, 1841) | White-barred boxfish | M | | | M | | + | MR | - |
| *Aracana aurita* (SHAW, 1798) | Shaw's boxfish | M | | | M | | + | MR | - |
| TETRADONTIDAE | | | | | | | | | |
| *Arothron hispidus* ( LINNAEUS, 1758) | Lined pufferfish | M tropical | | | L | | + | MR | - |
| *Atopomycterus nicthemerus* (CUVIER, 1818) | Globe fish | M | | (D <&>2m BSOT) | L | | + | | - |
| *Contusus richei* (FREMINVILLE, 1831) | Prickly toadfish | M | C | (D <&>2m BSOT) | L/M | 32 | ++ | | - |
| *Lagocephalus sceleratus* (GMELIN, 1788) | Silver toadfish | M tropical | | | M | | + | MR | - |
| *Torquigener pleurogramma* (REGAN, 1903) | Banded toadfish/ common blowfish | M-E | C | D <&>2m Sc | L/M/U | 7 | +++++ | | R nuisance |

APPENDIX 3: A Species list of Aquatic Birds of the Swan River System (Chapter 5).

**Waders**

| | | Trans-equatorial migrant (M) or Australian Resident (R) |
|---|---|---|
| Ruddy turnstone | Arenaria interpress | M * |
| Pectoral sandpiper | Calidris melanotos | M |
| Curlew sandpiper | C. ferruginea | M * |
| Sharp-tailed sandpiper | C. acuminata | M * |
| Red-necked little stint | C. ruficollis | M * |
| Great knot | C. tenuirostris | M * |
| Red knot | C. canutus | M * |
| Sanderling | C. alba or Crocethia alba | M |
| Large Sand Plover/ dotterel | Charadrius leschenaultii | M * |
| Red-capped Plover/ dotterel | C. ruficappillus | R |
| Hooded plover | C. cucullatius | R |
| Black-fronted dotterel | C. melanops | |
| Mongolian dotterel | C. mongolus | M * |
| Banded stilt | Cladorhynchus leucocephalus | R |
| White-headed stilt | Himantopus himantopus | R |
| Black-tailed godwit | Limosa limosa | M * |
| Bar-tailed godwit | L. lapponica | M * |
| Broad-billed sandpiper | Limicola falcinellus | M |
| Eastern curlew | Numenius madagascariensis | M * |
| Whimbrel | N. phaeopus | M * |
| Grey plover | Pluvialis squatarola | M * |
| Eastern golden plover | P. dominica | M * |
| Red neck avocet | Recurvirostra novaehollandiae | R |
| Common sandpiper | Tringa hypoleuros | M * |
| Greenshank | T. nebularia | M * |
| Marsh sandpiper or little greenshank | T. stagnatilis | M * |
| Grey-tailed tattler | T. brevipes | M * |
| Terek sandpiper | Xenus cinerus | M * |

**Ducks and Swans**

| | |
|---|---|
| Grey teal | Anas gibberifrons |
| Black duck | A. superciliosa |
| Chestnut teal | A. castanea |
| Blue-winged/Australian shoveller | A. rhynchotis |
| White-eyed duck/ Hardhead | Athya australis |

# Swan-Canning Estuarine System