GOVERNMENT OF WESTERN AUSTRALIA

A Systematic Overview of the Naturalness and Representativeness of Rivers and Creeks in the Perth to Bunbury Region

Water Resource Allocation and Planning Series

Water and Rivers Commission Report WRAP 8

1997

Water and Rivers Commission

WATER AND RIVERS COMMISSION

HYATT CENTRE
3 PLAIN STREET
EAST PERTH
WESTERN AUSTRALIA 6004

TELEPHONE (08) 9278 0300
FACSIMILE (08) 9278 0301

Cover Photograph:
Swan River in flood at Walyunga National Park.
Photograph by Alan Hill, July 1978.

A SYSTEMATIC OVERVIEW OF THE NATURALNESS AND REPRESENTATIVENESS OF RIVERS AND CREEKS IN THE PERTH TO BUNBURY REGION

by

Tanya Bosveld, Alan Hill, and Pen Luke

Water and Rivers Commission
Policy and Planning Division

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For more information contact:

Roy Stone, Water and Rivers Commission
Policy and Planning Division
Hyatt Centre, 3 Plain Street
EAST PERTH WA 6004

Telephone (08) 9278 0300

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Foreword

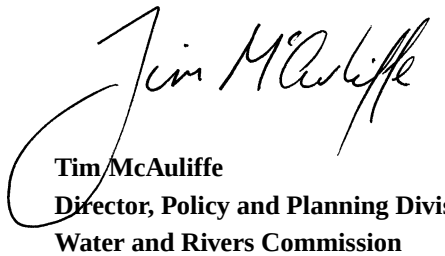
It is the vision of the Water and Rivers Commission to excel at water resource management by ensuring waters and rivers are used wisely by the community. The Water and Rivers Commission will manage the water resources of Western Australia for the benefit of present and future generations in partnership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

The Water and Rivers Commission is currently undertaking a series of studies aimed at developing a water resources allocation strategy for the regions into which the state has been divided for this purpose. Allocation is to be based on the ecological, cultural and water supply values and needs of the community.

Work to support water allocation in the Perth to Bunbury Region has been carried out between 1985 and 1997. As part of this Perth to Bunbury work, assessment of stream condition in the Perth to Bunbury Region was carried out to provide an identification of representative rivers and creeks that are of important natural value.

This report complements previous work and presents the results of the desk top study which has described the naturalness and representativeness of streams in the Perth to Bunbury Region. Using the condition assessment results, stream sections and whole stream systems were nominated as important on the bases of naturalness, representativeness and system size. The results of this study provide valuable information to those involved in the planning, protection and management of waterways.

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 inform 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
Water and Rivers Commission

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Summary

This study was undertaken to nominate stream systems in the Perth to Bunbury Region as important on the basis of naturalness, representativeness, and system size within natural resource zones. A desktop study was carried out to describe the environmental condition of the Region's rivers and creeks on the basis of the natural condition of their channel and catchment.

A Regional Allocation Plan is being developed for the Perth to Bunbury Region (see Figure 1.1) to guide the allocation, planning and management of these resources to the various forms of use that society requires of them, both now and in the future. Allocation is to be based on the ecological, cultural and water supply values and needs of the community. Various studies have been undertaken to review the significance of the above values for the water resources in the Perth to Bunbury Region.

Rivers and creeks of important natural value need to be identified and highlighted in part to meet and uphold international, national and state conservation strategies. This useful information can then be used to encourage and prioritise management which will conserve their natural heritage values. Research to identify important rivers and creeks has been undertaken in the Perth to Bunbury and Busselton-Walpole Regions, and proposed for the Denmark-Esperance Regions, and the catchments which drain to the sea between Perth and Geraldton.

The main objective of the present study was to clearly identify representative rivers and creeks in the Perth to Bunbury Region that are of important natural value. In order to determine the environmental condition of streams in the Perth to Bunbury Region a desk top study was undertaken using 1:25 000 orthophotographs and 1:100 000 satellite imagery. The stream condition assessments were based on the condition of the vegetation in the stream catchment. Maps of the Region showing stream condition assessments have been prepared at a scale of 1:250 000 scale. Using the evaluation results, stream sections and stream systems were nominated as important on the bases of naturalness, representativeness and system size within natural resource zones (see Figure 4.1).

The results of this study provide valuable information to those involved in the planning, protection and management of waterways. The results of this study should be used to encourage and prioritise management which will conserve the natural heritage of streams in the Perth to Bunbury Region.

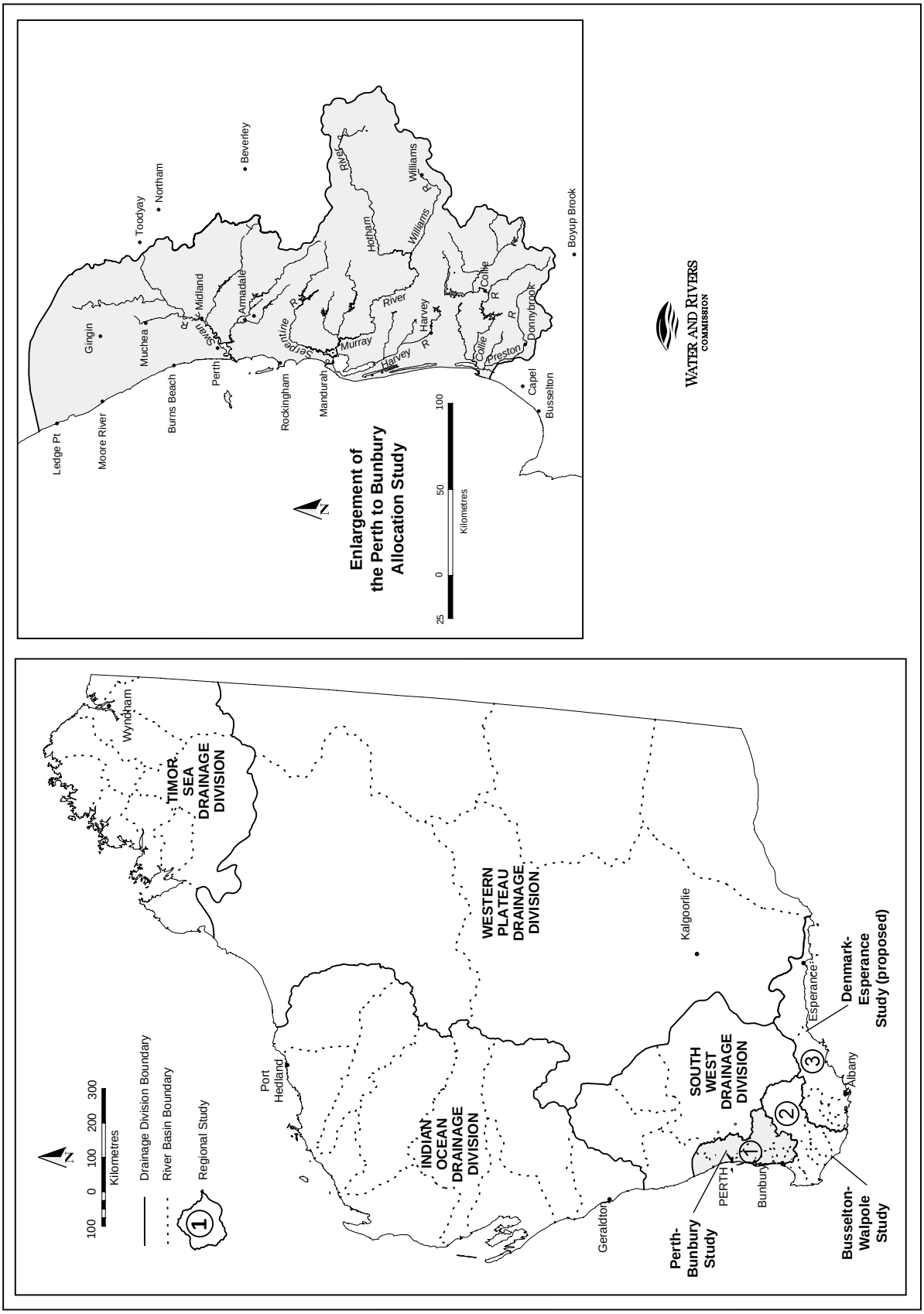


Figure 1.1: Water Resource Regions for regional water resource allocation in Western Australia

1. Introduction

1.1 Rationale

Two priority objectives have been outlined for water resource management in Western Australia (WAWRC 1991). Firstly, water resource management must aim to provide for the essential needs of the individual and society for water while ensuring that water resources are used on a sustainable basis. Secondly, water resource management must also aim to uphold the principles of world, national and state conservation strategies to maintain essential ecological processes and life support systems, preserve genetic diversity, and ensure the sustainable use of species and ecosystems (WAWRC 1991). In order to meet these objectives a process is being developed involving three tiers: regional allocation planning, use and protection planning, and use and protection management.

A Regional Allocation Plan is being developed for the Perth to Bunbury Region (Figure 1.1) in order to review the water resources of the Region and guide the allocation of these resources to the various forms of use that society requires of them, both now and in the future. Allocation is to be based on the ecological, cultural and water supply values and needs of the community. Various studies have been undertaken to review the significance of the above values for the water resources in the Perth to Bunbury Region.

In order to meet the second water resource management objective, rivers and creeks of important natural value need to be identified and highlighted. This information can then be used to encourage and prioritise management which will conserve their natural heritage values.

1.2 Study objectives

The objective of this study was to identify, at a regional level, representative rivers and creeks of the Perth to Bunbury Region that are of important value and regional significance, based on an assessment of naturalness.

The study involved defining river types, assessing their general condition and determining which rivers represent the best examples of type and ultimately what levels of protection are needed to ensure their conservation. Similar regional level work has been undertaken in the Busselton-Walpole Region (Pen 1997), and is proposed for the Denmark-Esperance Region and in the catchments which drain to the sea between Perth and Geraldton. It is hoped that by the end of these studies all the river types of the south-west will be identified, along with those which are poorly represented in reserves and those which represent important examples of type.

1.3 Aims of this study

The aims of Phase 1 of the study were as follows:

1. to describe the environmental condition of stream systems in the Perth to Bunbury Region;
2. to produce maps of the Region showing stream condition evaluations; and
3. to nominate whole stream systems and stream sections as important on the bases of naturalness, representativeness and stream size within natural resource zones.

1.4 River systems in the Perth to Bunbury Region

The Perth to Bunbury Region covers six (two in part only) river basins of the South West Drainage Division. These have been numbered by the Australian Water Resources Council (AWRC) as part of national system of river basins and drainage divisions (PWD 1984). The river basins in the Perth to Bunbury Region include the lower part of the Moore (part of basin 617), the lower catchment of the Swan/Avon (basin 616) and the whole of the Murray (basin 614), Harvey (basin 613), Collie (basin 612) and Preston River (basin 611) Drainage Basins. These basins are shown in Figure 1.2. In all they cover an area of 27 700 km^2 and drain to the west coast.

The character of a river is determined by a combination of its volume of flow, width, bed-slope, streamside vegetation and landform or topographic features. The Perth to Bunbury Region is characterised by a variation of natural vegetation due to declining rainfall inland and variation in soil type. Rainfall ranges from between 800 to 1300 mm between the coast and the Darling Range, to

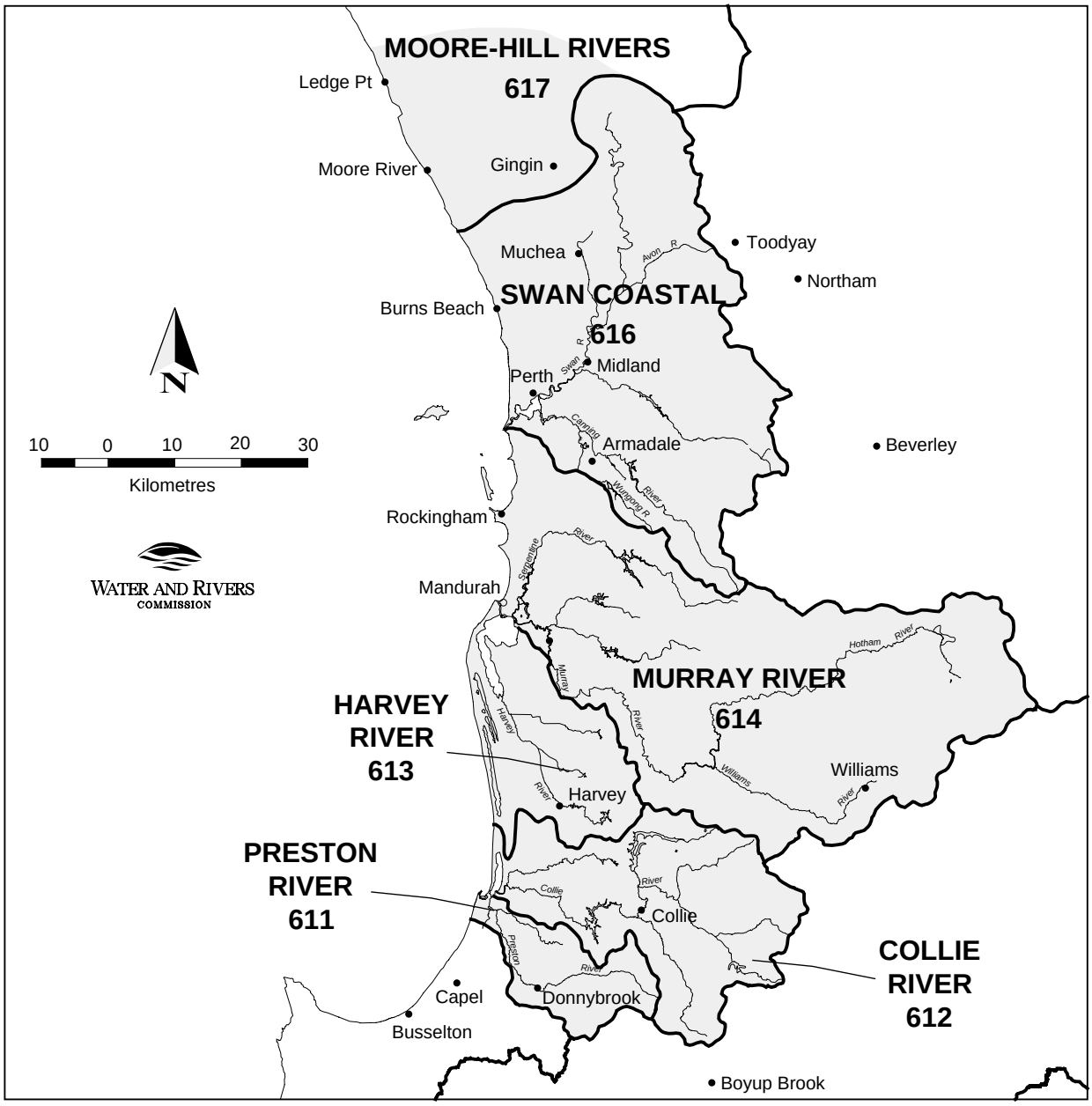


Figure 1.2: Major drainage basins of the Perth to Bunbury Region

less than 500 mm at the eastern most edge of the Murray catchment.

The longer rivers, such as the Avon River, begin on inland parts of the Yilgarn Plateau (east of the Perth to Bunbury Region) where rainfall is less than 350 mm and drainage patterns are almost invisible (Beard 1981). Towards the western coast, the plateau gently slopes relatively downwards and receives low rainfall and the watercourses are intermittent, flowing through broad flat valleys. From the inland areas to the eastern edge of the Darling Ranges the vegetation changes from mallee (annual rainfall less than 400 mm) to woodlands of York gum (*Eucalyptus loxophleba*) and salmon gum (*E. salmonophloia*) (annual rainfall 400-600 mm) to marri (*E. calophylla*) and wandoo (*E. wandoo*) woodlands (Beard 1981).

At the western edge of the Yilgarn Plateau the rivers are rejuvenated by uplift along the Darling Fault. Here the rivers flow through the steep forested valleys of the Darling Ranges. Owing to the Mediterranean climate of the south west, river flow is seasonal being strong during winter and minimal in summer. Long sections of rivers dry up to a string of pools when flow ceases in summer. The western edge, just inland from the Darling Scarp, receives the highest and most reliable rainfall and the lateritic soils support medium height forests of marri and jarrah (*E. marginata*). Here, a number of permanent

streams may maintain a trickle of flow along the rivers during the dry summer months. The westward flowing rivers drop down from the Yilgarn Plateau to the coastal plain over the steep Darling Scarp, often cutting deep into their granitic or doleritic bedrock.

As the river systems cross the sedimentary coastal plain the gradients are slight, causing the drainage patterns to be sluggish and serpentine. The natural vegetation of the coastal plain is characterised by low banksia (*Banksia sp.*) woodland on the deep sands, by jarrah and tuart (*E. gomphocephala*) woodlands, and scrub-heath towards the northern end. The river systems in the Perth to Bunbury Region drain naturally into the ocean via estuaries or inlets.

Many of the Region's rivers and creeks have been dammed to the east and upstream of the Darling Scarp to provide public water supply. Although these large reservoirs have reduced the natural value of the downstream reaches, they have also ensured high protection of the upstream catchments.

Many of the rivers and creeks on the coastal plain have been highly modified and degraded by urban and rural development. The coastal plain catchment is largely cleared. Many rivers and creeks that pass through urban areas have been modified into drains. Rural streams have often been modified by connecting them to networks of drains and irrigation channels. However, there are areas of streamline which retain considerable and quite valuable remnant vegetation.

The rivers and creeks that rise to the north and east of the Darling Range and state forests have suffered greatly from extensive clearing and agricultural activities. The removal of vegetation over huge areas has caused problems such as salinisation, soil erosion and stream sedimentation. In addition, clearing has increased catchment run-off, possibly causing increased flood intensity relative to rainfall. This has led to large river "training" programs, greatly modifying the river character by removing natural obstacles to flow.

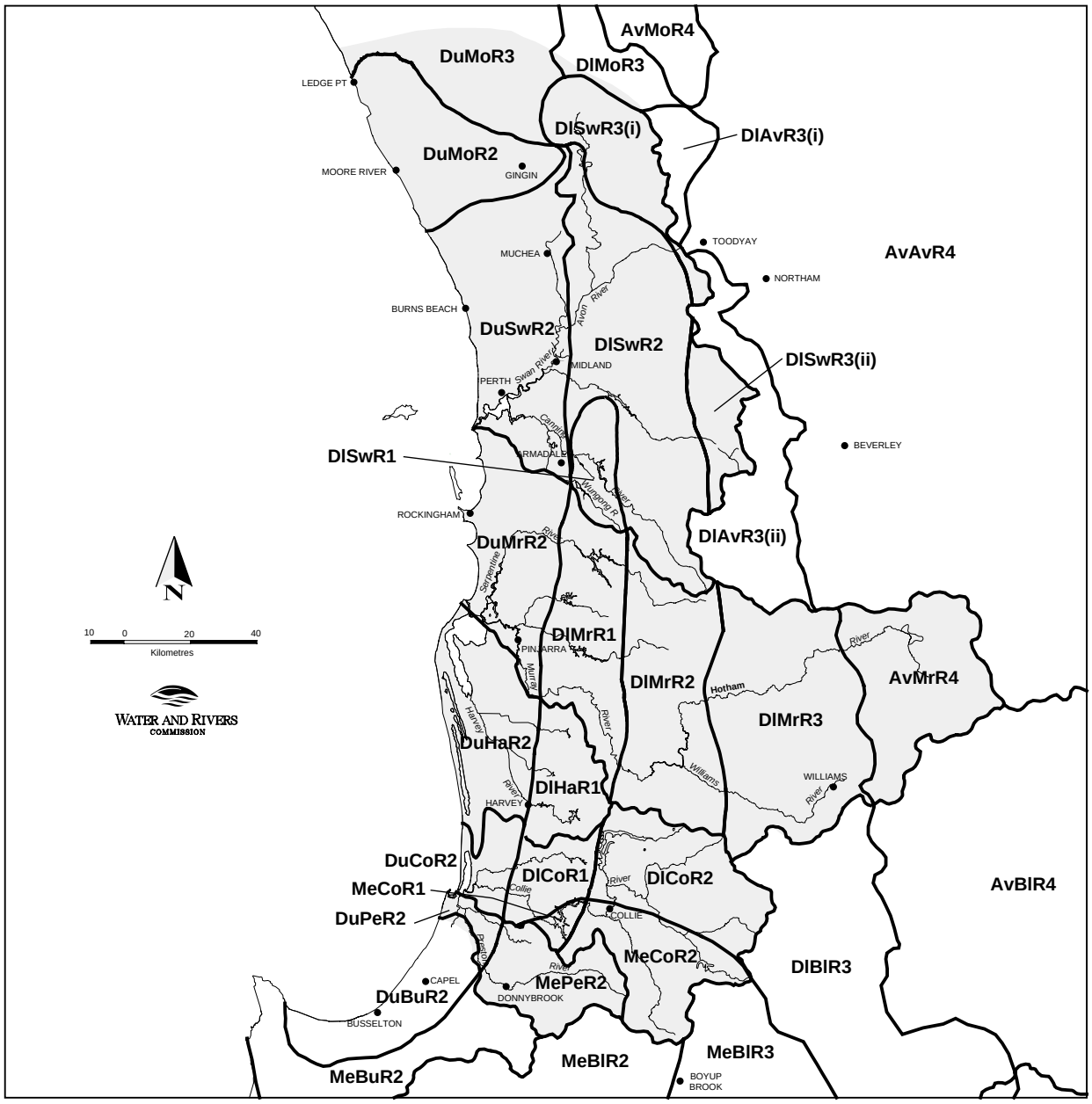
1.5 Natural Regions and Natural Resource Zones

On the bases 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 Perth to Bunbury Region. 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 Warren subdistrict is not within the Perth to Bunbury Region. The Avon Botanical district covers the upper catchment of the Hotham River. The result is four natural regions which cover the Perth to Bunbury Region.

For the south-west region, Beard's natural regions have been combined with water resource drainage basins (see Section 1.2) and the 1100 mm, 700 mm and 500 mm rainfall isohyets to create natural resource zones (Allison et al. 1993). In all 21 Natural Resource Zones (NRZs) constitute the Perth to Bunbury Region. They are shown in Figure 1.3 and listed in Table 1.1. These zones will be used throughout this report as the key sub-divisions of the study area, especially in the identification of representative rivers and creeks.

Table 1.1 Natural resource zones of the Perth to Bunbury Region (Allison *et al.* 1993).

Zone no.	Zone code	Botanical district (Natural region)	Drainage basin	Rainfall band (mm)
15	MePeR2	Menzies (Southern Jarrah forest)	Preston	700-1100
16	MeCoR1	as above	Collie	>1100
17	MeCoR2	as above	Collie	700-1100
31	DlSwR1	Dale (Northern Jarrah forest)	Swan Coast	>1100
32	DlSwR2	as above	Swan Coast	700-1100
33	DlSwR3(i)	as above	Swan Coast	500-700
34	DlSwR3(ii)	as above	Swan Coast	500-700
35	DlMrR1	as above	Murray	>1100
36	DlMrR2	as above	Murray	700-1100
37	DlMrR3	as above	Murray	500-700
38	DlHaR1	as above	Harvey	>1100
39	DlCoR1	as above	Collie	>1100
40	DlCoR2	as above	Collie	700-1100
45	DuPeR2	Drummond (Swan Coastal Plain)	Preston	700-1100
46	DuCoR2	as above	Collie	700-1100
47	DuHaR2	as above	Harvey	700-1100
48	DuMrR2	as above	Murray	700-1100
49	DuSwR2	as above	Swan Coast	700-1100
50	DuMoR2	as above	Moore/Hill	700-1100
51	DuMoR3	as above	Moore/Hill	500-700
61	AvMrR4	Avon (Wheatbelt)	Avon	<500



Note : Natural Resuource Zone Codes - the first two characters show the native vegtation 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
	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

River Catchment/Drainage Basins

Co	Collie River
Ha	Harvey River
Mo	Moore-Hill Rivers
Mr	Murray River
Pe	Preston River
Sw	Swan Coast

Rainfall Zones

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

Figure 1.3: Natural Resource Zones of the Perth to Bunbury Region (after Allison *et al.* 1993)

1.6 Use of results

The products of Phase One of this study are twofold: firstly, identification of important stream systems and sections and, secondly, an evaluation of the environmental condition of rivers and creeks in the Perth to Bunbury Region. Both of these provide valuable information to those involved in the planning, protection and management of waterways. The results of this study should be used to encourage and prioritise management which will conserve the natural heritage of streams in the Perth to Bunbury Region.

Water resource management in Western Australia reflects the principles of the world, national and state conservation strategies to maintain essential ecological processes and life support systems, preserve genetic diversity, and ensure the sustainable use of species and ecosystems (WAWRC 1991). The important streams nominated in this study were identified to meet these aims. The results of this study will be incorporated in Regional Water Resource Allocation Plans prepared by the Commission to help guide the future allocation of water resources.

Important streams and stream sections identified in this study should, where possible, be protected in the conservation for reserves process, and/or included in Environmental Protection Policies (EPPs) and State Planning Policies (SPPs) or through other protection processes.

The condition assessments can be used to describe management categories and management priorities for streams in the Perth to Bunbury Region (see Appendix 1). The conservation category streams should, where possible, be protected in the conservation through reserves process of the Second stage of the System 6 update program (see also Appendix 1).

The streamline condition data could also be used as input into the Commission's proposed foreshore reserves policy, where the condition of a watercourse reserve might guide its reserve classification and management.

The information on stream condition and important representative sections of streams presented in this report may also be useful to local government authorities in their preparation of District Conservation Strategies. Town planners can make use of the information presented in this report when implementing water sensitive urban design and strategic drainage planning.

1.7 Relationship to Previous Detailed Work

The information presented in this report complements a number of previous more detailed and other regional studies that included assessment and a preliminary identification of environmentally significant wetlands (including rivers) in the Perth to Bunbury Region.

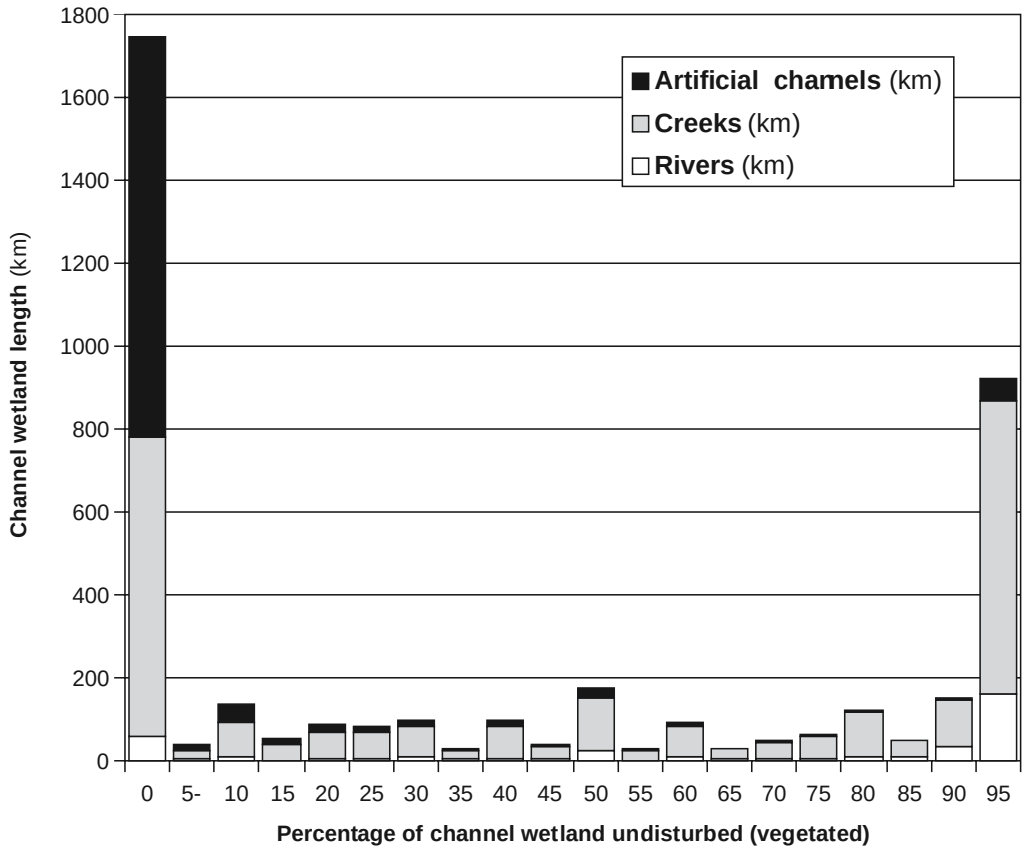
In 1991, an assessment was made of the naturalness of the wetlands in greater Perth Metropolitan Region (Moore River to Mandurah) using expert assessments from aerial photographs of the percentage of the wetland which is vegetated and undisturbed (Hill *et al*. 1996). The results of this assessment for channel wetlands are summarised in Figure 1.4.

This method of assessing stream condition differs from the present study in that it did not include a consideration of the catchment condition upstream of the segments. The present study complements this study in that it covers the entire Perth to Bunbury Region, while the 1991 naturalness assessment was limited to the Darling Scarp, Dandaragan Plateau and Coastal Plain areas from Moore River to Mandurah.

A preliminary identification of environmentally significant wetlands (including rivers) in the Perth to Bunbury Region was carried out by LeProvost, Semeniuk and Chalmer (1987). This appraisal reflected the knowledge of eleven groups or individuals expert in different and various fields of wetland ecology.

The stream condition assessment presented in this report provides additional information on rivers and creeks. Many of the stream systems nominated in the present study, especially those with well vegetated catchments, were also identified in the 1987 assessment. Other important streams identified in the present study should also be considered to be regionally significant and supplement the 1987 assessment.

Wetlands and rivers which are important for recreation (Feilman Planning Consultants 1987), Aboriginal significance (O'Connor *et al.* 1989), educational and scientific use (Coffey *et al*. 1990), and historical association (Lund and Martin 1996) have been identified in the Perth to Bunbury Region through a number of regional studies. The results of these studies have helped to guide and complement the draft regional allocation plan prepared for the Perth to Bunbury Region (WAWRC 1991).



1. Assessment dated mid-1992.
2. 45% of Wedge Island to Mandurah's channel wetlands assessed.

Figure 1.4: Summary of Channel Wetland Vegetation Status (Naturalness) Assessment after Hill *et al*. (1996).

2. River and creek evaluation

2.1 Basic method

2.1.1 Phase One

Phase One of the study consists of two parts: firstly, assessment of river and creeks on the basis of the vegetation condition of their catchments; and secondly, nominations of important stream systems on the bases of naturalness and representativeness. This document presents the results of Phase One of the study.

Condition Assessment

The study began with a broad survey of the rivers and creeks of the south-west using orthophotographs (at 1:25 000 scale, dated between August 1991 and February 1994), satellite imagery (image capture dated between February 1988 and February 1989) and topographic/ cadastral maps (at 1:100 000 to 1:50 000 scale) to evaluate all streams shown on 1:250 000 AUSLIG topographic maps on the basis of the condition of their catchments. The Perth to Bunbury Region was largely evaluated using 1:25 000 orthophotographs. The correspondence and accuracy of the results of evaluations using differing scales of photography has been compared in Appendix 2. The results of the condition assessment is presented in Chapter 3.

Stream condition evaluations in the Perth to Bunbury Region have been presented on maps using 1:250 000 scale streamlines and are available in digital and hardcopy form. In this report the stream condition evaluations have been presented by drainage basin at varying scales.

Information collected during this study, together with the results of the condition assessments have been collated in a spreadsheet (Microsoft Excel). All named streams have been included in the spreadsheet and the streams have been classified according to system size and their relationship to the larger system size that it belongs to. For example, it begins with a river where it discharges into the ocean and as you go upstream each tributary system is detailed according to system size. For each entry information on receiving waterbodies, natural resource zones, stream condition evaluation, dams and gauging weirs have been noted where relevant. The information collected, for some of the fields, is not necessarily complete but includes the best available data that was necessary for this study. A similar spreadsheet has been prepared for the streams in the Busselton-Walpole Region and a preliminary spreadsheet containing only a classification of streams has been prepared for the Denmark to Esperance Region.

Important stream nominations

The condition assessments were used to nominate stream sections or whole stream systems which have important natural value. Important representative streams were nominated for each natural resource zone by system size. The important streams in the Perth to Bunbury Region are described in Chapter 4. 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; firstly, where only one system of a certain size exists within a biogeographic region and, secondly, where an important candidate contains important streams of a smaller size. Therefore, where only one candidate 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 stream not only pertain to its catchment but also to the quality of the larger stream system to which it is connected. Therefore, a stream 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 importantly 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 representative stream system may be considered to contain smaller important stream systems, thus obviating the need for further searching for smaller systems 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. Only when more than one system is nominated, will the more detailed work of Phase 2 be required to identify which one is the more important.

2.1.2 Phase Two

Where more than one nomination of a stream of a particular size and natural resource zone is made, more detailed information is needed to determine which of the systems is the more important and if there are real differences. This information includes the following:

Positive:

- Vegetation associations
- Habitat types — pools, riffles, runs, flood plain, associated swamps
- Presence of unique habitats and rare species
- Natural obstructions — cascades, waterfalls

Negative:

- Roads and tracks
- Artificial stream obstructions — dams, weirs, culverts, etc
- Recreational sites — camping, picnicking, boat launching
- Fire and logging history
- Disease areas
- Presence of developments

This information can be obtained from maps and orthophotomaps at 1:25 000 and 1:50 000 scales and from generally available digital spatial information from CALM, DOLA and AUSLIG.

Table 2.1 Whole stream systems of the Perth to Bunbury 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 (> 8000 km^2)	Large (2000-8000 km^2)	Medium (750-2000 km^2)	Small (350-750 km^2)	Major creek (90-350 km^2)	Creek (30-90 km^2)	Minor creek (< 30 km^2)
Stream systems which flow to the sea or to an inlet	Moore Avon	Murray Collie	Canning Serpentine Harvey Preston			Bull Creek Coolup Main Drain "Brunswick Drain" Mayfield Drain	"Lakes Drain"

Table 2.2 River types of south-west Western Australia (after Williams in WAWRC 1992)

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. Murray River).
T2	Medium length rivers originating in the medium rainfall marri/wandoo woodlands and taking a westward course (e.g. Collie 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).
T4	Rivers of the coastal plain flowing largely through low jarrah forest such as the sunklands with high rainfall (e.g. Brockman River).
T5	Coastal plain rivers flowing through tuart/marri woodlands receiving medium to high rainfall (e.g. Ellen Brook).
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).
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).
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).
T10	Shorter rivers contained more or less entirely within medium rainfall low jarrah and jarrah/marri forest or wandoo woodland (e.g. Denmark River).
T11	Short ephemeral rivers flowing south through mallee heath following intensive but infrequent rainfall events (e.g. Young River).

Catchment assessment would also involve a field component, using a method of stream habitat assessment developed in Victoria and modified for south-west Western Australian conditions. This method is still in a developmental stage, but is described in Appendix 2 in Pen and Scott (1995). Field inspections would be done at selected points on the stream system, mainly where access is readily available.

The results of the second phase of the study will be reported separately.

2.2 Stream system size

Stream system size was divided into seven general size categories (See Appendix 3 for streamsize guidelines and catchment size). These are listed in Table 2.1 along with whole stream systems that fall into each respective category.

2.3 Stream types and representativeness

Whole river systems, as opposed to small creek size systems, were categorised using the classification first outlined in The State of the Rivers of the South West publication (WAWRC 1992). These types are described in Table 2.2.

Stream systems were divided into types on the bases of size (Section 2.2) and the general location of their catchments in relation to the natural resource zones (equivalent to biogeographic zones) as defined by the Allison *et al*. (1993) (See Figure 1.3). Representativeness of whole systems and stream sections will be on the basis of natural resource zones.

2.4 Method of evaluation

The approach of the study was to identify the best (i.e. most natural and representative) whole stream systems and sections of streamline in each natural resource zone in the Perth-Bunbury Region. River sections were evaluated in a hierarchical fashion, from least disturbed to most disturbed, into the following groups:

A. Conservation river reaches

A1. Pristine (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:

- increased fire frequency since European settlement
- track and road construction
- logging and 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 National Parks)

No significant extensive change in ecosystem function despite human activity within the catchment. For example, the river section 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: None in Perth to Bunbury Region. Denmark-Esperance Region contains St. Mary River, which is wholly contained within the Fitzgerald River National Park. Very few Near Pristine Rivers remain.

A3. Relatively natural (i.e.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 (i.e.altered size structure of trees due to logging)
- upstream water abstraction may be occurring

Example: The upper Serpentine River.

B. Natural resource river reaches

B1. Relatively natural river section

In this category the river section lies within a reserve or large private bush block, 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 section retains significant ecosystem and heritage value.

Example: Murray River in the Lane Pool Conservation Reserve.

B2. Corridor river

A corridor river section, 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 lower 40 km of the Kalgan River near Albany.

B3. Habitat river section

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 (i.e. *Gambusia*). This type of river section generally requires management (mainly fencing) to maintain its habitat value. It may also have considerable landscape and cultural values.

Examples: The Collie River Southern Branch south-east of the Town of Collie, Hotham River.

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. 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. Multiple use 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. 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 limited 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, i.e.more weeds, vandalism, rubbish disposal, pollution, etc, and therefore management is more complicated. There is significant potential for improvement of these channels to provide other benefits using the principles of water sensitive design.

Examples: Lower Harvey River (agricultural drain) and lower Preston River (urban drain).

3. State of the rivers and creeks

3.1 Lower Moore River (DuMoR2, DuMoR3)

The Perth to Bunbury Region includes the part of the lower Moore River which is downstream from the Brand Highway Bridge. The lower reaches have important cultural and landscape values. The condition assessment of the Lower Moore River is shown in Figure 3.1. The lower Moore River mainly passes through cleared land, although much of this river stretch is lined with remnant vegetation. The understorey has been removed in many places, and much of the land is grazed to the river's edge. Much of the Upper Moore River catchment has been extensively cleared and the lower Moore River receives a high sediment loading from these cleared upstream areas. Drains or channels have been dug in many of the wetland areas on this part of the coastal plain and levee banks have been placed along the river on the eastern side to reduce flooding.

Gingin Brook joins Moore River at the head of the Moore River Estuary. The Gingin Brook catchment is dominated by cleared farmland, with remnant vegetation lining much of the main channel, producing stream evaluations as high as A3 and B1 but generally between B3 and C3. Many of the minor tributary creeks that pass through cleared private land have almost no remnant vegetation at all and are just bare and degraded watercourses (C1-C2), while others have been modified into drains and channels (C3). Boonarring Brook (A3-C1) has its headwaters in an area of remnant bushland (A3) and its downstream area passes through a mosaic of remnant bushland and cleared farmland with a vegetated buffer zone. Red Gully Brook (B1-C2) passes through a mosaic of remnant natural bushland and cleared farmland and discharges its water into a large wetland area, as does Whitefield Brook, an intermittent watercourse flowing through a system of wetlands, partly within the Moore River National Park. The upper section of Quin Brook (also known as Wanneroo Brook) passes through natural bushland (B1), much of it in large wetland areas.

3.2 Swan Coastal Drainage Basin (DuSwR2, DlSwR1, DlSwR2, DlSwR3(i) and (ii))

The Swan Coastal Drainage Basin is made up of the Swan River Estuary and its tributaries: the Swan/Avon, the Helena, and Canning Rivers. The condition of streams in the Swan Coastal Drainage Basin is shown in Figure 3.1.

3.2.1 Swan/Avon River below Toodyay (DuSwR2, DlSwR2, DlSwR3(i))

The condition of the Swan/Avon River was evaluated downstream from the township of Toodyay. Here the river system mainly drains cleared farmland, and also some state forest and conservation reserves. The catchment of the Avon River upstream from Toodyay has been extensively cleared and dominated by agricultural land uses.

Downstream from Toodyay, a stretch of the Avon River drains some cleared farmland before it passes through a long stretch of mainly forested valley, until it flows down onto the coastal plain, and becomes known as the Swan River. The stretch of river between Julimar Brook and Wooroloo Brook (Gidgegannup Branch) passes through the Avon Valley and Walyunga National Parks, corridors of natural bushland and a few areas of cleared land. A railway lines follows the river along the southern side. Many of the tributaries feeding into this stretch of river drain a mixture of cleared farmland and remnant bushland (A3-B3-C2), although the tributaries between Julimar (A3-B3-C1) and Moondyne Brooks are A3, draining National Park and remnant bushland.

The medium size Brockman River, flows into the Swan/Avon a little downstream of Wooroloo Brook (A3-C2). The Brockman drains a catchment that is mainly cleared farmland, and many of the watercourses are lined with remnant vegetation or trees (B3-C1). Some of the tributaries have been totally cleared of any remnant vegetation and others have been modified into drainage systems (C2-C3). The upper reaches of the creeks which drain the Darling Range are in A3-B2 condition. The upper Wootra Brook is mainly A3, with a little B1 due to clearing in the catchment, and is within a large

Commonwealth Army Training Area. The upper Spice Brook (A3- C2) is within a large area of natural forest reserved as a conservation park. A few small areas of cleared private land (B3-C2) surrounded by conservation park have reduced the habitat value of forested downstream reaches.

The main channel of the Swan River has very few large areas of natural bushland, although areas of remnant vegetation line parts of the river. Ellen Brook drains a catchment which is mainly cleared (B3-C3), although it has a number of areas which have considerable remnant vegetation in good condition. Susannah (B2-C1) and Jane (A3-C1) Brooks drain the Darling Scarp and coastal plain. Both of these tributaries have their middle reaches in natural bushland areas (Jane Brook passes through John Forrest National Park) and their upper and lower reaches drain a mixture of cleared private land, urban areas, remnant vegetation and partly cleared land. Bennett Brook drains a mixture of urban and rural landuses but still largely supports good stands of remnant vegetation, its condition mainly B3 with some C1 areas.

3.2.2 The Helena River
(DuSwR2, DlSwR1, DlSwR2, DlSwR3(ii))

The medium size Helena River drains an area largely comprised of state forest, together with areas of cleared private land. The Helena River has been dammed by Mundaring Weir, and downstream areas receive a diminished flow. The stretch of river between the weir and the pipehead dam passes through natural vegetation (B1-B3), although some of the tributaries pass through areas of cleared private land or pine plantation. Downstream from the pipehead dam the Helena River flows across the coastal plain through a mixture of urban and agricultural landscapes (B3-C2), with much of the streamline being buffered by remnant vegetation.

Upstream from Mundaring Weir the upper Helena River and its major tributary Darkin River pass largely through state forest. The catchment of the upper Helena is mainly state forest (A3-B1) with a number of pine plantations (B3-C1) and a number of cleared alienated lands (C1-C2). The catchment of the Darkin River (A3-C2) and its tributaries is almost entirely forested except for a small area of cleared farmland near its headwaters, and some pine plantations.

3.2.3 The Canning River
(DuSwR2, DlSwR1, DlSwR2)

Although a large part of the Canning River catchment is within state forest, the habitat value of these reaches is compromised by the four large reservoirs on the Canning River and three of its tributaries: Munday, Churchmans and Wungong Brooks. The entire catchment of the streams upstream from these four reservoirs is within state forest, and the streams are mainly in A3 condition. However, a small area of pine plantation (B3-C1) along the upper Canning River has reduced the habitat value of downstream reaches, as has bauxite mining operations in the upper Wungong Brook catchment (B1-B3). The reaches of the river and tributaries downstream from the reservoirs pass firstly through areas of native vegetation and then through mosaics of public land, cleared rural and urban land on the coastal plain, with habitat ranges from remnant bushland to grassed parklands and grazed pastures.

3. 3 Murray River Basin
(DuMrR2, DlMrR1, DlMrR2, DlMrR3, AvMrR4)

The Murray River Basin is made up of three river systems which flow into Peel Inlet, and out to sea near Mandurah: the Murray, the Dandalup, and the Serpentine Rivers. The condition of streams in the Murray River Basin is shown in Figure 3.2.

3.3.1 The Murray River and its tributaries
(DuMrR2, DlMrR1, DlMrR2, DlMrR3, AvMrR4)

The Murray River has two main tributaries: the large Hotham River and the medium size Williams River, both of which begin in the low rainfall areas which have been extensively cleared for cereal cropping and grazing. The main channel of both the Hotham and the Williams Rivers are mostly lined with remnant vegetation (B3-C1). The condition of the tributaries in the cleared farmland range between B3 and C2. There are few areas of natural bushland catchments remaining along both the Hotham and the Williams, apart from a few areas of state forest (A3-B2) along upper Bannister River and Gringer Creek, and upper Old Stockyard Brook.

The Murray River (A3-C3) begins at the confluence of the Hotham and Williams Rivers and much of the catchment is CALM land (A3-B2), with a number of pine plantations (B3-C1) and areas of cleared private land (B3-C2), until the river reaches the coastal plain. The main channel of this section of the Murray River passes through Lane Poole Reserve and the tributary Bell Brook (A3) is largely within the part of Lane Pool Reserve which has recently become part of a National Park. Although the section of the Murray River which flows across the coastal plain passes through cleared private land, the main channel retains much remnant vegetation in reasonable condition (B3-C1) and has never been trained. The tributaries flowing into this section of the Murray River drain the Darling Scarp and a number of the headwater regions are within state forest. However, many of the tributaries in this part of the catchment are in very poor condition (C1-C3).

3.3.2 The Dandalup River (DuMrR2, DlMrR1, DlMrR2)

The two short rivers, the South and North Dandalup Rivers, drain the state forest areas of the Darling Scarp, the water of which is captured by two reservoirs and a pipehead dam: the North Dandalup Dam, the South Dandalup Dam and the Conjurunup Pipehead Dam. The state forest areas upstream from the reservoirs is mainly in A3 condition, with parts of upper Conjurunup Creek and South Dandalup Dam tributaries being in B2 condition, due to bauxite mining operations in their catchments. The sections of the North and South Dandalup Rivers downstream from the reservoirs and on the coastal plain pass through cleared private land with very little remnant vegetation and are in very poor condition (C1-C3) before joining the Murray River between Pinjarra and Ravenswood.

3.3.3 The Serpentine River (DuMrR2, DlMrR1, DlMrR2)

The catchment of the Serpentine River system can easily be divided into two areas: the area upstream of the Serpentine Pipehead Dam and Reservoir and the area downstream on the coastal plain. The upper Serpentine River upstream of the Serpentine Reservoir is almost entirely within A3 condition state forest, with one small upper part of a tributary in buffered pine plantation. The section of the Serpentine River between the pipehead dam and the reservoir is within the Serpentine National Park, with A3 condition tributaries. The Gooralong Brook passes through a mosaic of state forest (A3-B1), pine forest (B3) and cleared private land (C1-C3). Downstream from the pipehead dam the Serpentine River flows down the Darling Scarp through Serpentine National Park and then meanders across the coastal plain to enter Peel Inlet. The coastal plain sections of the Serpentine River have been severely modified by training and extensive drainage systems (C3) which flow into the river. The tributary Folly River has also been severely trained and modified into a drainage network. Only two areas of remnant vegetation (B3) remain along the Folly and Maramanup Pools. The lower section of the Serpentine River passes through a series of wetlands which have not been drained and retain considerable remnant vegetation, before discharging into Peel Inlet.

3.4 Harvey River Basin (DuHaR2, DlHaR1)

The condition of streams in the Harvey River Basin is shown in Figure 3.3. The Harvey River Basin includes the Harvey River and its tributaries as well as a number of drain systems which discharge into Peel Inlet and Harvey Estuary. These drains have very little habitat value as they pass through private land almost totally cleared of remnant vegetation, and their condition has been evaluated as C3.

The upper reaches of the Harvey River have their catchment in state forest with conditions mainly A3-B1, but B3-C1 in areas of pine plantation. These forested river sections have been dammed by the Stirling and Harvey Reservoirs. The Harvey River and its tributaries on the coastal plain have been greatly modified by straightening and deepening and also by digging networks of drainage channels that discharge into the river, resulting in very little remaining habitat (C3). A major diversion drain has been dug to the west of Harvey that diverts most of the water of the Harvey River to the sea at Myalup Beach. The tributaries of the Harvey River, including Clarke, Logue, Bancell, Samson and Drakes Brooks, have had their lower reaches severely modified (C3). Much of their upper reaches are in state forest and almost all of these larger streams flowing down the Scarp have been dammed. The condition of the streams where they flow through cleared private land is mainly B3 to C1.

3.5 Collie River Basin (DuCoR2, MeCoR1, MeCoR2, DlCoR1, DlCoR2)

3.5.1 Collie River(DuCoR2, MeCoR1, MeCoR2, DlCoR1, DlCoR2)

The Collie River system drains a large patchwork of cleared farmland and state forest and conservation reserves. The condition of streams in the Collie River Basin are shown in Figure 3.4. The Collie River system has been dammed twice: Wellington Dam, a very large dam on the Collie River, and the newer Harris Dam on the Harris River.

The Harris River is the only small river size system whose catchment is almost entirely within state forest and conservation reserves. The large reservoir has somewhat reduced the habitat value of the downstream reaches, but all the tributaries flowing into the Harris River are in A3 condition, except one tributary which has its headwaters in cleared private land (C1) and its downstream reaches in state forest (B1).

The small size Bingham River has many of its tributaries (A3) in state forest and stretches of the Bingham's main channel also pass through areas of state forest. A number of cleared areas (B3-C2) along the main channel and some of the tributaries have reduced the habitat value of a large part of this system. Although a large part of the catchment of the small size Collie River South (A3-B3-C3) is within state forest areas, there is also a large amount of cleared private land and open cut coal mining operations in the catchment. This has reduced the habitat value of this catchment to such a degree that only a few creek sized systems and minor creeks are wholly within forest (A3). The upper Collie River and Collie River East pass largely through cleared farmland, with the condition of the main channel ranging from B1 to C3, generally B3 to C1. There are a number of creek systems and minor creeks within state forest land, but many have portions of their streamline within cleared private land. The upper reaches of Collie River East are largely within cleared farmland and in poor condition (C1-C3).

The lower Collie River, downstream from Wellington Reservoir, passes through a stretch of forested catchment (state forest), with the condition of the main channel being B1, with A3 tributaries. Although this area has a catchment in very good condition, it is subject to a discharge of brackish water for several weeks in late spring when Wellington Reservoir is scoured. Downstream from the area of state forest the Collie River passes across the coastal plain where almost the entire catchment (streams B3-C3) has been cleared. A system of drainage and irrigation channels have been dug on the coastal plain which discharge into natural watercourses, many of which have been severely modified into drainage channels themselves. Areas of valuable remnant vegetation remain along reaches of the river and near the entry of the river into the Leschenault Estuary.

3.5.2 Brunswick River (DuCoR2, DlCoR1)

The major creek size Brunswick River begins in the Darling Range and crosses the coastal plain to join the lower Collie River at The Elbow, just before the Collie River discharges into the Leschenault Estuary. The upper reaches of the Brunswick River, and the upper reaches of its tributary Lunenberg River, drain state forest areas of the Darling Ranges. The condition of the watercourses are mainly A3 to B3, the provision of habitat limited by extensive pine plantations and small areas of cleared private land within the catchment. The catchment of the Brunswick River on the coastal plain is entirely cleared, with the condition of the watercourses ranging from B3 in areas of remnant vegetation to C3 where streams have been modified and made part of a network of drains and irrigation channels.

3.6 Preston River Basin (DuPeR2, MePeR2)

The catchment of the medium size Preston River is a patchwork of cleared farmland and state forest. The condition of streams in the Preston River Basin is shown in Figure 3.5. The main channel of the Preston River passes entirely through cleared farmland (B3-C1), lined with remnant vegetation in many places. The upper reaches of many of the tributaries of the Preston River are A3 condition, being wholly within state forest, while most of the lower reaches are in cleared farmland (B3-C2). The largest stream system in A3 condition are creek size systems, such as the Gavin Gully system and the upper reaches of Thomsons Brook. The lower part of the Preston River, between Picton and Bunbury, has been straightened and confined within levee banks to reduce flooding in East Bunbury. On the coastal plain near Picton, the Preston River is joined by the Ferguson River. The headwaters of the Ferguson are within state forest (A3), but the river mainly passes through cleared farmland (B3-C1). The lower sections of the Ferguson, Preston and Collie Rivers are joined by a network of irrigation and drainage channels (C3).

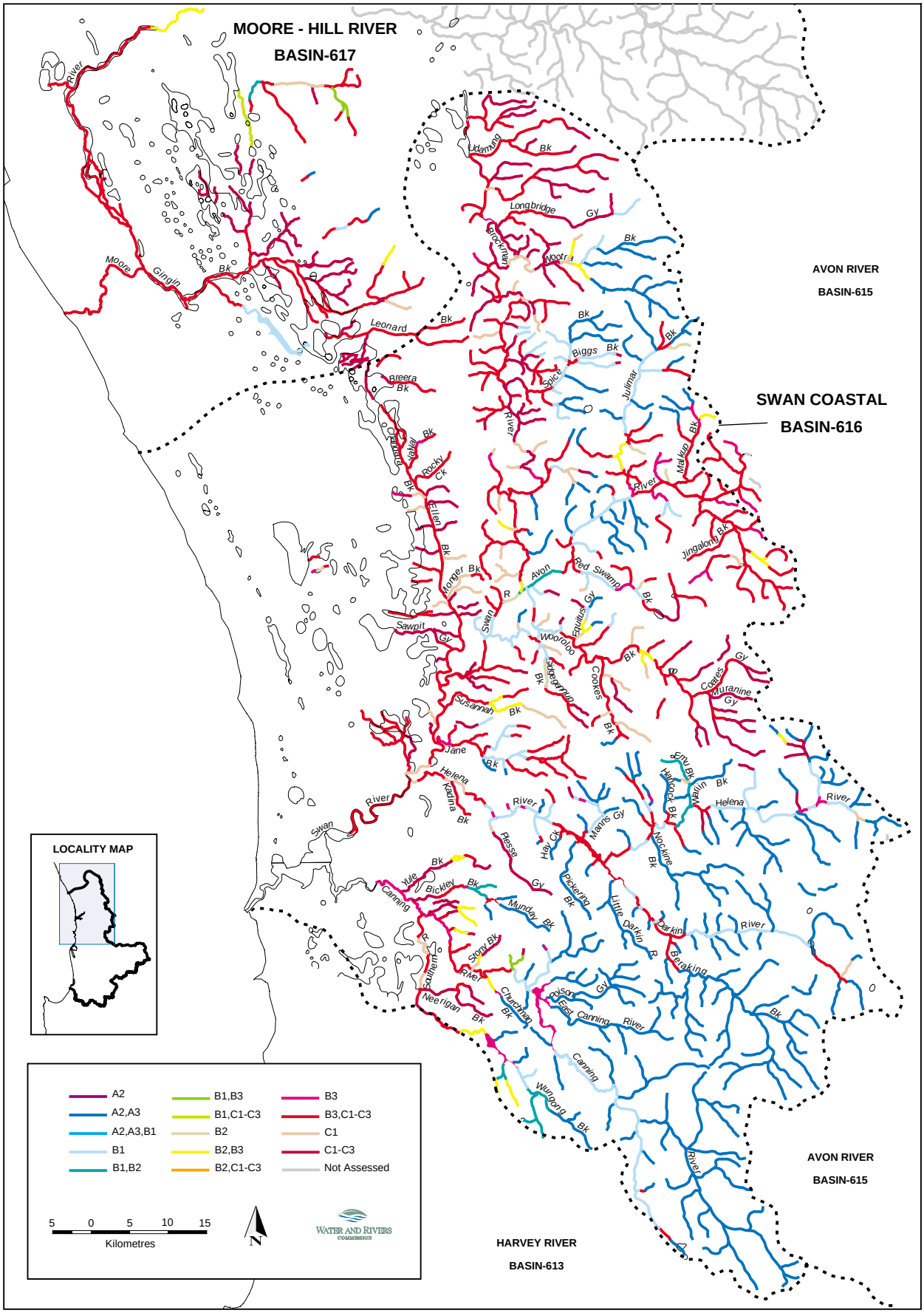


Figure 3.1: Condition of streams in the Lower Moore River and the Swan Coastal Drainage Basin

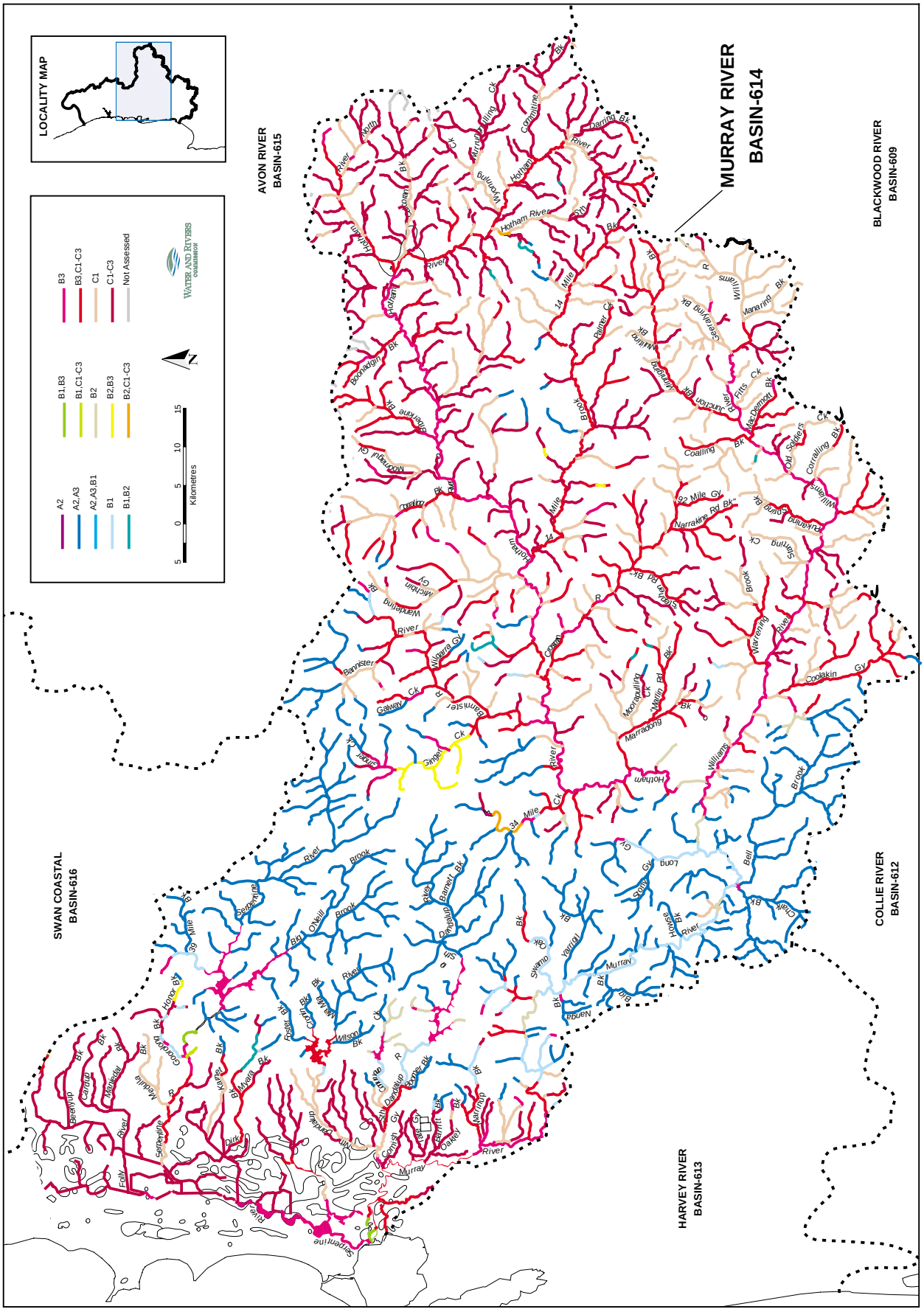


Figure 3.2: Condition of streams in the Murray River Basin

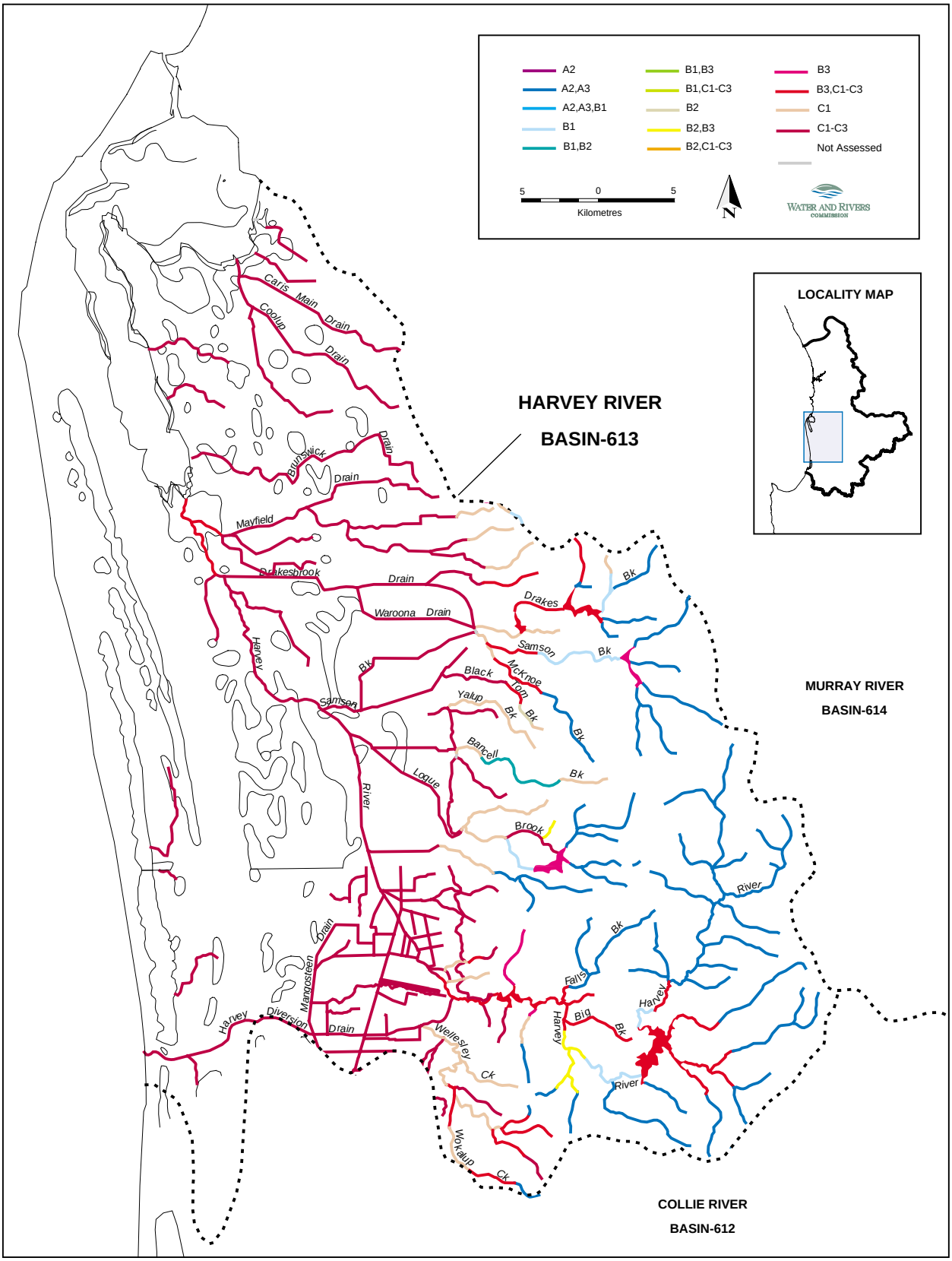


Figure 3.3: Condition of streams in the Harvey River Basin

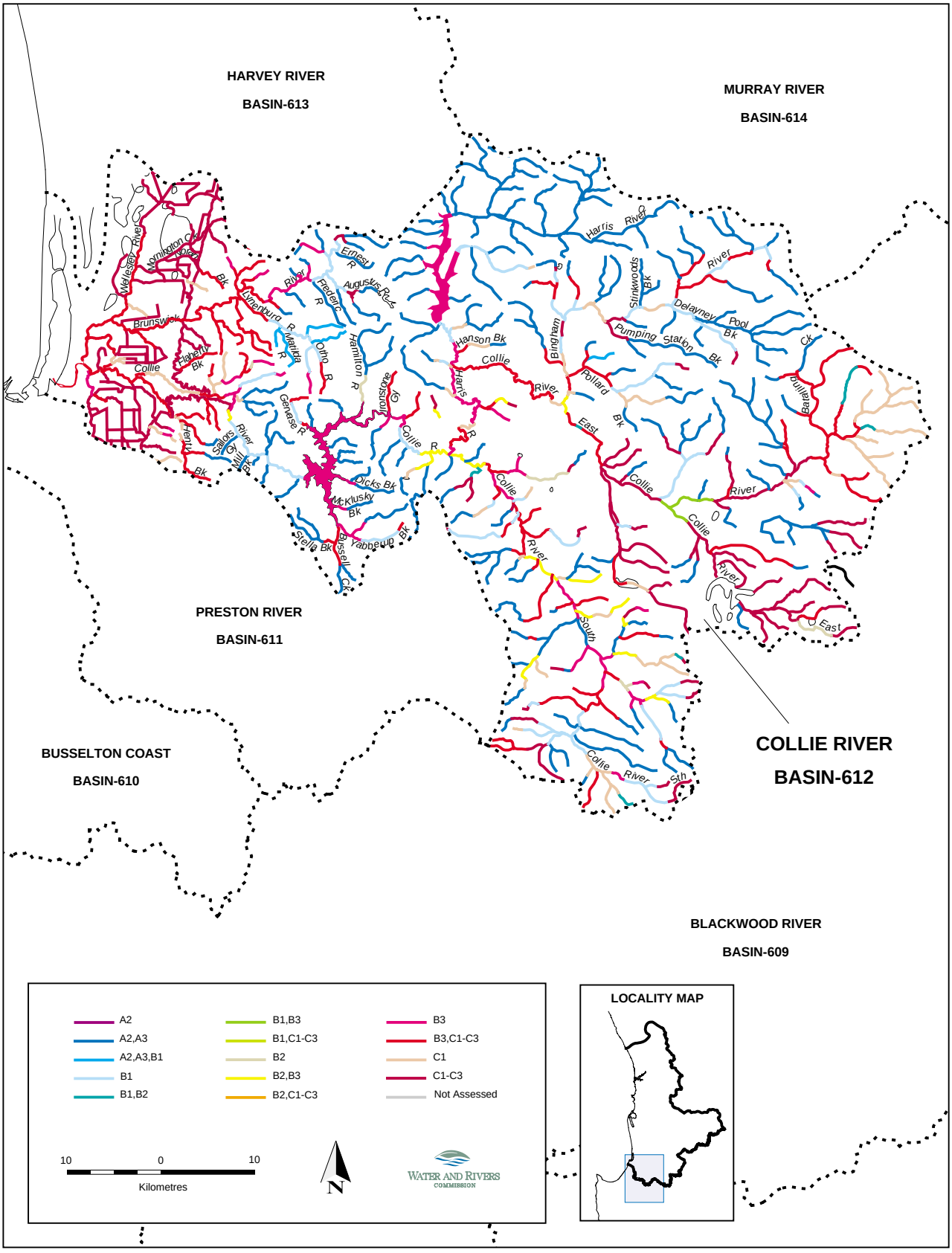


Figure 3.4: Condition of streams in the Collie River Basin

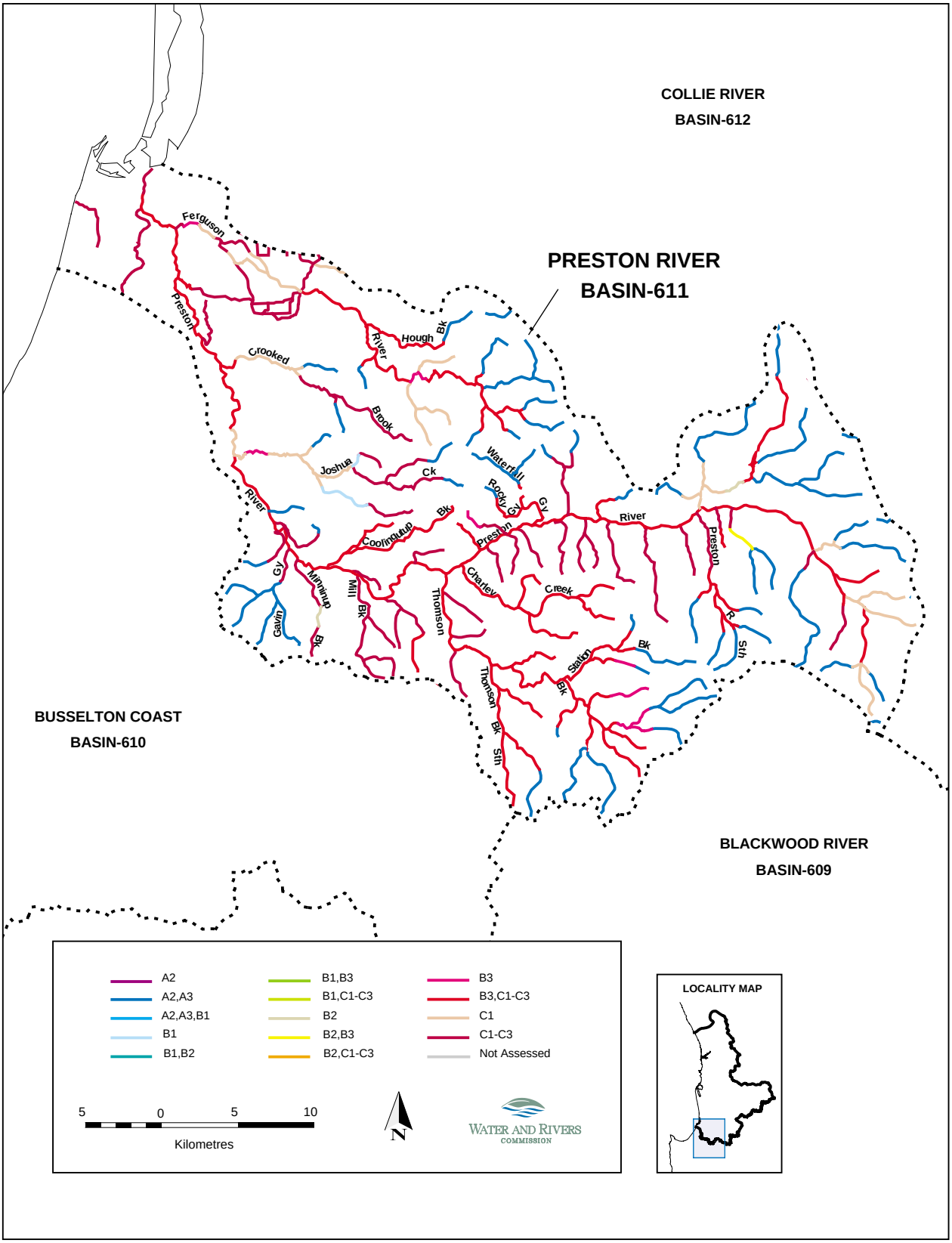


Figure 3.5: Condition of streams in the Preston River Basin

4. Important representative rivers and creeks

4.1 River types and important representative qualities

Six of the eleven river types of the south-west of Western Australia are found in the Perth to Bunbury Region (see Table 3.1). The Moore, Avon and Murray Rivers are the T1 rivers, although large parts of the upper catchments of the Moore and Avon Rivers are not included in the Perth to Bunbury Region. Of these three, the Murray River retains the most remnant vegetation in its catchment, most of which is in state forest or conservation estate.

The two T2 rivers are the Collie and Helena Rivers, and both retain considerable amounts of native vegetation (remnant vegetation, state forest or conservation estate) in their catchments. The upper part of the Helena River (upstream from Mundaring Weir) has most of its catchment in state forest and conservation reserves, although there was a more important small river, the upper Canning River, within that natural resource zone.

There are many T3 rivers (and river tributaries) within the Perth to Bunbury Region, including the Preston, Brunswick, Ferguson, North and South Dandalup, Serpentine, Canning and Harvey Rivers. The upper reaches of almost all these rivers are largely or wholly within state forest and conservation reserves, and many sections of these have been nominated for important value (see Section 4.2).

Wellesley and Brockman Rivers are T4 systems, but both of their catchments are almost entirely cleared and only retain sections of remnant vegetation. Ellen Brook is a T5 system which also has a largely cleared catchment. Gingin Brook is a T6 system and, although most of its catchment has been cleared, a number of tributaries have been nominated for important value.

4.2 Nominations of important representative rivers and creeks

The condition assessments presented in Chapter 3 were used to nominate whole stream systems or stream sections which have important natural value. Nominations have been given, by stream system size, in each of the natural resource zones in the Perth to Bunbury Region (see Section 2.1). The nominations have been discussed in the following sections by drainage basin. In most coastal natural resource zones very few important natural streams remain. In these zones, streams or stream sections which have the best remnant vegetation have been nominated as representatives. Rivers and creeks in the Perth to Bunbury Region which have been nominated as important are shown on Figure 4.1.

4.2.1 Lower Moore River (DuMoR2, DuMoR3)

Although the lower Moore River catchment has been greatly altered and there are no stream systems (even minor creeks) with entire catchments in A3 condition, there are still a few streams which retain significant natural value. The lower Moore River is lined with a considerable amount of remnant vegetation, but cannot be considered to have important natural value because the streamline and vegetation are degraded due to deposition of sediments from the extensively cleared upper catchment and by grazing livestock.

The Gingin Brook is the only small river in this catchment and so is important by default. However, it is not importantly natural because much of its catchment is cleared farmland with widespread degradation from grazing livestock and the water ranges from fresh in its upper catchment to marginal at its confluence with the Moore River (Olsen and Skitmore 1991).

Quin Brook (also known as Wanneroo Brook), a tributary of Gingin Brook, is important in the DuMoR2 natural resource zone because much of this section is within natural vegetation of B1 condition. Although Lennard Brook and Gingin Brook both have fresh water and are lined in most places with remnant vegetation, their catchments are mainly cleared farmland and so cannot be considered important stream ecosystems.

Within the natural resource zone DuMoR3 there are a few streams which retain considerable natural value. Boonarring Brook has its headwaters in A3 condition natural bushland and its downstream reaches pass through cleared farmland with a buffer of remnant vegetation and

a section of natural bushland. The intermittent Whitefield Brook passes through Moore River National Park, which largely contains native vegetation, and through a chain of wetlands, although parts of the area appear to have the understorey removed.

Table 4.1 Nominated important representative streams of Lower Moore River

Stream System Size	Natural Resource Zone	Nominated Stream
Small River		None
Creek	(DuMoR2) (DuMoR3)	Quin Brook Whitefield Brook Boonarring Brook

4.2.2 Swan Coastal Drainage Basin (DuSwR2, DlSwR1, DlSwR2, DlSwR3(i) and (ii))

The large catchment of the Swan/Avon, the Helena and the Canning Rivers, and their tributaries is characterised by having upper reaches of rivers in the forested Darling Range and the lower reaches having cleared coastal plain catchments. The Swan Coastal Drainage Basin has been divided into four natural resource zones: DuSwR2 is the coastal plain part of the catchment, DlSwR1, DlSwR2 and the two parts of DlSwR3 comprise the Darling Range and Scarp catchments.

DuSwR2

There remain very few areas of coastal plain streamline which have important natural value. The river size sections in the best condition are only of B3 standard as they are lined with remnant vegetation, so no river size sections can be described as having important natural value. Ellen Brook is the only small river size system in this natural resource zone and although it is therefore important by default, its catchment has been greatly altered. A very small section of a Canning River tributary is of B2 to B3 condition, but the catchment area is most likely less than ten square kilometres. Remnant vegetation occurs in relatively good condition along parts of the lower Swan River, but these reaches have been trained and greatly modified in the past. The Bennett Brook creek system supports good stands of remnant vegetation and can be considered to be of important value compared to much of the coastal plain catchment.

DlSwR1, DlSwR2 and DlSwR3(i) and (ii)

These three natural resource zones contain many river sections in A3 condition, although all of the larger systems have been dammed to provide public water supply. Although these large reservoirs have reduced the natural value of the downstream reaches, they have also ensured high protection of the upstream catchments.

The DlSwR2 natural resource zone contains the upper Canning River which is the most obvious candidate for an importantly natural small river since its catchment contains fewer areas of pine plantation and cleared farmland than the Darkin River. The catchment of the upper Canning is entirely within state forest and conservation park and in A3 condition, except for an area of pine plantation along the upper reaches of a tributary which have reduced the value of downstream forested reaches to B1.

The large major creek system of Beraking Brook is entirely within conservation parks and state forest and is importantly natural. All of the catchment, apart from the pine plantation along its lowest section, is in A3 condition, with a many creek size tributaries. The East Canning River is also a candidate for nomination as an important natural major creek system as its catchment is entirely within A3 condition upstream of Canning Reservoir. It has fewer creek systems entering it than the Beraking Brook system.

The upper Wungong Brook is the only major creek in the DlSwR1 natural resource zone, and it may also be considered importantly natural even though there are bauxite mining operations within its catchment. In the DlSwR3(i) zone the upper Wootra Brook and upper Spice Brook are the two candidates for major creek nominations. The upper Wootra Brook has less cleared area in its catchment than upper Spice Brook, and these cleared areas are lined with a wide buffer of remnant vegetation.

Since large parts of these natural resource zones are state forest and conservation reserves, particularly the southern half, there are many creek systems within this drainage basin which are in important natural condition. The DlSwR1 zone contains three candidates for important creeks in state forest: Pickering Brook, Munday Brook (upstream from Victoria Reservoir) and Churchman's Brook (upstream from the reservoir). The DlSwR2 natural resource zone contains many creek size systems within the systems nominated above as importantly natural, although there are many more creek size systems in A3 condition. There are five creeks in the DlSwR3(ii) natural resource zone which are candidates for nomination as importantly natural creek systems: "Ridley Island Brook" (a tributary that joins the upper Helena River near Ridley Island, two other unnamed tributaries of the upper Helena and two unnamed tributaries of the upper Darkin River.

Table 4.2 Nominated important streams representative in the Swan Coastal Drainage Basin

Stream System Size	Natural Resource Zone	Nominated Stream
Small River	DlSwR2	Upper Canning River
Major Creek	DlSwR1	Upper Wungong Brook
	DlSwR2	Beraking Brook
		East Canning River
	DlSwR3(i)	Upper Wootra Brook
Creek	DuSwR2	Bennett Brook
	DlSwR1	Pickering Brook
		Upper Munday Brook
		Upper Churchmans Brook
	DlSwR3(ii)	"Ridley Island Brook"
		2 tributaries of upper Helena River
		2 tributaries of upper Darkin River

4.2.3 Murray River Basin (DuMrR2, DlMrR1, DlMrR2, DlMrR3, AvMrR4)

The Murray River Basin has been divided into five natural resource zones, ranging across four rainfall zones and three vegetation regions. The catchment is a mosaic of cleared land, state forest and conservation reserves and there are very few important systems in the DuMrR2, DlMrR3 and AvMrR4 natural resources zones since these zones have largely been cleared. The DlMrR1 and DlMrR2 natural resource zones have most of their catchments within state forest and conservation reserves.

The upper Serpentine River is the obvious candidate for important small river since its catchment upstream from Serpentine Reservoir is entirely within state forest (A3) and flows through both of these two natural resource zones. There are number of candidates for nomination as important major creeks in these two natural resource zones: the Big Brook, upper South Dandalup River (upstream from reservoir), upper North Dandalup River (upstream from reservoir) and Bell Brook systems are entirely within state forest and conservation reserves. There are also numerous creek size systems entirely within A3 forest, in addition to those which are part of the larger systems mentioned above.

The DlMrR3 natural resource zone contains nothing larger than a few creek size systems within entirely forested catchments. Headwater tributaries of upper Bannister River, an unnamed tributary Fourteen Mile Creek and the upper reaches of "Carrabin Road Brook" are the few parts of creek systems in forested land. The stretch of the Hotham River which passes through this natural resource zone is largely lined with remnant vegetation in reasonable condition (B3), and may be considered to be an important river section.

The catchment contained within the AvMrR4 natural resource zone is almost entirely cleared farmland, with only minor creeks having part of their catchment in state forest or large patches of remnant vegetation. "Yornaning Brook" would have to be considered to be the important stream in this zone because it has its headwaters in state forest and its middle reaches pass through the edge of a block of state forest, even though it passes through two sections of cleared and degraded farmland. The section of the Hotham River west of the Great Southern Highway in this natural resource zone may be considered to be of important value, when compared with the condition of the majority of the zone's watercourses, since it is lined with considerable remnant vegetation.

The best sections of river in the DuMrR2 natural resource zone is the lowest section of the Serpentine River that passes through a series of wetlands, and is lined with remnant vegetation. This section can be considered to be important because, together with the lower Murray River, they are the most natural sections of river that remain on the coastal plain.

Table 4.3 Nominated important representative streams in the Murray River Basin

Stream System Size	Natural Resource Zone	Nominated Stream
Small River	DlMrR1 and DlMrR2	Upper Serpentine River
Major Creek	DlMrR1 and DlMrR2	Big Brook (off Serpentine River)
		Upper South Dandalup River
	DlMrR1	Upper North Dandalup River
	DlMrR2	Bell Brook
Creek	DlMrR1	Nanga Brook
		Big Brook (off Murray River)
		Yarragil Brook
	DlMrR2	Stony Gully
		Chalk Brook
		"Boggy Brook Road Brook"
	DlMrR3	Upper Bannister River tributaries
		Tributary of Fourteen Mile Brook
	AvMrR4	"Yornaning Brook"
River section	DuMrR2	Lower Serpentine River
		Lower Murray River
	DlMrR3 and AvMrR4	Hotham River west of Great Southern Hwy

4.2.4 Harvey River Basin (DuHaR2, DlHaR1)

The lower Harvey River and its tributaries that pass across the coastal plain are highly modified systems and make up the DuHaR2 natural resource zone. The only area with some natural value in this zone is the lowermost section of the Harvey River, from the Drakesbrook Drain junction to where it discharges into the Harvey Estuary. This section of the river is surrounded by disturbed remnant vegetation (B3-C2).

The DlHaR1 natural resource zone is comprised of the upper reaches of the Harvey River and the tributaries within the Darling Range that have a large proportion of their catchment within state forest and conservation reserve. The upper Harvey River is the only river in this basin and so is important by default. Upstream from the Harvey Reservoir the Harvey River is the size of a small river and it has considerable natural value. There are some areas of cleared private land and pine plantations within the lower area of this part of the catchment. Upstream from the pine plantation (to the north east of Stirling Reservoir) the upper Harvey River is entirely within state forest (A3), and so is the most appropriate candidate for important major creek. In addition, the DlHaR1 zone are a number of creek size candidates (all A3): Samson Brook upstream from Lake Kabbanup, Logue Brook upstream from Lake Brockman, Falls Brook, and the upper reaches of Tallanalla Creek.

Table 4.4 Nominated important representative streams in the Harvey River Basin

Stream System Size	Natural Resource Zone	Nominated Stream
Small River		None
Major creek	DlHaR1	Uppermost Harvey River (upstream from Stirling Reservoir and pine plantation)
Creek	DlHaR1	Upper Samson Brook Upper Logue Brook Falls Brook Upper Tallanalla Creek
River Section	DuHaR2	Lowermost section of Harvey River (downstream from Drakesbrook Drain)

4.2.5 Collie River Basin (DuCoR2, DlCoR1, DlCoR2, MeCoR1, MeCoR2)

The Collie River system drains a large patchwork of cleared farmland, state forest and conservation reserves. It has been divided into five natural resource zones covering three vegetation regions and two rainfall zones.

The DuCoR2 zone consists of the coastal plain part of the Collie River catchment, which has been almost entirely cleared. Although the lowest sections of the Collie River and the lower Brunswick River are lined with remnant vegetation, these areas do not really have important natural value since the tributaries that discharge into them are no more than networks of drainage and irrigation channels.

The small MeCoR1 natural resource zone contains the Wellington Reservoir and a section of the Collie River downstream from the reservoir, together with some minor creeks. The stretch of the Collie River downstream from the reservoir is important because the catchment is all state forest, although the river receives discharges of brackish water in late spring when Wellington Reservoir is scoured. The few minor creeks in this zone are almost all in A3 condition, although there are no systems larger than this.

The DlCoR1 natural resource zone contains the upper section of the Brunswick River and part of the middle section of the Collie River. A large part of this catchment is cleared farmland, with the upper areas of the Darling Scarp being state forest. There are a number of creek size candidates for important creek within this zone: Frederic River (A3) and Mathilda River (A3-B1) which are part of the Brunswick River system, two Collie River tributaries: Roe Range Brook system (A3) and Hamilton River (A3-B2), and the tributaries flowing into the western side of the Harris River Dam. Systems larger than creek size in this natural resource zone have been modified too much to be described as important.

The catchment contained in the DlCoR2 natural resource zone is a mosaic of state forest and cleared farmland. The catchment of the Harris River has been dammed but is almost entirely within state forest and conservation reserves. The Bingham River is also largely within state forest and has not been dammed, but it has larger areas of cleared farmland in its catchment. Therefore, the Harris River is the most appropriate candidate for important small river. Harris River upstream from the dam is completely within state forest or vegetated wetland and so is the only candidate for important major creek.

This zone also contains a number of creeks whose catchment is largely contained within state forest. Stinkwood Brook, a minor creek system totally within state forest, and "Delayney Road Brook", large creek in state forest (A3-B1) with cleared area on upper section of a tributary, are two important sections of Bingham River. The upper Collie River contains a candidate for important creek: the "Batalling Road Brook" system, upstream from cleared lower section, is within state forest.

Because the catchment of the MeCoR2 zone is a mosaic of cleared farmland and state forest, there are only two creek systems which have their whole catchment in state forest. These are two unnamed tributaries of upper Collie River South. There are many more creeks or parts of creek systems within state forest but most have cleared farmland as part of their catchment.

Table 4.5 Nominated important representative streams in the Collie River Basin

Stream System Size	Natural Resource Zone	Nominated Stream
Small River	DlCoR2	Harris River
Major Creek	DlCoR2	Upper Harris River
Creek	DlCoR1	Frederic River
		Roe Range Brook
		Tributaries west of Harris River Dam
		Mathilda River
		Hamilton River
	DlCoR2	Stinkwood Brook
		"Delayney Rd Brook"
		"Batalling Rd Brook"
	MeCoR2	2 tributaries of upper Collie River South
River Section	MeCoR1	Collie R downstream from Wellington Dam

4.2.6 Preston River Basin (DuPeR2, MePeR2)

The main channel of the Preston River flows entirely through cleared farmland, although a number of creeks and many minor creeks have their catchment in state forest. The lower sections of the Preston and Ferguson Rivers pass across the cleared coastal plain, where remnant vegetation lining the Preston River and some billabongs are the only areas of habitat remaining. The DuPeR2 natural resource zone includes the coastal plain part of the Harvey catchment as well as the western part of the Blackwood Plateau. There is one minor creek, a tributary of Crooked Brook, which is the only stream that remains in A3 condition, and so is important.

The MePeR2 natural resource zone contains one major creek size system, Thomsons Brook, and although it is therefore important by default, catchment has been greatly altered. Although the major part of the Thomsons Brook system is in cleared farmland of B3-C1 condition, the upstream creek size systems have their B3 lower sections in plantations and their A3 upper reaches in state forest. This natural resource zone also contains a number of A3 creeks in addition to those part of the Thomsons Brook system: Gavin Gully, upper Ferguson River, upper Waterfall Gully, tributaries of "Mervyn Dam Creek", and upper unnamed tributary of upper Preston River.

Table 4.6 Nominated important representative streams in the Preston River Basin

Stream System Size	Natural Resource Zone	Nominated Stream
Small River		None
Major Creek		None
Creek	MePeR2	Upper Thomsons Brook tributaries
		Gavin Gully
		Upper Ferguson River
		Tributaries of "Mervyn Dam Creek"
		Upper unnamed tributary of upper Preston River
Minor Creek	DuPeR2	Crooked Bk tributary

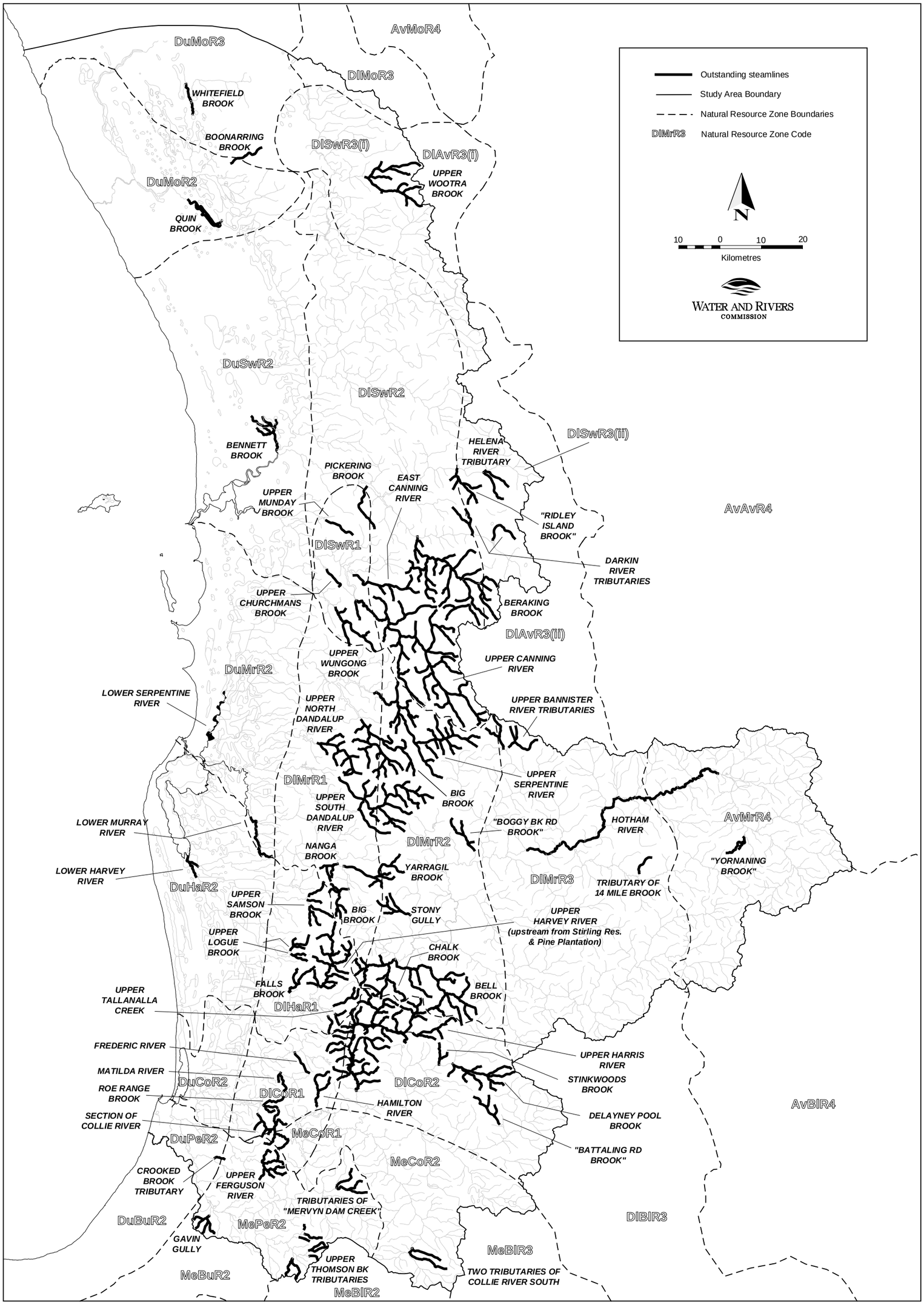


Figure 4.1: Important representative rivers and creeks in the Perth to Bunbury Region

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Appendix 1: Important Rivers Work and the System Six Update

The work presented in the main body of the report can be used to supplement the information provided for Stage 2 of the System Six update program.

The Water and Rivers Commission has developed three management categories into which the water resources can be placed. The three management categories and their management objectives are as follows:

1. Conservation (C): to maintain and enhance natural attributes and functions of the wetland.
2. Resource Enhancement (R): to maintain and enhance existing ecological functions.
3. Multiple Use (M): to consider wetlands in the context of catchment and land-use planning, in terms of current value and potential value if rehabilitated.

The present study used a different set of terms and categories (see Section 2.4 of report) since it focused on condition rather than management. An attempt is made here to place the river condition groups in the context of the water resource management classification. The river condition groups are described below, assigned to the three management categories. In general the following assignment of river condition groups to management categories can be used:

Wetland Management Category	**River Condition Group** (see Appendix 1)
Conservation (C)	A1, A2, A3, B1, B2
Resource Enhancement (R)	B3, B3-C1
Multiple Use (M)	C1, C2, C3

The condition of certain river sections were in many cases more a mosaic of conditions than just one condition and so a number of combination groupings have been used. For example, certain sections of rivers that pass through cleared farmland were often lines with trees and patches of remnant vegetation, which would be described as B3-C1 (see below). The maps prepared as part of the present study have a number of categories which include a range in river condition, which can also be assigned to a preliminary wetland management category. The following categories are shown on the report's maps with their associated preliminary wetland management category:

Map Condition Category	**Wetland Management Category**
A2	Conservation
A2, A3	Conservation
A2, A2, B1	Conservation
B1	Conservation
B1, B2	Conservation
B1, B3	Conservation
B1, C1-C3	Conservation
B2	Conservation
B2, B3	Conservation
B3	Resource Enhancement
B3, C1-C3	Resource Enhancement
C1	Multiple Use
C1-C3	Multiple Use

The river condition evaluation work was used to determine which stream systems and stream sections in each natural resource zone were of important natural value.

Further first tier evaluation work may be necessary to add to the resulting preliminary categories. For example, certain river sections may have other environmental, cultural or social values, uses or attributes that will require better protection than that implied by the preliminary management category determined by river condition alone.

The important river sections nominated in the Perth to Bunbury Study Regional Allocation Plan (WAWRC 1991) or in the earlier System 6 Update Program Water Authority Submission should be assigned to the "Conservation" preliminary management category regardless of their condition.

Appendix 2: Correspondence and accuracy of results using differing scales of photography

The rivers and creeks shown on 1:250 000 AUSLIG topographic maps were assessed in both the Busselton to Walpole and Perth to Bunbury Regions. Although the accuracy of the results of the evaluations must be comparable between the two regions, the results of the two Regions were obtained using different evaluators and imagery of different scales and dates.

The condition of the rivers in the Busselton to Walpole Region were evaluated by Luke Pen (evaluator X) using 1:100 000 satellite images (dated variously from February 1988 to February 1989). The condition of Perth to Bunbury Region's rivers were evaluated by Tanya Bosveld (evaluator Y) using 1:25 000 orthophotographs (dated variously from August 1991 to January 1993).

In order to determine the correspondence of the evaluation results in the Busselton-Walpole and Perth to Bunbury Regions, selected rivers sections were assessed by both evaluators, using both 1:25 000 and 1:100 000 scales (image capture between 1991-1994 and 1988-1989, respectively), and the various results were compared.

Comparison of Scale in Busselton Coast Drainage Division

The rivers and creeks in the Busselton Coast Drainage Division were first evaluated by evaluator X using 1:100 000 scale imagery as part of the Busselton-Walpole Study and later evaluated using 1:25 000 orthophotos by evaluator Y. The results of the two evaluations were compared to determine the level of accuracy of the 1:100 000 results with respect to the 1:25 000 results.

The comparison of 1:100 000 and 1:25 000 evaluation results in the Busselton Coast Drainage Division showed that generally the delineation between segments of river sections was very similar for both scales. However, while the accuracy of delineation between segments was very similar for the two scales, the level of detail defined was much greater in the 1:25 000 results. The lack of detail available in 1:100 000 images resulted in that a number of stream conditions were either overrated or underrated.

It was found that there were three general situations when the stream condition was underrated. Firstly, where the main area of a channel's catchment was cleared farmland, 1:100 000 evaluations often missed areas of remnant vegetation which lined the watercourse (eg. lower and middle Wilyabrup Brook, parts of Annie Brook, Station Gully and Mary Brook).

Secondly, in areas of pine plantations it was often difficult to determine on the 1:100 000 imagery the extent of the buffers of natural vegetation that lined the streams. These buffers were quite narrow at times (B3-C1), but also could form wide buffers/narrow corridors (B2-B3) (eg. upper Margaret River).

Thirdly, when using 1:100 000 imagery it was sometimes difficult to determine the exact extent and position of a watercourse. This meant that it was hard to determine whether or not a watercourse passed through areas of native vegetation in A3 or B1 condition, or passed around the edge (eg. tuart forest on lower Abba River, upper Mary Brook). In addition, channels which were largely in cleared farmland but had their headwaters in areas of native vegetation, were often underrated (eg. Gynudup Brook).

There were three main situations in which the stream condition was overrated. In areas where the stream condition appeared on 1:100 000 imagery to be in B3-C1 condition, 1:25 000 imagery revealed that certain sections, particularly the upstream reaches, were quite degraded and in C2 condition (eg. Cowaramup Brook). Small cleared areas within larger areas of native vegetation were sometimes overlooked on the 1:100 000 imagery (eg. Miamup Brook). When using 1:100 000 imagery, streams that largely have a forested catchment sometimes have cleared headwaters overlooked.

Comparison of Scale and Evaluators in the Tone River Region

Selected sections of Tone River, a tributary of the Warren River, were evaluated by both evaluators, each using both

scales. Comparisons of the four sets of results enabled the differences between scales and the differences between the evaluators to be determined.

Comparison of the Tone River evaluation results revealed that the major difference was between the results of the two scales. It was found that a greater level of detail was able to be defined using 1:25 000 images. For example, using 1:100 000 imagery the Chowerup Creek was evaluated to have only a few segments of differing conditions (2 or 4 segments, depending on evaluator), while the 1:25 000 evaluation defined at least nine condition segments. The 1:25 000 results revealed that the 1:100 000 evaluation underrated certain areas of remnant vegetation by combining them in the larger C1 to C3 condition segment.

Another example of the value of the detail provided by the 1:25 000 images is when small areas of cleared farmland were detected on the headwaters of a creek which passes largely through forest, or forested headwaters of a creek which passed largely through cleared farmland. It was often very difficult to see this using 1:100 000 imagery because it was, at times, difficult to determine the exact extent and position of the watercourses.

In addition, when using 1:100 000 scale images it was often difficult to discern between the different "C" categories and the condition of these segments were mainly described as C1-C3. The 1:25 000 scale imagery allowed evaluation of these areas to be more definite and could discern between watercourses which were either lined with trees, cleared of all native vegetation, or channelised and badly degraded.

The comparison of results also revealed small differences due to evaluations being done by different evaluators. In most cases the differences were minor, such as one evaluator would classify a segment as C2, while the other evaluator would describe it as C2-C3. However, certain river sections have been evaluated in greater detail by either one of the evaluators, although the overall condition range for those particular sections was generally equivalent for both. For example, a section of Chowerup Creek was defined by evaluator Y as C1-C3, while evaluator X further detailed this section into six segments: C2, C1-C3, C1-C2, C3, B3-C2, and C1 (both evaluations using 1:25 000 images). Another example is the evaluation of the upper Tone River using 1:100 000 imagery (sheet 2229) where evaluator X described the whole catchment as being in B3-C3 condition while evaluator Y broke this larger region into smaller segments, although the range for both evaluations was the same.

In some cases differences between the evaluations were due to differences in the way the catchment area was described. For example, one tributary passed almost entirely through native vegetation except for a small patch of cleared area in its upper catchment. This stream was evaluated as largely B1 with a small C1 area and headwaters in A3 condition by evaluator Y. Evaluator X described the condition of the same stream as A3-B1, since the cleared area was relatively very small. In areas where the catchment was a mosaic of landuses the two evaluators sometimes used different delineations to define segment of mosaic conditions, but overall the range was very similar.

In two cases, however, the two evaluators described the same stretch of river or creek differently. Firstly, a stretch of the main channel of the lower Tone River was described by evaluator X as B3-C1, while evaluator Y assessed it as B2-B3. Secondly, a tributary of the Tone River was described by evaluator X as B3-C2, while evaluator Y assessed the lower section of the tributary to be C1-C3 and the upper section as A3.

Comparison of dates of image capture

The 1:100 000 scale satellite imagery used in the above study was captured between February 1988 and February 1989, while the orthophotographs were taken between August 1991 and February 1994. Together this spans a time frame of six years. The difference in time would not have affected the accuracy of the results because river catchment condition would be unlikely to have changed significantly during this short period of time.

Comparison of relative costs

The Perth to Bunbury and Busselton-Walpole Regions were evaluated using the images that were available at the time, but further studies will require new imagery to be purchased. The cost associated with 1:25 000 and 1:100 000 scale evaluations is an important consideration when choosing which scale to use in evaluations of other regions.

Cost of Imagery

There are sixteen 1:25 000 images for every 1:100 000 image. New 1:25 000 orthophotograph images are no longer being made available by DOLA as glossy bromides (as were used for most of the Perth to Bunbury river

study). They are now available in two forms: digital TIF files (average of 60 megabytes per file) and black and white paper plots with map grids. The digital files each contain one 1:25 000 image. The costs involved in obtaining digital files include a $25 adminstration fee, $25 per compact disc and then $12.50-17.50 for the first file and $5-10 per other files. The black and white paper plots are $25 each. On the other hand, the 1:100 000 satellite images cost between $250-300. The following list gives a comparison of the cost of the three types of images:

1 × 1:100 000 image:	$250-300
16 × 1:25 000 digital image:	$120-200[1]
16 × 1:25 000 paper plot:	$400

Cost of Staff Time

In addition to the cost of the images themselves, consideration of relative staff time involved in both evaluations is necessary. Although sixteen 1:25 000 images must be evaluated for every 1:100 000 image, the detail which the former images show allows the evaluator to work with relative speed. This is because identification of the watercourses' location and extent, together with the stream condition, is relatively easy and can be done with confidence. The 1:100 000 image evaluation is slowed done by difficulties in identification of position, extent and condition of streamlines. In general, the time to be allowed for evaluations would be similar for both scales.

Conclusion

The results of the above study show that the 1:100 000 and 1:25 000 evaluation results correspond to the level required to determine important stream sections. However, the study also shows that the detail provided by the 1:25 000 makes this scale the most appropriate for carrying out river condition evaluations. The 1:25 000 image allows the evaluation work to be done with confidence due to the ease of identification of stream position, extent and condition. However, it must be noted that further studies (for example in the Denmark to Esperance Region) will be in areas where the orthophoto coverage to date is limited. Digital orthophotos have not yet been viewed with respect to usefulness in river evaluation work.

[1] This price range does not include the cost of the compact discs.

Appendix 3: Stream size guidelines based on catchment size

Stream size (catchment size)	**BUSSELTON-WALPOLE EXAMPLES**		**PERTH TO BUNBURY EXAMPLES**	
	System Name	**Catchment size** (km^2)	**System Name**	**Catchment size** (km^2)
Very large river (> 8 000 km^2)	Blackwood River	20 500	Moore River Avon River	>12 000 >119 000
Large river (2000-8000 km^2)	Warren River Frankland River	4 348 4 549	Collie River Hotham River Murray River	2 920 >4 015 >7 300
Medium river (750-2 000 km^2)	Deep River Tone River Donnelly River	1 003 1 228 1 667	Harvey River Serpentine River Gingin Brook Canning River Preston River Serpentine drain Collie Riiver East Williams River Brockman River Helena River	>727 769 826 >960 >1 080 >1 128 1 340 >1 437 >1 514 >1 580
Small river (350-750 km^2)	Lefroy Brook Barlee Brook Margaret River Wilgarup River Gardner River St John Brook Shannon River Capel River Scott River Perup River	358 424 443 460 529 570 612 616 632 690	South Dandalup River Harris River Bingham River Wooroloo Brook Ellen Brook Collie R South Darkin River	>350 >382 >407 >536 >590 660 >663
Major creek (90-350 km^2)	Cantebury River Sabina River Quinup Brook Meerup River Carey Brook Abba River Buayanup River Carbunup River Ludlow River Rosa Brook Yarraminup Vasse River	94 105 113 116 124 140 158 166 208 215 236 274	Canning East Nth Dandalup River Julimar Brook Bell Brook Brunswick River Big Brook	>76 >153 >179 >207 >228 >243
Creek (30-90 km^2)	Forth River Big Easter Brook Gunyulgup Brook Smith Brook Turner Creek Buldania Inlet River Boodjidup Brook Fly Brook Chesapeake Wilyabrup	>34 44 47 52 54 54 56 60 63 81 88	Glen Mervyn Dam Creek Augustus River Preston R South Pickering Brook Little Darkin River Conjurunup Creek Gooralong Brook Lunenburg River Joshua Creek Davis Brook Chalk Brook	>20 >24 >24 >31 >40 >40 >51 >57 >57 >67 >104
Minor creek (< 30 km^2)	Cowaramup West Bay Calgardup	22 26 29	Hay Creek Stones Brook Death Adder	14 15 >17

Water and Rivers Commission

Hyatt Centre
3 Plain Street
East Perth Western Australia 6004

Telephone (08) 9278 0300
Facsimile (08) 9278 0301