A Systematic Overview of Environmental Values of the Wetlands, Rivers and Estuaries of the Busselton-Walpole Region

Water Resource Allocation and Planning Series

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1997

Water and Rivers Commission

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Cover Photograph:
Lake Muir is a seasonal lake and an important summer drought refuge for waterbirds.
Photograph by Luke Pen, September 1994.

A SYSTEMATIC OVERVIEW OF ENVIRONMENTAL VALUES OF THE WETLANDS, RIVERS AND ESTUARIES OF THE BUSSELTON-WALPOLE REGION

Luke Pen

Water and Rivers Commission
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WATER AND RIVERS COMMISSION
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This report contributes to a series of documents published for the purposes of water allocation planning in the Busselton to Walpole Region. Other publications focus on the following topics:

- An Investigation into the Aboriginal Significance of Wetlands and Rivers in the Busselton-Walpole Region
- Educational and Scientific Use of Wetlands and Rivers in the Busselton-Walpole region
- Recreational Use of Water Bodies in the Busselton-Walpole Region
- Mapping and Classification of Wetlands from Augusta to Walpole in Southwestern Australia
- The Distribution of Freshwater Fish in the South Western Corner of Western Australia
- Historical Significance of Wetlands and Rivers in the Busselton-Walpole Region
- Divertible Surface and Groundwater Water Resources of the Busselton-Walpole Region
- An Investigation of a Hierarchical Approach to Describing Wetland Resources: The Busselton-Walpole Water Resource Region and the Lake Muir Lowland Wetland Region
- A Description of the Hydrology of the Lake Muir Lowland Wetland Region and Implications for Management
- Preliminary Allocation Discussion Paper and Review of Public Submissions
- Busselton-Walpole Region Water Resources Allocation Plan

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Foreword

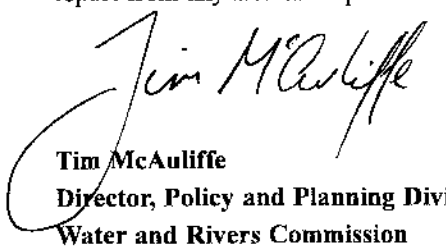
The vision of the Water and Rivers Commission is to excel at water resource management by ensuring waters and rivers are used wisely by the community. The Commission has made a commitment to manage the water resources of Western Australia for the benefit of present and future generations in partnership with the community.

The Commission is currently undertaking a series of studies aimed at developing a water resources allocation strategy for the Busselton-Walpole Region. Allocation is to be based on the ecological, cultural and water supply values and needs of the community.

Currently, the Commission is working in the Busselton-Walpole Region of the South West. It is the second region covered and follows a study of the Perth-Bunbury Region carried out between 1985 and 1991. As part of the Busselton-Walpole study, a systematic overview of the environmental values of the Region's water resources was prepared.

This report constitutes a systematic overview of the environmental values of the wetlands, rivers and estuaries of the Busselton-Walpole Region. The report describes the state of the water resources for the Region using new condition assessment methods developed for wetlands, rivers and estuaries. The descriptions are also supplemented using existing literature and information from a number of consultant reports to the Commission. Secondly, this report provides the first regional identification of many of the important and valuable wetlands that warrant planning and management protection. The major threats to these values are also described together with implications for management. This report is being published to make the environmental information used in the allocation process available to the public.

Together with the other reports being made available as part of the regional study, it is hoped that this report will encourage preservation, management and wise use of water resources and also engender wide community debate on how the community may wish to more effectively protect and sustainably use the region's water resources. The Commission welcomes comments on the report from any interested person or organization.



Tim McAuliffe
Director, Policy and Planning Division
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Summary

The Water and Rivers Commission is currently working on the Busselton-Walpole Regional Allocation Study in order to guide current and future management of water resources for their effective protection and sustainable use. As part of the Busselton-Walpole Study, this report was prepared to present a systematic overview of the environmental values of the Region's wetlands, rivers and estuaries. This report is being published to make the environmental information used in the allocation process available to the public.

This report details the condition and environmental values of rivers, wetland and estuarine systems of the Busselton-Walpole Region. The report firstly describes the state of the water resources for the Region using new condition assessment methods developed for wetlands, rivers and estuaries. The descriptions are also supplemented using existing literature and information from a number of consultant reports to the Commission.

Secondly, the report provides a first regional identification of many of the important and valuable water resources that warrant planning and management protection. These important water resources are shown on Figure 8.1. The major threats to these values are also described together with implications for management.

This report is one of a series of technical reports published for the purposes of water allocation planning in the region. It also provides a summary of our scientific knowledge of water dependant ecosystems and includes existing evaluations of wetland values, including Ramsar, National Estate, the System Studies and Wetlands of National Significance. This work presents the Water and Rivers Commission's appreciation of the water related environmental values of the region.

The Busselton-Walpole Region is located in the south-west corner of Western Australia (Figure 1.1. It covers a total area of 35 050 km^2 and includes 45 streams systems that drain the land from just south of the City of Bunbury on the west coast to just beyond the small township of Walpole on the south coast. There are 5 principal river basins: Geographe Bay, Blackwood, Donnelly, Warren and the Shannon Basin (includes the Gardner, Shannon, Deep and Walpole Rivers). There is also a raised western coastal area known as the Leeuwin-Naturaliste Ridge which is drained by many small stream systems and is dissected by the Margaret River system. There are 10 estuarine systems, mainly along the south coast, and 4 have seasonally or permanently open broad inlets. Wetland systems are found mainly along the low lying coastal plains, where they are mostly extrusions of the shallow groundwater; also in an area of relative internal drainage at the upper ends of the Warren and Shannon Basins (Muir/Unicup systems); and along ancient drainage lines of the upper Blackwood and Warren catchments.

Large areas of the region, mainly towards the coast, retain much forest and other forms of natural vegetation within National Parks, State Forest and other types of conservation estate. Here stream, wetland and estuarine systems often retain their fringing vegetation and are well connected to each other, such that habitat and the concomitant biodiversity values are extremely high, with a number of unique and rare species of flora and fauna, often restricted to unique and uncommon habitats. Of particular significance are the broad wetland systems of the D'Entrecasteaux National Park, including Lake Jasper, the State's largest natural freshwater lake, and the Broke Inlet, a large seasonal inlet with a catchment that is now virtually entirely within National Park. A relatively short distance inland are the Muir/Unicup wetland systems, which have extremely important habitat and represent the best remaining area of inland lakes and swamps in the south-west. On the coast near Busselton, the large and highly modified Vasse-Wonnerup estuarine system and associated wetlands, although degraded by the effects of adjacent land uses, retains highly significant waterbird habitat.

In inland areas, catchments are largely cleared and their rivers and wetlands are affected by the consequent hydrological changes and the effects of adjacent broad scale land uses, namely salinisation and eutrophication. Not withstanding widespread degradation, wetland values remain high, especially as waterbird breeding, feeding and drought refuge habitat; the best example being Lake Toolibin, which is the south-west's most important centre for waterbird breeding.

The chief threats to the conservation of the environmental values of the streams, wetlands and estuaries of the region are salinisation, eutrophication, habitat loss and fragmentation, development pressure (coastal areas mostly) and weeds and feral animals. There are also concerns held by members of the community that some land use practises in forest and agricultural areas, including those of water supply, may not be sustainable. These concerns are largely being addressed through CALM's Forest Management Plan and Agriculture WA's Sustainable Rural Development Program, and through environmental water provisions placed on water provisions placed on water supply developments by the Water and Rivers Commission. With respect to agricultural lands, the Government recently launched a Salinity Action Plan which addresses the problem of salinisation in the south-west.

PART 1:
Background and approach

1. Introduction

1.1 Background: Busselton-Walpole regional water allocation

1.1.1 Water resource allocation, uses and values

Water is present in the environment in a cycle. It falls mostly as rain from the atmosphere to the land or sea, moves over or through the land to the ocean and returns to the atmosphere through evaporation or evapo-transpiration after having passed through plants and animals. For the most part, water, while it is present on or in the land, as a stream or as groundwater respectively, can be considered a water resource.

Modern civilisation places large demands on water resources, to support agricultural, industrial, urban and domestic household activities. The typical annual water use per person in south-west WA in 1984 was 550 kL, such that the total population of the region could have consumed the entire flow of the Shannon, Donnelly and Margaret Rivers, had the water in these rivers been of suitable quality (WAWRC 1986). With a steady increase in the population and development in the south-west there is a growing demand for more and more water.

Water present in its natural forms, as streams, wetlands, estuaries and aquifers, has important environmental and social values. A new nomenclature to precisely describe water resource values has been developed by Claridge (1991) and is discussed in Section 3.3. Water supply developments and the extraction of water from the natural environment can adversely affect these values and a limit needs to be determined and placed on the ultimate level of development allowable. This setting of the sustainable limit on the extent of water resource development allowable is the primary task of water resource allocation.

Once the sustainable limit on development has been set, the secondary task of apportioning sufficient water to maintain the environmental values desired by the community can begin. The process of dividing up or sharing the resource is essentially *water resource allocation*.

The uses to which water is allocated can be divided into three categories: environmental, non-consumptive (or *in situ*) and consumptive and they imply different and competing water resource values.

Environmental use

Prior to any human use, water resources can be considered to be used by the ecosystems sustained by them. Stream ecosystems, including river pools, riffles and floodplains are an obvious example. Lakes and swamps, formed by the extrusion of shallow groundwater aquifers above the ground, are another. Less obvious are some dryland plant communities that are dependant on tapping groundwater via their deep root systems. Certain marine communities, such as seagrass beds, may also be dependant on the oceanic discharge from shallow and deep aquifers. These ecosystems are in turn used by humans and are therefore considered to be natural water or marine resources in their own right.

Non-consumptive use

Swimming, boating and fishing are examples of the use of water while it is present in the environment and allowed to remain so, hence the term *in situ* use. These examples are grouped under *recreation*. There are also *cultural* uses, including Aboriginal significance, historical association and scientific and educational use. It is important to note however, that while these uses rarely preclude one another, some may have an impact on the resource and degrade some resource values. For example, heavy recreational usage of a relatively natural river may result in littering, damage to riparian vegetation and a detraction from wilderness qualities.

Consumptive use

Any use of a water resource which requires that the water be diverted from the environment, and hence from the water cycle, is considered to be *consumptive*, that is to consume the water such that all other uses are precluded. Water may be diverted by a simple pump and pipeline, via a small dam or bore, for individual self supply, or by the use of a large pipehead and/or storage dam or borefield, for a large scale scheme supply. Whether self or scheme supply, the water diverted may be used in several ways. It is important to note, that at some stage, following the use of the water, it must be returned to the water cycle. It is at this stage that the pollution of inland water or marine resources allocated to their own particular uses may become a problem.

A water resource which has the potential to be diverted for human uses is considered to be a *divertible water resource*. However, the whole of the resource, if any, is rarely allocated exclusively to consumptive use.

1.1.2 Regional allocation and this study

Water resource allocation is the process by which water resources are allocated, in a notional sense, to different combinations of values and uses on the basis of existing and potential water resource values. The initial objective is to set a limit on the overall extent of water resource development. This ecologically sustainable limit is aimed at providing an appropriate balance between the needs of the environment and the community. Once this limit is set, the second objective is to maximise the value of the water to the human community by optimising the allocation of water amongst the various uses. The process requires a qualitative and where possible quantitative assessment of water resource values, including environmental, recreational, cultural and potentially divertible values.

Water resource allocation is done at two levels, regional and local. While local allocation recognises local values, it must also receive guidance at a regional level to ensure that resource allocation overall meets the needs of the wider community and the state as a whole, while at the same time allowing the State and Federal Governments to meet National and International commitments.

As an example, a quantity of groundwater, representing a sustainable draw on a shallow aquifer, may be allocated to local horticulture, leaving sufficient water to sustain wetlands which support migratory wading birds, whose habitat is protected by an international convention for which the Federal Government is a signatory.

Another example is the Regional Forest Agreement which includes a process to conserve representative forest ecosystems. Here the Commission and the Department of Conservation and Land Management (CALM) will continue to liaise in the development of appropriate methodologies used in the Comprehensive Regional Assessment process. This process includes the identification of relatively undisturbed streams, wetlands and whole catchments for protection. The environmental values identified as part of the regional water resource allocation will contribute to this assessment process.

For the purpose of regional water allocation in Western Australia, the state is being divided into a number of regions, those to date are shown in Figure 1.1. A regional allocation draft plan for the region in which water resources are under the greatest demand for use, namely Perth-Bunbury, was carried out between 1985 and 1991 (WAWRC 1991). Presently, the Water and Rivers Commission is engaged in preparing a draft allocation for the Busselton-Walpole region. A number of investigations into the water resource values of the region have been commissioned and most published and distributed to government agencies and community groups to elicit comment. This report details the environmental values of the Busselton-Walpole region and draws upon existing knowledge and investigations sponsored by the Commission (see opening pages).

1.2 Aims of this study

The overall objective of this study was to describe, assess and present the environmental values of water resources of the Busselton-Walpole Region. The specific tasks were to assess the condition and value of wetlands, rivers and estuaries and to identify those of important value, including those currently recognised as having values of National and International significance. A secondary aim was to describe the major threats to these values and to discuss implications for management.

1.3 Brief description of the study area

The Busselton-Walpole region is part of the South West Drainage Division, and consists of all the catchments between Bunbury and Walpole, from the Capel River, just south of Bunbury, and the Collier Creek, which flows

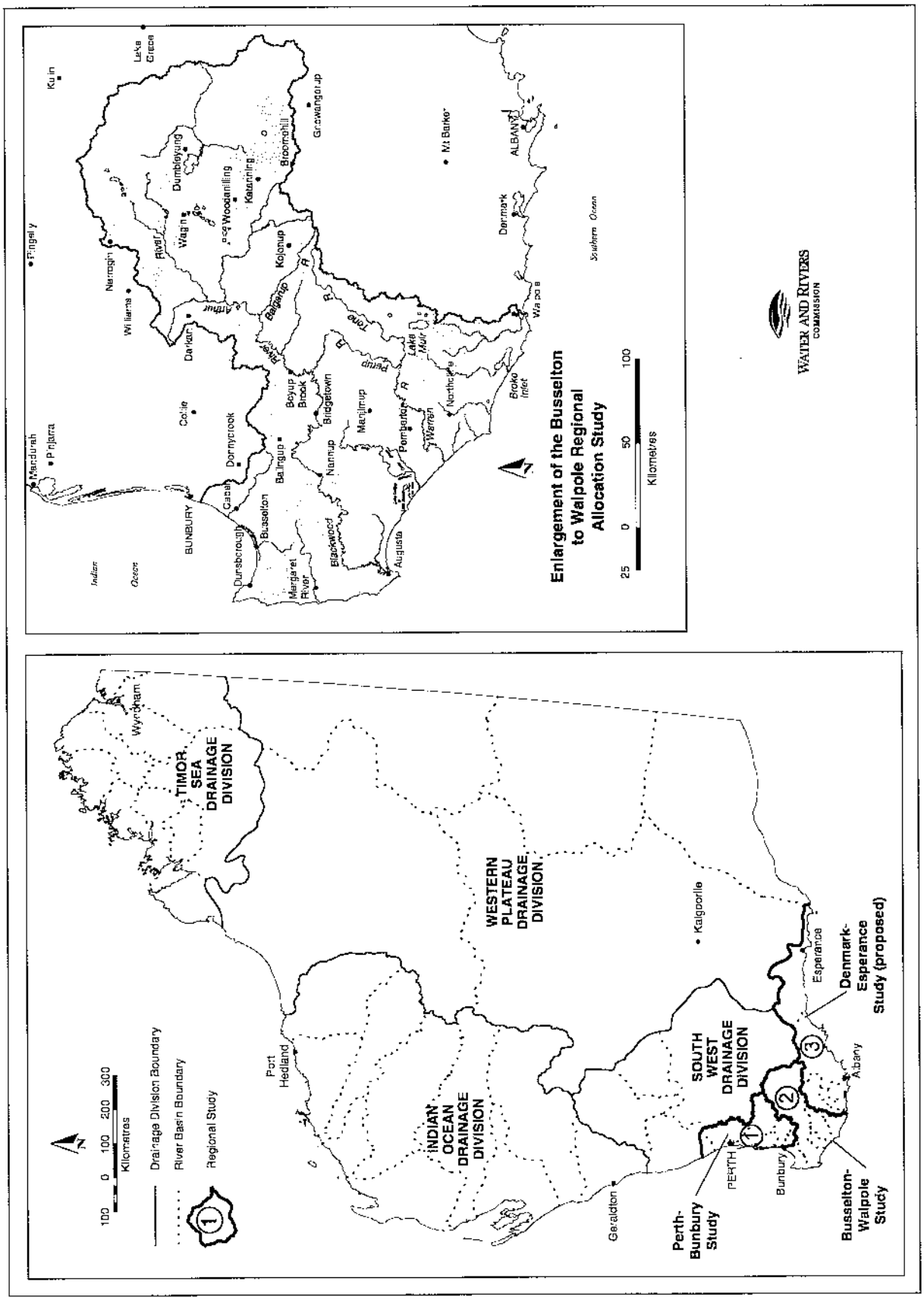


Figure 1.1: Water resource regions for regional water resource allocation in Western Australia and the Busselton-Walpole study area

into the eastern side of Walpole Inlet. In all, there are six major drainage basins: Geographe Bay, Margaret, Blackwood, Donnelly, Warren and the Shannon, draining the southern most portion of the Swan Coastal Plain, the Blackwood Plateau, southern Darling Range and in the case of the Blackwood, the western edge of the Yilgarn Plateau. In addition, the study area includes the many small catchments along the Leeuwin-Naturaliste Ridge and the areas of internal drainage about Unicup and Lake Muir. The catchments cover an area of 35 050 km^2 and include over 7 000 km of stream line of 3rd order or greater and at least 1 700 km^2 of wetland[1].

The study area contains some of the most important water resources in the state, for the full range of uses and values. Of the total of 1210 GL per annum of surface water potentially available for diversion, only 0.3 % has so far been exploited (Williams In Prep.). This leaves many rivers to flow unobstructed to the ocean. There are also large areas of National Park, State Forest and Conservation Reserves, particularly in the high rainfall and densely drained karri forest region and along the south coast coastal plains where wetlands are extensive and diverse. Thus environmental, recreational and cultural values are of a high order, at least towards the coast.

Further inland, widespread clearing has led to hydrological change manifest as widespread water logging and salinisation, which are killing native vegetation over large areas. Together with over clearing, eutrophication and soil erosion, these problems have greatly reduced water resource values, particularly habitat for native flora and fauna. Nevertheless, many of the larger inland lake systems support large numbers of waterbirds and some represent significant habitat at a National or International level.

1.4 Scope and approach

In this study, the environmental values of water resources pertain to rivers, estuaries and all other wetland types treated collectively and referred to as wetlands. Since a regional approach deals with values at a regional scale, the recognition of wetlands, eg lakes, swamps and floodplains, was similarly broad (at 1:250 000 map scale), with one exception; all wetlands, though not all streams, that are named on maps were assessed. In this way, particularly conspicuous wetlands and ones with a high local recognition were not omitted and the report will serve its purpose in eliciting community feedback.

The values to be assessed included naturalness, as reflected by condition, representativeness, uniqueness, wetland function and a range of habitat values. These are defined in Section 7. The assessment of wetlands and estuaries used methods which are consistent with similar studies done for the Perth-Bunbury region, but stream condition and evaluation involved new methods, described for the first time in this study and since used retrospectively in the Perth-Bunbury region (Bosveld and Pen, 1997).

All of the major pressures that threaten the environmental values of water resources were identified and described briefly (Section 9). An appreciation of these pressures was used in conjunction with the assessed values of the region to highlight implications for water resource allocation and management.

[1] These figures were derived from 1:250 000 scale hydrological data.

2. Regional characteristics

2.1 Climate

The climate of the Busselton-Walpole Region is Mediterranean, with cool, wet winters and hot, dry summers. The weather is determined by an alternating succession of high and low pressure systems steadily moving eastward. In summer, the high pressure systems tend to block the movement of low pressure systems and thus deflect rain bearing frontal systems to the south below the continent. In winter, the highs move further north and their blocking effect weakens, with the effect that low pressure systems can carry rain bearing fronts across the south-west.

Annual average rainfall generally decreases inland in a more or less north-western direction from the south-west corner, ranging from 900 to 1400 mm on the coast to less 400 mm in the upper most parts of the Blackwood catchment (see Figure 2.1). The wettest period of the year is from May to September, and prolonged summers are common. In inland areas sporadic thunderstorms may bring isolated heavy falls, while the south coast may receive light local rain, during summer and autumn. Very occasionally widespread heavy rain may occur during the southward passage of a decaying tropical cyclone.

The evaporation gradient is in the same general direction to that of rainfall but is reversed, with 800 to 1200 mm average annual evaporation in coastal areas increasing to over 1800 mm in the upper Blackwood catchment (Figure 2.1). Consideration of rainfall and evaporation enable the region to be divided into two climatic zones, the Moderate Mediterranean, with only 3-4 dry months per year, which extends southwards from a line drawn roughly from Cape Naturaliste to Tonebridge, and the Dry Mediterranean, with 5-6 dry months per year, which extends northward of this line (Beard 1981).

The climatic features and patterns of the Busselton-Walpole Region have been further described by the V. & C. Research Group (1997a) with respect to understanding the development of wetland types and their distribution.

2.2 Geology and geomorphology

Most of the Busselton-Walpole Region is located on the ancient Western Archaean Shield, an extensive region underlain by Precambrian rocks of granite and gneiss which have remained stable over the last 570 million years (Beard 1981). The Shield is bordered on the western side by the Darling Fault that runs more or less north-south through Donnybrook and Nannup. To the west of the fault is a trough known as the Perth Basin, most of which is now beneath the ocean. In the study area, it includes the southern end of the Swan Coastal Plain, the Blackwood Plateau (also known as the Donnybrook Sunklands), the western half of the Scott Coastal Plain and a portion of slightly raised Precambrian crust known as the Leeuwin Naturaliste Ridge.

The south-western part of the Western Shield is known as the Yilgarn Block. North of the study area, its western extent is marked by the Darling Scarp which runs roughly along the fault and gives rise to the Darling Range or Plateau. This plateau continues south and the scarp swings south-west away from the fault line near Brunswick Junction to form the Whicher Range. This range, which abuts the southern portion of the Swan Coastal Plain, is the northern edge of the Blackwood Plateau, which is about 50 km wide and is about 100 m high. At the fault line it gives way to the Darling Plateau, which is about 60 km wide in the study area and rises to about 300 m. The southern crest of the plateau runs parallel to the south coast along a line, known as the Jarrahwood Axis that roughly passes through Manjimup. Southwards of this line the Darling Range slopes gently down to the south coast in a formation known as the Ravensthorpe Ramp. The Ramp is marked by many relatively short rivers running roughly perpendicular to the coast between Augusta and Albany. To the east the range gives way to the Bannister Uplands, which rise over about 30-50 km to the Yilgarn Plateau, which approaches 380 m above mean sea level.

Each of the main physiographic units (Beard 1981) of the study area, shown in Figure 2.2, are described in detail on the following pages:

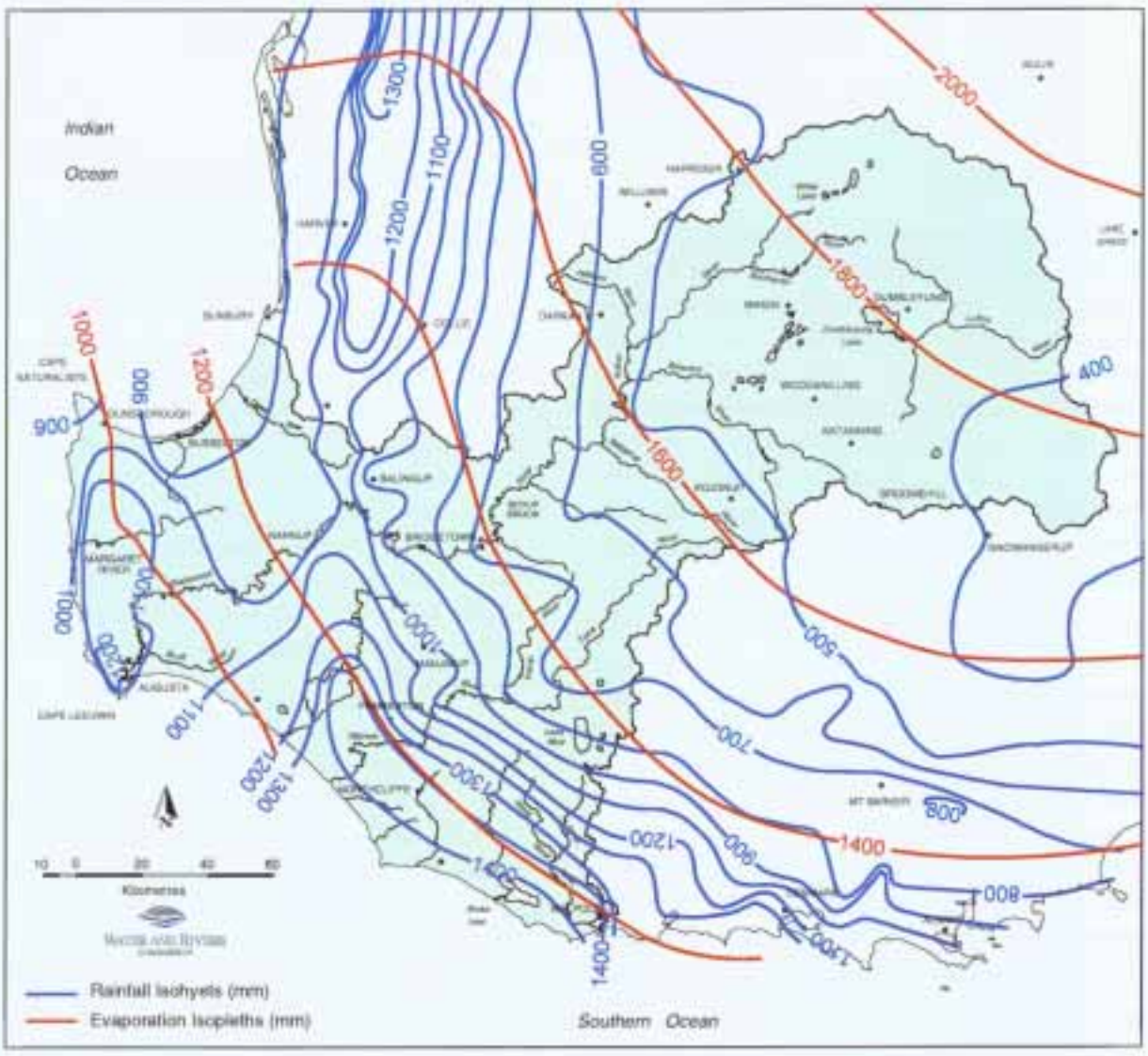


Figure 2.1: Rainfall and evaporation isohyets in relation to the Busselton-Walpole Region

The Swan Coastal Plain in the study area extends from the base of the Whicher Range for about 20 km to the sea between Capel and Dunsborough. Mostly it consists of the low lying seasonally wet flats with alluvial soils, which characterise a sub-unit of the coastal plain known as the Pinjarra Plain. Bassendean Dunes with grey quartzite soils are dispersed about the plain, especially in the north-east, while the yellow sands, over limestone, of Spearwood dunes back onto the coastal partially mobile Quindalup Dunes, which are of recent origin. Between the Quindalup and the Spearwood, are elongate estuarine lagoons and swampy flats of the Vasse-Wonnerup and Broadwater wetland systems.

The Blackwood Plateau is a gently undulating area of moderately raised land (some 80-180 m above AHD) with laterite and sand overlaying Mesozoic rocks (V. & C. Semeniuk Research Group 1997a). The plateau slopes downward to the south where it meets the Scott Coastal Plain and is dissected in southern half by the winding course of the Blackwood River.

The Leeuwin-Naturaliste Ridge consists of Precambrian granite and granulite forming hills, running in a north-south direction between the Capes, and rising to about 200 m. Most of the rock is capped by laterite, sand and calcarenite and the coast is rugged rock with small sandy embayments sheltered by granite or limestone headlands.

The Scott Coastal Plain stretches for over 140 km from Hardy Inlet to Walpole narrowing from about 20 km to 5 km wide. The land is sandy, low-lying and very swampy with dunal remnants forming low hills and ridges. Along

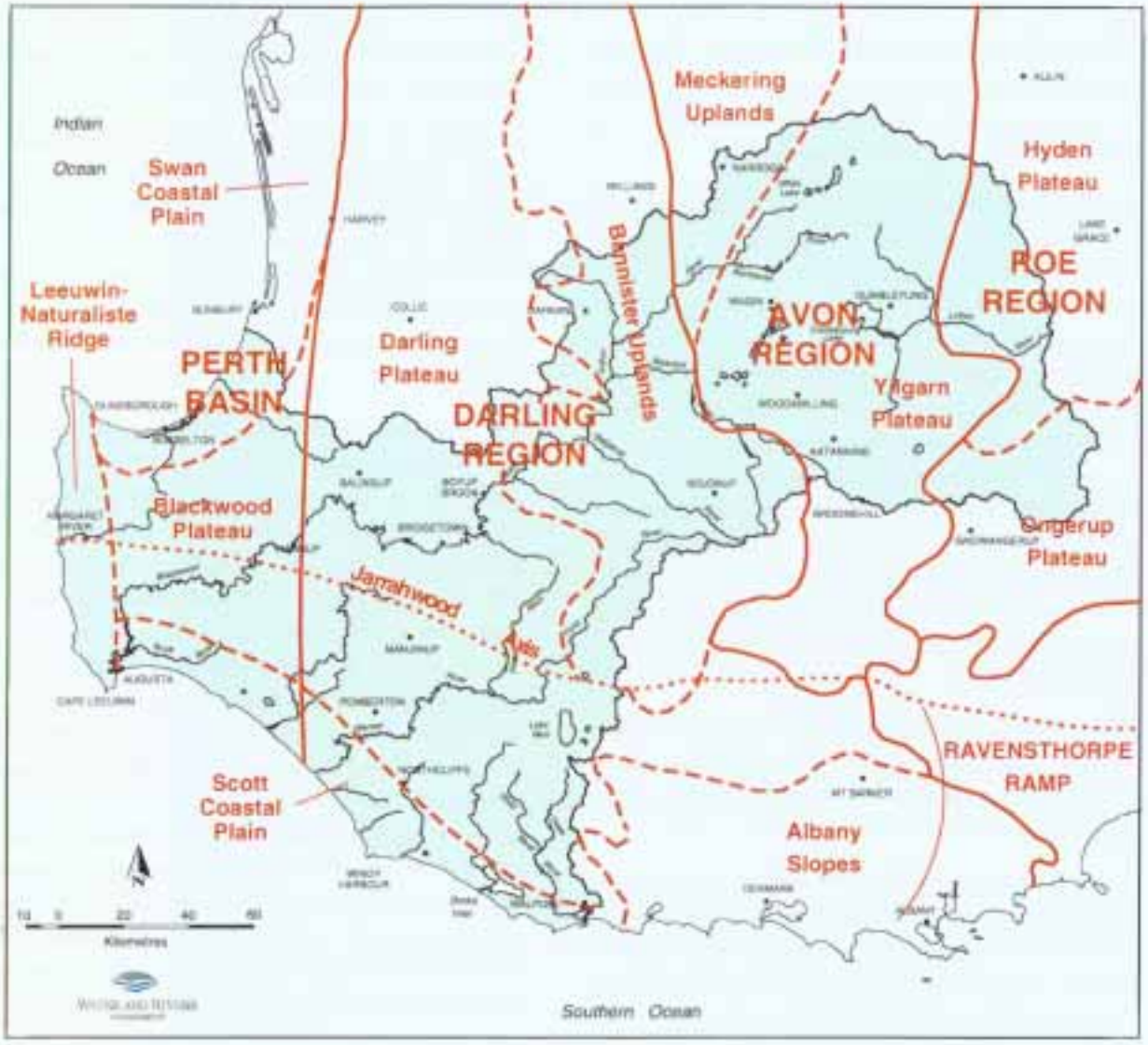


Figure 2.2: Physiographic units/natural regions of the Busselton-Walpole Region (after Beard 1981)

the coast there is a narrow coastal strip of active and lithofied dunes, and there are many blow-outs, sometimes reaching as far as 8 km inland and covering swampland and lakes. Occasionally granite domes emerge from the flat terrain. There are also two coastal inlets, the Broke and Walpole-Nornalup, at the eastern end of the plain.

The Darling Plateau is the uplifted broadly undulating surface with laterite overlying Precambrian crystalline rocks situated approximately at 200-300 m (V. & C. Semeniuk Research Group 1997a). The Darling Plateau broadens out in the study area, and from about Manjimup the Ravensthorpe Ramp slopes gently down to meet the Scott Coastal Plain. Soils are mostly gravelly ironstone, over hard lateritic duracrust, but become increasingly sandy and acidic in poorly drained country near the coast and in the south-east where the Unicup and Muir wetland systems have formed. In Beard's Warren Botanical Sub-district, found along the coast (see Section 2.5), red earth and yellow soils support the best growth of karri forest. Both the Warren and the Blackwood Rivers dissect the plateau, forming deep narrow valleys.

The Bannister Uplands were formed when the continent rose at the end of the Cretaceous period causing a partial rejuvenation of the ancient water courses which had largely ceased flowing. As a consequence new river valleys were formed in the middle reaches of the Blackwood and headwaters of the Warren, and the land took on more varied and undulating form, exposing the

lateritic duracrust below the region's sandy and yellow mottled soils with varying contents of gravel. Part of the Blackwood catchment around Narrogin falls within the Meckering Uplands, which in this vicinity shares most of the features of that of the Bannister.

The Yilgarn Plateau is a relatively high and largely flat featureless area of salt-lakes and sandplains, which slopes gently downward from about 370 m in the east to 250 m in the west. With little fall, the ancient river valleys are broad and shallow and contain chains of salt-lakes and floodplains formed by a combination of fluvial and aeolian processes. Only very occasionally, after a period of exceptionally wet winters or during the passage of decaying tropical cyclones, are the river/lake systems flushed with water. Soils of the area are highly variable and may be duplex in form. On the sandplains, the sandy soils may overlay or contain ironstone and there may be breakaways and outcroppings of exposed ironstone on boundaries. The absence of ironstone breakaways distinguishes the

Hyden Plateau, which is found to the east of the Yilgarn and is essentially an extension of it, and which is drained along its western margin by the ancient streams of the upper Blackwood.

A more detailed description of the geology and geomorphology of the Busselton-Walpole Region, particularly with respect to the development of wetland systems, is given in a report to the Water and Rivers Commission by the V. & C. Semeniuk Research Group (V. & C. Semeniuk Research Group 1997a).

2.3 Drainage basins

The Busselton-Walpole region contains five drainage basins, as identified by the Australian Water Resources Council (PWD 1984). The basins are shown in Figure 2.3 and each is described below.

The Busselton Basin consists of 26 river and creek systems that discharge to the coast between Bunbury and Augusta. It covers an area of 2560 km^2. Between Bunbury and Cape Naturaliste 9 short rivers and major creeks drain the Whicher Range and/or the Swan Coastal Plain and discharge into Geographe Bay. The more substantial systems are the Capel, Ludlow, Abba and Sabina which have head waters in the forested Whicher Range. Many of the creek systems and lower reaches of the rivers have been either entirely or partially modified as part of artificial drainage systems to drain the very low-lying and now cleared Swan Coastal Plain and thus enable its use for dairy farming and other forms of agriculture.

Seventeen minor creeks occur along Leeuwin-Naturaliste Ridge, three of which flow to Geographe Bay on the western side of Cape Naturaliste. Many of these small systems are either partially or wholly contained within remnant coastal vegetation. The only true river system to pass through the ridge is the Margaret, which drains the north-western corner of the forested Blackwood Plateau.

The Blackwood River Basin is the largest in the study area and has a catchment of about 20 000 km^2. It reaches some 330 km inland to drain the Yilgarn Plateau some 380 m above mean sea level, but in fact receives little water from this zone. This far inland the landscape is flat and ordinarily receives insufficient rainfall to cause the broad almost indiscernible streamlines to flow, and of what flow there is, usually only fills the large lake and floodplain systems that stretch along the upper Arthur and Beaufort River systems (Hodgkin 1978, Beard 1981, Williams In Prep.). Below these lake systems, as the major branches of the Blackwood, Hillman, Arthur, Beaufort and Balgarup Rivers pass through the Bannister Uplands and the Darling Plateau, the river system becomes rejuvenated and seasonal flows occur as far downstream as Nannup, where upon the river becomes more or less permanently flowing as it winds its way through the high rainfall Blackwood Plateau.

Most of the Blackwood catchment is cleared for agriculture, especially in the upper catchment, and discharges brackish to saline water; made more so in recent times by the altered catchment hydrology of the cleared landscape (see Section 4.2.3-4.2.5). Only in the lower reaches of the river, below Bridgetown, where rainfall is high and evaporation relatively low, and large areas of forest and tree plantation occur, do the tributaries of the Blackwood carry fresh water.

The Blackwood basin includes the Scott River, a lower tributary of the river's estuary, which drains the western Scott Coastal Plain.

The Donnelly Basin consists of the single Donnelly River system, most of which drains high rainfall forested country. The catchment covers an area of 1670 km^2 and is divided mostly between the south-east corner of the Blackwood Plateau and the lower south-west corner of the Darling Plateau.

The Warren Basin, as with the Donnelly, consists of the single Warren River system. The catchment covers 4350 km^2 and passes across mostly forested parts of the southern Darling Plateau, to drain woodland and cleared land on the southern end of the Bannister Uplands where salt discharge from cleared land is significant. The basin includes the Unicup Wetlands system and also drains a substantial portion of densely vegetated Scott Coastal Plain (see Section 4.2.7).

The Shannon Basin consists of 12 creek size systems and three true rivers, although two, the Gardner and the Shannon, are quite small. All up, the basin covers a high rainfall area of about 2490 km^2 on the southern Darling Plateau (or Ravensthorpe Ramp) and Scott Coastal Plain and is mainly covered in dense natural forest and wetland vegetation. Only the Meerup, Gardner and Walpole River catchments are heavily cleared. A number of creeks and rivers discharge into the Broke and Walpole-Nornalup Inlets. The basin includes the Lake Muir wetland system, which occurs in a partially cleared sub-basin of internal drainage in the upper Deep Catchment. There is some conjecture over whether the basin ever overflows into the Deep River.

2.4 Estuaries and inlets

There are ten estuaries in the Busselton-Walpole Region (Figure 2.3). They vary greatly in form and size, ranging from narrow river estuaries, like that of the Donnelly, Warren and Gardner Rivers to broad basins, like the Broke and Nornalup-Walpole, which receive most flow from the Shannon and Deep Rivers, respectively. The small Meerup and Doggerup stream systems have tiny short river form estuaries. Intermediate between these two forms is the flooded valley form of the Hardy Inlet and Margaret River estuary, the former of which is the estuary of the large Blackwood River system. On the Swan Coastal plain there are two elongate lagoons parallel to the coast and separated from the ocean by narrow beach ridges, the large Vasse-Wonnerup System, near Busselton, and the small Toby's Inlet, near the small settlement of Quindalup. Both these systems have modified connections to the ocean and receive flow from a number of partially artificial stream systems draining the coastal plain and the Whicher Range. All the estuaries are described in greater detail in Section 6.3 and their location shown at a larger scale on Figures 5.1-5.6.

2.5 Vegetation and natural regions

2.5.1 The plant communities

The natural vegetation of the south-west has been described by Beard (1981) on the basis of height, projective foliage cover and dominant species. About 18 of the 44 plant community associations recognised are found in the Busselton-Walpole Region. The associations are described briefly in Table 2.1 and their extent illustrated in Figure 2.4.

2.5.2 Natural vegetation

Swan Coastal Plain

The broad seasonally wet areas of Pinjarra Plain soils once supported Jarrah-Marri forest and Marri woodland, but much of this has now been cleared for agriculture. In sandy areas low woodlands of Banksia species with or without jarrah predominated, particularly on the broad sandy areas about Capel and towards Bunbury. On the better quality Spearwood Dune soils, tall woodland of tuart occurred in a narrow coastal strip between Busselton and Bunbury. Much of this plant community has been reserved in National Park, but is somewhat degraded as a result of logging and livestock grazing. Low woodlands and thickets of peppermint and paperbarks, sedgelands and samphire marshes (Succulent Steppe) were found about the Vasse-Wonnerup and Broadwater estuarine wetlands, but much of this has been cleared or severely degraded by weed invasions, grazing and alteration to the natural hydrological regimes caused by drainage and the prevention of saline tidal inflows. In the wetter and fresher sites thickets of Melaleucas were found and many still remain, particularly near Capel and south of the Broadwater.

Leeuwin-Naturaliste Ridge

The greater part of the Leeuwin-Naturaliste Ridge supported Jarrah-Marri forest, but most of this has now been cleared for agriculture. In a few small sandy sites Banksia low woodland was found, while pockets of the better soils supported karri tall forest which grew in large stands in the Boranup area, south of Margaret River, and down to Augusta. Much of this tall forest remains in National Park. Thickets of Acacia and other species are found along the coast, backing onto scrub and low woodland dominated by WA peppermint, mostly in the Leeuwin-Naturaliste National Park that runs between the Capes.

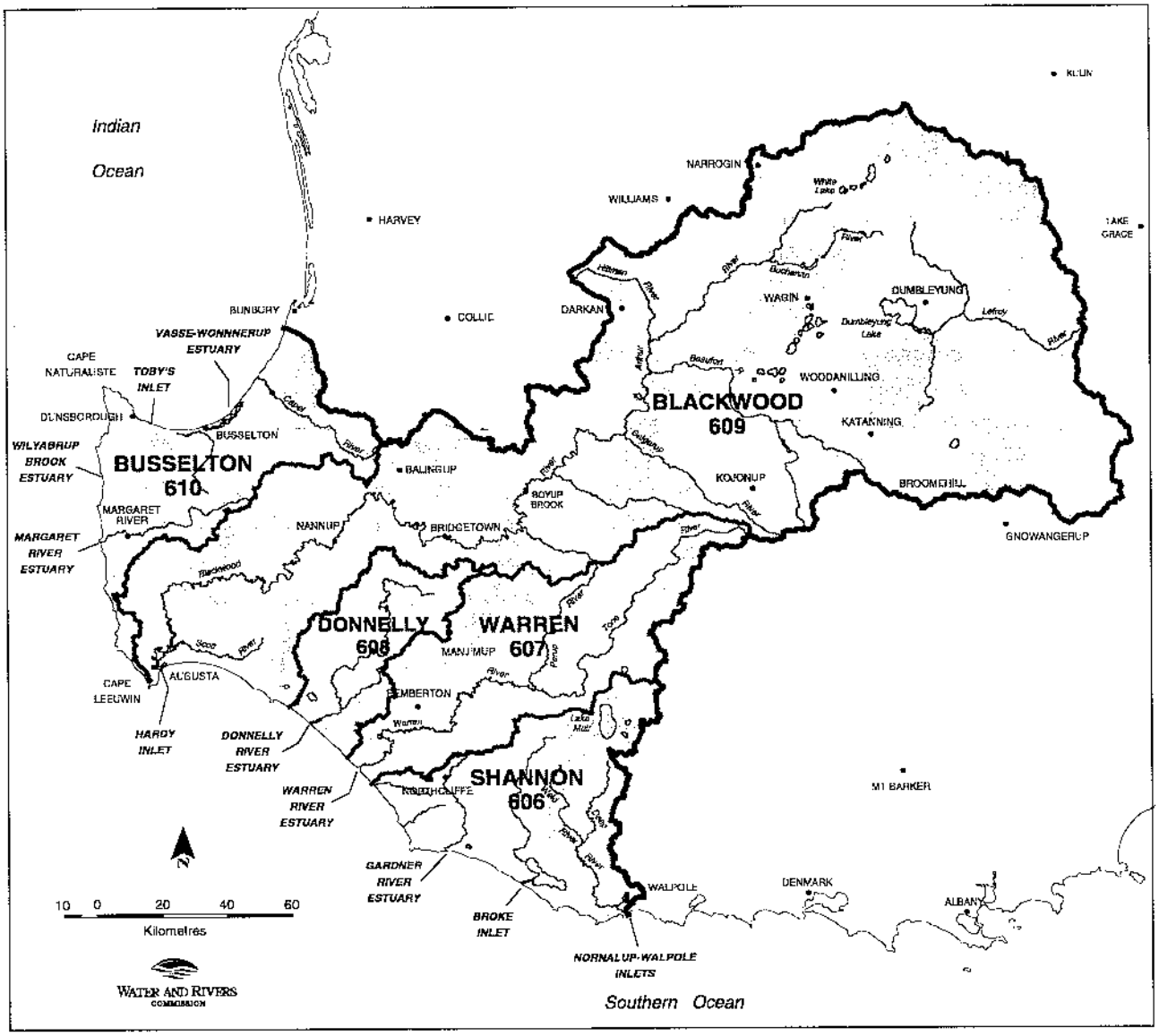


Figure 2.3: Major drainage basins and estuaries of the Busselton-Walpole Region

Scott Coastal Plain

The vegetation of the Scott Coastal Plain is quite complex. The sandy coastal areas support low woodlands, scrub and scrub heaths dominated by WA peppermint and a variety of other Myrtaceacae and Proteacae species. Somewhat inland sedgelands are found in the many broad seasonally or permanently wet areas and near lakes, while low woodlands of Banksias and stunted jarrah are found on broad sandy rises. Here and there are pockets of karri tall forest and forests of marri, jarrah and coastal yate (*Eucalyptus cornuta*). Most of the vegetation is intact within the D'Entrecasteaux National Park, Gingilup Nature Reserve and as remnant vegetation on private land, but very large areas have been cleared for agriculture in the western portion of the plain over a distance of about 30 km.

Blackwood and Darling Plateaus

The natural vegetation of these areas is mostly forest of jarrah and marri, slowly grading to marri-wandoo woodland on the eastern margins of the Darling. The only other vegetation association of broad distribution is the karri forest, found on red earth or karri loam soils, over a broad area 20 to 30 km wide, from about Walpole to just short of Nannup, where rainfall generally exceeds 1000 mm annually. This karri forest region also includes extensive Jarrah-Banksia low woodland in sandy areas and low woodland and thickets of paperbark and sedgelands in swampy areas, especially in the Shannon Basin. These same associations occur around the Lake Muir area, with paperbark low woodland extending up into the Tone catchment.

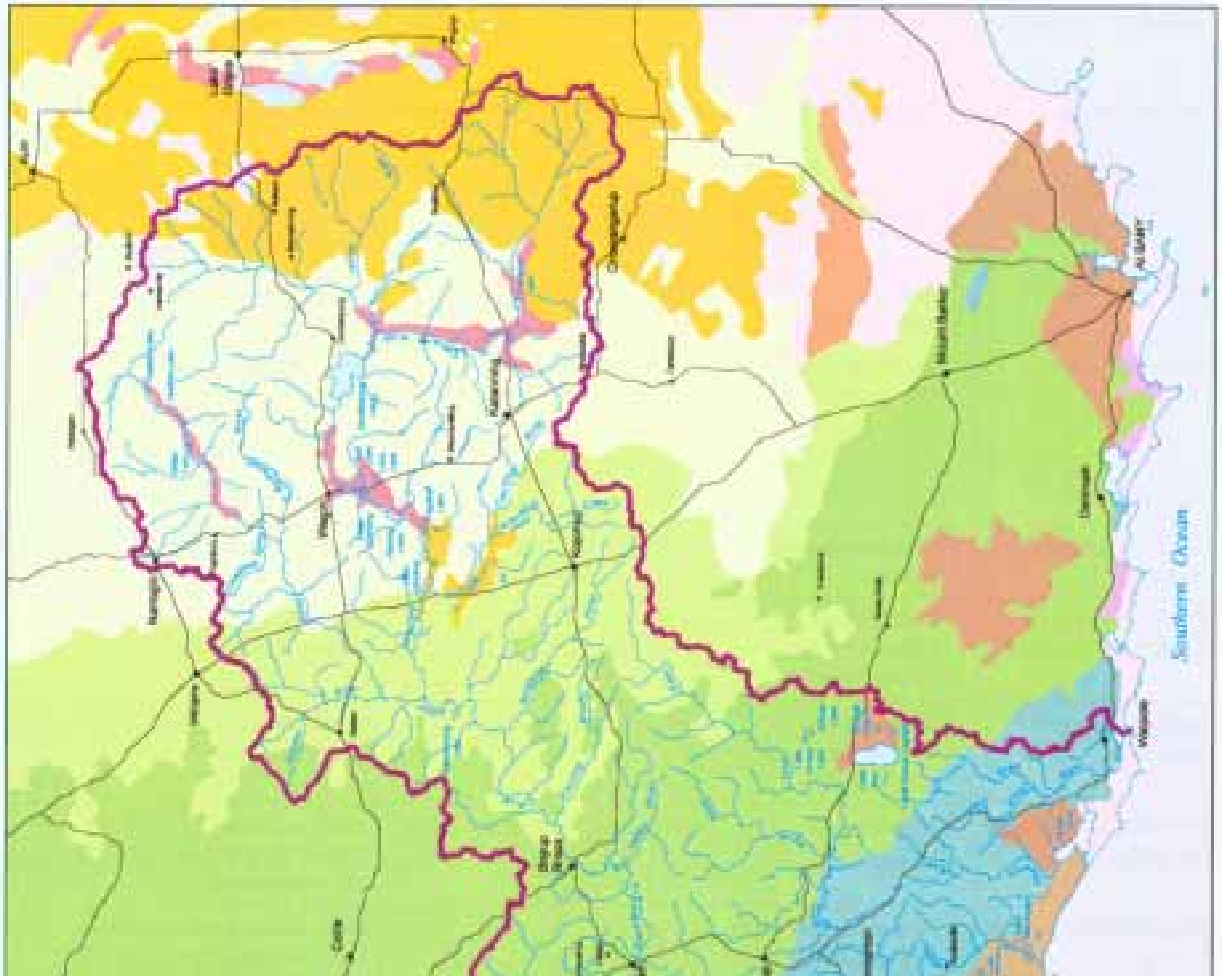


Figure 2.4: Major vegetation associations of the Busselton-Walpole Region

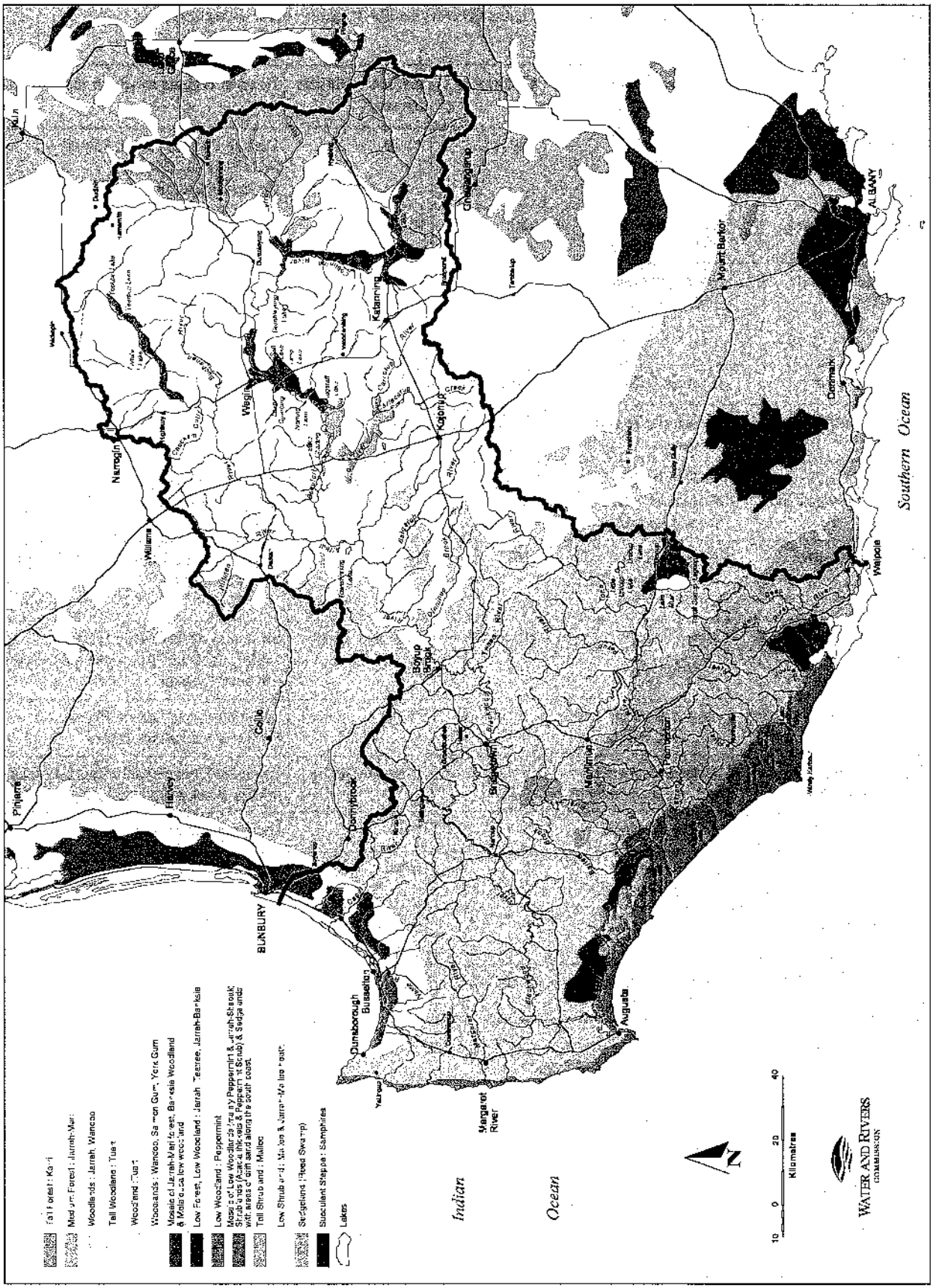


Figure 2.4: Major vegetation associations of the Busselton-Walpole Region

Most of the vegetation in this part of the study area has been cleared, especially along the middle Blackwood and upper Warren catchment. However, large areas of forest, woodland and sedgeland still remain on the Blackwood Plateau and western Darling Plateau and in or near the Karri forest region; where soils were found to be unsuitable for farming and forest resources were found to be high.

Upper Blackwood

With decreasing rainfall the natural vegetation of the upper Blackwood becomes increasingly lower and narrower. Above Boyup Brook the Jarrah-Marri forest gives way to Marri-Wandoo woodland, mainly on the Bannister Uplands. This in turn gives way, on the Yilgarn Plateau above Arthur River and 10 km west of Katanning, to woodland of mainly York gum, wandoo and salmon gum, with patches of powder-bark wandoo and mallet. By Nyabing in the extreme upper parts of the catchment on the Hyden Plateau, the vegetation turns to Mallee with patches of the previous woodland or heath and scrub heath of a variety of species.

Table 2.2: Natural resource zones of the Busselton-Walpole region (Allison *et al.* 1993)

Zone no.	Zone code	Botanical district (Natural region)	Drainage basin	Rainfall band (mm)
1	WaBuR2	Warren (Karri forest)	Busselton	700-1100
2	WaBlR2	as above	Blackwood	700-1100
3	WaDoR1	as above	Donnelly	>1100
4	WaWrR1	as above	Warren	>1100
5	WaShR1	as above	Shannon	>1100
11	MeBuR2	Menzies (Southern Jarrah Forest)	Busselton	700-1100
12	MeBlR3	as above	Blackwood	500-700
13	MeBlR3	as above	Blackwood	500-700
14	MeDoR2	as above	Donnelly	700-1100
18	MeWrR2	as above	Warren	700-1100
19	MeWrR3	as above	Warren	500-700
20	MeShR2	as above	Shannon	700-1100

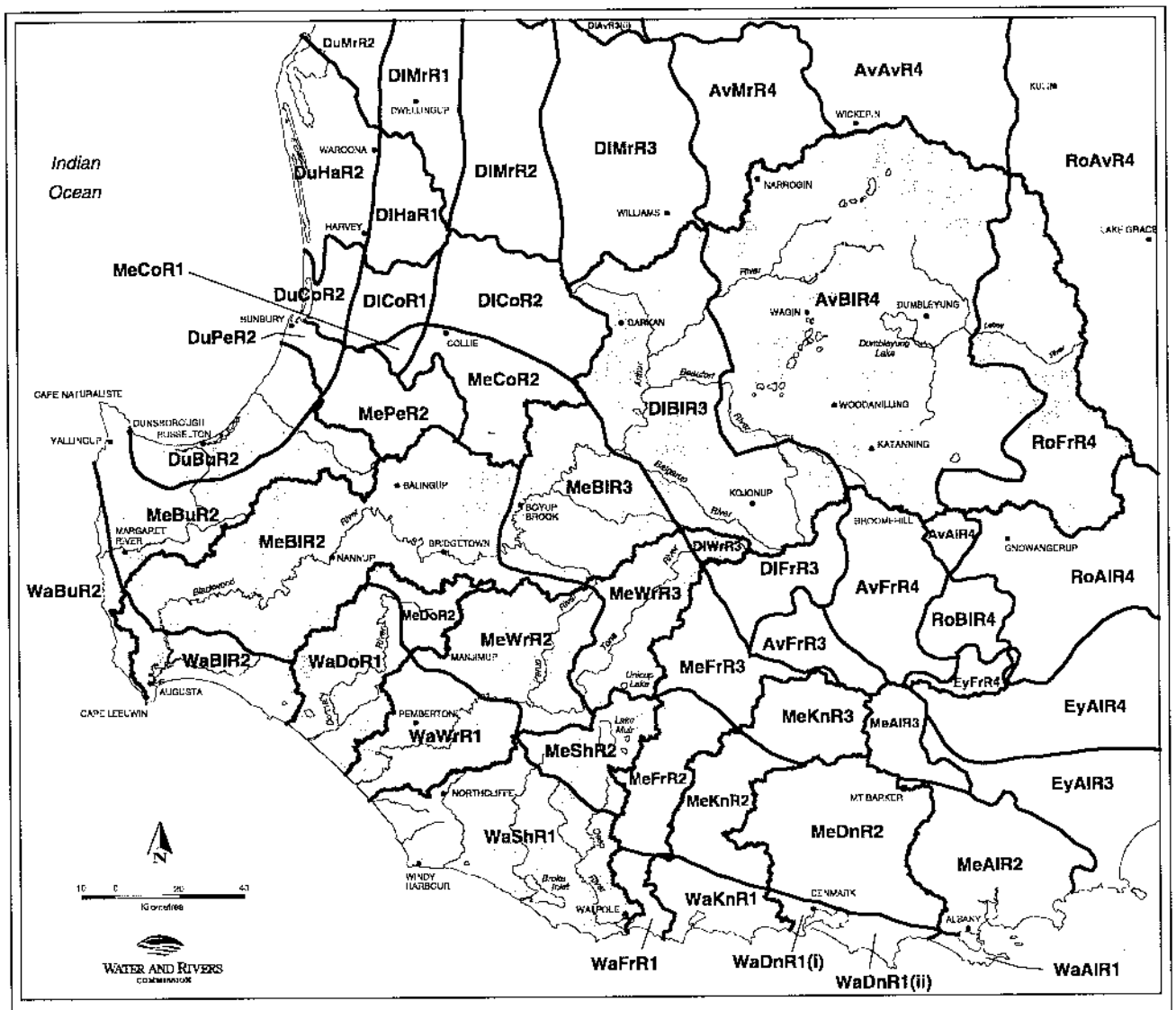
The broad saline water courses of the Coblinine, Dongolocking, Arthur, Beaufort and Buchanan Rivers support Succulent Steppe vegetation with samphires and sparse salt-tolerant paperbarks and sheoaks. Between Arthur River and Kojonup on the floodplains of the Beaufort and Carrolup Rivers there are thickets of paperbarks with scattered York gums, swamp yate (*Eucalyptus occidentalis*) and wandoo in and about samphire marshes.

This part of the study area is part of the wheat-belt and has been 80-90 percent cleared of its native vegetation. Much of what is left is becoming increasingly degraded through a variety of processes, including salinisation, waterlogging, weed invasions and disease.

2.6 Natural regions and Natural Resource Zones

On the basis of similar vegetation associations and associated physiographic, geological and soil characteristics, Beard (1981) divided the south-west into six botanical districts, of which one, the Darling, largely covers the Busselton-Walpole region. Another two, the Avon and Roe cover the upper catchment of the Blackwood. The Darling is further divided into four sub-districts, Drummond, Dale, Menzies and Warren which are synonymous with Swan Coastal Plain, northern jarrah forest, southern jarrah forest and the karri forest region, respectively. The result is six natural regions that cover the Busselton-Walpole region.

For the south-west region, Beard's natural regions have been combined with water resource drainage basins (see Section 2.3) and the 1100 mm, 700 mm and 500 mm rainfall isohyets to create natural resource zones (Allison *et al.* 1993). In all 14 Natural Resource Zones (NRZs) constitute the Busselton-Walpole region. They are shown in Figure 2.5 and listed in Table 2.2. These zones will be used throughout this report as the key sub-divisions of the study area, especially in the identification of representative wetlands, including streamlines.



Note : Natural Resuource Zone Codes - the first two characters show the native vegetation type, the second two show the river catchment or drainage basin, and the last two show the rainfall zone.

Native Vegetation Regions

Code	Formal Name	Common Name
Av	Avon Botanical District	Wheatbelt
Ro	Roe Botanical District	Mallee
	Darling Botanical District	South West Forest
Du	- Drummond Sub district	- Swan Coastal Plain
Dl	- Dale Sub district	- Northern Jarrah Forest
Me	- Menzies Sub district	- Southern Jarrah Forest
Wa	- Warren Sub district	- Karri Forest

River Catchment/Drainage Basins

Bl	Blackwood River
Bu	Busselton Coast
Do	Donnelly River
Sh	Shannon River
Wr	Warren River

Rainfall Zones

R1	greater than 1100mm
R2	700-1100mm
R3	500-700mm
R4	less than 500mm

Figure 2.5 Natural resource zones of the Busselton-Walpole Region

3. Wetland assessment and evaluation

3.1 Types of wetlands

Wetlands are defined as *"areas of seasonally, intermittently or permanently waterlogged soils or inundated land, whether natural or otherwise, fresh or saline, e.g. waterlogged soils, ponds, billabongs, lakes, swamps, tidal flats, estuaries, rivers and their tributaries"* (Wetlands Advisory Committee 1977). This definition was agreed upon by the Wetlands Advisory Committee of WA and is often used by the scientific community in Western Australia.

In practice, wetland may be distinguished from upland by the occurrence of water, or waterlogged soils, or vegetation typical of water conditions (e.g., paperbarks, rush beds, samphires), or hydric soils (i.e., formed in response to prevailing water inundation or waterlogging, and including peats, peaty sands, carbonate muds, etc) (Hill *et al.*1996). Rivers and creeks are, by definition, wetlands. However, they are often treated in isolation from the floodplains, damplands, sumplands and palusplains that surround them. While this can sometimes be a useful distinction, it is important that rivers, creeks, artificial channels are recognised as wetlands which are intimately connected to other wetland types.

3.2 Wetland classification, mapping and evaluation

3.2.1 Broad wetland classification and mapping

Wetlands are classified and subsequently mapped in different ways depending on the scale at which information is obtained. For example, wetland mapping on AUSLIG's Topographic Series at 1:250 000 recognises seven basic categories:

- perennial and intermittent watercourses,
- perennial and intermittent lakes,
- swamp,
- area subject to inundation, and
- artificial basin.

DOLA's Cadastral/Topographic Series at 1:50 000 scale recognises 12 categories:

- perennial and intermittent streams,
- perennial and intermittent lakes,
- mainly dry lakes and streams,
- clay pan,
- flood plain,
- creek or brook,
- perennial and intermittent swamps and
- land subject to inundation.

The number and extent of wetlands also varies with scale. Not surprisingly, more wetlands and more small wetlands are recognised and mapped more accurately at 1:50 000 scale than at 1:250 000 scale. In this study the 1:250 000 wetland data was used to express the wetlands of the Busselton-Walpole Region (see Sections 4 and 5), while the identification of wetland groups was done using the more detailed 1:50 000 data.

It is important to recognise that these categories are part of a continuum of wetland types. For example, the middle of a lake area may be permanently inundated all year long for most years, while the outer fringes only inundated in most winters and the adjacent floodplains only in very wet periods which occur intermittently. Furthermore, the lake may be fringed in places by vegetated swampland which in turn gives way to seasonal swampland. This continuum is recognised in this report by the use of the terms permanent, seasonal (synonymous with regular) and intermittent in Sections 4-8.

3.2.2 Detailed wetland classification and mapping

Some areas in the Busselton-Walpole Region were so rich in wetland area and type, that detailed wetland classification and mapping was warranted. These areas include the southern Swan Coastal Plain, western Scott Coastal Plain, the South Coast between the Donnelly River and Walpole, also known as the southern acid peat flats of the D'Entrecasteaux National Park and the Muir-Unicup and Deep River areas. In order to explore the extent and diversity of wetlands in these areas detailed wetland mapping at 1:25 000 scale was carried out using a standard geomorphic approach pioneered on the northern Swan Coastal Plain (Hill *et al.*1996). An abbreviated description of this method, taken from V. & C. Semeniuk (1997a), follows:

Geomorphic wetland mapping and classification

By grouping wetlands according to the landform in which they are located and their permanency of water, this system highlights fundamental differences or similarities between wetlands (Semeniuk 1987). The system differentiates five landform types which can be host to wetlands and four water longevity categories. These are shown in Table 3.1 with the thirteen resultant types of wetland.

Not all wetland types will be present in a given locality. This classification system has been designed for world-wide use and so incorporates landform and water regimes for different climatic settings. As an example of the classification system, a flat which is seasonally inundated is classified as a floodplain while a wetland which is a seasonally waterlogged basin is classified as a dampland.

If further differentiation is required between wetlands of the same basic type, then the classification can be augmented by describing the wetland's vegetation, its shape, water salinity or other characteristics. Numerous wetland descriptors have been developed for use with the geomorphic classification system. One of the most useful descriptors is for wetland vegetation cover and organization (Semeniuk *et al.*1990).

At a higher level individual wetlands can be grouped into what are known as consanguineous suites. These suites contain wetlands which are related to each other because they have similar geomorphic, stratigraphic and hydrologic features, and similar processes of formation and maintenance (Semeniuk 1988). Consequently, within a given suite, similar wetland types, have similar geometry, similar history, similar recharge and discharge mechanisms, similar water salinity, and similar sediments specific to basins, flats or channels.

The reader is referred to Hill *et al.*(1996) for further information.

Wetland mapping and classification for the southern Swan Coastal Plain has been published by the Water and Rivers Commission and the Department for Environmental Protection (Hill *et al.*1996). The results of the geomorphic wetland classification and mapping between Augusta and Walpole are reported in a separate volume (V. & C. Semeniuk Research Group 1997b). However, the major findings of the detailed wetland mapping, including the extent, types and consanguinity of wetlands, are also presented and discussed in Section 4.3.

3.3 Condition versus evaluation

Wetlands are valued by society for many varied and complex reasons. It is helpful to precisely describe the values of a given wetland so that they may be more readily understood, communicated and protected. Claridge (1991) developed a comprehensive nomenclature which can be used to describe wetland values and is described below.

The VALUE of a wetland benefit (function, use or attribute) may be defined as a measure or expression of the worth placed by society on that particular function, use or attribute (Claridge, 1991), where:

CHARACTERISTICS are those properties of a wetland which describe the area in the simplest and most objective possible terms. e.g. wetland size, species present, soils and water quality.

Characteristics, singly or in combination, give rise to benefits (existing or future) which may be functions, uses or attributes of a wetland.

A FUNCTION is some aspect of a wetland that, potentially or actually, supports or protects a human activity or human property without being used directly.

A USE is some direct utilization of one or more of the characteristics of a wetland.

An ATTRIBUTE of a wetland is some characteristic or combination of characteristics which is valued by a group

Table 3.1: Wetland types defined within the global geomorphic classification system

	Landform				
Water longevity	**Basin**	**Channel**	**Flat**	**Slope**	**Highland**
permanent inundation	lake	river	-	-	-
seasonal inundation	sumpland	creek	floodplain	-	-
intermittent inundation	playa	wadi	barlkarra	-	-
seasonal waterlogging	dampland	trough	paluspiain	paluslope	palusmont

within society, but which does not necessarily provide a function or support a use (Claridge, 1991).

Dugan (1990) similarly uses the terms 'functions', 'products' and 'attributes' to help describe wetland values for the International Union for the Conservation of Nature.

Some of the characteristics, functions, uses and attributes derived from wetlands are listed in Table 3.2 (Dugan, 1990; Claridge, 1991).

In this report the distinction was made between the condition of a wetland and its value. Condition refers to the degree to which a wetland has departed from its natural state. For example, a typical wheatbelt lake, suffering from over grazing, drowning, salinisation and eutrophication and exhibiting a range of symptoms, such as extensive tree death, absence of native mammals, algae blooms and reduced waterbird breeding, would be considered to be in poor condition. Nevertheless, this wetland may still function as an important drought refuge for waterfowl, and therefore have high value. Condition assessment of wetlands is dealt with in Sections 4 to 6 and evaluation in Chapter 7. Wetlands of important value are recognised in Chapter 8.

Table 3.2 Characteristics, Functions, Uses and Attributes of Wetlands (Dugan 1990, Claridge 1991)

Characteristics	Functions	Uses	Attributes
• size; • shape; • species present; • abundance of species vegetation structure; • extent of vegetation; • pattern of vegetation distribution, soils; • geology; • geomorphology; • processes occurring (Physical and biological); • nature and location of water entry; • nature and location of water exit; • climate; • location in respect of human settlement and activities; • location in respect of other elements in the environment; • water flow/turnover rates; • water depth; • water quality; • altitude; • slope fertility; • nutrient cycles; • biomass production/export; • habitat present; • area of habitat; • habitat interspersion; • drainage pattern; • area of open water; • recent evident of human usage; • historic or prehistoric evidence of human usage; • pH; • dissolved oxygen; • suspended solids; • evaporation/precipitation balance; • tidal range/regime; • characteristics of the catchment; • characteristics of other wetlands in the region.	• Groundwater recharge; • Flood control; • Shoreline erosion/ stabilization control; • Sediment retention; • Nutrient/pollutant absorption; • Export of nutrient; • Storm protection/ windbreak; • Microclimate stabilization; • Flow regulation/ maintenance; • Nursery/breeding area; • Habitat for fish; • Habitat for wildlife; • Contribution to the maintenance of existing processes or natural systems; • Wildlife corridor.	• Extraction of naturally occurring plant products; • Extraction of naturally occurring animal products; • Extraction of mineral products; • Water supply/storage; • Production of plant products; • Production of animal products; • Recreation/ tourism; • Water transport; • Research site; • Monitoring site; • Education site; • Waste disposal/ water treatment.	• Richness or diversity of flora or fauna; • Landscape/aesthetic qualities; • Valued as a cultural, symbolic or spiritual place by a defined group within the community; • Presence or rare, endangered or uncommon flora, fauna, communities, ecosystems, natural landscapes, processes or wetland types; • Site of historically significant research or other historically significant event; • Wilderness; • Type locality of a taxon; • Constitutes a significant gene pool; • Contains evidence of products of past processes important in the evolution of flora, fauna, landscapes, wetland systems or climate; • Contains evidence demonstrating, or contributing to the maintenance of, existing processes or natural systems at the local, regional or national level; • Source of information which has lead to a better understanding of evolutionary processes, existing natural systems or processes or the history of human occupation; • Presence of a distinctive way of life, custom, process, land use, function or design in danger of being lost; • Demonstrates the principal characteristics of one or more of the range of types of wetlands, or landscapes; • Demonstrates the principal characteristics of the range of human activities in the wetland environment.

PART 2:
The state of the wetlands, rivers and estuaries of the Busselton-Walpole region

The broad definition of wetlands, as given above, includes rivers and estuaries. But the more often used narrow definition, used in everyday discussion, does not include them. And so it will be for this report from here on. In other words this report will recognise as separate groups wetlands (damplands, swamps, lakes, etc), rivers and estuaries.

4. State of the wetlands

4.1 Methodology

4.1.1 Wetland type and size

In this chapter simple wetland terms will be used. Basin wetlands which contain standing water or which partially or wholly dry out to bare ground will be referred to as lakes. Lakes may be lightly to heavily wooded with open areas or entirely open. Wetlands which support dense vegetation all year round and no significant open water will be referred to as swamps. Areas which are subject to inundation during heavy rainfall or river flooding are referred to as floodplains. Lakes and swamps are further divided into permanent, seasonal and intermittent. The size of wetlands is divided into small (<500 m across), medium (500-1000 m across) and large (>1000 m across). Very large wetlands are many kilometres across.

4.1.2 Wetland groups

The Busselton-Walpole region contains thousands of wetlands. Because it is not possible to assess the condition of all of them, and because such an exercise would be beyond the scope of this report, the wetlands of the region have been grouped on the basis of proximity and apparent hydrological and geomorphic association. A total of 140 wetland groups were distinguished for the region.

This report will focus on the wetland groups and draw out for discussion the more important individual wetlands within them. Important wetlands have been identified as those with names (indicating local recognition), those in reserves or those known to support significant wildlife habitat.

4.1.3 Assessment method

The condition of each wetland group was assessed using 1:100 000 scale Landsat satellite imagery for the quality of habitat on the basis of the presence of associated non-wetland remnant vegetation. Four main categories were recognised:

A. Wetland in a large National Park, Nature Reserve or State Forest;

B. Wetland in a small reserve or large block of remnant vegetation;

C. Some remnant vegetation connected to the wetland; and

D. Wetland surrounded by cleared land.

The D category is further sub-divided into three categories on the basis of remnant vegetation within the wetland:

Dl. Lake surrounded in cleared land (may be degraded fringing strips of vegetation);

Ds. Swampland retains native wetland vegetation but surrounded land cleared; and

Dc. Swampland cleared of native wetland vegetation (i.e. now wet or boggy pasture).

4.1.4 Rare flora and fauna

Plant and animal species which are rare or restricted in distribution are referred to in this report as 'rare flora' or 'rare fauna'. Rare and endangered flora are acknowledged formally by CALM as Declared Rare Flora (DRF) or Priority Species 1-5 (See Hopper *et al.* 1990). Rare species are placed into one of these categories on the basis of their threatened status, and their protection under law is reflected by this status. Some species are found in critically low numbers in only one or a few locations and are afforded the maximum protection (ie DRF), while others may be presumed extinct, restricted in distribution or only found in habitats which are particularly threatened by degradation or in need of monitoring to ensure survival (Priority species). Only those species which are considered 'rare' and which are known to be dependant on wetland habitats within the Busselton-Walpole Region are referred to in this report. A list of rare wetland flora was obtained from CALM (see Acknowledgements).

Rare wetland animals were determined by searching the relevant literature on the study area or inferred by their restricted distributions.

The presence of rare flora and fauna in wetlands is stated in the individual reports of wetland condition (Section 4.2).

4.2 Wetland description and condition

Wetland groups are described below within broad sub-regions of one of more natural resource zones. Supplementary information on individual wetlands or groups from published documents is provided where available.

4.2.1 Geographe Bay, Leeuwin-Naturaliste Ridge and Margaret River catchments

Most of the wetlands is this area are located between Bunbury and Busselton in the lower coastal plain catchments of the Sabina, Abba, Ludlow and Capel Rivers (see Figure 4.1). The wetlands range from small to large seasonal and permanent swamps and floodplains. There are also a number of small permanent lakes. The larger fresh wetlands, including the Boyanup Wetland group (see below), lie between Bunbury and the Capel River, and a number run along the coast (Figure 4.1). The large elongate estuarine wetland systems of the Vasse-Wonnerup and Broadwater run along the coast for about 50 km either side of Busselton. These systems are described in greater detail below.

Away from the coastal plain, on the Blackwood Plateau and the Leeuwin-Naturaliste Ridge, wetlands are few and are mainly small lakes and swamps. Exceptions include areas of floodplain and seasonal swamp on Turner Brook near Augusta. There are also narrow floodplains supporting wetland vegetation along the upper ranches of the Margaret River (not shown).

The condition of most of the wetlands is poor, ranging from C to D, as much of the coastal plain has been cleared and/or drained for farming. Some B grade wetlands remain in small blocks of remnant bush, but few of these are reserved on public land. As a result, none of the wetland groups on the coastal plain are A grade. Similarly, most of the Leeuwin-Naturaliste Ridge has also been cleared, but here one A grade wetland, Lake Davies, remains, secure in National Park.

Specific information on each of the 31 wetland groups of this part of the study area, shown in Figure 4.1, is given in Table 4.1.

Boyanup Swamps. Large area of small to medium swamps and floodplain and small lakes west of the Preston River, mainly on private land. The group includes Rush Swamp, Lake Beridup, Lake Waneragup and Cokelup Swamp. Some remnant vegetation remains in the area and is connected to the wetlands and many of the swamps retain their natural vegetation, but condition is no better than C grade and is as poor as D grade. A number of the wetlands support the rare aquatic herb, *Aponogeton hexatepalus* (CALM data).

Capel Swamps. Area of scattered small swamps between the Ludlow and Capel Rivers (Figure 4.1). Most of the swamps are located on partially cleared private land, but a number are located wholly or partially within bushland public reserves. Because the area retains considerable remnant vegetation, including the rare aquatic herb, *Aponogeton hexatepalus*, wetland condition is as good as B grade, but ranges to as poor as D grade. Some wetlands are located close to sand mining.

Ludlow Wetlands. Small area of small lakes, swamps and floodplain, just to the east of the Busselton Highway, on private land (Figure 4.1). Wetland condition ranges from B to D, with the small lakes being C grade. The group includes **McCarley's Swamp** which is listed as a wetland of National Significance (ANCA 1993). This fresh wooded permanent swamp, covering an area of 25 ha, is important waterbird habitat, supporting as many as a thousand or more individual birds and 31 species, nine of which breed in the wetland. McCarley's Swamp is known to support the largest breeding colonies of the great egret and straw necked ibis in the south-west and is regionally significant for three other species (see ANCA 1993). Waterbird habitat is threatened by the die-off of paperbarks, the cause of which is not clear (Jaensch and Vervest 1989). Some nearby wetlands within the group support the rare aquatic herb *Aponogeton hexatepalus* (CALM data).

Ironstone flats. A floristic survey of the southern Swan Coastal Plain discovered seasonally waterlogged flats on ironstone country in two areas at the base of the Whicher Range, between the Capel and Carbunup Rivers (Gibson *et al.* 1994). These wetlands were found to support rare plant communities with some rare flora, and are considered to be threatened (Gibson *et al.* 1994).

Ludlow-Abba Wetlands. Small lakes and swamps and medium floodplain between Ludlow and Abba Rivers; some in State Forest, but most on private land. The Swan Coastal Floristic Survey found rare wetland plant species in freshwater paperbark swamps on claypans in the Ludlow tuart forest (Gibson *et al.* 1994; pers. comm, Greg Keighery cited in Drake 1995). The rare aquatic herb *Aponogeton hexatepalus* and sedge *Schoenus natans* are also known from the area (CALM data).

Vasse-Wonnerup Wetland System. A very large wetland of estuarine marshland and tidal floodplain, mainly on private land, about the Vasse-Wonnerup estuarine lagoon. It is as wide as 1.5 km and runs for about 25 km behind narrow coastal dunes. Today most of the wetland is cleared and the natural hydrology has been greatly altered by tidal barrages and drainage; but some saline samphire marshes and stands of remnant estuarine forest trees remain in places, including on small CALM reserves on the Vasse Estuary and near its connection with the Wonnerup. Despite the wetland's very poor condition, which ranges from Dl to Dc, it remains highly significant waterbird habitat, both on a regional and international scale (ANCA 1993). Between 20 and 30 thousand birds may make use of the wetland annually, the numbers being swelled by migratory wading species which use the system as a major 'stopover'. Out of the thousand or so wetlands in the south-west which are surveyed for waterfowl every so often, this system often tops the counts or is in the top 15 wetlands (Halse *et al.* 1990, 1992 and 1994). In all, 78 species have been observed on the wetland and 12 species are known to breed there, including the largest breeding population of black swan (ANCA 1993). Despite the importance of the Vasse-Wonnerup, it is threatened by eutrophication, development pressure and changes wrought by the exclusion of seawater, such as weed invasions.

Broadwater floodplain. Very large area of tidal floodplain and lagoon on the modified Vasse and Buayunup Rivers (Figure 4.1). The lagoon, known as the **Broadwater**, is mostly contained with a CALM reserve, but the rest of the wetland is mainly cleared pasture. Even the lagoon itself is mainly surrounded in pasture, with only a fringe of wetland vegetation on the north and north-western sides and a broad paperbark forest on the southern and eastern sides. The condition of the wetland is poor, mainly ranging from Dl to Dc with some C grade parts. Nevertheless, the wetland, with its remnant shrub and paperbark thickets, is important waterbird habitat, supporting 41 species, 8 breeding species and as many as 6000 individuals (Jaensch *et al.* 1988). The rare aquatic herb, *Villarsia submersa*, is known from the area (CALM data).

This wetland group also includes the small and very narrow **Toby's Inlet**, which once received flow from the modified Carbunup River and Mary Brook. It is located just to the west of Dunsborough. The freshwater wetlands around the inlet are all but cleared (Dc) and the inlet itself retains only a narrow fringe of vegetation and is connected to a small patch of upland bush (C) (See also Section 6.3).

Unique wetlands of the Leeuwin-Naturaliste Ridge. This region supports a range of unique wetland habitats, reflected in the occurrence of a number of rare organisms, such as rare snails, microbiolite formations and cave invertebrate fauna (Drake 1995). While some of these wetlands are safe within National Park, others are located in partially cleared private land and have become degraded (see for example the relevant wetlands in Table 4.1).

Table 4.1: The condition of wetlands of the Geographe Bay, Leeuwin-Naturaliste Ridge and Margaret River Catchments; Natural Resource Zones DuBuR2, MeBuR2 and WaBuR2.

Wetland group	Named wetlands (condition)	Approx. wetland area (ha)	Brief description	Overall condition	Habitat notes
Dalyellup Swamps		-	Area of small swamps south of Bunbury about Dalyellup, mostly on private land.	B - D	Three swamps closest to the coast are in remnant vegetation.
Boyanup Wetlands	Rush Swamp Lake Beridup Lake Waneragup Cokelup Swamp	1850	Large area of scattered small to medium swamps, lakes and floodplain west of the Preston River, mostly on private land.	C - D	One rare plant species (aquatic herb).
Bussel-Highway Swamp		630	Very long area of swampland west of the Bussel Hwy, mostly on private land.	B	Most of the wetland is amongst remnant coastal dune vegetation.
Stirling Swamp		90	Medium swamp on the coast on private land.	Ds-c	
King Rd Lakes		70	Two small lakes and a medium swamp on private land.	C - Dl	
Lower Gynadup Creek Wetlands		500	Scattered small to medium swamps and a small lake on a lower tributary of Gynadup Ck. All private.	C - D	
Upper Gynadup Ck Wetlands		2000	Large area of swamp on private land.	Dc	
Capel River Marshes		220	Coastal floodplain marshes, medium in size, at the bottom of the Capel River.	Ds-c	
Layman Gully Lakes		50	Medium lakes south-west of Capel on private land.	Dl	
Capel Swamps		180	Scattered medium swamps between the Ludlow and Capel Rivers. Mainly on private land, but some on reserved land.	B - Ds-c	Much remnant veg. in the area. One rare plant species (aquatic herb).
Ludlow Wetlands	McCarley Swamp[NS] (B)	30	Small area of small lakes, swamps and floodplain east of Bussel Hwy, all on private land.	B - Dc	McCarley Swamp is an important waterbird breeding habitat. One rare plant species.
Tutunup Rd Lake			Small lake north of the Ludlow River on private land.	B	
Tutunup Rd Swamps			Two small swamps east of Tutunup Rd on private land.	Ds-c	
Wonnerup Rd Swamp			Small swamp on the headwaters of the Ludlow River on private land.	Ds	
Ludlow-Abba Wetlands		10	Small lakes and swamps and medium floodplain between the Ludlow and Abba Rivers. Nearly all on private land.	B - Dl-c	Rare wetland habitat that supports a number of rare plant species.
Princefield Rd Floodplain		200	Large floodplain on a tributary of Vasse Estuary on private land.	Dc	

Table 4.1: Continued

Wetland group	Named wetlands (condition)	Approx. wetland area (ha)	Brief description	Overall condition	Habitat notes
Vasse-Wonnerup Wetland System	Vasse-Wonnerup Estuary[NS, RMR] The Deadwater	2000 ha (About 1.5 km wide and 25 km long)	Very large estuarine marshland and tidal floodplain about the Vasse-Wonnerup estuarine system, mainly on private land (see text).	Dl-c, Ds	Although greatly altered by clearing and grazing and with tidal barrages on the inlet, the system retains very important waterbird habitat.
Broadwater Floodplain	Broadwater[R] (C) Toby's Inlet (C)	700 ha (65 ha in NR)	Large area of tidal floodplain and lagoons (reserved) on the original Vasse and Carbunup Rivers, mainly on private land (see text).	C, Dl-c	Mainly pastured land but retains waterbird habitat. One rare plant species (aquatic herb).
Williamson Rd Swamp		40	Small seasonal swamp on private land.	Dc	
Bunkers Bay Lake		4	Small lake behind beach dune on private land.	C	Much tree cover remains around the lake. Very pretty.
Naturaliste Lake Wetlands			Small lake and swamp on the headwaters of the "Eagle Bay Creek", on private land.	B	Located on the edge of a large area of coastal vegetation.
Quininup Rd Lake Wetlands			Small lake and swamp on the headwaters of Wyadup Bk.	C - Dc	Much of general area is bushland, but wetlands on partially cleared block.
Moses Rock Rd Swamp			Medium swamp on private land.	Ds-c	
Silverwood Rd Swamp			Tiny swamp on private land.	Dc	
Ablett Rd Swamp			Tiny swamp on private land.	Ds-c	
Margaret River Swamps			Small to medium permanent and seasonal swamps and floodplains along the upper reaches of the Margaret River system.	A	All in state forest.Important wetland habitat, very natural and isolated.
Kilcarnup Rd Swamps			Small swamps west of Caves Rd on private land	Ds-c	
Wilderness Drive Swamps			Small swamps located about a golf course.	Dc	
Devils Pool	Devils Pool		Small pool on Boodjidup Bk on the edge of public and private land.	B	Surrounded in high quality native veg.
Lake Davies Wetlands	Lake Davies[NP]		Three small swamps and a small lake in the Leeuwin-Naturaliste NP.	A	High due to natural condition of surrounds.
Turner Brook Wetlands		220	Areas of floodplain on Turner Bk on private land.	C - Ds-c	

Floodplain = area seasonally or occasional inundated in water

A = wetland within a large area of healthy bushland

B = wetland within a small healthy bushland block

C = wetland connected to healthy bushland

D = wetland surrounded by cleared land;

l = cleared lake;

s = swamp/floodplain with remnant veg.;

c = cleared wetland;

s-c = transitional.

R = in reserve

NP=in National Park

NS=National Significance Wetland (ANCA 1993)

RMR=Ramsar Wetland

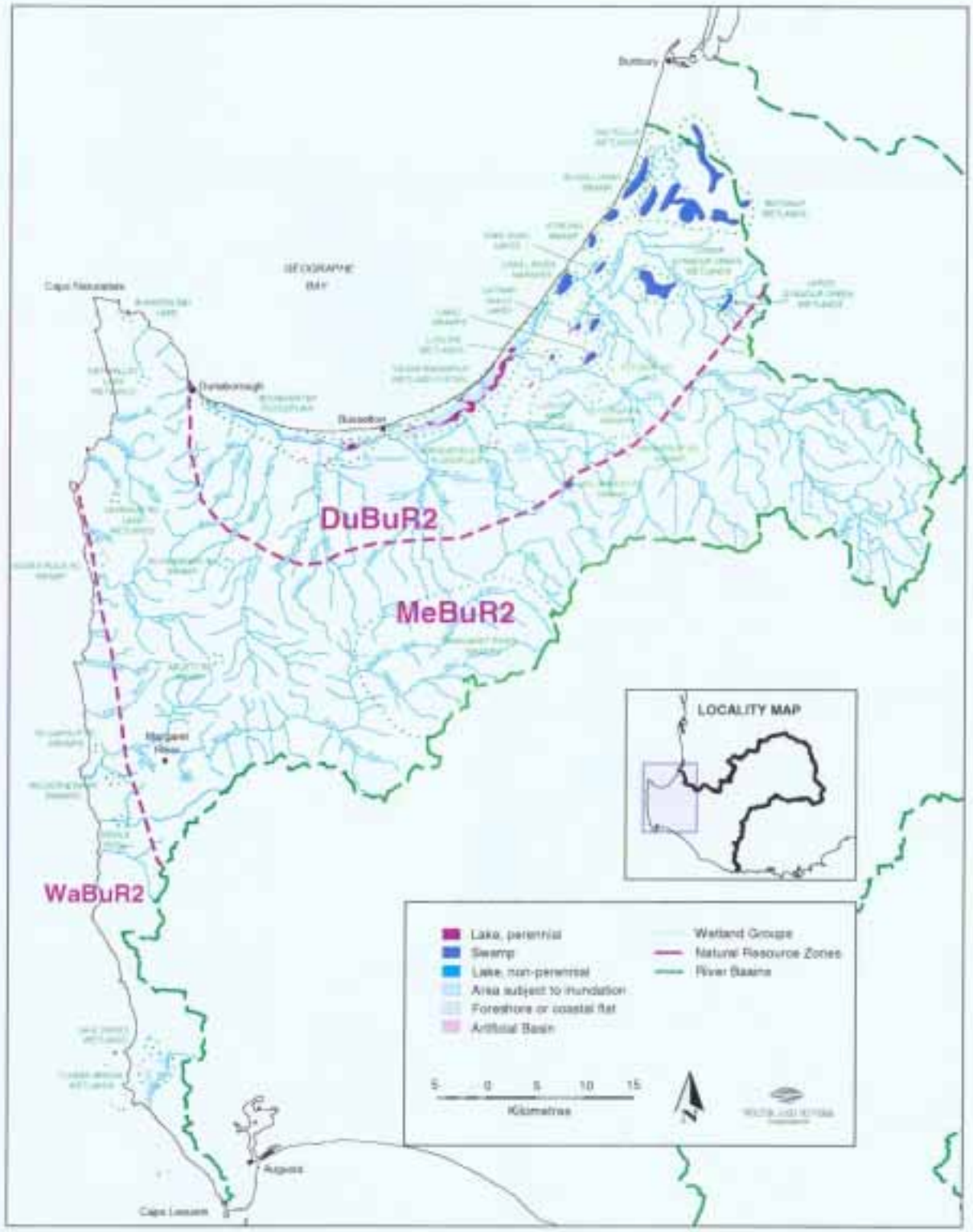


Figure 4.1: Wetland groups of the Geographe Bay, Leeuwin-Naturaliste Ridge and Margaret River Catchments

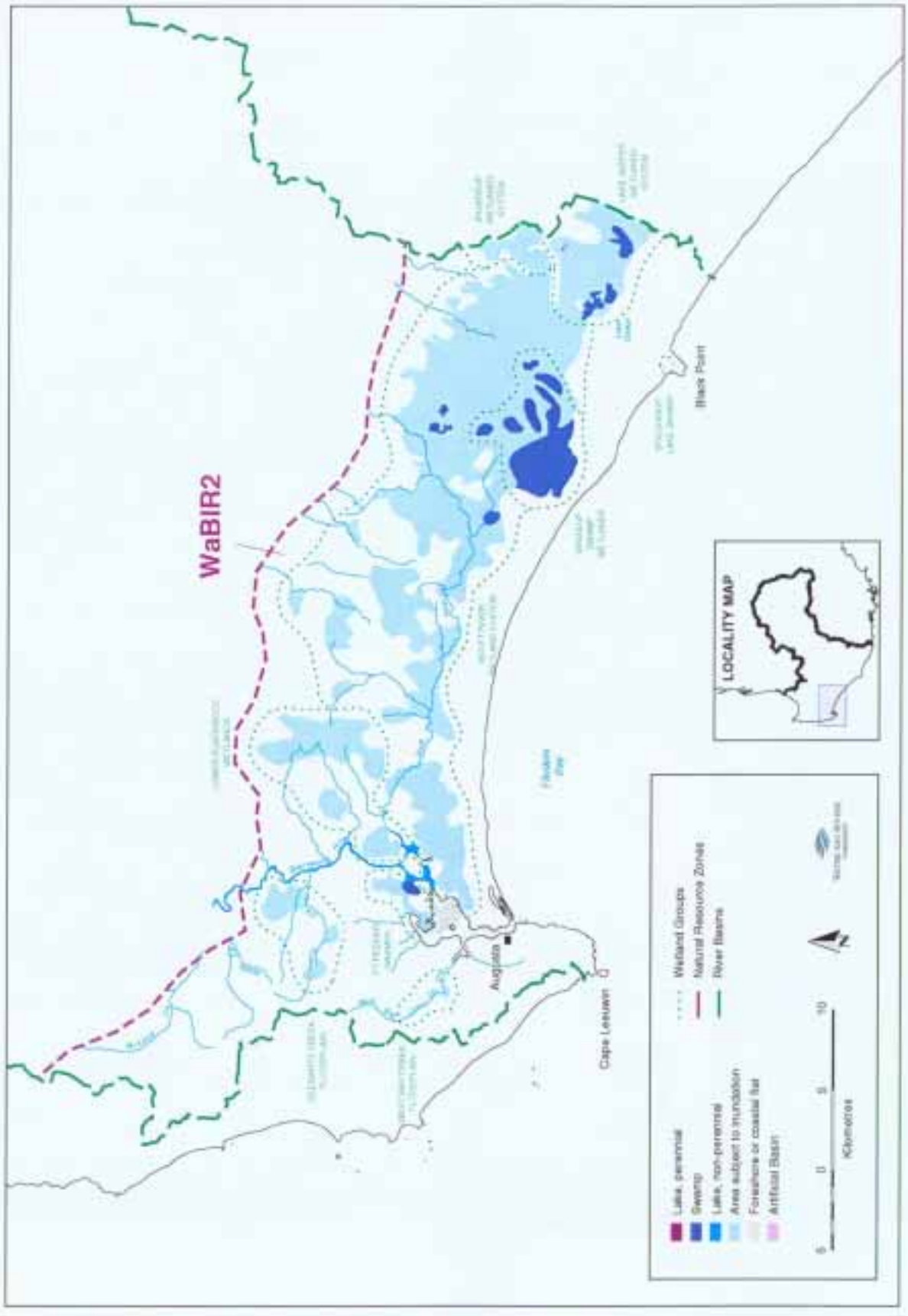


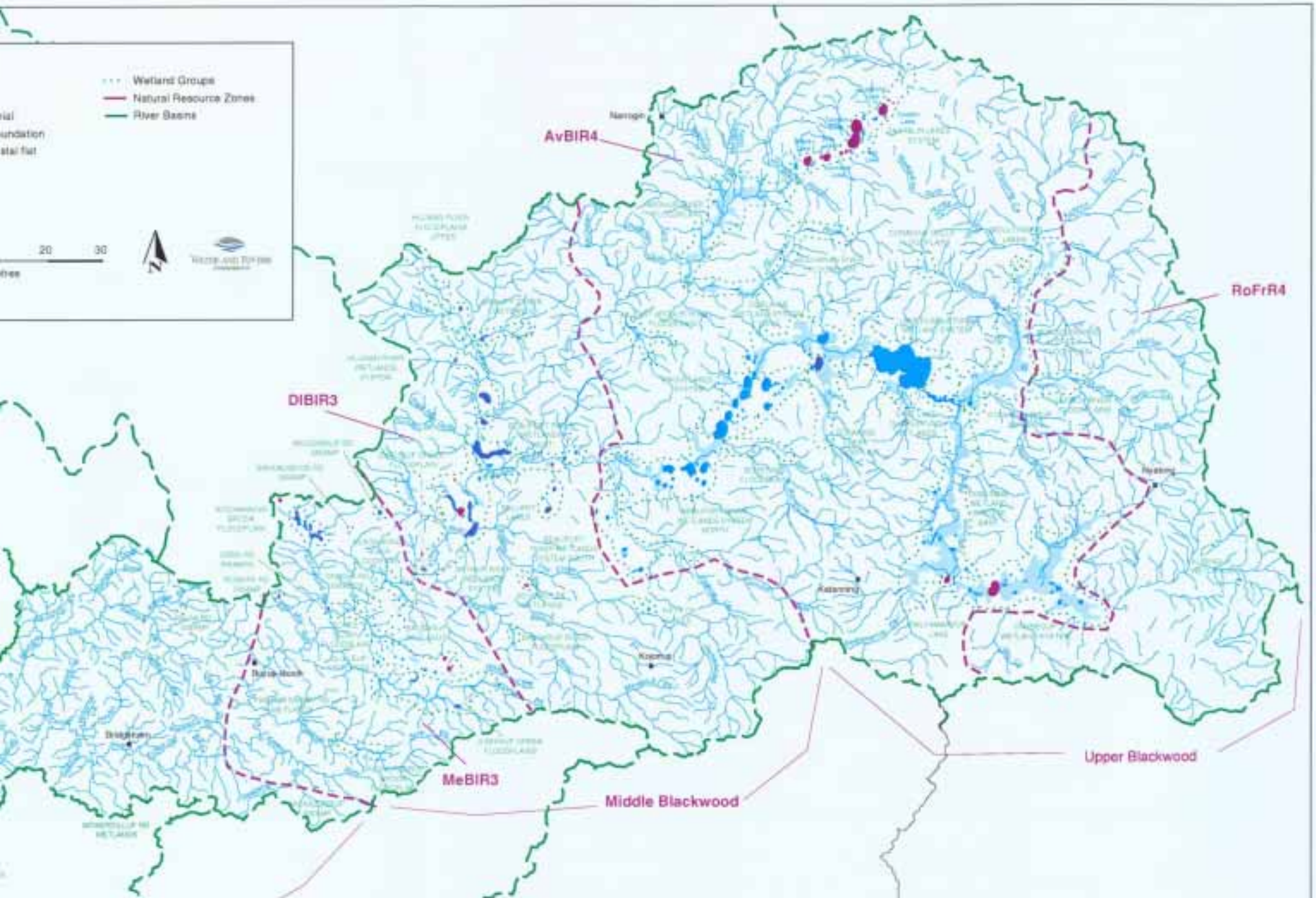
Figure 4.2 Wetland groups of the Western Scott Coastal Plain

s been cleared and drained for farming, rendering
f the wetlands C-D grade, but B grade wetlands
in large blocks of remnant bush, in the Scott
al Park near the Blackwood River estuary and in
g State Forest to the north. The 2 km long Long
is mostly located on the edge of the south-east
of the Scott National Park, but extends into remnant
ion near cleared private property, rendering it B
The large permanent **Gingilup Swamp** is mainly
, having been protected in the large Gingilup Nature
e, but even parts of this system are D grade where
es onto cleared farmland to the north. A tiny, and
ly quite unique, wetland on Black Point is also A
rotected within the D'Entrecasteaux National Park.

h fauna of the Scott catchment is relatively rich,
7 of the south-west's 8 endemic fish species
n *et al.* 1996). There are also at least seven rare
d plant species in the area, including rare shrub and
ub species found in the more natural areas near
Inlet and about Gingilup Swamp (ANCA 1993,
data).

tt Coastal Plain;

	Overall condition	Habitat notes
s with West	C - Ds-c	Minor connection to remnant bush.
nal Ck	B - Dc	Large area of remnant veg. at the base of the creek system.
d near d.	B	Wetlands are in remnant vegetation about the mouth the Blackwood.


Wetland Groups
Natural Resource Zones
River Basins
20
30
AvBIR4
RoFrR4
DIBIR3
MeBIR3
Middle Blackwood
Upper Blackwood

Details on the wetland systems shown in Figure 4.2 are given in Table 4.2. The Lake Jasper and Jinjardup wetland systems which fringe across very low lying country from the neighbouring Donnelly catchment are described below (see Section 4.2.6). The Gingilup Swamp system and the neighbouring and linked Lake Jasper system are collectively recognised as a wetland system of National Significance (ANCA 1993).

4.2.3 Lower Blackwood catchment

Wetlands are uncommon, or at least inconspicuous, in this deeply dissected and heavily forested area of the Blackwood and western Darling Plateaus. Small to medium swamps are found at the base of Spearwood Creek and Adelaide Brook (Figure 4.3). Medium to large narrow floodplains and swampland, which support dense wetland vegetation, are found along many of the Blackwood's lower tributaries. Those on the Milyeannup Brook and Red Gully are among the larger ones (Figure 4.3). These types of riparian habitats are known to be important habitat for two frog species of the *Geocrinea rosea* complex (Roberts *et al.*1990). In fact one species, the white-bellied frog (*Geocrinea alba*), is known only from sparse remnant habitat on a few creeklines passing through cleared farmland in the Witchcliffe-Karridale area, while the orange bellied frog (*G. vitellina*) is known only from Spearwood Creek and a few adjacent creeklines (Roberts *et al.*1990, Wardell-Johnson and Roberts 1991, 1993). In addition to these habitats, there are also some small swamps and lakes on the headwaters of some tributaries (see Figure 4.3 and Table 4.3). Most of the wetlands are in State Forest and are therefore A grade (see Table 4.3).

Table 4.3: The condition of wetlands of the lower Blackwood Catchment; Natural Resource Zone MeBlR2

Wetland group	Named wetlands (condition)	Approx. wetland area (ha)	Brief description	Overall condition	Habitat notes
Spearwood Creek Swamp	Spearwood Swamp^{R} (A)		Small swamp at the base of Spearwood Creek in State Forest (SF).	A	Important frog habitat.
Adelaide Brook Swamps	*(Spearwood Swamp on some maps)*	70	Small to medium swamps on the lower reaches of Adelaide Bk in State Forest.	A	Many linear swamps on many of the creeks in this area.
Kookaburra Rd Creek Floodplain			Medium to large floodplains and small swamps on the headwaters of a creek west of Milyeannup Bk in SF.	A	
Milyeannup Brook Floodplains			As above but for Milyeannup Brook.	A	
Red Gully Floodplains			As above but for Red Gully in State Forest.	A	One rare plant species.
Mokerdillup Rd Wetlands			A number of small lakes and swamps at the top of Quagaminup Bk on private land.	Dl, Ds	
Wilga Rd Swamp			Small swamp on the headwaters of the east branch of Balingup Bk in State Forest.	A	

Floodplain = area seasonally or occasional inundated in water

A = wetland within a large area of healthy bushland

B = wetland within a small healthy bushland block

C = wetland connected to healthy bushland

D = wetland surrounded by cleared land;

l = cleared lake;

s = swamp/floodplain with remnant veg.;

c = cleared wetland;

s-c = transitional.

R=in reserve

NP=in National Park

NS National Significance Wetland (ANCA 1993)

RMR=Ramsar Wetland

4.2.4 Middle Blackwood catchment

In the middle Blackwood where the land becomes flatter and drainage becomes increasingly sluggish, wetlands are common, varied in form and size and relatively broadly distributed. Twenty-four wetland groups were recognised for the area (Figure 4.3 and Table 4.4). Eight of these are basically individual or loose clusters of permanent, seasonal and intermittent swamps restricted to the lower part of the middle Blackwood below the Arthur River (the MeBlR3 NRZ). Eight groups consist of floodplains, with or without a few associated small swamps, on the main channel of the Blackwood, Arthur and Hillman Rivers or some of their major tributaries. Away from the main drainage lines there are five clusters of permanent, seasonal and or intermittent lakes and swamps, the largest of which is the Qualeup Group which covers a distance of about 15 km (see below). The largest groups consist of small to large, permanent to intermittent lakes and swamps amongst extensive floodplain along the Arthur, Beaufort and Hillman Rivers and cover distances of 20-30 km. These systems are described in greater detail below.

As nearly all of the middle Blackwood is used for farming, it is not surprising that nearly all of the wetlands are in poor condition, ranging from C to D grade, with the majority falling into the D category. Some smaller ones are located in nature reserves (B grade) or partially within them (C grade), particularly the lakes.

Qualeup Wetlands. This group consists of small to medium permanent and intermittent lakes, swamps and floodplain, mostly in farm land. The condition of individual wetlands varies between B and D, most being from C to D (Table 4.4). The group includes the medium size Lake Qualeup, which is permanent and Lake Boyup, which is seasonal. The actual water body of Lake Qualeup is in a Nature Reserve. **Lake Boyup** is a small fresh sedge swamp in a small nature reserve. It supports a moderate number of waterbird species, but little breeding (Halse *et al.* 1993b).

Arthur River Wetlands System. Many small and some medium permanent lakes and swamps and intermittent lakes and one large permanent lake (Towerinning), amongst extensive floodplain along the lower Arthur River. The system extends for about 32 km from the Hillman River to just past the junction with the Balgarup and the floodplain may be as broad as 1.5 km. Most of the wetlands are located on private land and are in a poor condition, C to D.

The most important wetlands of the group are Lake **Towerrinning, Wildhorse** Swamp and the **Moodiarrup** Swamps, the latter of which fringes Towerrinning. All three are saline to brackish and the latter two support dense vegetation, although much of this is now dead through salinisation and drowning (Jaensch *et al.* 1988; Halse *et al.* 1993b). Waterbird usage of Towerinning, Wildhorse and Moodiarrup has been studied by the RAOU (Jaensch *et al.* 1988, Halse *et al.* 1993); and the wetlands have been found to support a high numbers of species, high numbers of breeding species with moderate to high individual bird numbers. Both Towerrinning and Wildhorse are at least partially contained within nature reserves.

Hillman River Wetland System. Extensive floodplain, small to medium permanent swamps and intermittent lakes and one large unnamed swamp near the southern end of the system, which runs for about 20 km along the lower Hillman River. Most of the wetlands are on private land and are poor in condition, C-D. Mamine Swamp, which is actually an intermittent lake, is D grade, while the large unnamed swamp is C grade.

Beaufort River Wetlands — West. Small to medium intermittent and permanent lakes and extensive floodplain on the lower Beaufort River, mostly on private land. Much of the floodplain and many of the larger wetlands are found in remnant vegetation along the river, which renders much of the wetland area B grade, but elsewhere amongst farmland the wetlands are mostly D grade. Individual named wetlands include Emu Swamp, Nuning Swamp, Spratt's Lagoon and Dead Man's Swamp, and all but Emu are B grade as are two unnamed intermittent lakes in Reserve 5456 which also contains **Dean Man's Swamp.** This swamp has been studied for waterbird usage and found to support a high number of species (31) and a moderate number of breeding species (9) and individuals (~900) (Jaensch *et al.* 1988).

4.2.5 Upper Blackwood catchment

Virtually all of the wetlands of the upper Blackwood catchment are associated with the broad floodplains that are the ancient drainage lines of the Yilgarn and Hyden Plateaus (Figure 4.3). Two of these, the upper Arthur and the lower Beaufort/Coblinine are host to chains of small to large lakes, including many which are permanent (see Figure 4.3). These systems have been divided into six wetland groups, the Taarblin, Beaufort-north, Wagin, Coblinine-west, Dumbleyung and East Dumbleyung, (see

Table 4.4: The condition of wetlands of the middle Blackwood Catchment; Natural Resource Zones MeBlR3 and BlBlR3

Wetland group	Named wetlands (condition)	Approx. wetland area (ha)	Brief description	Overall condition	Habitat notes
Mickalurrup Swamp	Mickalurrup Swamp[R]		Small swamp in a small nature reserve.	B	
Rogers Rd Swamp		40	Small seasonal swamp on private land.	Dc	
Gibbs Rd Swamps		35	Scattered small swamps along the Blackwood River on private land.	C - Ds-c	One swamp retains remnant veg.
Kitchanning Brook Floodplain		540	Floodplain on the upper Kitchanning Brook system, on private land.	C - Ds	Much remnant veg. in the area.
Sandalwood Rd Swamp			Small swamp on private land.	C - Dc	
Moodiarup Rd Swamp		60	Small to medium swamp on private land.	B	In large block of remnant veg.
Blackwood River Floodplain		520	Floodplain along the upper Blackwood and a major tributary, mostly on private but also Crown Land along channel.	C - Ds-c	
Craigie Rd Swamps			Scattered small swamps on private land.	Ds	
Balgarup Wetlands			Scattered intermittent small swamps on private land.	C - Dc	
Boree Gully Floodplain		350	Large floodplain along Boree Gully, nearly all in private land, except for a few small water reserves.	C - Ds-c	Some blocks of remnant vegetation connecting.
Qualeup Wetlands	Lake Qualeup[R] (C) Lake Boyup[R] (B)	600	Small to medium permanent, seasonal and intermittent lakes and swamps on private land.	B, C-Ds-c	Basins of named wetlands in nature reserves. Lake Boyup is valuable waterbird habitat.
Parson Swamp Rd Wetlands			Scattered small intermittent and permanent lakes on private land.	Ds-c	Some remnant veg in the area but heavily degraded.
Dinninup Creek Floodplains		1280	Large floodplain with small swamps along Dinninup Ck and tributaries.	Ds-c	Floodplains, about 300 m across and 5-6 km long.
Gnowergerup Brook Floodplain		410	Large floodplain along Gnowergerup Bk on private land.	Ds-c	Floodplains, about 200 m across and 6 km long.

Floodplain - area seasonally or occasional inundated in water

A = wetland within a large area of healthy bushland

B = wetland within a small healthy bushland block

C = wetland connected to healthy bushland

D = wetland surrounded by cleared land;

I = cleared lake;

s – swamp/floodplain with remnant veg.;

c = cleared wetland;

s-c = transitional.

R=in reserve

NP–in National Park

NS–National Significance Wetland (ANCA 1993)

RMR Ramsar Wetland

Table 4.4: Continued

Wetland group	Named wetlands (condition)	Approx. wetland area (ha)	Brief description	Overall condition	Habitat notes
Arthur River Wetlands System	Lake Towerrinning[R] (C-D) Wild Horse Swamp[R] (C-D) Moodiarrup Swamps (C-D)	1600	Many small to medium permanent swamps and lakes and intermittent lakes and one large permanent lake (Towerrinning), amongst extensive floodplain along the Arther River, mainly on private land.	C - Dl	The floodplain in this group extends over 32 km and is generally 500-1500 m across. Valuable waterbird habitat.
Darlinup Creek Floodplain		640	Large floodplains along tributaries of the Darlinup Ck, on private land.	Ds-c	
Kojonup Brook Wetlands		100	Medium perennial lake and intermittent swamp on private land.	Ds-c.	
Balgarup River Floodplain		90	Small areas of floodplain on the Balgarup R. system.	Ds-c	
Hillman River Floodplains - Upper		310	Narrow floodplain along the upper Hillman River.	Ds-c	
Swampy Creek Wetlands		220	A small permanent and one intermittent swamp and some floodplain on Swampy Ck, on private land.	C - Dc	
Hillman River Wetland System	Mamine Swamp (Dc)	380	Small to large floodplains, permanent swamps and intermittent lakes along the Hillman River, on private land.	C - Dc	The group includes a single large swamp (C).
Beaufort River Wetlands - West	Dead Man's Swamp[R] (B-C) Emu Swamp (Dl) Nuning Swamp (B) Spratts Lagoon (B)	1340	Small to medium intermittent and permanent lakes and extensive floodplain along the Beaufort River, mainly on private land.	B - Dl	Valuable waterbird habitat.
Bellany Lakes		150	Small to medium intermittent and permanent lakes on private land.	D	
Fifty Creek Lakes	Clear Lake (D) Rushy Lake (D)	50	Small to medium intermittent lakes on the headwaters of Kojonup Bk, on private land.	D	

Floodplain - area seasonally or occasional inundated in water

A = wetland within a large area of healthy bushland

B = wetland within a small healthy bushland block

C = wetland connected to healthy bushland

D = wetland surrounded by cleared land;

l = cleared lake;

s = swamp/floodplain with remnant veg.;

c = cleared wetland;

s-c = transitional.

R=in reserve

NP = in National Park

NS=National Significance Wetland (ANCA 1993)

RMR=Ramsar Wetland

Figure 4.3), and are described in detail below. Others consist mainly of floodplain, but with one or two permanent lakes and/or a few intermittent lakes and swamps. The more important of these groups include the Beaufort-south, Coblinine-east, Coomelberrup, Ewlymartup and Coyrecup (see Figure 4.3), the latter four described in detail below. A few small intermittent lakes appear distinct from drainage lines and are located close to or within the Hyden Plateau. The more prominent of these are recognised as the Moulyinning and Kuringup groups (see Figure 4.3).

Nearly all of the upper Blackwood catchment has been cleared for farming, but considerable remnant vegetation is to be found along the broader and presumably wetter and more saline floodplains of the upper Coblinine, upper Arthur and lower Carrolup Rivers. Even so wetland condition is overwhelmingly poor, mostly ranging between C and D, with the majority falling into D grade. Only along the aforementioned rivers does wetland condition reach or approach B grade.

Information on all 20 wetland groups of the upper Blackwood is given in Table 4.5.

The upper Blackwood catchment, with its many permanent and highly variable wetlands, remains one of the most important waterbird regions in the south-west, despite widespread wetland degradation. In surveys involving over a thousand wetlands throughout the south-west, Lakes Dumbleyung, Coyrecup, Norring and Coomelberrup have frequently been in the top 15 for waterfowl[2] numbers (Halse *et al.*1990, 1992, 1994). The area as a whole has been estimated to carry as much as 20% of the south-west's waterfowl in some seasons (Halse *et al.*1992).

Taarblin Lakes System. Small to medium permanent, seasonal and intermittent lakes, swamps and floodplains and a number of large permanent lakes, many of which are within or partially within nature reserves (see Table 4.5). Large named permanent lakes include Taarblin, Toolibin, Nomans and White. Small to medium seasonal and permanent lakes include Dulbinning, Walbyring, Ibis, Billy, Lukin, West White (= Little White) and Bokan. Overall, wetland condition ranges from B to D. Individual wetland condition is given in Table 4.5.

Twelve of the lakes of this system have been monitored for waterbird usage by CALM and the RAOU, five of them regularly (Halse *et al.*1990, 1992,1993b, 1994), Toolibin, Taarblin, Dulbining, West White and Walbyring. The large, fresh to brackish and heavily wooded **Lake Toolibin** provides the most important waterbird habitat in the south-west, supporting 41 species, including 24 breeding species, the highest number of breeding species for any wetland in WA (Halse 1987, Halse *et al.*1993a and b, ANCA 1993). The number of birds on the lake may be as many 1600 (high), including up to 600 of the very rare and endangered freckled duck, which also regularly breeds in the wetland. The high habitat value is derived from the surviving lake-bed woodland/forest community, which is now rare in the region. This community is partly characterised by a restricted paperbark species, *Melaleuca strobophylla* (ANCA 1993).

Like most inland wetlands of the south-west Lake Toolibin is threatened by salinisation, drowning and eutrophication, but because its loss would have a marked effect on the populations of several waterbird species in the south-west, CALM is coordinating a recovery programme involving flow diversion, tree planting and land acquisition (Halse 1987, NARWC 1987, Froend *et al.*1987, Government of Western Australia 1996). Lake Toolibin is a Ramsar wetland and is listed as a wetland of National significance (ANCA 1993).

The **Lake Taarblin** is similar to Toolibin in terms of habitat and waterbird usage, being not quite as impressive in number of species or for breeding, but carrying larger numbers of individuals (Halse *et al.*1993b, Jaensch *et al.*1988). This is probably because, although it is a larger system, it is more degraded with extensive areas of dead trees (Halse *et al.*1993a).

Lakes **Dulbinning**, **Ibis**, **Walbyring**, **White** and **West White** are seasonal and brackish to saline and have extensive areas of dead trees. They support a moderate number of waterbird species, moderate numbers of breeding species and high numbers of individuals (Halse *et al.* 1993b). Similar habitat and waterbird usage have been found for Lakes Billy, Bokan, Nomans and Lukin collectively (Jaensch *et al.*1988).

Beaufort River Wetlands System — North. Small to large intermittent to permanent lakes and swamps and extensive floodplain along the broad floodway of the middle Beaufort River (Figure 4.3). The majority of small

[2] Waterfowl are swans, ducks, teal, geese and coots.

wetlands are on private land, while most of the larger ones are contained within nature reserves, including Lakes Flagstaff, Murapin, Queercarrup, Charling and Martinup. Most of the reserved lakes, including the small Lake Wardering, have only narrow bands of remnant vegetation and a few are connected to relatively large bush blocks. Wetland condition is therefore poor with most rating D grade and some C grade (See Table 4.5 for details).

Lakes **Flagstaff, Miripin, Murapin, Martinup** and **Wardering** are seasonal, brackish to saline lakes and have large areas of dead trees. They support a moderate number of waterbird species, moderate number of breeding species and generally a high number of individual waterbirds (Jaensch *et al.*1988, Halse *et al.*1993a and b). Flagstaff is also known to be an important wetland for black swans and Wardering for grey teal (Jaensch and Vervest 1988).

Wagin Lakes System. A chain of connected small to large intermittent to marginally seasonal lakes and swamps among extensive floodplain, receiving flow initially from the large Coblinine system and finally discharging into the Beaufort. Medium to large named lakes include Wagin, Packeyerring, Little Packeyerring, Quarbing, Norring and Little Norring, Salt and Lime, and all are barely contained within nature reserves which mostly provide only for narrow belts of fringing vegetation and remnant bush, rendering the condition of most of them C to D grade (see Table 4.5).

Lakes **Packeyerring** and two lakes to the east of Wagin (in Reserves 2085 and 2088) support a moderate number of waterbird species, moderate number of breeding species and generally a moderate to high number of individual waterbirds (Jaensch *et al.*1988, Halse *et al.*1993b). Both Packeyerring and Norring were in the top 15 wetlands for waterfowl numbers out of a total 1115 south-west wetlands in March 1991 (Halse *et al.*1994). Norring is also known to be important the Australasian shelduck (Jaensch and Vervest 1988).

Coblinine Wetland System — West. Broad area of floodplain with small to large intermittent lakes and swamps, mostly on private land, along the floodway of the Coblinine River west of Lake Dumbleyung (see Table 4.5). Wetland condition is universally poor at D grade. The group includes the large seasonal and saline Lake **Gundaring**, much of which is located within a Nature Reserve. It supports a high number of waterfowl, being in the top 15 for waterbird numbers of over 1000 out south-west wetlands surveyed in November 1990 and March 1991 (Halse *et al.*1994), but probably because of extensive tree death, the number of species and breeding species is only moderate (Halse *et al.*93a and b, Jaensch *et al.*1988).

Lake Dumbleyung and East Lake Dumbleyung Groups. The Dumbleyung group consists of a very large semi-permanent lake, which is mainly reserved and small intermittent lakes and floodplain to the south on private land. There is very little remnant vegetation and condition is therefore D grade. The East Lake Dumbleyung group includes a 10 km long 1-2.5 km wide wetland of floodplain, swamp and open lagoon on the eastern end of Lake Dumbleyung, known as the Coblinine River Nature Reserve (see Halse *et al.*1993a). It retains considerable, but degraded, wetland vegetation and rates no higher than C grade. The group also includes a number of small intermittent lakes to north of the nature reserve and east of Lake Dumbleyung, all of which is are D grade.

The **Lake Dumbleyung** wetland covers an area of about 55 km^2, of which 45 km^2 is actual lake area (Halse *et al.*1993a). At up to five metres deep, the lake is more than large enough to capture the generally meagre flows of the large saline Coblinine and Dongalocking systems. Only in very wet periods does the lake overflow into the Wagin Lakes, something which has happened only three times this century so far (ANCA 1993).

Lake Dumbleyung was once fresh, but today is saline and shrouded in dead trees (ANCA 1993, Halse *et al.*1993a). Despite this, the lake is still a major drought refuge for waterbirds, carrying over 40 000 birds in some summers, and is a major moulting site for Australasian shelduck, whose numbers may be over 30 000 at times. In all, 40 species are known to use the wetland, but because of the loss of habitat only five are known to breed there (ANCA 1993, Halse *et al.*1993b). Apart from salinisation, the lake is also threatened by a lack of upland buffering vegetation, eutrophication, siltation and human disturbance from active recreation (ANCA 1993). Lake Dumbleyung is recognised as a wetland of National Significance (ANCA 1993).

The **Coblinine** Nature Reserve supports a moderate number of waterbird species, moderate number of breeding species and a high number of individuals (Jaensch *et al.*1988, Halse *et al.*1993b). The wetland has been observed to be an important refuge for birds from Lake Dumbleyung, escaping disturbance caused by power boating.

Coomelberrup Lakes. Small to medium seasonal and intermittent lakes in the fork of the Coblinine and Dongolocking river systems. All lakes are D grade. **Lake Coomelberrup** itself is a medium sized, saline and seasonal lake with extensive dead trees and is largely reserved. It supports a high number of waterbird species, moderate number of breeding species and a disproportionately high number of individuals (Jaensch *et al.*1988, Halse *et al.*1993b, 1994). As many as 130 of the rare freckled duck have counted on the lake, but breeding was not observed (Jaensch *et al.*1988).

Coblinine Wetland System — East. Broad areas of floodplain along the broad floodway of the Coblinine River below Dumbleyung, with scattered small to large intermittent and small permanent lakes. The Coblinine floodway forms a 40 km long shallow wetland system over a 1-5 km broad floodplain with imbedded and 'satellite' lakes. A number of reserves that run along the wetland system are collectively known as the Coblinine Flat Nature Reserve, but much of the vegetation within it or near it, is greatly degraded by grazing and salinisation. Thus few wetlands rate better than D or C grade Table 4.5). The medium size **Lake Casuarina** and small Kailagup Swamp are at least partially reserved and are C grade. Lake Casuarina is covered in dead trees, but supports a moderate number of waterbird species, moderate number of breeding species and a high number of individuals (Jaensch *et al.*1988, Halse *et al.*1993a and b). The 'flats' as a whole fell in the top 15 for waterfowl numbers out of over 1000 south-west wetlands surveyed in march 1990 (Halse *et al.*1994).

Ewlyamartup Lake. A medium permanent lake (Ewlyamartup) and small intermittent lakes. Ewlymartup is contained mostly within a nature reserve and is connected on the north-eastern corner to a large block of remnant bush, thus rendering it C grade. The other smaller wetlands are on private land and are D grade.

Coyrecup Wetland System. Medium to large permanent lakes, small intermittent lakes and a huge area of floodplain, mainly on private land (Figure 4.3, Table 4.5). The main feature of the group is **Lake Coyrecup**, a large, permanent and saline lake with saline marshes and extensive areas of dead trees (Halse *et al.*1993a). It is located, within nature reserve, towards the lower end of the floodplain area and receives flow from the east and discharges into the Coblinine. Coyrecup supports a high number of waterbird species, moderate number of breeding species and high number of individuals. In summer it is often a major drought refuge, carrying 6000 to 20 000 birds (ANCA 1993, Halse et a. 1993b). It is threatened by salinisation, drowning, eutrophication and siltation, but remains a wetland of National Significance (ANCA 1993).

4.2.6 Donnelly catchment

Most of the Donnelly catchment is deeply dissected and heavily forested, but is does flatten out and become relatively low lying towards the coast and in the uppermost sections north-west of Manjimup. In these areas wetlands, which are all fresh, are common and extensive, supporting paperbark thickets, heath and sedgeland. Most of the wetland area, is however, found towards the coastal end of the of the catchment, either on or on the edge of the Scott Coastal Plain, where five wetland groups are recognised (Figure 4.4 and Table 4.6). Here wetlands consist of the small to large permanent lakes and swamps and seasonal swamps and extensive floodplain, mostly in State Forest and National Park. The large Lake Jasper and Jingardup Systems also extend across very flat terrain into the neighbouring Scott River Catchment (see Figures 4.4 and 4.6). Despite the abundance of natural vegetation in the area, the placement of many cleared blocks renders a range of wetland conditions, from A to Dc, though A to B grades predominate. At the other end of the catchment, the Donnelly River Floodplain group consists of scattered swamps and floodplain and a medium lake (once swamp), mostly on private land. The condition of the various wetlands range from A to D. Information on each wetland group is provided in Table 4.6.

Lake Jasper Wetland System. Large area of small to large permanent lakes and swamps and seasonal swamps draining into the upper Scott and lower Donnelly Rivers. The northern parts of the system fall on partially cleared private land, but all the lakes, including the large **Jasper** and **Quitjup** and the small **Smith** and **Wilson** are within National Park, although Jasper only just. The condition of the system ranges from A to D, but is mostly A or B (Table 4.6). The lakes collectively have 530 ha of open water and 260 ha of directly associated swampland and represent some of the most pristine wetland habitat anywhere in the south-west. Lake Jasper itself has 440 ha of open water and is 8-10 m deep, making it the deepest and largest permanent freshwater lake in the south-west, if not the entire state[3].

[3] Excepting dam impoundments.

Table 4.5: The condition of wetlands of the upper Blackwood Catchment; Natural Resource Zones AvBlR4 and RoFrR4.

Wetland group	Named wetlands (condition)	Approx. wetland area (ha)	Brief description	Overall condition	Habitat notes
Taarblin Lakes System	Lake Taarblin[R](C) Dulbining Lake[R] (C) Walbyring Lake[R] (C) Ibis Lake[R] (B) Billy Lake[R] (B) Nomans Lake[R] (C-D) Lukin Lake[R](C-D) White Lake[R] (C) South White Lake[R](C-Dl) West White Lake[R] (C-Dl) Lake Toolibin[R NS RMR] (C) Bokan Lake[R](B)	1250	Small to medium permanent, seasonal and intermittent lakes, swamps and floodplains and a number of large permanent lakes, many of which are in or partially in nature reserves.	B - C - Dl	All of the named wetlands are at least partially contained within nature reserves (see text). One restricted paperbark species.Important waterbird habitat despite salinization. Lake Toolibin is especially important water-bird breeding habitat.
Arthur River Floodplain		5700	Large broad area of floodplain along the upper Arthur River, about half of which is reserved. Also one small intermittent lake (C).	C, Ds-c	Remnant veg greatly salt-affected and much of the floodplain is eroding.
Buchanan River Floodplain		1300	Large broad areas of floodplain and seasonal lakes along the Buchanan River, mostly on private land.	Dc	Remnant veg greatly salt-affected and much of the floodplain is eroding.
East Arthur River Floodplain		480	Medium to large floodplains on a tributary of the Arthur R. with a intermittent swamp.	Ds-c	The floodplain supports degrading remnant vegetation.
Beaufort River Wetlands System - South	Fitze's Swamp (C-Dl) Koolbooking Swamp (C) Toojeelup Swamp (C)	550	Small to medium intermittent to seasonal swamps and lakes and floodplain on or south of the Carrolup River (see text). All on private land.	C - Ds-c	Fitz's Swamp is important waterbird habitat (Halse et al. 1994).
Beaufort River Wetlands System - North	Bush Swamp (Dl) Billielight Swamp (Dl) Grandfather Swamp (Dl) Flagstaff Lake[R] (C) Queercarrup Lake[R] (Dl) Lake Charling[R] (Dl) Small Lake (C-Dl) Martinup Lake[R] (C-Dl) Murapin Lake[R] (Dl) Kidney Swamp (Dl) Miripin Lake[R] Wardering (Dl) Lake[R] (C-Dl)	4000	Small to large intermittent to permanent lakes and swamps and extensive floodplain along the broad floodway of the Beaufort River. Most of the smaller wetlands are on private land, while most of the larger ones are contained within nature reserves.	C - D	Most of the reserved lakes have only narrow bands of remnant bush around them and a few are connected to small remnant bush blocks.One rare herb species near where Albany Hwy crosser the Beaufort River.
Boyerine Floodplain		120	Small floodplains and intermittent lakes on Boyerine Creek	Ds-c	
Wagin Lakes System	Wagin Lake[R] (C) Packeyerring Lake[R] (C) Little Packeyerring[R] (C) Lake Quarbing[R] (C) Little Norring[R] (Dl) Norring Lake[R] (Dl) Salt Lake[R] (C) Lime Lake[R] (B) Murrin Lake (Dl)	3800	A chain of small to large intermittent lakes and swamps and extensive floodplains receiving flow from the Coblinine System and discharging into the Beaufort. Many of the lakes are in nature reserves (see text).	B, C - Dl	Generally valuable waterbird habitat despite salinization.
Coblinine Wetland System - West	Lake Gundaring[R] (Dl) Little Dornduckling Lake (Dl) Dornduckling Lake (Dl) Minacklin Swamp (Dc)	5400	Broad area of floodplain with small to large intermittent and seasonal lakes and swamps, mostly on private land.	Dl, Dc	Generally valuable waterbird habitat despite salinization.

Table 4.5: Continued

Wetland group	Named wetlands (condition)	Approx. wetland area (ha)	Brief description	Overall condition	Habitat notes
Bockaring Creek Floodplain		4000	Broad area of floodplain along the Bockaring Ck, with a few intermittent small lakes and one intermittent large swamp, on private land.	Ds-c, Dl	Very little remnant veg.
Lake Dumbleyung Wetland SystemNS	Lake DumbleyungR (Dl)	6500	Very large permanent lake, mainly reserved, with many small intermittent lakes and extensive areas of floodplain on private land.	Dl, Dc	Important waterbird habitat despite salinization. Dumbleyung is a major drought refuge.
East Lake Dumbleyung Wetlands		500	Small to medium intermittent lakes amongst extensive swampland and floodplain, along the Coblinine floodway just to E of Lake Dumbleyung; and many small intermittent lakes to the N of this area.	C-Dl	
Moulyinning Lakes		10	Small intermittent lakes on private land.	Dl	Wetlands salt-affected.
Doradine Gully Floodplain		230	Large floodplain on the headwaters of Doradine Gully	Ds-c	
Dongo-locking Creek Floodplain		7300	Broad area of floodplain with scattered small intermittent lakes, mainly on private land.	Dl, Dc	Floodplain greatly salt-affected.
Coomel-berrup Lakes	Coomelberrup LakeR (Dl)	500	Small to medium seasonal and intermittent lakes in the fork of the Coblinine and Dongolocking.	Dl	Important waterbird habitat despite salinization.
Coblinine Wetland System - East	Lake Minerup (C)Perlungup Swamp (C)Casuarina LakeR (C)Kailagup SwampR (C)Unnamed lakeR9056 (C)Corackin Swamp (Dc)	9600	Broad areas of floodplain along the broad floodway that forms the Coblinine River, and small to large intermittent lakes and small permanent lakes.	B - Ds-c	The floodplain, which is 1-5 km across and about 40 km long, retains much remnant veg which is greatly degraded by salinization and grazing. Much of this area is in nature reserve (see text).
Ewlyamartup Lakes	Ewlyamartup LakeR (C)	120	A medium permanent lake and small intermittent lakes. Smaller wetlands on private land.	C - Dl	Some valuable waterbird habitat despite salinization.
Coyrecup Wetland SystemNS	Lake CoyrecupR (C)	11000	Medium to large permanent lakes, small intermittent lakes and broad areas of floodplain, mainly on private land.	B - Dl, Dc	Large area of relatively healthy remnant veg east of Coyrecup.Important waterbird habitat despite salinization.
Lefroy River Floodplains		800	Scattered floodplain along the Lefroy River, on private land.	Dc	
Kuringup Wetlands			Small intermittent lake and swamp.	Dl, Ds	

Floodplain = area seasonally or occasional inundated in water
A = wetland within a large area of healthy bushland
B = wetland within a small healthy bushland block
C = wetland connected to healthy bushland
D = wetland surrounded by cleared land;
l = cleared lake;
s = swamp/floodplain with remnant veg.;
c = cleared wetland;
s-c = transitional.
R=in reserve
NP=in National Park
NS=National Significance Wetland (ANCA 1993)
RMR Ramsar Wetland

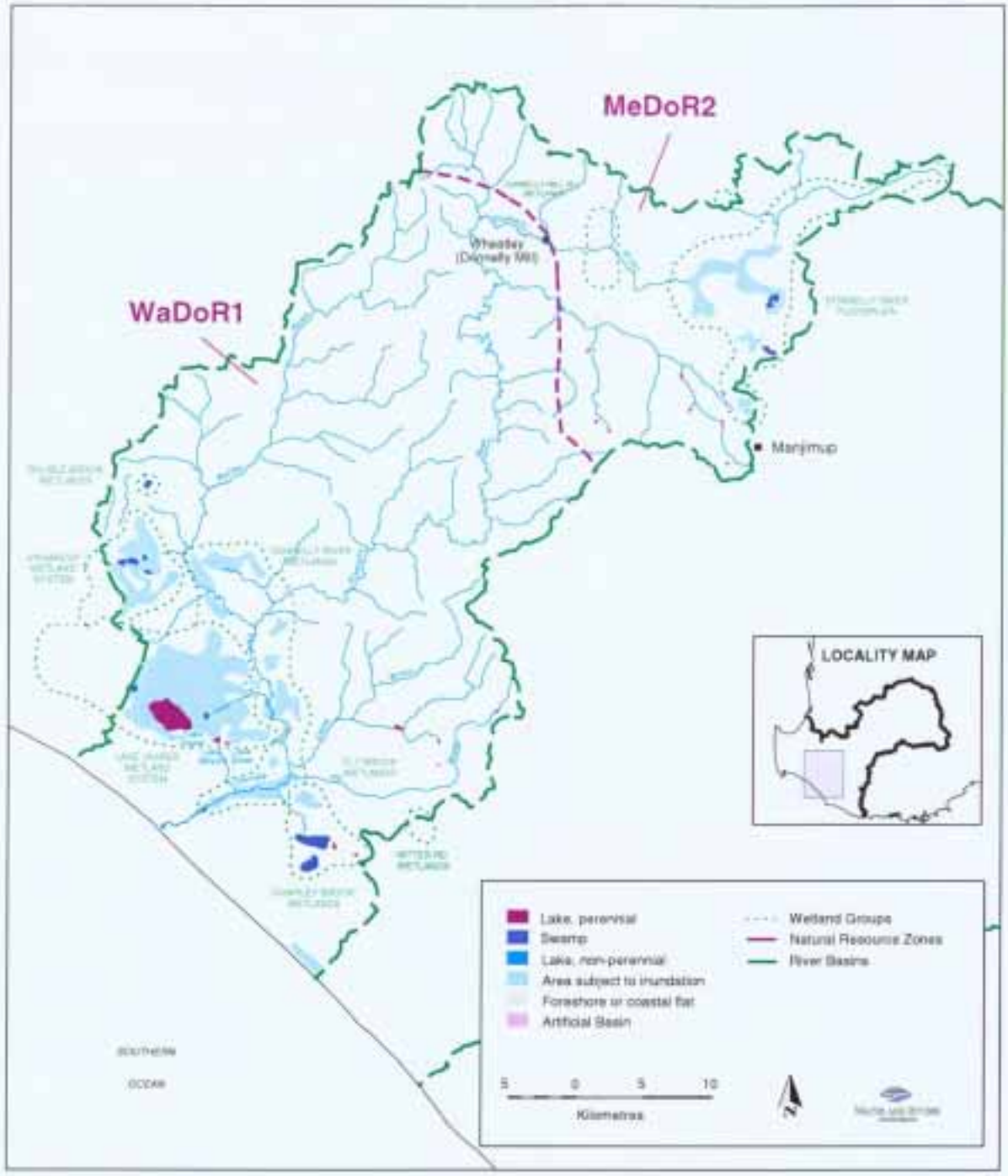


Figure 4.4: Wetland groups of the Donnelly Catchment

The habitat value of the lakes is reflected in the importance of these lakes and associated wetlands to wetland flora, aquatic invertebrates, fish, frogs and waterbirds, as shown in a surveys of 27-32 permanent wetlands along the south coast between Cape Naturaliste and Albany, carried out in 1992. Both Jasper and Quitjup have high floristic value, supporting extensive and very tall sedgelands and in the case of Jasper, unique thickets of *Agonis floribunda*, amongst other floristic attributes (Robinson 1992, ANCA 1993). The fresh, low nutrient and acidic waters of all four lakes impart a high habitat status for these wetlands (Edwards *et al.* 1994). Lake

Table 4.6: The condition of wetlands of the Donnelly River Catchment; Natural Resource Zones WaDoR1 and MeDoR2.

Wetland group	Named wetlands (condition)	Approx. wetland area (ha)	Brief description	Overall condition	Habitat notes
Lake Jasper Wetland System[NS]	Lake Quitjup[NP] (A) Lake Jasper[NP] (B) Lake Wilson[NP] (A) Lake Smith[NP] (A)	7500	Small to large permanent lakes and swamps and seasonal swamps draining into the Donnelly and Scott Rivers.	A - B -Dc	Parts of the system fall in cleared land, but mainly in densely vegetated National Park.Important habitat for a broad range of flora and fauna. Major biological reservoir.
Jingardup Wetland System		2000	Small permanent lakes and small to medium permanent and seasonal swamps, and extensive floodplain north of Lake Quitjup, mainly in National Park.	B - Dc	Central part of this system is in partially cleared private land.
Double BrookWetlands		30	Small to medium seasonal and permanent swamp on the headwaters of Double Creek, in State Forest.	A	
Donnelly River Wetlands		6200	Extensive areas of permanent and seasonal swampland and floodplain adjacent to the lower Donnelly River and lower Barlee Brook in State Forest and National Park..	A - B	
Charley Brook Wetlands		450	Small lakes, swamps and floodplain at the top of Charley Bk and a large area of floodplain and swampland on the lower Donnelly. All in National Park and State Forest.	A	
Donnelly Mill Rd Wetlands			Small isolated swamps in State Forest or other reserved land.	A	Rare plant species (orchid)
Donnelly River Floodplains	Gunagulup Swamp (C-Dl)Unnamed lake (Dl)	1600	Very large area of scattered swamps and floodplain, and a medium lake (C), along the upper Donnelly, mostly on private land.	A - Dc.	

Floodplain - area seasonally or occasional inundated in water
A = wetland within a large area of healthy bushland
B = wetland within a small healthy bushland block
C = wetland connected to healthy bushland
D = wetland surrounded by cleared land;
l = cleared lake;
s = swamp/floodplain with remnant veg.;
c = cleared wetland;
s-c = transitional.
R= in reserve
NP= in National Park
NS=National Significance Wetland (ANCA 1993)
RMR=Ramsar Wetland

Jasper is a major biological reservoir for freshwater fish, supporting seven of the exclusively freshwater species of the south-west and no exotic species, which is even more exceptional (Jaensch 1992a, ANCA 1993, Morgan *et al.*1996). At least eight frog species are associated with the lakes (Jaensch 1993, ANCA 1993). Finally, Lake Jasper rated fifth for waterbird usage out of the 27 south coast wetlands surveyed (Jaensch 1992b). Lake Jasper wetland system, together with the Gingilup Swamps (see above), are recognised as a wetland system of National Significance (ANCA 1993).

4.2.7 Warren — Unicup catchments

A total of 28 wetland groups were recognised for the large Warren River catchment, which for this study includes the low lying areas about Unicup and Moorinup in the south east corner of the Tone catchment (see Figure 4.5). Apart from these areas, the Warren catchment is mostly well drained and dissected and wetland systems are not extensive. In the lower catchment (WaWrR1), wetlands consist of small to large seasonal swampland and floodplain, with the Yeagarup Group, near the coast, hosting three small permanent lakes (see below). As much of this area is State Forest or National Park, wetland condition is high, being mostly A grade (see Table 4.7).

Right on the coast the Warren Beachside Wetlands Group consists of many small swamps and ponds of fresh water within the depressions of parabolic dunes (see V. & C. Semeniuk Research Group 1997b). This large unique wetland system is about 1000-1500 metres broad and runs parallel to the shore over a distance of about 20 kilometres. It extends along the coast of the neighbouring Donnelly and Shannon Basins and is bisected by the Warren and Meerup Rivers (see Figures 4.4. to 4.6).

The middle catchment (MeWrR2) is marked by wetland groups with one or more small to medium seasonal to permanent lakes and swamps, with floodplains more or less restricted to headwater streams (see Figure 4.5). Although State Forest and Nature Reserve are extensive in this part of the catchment, many of the lakes and swamps are located in cleared blocks, with the effect that condition ranges from A to D, and is mostly poor (C-D). This is true of the Kepalarup, Codarup/Oaljalup, Yackerlup and Kelpalurip groups (see Figure 4.5 and Table 4.7).

The highly cleared and salinized upper catchment of the Tone River (MeWrR3) supports medium to large floodplains with or without small intermittent lakes and seasonal swamps, which retain some remnant vegetation, albeit becoming increasingly degraded by grazing and salinisation. Hence, wetland condition is mainly poor, ranging from B to D (Table 4.7). The middle catchment of the Tone is in somewhat better condition, due possibly to a higher proportion of remnant vegetation, much of which is in nature reserve (see Moorinup and Unicup groups below). Here wetland condition is often B grade, but still ranging to D grade on private land.

Brief descriptions of all 26 wetland groups are given in Table 4.7. The significant wetland groups are discussed in detail below:

Yeagarup Wetlands. Small lakes and swamps and floodplains north of the lower Warren River, in State Forest. The system incudes **Yeagarup Lake, Naenup Swamp** and an unnamed lake. All are A grade. Two of the southern lakes are being filled by a large sand dune. Biological surveys of the lakes of the south coast found that Yeagarup lake had moderate to high habitat value for wetland flora and fauna (Robinson 1992, Jaensch 1992a, 1992b, 1993).

Perup Swamps. A number of small swamps and large floodplain in an area of extensive bushland in nature reserve dotted with cleared blocks (Figure 4.5). Boyicup, Meelinup and Jibargup are in nature reserve and range from A to B grade. Two swamps to the north of Meelinup are also A grade as is one NEE of Boyicup. Camelarup Swamp and ones E of Jibargup and SE of Boyicup, are on private land and range from C to D.

Moorinup Wetland System. Extensive wetland system to the north of the Unicup System of small to large permanent and seasonal swamps and floodplains, on private land or in nature reserves. Moorinup Lake itself and a number of small swamps to the E, SE and S are in a nature reserve and are B grade. Outside of the reserves remnant vegetation is degraded, probably through grazing, and wetland condition ranges from C to D.

Unicup Wetland System. Large wetland system of small to large permanent lakes, permanent and seasonal swamps and floodplains in the upper Tone catchment (although rarely discharges to the Tone River). Most of the well defined wetlands are in nature reserves, and are therefore B grade. However, beyond the reserves on private land, remnant vegetation is sparse, and wetland condition is poor, ranging between C and D. Nevertheless, most of the system is B grade. Of the named wetlands, the large Lake Unicup and smaller Little Unicup, Tolkerup Swamp, Kulinilup Lake and Bokarup Swamp, all in reserves, are B grade, while Yarnup, narrowly within a reserve is C grade. Burangup and Kodjinup Swamps, both on private land, are C and B grade, respectively.

Table 4.7: The condition of wetlands of the Warren Catchment; Natural Resource Zones WaWrR1, MeWrR2 and MeWrR3.

Wetland group	Named wetlands (condition)	Approx. wetland area (ha)	Brief description	Overall condition	Habitat notes
Warren Beachside Wetlands		1300	Small swamps and ponds of fresh water within depressions amongst parabolic dunes.	A	Over a very large area and very close to the ocean.
Warren River Wetlands		210	Medium size swamps, floodplains and seasonal lakes along the lower Warren River in NP.	A	
Yeagarup Wetlands	Yeagarup Lake[R] Maenup Swamp[R] Unnamed lake[R]	540	Small lakes and swamps and floodplain north of the Warren River in SF.	A	Some lakes being filled by large sand dune. Moderate to high habitat value.
Ritter Rd Swamps		120	Small to medium swamp and seasonal swampland in NP and SF.	A	
Deep Gully Floodplain		150	Medium size floodplain and seasonal swamp on the headwaters of Deep Gully in State Forest.	A	
Snake Gully Floodplain		100	Large floodplain and seasonal swamp at the head of Snake Gy in SF.	A/B	Very close to cleared land.
Big Hill Brook Swamp		350	Large seasonal swamp to the east of Big Hill Bk in State Forest.	A	
Chungarup Swamp	Chungarup Swamp	10	Small lake on private land in the Wilgarup catchment.	Dl	
Yackerlup Swamps	Yackerlup Swamp (Dc) Dudijup Swamp (Ds-c)		Small permanent swamps in cleared private blocks in or near State Forest.	Ds-c	Both swamps in cleared blocks
Codarup and Oaljalup Lakes	Codarup Lake Oaljalup Lake	20	Two permanent lakes in the Wilgarup Catchment on private cleared blocks surrounded in SF.	Dl	Both lakes in cleared blocks
Bonybeap Swamps	Bonybeap Swamp[R]	10	Small permanent swamp and medium seasonal swamps and floodplain in State Forest.	A	
Bonybeap Gully Floodplain		80	Medium size floodplain and seasonal swamp on the headwaters of Bonybeap Gully in SF.	A	
Kepalarup Wetlands	Kepalarup Lake[R] (C) Yeticup Swamp (C)	100	A medium lake, small swamp and large areas of seasonal swampland and floodplain, on private land and State Forest	B - C	Named wetlands in cleared blocks surrounded by State Forest.
Yerraminnup Floodplain - Lower		Up to 200 m across.	Large floodplain with seasonal swampland along the lower Yerraminnup River, mostly in SF.	A - Dc	
Perup River Floodplain		Up to 250 m across.	Large floodplain with seasonal swamps. About half in State Forest.	B - Dc	
Yackelup Floodplain			Floodplain and seasonal swamps on the eastern tributary of the Perup River in nature reserve.	A	
Corbalup Swamps	Corbalup Swamp (Dc)	15	Small swamps and floodplain in State Forest and private land.	C - Dc	

Table 4.7: Continued

Wetland group	Named wetlands (condition)	Approx. wetland area (ha)	Brief description	Overall condition	Habitat notes
Yerraminnup Floodplain - Upper		Up to 100 m across.	Floodplain and seasonal swamps along the upper Yerraminnup River, mostly in State Forest.	B - Dc	
Perup Swamps	Camelarup Swamp (C) Boyicup Swamp[R] (B-C) Meelinup Swamp[R] (A) Jilbargup Swamp[R](A/B)	200	Small swamps and large floodplain on private land and nature reserve (see text).	A - Dc	Large area of bushland in nature reserve with many cleared blocks.
Yendicup Swamps		20	Small to medium swamps in nature reserve.	B - C	
Kelpalurip Swamps	Kelpalurip Swamp (C-Dc)	40	Three small to medium swamps on cleared blocks amongst nature reserve.	C - Dc	
Tone River Floodplain		150	Large floodplain and small seasonal swamps along the upper Tone, nearly all on private land.	B, C - Dc	Large blocks of remnant vegetation remains, some of which is in nature reserve.
Tone River Road Swamp			Small to medium floodplain or swamp on private land.	Dc	
Talyelwelup Wetlands	Lake Talyelwelup (Ds-c) Lake Clabburn (Ds-c) Cootayerup [NRR:6031] (B)		Small intermittent lakes and seasonal swamps, mainly on private land.	B - Dc	Large blocks of remnant vegetation remain in the area but are becoming increasingly degraded.
Furnis Loop Floodplain		~ 200 m across and 4 km long.	Large floodplains in an area of internal drainage in the upper Tone catchment. Much degraded remnant veg in locale.	Ds-c	
Murin Brook Floodplain		120	Large floodplain on Murin Brook.	Dc	
Moorinup Wetland System	Moorinup Lake[R] (B)	800	Extensive wetland system to the north of the Unicup System of small to large permanent and seasonal swamps and floodplains, on cleared and naturally vegetated private land or in NRs.	B - Dc	Remnant veg outside nature reserves degraded and being passively cleared.
Unicup Wetland SystemNS	Unicup Lake[R] (B) Little Unicup Lake[R] (B) Tolkerlup Swamp[R] (B) Kulinilup Lake[R] (B) Bokarup Swamp[R] (B) Buranganup Swamp (C) Yarnup Swamp[R] (C) Kodjinup Swamp (B)	2500	Large wetland system of small to large lakes, permanent and seasonal swamps and floodplains in the upper Tone catchment (although only rarely discharges to the Tone River). Most of the well defined wetlands are in nature reserves. Wetlands on private land are generally of poor quality as there is little remnant vegetation outside the reserves.	B - Dc	Three rare plant species (2 orchids and 1 sedge). Important wetland habitats, some of which support secretive waterbirds and waterbird breeding.

Floodplain = area seasonally or occasional inundated in water

A = wetland within a large area of healthy bushland

B = wetland within a small healthy bushland block

C = wetland connected to healthy bushland

D = wetland surrounded by cleared land;

l = cleared lake;

s = swamp/floodplain with remnant veg.;

c = cleared wetland;

s-c = transitional.

R=in reserve

NP=in National Park

NS National Significance Wetland (ANCA 1993)

RMR Ramsar Wetland

ents mentioned above, range to D grade, but only
rdner and Bell Brook groups are no better than B
All of the lakes are A grade.

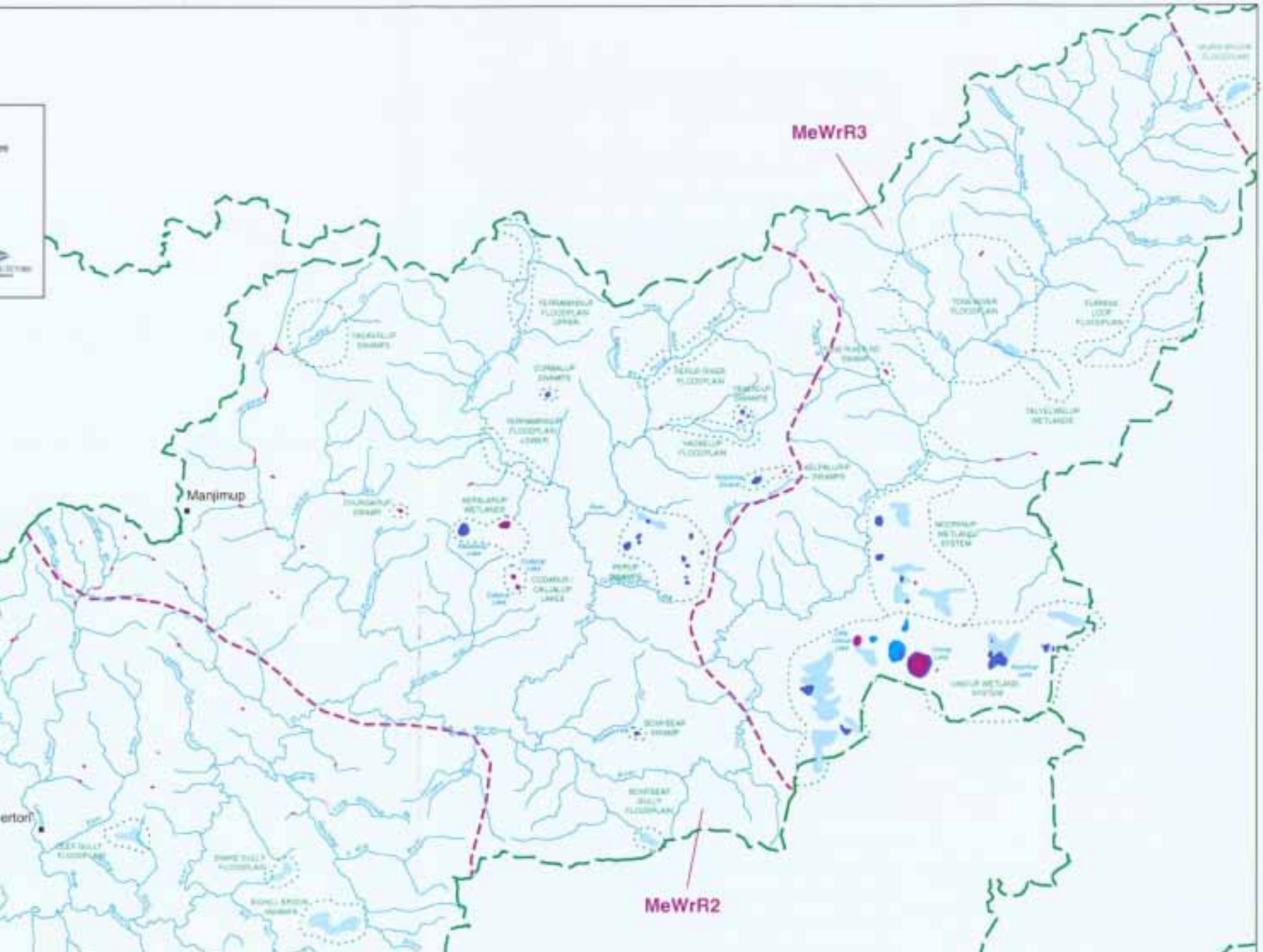
studies of the fauna of this region highlight its
ance for endemic and relic fauna, which may be
restricted in distribution (Pusey and Edward 1990,
1992, Wardell-Johnson 1991, Edwards *et al.* 1994,
z 1994a, Morgan *et al.* 1996). For instance, the
on Basin is the focus for the distribution of
ater fish in the south-west, with seven of the south-
eight endemic freshwater fish commonly found in
eams, lakes and pools of the area (Allen 1982,
n *et al.* 1996). Although, no collections of the
ater cobbler have been made in the area, word of
suggests that the species is present in the deeper
Coy 1978, Allen 1982).

species of frog (*Geocrinea lutea*) is confined to the
ater wetlands within 12 km radius of Walpole
s *et al.* 1990) and the north-eastern part of the Lower
on Basin is important habitat for the roseate frog
inea rosea) (Roberts *et al.* 1990, Wardell-Johnson
berts 1991, 1993). Restricted and relic species of
crustaceans and new species of Isopod and
ing freshwater crayfish are known to occur in
parts of the region and near Northcliffe (Bayley
Horwitz 1994a).

annon Basin supports at least eight rare wetland
pecies, mostly orchids and sedges (ANCA 1993,
data). Other wetland species have been noted as
ndescribed, apparently restricted in distribution and/
ly collected (CALM 1987).

tire catchment of the Broke Inlet, which is now in
al Park is recognised as containing wetland systems
onal Significance (ANCA 1993).

escriptions of all 16 wetland groups are given in


MeWrR3
Manjimup
MeWrR2

1992, Edwards *et al.* 1994, Horwitz 1994a and Morgan *et al.* 1996). In the case of fish, this wetland system supports 7 of the 8 endemic freshwater fish species of the south-west, and as with Lake Jasper exotic fish species appear absent (Jaensch 92a and b, ANCA 1993 and Morgan *et al.* 1996). The system also supports a geographically restricted sedge species, *Schoenus multiglumus*. Although, the wetlands are reserved for conservation, they are considered to be threatened by frequent fires, leading to erosion, siltation and peat loss (ANCA 1993). This system has been recognised to have National Significance (ANCA 1993).

Gardner River Wetlands — Lower. Huge area of seasonal swamp and floodplain, with small to large permanent swamps and lakes, mostly in National Park. Wetland condition is mainly A grade and ranging to B grade, with a little D grade on the margins. The main feature of the group is **Lake Maringup**. This large 5 m deep alkaline lake with its extensive peatland marshes supporting sedgelands and cedar (Agonis) forest is a major biological reservoir and summer drought refuge for fish and other animals (ANCA 1993). It has the highest floristic value of any of the south coast lakes (Robinson 1992), including an undescribed and restricted sedge species (ANCA 1993), while being in the top 3 and 5 of these wetlands for fish and waterbird use, respectively (Jaensch 1992a and b). The lake bed is covered in a unique algae/organic suspension and giant karri stumps are exposed during falling water levels (ANCA 1993). Despite the high habitat value and its protected status, the lake is considered to be threatened by groundwater extraction, frequent fires and weeds (ANCA 1993).

Ponds along the Windy Harbour Road are known to support a number of tiny crustaceans that prefer the acidic waters of the south coast. A number of the species are considered to be ancient relicts, in existence for tens of millions of years, and are known only from the Northcliffe area (Bayley 1992)

Broke Inlet Catchment. The six wetland groups in the catchment of Broke Inlet, and including the estuarine basin, have been recognised collectively as a wetland system of National Significance (ANCA 1993). The wetland system consists of a permanent river (the Shannon), seasonal creeks, freshwater swamps and floodplains, freshwater ponds and marshes, shrub swamps and peatlands, the latter three of which have many small acidic ponds, and all in near pristine forest, scrub, heath and sedgeland or logged over State Forest (ANCA 1993, CALM 1987). Lakes in the catchment are known to be important habitat for the black striped minnow, salamander fish and the rare Balston's perchlet and there are some gazetted rare and restricted flora (ANCA 1993, Jaensch 1992a). There is also heavy waterbird usage but as this pertains to estuarine habitat it will be discussed under estuaries in Section 7.3.

Table 4.8: The condition of wetlands of the lower Shannon Basin; Natural Resource Zone WaShR1

Wetland group	Named wetlands (condition)	Approx. wetland area (ha)	Brief description	Overall condition	Habitat notes
Meerup River Wetlands		2600	Large seasonal swamps and floodplain with tiny lakes in the Meerup catchment, on cleared private land or national park.	A - Dc	Lakes are in National Park. Valuable wetland habitat.
Doggerup Creek Wetland SystemNS	Doggerup Lake[NP] (A) Lake Samual[NP](A) Lake Florence[NP] (A)	1500	Large permanent and seasonal swamps and floodplain and small permanent lakes, mostly in National Park (NP).	A - B	Rare plant species (sedge). High habitat value, especially for fish and frogs.
Gardner River Wetlands - Lower	Lake Maringup[NS NP] (A)	12 000	Huge area of seasonal swamp and floodplain, with small to large permanent swamps and lakes, mostly in National Park.	A - B, Dc	Very wet in winter. Rare sedge species and unique 'algae/organic' suspension in Lake Maringup.
Gardner River Wetlands - Upper		140	Areas of floodplain in the upper Gardner River catchment, either side of Northcliffe, in private land and State Forest.	B - Dc	

Table 4.8: Continued

Wetland group	Named wetlands (condition)	Approx. wetland area (ha)	Brief description	Overall condition	Habitat notes
Canterbury River Swamps		60	Floodplain and seasonal swamp on a tributary of the Canterbury, in SF.	A	Valuable wetland habitat.
Broke Inlet Wetlands - WestNS		3 600	Large swamps and, floodplains and small lakes to the west of Broke Inlet over a large area of National Park and SF.	A	Highly valuable wetland habitat, especially for fish, frogs and a range of invertebrates, some of which are rare and relictual, and number of rare plant species.
Chesapeak Brook Floodplain[NS]		2600	Large seasonal and permanent swamps and small lakes in the Chesapeak Brook catchment, in NP.	A	
Shannon River Wetlands - Lower[NS]		750	Small to large seasonal swamps and floodplain and small lakes along the lower Shannon, in National Park.	A	
Shannon River Wetlands - Middle[NS]		1600	Small to large seasonal swamp and floodplain along the middle reached of the Shannon River, in National Park.	A	
Weld River Wetlands		270	Small to large permanent seasonal swamp and floodplain in the Weld catchment, in SF.	A	
Broke Inlet Wetlands - North East[NS]		1400	Small to large seasonal swamps and floodplain and small lakes within the NE and E catchment of Broke Inlet.	A	One rare plant species. Habitat values as above.
Bell Brook Floodplains		210	Small to large seasonal swamps and floodplain on Bell Brook, in SF close to cleared land.	B - C	One rare plant species.Rare frog species.Habitat values as above.
Walpole River Floodplains		~300 m across	Small to large floodplains and seasonal swamps in State Forest and NP.	A	Rare frog species.Habitat values as above.
Nornalup - Lower Deep Wetlands	Crystal Lake[NP] (A) Boggy Lake[NP](A)	180	Small to large seasonal swamp and floodplain and small permanent swamps and lakes, mostly in NP.	A - B	Many of the private blocks retain remnant vegetation over wetland.Rare frog species.
Deep Rivers Wetlands - Middle		2900	Small and large seasonal swamps and floodplain along tributaries of the middle Deep River in SF.	A	Important wetland habitat, especially for relatively restricted frog species.
Collier Creek Wetland		130	Swamp at the base of Collier Ck and Junior River on Walpole Inlet, largely in NP.	A - B	One rare plant species.Rare frog species.

Floodplain = area seasonally or occasional inundated in water

A = wetland within a large area of healthy bushland

B = wetland within a small healthy bushland block

C = wetland connected to healthy bushland

D = wetland surrounded by cleared land;

l = cleared lake;

s = swamp/floodplain with remnant veg.;

c = cleared wetland;

s-c = transitional.

R in reserve

NP=in National Park

NS=National Significance Wetland (ANCA 1993)

RMR=Ramsar Wetland

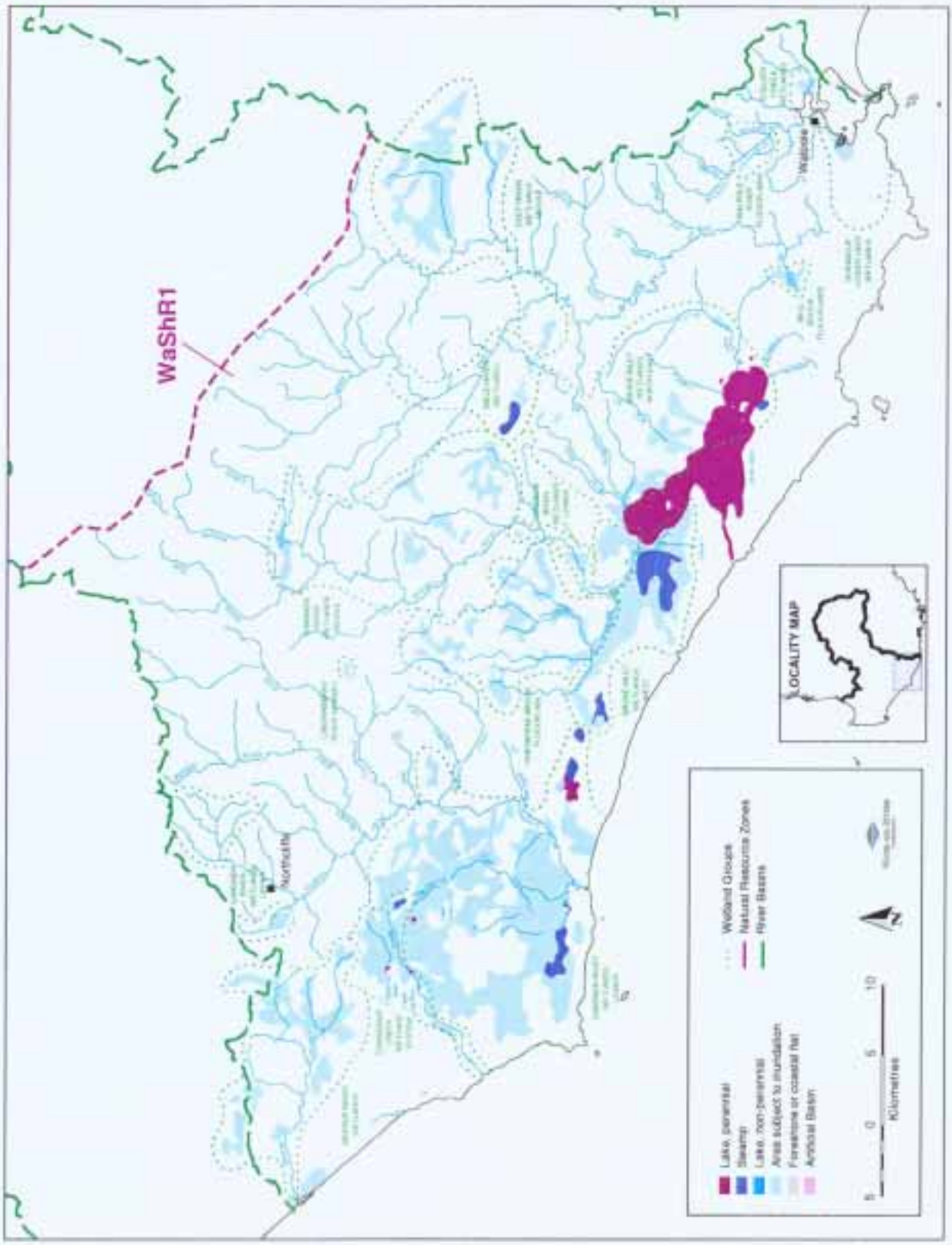


Figure 4.6: Wetland groups of the Lower Shannon Basin

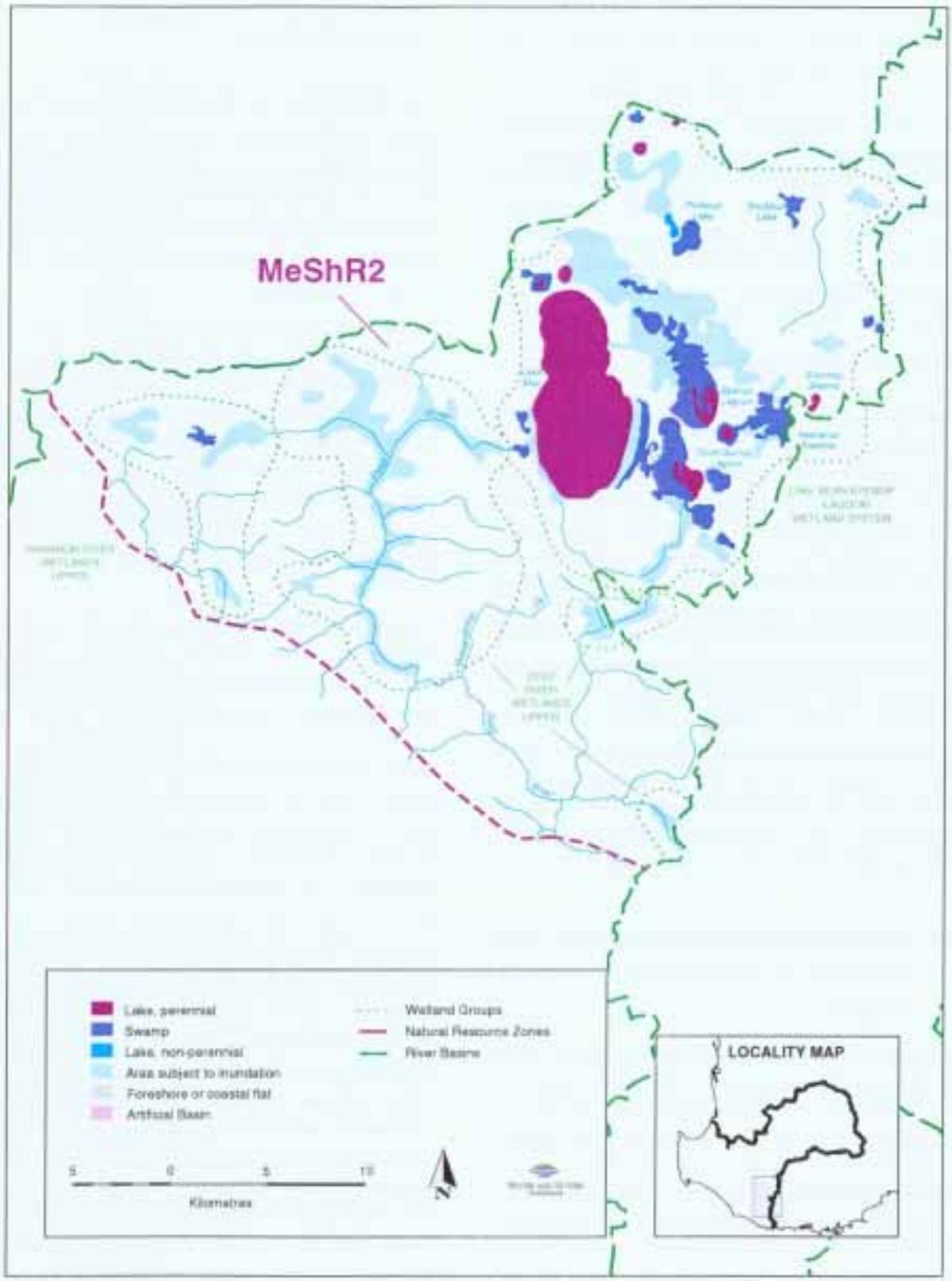


Figure 4.7: Wetland groups of the Lake Muir and Upper Shannon and Deep Catchments

species on private land (CALM data). The lake supports a moderate number of waterbird species (about 23), but with only low breeding (2 species) (Halse *et al.*1993b). However, it is a major drought refuge and moulting area for waterfowl and about five species of migratory waders use the lake as a stopover on their long migrations (ANCA 1993). Overall waterbird numbers may exceed 50 000 and Lake Muir has topped the count of waterbirds for over thousand south-west wetlands at least once and has been in the top 15 on a number of occasions (Halse *et al.*1990, 1992 and 1994). The only threat to the lake appears to be vehicles on the lake bed (ANCA 1993).

The neighbouring wetlands to the Muir are a complex of fresh to brackish paperbark and sedge lakes and swamps. Indeed they support some of the largest natural sedgelands in the state, rendering the habitat particularly important to the secretive bitterns, including the Australian and little bittern, the latter of which is known to breed in relatively large numbers (Jaensch and Vervest 1988, ANCA 1993). The large expanses of water of Byenup Lagoons and Tordit Gurrup Lagoons can carry tens of thousands of waterfowl, mainly moulting shelducks, in some years, and Byenup was actually in the top 15 wetlands waterfowl counts for over 1000 south-west wetlands (ANCA 1993, Halse *et al.*1992, 1993b). The two lagoons each support a moderate number of waterbird species and low and moderate number of breeding species, respectively (Halse 1993b). Habitat within the Lake Muir group is known to support five rare plant species, three orchid species, an aquatic herb (*Villarsia submersa*) and sedge (*Leptocarpus ceramophalis*) (ANCA 1993, CALM data).

4.3 Detailed wetland classification and mapping in the Busselton-Walpole Region

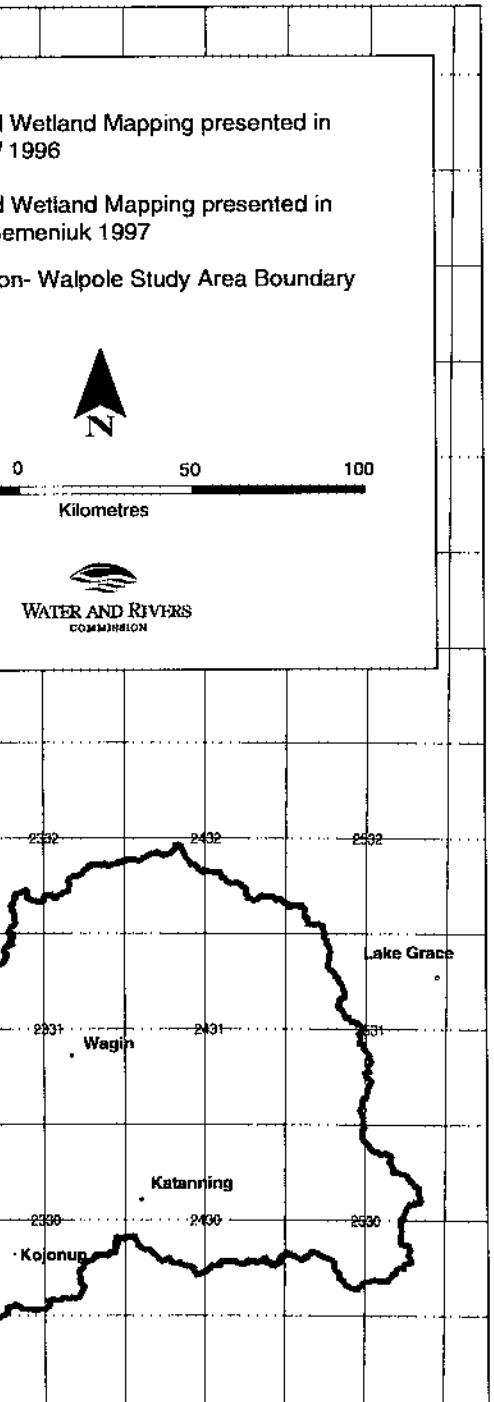
Geomorphic wetland mapping and classification within the Busselton-Walpole Region is detailed in Figure 4.8. Two reports cover the geomorphic wetland mapping completed to date. Wetland mapping and classification of the Swan Coastal Plain between Bunbury and Dunsborough has been published by the Water and Rivers Commission and the Department of Environmental Protection (Hill *et al.*1996). Mapping and classification of wetlands between Augusta and Walpole is being published by the Water and Rivers Commission (V. & C. Semeniuk Research Group 1997b). Detailed wetland mapping has significant value for the community in supporting and directing sustainable development towards highland, and supporting environmental services (e.g. nutrient stripping, flow regulation) provided by the vegetated wetland areas.

In all forty-seven 1:25 000 detailed wetland maps have been completed for the Busselton-Walpole Region (See Figure 4.8). Nine of the 1:25 000 scale maps cover the Bunbury to Dunsborough area. Thirty-eight 1:25 000 map sheets were completed for the Augusta to Walpole area, including the Muir-Unicup area. These detailed wetland maps are available from the Water and Rivers Commission in digital and hardcopy form.

Detailed wetland mapping of the Swan Coastal Plain within the Busselton-Walpole Region showed that 51% of the mapped area (1345 km^2) was wetland. Within the Augusta to Walpole area (3900 km^2) the total area of wetland was also very high, about 35%, indicating that much of the Augusta to Walpole area is a mosaic of wetland ecosystems, supporting sedgeland, heath and low forest, surrounding islands of dry upland with characteristic dunal, scrub, forest and tall forest vegetation.

The extent of wetland evident within the Augusta to Walpole area at the 1:25 000 scale is shown in Figure 4.9. This work considerably increased the accuracy of the presentation of wetlands, indicating wetlands which were not evident at the 1:250 000 or 1:50 000 scales; mainly of palusplain and dampland (see Figure 4.9 and Section 3.2.2). The diversity of wetland types was very high, including lakes, estuaries, sumplands, river and estuarine floodplains, palusplains, paluslopes and damplands (V&C Semeniuk Research Group 1997b).

The investigation into consanguinity of wetlands in the Augusta to Walpole area produced only a preliminary identification of suites. Due to the remoteness of many of the large number of wetlands in the region and the difficulty in gaining access to them, it was not possible, within the time and budget constraints of the project, to collect sufficient information to fully address the criteria necessary to enable the comprehensive identification of suites. Nevertheless, a total of 36 preliminary consanguineous suites were recognised, of which 23 were found in the coastal portion of the Shannon Basin, 3 in the Muir-Unicup area and four within the Deep River catchment. The large number of suites in close proximity to each other in the Shannon Basin, renders this area particularly significant for wetland diversity. Ten preliminary suites were identified between Northcliffe and Windy Harbour alone and many suites were only found within the basin (V. & C. Semeniuk Research Group 1997b).


l Wetland Mapping presented in
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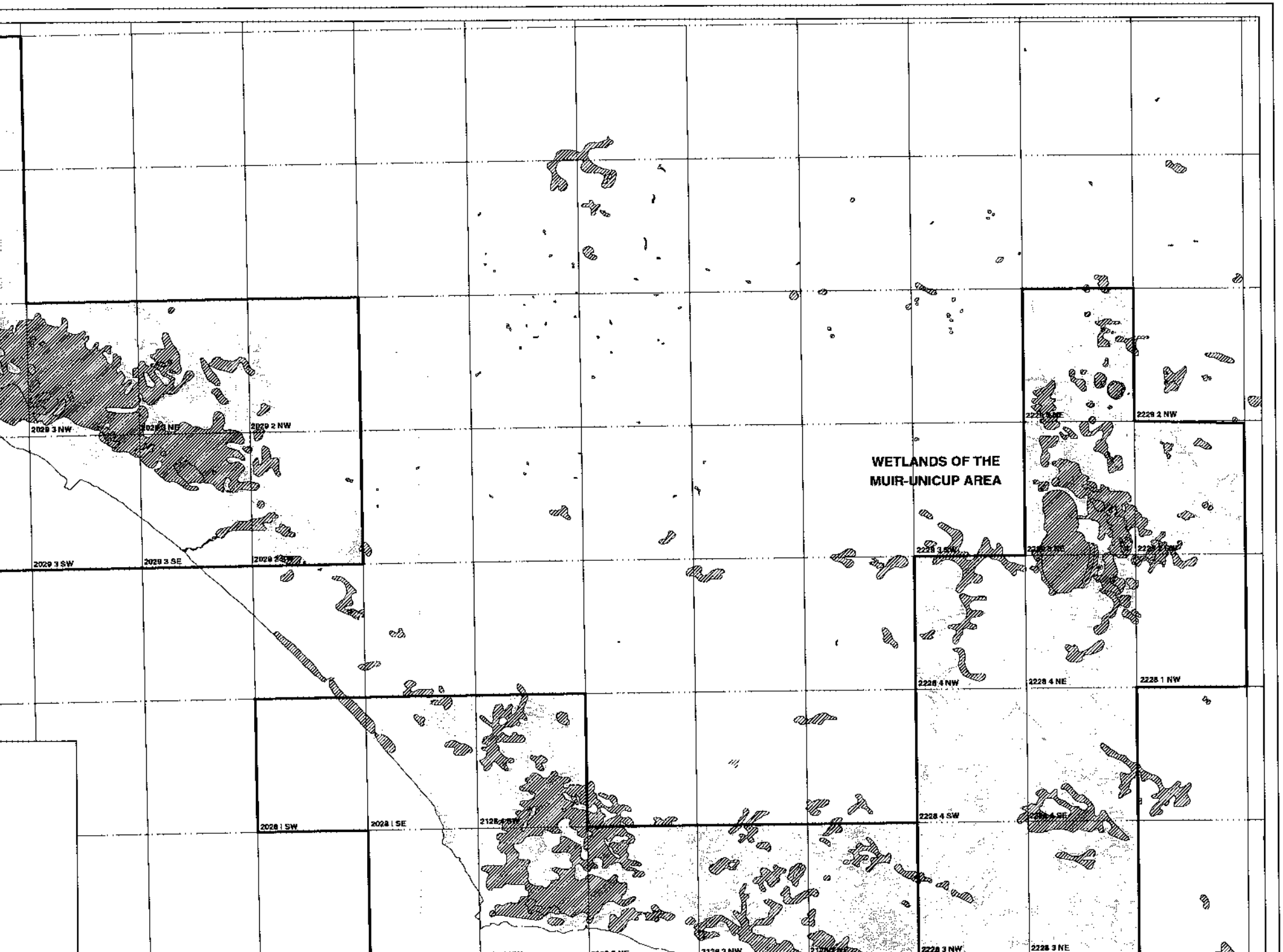
WETLANDS OF THE
MUIR-UNICUP AREA
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2029 3 NE
2029 2 NW
2029 3 SW
2029 3 SE
2028 1 SW
2028 1 SE
2228 4 NW
2228 4 NE
2228 1 NW
2228 4 SW
2228 3 NW
2228 3 NE

5. State of the Rivers

The state of the rivers of the south-west was been described recently by Olsen and Skitmore (1992). While this work included the rivers of the Busselton-Walpole region it was largely qualitative. In this study a quantitative approach was taken, based on the conditions of the riparian zone and water quality. Both are determined by catchment landuse, with upstream land uses determining water quality and adjacent landuse largely determining the condition of the riparian zone.

For example, the absence of high water using vegetation in the upper Blackwood catchment, as a part of broad acre farming, has led to the problem of salinisation which has increased the salinity of the Blackwood all the way to the ocean, even in densely forested areas. Furthermore, a combination of increased runoff, soil erosion and fertilizer application has resulted in the eutrophication of many of the region's rivers. The failure to protect riparian zones in rural and urban areas has led to the loss of native fringing vegetation through grazing, recreation, frequent fires and weed invasions. The consequences have been bank and bed erosion, siltation and general habitat degradation of many stream ecosystems. Only in natural vegetated areas are riparian zones in a generally healthy state, but water quality will only be of a high quality where the catchment remains largely in its natural state.

5.1 Methodology

Given that the condition of a section of river or creek is largely determined by the nature of the catchment area feeding into it, condition assessment was based on catchment landuse and a knowledge of the sort of riparian and water quality impacts that are associated with the various land uses and combination of land uses. In order to assess representativeness, stream systems were recognised by type and size and location (see below).

5.1.1 River types and representativeness

Whole river systems, as opposed to small creek size systems, can be categorised using the classification first outlined in The State of the Rivers of the South West publication (WAWCR 1992). These types are described in Table 5.1.

Stream systems will be divided up on the basis of size (see below) and the general location of their catchments in relation to the natural resource zones as defined by the DEP (Allison *et al.*1993). Representativeness of whole systems and stream sections will be on the basis of natural resource zones. River types will be evaluated on the basis of their condition and the important ones identified (see Section 8.4).

5.1.2 River/creek system size

Stream system size was divided into seven general size categories. These are listed in Table 5.2 along with whole stream systems that fall into each respective category.

5.1.3 Condition assessment categories

The study began with a broad survey of the rivers of the Busselton-Walpole Region using satellite imagery and topographic/cadastral maps (at 1:100 000 to 1:50 000 scale) to evaluate streams or stream sections on the basis of the condition of their catchments. (This information was used to recognise stream sections or whole stream systems which have important natural values (see Section 8.3)).

River reaches will be evaluated in a hierarchical fashion, from least disturbed to most disturbed, into the following groups:

A. Conservation river reaches

A1. Pristine: the catchment of the stream is pristine.

A2. Near pristine: the catchment is almost pristine but there is some evidence of human activity, feral animals and weeds (ie large Conservation Reserves and distant National Parks).

A3. Relatively natural: the catchment is dominated by native species, but is modified by human activity, such as logging and recreation (ie typical National Parks, State forest).

B. Natural resource river reaches

B1. Relatively natural river section: In this category the river section lies within a reserve or National Park, but the upstream catchment has been

Table 5.1: River types of south-west Western Australia (after Williams in WAWCR 1992)

Type	Description and example	Type	Description and example
T1	Longer rivers originating in the low rainfall mallee and york gum/salmon gum woodland areas, flowing west or south-west through the marri/wandoo woodlands and the jarrah/marri forest, descending the Darling Scarp and crossing the Swan coastal plain to estuary and sea (e.g. Blackwood River).	T6	Northern coastal plain rivers flowing through banksia low woodland receiving only moderate rainfall (e.g. Gingin Brook).
		T7	Northern coastal plain rivers flowing through low rainfall areas of scrub heath in many cases never reaching the coast (e.g. Cockleshell Gully).
T2	Medium length rivers originating in the medium rainfall marri/wandoo woodlands and taking a westward course (e.g. Collie River).	T8	Medium length rivers originating in the medium rainfall marri/wandoo woodlands, flowing through jarrah/marri forest and the high rainfall karri country to the coast (e.g. Warren River).
T3	Shorter rivers originating in the higher rainfall jarrah/marri forest before descending the Darling Scarp to coastal plain and on to the sea (e.g. Brunswick River).	T9	Shorter rivers contained entirely within the high rainfall karri country or just extending north-east a short distance into jarrah forest (e.g. Donnelly River).
T4	Rivers of the coastal plain flowing largely through low jarrah forest such as the sunklands with high rainfall (e.g. Margaret River).	T10	Shorter rivers contained more or less entirely within medium rainfall low jarrah and jarrah/marri forest or wandoo woodland (e.g. Denmark River).
T5	Coastal plain rivers flowing through tuart/marri woodlands receiving medium to high rainfall (e.g. Abba River).	T11	Short ephemeral rivers flowing south through mallee heath following intensive but infrequent rainfall events (e.g. Young River).

Table 5.2: Whole stream systems of the Busselton-Walpole region that flow to the coast or to an inlet, divided into seven general size categories on the basis of catchment size.

SIZE	Very large river (> 8000 km²)	Large river (2000-8000 km²)	Medium river (750-2000 km²)	Small river (350-750 km²)	Major creek (90-350 km²)	Creek (30-90 km²)	Minor creek (< 30 km²)
Stream systems which flow to the sea or to an inlet	Blackwood	Warren	Donnelly Deep	Capel Margaret Scott Gardner Shannon	Ludlow Abba Sabina Vasse Buayanup Carbunup Meerup	Island Mary Gunyulgup Wilyabrup Boodijup Doggerup Forth Inlet Big Walpole	"Dunn Bay" Dandalup Meelup "Eagle Bay" Jingarmup Yallingup Wyadup Quininup Biljedup Veryuica Miamup Cowaramup Ellen Calgardup Turner Juniour Butler Collier

significantly altered. Adjacent land has the character of an A3 catchment, but upstream the catchment may be partially or wholly cleared, support agriculture, plantations, urban development and mining.

B2. Corridor river: A corridor river reach, for the most part, retains natural vegetation along its immediate river valley or flood plain sufficient to provide a substantial area of habitat.

B3. Habitat river reach: A habitat river has been greatly impacted by upstream and adjacent landuse, but retains sufficient habitats to sustain viable populations of native plants and animals.

C. Multiple Use rivers

C1. Landscape river: The river has been heavily impacted by upstream and adjacent land use to the extent that most native plants and animals are extinct. However, important landscape components remain, such as river form (deep valleys, undulations), native trees and bodies of water, contributing to the character of the local area.

C2. Multiuse enhancement: Highly degraded streams in rural, rural/residential or residential land which have been or have some potential to be rehabilitated as part of the provision of local parkland or open space fall into this category. In other words the stream retains its natural form, though it is highly degraded.

C3. Drain: The stream has little value other than to convey water. It may be part of a drainage or irrigation scheme, it may be heavily eroded or completely channelised, lined with concrete or not and supporting a few remaining native trees and abundant weeds.

A more detailed description of these groups is given in Appendix 1.

5.1.4 Different scales

In those areas where substantial sections of streamline are likely to be of important value, evaluation was done using 1:100 000 to 1:25 000 imagery, including satellite photos and orthophotomaps, for all streams shown on 1:250 000 Auslig topographic maps. This level of stream line examination was found to be warranted for the entire Busselton-Walpole region, except for the Blackwood above the Maranup Bridge, which is about 10 km west of Bridgetown. Above this point the Blackwood passes through extensive farmland and little remnant vegetation remains. For this area, where the majority of streams appeared to be severely degraded, only streamlines shown on 1:1 000 000 Auslig maps were examined.

5.2 River description and condition

A total of 45 stream systems flow to the coast or to coastal lagoons in the Busselton-Walpole Region (Table 5.3). Details on each of these systems, including length, catchment area, proportion of catchment cleared, estimated average annual discharge and salinity are given in Table 5.3.

Condition assessments are shown in Figures 5.1-6. General condition assessments for whole stream system and major tributaries are given in Table 5.4. The proportion of stream length falling into A, B1, B2, B3 and C categories for the major basins are given in Table 5.5.

5.2.1 Geographe Bay, Leeuwin-Naturaliste Ridge and Margaret River catchments

Geographe Bay catchment (DuBuR2, MeBuR2)

The Capel River is the largest system in the basin and has been classified in size as a small river (see Figure 5.1). The lower and middle reaches retain some riparian vegetation which imparts considerable habitat and landscape values (B3-C1) (Figure 5.1). The upper catchment is mostly a combination of farmland, state forest, remnant bush on private land and corridors of vegetation along streamlines (A3-C3). Some minor headwater creeks lie in state forest (A3 value), particularly along the southern branch of the river (Figure 5.1).

Most of the other natural streamlines are now part of extensive agricultural drainage systems and have little or no natural values (C3) (Figure 5.1). The headwaters of the **Ludlow** and **Sabina** Rivers (A3), both major creeks, lie in reserved forest and both retain substantial riparian vegetation with landscape and habitat value in lower reaches (C1+). Some sections of headwater streams of the Carbunup and Buayanup Rivers are also in reserved forest (A3).

Some minor coastal streams on Cape Naturaliste have habitat value (Figure 5.1). Mialup Brook is in the best condition (B1+), draining mostly a small area of remnant bush.

Table 5.3: The approximate length, catchment area, median catchment rainfall, extent of clearing, estimated mean annual discharge and salinity of the larger stream systems of the Busselton-Walpole Region.

System	Estuary	Approx. length (km)	Catchment area (km^2)	Median rainfall (mm)	Clearing (%)	Mean annual flow (ML)	Salinity at mouth
Capel	-	45	620	950	30	88 600	Fresh
Ludlow	Wonnerup	30	210	915	25	17 200	Fresh
Abba	Vasse-Wonnerup	20	140	895	35	11 900	Fresh
Sabina	Vasse	25	105	950	40	11 300	Fresh
Vasse	Vasse	45	270	900	58	35 800	Fresh
Buayanup	-	25	160	1010	70	46 600	Fresh
Carbunup	-	30	170	1050	75	60 400	Fresh
Mary	-	30	89	1020	70	25 100	Fresh
Gunyulgup	-	10	47	975	70	11 900	Fresh
Willyabrup	-	15	88	1100	70	30 700	Fresh
Cowaramup	-	10	22	1030	59	5 400	Fresh
Ellen	-	12	28	1060	50	6 880	Fresh
Margaret	-	60	470	1075	29	120 300	Fresh
Boodijup	-	12	60	1105	40	15 200	Fresh
Calgardup	-	6	29	1105	35	6 800	Fresh
Turner	-	6	54	1175	65	22 400	Fresh
Blackwood	Hardy		21400	600	84	940 000	Brackish
Scott	Hardy	35	630	1080	30	113 900	Fresh
Donnelly	-	60	1670	1225	15	287 000	Fresh
Warren	-	150	4350	850	35	413 200	Marginal
Meerup	-	17	120	1405	5	29 800	Fresh
Doggerup	-	11	75	1390	0.5	17 500	Fresh
Gardner	-	35	530	1420	16	160 000	Fresh
Shannon	Broke	47	610	1320	10	141 000	Fresh
Forth	Broke	10	24	1420	5	6 900	Fresh
Inlet	Broke	14	56	1410	5	15 700	Fresh
Deep	Nornalup	120	1000	1120	3	166 800	Fresh
Walpole	Walpole	15	60	1415	13	19 100	Fresh
Collier	Walpole	6	14	1320	20	4 100	Fresh
Total	**Busselton-Walpole Region**	-	**33 400**	-	**65**	**2 851 000**	-

River and creeks between Cape Naturaliste and Cape Leeuwin (McBuR2, WaBuR2)

One small river, three creek and eleven minor creek systems drain to the coast between the Capes. All but one drain farmland or are subject to some form of degrading landuse, such as rural residential development, and most pass through a narrow belt of reserved coastal vegetation before reaching the ocean. Only the tiny Veryuica Brook (A3) drains an area virtually wholly dominated by native bush (Figure 5.1). Of the minor creeks which drain farmland, the Yallingup Brook (B1 mostly) drains the least and only the Boodjidup Brook (some A3) has a substantial headwater in reserved forest (Figure 5.1).

The **Margaret** River mostly drains farmland in the lower to middle reaches (B2-C3) with some state forest on Bramley Bk (A3-B1) and on the main channel of the river just upstream of the township of Margaret River where there are two A3 minor creeks (Figure 5.1). The upper reaches, which divide into the creek size north and south branches, mostly drain state forest, but because headwater creeks are partially located in the pine plantations and some cleared land, the value of both streams is B1 at best. Nevertheless, some tributaries are A3 and the two branches have considerable natural value which would be representative of the river in the MeBuR2 zone.

5.2.2 Blackwood catchment

Lower Blackwood River System below Maranup Bridge (MeBlR2)

The **Blackwood** River system was examined between Hardy Inlet and the Maranup Bridge 10 km west of Bridgetown, all of which falls into the MeB1R2 zone (see Figure 5.2). Here the river system drains large areas of natural vegetation as well as farmland, whereas upstream of the bridge it drains an area which is almost entirely dominated by agriculture and its concomitant environmental impacts[4], and as a result has virtually no natural stream sections.

The Blackwood River between Hardy Inlet and the Warner Glen Bridge mostly drains agricultural land. Although there are a large areas of remnant bush and National Park along the estuarine reaches (B1), most of the river and its tributary creeks in this section range in value from B2 to C3. A few sections of streamline pass through vegetated corridors or state forest (A3-B2). Upstream of the Warner Glen Bridge, some 25 km from the inlet, the river passes through dense forest for about 30 km as the fish swims, and most of the adjacent tributary creek systems are wholly contained within state forest or conservation reserve. Here the main channel is B1 and all the creeks are A3 condition. In this area the Blackwood passes through the Blackwood Conservation Park, created to protect the scenic quality of this the highest order stream in the south-west.

Upstream of the park, the Blackwood River itself passes through a narrow corridor of mostly farmland but with some conservation reserve, surrounded by state forest, until it reaches Nannup. Here the main channel is degraded and varies between B2 and C3, but most of the tributaries are mostly of A3 condition. The St John Brook enters in this section and is the largest tributary below Nannup, but as it drains considerable areas of farmland and pine plantation, its value ranges between A3 and C3. Only its large tributary, the St Pauls Brook, a major creek, has a catchment draining mostly state forest and is mostly A3 condition.

The Blackwood River and its tributaries between St Johns Brook and the Maranup Bridge are found in catchment dominated by farming, mining and pine plantations, with some relatively natural jarrah forest remaining in the Balingup Brook catchment. As such streams in this area range from A3 headwaters in state forest to C3 creeks on farmland.

Upstream of the Maranup Bridge, the condition of the Blackwood River system is very poor, mostly falling between B3 and C grade (see Figure 5.3). Only a very few short sections of streamline fall in bush blocks are therefore B grade. And only on the headwaters of the Tweed River, which drain State Forest and Nature Reserve, does the condition attain A grade (see Figure 5.3).

Scott River (WaBlR2)

The Scott River drains an area of low lying farmland with all the tributary creeks being rated at B3-C3 and most of the main channel at B2-3 mostly. The estuarine reaches of the river and a large section of the upper main channel fall in National Park (B1).

[4] These include salinisation and waterlogging, erosion and siltation, livestock and feral animal grazing and trampling, weed infestation, eutrophication, stagnation and toxic algae blooms, habitat fragmentation and damming.

Table 5.4: The general condition of whole stream system and major tributaries, of the Busselton-Walpole Region

Stream system	Size	General condition	Range and *main condition*
Capel River	Small river	C	A3-C3
Ludlow River	Major creek	C	A3-C3
Abba River	Major creek	C	A3-***C1***
Sabina River	Major creek	C	A3-C3
Vasse River	Major creek	C	C3
Buayanup River	Major creek	C	A3-***C3***
Carbunup River	Major creek	C	A3-***C1-3***
Mary Bk	Creek	C	B3-C3
"Dunn Bay Ck"	Minor creek	C	B2-C1
Dandalup Spring	Minor creek	B	B2-3
Meelup Bk	Minor creek	B+	B1+
Jingarmup Ck	Minor creek	B	***B3***-C1
Yallingup Bk	Minor creek	B	***B1***+-C1
Gunyulgup Bk	Creek	C	B3-C1
Wyadup Bk	Minor creek	C	B3-C1
Quininup Bk	Minor creek	C	B3-C1
Wilyabrup Bk	Creek	C	B1-***C3***
Biljedup Bk	Minor creek	C	C3
Veryuica Bk	Minor creek	A	A3
Miamup Bk	Minor creek	B	B1
Cowaramup Bk	Minor creek	C	B1-C1
Ellen Bk	Minor creek	B	B1-C3
Margaret River	Small river	B	A3-***B1-3***-C3
North Branch	Creek	B	A3-***B1-3***-C1
South Branch	Creek	B	A3-***B1***-B3
Boodjidup Bk	Creek	C	A3-***C3***
Calgardup Bk	Minor creek	C	B1-C1
Turner Bk	Minor creek	C	B1-C3
Blackwood River	Very large river	C	A3-***C3***
Rosa Bk	Major creek	A	A3
St John's Bk	Small river	B+	***A3-B1-C3***
Balingup Bk	Small river	B	A3-***B1-3***-C3
Tweed River	Small river	C	A-***C***
Gnowergerup Bk	Small river	C	B3-C
Dinninup Bk	Small river	C	B3-***C***
Balgarup River	Small river	C	B3-***C***

Table 5.4: Continued

Stream system	Size	General condition	Range and *main condition*
Arther River	Large river	C	B1,B3-***C***
Kojonup Bk	Small river	C	B1,B3-***C***
Beaufort River	Large river	C	B1,***B3-C***
Carralup River	Large river	C	B3-***C***
Coblinine River	Large river	C	B1,***B3-C***
Dongolocking Gy	Medium river	C	B1,B3-***C***
Hillman River	Small river	C	B3-***C***
Buchanan River	Small river	C	***C***
Donnelly River	Medium river	B	A3-***B1-3***-C3
Barlee Bk	Small river	A	***A3***-C1
Warren River	Large river	B	A3-***B1-3***-C3
Dombakup Bk	Creek	B	***B1***-C1
Lefroy Bk	Major creek	B	A3-C1
Quinninup Bk	Major creek	A	***A3***-C1
Wilgarup Bk	Small river	B	A3-***B1-3***-C3
Perup River	Small river	B	A3-***B1-3***-C1
Yerraminnup River	Major creek	B	***A3-B1***-C1
Tone River	Medium river	C	A3-***C3***
Meerup River	Major creek	B	A3-***B1-C3***-C1
Doggerup Ck	Creek	A	A2
Gardner River	Small river	B	A3-***B1-2***-C1
Buldania Ck	Creek	A	A3
Canterbury River	Major creek	B	A3-***B1***-B2
Boorara Bk	Creek	B	A3-***B1***-B2
Shannon	Small river	A	A2-3
Forth River	Creek	A	A2-3
Inlet River	Creek	A	A3+
Big Ck	Minor creek	A	A2-3
Creek 2	Minor creek	A	A2
Creek 3	Minor creek	A	A2
Creek 4	Minor creek	A	A2
Deep River	Medium river	A	***A3***-B2
Weld River	Major creek	B	A3-***B1-3***-C1
Walpole River	Creek	B	A3-***B3-C1***
Junior River	Minor creek	C	B1-***B3-C1***
Butler Ck	Minor creek	C	A3-B1
Collier	Minor creek	B	A2-C1

Table 5.5: The proportion of stream length falling into selected condition assessment categories for the major basins or subregions of the Busselton-Walpole Region

Basin or subregion	Condition					Length of streamline assessed (km)
	A	B1	B2	B3	C	
Geographe Bay	16	1	0	3	79	1 084
Leeuwin-Naturaliste Ridge	4	12	4	10	71	166
Margaret	23	17	6	21	34	261
Blackwood - lower*	44	12	1	6	36	1 906
Scott	0	13	0	22	65	84
Donnelly	52	27	3	6	12	594
Warren	29	14	5	13	38	1 773
Shannon	78	8	6	1	6	1 205
Total	40	12	3	7	37	7 073
Blackwood - upper+	0.2	0.5	0.2	19	80	2 582

* The lower Blackwood refers to that part of the system below the Maranup Bridge.

+ The upper Blackwood refers to that part of the system above the Maranup Bridge.
Only stream lines shown on 1:1 000 000 hydrological data were assessed.

5.2.3 Donnelly catchment (WaDoR1, MeDoR2)

The Donnelly River system mainly drains state forest and conservation reserves, with only a few areas of farmland, mainly to the west of the township of Manjimup on the Manjimup Brook catchment and at the very top of the Donnelly system. Unfortunately a small number of small isolated cleared farmland areas are located on streamlines (B2-3 mostly) and these have the effect of reducing the quality of a considerable length of streamline throughout the system (Figure 5.4). For example the main tributary of the Donnelly, the small river system Barlee Brook, has small blocks of farmland along its middle reaches and at the very top of the catchment. Similarly, the creek size Fly Brook and major creek Carey Brook drain small areas of farmland into the lower Donnelly. For this reason most of the main channels are B1 condition, while ironically most of the tributary creeks and minor creeks are A3 (Figure 5.4).

5.2.4 Warren catchment (WaWrR1, MeWrR2, MeWrR3)

The catchment of the Warren River system is a patchwork of farmland, state forest and conservation reserves mostly. Forested catchment is most extensive in the lower reaches where minor tributaries are of mostly A3 to B1 condition and the main river channel ranges from B1 to B2 (Figure 5.5). Even so the larger of the tributaries, the creek sized Dombakup (A3-C3) and the major creek Lefroy Brook (A3-C3) drain substantial areas of farmland. Only the major creek, Quinninup Brook has the majority of its catchment, including most of the upper reaches, in state forest. In the middle reaches of the Warren, farmland becomes more extensive, especially along the main channels of the small Wilgarup and Perup Rivers where stream condition ranges from B1-C3 and B3-C3, respectively (Figure 5.5). Some A3 and B1 tributaries remain on both rivers, however, and especially on the Yerraminnup River, a tributary of the Perup, whose middle

reaches and associated tributaries range from A3 to B1 mostly. Upstream of the Perup River, the Warren River becomes the medium sized Tone River, which in its lower 35 km drains large areas of state forest and nature reserve (A3-B2). However, upstream of this section, the Tone drains a large area of farmland with much remnant vegetation along streamlines, producing stream conditions as high as B2 but generally between B3 and C3.

5.2.5 Shannon Basin (WaShR1, WaShR2)

The Shannon River Basin is made up of 15 individual drainage systems, including one medium size river, the Deep, and two small river systems, the Gardner and Shannon. One major creek, the Meerup River, and one creek, the Doggerup, drain directly to the sea. The remaining five creeks and five minor creeks flow into the Broke or Walpole Inlets. These systems mostly span the WaShR1 zone but the very upper reaches of the Shannon and the upper catchment of the Deep comprise the MeShR2 zone.

Meerup River and Doggerup Creek

Both the **Meerup** River and **Doggerup** Creek are major creek and creek size systems respectively, which flow to the ocean directly, and not via an inlet. They are the only two relatively small drainage systems on the south coast west of Albany to do so, and therefore are quite unique.

The Meerup River mostly drains swampy land supporting coastal heath, sedgeland and forest, most of which is near pristine, especially along the lower reaches of the system, where it flows in a deep, narrow valley through dunes (Hodgkin and Clark 1989). Unfortunately, most of the headwaters are in farmland and substantial sections of the middle reaches flow through farmland also, rendering most of the system only B1-3 condition at best (Figure 5.6).

By contrast the neighbouring Doggerup Creek, which drains similar country to the Meerup, has virtually no farmland in its catchment and apart from one or two tracks and possibly excessive burning, has not been affected significantly by human activity. For this reason the system has been rated as A2 (Figure 5.6).

The Gardner River

The small size Gardner River system, as with the Donnelly and the Warren, discharges directly to the ocean, and is the most eastern river system to do so west of Albany.

The lower reaches of the Gardner drain an area of almost pristine sedgeland, heath and forest of the D'Entrecasteaux National Park. The three lower tributaries, Maringup Creek (minor), Buldania Creek (medium) and Una Brook (minor) are all A3 condition (Figure 5.6). However, upstream the major tributaries, the Canterbury River (major creek), Boorara Brook (creek) and the upper Gardner (creek) drain or pass through large blocks of farmland amongst patches of dense forest. The condition of these systems mostly ranges between B1 and B2, but with A3 headwater creeks and sections as poor as C1 (Figure 5.6).

The Shannon River

The small size Shannon River system is today virtually completely contained within National Park. As the catchment has been extensively logged on the recent past, it is generally of A3 value, but A2 creeks should exist in the lower reaches where the system drains heath, sedgeland and scrub, little affected by human activity (Figure 5.6).

Creeks of Broke Inlet

Seven creek systems are shown on maps to discharge into Broke Inlet. Two of these, the Forth River and Inlet River, are creek size and four are minor creek size, Big Creek and the unnamed creeks 2, 3 and 4 (see Figure 5.6). Creek 1, shown on maps, is not a well defined channel and has not been included in the study. All of the systems drain land that has been little affected by human activity and so range in condition from A2-3 (Figure 5.6). Creeks 2 and 3 drain the most extensive near pristine area on the Inlet and are therefore of A2 condition.

The Deep River

Nearly all of the medium size Deep River system is in state forest, including all of the upper Deep and Weld River systems, and is therefore mostly A3 condition (Figure 5.6). Only in the lower reaches do a few tributary creeks, Croea Brook (A3-B2), Our Brook (B1-3), Bell Brook (A3-B2), Landers Gully (A3-B2) and Crystal Brook (A3-B2), drain farmland, some of which runs along the very lower section of the Deep (Figure 5.6).

Creeks of the Walpole Inlet

Three minor creeks and one creek size system, the Walpole River, drain into the Walpole Inlet, an arm of the much larger Nornalup Inlet. Although these systems mainly drain state forest and National Park, the headwaters of most of them also drain farmland, reducing the condition of the streams to between B1 and C1. The westward flowing tributaries of the lower Walpole, including Felix Brook, and the upper Collier Creek are the best examples of A3 streams in the Walpole Inlet catchment (Figure 5.6).

5.3 A note on salinisation

The salinity of the streams in the Busselton-Walpole Region is described in detail in the report on divertible water resources (Williams, In Prep.). A general description will be given here.

All of the creek and short river systems that largely drain the forested and/or high rainfall (>1100 mm) areas of the region are very fresh (<500 mg/L TDS). Only the larger rivers, the Blackwood, Warren and to a limited extent the Donnelly, which drain highly cleared farmland in their upper catchments have salinities that are marginally fresh, brackish or saline. It is likely that the upper reaches of Warren and Blackwood were always at least marginally fresh and brackish, respectively, but have become much more saline as a result of land clearing in low rainfall areas (<700mm).

The upper Blackwood above the Wagin Lakes (see Section 4) is mainly saline, but this area seldom discharges water into the lower Blackwood. The Arthur River and the main channel of the Blackwood River are brackish. Lower reaches of the Blackwood become increasingly fresher downstream as a result of the input of fresh water from forested and or high rainfall catchments near the coast. Tributaries between Bridgetown and Balingup are fresh to marginally fresh, but very high quality fresh water (<500 mg/L TDS) tributaries are mainly found below Nannup.

The Donnelly River is marginally fresh in its upper catchment, becoming increasingly fresh downstream.

The main channel of the Warren River is only marginally fresh below Pemberton due to the input of brackish water from the largely cleared Perup and Tone systems. The Wilgarup River and major creeks about Manjimup are marginally fresh. The forested sections of the tributaries of the Tone, Perup and Wilgarup are fresh, as are all the Warren's tributaries below the South West Highway.

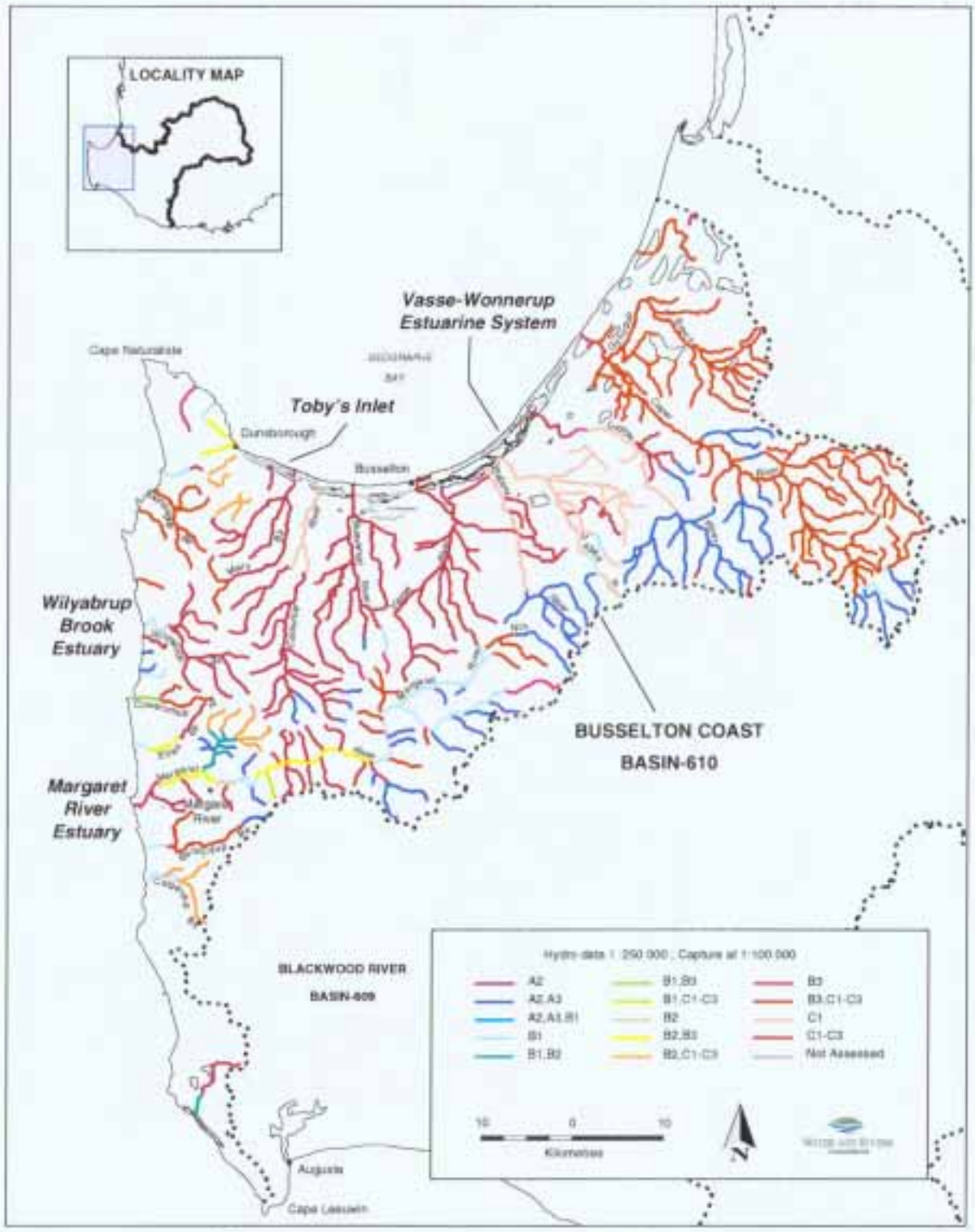

Figure 5.1: The condition of streams in the Geographe Bay, Leeuwin-Naturaliste Ridge and Margaret River Catchments

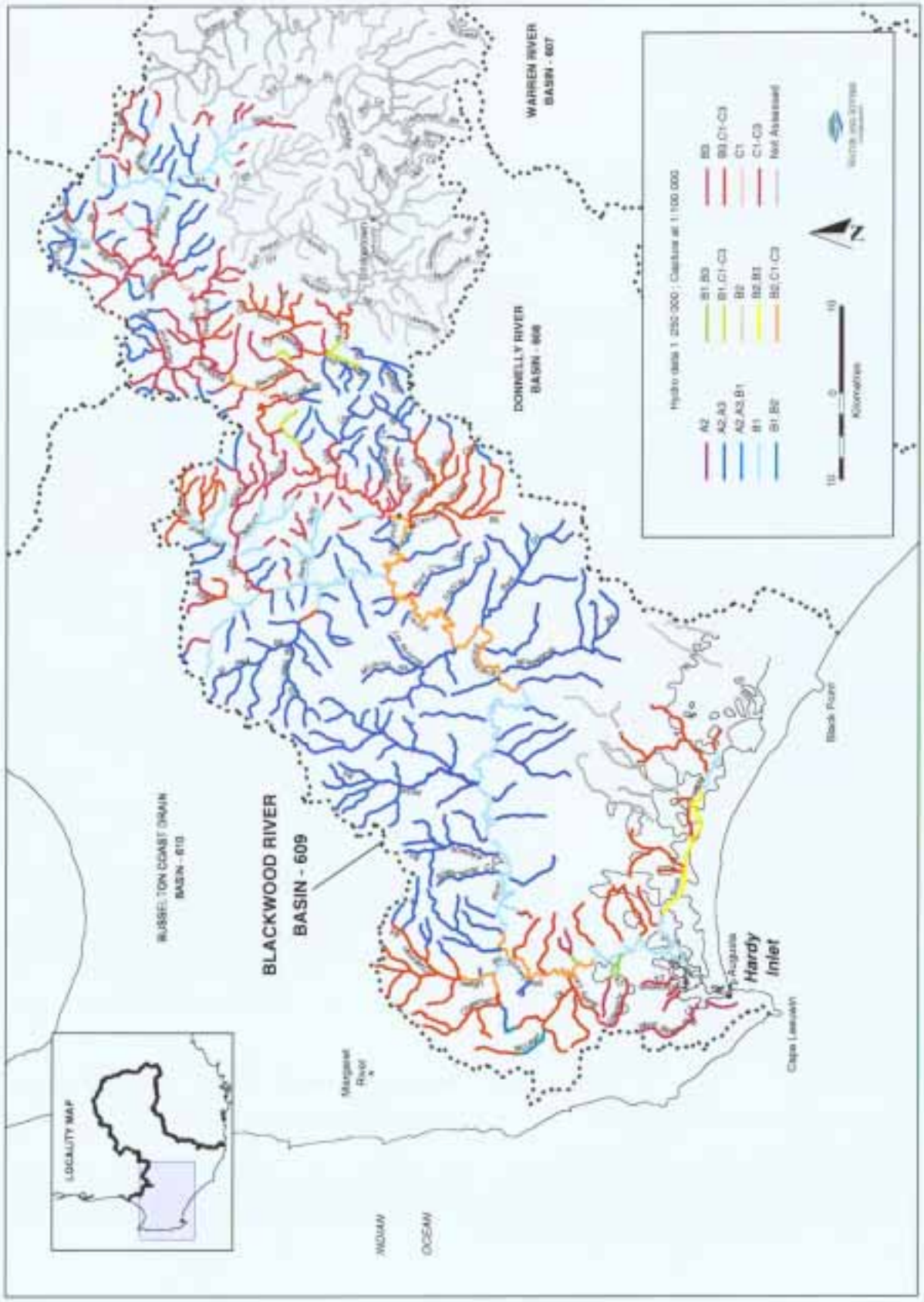

Figure 5.2: The condition of streams in the Lower Blackwood Catchment and on the Western Scott Coastal Plain

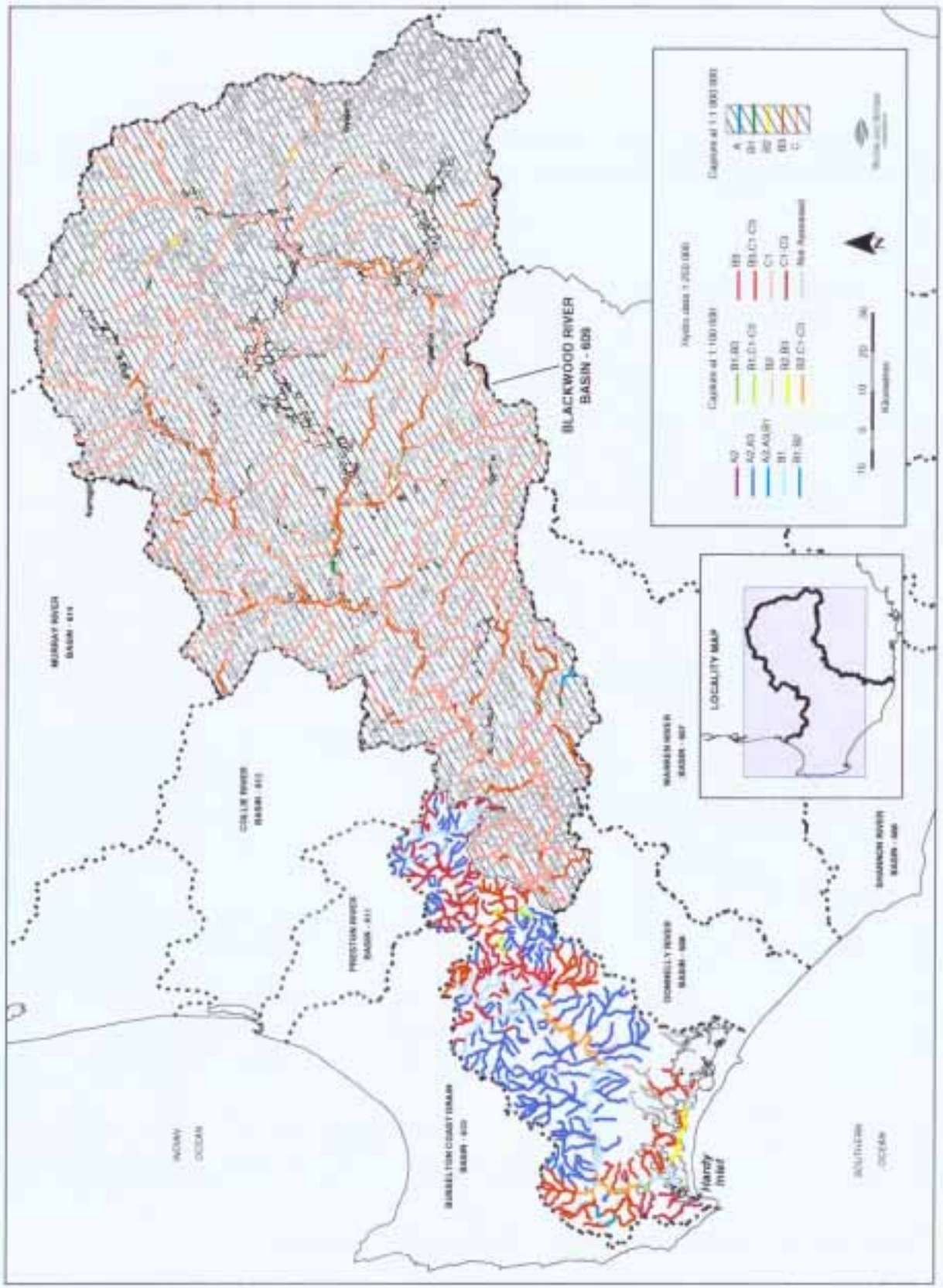

Figure 5.3: The condition of streams in the Blackwood Catchment

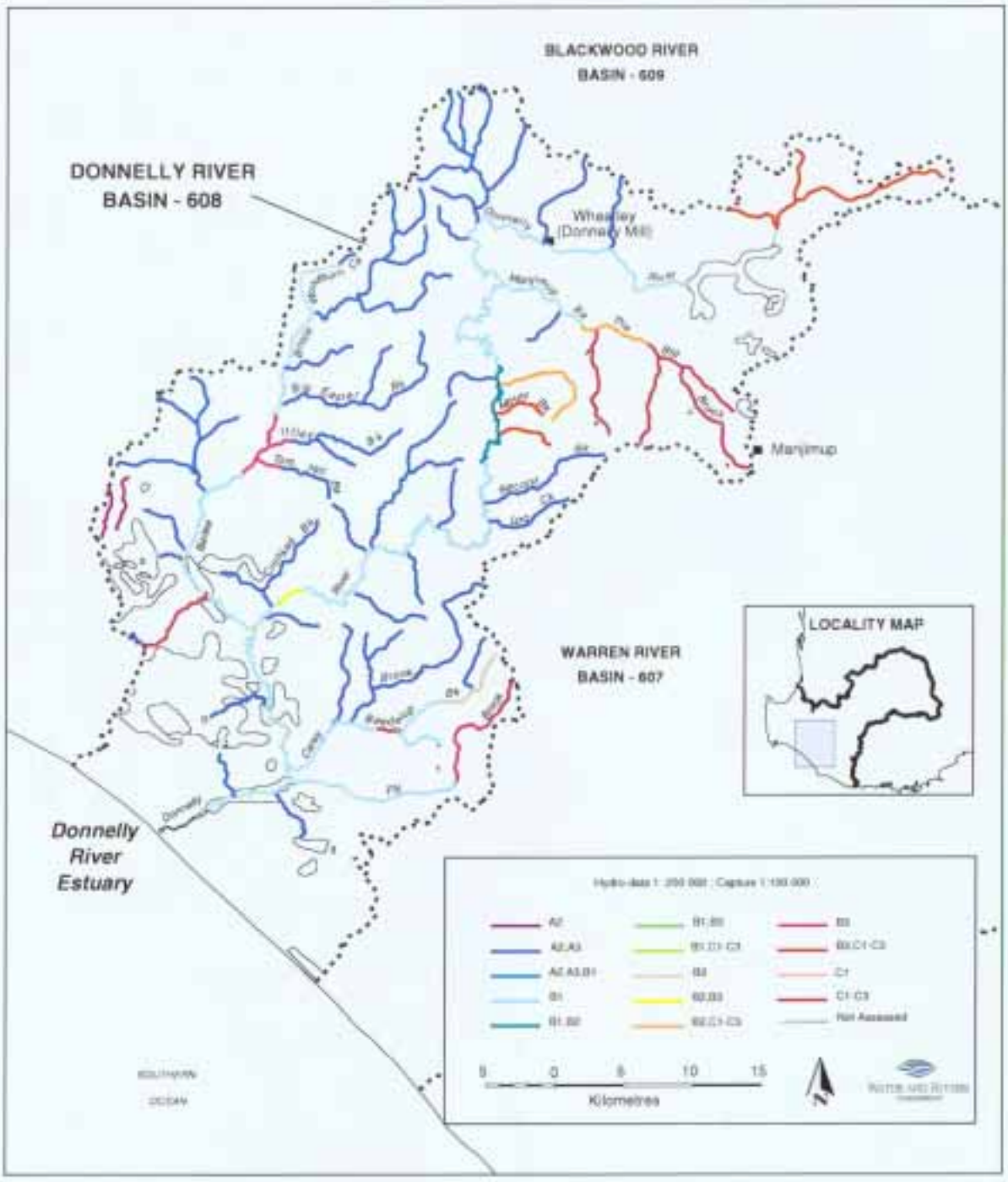

Figure 5.4: The condition of streams in the Donnelly Catchment

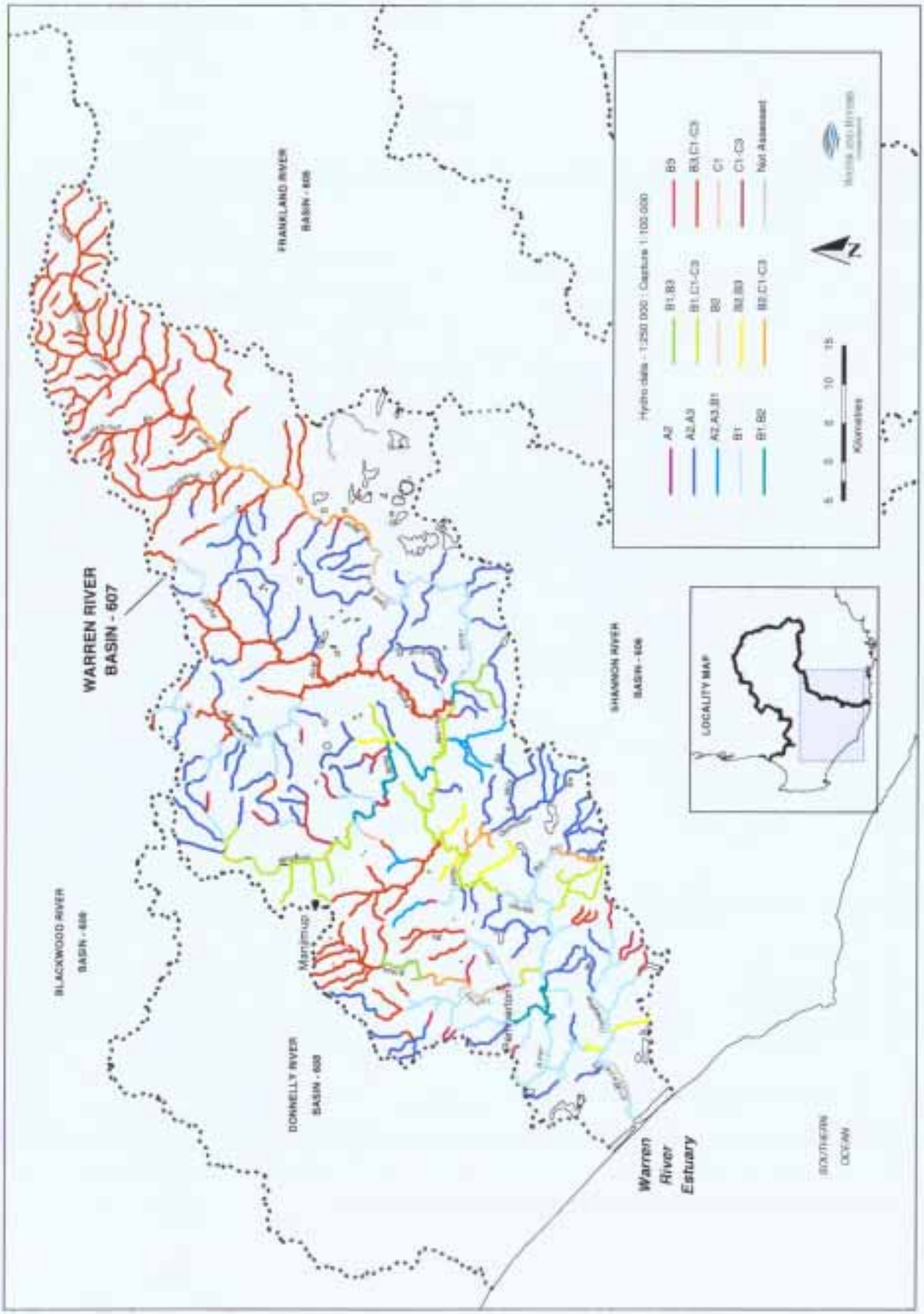

Figure 5.5: The condition of streams in the Warren Catchment

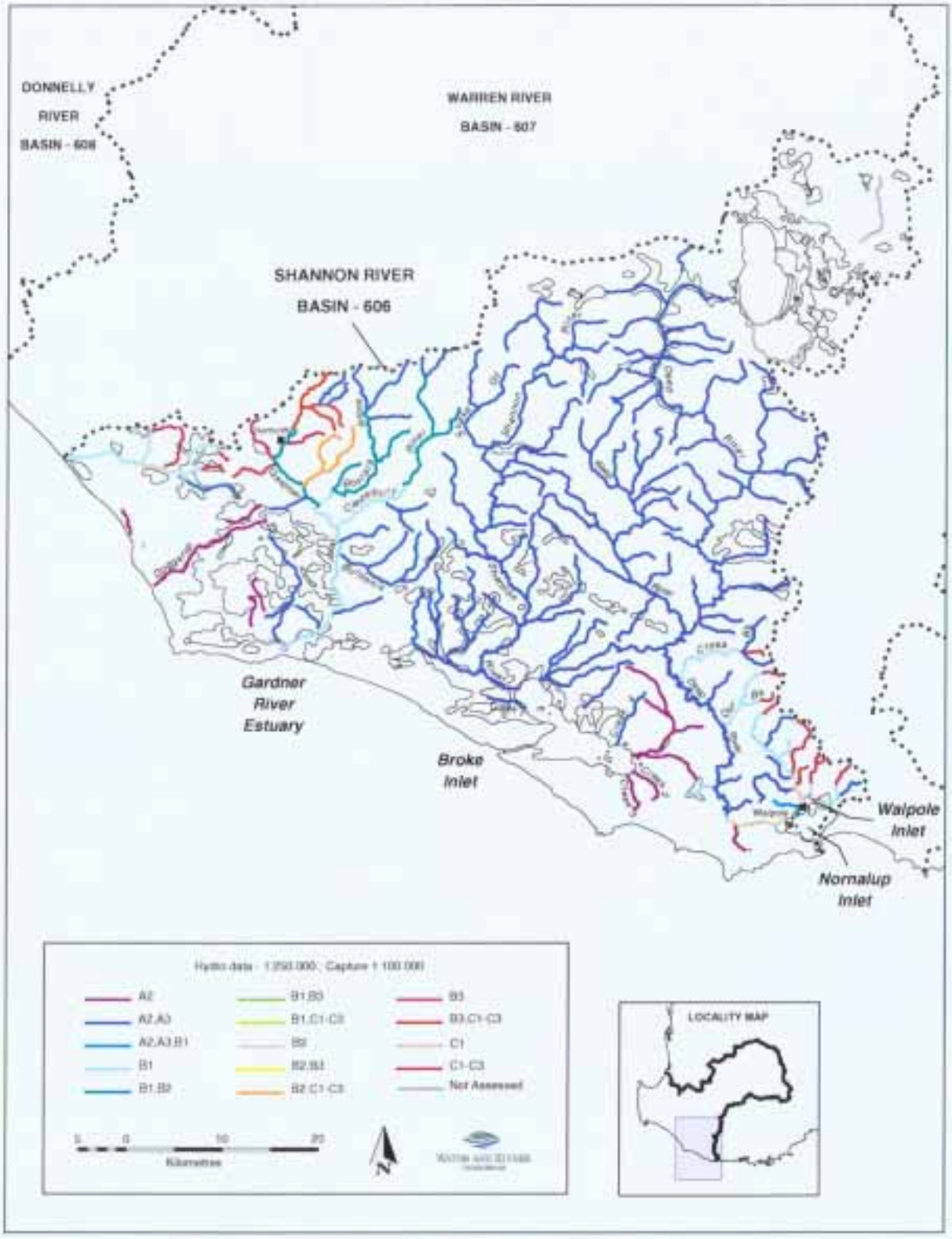

Figure 5.6: The condition of streams in the Shannon Basin

6. State of the estuaries

6.1 Basis of condition assessment

The condition of an estuary is determined by three factors: the state of its catchment, the state of peripheral wetlands and the status of its connection to the ocean. Cleared catchments discharge a greater quantity of water, salts and nutrients to estuaries, resulting in changes to the hydrological regime and nutrient status. Most estuaries with substantial agricultural areas within their catchments exhibit the symptoms of eutrophication, such as seagrass loss, excessive algae growth and fish deaths. Wetlands on the floodplains adjacent to estuaries are important habitat and contribute to the nature of estuarine ecosystems and their assimilative capacities. Many estuaries in the south-west have been altered hydrologically by drainage diversions, dredging, reclamation, artificial connections (known as cuts), and by the removal or early breaching of ocean bars, which is done to increase ocean flushing, prevent flooding, increase fish stocks or enhance boating.

6.2 Condition assessment categories

Condition assessment of estuaries is therefore based on the above three factors and is two phased, being largely a combination of wetland and stream assessment techniques used in Sections 4 and 5. The scheme is as follows:

A. Estuary contained within a large area of natural vegetation.

B. Estuary contained within a small area of natural vegetation.

C. Estuary partially connected to a large area of natural vegetation.

D. Estuary surrounded in cleared land.

1. Catchment virtually entirely naturally vegetated.

2. Catchment mostly naturally vegetated.

3. Catchment mostly cleared, but main channels mostly within vegetated corridors.

4. Catchment mostly cleared and main channels not within vegetated corridors.

* modified ocean connection

Thus an estuary within coastal bushland, with a mostly cleared catchment with few main channels in vegetated corridors and an ocean connection which is breached early to prevent flooding would be B4*.

6.3 Estuary description and condition

Details on each of the region's 11 estuaries, including condition, are given in Table 6.1. Location of the estuaries has been shown on Figures 5.1-5.6.

Hodgkin (In Prep.) identifies four main types of estuaries in the south west: narrow shore-parallel interbarrier lagoons which are separated from the ocean by high beach ridges formed by waves and wind; river valleys which have been flooded during the last sea level rise; the lower estuarine reaches of rivers which have no sizeable lagoons and more or less discharge directly to the ocean; and inlets where coastal plain depressions have become flooded by the ocean. All four forms are found in the Busselton-Walpole Region and are somewhat discrete from one another physiographically.

The Vasse-Wonnerup and Toby's inlet are large and small examples, respectively, of the interbarrier type and are located on the Swan Coastal Plain. The Wilyabrup Brook, Margaret River estuary and the Hardy Inlet are associated with the Leeuwin-Naturaliste Ridge; the Wilyabrup and Margaret dissecting it and the mouth of the Blackwood being hard up against it. The Wilyabrup and Margaret are river form estuaries, while the Hardy has a flooded valley form. The Donnelly, Warren and Gardner systems are also river form and have formed on the wave and dune dominated, NW-SW oriented high energy coast between Cape Leeuwin and just beyond Windy harbour. Lastly the Broke and Nornalup-Walpole Inlets have formed behind raised shoreline dominated by high granite hills and coastal dunes. The Walpole Inlet lies inside the Nornalup. These type of basin estuaries are characteristic of the Ravensthorpe Ramp and continue right through to Albany.

All the estuaries have sand bars at their mouths and all except the Nornalup close periodically when stream flow is minimal. The Vasse-Wonnerup and Toby's Inlet have

Table 6.1: Estuarine basin area, major drainage systems, catchment area, catchment clearing, surrounding land use and environmental condition of the estuaries of the Busselton-Walpole Region

Estuary	Basin area (ha)	Major drainage systems	Catchment area (km^2) (Discharge ML)	Catchment clearing (%)	Surrounding land use	Condition
Vasse-Wonnerup	1000	Capel Ludlow Abba Sabina Vasse	1500[1] (210 000)	39	Farming and residential	D4*
Toby's Inlet	20	Carbunup Mary	260 (48 000)	73	Residential mainly	D4*
Wilyabrup Brook Estuary	2	Wilyabrup	90 (30 700)	70	Private bushland	B4*
Margaret River Estuary	20	Margaret	470 120 000)	29	Farming and National Park	B/C2
Hardy Inlet	900	Blackwood Scott	22 000 (1 058 000)	84	Farming, residential and National Park	C4
Donnelly River Estuary	~50	Donnelly	1 670 (287 000)	15	National Park	A2
Warren River Estuary	~20	Warren	4 350 (413 000)	35	National Park	A2
Gardner River Estuary	~8	Gardner	530 (160 000)	16	National Park	A2
Broke Inlet	4800	Shannon Inlet	928[2] (170 000)	4.52	National Park	A1
Nornalup Inlet	1300	Deep Frankland	7 400[3] (410 000)	543	National Park and some holiday facilities	A4
Walpole Inlet	~100	Walpole Collier	~75 (23 000)	~10	Parkland, residential and tourism	C2

[1] Much of this no longer drains to the estuary

[2] From Hodgkin and Clark 1989

[3] From Hodgkin 1976

been greatly altered hydrologically by drainage schemes on the coastal plain, involving the diversion of a number of streams directly to the sea and tidal barrages.

Swan Coastal Plain interbarrier estuaries

The **Vasse-Wonnerup Estuarine System** is about 25 km long and from 1-3 km wide, covering an area of about 1000 ha (Figure 5.1). It once consisted of a complex of brackish seasonal lakes, marshland, estuarine forest and saline lagoons, receiving fresh water from the Capel, Ludlow, Abba, Sabina and Vasse Rivers. Today the Capel and Vasse have been diverted directly to the sea, forming short canal-like estuaries of little habitat value, and tidal barrages have also been located near the estuary's mouth to reduce the inflow of marine water. These changes, together with widespread clearing and drainage on the coastal plain, have reduced the system to little more than a grassy sumpland with some relic marshland and fringing forest. However, although the condition of the "estuary" is only D4*, it retains considerable habitat value for waterbirds and is one of the most important wetlands for waterbird usage in the south-west (See Section 4.2.1).

Toby's Inlet is a miniature version of the Vasse-Wonnerup, being about 4.5 km long and 50 m across (Figure 5.1). It once received flow from the Carbunup River and Mary Brook systems, via a freshwater wetland

that bends behind a narrow ridge just to the landward of the estuary. Today these streams have been diverted to the sea and most of the land around the inlet has been or continues to be developed for housing. Some remnant rushes, fringing wetland forest and bushland remain, enhancing the minor habitat value of the inlet.

Leeuwin-Naturaliste Ridge river form estuaries

The Wilyabrup Brook and Margaret River (see Figure 5.1) form small very narrow north-easterly orientated lagoons behind beach sand. Both have a peninsular of high land on their north-west bank, largely supporting bush. The **Wilyabrup** lagoon is the smaller of the two, being about 1 km long and only 70 m wide at the mouth, tapering to about 5 m wide upstream. While its catchment is largely cleared and most river tributaries are dammed, the lagoon is remains within a relatively natural area of private bushland and sand dune. Its condition is therefore B4*. The main lagoon of the **Margaret River** estuary is about 1 km long and about 200 m wide, thereafter tapering to about 10 m wide over a distance of 2 km. The lagoon, which has an area of about 20 ha, is connected to the ocean via a 500 m long 50 m wide entrance channel that twists around a headland. The north-western side of the estuary is public bushland and although the land on the opposite bank is mostly cleared, the estuary retains a good buffer of wetland and riparian vegetation along most of its length. With a largely naturally vegetated catchment, the condition of the estuary is close to B2.

Hardy Inlet flooded valley estuary

The main basin and intertidal area of the **Hardy Inlet** cover an area of about 9 km^2 and extend over a distance of 5 km from the entrance channel to the mouths of the Blackwood and Scott Rivers (Figure 5.2). The estuarine reaches of these rivers extend for a further 30 and 8 km upstream, respectively. The entrance channel itself is 3 km long and about 300-600 m across. To the east of the mouth, amongst sand dunes, are the large Deadwater and Swan Lake lagoons where the previous entrance channel once wound its way to the sea. The middle estuary is complex in form, due mainly to past river meandering which has produced backwaters and islands. There are also small bays, mudflats and large peripheral wetlands, with intact native vegetation, and areas of permanent water supporting seagrass beds. Hence the habitat value of the inlet is high, which is reflected by high waterbird usage and significant recreational and commercial fish populations (Hodgkin 1978).

Western Scott Coastal Plain river form estuaries

The lower reaches of **Donnelly**, **Warren** and **Gardner** Rivers (Figures 5.4, 5.5 and 5.6 respectively) are confined to winding narrow and often steeply sloping sandy valleys as they pass through a 9 km wide coastal belt of sand dunes supporting coastal vegetation. They all open onto long sandy beaches, with the Warren snaking its way to the north-west behind the beach for about 2 km before breaking out to the sea. All have narrow lagoons which may be 50-100 m across and stretch back for 4 km or more, in the case of the two larger rivers and 1.5 km in the case of the Gardner. The Donnelly has a prominent rocky headland at the mouth on the southern bank and the Gardner has occasional rocky bars, including one at the mouth. All three rivers become barred from the sea by beach sand during periods of minimal flow, but when open, only the Donnelly and Gardner are considered to become tidal, to a distance of 12 and 5 km respectively (Hodgkin and Clark 1989). All three estuaries mostly support narrow belts of fringing sedges, rushes and paperbarks, but the Donnelly has a broad lagoon with peripheral wetlands, known as the Broadwater, about 3.5 km upstream from the mouth. As all three estuaries are located in National Park and their catchments are mostly naturally vegetated their conditions are A2. It should be noted however that squatters shacks are located near the mouths.

The small **Meerup River** and **Doggerup Creek** systems flow to the ocean between the Warren River and Point D'Entrecasteaux, but neither is thought to be estuarine (Hodgkin and Clark 1989). The mouth of the Meerup 'spreads out in braided channels over the coastal plain to the high beach, while the Doggerup flows to the sea over a mobile dune between the granite shore of Black Head and the limestone cliffs of Point D'Entrecasteaux' [*sic*].

The Ravensthorpe Ramp basin estuaries

Broke Inlet is a large elongate shallow lagoon (~1.5 m deep) covering an area of 48 km^2 and receiving flow from the Shannon River and a number of much smaller systems, of which the largest is the Inlet River (Figure 5.6). When the inlet is open to the sea, via its 3.5 km long and 250 wide entrance channel, the rivers are tidal for 3 km and 2 km, respectively. The inlet has a number of small islands and supports narrow bands of fringing vegetation, with extensive freshwater wetlands to the landward, especially near the mouth of the Shannon. Waterbird usage is relatively high with as many 2-3000 individual birds and

18 species being seen on the inlet (ANCA 1993). Seventeen commercial fish species are regularly caught on the inlet with professional catches ranging from 5-10 tonnes annually (Hodgkin and Clark 1989). The surrounding wetlands are important habitat for a number freshwater fishes and the inlet is a major drought refuge for the musk duck (ANCA 1993). The near pristine nature of the inlet and its surrounding wetlands and its near fully vegetated catchment give the estuary the highest condition rating, A1, of all of the Busselton-Walpole region's estuaries. The inlet's near pristine and wilderness condition is recognised in its listing as a wetland of National significance (ANCA 1993).

The **Nornalup Inlet** is located between high coastal granite hills and sand dunes covered in dense coastal heath, scrub and forest (Figure 5.6). It covers an area of about 13 km^2 and ranges from 3-5 m in depth mostly. The inlet receives water from the large Deep and Frankland Rivers which maintain sufficient flow to keep the narrow entrance channel permanently open against the rocky western headland. The rivers are tidal to about 6 and 12 km upstream from their mouths, respectively. The fringing vegetation of estuarine and freshwater sedgelands and low forest of paperbark and tea trees are extensive along the lower estuarine reaches of the rivers and especially at the mouths. Adjacent upland vegetation has only been displaced by a few roads and tracks and small holiday facilities. Although the entire Deep catchment is virtually naturally vegetated, the Frankland (which is not part of the Busselton-Walpole Study) is mostly cleared. Hence the condition of the inlet is A4.

The **Walpole Inlet** is only about kilometre in area and about 1 m deep (Figure 5.6). It is connected to the Nornalup via a 1 km long channel flanked by high hills covered in dense karri forest. Much of the upland areas around the inlet have been cleared for residential, tourism and recreational development, but fringing wetlands remain largely in their natural state. The Walpole River and Collier Creek discharge into the inlet and their catchments are only partially cleared. The condition of the estuarine system is therefore C2.

The scenic beauty of the Walpole-Nornalup System is unlike anywhere else in WA, with open waters adjacent to high hillsides clad in tall karri and red tingle forest of the National Park of the same name. Habitat values are also high with significant water bird usage and 37 species of fish known to be found in the estuary which is closed to commercial fishing (Hodgkin and Clark 1988, CALM 1992).

PART 3:
The environmental values of wetlands, rivers and estuaries of the Busselton-Walpole Region

7. Environmental evaluation of wetlands, rivers and estuaries

Environmental values are essentially the values that a wetland, river or estuarine system has in its natural state. A comprehensive treatment of wetland values is described by Dugan (1990) and Claridge (1991) (See Section 3.3). This Busselton-Walpole study focuses principally on the evaluation of selected natural attributes.

All wetlands have value. World wide there have been moves to protect the values associated with wetlands. Natural wetlands have particular value. Values are largely a factor of the condition of the system, but are not necessarily equal for systems of similar naturalness, as one wetland may have a greater range of habitats than another and thus support a greater range of plants and animals. Even a heavily degraded system may remain an important wildlife sanctuary or retain its flood mitigation function (eg Lake Dumbleyung). Recognition of value for a system may also be derived from unique features or from the fact that it is an excellent example of its type or contains features characteristic of a range of wetland types.

This chapter presents an overview of important environmental values of the Busselton-Walpole Region's wetlands on the basis of condition and available scientific information.

7.1 Wetland evaluation

7.1.1 Evaluation criteria and method

Their are two levels of wetland evaluation: first tier and second tier. The first tier assessment is based on existing evaluations of important value at the local, regional, national and international level (See Appendix 2). The Conservation Through Reserves recommendations (Systems studies, DCE 1983) for the reservation of wetlands is an example of regional recognition of important value, while the National Estate identification of important wetlands is at a national level. The Australian Nature Conservation Agency's Directory of Important Wetlands in Australia (ANCA 1993), which includes Ramsar wetlands is an example of recognition of important wetland value at both the national and international levels. However, first tier assessment only provides high level evaluations of wetlands which have been studied in some detail and for which there is information on which to base an evaluation. Many wetlands which have been ignored by researchers may indeed have important values which are unknown.

Where the evaluation of wetlands is required but there is little comprehensive information available or there are a high number of wetlands in the area and there are insufficient resources for first tier (expert) assessments, a second tier approach is required. In this study second tier assessment of value was undertaken for all wetland groups, using the condition assessments reported in Chapter 4, together with existing scientific information. The criteria used for evaluation are those recommended by LeProvost, Semeniuk and Chalmer (1987). They recognised 16 criteria for the evaluation of wetlands, of which nine relate to the environment. Each of the nine environmental criteria are described below.

Uniqueness. Refers to the degree to which the type of wetland in question, degraded or otherwise, is restricted in distribution or is relatively widespread. For example,

Lake Jasper being permanent, fresh, 10 m deep and covering some 440 ha is very unique, whereas the saline shallow Lake Wagin is typical of a type quite common in the wheatbelt.

Representativeness. A wetland may be a good or poor example of the type wetland which once occurred in a region. For example, Lake Toolibin is a good example of a large size wooded lake.

Wetland function. Wetlands provide a number of water resource functions in addition to the provision of habitat, including biofiltering, flood mitigation, groundwater recharge/discharge, erosion control, etc. Lake Dumbleyung, for example, has a very significant flood mitigation capacity.

Ecological and geological features. Some wetlands have very unique features of National and International significance. The large number of breeding waterbird species using Lake Toolibin and the Microbiolites at Lake Clifton are examples.

Habitat values

Naturalness. This refers to the state of the wetland. The more natural the more native species are likely to be present and the less altered would be the natural ecological processes.

Large faunal populations. To what extent is the wetland known to support native animals? For example, some wetlands are known to support large numbers of waterfowl, including many breeding species.

Sanctuary. Does the wetland function as an important regional wildlife sanctuary, even if the flora and fauna are not endangered? McCarley's Swamp with the largest breeding colonies of the great egret and straw necked ibis in the south-west is an example of an important sanctuary.

Rare and endangered species. Is the wetland known to support any rare and endangered species? For example a number of wheatbelt lakes are known to support small breeding populations of the freckled duck.

Linkage. Does the wetland constitute a linked natural system such as a stopover on a migratory flight route? Wetlands, especially linear swamps and floodplains on streams may be important wildlife corridors.

The actual environmental evaluation for wetland groups and selected individual wetlands was done by scoring each criteria from 1 to 5 according to the system developed by LeProvost, Semeniuk and Chalmer (1987):

1 = Low — not significant

2-4 = Moderate — graded scale of moderate significance

5 = High — high significance

Each wetland group was rated against the criteria on the basis of the condition of the individual wetlands within it (see Chapter 4) and/or available relevant information on specific individual wetlands within the group. Scores are given as a range to express the range of values achieved by the various individual wetlands in the group. Individual named wetlands were scored separately where wetland value within a group varied greatly.

Where a criterion required specific information and none was available, no score was given, unless it could be inferred from scores on similar wetlands, within the same Natural Resource Zone (NRZ), for which information was available. For criteria requiring a comparison with other wetlands (ie uniqueness and representativeness), only wetlands of similar form within the same NRZ were considered for comparison.

The overall score for a wetland group was not given as an average, but rather as the range of scores achieved for the various criteria. Overall score for an individual named wetland is the maximum score achieved by any of the criteria (see tables). In the case of an individual wetland which has been identified as having important value in the first tier assessment, its overall score will automatically be high.

7.1.2 Evaluation results

Evaluations of wetland groups and selected individual wetlands are given in Tables 7.1 - 7.9.

Geographe Bay, Leeuwin-Naturaliste Ridge and Margaret River catchments

The majority of wetland groups and wetland area had low to moderate value, but a sizeable minority of the groups rated highly. The chief values were uniqueness, naturalness and large faunal populations. Naturalness scored highest for wetlands in conservation estate, either in state forest or in the Leeuwin-Naturaliste National Park, although wetlands south of Bunbury rated highly because of large areas of remnant vegetation that remain in that area. Wetland function often rated as moderate, mostly

for flood mitigation on the coastal plain. Low lying coastal wetlands between Bunbury and Dunsborough scored highest for faunal and sanctuary values (See Table 7.1). McCarley's Swamp, in particular, is recognised as a wetland of National Significance (ANCA 1993), as is the large formerly estuarine Vasse-Wonnerup System which is a Ramsar Wetland and is subject to a System 6 recommendation (ANCA 1993, Department of Conservation and Environment 1976).

Western Scott Coastal Plain and lower Blackwood catchments

Although most of the wetland area in this region has been cleared, all of the wetland groups retain at least some areas having moderate to high wetland value, especially near Hardy Inlet and in eastern portion of the area around Gingilup Swamp and towards Lake Jasper (See Table 7.2). The high scoring values were for uniqueness, representativeness, function and naturalness, with faunal populations and sanctuary values being moderate mostly (see Table 7.2).

Lower Blackwood catchment

As most of this area is in State Forest or Conservation Reserve, wetland value is mostly high, with the chief values being representativeness and naturalness. While known or inferred faunal values can rate as only moderate, the sanctuary value for rare frog species imparts considerable value to two wetland groups (see Table 7.3).

Middle Blackwood catchment

In this highly cleared part of the study area, wetland values are mainly low to moderate. But the chains of lakes, swamps and floodplains about Qualeup and on the Beaufort and Arthur Rivers score highly for uniqueness, representativeness and naturalness, although many of these are somewhat altered by land use. Some of the larger named lakes score highly for faunal values and linkage (see Table 7.4).

Upper Blackwood catchment

As with the middle part of the Blackwood catchment, the upper part is heavily cleared as are many of the wetlands or there immediate fringes, and as a result wetland values are mostly only low to moderate. The lakes are important in flood mitigation and so wetland function often scores moderate to high. The large waterbird populations characteristic of the area impart high faunal, sanctuary and linkage values, especially for the lakes along the Beaufort, Coblinine and Arthur Rivers (See Table 7.5). Lakes Toolibin, Dumbleyung and Coyrecup and their adjoining wetlands are recognised as wetlands of National Significance (ANCA 1993). Lake Toolibin is also a Ramsar Wetland, of international significance (ANCA 1993).

Donnelly catchment

Most of the Donnelly catchment is naturally vegetated and this is reflected in the generally high and diverse range of values of wetlands in the area, especially those near the coast. The large wetland system that surround and include Lakes Quitjup, Jasper, Smith and Wilson is recognised as a system of National Significance (ANCA 1993).

Warren-Unicup catchments

Natural vegetative cover in the Warren Catchment is high, but very fragmented. Curiously, many wetlands are actually cleared, while the large part of their catchments remains forested (see Section 4.2.7). Nevertheless, wetland value is high, principally for representativeness, function and naturalness and for the large named wetland systems for uniqueness and faunal habitat and sanctuary (see Table 7.7). Lake Unicup and surrounding lakes and swamps are recognised as wetlands of National Significance (ANCA 1993).

Lower Shannon Basin

As with the Donnelly catchment, the Shannon Basin is dominated by natural vegetation, rendering nearly all of the wetland areas in a natural and even near pristine state. Not surprisingly wetland values are very high, diverse and broadly cover this very wet area (see Figure 4.6 and Table 7.8). Lake Maringup is recognised as a wetland of National Significance (ANCA 1993).

Lake Muir and upper Shannon and Deep catchments

The wetland values of the upper Shannon and Deep River catchments, which are entirely naturally vegetated, are moderate to high, mainly for representativeness, function and naturalness (see Table 7.9). Although the neighbouring Lake Muir catchment is heavily cleared, much remnant vegetation remains in reserves and on private land, imparting similar high values, as well as sanctuary value in some of the large and densely vegetated

sedge swamps. The wetlands of the Lake Muir system are recognised as significant at the National level (ANCA 1993).

7.2 River evaluations

The comprehensive environmental evaluation of streamlines has never been carried out in the south-west Western Australia. Habitat evaluations, similar to that carried out for all streams in Victoria are only now being trialed (Pen and Scott 1995). Theoretically, stream evaluations could be done in the same way as for wetlands: lakes, swamps and floodplains (see Section 7.2). Unfortunately this requires at least some broad survey data, and while such data is available for estuaries, lakes and swamps, little has been collected for rivers and creeks. Thus there is insufficient data to assess uniqueness, the presence of unusual ecological and geological features, faunal use, sanctuary value and the presence of rare and endangered animals. Criteria such as representativeness, wetland function, naturalness and linkage or corridor value are expressed in the condition assessments, as the value of each criterion increases with increasing cover abundance of native vegetation in the catchment and especially in the riparian zone. Therefore, to the extent that broad scale evaluations of streams are possible they are most adequately represented by the condition assessments presented in Section 5.2. The better the condition the greater the stream values.

The condition assessments described in Section 5.2 are thus second tier value assessments (see Section 7.1). But at least one first tier assessment of a river has been carried out in the Busselton-Walpole Region as part of the recognition of wetlands of National Significance ANCA 1993), on the lower Blackwood River[5]. The broad high order permanently inundated reaches of the Blackwood River and associated tributary creeks in densely forested country between Sue's Bridge and Malloy Island are considered a good example of the lower reaches of a south-west river, and good examples of near pristine creeks (ANCA 1993). Furthermore, this part of the Blackwood system is known to support a number of rare frogs, secretive waterbirds and a variety of fish species, possibly including the rare Balston's perchlet (Hodgkin 1978, Wardell Johnson & Roberts 1991, ANCA 1993, Morgan *et al.*1996). While the Doggerup Creek system has also been recognised as having National Significance, this has mainly been for the associated wetland values (see Sections 4.2.8 and 5.2.5).

Some stream systems, either whole river or creek systems, or tributary systems fall in areas which are virtually entirely naturally vegetated or have substantial natural vegetative cover along or within the riparian zone. These systems have a high representative value for natural streams in the region and especially within the respective Natural Resource Zones. The identification of representative or outstandingly natural streams is dealt with in the following chapter.

7.3 Estuary evaluations

Estuaries, for which there is a relatively large amount of scientific information, have been evaluated in the same way as wetlands. For a description of the methodology, see Section 7.1. Overall, all the estuaries except the tiny Toby's Inlet were considered to have high value, with the main high scoring values being uniqueness, representativeness, naturalness and faunal populations (see Table 7.10). The only first tier assessment is for Broke Inlet which has been recognised as a wetland of National Significance, largely because its catchment is nearly entirely dominated by native vegetation in National Park, albeit that some of it has been logged over many years (ANCA 1993; CALM 1987). The shallow estuarine basin also supports heavy water bird usage (see Section6.3). The Vasse-Wonnerup has been recognised also, but mainly for heavy waterbird usage of the severely degraded floodplain areas which are no longer estuarine.

[5] The only other river reach in the south-west assessed as having National Significance is the Avon River Valley (ANCA 1993).

Table 7.1: Environmental evaluation of wetlands of the Geographe Bay, Leeuwin-Naturaliste Ridge and Margaret River Catchments; Natural Resource Zones DuBuR2, MeBuR2 and WaBuR2

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Dalyellup Swamps			1	2	1		3	1	1		1	1-3	Natural
Boyanup Wetlands			1	1	2		2	1	1	1-5	2	1-5	Rare species
Bussell Highway Swamp			3	3	3		4	1	1		3	4	Unique, Rep., Floodplain and Natural
Stirling Swamp			1	1	1		1	1			1	1	
King Rd Lakes			1	1	2		1	1	1		1	1-2	
Lower Gynadup Creek Wetlands			1	1	2		1	1	1		1	1-2	
Upper Gynadup Creek Wetlands			1	1	2		1	1	1		1	1-2	
Capel River Marshes			1	1	2		1	1	1		1	1-2	Rare species
Layman Gully Lakes			1	1	2		1	1	1		1	1-2	
Capel Swamps			1	1-3	2-3		1-4	1	1	1-5	2	1-5	Rep., Fldpln, Ntrl and Rare species.
Ludlow Wetlands			1-3	1-3	1-2		1-4	1-5	1-5	1-5	2	1-5	Unique, Rep., Natural,
	McCarley's Swamp	National Sign.	3	3	2		4	5	5		2	5	Faunal Pops and Sanctuary
Tutunup Rd Lake			3	4	1		4	(3)	(3)		2	4	Unique, Rep., Natural, Faunal Pops and Sanctuary
Tutunup Rd Swamps			1	1	1		1	1	1		1	1	
Wonnerup Rd Swamp			1	2	2		2	(2)	(2)		(2)	1-2	
Ludlow-Abba Wetlands			1	2	1		1-4	(1-2)	(1-2)	1-5	1	1-5	Natural and Rare species.
Princefield Rd Floodplain			1	1	3		1	1	1		1	1-3	Floodplain

Key

1. Uniqueness
2. Representativeness
3. Function
4. Features
5. Naturalness
6. Large faunal populations
7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

Table 7.1: Continued

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Vasse-Wonnerup Wetland System	Vasse-Wonnerup Estuary	RamsarNational Sign.National EstateSystem 6	1	1	3		1-2	5	5		5	5	Floodplain, Faunal Pops, Sanctuary and Sanctuary.
Broadwater Floodplain		National Estate	1	1-2	1-3		1-2	1-5	1-3	1-5	5	1-5	Floodplain, Faunal Pops, Sanctuary, Rare species and Linkage.
	Broadwater			1	3		2	5	3		5	5	
	Toby's Inlet		1	1	1		2	1	1		3	3	Linkage
Williamson Rd Swamp			1	1	1		1	1	1		1	1	
Naturaliste Lake Wetlands			4	4	3		4	1	1		1	4	Unique, Rep., Floodplain and Natural.
Bunkers Bay Lake			5	1	1		2	1	1		1	5	Unique
Quininnup Rd Lake Wetlands			4	1	1		2	1	1		1	1-4	Unique
Moses Rock Road Swamp			1	1	1		1	1	1		1	1	
Silverwood Rd Swamp			1	1	1		1	1	1		1	1	
Ablett Rd Swamp			1	1	1		1	1	1		1	1	
Margaret River Swamps			3	4	4		5	(3)	(3)		1	3-5	Many values
Kilcarnup Rd Swamps			4	2	1		1-2	1	(1-2)		1	1-4	Unique.
Wilderness Drive Swamps			1	1	1		1	1	1		1	1	
Devil's Pool			5	1	3		5	(3)	(2)		1	5	Unique, Fldpln, Ntrl and Faunal Pops.
Lake Davies Wetlands			4	3	3		5	(3)	(2)		1	1-5	Unique, Rep., Fldpln, Natural and Faunal Pops.
Turner Brook Wetlands			1	1	3		2	1	1		1	1-3	Floodplain.

Key

1. Uniqueness
2. Representativeness
3. Function
4. Features
5. Naturalness
6. Large faunal populations
7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

Table 7.2: Environmental evaluation of wetlands of the Western Scott Coastal Plain; Natural Resource Zone WaBIR2

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
West Bay Creek Floodplain			1	1	2		2	1	1		3	1-3	Linkage
Glenarty Creek Floodplains			1	1-5	1-5		3-4				3	1-3	Rep., Floodplain, Natural and Linkage.
Pt Pedder Swamps			4	5	5		4	(3)	(2)		2	2-5	Many values
Lower Blackwood Wetlands			1	1-5	1-5		3-4	(2-3)	(1-3)		2	1-5	Rep., Floodplain, Natural, Faunal Pops and Sanctuary.
Scott River Wetland System		(National Estate)	1	1-5	1-5		3-4	(2-3)	(1-3)	1-5	2	1-5	
	Long Swamp		1	3	3		3	(3)	(3)		2	1-3	
	Bullrush Swamp		1	4	3		4	(3)	(3)		2	4	
	Milyeaanup Swamp (Ds-c)		1	1	1		1	(2)	(1)		1	1-(2)	
Gingilup Swamp Wetlands		(National Estate)	4	5	5		1-5	(1-3)	(1-4)	1-5	2	1-5	Unique, Rep., Floodplain, Natural, Faunal Pops. and Sanctuary.
	Gingilup Swamp		4	5	5		5	(3)	(4)	5	2	5	
Bolghinup Lake Swamp	Bolghinup Lake		5	1	2		5	(2)	(1)		1	5	Unique and Natural.

Key

1. Uniqueness
2. Representativeness
3. Function
4. Features
5. Naturalness
6. Large faunal populations
7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

Table 7.3: Environmental evaluation of wetlands of the lower Blackwood Catchment; Natural Resource Zone MeBlR2

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Spearwood Creek Swamp			3	4	3		5	(3)	4	5*	1	5	Many values, including rare species.
Adelaide Brook Swamp			3	4	3		5	(3)	4	5*	1	1-5	
Kookaburra Rd Creek Floodplain			3	4	5		3-5	(3)	(2-3)		1	1-5	Many values.
Milyeannup Brook Floodplains			3	4	5		3-5	(3)	(2-3)		1	1-5	
Red Gully Floodplains			3	4	5		3-5	(3)	(2-3)	1-5	1	1-5	
Mokerdillup Rd Wetlands			1-3	1-2	2		1-2	(1)	(1)		1	1-3	
Wilga Rd Swamp			3	4	3		5	(2)	(2)		1	5	Unique, Rep., Fldpln and Ntrl.

Key

1. Uniqueness
2. Representativeness
3. Function
4. Features
5. Naturalness
6. Large faunal populations
7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

*Rare frog habitat (four species of the *Geocrinea* complex)

Table 7.4: Environmental evaluation of the wetlands of the middle Blackwood Catchment; Natural Resource Zones MeBlR3 and BlBlR3

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Mickalurrup Swamp			1	4	3		4	(3)	(2)		1	4	Rep., Fldpln, Ntrl. & Faunal
Rogers Rd Swamp			1	1	1		1	1	1		1	1	
Gibbs Rd Swamps			1	1-2	1-2		1-2				3	1-3	Linkage.
Kitchanning Brook Floodplain			3	2	3		2				3	2-3	Unique, Floodplain andLinkage.
Sandalwood Rd Swamp			1	1	1		2				1	1-2	
Moodiarup Rd Swamp			4	4	2		4	(3)	(2-3)		1	4	Unique, Rep., Natural and Faunal Pops and Sanctuary.
Blackwood River Floodplain			1	2	3		1-2	(2-3)	(1-2)		3	1-3	Floodplain and Sanctuary.
Craigie Rd Swamps			1	2	2		2	2	(1-2)		1	1-2	
Balgarup Wetlands			1	1	1		2				1	1-2	
Boree Gully Floodplain			1	(1-2)	3		2				3	1-3	
Qualeup Wetlands			2-4	1-4	1-2		1-4	(3)	(2)		2	1-4	Unique, Rep., Natural, Faunal Pops and Sanctuary.
	Lake Qualeup		2	1	2		2	2	3		1	1-3	Sanctuary.
	Lake Boyup		4	4	3		4	2	2		1	1-4	Unique, Rep., and Ntrl.
Parson Swamp Rd Wetlands			1	1-2	1-2		1-2	(1-2)	(1-2)		1	1-2	
Dinninup Creek Floodplains			1	1-2	3		2	(1-2)	1		3	1-3	Floodplain and Linkage.
Gnowergerup Brook Floodplain			1	1-2	3		2	(1-2)	1		3	1-3	
Arthur River Wetlands System			1-4	1	1-3		1-2	1-5	1-3		4	1-5	Unique, Floodplain,Faunal Pops and Sanctuary.
	Lake Towerrinning		4	1	3		1	5	3		4	5	Unique, Floodplain, Faunal Pops, Sncty and Linkage.
	Wild Horse Swamp		1	1	2		2	5	3		4	5	Faunal Pops, Sanctuary and Linkage.
	Moodiarrup Swamps		1	1	2		2	5	3		4	5	

Key

1. Uniqueness
2. Representativeness
3. Function
4. Features
5. Naturalness
6. Large faunal populations
7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

Table 7.4: Continued

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Darlinup Creek Floodplain			1	2	3		1				1	1-3	Floodplain
Kojonup Brook Wetlands			1-3	1-2	2-3		1-2	(1-3)	(3)		1	1-3	Unique, Fldpln, Faunal Pops and Sanctuary.
Balgarup River Floodplain			1	1-2	1		1-2		1		2	1-2	
Hillman River Floodplains - Upper			1	1	1-3		1-2		1		2	1-3	Floodplain
Swampy Creek Wetlands			1	1	1		1-2	(1-2)	1		1	1-2	
Hillman River Wetland System			1	1	1-3		1-2	(1-2)	1		2	1-2	Floodplain
	Mamine Swamp		1	1	1		1	1	1		1	1	
Beaufort River Wetlands - West			1-3	1-4	1-3		1-4	2-4	(1-3)		4	1-4	Rep., Ntrl, Faunal Pops and Linkage
	Dead Man's Swamp		2	2	3		3	4	(3)		4	4	Faunal Pops and Linkage
	Emu Swamp		1	1	2		1	(4)	(3)		4	4	
	Nuning Swamp		3	4	3		4	(4)	(3)		4	4	Unique, Rep., Natural Faunal Pops and Linkage
	Spratts Lagoon		3	4	2		4	(4)	(3)		4	4	
Bellany Lakes			1	1	1-2		1	(1-2)	(2)		1	1-2	
Fifty Creek Lakes	Clear Lake		1	1	1		1	1	1		1	1	
	Rushy Lake		1	1	1		1	1	1		1	1	

Key

1. Uniqueness
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4. Features
5. Naturalness
6. Large faunal populations
7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

Table 7.5: Environmental evaluation of wetlands of the upper Blackwood Catchment; Natural Resource Zones AvBlR4 and RoFrR4

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Taarblin Lakes System			1-5	4	3-5		1-4	3-5	2-5	1-5	4	1-5	Many values
	Lake Taarblin		4	2	3		2	5	4	3	4	5	Unique, Faunal Pops, Sanctuary and Linkage.
	Dulbining Lake		1	2	1		2	3	3		4	4	Faunal Pops, Sanctuary and Linkage.
	Walbyring Lake		1	2	2		2	3	3		4	4	
	Ibis Lake		1	4	4		4	3	3		4	4	Rep., Floodplain, Faunal Pops, Sanctuary and Linkage.
	Billy Lake		1	4	4		4	3	3		4	4	
	Nomans Lake		1	1	2		2	3	3		4	4	Faunal Pops, Sanctuary and Linkage.
	Lukin Lake		1	1	2		2	3	3		4	4	
	White Lake		1	2	3		2	3	3		4	4	
	South White Lake		1	1	1		2	(3)	(3)		4	4	
	West White Lake		1	1	2		1	3	3		4	4	
	Lake Toolibin	Ramsar Nat. Sign. National Estate	5*	2	3		2	5	5	5[#]	5	5	Unique, Fldplan, Faunal Pops, Sanctuary, Rare Species and Linkage.
	Bokan Lake		1	4	4		4	3	3		4	4	As above but not unique.
Arthur River Floodplain			1	1	3		1-2	(2-3)	(1)		3	1-3	Fldpln, Faunal Pops and Linkage.
Buchanan River Floodplain			1	1	3		1	(1)	(1)		2	1-3	Floodplain.
East Arthur River Floodplain			1	1	3		1-2	(1)	(1)		2	1-3	Floodplain.

Key

1. Uniqueness
2. Representativeness
3. Function
4. Features
5. Naturalness
6. Large faunal populations
7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

*One of few remaining relatively healthy wooded lakes.
[#]Rare freckled duck breeding habitat
[$]*Melaleuca strobophylla*

Table 7.5: Continued

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
		(National Estate)	1	1-2	1-3		1-2	(1-3)	(1-2)		2	1-3	Floodplain, Faunal Pops and Linkage.
Beaufort River Wetlands System - South	Fitze's Swamp		1	1	3		2	(3)	(2)		1	3	
	Koolbooking Swamp		1	1	2		2	(3)	(2)		1	3	Faunal Pops
	Toojeelup Swamp		1	1	1		2	(3)	(2)		1	3	Faunal Pops
Beaufort River Wetlands System - North		(National Estate)	1	1-2	1-3		1-2	(4)	(3)	1-3	3-4	4	Floodplain, Faunal Pops, Sanctuary and Linkage.
	Bush Swamp		1	1	1		1	(4)	(3)		2	(4)	Faunal Pops and Sanctuary.
	Billielight Swamp		1	1	2		1	(4)	(3)		2	(4)	
	Grandfather Swamp		1	1	1		1	(4)	(3)		2	(4)	
	Flagstaff Lake		1	2	3			4	3		4	4	Floodplain, Faunal Pops, Sanctuary and Linkage.
	Queercarrup Lake		1	1	3		1	(4)	(3)		4	(4)	
	Lake Charling		1	1	3		1	(4)	(3)		4	(4)	
	Small Lake		1	1	1		1	4	3		3	(4)	Faunal Pops, Sanctuary and Linkage.
	Martinup Lake		1	1	1		2	4	3		2	4	
	Murapin Lake		1	1	2		1	4	3		2	4	
	Kidney Swamp		1	1	1		1	(4)	(3)		1	(4)	
	Miripin Lake		1	1	1		1	4	3		2	4	
	Wardering Lake		1	1	2		2	4	3		2	4	
Boyerine Floodplain			1	1	1		1	(1)	(1)		2	1-2	
Wagin Lakes System			1-4	1-3	1-5		1-2	1-4	1-3		4	1-5	Many values
	Wagin Lake		1	1	2		2	3	3		4	4	Floodplain, Faunal Pops, Sanctuary and Linkage mainly.
	Packeycrring Lake		1	2	3		2	3	3		4	4	

Key

1. Uniqueness
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8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

Table 7.5: Continued

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
	Little Packeyerring		1	2	3		2	4	3		4	4	
	Lake Quarbing		1	2	3		2	(3-4)	(3)		4	4	
	Little Norring		1	1	3		1	(3-4)	(3)		4	4	
	Norring Lake		1	1	3		1	(4)	(3)		4	4	
	Salt Lake		1	2	3		2	(3-4)	(3)		4	4	
	Lime Lake		4	3	5		4	(3-4)	(3)		4	5	Many values.
	Murrin Lake		1	1	1		1	(3-4)	(3)		4	4	Faunal, Sanctuary and Linkage.
Coblinine Wetland System - East			1	1	1-3		1	1-3	1-2		2-3	2-3	Floodplain, Faunal Pops and Linkage.
	Lake Gundaring		1	1	3		1	3	(2)		3	3	
	Little Dornduckling Lake		1	1	1		1	(3)	(2)		2	(3)	Faunal Pops.
	Dornduckling L.		1	1	1		1	(3)	(2)		2	(3)	Faunal Pops.
	Minacklin Swamp		1	1	1		1	(2)	1		2	(2)	
Bockaring Creek Floodplain			1	1	3		1	(2)	(1)		2	1-3	Fldpln.
Lake Dumbleyung Wetland System		Nat. Sign.	1-4	1	1-3		1-2	1-3	1-4		2-4	1-4	Many values.
	Lake Dumbleyung		4	1	3		1	3	4		4	5	Unique, Fldpln, Faunal and Linkage.
Moulyinning Lakes			1	1	1		1	(2)	(1)		1	1-2	
Dongo-locking Creek Floodplain			1	1	3		1	1	1		2	1-3	Floodplain.
Coomelberrup Lakes		National Estate	1	1	1-2		1	1-4	(1-4)	(1-5)	2	1-3	Faunal Pops and Sanctuary.
	Coomelberrup Lake		1	1	2		1	4	5	5[+]	2	3	Faunal Pops and Sanctuary.

Key

1. Uniqueness
2. Representativeness
3. Function
4. Features
5. Naturalness
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7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

[+]Rare freckled duck breeding habitat

Table 7.5: Continued

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
East Lake Dumbleyung Wetlands			2	1	1-3		1-2	3	(4)		3	1-4	Floodplain, Faunal Pops, Sanctuary and Linkage.
Coblinine Wetland System - East		National Estate	1	1	1		1-2	1-4	1-4		3	1-4	Faunal Pops, Sanctuary and Linkage.
	Lake Mincrup		1	1	1		2	(3)	(2)		3	3	Faunal Pops Linkage
	Perlungup Swamp		1	1	1		2	(3)	(2)		3	3	
	Casuarina Lake		1	1	2		2	4	3		3	4	Faunal Pops, Sanctuary and Linkage
	Kailagup Swamp		1	1	1		2	(3)	(2)		3	3	Faunal Pops and Linkage
	Unnamed lakeR9056		1	1	2		2	(4)	(3)		3	4	Faunal, Sanctuary and Linkage
	Corackin Swamp		1	1	1		2	(3)	(2)		3	3	Faunal Pops and Linkage
Ewlyamartup Lakes			1	1	1-2		1-2	(1-4)			2-3	2-4	Faunal Pops and Linkage.
	Ewlyamartup Lake		1	1	2		2	(4)	(3)		3	4	Faunal Pops, Sanctuary and Linkage.
Coyrecup Wetland System		Nat. Sign. National Estate	1-3	2-3	2-3		1-4	1-4	(1-3)		3	1-4	Many values.
	Lake Coyrecup		1	2	3		2	4	(3)		3	5	Floodplain, Faunal Pops, Sanctuary and Linkage.
Lefroy River Floodplains			1	1	3		1	1	1		1-3	1-3	Floodplain and Linkage.
Kuringup Wetlands			1	1	1		1-2	(1-2)	(1)		1	1-2	

Key

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2. Representativeness
3. Function
4. Features
5. Naturalness
6. Large faunal populations
7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

Table 7.6: Environmental evaluation of wetlands of the Donnelly Catchment; Natural Resource Zones WaDoR1 and MeDoR2

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Lake Jasper WetlandSystem		Nat. Sign. National Estate	1-4	4-5	4		4	5	4	3	2	1-5	Many values
	Lake Quitjup		4	5	4		5	5	4		2	5	Many values
	Lake Jasper		4	4	4	3	4	5	4		2	5	Many values
	Lake Wilson		4	4	3		5	5	4		2	5	Many values
	Lake Smith		4	4	3		5	5	4	3	2	5	Many values
Jingardup Wetland System			1-3	2-4	2-5		1-4	(1-4)	(1-4)		2	1-5	Many values
Double BrookWetlands			1	4	3-4		5				2	1-5	Rep., Floodplain and Natural.
Donnelly River Wetlands		National Estate	1	4	5		4-5				2	1-5	
Charley Brook Wetlands		National Estate	1	4-5	5		5	(1-4)	(1-4)		2	1-5	Rep., Floodplain, Natural, Faunal Pops and Sanctry
Donnelly River Floodplains			1-3	2-5	1-5		2-5				1	1-5	Unique, Rep., Floodplain and Natural.
	Gunagulup Swamp (C-Dl)		3	1	2		2				1	1-3	Unique
	Unnamed lake (Dl)		1	1	2		1				1	1-2	

Key

1. Uniqueness
2. Representativeness
3. Function
4. Features
5. Naturalness
6. Large faunal populations
7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

Table 7.7: Environmental evaluation of wetlands of the Warren Catchment; Natural Resource Zones WaWrR1, MeWrR2 and MeWrR3

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Warren Beachside Wetlands		National Estate	5	1			5					5	Unique and Natural
Warren River Wetlands		National Estate	3	4	4		5				2	5	Rep., Fldpln and Ntrl
Yeagarup Wetlands		National Estate	5	5	3-4		5	3-5	3-5		2	2-5	Many values
	Yeagarup Lake		4	5	3		5	5	5		2	5	Many values
	Maenup Swamp		4	5	3		5	5	5		2	5	Many values
	Unnamed lake		4	5	3		5	5	5		2	5	Many values
Ritter Rd Swamps			4	5	3		5	5	5		2	5	Many values
Deep Gully Floodplain			3	5	3-4		5				2	5	Unique, Rep., Fldpln and Natural.
Snake Gully Floodplain			3	5	3-4		5				1	5	
Big Hill Brook Swamp			3	5	4		5				1	5	
Chungarup Swamp			3	4	4		5				1	5	
	Chungarup Swamp		1	1	1		1				1	1	
Yackerlup Swamps			1	1-2	1		1-2				1	1-2	
	Yackerlup Swamp		1	1	1		1				1	1	
	Dudijup Swamp		1	1/2	1		1/2				1	1-2	
Codarup and Oaljalup Lakes	Codarup Lake		1	1	1		1				1	1	
	Oaljalup Lake		1	1	1		1				1	1	
Bonybeap Swamps			3	4	3-4		5				1	3-5	Unique, Rep., Floodplain and Natural
	Bonybeap Swamp		3	4	3		5				1	5	
Bonybeap Gully Floodplain			4	4	4		5				1	1-5	

Key

1. Uniqueness
2. Representativeness
3. Function
4. Features
5. Naturalness
6. Large faunal populations
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8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

Table 7.7: Continued

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Kepalarup Wetlands			2-3	1-3	1-4		2				1	1-4	Unique, Rep. and Floodplain.
	Kepalarup Lake		2	1	1		1				1	1-2	
	Yeticup Swamp		2	1	1		2				1	1-2	
Yerraminnup Floodplain - Lower			3	4	5		5				3	3-5	Unique, Rep., Floodplain, Natural and Linkage.
Perup River Floodplain			2-3	1-4	3-5		1-4				3	1-5	
Yackelup Floodplain			3	4	4		5				3	3-5	
Corbalup Swamps			1-3	1	1		1-2				1	1-3	
	Corbalup Swamp (Dc)		1	1	1		1				1	1	
Yerraminnup Floodplain - Upper			1-3	1-3	1-5		1-5				3	1-5	Unique, Rep., Floodplain, Natural and Linkage.
Perup Swamps			1-3	1-4	1-4		1-5				1	1-5	Unique, Rep., Fldpln and Ntrl.
	Camelarup Swamp		2	1	1		2				1	2	
	Boyicup Swamp		2/3	1/2	1/2		3				1	3	
	Meelinup Swamp		4	4	2		5				1	5	Unique, Rep. and Natural.
	Jilbargup Swamp		3/4	3/4	2		4				1	4	
Yendicup Swamps			2-3	1-3	1-2		1-4				1	1-4	Unique, Rep. and Natural.
Kelpalurip Swamps			1-3	1	1		1-2				1	1-3	Floodplain.
	Kelpalurip Swamp		1-2	1	1-2		1-2				1	1-2	
Tone River Floodplain			1-2	1-3	1-4		1-4				2	1-4	Rep., Floodplain and Ntrl.
Tone River Road Swamp			1	1	1		1				1	1	

Key

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7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

Table 7.7: Continued

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Talyelwelup Wetlands			2	1-3	1-2		1-4				1	1-4	Rep. and Natural.
	Lake Talyelwelup		1	1/2	1		1/2				1	1/2	
	Lake Clabburn		1	1/2	1		1/2				1	1/2	
	Cootaycrup NR[R16031]		2	3	2		4				1	4	Rep. and Natural.
Furnis Loop Floodplain			1	1-2	3		1/2				2	1-3	Floodplain.
Murin Brook Floodplain			1	1	3		1				1	1-3	Floodplain.
Moorinup Wetland System			1-3	1-3	2-3		1-4				2	1-4	Unique, Rep., Floodplain and Natural.
	Moorinup Lake		3	3	2		4				2	5	Unique, Rep. and Natural.
Unicup Wetland System		Nat. Sign.	1-4	1-3	1-4		1-4	1-3	1-5	1-5	2	5	Many values.
	Unicup Lake	Nat. Sign.	4	3	4		4	3	3		2	5	Many values
	Little Unicup Lake	Nat. Sign.	4	3	4		4	(3)	(3)		2	5	Unique, Rep., Floodplain, Ntrl, Faunal Pops and Snctry.
	Tolkerlup Swamp	Nat. Sign.	3	3	2		4	(3)	(3)		2	5	Unique, Rep., Ntrl, Faunal Pops and Sanctuary.
	Kulinilup Lake	Nat. Sign.	4	3	4		4	3	4		2	5	Many values
	Bokarup Swamp	Nat. Sign.	3	3	2		4	(3)	(3)		2	5	Unique, Rep., Ntrl, Faunal Pops and Sanctuary.
	Buranganup Swamp	Nat. Sign.	3	3	2		2	(3)	(3)		2	3	Unique, Rep., Faunal Pops and Sanctuary.
	Yarnup Swamp	Nat. Sign.	3	3	2		2	3	5*		2	5	
	Kodjinup Swamp	Nat. Sign.	3	3	2		4	(3)	(3)	5	2	5	Unique, Rep., Natural, Faunal Pops, Sanctuary and Rare species.

Key

1. Uniqueness
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8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

*Little Bittern habitat

Table 7.8: Environmental evaluation of wetlands of the lower Shannon Basin; Natural Resource Zone WaShR1

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Meerup River Wetlands			1-4	1-5	3-5		1-5	(3)	(4)		2	1-5	Many values
Doggerup Creek Wetland System			1-4	4-5	5		4-5	(4-5)	(4-5)	1-3+		5	Many values
	Doggerup Lake		4	5	5		5	5	5	3+		5	Many values
	Lake Samual		5	5	5		5	5	5			5	Many values
	Lake Florence		4	5	5		5	5	5			5	Many values
Gardner River Wetlands -		National Estate	1-5	1-5	3-5		1-5	(3-5)	(1-5)	1-2[1]	2	1-5	Many values
Lower	Lake Maringup	Nat. Sign.	5	4	5	4*	5	5	5	3	2	5	Many values
Gardner River Wetlands - Upper			1	1-4	3-4		1-4				1	1-4	Rep., Floodplain and Natural.
Canterbury River Swamps			1	4	4		5	(3)	(3)		1	1-5	Rep., Floodplain, Natural, Faunal and Sanctuary.
Broke Inlet Wetlands - West		National Significance	1	5	5		5	4	4	1-3[-]	2	1-5	Rep., Floodplain, Natural, Faunal Pops., Sanctuary and Rare Species.
Chesapeak Brook Floodplain		National Significance	1	4	5		5	4	4	1-3[+]	2	1-5	
Shannon River Wetlands - Lower		National Significance	1	4	5		5	4	4	1-3[1]	2	1-5	
Shannon River Wetlands - Middle		National Significance	1	4	5		5	4	4		2	1-5	Rep., Floodplain, Natural, Faunal Pops. and Sanctuary.
Weld River Wetlands			1	4	5		5	4	4	1-3[-]	2	1-5	Rep., Floodplain, Natural, Faunal Pops., Sanctuaryand Rare Species.
Broke Inlet Wetlands - North East		National Significance	1	4	5		5	4	4	1-5[1]	2	1-5	
Bell Brook Floodplains			1	2-4	4		2-4	4	4	1-5	2	1-5	Rep., Floodplain, Natural, Faunal Pops, Sanctuary and Rare species.
Walpole River Floodplains			1	4	3-5		5	(3)	(3)	5[#]	2	1-5	
Nornalup - Lower Deep Wetlands		National Estate	1	5	4		4-5	(3)	(3)	5[#]	1	1-5	
	Crystal Lake		3	4	3		5	(3)	(3)		1	5	Unique, Rep., Fldpln, Ntrl.
	Boggy Lake		3	4	3		5	(3)	(3)		1	5	Faunal Pops and Sanctuary.
Deep River Wetlands - Middle		National Estate	1	5	5		5				1	5	Rep., Floodplain and Natural and Rare species.
Collier Creek Wetland		National Estate	1	4	5		4-5			5[#]	1	5	

Key

1. Uniqueness
2. Representativeness
3. Function
4. Features
5. Naturalness
6. Large faunal populations
7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

*Ancient giant tree stumps, rare algae/organic suspension and tall sedgeland (*B.articultata*) [1]Rare fish — Balston's perchlet (*Nannatherina balstoni*) #Rare frog — *Geocrinea lutea*

Table 7.9: Environmental evaluation of wetlands of the Lake Muir and Upper Shannon and Deep Catchments; Natural Resource Zone MeShR2

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Shannon River Wetlands - Upper		National Signif.	1	5	5		5				2	5	Representativeness, Floodplain and Naturalness.
	Gobblecannup Swamp	National Significance	1	5	5		5				2	5	
Deep River Wetlands - Upper			1	5	5		5			1-5	3	5	Rep., Floodplain, Natural, Rare species and Linkage.
Lake Muir - Byenup Lagoon Wetlands System		Nat. Sign. National Estate	5*	1-5	1-5		1-5	3-4	3-4	1-5	2	5	Unique, Rep., Floodplain, Natural and Rare species.
	Lake Muir		5	1	3		2	4	4		4	5	Unique, Floodplain, Faunal Pops, Sanctuary and Linkage.
	Byenup Lagoon		4	1	3		2	4	4		(4)	5	
	Tordit-Gurrup Lagoon		4	1	3		2	4	4		(4)	5	
	Myaldelup Lagoon/ Poorginup Swamp		3	4	3		4	(3)	(4)		2	5	Unique, Representative,Floodplain, Natural, and Faunal Pops.
	Neeranup Swamp		3	4	3		4	(3)	(4)		2	5	
	Wimbalup Swamp		2	4	2		4	(3)	(4)		2	5	Representative, Natural, Faunal Pops and Sanctuary.
	Coorinup Swamp		2	4	2		4	(3)	(3)		2	5	
	Cowerup Swamp		3	4	3		4	(3)	(4)		2	5	Unique, Rep., Floodplain, Ntrl, Faunal Pops and Snctry.
	Pindicup Lake		3	3	3		4	(3)	(4)		2	5	
	Noobijup Lake		3	4	3		4	(3)	(4)		2	5	
	Red Lake		2	3	3		4	(3)	(3)		2	5	Representative, Floodplain, Faunal Pops and Sanctuary.
	Bodginup Swamp		2	4	2		4	(3)	(3)		2	5	
	Galamup Swamp		2	4	2		4	(3)	(3)		2	5	
	Cobertup Swamp		2	4	2		4	(3)	(4)		2	5	
	Pinticup Swamp		2	4	2		4	(3)	(3)		2	5	

Key

1. Uniqueness
2. Representativeness
3. Function
4. Features
5. Naturalness
6. Large faunal populations
7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

*The least degraded inland wetland in south-west Western Australia.

Table 7.10: Environmental evaluation of estuaries in the Busselton-Walpole Region.

Wetland Group	Individual named wetlands	1st Tier evaluation	2nd Tier Evaluation *Criteria*									Overall 1st and 2nd tier evaluation	Main values
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
Vasse-Wonnerup**		National Significance	1	1	3		1-2	5	4		5	5	Floodplain, Faunal Pops., and Sanctuary.
Toby's Inlet			1	1	1		1	1	1		1	1	
Wilyabrup BrookEstuary			4	4	3		4				1	4	Unique, Representative and Natural.
Margaret RiverEstuary			4	3	2		3				1	4	Unique, Representative and Natural.
Hardy Inlet			4	3	3		2-4	4	(3)		2	4	Unique, Rep., Fldpln, Natural (many parts), Faunal Pops and Sanctuary.
Donnelly River Estuary			4	5	1		5	(3)	(2)		2	5	Unique, Representative, Natural and Faunal Pops.
Warren River Estuary			4	5	1		5	(3)	(2)		2	5	
Gardner River Estuary			4	5	1		5	(3)	(2)		2	5	
Broke Inlet		National Significance	3	5	5	5#	5	5	4		4	5	Many values.
Nornalup Inlet			5	2	3	4*	5	(3)+	(1)		4	5	Unique, Fldpln, Ecol. Feature, Natural, Faunal Pops and Linkage.
Walpole Inlet			3	3	3		2-4	(3)+	(2)		3	4	Unique, Rep., Fldpln, Natural, Faunal Pops and Linkage.

Key

1. Uniqueness
2. Representativeness
3. Function
4. Features
5. Naturalness
6. Large faunal populations
7. Wildlife sanctuary
8. Rare species
9. Habitat linkage

Ramsar: Ramsar wetland (ANCA 1993)
Nat. Sign.: wetland acknowledged to be of National Significance (ANCA 1993)
System 6: wetland was or is subject to a System 6 recommendation (DCE 1983)
National Estate: on register of National Estate

#Entire catchment covered in natural vegetation.
*Only place in the south-west where karri forest comes down to the sea.
+Marine and estuarine fish - the inlets are not open to commercial fishing.
**Only partially estuarine today due to tidal barrages at the mouths.

8. Wetlands, rivers and estuaries of important value

Wetlands, rivers and estuaries which are recognised as being of important value, are those which are most representative of broad wetland values in the region or constitute the best and most crucial wetland habitat of the region. The loss of any one would constitute a serious loss of habitat for many plant and animal species and major reduction in representative examples of our wetland heritage.

8.1 Recognising important values

Important wetlands, rivers and estuaries are recognised on the basis of naturalness and representativeness within each of the natural resource zones (NRZ) and for the Busselton-Walpole Region as a whole. In the case of wetlands and estuaries it may also be recognised on the basis of known habitat and sanctuary values. For example, Lake Dumbleyung is highly degraded and no longer particularly representative of any of the lake systems of its NRZ in their natural state, but retains important habitat values for waterbirds, even if only by virtue of its sheer size. In the case of rivers, it is also worth mentioning those systems which are representative of south-west river types (see Section 8.4).

Wetlands, rivers and estuaries of important value are shown in Figure 8.1.

8.2 Important wetlands

Important wetland groups and individual wetlands are listed in Table 8.1.

Geographe Bay, Leeuwin-Naturaliste and Margaret River catchments

On the coastal plain and eastern side of the Leeuwin-Naturaliste ridge most of the wetland area has been cleared or greatly modified by drainage. Therefore, any wetlands which have survived within remnant bush, National Park or State Forest have important values, almost by default. They include the Bussell Highway Swamps, Ludlow Wetlands (some only), Ludlow-Abba Wetlands and the small and extensive wetlands of the Leeuwin-Naturaliste National Park and State Forest on the Blackwood Plateau and Whicher Range (See Figure 4.1 and Table 8.1).

The exceptions to this are the Vasse-Wonnerup and Broadwater Systems, which have important value through the large waterbird populations that they support.

Western Scott Coastal Plain

As with the Swan Coastal Plain, the Scott Coastal Plain is highly cleared and drained, and most of the wetland area is degraded. Thus remnant wetlands in the Scott National Park, near Hardy Inlet, fringing in state forest to the north and in Gingilup Nature Reserve, including Bulrush and Gingilup Swamps, have important representativeness and naturalness values (Table 8.1). Gingiliup Swamp almost certainly has important sanctuary value.

Lower Blackwood catchment

All of the wetlands of this area in State Forest, which is most of them, have important representativeness and naturalness values (see Table 8.1).

Middle Blackwood catchment

Wetlands with important naturalness and representative values are few and far between in this highly cleared and salinized part of the Blackwood catchment. A few small wetland groups, including Mickalurrup and Moodirup Road Swamps, are located within small blocks of remnant vegetation, and are therefore important by default (see Table 8.1). A number of wetlands, in the Qualeup, Arthur River and Beaufort River wetland groups, have important faunal values and/or are present within bushland blocks, imparting additional representative and naturalness values (see Table 8.1).

Upper Blackwood catchment

The sheer number and extent of wetlands in the upper Blackwood virtually ensures that at least some wetlands will have important values, despite widespread clearing

Table 8.1: Important wetlands of the Busselton–Walpole Region

Area	Wetland Group	Named wetlands	Outstanding values			
			Rep.	Nat.	Faunal	Sanc.
Geographe Bay, Leeuwin-Naturaliste Ridge and Margaret River Catchments	Bussel Hwy Swamp			*		
	Ludlow Wetlands			~	~	~
		McCarley's Swamp		*	*	*
	Tutunup Rd Lake		*	*		
	Ludlow-Abba Wetlands			*		
	Vasse-Wonnerup Wetland System				*	*
	Broadwater Floodplain				*	
	Naturaliste Lake Wetlands		*		*	
	Margaret River Swamps		*	*		
	Devil's Pool			*		
	Lake Davies Wetlands			*		
Western Scott lower Coastal Blackwood Plain and Catchment	Pt Pedder Swamps		*	*		
	Lower Blackwood Wetlands		~	~		
	Scott River Wetland System		~	~		
		Bulrush Swamp	*	*		
	Gingilup Swamp Wetlands		+	+		+
		Gingilup Swamp	*	*		*
	Bolghinup Lake Swamp			*		
Lower Blackwood Catchment	Spearwood Creek Swamp		*	*		*
	Adelaide Brook Swamp		*	*		*
	Kookaburra Brook Floodplains		*	*		
	Milyeanup Bk Floodplains		*	*		
	Red Gully Floodplains		*	*		
	Wilga Road Swamp		*	*		
Middle Blackwood Catchment	Mickalurrup Swamp		*	*		
	Moodiarup Rd Swamp		*	*		
	Qualeup Wetlands		~	~		
		Lake Boyup	*	*		
	Arther River Wetlands System				~	
		Lake Towerrinning			*	
		Wildhorse Swamp			*	
		Moodiarrup Swamps			*	
	Beaufort River Wetlands - West		~	~	~	
		Dead Man's Swamp			*	
		Emu Swamp			*	
		Nuning Swamp	*	*	*	
		Spratts Lagoon	*	*	*	

* Entire wetland or wetland group is important

\+ Most of the wetlands within the group are important

~ Some of the wetlands within the group are important

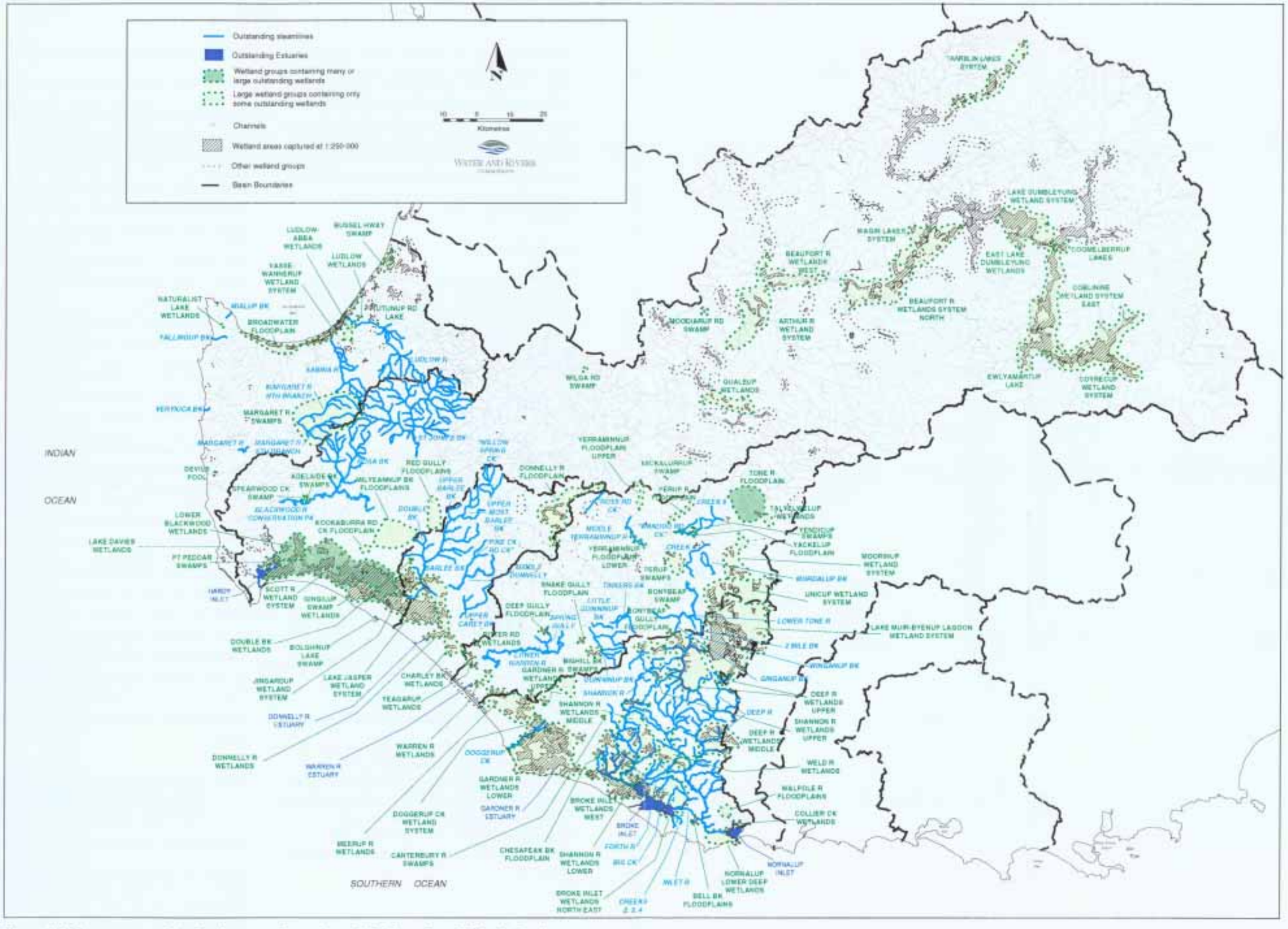

Figure 8.1: Important wetlands, rivers and estuaries of the Busselton-Walpole Region

and salinisation. A few wetlands, mostly those within small Nature Reserves and mostly in the Tarblin and Wagin Lakes systems, have important representative and naturalness values (see Table 8.1). But by far the dominant important attribute of the area, and particularly for many of the medium to large lakes, is large faunal populations, mainly waterbirds, with some wetlands having important sanctuary value for fauna (Table 8.1). Many of the lakes and swamps along the Beaufort and Coblinine Rivers are important for these values.

Donnelly catchment

The high proportion of land in its near natural state in this catchment ensures that most wetlands have important natural values (Table 8.1). The lakes and swamp systems on the coastal plain, Quitjup, Jasper, Wilson and Smith, provide important habitat for aquatic animals, particularly fish and frogs, and plant communities.

Warren-Unicup catchments

Owing to the fragmentary nature of bushland in this catchment, wetlands with important values tend to be scattered about and many of the wetland groups away from the coast have only some wetlands with important values, mainly for naturalness (Table 8.1). The Yeagarup Wetlands are particularly important for representativeness, naturalness, faunal populations and sanctuary.

Shannon Basin

The vast majority of wetlands in this area have important natural value (Table 8.1). Only in the upper Meerup, Gardner and Walpole catchments have values of important quality been compromised and then only for some wetlands.

Lake Muir and upper Shannon and Deep catchments

The wetlands within the upper Shannon and Deep catchments are entirely within naturally vegetated land and therefore retain important representative and naturalness values (Table 8.1). Most of the wetlands in the Lake Muir-Byenup Lagoon Wetland System have important value, if not for representativeness and/or naturalness, then for faunal populations and/or sanctuary (Table 8.1).

8.3 Important rivers and creeks

Nominations of streams for important natural significance are divided into drainage system size categories and biogeographic zones. The recognition of candidates began at whole river systems and worked down to creek level. A degree of redundancy has been built into the methodology; where only one system of a certain size exists within a biogeographic region and where an important candidate contains important streams of a smaller size. Therefore, where only one river or creek stream system exists no further work can be done and where at least one candidate has been found of a certain size no further work to recognise important smaller systems need be done.

In the second case of redundancy outlined above, an explanation is required. Here it is considered that the important qualities of a river or creek not only pertain to its catchment but also to the quality of the larger stream system to which it is connected. Therefore, a river or creek system which is wholly contained within a natural catchment, but is connected downstream to a greatly altered larger catchment is less valuable than one of equal size in the same biogeographic region that is part of a larger stream system which in itself is outstandingly natural. This acknowledges that the conservation potential of a stream ecosystem in the long term is greatly enhanced by being connected to a broader natural area. Hence, an important stream system may be considered to contain smaller important stream systems, thus obviating the need for further searching for smaller system in other less natural catchments in the same biogeographic region.

If only one system of a particular size or natural resource zone is nominated, then further work is unnecessary. In the case of higher order streams it is often the case that only relatively natural sections remain to be nominated.

Important stream systems and river sections are listed in Table 8.2.

8.3.1 Geographe Bay, Leeuwin-Naturaliste Ridge and Margaret River catchments (DuBuR2, MeBuR2, WaBuR2)

Geographe Bay catchment (DuBuR2, MeBuR2)

Although the drainage basin is greatly altered, three of the larger streams, the Capel, Ludlow and Sabina Rivers, retain considerable natural value. Since all three fall into the DuBuR2 and MeBuR2 Natural Resource Zones

Table 8.1: Continued

Area	Wetland Group	Named wetlands	Outstanding values			
			Rep.	Nat.	Faunal	Sanc.
Upper Blackwood Catchment	Taarblin Lakes System		~	~	~	~
		Lake Taarblin			*	*
		Ibis Lake	*	*		
		Billy Lake	*	*		
		Lake Toolibin			*	*
		Bokan Lake	*		*	
	Beaufort River Wetlands System - North				~	
		Bush Swamp			*	
		Billielight Swamp			*	
		Grandfather Swamp			*	
		Flagstaff Lake			*	
		Queercamp Lake			*	
		Lake Charling			*	
		Small Lake			*	
		Martinup Lake			*	
		Murapin Lake			*	
		Kidney Swamp			*	
		Miripin Lake			*	
		Wardering Lake			*	
	Wagin Lakes System			~	~	
		Little Packeyerring			*	
		Norring Lake			*	
		Lime Lake		*		
	Lake Dumbleyung Wetland System					~
		Lake Dumbleyung				*
	East Lake Dumbleyung Wetlands					*
	Coomelberrup Lakes				~	~
		Lake Coomelberrup			*	*
	Coblinine Wetlands System - East			~	~	
		Casuarina Lake			*	
		Unnamed Lake (R9056)			*	
	Ewlyamartup Lakes				~	
		Ewlyamartup Lake			*	
	Coyrecup Wetland System			~	~	
		Coyrecup Lake			*	

* Entire wetland or wetland group is important

\+ Most of the wetlands within the group are important

~ Some of the wetlands within the group are important

Table 8.1: Continued

Area	Wetland Group	Named wetlands	Outstanding values			
			Rep.	Nat.	Faunal	Sanc.
Donnelly Catchment	Lake Jasper Wetland System		*	*	*	*
		Lake Quitjup	*	*	*	*
		Lake Jasper	*	*	*	*
		Lake Wilson	*	*	*	*
		Lake Smith	*	*	*	*
	Jingardup Wetland System		~	~	~	~
	Double Brook Wetlands		*	*		
	Donnelly River Wetlands		*	*		
	Charley Brook Wetlands		*	*	*	*
	Donnelly River Floodplain		~	~		
Warren Catchment	Warren River Wetlands		*	*		
	Yeagarup Wetlands		*	*	*	*
	Ritter Rd Swamps		*	*	*	*
	Deep Gully Floodplain		*	*		
	Snake Gully Floodplain		*	*		
	Big Hill Brook Swamp		*	*		
	Bonybeap Swamps		*	~		
		Bonybeap Swamp	*	*		
	Bonybeap Gully Floodplain		*	*		
	Yerraminnup Floodplain - Lower		*	*		
	Perup River Floodplain		~	~		
	Yackelup Floodplain		*	*		
	Yerraminnup Floodplain - Upper			~		
	Perup Swamps		~	~		
		Meelinup Swamp	*	*		
		Jilbargup Swamp		*		
	Yendicup Swamps			~		
	Tone River Floodplain			~		
	Talyelwelup Wetlands			~		
		Cootayerup NR (R16031)		*		
	Moorinup Wetland System			~		
		Moorinup Lake		*		
	Unicup Wetland System			~		~
		Unicup Lake		*		
		Little Unicup Lake		*		
		Tolkerlup Swamp		*		
		Bokanup Swamp		*		
		Kulinilup Lake		*		*
		Yarnup Swamp				*

* Entire wetland or wetland group is important

\+ Most of the wetlands within the group are important

~ Some of the wetlands within the group are important

Table 8.1: Continued

Area	Wetland Group	Named wetlands	Outstanding values			
			Rep.	Nat.	Faunal	Sanc.
Shannon River Basin	Meerup River Wetlands		+	+		+
	Doggerup Creek Wetland System		*	*	*	*
	Broke Inlet Wetlands - West, East and Northeast		*	*	*	*
	Shannon River Wetlands - Lower		*	*	*	*
	Weld River Wetlands		*	*	*	*
	Bell Brook Wetlands		*	*	*	*
	Gardner River Wetlands - Lower		+	+	+	+
		Lake Maringup	*	*	*	*
	Gardner River Wetlands - Upper		~	~		
	Canterbury River Swamps		*	*		
	Walpole River Floodplains		*	*		
	Nornalup - Lower Deep Wetlands		*	*		
	Deep River Wetlands		*	*		
	Collier Creek Wetlands		*	*		
Lake Muir and Deep Upper Shannon and Catchments	Shannon River Wetlands - Upper		*	*		
	Deep River Wetlands - Upper		*	*		
	Lake Muir - Byenup Lagoon Wetlands System		~	~	~	~
		Lake Muir			*	*
		Byenup Lagoon			*	*
		Tordit-Gurrup Lagoon			*	*
		Myaldelup Lagoon/ Poorginup Swamp	*	*		*
		Neeranup Swamp	*	*		*
		Wimbalup Swamp	*	*		*
		Cocrup Swamp	*	*		*
		Noobijup Lake	*	*		*
		Cobertup Swamp	*	*		*
		Coorinup Swamp	*	*		
		Bodginup Swamp	*	*		
		Galamup Swamp	*	*		
		Pinticup Swamp	*	*		
		Pindicup Swamp		*		*
		Red Lake		*		

* Entire wetland or wetland group is important

+ Most of the wetlands within the group are important

~ Some of the wetlands within the group are important

(NRZs), as do most of the other streams, each system can be considered representative of natural streams of these zones. The Capel is the only small river and is therefore important by default, but since it is polluted (ref), retains little natural habitat and has been realigned artificially in the lowest reach to discharge to the sea, it cannot be considered to have important natural value. Of the minor coastal streams, Mialup Brook remains in the best condition. Therefore, the nominations for the most important streams are the Sabina and Ludlow Rivers and Mialup Brook.

Leeuwin-Naturaliste Ridge and Margaret River catchments (MeBuR2, WaBuR2)

The Margaret River is the only river size system in the MeBuR2, WaBuR2 NRZs and although it is important by default, its catchment has been greatly altered, especially in middle to lower reaches (B2-3). Large areas have been cleared for agriculture and considerable land along the lower reaches is now subject to real estate development. In the upper catchment areas of forest have been cleared for pine plantations. Nevertheless the North and South Branches of the river, both creek size, retain considerable habitat value (A3-B3 mostly). Also, the section of the lower Margaret River just above the township of Margaret River, is the most northerly section of river to pass through karri forest (B1).

The tiny Veryuica Brook is the only completely coastal A3 stream in this area. Yallingup Brook (B1) comes close with only a small area of cleared farmland in its headwaters. These two minor creeks best represent the coastal creeks between the Capes.

8.3.2 Lower Blackwood catchment (MeBlR2)

The important part of the Blackwood system in the MeB1R2 zone is located about 30 km downstream, as the fish swims, of the township of Nannup in an area of dense jarrah forest. It is shown as a cluster of A3 tributaries, including the major creek Rosa Brook, wholly contained within CALM managed forest and discharging into about a 25 km section of B1 value main channel known as the Blackwood Conservation Park (see Figure 8.1). This section of the Blackwood River represents the highest quality streamline on the main trunk or main branches of the entire river system.

The Blackwood Conservation park is worthy of nomination as important. Although it is downstream of a huge agricultural catchment, its surrounding riparian vegetation is very healthy and it represents a substantial section of the highest order streamline contained within public land anywhere in the south-west.

However, the important system is clearly the 4th order major creek, Rosa Brook, which is wholly contained within state forest (see Figure 8.1). Although the similar sized St Paul's Brook is mostly in forest, it has a small area of cleared farmland on a lower reach, which renders it less valuable than Rosa Brook. At a larger scale, of the 5th order St Johns and Balingup Brooks, the former is clearly less altered of the two and therefore by default is the more important.

Scott River (WaBlR2)

The estuarine reaches of the river and a large section of the upper channel fall in National Park, but as the adjacent catchments of these sections support agriculture, they cannot be considered to have important natural value as stream ecosystems. However, they remain the better representative sections of natural streams in the WaB1R2 zone.

8.3.3 Donnelly catchment (WaDoR1, MeDoR2)

Although the Donnelly River is substantially in CALM managed forest and conservation estate, nothing above a creek size system is wholly contained within it. As a result there are a number of obvious nominations for creek systems, which are listed below, but nothing obvious above that. In the upper of the two NRZs the "Willow Spring" creek system is the most important (Figure 8.1).

The most important section of river is that on the middle Donnelly between just above the Vasse Highway and just below Graphite Road (Figure 8.1). This is the longest section of river size channel on either the Donnelly River or Barlee Brook where all the adjacent tributary streams are wholly contained within state forest or conservation estate. However, unlike the Donnelly, the Barlee Brook has much less cleared farmland in its catchment, and almost none in its upper catchment. Therefore Barlee Brook is the appropriate candidate for important small river and/or, in the upper reaches, important major creek.

Table 8.2: Important stream systems of the Busselton–Walpole Region

(See Figure 8.2 for location of the streams)

Area	Stream system size	Natural Resource Zone	Stream system name
Geographe Bay Catchment		DuBuR2, MeBuR2	
	Small river		None
	Major creek		Ludlow and Sabina Rivers
	Minor coastal creek		Mialup Brook
Cape Naturaliste - Cape Leeuwin Catchments		MeBuR2, WaBuR2	
	Small river		None
	Creek		Margaret River - North Branch
			Margaret River - South Branch
	Minor coastal creek		Veryuica Brook
			Yallingup Brook
	River section		Just upstream of Margaret River township
Lower Blackwood Catchment		MeBlR2	
	Small River		St Johns Brook
	Major Creek		Rosa Brook
	High order river section		Blackwood River Conservation Park
Donnelly River Catchment Catchment		WaDoR1, MeDoR2	
	Small river		Barlee Brook
	Major creek		Upper Barlee Brook
	Creek	WaDoR1	Big Easter Brook
			Upper Carey Brook
			"Pine Creek Road Creek"
			Double Brook
			Upper most Barlee Brook
		MeDoR2	"Willow Spring Creek"
	High order river section		Middle Donnelly
Warren River Catchment		WaWrR1, MeWrR2, MeWrR3	
	Major Creek	WaWrR1	Quinninup Brook
	Creeks	WaWrR1	Spring Gully
			Little Quinninup Brook
			Tinkers Brook
		WaWrR2	"Ross Rd Creek"
			"Wandoo Rd Creek"
			Ginganup Brook
			Winganup Brook
			Two Mile Brook
		MeWrR3	Creek 4
			Creek 8
			Mordalup Brook
	River sections	WaWrR1	Lower Warren River
		MeWrR2	Lower Tone River
			Middle Yerraminnup River
		MeWrR3	Lower Tone River
Shannon Basin		WaShR1, WaShR2	
	River	WaShR1, WaShR2	Deep River
	Small river	WaShR1	Shannon
	Coastal creeks	WaShR1	Forth River
			Inlet River
			Doggerup Creek
	Coastal minor creeks	WaShR1	Big Creek
			Creeks 2-4

8.3.4 Warren catchment (WaWrR1, MeWrR2, MeWrR3)

The large Warren River catchment is a mosaic of state forest, conservation reserves and farmland. As such there are few stream systems, even down to creek scale, which have complete naturally vegetated catchments in state forest or conservation reserves. Consequently, there are few whole system candidates for important value for each of the three NRZs over which the catchment falls. In the lower WaWrR1 zone, only the creek size Spring Gully (A3), on the lower Warren, is a candidate. However, there are three systems which are largely A3 condition, the creek size Little Qinninup Brook and Tinkers Brook and the major creek, Quinninup Brook. The middle MeWrR3 zone has five creek size candidates (all A3), "Ross Rd Creek" on the Wilgarup River, "Wandoo Rd Creek" on the Perup and Ginganup Brook, Winganup Brook and Two Mile Creek on the lower Tone River. The upper MeWrR3 zone has three creek size candidates (all A3), the Mordalup Brook and two unnamed creeks (Nos 4 and 8, see Figure 8.1), also on the lower Tone. The upper Tone River is completely dominated by agriculture (C1-3).

In the absence of high order whole system candidates for important value, it only remains to nominate important river sections. In the WaWrR2 zone, the lower Donnelly between Domakup Brook and Treen Brook is a 5th order stream worthy of nomination. Here, most of the tributaries drain conservation estate or state forest and the river passes through the highly scenic Warren National Park. At 3rd order and in the MeWrR2 zone, the lower Tone between the Perup River and the Manjimup-Frankland Rd, has a number of important creek systems (see above) wholly contained within conservation estate. A second section worthy of nomination in this NRZ occurs along the middle Yerraminnup River, a major branch of the Perup River (see Figure 8.1), where most tributary creeks drain conservation reserves or state forest. In the upper MeWrR2 zone, a short section of the lower Tone is in a vegetated corridor with important creeks draining the large Perup Nature Reserve (Figure 8.1).

8.3.5 Shannon Basin (WaShR1, WaShR2)

Of all the drainage basins in the Busselton - Walpole region, the Shannon contains the greatest proportion of overall catchment with natural vegetation, nearly all of which is state forest or conservation estate. As a result, candidate stream systems for important value, up to medium river size, are relatively common.

The Deep River is the only medium size system in the basin and crosses both the WaShR1 and WaShR2 zones. Despite the presence of cleared farmland along the very lower reaches of the river and on headwaters of a few tributary creeks, also in lower reaches, the very high proportion of catchment retaining natural vegetation renders this system important, not only for the basin, but for the region as a whole. No other river system of this size in the region or the south-west is in such a relatively natural state.

The small sized 4th order Shannon River system is almost wholly contained within National Park and is the only river system in the south-west to be so protected. Although parts of the catchment have been heavily logged and has a small dam on an upper reach, the system is in a far more natural state than the neighbouring Gardner River system which has much farmland in its catchment. Because the upper 4th order reaches of the Deep, which are similar in stream order to the whole Shannon, are mostly in the WaShR2 zone, while the Shannon is mostly in the WaShR1 zone, the two systems are not comparable.

The Meerup River is the only major creek size coastal system in the basin. Although this makes it important by default it is not worthy of nomination because much of its catchment is farmland and its values are very likely adequately represented in the neighbouring Doggerup Creek system.

Of the coastal streams which run to the ocean or to an inlet of the ocean there are three nominations for important creek, the Forth River, Inlet River and Doggerup Creek, and four for minor creek, the Big Creek and creeks 2 to 4 (see Figure 8.1). These systems mostly drain low lying land, supporting healthy sedgeland vegetation, which has suffered relatively little from human activity and therefore they probably represent the most near pristine streams anywhere in the south-west except perhaps for those wholly contained within the Fitzgerald National park.

8.4 River types and important qualities

Five of the eleven river types of the south-west of Western Australia are found in the Busselton-Walpole region, spread over 15 river systems (see Table 4.2). Of these two systems, the Shannon and the Deep, both T9, are fully represented in state forest and conservation estate and have important value. The remaining four types, spread over 5 rivers, have sections or tributary systems, which have been nominated for important value (see Table 4.2).

The Blackwood is the only T1 system found in the region and is one of five in the entire south-west, the other four being the Moore, Avon, Murray and Frankland. Of these the Blackwood, along with the Murray and Frankland, retain considerable remnant vegetation in their lower catchments, most of which is in state forest or conservation estate.

The Margaret and Scott Rivers are the only T4 systems, both in the Busselton-Walpole region. The Margaret is the more important (see Section 8.3.1). The seven river systems draining into Geographe Bay comprise the total number of T5 systems and two, the Ludlow and Sabina, have been nominated for important value (see Section 8.3.1).

The Warren River is the only T8 system and has sections and whole tributary systems with important value

8.5 Important estuaries

Most of the estuaries of the Busselton-Walpole Region occupy separate natural resource zones and therefore their representativeness and other important qualities are better assessed from the perspective of the larger south-west region, from Geraldton to Esperance. In this respect Donnelly, Warren, Gardner, Broke and Nornalup are important in that they all located areas of dense natural vegetation within National Parks (Table 8.3). Of these Broke Inlet is the most important as it has a catchment which is entirely naturally vegetated and within National Park.

The Vasse-Wonnerup Estuary has important faunal value, but because its connection to the sea has been greatly modified by tidal barrages and diversions, the "estuary" itself cannot be considered important. Rather, its important faunal values have been recognised under wetlands.

Table 8.3: Important estuaries of Busselton–Walpole Region

Estuary name	Outstanding values			
	Rep.	Natural.	Faunal	Sanct.
Hardy Inlet		*	*	
Donnelly		*		
Warren		*		
Gardner		*		
Broke Inlet	*	*	*	*
Nornalup		*		

PART 4:
The management and protection of wetlands

9. Major degradation challenges and opportunities

9.1 Effects of groundwater rise: salinisation and waterlogging

Broad scale clearing for agriculture in the middle and upper catchment of the Blackwood River and the upper catchment of Warren River has reduced water consumption by plants with the effect that ground waters are rising rapidly in cleared areas, carrying fossil salt to the land surface (Wood 1924, Schofield *et al.* 1988, Anon. 1996). The area and volume of saline discharge is increasing with the effects on water resources including stream salinisation, wetland vegetation death, caused by the combined effects of salinisation and waterlogging, and the extinction or decline in populations of aquatic flora and fauna, with consequent major changes on stream ecology.

Stream salinisation and waterlogging

Many streams and wetlands with catchments in the less than 1100 mm rainfall zone are exhibiting elevated salinities. The Blackwood and Warren Rivers are the best examples of salt affected rivers, having reached salinities of about 1000 and 2000 mg/L in their respective lower reaches and with average annual increases in salinity of the order of 15 and 50 mg/L, respectively (Schofield and Ruprecht 1989).

Another effect which has received little attention, but which must certainly be occurring, is increased inundation and waterlogging of streamlines. With rising water tables and greater groundwater discharge and runoff, not only are seepage areas along stream embankments likely to be larger, but prevailing flows are probably at higher levels and of greater duration. Many streams which would have ordinarily dried out each summer, probably now flow all year round or at least have beds and banks which remain waterlogged for longer periods. The effect of greater inundation and waterlogging, together with salinisation, probably explains the extensive stands of dead and dying trees along water courses of the middle to upper Blackwood and Warren Rivers.

Wetland salinisation

Many wetlands in cleared areas of the low rainfall zone (<900 mm) are suffering the combined effects of groundwater rise, namely salinisation and waterlogging, but salinisation alone is often as a result of saline inflows. Lake Towerinning is the best example of a lake effected in this way and it is currently being protected from saline inflows by means of diversion drains. Unfortunately, the lake is threatened in the long term by a steadily rising groundwater table.

Effects of salinisation on aquatic flora and fauna

Very little work has been done on the effects of salinisation in Western Australia. Most of what has been done concentrates on aquatic macrophytes and wetland trees (see the work of Brock and Lane 1983 and Brock and Shiel 1983; Froend *et al.* 1987 and van der Moezel and Bell 1987a and b, van der Moezel *et al.* 1988), and a small amount of work has been done to examine the impact of salinized lakes on waterbird breeding (Halse 1981, 1987).

Hart *et al.* (1991) carried out a review of the effects of salinisation on plants and animals, including that of the above. The major findings of this work are as follows:

Microbial community. Small changes in salinity may have little effect on microbial processes (detrital processing), but significant impacts upon the microbial community may occur if salt inputs interact with other environmental factors to create unnatural conditions (eg stagnation, stratification, deoxygenation).

Macrophytes and microalgae. Many aquatic plants are salt sensitive, with 1000-2000 mg/l. likely to be lethal. Below this level macrophytes and micro-algae may exhibit sub-lethal effects.

Fringing vegetation. Adverse effects are often apparent at salinities greater than 2000 mg/L. However, considerable variation between species and populations of the same species has been found. Generally, specimens from existing saline situations exhibit a greater tolerance to salinity than those from fresher sites. Salinity and water logging act synergistically and together probably cause greater stress to plants than either a single factor acting alone. Whether one or the other, or both factors in combination, wetland vegetation, including that along streamlines, is highly stressed and much has died in the upper catchments of the Blackwood and Warren Rivers, and it would appear increasingly so for the middle Blackwood. However, it is important to note that other factors are contributing to vegetation death, such as overgrazing and disease, and that vegetation already stressed by salinisation and waterlogging may more easily succumb to other sources of stress.

Invertebrates. These seem to be amongst the most obviously sensitive of freshwater animals to increases in salinity, with adverse effects being shown at salinities above 1000 mg/L. The most sensitive groups appear to be multicellular organisms and certain groups of insects and molluscs. Work carried out on Marron (see Morrissy 1978) has shown that the incipient lethal salinity for adult and juvenile marron appears too be in vicinity of 17 000 mg/L. Salinities of this magnitude and greater are only attained in the very headwaters of inland rivers during summer. It is possible that the embryos and larval young carried by spawning mothers are less tolerant to salinity, but salinities in the upper reaches of major rivers are at a minimum in spring time when spawning occurs. Present day distribution of marron, in relation to salinity, is well below the incipient lethal level but above that of the upper limit for freshwater, ie 500-5000 mg/L. The disappearance of marron along the middle Blackwood, as documented by Horwitz and Wardell-Johnson (1996), where salinities are towards the upper end of this range, is therefore more likely a result of other forms of degradation, such as low oxygen levels caused by organic pollution.

Fish. Most inland "freshwater" species are relatively recently derived from marine ancestors and appear tolerant up to or greater than 10 000 mg/L. Although larval fish are more sensitive than either adults or eggs, those born in spring would not be exposed to the most saline conditions of the year. The introduced redfin perch, an important table fish, has declined along the middle Blackwood and upper Warren (Horwitz and Wardell-Johnson 1996), probably as a consequence of salinisation and low oxygen levels. Other species, such as the estuarine Swan River hardyhead and the Swan River Goby appear to have moved upstream, probably in response to the saline conditions (Morgan *et al.* 1996).

Frogs. Most species are sensitive to changes in salinity, although some species are associated with moderately saline environments. Tadpoles and egg masses may be very sensitive indicators of salinity changes in wetlands. The probable impact of salinisation on frogs has not been documented.

Tortoises. Appear to be at risk from salinisation, even those species with salt secreting glands, but are still present in river pools and lakes that exhibit considerable degradation.

Waterbirds. Tolerance to saline conditions varies greatly among species. Many species of water fowl are able to feed on saline wetlands but require a nearby source of fresh water to drink from. In south-west wetlands low breeding success for some waterfowl species has been recorded for salinity increases above 3000 mg/L, possibly due to the limited ability of ducklings to move off-site in search of freshwater. Nevertheless, many of the lakes of the upper Blackwood catchment remain important waterbird habitat, albeit less so for breeding.

The Avon experience. Anecdotal and museum collection evidence has been used to document the disappearance and decline of some animals in the Avon River in the vicinity of the Avon Valley (Kendrick 1976). The freshwater mussel, freshwater cobbler, black bittern, two small snails, a welk and a limpet appeared to have undergone major declines in abundance since the 1940s. A small estuarine mussel, on the other hand appears to have increased in abundance in response to the more saline conditions. These effects are probably also relevant to the Blackwood.

Wetland drowning

Another problem which may compound salinisation and waterlogging through groundwater rise is wetland drowning (see for example Froend and Van der Moezel 1994). In an environment with increased run-off rates following rainfall on cleared catchments and an increasing density of artificial drainage to combat rising groundwaters, lake systems may increasingly become sumps with higher

average water levels than had normally occurred in the past. Fringing plant communities may thus be subject to greater levels of inundation by floodwaters, in addition to existing stresses of waterlogging from rising groundwater. Perhaps wetland drowning has already contributed to the shrouds of dead trees that cover or ring most of the lakes of the upper Blackwood catchment (see Halse *et al.* 1993b). For the Lake Muir internal drainage wetland system, which is likely to be subject to heavy drainage of adjacent farmland, prolonged flooding may be a particularly pertinent problem (CALM In Prep.).

9.2 Eutrophication, sedimentation and stagnation

The export of soil and nutrients from cleared catchments contributes towards the sedimentation and eutrophication of rivers and lakes. The build-up and subsequent decay of organic matter in river pools and the estuarine reaches of rivers appears to cause oxygen depletion, which apart from the death of aquatic fauna, also brings about the release of stored nutrients which can fuel algae blooms. There is a need to reduce soil and nutrient export from farmland to water bodies to sustainable levels. In this sense sustainability refers to the quantities of nutrients and sediment that can be transported into and along a river system without a significant long term degradation to its ecology and hydrological efficiency.

Rivers of the Busselton-Walpole Region which drain large areas of agricultural land are showing increasing signs of sedimentation and eutrophication. For example, the Blackwood has large sediment deposits in middle reaches and exhibits severe blue-green algae blooms over summer and autumn. In the summer of 1993/94 nearly the entire river supported a blue-green algae bloom.

Of the estuaries of the region, only the Vasse-Wonnerup is known to exhibit problematic algae blooms and fish kills, characteristic of ultra-eutrophic conditions (see McAlpine *et al.* 1989, Hodgkin and Clark 1988, 1989), but undoubtably the Hardy and the smaller Margaret and Wilyabrup River estuaries and Tobys Inlet, with their highly developed catchments must be nutrient enriched.

9.3 Riparian zone degradation

The degradation of riparian zones by landuse activities such as grazing and recreation and by weed invasions is a widespread problem in the Busselton-Walpole Region. The loss of protective native vegetation leads to erosion and the loss of habitat and wildlife corridors.

The riparian zone is prone to degradation from over grazing, weed invasion, frequent burning and recreation, as well as erosion, as the protective native vegetation diminishes over time. The primary pressure is the failure to manage riparian zones through a lack of appreciation of the environmental services that a healthy well vegetated riparian zone provides.

However, an awareness of the benefits of maintaining well vegetated riparian zones is growing amongst urban and rural landowners and managers. In State Forest, CALM maintains a system of informal reserves for the protection of riparian corridors. On private land, landcare programs are addressing riparian management as a priority issue.

Most streamlines in urban and agricultural lands are becoming degraded through a variety of landuse activities. By far grazing (by livestock and rabbits) and frequent burning have the most broad scale effect, but recreation can have a serious impact at points along rivers or over long sections. The main form of the degradation is the loss of native vegetation and its subsequent replacement by annual or perennial woody weeds. These adventives do not provide protection against erosion or maintain habitat, corridor and landscape values, but may in some circumstances compromise the drainage efficiency of waterways. Degradation arising from livestock grazing can only be prevented by the protection of waterways. This may be achieved by fencing to control the level of grazing sufficiently to enable the native vegetation to regenerate or to exclude grazing altogether.

9.4 Weed invasions and feral mammals

Exotic plants are becoming increasing problem for waterways and wetlands in the south-west region. In the absence of predators and pathogens, but having the requisite conditions for breeding, a proportion of the exotic plants introduced to the south-west have established very successful populations, which are in many cases displacing native plant species. Some plant species are favoured by changes in environmental conditions, such as an increase in fire frequency. Veldt grass is an example of such a species. Others, such as tall grasses, everlastings and woody shrubs, have exploited

cleared upland sites adjacent to rivers and wetlands. Many species of vines and creepers, deciduous trees, tall herbs and mat grasses have exploited the moist environment of the disturbed river valley (Pen 1994). For example, on the middle Blackwood River which passes through pine plantations and orchards, pines and fruit trees are coming up amongst the native plant community of the upper river embankments. Furthermore, weed invasions along rivers are particularly intense near towns like Nannup, Bridgetown and Balingup, where a wide range of garden plants are available to "escape" into river valleys

Exotic species do not afford the typical habitats of native flora and fauna and thus make fundamental changes to the ecology of south-west wetlands. On top of the direct effects of weeds are the very different grazing, foraging and predation regimes wrought by rabbits, pigs, goats, cats and foxes, which further threaten many native wetland species.

9.5 Introduced fish

A number of freshwater fish have been introduced to the south-west, but fortunately only two have formed broadly distributed breeding populations, the tiny mosquito fish (*Gambusia holbrooki*, to 50 mm long) and the large redfin perch (*Perca fluviatilis*, to 450 mm long). Both species are prolific breeders and are known to prey heavily upon native fauna (Merrick and Schmida 1984). The mosquito fish forms "super populations" over the summer which must have a major impact on the abundance, structure and composition of planktonic and benthic invertebrate populations (Horwitz 1994b). The species has also been linked circumstantially to the decline in native species where it has been introduced in other parts of the world (Cadwallader and Backhouse 1983). In the south-west it has been observed to attack native fishes in certain habitats (Morgan *et al.* 1996, Pen pers obs.), while apparently living in harmony with native species in others (Pen and Potter 1991). Certainly the species is more tolerant of poor water quality than native species and apparently replaces them in degraded environments in the south-west (Merrick and Schmida 1984).

The mosquito fish is presently not found at all or in abundance in the very important fish habitats of the south coast and this situation needs to be maintained to ensure the survival of several of the south-west's endemic fish species (Morgan *et al.* 1996).

The redfin perch is known to prey heavily upon freshwater crayfish and on certain native fish species. It has been circumstantially linked to the loss of the western pygmy perch (*Edelia vittata*) in the Murray River (Hutchinson 1991).

Both the mosquito fish and the redfin perch, infest river pools and presumably impoundments, placing them in close proximity to native fauna as they contract to permanent waters over the summer. At these times predation of native fauna by these abundant introduced species must be high. This situation has significant ramifications for the management of water supply dams in conservation estate (see Section 9.7).

Although the redfin perch and two trout species were introduced as sporting and table fish, both species are considered to provide only limited fisheries; as a result of perceived poor sporting qualities and a propensity to run at high population densities, in the case of redfin, and limited cool water habitats, in the case of the trout. As a consequence there is a growing demand among recreational fishers to introduced eastern state species to artificial and natural waters of the south-west (Prokop 1995). New species are also demanded for aquaculture, for which the high quality waters of the south-west appear to have much potential (WAPC 1997).

Translocation of fish species is subject to legislation and penalties exist to prevent inadvertent and malicious introductions (Lawrence 1993). Given the impact of mosquito fish and redfin perch on natural aquatic systems, any consideration of further introduction of exotic fish species, must take into account the possibility for escape and subsequent infestation and the likely impacts on natural water resource values. To this end, the Fisheries Department has produced guidelines for the assessment of proposed translocations (Lawrence 1993).

9.6 Habitat loss and fragmentation

Through active clearing (by bulldozer), passive clearing (in summer by hungry livestock) and through many forms of degradation, such as salinisation and waterlogging, heavy grazing, frequent fires, weed invasions, grazing and predation by feral animals and disease, some habitat types have or are continuing to undergo major decline in extent and health, along with their constituent populations of native plants and animals. For example, the lake and swamp systems of the upper Blackwood and Warren

catchments and the floodplain and swamp habitats of the southern Swan and western Scott Coastal Plain.

Wetland habitats on private land are particularly threatened, but even those in State Forest, National Parks and Nature Reserves are not secure from degradation. Even with scientifically based management, resources are limited and some environmental problems, such as disease (dieback), salinisation and weed invasions, appear insurmountable, at least in the short to medium term.

The main factors contributing towards the loss of habitat and biodiversity are further clearing of natural vegetation, the fragmentation of bushland blocks and the degradation of what habitat remains. Small areas of wetland habitat may not be large enough to support viable populations of native plants and animals and because of their small size are subject to edge effects, whereby adjacent land uses may spill-over into the bush; in the form of weed invasions, frequent fires, herbicide and fertiliser drift, livestock droppings and groundwater rise. A lack of connection between blocks exposes populations to the risk of extinction through catastrophe, with limited opportunity for recolonisation by natives, but with marked opportunity for weed invasion and feral animal colonisation. Some wetlands in small conservation reserves in the highly cleared areas of the upper Blackwood and Warren are also threatened by rising water tables.

Development pressure

A number of environmental problems are posed by urban and rural residential development in areas of high wetland value, such as on the southern Swan Coastal Plain and along the Leeuwin-Naturaliste Ridge. For example, land owners may be unable to meet the increased fire management responsibility that comes with properties adjoining natural areas (There is an increased risk of fire arising from the close proximity of bushland and land owners who are ignorant of the serious fire hazards that bushland presents). This burdensome responsibility takes the form of more extensive firebreaks, increased fuel reduction and complex "burning-off" regimes. Furthermore, natural areas are degraded by weeds, pets, rubbish, disease, escaped livestock, trampling and unmanaged firewood collection and timber harvesting. In many cases natural areas are privatised in the absence of formal community or shire management. All of this leads to the destruction of the very values that led to the development in the first place.

Recreation and tourism in natural areas

A growing problem is the opening up of natural areas to recreation and tourism in highly natural areas, especially along the south coast. For example, water skiing is permitted on both Lakes Unicup and Jasper. Such activities, through infrastructural developments, effluent disposal, noise, odours, dust, trampling, littering, erosion, etc, threaten to degrade natural areas; and do so in the long term.

Mining

Mining activities, such as those at Greenbushes, near Capel and proposed for the south coast, threaten the same sort of problems in the short term as those discussed above, but are strictly controlled and the land areas involved, including wetlands, are often rehabilitated.

Impacts of infrastructure development

Habitat fragmentation and loss occurs through the development of infrastructure. For example long corridors of bushland are cleared for roads, powerlines and pipelines. Large areas of streamline and wetland habitat are drowned by dams. Irrigation channels through bushland are a significant barrier to faunal movements.

9.7 Problems of dams, weirs and culverts

Most long lived aquatic fauna withdraw to permanent waters over the summer period and disperse to seasonal waters in winter. At least three species of native fish actually go on annual spawning migrations in winter and spring and the pouched lamprey migrates up from the ocean to spawn in permanent low order streams of the karri forest region (see references Morgan *et al.* 1996). Although some aquatic fauna, such as the marron and turtle can leave the water to negotiate obstructions to movement, most are severely limited in their capacity for cross-country movement. Therefore the many dams and weirs of the south-west present additional obstructions to faunal passage, either resulting in the complete blockage of movement or the injury and exhaustion of animals. For example, lampreys can climb small dams, but are often injured in the process and many dead animals can be seen below obstructions each spring.

Sometimes an obstruction presents a barrier to movement, not by its size but by its design. For example, the rainbow gauging weir has a metal plate fixed to the lip of the crest, jutting out a right angles which prevent lampreys from moving across the wall of the weir. Road culverts are often raised above the level of the stream bed. In both cases animals can only move upstream if they can leave the water, which can be very hazardous, or when the weir or culvert floods out. Prior to these opportunities animals expend much needed energy maintaining position below the obstruction, an action which may render them prone to predation, injury or exhaustion.

Dams and weirs present obstructions to movement in both directions, preventing animals from moving upstream to reach seasonal breeding habitat or from recolonising habitat formerly dry due to drought; and preventing animals from moving downstream, either juveniles and eggs washed down from upstream breeding areas or animals retreating downstream as streams dry out from drought. In the latter case impoundments infested with introduced fish may represent a serious threat to the survival of native populations, when drought forces them to withdraw downstream into permanent waters which support their chief predators in large numbers.

The impoundments of dams and weirs represent a new form of habitat which may provide a vacant niche for some exotic species, like trout and redfin perch. As described above, these populations may affect native populations, possibly even eliminating them, during times of drought. But they may also migrate upstream themselves, as both trout and redfin are known to do (Merrick and Schmida 1984, Bregazzi and Kennedy 1982), leading to heavy predation of tributary fauna.

The Big Brook Dam on the Lefroy system, is an excellent case study. This dam is known to block the upstream movements of the western pygmy perch and the annual migration of the pouched lamprey (Pen *et al.* 1988, 1991). The upstream creeks which once supported larval lampreys are now devoid of them. Furthermore, the impoundment is known to support a serious infestation of redfin perch, as well as rainbow trout. The western mud minnow (*Galaxiella munda*), a species virtually restricted to south coast streams, and which was formerly abundant in the headwaters above the dam disappeared following the severe drought of 1994/95 in which all of the system bar the impoundment dried out for several months (Pen *et al.* 1988, 1991, Morgan *et al.* 1996, unpublished data).

9.8 Problems of adjacent land use

Certain land uses, while being well sequestered on upland areas, may still affect wetlands and waterways. This section discusses the impacts of some of the more extensive or common "adjacent landuses" of the Busselton-Walpole Region.

Forest management

Clearfelling for logging and mining activities may bring about a short term rise in groundwater leading to minor, but nevertheless biologically significant, saline discharge in the period between logging and regeneration. This is considered to be a potential problem in the intermediate rainfall zone (IRZ) (900-1100 mm) where rainfall has not been high enough to flush all salts from the soil, but is sufficient to produce rapid groundwater rises. CALM's Forest Management Plan (CALM 1994) allows for this by a programme of phased logging in the IRZ which minimises groundwater rise.

Other impacts of logging on streams, such as nutrient and sediment loss, are buffered using a system of riparian corridors which range in width from 60, 150 and 200 m for first to third, fourth and fifth and greater order streams, respectively (CALM 1994). Similar buffers 50 m wide are maintained along ecotones that separate particularly diverse habitats, which include wetlands.

CALM also maintains a programme of prescribed burning to prevent wildfires which are difficult to control and which damage property and threaten human life. Recently prescribed burning practices have been criticised by some scientists for their lack of sensitivity towards the protection of wetlands, particularly those with peaty soils and which are considered unduly prone to fire damage (Wardell-Johnson and Horwitz 1996, Horwitz *et al.* 1996).

However, CALM's burning regime is strategic in nature and is designed to meet particular nature conservation objectives, including the protection of peat swamps (Haswell, D. Pers. Comm.)

Plantations and horticulture

Large areas of timber plantations and fruit tree orchards are found in the Donnelly, Warren and Blackwood catchments. These types of landuse have a variety of impacts on waterways. The large pine plantations along the Blackwood between Nannup and Bridgetown are giving rise to pine regeneration in the riparian zone of the river which may in the long term displace the native fringing vegetation and alter the ecology of the Blackwood River. Blue-gums threaten a similar problem, as evident along

the lower King River near Albany. However, most bluegum plantations are only comparatively young and there is little evidence of riparian zone invasion in the Busselton-Walpole region. Fruit trees are also coming up in the riparian zones of rivers and creeks of the region, but only in small numbers at present.

The drift and leaching of herbicides and pesticides used to protect horticulture from weeds and insect pests may be a problem to aquatic systems in the region but little research has been done to investigate the matter (Lane and McComb 1988). High levels of a pesticide were found in the Lefroy Brook, near Pemberton, in 1981 and significant levels were found in the Blackwood, Carbunup and Scott Rivers in the mid-1980s (Rutherford 1989).

Excessive nutrient loss from rapidly growing horticultural development in the Manjimup region may become a problem for waterways in the future. Certainly the proposed large horticultural developments on the sandy soils of the Scott Coastal Plain, threaten the eutrophication of the Hardy Inlet and possibly even Lake Jasper (Jeff Kite, pers. comm., WAPC 1997).

Point source pollution

The discharge or leakage of contaminants, including nutrients, from point sources into surface or ground waters may be a problem in certain areas. Examples of point sources of pollutants are livestock sale yards, sewage treatment plants, rubbish tips, mine operations, industrial sites, petrol stations, feedlots, dairies, piggeries and chemical storage sites. There are many such points in the landscape at which pollutants are being released into the environment. Although most of these are known and are controlled many, such as farm dairies, piggeries and feedlots, are not. There may be a need to identify and register points of wetland pollution or points with potential for pollution and to implement the appropriate regulation, and if necessary clean-up.

10. Wetland management and protection

10.1 Restoration of a hydrological balance

The only means of reversing the processes of salinisation and waterlogging, and of restoring the surface streams and wetlands to their original fresh or marginal quality, is by means of re-establishing something close to the natural hydrological balance. This can only be done by increasing water usage and thereby reducing groundwater recharge. Water usage may be increased in a number of ways: through the use of high water using crops, including blue-gums and oil mallees; by replanting a portion of the cleared catchment with deep rooted native plants, particularly along water courses or near wetlands; by increased capture and storage of runoff for its subsequent use over summer; or by a combination of the above approaches (Government of Western Australia 1996). In the mean time, drainage works may be necessary to dry out areas and thus make them available for replanting. It is acknowledged that drainage will increase catchment discharge of water, nutrients and sediment, which may degrade downstream waterways, at least in the short term.

In 1996 the Government of Western Australia launched a Salinity Action Plan to address dryland salinisation in the south-west of the State (Government of Western Australia 1996).

10.2 Minimising nutrient and sediment loss

The means must be found to minimise the export of nutrients and sediment from farmland to downstream waterways and wetlands. To achieve this, catchment management must increasingly make use of best management practices (BMPs), to minimise soil erosion and the subsequent transport of sediment and nutrients offsite. Commonly used BMPs include soil testing to minimise fertiliser application; contour ploughing, stubble retention and minimum tillage farming to reduce erosion and the maintenance of contour banks and/or grassy buffer strips to trap sediment and nutrients.

10.3 Riparian zone management

Riparian zones, whether along minor creeks or main river channels, need to be managed to maintain their stability. Healthy fringing vegetation not only supports the bed and banks against erosion, it also filters out nutrients and sediment. In this way much of the nutrients are assimilated by the fringing vegetation and cannot nourish problematic algae growth. Furthermore organic matter trapped by the vegetation can breakdown in the air where it causes no problems, rather than in deep river pools, which are needed in a healthy state to provide permanent aquatic habitat over the long dry periods which may last for years.

Riparian zone management need not always take the form of fenced off water ways lined with local native plant species and excluded from farm production. This is certainly needed where habitat conservation is a priority. But on the farm, creeks can be stabilised with fodder crops, fenced off and only grazed in winter or used for hay production at a time when the growing hay crop can form an effective biofilter by capturing and assimilating nutrients.

Broad bands of bushland maintained along the major rivers, particularly the upper Blackwood and Warren, could be important habitat and wildlife corridors. Although these rivers would receive nutrients and sediment from tributaries draining farmland, they would retain substantial riverine habitat and through river biofiltering, would help to buffer the estuaries from siltation and nutrient enrichment. Deep river pools along these rivers would also retain considerable recreational appeal and would become important recreational and tourism assets. In order to protect water resource values of the rivers and the coastal inlets vegetated corridors should be fenced off and extended and rehabilitated where necessary.

10.4 Wetland protection

Ideally wetlands should be managed as for remnant sustainable bushland; that is protected from grazing and *periodically burned*, weeded and baited for feral animals. For those suffering the impact of salinisation, waterlogging and possibly drowning, buffering against groundwater rise through the protection and/or replanting of native vegetation and the diversion of flooding and saline flows is necessary. However, for most wetlands, including many in reserves, the resources needed to achieve this level of management are not available. In these cases, grazing and burning of wetland vegetation should be minimised and wetlands should, at the very least, not be treated as drainage sumps. A key indicator

for the maintenance of wetlands with minimal but nevertheless crucial habitat value is the continued recruitment of native trees: flooded gums, paperbarks and sheoaks.

10.5 Habitat continuity and connectivity

High value wetland habitats on the Swan Coastal and Scott Coastal Plains and in the upper Blackwood and Warren catchments, including the Muir and Unicup systems are becoming increasingly isolated as intervening remnant bushland continues to deteriorate through a combination of active clearing, passive clearing and vegetation death due to salinisation and waterlogging. For these wetlands to continue in their role of supporting a useful range of plant and animal species, it is necessary that they remain as contiguous as possible with adjacent upland vegetation and other wetlands or at least that corridors enabling connection between wetlands are created and maintained.

Riparian corridors are especially important as many aquatic animals are restricted to the water and need free flowing streams to move across the land; to recolonise old habitats or reach breeding habitat. Although obstructions are inevitable, facilities can be constructed to enable upstream movement. One example, is the lamprey guides on the Lefroy Brook which assist lampreys in their cross-country movements on dark rainy nights to negotiate the Pemberton and Rainbow Gauging Weirs. In some cases obstructions to streamline movement can be eliminated through sensitive design, eg lowering road culverts to the level of the stream bed. High quality riparian corridors with structures incorporating "habitat sensitive design", born of an understanding of the physiology and behaviour of native species, are essential to maximise the value of what wetland habitats remain in a relatively natural condition.

The maintenance of stream flows and wetted habitat below water supply facilities is a growing concern in Australia (Cullen 1996). In the future the management of all water supply developments on streams will have to make provision for the maintenance of 'environmental flows' for the protection of water quality and streamline habitat.

10.6 Stream and wetland protection in conservation estate

Many wetlands of the Busselton-Walpole Region are located within National Parks, Conservation Reserves or State Forest. Their management is the responsibility of CALM, and with respect to the problems of fire hazard, recreational use, weeds and feral animals, management is possible and only limited by resources. In State Forest the management of wetlands and streams is subject to CALM's *Forest Management Plan 1994-2003* (CALM 1994). Generally, wetlands are better managed and remain in better condition when they have broad upland buffers of bushland (Davies and Lane 1995). However, in the upper Blackwood and Warren catchments, wetlands are threatened by the broader problem of large scale hydrological change and, even when surrounded in upland bushland, can only be fully protected and conserved by a catchment wide programme to restore the hydrological balance (see Section 10.1).

The quality of stream habitat is largely determined by the condition of the catchment discharging into it with the surrounding buffer, while contributing significantly towards the quality of the riparian zone, playing only a minor role in determining the water quality. Therefore the best stream habitats are those surrounded by native vegetation and having a catchment entirely dominated by natural plant communities. These representative streams were identified as part of this study (see Section 8.3) and since many pass through forest subject to logging, their long term protection is subject to negotiations between CALM and the Water and Rivers Commission. Already, protection measures are being developed for high value stream habitat in the intermediate rainfall zone (900-1100 mm), where short term saline flushes following timber harvesting have been identified as a potential problem where no stream reserve is retained (see Section 9.8).

An emerging problem which has ramifications for surface water supply developments in forested areas, is the compounding effect of impoundments, drought and feral fish, as outlined in Section 9.7, which appears to have the potential to eliminate native fish species from streams in conservation estate. There is a need to conduct research into the problems so that a management response can be

[6] Sustainable utilisation is defined as "human use of a wetland so that it may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations" (Ramsar Convention, Article 3)

[7] Natural properties of the ecosystem are defined as those physical, biological or chemical components such as soil, water, plants, animals and nutrients and the interactions between them" (Ramsar Convention, Article 3).

formulated which will permit the development of water resources in the region without considerable risk to the region's fish fauna.

10.7 Wise use of the Region's wetlands

The concept of wise use is important for the sustainable use of the regions wetlands. The concept of wise use is outlined below (after Hill *et al.* 1996):

> "The wise use of wetlands is their sustainable utilisation[6] for the benefit of humankind in a way compatible with the maintenance of the natural properties[7] of the ecosystem".
>
> This definition of wise use specified under the Ramsar Convention, to which Australia is a signatory, provides a sound overarching objective for wetland management and protection.
>
> Guidelines to wetland use as recommended by the Third Ramsar conference recognised wise use involves the promotion of wetland policies containing the following elements:
>
> 1a. a national inventory of wetlands;
>
> 1b. identification of the benefits and values of these wetlands;
>
> 1c. definition of the priorities for each site in accordance with the needs and socio-economic conditions in each country;
>
> 1d. proper assessment of environmental impact before development projects are approved, continuing evaluation during the execution of projects and full implementation of environmental conservation measures which take full account of the recommendations of this process of environmental assessment and evaluation;
>
> 1e. use of development funds for projects which permit conservation and sustainable utilisation of wetland resources;
>
> 1f. regulated utilisation of wild fauna and flora such that these components of the wetland ecosystem are not over-exploited.
>
> While detailed policies are being established, immediate action should be taken on:
>
> 2a. interchange of experience and information between countries seeking to elaborate national wetland policies;
>
> 2b. training of appropriate staff in the disciplines which will assist in the elaboration of such policies;
>
> 2c. pursuit of legislation and policies which will stimulate wetlands conservation action including the amendment as appropriate of existing legislation; and
>
> 2d. review of traditional techniques of sustainable wetland use and elaboration of pilot projects which demonstrate wise use of representative national and regional wetland types (Environmental Policy and Law 17/5 1987, p 203-204).

While there is much to be done to meet the above guidelines, the completion of the work in this report can be seen to make a significant contribution to wise use of the Region's most productive places.

Many organisations and groups help shape the state of Western Australia's wetland resource through their planning and management activities. The Department of Conservation and Land Management (CALM) has played an important part in coordinating the nomination of wetlands to the Ramsar Convention and the State's contribution to the recent Australian Nature Conservation Agency's Directory of Important Wetlands in Australia.

Currently, 'on-the-ground' management of the Region's wetlands and their catchments is undertaken by the Water and Rivers Commission, CALM, Water Corporation, Local Government Authorities and private property owners. There is potential for further, future management to be undertaken by community groups, with the guidance of management plans.

The wetland mapping and evaluation work coordinated by the Water and Rivers Commission is making a complementary contribution in the areas of wetland inventory, identification of benefits and values (1a & 1b above) and is itself a pilot project encouraging wise use of regional representative wetland types (2d).

Recent work in Western Australia has adopted an approach in which wetlands are assigned to three management categories: 'Conservation', 'Resource Enhancement' or 'Multiple Use' based on identified values and best available information. While management categories have been described in the Moore River to Mandurah area, this work is yet to be initiated further south on the Swan Coastal Plain or elsewhere in the Busselton-Walpole Region.

Studies investigating Horticulture on the Swan Coastal Plain, Water Conservation Through Good Design and the Perth-Bunbury Regional Water Allocation Study are just three such examples that have made major contributions

to sustainable utilisation and planning for wise use of wetlands.

In 1989, Western Australia's State Planning Commission prepared a development control policy titled 'Planning Considerations in the Metropolitan Region for Sources of Public Water Supply and Sensitive Water Resources Areas'. While still not used anywhere near what is required for wise use of wetlands, this policy has assisted wetland values and water resources management concerns being considered by town planners.

There has been the separate evolution of a set of design techniques called 'Planning and Management Guidelines for Water Sensitive Urban Design' (DPUD, EPA, WAWA, 1994), which when used, assists local and regional water resources management. Water Sensitive Design incorporates water resource management into the land planning and development process and has the objectives of:

- management of water balance;
- maintenance, and where possible, enhancement of water quality;
- maintenance of water related environmental, recreational and cultural values; and
- encouragement of water conservation.

The implementation of water sensitive design principles which will act to make the resulting urban development a better 'neighbour' to existing wetland areas and receiving water bodies is consistent with the wise use guidelines (Hill *et al.* 1996).

11. Implications for water resource allocation

Conservation and restoration of wetland values

The wetlands and streams of the Busselton-Walpole Region outside the larger National Parks, State Forests and Nature Reserves are generally not well protected. Most have little or no remnant vegetation associated with them and are slowly degrading through a variety of pressures (see Section 9). There is inadequate representation, approaching with time virtually no representation at all, of wetland and stream types on the southern Swan Coastal Plain and the upper Blackwood and Warren catchment (excepting the Unicup Wetlands), mostly due to overclearing (active and passive) and in the case of the upper catchment areas, the problems associated with groundwater rise and insufficient buffering. Representation is barely adequate in the middle Blackwood for wetlands and completely inadequate for streams, again due to overclearing and groundwater rise. Whilst significant bushland areas remain in the middle Warren, representation of wetlands is inadequate due to the curious block clearing of lakes and swamps (see Section 4).

There is a need to consider the rehabilitation and protection of representative wetlands within each of the natural resource zones at one level and within each of the major wetland groups at a lower level. However, for the Blackwood and Warren catchments there is little point in this exercise until the hydrology of cleared areas stabilises or is returned to something similar to the original balance.

Development pressure

In areas which are particularly scenic or which provide recreational amenity, there is increasing development pressure for tourism and rural lifestyles. Bridgetown, Busselton, Dunsborough, Margaret River and Augusta in particular are subject to heavy development pressure. Unfortunately, these areas by their very nature, usually have high environmental values, like the Busselton area which is growing rapidly around the Vasse-Wonnerup Wetland System. Thus arises the problem of balancing environmental conservation and management with the heavy demand for residential, industrial, tourism and other forms of commercial development. It should be noted that development opportunities and demands are not uniform across the region. The implication is that while development may degrade natural resource values in some "high demand" areas, there is much opportunity now to plan for the protection in areas which are not now subject to similar pressures.

Protection of important streams

A list of important streams in the Busselton-Walpole Region is given in Section 8.3. At least one system at each stream order between river and creek size, where nominations exist, should be managed to conserve the unique environmental values of near-pristine streams. The Commission will continue negotiations with CALM to ensure that a suite of environmentally sensitive streams is jointly recognised and managed appropriately. In some cases it may be possible to recognise more than one stream system, with differing degrees of environmental sensitivity, warranting different degrees of land use constraints. For example, the Shannon River, which is entirely within National Park will become increasingly significant and may be managed at a very fine level, such that existing structures on streamlines, like culverts, some types of bridges and weirs, are removed or modified to comply with the sensitive nature of the system and the very unique values it sustains. On the other hand, the neighbouring Deep River system may continue to be logged and gauged for flow, but may be excluded from large scale water supply development to maintain the high order stream values that are unique to that system, not only for the Shannon Basin, but for the entire south-west.

Protection of important wetlands

The environmental values of wetlands and their need for protection and management are well recognised by

CALM and the DEP, and it remains here only to discuss their management in terms of divertible water supply and the wise use of water resources.

The allocation of water resources to the growing horticultural developments on the Scott Coastal Plain could have serious impact on the important environmental values of the Hardy Inlet, Scott River, Gingilup Swamp and Lake Jasper systems; not from the abstraction of groundwater, but from the contamination of groundwater resulting from its use on heavily fertilized and porous sandy soils. Already much of the low lying coastal plain, including a large area to the north of Lake Jasper are drained by a network of artificial drains. Ultimately, nutrient rich groundwater will enter the Scott and Donnelly Rivers, possibly leading to nutrient pollution of the Hardy Inlet, if not also the Donnelly River estuary.

Protection of freshwater fish habitat

The most important habitats for freshwater fish species in the south-west lie within National Parks and State Forest of the karri forest and southern acid peat flats areas along the South Coast between Augusta and Walpole. Indeed most of the Shannon Basin, the most important area for the distribution of the smaller endemic freshwater fish species, is reserved within National Park and State Forest. However, as the experience on Lefroy Catchment shows, impoundments in conservation estate may constitute a serious threat to the survival of populations of some species. Therefore, until this issue is thoroughly explored and remedial measures developed, every precaution should be taken, in the placement of dams in conservation estate, to reduce the risk of inadvertently causing the extinction of local populations of freshwater fish.

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Appendix 1: River condition categories based on catchment condition

A. Conservation river reaches

A1. Pristine (e.g. wilderness area)

No catchment alteration and no artificial barriers across the connecting stream to the ocean or internal drainage lake system. The following has not occurred:

- significant change in fire frequency since European settlement
- track and road construction
- increased disease levels
- clearing
- introduction of foreign plants and animals
- building construction
- obstruction built across the downstream waterway
- alteration to landscape
- no upstream water abstraction

Example: No Pristine Rivers remain in the South West.

A2. Near pristine (i.e. large Conservation Reserves and distant NPs)

No significant extensive change in ecosystem function despite human activity within the catchment. For example, the river reach may support *Gambusia holbrooki*, an introduced fish, but all the native aquatic animal species remain. The following is characteristic:

- some increase in fire frequency
- some minor foot and vehicle tracks which are seldom used
- no increase in disease levels
- no logging or clearing has occurred
- some introductions of plant and animal species, not serious
- no building construction
- no obstructions placed along downstream waterways
- no alteration to landscape

Example: St Mary River, which is wholly contained within the Fitzgerald River National Park. Very few Near Pristine Rivers remain.

A3. Relatively natural (ie typical National Parks, State forest)

The catchment has been altered significantly, but is essentially dominated by native species. The following is characteristic:

- increased fire frequency
- tracks and gravel and sealed roads present which are often used
- disease levels may be increased
- logging and clearfelling may occur or have occurred within the last 100 years
- introduced plants and animals are present and may dominate in some areas
- some small buildings (i.e. toilet blocks, BBQs)
- obstructions may have been built across downstream waterways
- landscape may have been altered but still dominated by native species (ie altered size structure of trees due to logging)
- upstream water abstraction may be occurring

Example: The Shannon River.

B. Natural resource river reaches

B1. Relatively natural river section

In this category the river section lies within a reserve, but the upstream catchment has been significantly altered. Adjacent land has the character of a A3 catchment, but upstream the catchment may be partially or wholly cleared, support agriculture, plantations, urban development and mining or may be significantly degraded by weed infestation and disease or may have a water supply dam. The downstream waterway may have an obstruction. This type of river retains significant ecosystem and heritage value.

Example: Murray River in the Lane Poole Conservation Reserve.

B2. Corridor river

A corridor river reach, for the most part, retains natural vegetation along its immediate river valley or flood plain sufficient to provide a substantial area of habitat and ecological corridor to connect stands of remnant bush, either directly or via road and railway reserve corridors. Ideally it would be fenced off and managed. This type of river retains significant ecosystem and heritage value.

Example: The Kalgan River near Albany.

B3. Habitat river reach

A habitat river has been greatly impacted by upstream and adjacent landuse, but retains sufficient habitats to sustain viable populations of native plants and animals. There are typically large populations of weeds and introduced animals (ie *Gambusia*). This type of river reach generally requires management (mainly fencing) to maintain its habitat value. It may also have considerable landscape and cultural values.

Example: The Collie River Southern Branch south-east of the Town of Albany.

C. Multiuse river reaches

C1. Landscape river

The river has been heavily impacted by upstream and adjacent land use to the extent that most native plants and animals are extinct. However, important landscape components remain, such as river form (deep valleys, undulations), native trees and bodies of water, contributing to the character of the local area. Many native animal species may still make use of the river which is important to their conservation and recreational use may be an important to the local human community. As the river has been presumably subject to modern land use practices, it may have considerable cultural value.

Example: Avon River between Toodyay and Beverley

C2. Multiuse enhancement

Highly degraded streams in rural, rural/residential or residential land which have been or have some potential to be rehabilitated as part of the provision of local parkland or open space fall into this category. In other words the stream retains its natural form, though it is highly degraded. It would also include artificial drains which have been constructed and landscaped to appear creeklike and provide some aquatic habitat. These streams need not have significant natural resource value, but would have the potential to support some natural resource values, such as native plants and aquatic animals. In either case the local community would value the stream for parkland or open space.

Examples: Lower Southern River, Bassendean Main Drain, Karawarra Drain

C3. Drain

The stream has no value other than to convey water. It may be part of a drainage or irrigation scheme, it may be heavily eroded or completely channelised, lined with concrete or not and supporting a few remaining native trees and abundant weeds. If the drain had significant cultural values, other than water conveyance, these have disappeared with most of the natural resource values. The urban drain differs from the rural drain in that the range of impacts on the urban drain is greater, ie more weeds, vandalism, rubbish disposal, pollution, etc, and therefore management is more complicated.

Examples: Upper Kent River (agricultural drain) and lower Preston River (urban drain).

Appendix 2: International and National Recognition of Wetlands

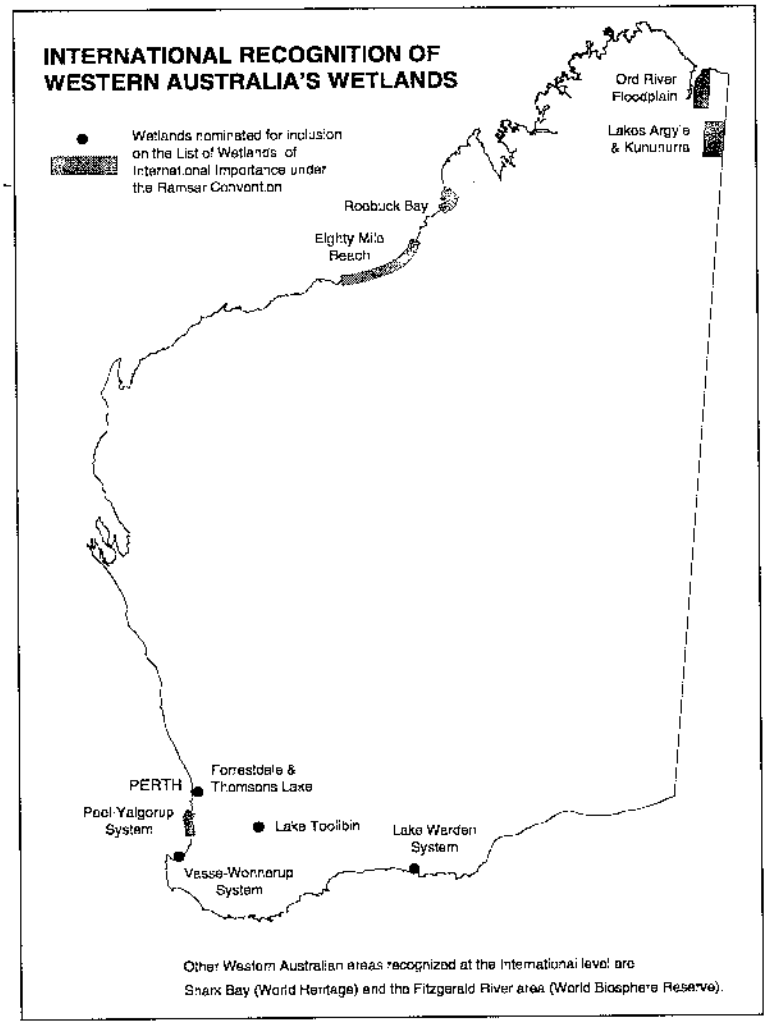
International Recognition

The Ramsar Convention

The Ramsar Convention was established in 1971 as the Convention on Wetlands of International Importance. The Convention promotes wetland conservation in a number of ways including:

- encouraging contracting parties to nominate sites to the List of Wetlands of International Importance, and thereafter monitoring and maintaining them is a way which retains their ecological characteristics;
- encouraging the development of national policies and management frameworks for Ramsar and other wetlands;
- the development of Guidelines for the Wise Use of Wetlands.

Australia is one of seventy countries which are party to the Convention, and has listed forty wetlands. Nine Western Australian wetland systems are included on the Ramsar List of Wetlands of International Importance.



A Description of Busselton-Walpole's Ramsar Wetlands

Lake Toolibin: The listed area includes Lake Toolibin and the surrounding bushland in Nature Reserve No. 24556 and Game Reserve No. 9617 south of the Wickepin-Harrismith Road.

Vasse-Wonnerup System: The Vasse-Wonnerup wetlands between Forrest Beach Road and the southern extension of Ford Road near Busselton, south Western Australia, consisting of Wonnerup Estuary, Vasse Estuary and Wonnerup Inlet.

National Recognition

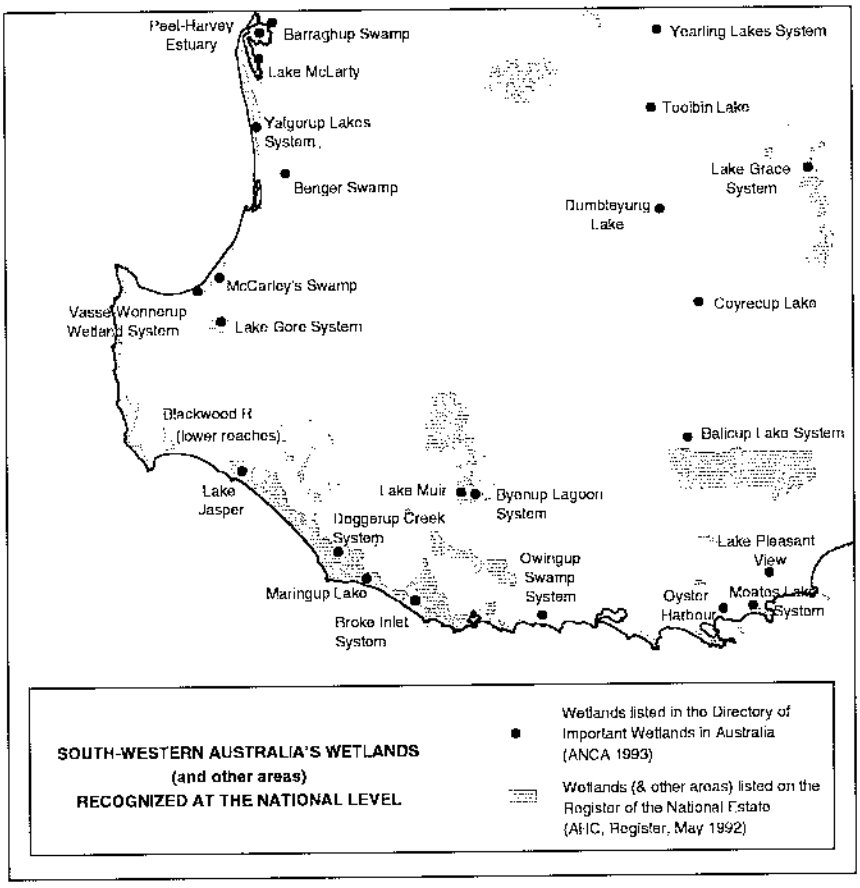
The Directory of Important Wetlands in Western Australia

The Directory provides the best national compilation available at present of Australia's important wetlands. It has been a co-operative project between the Commonwealth, State and Territory governments to promote the conservation and better management of Australia's wetlands. The criteria for determining "important" wetlands included representativeness, rarity, biodiversity, wetland functions and historic and cultural significance.

Eighty-eight wetland systems in Western Australia have been included in the National Directory. Those wetlands in southwestern Western Australia are shown on the map below (ANCA 1993).

The National Estate

The Register of the National Estate is a national list of all those parts of Australia's natural, historical and cultural heritage. The list is compiled and maintained by the Australian Heritage Commission. Areas of southwestern Western Australia listed on the Register of National Estate are shown on the map below.



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