GOVERNMENT OF WESTERN AUSTRALIA

Bunbury - Mandurah Region Water Resources Review and Development Plan October 1996

Volume I of II

Water Resource Allocation and Planning Series

Water & Rivers Commission Report WRAP 1 1996

Water and Rivers Commission

Bunbury - Mandurah Region Water Resources Review and Development Plan October 1996

Volume I of II

by
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Policy and Planning

Water and Rivers Commission
Water Resource Allocation and Planning Series
Report No. WRAP 1 1996

Acknowledgments

I wish to thanks the following people for their efforts: Jade Coleman, Peter Goodall, Jenny Hart, Ian Loh, Gerry McCourt, John Ruprecht and Peter Van De Wyngaard of the Water and Rivers Commission and Chris Bryant, Lee Henville and Sean Tonkin of the Water Corporation

Reference Details

The recommended reference for this publication is: Water and Rivers Commission 1996, *Bunbury-Mandurah Region Water Resources Review and Development Plan, Volume 1 of 11,* Water and Rivers Commission, Water Resource Allocation and Planning Series No. WRAP 1.

ISBN: 0-7309-7251-8

Contents

Figures

Tables

Executive Summary

Introduction

The Bunbury - Mandurah Region is currently experiencing significant growth in population. The town of Australind, with an annual growth rate of almost 4%, is one of the fastest growing towns in Western Australia. Expansion proposals for the Kemerton Heavy Industry Area indicate a growth in water consumption of 4 to 6 times the current water usage, and developments in the Collie Basin indicate potential dramatic changes in water consumption patterns. These, coupled with the possible changes in management of the irrigation districts, mean that a strategic understanding of the development of the region and the resulting impact on the region's water resources is essential. This study is intended to provide that understanding. Up to date information on divertible water resources of the region have been collected and consolidated and the likely water requirements of existing and potential developments have been determined. The study area includes the Preston, Harvey and Collie Drainage Basins.

The objectives of this study are:

- To collate current information on existing and potential divertible surface water and groundwater resources in the Bunbury - Mandurah Region.
- To consolidate all available surface water information pertaining to the region.
- To consolidate all available groundwater information pertaining to the region.
- To collate current information on domestic, industrial, agricultural and environmental water demands in the region.
- To predict all future water demands within the study area for a thirty year planning horizon.

Water Resources

The most up to date surface water and groundwater resources of the region have been collated, analysed or assessed. These have been grouped according to the relevant drainage basin. Information pertaining to water resources includes the water source (dam site or aquifer), water quality, yield, development potential and development constraints.

This document is primarily an inventory of the water resources in the study area, no attempt is made to consider specific significant environmental issues. However, some general consideration has been given to the existence of conservation reserves in the CALM estate which may be affected by water resource development. This very preliminary assessment has indicated that in some cases environmental values are likely to be significantly affected by water resource development, while other potential developments may remain relatively unconstrained.

Projections

Population and water demand projections have been undertaken. Population projections for each town were undertaken to form the basis of the town water supply projections.

Total water demands from surface water and groundwater sources have been calculated separately for each drainage basin.

Water Resource Development Plans

Most towns in the study area obtain their water from groundwater resources. Most have enough surplus capacity available in the aquifer to allow for expansion of their existing borefields. Some towns which currently use groundwater do not have adequate surplus capacity to meet anticipated demands in the planning period. This additional demand can usually be met by extracting groundwater from a different aquifer or from groundwater resources nearby.

The Donnybrook Town Water Scheme currently extracts water from the Leederville Formation with sufficient water to meet future needs. However, the horticultural industry near Donnybrook also requires water from the

Leederville Formation. There is insufficient water in the Leederville to meet both requirements and one or both will be required to expand into the Yarragadee Formation.

Minor industries primarily obtain their water from town water schemes or direct abstraction of water from groundwater resources. Of particular interest is the Kemerton Water Supply which is expected to obtain water from a scheme which harnesses Wellington Dam releases in the Lower Collie River.

Future agricultural and horticultural needs are likely to be met from existing sources (ie. groundwater and the existing Irrigation Districts and Dams).

As demand for water in Perth grows, there will be increasing pressure for inter-regional transfers of water from the study area to the Perth Metropolitan Area. Of particular note is the Water Authority of WA document "Perth's Water Future" which proposes construction of a new dam on the Harvey River and a pumpback on the Wellesley Creek before 2021. Even though that study does not identify any further source developments in the study area to supply the Perth Metropolitan Region, it can be anticipated that there will be further pressure to develop sources in the study area to meet Perth's future demands.

Conclusions

A summary of the existing and future water supply and demand for the region is presented in Figure I. 1.

At present the potential available surface water greatly exceeds the regional demand. This situation will also prevail in 2025 provided there is no augmentation to Perth. The potential surface water supply and likely demand within each basin is presented in Table 11.1. Essentially, the potential exists for extensive development of surface water sources to meet future demands within the region. Surplus capacity also exists to cater for inter - basin transfers.

At present less than half of the potential available groundwater is being utilised in the Preston River Basin. By the year 2025 the demand for groundwater is expected to remain less than half of the potential available groundwater. More than half of the potential available groundwater is being utilised in the Collie River Basin. By the year 2025 no excess groundwater will be available in this basin. Only a small portion of the available groundwater within the Harvey River Basin is currently utilised and the demand for groundwater in this basin is not expected to increase greatly by the year 2025.

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A/Director, Policy and Planning

Date 9/10/96

....

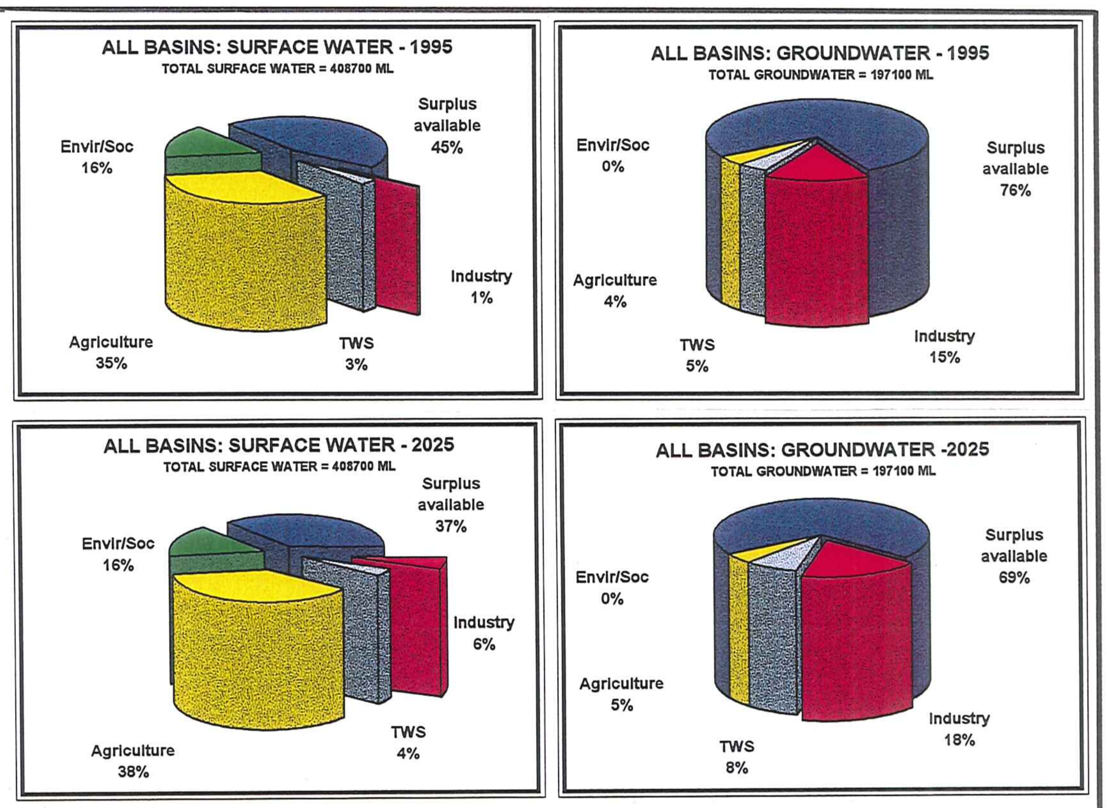
Chief Executive Officer

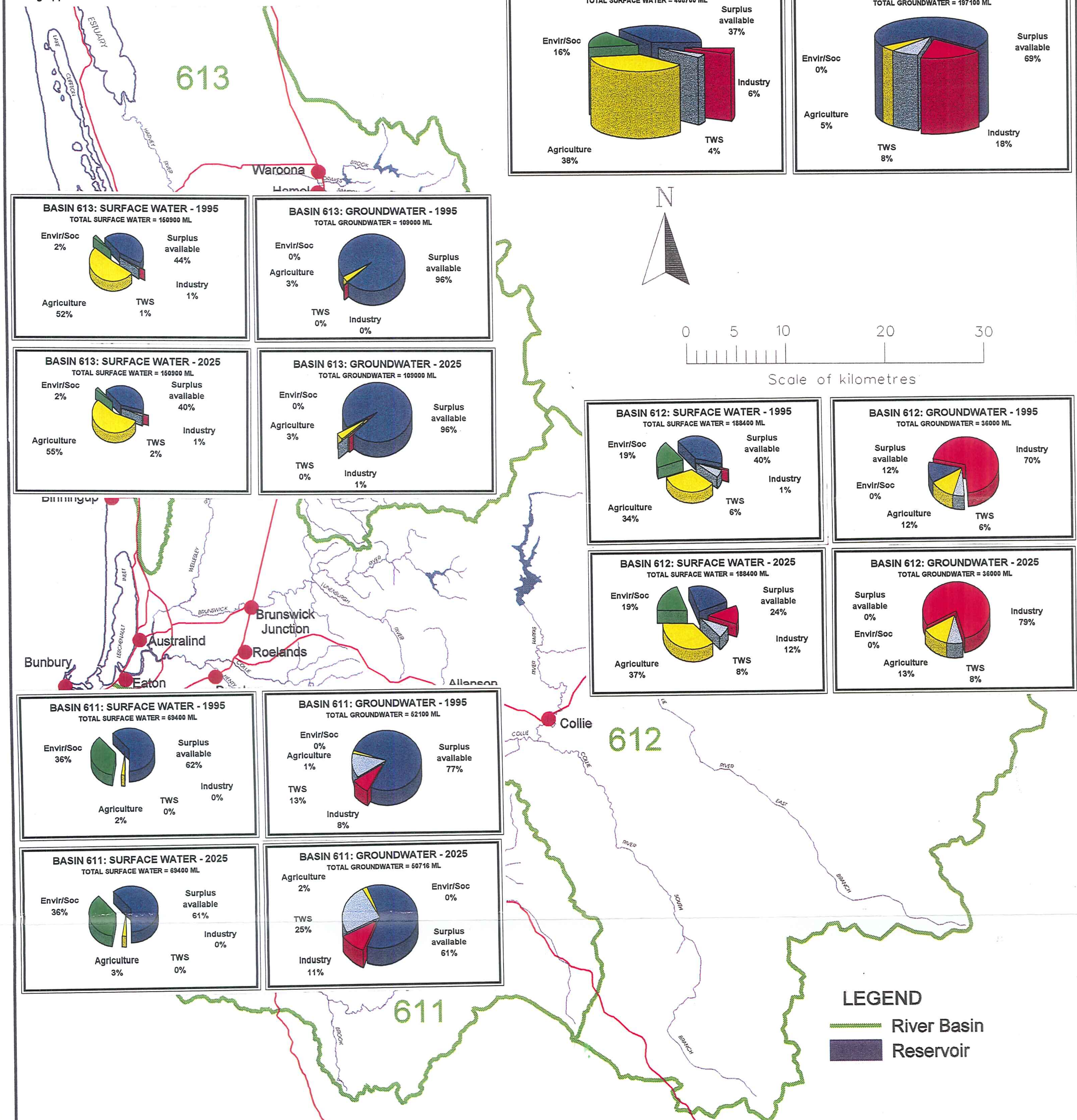
Date 15.10.96

Environmental/Social Considerations

GROUNDWATER: In the study area, the amounts of unconfined groundwater needed to maintain the saltwater interface appear to be sufficient to maintain the wetlands. Hence, the "surplus available" volume equals the "environmental sustainable" volume and no available groundwater needs to be foregone. This will need to be further assessed and monitored as the resources are developed. Extraction from artesian groundwater is not constrained by environmental/social factors since artesian water is not associated with wetlands. Nevertheless, Water and Rivers Commission policy limits the use of artesian resources to sustainable levels over the long term.

SURFACE WATER: Surplus available surface water was foregone for development where the diversion development, such as a dam, would have an unacceptably adverse impact on environmental/social issues. Specific amounts will be determined for each development according to the downstream environmental/social needs by the environmental impact assessment process through which each must pass before being approved.





Bunbury-Mandurah Region Water Resources Review and Development Plan

SUPPLY AND DEMAND FROM SURFACE AND GROUNDWATER SOURCES

Figure I.1

1. Introduction

1.1 Background

The Bunbury - Mandurah Region Water Resources Review arises from the need to collect and consolidate up to date information on the divertible water resources of the region and to determine the likely water requirements of existing and potential developments. The review is strategic in nature. This means that it is long term and provides for the region's water needs for the next 30 years to the year 2025. The review builds on the research and planning of the past. It acknowledges the fact that Bunbury, through its industry and port, and Collie, through its coal mining and energy generating infrastructure, are at the heart of the south-west and are essential to the development of Western Australia.

This review has been undertaken to complement previous studies. These studies include past reviews of similar content or studies containing complementary information. Though many reports and studies were consulted (see bibliography) the reports which have direct bearing on this study are:

- GOODALL P.J., 1990. Bunbury Region Water Source Development 1990 to 2020, Volumes I & II. Water Authority of Western Australia, Report No WP 86, April 1990. This study covers most of the current study area and has similar content. It can be regarded as the forerunner and consequently much of the information it contains has been superseded.
- WESTERN AUSTRALIAN WATER RESOURCES COUNCIL (WAWRC), 1991. Safeguarding Our Water Resources. Perth - Bunbury Draft Regional Allocation Plan. Western Australian Water Resources Council, September 1991. This study is most important in defining at a regional scale the divertible water available for consumptive use. The allocation plan took account of regionally significant environmental/social constraints on diversion.
- SOUTH WEST DEVELOPMENT COMMISSION (SWDC), 1994. South West Strategy. South West Development Commission, November 1994.
- WESTERN AUSTRALIAN PLANNING COMMISSION (WAPC), 1995. Bunbury Wellington Region Plan. Ministry for Planning, December 1995.

Much of the most up to date planning and growth information has been abstracted from these latter two reports.

This study was initiated prior to the re-structuring of the water industry in Western Australia. Consequently reference is made to the Water Authority of Western Australia (WAWA) when relating to issues and information prior to 1996. Reference is made to the Water and Rivers Commission (WRC), the Water Corporation and the Office of Water Regulation (OWR) for issues and information referred to after 1 January, 1996.

1.2 Objective and Scope

The objectives of this study are:

- To collate current information on existing and potential divertible surface water and groundwater resources in the Bunbury - Mandurah Region.
- To consolidate all available surface water information pertaining to the region.
- To consolidate all available groundwater information pertaining to the region.
- To collate current information on domestic, industrial, agricultural and environmental water demands in the region.
- To predict all future water demands within the study area for a thirty year planning horizon.

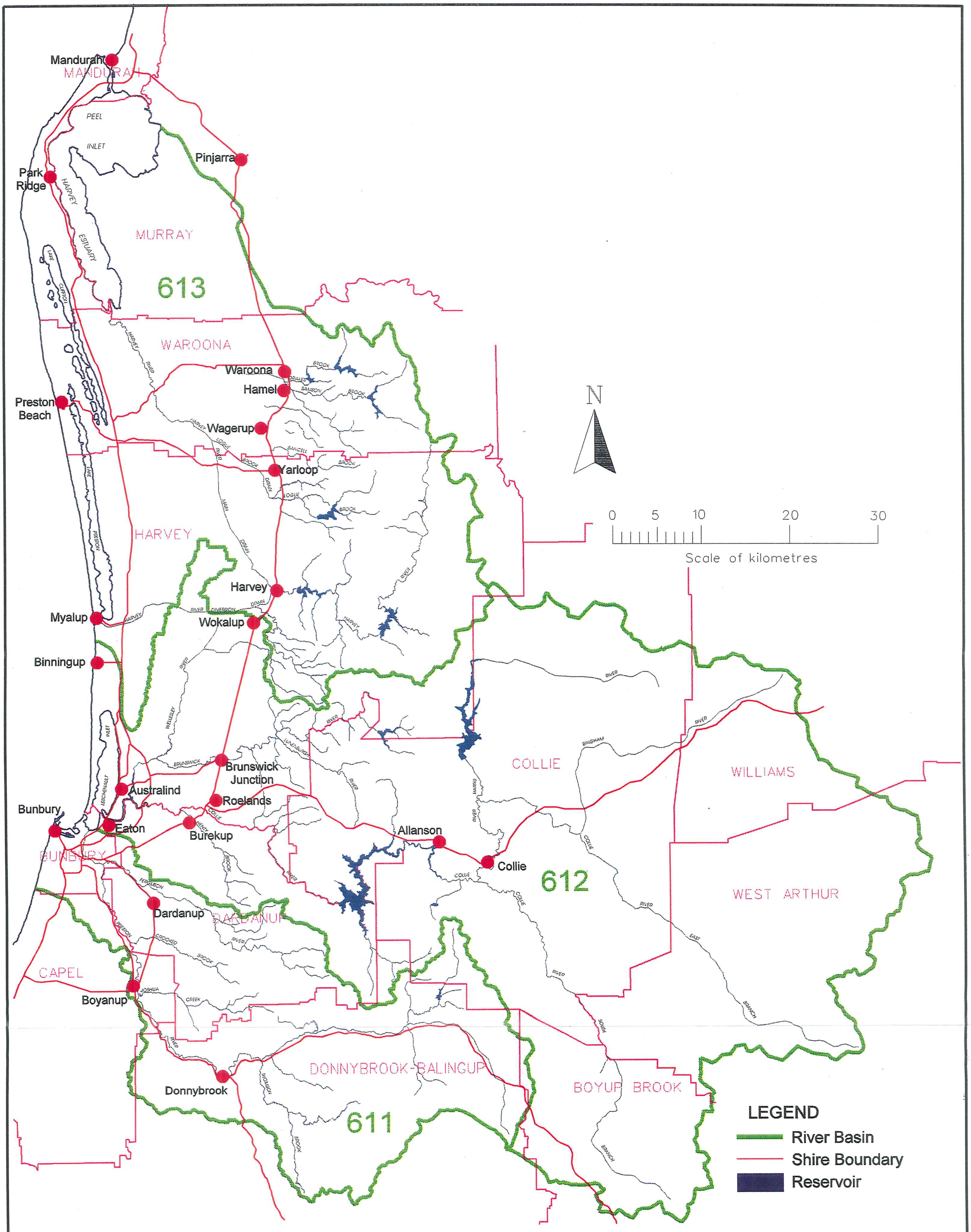
1.3 Study Area

The study area (Figure 1.1) comprises three drainage basins (WAWRC, 1987). These are the Preston (611), Collie (612) and Harvey (613) River Basins. The total area of these three basins is 6886 square kilometres. The City of Bunbury and the Shires of Collie, Dardanup, Harvey and Waroona are fully contained within the study area. The Shires of Boyup Brook, Capel, Donnybrook - Balingup, Murray, West Arthur and Williams are partly contained within the study area.

There are a total of twenty towns and sub - divisions in the study area. The major towns are Australind, Bunbury, Collie, Dardanup, Eaton, Harvey and Waroona. The other townsites are, Allanson, Binningup, Brunswick Junction, Boyanup, Burekup, Donnybrook, Hamel, Myalup, Park Ridge, Preston Beach, Roelands, Wokalup and Yarloop/Wagerup.

A large proportion of the study area has been cleared for agriculture, particularly in the Collie catchment. This has resulted in significant degradation of water and soil resources. The western edge of the South - West Irrigation Area is affected by high saline groundwaters. Most natural forest cover occurs in state forest, national parks and other reserves. These are located mainly east of the Darling Scarp. Remnant vegetation exists on private land, particularly along the coast.

For purposes of this study, water yields, demands and projections will be presented for each basin separately and then summarised for the region as a whole. The area of study will be referred to as the 'study area' throughout this text but may also be referred to as 'the region' when appropriate.



Bunbury-Mandurah Region Water Resources Review
STUDY AREA (Basin 611,612 & 613)

Figure 1.1

2. Regional Characteristics

2.1 Physiography

The landscape of the region is determined by six distinctive physiographic areas:

- The Darling Plateau is an ancient crystalline granite rock which varies in height from 160 to above 360 m AHD. It is covered by lateritic hardcap and associated clays and has been dissected by present and old river systems which have eroded back from the scarp giving it an undulating and even, hilly surface and forming low alluvial fans which extend into the Swan Coastal Plain.
- The Darling Scarp is a dominant, steep, continuous feature (forming the western edge of the Darling Plateau) which traverses the region from the north to south to the vicinity of Dardanup and continues in less identifiable form to the south coast.
- The Whicher Scarp is less steep than the Darling Scarp. It begins at a junction with the Darling Scarp at approximately the Dardanup townsite and traverses south parallel to the coast. The Whicher Scarp averages only 50 m AHD and is believed to have formed as a result of marine erosion.
- The Swan Coastal Plain is the land area west of the Darling Scarp and comprises a predominantly low lying and gently undulating to flat surface. The coastal fringe of the plain consists of the Quindalup and Spearwood Dune Systems and the balance comprises the Bassendean Dune System and the Pinjarra Plain.
- The Collie Basin is a sediment filled basin formed by faulting and subsequent land subsidence within the Darling Plateau. It is distinct from the Darling Plateau because it represents remnants of a former sedimentation basin which contains commercial coal deposits.
- The Blackwood Plateau is bounded by the Whicher Scarp to the north-west and the Darling Scarp to the east. It varies in elevation from 80 - 160 m AHD, has an undulating surface and is covered by a mantle of laterite, sands and soil.

2.2 Climate

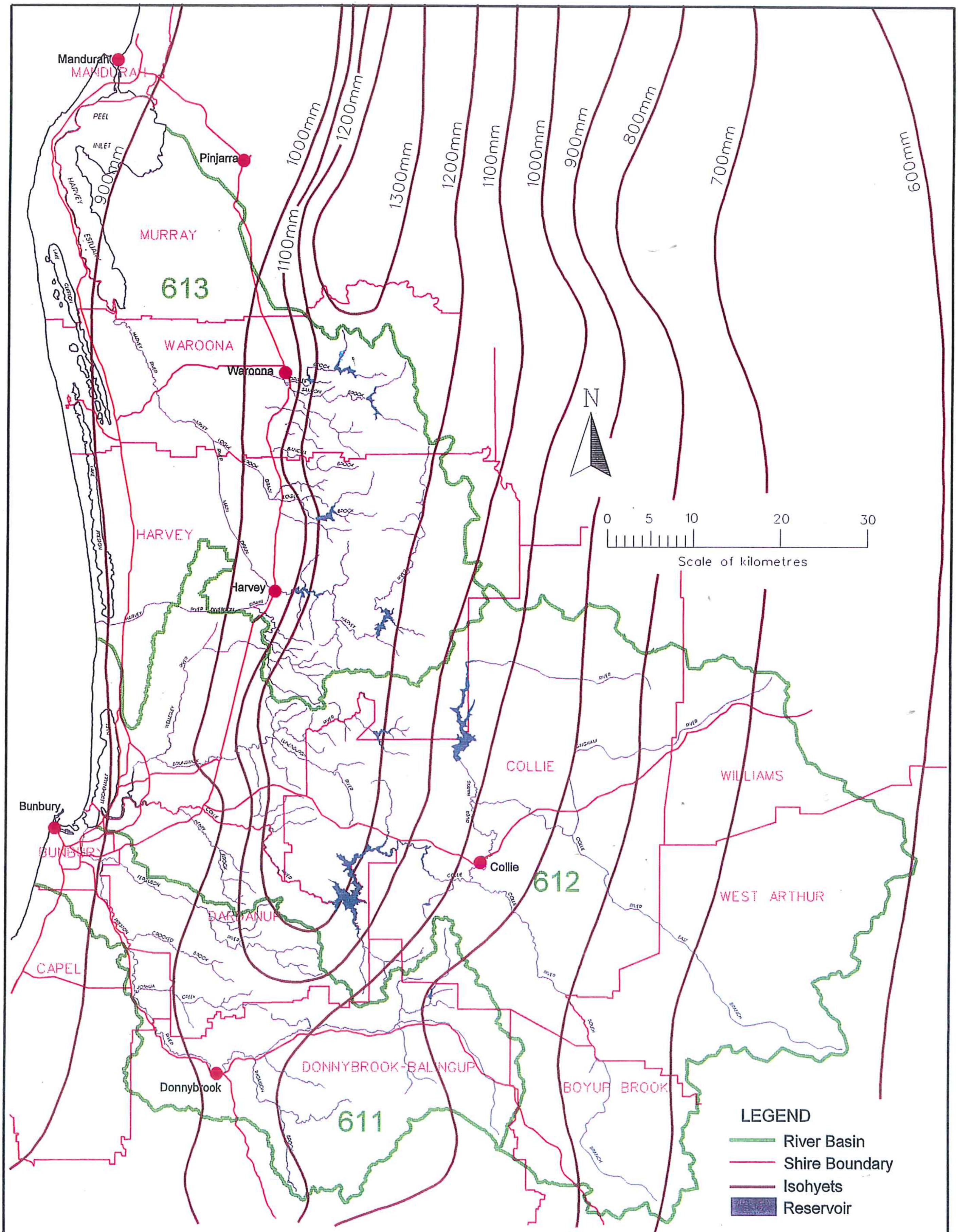
The climate of the Bunbury - Mandurah Region is a warm temperate Mediterranean' type climate with distinct seasons. Summers are dry and warm to hot, the winters are wet and cool. Seasonal and annual variation in climate results from the migration of the sub - tropical anti-cyclone belt. The change of continental and maritime airflows dominates the whole climate. The continent provides dry air masses from the east and north in the summer while the ocean provides humid air masses from the west and south in the winter. There is a distinct gradient of climatic factors across the study area with increasing distance from the coast.

Daily mean temperatures range from 22 - 23°C in January to 10 - 13°C in July. January and February are the hottest months, July and August are the coolest months. Mean summer maximum and winter minimum temperatures are 30°C and 8°C, respectively.

The region is a winter rainfall zone with most rain falling between May and September. Average annual rainfall ranges from 840 mm along the coast to 600 mm along the eastern boundary of the study area. The catchments of some of the rivers flowing into the area receive in excess of 1200 mm rainfall, but most receive less than 800 mm rainfall. The eastern boundary of the Collie River Catchment receives less than 600 mm rainfall. Rainfall histograms for various towns within the region and representing the three basins are presented in (Appendix A 1) and rainfall isohyets for the region are presented in Figure 2.1.

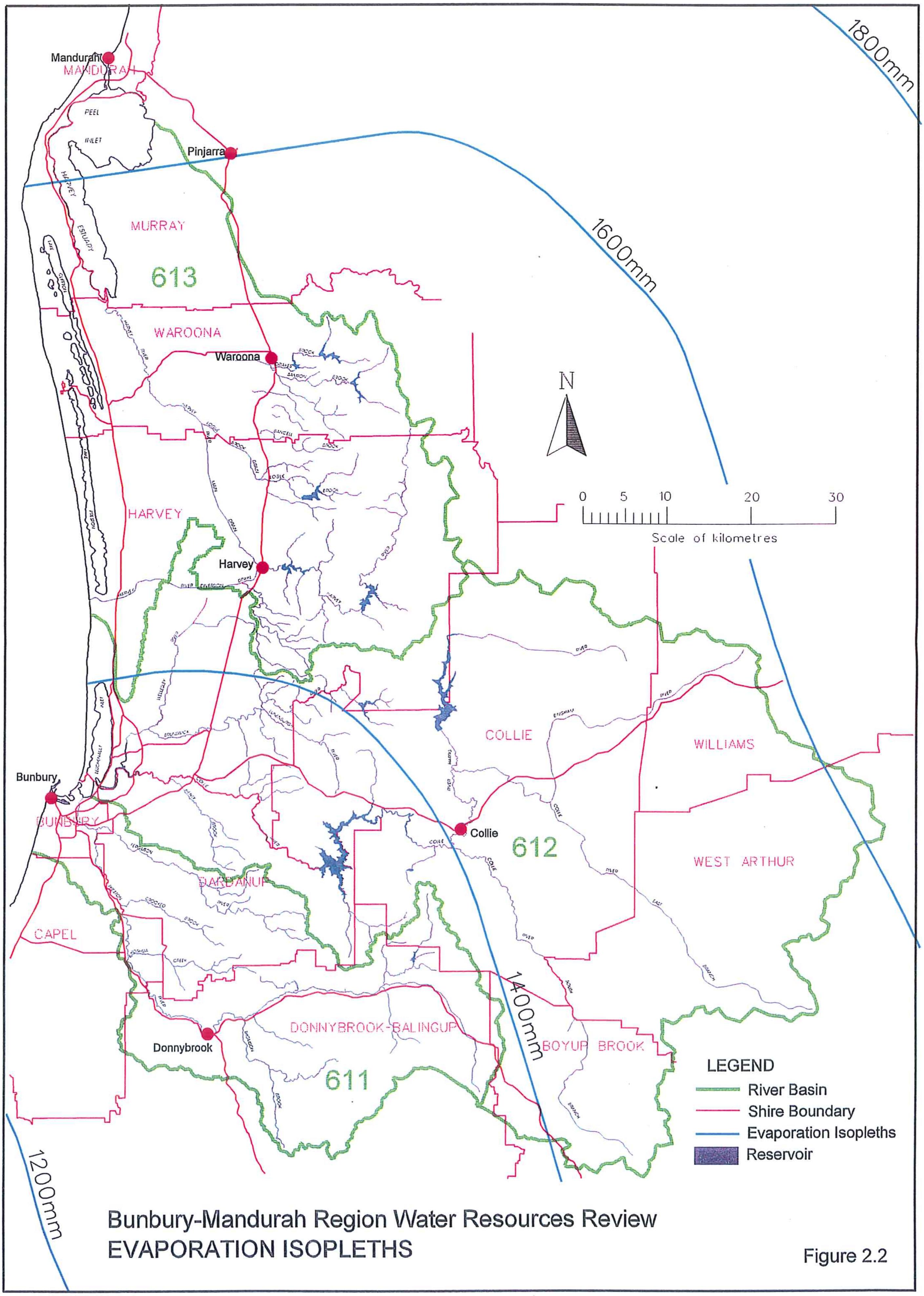
The impact of climate change on rainfall is still not clear. Recent work is summarised in Sections 5.5 and 5.6.

Average evaporation varies from around 1200 mm a year in the south-west of the study area to 1600 mm a year in the north-east of the study area. Monthly evaporation within the region varies from around 50 mm in June to almost 300 mm in January. Evaporation isopleths for the region are presented in Figure 2.2.



Bunbury-Mandurah Region Water Resources Review
RAINFALL ISOHYETS

Figure 2.1



Bunbury-Mandurah Region Water Resources Review
EVAPORATION ISOPLETHS

Figure 2.2

2.3 Soils And Landforms

The Darling Plateau and Scarp have the following characteristics:

- The scarp consists of moderate to steep slopes with shallow red and yellow soils and rock outcrops.

- The plateau surface is dominated by lateritic duricrust, soils include shallow sands over sheet laterite, gravelly duplex soils and grey sands. Areas of laterite and granitic outcrop also occur.

- Minor valleys are the shallow valleys on the plateau surface. Gravelly duplex soils occur on the side slopes of the Yarrigal and Pinallup units while red and yellow duplex soils occur on the Catterick unit. Valley floors are often broad and swampy.

- Major valleys include the Lowden, Helena, Murray, Balingup and Bridgetown units. These valley systems are deeply incised, dissecting the plateau surface. Soil types are gravelly duplex soils and red and yellow duplex soils and earths. Slope gradients range from gentle to steep and granitic rock outcrop is often present.

The Swan Coastal Plain has the following characteristics:

- The Quindalup Dune System consists of the Quindalup Dunes, composed of calcareous sand, and the Quindalup flats which consist of sheltered flats and calcareous sand.

- The Estuarine and Lagoonal System consists of poorly drained plains composed of mixed and unconsolidated estuarine and marine deposits, located in low lying areas and fringing the estuaries, inlets, coastal lake systems and river deltas.

- The Spearwood Dune System is situated east of the Quindalup Dunes and consists of siliceous sands overlying the Tamala limestone.

- The Bassendean Dune System is situated immediately east of the Spearwood Dune System and consists of low dunes which are generally leached of calcium carbonate, leaving a light grey to off - white sand of quartz grains.

- The Pinjarra System consists of an alluvial surface which slopes westwards between the hills and the edge of the Bassendean Dune System. Ten soil units comprise the system.

The Collie Basin has the following characteristics:

- The basin lies within the Darling Plateau and consists of lateritised Permian and younger sedimentary rocks. Three soils units comprise the basin: Collie, Cardiff and Muja.

The Blackwood Plateau has the following characteristics:

- The plateau is gently undulating and has a sedimentary geology with exposed extensive laterite.

- The soils of the Plateau consist of acidic gravelly, sandy and loamy soils. Six soil units comprise the plateau.

- The three broad components of the plateau are the scarp, lateritic uplands and valleys.

2.4 Vegetation and Wildlife

The Bunbury - Mandurah Region falls within the Darling District of the South West Botanical Province. The region has a large number of species which do not occur elsewhere. These species, especially the woody shrubs, are common in all the ecological formations.

The diverse range of vegetation communities provides a variety of wildlife inhabitants and these can be divided into four broad types; dry land vegetation, wetland vegetation, developed farmlands and the Jarrah forest.

The natural vegetation of the Coastal Plain contains forest and woodland, predominantly of Tuart, Marri and Jarrah with an understorey of acacia, banksia and where there are clay soils, Wandoo. The open heath found on the coastal fringe contains fragile dune stabilising plants. The swampy areas contain paperbark and an understorey of shrubs and ground plants is present throughout.

The wetlands of the Swan Coastal Plain provide essential ecological requirements for at least 62 species of water birds, many of which are trans - equatorial migrants.

The Darling Scarp and Plateau supports Marri and Jarrah forests with occasional Wandoo. The open woodland of this area comprises a diverse understorey. The natural vegetation of the Whicher Scarp and Blackwood Plateau is similar to that of the Darling Scarp and Plateau.

The terrestrial fauna of the region is divided into invertebrates and vertebrates including birds, mammals, amphibians, reptiles and feral animals. There are also marine fauna which are found in the estuaries, rivers and coastal waters.

Although current knowledge of the invertebrate fauna is not extensive it is known that large numbers occur in habitats of relatively undisturbed vegetation.

Documented survey data indicates very diverse vertebrate fauna in the region with bird species being the most abundant. Again, information on vertebrates is somewhat limited and hence a complete picture of the state of wildlife cannot be formed.

2.5 Geology

The study region covers parts of the Perth Basin and the Yilgarn Craton and includes the Collie and Wilga Basins.

The Perth Basin contains between 7000 m and 9000 m of sedimentary rocks of Permian to Quaternary age and is separated from the Yilgarn Craton by the Darling Fault along its eastern boundary.

The Quaternary superficial formations on the Swan Coastal Plain extend to about 30 m below sea level along the coast and consist mainly of clay in the eastern part of the coastal plain and sand and limestone in the western part. The superficial formations are underlain by the Cretaceous Leederville Formation, an interbedded sand shale sequence, which is up to 400 m thick. To the south of Kemerton the Leederville Formation overlies the Upper Jurassic Yarragadee Formation, which is predominantly sandstone, and as much as 800m thick. North of Kemerton the Leederville Formation overlies the Lower Jurassic Cattamarra Coal Measures and Eneabba Formation.

Basalt of Lower Cretaceous age separates the Leederville Formation from the Yarragadee Formation in the Donnybrook - Bunbury area.

The Yilgarn Craton is composed mainly of granite and gneiss cut by dolerite dykes. These crystalline rocks are commonly weathered, with laterite at the surface overlying up to 30 m of rock weathered to a sandy clay.

The Collie and Wilga Basins are outliers of the Perth Basin, and contain Permian coal measures, sandstone, and a basal claystone of glacial origin. The Collie Basin contains a thickness of up to 1400 m, whereas the Wilga Basin contains only about 300 m of sediments. The Permian sediments are covered by a layer of Cretaceous sand and clay 10 m to 30 m thick.

2.6 Minerals and Basic Raw Materials

The known mineral resources within the Bunbury - Mandurah Region consist primarily of bauxite, coal and heavy mineral sands with minor occurrences of gold and base metal. The area also contains basic raw materials for construction including kaolin, limestone, silica sand, gravel, aggregate or building stone.

The principle area for bauxite is the Darling Plateau laterites, east of the Darling Scarp and extends 50 - 60 km inland. Particularly high concentrations of ore occur within this area in a 15 - 30 km wide strip between the Canning and Harvey rivers.

Heavy mineral sands are found on old and current beach lines, submarine locations and former river channels. The heavy minerals are ilmenite, leucoxene, rutile, zircon, monazite and xenotime.

Coal is present in the Collie Basin as a sequence of seams. It is sub - bituminous, non coking, has low ash and high inherent moisture content. Collie coal is the only coal commercially exploited in WA and is high - quality, low sulphur steaming coal.

Kaolin, a clay, is highly plastic and suitable for use in the ceramic and refractory industries. The Tamala Limestone, which parallels the coast, forms the region's source of limestone. Low and medium grade limestone has been quarried from several locations east of lake Preston and within State Forest 16. High grade limestone is rare with only the area between Myalup and Binningup considered as a potential source.

Sand is obtained primarily from Safety Bay Sand and less frequently from the Spearwood and Bassendean Dune systems. Gravel is extracted from sites in the Darling Plateau and rock aggregate is quarried from dolerite rocks on the plateau.

Building stone such as limestone, Donnybrook Sandstone and granite rocks of the Darling Plateau are quarried in generally small scale operations throughout the region.

2.7 Water

Water resources in the region can be divided into two components; surface and ground water.

The surface water resources include the region's rivers, streams, wetlands, pools, lakes and associated estuaries, plus lakes and wetlands which are not associated with any river.

The region conforms to hydrologic boundaries, it includes the Harvey River Basin, the Collie River Basin and the Preston River Basin.

A number of major and minor rivers flow from the eastern, largely forested portion of the region and descend the Darling Scarp, combining into a few major river channels which flow westwards to the sea. Major rivers of the region are the Harvey, Brunswick, Collie and Preston Rivers. Surface water from the Swan Coastal Plain have been depleted by extensive drainage works, however, those that remain include the Leschenault Estuary, Benger Swamp and Lake Preston.

The region has many surface rivers and streams, most of which have the potential to be dammed.

The region's groundwater resources are contained within the Perth and Collie Basins. The major aquifers of the Perth Basin are (in increasing depth) the Superficial, Leederville, Yarragadee and Cockleshell Gully Formations. The region does not conform precisely to the groundwater management area boundaries, however, it does contain the South West Coastal, Bunbury and Collie Groundwater Areas and two subareas of both the Murray Groundwater Area and the Busselton - Capel Groundwater Area.

The Superficial Formation is used as a source of fresh water for homes and small farms and is recharged directly from rainfall.

The Leederville Formation is used for public water supply at Preston Beach, Park Ridge, Myalup, Binningup, Australind, Bunbury, Dardanup and Donnybrook and for industrial purposes at Kemerton, Australind and Picton. It is recharged by leakage downward from the Superficial Formation.

The Yarragadee Formation is considered to be of great importance as it contains a large quantity of good water. Within this region it is used for public water supply at Bunbury, Boyanup and Eaton and for mineral processing at Boyanup. This formation is recharged by the overlying superficial sediments and the surface streams that descend from the Blackwood Plateau.

Groundwater at Collie is characterised by a salinity of around 1000 mg/L TDS and is largely used for cooling purposes at the Muja Power Station. Recharging occurs from direct infiltration of rainfall as well as infiltration from the main branches of the Collie River and tributaries.

2.8 Coast

The region has 100 km of coastline of almost unbroken sandy beaches extending south from the City of Mandurah to the City of Bunbury. The coast is the interface between the marine and terrestrial environments and is influenced by natural processes and human activities which are most obvious in the near shore, beach and dune areas. Influences such as currents, climate and activities in catchments can be local, regional or global.

The interaction of human activities and natural processes is complex. It is often difficult to predict the consequences of decisions to develop in coastal environments and the occurrence of several extreme simultaneous natural events.

The coast, and its adjoining land and marine areas, is inherently unstable in the Bunbury - Mandurah Region. The coastal barrier system was influenced by changes in sea level over the past ten thousand years and the Quindalup Dune System, which overlays the more stable Spearwood Dune System, can be steep, mobile and change significantly over a short period of time.

The coastline is a major attraction for people. There is a concentration of people who live near the coast and they attach great value to coastal land ownership. Increasing competition between housing, recreation, conservation, industry, mining and farming for the coastal resources is occurring.

Management based on an understanding of the natural processes over a long period of time is fundamental to conserving the natural values of the coast and reducing the risk to public and private property.

2.9 Population

The population of the Bunbury - Mandurah Region in 1994 was approximately 65 700. This is based on the Australian Bureau of Statistics (ABS) official Estimated Resident Population (ERS) figures (1994). Population change in the region in recent census periods is presented in Table A2.1, Appendix A 2.

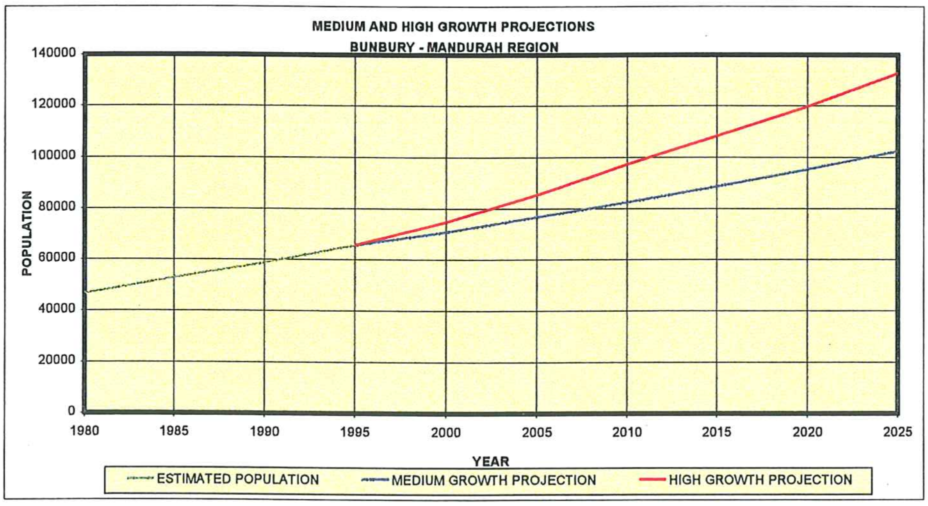
Future population projections (scenarios) are indicated in Table A2. 1 and Table A2. 2, Appendix A 2 and graphically in Figure 2.3.

The medium population projection results in regional populations of approximately 81 700 and 100 100 by the years 2010 and 2025 respectively. This scenario assumes continuation of recent population trends for the region. The high population projection results in regional populations of approximately 97 000 by 2010 and 131 000 by 2025.

These projections are based on the Bunbury - Wellington Region Plan scenario, Western Australian Planning Commission - WAPC (1995) and to a lesser degree the Peel Regional Plan scenario, Department of Planning and Urban Development - DPUD (1990a). The medium population projection scenario assumes the continuation of recent population trends for the region. The high population projection scenario assumes ongoing population growth rates, plus it takes into consideration existing Government policy initiatives and private sector investment decisions. There was no low population projection scenario (Figure 2.3). Speculative developments are not considered. A major industry can create many permanent direct and indirect jobs which would boost population growth. The new 300 - megawatt Collie Power Station, on which construction commenced during 1995, will create 3000 direct and indirect jobs. It should be noted that the above projections are subject to a range of changing circumstances and are, therefore, subject to amendment from time to time.

Comprehensive discussion and projections for each town were undertaken and are discussed and presented graphically in Section 7.

Figure 2.3: Future Population Projections



3. Surface Water

3.1 Introduction

Background information for each river basin is presented in the following sub-section. Existing surface water sources are then described in the following sub-section and potential surface water sources are described in the final sub-section.

Existing and known potential surface water development sites are shown in Figure 3.1 and listed in Table A3. 1, Table A3. 2 and Table A3. 3, Appendix A 3. The sources are grouped under Australian Water Resources Council river basins and are listed from upstream to downstream (ie. as each sub-catchment contributes to the total catchment). Information sheets relating to each site are presented in Appendix A 3.

The hydrology for each site, based on the most up to date data, has been analysed for this study. Only the Mean Annual Flow (MAF) and the yield for a specific reservoir capacity are presented in this report. Should a more comprehensive yield analysis be required all the necessary data and analysis spreadsheets are available from the Hydrologic Services Section of the WRC.

3.2 River Basins

3.2.1 Preston River Basin (611)

The Preston River Basin (611) contains a total area of 1134 km^2. The Preston River rises in forested country on the Darling Plateau south-west of Collie. It flows through farmland for most of its length, through deeply incised valleys to Donnybrook at the foot of the Darling Scarp, then across the low Blackwood Plateau to Boyanup and across the Swan Coastal Plain to Bunbury, where it discharges into the southern end of the Leschenault Estuary. The Ferguson River, which drains the Darling Scarp further to the north joins the Preston River at Picton.

Farmland on the coastal plain is drained into both rivers. Loss of riparian vegetation, sedimentation, and pollution with nutrients and pesticides are the principal forms of degradation found in the Preston River Basin.

Between Picton and Bunbury, the Preston River, in its natural state, was a sluggish river meandering through seasonal wetlands. To improve the drainage and reduce flooding in East Bunbury, the river has been straightened, and confined within levee banks. It was also redirected further to the north-east to allow room for construction of Bunbury's Inner Harbour. The same project closed Leschenault Estuary's outlet to the sea, so a new "cut" was made further north, opposite the mouth of the Collie River. This new outlet discharges flood waters to the sea more efficiently than the original estuary mouth and has lowered flood levels around the estuary margin.

Loss of flow in the Preston River in summer, due to the use of river water by farmers for irrigation, is partly compensated by water releases from Glen Mervyn Dam near Mummballup.

Surface water data has been collected in the basin since 1939. The first continuous streamflow measurements started on the Preston River in 1939. There are currently 5 gauging stations operated by the Water and Rivers Commission in this basin and all have at least 20 years of operation. Data collection was initially concentrated on the Preston River but now there is a fairly even coverage across the whole basin.

The Preston River Basin is approximately 60% cleared, principally in the valleys and the upper and lower parts of the basin. Water sampling to date has not detected significant levels of chemical residue. In 1989 samples indicated that the measure of pesticide contamination was hundreds of times below the maximum permissible NH&MRC guideline levels. However, with further development on the catchment area there is a possible risk that contamination of the Preston River might occur in the future, and a major effort would be required to manage the catchment area to protect water quality.

3.2.2 Collie River Basin (612)

The Collie River Basin (612) envelopes a total area of 3697 km^2. There are two major dams situated in the basin. These are the Wellington Dam on the Collie River and the Harris Dam on the Harris River.

Wellington Reservoir has a catchment area of 2448 km^2 (excluding the Harris River at the Harris Dam). Most of the Wellington Reservoir catchment is on the Yilgarn Plateau, extending east to the 600 mm rainfall isohyet near Darkan, and south almost to Boyup Brook. Approximately 30% of the Wellington catchment has been cleared. The majority of this was as a result of agricultural development in the early 1960's, but a significant proportion can also be attributed to mining and the influences of electrical power generation and distribution.

The inflow salinity to Wellington Reservoir for a median flow year has increased from 280 mg/L in 1945 to approximately 1030 mg/L at present. This increase to the inflow salinity is an effect of clearing for agriculture in the Wellington Reservoir catchment. Contributions of fresh water to the system, from small forested catchments, reduces the average salinity of the dam water. Evaporation from the dam surface raises the average salinity, while the annual scouring of about 38 million cubic metres of brackish water from the bottom of the reservoir during the months of June to September lowers the average salinity of the stored water.

Further clearing of the catchment has been controlled since 1976. Had no reforestation occurred the estimated inflow salinity would have been 1150 mg/L at present. During the past 15 years significant reforestation has been undertaken. The majority was initiated by the Water Authority in strategic parts of the eastern catchment in an attempt to reduce stream salinities in the Collie River. At present plantations constitute approximately 5% of the Wellington catchment. With effective catchment management the inflow salinity is expected to stabilise at approximately 800 mg/L by the year 2010. However with no catchment management and continued clearing the inflow salinity would exceed 1500 mg/L by 2010.

Harris Reservoir has a catchment area of 328 km^2. The Harris Reservoir catchment has remained almost fully forested. Salinity levels in the Wellington Reservoir are maintained below 1000 mg/L by a combination of scouring of brackish water and the release of fresh water from the Harris Reservoir.

Where the Collie River tributaries flow through forest, the riverine habitat is well conserved. However, in cleared areas, loss of riparian vegetation, river bank erosion, sedimentation of pools and nutrient pollution are widespread. Also, groundwater pumping to de-water the open cut coal mines in the Collie Basin east of Collie has affected local water tables, and may be causing the water level to drop in some summer pools in the south branch of the Collie River.

The Brunswick and Wellesley Rivers, both tributaries, join the Collie River on the coastal plain before it discharges into the Leschenault Estuary.

Surface water data has been collected in the basin since 1939. The first continuous streamflow measurements started on the Collie River in 1945. There are currently 25 gauging stations operated by the Water and Rivers Commission in this basin of which 18 have at least 20 years of operation. A fairly even coverage of data collection exists across the whole basin.

The Collie River Basin is approximately 35% cleared, principally in the valleys and the upper and lower parts of the basin.

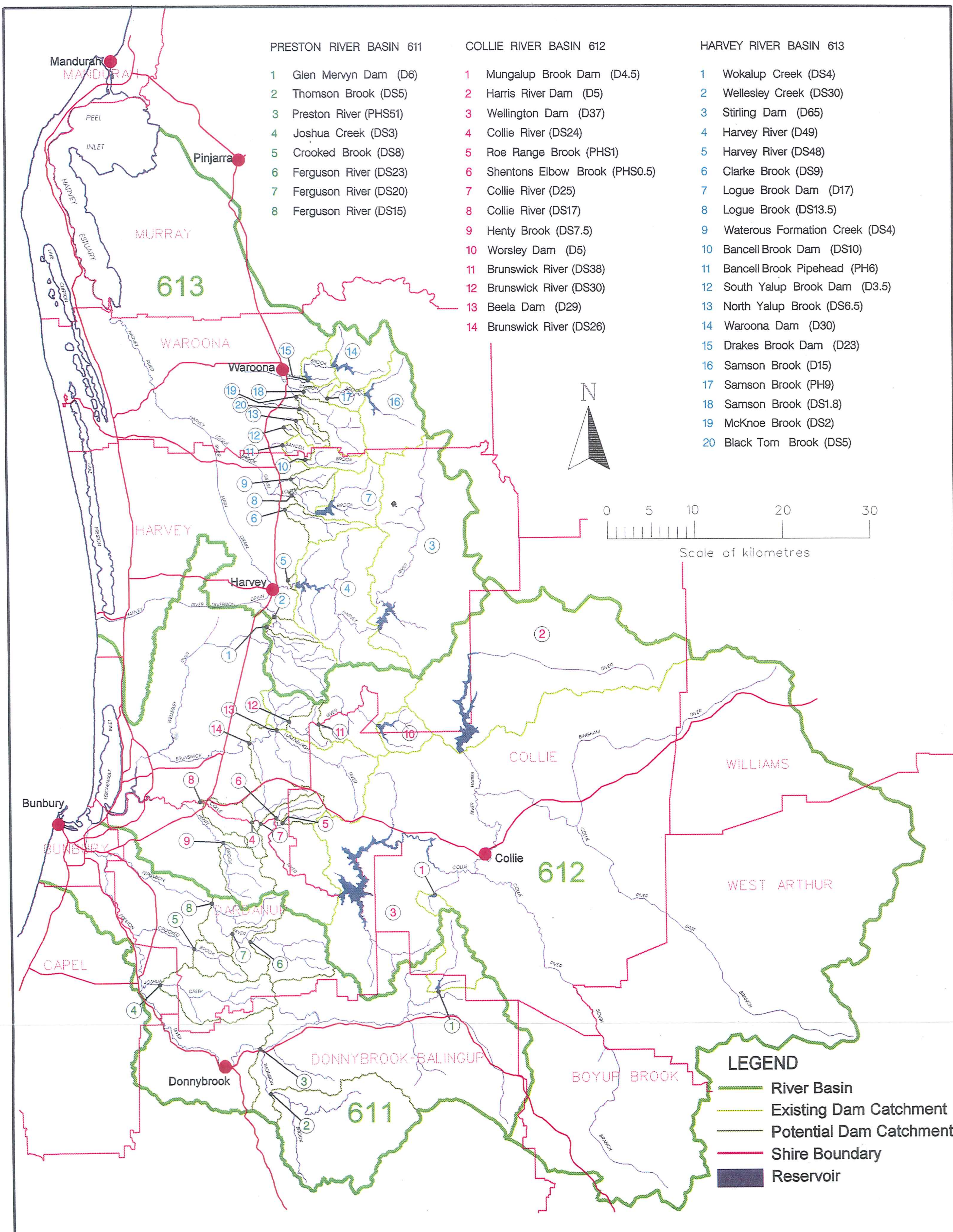
3.2.3 Harvey River Basin (613)

The Harvey River Basin (613) envelopes a total area of 2055 km^2. There are two major dams situated in the basin. This river basin contains a series of small rivers and brooks which drain the Darling Scarp and its forested hinterland, between Harvey and Waroona. The Harvey River is the largest and most southerly of these rivers and is dammed by the Stirling Dam and the Harvey Weir, with most of the impounded water being used for irrigation.

Several of the small streams north of the Harvey River are also dammed, namely Logue, Bancell, Yalup, (private dam), Samson and Drakes Brooks. Their forested tributary streams, as well as the undammed McKnoe Brook, contain some well preserved stretches of riverine habitat.

Open cut bauxite mining is in progress on hillsides in the catchments of some of these streams. Meticulous control of runoff from mined areas and haul roads is needed to prevent the contamination of the streams with sediment.

From the foot of the Darling Scarp, the Harvey River in its natural state meandered in a north-westerly direction across the Swan Coastal Plain through low-lying, seasonally wet flats and swamps, to drain into the southern end of the Harvey Estuary, then via Peel Inlet to the sea at Mandurah. En route across the coastal plain,



Bunbury-Mandurah Region Water Resources Review
SURFACE WATER DEVELOPMENT SITES

Figure 3.1

it collected flow from all the other small streams draining the scarp further to the north. This drainage system has been greatly modified since European settlement. To reduce the flooding farmland, many drains were excavated, directing water into the rivers, which were themselves straightened and deepened to improve their hydraulic efficiency. In addition, a major diversion drain for the Harvey River was excavated during the 1930's to divert most of the river's water directly to the sea west of Harvey at Myalup Beach. This pattern of water movement across this part of the coastal plain has been modified greatly, and little of the original river habitat remains intact.

One consequence of land drainage and agricultural development on the sandy soils of the coastal plain within the Harvey River catchment has been the leaching of phosphate from fertiliser applied to the soil, into drain water. This phosphate, which is flushed into the drains and rivers each winter and spring, has been responsible for eutrophic changes in Harvey Estuary and Peel Inlet, culminating in massive spring blooms of blue green alga, followed by rampant growth of green macro-algae.

Surface water data has been collected in the basin since 1939. The first continuous streamflow measurements started on the Harvey River in 1939. There are currently 30 gauging stations operated by the Water and Rivers Commission in this basin of which 17 have at least 20 years of operation. Data collection was initially concentrated on the Harvey River but now there is a fairly even coverage across the whole basin.

The Harvey River Basin is approximately 45% cleared, principally in the valleys and the lower parts of the basin.

3.3 Existing Surface Water Sources

3.3.1 General

The following information is relevant to existing and potential surface water sources.

3.3.1.1 Site Classification

Sites are classified as follows:

- D = Dam (existing);
- DS = Dam site (potential);
- PH = Pipehead (existing);
- PHS = Pipehead site (potential);

Sites are identified by the distance in kilometres from the ocean or upstream of the confluence with a larger stream or river. Distances are rounded to the nearest kilometre except where the existence of another possible development site makes it necessary to go to the first decimal place.

3.3.1.2 Streamflow Data

The streamflow data has been based on the period record from 1962 to 1994. The mean annual flow for specific sites was based on at-site data and regional relationships. The regional relationships were derived from the average annual rainfall and the level of clearing.

3.3.1.3 Reservoir Yield Data

The reservoir yield data has been based on water balance modelling at specific sites and regional relationships. The water balance modelling was preliminary and based on the 1962 to 1994 period of record. However, the lower flow period (1975 to 1994) was also analysed. The regional relationships were derived based on the variation of the inflow to the reservoirs.

3.3.2 Preston River Basin (611)

3.3.2.1 Lyalls Mill Stream

Lyalls Mill Stream, a tributary of the Preston River, is regulated by the Glen Mervyn Dam (D6) as a supply to the Preston Irrigation District. This dam was constructed in 1969. It is 13 m high, has a reservoir storage capacity of 1.1 GL and a surface area of 26 ha at the full supply level (FSL) of 198.5 m AHD. The estimated annual average streamflow of Lyalls Mill Stream at Glen Mervyn Dam is 3.5 GL with an existing annual yield of 1.0 GL. Streamflow utilisation is about 30%.

Streamflow to the Glen Mervyn Reservoir is of good quality. Current operation involves controlled water releases in summer from the dam to the water course for downstream irrigation use.

Glen Mervyn Dam is the only impoundment on this river system at present. No research into major ecological, social or other constraints has been undertaken as part of this study. Lyalls Mill Stream and Glen Mervyn Dam provide regionally significant opportunities for water dependent and water orientated recreation activities.

The reservoir yield of Glen Mervyn Dam may be potentially increased to 2.6 GL, but the data used to establish this was of poor quality and the yield is only a regional estimate.

3.3.3 Collie River Basin (612)

3.3.3.1 Collie River

The Collie River is regulated by four dams and an irrigation canal diversion weir:

- **Wellington Diversion Weir** (D25) was constructed in 1932 and upgraded in 1961. It is 9 m high and has a negligible capacity. The crest level is 53.4 m AHD. The yield is minimal as the purpose of this weir is to divert Wellington Dam releases into the Collie River Irrigation District canal system.

- **Wellington Dam** (D37) was constructed in 1933 and raised in 1944 and again in 1960. It is 34 m high, has a reservoir storage capacity of 185 GL and a surface area of 1610 ha at the FSL of 166.6 m AHD. The estimated annual average streamflow of the Collie River (excluding the Harris River upstream of Harris Dam) at Wellington Dam is 182.2 GL with a current annual yield of 90.0 GL. Streamflow utilisation is about 49%. Any increase in potential yield of this dam will be constrained by state forest.

- **Mungalup Dam** (D4.5) was constructed in 1935 upstream of the Wellington Dam on Mungalup Brook, a tributary of Collie River. It is 13 m high, has a reservoir storage capacity of 0.7 GL and a surface area of 16 ha at the FSL of 251.5 m AHD. The estimated annual average streamflow of the Mungalup Brook at Mungalup Dam is 0.55 GL with a current annual yield of 0.25 GL. Water is presently used to supplement Collie Town Water Supply. This is a small storage dam on a tributary of the Collie River and was not considered for a potential yield increase estimate.

- **Harris Dam** (D5) was constructed in 1990 upstream of the Wellington Dam on the Harris River, a tributary of the east branch of the Collie River. It is 30 m high, has a reservoir storage capacity of 72 GL and a surface area of 943 ha at the FSL of 223.5 m AHD. The estimated annual average streamflow of the Harris River at Harris Dam is 27.2 GL with a current annual yield of 17.5 GL. Any increase in potential yield of this dam will be constrained by a proposed national park to the east.

Considerable clearing for agricultural development has taken place in the Wellington Dam catchment and water from the Wellington Reservoir is only just suitable for irrigation. Annually, the Wellington Dam supplies 64 GL to downstream irrigators in the Collie River Irrigation District. The remaining 38 GL is currently used to improve the quality of water retained in Wellington Reservoir by means of winter scouring on an annual basis.

The Harris Dam catchment is mainly forested and consequently water impounded in the Harris Reservoir is of drinking water quality. Harris Dam operates as a supply to the GSTWS, which at present utilises 7.8 GL of water per annum. Water is released downstream from the Harris Reservoir to Wellington Reservoir to improve its water quality. The water released from Harris Reservoir ranges from 0 to 30 GL. These releases occur when the level at Wellington Reservoir is low, the salinity high, and the combined storage in Wellington and Harris Reservoirs is sufficient.

3.3.3.2 Brunswick River

The Brunswick River headwater is regulated by two dams:

- **Beela Dam** (D29) was constructed in 1938. It is 4 m high, has a reservoir storage capacity of 0.02 GL and a surface area of 1.8 ha at the full supply level (FSL) of 98 m AHD. The estimated annual average streamflow of the Brunswick River at Beela Dam is 37 GL with a current annual yield of 0.54 GL.
  Streamflow utilisation is about 1%. To increase the potential yield of this source, a new potential source has been considered (refer to section 3.4.2.6).

- **Worsley Dam** (D5) was constructed upstream of Beela Dam on the Augustus River in 1982. It is 32 m high, has a reservoir storage capacity of 5.8 GL and a surface area of 55 ha at the FSL of 238.0 m AHD. The estimated annual average streamflow of the Augustus River at Worsley Dam is 5.2 GL with a current annual yield of 4.8 GL. There is no significant available increase in yield from this source.

The Worsley Dam catchment is mainly forested and consequently water impounded in the Worsley Reservoir is of drinking water quality. Worsley Dam operates solely as source for Worsley Refinery industrial and domestic water supply needs. In the past, when demand from Beela Dam was high, water was released from

Worsley Dam to maintain levels in Beela Dam. This only occurred when surplus water was available from Worsley Dam and is unlikely to occur in the future.

The Beela Dam catchment is mainly forested and consequently water impounded in the Beela Reservoir is of drinking water quality. Beela Dam supplies the Brunswick Junction Regional Water Supply Scheme. This water is used with water from the Wellington Dam on the Collie River. Water from Wellington Dam is supplied via the irrigation channel.

In terms of water supply development, the Brunswick River has the potential to yield considerable quantities of additional potable water.

3.3.4 Harvey River Basin (613)

3.3.4.1 Harvey River

The Harvey River headwater is regulated by two dams:

- **Harvey Weir** (D49) was constructed in 1916 and raised in 1931. It is 20 m high, has a reservoir storage capacity of 9 GL and a surface area of 150 ha at the FSL of 64.2 m AHD. The estimated annual average streamflow of the Harvey River at Harvey Weir is 43.5 GL (excluding Harvey River upstream of Stirling Dam) with an existing annual yield of 16 GL.

- **Stirling Dam** (D65) constructed upstream of the Harvey Weir in 1948. It is 42 m high, has a reservoir storage capacity of 56 GL and a surface area of 394 ha at the FSL of 158.5 m AHD. The estimated annual average streamflow of the Harvey River at Stirling Dam is 59.4 GL with an existing annual yield of 37.8 GL. The potential increase in the yield from the sources on the Harvey River are considered to be approximately 32 GL. This additional yield could be obtained from a major new dam at Harvey or a combination of a new dam at Harvey and the raising of Stirling Dam (refer to section 3.4.3.3).

The Stirling Dam catchment is mainly forested and consequently water impounded in the Stirling reservoir is of drinking water quality. There is extensive dieback throughout the catchment. Stirling Dam operates as an upper dam of a system and water is released downstream to Harvey Reservoir as and when required. Considerable clearing for agricultural development has taken place in the Harvey Weir catchment. Water from Harvey Reservoir requires full treatment to satisfy drinking water standards. Water drawn from the Harvey system is used primarily for irrigation but also for supply to the town of Harvey.

The current allocation of water from these schemes to irrigation users has recently been reviewed in the South West Irrigation Strategy Study which suggests that rationalisation of irrigation water supply may release some of the existing yield for other uses.

These sites have been well documented (WAWA, 1994b).

3.3.4.2 Logue Brook

Logue Brook, a tributary of the middle Harvey River, is regulated by the Logue Brook Dam (D17) as a supply to the Harvey Irrigation District. This dam was constructed in 1963. It is 45 m high, has a reservoir storage capacity of 25 GL and a surface area of 200 ha at the FSL of 158 m AHD. The estimated annual average streamflow of Logue Brook at the dam is 14 GL with an existing annual yield estimated at 11 GL. Streamflow utilisation is about 79%.

Streamflow to the reservoir, Lake Brockman, is of good quality. Current operation involves controlled water releases in summer from the dam to the water course for downstream irrigation and rural use.

This site has been well documented (WAWA, 1994b).

3.3.4.3 Bancell Brook

Bancell Brook, a tributary of the middle Harvey River, is regulated by the Bancell Brook Pipehead Dam (PH6) as a supply to the Harvey Irrigation District. This dam was constructed in 1952. It is 2 m high and has a minimal storage capacity and surface area. The FSL is 111 m AHD. The estimated average annual streamflow of Bancell Brook at the dam is 7.7 GL with current annual yield of 0.1 GL. The annual average streamflow would reduce to 2.8 GL if site DS10 upstream is developed (refer to section 3.4.3.7). Streamflow utilisation is minimal.

Streamflow to the reservoir is of good quality. Current operation involves controlled water releases in summer from the dam to the water course for downstream irrigation use.

3.3.4.4 South Yalup Brook

Wagerup Dam (D3.5) was constructed in 1978. It is 13 m high, has a reservoir storage capacity of 1.2 GL and a surface area of 28 ha at the FSL of 53.0 m AHD. The estimated annual average streamflow of the South Yalup Brook at the dam is 1.4 GL with an annual yield of 1.0 GL. The yield from this dam is augmented from additional mine site runoff and recycling.

Streamflow to the reservoir is of good quality. Wagerup Dam operates solely as source for Wagerup Refinery (ALCOA) industrial and domestic water supply needs.

3.3.4.5 Drakes Brook

The Drakes Brook headwater is regulated by two dams:

- **Drakes Brook Dam** (D23) was constructed in 1931. It is 17 m high, has a reservoir storage capacity of 2.3 GL and a surface area of 42 ha at the FSL of 71.2 m AHD. The estimated annual average streamflow of Drakes Brook at the dam is 3.0 GL with an existing yield of 1.8 GL. Streamflow utilisation is about 60%.
- **Waroona Dam** (D30) built upstream of Drakes Brook Dam was constructed in 1966. It is 36 m high, has a reservoir storage capacity of 15 GL and a surface area of 144 ha at the FSL of 211 m AHD. The estimated annual average streamflow of Drakes Brook at Waroona Dam is 11.6 GL with an existing yield of 7.9 GL. Streamflow utilisation is about 70%.

There is some uncertainty in the current divertible yield for the Drakes Brook sources. A study into the south-west irrigation sources will provide more information on the existing and potential expansion of these sources.

The Waroona Dam catchment is a State Forest and is currently managed as a Class 3 Developed Catchment - Irrigation Dam which permits liberal access and recreation within the catchment and reservoir. The Waroona Reservoir, Lake Navarino, stores river flow to be discharged as controlled releases over the dry season to maintain volumes in the Drakes Brook storage, Lake Moyanup. Transfer from the upper to the lower dam is achieved by direct releases to the brook. Drakes Brook Dam supplies the Waroona Irrigation Scheme.

Waroona Dam is used extensively for water oriented recreation activities.

3.3.4.6 Samson Brook

- **Samson Brook Dam** (D15) and its reservoir, Lake Kabbamup, regulate the upper reaches of the Samson Brook. Samson Brook Dam was constructed in 1941. It is 31 m high, has a reservoir capacity of 9 GL and a surface area of 104 ha at the FSL of 245 m AHD. The estimated annual average streamflow into Lake Kabbamup is 16.6 GL with an existing annual yield of 7.6 GL. The Water Corporation is currently considering delivering water from Samson Brook Dam to Waroona Dam via a tunnel. Any increase in potential yield of this dam will be constrained by state forest and conservation park.
- **Lower Samson Brook Pipehead Dam** (PH9) was constructed in 1962. It is 2m high and has a negligible capacity. The crest level is 101m AHD. The annual yield is minimal as only 0.1 GL (1.0 potential) is abstracted.

The Samson Brook Dam catchment is mainly State Forest. Water is released directly into the stream as required by the Waroona Irrigation Scheme.

Samson Brook is used extensively for water oriented recreation activities.

This site has been documented in the "Inventory of Potential Water Supply Schemes" (WAWA, 1994b).

3.4 Potential Surface Water Sources

3.4.1 Preston River Basin (611)

3.4.1.1 Thomson Brook (Site DS5)

Thomson Brook, a tributary of the Preston River, has the potential to be regulated by a dam at site DS5. This dam would be 16.0 m high, have a reservoir storage capacity of 47 GL and a surface area of 413 ha at the FSL of 158 m AHD. The estimated annual average streamflow of Thomson Brook at the site is 22.5 GL with a potential annual yield of 16 GL.

Streamflow at the site is still of reasonable quality although half of the catchment has been cleared for intensive crop production and pastures. Water treatment may be necessary if water is to be used for urban and industrial purposes.

This resource would most likely be used to supplement the Preston Irrigation District supply. Water could also be allocated for urban and industrial use.

No research into major ecological, social or other constraints has been undertaken as part of this study. Thomson Brook provides moderate opportunities for water orientated recreation activities.

3.4.1.2 Preston River (Site PHS51)

The Preston River, has the potential to be regulated by a pipehead dam at site PHS51. The height and capacity of this dam is constrained due to farming development in the valley, hence a pipehead. The estimated annual average streamflow of Preston River at the site is 88.0 GL (reduces to 62 GL if Thomson River and Lyalls Mill Stream are excluded) with a potential annual run of the river yield of 34.0 GL.

Streamflow at the site is still of reasonable quality although half of the catchment has been cleared for intensive crop production, orchards and pastures. Water sampling to date indicates that there are no significant levels of chemical residue. In 1989 samples indicated that the measure of pesticide contamination was hundreds of times below the maximum permissible levels. However, with further development on the catchment area there is a possible risk that contamination of the Preston River might occur in the future, and a major effort would be required to manage the catchment area to protect water quality. Water treatment may be necessary if water is to be used for urban and industrial purposes.

The most likely water user would be Donnybrook and the Bunbury Water Board, who would abstract water during winter and spring to supplement the groundwater sources. The use of this water for town water supply is subject to the degree of pesticide contamination as discussed and the economics of conjunctive use in this instance. The Lower Preston River has been identified as a wetland of ecological significance and has the potential for water oriented recreation. Consequently it should be managed with the goal of maintaining this.

The combined Thomson Brook Dam and Preston River Pipehead system would have a yield of 45.2 GL.

3.4.1.3 Joshua Creek (Site DS3)

Joshua Creek, a tributary of the Preston River, has the potential to be regulated by a dam at site DS3. This dam could be up to 25 m high, have a reservoir storage capacity of 31 GL and a surface area of 334 ha at the FSL of 71.0 m AHD. However, the height and capacity of this dam would be constrained due to farming development in the valley. The estimated annual average streamflow of Joshua Creek at the site is 8.0 GL with a potential annual yield of 5.5 GL.

Streamflow at the site is still of reasonable quality although a third of the catchment has been cleared for dairying and orchards. Water treatment may be necessary if water is to be used for urban and industrial purposes.

This resource would most likely be used for urban and industrial water supply.

No research into major ecological constraints has been undertaken as part of this study. Joshua Creek provides moderate opportunities for water orientated recreation activities.

3.4.1.4 Crooked Brook (Site DS8)

Crooked Brook, a tributary of the Preston River, has the potential to be regulated by a dam at site DS8. This dam could be up to 5 m high, have a reservoir storage capacity of 0.1 GL and a surface area of 7 ha at the FSL of 49.0 m AHD. The estimated annual average streamflow of Crooked Brook at the site is 2.4 GL with a potential annual yield of 1.8 GL.

Streamflow at the site is still of reasonable quality although a third of the catchment has been cleared for dairying and orchards. Water treatment may be necessary if water is to be used for urban and industrial purposes.

This resource would most likely be used for urban and industrial water supply.

No research into major ecological constraints has been undertaken as part of this study. Crooked Brook provides moderate opportunities for water orientated recreation activities.

3.4.1.5 Ferguson River (Site DS20)

Ferguson River has the potential to be regulated by a dam at site DS20. This dam could be up to 43 m high, have a reservoir storage capacity of 71 GL and a surface area of 440 ha at the FSL of 110.0 m AHD. However, the height and capacity of this dam would be constrained due to farming development in the valley. The estimated annual average streamflow of Ferguson River at the site is 15.6 GL with a potential annual yield of 13.4 GL.

Streamflow at the site is still of reasonable quality although a third of the catchment has been cleared for dairying and orchards. Water treatment may be necessary if water is to be used for urban and industrial purposes.

This resource would most likely be used for town, industrial and agricultural water supply.

No research into major ecological constraints has been undertaken as part of this study. Ferguson River provides moderate opportunities for water orientated recreation activities.

Two other less potentially viable sites exist on the Ferguson River. One is situated upstream at site DS23 and one downstream at site DS15.

3.4.2 Collie River Basin (612)

3.4.2.1 Collie River (Site DS24)

The Collie River has the potential to be regulated by a dam at site DS24. A dam 60 m high, with a reservoir storage capacity of 14.8 GL and a surface area of 420 ha at the FSL of 50 m AHD would be feasible. The estimated annual average streamflow of the Collie River at the site is 98 GL with a potential annual yield of 20 GL.

3.4.2.2 Roe Range Brook (Site PHS1)

Roe Range Brook has the potential to be regulated by a pipehead at site PHS1. The estimated annual average streamflow of Roe Range Brook at the site is 1.1 GL with a potential annual yield of 0.7 GL.

The catchment is not cleared and consequently streamflow is of good quality. Operation would involve controlled water releases in summer from the dam to the water course for downstream irrigation use and industrial water supply.

The ecological value of the stream is high and a damsite is uneconomic. The site should be developed by a pipehead only.

This is not regarded as an economic site and development in the medium to long term is unlikely.

3.4.2.3 Shentons Elbow Brook (Site PHS0.5)

Shentons Elbow Brook has the potential to be regulated by a pipehead at site PHS0.5. The estimated annual average streamflow of Shentons Elbow Brook at the site is 1.3 GL with a potential annual yield of 0.85 GL.

The catchment is slightly cleared and consequently streamflow is of good quality.

The ecological value of the stream is high and a damsite is uneconomic. The site should be developed by a pipehead only.

This is not regarded as an economic site and development in the medium to long term is unlikely.

3.4.2.4 Henty Brook (Site DS7.5)

Henty Brook, a tributary of Collie River, has the potential to be regulated by a dam at site DS7.5. This dam could be up to 28 m high, have a reservoir storage capacity of 20.5 GL and a surface area of 14.7 ha at the FSL of 74.0 m AHD. The estimated annual average streamflow of Henty Brook at the site is 4.8 GL with a potential annual yield of 3.4 GL.

The catchment is slightly cleared and consequently streamflow is of good quality. Operation would involve controlled water releases in summer from the dam to the water course for downstream irrigation use and urban and industrial water supply.

No research into major ecological, social or recreational constraints has been undertaken as part of this study. Henty Brook provides moderate opportunities for water orientated recreation activities.

3.4.2.5 Collie River (Site DS17)

This is the most likely site to situate a pipehead dam for the diversion of water released from Wellington Dam for use by industries at Kemerton (part of the 20 GL/year allocation for industry). This site has been documented in a recent report by BHP Engineering (BHP Engineering, 1993). A pipehead weir would be constructed across the river bed to provide a minimum depth of water over the inlet from which water would be pumped to a tank sited within Kemerton. The estimated annual average streamflow of Collie River at the site is 8.5 GL with a potential annual diversion yield (excluding Wellington Reservoir releases) of 4.0 GL.

The impoundment would be retained within the river banks.

3.4.2.6 Brunswick River (Site DS26 - Olive Hill Site) and others

The Brunswick River, a tributary of the Collie River, is one of the largest undeveloped freshwater resources on the Darling Scarp between Bunbury and Perth. The Olive Hill site is a prime site for further development. It has the potential to play a major role in future water supply developments in the South West. It could be a further water supply source for either the Perth metropolitan area or the GSTWS and could augment South West Irrigation supplies.

A dam 49 m high, with a reservoir storage capacity of 61.0 GL and a surface area of 451 ha at the FSL of 99.0 m AHD would be feasible. The estimated annual average streamflow of Brunswick River at the site is 62.4 GL with a potential unconstrained annual yield of 46.8 GL.

Streamflow at the site is still of excellent quality as only 10% of the catchment has been cleared, some of this for services and an alumina refinery.

The inundation area is generally cleared, with remnant vegetation on the steeper rockier areas. Some areas have been planted to Eucalypt plantations along the southern side of the valley. Construction of a dam would require the relocation of Beela Road and railway line clear of the inundation area. The reservoir would inundate a large portion of agricultural land and Beela Dam, with consequent social impact. River flows are, at present, effectively uncontrolled resulting in seasonal flows. A dam would significantly alter this flow regime and would impact on the Leschenault Inlet and lower Collie River with the reduced input of fresh water.

Two other less potentially viable sites exist on the Brunswick River. Both are situated upstream at site DS30 and site DS38. Dams at either of these sites would result in similar social and environmental impacts, but to a lesser degree due to their smaller potential capacities. Construction of these dams would not require the relocation of Beela Road and the railway line and Beela Dam would not be inundated.

The yield from the Brunswick River may be optimised by developing a pipehead at Olive Hill and a large reservoir at DS30. This combination would yield 36.2 GL.

Brunswick River provides regionally significant opportunities for water dependent and water orientated recreation activities.

Brunswick River sites have been documented in two recent reports (BHP Engineering, 1993 and Dames & Moore, 1985).

3.4.3 Harvey River Basin (613)

3.4.3.1 Wokalup Creek (Site DS4 - Wokalup Creek Pumpback)

Wokalup Creek flows south of the Harvey River into Wellesley Creek and is currently unregulated. This scheme is an alternative to Wellesley Creek Pumpback, but due to its limited yield potential is not considered as a viable competitor.

3.4.3.2 Wellesley Creek (Site DS30 - Wellesley Creek Pumpback)

If the New Harvey Dam is constructed its larger storage could be used to store water pumped from Wellesley Creek or Wokalup Creek. This combination has been investigated by the Water Corporation.

Wellesley Creek flows south of the Harvey River into the Harvey River Diversion Drain and is currently unregulated. A potential pumpback scheme would consist of a 6.5 m high dam, with a reservoir storage capacity of 1.6 GL and a surface area of 64 ha at the FSL of 56.5 m AHD would be feasible. The estimated annual average streamflow of Wellesley Creek at the site is 17 GL with a potential annual yield of 11 GL (abstracted between June and November). Expected streamflow utilisation is about 60%.

Streamflow at the site is still of reasonable quality although half of the catchment has been cleared for dairying and orchards, the remainder being State Forest. Catchment management activities would need to be closely monitored and appropriate restrictions imposed to maintain water quality. No research into major environmental or social constraints has been undertaken as part of this study.

This site has been documented in the report "Inventory of Potential Water Supply Schemes" (WAWA, 1994b).

3.4.3.3 Harvey River (Site DS48 - New Harvey Dam)

A new dam at damsite DS48, known as the New Harvey Dam, on the Harvey River would be a further means of developing this resource. A dam 45 m high, with a reservoir storage capacity of 140 GL and a surface area of 950 ha at the FSL of 90.0 m AHD would be feasible. The estimated annual average streamflow of Harvey River at the site is 43.6 GL (excluding overflow from Stirling Reservoir) with a potential annual yield of 48.6 GL (including overflow from Stirling Reservoir). The combined Harvey - Stirling system could produce an average yield of up to 85.6 GL as part of an integrated system the yield could be increased. A number of existing roads would be inundated by the larger Harvey Reservoir and replacement roads would need to be constructed. This scheme has been proposed by the Water Corporation and is currently being investigated.

Alternatively, a smaller dam could be constructed with a lower yield increment available. The dam size could range from 20 GL storage (dam height 25 m, FSL 69.2 m) to a maximum of 140 GL.

The enlarged reservoir would inundate areas of freehold land, Crown Reserve and State Forest. The freehold land consists of a number of private farms most of which are engaged in dairying.

Harvey River has been identified as a wetland of ecological significance, consequently ecological constraints exists.

This site has been documented in the report "Inventory of Potential Water Supply Schemes" (WAWA, 1994b).

3.4.3.4 Clarke Brook (Site DS9)

Clarke Brook, a tributary of the middle Harvey River, is currently unregulated. Installation of a dam at this site is feasible. This dam could be up to 40 m high, with a reservoir storage capacity of 2.7 GL and a surface area of 16 ha at the FSL of 160 m AHD, though it would not be an very economic source. The estimated annual average streamflow of Logue Brook at this site is 2.9 GL with a potential annual yield of 2.4 GL.

Streamflow is of good quality. Operation would involve controlled water releases in summer from the dam to the water course for downstream irrigation use and/or town and industrial water supply.

No research into major ecological constraints has been undertaken as part of this study, though much of the basin is used for agricultural purposes, which could have social implications.

This is not regarded as an economic site and development in the medium to long term is unlikely.

3.4.3.5 Logue Brook (Site DS13.5)

Logue Brook, a tributary of the middle Harvey River, is regulated by the Logue Brook Dam as a supply to the Harvey Irrigation District. Installation of an additional dam, at site DS13.5, downstream of the existing dam, is feasible. This dam would be up to 50 m high, with a reservoir storage capacity of 8.5 GL and a surface area of 49 ha at the FSL of 120 m AHD. The estimated annual average streamflow of Logue Brook at this site will be 3.8 GL with a potential annual yield of 3.0 GL.

Streamflow is of good quality. Operation would involve controlled water releases in summer from the dam to the water course for downstream irrigation and rural use and/or urban and industrial water supply. This is not regarded as an economic site and development in the medium to long term is unlikely.

3.4.3.6 Waterous Formation Creek (Site DS4)

Waterous Formation Creek, a tributary of Logue Brook, has the potential to be regulated by a dam at site DS4. This dam could be up to 34 m high, have a reservoir storage capacity of 5 GL and a surface area of 56 ha at the FSL of 87.0 m AHD. The estimated annual average streamflow of Waterous Formation Creek at the site is 1.7 GL with a potential annual yield of 1.3 GL.

The catchment is not cleared and consequently streamflow is of good quality. Operation would involve controlled water releases in summer from the dam to the water course for downstream irrigation and rural use and/or town and industrial water supply. No research into major ecological, social or recreational constraints has been undertaken as part of this study.

3.4.3.7 Bancell Brook (Site DS10)

Bancell Brook, a tributary of the Harvey River, has the potential to be regulated by a dam at site DS10, upstream of Bancell Brook Pipehead. This dam could be up to 45 m high, have a reservoir storage capacity of 10 GL and a surface area of 66 ha at the FSL of 245.0 m AHD. The estimated annual average streamflow of Bancell Brook at the site is 4.9 GL with a potential annual yield of 4.2 GL.

Streamflow at the site is still of reasonable quality although a fifth of the catchment has been cleared for dairying and orchards. This resource would most likely be used for urban and industrial water supply.

No research into major ecological, social or recreational constraints has been undertaken as part of this study.

3.4.3.8 North Yalup Brook (Site DS6.5)

North Yalup Brook, a tributary of Samson Brook, has the potential to be regulated by a small dam at site DS6.5. It would be approximately 10 m high and have a reservoir storage capacity of around 1.0 GL. The estimated annual average streamflow of the North Yalup Brook at the dam is 2.4 GL and the annual yield is expected to be around 1.0 GL.

Streamflow is of good quality. This dam would operate solely as source for Wagerup Refinery (ALCOA) industrial and domestic water supply needs.

No research into major ecological, social or recreational constraints has been undertaken as part of this study.

3.4.3.9 Samson Brook (DS1.8)

Samson Brook, a tributary of the Harvey River, has the potential to be regulated by a additional dam at site DS1.8, downstream of Samson Brook Dam and Lower Samson Brook Pipehead. This dam could be up to 42 m high, have a reservoir storage capacity of 5 GL and a surface area of 38 ha at the FSL of 92.0 m AHD. The estimated annual average streamflow of Samson Brook at the site is 1.8 GL with a potential annual yield of 1.6 GL.

Streamflow at the site is still of reasonable quality as the catchment is mainly State Forest. This resource would most likely be used for urban and industrial water supply.

No reasearch into major ecological constraints has been undertaken as part of this study. Samson Brook is used extensively for water oriented recreation activities.

This is not regarded as an economic site and development in the medium to long term is unlikely.

3.4.3.10 McKnoe Brook (DS2)

McKnoe Brook, a tributary of Samson Brook, has the potential to be regulated by a dam at site DS2. This dam could be up to 30 m high, have a reservoir storage capacity of 2.7 GL and a surface area of 23 ha at the FSL of 100.0 m AHD. The estimated annual average streamflow of McKnoe Brook at the site is 10.6 GL with a potential annual yield of 8.6 GL.

The catchment is only 5% cleared and consequently streamflow is of good quality. This resource would most likely be used for urban and industrial water supply.

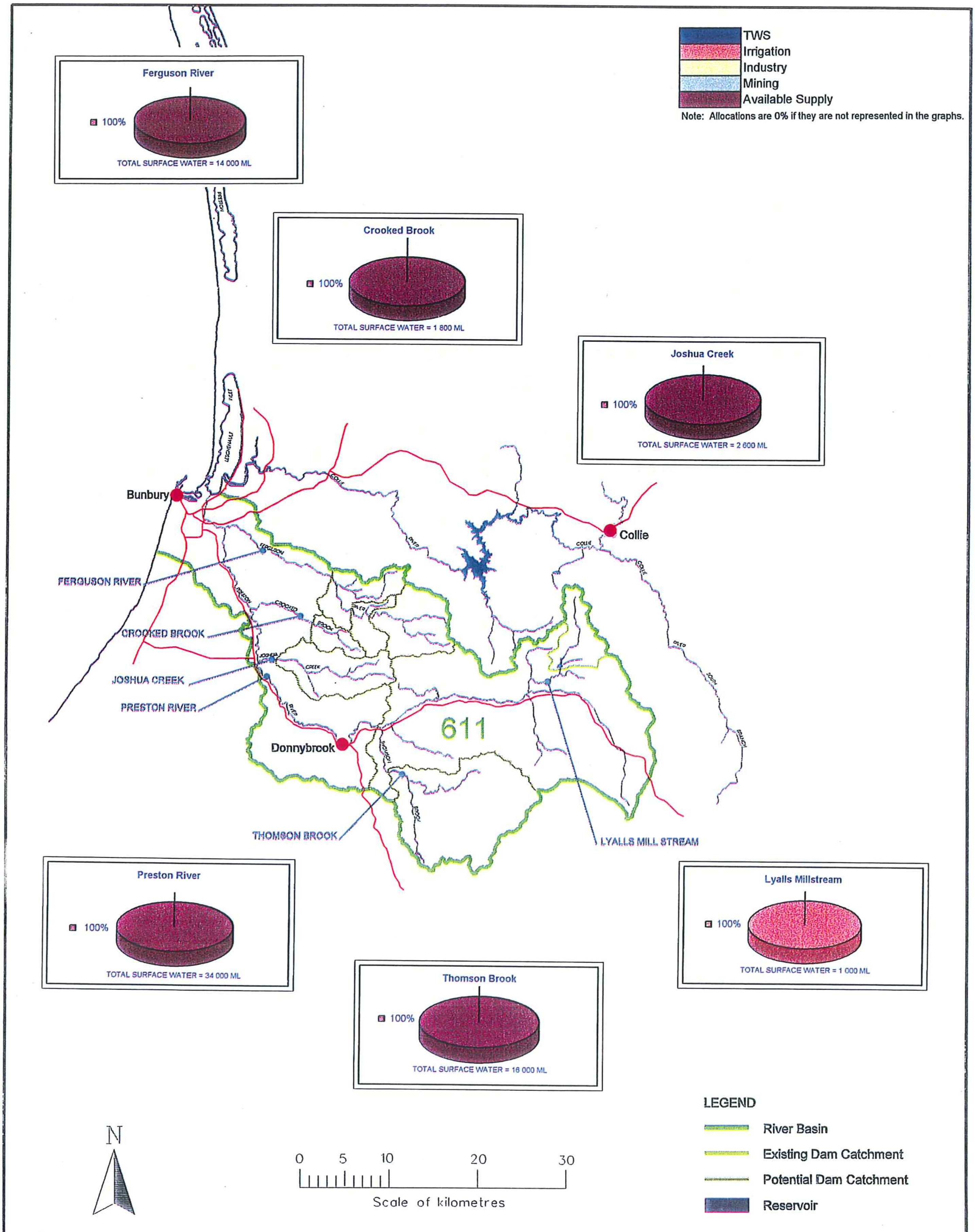
No research into major ecological, social or recreational constraints has been undertaken as part of this study. This is not regarded as an economic site and development in the medium to long term is unlikely.

3.4.3.11 Black Tom Brook (DS5)

Black Tom Brook, a tributary of Samson Brook, has the potential to be regulated by a dam at site DS5. Very limited hydrological data is available. This dam could be up to 10 m high, have a reservoir storage capacity of 1 GL and a surface area of 2 ha at the FSL of 107.0 m AHD. The estimated annual average streamflow of Black Tom Brook at the site is 1 GL with a potential annual yield of 0.75 GL.

The catchment has been minimally cleared and consequently streamflow is of good quality. This resource would most likely be used for urban and industrial water supply.

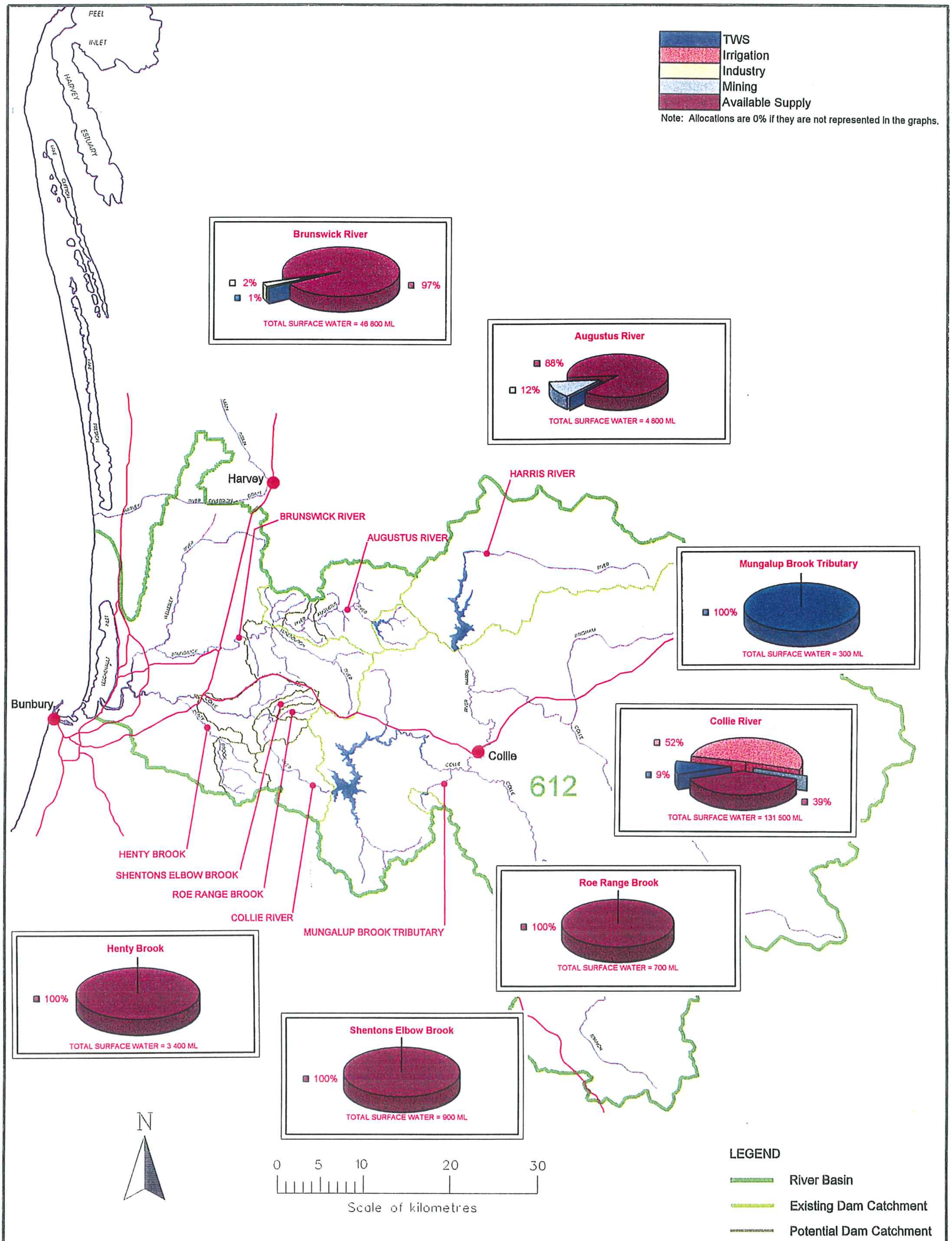
No research into major ecological, social or recreational constraints has been undertaken as part of this study.



Bunbury-Mandurah Region Water Resources Review

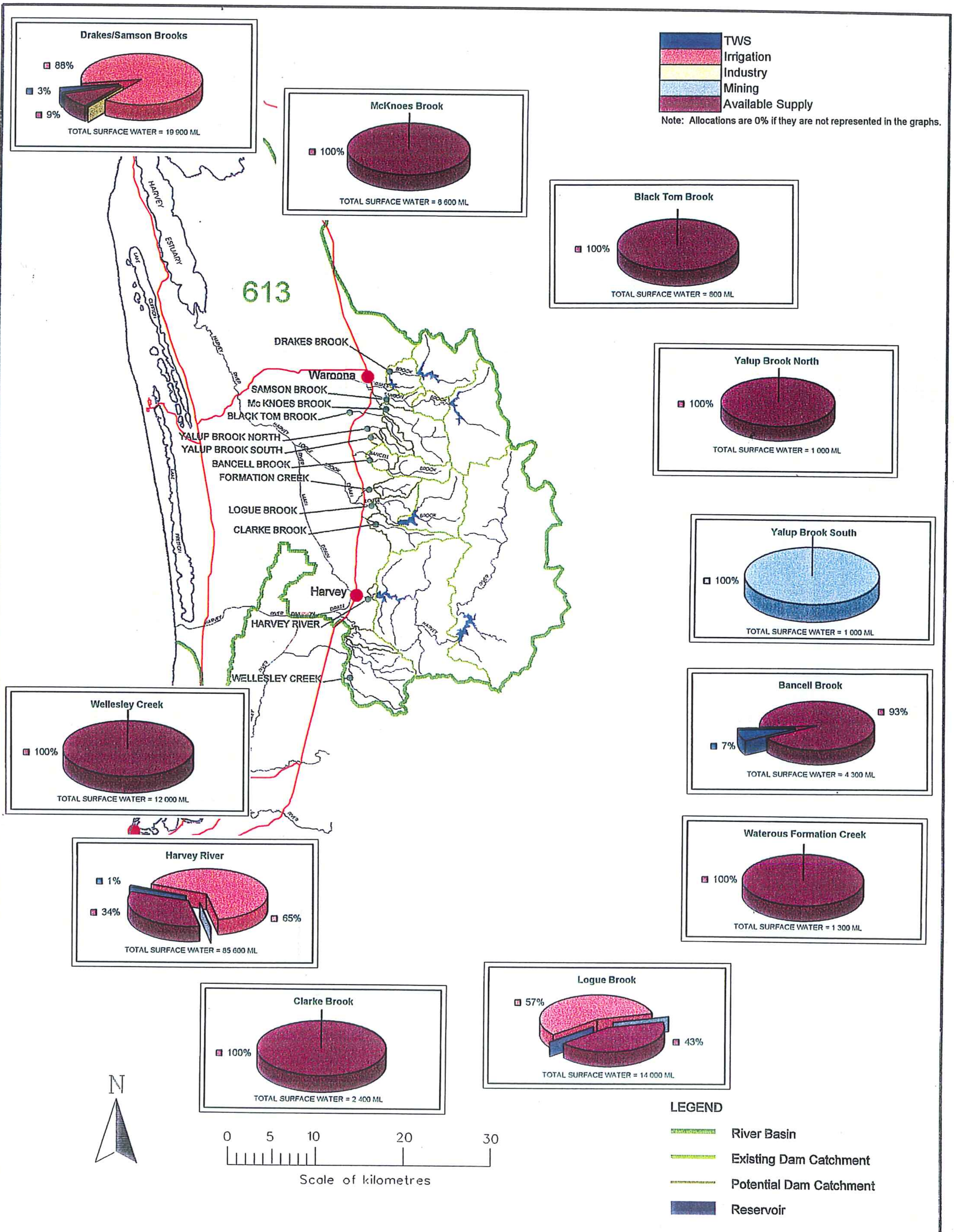
SURFACE WATER RESOURCE ESTIMATES BASIN 611

Figure 3.2a



Bunbury-Mandurah Region Water Resources Review
SURFACE WATER RESOURCE ESTIMATES BASIN 612

Figure 3.2b



Bunbury-Mandurah Region Water Resources Review
SURFACE WATER RESOURCE ESTIMATES BASIN 613

Figure 3.2c

4. Groundwater Resources

4.1 Introduction

The major groundwater resources in the region are contained in the sedimentary formations of the Perth and Collie Basins.

The crystalline rocks in the Yilgarn Craton contain only localised groundwater in fractures, which is commonly brackish to saline. There is very little groundwater abstraction from the Yilgarn Craton in the region. Groundwater conditions may be inferred to be similar to the Boddington goldmine in the Murray catchment to the north, where substantial yields are obtained and where the salinity range in the bedrock is 2000 - 8000 mg/L. There may be local fresh to brackish groundwater resources in alluvial sediments within the Yilgarn Craton, such as in the valley of the Preston River, but these resources have not yet been explored or assessed.

To facilitate long term management of the groundwater resources most of the region covering these basins has been proclaimed as Groundwater Areas (GWA's) under provisions of the Rights in Water and Irrigation Act (1914) (RIWI). A substantial portion of the study area (east of the darling fault) does not overlay any sedimentary basin and consequently has not been proclaimed as a GWA. The location of each existing GWA in the study area is indicated on Figure 4.2. The main feature of groundwater management is the licensing of groundwater abstractions. The groundwater resources are managed in accordance with the sustainable yield concept embodied in the State Conservation Strategy.

The Bunbury Groundwater Area and the Collie Groundwater Area are wholly contained in the study area. The South West Groundwater Area is contained within the study area except for the Mandurah subarea, which falls in the Murray River Basin (614). Partially contained within this area is the Murray Groundwater Area and the Busselton - Capel Groundwater Area. These groundwater areas are well documented in the relevant Groundwater Area Management Plans.
These are:

- Bunbury Groundwater Area Management Plan (Draft - WAWA, 1994);
- Busselton - Capel Groundwater Area Management Plan (WAWA, 1995);
- Collie Coal Basin Water Resources Management Strategy (Ventriss, 1988);
- Murray Groundwater Area Management Plan (Draft - King, 1996); and
- South West Coastal Groundwater Area: Groundwater Management Review (Hammond, 1989).

Each groundwater area is sub-divided into a number of subareas (apart from Collie). The subarea boundaries are based on a combination of hydrogeology, shire divisions and major physical features, such as rivers and roads. The subareas do not represent discrete flow systems.

The groundwater resource estimates, shown in Figure 4.3, were established from the total groundwater availability of each subarea in the study area. The Mandurah, Stratham-Gelorup, Boyanup, Donnybrook and Elgin-Capel River subareas are not wholly contained within the study area. However, for the purposes of this study, the total groundwater resource within these subareas were assumed to be contained within the study area.

Background information for each groundwater area is presented in the following sub-sections.

Information sheets relating to each groundwater subarea shown in Figure 4.2 are presented in Appendix A 4 and summarised in Table A4. 1, Table A4. 2 and Table A4. 3.

4.2 Hydrogeology

4.2.1 Superficial Formations

The superficial formations on the Swan Coastal Plain form an unconfined aquifer system, up to 25 m thick, which is recharged directly from rainfall, and discharges to drains, rivers, coastal lakes and the ocean. The main fresh to marginal groundwater resources are in the sand and limestone of the Yanget and Mialla Mounds in the centre of the coastal plain west of Harvey - Waroona (Deeney, 1989a). Groundwater salinity is generally high on the eastern part of the coastal plain, exceeding 14 000 mg/L in the clay and exceeding 3000 mg/L in places in the basal sand. West of Leschenault and Peel Inlets, and west of the coastal lakes, there is a thin layer of fresh groundwater overlying saline and hypersaline groundwater derived from evaporation from the lakes (Commander, 1988).

4.2.2 Leederville Formation

The Leederville Formation consists of interlayered sand and shale and is present in the Perth Basin throughout the region except near Bunbury. It reaches a thickness of 400 m in the Australind - Donnybrook and Mandurah - Dawesville areas, but is generally 200 m thick in the Harvey - Waroona area. There is a major resource in the Australind - Donnybrook area where groundwater salinity is less than 500 mg/L throughout the aquifer (Commander, 1982, 1984; Wharton, 1980, 1981), but elsewhere in the region the salinity generally exceeds 1000 mg/L and there are only thin zones of lower salinity. The high salinity reflects the recharge by leakage from the superficial formations, which is limited to small areas adjacent to the Darling Fault or in the centre of the coastal plain. In the Mandurah - Dawesville area there is salt water intrusion from Peel Inlet in the upper parts of the aquifer (Commander, 1982), which isolates the fresh groundwater from recharge.

4.2.3 Yarragadee Formation

The Yarragadee Formation is mainly sandstone and occurs only in the southern part of the Perth Basin in the region, south of Kemerton (Commander, 1982, 1989). The formation thickens southwards and is 800 m thick along the Boyanup Line (Smith, 1984). The groundwater salinity is mostly 300 - 500 mg/L, although it increases at its northern extent. The formation subcrops beneath the superficial formations around Bunbury (Commander, 1982a), and elsewhere it is overlain by the Bunbury Basalt or the Leederville Formation.

The Yarragadee Formation represents the largest fresh groundwater resource in the region and contains a very large storage of fresh groundwater (less than 500 mg/L). Recharge to the formation is by leakage from the Leederville Formation and by direct recharge in an area 70 km south of Donnybrook (Thorpe and Baddock, 1994).

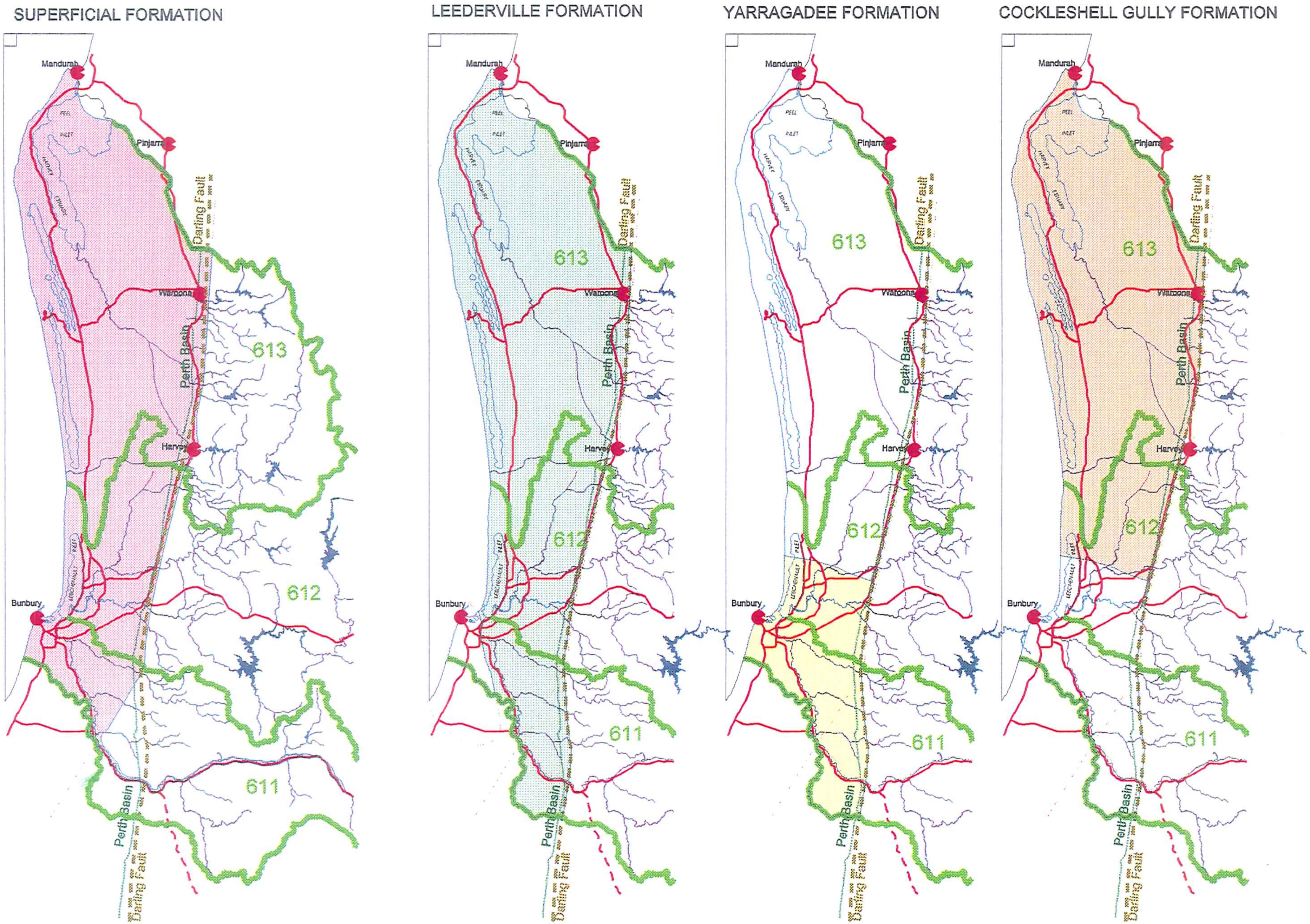
4.2.4 Cattamarra Coal Measures and Eneabba Formation

Sedimentary formations previously assigned to the Cockleshell Gully Formation are now referred to as the Cattamarra Coal Measures and the Eneabba Formation. These are a sequence of interbedded shale with minor sandstone in the Bunbury - Mandurah Region. The groundwater is mainly brackish to saline (Deeney, 1989b, 1989c), and fresh or marginal quality groundwater only occurs in parts of the formations where leakage from the Yarragadee or Leederville Formations can take place.

4.2.5 Collie Coal Measures

The Collie Coal Measures is predominantly sandstone, with minor shale and coal horizons, and crops out or occurs close to the surface throughout the Collie Basin. Recharge occurs directly from rainfall and in places from the Collie River (South Branch), and groundwater discharges to the Collie River in the north west of the basin. The groundwater salinity is generally less than 1000 mg/L throughout the basin (Moncrieff, 1993).

Sediments equivalent to the Collie Coal Measures occur in the Wilga Basin. Groundwater salinity in the West Wilga Basin has been found to be marginal or brackish, whereas in the East Wilga Basin fresh groundwater extends to 100 m, although at the base of the sequence the groundwater is brackish.



Bunbury-Mandurah Region Water Resources Review
GEOLOGICAL FORMATIONS

Figure 4.1

4.3 Groundwater Management Areas

4.3.1 South West Coastal Groundwater Area

4.3.1.1 General

This GWA consists of 11 subareas and covers a total area of 693 km^2. The Mandurah subarea is the only subarea excluded from the study area. Refer to Figure 4.2 and Appendix A 4.

The areas north and west of the Peel/Harvey Estuary have a thin lens of fresh groundwater. Consequently, these areas have limited groundwater abstraction potential. The coastal area west of Lake Clifton and Lake Preston also has a thin lens of fresh groundwater above saline groundwater with very limited development potential.

The areas immediately east of Lake Clifton and Lake Preston and the Harvey, Wellesley and Myalup areas contain groundwater of a quantity and quality suitable to allow large scale irrigation.

There is a major area of horticulture on the Swan Coastal Plain in the study area. Major problems and limitations to horticultural development are:

- Potential saline intrusion from below Lake Clifton, Lake Preston and the ocean.
- Recycling and concentration of salts due to high abstractions locally.
- Protection of wetlands, mainly from lowered water levels.
- Excessive use of fertiliser which may be transported to the Peel Harvey Estuary via drains or groundwater movement or a combination of both.

Resources in the Leederville aquifer are of a quality suitable for development, but recharge is limited. This water is generally being reserved for public purposes. Town water supplies for Australind, Myalup and Binningup are presently obtained from this aquifer.

Deeper aquifers (mainly the Cockleshell Gully Formation) generally contain water of a salinity unsuited to development.

The total available groundwater resource of the South West Coastal GWA is 60 million m3/year of which 39% has been committed.

4.3.1.2 Groundwater Availability

The subareas reflect fairly discrete flow systems of the superficial aquifer. For consistency the Leederville aquifer is also considered in terms of these subareas though its flow system is generally more extensive. Details of groundwater use and constraints on this use are outlined for each subarea in Appendix A 4.

4.3.1.2.1 Superficial Formation

Falcon Subarea

The superficial aquifer has no groundwater throughflow to the Falcon subarea. Fresh groundwater is wholly derived from infiltration of rainfall. The fresh groundwater forms a thin lens floating on saline groundwater which can be easily overdrawn resulting in upconing of the underlying saline water. Saline groundwater has resulted from the ocean and the Peel - Harvey Estuary on either side of the area.

Availability has been assessed as being limited and considered to be about 10% of the average annual rainfall. This is because the availability must allow for saltwater interface maintenance by only abstracting 50% of the recharge. It also assumes that recharge is 20% of the average annual rainfall.

There are no town water supplies obtained from superficial aquifers in this subarea. Domestic water supplies in Special Rural subdivisions are obtained from onsite private wells or rainwater tanks. Higher density housing divisions (Falcon) obtain their domestic water supplies from the Mandurah Scheme.

White Hill Subarea

The superficial aquifer has groundwater movement in this subarea similar to that of the Falcon subarea. Groundwater availability is limited.

The Special Rural subdivisions obtain their water supplies from private domestic wells or rainwater tanks. Higher density developments at Miami/Falcon and Pleasant Grove obtain water supplies from the Mandurah Scheme. There are no public schemes based on the superficial aquifer. Park Ridge obtains water supplies from the Leederville Formation.

Island Point Subarea

The superficial aquifer is saline apart from the top. This is due to the influence of Harvey Estuary to the east and Lake Clifton to the west. The hydrogeological situation is very similar to that of the Falcon and White Hill subareas, that is, a thin fresh lens of groundwater floating on saline groundwater. There is limited throughflow, with its origins at the Yanget Mound. Groundwater availability has been assessed as being limited and is based on an estimated 20% of rainfall recharge and 50% of this for saltwater interface maintenance.

There are no scheme water supplies drawing on the superficial aquifer. Domestic water supplies for the Clifton Downs and Island Point communities are obtained from private superficial wells or rainwater tanks.

Coastal Subarea

The superficial aquifer in this subarea is saline except for the upper few metres. Fresh groundwater is derived from rainfall recharge only. The fresh resources form a thin lens floating on saline groundwater. Recharge is estimated to be about 20% of the rainfall. Due to the limited depth of fresh water it is recommended that draw be restricted to only 25% of the recharge. Groundwater availability is limited.

There are no town water supplies drawing from the superficial aquifer. Local private domestic supplies are obtained from this aquifer or rainwater tanks.

Lake Clifton Subarea

The superficial aquifer receives an estimated throughflow equating to a net rainfall recharge of approximately 4% over the subarea. Direct local recharge is considered to be the main mechanism of aquifer replenishment. Recharge is estimated to be about 10% of the rainfall.

To allow for saltwater interface maintenance it is recommended that draw be restricted to only 75% of the recharge. As the water table is relatively flat and the aquifer is mostly underlain by saline water, the draw should be spread over as much of the area as possible. Availability has been assessed as 3 GL/yr.

There is no scheme water currently supplied in this subarea. Communities such as Tuart Grove obtain domestic supplies from private wells or rainwater tanks.

Colburra Downs Subarea

The superficial aquifer has very little groundwater throughflow. The main source of groundwater is direct infiltration of rainfall, but this is limited by the shallow depth to the water table. Hence, the area is extensively drained. Most of the subarea contains groundwater of salinity greater than 1500 mg/L. Availability has been assessed as 1.6 GL/yr.

There are no public water supplies in this subarea.

Lake Preston Subarea

The superficial aquifer is relatively flat and therefore, when local draw exceeds local throughflow, salts are recycled. The use of the Leederville aquifer, with its more saline water, may be contributing to the problem. Availability has been assessed as 19.8 GL/yr, assuming rainfall as recharge of 20% and retaining 25% throughflow for saltwater interface maintenance.

There are no local town water supplies drawn from the superficial formations.

Harvey Subarea

The superficial aquifer has groundwater movement in an easterly direction toward the Harvey River, Harvey Main Drain and other drains. The total availability is estimated to be 15.7 GL/yr, assuming recharge as 20% of the rainfall and allowing 25% of throughflow to pass.

There are no public water supplies currently based on the superficial aquifer in this subarea.

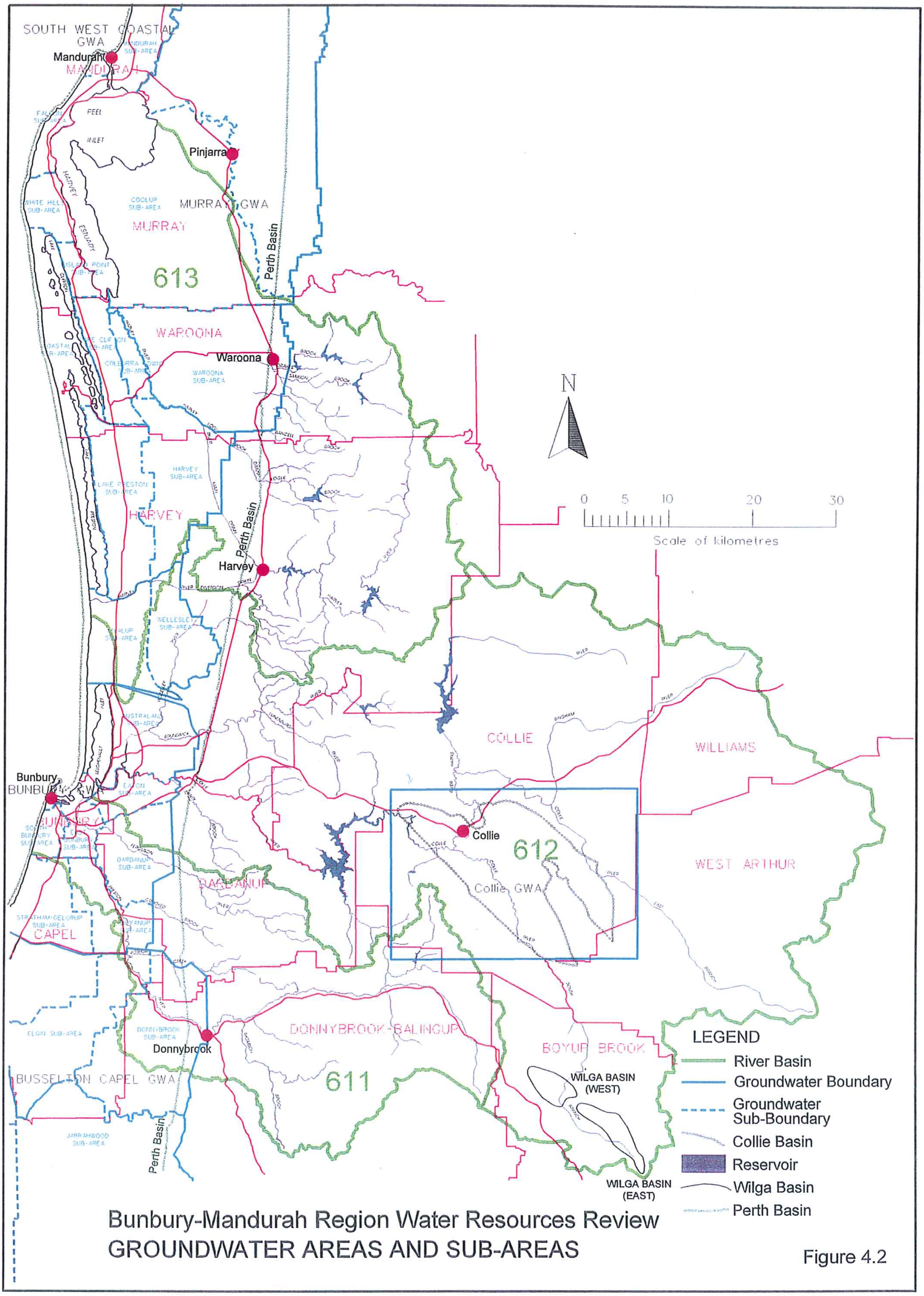
Myalup Subarea

Generally, in the superficial aquifer, throughflow is westwards except near the coastal mound where there may be some north/south movement. The availability for abstraction is considered to be 11.9 GL/yr, assuming recharge is 20% of the average rainfall and 25% must remain to maintain the saltwater interface.

There are no public water supplies obtained from the superficial aquifer in this subarea.

Wellesley Subarea

The superficial aquifer has groundwater movement toward the Harvey River Main Drain, or the Wellesley River main drain or the Wellesley River. There is also downward movement to the underlying Leederville



Bunbury-Mandurah Region Water Resources Review
GROUNDWATER AREAS AND SUB-AREAS

Figure 4.2

aquifer. The availability is assessed to be 3 GL/yr, assuming recharge is 10% of the average annual rainfall. There are no public water supplies in this subarea.

4.3.1.2.2 Leederville Formation

Falcon Subarea

The Leederville Aquifer contains groundwater of salinity between 1000 - 3000 mg/L. No direct recharge occurs locally and all throughflow derives from recharge areas east of the Peel Inlet. Fresh throughflow must pass below the Peel Estuary saltwater plume which has invaded the upper Leederville. As a consequence, the Leederville aquifer is in a delicate balance. Groundwater draw must be kept to a minimum to avoid saline contamination. Availability has been assessed as being limited.

There are no town water supplies presently drawing from the Leederville aquifer.

White Hill Subarea

The groundwater availability of the Leederville Aquifer is limited, with recharge occurring east of the Harvey Estuary. The Park Ridge Town Water Supply wells are screened within a fresh layer of the Leederville Formation. More saline water is found above and below. Fresh groundwater resources are in delicate balance and draw should be kept to a minimum. Park Ridge's water supply is now being augmented by water from the Mandurah Scheme.

Island Point

The Leederville Aquifer is thought to contain water in the salinity range 1000 - 3000 mg/L TDS. Saline water may have invaded the upper section of the formation. Recharge to the aquifers occurs east of the subarea and therefore availability is by way of throughflow only. Availability of fresh groundwater is expected to be very small.

No town water supplies occur from the Leederville aquifer.

Coastal Subarea

The Leederville Aquifer contains water with salinity generally in the range of 1000 - 3000 mg/L TDS. In the north, the upper sequences have been invaded by saline water. There is a thin layer of fresh water in the southern half of the subarea, which corresponds to recharge east of the subarea. Groundwater in the subarea is derived from throughflow and availability is limited.

The Yalgorup Town Water Supply is obtained from wells screened in the upper Leederville aquifer.

Lake Clifton Subarea

The Leederville Aquifer is expected to contain groundwater of salinity between 1000 - 3000 mg/L in the Lake Clifton subarea. In the north, there may be groundwater of salinity greater than 3000 mg/L, representing a southern extension of the Peel Estuary invasion. Recharge may occur in the west of the subarea. Throughflow within the Leederville is limited and is largely committed to the Yalgorup Town Water Supply. Groundwater availability is limited.

There are no artesian town water supplies drawn in this subarea. However, throughflow must be protected for the Yalgorup Township.

Colburra Downs Subarea

The Leederville Aquifer has limited groundwater availability. There may be some recharge occurring in the south of the subarea.

There are no public water supplies in this subarea.

Lake Preston Subarea

The Leederville Aquifer contains groundwater derived from recharge west of the Harvey Main Drain and east of the subarea by downward percolation from the superficial formations. The recharge is considered to be small and therefore the total available resource small. The Leederville aquifer may be discharging into the Lake Clifton subarea superficial aquifer because it has an upward head. Generally, groundwater is of salinity between 1000 - 3000 mg/L.

There are no abstractions of artesian groundwater for public purposes within this subarea. However, draw does occur to the north-west and south-west (Yalgorup and Myalup, respectively). Any future draw in this area must take into account present and future requirements of these schemes.

Harvey Subarea

The Leederville Aquifer contains groundwater of salinity between 1000 - 3000 mg/L. Local recharge is believed to occur from overlying superficial sediments. Availability from the Leederville is not known, but is believed to be small. It is committed in part via throughflow to Yalgorup and Myalup.

There are no artesian public water supplies. Throughflow is required by coastal communities and their requirements must be considered.

Myalup Subarea

The Leederville Aquifer contains water of salinity between 1500 - 3000 mg/L. Its upper strata generally contains water of salinity less than 1500 mg/L. Higher salinity water is found west of the Myalup Swamp as a result of evapotranspiration concentration within the swamp. Recharge is believed to be occurring from overlying superficial sediments east of the Myalup Swamp and west of the Wellesley River. The water not lost to the superficial formations discharges to the ocean after passing below the coastal saline intrusion. Groundwater resources of the Leederville Formation are considered to be small.

The Myalup and Binningup Town Water Supplies are obtained from the Leederville aquifer.

Wellesley Subarea

The Leederville Aquifer contains groundwater derived directly from infiltration from overlying sediments. East of the Wellesley River the Leederville Formation contains water of a salinity greater than 3000 mg/L. West of the Wellesley River the Upper Leederville contains water of salinity less than 1500 mg/L. Groundwater availability is limited.

There are no town water supplies in this subarea. It is however, the recharge area for the Leederville aquifer drawn on by communities such as Binningup.

4.3.2 Murray Groundwater Area

4.3.2.1 General

This GWA consists of 4 subareas and covers a total area of 1046 km^2. Only two of these subareas, Coolup and Waroona, are in the study area. Their total area is 596 km^2. Refer to Figure 4.2 and Appendix A 4.

The groundwater resources in this GWA do not generally favour large abstractions.

Bore yields from the shallow unconfined aquifer are generally low due to the clayey nature of the sediments and the limited thickness of the aquifer. Groundwater salinity exceeds 1000 mg/L in areas.

Groundwater recharge to the Leederville Formation is limited by the clay content of overlying strata. As a consequence availability is small and is generally reserved for public water supply purposes.

Recharge to the deep artesian aquifer (Cockleshell Gully Formation) occurs only near the Darling Scarp and therefore recharge is very limited. The majority of this aquifer's sustainable yield has been committed to industrial users. This allocation is from the Pinjarra Subarea, which is located outside of the study area, but does limit the available draw from the Cockleshell Gully aquifer in the Coolup Subarea.

The major issue related to groundwater use in the Murray GWA is potential impacts of irrigated developments on nutrient inputs to the Peel - Harvey Estuary.

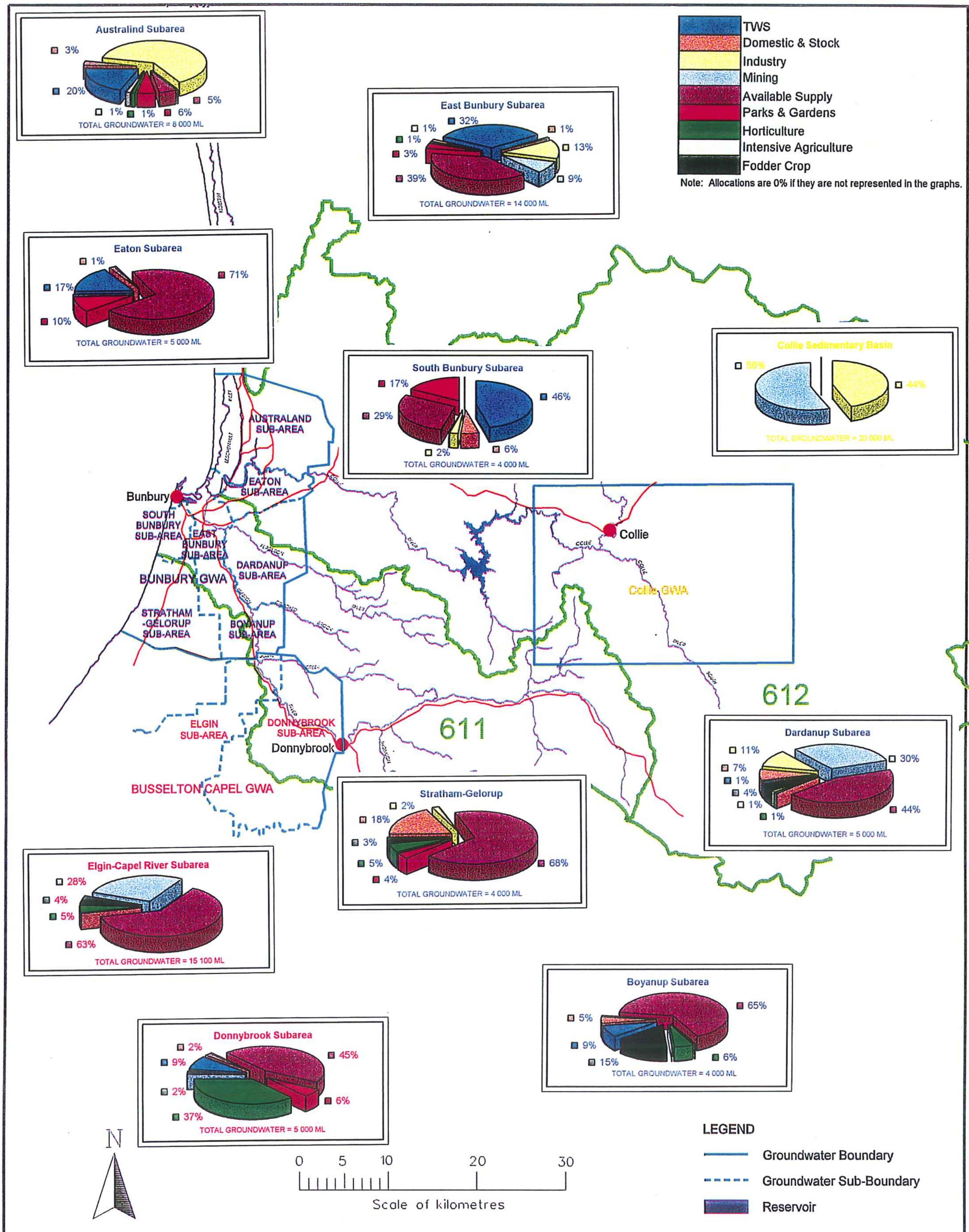
The total available resource from the two subareas of this GWA within the study area is estimated to be 47 GL/year of which 19% has been committed. Most of the remaining groundwater is available from the superficial aquifer. Minimal groundwater is available from the Leederville and Yarragadee aquifers.

4.3.2.2 Groundwater Availability

4.3.2.2.1 Superficial Formation

The presence of watercourses, lakes and inlets has resulted in the formation of a complex groundwater flow regime. Three regional flow systems are recognised in the superficial aquifer between Pinjarra and Bunbury (Deeney, 1988). These are the Serpentine, Waroona and Myalup flow systems.

Recharge to the aquifer system is by direct infiltration of rainfall with subordinate amounts from runoff. Recharge rates vary across the coastal plain as a result of the variation in lithology, depth to water table and topographic gradient.



Bunbury-Mandurah Region Water Resources Review

GROUNDWATER RESOURCE ESTIMATES BASINS 611 & 612

Figure 4.3a

Inflow to the superficial aquifer may occur locally by upward leakage from the Leederville aquifer. This occurs in the western part of the Murray Groundwater Area, where there are increasing hydraulic heads with depth and where there are no confining beds between the underlying aquifer and the superficial aquifer.

Groundwater discharges from the superficial aquifer into the major watercourses, inlets and coastal lakes that form the flow system boundaries. Groundwater also discharges to the large number of drains and smaller rivers which are present in the central and eastern parts of the area.

Salinity generally increases in the direction of groundwater flow. However, other factors strongly influence the salinity distribution and these include; variations in permeability, evapotranspiration from the shallow water table, irrigation in the Waroona area, downward leakage through the Guildford Clay and upward leakage locally from Mezozoic sediments.

4.3.2.2.2 Leederville Formation

The Leederville aquifer is recharged by downward leakage from the superficial aquifer. Recharge occurs mainly along the eastern margin of the Swan Coastal Plain where downward hydraulic heads prevail. Pumping has reduced the hydraulic heads within the aquifer, increasing the area over which recharge is occurring.

Groundwater in the Leederville aquifer flows westward to discharge offshore. Discharge to the underlying Yarragadee and Cockleshell Gully aquifers may occur by downward leakage where the South Perth Shale is absent and where downward hydraulic gradients exist.

The salinity of the groundwater in the upper part of the Leederville aquifer is between 500 mg/L and 2000 mg/L TDS. In the lower part of the aquifer, the salinity is generally less than 3000 mg/L TDS. However, near the Harvey Main Drain, the groundwater may exceed 7000 mg/L TDS. Near the Peel Inlet, saline groundwater extends into the Leederville aquifer.

4.3.2.2.3 Cockleshell Gully Formation

Recharge to the Cockleshell Gully aquifer occurs only near the Darling Scarp and therefore recharge is very limited.

The apparent groundwater flow direction in the Cockleshell Gully aquifer is westwards. Groundwater movement is considered to be very slow at depth, where the groundwater is saline. It is likely that most of the groundwater flow occurs in the top 500 m of the aquifer (Davidson, 1995).

Groundwater in the Cockleshell Gully aquifer generally discharges offshore. Some discharges to the Leederville aquifer may occur near the Harvey River Main Drain where upward hydraulic heads are present.

Groundwater salinity in the Cockleshell Gully aquifer is generally brackish to saline.

4.3.3 Bunbury Groundwater Area

4.3.3.1 General

This GWA consists of 9 subareas and covers a total area of 525 km^2. Refer to Figure 4.2 and Appendix A 4.

Nearly half of the Bunbury GWA unconfined aquifer contains groundwater of a salinity too high to be useful for agriculture or similar activities. Of the good quality water available from this aquifer, most will be used for small farm agricultural and domestic requirements.

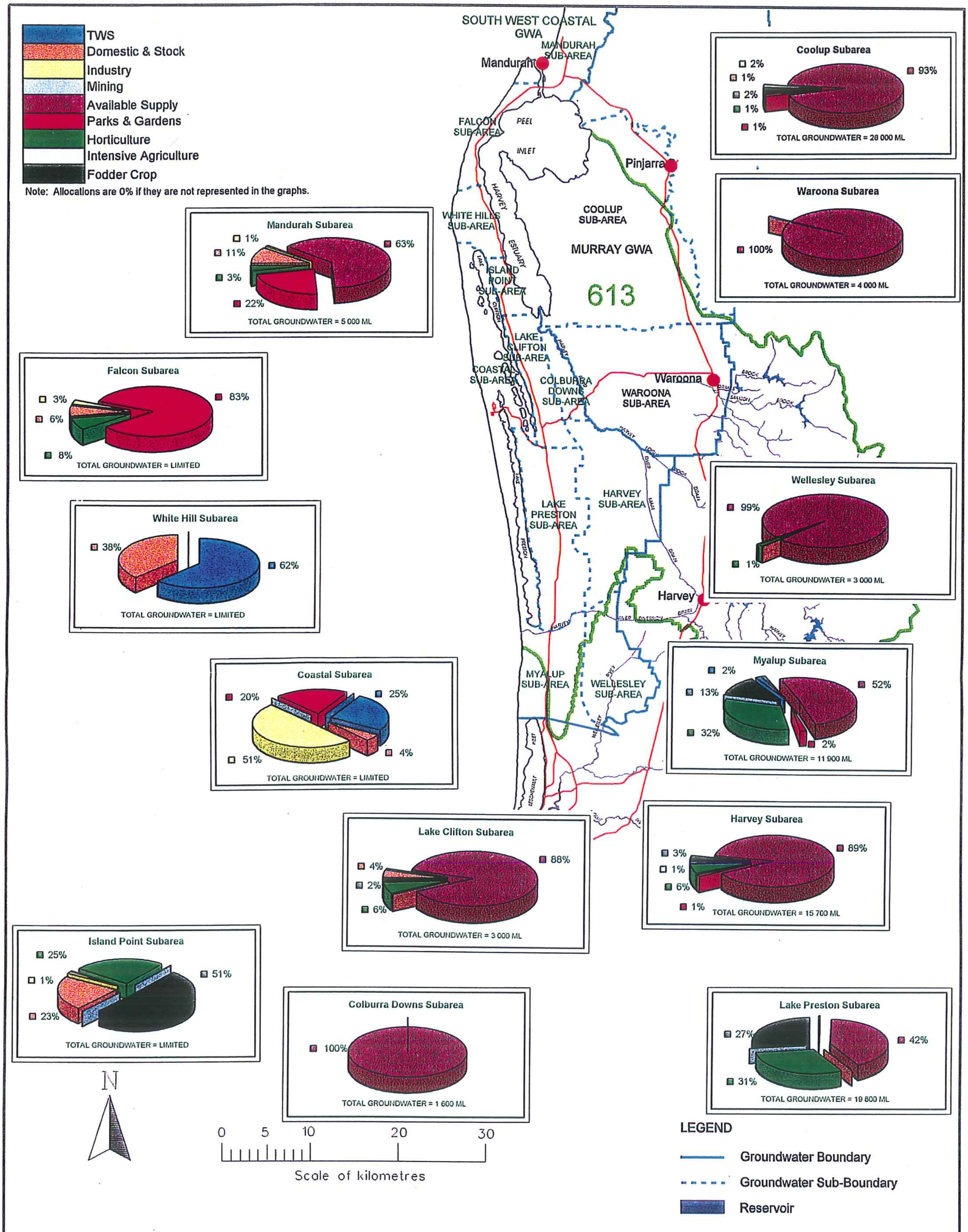
The Leederville Formation contains good quality water. Most of this resource is drawn by or committed for industrial purposes and includes supply to industry at Kemerton, Boyanup and Picton. This resource is also committed for public water supply requirements of Australind and for public purpose uses such as golf courses and recreational areas.

The Yarragadee Formation contains good quality water except in the north of the Bunbury GWA. Most of this resource is needed to meet the public water supply requirements of Bunbury and Eaton. A small component of this resource has been allocated to industry near Australind and Kemerton.

The sustainable fresh groundwater draw in the Bunbury GWA is 45 GL/year of which approximately 59% is currently used.

4.3.3.2 Groundwater Availability

Groundwater availability, or long term safe supply, depends on a number of factors including maintenance of water levels, environmental considerations, water quality and enhanced recharge. As each formation has its



Bunbury-Mandurah Region Water Resources Review
GROUNDWATER RESOURCE ESTIMATES BASIN 613

Figure 4.3b

own hydraulic parameters and recharge mechanisms, availability will vary between aquifers. The availability for each main aquifer system is described below.

4.3.3.2.1 Superficial Formation

The superficial formations are extremely variable in quality and available storage, being greatly dependent on the proportion of sand to clay in the formation. High percentages of clay are usually associated with poor quality water. Environmental concerns associated with wetlands and native forests also limits groundwater availability.

Estimating groundwater availability in the superficial formations using throughflow or recharge methods is extremely difficult because:

- The lack of a strongly defined regional flow system;
- The presence of numerous rivers, drains and wetlands;
- The variable nature of the sediments, which range from clays to sands to limestone;
- The variable thickness of the formation; and
- The varying impact of the underlying formations, which range from Bunbury Basalt, to impervious clays of the Leederville Formation, to sands and sandstone of the Yarragadee Formation.

Owing to this extreme diversity, it is not possible to provide a regional estimate of the availability for the formation. Groundwater availability is set at the current licensed allocation.

The overall quality of the superficial formations is extremely variable. Water quality is directly dependent on the proportion of sand versus clay in the soils. The higher the clay content, the higher the accumulation of salts. In general, the salinities range from 300 mg/L to as high as 10 000 mg/L, with the higher salinities occurring in the north-east of the Bunbury Groundwater Area.

4.3.2.2.2 Leederville Formation

The majority of the groundwater in the Leederville Formation flows along an elongated flow tube originating south west of Donnybrook and terminating in the ocean near Australind. Recharge mainly occurs above the Whicher Scarp on the Blackwood Plateau and discharge occurs to the ocean west of the Leschenault Inlet. Investigation drilling along the Leschenault Peninsula has indicated that the saltwater interface in the Leederville Formation is offshore for most of the Formation. However, from drilling at the Pelican Point project, it appears that Leschenault Inlet has invaded the Upper Leederville Formation in that area. The extent of invasion needs further investigation, particularly with regard to the Australind water supply production bores in the Leederville Formation.

Total availability is estimated to be 12 GL/yr. Drilling on the Leschenault Peninsula indicated the saltwater interface for this aquifer is offshore, and not along the Inlet. However, if large localised abstraction at Australind occurs, saltwater intrusion from the Inlet into the superficial and Leederville Formations, may occur.

Water quality in the Leederville Formation is usually less than 500 mg/L. In the east, where the Formation is thick, it is between 250 - 300 mg/L. In the west, where the Leederville Formation pinches out against the Bunbury Basalt, quality deteriorates to over 1000 mg/L. The Australind Town Water Supply draws water from the Leederville aquifer.

4.3.3.2.3 Yarragadee Formation

The Yarragadee Formation extends as a continuous system from the Scott Coastal Plain, 120 km south of the Bunbury Groundwater Area, to just north of Kemerton. The GSWA has estimated that 300 ML of groundwater is in storage between Bunbury and the Scott Coastal Plain. The annual throughflow in the Bunbury Trough, between the Darling and Busselton Faults, is estimated to be approximately 100 GL/yr or 2 GL/yr/km, by GSWA (Commander, 1982). Of this, some 33 GL/yr passes through the Bunbury Groundwater Area, with the remaining 67 GL/yr in the Busselton - Capel Groundwater Area. To quantify the dynamics of the aquifer due to large scale pumping and obtain a more accurate figure of the Yarragadee Formation's annual throughflow, a study should be carried out when abstraction levels from the Yarragadee are close to the current estimate of throughflow. Groundwater availability is estimated to be 33 GL/yr.

The Yarragadee Formation has distinct layers of salinity. The upper 100 m of the aquifer is of moderate to poor quality, in the order of 500 - 1000 mg/L. Quality is poor where clay layers are numerous, or the flow is toward the superficial formations. Where the Leederville Formation and the Bunbury Basalt overlay the Yarragadee, the quality deteriorates further. Below this layer of poor quality water, the salinity improves to about 250 mg/L. The quality remains near this value to approximately -850 m AHD. From here it gradually increases to over 1000 mg/L.

In the eastern half of the Bunbury Groundwater Area, near Brunswick Junction, the Leederville Formation thins and leakage from the Leederville to the Yarragadee Formation is believed to occur. This increase in recharge to the Yarragadee results in improved quality.

In the north of the Bunbury Groundwater Area, the Yarragadee Formation thins and throughflow is reduced. The quality gradually deteriorates in association with the thinning. North of Australind, it reaches 1000 mg/L, where the Yarragadee Formation is replaced by the Cockleshell Gully Formation.

The Bunbury, Boyanup and Eaton Town Water Supplies draw water from the Yarragadee aquifer.

4.3.3.2.4 Cockleshell Gully Formation

The Cockleshell Gully aquifer has not been extensively utilised in the Bunbury Groundwater Area due to its occurrence at depth. In the northern section of the Australind subarea, where the Yarragadee is absent, the Cockleshell Gully aquifer offers a useable resource. However, due to the limited number of bores, very little is known about the aquifer in this area. Water quality is generally between 500 - 1000 mg/L in the centre of the coastal plain.

4.3.4 Collie Groundwater Area

The water resources of the Collie Basin is of such importance that the Collie Water Advisory Group (CWAG) was recently formed to coordinate an in depth study of the basin. The report, Strategies for water Resource Management in the Collie Basin (CWAG, 1996), has just been published. This report contains an in depth discussion of this GWA.

This GWA comprises all of the Collie Basin and is not subdivided into subareas. The basin occupies an area of 230 km^2, and has the general form of two adjoining parallel lobes with a north west - south east alignment. Refer to Figure 4.2 and Appendix A 4.

Groundwater recharge to the basin is estimated to between 20 and 30 GL/year. The quality varies but is generally of low salinity.

The assessed annual recharge of the basin is in the same order as that which is currently required for power generation and coal mining activities in the area. When these mining and power generation activities are increased as a result of the new Collie Power Station to be completed in 1999, it is estimated that abstraction will greatly exceed recharge.

This additional demand will need to be met by depleting the storage of the aquifer, if a suitable source of surface water cannot be provided. Due to the nature of the groundwater resource and the strategic importance of the power generation and mining operations, minimal depletion of this resource is considered to be acceptable.

A major water management issue for the basin is the disposal of poorer quality effluent from mining and power generation to the Collie River. This has detrimental effects on both the environment and the quality of water in the Wellington Reservoir.

This matter is being resolved by all involved parties. Western Power is converting Muja Power Station to a zero effluent industry (1996) and the new Collie Power Station will be provided with an effluent pipeline and a sea outfall to convey treated effluent. Future industries will also be required to provide an effluent pipeline for the disposal of treated effluent.

4.3.5 Busselton - Capel Groundwater Area

4.3.5.1 General

The GWA consists of 9 subareas, 2 of which are contained within the study area. These are the Donnybrook and Elgin-Capel River Subareas. The groundwater area covers a total area of 2586 km^2. Refer to Figure 4.2 and Appendix A 4.

The superficial aquifer is utilised mainly for domestic irrigation, small irrigation projects and by the local Shires to water lawns. Recharge is mainly by direct infiltration of rainfall, and in part of the area bordering the coast, by upward leakage from the underlying Leederville aquifer. Near the coast, groundwater in the superficial aquifer is brackish, while inland of the coast and north of the Whicher Scarp, groundwater is marginal.

The Leederville aquifer is the most heavily utilised aquifer in the Busselton - Capel GWA. It contains large quantities of groundwater, which are easily accessible and relatively cheap to exploit. The aquifer supplies water to the towns of Busselton, Donnybrook and Dunsborough and is used for farm irrigation projects, market gardening by the local Shires, mining interests and for recreational facilities. Recharge occurs by direct infiltration of rainfall on the Blackwood Plateau where the formation subcrops, and by downward leakage from the superficial aquifer adjacent to the Whicher Scarp. Salinity is generally fresh, but increases gradually in the direction of the groundwater flow, toward the coast, where the saltwater interface is found.

In the Donnybrook subarea, the Leederville aquifer is heavily utilised by apple growing concerns. In the Vasse Shelf, the aquifer is fully allocated and several applications for licences have been refused. A saltwater interface currently at the coast may be induced to move inland should pumping be increased.

The Yarragadee aquifer exists only in the Bunbury Trough. It contains the largest groundwater resources in the Busselton - Capel GWA and has great potential for future development. However, due to its depth below the surface, the aquifer is not heavily utilised. Currently it is used to service the towns of Capel, Peppermint Grove Beach and Busselton. Additionally, the aquifer is tapped by large mining concerns in support of the sand mining activities near Capel. Recharge to the aquifer is believed to occur south near the Karridale Line of wells, in areas where it is covered by sediments which have a high permeability. The Yarragadee is also recharged by leakage from the overlying Leederville aquifer, south of the Whicher Scarp. Salinity is fresh to marginal , with an apparent increase toward the north-east.

The total available resource from the two subareas of this GWA within the study area is estimated to be 21.3 GL/year of which 47% has been committed.

4.3.5.2 Groundwater Availability

4.3.5.2.1 Superficial Formation

The superficial aquifer is extremely variable in quality and available storage depends on the proportion of sand to clay in the aquifer. In the Busselton - Capel Groundwater Area, the superficial aquifer is significant only west and north of the Whicher Scarp. Groundwater in the superficial aquifer also supports environmental features such as wetlands and native vegetation. Concerns associated with the retention of such environmental features limits the quantity of groundwater that may be drawn.

In areas near the coast, the quantity of groundwater available for abstraction is limited to 75% of the annual recharge. This allows some water in the weak regional flow system to flow to the ocean and to protect the environmentally sensitive coastal wetlands. In inland areas, all of the annual groundwater recharge may be allocated, as there are no significant wetlands or other environmentally sensitive areas.

Groundwater availability from the superficial aquifers in the Donnybrook and Elgin-Capel River subareas are estimated to be small and 9.4 GL/yr, respectively.

Large variations in individual well yields are expected, as yield depends on the thickness of the aquifer and the proportion of sand and clay in the soil.

In the Busselton - Capel Groundwater Area, groundwater salinity near the ocean exceeds 1000 mg/L, mainly due to the high evaporation rates of the wetlands in the area. Salinity decreases to the south, to less than 500 mg/L near the Whicher Scarp.

4.3.5.2.2 Leederville Formation

The Leederville aquifer is a major aquifer in the Busselton - Capel Groundwater Area and because it is found at a shallow depth, is readily accessible.

Groundwater in the Leederville aquifer flows mainly from the south to the north, discharging into the ocean. Recharge mainly occurs south of the Whicher Scarp on the Blackwood Plateau. A saltwater interface exists near the coast which may migrate inland if the aquifer is over pumped.

Groundwater availability from the Leederville Formations in the Donnybrook and Elgin-Capel River subareas are 3.9 GL/yr and 1 GL/yr, respectively.

Groundwater salinity increases gradually to the north, in the direction of groundwater flow. South of the Whicher Scarp, salinity ranges from 165 - 500 mg/L. There is no simple relationship between salinity and depth or location.

The Donnybrook Town Water Supply draws water from the Leederville aquifer.

4.3.5.2.3 Yarragadee Formation

The recharge areas of the Yarragadee aquifer have not been accurately identified, but are known to be located south of the Whicher Scarp, in State forest. Additional in-fill drilling is required to better identify the area over which the Yarragadee aquifer subcrops and outcrops. Groundwater availability from the Donnybrook and Elgin-Capel River subareas is estimated to be 1.5 GL/yr and 5.5 GL/yr, respectively.

There is a slight increase of salinity toward the north-east, in the direction of groundwater flow. Salinity also generally increases with depth. Fresh groundwater extends to depths from -800 m AHD to more than -1500 m AHD.

5. Resources Management and Development Issues

5.1 Environmental Management

5.1.1 General

This document is primarily an inventory of the water resources in the study area, no attempt is made to consider specific significant environmental issues. However, some general consideration has been given to the existence of conservation reserves in the CALM estate which may be effected by water resource development. The current and proposed conservation reserves are superimposed on the surface water catchments and groundwater areas in Figure 5.1 and Figure 5.2 respectively.

This very preliminary assessment has indicated that in some cases environmental values are likely to be significantly affected by water resource development, while other potential developments may remain relatively unconstrained.

5.1.2 Ecologically Sustainable Development

The Draft National Strategy for Ecologically Sustainable Development (ESDSC, 1992) states that the goal of "Ecologically Sustainable Development" is "development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends". Three objectives elaborate on this goal:

- to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations.
- to provide for equity within and between generations.
- to protect biological diversity and maintain ecological processes and systems.

The Draft Strategy recommends that, to achieve sound water resource management, government should:

- promote an awareness of the interdependence of the components that compromise natural ecosystems and the need to develop a commitment to an integrated approach to the development and management of waterresources.
- manage water and related resources in such a way as to maintain their essential biophysical functions and to achieve a balanced response to the economic, social and environmental aspirations of the community.

Applying the principles of ecologically sustainable development water supply in Western Australia requires that:

- developed water resources are used as efficiently and as practically possible, thereby minimising the need for new supply sources.
- the full range of benefits and costs which accrue to the community and environment, in the development of new sources of water supply, are recognised, and that the benefits outweigh the costs.
- essential human and environmental values be protected.
- the benefits and costs of water supply enhancement be equitably borne by individuals, sectors of the community and the environment, now and in the future. This includes the concept of indefinite sustainable useof the water resource and maintenance of environmental values.
- supply system management minimises adverse impacts and maximises benefits to the community and the environment, within practical limits. Effective environmental planning, including formal Environmental Impact Assessment (a process of adaptive environmental management, and public participation) all contribute to optimising management.
- provision be made for genuine public participation in resource planning and management.

5.2 Perth Bunbury Allocation Plan

A management process with three tiers has been developed to meet the challenge of managing our water resources to preserve their most important current and long-term values to the community. This document is the second tier of this process. The Perth - Bunbury Regional Allocation Plan (1991) (currently in draft form) is a key component of the first tier to allocate the region's water resources according to their current and long-term values to the community.

The draft Allocation Plan provisionally allocates the water resources of the Perth - Bunbury region to priority uses in order to guide current and future management for their effective protection and sustainable use. The resources are allocated according to their individual most important uses, based on a series of allocation principles, rather than to meet future projected supply requirements.

Water resources are provisionally allocated into three broad use categories of environmental/social (in situ use such as for wildlife support and recreation), scheme supply (consumer use via supply schemes) and self supply (consumer use through private diversion such as irrigation from bores). It is the scheme supply and self supply portions of these allocations which are addressed in this study.

In the draft Allocation Plan allocation is achieved by:

- Designating "beneficial uses" for water resources within the three categories. A beneficial use is a current or future use having priority over other potential uses because of its regional significance to the community. Many resources were designated to multiple, compatible beneficial uses. Management requirements for such resources are determined by the beneficial use which requires the highest quality water. The potential for diverting some resources was foregone when priority was given to environmental/social uses. Designation of a diversion beneficial use did not eliminate all environmental/social values of a resource. Those retained could therefore also be designated.

- Assigning "divertible water" to the three broad use categories in accordance with the beneficial use designations. Divertible water is expressed as the average annual volume which could be removed from a source on a sustainable basis. These assignments indicate the divertible water volumes which are set aside for each of the three broad use categories.

The beneficial use designations provide guidance for the next two tiers in the allocation process - planning and then management for use and protection of the region's water resources. This document presents current levels of use and indications as to expected demands on the available water resources of the Bunbury - Mandurah portion of the region covered by the Perth Bunbury Allocation Plan and suggests allocation guidance for those resources. The actual planned allocations are made in the water resource Management Plans for the region which provide instructions for licensing of the withdrawal and use of those resources. Groundwater Management Plans are mostly in place, but surface water plans are not developed yet.

5.2.1 Environmental Water Requirements

The Water Authority's (and now the Water and Rivers Commission) groundwater allocation planning has placed importance on establishing environmental water provisions for groundwater fed ecosystems. Over the years, more sophisticated approaches have been developed by the Authority for determining environmental (ie. in situ) water requirements (EWRs). In the Perth area, EWR studies have centred on the protection of wetlands and phraetophytic vegetation from the impacts of groundwater abstraction. Sufficient resources to ensure protection of the ecosystems which depend on groundwater are allocated first. Water is then allocated to current and future consumptive users so as best meet their needs.

A complimentary process does not exist for surface water resources. No formal policy has been adopted for determining streamflow requirements downstream of surface water schemes, either in terms of in situ uses or consumptive uses. The Water Corporation is licensed by the Water and Rivers Commission for river release flows. The Water Corporation has, as part of its operating procedures, ensured sufficient releases of water to maintain downstream consumptive uses which existed prior to establishment of a diversion (ie. dam or pumpback). This operating practice is determined on a case by case basis.

It is important to recognise that EWRs need to be identified for surface water sources as have been identified for groundwater sources. Research is being carried out to enable a complementary process to be developed. Work is currently being carried out on EWRs for the Collie River.

Historically storage structures have been designed to intercept a high proportion of average annual streamflow. This means that in low flow years all of the inflow to a storage will be intercepted and only in high flow years will flows bi-pass the storage. This produces large perturbations in the hydrological regime and ecological processes downstream of the structure.

Diversion structures, such as pipehead and pumpback facilities, intercept a smaller proportion of flow and have a correspondingly smaller impact on the downstream environment. They still represent an obstacle to aquatic fauna movement upstream.

Water can be released from structures to compensate for the intercepted flow, but this is not yet a common practice in Western Australia. The reduction in high flows does impact stream morphology.

Dams and reservoirs occupy much larger areas of land than do groundwater scheme facilities. Locations most suitable to dam establishment are also a particularly valuable environment for flora and fauna. These moist valley environments also only represent a small proportion of the area of the Darling Scarp, therefore concentration of water supply schemes has a proportionately greater impact.

5.3 Water Quality Protection

There are a variety of state government agencies (eg. DEP/EPA, Water and Rivers Commission, Water Corporation, WAPC, CALM) which play some role in the protection of water resources through their respective responsibilities. Either their mandate includes protection of water supply resources (eg. Water and Rivers Commission) or their activities (eg. CALM) and decision making (eg. WAPC) have significant implications for the protection through different mechanisms and to varying degrees.

5.3.1 Surface Water Protection

The water quality of surface water catchments is protected through the proclamation of catchment areas as Water Reserves. This proclamation enables the Water and Rivers Commission to impose conditions on the activities in the catchment area and to abstract water for public water supply. For example, certain types of land use may be prohibited or closely controlled to reduce the risk of contamination of water quality. Controls may be required on the density and location of septic waste disposal systems. Recreational activities in or on the reservoir are usually prohibited and recreational use of the catchment area is restricted to the areas which are unlikely to result in contamination.

5.3.2 Groundwater Protection

The Water Authority developed a groundwater classification system designed to give a level of protection to water sources which reflects the relative importance of the land and groundwater resources of a particular area. The wellfield areas are designated as:

- priority 1 (P1) source protection areas;
- priority 2 (P2) source protection areas; or
- priority 3 (P3) source protection areas.

P1 and P2 areas are considered most important for public water supply, and development should be restricted in these areas. The P1 classification applies to areas where the groundwater is naturally of high quality, has strategic importance, and where development can be directed to other less sensitive areas. Only those activities that leave the vegetation largely unchanged or do not involve the use of contaminants are normally compatible with this level of protection (eg. forestry, environmental reserves, passive recreation).

The P2 classification applies to areas where the water is strategically important as a source of drinking water and the land is largely privately owned and developed for non-contaminating purposes. Land uses typically include low intensity rural residential, non-intensive agriculture, and small scale urban residential and commercial development. Urban development is not considered a preferred land use in P2 source protection areas.

P3 areas are typically areas where substantial water resources of economic or strategic importance exist in urban areas or in planned urban areas. They are not as strategically important as P1 or P2 areas for water supply. For this reason their protection objectives are primarily aimed at managing land use rather than at restricting development. Within P3 areas some increase in water quality degradation is expected with intensified development. This may lead to remedial treatment or the abandonment of some of the source if remedial treatment is uneconomic, unsafe or unacceptable to the community.

5.4 Control Of Land Alienation And Clearing

During the 1960's and 1970's it became increasingly apparent that extensive clearing of land for agriculture was causing deterioration of water resources due to increasing salinity. This lead the government to introduce controls on land alienation (ie. the release of Crown land for private ownership) in the south-west of the State.

It was realised, however that alienation controls would be insufficient to maintain satisfactory stream salinities in some marginal catchments. This was because land owners had the option to further clear their properties which would have led to an increased rate of deterioration of water quality. In addition, the full effect of past clearing had not been felt. A consequence of the time lag between land clearing and increased stream salinity.

To minimise the increase in stream salinities it was necessary for the government to introduce clearing controls for land under private ownership. In November 1976, the Country Areas Water Supply Act 1947 was amended to provide control of clearing of native vegetation within the Wellington Dam Catchment Area. That amendment allows persons wanting to clear to apply for a licence. Under the Act, if the application for a licence to clear is refused the applicant has a right to claim compensation.

5.5 Climate Variability

Australian rainfall is the most variable in the world. The duration and frequency of drought sequences is extreme and interspersed with sequences of above average rainfall (Fleming, 1995). However, it has been shown that the last 20 years have not been interspersed with sequences of above average rainfall.

These sequences of above average rainfall provide most of the recharge to groundwater and when individual events are large, significant surface runoff occurs. Thus rainfall is transformed into surface runoff and groundwater recharge by a residual process. Australian streamflow shows an amplified variability, particularly in the sub-humid to semi-arid zones and the variability increases with catchment size (Fleming, 1995).

This amplified variability is highlighted in the south-west of Western Australia. A decline in annual rainfall of approximately 10% has led to an annual reduction in streamflow of approximately 30-40% for catchments in the jarrah forest.

5.5.1 Surface Water

There has been a statistically significant reduction in streamflow for the last 20 years (1975 to present) compared to the observed record (1939-1974) or, modelled record (1911-1974). This reduction in streamflow is considered to be a jump, not a linear trend. The relationship between climate variability and water quality is complex. The annual stream salinity for rivers, which are fully forested, have tended to remain stable or even decline. However, rivers which have significant parts of their catchment cleared, have shown higher stream salinities. Conversely, the salt loads for these rivers would probably have declined.

5.5.2 Groundwater

Groundwater levels respond to variations in annual rainfall, as well as land use changes and groundwater abstraction, and it is difficult to separate these effects on a regional scale. The water table in places has responded to lower than average rainfall, and levels in the coastal lakes closely follow annual rainfall variations (Commander, 1988). However, hydraulic pressures in the confined aquifers in the Bunbury - Donnybrook area have risen steadily in the last twenty years presumably in response to increased recharge from clearing the native vegetation for agriculture (Commander, 1991). Locally pressures have fallen in some monitoring bores, where they are close to centres of groundwater abstraction.

5.5.3 Implications For Management

The reduced streamflows, if they are sustained, have serious implications for water supply. The issue of how much water should be allocated to competing users of water such as water supply, irrigation or the environment is made much more difficult by changes, particularly reductions in streamflow. Explicit decisions need to be made on the priority of users or equitable reductions in water allocations.

Significantly different environmental water flow or environmental water levels are derived depending on the period of record used.

The variability due to climate can be larger or mask changes in hydrology due to land use change.

5.6 Climate Change

Global climate change, according to current scientific understanding, is very likely to occur in the next few decades as a result of increasing levels of greenhouse gases in the earth's atmosphere, particularly carbon dioxide and methane. Global warming is the result of an increase in the amount of the sun's energy retained in the atmosphere due to the accumulation of greenhouse gases. Accurate predictions of future climate change are not yet possible. The potential impact of the 'Greenhouse Effect' on the State's climate by the middle of next century cannot be ignored. According to Chittleborough (1985), the south-western portion of the State will become drier.

Climate change scenarios have been developed for the Australian Region by the Climate Impact Group (1992a), CSIRO Division of Atmospheric Research. They are continuously updated as new information becomes available. Global Climate Models are used to estimate global changes. However, uncertainty in future greenhouse gas emissions and deficiencies in existing climate models make it difficult to translate global estimates into regional estimates. Consequently, it is not yet possible to make detailed predictions of changes in climate at a regional level.

The latest climate change scenarios for the south-west of the State are briefly outlined below. They represent a range of possible futures and as such should be used as guide for sensitivity studies only. Prior to applying these scenarios to any particular problem, the Climate Impact Group should be contacted to ensure the most up to date information is used. The values mentioned are relative to 1990 values. It is stressed that the scenarios are not forecasts.

Global Climate Models indicate that global warming could be between 0.6°C and 1.7°C by the year 2030. In the south-west region the temperature change could be between +0.5°C and +2.0°C. This is a downward revision on earlier 'predictions'.

Rainfall change for the summer half - year (November to April) and for the winter half - year (May to October) could be 0% to + 20% and -10% to +10%, respectively. Evaporation increases between 1% to 8% could result.

A general increase in rainfall intensities, and in the occurrence of heavy rains is plausible. There is the possibility of longer dry spells and a reduction in the number of days on which rain falls. Extreme events are likely to change in magnitude and frequency more rapidly than the averages. This means that there could be more very hot days, fewer frosts, more floods and more dry spells.

A sea level rise of 50 to 350 mm above the 1990 level by year 2030 could be realised.

It is estimated that the rate at which the surface water yield will reduce is double the rate at which the rainfall reduces. Conversely, it is estimated that the rate at which the surface water yield will increase is half the rate at which the rainfall increases. The current estimate of a 10% decrease or increase in winter rainfall in the area by 2030 would result in a net streamflow decrease or increase of approximately 20% and 5%, respectively. The variation in yield from groundwater sources would be less evident than those for surface water sources. The sustainable yield is not expected to reduce perceptibly during the period adopted for this study.

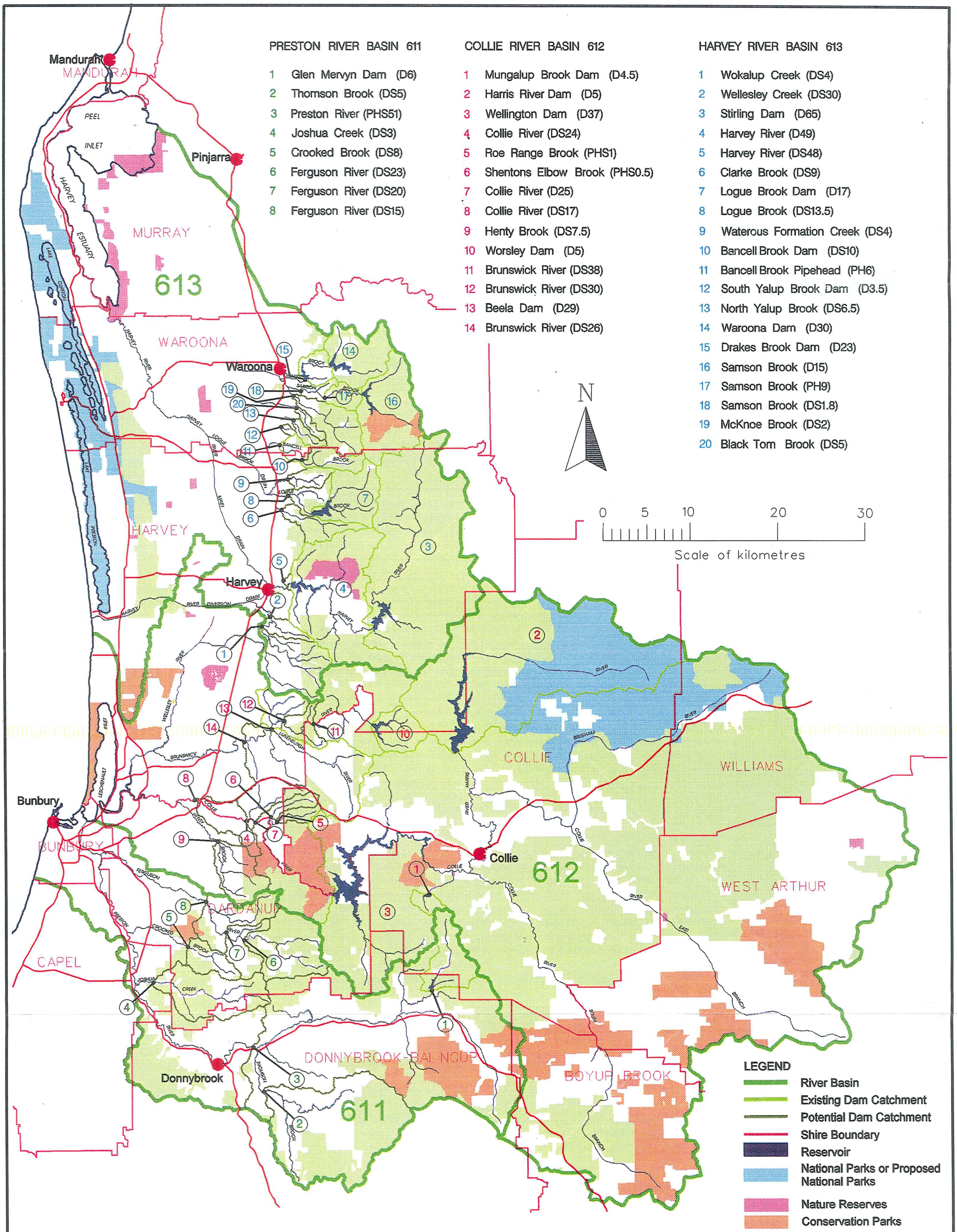
Long term effects on groundwater systems of climate change are likely to be less than the effects of land use changes made in the last 100 years.

For shallow unconfined groundwater where the water table is close to the surface, reduced recharge from rainfall may result in a slightly lower water table, and decreased evapotranspiration and discharge to drains. Groundwater flow from areas such as the Harvey Flats where the aquifer is full, and the water balance is dominated by evapotranspiration, is likely to be relatively unaffected.

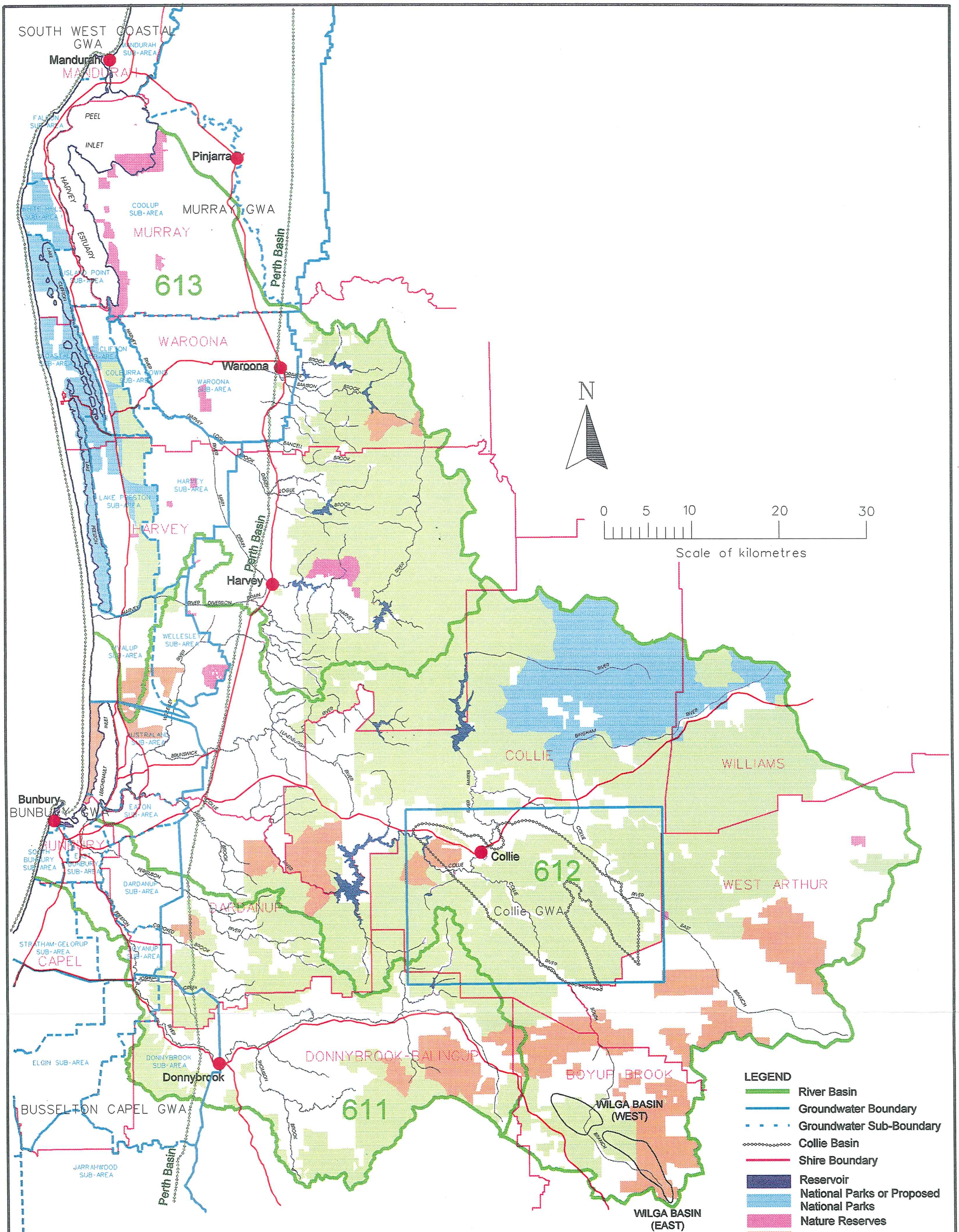
Where the water table is deep, there may be a more significant effect, with vegetation relatively unaffected and groundwater recharge much reduced.

The confined aquifers will respond very slowly to climate change as the groundwater systems, such as in the Yarragadee Formation, contain water accumulated over periods of tens of thousands of years. Direct recharge is probably less important than leakage from the unconfined aquifers, and groundwater throughflow is very small in relation to the total storage.

Note: No climate change has been applied to the hydrological and hydrogeological quantities presented in this study.



Bunbury-Mandurah Region Water Resources Review
CONSERVATION RESERVES - SURFACE WATER CATCHMENTS Figure 5.1



Bunbury-Mandurah Region Water Resources Review
CONSERVATION RESERVES - GROUNDWATER AREAS

Figure 5.2

6. Existing Water Supplies

6.1 Towns In The Preston River Basin (611)

6.1.1 Boyanup Town Water Supply Scheme

The town water supply is drawn from two production wells. These wells are located adjacent to one another on the north-west side of the townsite and are screened in the Yarragadee Formation. Salinity has remained relatively consistent between 300 mg/L and 340 mg/L. Overall groundwater quality, with the exception of iron and manganese, is within current NH&MRC drinking water guidelines. The groundwater is treated to prevent microbiological contamination by injection of chlorine at the wellheads, and by aeration and filtration to reduce iron and manganese concentrations. Wellfield production in 1994/5 totalled 287 ML (refer to Table A6. 1). Sufficient groundwater is available from the Yarragadee Formation for future expansion.

6.1.2 Bunbury Water Board

The area served by the Bunbury Water Board is currently supplied from nineteen bores feeding into eight treatment plants. Four of the plants (Irwin St, Spencer St, Mangles St and Hastie St) are located within 1.5 km of the coast and are separated by an average of 1 km in the north-south direction. The remaining four plants (Skewes St, Kelly Pk, Robertson and Tech School) are located between 1.5 and 3 km inland and are separated by an average of 2 km in the north-south direction.

The total available quantities of water from the Leederville and Yarragadee aquifers for Bunbury are abstracted at 2000 ML and 17 000 ML respectively. The licensed allocations from the two aquifers are at present 891 ML and 11 774 ML respectively. The available allocations from the two aquifers as of 1994 are 1109 ML and 5226 ML respectively. During the 1994/5 financial year approximately 6200 ML of water was abstracted (refer to Table A6. 1).

The Kelly Pk plant is used for emergency purposes only and the remaining seven plants have a combined capacity of 39 ML/day. The whole system is integrated and connected to four storage reservoirs with a total storage capacity of 117 ML of which 92 ML is reserve storage. Daily production varies from 10 ML to 35 ML. Water is treated for iron and manganese using aeration, filtration, clarification and chemical dosing.

6.1.3 Dardanup Town Water Supply Scheme

The town water supply is drawn from two production wells. These wells are located beside the highway, 1.5 km south of the townsite and are screened in the Leederville Formation. Salinity has fluctuated rapidly between 150 mg/L and 380 mg/L. Overall groundwater quality, with the exception of pH, is within current NH&MRC drinking water guidelines. The groundwater is treated to prevent microbiological contamination by injection of chlorine at the wellheads, and by aeration for iron removal. Low pH values may require future sodium hydroxide dosing. Wellfield production in 1994/5 totalled 65 ML (refer to Table A6. 1).

Sufficient groundwater is available from the Leederville Formation for future expansion.

6.1.4 Donnybrook Town Water Supply Scheme

The town water supply is drawn from six production wells which are screened in the Donnybrook Sandstone, which is a member of the Leederville Formation. The wells are located on the western edge of the town. Groundwater salinity has remained relatively stable. The salinity of production wells range from around 100 mg/L to 800 mg/L. Overall groundwater quality, with the exception of pH, is within current NH&MRC drinking water guidelines.

The groundwater is treated by injection of sodium hydroxide along the supply main to neutralise the acidity. Wellfield production in 1994/5 totalled 331 ML (refer to Table A6. 1).

Sufficient groundwater is available from the Leederville and Yarragadee Formations for future expansion. Additional wells drawing from the Leederville Formation is the more economic alternative. Allocation of additional water from the upper Leederville aquifer to the Water Corporation will have little impact on future horticultural development in the area. Allocating it for horticulture would only postpone the need for the horticulture industry to access the alternative water sources by about two years.

6.2 Towns In The Collie River Basin (612)

6.2.1 Allanson Town Water Supply Scheme

The town water supply is served from the Great Southern Town Water Supply Scheme (GSTWS) from two off takes. These two off takes are known as the Allanson Town and the Allanson Park off takes. They are interconnected and normal operating procedure is to use only one off take at a time. The main source for the GSTWS is the Harris Dam on the Harris River.

No treatment for turbidity and colour is required. Water is chlorinated and fluoridated prior to distribution. Water delivered to Allanson and Allanson Park in 1994/5 totalled 90 ML (refer to Table A6. 2).

6.2.2 Australind Town Water Supply Scheme

The town water supply is drawn from four production wells, three of which are screened in the Leederville Formation. The remaining well is screened in the Yarragadee Formation. The Leederville Formation is favoured over the Yarragadee Formation because of its lower salinity and the relative ease of treatment to reduce iron and manganese concentrations. Salinity levels in the Leederville wells range between 300 mg/L and 500 mg/L, whilst the salinity level of the Yarragadee well ranges between 950 mg/L and 1050 mg/L. Overall groundwater quality, with the exception of iron and manganese, is within current NH&MRC drinking water guidelines.

The groundwater is treated for microbiological contamination by injection of chlorine at the wellheads, and by aeration and filtration to reduce iron and manganese concentrations. Wellfield production in 1994/5 totalled 1131 ML (refer to Table A6. 2).

Sufficient groundwater is available from the Leederville and Yarragadee Formations for future expansion. The first new well will be required in 1996/7.

6.2.3 Binningup Town Water Supply Scheme

The town water supply is drawn from two production wells located 2.5 km east of the townsite. The wells draw water from the Leederville Formation. Salinity levels in both wells and the reticulation supply have remained stable between 710 mg/L to 740 mg/L. Overall groundwater quality, with the exception of iron and manganese, is within current NH&MRC drinking water guidelines.

Water is treated by means of aeration, filtration and chlorination which ensures acceptable iron and manganese levels in the reticulation supply. Wellfield production in 1994/5 totalled 115 ML (refer to Table A6. 2). Sufficient groundwater is available from the Leederville Formation for future expansion.

Further wells will be sited to the north of the existing wells.

6.2.4 Brunswick Junction Town Water Supply Scheme

The town water supply is served from the Brunswick Junction Regional Water Supply Scheme. Water from Beela Dam on the Brunswick River is used conjunctively with water from the Wellington Dam on the Collie River. During periods of high consumption the supply main from the Beela Dam does not have sufficient capacity to meet demand. At this stage Wellington Dam water is used. Water from Wellington Dam is supplied via the irrigation channel.

When demand is high water is released from Worsley Dam on the Augustus River, upstream of Beela Dam, to maintain sufficient water in Beela Dam. This only occurs when surplus water is available from Worsley Dam. During the 94/95 summer Worsley expressed considerable concern over the level in their dam and indicated that they may be unable to continue to release the required quantities in the future.

Water is treated for turbidity and colour by filtration and clarification. Water is chlorinated prior to distribution. Water delivered to Brunswick Junction in 1994/5 totalled 385 ML (refer to Table A5.2).

6.2.5 Burekup Town Water Supply Scheme

The town water supply is served from the Brunswick Junction Regional Water Supply Scheme. Water from Beela Dam on the Brunswick River is used conjunctively with water from the Wellington Dam on the Collie River. Water from Wellington Dam is supplied via the irrigation channel. Water is also released from Worsley Dam on the Brunswick River, upstream of Beela Dam, to supplement supply when available and in demand.

Water is treated for turbidity and colour by filtration and clarification. Water is chlorinated prior to distribution. Water delivered to Burekup in 1994/5 totalled 61 ML (refer to Table A6. 2).

6.2.6 Collie Town Water Supply Scheme

The town water supply is served from the Great Southern Town Water Supply Scheme (GSTWS). The main source for the GSTWS is the Harris Dam on the Harris River. Water supply is supplemented from Mungalup Dam.

Water from the Harris Dam is chlorinated and has fluoride added. Water from Mungalup Dam is chlorinated prior to distribution. Water delivered to Collie in 1994/5 totalled 1421 ML (refer to Table A6. 2).

6.2.7 Eaton Town Water Supply Scheme

The town water supply is drawn from two production wells which are screened in the Yarragadee Formation. Salinity has remained relatively consistent between 320 mg/L and 360 mg/L. Overall groundwater quality, with the exception of iron and manganese, is within current NH&MRC drinking water guidelines. The groundwater is treated for microbiological contamination by injection of chlorine at the wellhead, and by aeration and filtration to reduce iron and manganese concentrations. Wellfield production in 1994/5 totalled 768 ML (refer to Table A6. 2).

Sufficient groundwater is available from the Yarragadee Formation for future expansion.

6.2.8 Great Southern Towns Water Supply Scheme

The main source for the GSTWS is the Harris Dam on the Harris River. A number of local storage dams service peripheral towns within the GSTWS and contribute slightly to the scheme. The GSTWS contains 34 towns which range in size from one service like Bendering to Collie which at present has 3256 services. Only Collie and Allanson are situated within the Collie River Basin and consequently they are discussed separately. The GSTWS also provides water to farmland service connections along its route.

Water from the Harris Dam is chlorinated and has fluoride added. Water delivered to the GSTWS in 1994/5, excluding Collie and Allanson, totalled 8818 ML (refer to Table A6. 2).

6.2.9 Roelands Town Water Supply Scheme

The town water supply is served from the Brunswick Junction Regional Water Supply Scheme. Water from Beela Dam on the Brunswick River is used conjunctively with water from the Wellington Dam on the Collie River. Water from Wellington Dam is supplied via the irrigation channel. Water is also released from Worsley Dam on the Brunswick River, upstream of Beela Dam, to supplement supply when available and in demand.

Water is treated for turbidity and colour by filtration and clarification. Water is chlorinated prior to distribution. Water delivered to Roelands in 1994/5 totalled 33 ML (refer to Table A6. 2).

6.3 Towns In The Harvey River Basin (613)

6.3.1 Hamel Town Water Supply Scheme

The town is served from the Waroona and Hamel Water Supply Scheme. Water is drawn from a pipehead dam on Samson Brook. The supply to Hamel Town Water Supply is drawn from the Waroona Supply Main just downstream of the treatment plant.

Water is treated for turbidity and colour by filtration and is chlorinated prior to distribution. Water delivered to Hamel in 1994/5 totalled 17 ML (refer to Table A6. 3).

6.3.2 Harvey Town Water Supply Scheme

The town water supply is served from the Harvey Town Water Supply Scheme. The water supply is drawn from the Harvey Weir on the Harvey River.

Water is treated for turbidity and colour by filtration and is chlorinated before distribution. Water delivered to Harvey in 1994/5 totalled 696 ML (refer to Table A6. 3).

The Harvey Weir is also used as a source for the Harvey piped irrigation scheme.

6.3.3 Myalup Town Water Supply Scheme

The town water supply is drawn from two production wells (duty and standby) located 2.5 km east of the townsite. The wells draw water from the Leederville Formation. Salinity levels in the production well has gradually increased from 850 mg/L to 950 mg/L. The standby well is more variable with peaks around 900 mg/L in late summer falling to 600 mg/L in winter.

Overall groundwater quality, with the exception of iron, is within current NH&MRC drinking water guidelines. Iron values in the standby well have been as high as 7.5 mg/L. Wellfield production in 1994/5 totalled 37 ML (refer to Table A6. 3).

Sufficient groundwater is available from the Leederville Formation for future expansion which is expected to be minimal.

6.3.4 Preston Beach Town Water Supply Scheme

The town water supply is drawn from two production wells located in the townsite. The wells draw water from the Leederville Formation. Salinity levels in both wells and the reticulation supply have remained stable between 850 mg/L to 980 mg/L. Overall groundwater quality is within current NH&MRC drinking water guidelines. Water is chlorinated prior to distribution. Wellfield production in 1994/5 totalled 71 ML (refer to Table A6. 3).

Existing wells are capable of meeting increases in demand.

6.3.5 Park Ridge Town Water Supply Scheme

The water supply is drawn from two bores. The water has iron levels greater than 0.35 mg/L. The water is sequestered using sodium silicate to maintain the iron in suspension and is chlorinated prior to distribution. Salinity levels in both wells and the reticulation supply have remained stable between 660 mg/L to 690 mg/L. Overall groundwater quality, apart from the iron content, is within current NH&MRC drinking water guidelines. Water delivered to Park Ridge in 1994/5 totalled 91 ML (refer to Table A6. 3).

The Park Ridge Town Water Supply can be augmented from the Mandurah Regional Water Supply Scheme. The recommendation is that draw from the aquifer supplying the Park Ridge Town Water Supply not exceed 100 ML per year. Growth in consumption indicated that this figure would have been exceeded during the 1994/95 year. The inclusion of Park Ridge in the Perth Metropolitan Class I water restriction limited the demand to 91 ML for 1994/95 which resulted in no abstractions from the Mandurah Scheme.

6.3.6 Waroona Town Water Supply Scheme

The town is served from the Waroona and Hamel Water Supply Scheme. Water is drawn from a pipehead dam on Samson Brook.

Water is treated for turbidity and colour by filtration and is chlorinated prior to distribution. Water delivered to Waroona in 1994/5 totalled 462 ML (refer to Table A6. 3).

6.3.7 Wokalup Town Water Supply Scheme

The town water supply is served from the Harvey Town Water Supply Scheme. The water supply is drawn from the Harvey Weir on the Harvey River.

Water is treated for turbidity and colour by filtration and is chlorinated before distribution. Water delivered to Wokalup in 1994/5 totalled 20 ML (refer to Table A6. 3).

6.3.8 Yarloop/Wagerup Town Water Supply Scheme

The town water supply is drawn from a pipehead dam on Bancell Brook.

Water is treated for turbidity and colour by filtration and is chlorinated prior to distribution. Water delivered to Yarloop/Wagerup in 1994/5 totalled 288 ML (refer to Table A6. 3).

7. Town Population and Water Supply Projections

7.1 General

Section 2.9 refers to the projected population growth within the shires and shire segments contained within the Bunbury - Mandurah Region. This section refers to the projected population and water supply demand growth of individual towns within the region. Two population growth scenarios have been developed - 'medium' and 'high'. The 'medium' scenario is based on past and present population trends and is referred to in this chapter as 'projected population'. The 'high' scenario reassessed those projections based on a regression analysis of past and future growth and a combination of other factors and likely occurrences to produce a high result concept. This has been referred to as the 'feasible population' and is used to demonstrate the likely maximum needs in the respective areas.

Growth scenario projections (population and water demand) to the year 2025 for each town are presented graphically below. Included are projections for each drainage basin, and projections for the region as a whole.

7.2 Towns In The Preston River Basin (611)

7.2.1 Boyanup

There are currently 251 services supplied in Boyanup. Of these services 201 are residential. The long term average annual production per service is 876 kL. This has increased to 1144 kL per service in recent years. During the 1994/5 financial year the residential and industrial/commercial consumptions were 85 ML and 110 ML respectively. The mean population growth projections based on the two growth scenarios are 2.0% and 2.7%. This will result in total services of 457 and 562 and an annual water requirement of 523 ML and 643 ML in 2025 for each growth scenario respectively. Refer to Figure 7.1 and Figure 7.2.

Figure 7.1: Population Projections - Boyanup

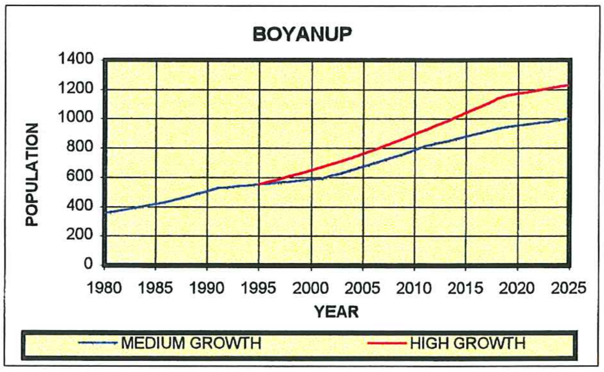
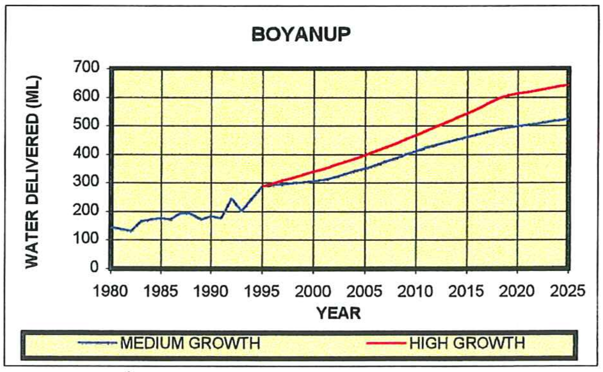


Figure 7.2: Water Demand Projections - Boyanup



7.2.2 Bunbury

There are currently 11 197 services supplied in Bunbury. Of these services, 10077 are residential. The long term average annual production per service is 650 kL. This has reduced to 551 kL per service in recent years. During the 1994/5 financial year the residential and industrial/commercial consumptions were approximately 3426 ML and 1820 ML respectively. The mean population growth projections based on the two growth scenarios are 1.1% and 2.3%. This will result in total services of 15 676 and 22 161 with an annual water requirement of 8641 ML and 12 216 ML in 2025 for each growth scenario respectively. Refer to Figure 7.3 and Figure 7.4.

Figure .7.3: Population Projections - Bunbury

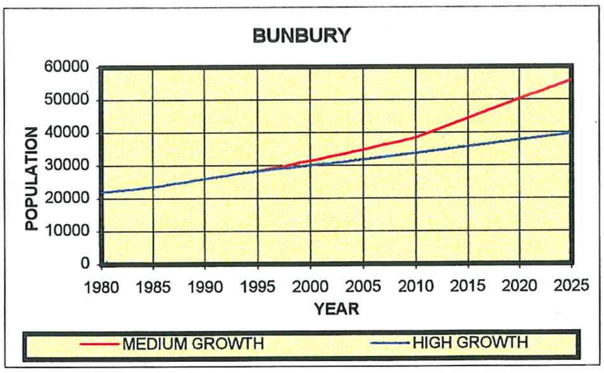
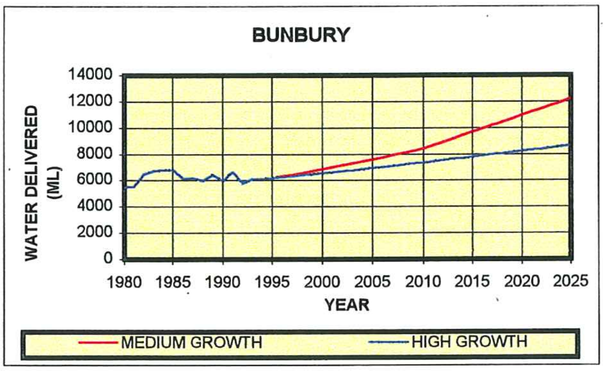


Figure 7.4: Water Demand Projections - Bunbury



7.2.3 Dardanup

There are currently 131 services supplied in Dardanup. Of these services 108 are residential. The long term average annual production per service is 443 kL. This has increased to 496 kL per service in recent years. During the 1994/5 financial year the residential and industrial/commercial consumptions were 41 ML and 9 ML respectively. The mean population growth projections based on the two growth scenarios are 1.0% and 1.4%. This will result in total services of 177 and 199 and an annual water requirement of 88 ML and 99 ML in 2025 for each growth scenario respectively. Refer to Figure 7.5 and Figure 7.6.

Figure 7.5: Population Projections - Dardanup

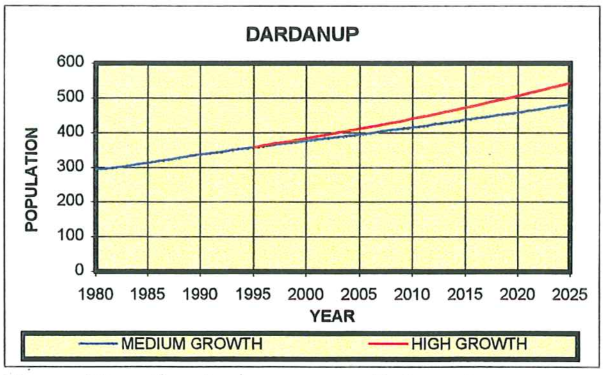
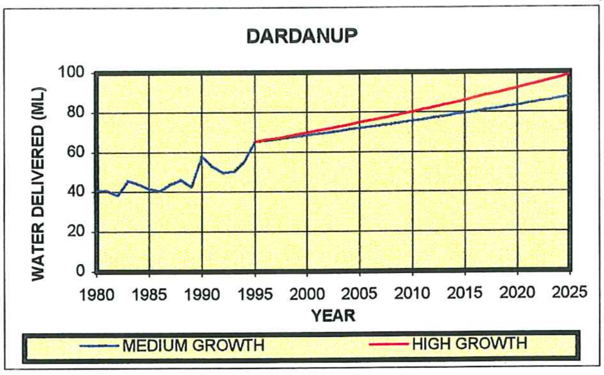


Figure 7.6: Water Demand Projections - Dardanup



7.2.4 Donnybrook

There are currently 763 services supplied in Donnybrook. Of these services 608 are residential. The average annual demand per service is 460 kL. During the 1994/5 financial year the residential and industrial/ commercial consumptions were 226 ML and 83 ML respectively. The mean population growth projections based on the two growth scenarios are 1.5% and 2.3%. This will result in total services of 1193 and 1509 and an annual water requirement of 518 ML and 656 ML in 2025 for each growth scenario respectively. Refer to Figure 7.7 and Figure 7.8.

Figure 7.7: Population Projections - Donnybrook

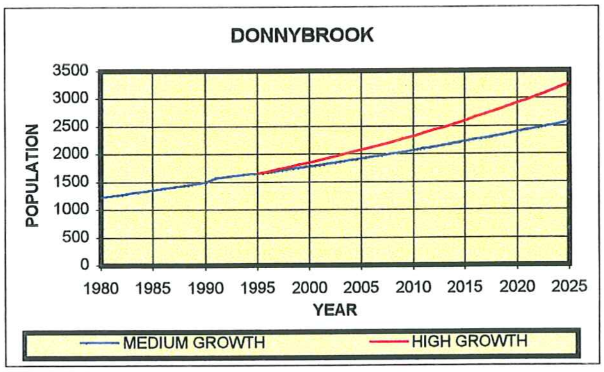
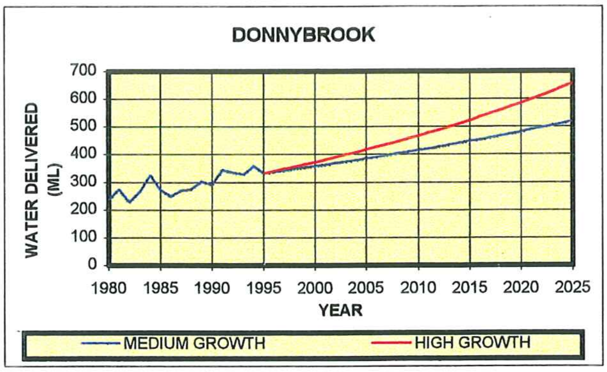


Figure 7.8: Water Demand Projections - Donnybrook



7.2.5 All Towns: Basin 611

There are currently 12 342 services supplied in Basin 611. Of these services 10994 are residential. The average annual demand per service is 641 kL. During the 1994/5 financial year the residential and industrial/commercial consumptions were approximately 3777 ML and 2022 ML respectively. The mean population growth projections based on the two growth scenarios are 1.2% and 2.3%. This will result in total services of 17 502 and 24 432 and an annual water requirement of 9769 ML and 13 613 ML in 2025 for each growth scenario respectively. Refer to Figure 7.9 and Figure 7.10.

Figure 7.9: Population Projections - All Towns Basin 611

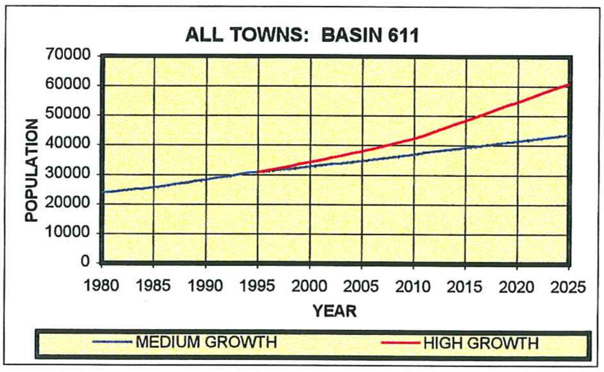
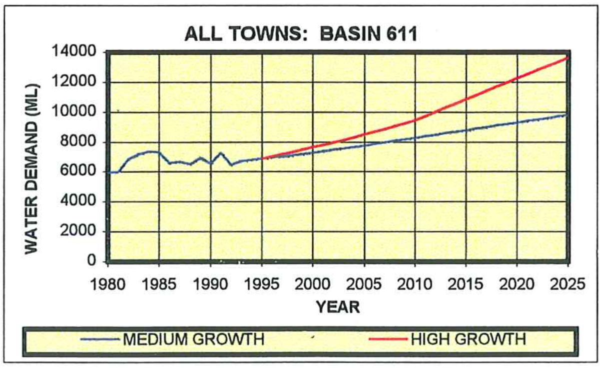


Figure 7.10: Water Demand Projections - All Towns Basin 611



7.3 Towns In The Collie River Basin (612)

7.3.1 Allanson

There are currently 189 services supplied in Allanson. Of these services 168 are residential. The average annual demand per service is 475 kL. During the 1994/5 financial year the residential and industrial/commercial consumptions were 73 ML and 5 ML respectively. The mean population growth projections based on the two growth scenarios are both 1.2%. This will result in total services of 269 and an annual water requirement of 128 ML in 2025 for both growth scenarios. Refer to Figure 7.11 and Figure 7.12.

Figure 7.11: Population Projections - Allanson

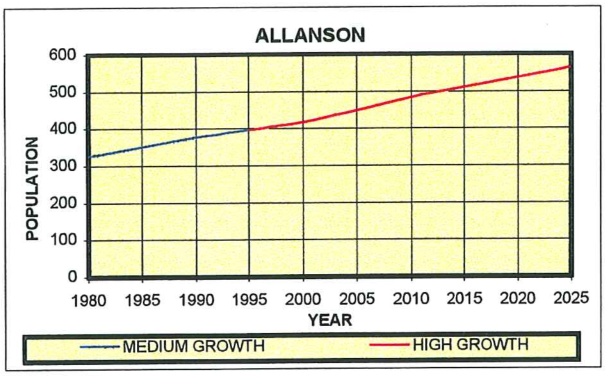
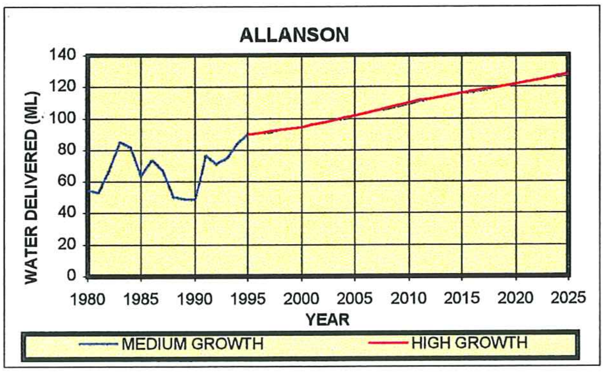


Figure 7.12: Water Demand Projections - Allanson



7.3.2 Australind

There are currently 2564 services supplied in Australind. Of these services 2360 are residential. The average annual demand per service is 421 kL. During the 1994/5 financial year the residential and industrial/commercial consumptions were 1074 ML and 140 ML respectively. The mean population growth projections based on the two growth scenarios are 2.7% and 4.1%. This will result in total services of 5640 and 8671 and an annual water requirement of 2488 ML and 3825 ML in 2025 for each growth scenario respectively. Refer to Figure 7.13 and Figure 7.14.

Figure 7.13: Population Projections - Australind

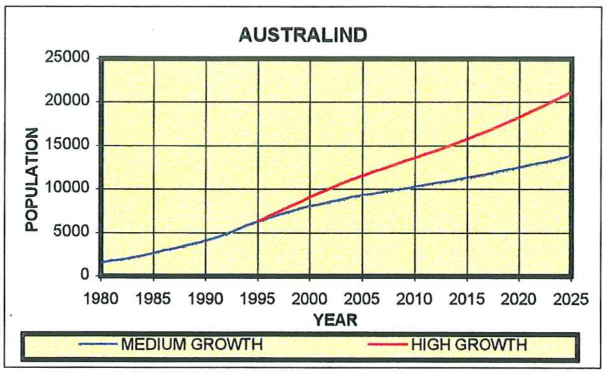
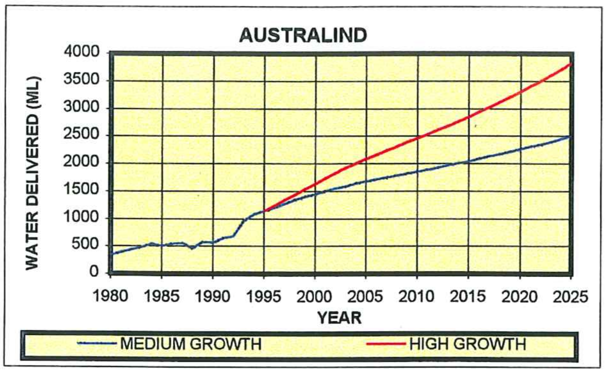


Figure 7.14: Water Demand Projections - Australind



7.3.3 Binningup

There are currently 387 services supplied in Binningup. Of these services 349 are residential. The average annual demand per service is 341 kL. During the 1994/5 financial year the residential and industrial/commercial consumptions were 97 ML and 6 ML respectively. The mean population growth projections based on the two growth scenarios are 3.8% and 4.8%. This will result in total services of 1201 and 1598 and an annual water requirement of 356 ML and 474 ML in 2025 for each growth scenario respectively. Refer to Figure 7.15 and Figure 7.16.

Figure 7.15: Population Projections - Binningup

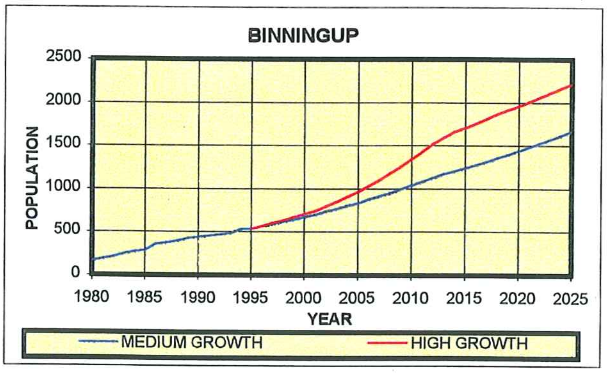
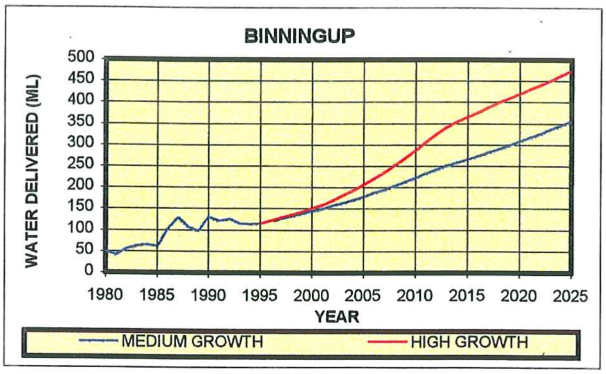


Figure 7.16: Water Demand Projections - Binningup



7.3.4 Brunswick Junction

There are currently 412 services supplied in Brunswick Junction. Of these services 333 are residential. The average annual demand per service is 789 kL. During the 1994/5 financial year the residential and industrial/commercial consumptions were 126 ML and 174 ML respectively. The mean population growth projections based on the two growth scenarios are 2.0% and 3.0%. This will result in total services of 746 and 990 and an annual water requirement of 698 ML and 926 ML in 2025 for each growth scenario respectively. Refer to Figure 7.17 and Figure 7.18.

Figure 7.17: Population Projections - Brunswick Junction

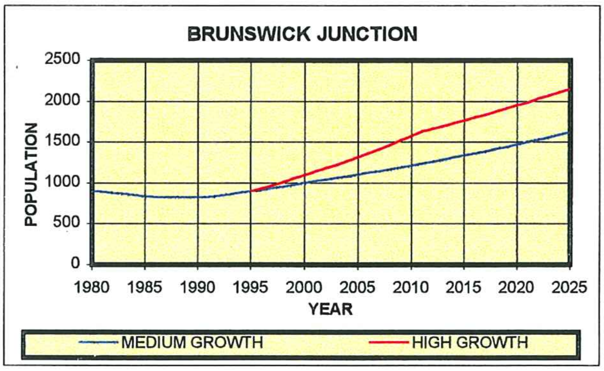
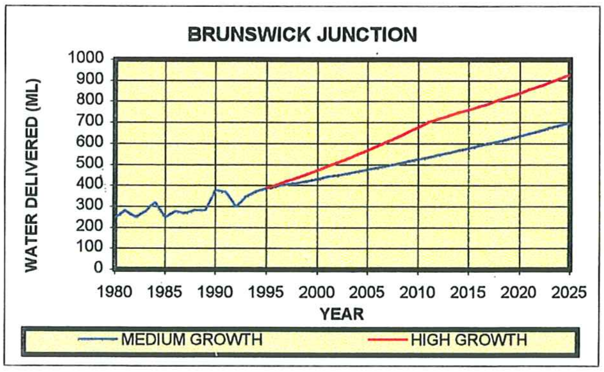


Figure 7.18: Water Demand Projections - Brunswick Junction



7.3.5 Burekup

There are currently 126 services supplied in Burekup. Of these services 110 are residential. The average annual demand per service is 424 kL. During the 1994/5 financial year the residential and industrial/commercial consumptions were 44 ML and 4 ML respectively. The mean population growth projections based on the two growth scenarios are 1.5% and 2.7%. This will result in total services of 199 and 280 and an annual water requirement of 76 ML and 107 ML in 2025 for each growth scenario respectively. Refer to Figure 7.19 and Figure 7.20.

Figure 7.19: Population Projections - Burekup

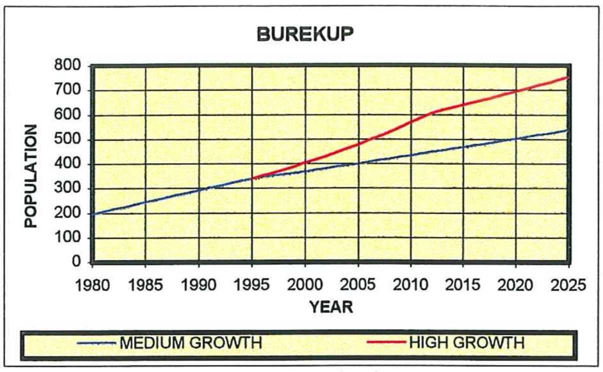
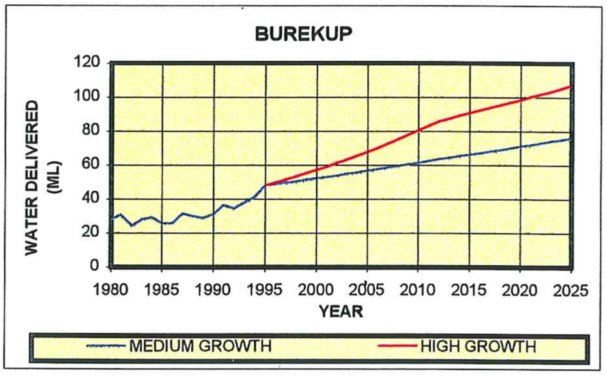


Figure 7.20: Water Demand Projections - Burekup



7.3.6 Collie

There are currently 3256 services supplied in Collie. Of these services 2914 are residential. The average annual demand per service is 391 kL. During the 1994/5 financial year the residential and industrial/ commercial consumptions were 1068 ML and 210 ML respectively. The mean population growth projections based on the two growth scenarios are 0.4% and 0.8%. This will result in total services of 3704 and 4180 and an annual water requirement of 1617 ML and 1825 ML in 2025 for each growth scenario respectively. Refer to Figure 7.21 and Figure 7.22.

Figure 7.21: Population Projections - Collie

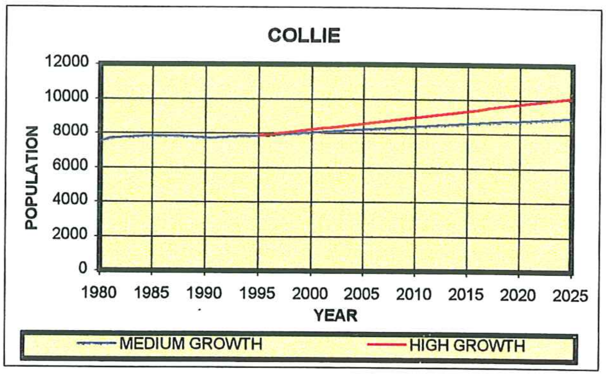
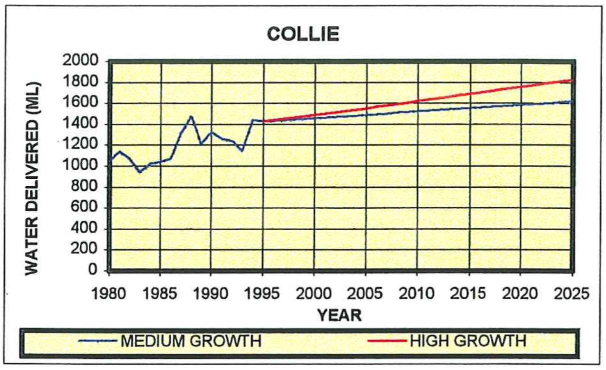


Figure 7.22: Water Demand Projections - Collie



7.3.7 Eaton

There are currently 1502 services supplied in Eaton. Of these services 1380 are residential. The average annual demand per service is 503 kL. During the 1994/5 financial year the residential and industrial/ commercial consumptions were 600 ML and 38 ML respectively. The mean population growth projections based on the two growth scenarios are 1.8% and 2.0%. This will result in total services of 2596 and 2681 and an annual water requirement of 1327 ML and 1371 ML in 2025 for each growth scenario respectively. Refer to Figure 7.23 and Figure 7.24.

Figure 7.23: Population Projections - Eaton

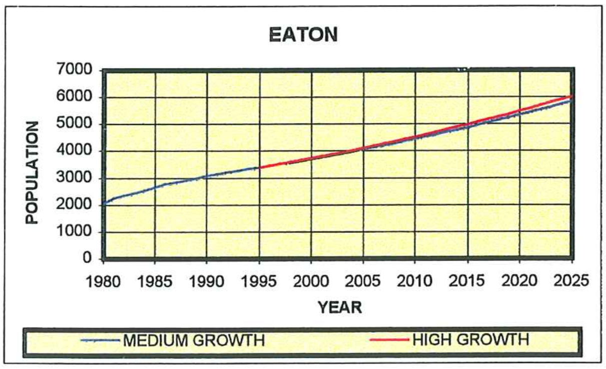
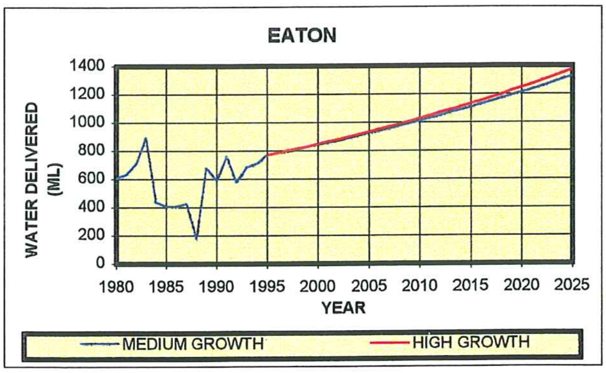


Figure 7.24: Water Demand Projections - Eaton



7.3.8 Roelands

There are currently 61 services supplied in Roelands. Of these services 49 are residential. The average annual demand per service is 474 kL. During the 1994/5 financial year the residential and industrial/ commercial consumptions were 23 ML and 3 ML respectively. The mean population growth projections based on the two growth scenarios are 0.5% and 1.0%. This will result in total services of 71 and 82 and an annual water requirement of 39 ML and 45 ML in 2025 for each growth scenario respectively. Refer to Figure 7.25 and Figure 7.26.

Figure 7.25: Population Projections - Roelands

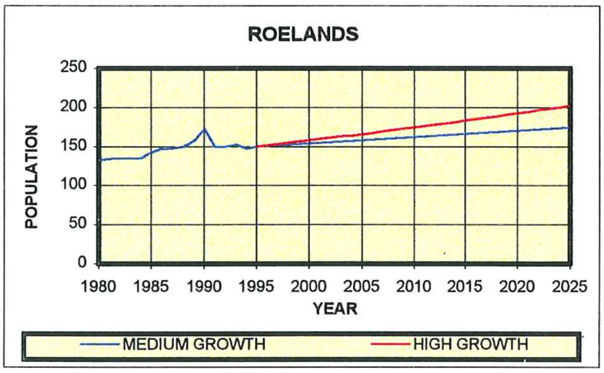
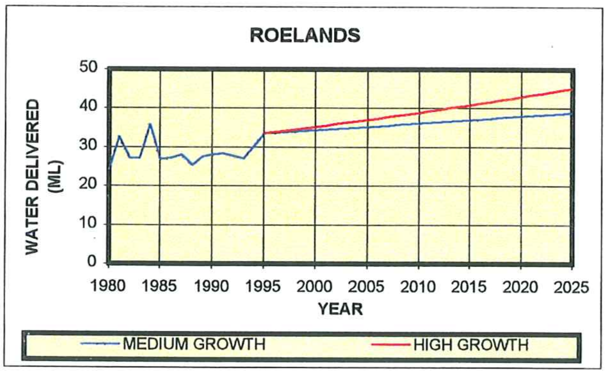


Figure 7.26: Water Demand Projections - Roelands



7.3.9 All Towns: Basin 612

Note: Statistics of services outside of this basin appear in parenthesis. Only services and demand growths outside of this basin have been considered. No population projections outside of Basin 612 are presented.

There are currently 8497 services supplied in Basin 612 (17 047 services are supplied outside of Basin 612). Of these services 7663 (9937) are residential. The average annual demand per service is 440 kL (611 kL). During the 1994/5 financial year the residential and industrial/commercial consumptions were 3106 ML (3890 ML)and 581 ML (7067 ML) respectively. The mean population growth projections based on the two growth scenarios are 1.8% (0.66%) and 2.6% (0.8%). This will result in total services of 14 426 (20 766) and 18 752 (21 651) and an annual water requirement of 6728 ML (10 743 ML) and 8699 ML (11 200 ML) in 2025 for each growth scenario respectively. Refer to Figure 7.27 and Figure 7.28.

Figure 7.27: Population Projections - All Towns Basin 612

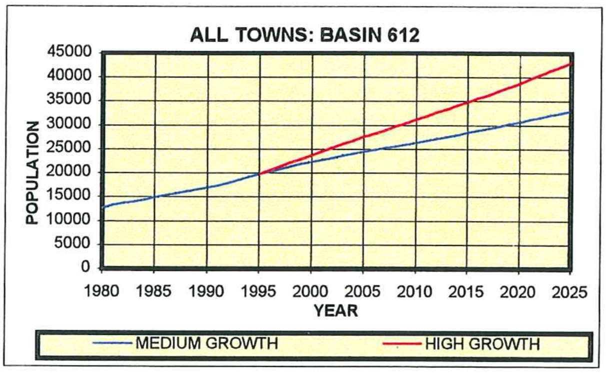
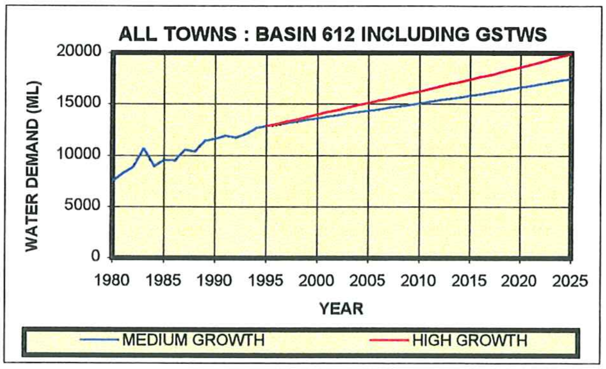


Figure 7.28: Water Demand Projections - All Towns Basin 612



7.4 Towns In The Harvey River Basin (613)

7.4.1 Hamel

There are currently 40 services supplied in Hamel. Of these services 35 are residential. The average annual demand per service is 431 kL. During the 1994/5 financial year the residential and industrial/ commercial consumptions were 14 ML and 0.5 ML respectively. The mean population growth projections based on the two growth scenarios are 0.2% and 0.5%. This will result in total services of 42 and 46 and an annual water requirement of 18 ML and 20 ML in 2025 for each growth scenario respectively. Refer to Figure 7.29 and Figure 7.30.

Figure 7.29: Population Projections - Hamel

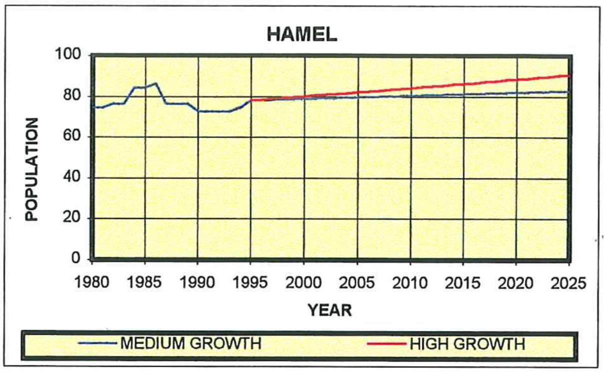
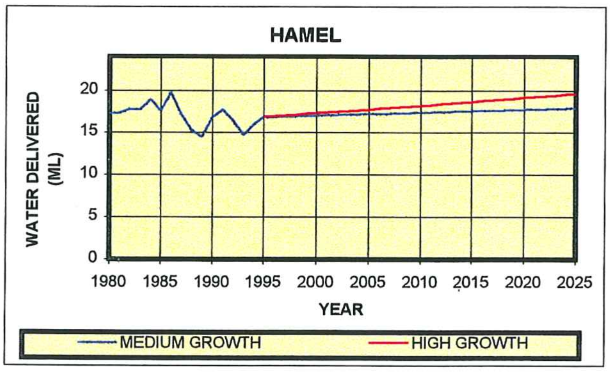


Figure 7.30: Water Demand Projections - Hamel



7.4.2 Harvey

There are currently 1136 services supplied in Harvey. Of these services 927 are residential. The average annual demand per service is 477 kL. During the 1994/5 financial year the residential and industrial/commercial consumptions were 385 ML and 135 ML respectively. The mean population growth projections based on the two growth scenarios are 0.1% and 1.1%. This will result in total services of 1188 and 1564 and an annual water requirement of 750 ML and 987 ML in 2025 for each growth scenario respectively. Refer to Figure 7.31 and Figure 7.32.

Figure 7.31: Population Projections - Harvey

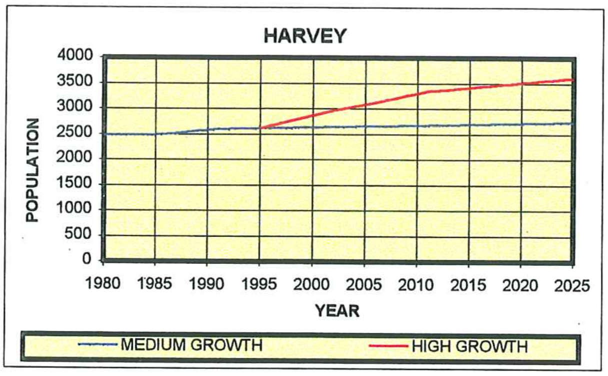
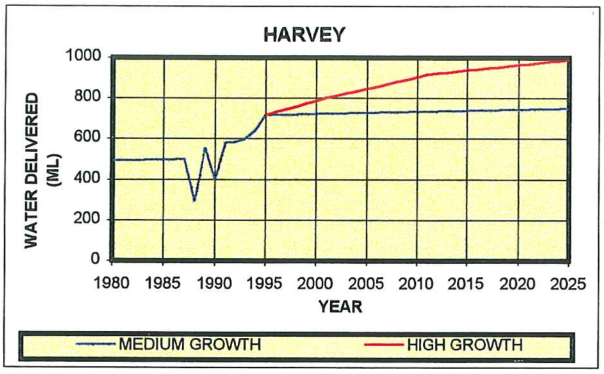


Figure 7.32: Water Demand Projections - Harvey



7.4.3 Myalup

There are currently 113 services supplied in Myalup. Of these services 93 are residential. The average annual demand per service is 238 kL. During the 1994/5 financial year the residential and industrial/ commercial consumptions were 23 ML and 12 ML respectively. The mean population growth projections based on the two growth scenarios are 1.0% and 3.0%. This will result in total services of 152 and 276 and an annual water requirement of 50 ML and 91 ML in 2025 for each growth scenario respectively. Refer to Figure 7.33 and Figure 7.34.

Figure 7.33: Population Projections - Myalup

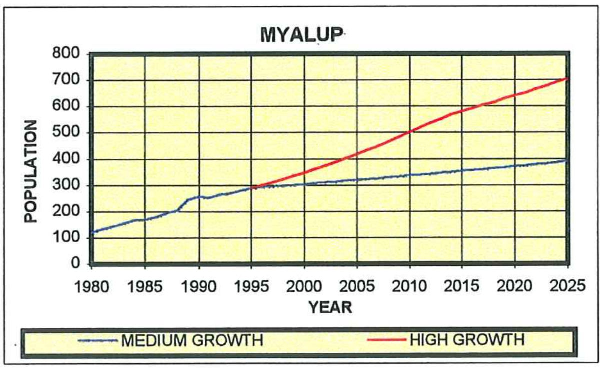
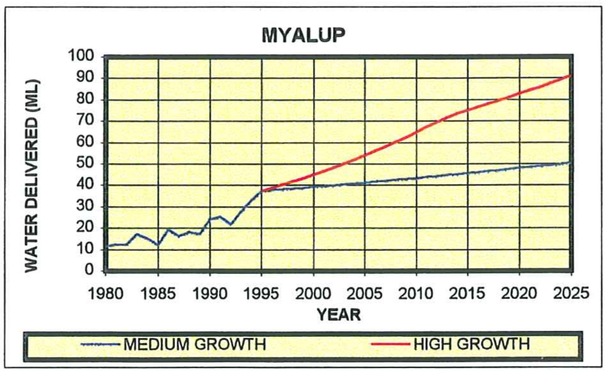


Figure 7.34: Water Demand Projections - Myalup



7.4.4 Preston Beach

There are currently 252 services supplied in Preston Beach. Of these services 219 are residential. The average annual demand per service is 363 kL. During the 1994/5 financial year the residential and industrial/commercial consumptions were 52 ML and 6 ML respectively. The mean population growth projections based on the two growth scenarios are 0.9% and 1.1%. This will result in total services of 331 and 348 and an annual water requirement of 93 ML and 98 ML in 2025 for each growth scenario respectively. Refer to Figure 7.35 and Figure 7.36.

Figure 7.35: Population Projections - Preston Beach

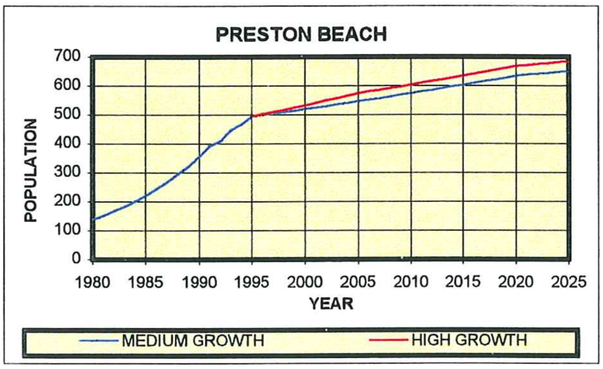
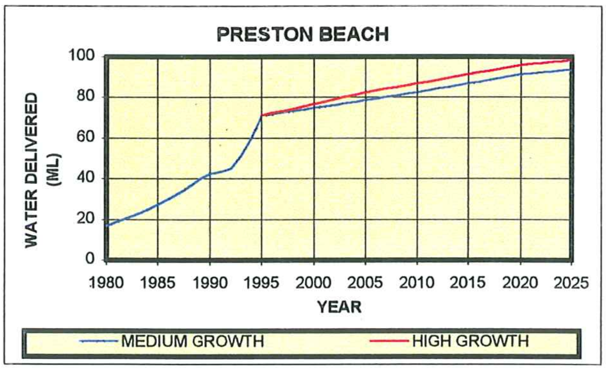


Figure 7.36: Water Demand Projections - Preston Beach



7.4.5 Park Ridge

There are currently 281 services supplied in Park Ridge. Of these services 233 are residential. The average annual demand per service is 363 kL. During the 1994/5 financial year the residential and industrial/commercial consumptions were 81 ML and 4 ML respectively. The mean population growth projections based on the two growth scenarios are 1.0% and 1.5%. This will result in total services of 379 and 439 and an annual water requirement of 123 ML and 143 ML in 2025 for each growth scenario respectively. Refer to Figure 7.37 and Figure 7.38.

Figure 7.37: Population Projections - Park Ridge

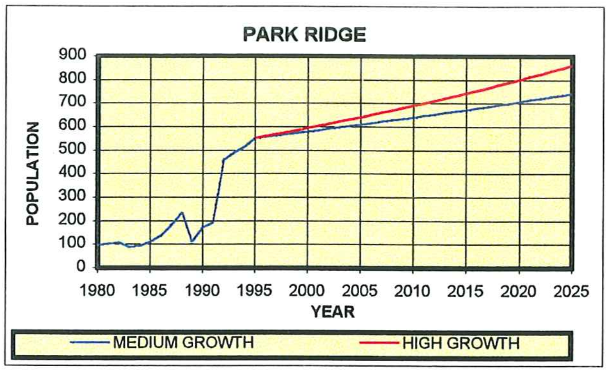
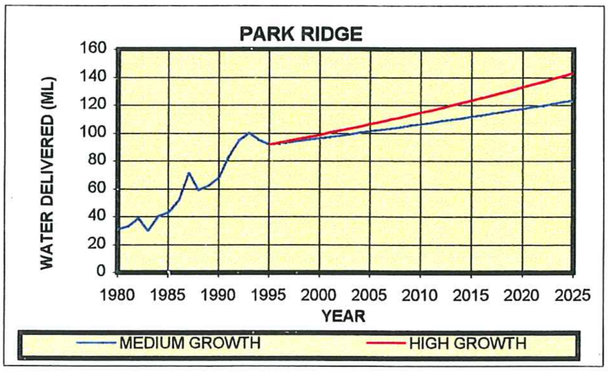


Figure 7.38: Water Demand Projections - Park Ridge



7.4.6 Waroona

There are currently 847 services supplied in Waroona. Of these services 715 are residential. The average annual demand per service is 483 kL. During the 1994/5 financial year the residential and industrial/commercial consumptions were 276 ML and 66 ML respectively. The mean population growth projections based on the two growth scenarios are 2.0% and 2.5%. This will result in total services of 1534 and 1777 and an annual water requirement of 838 ML and 970 ML in 2025 for each growth scenario respectively. Refer to Figure 7.39 and Figure 7.40.

Figure 7.39: Population Projections - Waroona

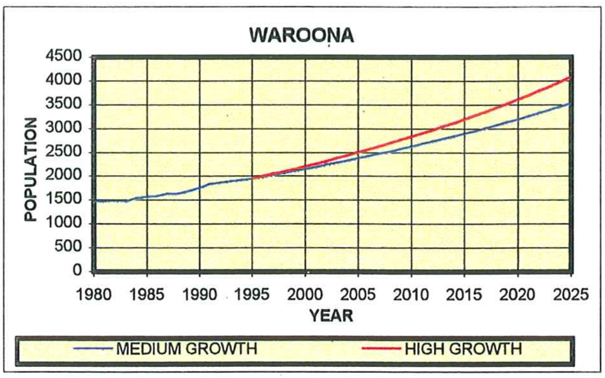
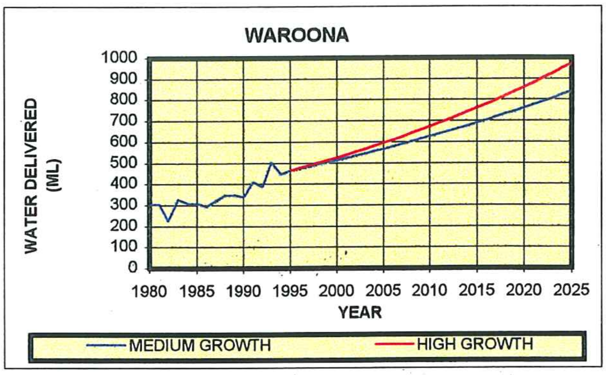


Figure 7.40: Water Demand Projections - Waroona



7.4.7 Wokalup

There are currently 49 services supplied in Wokalup. Of these services 28 are residential. The average annual demand per service is 280 kL. During the 1994/5 financial year the residential and industrial/ commercial consumptions were 7 ML and 10 ML respectively. The mean population growth projections based on the two growth scenarios are 0.2% and 0.4%. This will result in total services of 53 and 55 and an annual water requirement of 22 ML and 23 ML in 2025 for each growth scenario respectively. Refer to Figure 7.41 and Figure 7.42.

Figure 7.41: Population Projections - Wokalup

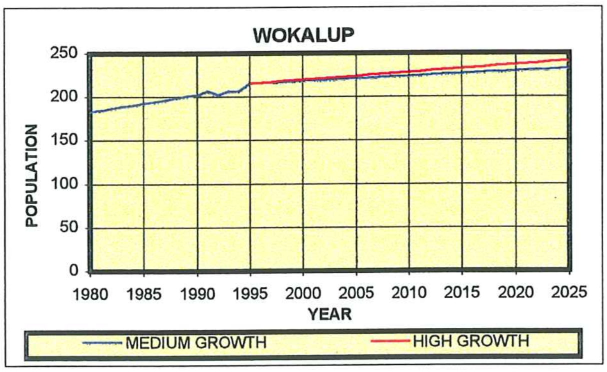
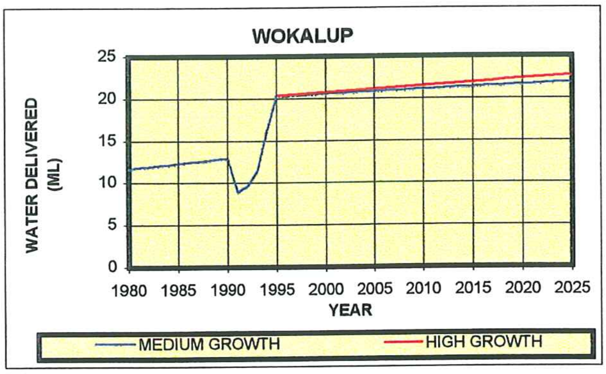


Figure 7.42: Water Demand Projections - Wokalup



7.4.8 Yarloop/Wagerup

There are currently 255 services supplied in Yarloop/Wagerup. Of these services 216 are residential. The average annual demand per service is 692 kL. During the 1994/5 financial year the residential and industrial/commercial consumptions were 85 ML and 35 ML respectively. The mean population growth projections based on the two growth scenarios are 1.1% and 1.2%. This will result in total services of 355 and 360 and an annual water requirement of 401 ML and 407 ML in 2025 for each growth scenario respectively. Refer to Figure 7.43 and Figure 7.44.

Figure 7.43: Population Projections - Yarloop/Wagerup

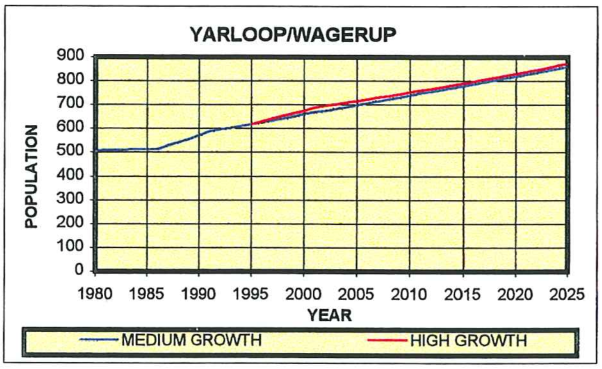
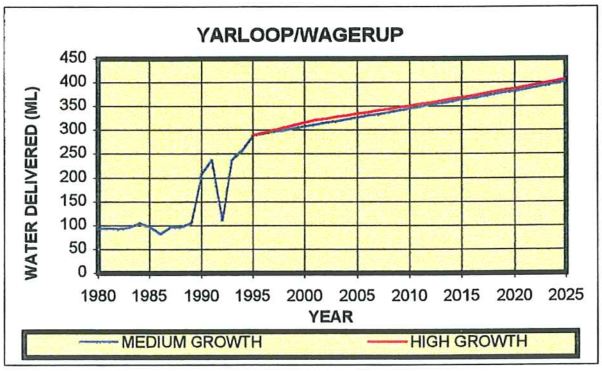


Figure 7.44: Water Demand Projections - Yarloop/Wagerup



7.4.9 All Towns: Basin 613

There are currently 2973 services supplied in Basin 613. Of these services 2466 are residential. The average annual demand per service is 490 kL. During the 1994/5 financial year the residential and industrial/ commercial consumptions were 923 ML and 269 ML respectively. The mean population growth projections based on the two growth scenarios are 1.0% and 1.6%. This will result in total services of 4003 and 4776 and an annual water requirement of 2295 ML and 2738 ML in 2025 for each growth scenario respectively. Refer to Figure 7.45 and Figure 7.46.

Figure 7.45: Population Projections - All Towns Basin 613

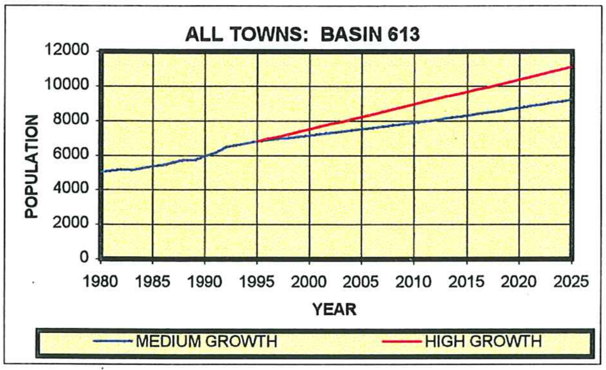
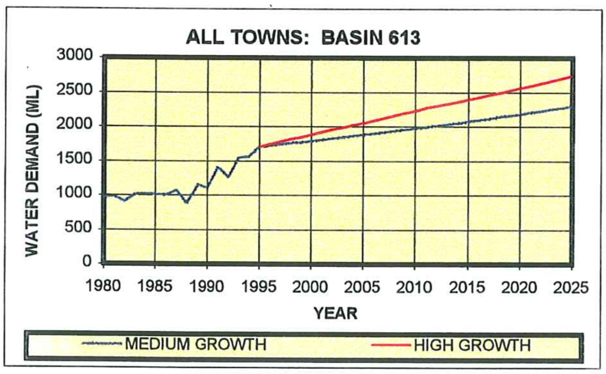


Figure 7.46: Water Demand Projections - All Towns Basin 613



7.5 All Towns: Basin 611, 612 & 613

There are currently 23 812 services supplied in all the basins. Of these services 21 123 are residential. The average annual demand per service is 555 kL. During the 1994/5 financial year the residential and industrial/ commercial consumptions were 7806 ML and 2872 ML respectively. The mean population growth projections based on the two growth scenarios are 1.1% and 1.8%. This will result in total services of 35 932 and 47 960 and an annual water requirement of 29 535 ML and 36 250 ML in 2025 for each growth scenario respectively.

Figure 7.47: Population Projections - All Towns Basins 611, 612 & 613

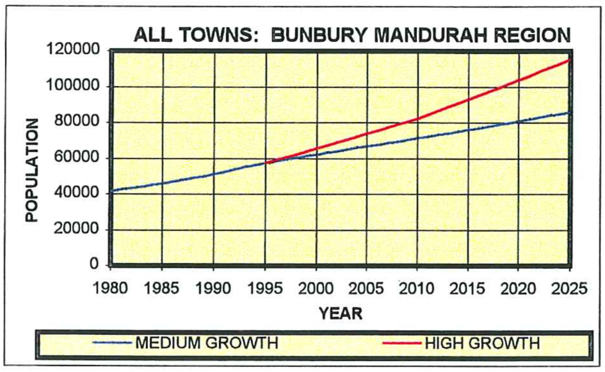
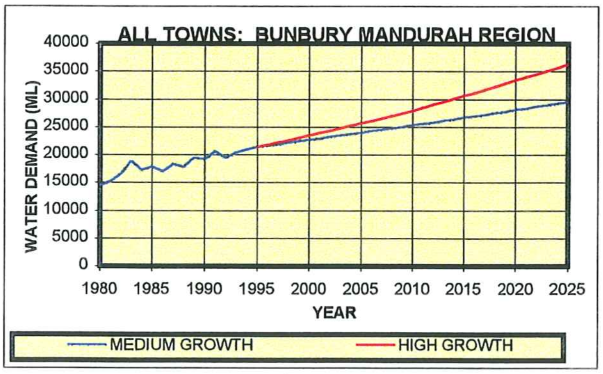


Figure 7.48: Water Demand Projections - All Towns Basins 611, 612 & 613



7.6 Delivery/Person and Average Delivery/Service Derived Projections

The estimated growth in water requirements described in the above section were based on population projections. Water delivery for each subsequent year was predicted from the ratio of water delivered/population for the previous year. An alternative scenario is to derive water requirements based on the average water delivery per service. This was completed as part of the study. However, the figures based on delivery/person were chosen to represent the expected water requirements, since in most cases, these represented a maximum future water requirement and the figures based on delivery/service were derived from taking an average over both the historical record and the planning period (see Table 7.1).

BASIN 611					
TOWN	Delivery 1995 (ML)	Scenario 1 (based on delivery/person) (ML)		Scenario 2 (based on average delivery/service) (ML)	
		medium	high	medium	high
Boyanup	287	401	492	523	643
Bunbury	6172	10186	14400	8641	12216
Dardanup	65	83	88	88	99
Donnybrook	331	548	694	518	656

BASIN 612					
TOWN	Delivery 1995 (ML)	Scenario 1 (based on delivery/person) (ML)		Scenario 2 (based on average delivery/service) (ML)	
		medium	high	medium	high
Allanson	90	128	128	128	128
Australind	1131	2375	3651	2488	3825
Binningup	115	410	545	356	474
Brunswick Junction	385	588	781	698	926
Burekup	61	85	119	76	107
Collie	1422	1448	1634	1617	1825
Eaton	768	1307	1350	1327	1371
Roelands	33	34	39	39	45

BASIN 613					
TOWN	Delivery 1995 (ML)	Scenario 1 (based on delivery/person) (ML)		Scenario 2 (based on average delivery/service) (ML)	
		medium	high	medium	high
Harmel	17	18	20	18	20
Harvey	696	567	746	750	987
Myalup	37	36	66	50	91
Preston Beach	71	120	126	93	98
Park Ridge	91	198	230	123	143
Waroona	463	741	858	838	970
Wokalup	20	15	15	22	23
Yarloop/Wagerup	288	246	249	401	407

Table 7.1: Delivery/Person and Average Delivery/Service Based Projections for 2025

8. Industrial Development and Growth Potential

8.1 General

All recent studies, including the South West Strategy (SWDC, 1994) and the Bunbury - Wellington Plan (WAPC, 1995), acknowledge that the future industrial development of the region is of prime importance.

Much of the regions industry is focused upon the extraction and processing of primary resources, particularly minerals, timber and agricultural produce. These industries also contribute directly to activity in the construction sector and both directly and indirectly to various light and service industries.

The need for greater downstream processing of raw materials to add value to Australian exports and to help replace imports is now widely accepted. In addition, it is State Government policy to foster major industrial development in regional areas rather than creating further major industries close to Perth.

Existing major industries in the region include:

- alumina refineries at Wagerup and Worsley;
- coal - fired power stations at Collie (Muja) and Bunbury;
- sawmill, particle board plant and resin factory at Moore Road, Dardanup;
- superphosphate fertiliser plant at Picton;
- titanium dioxide pigment plant at Kemerton (plus finishing plant at Australind);
- silicon smelter at Kemerton;
- mineral sands separation at Picton and Boyanup;
- several abattoirs, the largest being near Harvey; and
- dairy goods factories at Brunswick and Boyanup.
- Many of these industries are located in existing industrial zones in various parts of the region. Some timber mills and mineral sands operations have 'stand alone' locations due to proximity of raw materials, timber and agricultural resources.

This region has a number of advantages that create opportunities for future major industrial development. These include:

- a wide variety of primary resources including extensive mineral deposits, construction materials, timber and agricultural resources;
- well developed infrastructure including a major port, railways, roads, electricity, gas, and significant water resources;
- an established role in the 'industrial heartland', of the state between Perth and Bunbury, where there is a concentration of mining, processing, infrastructure and other industry;
- available skilled work force;
- a range of existing core industries;
- significant zoned industrial land and well planned industrial estates (such as Kemerton);
- community involvement in industries, not just through employment but liaison and consultation, such as the Kemerton Community Committee.

Bearing in mind these advantages, opportunities for major industrial development in the region fall into four broad categories. These are:

- expansion of existing industry;
- further processing of available materials (processing to a more finished stage);
- upstream processing (provision of inputs to existing or potential industries); and
- new industries utilising new raw materials or processes.

The following factors will influence future industrial development:

- The industrial component of the region is likely to expand and become more complex during the next 20 years, this is likely to occur mainly through progressive growth in existing major industries, with a gradual shift to further downstream processing in the mineral sands, agriculture and aluminium smelting) industries. Technology parks, which focus on research and development into these processes, assist in this area.
- Due to the relatively moderate scale of existing development, there is potential for a single major new industry to have a large impact on the pace of development in the region.
- General and heavy industry is likely to be export - oriented and hence centred strongly on the Kemerton, Preston and Bunbury Port industrial areas.
- Local light, general and service industries are expected to continue their current steady growth, driven by population and heavy industrial development.

8.2 Industrial Water Supply Projections

Apart from the considerations above, and after consultation with the Department of Resources and Development, direct contact was made with most industries in order to get an appreciation of their medium to long term growth and water demands. This has been referred to as the 'medium growth' and is used to demonstrate the likely water demands in the respective areas.

Current water demands and future water demand projections of medium to large industries are presented in Table A7. 1, Table A7. 2 and Table A7. 3. The total demand projections of industries within each catchment and within the region as a whole are presented graphically below.

Note: Industries are grouped according to the industrial area in which they are situated. This in turn is related to the groundwater subarea from which the water is directly abstracted. In some areas most water is provided by the relevant town water scheme. In these instances the industrial area is still related to the groundwater subarea in which it is situated, providing a subarea has been identified.

8.3 Industries In The Preston River Basin (611)

8.3.1 Boyanup

Boyanup is geographically central to many of the mineral sands operations and to much of the dairy pastures land in the Bunbury region. It is therefore an attractive locality for development of related industries.

The main industry located in the area is:
Masters Dairy Boyanup, the main dairy centre for the Masters operation and produces milk, butter and milk powders. There are currently no plans for expansion.

8.3.2 Dardanup (Including Preston & Waterloo Industrial Parks)

Preston Industrial Park is an amalgamation of Picton, Moore Road and East Davenport industrial areas. Together with the adjacent Waterloo industrial area there is the potential to expand the total area by 5000 hectares. The area has the potential to accommodate medium-scale, general and heavy industry requiring good transport infrastructure and ready access to the port, but is constrained in its suitability for heavy industry by the proximity of residential areas at Eaton and Glen Iris, and special rural zones proposed to the north-east and south-east.

The main industries located in the area are:

- Bennet Clunning, a company which specialises in the cleaning of edible animal products. At present there are no expansion plans, but ultimately production could increase by 25%.
- Brookes Transport, a trucking company.
- Dyno Industries, which manufactures resin for use in the manufacture of particle board by Wesfi Industries. A steady growth in the industry is expected over the next 3 - 5 years.
- ISK Minerals, which was a major industry in the area, but ceased operation in 1993. The company still abstracts water for maintenance purposes. It is unknown when operations will re-commence.
- Koppers Timber Preservation, which treats timber using various procedures. Production is expected to increase at a rate of 10% per year.
- Midland Brick Company, which has a long established brickworks in the area and uses water in the production process.
- Westpine Industries, a sawmill, processing 200 000 cubic metres of logs per annum at present. This will increase to 400 000 cubic metres by the turn of the century. Logs are converted to milled boards for the building and allied industries and are sold intra and inter state as well as overseas.
- Westralian Forest Industries which operates a pine chipping mill and uses resin from Dyno Industries combined with the pine chips to manufacture particle board. WFI produces 160 000 cubic metres of particle board per year and uses water for resin mixing, cleaning and moisture control on stockpiles.
- Westralian Sands which operates the Yoganup Mine in the Boyanup - Elgin area. This mine is expected to operate for at least six years after which operations will be located to South Capel. The separation of minerals from concentrated ore occurs at the North Capel Processing plant. In addition, synthetic rutile is manufactured.

8.3.3 East Bunbury (Including Bunbury Port Area)

The existing berthing facilities at the port consist of two Outer Harbour breakwater berths and three Inner Harbour berths. The outer berths are used for grain and mineral sands exports and have rail and road access. The Inner Harbour comprises 567 hectares of land and currently has three berths, while there is potential for expansion to allow for at least eight more berths. The Port of Bunbury has the potential to expand south-east approximately 1000 metres from its existing eastern extremity. A large casting basin facility on a 17 ha site to facilitate the construction of concrete off-shore rigs has recently been completed in the Inner Harbour.

The main industries located in the area are:

- Alcoa, which currently exports processed alumina from the Port of Bunbury. Their major water use is in refilling ship fresh water storage, their caustic soda operation and the washing down of berths, hoppers etc. Alcoa will expand their port operation to accommodate the expected increased output resulting from future refinery expansions. Water is supplied via the Port Authority.
- BFP Chip Operations which is situated within the port area exports wood chips delivered from inland chipping operations. Their main water use is moisture control in stockpiles, the washing down of berths, conveyors etc. And for domestic use. Water is supplied via the Port Authority.
- Bunbury Port Authority which controls and maintains the Port of Bunbury and the infrastructure within the port, including a land mass of approximately 380 ha. Within the port there are 5 operating berths through which 275 vessels per year carry an estimated total trade of 8 million tonnes. Main cargoes are alumina, caustic soda, mineral sands and woodchips. The Authority supplies water to land tenants.
- Cable Sands, which exports mineral sands. The Bunbury operation situated within the port area separates various minerals from concentrated ore delivered from various mine sites.
- Geographe Enterprises, a manufacturer of parts for heavy equipment. The major water use being for cooling of castings, machinery and general steel processing. Operations are expected to increase by 20% in the long term.
- Dardanup Butchering Company, which operates an abattoir that processes 110 000 animals per year and uses water for cleaning and manufacture of small goods. The abattoir is currently operating at capacity. A 50% expansion programme is anticipated within the next five years. Water is supplied from a private bore.
- Readymix: Denning Road, a premix concrete plant which produces 25 000 cubic metres of concrete per year. Water is supplied via the TWS.
- Pioneer: Denning Road, a premix concrete plant which produces 15 000 cubic metres of concrete per year. Water is supplied via the TWS.
- Malatesta, a trucking and road paving firm primarily involved in transport of mineral sands. Malatesta expects a 16% per annum growth rate in the foreseeable future. The main water use is in cleaning equipment and vehicles.
- Handicrete, a premix concrete and precast concrete manufacturer and produces 7000 cubic metres of concrete per year. There are currently no plans for relocation or expansion. Water is supplied via the TWS.
- Meadow Lea, which processes vegetable oils and related products at a rate of 30 000 tonnes per annum. There are currently no plans for expansion or relocation. Water is supplied from a private bore.
- V&V Walsh Bunbury (Derby Industries/Globe Meats), a major abattoir which processes 450 000 animals per year. The current expansion programme will increase cattle processing from 75 000 a year to 1 000 000 a year by the year 2000. Total processing will approach 500 000 animals a year. Water is supplied from a private bore.

8.3.4 Stratham/Gelorup

The main industry located in the area is:

- Bunbury Steam Laundry, which washes 286 000 kg of laundry per year. There are currently no plans for relocation and expansion.

8.3.5 Donnybrook

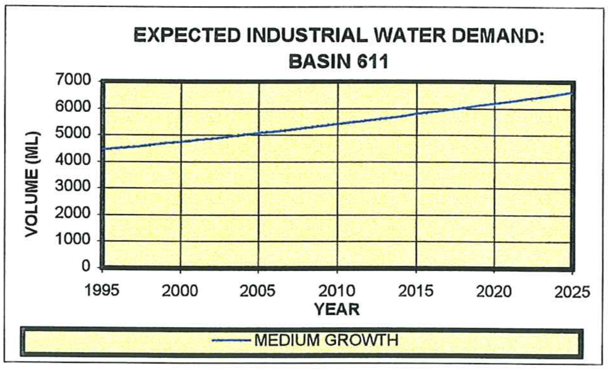
The main industry located in the area is:

- Readymix: Sandhill Street, a premix concrete plant which produces 15 000 cubic metres of concrete per year. Water is supplied via the TWS.

8.3.6 All Industries: Basin 611

The current industrial water demand in Basin 611 is 4493 ML. During the 1994/5 financial year the industrial consumption from town water schemes, private bores and surface water impoundments were 220 ML, 4220 ML and 0 ML respectively. These are expected to grow to 334 ML, 6272 ML and 0 ML by the year 2025 respectively. This relates to a constant growth in demand of 1.3 % per year (see Figure 8.1). It should be noted that the total annual commercial/industrial demand from the town water schemes as presented in the towns section is 2021 ML. This includes commercial users which are not accounted for in the industries section.

Figure 8.1: Industrial Water Demand Projections For Basin 611



8.4 Industries In The Collie River Basin (612)

8.4.1 Australind (Including Kemerton Industrial Park)

Kemerton Industrial Park is in the locality of Wellesley, Harvey Shire, 17 kilometres north of Bunbury. There are 1 056 hectares available in the core area for major industry and approximately 300 hectares for a separate support industry area. Two hundred hectares are presently occupied by industry.

The main industries located in the area are:

- Simcoa Operations, a silicon smelter, and associated charcoal plant. The plant produces 30 000 t/a premium grade silicon metal. A study is currently being carried out to determine the feasibility of increasing the output of the plant.
- SCM Chemicals Australind. This finishing plant will remain in Australind until the end of their lease in 2031. No water is used in the finishing process and no effluent is generated. When the SCM plant ultimately relocates, it is anticipated that no new industry will develop at this site.
- SCM Chemicals Kemerton constructed a 79 000 t/a titanium dioxide pigment plant in 1991. Raw material for the plant is titanium - rich ore obtained from Western Australian producers. A chlor - alkali plant situated adjacent manufactures chlorine. Oxygen and nitrogen is also manufactured on site. It has been proposed to expand the titanium dioxide plant to produce 150 000 t/a.
- Nufarm - Coogee, a chlor - alkali plant located adjacent to the titanium dioxide plant, manufactures approximately 50 tonnes per day of chlorine for the titanium dioxide pigment plant. Salt is the raw material. Approximately 60 tonnes per day of caustic soda is co-produced, plus smaller quantities of hydrochloric acid and sodium hypochlorite.
- CIG, an air separation plant that supplies oxygen and nitrogen to the titanium dioxide pigment plant.
- Cockburn, a manufacturer of slaked lime for supply to the titanium pigment plant.
- Goodchilds Abattoir processes approximately 170 000 animals per year. These are mostly sheep and cattle.
- Australian Natural Pork Pty Ltd is a 200 sow unit comprising approximately 2000 pigs in total. Pigs are sent to the Waroona Abattoir.

Potential new industries:

Apart from expansion to existing industries at Kemerton, the most likely new industries to the area would be undertaken by:

- Gwalia Consolidated and Itochu Corporation, who have commenced construction on a dry mining and dredge mining project to produce 400 000 t/a of silica sand for export. This is expected to ultimately increase to 1 Mt/a.
- Wesfarmers Bunnings, who recently undertook a feasibility study for an integrated pulp and paper mill development. Kemerton was one of a number of potential sites in the South West that was considered. Kemerton has a good chance of being selected as the optimal site, though this scheme is likely to be shelved for at least 5 years.

8.4.2 Brunswick Junction

There is no associated groundwater area for Brunswick Junction. Industry obtains water from the town water scheme.

The main industry located in the area is:

- Peters Creameries, a dairy manufacturing dairy products.

No new industry is expected to establish at Brunswick Junction.

8.4.3 Collie (Including mines and power stations)

Heavy industrial development around Collie is coal mining and power generation. Light and general industrial activity is based mainly around servicing the coal mining and power generation activities. The principal industrial estate is located on the north-western fringe of the town. It is intended that this area not be expanded. Future industrial development is likely to occur in the proposed new industrial areas. These are:

Coolangatta (Collie Industrial Park) is located 6.5 km north-east of the Collie townsite and is a site of approximately 330 hectares. It lies within the property which forms the core of the Western Power land holding on which Collie Power Station is sited. Potential for the development of the site is linked with the construction of the new power station and related service industry.

Worsley Siding is located approximately 16 km north-west of Collie and is adjacent to the operations of Worsley Alumina. The Worsley Siding area may be attractive for industry processing material associated with the production of alumina.

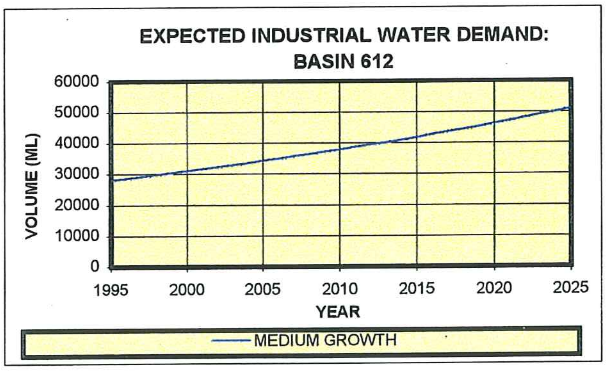
The main industries located in the Collie Area are:

- Bunnings Forest Products, a timber mill.
- Worsley Alumina produces 1.75 Mt/a of alumina. Planning is currently under way to double production to 3.5 Mt/a.
- Muja Power Station operated and owned by Western Power.
- Collie Power Station, a 300 MW coal-fired power station presently under construction, to be operated and owned by Western Power.
- Premier Mine operated by Western Collieries.
- Muja Open Cut Coal Mine operated by Griffin Coal Mining Company.
- Chicken Creek Mine operated by Griffin Coal Mining Company.
- Ewington II Mine operated by Griffin Coal Mining Company.

8.4.4 All Industries: Basin 612

The current industrial water demand in Basin 612 is 27 977 ML. During the 1994/5 financial year the industrial consumption from town water schemes, private bores and surface water impoundments were 174 ML, 25 303 ML and 2500 ML respectively. These are expected to grow to 179 ML, 28 625 ML and 22 235 ML by the year 2025 respectively. This relates to a constant growth in demand of 2.0 % per year (see Figure 8.2). It should be noted that the total annual commercial/industrial demand from the town water schemes as presented in the towns section is 580 ML. This includes commercial users which are not accounted for in the industries section.

Figure 8.2: Industrial Water Demand Projections For Basin 612



8.5 Industries In The Harvey River Basin (613)

8.5.1 Coolup (Including Harvey and Waroona Industries)

The main industries located in the area are:

- Cable Sands, a mineral sands mine.
- E.G. Green and Sons Abattoir processes in excess of 150 000 animals per year, predominantly sheep and cattle. The potential exists for the establishment of a biotechnology industry to produce blood plasma.
- Harvey Fresh, a fruit juice company.

8.5.2 Yarloop/Wagerup

The main industries located in the area are:

- Alcoa is undertaking a feasibility study to increase production at their Wagerup Refinery from 2.2 Mt/a to 3.3 Mt/a.
- Bunnings Forest Products, a timber mill.

8.5.3 All Industries: Basin 613

The current industrial water demand in Basin 613 is 1404 ML. During the 1994/5 financial year the industrial consumption from town water schemes, private bores and surface water impoundments were 28 ML, 410 ML and 966 ML respectively. These are expected to grow to 33 ML, 814 ML and 1026 ML by the year 2025 respectively. This relates to a constant growth in demand of 1.0 % per year (see Figure 8.3). It should be noted that the total annual commercial/industrial demand from the town water schemes as presented in the towns section is 269 ML. This includes commercial users which are not accounted for in the industries section.

Figure 8.3: Industrial Water Demand Projections For Basin 613

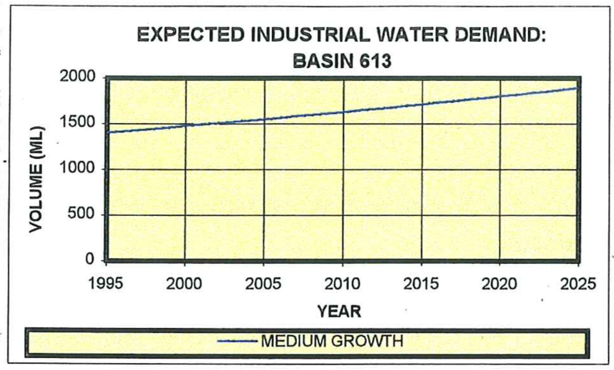
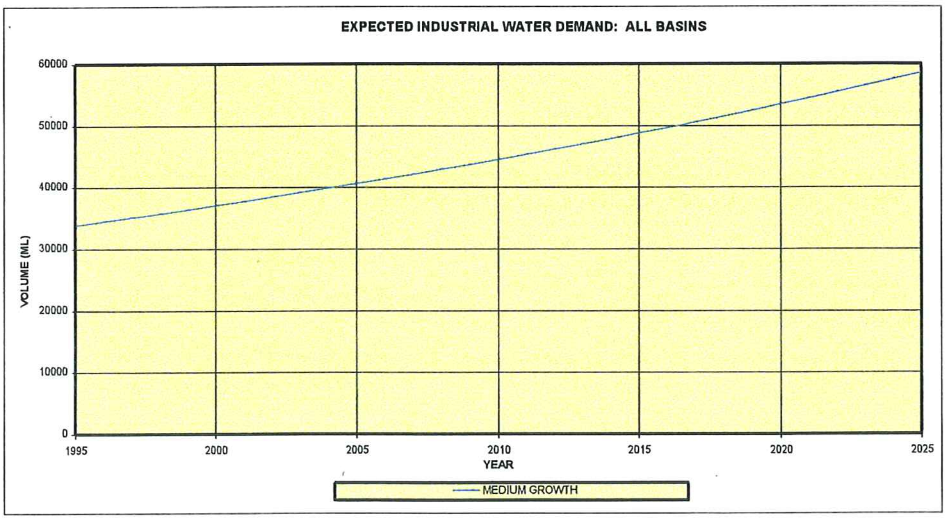


Figure 8.4: Industrial Water Demand Projections For All Basins



9. Agriculture Development and Growth Potential

9.1 General

The rural (primary) industries have historically been the mainstay of the regional economy and agriculture has significance to the future of the region.

The region contributes significantly to the State's agricultural production. It:

- is accessible to Perth and regional markets;
- has a large concentration of dairy farms close to processing facilities;
- has a well developed horticulture industry with substantial supporting infrastructure and opportunities for expansion; and
- has scope for additional processing of local agricultural products.

The relationship between agriculture, the natural environment and other land uses in the region are changing and values placed on agriculture and its location are being redefined.

Infrastructure in the irrigation districts is deteriorating and will be costly to restore or modify. Some of the land in the irrigation districts is somewhat salt affected.

The processing of agricultural products within the region has particular development potential. Effluent disposal from these industries is a vital issue. In particular, dairying and horticulture/hydroponics are industries which already contribute significantly to the region but also have potential for further development.

Agricultural areas cannot be easily grouped into specific drainage basins as in many cases they continue across divides. In order to group agricultural water use within specific drainage basins, a table, (see Appendix A 9) has been prepared. This contains the current allocations to the various water users including agricultural water users. Groundwater sub-areas are grouped within the surface water catchment basins which overlay them. No attempt has been made to project these agricultural allocations.

Past and current water demands and future water demand projections relating to various agricultural areas are presented graphically in Figure 9.2, Figure 9.3 and Figure 9.4.

9.2 Non - irrigated Agriculture

The Swan Coastal Plain is under pressure from the expansion of Greater Bunbury. Many parts of the plain, particularly some areas to the north and south of Bunbury, are of marginal agricultural value and have been included in the Greater Bunbury urban area. The remainder, with the exception of irrigation districts, towns and coastal districts, will continue to be used for dryland grazing (dairy, meat and wool) and some cropping, although there are some parts of the plain which are highly suitable for orchards, vineyards and market gardens.

Similar areas for grazing and cropping exist on the Darling Plateau, such as Preston and Ferguson River Valley, which cut through the plateau. The Preston River Valley is particularly valuable for all agricultural activities, including orchards and vineyards, and the future of these activities is likely to be constrained by impacts on the river system. Other areas in the Darling Plateau , east of Yarloop, Harvey and Brunswick Junction, and north and east of Collie will also remain predominantly for grazing.

9.3 Irrigated Agriculture

There are five rural districts under irrigation in the region. These are the Collie, Harvey, Waroona (South West Irrigation Area) and Preston Irrigation Districts and the coastal wetlands area east of Lake Preston on the Swan Coastal Plain (refer to Figure 9.1).

- The Lake Preston area supports successful market gardens. These uses are constrained by the availability of groundwater and the pollution of the groundwater.

- The Preston Irrigation District supports a stone fruit industry on the undulating slopes of the Preston Valley. Water is supplied from a combination of releases from the Glen Mervyn Dam in the upper reaches of the Preston River Valley, and from shallow groundwaters in the lower part of the valley west of the Darling Fault.

- The South West Irrigation area supports a major dairying and beef industry, with some horticulture on the heavier soils on the eastern side of the coastal plain. The area is watered from three sets of surface water storage's in the Darling Range. The Waroona, Drakes Brook and Samson Reservoirs, in the Harvey River Basin (613), supply the Waroona District. The Logue Brook, Stirling and Harvey Reservoirs, also in the Harvey River Basin, supply the Harvey District. The Wellington Reservoir and Collie River Diversion Weir, in the Collie River Basin (612), supply the Collie Irrigation District.

9.3.1 South West Irrigation Area

The South West Irrigation Area is located within all three basins presented in this study (refer to Figure 9.1).

A major review of the future direction of the South West Irrigation Service was recently carried out (SWIRT, 1994). An independent agency of irrigation farmers is to be established, as a cooperative, to manage the distribution of irrigation water in the combined South West Irrigation Area. The Water Corporation will supply bulk water to the irrigation cooperative. The Water and Rivers Commission will licence the Water Corporation to divert the water resource and licence the cooperative to use this water for irrigation purposes. This restructuring is aimed at:

- directly involving irrigators in the management of the irrigation service;
- making the costs of the irrigation service clearly transparent;
- promoting increasing financial viability over time by:
  - reducing operating and maintenance costs;
  - increasing revenue;
  - improving planning for the refurbishment of assets.
- promoting more efficient use of water through:
  - enabling the transferability of water allocations between farmers and between the irrigation sector and other sectors of the water industry (by means of a Transferable Water Entitlement (TWE) system);
  - reducing subsidies in the water charges.

Increased pressures are also developing to reduce nutrient export from the irrigation districts. Reduced pasture yields, due to high soil salinity, occurs within all three districts particularly in their western areas. While the salinity of supply to the Collie District (from Wellington Reservoir) is of marginal quality, the major cause of the salinity problem is the naturally saline soils and high water tables. Further reductions in pasture production are unlikely in the central and eastern areas of the Harvey and Waroona Districts. Without improvements in on - farm irrigation practices further productivity losses could occur in the central and eastern portions of the Collie District.

In the medium to longer term the changes in administrative and financial arrangements and environmental influences are likely to:

- reduce the area watered in the western areas of the district;
- promote a change to higher valued crops (horticulture) where soils are suitable;
- reduce the amount of water used per unit area irrigated.

The potential for trade in water between farmers and between irrigators and other users is high. The degree to which this occurs will depend on the future irrigation water charges and the degree of competition for water which develops. Inter - sectoral transfer could exceed 30 GL during the next 20 years.

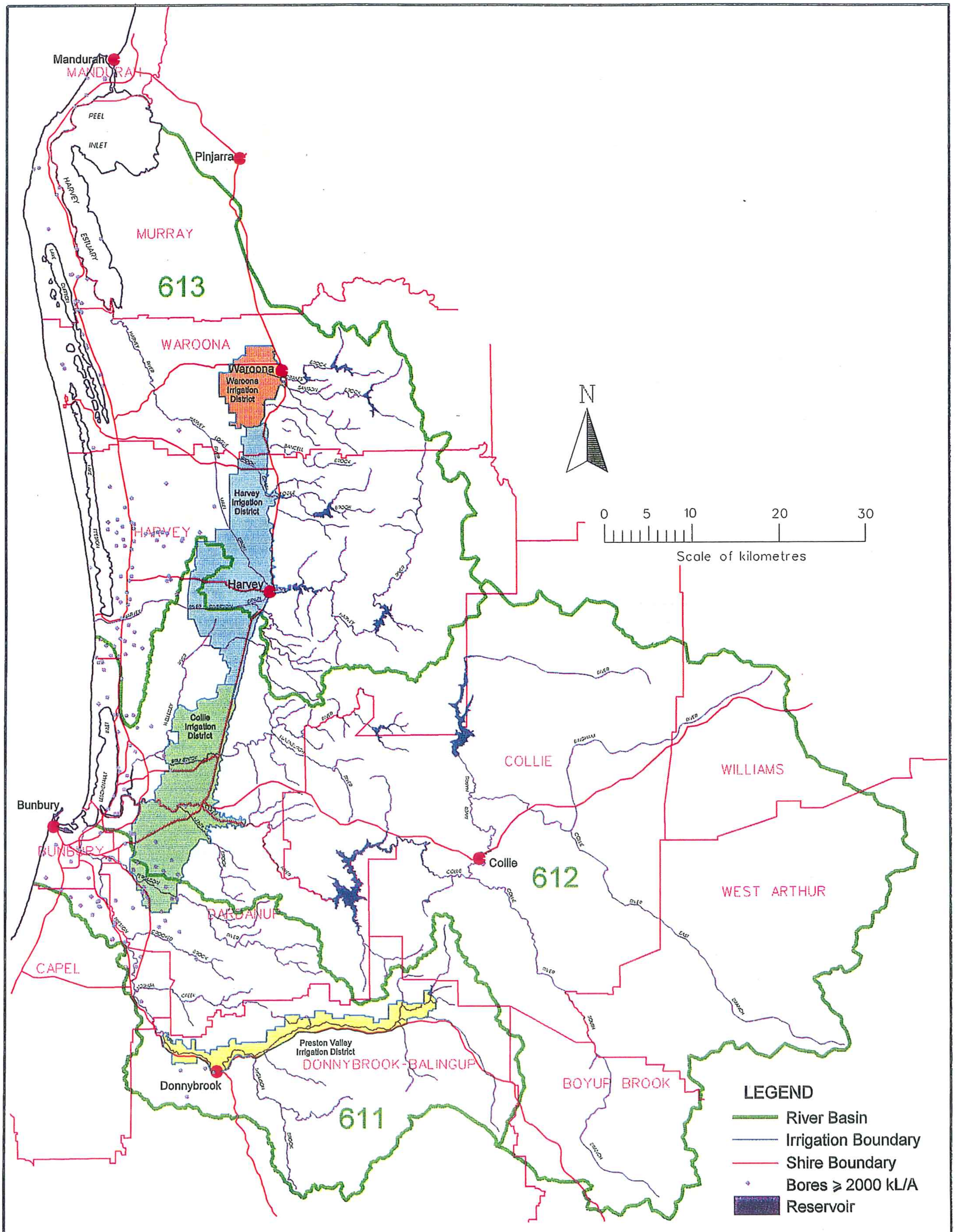
The total area of the South West Irrigation Area is divided into the three basins in the following proportions: Preston River Basin (611) - 5%; Collie River Basin (612) - 53% and the Harvey River Basin (613) - 42%. Water demand projections have been undertaken for each district and then combined for the whole scheme. The Harvey and Waroona Districts abstract their water from the Harvey River Basin (613) and the Collie District abstracts water from the Collie River Basin (612). Where a figure is quoted for a specific basin the above combinations are adhered to. This also applies to private surface water and groundwater abstractions within the area. Refer to Figure 9.2.

9.3.2 Preston Valley Irrigation Area

The Preston Valley Irrigation Area is located within Basin 611 (refer to Figure 9.1). Since it is managed as a single system, the water demand projection has been undertaken for the whole scheme. This also applies to private surface water abstractions within the area. Refer to Figure 9.3.

9.3.3 Shire of Donnybrook - Balingup

In the Donnybrook area, there is local competition for groundwater resources between the Water Corporation and the local horticultural district. For this reason, the groundwater used for agriculture within the Shire of Donnybrook - Balingup has been included in the water



Bunbury-Mandurah Region Water Resources Review
IRRIGATION DISTRICTS

Figure 9.1

Figure 9.2: South West Irrigation District Projections

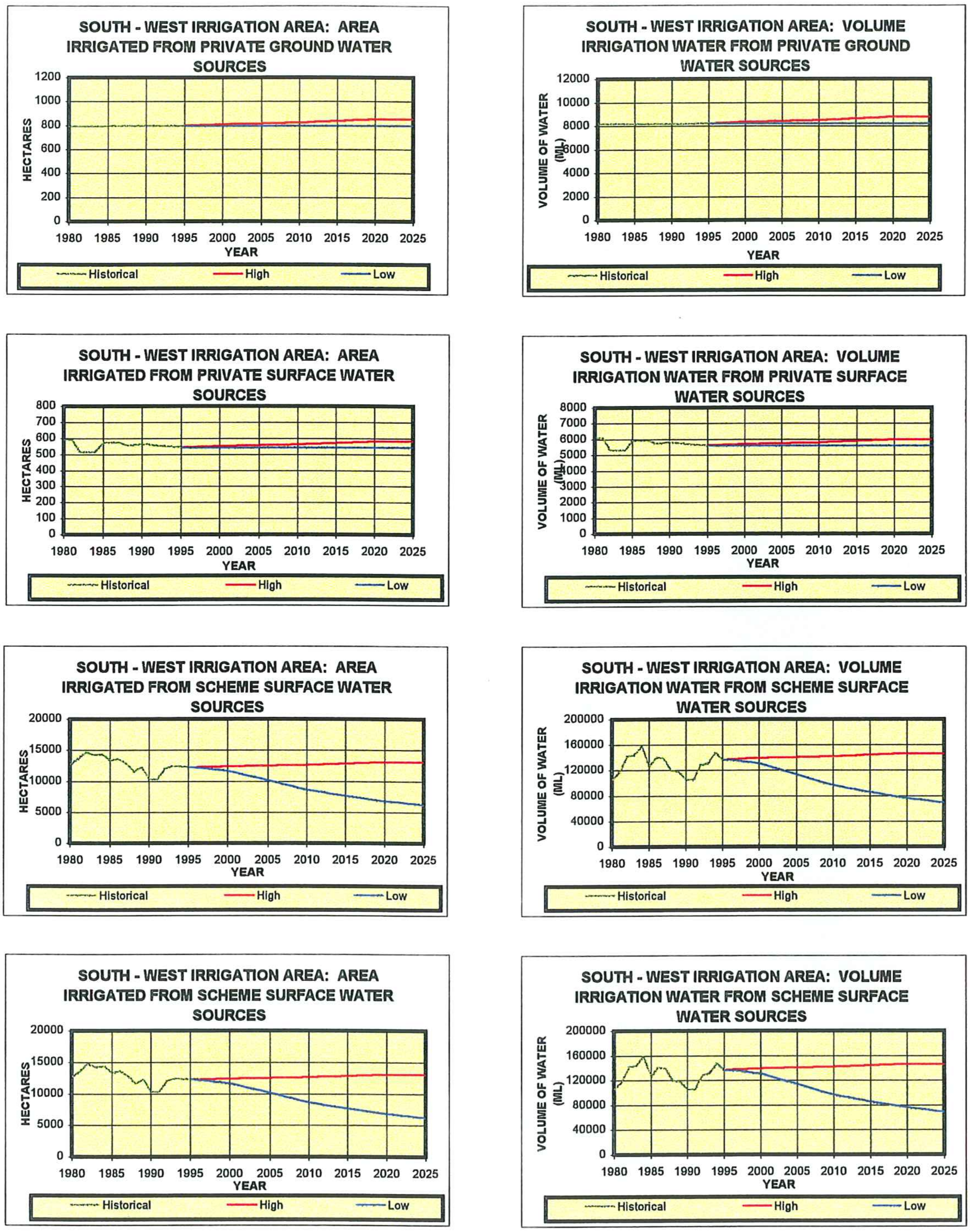
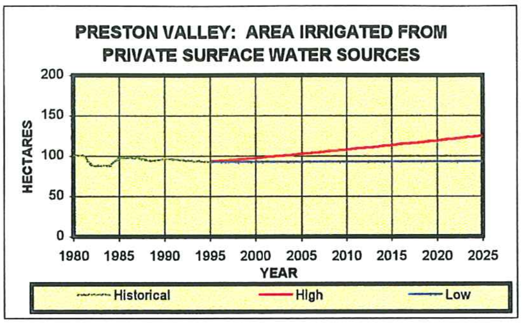
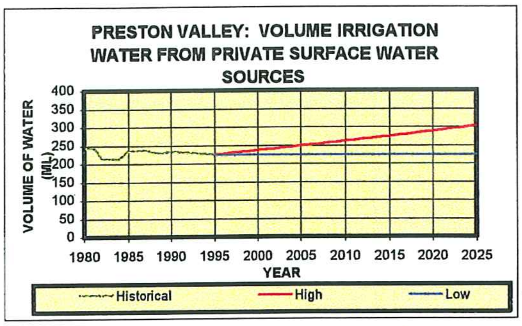
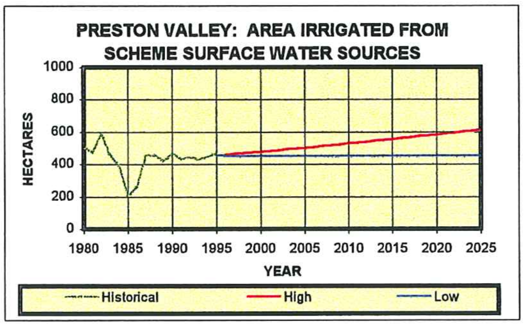
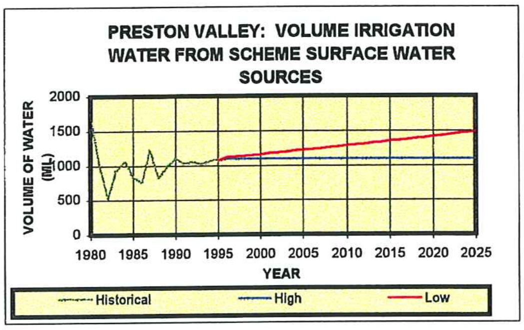


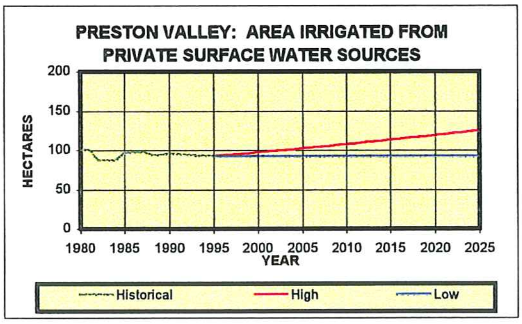
Figure 9.3: Preston Irrigation District Projections











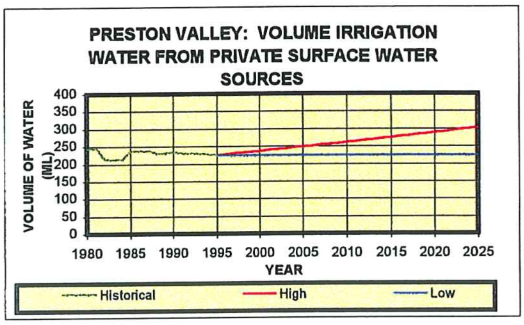
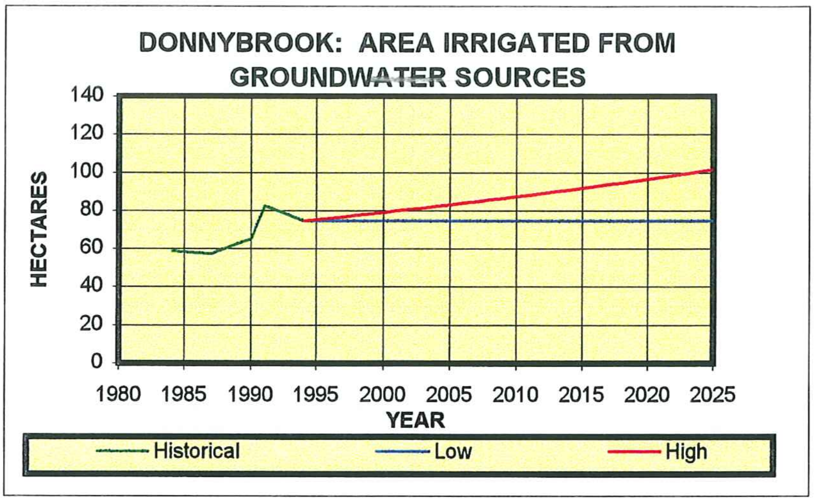
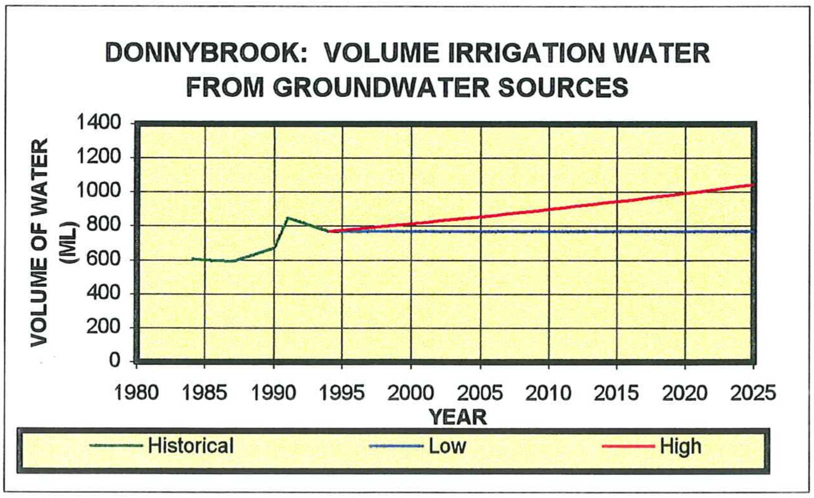


Figure 9.4: Shire of Donnybrook - Balingup Projections





demand projections. Approximately 45% of the Shire of Donnybrook - Balingup falls within the study area and the projected water demands have been adjusted accordingly. Refer to Figure 9.4.

9.4 Horticulture

Groundwater availability information and land capability in terms of potential use for horticulture has been collated by the Department of Agriculture, Western Australia. This information is mapped and currently in draft form and has been used in this study to identify the horticultural potential in each groundwater area in the study area.

The study region is divided into groundwater subareas in which land capability, in terms of the potential for horticultural use and groundwater resources, are identified. Land capability for horticultural use is divided into 3 general categories, which include areas covered by remnant vegetation. Category 1 land is well suited to most horticultural uses. Category 2 land will restrict some horticultural uses, particularly (but not exclusively) market gardens. Category 3 land is not recommended for standard horticultural activities. For land use planning, the most versatile land is generally the most valuable and good planning and management would make most category 1 and 2 land suitable for horticulture.

The water resource figures generally refer to fresh water from superficial aquifers that are suitable for horticultural use. However, it is not possible to account for local variations in water supply, quality or depth. The water resource available is described in terms of the area of land that could be used for the cultivation of either wine grapes or market gardens. Estimates of the total area of wine grapes and markets gardens which could be planted, given the available water resources, are based on the assumption that wine grapes require 4 ML/year/ha and market gardens require 15 ML/year/ha. This water availability is the total unallocated groundwater source in each groundwater area subarea.

The horticultural potential of the Bunbury - Mandurah Region is summarised in Table 9.1 and Figure 9.5.

9.4.1 South West Coastal Groundwater Area

Superficial groundwater resources are available in all subareas except Falcon, Coastal, Island Point and White Hill. These subareas have land which is mostly suitable for only some types of horticulture (category 2). The Harvey subarea contains the second largest superficial groundwater resource, but most of the land in the area is category 2 or category 3 (see Table 9.1 and Figure 9.5). The Myalup and Lake Preston subareas have the greatest amount of category 1 land and also have relatively large superficial groundwater resources. These areas have the greatest potential for horticultural development in the South West Coastal Groundwater Area, although the amount of land supported by the superficial groundwater resource for horticultural activities in the subareas is greater than the amount of category 1 land available for use. This is the case for all other subareas in the South West Groundwater Area. There is enough category 2 land in each subarea to support horticultural activities, given the available superficial groundwater resource, although this land is only suitable for some types of horticultural activities and may restrict some uses. The quality of the land is, therefore, the limiting factor for horticultural development in this groundwater area.

Horticultural potential in the South West Coastal Groundwater Area is marginal, based on the quality of land available.

9.4.2 Murray Groundwater Area

The Coolup and Waroona subareas of the Murray Groundwater Area are contained within the study region. These subareas have relatively large superficial groundwater resources (Coolup has the largest superficial groundwater resource), although the land within the subarea is mainly category 3. In both subareas, only about 6% of the subareas have land of category 1 capability and about 20% of the subareas have land of category 2 capability (see Table 9.1 and Figure 9.5).

The potential horticulture of wine grapes, in both subareas, is limited by the amount of good quality, category 1 land. There is enough category 2 land in each subarea to support horticultural activities, given the available superficial groundwater resource, although this land is only suitable for some types of horticultural activities and may restrict some uses. The quality of the land is, therefore, the limiting factor for horticultural development in this groundwater area.

Horticultural potential in the Murray Groundwater Area is marginal, based on the quality of land available.

9.4.3 Bunbury Groundwater Area

The Bunbury Groundwater Area contains limited superficial groundwater resources and has relatively small areas of category 1 land compared to the amount of category 2 and category 3 land in each subarea (see Table 9.1 and Figure 9.5). Given the lack of superficial groundwater resources in the groundwater area, and the small amounts of category 1 land, the limiting factors for horticultural development in this groundwater area are both limited superficial groundwater resources and poor land quality.

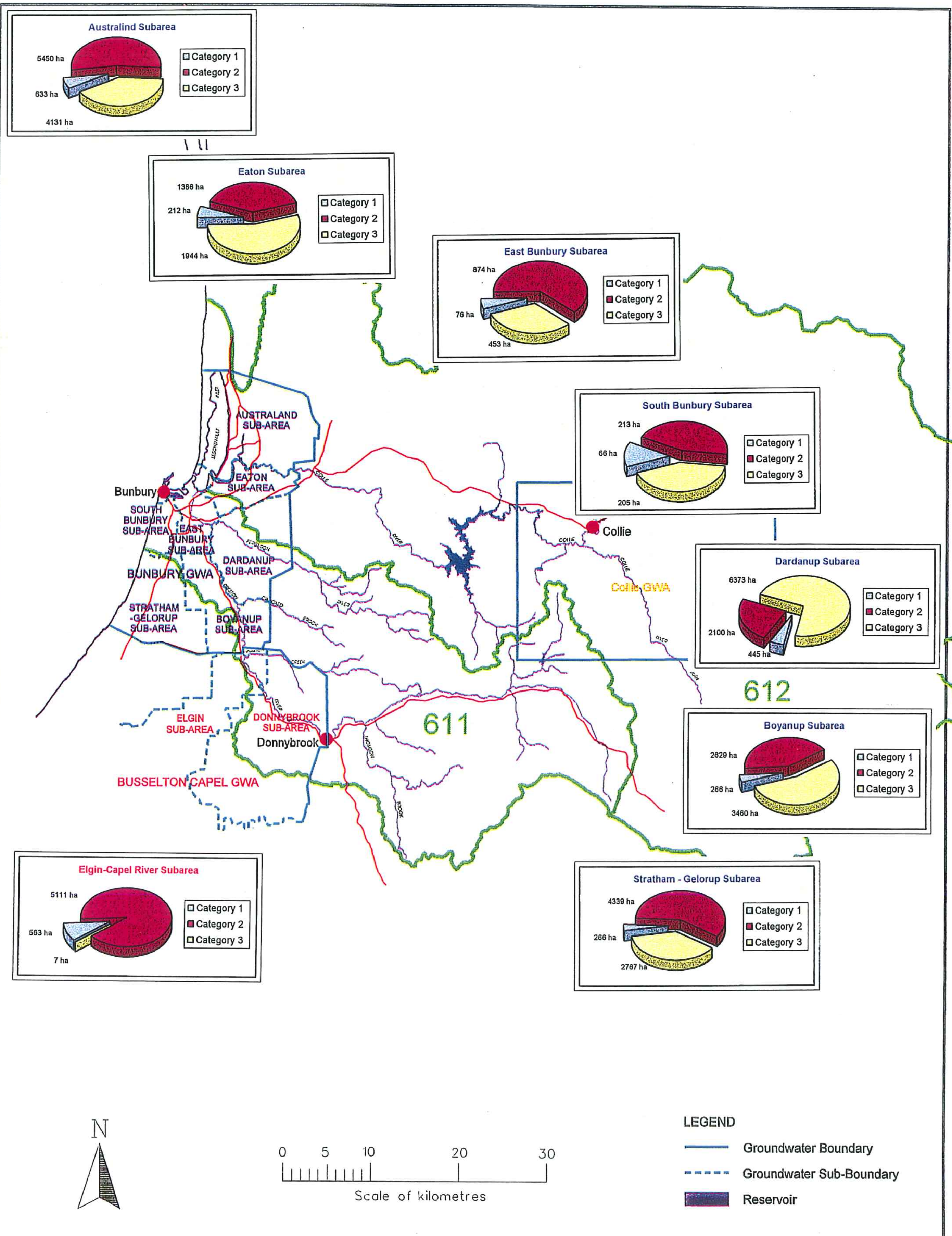
If water resources were obtained from surface water sources or scheme supplies, the potential for horticultural activities in the groundwater area may be increased, but this will depend on the amount of water that could be obtained to support horticultural activities relative to the amount of suitable land available for horticultural activities. Considering only the available superficial groundwater resources, this groundwater area is not suitable for horticultural development.

Horticultural development in the Bunbury Groundwater Area is minimal as appropriate land is not available and local water is also not available.

9.4.4 Busselton - Capel Groundwater Area

The Donnybrook and Elgin-Capel River subareas of the Busselton - Capel Groundwater Area are contained within the study region. There is little information available for the Donnybrook subarea. The Elgin-Capel River subarea has a very small superficial groundwater resource. The land within the Elgin-Capel River subarea is mainly category 3, but due to the small groundwater resources available, the potential for both wine grapes and market garden horticulture is limited by the availability of these groundwater resources.

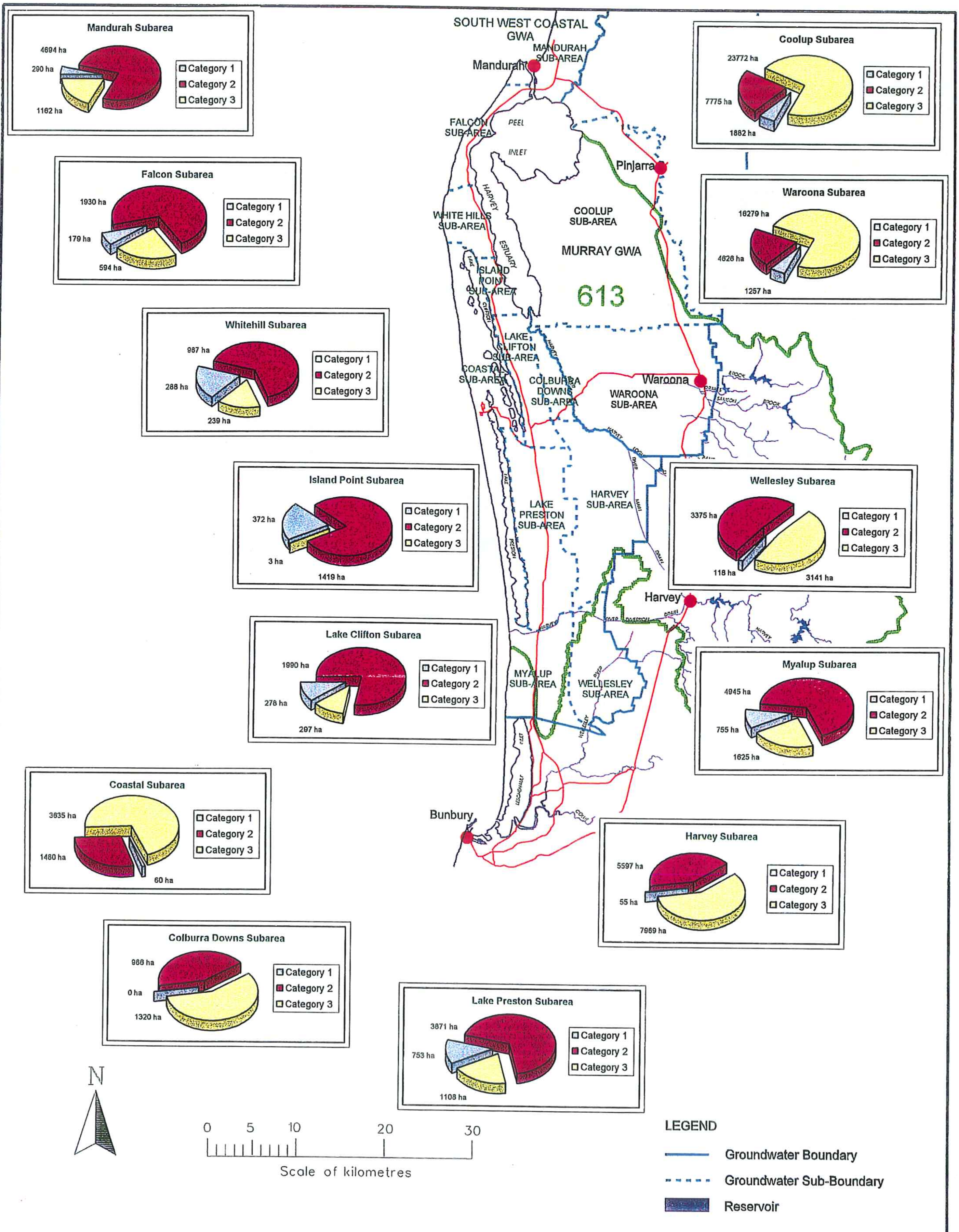
Horticultural potential in the Busselton - Capel Groundwater Area is minimal, based on the availability of superficial groundwater.



Bunbury-Mandurah Region Water Resources Review

POTENTIAL HORTICULTURAL LAND USE BASINS 611 & 612

Figure 9.5a



Bunbury-Mandurah Region Water Resources Review
POTENTIAL HORTICULTURAL LAND USE BASIN 613

Figure 9.5b

Table 9.1: Potential Horticulture in the Bunbury - Mandurah Region

GWA Subarea	Groundwater Available (ML/year)	Wine Grapes (ha)	Market Gardens (ha)	Category 1 Land (ha)	Catagory 2 Land (ha)	Catagory 3 Land (ha)
Mandurah	3975	994	265	290	4694	1162
Falcon	0	0	0	179	1930	594
White Hill	0	0	0	288	967	239
Island Point	0	0	0	372	1419	3
Coastal	0	0	0	60	1480	3635
Lake Clifton	2620	655	175	278	1990	297
Colburra Downs	1600	400	107	0	960	1320
Lake Preston	8669	2167	578	753	3871	1108
Harvey	13934	3484	929	55	5597	7969
Myalup	6546	1637	436	755	4945	1625
Wellesley	2949	737	197	118	3375	3141
Coolup	17800	4450	1186	1882	7775	23772
Waroona	7500	1875	500	1257	4626	16279
Stratham-Gelorup	0	0	0	266	4339	2767
East Bunbury	0	0	0	76	874	453
South Bunbury	0	0	0	66	213	205
Boyanup	0	0	0	266	2629	3460
Dardanup	0	0	0	445	2100	6373
Eaton	0	0	0	212	1386	1944
Australind	0	0	0	633	5450	4131
Donnybrook	0	0	0	0	0	0
Elgin-Capel River	7	2	0	563	5111	7

10. Water Resource Development Plans

10.1 General

The following section outlines the potential development of water resources in the study area for future town water supply, industrial and agricultural use. The various towns described and the surface water development sites are shown in Figure 1.1 and Figure 3.1, respectively. Schematics of each town water supply scheme are shown in Appendix A 8.

No attempt has been made to identify specific environmental/social issues related to the individual potential developments. Environmental/social water requirements will be determined by the environmental impact assessment process through which each source development proposal must pass before being approved.

10.2 Public Supply Schemes in the Preston Drainage Basin (611)

10.2.1 Boyanup Town Water Supply Scheme

The town water supply obtains its water from groundwater in the Yarragadee Formation. Population projections indicate a high growth scenario water demand of 643 ML from the supply scheme in the year 2025. This exceeds the current groundwater licence of 325 ML by 318 ML and a new licence will have to be obtained from the Water and Rivers Commission at the appropriate time. With an estimated availability of 1694 ML pa from the Yarragadee Formation, there is sufficient groundwater available for future expansion of the existing borefield to at least 2025.

An additional potential water source for Boyanup is a dam at site DS3 on Joshua Creek, a tributary of the Preston River. The potential annual yield is estimated to be 5.5 GL. This source could also be utilised by industry. Water treatment may be necessary for town water supply and industrial use.

10.2.2 Bunbury Town Water Supply Scheme

The town water supply obtains its water from groundwater in the Leederville and Yarragadee Formations. Population projections indicate a high growth scenario water demand of 12 216 ML from the supply scheme in the year 2025. This exceeds the current groundwater licence of 9200 ML by 3016 ML and a new licence will have to be obtained from the Water and Rivers Commission at the appropriate time. With a combined estimated availability of 5198 ML pa from both formations, there is sufficient groundwater available for future expansion of the existing borefield to at least 2025.

10.2.3 Dardanup Town Water Supply Scheme

The town water supply obtains its water from groundwater in the Leederville Formation. Population projections indicate a high growth scenario water demand of 99 ML from the supply scheme in the year 2025. This exceeds the current groundwater licence of 75 ML by 24 ML and a new licence will have to be obtained from the Water and Rivers Commission at the appropriate time. With an estimated availability of 533 ML pa from the Leederville Formation, there is sufficient groundwater available for future expansion of the existing borefield to at least 2025.

Additional potential water sources for Dardanup are a dam at site DS8 on Crooked Brook and a dam at site DS20 on the Ferguson River. The potential annual yields are estimated to be 1.8 GL and 13.4 GL, respectively. These sources could also be utilised by industry. Water treatment of both sources may be necessary for town water supply and industrial use.

10.2.4 Donnybrook Town Water Supply Scheme

The town water supply is screened in the Donnybrook Sandstone which is a member of the Leederville Formation. Population projections indicate a high growth scenario water demand of 656 ML from the supply scheme in the year 2025. This exceeds the current groundwater licence of 450 ML by 206 ML and a new licence will have to be obtained from the Water and Rivers Commission at the appropriate time. With an estimated availability of 1020 ML from the Leederville Formation, there is sufficient groundwater available for future expansion of the existing borefield to at least 2025.

An alternative would be to tap into the resources of the Yarragadee Formation with an estimated availability of 1500 ML. However, additional wells drawing from the Leederville Formation is the more economic alternative. Increased pumping from this subarea from the confined aquifers will reduce groundwater availability downstream. A saltwater interface, currently at the coast, may be induced to move inland should pumping be increased.

There is local competition for these water resources between the Water Corporation for water supply use and the local horticultural district. Groundwater from the Leederville Formation for future scheme use has been allocated to the Water Corporation.

In the Donnybrook subarea groundwater is heavily utilised by apple growing concerns. In the Vasse Shelf, the aquifer is fully allocated and several applications for licences have been refused. The groundwater available in the Leederville Formation to the horticultural district (after future town water supply scheme allocation) is 100 ML pa (upper Leederville). If future demand from apple growing concerns increases beyond this, alternative sources will have to be investigated.

The available groundwater in the lower Leederville is 920 ML and in the Yarragadee a further 1500 ML. However, the depth required to reach these Formations may be cost prohibitive for private users.

A review, Donnybrook Water Supply Source Review and Assessment (Forrest, 1995), was initiated by the South West Region due to the large quantity of water being overdrawn from the Leederville Formation. The local horticulturalists wanted an alternative source found to meet future demand. Three surface water options were identified. These were:

- a dam on Coolingutup Brook with a gravity supply to the reservoir and a pumpback from Waterfall Gully or Preston River; or
- a dam on Waterfall Gully with a gravity supply to the reservoir.

The key issues of the surface water options would be clearing of areas of forest which would be flooded by the construction of a dam, impact on flora and fauna and the effect on river flows. Using Glen Mervyn Dam as a source would minimise these impacts. However, Glen Mervyn Dam has turbidity and colour problems, particularly during winter. Also, the Glen Mervyn Dam has already been fully allocated to horticulturalists and consequently, does not resolve the problem of releasing additional water to the horticulturalists.

10.3 Public Supply Schemes in the Collie Drainage Basin (612)

10.3.1 Australind Town Water Supply Scheme

The town water supply obtains its water from groundwater in the Leederville Formation. Population projections indicate a high growth scenario water demand of 3825 ML from the supply scheme in the year 2025. This exceeds the current groundwater licence of 1700 ML by 2125 ML and a new licence will have to be obtained from the Water and Rivers Commission at the appropriate time. With an estimated availability of 237 ML pa from the Leederville Formation, there is insufficient groundwater available in the Leederville Formation for future expansion of the existing borefield up to 2025.

Alternatives to meet this demand will be to tap into the resource of the Yarragadee Formation, with an estimated availability of 1199 ML pa or the development of the Olive Hill dam site and two sites upstream on the Brunswick River, with an optimised potential annual yield of 36.2 GL. Another option may be releases from Wellington Dam with a pipehead dam downstream to divert the water resource. A pipehead dam would be constructed across the river bed to provide a minimum depth of water over the inlet from which water would be pumped to Australind.

10.3.2 Binningup Town Water Supply Scheme

The town water supply obtains its water from groundwater in the Leederville Formation. Population projections indicate a high growth scenario water demand of 474 ML from the supply scheme in the year 2025. This exceeds the current groundwater licence of 150 ML by 324 ML and a new licence will have to be obtained from the Water and Rivers Commission at the appropriate time. Resources in the Leederville Formation are limited and overdraw may be occurring in the Binningup area. It is recommended that no new licences should be issued.

An alternative would be to use the local superficial resources with an estimated availability of 6546 ML, although it is recommended that draw should not be allowed to exceed 4000 kL/ha. This would require a large network of low yielding bores which could be expensive.

10.3.3 Brunswick Junction Regional Town Water Supply Scheme

The Brunswick Junction Regional Water Supply Scheme serves the towns of Brunswick Junction, Burekup and Roelands. Population projections for the year 2025 indicate high growth scenario water demands of 926 ML, 107 ML and 45 ML from Brunswick Junction, Burekup and Roelands, respectively. The total projected demand for 2025 is 1078 ML. This exceeds the current surface water licence from Beela Dam of 560 ML by 518 ML and a new licence will have to be obtained from the Water and Rivers Commission at the appropriate time. The assessed annual yield of Beela Dam is 0.56 GL.

Currently, during periods of high consumption, Beela Dam is unable to meet demand, and in this situation, water from Wellington Dam is used. Water released from Worsley Dam (upstream of Beela Dam) is also used when surplus water is available. However, during the 94/95 summer Worsley expressed considerable concern over the level in their dam and indicated that they may be unable to continue to release the required quantities in the future.

To meet future demand, a new source will need to be developed to supply Brunswick Junction, Burekup and Roelands. The Brunswick River is one of the largest undeveloped freshwater resources on the Darling Scarp between Bunbury and Perth. A new dam at the Olive Hill Site (DS26) has the potential to play a major role in future water supply developments in the south-west and could provide a further water supply source for Perth or the GSTWS. Two other less potentially viable sites (DS30 and DS38) exist on the Brunswick River.

Construction of a dam would require the relocation of Beela Road and railway line clear of the inundation area. The reservoir would inundate a large portion of agricultural land and Beela Dam. A dam would also significantly alter the river flow regime and would impact on the Leschenault Inlet and lower Collie River with reduced input of freshwater.

The yield from the Brunswick River may be optimised by developing a pipehead at Olive Hill and a large reservoir at DS30. This combination would yield 36.2 GL which would sufficiently provide for the projected demand of Brunswick Junction, Burekup and Roelands in the year 2025, as well as potentially providing a further water supply source for Perth or the GSTWS.

10.3.4 Great Southern Town Water Supply Scheme

The Great Southern Town Water Supply Scheme (GSTWS) serves the towns of Collie and Allanson as well as 32 towns outside the study area. The main source for the GSTWS is the Harris Dam on the Harris River. Water supply to Collie is supplemented by Mungalup Dam. Population projections for the year 2025 indicate high growth scenario water demands of 1825 ML and 128 ML from Collie and Allanson, respectively. The total projected demand in the year 2025 for the GSTWS is 13 153 ML.

The Harris River has a potential annual yield of 17.5 GL at Harris Dam and Mungalup Brook has a potential annual yield of 0.25 GL at Mungalup Dam. However, some water is released downstream from the Harris Reservoir to Wellington Reservoir to improve its water quality. The water released ranges from 0-30 GL.

The GSTWS could be additionally supported by the development of the Olive Hill Site (DS26) along with two other sites upstream (DS30 and DS38) on the Brunswick River. The optimised potential annual yield from the development of the Brunswick River is 36.2 GL.

10.3.5 Eaton Town Water Supply Scheme

The town water supply obtains its water from groundwater in the Yarragadee Formation. Population projections indicate a high growth scenario water demand of 1371 ML from the supply scheme in the year 2025. This exceeds the current groundwater licence of 1100 ML by 271 ML and a new licence will have to be obtained from the Water and Rivers Commission at the appropriate time. With an estimated availability of 4000 ML pa from the Yarragadee Formation, there is sufficient groundwater available for future expansion of the existing borefield to at least 2025.

10.4 Public Supply Schemes in the Harvey Drainage Basin (613)

10.4.1 Harvey Town Water Supply Scheme

The Harvey Town Water Supply Scheme serves the towns of Harvey and Wokalup. The water supply is drawn from the Harvey Dam on the Harvey River. Population projections for the year 2025 indicate high growth scenario water demands of 987 ML and 23 ML from Harvey and Wokalup, respectively. The total projected demand for 2025 is 1010 ML.

The Harvey River has a potential annual yield of 16 GL at the Harvey Dam which will sufficiently meet future demand of both Harvey and Wokalup to at least 2025.

An additional potential source is a dam at site DS48 on the Harvey River. This is estimated to have a potential annual yield of 43.6 GL (excluding overflow from Stirling Reservoir). A number of existing roads would be inundated by the larger Harvey Reservoir and replacement roads would need to be constructed. The enlarged reservoir would inundate areas of freehold land, Crown Reserve and State Forest. Harvey River has been identified as a wetland of ecological significance and consequently, ecological constraints exist.

This scheme has been proposed by the Water Corporation to augment the Perth Metropolitan Water Scheme and is currently being investigated. In this event, the Harvey Town Water Scheme should be integrated with the Perth Metropolitan Scheme.

10.4.2 Myalup Town Water Supply Scheme

The town water supply obtains its water from groundwater in the Leederville Formation. Population projections indicate a high growth scenario water demand of 91 ML from the supply scheme in the year 2025. This exceeds the current groundwater licence of 55 ML by 36 ML and a new licence will have to be obtained from the Water and Rivers Commission at the appropriate time. However, resources in the Leederville Formation are limited and overdraw may be occurring. It is recommended that no new licences should be issued.

An alternative would be to use the local superficial resources with an estimated availability of 6546 ML pa, although it is recommended that draw should not be allowed to exceed 4000 kL/ha. This would require a large network of low yielding bores which could be expensive.

10.4.3 Preston Beach Town Water Supply Scheme

The town water supply obtains its water from groundwater in the Leederville Formation. Population projections indicate a high growth scenario water demand of 98 ML from the supply scheme in the year 2025. This exceeds the current licence of 55 ML by 43 ML and a new licence will need to be obtained from the Water and Rivers Commission at the appropriate time. Resources in the superficial and Leederville Formations are limited and consequently, it is recommended that the limited availability should be kept for public purposes and not allocated for private use. Further expansion may require the development of a new source or the connection to another town scheme in the area.

10.4.4 Park Ridge Town Water Supply Scheme

The town water supply obtains its water from groundwater in the Leederville Formation. Population projections indicate a high growth scenario water demand of 143 ML from the supply scheme in the year 2025. This exceeds the current groundwater licence of 110 ML by 33 ML and a new licence will have to be obtained from the Water and Rivers Commission at the appropriate time. Resources in the Leederville Formation are limited.

The Park Ridge Town Water Supply can be augmented from the Mandurah Regional Water Supply Scheme. The recommendation is that draw from the aquifer supplying the Park Ridge Town Water Supply not exceed 100 ML pa. Growth in consumption indicated that this figure would have been exceeded during the 1994/95 year. The inclusion of Park Ridge in the Class 1 water restriction limited the demand to 91 ML for 1994/95 which resulted in no abstraction from the Mandurah Scheme.

The Mandurah Scheme draws water conjunctively from South Dandalup Dam and the Yunderup Leederville Wells. Augmentation from the Mandurah Regional Water Supply Scheme will provide sufficient water supply to the Park Ridge Town Water Supply Scheme to at least 2025.

10.4.5 Waroona and Hamel Town Water Supply Scheme

The Waroona and Hamel Water Supply Scheme serve the towns of Waroona and Hamel. Water is drawn from a pipehead dam on Samson Brook. Population projections for the year 2025 indicate high growth scenario water demands of 970 ML and 20 ML from Waroona and Hamel, respectively. The total projected demand for 2025 is 990 ML. This exceeds the current surface water licence of 540 ML by 450 ML and a new licence will have to be obtained from the Water and Rivers Commission at the appropriate time. The combined divertible yield of the impoundments on Samson Brook is estimated to be 7.8 GL, which will sufficiently meet future demand to at least 2025.

An additional potential source is a dam at site DS1.8 on Samson Brook. This is estimated to have a potential annual yield of 1.6 GL. However, this is not regarded as an economic site and development in the medium to long term is unlikely.

10.4.6 Yarloop/Wagerup Town Water Supply Scheme

The town water supply is drawn from a pipehead on Bancell Brook. Population projections indicate a high growth scenario water demand of 407 ML from the supply scheme in the year 2025. This exceeds the current surface water licence of 320 ML by 87 ML and a new licence will have to be obtained from the Water and Rivers Commission at the appropriate time. Bancell Brook has a potential annual yield of 1.7 GL at the Bancell Brook Pipehead Dam. This yield is sufficient to meet future demand to at least 2025.

An alternative potential source would be a dam at site DS10 on Bancell Brook with a potential annual yield of 4.2 GL. If developed, this source would most likely be utilised for urban and industrial water supply.

10.5 Industries in the Preston Drainage Basin (611)

10.5.1 Boyanup Subarea

Current groundwater allocations for medium to large industries (10 ML) are drawn from the superficial formation. The projected demand in the year 2025 is 20 ML. The resource in the superficial formation is limited. With an estimated availability of 1700 ML pa in the Leederville Formation, there is sufficient groundwater to supply the expected future expansion of the industries to at least 2025.

A future alternative is the resource of the Yarragadee Formation, with an estimated availability of 1694 ML pa. However, the depth to the Yarragadee Formation may be cost prohibitive for private users. In addition, surface water could be used from the potential dam site DS3 on Joshua Creek (refer to section 10.2.1).

10.5.2 Dardanup Subarea

Current groundwater allocations for medium to large industries (2069 ML) are drawn from the superficial and Leederville Formations. Expected demand in the year 2025 is 2150 ML. The resource in the superficial formation is limited and the estimated resource available in the Leederville Formation is 533 ML pa. This is sufficient to supply the additional 81 ML increase in the industrial water demand up to the year 2025, as well as the 24 ML increase in demand projected for the Dardanup Town Water Supply Scheme (refer to section 10.2.3).

An alternative is the Yarragadee Formation with an estimated availability of 2000 ML pa. There is sufficient groundwater to supply the expected future expansion of the industries to at least 2025. However, the depth to the Yarragadee Formation may be cost prohibitive for private users. In addition, surface water could be used from the potential dam sites DS8 and DS20 on Crooked Brook and the Ferguson River, respectively (refer to section 10.2.3).

10.5.3 East Bunbury Subarea

Current groundwater allocations for medium to large industries (3219 ML) are drawn from the superficial, Leederville and Yarragadee Formations. Expected demand in the year 2025 is 4023 ML. The resource in the superficial formation is limited. The estimated resource available in the Leederville Formation is 1078 ML pa. The estimated resource available in the Yarragadee Formation is 3320 ML pa.

The resources in the Leederville and Yarragadee Formations are sufficient to supply the additional 804 ML increase in the industrial water demand to at least 2025, as well as the 3016 ML increase in demand projected for the Bunbury Town Water Supply Scheme (refer to section 10.2.2).

10.5.4 Stratham-Gelorup Subarea

Current groundwater allocations for medium to large industries (60 ML) are drawn from the superficial, Leederville and Yarragadee Formations. Expected demand in the year 2025 is 78 ML. The resource in the superficial formation is limited. The estimated resource available in the Leederville Formation is 0 ML pa. The estimated resource available in the Yarragadee Formation is 3546 ML pa.

The resource in the Yarragadee Formation is sufficient to supply the additional 18 ML increase in the industrial water demand to at least 2025. However, the proximity of the ocean and high localised abstraction from the Yarragadee Formation has resulted in the migration of the saltwater interface.

10.5.5 Donnybrook

Current water demand from medium to large industries is 8 ML, which is supplied by the Donnybrook Town Water Supply Scheme. Expected demand in the year 2025 is 11 ML. The resource in the superficial formation is limited. The estimated resource available in the Leederville Formation is 1020 ML pa. The estimated resource available in the Yarragadee Formation is 1500 ML pa.

The resource in the Leederville Formation (via the Donnybrook Town Water Supply Scheme) is sufficient to supply the additional 3 ML increase in the industrial water demand to at least 2025. Any industries which demand sources which are independent of the town water supply scheme will be required to obtain their water from the Yarragadee Formation. However, increased pumping from the Donnybrook subarea from the confined aquifers will reduce groundwater availability downstream.

10.6 Industries in the Collie Drainage Basin (612)

10.6.1 Australind Subarea

Current groundwater allocations for medium to large industries (except Kemerton) (2898 ML) are drawn from the superficial and Yarragadee Formations. Expected demand (except Kemerton) in the year 2025 is 1498 ML. The resource in the superficial formation is limited. The estimated resource available in the Leederville Formation is 237 ML pa. The estimated resource available in the Yarragadee Formation is 1199 ML pa.

No growth in the industrial water demand is expected from the industries in this area by the year 2025. Current groundwater allocation will sufficiently supply water demand to at least 2025.

10.6.1.1 Kemerton

Current groundwater allocations from Kemerton industries (2253 ML) are drawn from the superficial, Leederville, Yarragadee and Cockleshell Gully Formations. Expected demand for Kemerton in the year 2025 is 3320 ML from groundwater and 10 035 ML from surface water. The resource in the superficial formation is limited. The estimated resource available in the Leederville Formation is 237 ML pa. The estimated resource available in the Yarragadee Formation is 1199 ML pa. The estimated resource available in the Cockleshell Gully Formation is not defined.

The resource in the Yarragadee Formation is sufficient to supply the additional 1067 ML increase in the industrial groundwater demand by the year 2025. However, this is also a future source option for the Australind Town Water Supply Scheme, which is currently drawing from the Leederville Formation. The combined projected increase in demand from the Australind Town Water Supply and Kemerton is 3192 ML and exceeds the groundwater availability from the Leederville and Yarragadee Formations.

An alternative is the Cockleshell Gully Formation. However, the available resource and quality is undefined and further investigations are required to establish this.

Based on an estimated future surface water demand of 10 GL a pipehead dam, situated at site DS17 on the Collie River is the most suitable for use by industries at Kemerton (part of the 20 GL/yr allocation for industry in the Wellington Dam). This site has been documented in a recent report by BHP Engineering (BHP Engineering, 1993). A pipehead weir would be constructed across the river bed to provide a minimum depth of water over the inlet from which water would be pumped to a tank sited within Kemerton. The estimated annual average streamflow of Collie River at the site is 8.5 GL with a potential annual diversion yield (excluding Wellington Reservoir releases) of 4.0 GL.

A scheme to supply water to Kemerton is currently the subject of a tender process being conducted by the Office of Water Regulation.

10.6.2 Brunswick Junction

Current industrial water demand in this area is 150 ML. No growth in the industrial water demand is expected from these industries up to the year 2025. Current water supply will sufficiently supply water demand to at least 2025.

10.6.3 Collie Groundwater Area

Current industrial water demand is 24 ML from town water supply, 22 025 ML from groundwater and 2500 ML from surface water. Expected demand in the year 2025 is 29 ML from town water supply. 25 305 ML from groundwater and 12 200 ML from surface water. The estimated resource available in the Collie Sedimentary Formation is 19 960 ML pa.

The combined yields of the Harris and Mungalup Dams are sufficient to meet the increase in industrial water demand from the Collie Town Water Supply Scheme of 5 ML (refer to section 10.3.4).

The resource in the Collie Sedimentary Basin is sufficient to supply the additional 3280 ML increase in the industrial groundwater demand up to the year 2025. However, additional water requirements will deplete the storage of the aquifer.

The annual yield of Wellington Dam is sufficient to meet the increase in surface water demand (9700 ML) from industry in the Collie Groundwater Area.

10.7 Industries in the Harvey Drainage Basin (613)

10.7.1 Coolup Subarea

10.7.1.1 Harvey

Current industrial water demand is 7 ML from town water supply, 410 ML from groundwater and 906 ML from surface water. Expected demand in the year 2025 is 12 ML from town water supply, 813 ML from groundwater and 906 ML from surface water. The estimated resource available in the superficial formation is 13 934 ML pa. The estimated resource available in the Leederville Formation is limited.

The yield of the Harvey Dam is sufficient to meet the increase in industrial water demand from the Harvey Town Water Supply Scheme of 5 ML (refer to section 10.4.1).

The resource in the superficial formation is sufficient to supply the additional 403 ML increase in the industrial groundwater demand up to the year 2025. However, it is recommended that local draw should not be allowed to exceed 4000 kL/ha.

No growth in the industrial demand from surface water is expected up to the year 2025. Current water supply will sufficiently meet water demand up to the year 2025. Further water resources could be gained from the development of the New Harvey Dam (refer to section 10.4.1).

10.7.2 Yarloop/Wagerup

Current industrial water demand is 21 ML from town water supply and 60 ML from surface water. Expected demand in the year 2025 is 21 ML from town water supply and 120 ML from surface water.

No growth in the industrial water demand from the town water supply is expected up to the year 2025. Current water supply will sufficiently meet water demand up to the year 2025.

The annual yield of the Bancell Brook Dam (1.7 GL) is sufficient to meet the combined water demand of the town water supply scheme and industry (527 ML).

An alternative potential source is a dam at site DS10 on Bancell Brook (refer to section 10.4.6).

10.8 South West Irrigation Area

The Collie, Harvey and Waroona irrigation districts are collectively known as the South West Irrigation Area. The area is watered by the Waroona, Drakes Brook and Samson Reservoirs (Waroona District), the Logue Brook, Stirling and Harvey Reservoirs (Harvey District) and the Wellington Reservoir and Collie River Diversion Weir (Collie District).

Projected high growth scenario water demand from these schemes for the year 2025 is expected to increase to 14 615 ML pa (Waroona), 66 012 ML pa (Harvey) and 65 914 ML pa (Collie) from the current demand of 13 672 ML pa (Waroona), 61 753 ML pa (Harvey) and

60 789 ML pa (Collie). This equates to an overall increase of 10 327 ML in water demand by the year 2025. However, the low growth scenario projects a decrease of 67 241 ML in water demand by the year 2025.

The current licences for the Waroona Town Water Supply and Irrigation District, the Harvey Town Water Supply and Irrigation District and the Collie Town Water Supply and Irrigation District are 18 000 ML, 64 810 ML and 78 500 ML, respectively. The combined yield of the surface water storages supplying the Waroona, Harvey and Collie Districts are 17 300 ML, 64 000 ML and 90 000 ML, respectively.

The combined projected increase in town water supply and agricultural water demand is 15 605 ML (Waroona), 67 022 ML (Harvey) and 67 867 ML. The current water supply is sufficient to meet future water demand from the Waroona and Collie Town Water Supplies and Irrigation Districts to at least 2025. The combined yield of the surface water storages supplying the Harvey Town Water Supply Scheme and Irrigation District is insufficient to meet demand up to the year 2025.

An additional source for Harvey would be a dam at site DS48 on the Harvey River (refer to section 10.4.1). This is estimated to have a potential annual yield of 43.6 GL (excluding overflow from Stirling Reservoir). The combined Harvey - Stirling system could produce an average yield of up to 85.6 GL pa, which would be sufficient to meet water demand from the Harvey Irrigation District up to the year 2025.

10.9 Preston Valley Irrigation Area

The area is watered by the Glen Mervyn Dam as well as shallow groundwater resources. Projected high growth scenario water demand from this scheme for the year 2025 is expected to increase to 1485 ML pa from the current demand of 1097 ML. This equates to an increase of 388 ML in water demand by the year 2025. Current allocation for irrigation is 1500 ML which will meet water demand to at least 2025.

An additional potential source for the Preston Valley Irrigation Area is a dam at site DS5 on Thomson Brook, with a potential annual yield of 16 GL. Water could also be allocated for urban and industrial use. The combined Thomson Brook Dam (refer to section 10.2.4) and Preston River Pipehead system would have a yield of 45.2 GL.

10.10 Horticulture Irrigated from Groundwater

There is extensive irrigated horticultural activity throughout the study area. Irrigation is mainly provided by groundwater resources. To keep pace with domestic consumption and provide for continued expansion into export markets, the Department of Agriculture has identified the need to examine new areas for horticulture, to complement existing areas and provide for opportunities for new crops or extended periods of supply unable to be met from existing areas.

New groundwater licences, for the extension of existing horticulture or for new horticultural developments, must take into consideration the existing and potential competition for groundwater resources, as is already identified in the Donnybrook region.

11. Conclusion

11.1 Introduction

The prime focus of the study was:

- to provide an inventory of the divertible water resources of the region;
- to assess the current water requirements of existing developments;
- to predict the future water requirements of existing and potential developments.

11.2 Surface Water Resources

Hydrological analyses of all the existing and potential surface water sources were undertaken. Only limited information relating to each site has been presented in this report and can be used for preliminary design, feasibility studies and planning purposes. The presented information is based on dam and pipehead specifications that are considered to be the most feasible. Complete analyses, contained in spreadsheets, for each site have been archived and are available from the Hydrologic Services section of the WRC. This information should be used when planning specific schemes. Reduction in rainfall brought about by potential climate change has not been taken into account in the hydrological analysis and should be applied where and when deemed necessary (refer to section 2.2).

At present the potential available surface water greatly exceeds the demand. This situation will also prevail in 2025. If export of water to Perth occurs this situation may change.

Table 11.1 below indicates the potential surface water yield, likely demand and the quantity divertible within each basin at present and in the year 2025. Quantities are presented in ML.

Basin	**611**		**612**		**613**	
Year	**1995**	***2025***	**1995**	***2025***	**1995**	***2025***
Total Resources	69400	*69400*	188400	*188400*	150900	*150900*
TWS	0	*0*	10810	*14743*	1464	*2352*
Industry	0	*0*	2500	*22235*	966	*1026*
Agriculture	1321	*1788*	63758	*69088*	77778	*83142*
Total Demand	**1321**	***1788***	**77069**	***106066***	**80209**	***86521***
Reserved for Enviro/Social	25234	*25234*	36229	*36229*	3591	*3591*
Surplus Available	**42845**	***42378***	**75102**	***46105***	**67100**	***60788***
% Used	38	*39*	60	*76*	56	*60*

Table 11.1: Surface Water Supply and Demand Scenarios.

The environmental/social beneficial uses of water have been extracted on a pro - rata basis (percentage of basin total) from the report SafeguardingOur Water Resources. Perth - Bunbury Draft Regional Allocation Plan, (WAWRC), 1991. These demands are not easily quantifiable and are beyond the scope of this study. However, they should be accounted for in the relevant environmental impact study when any potential development is planned.

Essentially, the potential exists for extensive development of surface water sources to meet future demands within the region. Surplus capacity also exists to cater for inter - basin transfers from all three basins assessed in this study.

11.3 Groundwater Sources

Groundwater sources within GWA's are thoroughly addressed in the relevant groundwater area management plans.

At present less than half of the potential available groundwater is being utilised in the Preston River Basin. By the year 2025 the demand for groundwater is expected to remain less than half of the potential available groundwater. More than half of the potential available groundwater is being utilised in the Collie River Basin. By the year 2025 no excess groundwater will be available in this basin. Only a small portion of the available groundwater within the Harvey River Basin is currently utilised and the demand for groundwater in this basin is not expected to increase greatly by the year 2025. Most of the available groundwater in this basin is stored in the superficial aquifer and is difficult to extract except by numerous low capacity wells. Groundwater use in this basin is more suited to individual users abstracting small quantities from bores spread throughout the groundwater area. Table 11.2 below indicates the potential groundwater supply and likely demand within each basin. Quantities are presented in ML.

Basin	**611**		**612**		**613**	
Year	**1995**	***2025***	**1995**	***2025***	**1995**	***2025***
Total Resources	52100	*50716*	36000	*36000*	109000	*109000*
TWS	6855	*12779*	2013	*2746*	240	*386*
Industry	4219	*5722*	25303	*28625*	410	*814*
Agriculture	766	*1043*	4354	*4654*	3450	*3688*
Total Demand	**11841**	***19543***	**31670**	***36025***	**4100**	***4888***
Reserved for Enviro/Social	0	*0*	0	*0*	0	*0*
Surplus Available	**40259**	***31173***	**4330**	***0***	**104900**	***104112***
% Used	21	*36*	88	*100*	4	*4*

Table 11.2: Groundwater Supply and Demand Scenarios.

The environmental/social beneficial uses of water have been extracted on a pro - rata basis (percentage of basin total) from the report Safeguarding Our Water Resources. Perth - Bunbury Draft Regional Allocation Plan, (WAWRC), 1991. These demands are not easily quantifiable and are beyond the scope of this study. However, they should be accounted for in the relevant environmental impact study when any potential development is planned.

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12.2 Abbreviations

ABS	Australian Bureau of Statistics
AHD	Australian Height Datum (equivalent to mean sea level)
ANCOLD	Australian National Committee On Large dams
AWRC	Australian Water Resources Council
CALM	Department of Conservation and Land Management
CWAG	Collie Water Advisory Group
DEP	Department of Environmental Protection
DS	dam site
DPUD	Department of Planning and Urban Development
ESDSC	Ecologically Sustainable Development Strategy Committee
EPA	Environmental Protection Authority
ERS	Estimated Resident Population
FSL	full supply level
G&AWS	Goldfields and Agricultural Water Supply Scheme
GL	gigalitres (one million kilolitres)
GSTWS	Great Southern Towns Water Supply Scheme
GWA	Groundwater Area
ha	hectares
kl	kilolitres
km	kilometres
m	metres

MAF	Mean Annual Flow
mg/L	milligrams per litre
ML	megalitres
Mt/a	megatonnes per annum
MWS	Metropolitan Water Supply Scheme
N/A	not applicable
NH&MRC	National Health and Medical Research Council
OWR	Office of Water Regulation
PH	pipehead
RIWI	Rights in Water and Irrigation Act (1914) sq. km square kilometres
SWDC	South West Strategy
SWIRT	South West Irrigation Review Taskforce
TSS	Total Soluble Salts
TWS	Town Water Supply
WAPC	Western Australian Planning Commission
WAWA	Water Authority of Western Australia
WAWRC	Western Australian Water Resources Council
WR	Water reserve
WRC	Water and Rivers Commission

12.3 Glossary

Aquifer	A geological formation or group of formations capable of receiving, storing and transmitting significant quantities of water.
Artesian aquifer	See confined aquifer. A term not generally used now.
Beneficial use	The current or future uses for a water resource which have priority over other potential uses because of their regional significance to the community. Beneficial use designations provide guidance in determining the management and protection of the quality and quantity of the resource.
Bore	See well.
Brackish water	Water of salinity 1000-3000mg/L TSS.
Catchment	The surface area from which run-off flows to a river or a collecting reservoir such as a lake or dampland.
Chemical	Harmful alteration of the chemical properties of the environment, eg. the pollution water resource.
Confined aquifer	A permeable geological formation saturated with water under pressure and underlying a relatively impervious layer.
Criteria	Principles or standards by which a thing is judged.
Cubic metre	The volume occupied by a cube measuring one metre along each edge. On cubic metre contains one kilolitre of water.
Dam	A structure constructed across a river valley to store stream flow and allow it to be diverted for water supply use and for release in a controlled manner for downstream use.
Demand	The amount of water required from the water supply system.
Desalination	The process of removing salts from water to produce fresh water.
Diversion	Development of a water resource to harvest some or all of its divertible water.
Divertible water	The average annual volume of water which could be removed from developed or potential sources on a sustainable basis.
Effluent	The liquid, solid or gaseous products discharged by a process, treated or untreated.

Evaluation	The process of analysis to describe using decision factors and criteria, the implications of an thereby to help to determine the acceptability of, an option relative to a set of objectives.
Factors	Circumstance, fact or influence which contributes to a result.
Filtering	A more refined screening process of evaluating options and deciding whether the option should be considered for more detailed analysis at the next stage.
Fresh water	Water of salinity less than 500mg/L TSS.
Gigalitre	1000 Megalitres.
Groundwater	Water which occupies the pores and crevices of rock or soil.
Groundwater area	An area proclaimed under the Rights in water and Irrigation Act 1911 in which private groundwater abstraction is licensed.
Kilolitre	1000 litres (see also cubic metre).
Land use	Land use which is sufficiently significant to prevent an incompatible constraint development of a divertible water resource.
Marginal water	Water of salinity 500-1000mg/L TSS.
Megalitre	1000 Kilolitres.
Nutrients	Materials conveying, serving as or providing nourishment to some organisms.
Options	Alternative ways of meeting the objectives. In this case sources of water or water efficiency measures.
Pesticides	Collective name for a variety of insecticide, fungicides, herbicides, fumigants and rodenticides.
Pipehead	A small dam allowing some of the water flowing in a stream to be diverted into a pipe for water supply use.
Pollution	Any direct or indirect alteration of the physical, chemical, thermal, biological, or radioactive properties of any part of the environment by discharging, emitting or depositing wastes or substances so as to affect any beneficial use adversely, to cause a condition which is hazardous or potentially hazardous to public health, safety or welfare, or to animals or plants.
Potable water	Fresh and marginal water generally considered suitable for human consumption.
Pumpback	A pipehead dam diverting some streamflow by pumping through a pipeline into a storage dam.
Recharge	Water arriving at the water-table.
Recharge area	An area allowing water to percolate to the water-table. An unconfined aquifer is recharged by rainfall throughout its distribution. Confined aquifers are recharged in specific areas, where water leaks from overlying aquifers, or where the aquifer rises to meet the surface. Recharge of confined aquifers is often at some distance 'upflow' from points of extraction.
River basin	The catchment of river(s) as defined by the Australian Water Resources Council for presenting hydrological data.
Runoff	The discharge of water through surface streams into larger water courses.
Saline water	Water resources of salinity greater than 3000 mg/L TSS.
Salinity	The measure of the total soluble (or dissolved) salt, ie. mineral constituents in water. Water resources are classified on the basis of that salinity in terms of milligrams per litre Total Soluble Salts (mg/L TSS).

Saltwater	The interface between a layer of fresh groundwater and underlying saltwater.
Saltwater intrusion	The inland or upward intrusion of a layer of saltwater into a layer of fresh groundwater.
Scheme supply	Water diverted from a source (or sources) by a water authority or private company and supplied via a distribution network to customers for urban, industrial or irrigation use.
Scheme	A conceptual design or operating procedure to supply water from a source (see source).
Self supply	Water diverted from a source by a private individual, company or public body for their own individual requirements.
Service reservoir	A reservoir built near consumers to receive bulk supplies of water from major sources prior to final distribution to services.
Sewage	Domestic wastewater
Source	An actual water source such as a new dam, expansion of existing dams or development of groundwater which will contribute to meeting water needs (see scheme).
Storage reservoir	A major reservoir of water created in a river valley by constructing a dam.
Stormwater	Rain water which has runoff roads etc., and is usually disposed of by drains.
Strategy	A set of policies or means aimed at a set of objectives designed to bring various actions under unified direction in order that the organisation's or community's objectives may be effectively served. It may consist of one or more source options, water efficiency policies, as well as a commitment to research and develop "environmentally friendly" options.
Surface water	Water flowing or held in streams, rivers and other wetlands in the landscape.
Sustainable yield	The rate of water extraction from a source that can be sustained on a long-term basis without exceeding the rate of replenishment. Sustainable groundwater use limits extraction to no more than the recharge rate and requires sufficient throughflow to prevent significant ocean water intrusion into aquifers.
System yield	The maximum demand that the water supply system can sustain under specified expectation of restrictions (currently restrictions are expected in 10% of years).
Transpiration	The process by which plants take up water from the soil and release water vapour through the leaves.
Treatment	Application of techniques such as settlement, filtration, chlorination, to render water suitable for drinking purposes.
Turbidity	Clouding of water due to suspended material in the water causing a reduction in the transmission of light.
Unconfined aquifer	An aquifer which has its upper boundary at the earth's surface (the upper surface of the groundwater within the aquifer is called the water-table).
Upper dam	A major reservoir on a river upstream of a main dam.
Wastewater	Water which has been used for some purpose and would normally be discarded. Wastewater usually contains significant quantities of pollutant (see Pollution).
Water Reserve	An area proclaimed under the metropolitan water Supply Sewerage and Drainage Act or Country Areas water Supply Act to allow the use of water on or under land for public water supplies.

Water Resources	Water in the landscape (above and below ground) with current or potential value to the community and the environment.
Water-table	The surface of the unconfined groundwater, which may be above ground as swamps or lakes in low-lying areas. Measured as the level to which water rises in a well tapping an unconfined aquifer.
Well	A hole dug or drilled (bore) from the ground surface into a groundwater aquifer to monitor or to withdraw water. Household wells are commonly termed bores.
Wellfield	A grouping of wells to extract large volumes of groundwater, generally for scheme supply.
Wetland	Area of seasonally, intermittently or permanently waterlogged soils or inundated land, whether natural or otherwise, fresh or saline.
Yield benefit	The increase in system yield which occurs when a new source is added to the water supply system.

12.4 Computer Files

Most of the work in this study has been stored in Microsoft Word (Version 6), Microsoft Excel (Version 5) and MicroStation (Version5) files. All this information is stored on floppy disks which are contained in the relevant house file (Mandurah - Bunbury Water Resource Review - 1996), housed in the Development Planning Section of the WRC. These files, especially the Excel files containing the projections and additional information, could be a useful source of information when undertaking projects within the region.

Appendices
Volume II of II