CONTEXT REPORT ON
SOUTH WEST WATER RESOURCES
FOR:
EXPERT PANEL EXAMINING
KIMBERLEY WATER SUPPLY OPTIONS

Client Report to WA Government

March 2005

WATER FOR A HEALTHY COUNTRY
National Research Flagship
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Don McFarlane

WATER FOR A HEALTHY COUNTRY
National Research Flagship

March 2005
The Water for a Healthy Country National Research Flagship is a research partnership between CSIRO, state and federal governments, private and public industry and other research providers.

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EXECUTIVE SUMMARY

This report was commissioned by the West Australian Government to provide the Expert Panel examining water supply options from the Kimberley with contextual information about water supply and demand issues in the South West of Western Australia.

It does not contain information about water resources in the Kimberley, except at the state-wide scale. The report does, however, provide information about water supply and demand options that could be pursued were a Kimberley water supply not developed.

There remain considerable undeveloped water resources in the South West of the State, but there are issues surrounding their development for both private and public water purposes. Many of these issues are solvable but require more active management than has been needed in the past when water resources were less developed.

Most new sources will require detailed investigations, planning, staged development and long-term monitoring to see how they respond to water abstraction before their long-term sustainable yield can be accurately known. This usually requires long lead times, multi-disciplinary work and on-going community consultation. Without this work, more expensive options with shorter lead times will be needed to meet shortfalls in supply.

The effort and cost of managing existing resources increases markedly with increased level of use and as impacts become more apparent. The need to rationalise and optimise abstraction grows as competition, especially during dry periods, increases. The use of market forces, accepted regulatory frameworks and community involvement in decision making needs much more development so that issues can be resolved in an equitable, efficient and timely manner.

To date the impact of climate change on surface water resources has been better quantified than has the impact on groundwater resources, despite groundwater being the most important resource in the South West. The uncertainty about future climates makes the orderly development of new water resources difficult both in terms of how much water recharges the systems and how much will be available for abstraction in future. It also makes provision of water for the environment difficult as the drying trend has been so sudden and large.

Western Australia has been quick to respond to the drying conditions so there have been fewer water supply problems than would be expected given the magnitude of the change.

The state has also been conservative in its water allocation practices to date, which has resulted in fewer problems of over-allocation than have occurred in other states. However, the effort devoted to investigations, managing and protecting the state’s water resources is not keeping pace with increasing demand and the need to adapt to climate change, rapid development and community expectations.

Demand management has been a feature of water management with the state being a national leader in stormwater reuse, pay-for-use, dual flush toilets and subsidies that have changed the market for water-efficient washing machines. However, there are still more than 100 GL of both stormwater and treated wastewater entering outfalls each year. The state is poised to become a leader in managed aquifer recharge, but there remain significant barriers in the
form of subsidised alternatives, uncertain community acceptance and unclear regulatory procedures.

The state’s water resource manager, the Department of Environment (including the Board of the Water and Rivers Commission), and the major water service provider, the Water Corporation, have responded to water management needs but are increasingly under pressure to adjust plans in the face of rapidly changing, and increasingly complex, situations.

In summary, there is considerable potential for improved water resource and demand management and the South West is unlikely to run out of water in the near future. However management of impacts will become even more important and new water sources will become increasingly expensive and more complex to manage. Integrated Resource Planning is required to get the right balance between new source developments, water re-use and demand management options.
1. **INTRODUCTION**

1.1 **Background**

On 11 November 2004, the West Australian government announced a study of Kimberley water options for the South West and on 15 December 2004 it appointed an independent Expert Panel chaired by Emeritus Professor Reg Appleyard to examine the feasibility of the options.

The five Terms of Reference (TORs) of the Panel are:

1. The Panel will call for submissions for the supply of water from the Kimberley region to supplement the Integrated Water Supply Scheme (IWSS). The Panel is seeking significant proposals that can reliably deliver in excess of 50 Gigalitres per annum of water.

2. The Panel may utilise the services of independent consultants during the evaluation of proposals. It is envisaged that consultants may assist through the provision of technical evaluation and report preparation.

3. The Panel will evaluate the Watering Australia proposal, the Tenix canal proposal and any other proposals received relating to the Kimberley region during the submission period.

4. The Panel will provide a report to Government on its findings by September 2005.

5. The Panel will, through the course of the evaluation process, undertake public consultation to ensure that the community is kept informed of progress and findings as appropriate.

To assess the need to supplement the IWSS (TOR 1) and to identify where water would be provided without a new Kimberley source, the government of WA asked CSIRO to write a report that provides context for any decision on a Kimberley water source. This report does not draw hard conclusions about the need for a new water source or pre-empt the findings of the Expert Panel in any way.

This report has drawn heavily on material provided by the Department of Environment (DoE, the state’s water resource manager) and the Water Corporation (the state’s main water service provider). However, all responsibility for the conclusions drawn from this material is held by CSIRO’s Water for a Healthy Country Flagship.

Given the time to prepare this report (six weeks) it is a synopsis of up-to-date information with material presented in a pictorial manner where possible to aid interpretation. Information has been included if it was felt important to provide context for decisions about the need for a new water source. A more detailed report with new analyses will be produced by the end of June 2005 and a report on science gaps will be provided by August 2005.

The report considers demands from the private (non-scheme) sector that will grow at the same time that public drinking water supply (scheme) needs will increase.
There are a number of important interactions between scheme and non-scheme water systems, which will increase in importance over the planning period. These include trading, substitution and competition.

This report is therefore broader in scope than traditional water source development plans, but does not contain individual source details that are normally included in such documents.

### 1.2 Objectives

This report broadly identifies water sources and demand management options available in the South West of the state to meet the demand for drinking water\(^1\) in the next 15 years, with some projections to 2030. A Kimberley source would complement and/or compete with these options.

It provides an overview of the main features which affect the water industry in the South West of Western Australia. These features differ in significant ways from other states and need to be understood before conclusions can be drawn and decisions made.

Some of the resource availability and demand data have been presented in other publications (which are referenced at the end of the report) but an effort has been made to update these data, integrate datasets and portray the information in an informative manner.

The data in the tables and figures will be refined further in the June 2005 report, at which time scenarios such as the impact of more profound climate change or increased demand by the public and private sectors will be assessed.

### 1.3 Scope

The report covers the area that may be used to supply water to the Integrated Water Supply Scheme (IWSS) by 2030 (Figure 1.1). The future supply area is difficult to predict but there is a reasonable likelihood that the current inter-connected schemes will expand to incorporate water from the South West Yarragadee and another pipeline will access groundwater reserved for public water supplies to the north of Perth over this 25 year timeframe. Once a major artery is developed, history has shown that nearby towns become interconnected, thereby increasing system reliability and flexibility.

Currently the IWSS provides water to Perth, Mandurah, Pinjarra, Harvey, Waroona, Myalup and Binningup. However, it is also linked with schemes that supply water to parts of the wheatbelt, goldfields and Great Southern (see later). Therefore, from a demand perspective, the study has implications for public water supplies to about 1.7M people, or 85% of the state’s population. IWSS water use is however only 18% of state use, the other 82% being self supply use by private and industrial users.

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\(^1\) “Drinking” is used instead of “potable” throughout this report as they have identical meanings and drinking is clearer to many people. It is also assumed that any new Kimberley source would be used to supplement drinking water supplies as these are the most valuable use of water in most jurisdictions (e.g. ECS, 2003).
Figure 1.1  Scope of Study – Northern Perth Basin to South Coast
2. **Features of the South West WA Water Situation**

2.1 **Stage of Resource Development**

Unlike many other states, Western Australia’s water resources are less developed because of its small population (1.93 million) and large size (2.5 million km$^2$).

The Western Australian Water Assessment 2000 report indicated that 38% of the state’s surface water resources had been allocated to their sustainable limit and about 30% of Groundwater Management Areas$^2$ were nearly or were fully allocated (Water and Rivers Commission, 2000).

In some cases, water use lags behind allocations because abstraction may not reach its licensed amount until some time after the licence has been issued. The 2000 report indicated that about 18% of the state’s available groundwater (including saline groundwater) was being used, with about 39% of Perth Basin groundwater being used. At this time, about 13% of the state’s available surface water resources were being used. In recent years the state has been more proactive in recovering unused allocations and these figures may now be higher.

These figures could be interpreted as indicating that there remain abundant untapped resources in the South West of WA. However, as will be shown later in this report, many of these resources are located far from where they are needed, or have water quality or development aspects which limit their use. Therefore, it is not feasible for all water resources to be fully exploited before alternatives (including demand management and re-use) become the next best supply option.

It can be concluded, however, that the state still has new source options, unlike some states and nations where all viable options have already been developed and, in some cases, over-allocated. These new sources usually require significant investigations to prove their reliability and also have long lead times to be developed. Therefore there is a requirement for on-going investigations, planning and monitoring to allow their orderly development.

2.2 **Resource Allocation Methods Used in WA**

To understand the figures and tables referred to in this report it is important to understand how sustainable yields are calculated in Western Australia as they are a percentage of the mean annual flows (for rivers), and mean annual recharge (for aquifers).

Where water use requires active management, the Governor proclaims an area after receiving advice from the DoE that all water diversions other than those required for stock and domestic purposes$^3$ are required to be licensed.

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$^2$ There is a concentration of small GMAs near Perth which are highly allocated which can affect the % allocation figures.

$^3$ In some areas even stock and domestic supplies require a licence. However, these amounts are usually small (<1.5 ML/y) and the cost of issuing and managing the licences does not justify the improvements in management that result. All plans make provision for stock and domestic withdrawals. This includes backyard bores in the Perth area.
Water is managed through Allocation Plans which, in priority order, set aside water for the environment and future drinking water needs before licensing any private extraction (Kern 2003). The only other method whereby water can be reserved for future use is through State Agreement Acts, which cover major resource developments.

The **sustainable yield** is the amount of water that can be sustainably harvested each year after making provision for environmental and social values (Water and Rivers Commission, 2000, p14).

For all surface waters in the South West the sustainable yield was estimated to be about 55% of the economically divertible yield and 24% of the mean annual flow (Water and Rivers Commission, 2000).

For licensing purposes, the DoE sets and periodically reviews **Allocation Limits** for each water resource. These limits reflect constraints against the full amounts of annual flow or recharge being diverted for use. They are usually set conservatively to reflect the state of knowledge of the resource. Over time, the Allocation Limit will come to equate with the Sustainable Yield.

**Ecological Water Requirements** (EWRs) and **Environmental Water Provisions** (EWPs) are determined as part of the water allocation process. The EWRs are the water regimes (e.g. river flows or groundwater levels) needed to maintain ecological values of water dependent ecosystems at a low level of risk. The EWPs are the water regimes that are provided as a result of the water allocation decision-making process taking into account ecological, social and economic impacts. They may meet in part or in full the ecological water requirements. The EWPs are determined by the Water and Rivers Commission in accordance with the principles and processes set out in its “EWP Policy for WA (2000)”. The final decision on the EWPs is normally made by the Board of the Water and Rivers Commission. In cases where the decision may lead to a significant impact on the environment, the proposed EWP, or the related project that gave rise to the need to determine the proposed EWP, needs to be referred to the EPA for assessment under the **EP Act 1986**, then the Minister for the Environment sets the final conditions on the project and EWP.

In Western Australia, Allocation Limits have traditionally been set conservatively because of limited information on:

- mean annual flows and recharge rates,
- EWRs and EWPs,
- how the resource will respond to development, and
- concern about future climates.

For groundwater in particular it has been traditional to set a low allocation limit and then monitor the response of groundwater levels to pumping. The limit may be revised upwards if the EWPs are being maintained and groundwater levels are either not falling, or are not predicted to fall in future.
This is a conservative and robust method but can be a problem when:

- understanding of the resource (e.g. through monitoring and modelling) does not increase substantially as abstraction approaches the allocation limit,
- licensed allocations grow rapidly and the resource has not experienced, or equilibrated, to the increased rate of use,
- environmental, social and economic values change over time,
- draw points are concentrated near areas with high values, and
- sustainable yields reduce due to changes in rainfall, land use or land management.

This conservative approach may limit some development but it has also certainly resulted in fewer over-allocation problems than in some other jurisdictions. It may also reduce social and economic hardship and environmental damage if climate change requires sources to be significantly de-rated. The National Water Initiative places responsibility for risks associated with changed water availability due to climate change on water users.

Periodically the DoE tracks the gap between the level of use of a water resource and its management response (e.g. investigations and monitoring, modelling, revising EWRs, EWPs and Allocation Limits and establishing Water Resource Management Committees). The gap has been growing and was most recently highlighted in the Auditor General’s (2003) critical report to government on deficiencies in the state’s water resources management.

### 2.3 Integrated Water Supply Scheme

Western Australia has a long history of moving drinking water from the high rainfall west coast to lower rainfall zones in the Wheatbelt, Goldfields and Great Southern where the water resources are scarce or saline.

The coastal Integrated Water Supply Scheme (IWSS) links Perth wellfields and surface water sources with demand centres between Wanneroo and Harvey (Figure 2.1).

The 104 km Stirling Trunk Main has allowed water to be transferred from new sources south of Perth, greatly increasing the resilience of the overall system and opening up opportunities for trading with Harvey Water, a grower-owned irrigation Co-operative.

The 102 year-old Goldfields and Agricultural Scheme (GAWS) delivers about 11 GL of drinking water per annum to Wheatbelt towns and farms and another 15 GL to the Goldfields east of Southern Cross. The Helena Catchment, which supplies the Mundaring Weir, has had a reduced runoff in recent years as a result of lower rainfalls and vegetation management practices, requiring augmentation from other surface and groundwater sources.
The scheme for the Great Southern Towns is now supplied with water from the Harris Dam in the Collie Catchment. The original source of the Wellington Reservoir became too saline after partial clearing of native vegetation but it still supplies low quality irrigation water to the Collie Irrigation Area.

Such an integrated water supply scheme is possible because the Water Corporation supplies about 97% of the state’s domestic water services. In states where many service providers are present, supplies are often sourced from within their service delivery area. A similar low level of integration of systems across licence boundaries is present in the Bunbury and Busselton areas which are supplied by Aqwest and Busselton Water Boards respectively.

2.4 Importance of groundwater

The South West of Western Australia is unique in having such a high reliance on groundwater for both domestic use and irrigation. Figure 2.2 shows that in 1985 the amount of licensed water use was divided evenly between surface and groundwater but by 1997 groundwater use was estimated to be 75% larger than surface water use (WRC, 2000).
In 2000, total estimated use had doubled during the previous 15 years and it was anticipated to double again in the next 20 years. However, an audit of only licensed allocations from the 2005 licence database has shown that surface water use has grown by 244 GL (37%) and groundwater by 454 GL (40%) since 1997. New licensed allocations are currently running at about 100 GL per annum. This increase has probably been due to a combination of factors – rapid development (e.g. mining, horticulture, urban), surface water sources becoming less reliable, and a realisation that having a recognised water licence can improve security and allow trading in future.

Licensed amounts do not always equate with actual use. Surface water entitlements may not be fully available in dry years and groundwater entitlements may not be fully taken up after issuing. However, the total growth in the licensed amounts for private and public supply is significantly in excess of anticipated growth, which had included estimates for both licensed and unlicensed use (Figure 2.2). Licensed use of groundwater for de-watering for mining operations has grown significantly in the past five years and will contribute to some of this increase in excess of earlier predictions.

Groundwater use in the South West has risen relative to surface water as a result of increased demand through population and industrial use but it has also been influence by other factors, especially salinity, rainfall and geology.

Most large rivers originate in the saline Wheatbelt and are unsuitable for drinking or other uses (WRC, 2002a). Where they extend into the medium rainfall zone, even small areas of clearing have salinised streams and water supplies have been compromised as a result (eg Denmark, Warren, Kent and Collie Catchments).
Winter rainfall in the South West is usually of relatively low intensity but is more reliable than in many other parts of Australia. Coupled with the deeply weathered soil profiles that underlie much of the South West, runoff is usually a small proportion of rainfall. This has resulted in groundwater resources being more widespread and reliable than runoff in streams.

The Perth Basin, which extends from Geraldton to Augusta, is comprised of a thick sedimentary sequence in which fresh water can extend to depths of 2 km. The main aquifers are the unconfined superficial formation of the Swan Coastal Plain, and the deep confined aquifers, principally the Leederville and Yarragadee Formations. The main constraint on abstraction is the impact of low groundwater levels on groundwater dependent ecosystems (GDEs) and on wetlands, and the need for outflows to keep saline water from intruding the aquifer.

2.4.1 Public groundwater supply

Stream flows have more than halved since 1975 largely due to climate change (Figure 2.3) and as a result, scheme water supplies have relied increasingly on groundwater. Because of environmental concerns, scheme supplies have also extracted proportionally more water from the deep, confined aquifers which can have a wider impact and longer lag when compared with extraction from shallow aquifers.

Currently, groundwater supplies 60% of the IWSS demand of 265 GL/y, and 60% (or 95 GL) of this is currently supplied from confined aquifers. Groundwater abstraction for scheme use increased from 105.2 GL in 1998 to 158 GL in 2003 and 2004.

The widespread nature of groundwater can reduce some supply costs for scheme water, allowing new wellfields to be developed beside, or even under, new suburbs. This has been a feature of the expansion of the North West corridor in Perth. However, this saving is more than offset by the increased cost of treating and pressurising groundwater compared with gravity-delivered hills water.

2.4.2 Private groundwater supply

The presence of groundwater under much of the Swan Coastal Plain has enabled irrigators to develop their own water supplies. Currently, 55% of irrigation water in WA is self supplied, 90% of this being from groundwater (McCrea, 2004).

About 75% of the state’s irrigated land is watered using self-supply schemes (McCrea and Balakumar, 2003). The apparent larger area irrigated for water used in self-supply schemes is probably due to a combination of:

- greater use per hectare in surface water schemes (flood irrigation, higher water use crops),
- allocated amounts are not available each year for surface water uses, and
- actual use may exceed licensed allocations in some groundwater areas as most are not metered, unlike surface water schemes.
Whatever the reason, McCrea (2004) notes that water application rates in Western Australia (12 ML/ha) are about double the national average.

Self supply reduces the need for government or private industry to provide capital to develop irrigation source and delivery systems. However, it has also meant that the irrigators are often not in co-operatives, not used to trading and not use to contributing to joint management schemes. Growers may also not reduce their abstraction in response to years of low recharge, as occurs when surface water storages are low. If groundwater levels are not monitored and used to allocate annual amounts, over-abstraction can occur.

In Perth, many domestic gardens and public areas can be irrigated using groundwater that is “fit-for-purpose” which is unusual. It is estimated that about 112 GL/yr of groundwater is use to irrigate a third of Perth’s gardens (140-150,000 bores, increasing by about 5,000/yr) and another 42 GL/yr is used by local government (Davidson and Yu, 2004).

The use of shallow groundwater has allowed Perth to have a green environment, reduced the amount of stormwater discharging to the river and ocean and reduced the demand for scheme supplies by about 250 kL/household/year where gardens are watered with bore water.

A significant proportion of annual recharge to the Superficial Aquifer is recharged from stormwater. Roof runoff is recharged via soakwells and street runoff is recharged in absorption basins. Therefore use of the Superficial Aquifer is a form of stormwater reuse.

A feature of groundwater systems is the geographical limitation to trading. Surface water can be traded across many kilometres, even between states, but groundwater tends to be traded within a management unit where there are common environmental constraints on extraction. Deep groundwater systems can be more easily traded where their impacts are spread over a larger area. It has been stated that surface water trades quantity whereas groundwater trades potential impacts.

### 2.5 Climate change impacts

Since the mid 1970s the South West of Western Australia has probably experienced one of the most profound impact of climate change of anywhere in the world.

The May to July rainfall for the South West abruptly decreased by about 15% after 1975 (IOCI, 2004). The 170 and 300 mm isohyets have moved 70-100 km closer to the South West corner, while the 500 mm isohyet has moved by up to 200 km (Figure 2.3).
As well as a reduced average rainfall, the absence of very wet years has resulted in greatly reduced runoff and recharge.

Between 1975 and 1996, Water Corporation gauging has shown that rainfall decreased by 14% and runoff into Perth dams decreased by 48%. Since 1997 the rainfall decline has been 21% and the runoff has been 64% less than the long term average. In the four years since 2001, rainfall was 36% less and runoff a huge 88% less (Figure 2.4). Although rainfall is likely to be the dominant factor reducing runoff, catchment management (fire regimes, mining) and the spread of dieback disease could account for some changes as well.

In the mid 1990s the Water Corporation embarked on a major series of initiatives to increase supply and better manage demand as a result of the decreased runoff. These initiatives allowed Perth and its surrounding areas to continue to grow without the need for severe restrictions, or water prices having to increase faster than inflation.

This was a major achievement and in early 2001 the source development plan was quite positive about future prospects for meeting demand. However, runoff in that year was only 40 GL and the need to accelerate more sources and manage demand became even greater.
It is difficult to know which long term average supply level to use in the face of such rapid changes. The Water Corporation considered scenarios based on both the past 30 years of rainfall (1975 to 2004) and the past 8 years (1997 to 2004) and adopted the more recent 8 year scenario for planning purposes. The Water and Rivers Commission Board have adopted the 1975 to 2003 period for estimating surface water yields.

The impact of the reduced rainfall on groundwater recharge is less well defined than for runoff. One hydrograph study estimated that recharge under pines only occurred in months when rainfall exceeded 200 mm and under Banksia woodlands when monthly rainfall exceeded about 150 mm (R. Ferdowsian, unpublished report 2002). Months with more than 200 mm were relatively common in the 1960s and early 1970s but there have been only three such months in the past 20 years. This, together with recent chlorofluorocarbon tracer studies, indicates that the combination of land use (thick pine stands) and a reduced rainfall have together resulted in negligible recharge under a landuse that previously provided some.
3. **SURFACE WATER AVAILABILITY AND USE**

In February 2005 the DoE allocation and licensing databases showed that the total Sustainable Yield of “fresh water” from proclaimed rivers in the state was 4,878 GL/yr, of which 977 GL (20%) had been licensed and about 658 GL (13.5%) was being used (Table 1).

Almost two-thirds of the sustainable flows are located in the Timor Sea Drainage Division and about a quarter is in the South West Division (Figure 3.1). Climate predictions are likely to result in the relative contributions being increasingly weighted towards the Timor Sea drainages (Bryson Bates, *pers. comm.* 2005). The sustainable yield of South West rivers has been 57% allocated and 28% used, figures that are much higher than the state overall, due to population and development demand.

Estimates of the fresh and marginal sustainable yields, current licensed allocations and effectively committed resources of individual South West river basins (Figure 3.2) are shown in Table 2. The mean annual flow of each basin is also included in Table 2. This represents all water discharged from the river basin, including any brackish or saline discharge. River basins that extend well inland and drain the main agricultural zone of the South West, discharge large quantities of brackish water to the Indian and Southern Oceans. Examples include the Swan Coastal, Murray, Blackwood, Frankland River and Albany Coastal River Basins. The sustainable yields of these basins are limited to the fresh and marginal tributaries of the main rivers of these basins and are typically less than 20% the basin’s mean annual flow. The exception is the Shannon River Basin where all streamflow is fresh. The sustainable yield in this case is limited to potential developments that lie outside the new national parks of the Walpole Wilderness Area.

Public water supply represents the main use in both the Swan Coastal and Murray Basins, and represents almost half of the allocation in the Harvey River Basin. All three basins are close to full allocation. Some minor resources could be developed but have disadvantages as public drinking sources due to poor raw water quality, small size and consequent vulnerability to climate change (see details in Appendix 1). Significant unallocated resources occur in the Collie River Basin. About 17 GL/yr of marginal salinity water is available from the Collie River at Wellington Dam (from a 20GL/yr originally requested by the Water Corporation). A further ~35-40 GL/yr of fresh water from the lower Brunswick River and ~15-20 GL/yr of marginal salinity water from the lower Collie River could be harnessed within the Basin. For such developments to proceed, the downstream effects on Leschenault Estuary, and other environmental impacts, would require thorough assessment and be shown to be minor.

Significant amounts of unallocated water are also available from the River Basins further south. Developments of the larger resources, to as far south as the Warren River Basin, are likely to be cost competitive with desalination options to supply the southern Perth IWSS Demand (see Appendix 1).

However, care must be taken in interpreting these figures for the following reasons:

- Sustainable Yields in the South West River basins have not been adjusted for the drier years since 1975.
Indicative declines in average streamflows recorded across the region are presented in Appendix 1. These have been presented as a percentage of the average streamflow for the period 1962 to 1995 inclusive, representative of the data periods used to estimate the Sustainable Yields of Table 2. This comparison indicates that declines since 1975 were greatest in the northern part of the region, where declines in the Swan Coastal and Murray River Basins were greater than 35%. The declines were not as great in river basins where streamflow yields are high (the Harvey River Basin, for example) and in southern and South Coast basins where the surplus of rainfall over evapo-transpiration is greater. In these cases, declines in average streamflows from 1975 were generally less than 20%.

The declines since 1997 were also lower in the southern and South Coast Basins, but were still more than 30% below the data sets used in the 2000 Water Assessment.

DoE will update the annual regional flow model to provide estimates of mean annual flow for ungauged catchments in the South West by June 2005. DoE is aiming to provide revised estimates of the sustainable yields by June 2006.

- Not all of the resources that contribute to the Sustainable Yields of Table 2 will be suitable for development as sources of public drinking water.

Many small resources will prove not to be cost effective for development because of risks posed by existing catchment land use activities, high water treatment costs, remoteness from main demand centres and their reliability of supply, particularly if streamflows continue to decline. This is especially the case with small resources in the Busselton Coast and Blackwood River Basins.

- A number of the resources are of marginal salinity (Collie, Warren and Denmark Rivers) and further progress on implementing restoration strategies will be required before new developments are likely to proceed. Salinity recovery programs in the Denmark and Collie river catchments for surface water resources could achieve potable water in 5-10 years, and possibly 25-30 years for the Warren river catchment.

- The Sustainable Yields of Table 2 are inventory estimates only, based primarily on notional estimates of Environmental Water Provisions.

Thorough assessment of EWPs has only been carried out for new sources developed in recent years. Comprehensive EWPs will need to be determined before each new (large scale) development proposal could proceed. Setting appropriate EWPs will prove a difficult challenge if streamflows continue to decline.

- Having an annual allocation does not always result in the licensee receiving this amount each year. For example, in some years irrigators supplied by Harvey Water have received 50% or less than their entitlement due to low storages in irrigation dams. The Water Corporation has significantly de-rated their dams (see Section 5) but this is still not reflected in their licences. New estimates of average annual yields are being completed for the Harvey and Collie River Basins to assist trading.

- The fact that a full entitlement is not taken up every year is not evidence that a resource is under-used. It may mean that there have been some wet years which are a means of replenishing drought reserves.
Surface water supplies are usually specified in terms of reliability of supply. Irrigators with a perennial crop that would die without irrigation require higher security water than irrigators growing annuals who can choose not to grow as much crop in dry years.

Some streams, especially those on the South Coast, are yet to be proclaimed. As a result, little planning has been carried out and no licences have been issued in these catchments. Streams are being progressively proclaimed as the resources become more utilised, or supplies decline due to climate change.

The remaining surface water supplies in the Busselton Coast area, if developed, could be used to supply regional needs and local industries as described in Appendix 1.

Given the above, the following conclusions can be drawn from Figure 3.2 and Appendix 1.

Most surface water resources in the South West of the state north of the Collie River Basin are already highly allocated.

When Allocation Limits are reduced using more recent flow data, the percentage of water allocated to divertible use will increase.

The main areas with large undeveloped resources are in areas with sensitive environmental flows (e.g. the Brunswick River which discharges into the Leschenault Inlet) or within newly proclaimed National Parks (e.g. the Donnelly River within the Greater Beedalup National Park).

The Collie and Warren River Basins are significant resources and the work to reclaim them from salinity is well justified. Further work will be required to reduce salinity to drinkable levels.

Regional water needs are growing with increased development but the South West is experiencing lower flows.

The development of the larger undeveloped surface resources of the Collie River to Warren River Basins inclusive, are important options for meeting current and future IWSS demands, especially if streamflows of the last eight years become the norm.

The DoE’s senior surface water hydrologist believes that even if these southern sources are de-rated by 35%, to account for streamflows observed over the last eight years, and some sources are not developed for environmental reasons, surface water resources in these southern river basins could still provide an additional 120 to 150 GL/yr of water at costs cheaper than or comparable with current desalination costs. This represents most of the growth in the IWSS demand expected by 2025, and over 50% expected by 2050, under the 170 kL/person/yr Demand Scenario with Medium Population growth (see later).

Up-to-date details on each surface water basin are included in Appendix 1.
Figure 3.1  Drainage Divisions and Surface Water Regions of Western Australia (DoE, 2005)
## Table 1 Status of allocation of surface water in Western Australia (DoE, 2005)

<table>
<thead>
<tr>
<th>Surface Water Drainage Division</th>
<th>River Basin</th>
<th>Sustainable Yield (Allocation Limit)* ML/yr</th>
<th>Licensed Private Allocation ML/yr</th>
<th>Licensed Allocation to Public Water Supply Providers (e.g. WC) ML/yr</th>
<th>Total Licensed Allocation* ML/yr</th>
<th>% Allocated</th>
<th>Potential Balance Available for Future Licensing ML/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>South West</td>
<td>South Coast</td>
<td>443,000</td>
<td>35,406</td>
<td>3,894</td>
<td>39,300</td>
<td>9%</td>
<td>403,700</td>
</tr>
<tr>
<td></td>
<td>South West</td>
<td>862,000</td>
<td>186,787</td>
<td>322,213</td>
<td>509,000</td>
<td>59%</td>
<td>353,000</td>
</tr>
<tr>
<td></td>
<td>Mid-West Avon</td>
<td>10,000</td>
<td>5,340</td>
<td>60</td>
<td>5,400</td>
<td>54%</td>
<td>4,600</td>
</tr>
<tr>
<td><strong>Sub-total South West</strong></td>
<td></td>
<td><strong>1,315,000</strong></td>
<td><strong>227,533</strong></td>
<td><strong>326,167</strong></td>
<td><strong>553,700</strong></td>
<td><strong>42%</strong></td>
<td><strong>761,300</strong></td>
</tr>
<tr>
<td>Indian Ocean</td>
<td>Murchison-Gascoyne</td>
<td>200,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0%</td>
<td>200,000</td>
</tr>
<tr>
<td>Pilbara</td>
<td></td>
<td>202,000</td>
<td>60,000</td>
<td>15,000</td>
<td>75,000</td>
<td>37%</td>
<td>127,000</td>
</tr>
<tr>
<td>Timor Sea</td>
<td>Kimberley</td>
<td>3,160,000</td>
<td>347,900</td>
<td>700</td>
<td>348,600</td>
<td>11%</td>
<td>2,811,400</td>
</tr>
<tr>
<td>Western Plateau</td>
<td>Western Plateau</td>
<td>1,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0%</td>
<td>1,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>4,878,000</strong></td>
<td><strong>635,433</strong></td>
<td><strong>341,867</strong></td>
<td><strong>977,300</strong></td>
<td><strong>20%</strong></td>
<td><strong>3,900,700</strong></td>
</tr>
</tbody>
</table>

Table 2 Status of Allocation of Surface Water in the study area (DoE, 2005)

<table>
<thead>
<tr>
<th>River Basin</th>
<th>Mean Annual Flow from Basin</th>
<th>Sustainable Yield (Allocation Limit)</th>
<th>Licensed Private Allocation</th>
<th>Licensed Allocation to Public Water Supply</th>
<th>Total Licensed Allocation</th>
<th>Estimated Use (in all areas)</th>
<th>Total Effectively Committed (Licensed + Estimated Use in Unlicensed Areas)</th>
<th>Reserved for Future Public Water Supply</th>
<th>Additional Allocations Requested</th>
<th>Total Effectively Committed plus Allocations Requested</th>
<th>Balance potentially available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swan Coastal</td>
<td>683,000</td>
<td>125,000</td>
<td>2,048</td>
<td>102,600</td>
<td>104,648</td>
<td>115,700</td>
<td>115,700</td>
<td>93%</td>
<td>0</td>
<td>550</td>
<td>116,250</td>
</tr>
<tr>
<td>Murray River</td>
<td>897,000</td>
<td>133,000</td>
<td>12,240</td>
<td>109,207</td>
<td>121,447</td>
<td>82,000</td>
<td>121,447</td>
<td>91%</td>
<td>0</td>
<td>36</td>
<td>121,483</td>
</tr>
<tr>
<td>Harvey River</td>
<td>215,000</td>
<td>149,400</td>
<td>43,670</td>
<td>147,800</td>
<td>147,800</td>
<td>66,900</td>
<td>147,800</td>
<td>99%</td>
<td>0</td>
<td>10</td>
<td>147,810</td>
</tr>
<tr>
<td>Collie River</td>
<td>340,000</td>
<td>165,000</td>
<td>78,578</td>
<td>94,638</td>
<td>94,638</td>
<td>59,300</td>
<td>94,638</td>
<td>57%</td>
<td>0</td>
<td>17,085</td>
<td>111,722</td>
</tr>
<tr>
<td>Preston River</td>
<td>145,000</td>
<td>62,611</td>
<td>-</td>
<td>6,261</td>
<td>6,261</td>
<td>3,000</td>
<td>6,261</td>
<td>13%</td>
<td>0</td>
<td>271</td>
<td>6,532</td>
</tr>
<tr>
<td>Busselton Coast</td>
<td>599,000</td>
<td>135,000</td>
<td>1,989</td>
<td>1,040</td>
<td>3,029</td>
<td>6,500</td>
<td>6,500</td>
<td>5%</td>
<td>0</td>
<td>3,171</td>
<td>9,671</td>
</tr>
<tr>
<td>Blackwood River</td>
<td>1,046,000</td>
<td>112,000</td>
<td>-</td>
<td>1,116</td>
<td>1,116</td>
<td>13,600</td>
<td>13,600</td>
<td>12%</td>
<td>0</td>
<td>-</td>
<td>13,600</td>
</tr>
<tr>
<td>Donnelly River</td>
<td>331,000</td>
<td>91,000</td>
<td>9,278</td>
<td>-</td>
<td>9,278</td>
<td>1,864</td>
<td>1,864</td>
<td>10%</td>
<td>0</td>
<td>820</td>
<td>10,098</td>
</tr>
<tr>
<td>Warren River</td>
<td>411,000</td>
<td>207,000</td>
<td>28,740</td>
<td>1,864</td>
<td>30,604</td>
<td>8,600</td>
<td>30,604</td>
<td>15%</td>
<td>0</td>
<td>892</td>
<td>31,495</td>
</tr>
<tr>
<td>Shannon River</td>
<td>708,000</td>
<td>58,090</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4,800</td>
<td>4,800</td>
<td>8%</td>
<td>0</td>
<td>-</td>
<td>4,800</td>
</tr>
<tr>
<td>Frankland River</td>
<td>205,000</td>
<td>6,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1,100</td>
<td>1,100</td>
<td>18%</td>
<td>0</td>
<td>-</td>
<td>1,100</td>
</tr>
<tr>
<td>Kent River</td>
<td>170,000</td>
<td>20,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>600</td>
<td>600</td>
<td>3%</td>
<td>0</td>
<td>-</td>
<td>600</td>
</tr>
<tr>
<td>Denmark Coast</td>
<td>210,000</td>
<td>36,900</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1,000</td>
<td>1,000</td>
<td>3%</td>
<td>0</td>
<td>30,000</td>
<td>31,000</td>
</tr>
<tr>
<td>Alban Coast</td>
<td>330,000</td>
<td>19,000</td>
<td>-</td>
<td>2,000</td>
<td>2,000</td>
<td>3,100</td>
<td>3,100</td>
<td>16%</td>
<td>0</td>
<td>2,000</td>
<td>5,100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6,290,000</strong></td>
<td><strong>1,307,390</strong></td>
<td><strong>243,264</strong></td>
<td><strong>277,557</strong></td>
<td><strong>367,800</strong></td>
<td><strong>556,427</strong></td>
<td><strong>556,427</strong></td>
<td><strong>40%</strong></td>
<td><strong>0</strong></td>
<td><strong>54,835</strong></td>
<td><strong>611,262</strong></td>
</tr>
</tbody>
</table>
Notes:

0 Sustainable Yield figures and licensed quantities only partly reflect the drying climate of recent decades. Sustainable Yield updates and licensed allocations granted since 2001 have been based on climatic conditions since 1975. Licences issued earlier were generally based on the longest available record at the time.

1 Sustainable Yield estimates are for fresh or marginal resources only.

2 Sustainable Yield updated from Water Audit estimate in 2000 to reflect additional sustainable draws from Samson Brook (8 GL/yr) and the coastal plain section of the Harvey River (4.4 GL/yr).

3 Sustainable yield updated from the 2000 Water Audit estimate to account for preliminary EWP for the Collie River below Wellington Dam (a reduction of 5 GL/yr).

4 Based on Water Audit (2000) estimates of actual use in licensed and unlicensed areas.

5 The sum of licensed allocations in proclaimed areas and estimates of unlicensed use in unproclaimed areas.

6 Sustainable Yield reduced from the 2000 Water Audit estimate by 4.9 GL/yr. A potential pipehead on the Weld River was foregone as a result of the Walpole Wilderness Area.

* River basins where the licensing provisions of the RiWI Act 1914 do not apply. Where estimated use or other commitments are known, an effectively committed total is quoted.

Additional background notes on each river basin are available.

Additional Allocations requested by the Water Corporation:

(a) 20 GL/yr application from the Collie River - Preliminary assessment of 17 GL/yr available.

(b) 25 GL/yr - general request for major source on Denmark River to meet long term demand.

(c) 2 to 5 GL/yr - Marbellup Brook (Denmark River Basin) - to recharge groundwater.
Figure 3.2  Surface water allocation status of the South West River Basins (DoE, 2005)
4. GROUNDWATER AVAILABILITY AND USE

The DoE allocation and licensing databases show that the total of all Allocation Limits (ALs) for fresh water\(^4\) from Groundwater Areas (GWAs) on the Perth Basin is 1,453 GL/yr, of which 52% has been licensed already, 124 GL/yr (8%) is held in public reserves and another 161 GL/yr (11%) has been applied for and is still to be decided (Figure 4.1, Table 3). If all of the water that is applied for is granted, 71% of available groundwater will be allocated.

Public water supplies are currently concentrated on the Perth North area with smaller extractions from the Jandakot Mound (Perth South) and from regional aquifers for Bunbury, Busselton and Geraldton.

Care must be taken in interpreting the figures for the following reasons:

- Plans (incorporating approximate Environmental Water Provisions) have only been prepared for 60% of the GWAs in the Perth Basin and therefore the level of confidence in the Allocation Limits is generally low.

- The impact of the dry years since 1975, and the even drier period since 1997, is still to be considered in setting the Allocation Limits. However, as stated previously, ALs are usually set below what is thought to be the long term Sustainable Yield of the aquifer.

- Actual use may not match the licensed allocations because in new developments, the uptake of the full entitlement may take several years.

- In some areas, non-metered users may be using more than their licensed allocations. Allocations are based on estimates of the amount of water required to grow a particular crop at a certain time of the year. The “crop factors” used in these estimates could be too low, a matter that is currently being reviewed in the Carabooda area. Allocations in excess of 500 ML/yr require bores to be metered, but metering exists at lower levels of use in Carnarvon and the northern Wanneroo area, where a scheme to install meters started in 2004, and for new licences in the South West region (e.g. Myalup sub-area).

- The Blackwood GWA has an Allocation Limit that has been set low due to uncertainty about the resource. This AL is being refined through investigations associated with the Water Corporation’s application for a 45 GL licence from the South West Yarragadee (included in the requested column in Table 3). A new limit is estimated to be available in May 2005.

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\(^4\) Where the water quality is brackish to saline, the volumes are not included in these figures. Some reserves have a marginal quality (500 – 1500 mg/L) and are used for some town water supplies.
Given the above, the following conclusions can be drawn:

- About 115 GL/yr of unallocated public reserves remain in the northern Perth Basin – 72 GL/yr in Gingin, 20 GL/yr in Jurien and 23 GL/yr in Arrowsmith. Some of these reserves are of marginal water quality (500-1500 mg/L) which can limit their direct use. Areas where fresh groundwater occurs within these groundwater resources are not well known at present. In some of these areas, groundwater levels are rising as a result of recharge under annual crops and pastures despite lower rainfalls in the area (G. Bott; R. Speed, pers. comms.). However, the impact of private abstraction is still not certain in the Gingin area in particular and the availability of these reserves would require much more monitoring before they could be confirmed. Additional deep bores are required in the proposed Casuarina Sub-area of the Gascoyne GWA to better define the Yarragadee aquifer south of the Northampton Block. This work could significantly alter the Allocation Limit.

- The size of the additional allocation requested (Table 4) is an indication of areas undergoing rapid growth. These are most apparent in the Blackwood, Yanchep, Gingin, Busselton-Capel and Bunbury GWAs.

- The Collie GWA is over-allocated as a result of water being used to dewater open cut coal mines and for power generation. Groundwater abstraction at rates significantly greater than recharge is likely to continue well into the future. Mining the groundwater resources is allowed under a State Agreement (Collie Coal Agreement 1979) Act. The current rate of recharge is such that it will take several decades for groundwater levels to recover after extraction ceases. In the meantime, exposed sulphides will oxidise and groundwater acidity may rise.

- Reserving groundwater for public use may conflict with landuse if later work shows that the best wellfield location has already been contaminated or affected by abstraction for private benefit. The drinking water may not be needed for several decades and the eventual water service provider may not have been decided, making long-term protection difficult.

- Individual aquifers within a groundwater area may be fully- or over-allocated but the Allocation Status for the overall resource may be shown as “under-allocated” due to other aquifers being little used. Figure 4.2 shows the allocation status of aquifers using a four-fold classification with the highest allocation being >100% committed. The figure shows the percentage of groundwater resources in each category and is not weighted for resource size.

- Areas with 19% or more of their aquifers over-allocated include the Perth North region, Collie GWA and Busselton-Capel GWA. In the latter case the Allocation Limit is currently under review. However, in the Collie GWA and Perth North region, groundwater levels in several aquifers are in decline as a result of lower recharge and high extraction.

- A number of areas have aquifers with less than 30% allocated. Some of these may be expensive to develop or may contain poor quality water.
Groundwater Allocation Status of the Perth and Collie Basins

Groundwater Allocation*

- Licensed Private Allocation
- Licensed Allocation to Public Water Supply Providers
- Public Water Supply Reserve Committed
- Additional Allocation Requested
- Unallocated Groundwater

* Only allocations >1% of the allocation limit are displayed in the pie charts.

Figure 4.1  Groundwater allocation status in the Perth and Collie Basins (DoE, 2005)
Figure 4.2  Groundwater resource allocation category in the Perth and Collie Basins as at February 2005 (DoE)
<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gascoyne (Casuarina SA only)</td>
<td>15,300</td>
<td>-</td>
<td>-</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.00</td>
<td>15,300</td>
<td>Yarragadee 500-1000; potential major source for Geraldton</td>
<td></td>
</tr>
<tr>
<td>Arrowsmith GWA</td>
<td>183,500</td>
<td>35,309</td>
<td>14,640</td>
<td>49,949</td>
<td>27</td>
<td>22,700</td>
<td>40</td>
<td>480</td>
<td>73,129</td>
<td>40</td>
<td>110,371</td>
<td>Yarragadee and Parmelia; salinity 500-1000; potential for major source</td>
</tr>
<tr>
<td>Jurien GWA</td>
<td>89,500</td>
<td>4,479</td>
<td>2,790</td>
<td>7,269</td>
<td>8</td>
<td>20,000</td>
<td>30</td>
<td>5,390</td>
<td>32,659</td>
<td>36</td>
<td>56,841</td>
<td>Yarragadee and Superficial, about 30% &lt; 500; potential major sources</td>
</tr>
<tr>
<td>Gingin GWA</td>
<td>338,270</td>
<td>122,005</td>
<td>2,370</td>
<td>124,375</td>
<td>37</td>
<td>72,145</td>
<td>58</td>
<td>42,077</td>
<td>238,496</td>
<td>71</td>
<td>99,774</td>
<td>85% in Superficial and surficial; large proportion is &gt;1000; potential sources with environmental constraints</td>
</tr>
<tr>
<td>Perth North (Perth to Gingin)</td>
<td>272,190</td>
<td>124,467</td>
<td>153,748</td>
<td>278,215</td>
<td>102</td>
<td>-</td>
<td>102</td>
<td>8,121</td>
<td>286,337</td>
<td>105</td>
<td>-</td>
<td>Fully allocated, water levels falling in all aquifers</td>
</tr>
<tr>
<td>Perth South (Perth-Mandurah)</td>
<td>198,967</td>
<td>114,611</td>
<td>11,245</td>
<td>125,856</td>
<td>63</td>
<td>-</td>
<td>63</td>
<td>10,697</td>
<td>136,553</td>
<td>69</td>
<td>62,414</td>
<td>90% is Superficial, distributed, low yielding and much is &gt;500</td>
</tr>
<tr>
<td>South West Coastal GWA</td>
<td>72,320</td>
<td>29,507</td>
<td>530</td>
<td>30,037</td>
<td>42</td>
<td>40</td>
<td>42</td>
<td>1,468</td>
<td>31,505</td>
<td>44</td>
<td>40,775</td>
<td>All Superficial; major potential source on Yanget Mound &lt;250, elsewhere constrained by salt water interfaces</td>
</tr>
<tr>
<td>Regions in Perth Basin</td>
<td>Allocation Limit (ML/yr)</td>
<td>Licensed Private Allocation (ML/yr)</td>
<td>Licensed Allocation to Public Water Supply Providers (ML/yr)</td>
<td>Total Licensed Allocation (ML/yr)</td>
<td>% Allocated</td>
<td>Public Water Supply Reserve Committed (ML/yr)</td>
<td>% Allocated and Committed</td>
<td>Additional Allocation Requested (ML/yr)</td>
<td>Total Allocated, Committed and Requested (ML/yr)</td>
<td>% Allocation, Committed and Requested</td>
<td>Balance Available for Future Licensing (ML/yr)</td>
<td>Comments (salinity in mg/L TDS)</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------------</td>
<td>-----------------------------------</td>
<td>-------------------------------------------------</td>
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<td>---------------------------------</td>
<td>---------------------------------------------</td>
<td>---------------------------------</td>
<td>----------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Murray GWA</td>
<td>69,900</td>
<td>12,146</td>
<td>1,000</td>
<td>13,146</td>
<td>19</td>
<td>-</td>
<td>19</td>
<td>819</td>
<td>13,965</td>
<td>20</td>
<td>55,935</td>
<td>60% is Superficial, much &gt;500; most Leederville &gt;500; no monitoring network in Leederville</td>
</tr>
<tr>
<td>Bunbury GWA</td>
<td>54,600</td>
<td>20,141</td>
<td>13,744</td>
<td>33,885</td>
<td>62</td>
<td>2,925</td>
<td>67</td>
<td>8,107</td>
<td>44,840</td>
<td>82</td>
<td>9,760</td>
<td>45% in low yielding Superficial; balance distributed in Yarragadee and Leederville</td>
</tr>
<tr>
<td>Busselton-Capel GWA</td>
<td>131,660</td>
<td>64,935</td>
<td>8,500</td>
<td>73,435</td>
<td>56</td>
<td>6,387</td>
<td>61</td>
<td>31,785</td>
<td>111,605</td>
<td>85</td>
<td>20,055</td>
<td>All available water in low yielding distributed superficial, &gt;1000 along coast</td>
</tr>
<tr>
<td>Blackwood GWA</td>
<td>27,450</td>
<td>12,154</td>
<td>435</td>
<td>12,589</td>
<td>46</td>
<td>-</td>
<td>46</td>
<td>52,387</td>
<td>64,976</td>
<td>237</td>
<td>-</td>
<td>Includes 45 GL application for Yarragadee; large storage of &lt;500 in Yarragadee currently being assessed</td>
</tr>
<tr>
<td>Total Perth Basin</td>
<td>1,453,657</td>
<td>539,753</td>
<td>209,002</td>
<td>748,755</td>
<td>52</td>
<td>124,197</td>
<td>60</td>
<td>161,330</td>
<td>1,034,064</td>
<td>71</td>
<td>471,225</td>
<td></td>
</tr>
<tr>
<td>Collie GWA</td>
<td>22,300</td>
<td>33,727</td>
<td>33,727</td>
<td>33,727</td>
<td>151</td>
<td>3,470</td>
<td>37,196</td>
<td>167</td>
<td>37,196</td>
<td>167</td>
<td>471,225</td>
<td>Allocated for coal mining and power generation under State Agreement Act</td>
</tr>
<tr>
<td>Grand total</td>
<td>1,475,957</td>
<td>573,480</td>
<td>209,002</td>
<td>782,482</td>
<td>53</td>
<td>124,197</td>
<td>61</td>
<td>164,800</td>
<td>1,071,260</td>
<td>650</td>
<td>471,225</td>
<td></td>
</tr>
</tbody>
</table>
5. **WATER SUPPLY SCHEMES**

5.1 **Integrated Water Supply Scheme**

The relative size of surface and groundwater sources, and demand centres, within the current IWSS is shown in Figure 5.1. The last 30 years has been used as a planning base.

The following features are apparent from Figure 5.1:

- Most groundwater sources (Perth Basin) are lie north of the Swan River;
- All surface water sources (hills catchments) are located east or south of the Swan River;
- Metropolitan North demand is currently half that of the south (including Mandurah and South West towns);
- Many of the surface water sources are relatively small; and
- The demand from the G&amp;AWS exceeds the Mundaring and Lower Helena sources.

As climatic conditions change from year to year the resultant inflow to each surface water source can vary. While storage at most dams can provide capacity to store high inflows, or allow storage reserves to be used in low inflow years, it is rarely possible to use all sources in the same way each year. As a result the desired contribution from each surface water source can vary from year to year. The existing pipe network allows water from a variety of sources to be used to meet local area demands. Except during high summer demand periods there is flexibility to increase or to reduce use from each source and capacity to take most sources off line for maintenance.

With the existing pipe network it is also now possible to transfer water into Mundaring, Victoria and North Dandalup. Groundwater can be transferred to Mundaring or Victoria and surface water can be transferred to all three.

The interconnected system provides considerable flexibility but also increases operational complexity. The advantage is that enables water to be moved to areas which may have high demand, low seasonal inflows or high salinities. It also allows water to be added to reservoirs which would otherwise be too low to extract water of drinking quality (the final 10% of water is often not recoverable from reservoirs).

Currently the Wellington Reservoir is not connected to the IWSS but this connection is proposed if salinities can be reduced using state and federal funds and trihalomethanes (THM) generation problems are addressed. Water source protection requirements, including limits on recreational use, would also need to be met before the water could be used for drinking.

The impact of using 8 rather than 30 year average inflows to estimate the yield of surface and groundwater sources is shown by comparing Figure 5.1 with Figure 5.2. Points to note are:
The surface water sources (east of the coastal plain) reduce significantly more than groundwater sources (close to the coast), although both will be impacted by climate change;

The imbalance between demand from the Metropolitan South and its surface water sources becomes larger; and

The imbalance between sources and G&AWS demand now becomes much greater.
Figure 5.1 Demand centres and supply sources for IWSS sources assuming 30 year climate scenario (1975-2004) as at 2004 (Water Corporation)
Figure 5.2  Demand centres and supply sources for IWSS sources assuming 8 year climate scenario (1997-2004) as at 2004 (Water Corporation)
5.2 Goldfields and Agricultural Water Scheme

This scheme celebrated 100 years of operation in 2003. Its traditional water source has been the Mundaring Weir on the Helena Catchment. Clearing controls were introduced in 1978 to prevent salinity levels from exceeding drinking water standards. Currently, salinity levels exceed 400 mg/L in dry years, close to the 500mg/L recommended level for drinking water.

Ten years ago, raising the Mundaring Dam wall was planned to increase supply (WAWA, 1995). Since that time, the frequency of overflow of Mundaring Weir has decreased and raising the dam wall is no longer a priority. To provide a secure supply to the G&AWS, Mundaring Weir has been dependent on intermittent augmentation from other sources since 1979. In recent years the inflow has been so low that up to 85% of the water supplied from Mundaring Weir has come from other sources, including groundwater from the Coastal Plain.

The water demand in the GAWS (about 27 GL/yr) is increasing slowly, mainly due to increased demand from the Goldfields, which currently receives about 15 GL/yr. There has been an interest in developing a new source of water for the Goldfields, including a desalination plant at Esperance. The Economic Regulation Authority is currently evaluating the cost of transporting water from Perth to Kalgoorlie-Boulder so that it can be compared with the cost of providing desalinated seawater by pipeline from Esperance to Kalgoorlie-Boulder as proposal by United Utilities.

5.3 Great Southern Towns Water Supply Scheme

This scheme supplies about 11 GL/yr from the Harris Reservoir to Collie, towns located in the Upper and Lower Great Southern and nearby farmland. In most years there are up to 3 years’ supply held in reserve in the dam (after provision for the environment). The next highest use are dilution of saline water in the Wellington Reservoir and then the IWSS.

Town demand has stabilised in recent years and is not expected to grow significantly. There are tentative plans to desalinate groundwater from under the Katanning townsite which may replace scheme water supplied to businesses and residents in the town.

5.4 Gnangara and Jandakot Mounds

During the 1970s and 1980s the IWSS used groundwater to augment its surface water supplies for the growing northern suburbs. Currently the IWSS gets more than 60% of its water from groundwater sources and pumps it to the southern suburbs and the G&AWS.

The comparatively water-rich southern suburbs became water-poor with a decrease in runoff into the dams. A pump station at Belmont is very important for this north to south transfer. Consideration of future demand to some extent affects which source will be developed next – one north or one south of the city.

While public water abstraction from both Mounds is extremely important, it needs to be placed in context. Currently 151 of the 158 GL/yr of groundwater supplied to the IWSS comes from Gnangara Mound, and 93 of the 158 GL/yr (59%) comes from confined aquifers.
which have progressively been reserved for public water supplies since the late 1990s (Figure 5.3 and Figure 5.4).

Public groundwater abstraction currently constitutes only 32% of the total extraction from the Gnangara Mound. Both public and private abstraction has increased by more than 80% since 1992 (Figure 5.5). This period overlaps with the particularly dry period since 1997 and a maturing of the pines growing on about 23,000 ha of the Mound. As a consequence of these factors, storage in the main part of the Mound (north of Gnangara Road and east of Wanneroo Road) has declined by 400 GL since 1992 (Figure 5.6).

The intensity of use of the Mound can be seen by licence statistics. State-wide, the DoE manages 13,400 surface and groundwater licences, which excludes stock and domestic bores, as these no longer require a licence. About 7,600 licences (57%) are held in the Perth region.

Sustainable yields from the aquifers comprising the Gnangara Mound are currently under review and, because of concerns over the sustainability of the current rates of abstraction, may be revised downwards for both public and private water supply.
Figure 5.4  Jandakot Mound (Perth South) 2004 Groundwater Use (GL/yr)  
(from Davidson and Yu, 2004)

Figure 5.5  Increase in groundwater abstraction from the Gnangara Mound since 1980 (DoE, 2005)
Figure 5.6  Decrease in storage in the upper Gnangara Mound since 1979 (DoE, 2005)
6. **WASTEWATER AVAILABILITY AND USE**

6.1 **Current wastewater volumes and qualities**

The main wastewater treatment plants in the urban area collectively discharge about 100 GL of secondary treated wastewater to the Indian Ocean each year (Figure 6.1). This amount represents almost 40% of the drinking water supplied. Most of the balance is lost as evaporation after being applied to lawns and gardens. In the most part, Perth has a wastewater system that is completely separate from stormwater drainage and therefore it does not have the problems experienced by many cities in which storms can over-load the sewerage system.

About 45% of the treated wastewater is discharged through the Cape Peron Outfall; 20% through the Subiaco Outfall; and 35% through the Beenyup Outfall. Smaller, non-coastal treatment plants have been progressively replaced by the larger plants close to ocean outfalls.

Currently, Perth recycles about 5% of its wastewater. This figure increased from only 3% (3 GL/yr) in 2003 as a result of the Kwinana Water Recycling Plant (KWRP) which started to treat wastewater from Woodman Point WWTP in November 2004 using reverse osmosis desalination.

6.2 **Expected wastewater volumes and quantities**

By 2012 about 165 GL/yr of wastewater is expected to be generated throughout Western Australia. Achieving a 20% re-use target (Government of WA, 2003) will require 33 GL to be re-used.

It is anticipated that this re-use will be composed of:

- Country recycling – 15 GL/yr (9.1% of the 20% target amount)
- KWRP – 6 GL/yr (3.6%)
- In-treatment plant use – 3 GL/yr (1.8%)
- Alcoa 2 GL/yr (1.2%)
- To be decided – 7 GL/yr (4.3%)

Currently, country areas re-use 9 GL/yr, about 75% of the state’s total. By 2012, country re-use (15 GL/yr) should represent almost half of the state-wide re-use volume. Perth’s metropolitan re-use is low by Australian capital city standards but this should change if new schemes are implemented which result in the 20% target being met before the target date. A more ambitious target is worth considering in light of other sources options and opportunities for appropriate re-use of water.
Figure 6.1  Wastewater areas for the Perth Metropolitan area (Source: Water Corporation, 2002)
6.3 Substitution options

The additional 7 GL of re-use could be achieved, and even exceeded, if several current proposals are developed further. These include:

- Carabooda Horticultural Precinct – there is the potential to use about 20 GL/yr from the Beenyup (and eventually Alkimos) wastewater treatment plants through managed aquifer recharge of the aquifer up-gradient of the proposed precinct. This would require environmental, health and social factors to be addressed;

- Irrigation of public open space either directly (e.g. McGillivray Oval) or indirectly (e.g. recharge of aquifers in the Mosman Peninsula for eventual extraction for urban irrigation).

- Maintaining environmental values (e.g. Perry Lakes, groundwater dependent ecosystems in the northern Wanneroo area);

- Managed aquifer recharge for re-pressurising confined aquifers in public drinking water supply areas, if health, social and environmental factors can be addressed;

- Delivering treated wastewater, stormwater and/or groundwater through a dedicated (third) pipe network to new developments in the Southern River and Mandurah areas; and

- Retrofitting existing urban areas and large buildings to use treated wastewater.

Many of these options are being progressed by a group under the Water Taskforce which has the ability to address environmental and health concerns in the relevant regulatory authorities.

While there is considerable community interest in greywater re-use, the subsidy scheme for appliances has had limited uptake so far. This results from the added expense of plumbing the systems for use in toilet flushing, sub-surface irrigation, etc. Improvements in design, changes to regulations (Health Department, Local Government) and changes to the cost or availability of water alternatives should increase the rate of adoption in future.

The development industry has a strong interest in grey water reuse for greenfield estates (e.g. parks, garden use). All re-use is heavily influenced by the cost of alternative water sources (scheme, self supply) and by public perception of the risks and acceptability of different water sources. Studies are being carried out to better understand these perceptions.

The role of the Water Corporation in wastewater and stormwater re-use is constrained by its charter that requires it to act in a commercial manner unless directed by government and compensated with Community Service Obligation payments. A policy paper on drainage reform in the state may help to clarify future roles.
7. STORMWATER AVAILABILITY AND USE

About 40% of the Perth Metropolitan area is serviced by the main drain systems operated by the Water Corporation. It is estimated that these drains discharge between 100 and 130 GL of water per annum to river and ocean outfalls (Geoff Hughes, Water Corporation, pers. comm.).

Local government drains, which cover the entire Perth Metropolitan area and comprise approximately 80% of the constructed system, either discharge to Water Corporation main drains, or directly to aquifers, the river or the ocean. There is no reliable estimate of total stormwater discharge as very few drains are monitored.

The drains pick up both stormwater flows (from roads, driveways and low permeable soils) and groundwater (if the drains have been constructed to lower groundwater levels to protect built infrastructure).

Away from the river and ocean the drains usually discharge into absorption basins (which have no outlet other than seepage to the underlying Superficial Aquifer) or into compensation basins (which have an overflow – usually to the Ocean or river but sometimes to other basins). In a number of cases the water is pumped to allow it to discharge to one of these outlets.

Most local governments require residents to discharge their roof runoff on their block. This is achieved using soakwells at the base of each downpipe.

Many car parks are also required to direct runoff into large soakwells to reduce the water entering the street drainage system.

As a consequence of these actions, 70 to 80% of stormwater generated from hard standings is likely to recharge the Superficial Aquifer where it exists. On clayey soils close to river floodplains and the foothills, local infiltration is much more difficult. Options for reuse are limited and more traditional urban stormwater practices are used.

A review of Perth’s drainage scheme network is required to assess the opportunities to increase recharge to the groundwater and reduce the annual discharge to the rivers and ocean. Some local governments are engaged in this already (e.g. Western Regional Organisation of Councils, South Perth) and new developments in the Southern River area are required to have no net increase in nutrient loads to the Swan Canning Estuary as a result of their development.

Figure 7.1 shows suburbs in the main drain catchments (i.e. suburbs likely to be draining groundwater) where per capita scheme water use is more than 20 or more than 40% above the 2012 target of 105 kL/person/day. There may be potential to increase stormwater recharge in these areas and increase the number of domestic bores to reduce the use of drinking water on gardens and lawns. The potential probably also exists in other suburbs where groundwater levels are not in decline or where there are no sensitive wetlands being affected by reduced recharge as a consequence of reduced rainfall.

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5 This target is often quoted as 155 kL/person/day but this figure includes industrial use of scheme water.
Figure 7.1 Suburbs in the main drain catchments that exceed annual per capita water use targets by 20% (yellow) or 40% (red). Source: Water Corporation data.
8. **DRINKING WATER DEMAND TO 2030**

8.1 **Expected population growth**

According to the WA Planning Commission (WAPC, 2004) the Greater Perth area (Metropolitan Perth, Mandurah and Murray) had a population of 1.46M in 2001 and this is expected to grow to 1.99M in 2021 and to 2.22M in 2031. This is an annual rate of about 26,000 people and 12,000 dwellings. Therefore Perth is expected to be growing by about an Albany or half a Bunbury each year.

The Water Corporation use the data in Figure 8.1 to estimate future demand for water in the Perth region. They use the highest of three medium projections done by the ABS in 2003, and by the Ministry for Planning in 1995 and 2000.

![Figure 8.1 Population projections for the Perth Statistical Division (Water Corporation, 2005)](image)

On a regional basis, Perth contains about 73% of the state’s population (Figure 8.2) with the next largest regions being the South West (3.8%), Peel (4.1%), Wheatbelt (3.8%), Goldfields-Esperance and Great Southern (each 2.8%). It is therefore conceivable that the three integrated water supply schemes could be delivering water to almost 85% of the state’s population in 15-25 years time.

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6 Taking account of the fact that the GAWS and GSTWS does not service all people in these areas, and Bunbury and Busselton have independent supplies. Perth and Peel are expected to grow faster than the state average over this period.
8.2 Per capita consumption

Consumption of scheme water since 1940 has been as low as 100 kL/person/yr and as high as 235 kL/person/yr. Consumption has been affected by growth in affluence, periodic restrictions, the adoption of a pay-for-use scheme and educational campaigns.

Having easy access to the Superficial Aquifer has allowed substitution of scheme drinking water to occur in Perth much more than in comparable cities. This is one reason why per capita consumption did not return to pre-restriction levels after sprinkler bans were lifted in 1979. The number of domestic bores was estimated to have more than doubled in Perth during the next five years as a result of these restrictions.

The State Water Strategy has set an IWSS scheme water consumption target of 155 kL/person/yr by 2012 (Government of Western Australia, 2003). This is currently being achieved under two-day per week restrictions but the intention is to achieve this without the need for restrictions.
Because this target amount includes industrial water use, the domestic target is actually only 105 kL/person/yr. About 50 suburbs are currently using 150 kL/person/yr or more, which is 43% more than the target amount, even under 2 day a week sprinkler restrictions.

In 1995, Perth’s domestic water users were estimated to be amongst the highest water consumers in the world once self supply using domestic bores was taken into account (WAWA, 1995).

The imposition of restrictions in most Australian cities makes up-to-date comparisons difficult. However, most domestic bores are assumed to extract about 800 kL/yr and result in scheme water savings of about 250 kL/property. When added to the current scheme water demand, average water consumption by Perth users is almost certainly the highest in Australia and very high by world standards. It must, however, be remembered that the water used by domestic bores is effectively recycled stormwater which reduces the need to use drinking water outside the house. If the estimates of 800 kL per bore per year are correct (based on a consultant study for the WRC) then there is a lot of scope for improved efficiency, which may allow more bores to be installed with the same or less impact on the aquifer.

### 8.3 Drinking water demand

The current demand for water from the IWSS and GAWS under two day per week sprinkler restrictions is about 261 GL/yr with 158 GL of this being from Metropolitan south – which does include the Mt Eliza and Bold Park reservoir zone (Figure 5.1).
The Water Corporation has estimated the growth in demand under per capita consumption scenarios of 155 and 170 kL/person/yr and median and high population growth projections (Table 4). The current demand forecast under the 155 kL/person/yr scenario is 265 GL/yr, only marginally higher than the current demand with restrictions in place.

### Table 4 Estimated demand for drinking water in the IWSS and GAWS under various assumptions (Water Corporation)

<table>
<thead>
<tr>
<th>Time horizon</th>
<th>IWSS and GAWS Demand (GL/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>155 kL/person/yr Demand Scenario</td>
</tr>
<tr>
<td></td>
<td>Medium population growth</td>
</tr>
<tr>
<td>2005 Current demand under 2 day/week restrictions</td>
<td>261</td>
</tr>
<tr>
<td>2015</td>
<td>315</td>
</tr>
<tr>
<td>2025</td>
<td>360</td>
</tr>
<tr>
<td>2050</td>
<td>455</td>
</tr>
</tbody>
</table>

If the 155 target is not achieved, the IWSS will need to source an additional 28 GL in 10 years time and an additional 40 GL in 45 years time.

If 155 kL/person/yr can be achieved, then high population growth for the next 20 years could be serviced with the same amount of water that would be used for a 170 kL/person/yr consumption level and a medium population growth.

To achieve a 155 kL/person/yr target without permanent water restrictions of at least two days per week requires a number of measures. These are detailed in Section 11.
9. **TOTAL WATER DEMAND**

9.1 **Water demand by region**


These demand regions are based on local government administrative areas rather than on Groundwater Management Areas or Drainage Basins. However it is possible to approximately align demand and supply into a single map to show their relationships (Figure 9.1). The supply data relate to fresh and brackish surface water supplies and all groundwater supplies, most of these being fresh or brackish. That is, no saline surface water flows are included in the supply estimates.

The red dotted circles show the total water available in each demand centre. The Perth demand area presently has the greatest supply, which probably reflects the intensity with which these resources have been investigated and exploited rather than the hydrology of the Perth region.

If this is the case, the yield of the other seven demand regions is probably also underestimated and further investigations are required to better understand these resources.

The 2005 water demand for the Perth centre exceeds its available supply so that water from the Peel and Preston demand centres (Darling Range dams) to be transferred to Perth. In turn, the Perth region supplies 26 - 27 GL/yr to the Goldfields and Agricultural Water Scheme, a volume that is not included in the 2005 demand because it services another region. It is probably unusual for a city to supply so much of its demand.

If the South West Yarragadee licence is issued to the Water Corporation this will allow transfer of water from the Blackwood demand centre to Perth as well.

Figure 9.1 may over-estimate future supplies because of climate change but it may also under-estimate some supplies because of the precautionary approach used to set allocation limits in water resources with limited information.

Outside of Perth, only the Preston demand centre is expected to exceed its supply by 2020. It can therefore be tentatively concluded that the potential water supply will be greater than the expected demand in areas north and south of Perth for at least the next 15 years.

To date there has been relatively little trading of water to higher value uses in the South West, which would also facilitate water demands being met if recommendations from the National Water Initiative and/or the Irrigation Review Steering Committee are adopted.
Water Demand Scenarios

- Upper limit estimate of total water resource potential

- 2005 Potential demand
- 2010 Potential demand
- 2015 Potential demand
- 2020 Potential demand


Figure 9.1 Water demand by region in the South West (DoE, 2005)
9.2 Water demand by sector

The Water Assessment 2000 report (WRC, 2000) indicated that agriculture uses about 40% of the total water used in the state (65% of the surface water used, 25% of groundwater used) and mining uses a further 24% (Figure 9.2).

Figure 9.2 Water use by sector in 1999 – 2000 (WRC, 2000)

Household water use constitutes about 13% of all use, its source being split almost equally between surface and groundwater sources.

Public water supply represents 18.5% of the total water use in WA (Figure 9.3).

Figure 9.3 Statewide volume of water used by user group (public water supply providers versus private users) estimated for the year 2000 (WRC, 2000)
The main increases in demand for water are likely to come from agriculture and mining (Figure 9.4). These estimates were made using the Monash CGE (computable general equilibrium) model which estimates water demand growth as a function of economic growth.

Work for the Chamber of Minerals and Energy has recently concluded that a shortage of water was not an impediment for most mining companies as they usually develop their own groundwater sources close to mines and remote from other users (ECS, 2004). The life of the mines is finite, giving time for resources to be replenished after mine closure. Much of the water used in the mining sector is of poor quality and there are only a few parts of the South West where there is significant competition with other users (ECS, 2004).

![Figure 9.4 Estimated growth in water demand by sector (WRC, 2000).](image)

Growth in water demand for agricultural irrigation is harder to forecast but detailed estimates for the horticulture, viticulture and dairy industries in the South West (ECS, 2003) indicated that the demand closely approximated that made in the Water Assessment 2000 report, the state-wide results of which are shown in Figure 9.4. Different demand methodologies were used which gives some confidence in the results.
10. FUTURE POSSIBLE IWSS SOURCES

10.1 Direct sources for the IWSS

The Water Corporation periodically updates its source development plan, the most recent being in 2005. Previous major reviews were carried out in 2001 and 1995. The impact of new knowledge and climate change on the timing and sources has been significant as is shown in Appendix 2.

The current IWSS source development plan has the following sources being considered:

- **Seawater desalination.** A 45 GL/yr reverse osmosis plant located at Kwinana is due for commissioning in October 2006 if approval is given for construction in April 2005. The capital cost would be about $324M with an annual operating cost of $24M. Greenhouse gas emissions would be offset by increased renewable energy generation. The cost of water from the plant has been estimated at $1.11/kL.

  Desalination costs have decreased from about $2.80 to about $1.11/kL in the past 15 years, compared with an increased cost of piping water from the Kimberley of $4.80 to $6.05/kL over the same time period according to GHD (2004).

- **Water trading Stage 1.** About 17 GL/yr of water will be available for permanent trade after piping of irrigation supply channels in the Waroona and Harvey Irrigation Districts. The capital cost will be about $111M with annual operating cost between $1 and $2M. The trade will require current transfer capacity to be increased, contributing to the costs. The resulting cost of the water has been estimated at about $0.50/kL. A similar amount of water may be available in the medium term from efficiency improvements in the Collie Irrigation Area. However, this will depend on recovery of the Wellington Reservoir from salinity, for which a $30M engineering scheme under the National Action Plan has been started.

- **South West Yarragadee groundwater.** Abstraction of 45 GL/yr from this fresh water resource south of Nannup is planned if regulatory approvals are obtained in late 2005. Scheme construction would take a further two years. The capital cost is expected to be about $362M and the annual operating cost about $10M. This results in water costing about $0.85/kL. Some surface water sources may be developed at a later stage if harvesting of winter flows entering the saline Blackwood River is feasible.

- **Wellington Dam pumpback.** Between 12 and 17 GL/yr of currently unallocated water from the Wellington Reservoir water could be transferred to the Stirling Trunk Main if water quality considerations can be addressed. Total capital costs would be about $70M with an annual operating cost of about $5M. This would result in the water costing about $0.33/kL. As mentioned above, a further 15-20 GL/yr could be harvested from the Lower Collie River in the future.

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7 This estimate is based on yields in the South West Catchments since 1975.
- Eglinton groundwater. It is planned to extract 15 to 17 GL/yr from both the Leederville Formation and the Superficial Aquifer under new suburbs in the North West corridor. The bores can only be located once the structure plan has identified where roads and other infrastructure will be located. Use of this source option will remain constrained until urban land development is sufficiently advanced. The capital cost would be about $45M and the annual operating cost about $4M. The water will cost about $0.70/kL once it is treated and connected to the system.

- Yanchep groundwater. Similar to the Eglinton wellfield, between 9 and 11 GL could be extracted from under new urban developments. Bores using Yanchep groundwater will provide ongoing supply to the growing Two Rocks and Yanchep communities. Full development of the scheme will also be constrained by the rate of urban development.

- Pine harvesting over Gnangara Mound. Removal of the 22,000 ha of pines in the next 25 years could allow up to 20 GL of additional water to be withdrawn relative to the with-pines scenario, depending on what the pines are replaced with. CALM are to develop a plan for Gnangara Park which will enable nature conservation, recreation and water harvesting to be catered for. If removing the pines allows the recommissioning of bores that are currently switched off because of environmental considerations, the cost of this additional water from Gnangara could be as low as $0.20/kL. Options to preferentially remove pines near the wellfields are being explored. However, the pines will be processed by a new Laminated Veneer Lumber plant, which requires 40+ year old pines to be veneered. Recent fires and reduced growth rates due to low rainfall have resulted in the suitable pine resource being heavily committed already.

- Catchment management in the Darling Range water supply catchments. Up to 40 GL could be available at a cost of about $0.22/kL if excessive regrowth of the jarrah forest in existing water supply catchments is reduced, exotic plants are removed from rehabilitated bauxite mining sites and burning regimes are changed. If approved, a trial in the Wungong catchment will start in 2005/06 which could result in up to 6 GL/yr of additional runoff within five years.

- Karnup-Dandalup groundwater. Up to 22 GL/yr may be available to the Metropolitan South demand area and close to existing supply pipes. Considerable planning and investigations would be required well in advance of any wellfield being approved.

- Gingin groundwater. Between 20 and 30 GL/yr may be available from this source in future. There are issues about the complexity of the geology, competition with horticulturists and water quality. All these will require investigation, monitoring and planning well in advance of any development. As indicated in Section 3, public water has been set aside for future use in the Gingin, Jurien and Arrowsmith Groundwater Management Areas. However, there are limitations to their development.

- Brunswick River. Subject to investigations, between 25 and 30 GL/yr could be available from the Brunswick River, North East of Bunbury. Flow is into the environmentally sensitive Leschenault Inlet.
10.2 Indirect sources

There are several options being investigated which may benefit the IWSS indirectly. These include:

- **Seawater desalination at Esperance to provide drinking water to the Goldfields.** If a desalination plant is built it could reduce the IWSS water required for the GAWS scheme by about 15 GL/yr.

- **Desalination of saline groundwater from under rural towns to augment the scheme supply.** There is a proposal to develop a 200 m$^3$/day desalination plant in Katanning to provide water for an abattoir and reduce the demand on the Great Southern Towns Water Scheme by about 70 ML per annum. This would only be cost effective if it averted salinity damage to infrastructure results of about $1.6M over 20 years. If the capital costs were provided from either the state or federal governments, the operating costs would result in water costing about $1.25/kL.

- **Managed Aquifer Recharge (MAR) using treated wastewater for environmental maintenance and horticulture in the Carabooda area.** It has been proposed that up to 20 GL/ha of treated wastewater could be used to recharge the groundwater in the Carabooda area for indirect use in horticulture and to retain the conservation value of wetlands and the Yanchep caves. This is unlikely to result in increased public abstraction from the Gnangara Mound in areas that have bores turned off. However, it would increase the confidence with which wastewater is re-used and could accelerate its use in pressurising aquifers or in replacing scheme water used in current applications (e.g. third pipe schemes in new developments).

- **Increased self supply by industry using scheme water.** Not all industries need a supply of water that is of drinking standard. The price paid by industry is close to the marginal cost of supply so there is already an incentive for them to develop other sources if they are available.

- **Increased self supply by domestic users currently applying drinking water to lawns and gardens.** As shown in Section 11, reducing the amount of scheme water use on lawns and gardens by encouraging people to install domestic bores is the most cost-effective subsidy that the government currently has. However, this may increase total water use because bore owners have been estimated to use about three times more water on their gardens than scheme water users. This may be partly due to their having larger blocks and gardens but wasteful use of groundwater is a significant equity issue in Perth. Garden bores are a means of using stormwater that has recharged the Superficial Aquifer.

- **Installation of a third pipe to deliver groundwater, stormwater or treated wastewater for outdoor use in new urban developments.** A project funded by the Premier's Water Foundation is evaluating options in the Ranford Road and Southern River areas. These have the aim of ceasing all outdoor use of drinking water to help achieve the per capita consumption target of 155 kL/person/yr.
10.3 Options not currently under active consideration

*Brackish water desalination*

The Water Corporation has indicated that a second seawater desalination plant may be required if the last eight years’ rainfall is an indication of future climate, and the South West Yarragadee project does not proceed.

One option that has not been seriously considered is desalination of the extensive reserves of brackish water which exist in both groundwaters and surface waters in the South West of WA.

Brackish water only needs a pressure of 250 to 400 psi during desalination compared with 800 to 1000 psi for seawater.

Figure 10.1 shows that in 2000 the cost of desalinating brackish water was estimated to be $0.50 - 0.75/kL cheaper than desalinating seawater (Linstrum *et al.*, 2000). The current cost shown in Figure 10.1 is low because it doesn’t include the costs of connecting the water into the supply system. If energy prices rise significantly the relatively of all options will be affected.

Another option that may be worth exploring is the use of low salinity desalination water to dilute the salinity of brackish supplies to increase overall supply.
Donnelly River. Between 70 and 74 GL/yr of high quality surface water is potentially divertible from the Donnelly River. This may be suited to regional development in the Manjimup area if not the IWSS. The recent creation of a national park in the area was done with regard to its future potential as a water source.

Trading of on-farm water savings in irrigation areas. All water trading so far has been with Harvey Water who own savings arising from reduced irrigation channel leakage. Water of drinking standard is only contained in the Stirling, Samson and Logue Brook Dams. However, if salinity and recreational use issues can be addressed in Wellington Reservoir to the satisfaction of health authorities, improved water use efficiency on-farm could result in additional water being able to be traded from farms to other users. Flood irrigation of pastures for beef and dairy production is one such source of water, with the funds from trading allowing more expensive but efficient irrigation system to be installed on farm.

10.4 Supply and demand in 2030

One possible set of demand and supply options for the year 2030, assuming an 8 and 30 year climate scenario, is shown in Figure 10.2 and Figure 10.3. These can be compared with those for 2004 shown in Figure 5.1 and Figure 5.2.

By 2030 demand in the north Metropolitan area is expected to have grown by 43 GL (55%), the south metropolitan area (including Mandurah) by 93 GL (37%) and the GAWS by 8 GL (30%).

The Water Corporation is planning for imminent development of both the Perth Seawater Desalination Plant and the South West Yarragadee groundwater source. Under the 30 year climate scenario no further source development would be needed by 2030 to balance supply and demand. However a range of other initiatives are being pursued. The benefits from water trading opportunities, improvements to the management of surface water catchments and land use changes on the Gnangara Mound, and the reuse of wastewater using MAR are likely to be at various stages of development by 2030. This will potentially provide an excess of supply capacity.

However, for the 8 year climate scenario it will be essential that these other initiatives are providing benefits. Improved contributions from some existing source shown in Figure 5.2 are included in Figure 10.3. An additional 10 GL of runoff due to catchment management and an additional 10 GL of groundwater made available from land use changes and the reuse of wastewater in the Gnangara Mound area has been assumed. New water from Eglinton and Wellington is included to satisfy the supply demand balance by 2030.
Figure 10.2  Demand Centres and Supply Sources for IWSS: 30 year Climate Scenario at 2030
Figure 10.3  Demand Centres and Supply Sources for IWSS: 8 year Climate Scenario at 2030
11. WATER CONSERVATION OPTIONS

11.1 Background

A State Water Conservation Strategy with 38 draft recommendations for improved conservation was released by the West Australian Premier for comment in July 2002 (WRC, 2002b).

Many of these recommendations were subsequently included, with some additions, in the State Water Strategy (2003). These included:

- the adoption of integrated resource planning processes in water licensing and allocation planning,
- a 20% wastewater reuse target be achieved by 2012,
- a water conservation plan be required when issuing or re-issuing licences,
- water sensitive urban design principles to be adopted in urban design,
- funding be made available for developing water saving technologies such as Aquifer Storage and Recovery (Premier's Water Foundation),
- the state government takes the lead in the adoption of water conserving practices,
- a scheme water consumption target of 155 kL/person/yr be achieved by 2012,
- the ban on watering between 9 am and 6 pm be extended to include local government,
- Waterwise on the Farm programs be supported in WA,
- price setting be undertaken by an independent economic regulator, and
- the implementation of subsidies for water efficient devices.

Some options from the State Water Conservation Strategy, mainly relating to public water supplies, which have not yet been fully explored include:

- water service providers being able to pass the cost of water efficiency and reuse practices through to customers,
- the use of drought or scarcity pricing be investigated, along with the provision of subsidies for water efficient devices,
- peak pricing to be investigated in areas where future capital expenditure may be triggered by an inability to meet short peak demand periods,
- the introduction of volume-based wastewater pricing,
o externalities associated with water supply and wastewater treatment be included in the prices charged for these services,

o water efficiency and water re-use options be considered before Community Service Obligations (CSOs) are approved for new services,

o Billing cycles more closely match seasonal water use patterns, and

o penalties be considered for operating sprinklers during winter, and especially when it is raining.

The latter recommendations were less important than those included in the State Water Strategy but there was community and industry support for some of these measures and they may need to be considered again in future.

11.2 Regulatory measures

In planning future water supplies there has been a policy that some water restrictions would be required in 10% of years (i.e. 90% reliability) with severe restrictions (complete sprinkler ban) in 3% of years.

ECS (2002) estimated that a sprinkler ban would result in the loss of about 3,800 jobs in the nursery, lawn mowing, swimming pool and related industries in the first year after introduction, rising to about 4,000 jobs by the third year. This employment would largely be displaced to other sections of the economy. Decreased expenditure in the garden-related sector was estimated to be around $385 million per annum. A complete outdoor ban on watering was estimated to displace about 6,900 jobs and decrease garden-related expenditure by about $700 million in the first year.

In addition, there would be costs to consumers in adapting to the restrictions and the cost of recovering gardens and lawns after the bans were lifted. There would be some offset employment and business to areas such as brick paving but this would not compensate for the wider impact.

The Water Corporation now considers the risk of a complete ban should only be 0.5%, or one year in 200, which is more conservative than in most other Australian cities. In effect, this requires the buffer between water supply and demand to be much larger as future climate assumptions for planning will retain a large element of uncertainty.

The Government of WA introduced daytime (9am to 6PM) sprinkler bans for scheme users in 1994, for garden bores in 2001 and for local and state government (e.g. schools) in 2003. This has been extended to all non-commercial crop water users through licence conditions in 2005.

Consumer response to the two days per week restrictions has been very good with 37 to 53 GL/yr being saved in the first three years. The differences in savings are mainly explained by differences in summer temperatures and number of rain days. Consumer acceptance of the restrictions has consistently been around 80% and a section of the community would like the restrictions to be permanent.
Western Australia has been an active participant in the national Water Efficiency Labelling Scheme (WELS). Through providing subsidies for water-efficient washing machines, the state changed the market for front loader washers and forced top-loading washing machines to become more efficient to attract the subsidy.

Another example of good community response has been the acceptance of metering of private abstraction in horticultural areas north of Wanneroo. When the government announced that all bores with licences in excess of about 5 ML/yr would require a meter, there was good acceptance by the industry. This was probably facilitated by the government paying for the meters and industry concern about falling groundwater levels in the area.

11.3 Pricing

*Private water supply*

Western Australia is unusual in that almost no-one has to pay to receive or hold a water licence. In 2003 the Government assessed options for charging for water licenses and chose to continue the current practice of funding water management from Consolidated Revenue.

The Irrigation Review Steering Committee is likely to indicate that charging for licences may be acceptable to licence holders if the charge was accompanied by an increase in licence security and the funds raised were used to improve the current levels of service.

*Public water supply*

The Economic Regulation Authority is currently carrying out a review of pricing for urban water sewerage services.

The Water Corporation has universal metering of drinking water services and a progressive tariff regime which encourages water conservation. Western Australia led the nation in this regard. As a result of pay-for-service being introduced in the late 1970s drought, the progressive increase in per capita consumption with increasing affluence was curtailed.

As noted in the ERA discussion paper (ERA, 2004) and in de Lacy (2004), there are some unusual features about Perth’s water tariffs compared with other Australian cities:

- Five tariff steps, whereas all other major cities have only one or two block tariffs;
- The price of water has not increased in real terms since 1998 to reflect the increasing cost of new supplies (ERA, 2004);
- Water use comprises the lowest proportion of the water bill (i.e. the highest fixed charge). Perth has a proportional water use charge for a 250 kL/yr service of 47%, compared with 76% for Sydney and 90% for Hunter Water;
- Perth having the third highest household water use of scheme water (after Canberra and Adelaide) despite a reliance on self supply groundwater;
- The highest number of water quality complaints as a result of its high reliance on groundwater;
o The lowest operating cost for water services, and the second lowest operating cost for wastewater services amongst Australian cities; and

o All consumers having the same volumetric charge for their first 350 kL of consumption, despite the cost of supplying the service varying widely across the state.

In 2003, the price of water use in excess of 550 kL/yr was increased by 20%, and in excess of 1150 kL/yr by about 25% in the latest review of tariffs. About 6% of households consumed water in these price brackets in 2002/03 and the percentage of scheme water changed in these brackets would be much less again.

A review of urban water and wastewater tariffs in being carried out by the Economic Regulation Authority. One of their recommendations is to rebalance the fixed cost and use components of the tariff and equate prices with the Long Run Marginal Cost of bringing on water supplies such as desalination. As well as giving a price signal to consumers as to the cost of new water supplies and demand options, such a rebalance could save up to 20 GL / yr in water demand, as well as make reuse more attractive.

11.4 Incentives

In February 2003 the government introduced a subsidy scheme to encourage scheme water users to purchase water conservation products. The scheme was extended in 2004 and expanded to include additional products.

After two years in operation the scheme had attained water savings of 5 GL/yr at a cost of $17.9 M.

Figure 11.1 shows that about 76% of the funds were spent on washing machines, 18% on bores and 4% on rainwater tanks. The remaining products proved to be either unpopular (e.g. only twelve greywater systems were subsidised), cost very little (e.g. the showerhead subsidy was only $10 per unit) or have been subsidised for only one year (e.g. soil wetting agents).

The scheme water savings for products like garden bores is likely to be attained for 20 or so years, washing machines for about 8 years and only one year for garden mulch.

Taking this into account, in excess of 74 GL/yr should have been saved over the lifetime of the products from the funds spent so far; 52 GL/yr coming from bores (assuming that each bore reduces scheme water use by 250 kL/y) and 19 GL/yr from washing machines (Figure 11.1).

The cost effectiveness of the subsidies comes from a combination of savings per year, the size of the rebate and the lifetime of the product. The $3.1M in bore subsidies paid so far represents a cost of only $0.06 per kilolitre of scheme water saved.

The marginal cost of the next major water source ranges between $0.85 and $1.11 per kilolitre. All except soil wetting agents have a cost per kilolitre less than the marginal cost of the next water source, with washing machines being close to the cost.
This analysis is simplistic in that the savings may not be achieved for many years but the incurred cost is immediate. However in a drying climate, the value of water savings in future years may be even greater than at present. It also assumes that there would have been no demand for these products without the subsidy.

In considering the relativity of demand management versus additional sources, the following factors needs to be considered:

- There are environmental and social costs associated with developing new water supplies,
- For domestic bores, there may also be environmental impacts if they result in lower groundwater levels around wetlands or seawater intrusion occurs\(^8\),
- The cost of the subsidy is not the full cost of the item to the community – most are only 5 to 20% reductions off the retail price,
- Demand management savings can be immediate whereas new sources take several years to investigate and develop,
- Consumers get additional benefits from the item, including the financial benefit of reduced scheme water usage; and
- The savings from demand management may not be as secure in forward planning estimates as are new sources.

\(^8\) A study of the factors affecting groundwater levels under Perth is currently underway
Figure 11.1  Cost effectiveness of water subsidies February 2003 – February 2005
11.5 Education

Raising awareness of the need to conserve water, and educating consumers on how to reduce their scheme water use, has been a feature of Western Australia since the late 1970s.

ARCWIS (1999) summarised the main findings of work in a number of Australian cities in “The social basis for urban water provision in the 21st Century”.

One aspect of this was the grouping of peoples' attitudes to water into four types (Nancarrow et al., 1996):

- **Self interested** – only think about water in the context of their rights to goods or a service
- **Earthy** – think about water in terms of its aesthetics, conservation and utility
- **Environmentalists** – concerned about aesthetics and conservation (as above) but not about utility or water rights
- **Service orientated** – consider all aspects of water but are especially concerned about their rights, chemical additives in water and its utility.

About half of consumers can be considered part of the “earthy” group with the remainder being equally split between them.

While this classification can help explain people’s attitudes to water, it is interesting to note that it is not reflected in their consumption patterns.

A number of Waterwise programs have been successfully run in Western Australia. These include:

- Waterwise schools (180 in 1994)
- Waterwise plumbers (106) able to advise and fit water saving devices
- Waterwise garden irrigators (36)
- Waterwise garden centres (17)
- Waterwise display villages (14), and
- Waterwise businesses.

Some indication of the effectiveness of community education campaigns can come from comparing water consumption when water savings campaigns are being run or not.

A rough guide in the 2003/04 summer was that short-term savings could be achieved for about $200,000 per GL but this savings would progressively decrease with increasing advertising.
12. IWSS RELIABILITY

12.1 Response to different rainfalls

The choice of climate period on which to base future planning has a profound effect on estimated water yields and the need for new supplies.

Using a 30 year climate sequence, the 45 GL desalination plant due for commissioning in late 2006 will result in no further source development being required until 2021/22 assuming a consumption of 155 kL/person/yr, or until 2014/15 if consumption is 170 kL/person/yr.

Using an 8 year climate sequence, the desalination plant will not be sufficient to fully restore the reliability of supply under either consumption level, and additional source capacity will be required immediately. An additional 90 GL/yr will be required by 2010 in this dry scenario with a 155 kL/person/yr, and an additional 121 GL/yr with a 170 kL/person/yr demand.

Each component of the system has different degrees of reliability and response to climate change, except the desalination plant and, to some degree, deep confined aquifer pumping, which makes them very important components in the reliability of the system overall.

Most components also have a long lead time to develop and some, like Gnangara which currently supplies 60% of IWSS water, have an annual review of source capability which can reduce reliability.

Given the declines in both unconfined and confined groundwater levels on the Gnangara Mound, the long term yield under the current or future climates is uncertain, as is landuse which can profoundly affect both recharge and discharge. Environmental values are being progressively lost under the prevailing climate, land use and extraction. The annual allocation of remaining resources between the environment and private and public water supplies is decided each year after hills runoff and groundwater recharge amounts are known. Not knowing what climate to plan for makes decision making even more difficult. This is why the Indian Ocean Climate Initiative predictions about future climates for the South West region are particularly important.

Given these considerations, the next most viable water sources for the IWSS are trading with Harvey Water and developing the South West Yarragadee groundwater resource. Under an 8 year runoff scenario and 155 kL/person/yr demand, developing these two sources after the desalination plant is completed would delay the need for another major water source until 2017/18.

Temperature may also be an important driver because a warmer climate will increase water demands as well as decreasing system yields. There are some indications that higher temperatures and lower humidity are increasing water use by horticulturalists and reducing pine growth on the Gnangara Mound.
12.2 Response to water quality issues

Many water quality incidents arise as a result of rainfall after a dry period which has produced low water storages. Low storages expose dam riparian zones, increase the likelihood of acid sulphate soils (for groundwater) and reduce the ability of pollutants to be diluted.

The multiple barrier approach to water source protection adopted in Western Australia reduces the likelihood of a water quality incident. This involves preventing risky landuses from being permitted close to water sources, managing activities in catchments, real time monitoring and treating water before it is delivered.

The development of water source protection plans has been slow in recent years and there is a need for these to be completed and, as importantly, implemented. The multiple small sources, variety of sources and their inter-connectedness makes responding to a single source water quality incident easier in that the affected source can be taken off line and supply maintained from an alternative source. However, there are system limitations to supplying water to all parts of the demand network and some sources are much more critical than others.

12.3 Equity with non-scheme (private) users

Communities are recognising the value of water, driven through scarcity in some areas, and whilst they want to be involved in decision-making, they usually want government to make any hard decisions, especially in the areas of equitable water sharing.

Historically, water has been allocated on a first-in-first-served (FIFS) basis in WA. This approach is widely used across Australia and reasonably well accepted by communities where there is no huge demand for water, or where the demand is well within sustainable levels. The FIFS method is challenged where the demand exceeds supply, water resources move towards full allocation and a trading environment, and where there is inadequate vigour in administrating the licence application ‘queue’.

An alternative to FIFS being introduced in the northern Perth Basin is the Merit Selection method, where expressions of interest compete for the remaining groundwater on the basis of a set of environmental, social/cultural/heritage, and economic criteria which are defined by the local Advisory Committee. The Merit Selection process is normally triggered when a certain allocation threshold is reached. This process has been used successfully now for a number of years.

Long-standing issues such as large developments versus small enterprises and giving communities a say in how their local groundwater resources should be shared, are being addressed by this approach. However, in pursuing the objectives of optimising the benefits of groundwater resource use, there is a need to continue to explore mechanisms for encouraging highest and best use of the resources in accordance with CoAG principles.
Making more water available

Mechanisms for making more water available, such as water use efficiency, reuse and trading, are actively promoted. However, one of the most important principles in groundwater management to be adopted in WA is the requirement for licensees to utilise their full entitlement within a certified time period or have their annual entitlement reduced to reflect actual needs. This makes more water available to other users, which is particularly important where demand exceeds supply. It will avoid the position facing water managers and users in other States where a large proportion of groundwater resources are held by unused entitlements which, if activated, would threaten the sustainability of the resource and the socio-economic framework of communities that rely on them. This principle is also reflected in the DoEs Transferable Water Entitlements Policy that does not allow for the trading of entitlements which have never been used. Once trading of entitlements takes place, or if water users have to pay to hold onto water entitlements, this policy becomes less viable.

Urban versus rural debate

The ongoing urban versus rural debate is well illustrated in the Perth Basin because of the large and increasing population base in Perth creating a demand for additional water resources within the same groundwater systems providing groundwater to rural areas. Rural communities are fighting harder to retain local water resources as the key to regional prosperity and development, while metropolitan Perth also requires access to the same resources to satisfy its long term requirements for drinking water.

To ensure that both demands are reasonably satisfied in the long-term, the DoE has met this challenge by reserving large volumes of groundwater for future public use, whilst at the same time considering the temporary utilisation of these reserves by uses that are compatible with the resource’s beneficial use. In addition, DoE has developed a policy on regional transfers of water to provide a policy basis for an activity that has been going on for more than 100 years.

12.4 More science in groundwater allocation decisions

Communities want quick solutions to complex problems. They are now questioning the science behind many groundwater allocation decisions and may even legally challenge the science if there are sufficient economic incentives to do so. It becomes difficult to defend licence refusal decisions in sub-areas where the sustainable yield has been reached and there is a low level management response in place.

Technical understanding of groundwater issues will increasingly be viewed as either the framework or constraint within which community value-based decisions will be made. There are risks in allocating groundwater to a high level when there is only a low level management response in place. These risks must be weighed against community demands for water, which in many cases do not fit the timetable for developing higher-level management actions. In addition, greater community demands for water may be in contrast to the low level of monitoring and knowledge that is in place. Under such scenarios, and with increased and
more substantial community involvement in the decision-making processes, the risk of over-allocation should not be carried entirely by government, if at all.

The challenge for groundwater management is to determine robust allocation limits based on good science and with active community participation to ensure the environmental, social and economic issues of using the water are appropriately understood and addressed. This requires a good understanding of a groundwater resource and its dependent ecosystems when pressure for rapid economic development occurs in the face of inadequate monitoring and knowledge. Under these conditions it is important to ensure that the community understands the process and accepts the risks involved. The key is to negotiate binding arrangements on who pays if high-risk strategies fail. However, Australian communities are somewhat immature in these aspects. Ultimately, the Government has the responsibility for the difficult decisions, but they must be made in conjunction with community consultation and with adherence to the Precautionary Principle where necessary.

DoE is developing government/community partnerships through the establishment and support of statutory community-based Water Resource Management Committees (WRMC). The prime function of these Committees is to assist DoE on matters relating to its functions such as the development of water management plans, setting local trading and water sharing rules, and providing advice on non-conforming or large licence applications.
13. WATER PLANNING

13.1 Water resource planning

The balance between providing secure water entitlements to water users and preserving environmental values is one of the most important issues being addressed through the planning process. Although licensing is the prime statutory tool that is used by the Department of Environment to manage water allocation and use, water allocation and management plans are the tools that bring together the social, cultural, economic and environmental aspects of water management.

All management plans developed in the early 1990s by the then-Water Authority of WA, are progressively being reviewed. Each Plan contains a set of allocation principles that determine how much groundwater will be retained for the environment (either as a volume or a water regime) after environmental, social and economic issues have been taken into account and how much water can be allocated for consumptive uses. In addition, the plans set the rules and guidelines to be followed by each person or organisation issued with a licence to take groundwater. The plans are informative and available to any person or organisation interested in the management of groundwater resources.

There are 45 proclaimed groundwater areas in WA, of which 30 are currently covered by water allocation plans developed between 1989 and 2004, or have plans under development as shown in Table 5.

The small number of plans developed for the surface water resources indicate the heavy reliance of groundwater resources in WA.

Recent changes to the Rights in Water and Irrigation Act 1914 allow statutory plans to be developed which will provide more certainty and security to water users. These plans are necessarily more complex and to date none have been completed.
Table 5 Status of water resource allocation planning in WA as at February 2005 (DoE)

<table>
<thead>
<tr>
<th>Groundwater Allocation Plans</th>
<th>Date completed</th>
<th>Existing plans reviewed</th>
<th>New plans under development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albany</td>
<td>1991</td>
<td></td>
<td>2004/05</td>
</tr>
<tr>
<td>Arrowsmith</td>
<td>1995</td>
<td>2002</td>
<td></td>
</tr>
<tr>
<td>Blackwood</td>
<td>1990</td>
<td></td>
<td>2005/06</td>
</tr>
<tr>
<td>Bolgart</td>
<td>1994</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunbury</td>
<td>1994</td>
<td></td>
<td>2005/06</td>
</tr>
<tr>
<td>Busselton-Capel</td>
<td>1995</td>
<td>2005/06</td>
<td></td>
</tr>
<tr>
<td>Carnarvon</td>
<td>2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cockburn</td>
<td>1993</td>
<td>2005/06</td>
<td></td>
</tr>
<tr>
<td>Collie</td>
<td>1988</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derby</td>
<td>1992</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Esperance</td>
<td>1997</td>
<td></td>
<td>2005/06</td>
</tr>
<tr>
<td>Exmouth</td>
<td>1999</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gingin</td>
<td>1993</td>
<td>2002</td>
<td></td>
</tr>
<tr>
<td>Goldfields</td>
<td>1994</td>
<td></td>
<td></td>
</tr>
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<td>G内的指示:</td>
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<td>G内的指示:</td>
<td></td>
<td></td>
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<tr>
<td>Jandakot</td>
<td>2005/06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jurien</td>
<td>1995</td>
<td>2002</td>
<td></td>
</tr>
<tr>
<td>Kemerton</td>
<td>2004/05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mirrabooka</td>
<td>2004/05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Murray</td>
<td>1998</td>
<td></td>
<td>2004/05</td>
</tr>
<tr>
<td>Perth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perth NW Corridor groundwater mgt Plan</td>
<td>1992</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rockingham/Stake Hill</td>
<td>1988</td>
<td></td>
<td>2005/06</td>
</tr>
<tr>
<td>Rottnest Island</td>
<td>1987</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serpentine</td>
<td></td>
<td></td>
<td>2005/06</td>
</tr>
<tr>
<td>South West Coastal</td>
<td>1989</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swan</td>
<td>1997</td>
<td></td>
<td>2004/05</td>
</tr>
<tr>
<td>Wanneroo</td>
<td>1993</td>
<td></td>
<td>2004/05</td>
</tr>
<tr>
<td>Yanchep</td>
<td>2004/05</td>
<td></td>
<td></td>
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<td>Surface water allocation plans</td>
<td>Date completed</td>
<td>Existing plans reviewed</td>
<td>New plans under development</td>
</tr>
<tr>
<td>Harvey Basin</td>
<td>1998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perth to Bunbury</td>
<td>1997</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ord River</td>
<td></td>
<td></td>
<td>2004/05</td>
</tr>
</tbody>
</table>

13.2 Auditor General report and response

During 2003, the Auditor General (AG) completed a Control, Compliance and Accountability Examination of Management of Water Resources in Western Australia and reported to Parliament on the 24 September 2003. The audit found that a number of factors had seriously affected the Water and Rivers Commission’s capacity to manage the States water resources at an appropriate level. These included:

- A doubling of demand for water over the last 15 years;
A 33% decline in funding in real terms since 1998 for core water resource management operations of investigation, assessment, planning, licensing and regulation;

Amendments to the Rights in Water and Irrigation Act 1914. These amendments have considerably increased workload by requiring more rigorous environmental assessment and greater community consultation.

The audit further found that there are some major challenges now facing water resource management in WA. Following the Auditor General recommendations, the Commission prepared a Preliminary Response to the AG in October 2003 which:

- identified priorities for management of the State’s water resources;
- identified the resources required;
- recommended funding options; and
- established a time frame for implementation.

The prime areas identified in the Preliminary Response for immediate attention were the significant backlog of licence applications, expired licences and field surveillance to ensure licence compliance. Some funding has subsequently been provided to address these immediate priority issues and implementation of the necessary actions is proceeding. A second round of funding was provided in 2004 to address some of the priority needs of investigation, assessment and planning and additional funds were provided in 2004/05 to complement the second round. The Commission’s capacity has been improved in the four major components of a sound water resource management program as shown in Figure 13.1, but the Commission’s capacity to undertake an appropriate level of water resource management for the State will not be realised until an appropriate level of additional funding is available each year.

The Commission prepared a full response to the Auditor General in June 2004. This estimated that an additional $18M/yr in funding would be required to provide an appropriate level of water resource management for current water use levels (WRC, 2004).

Proactive water resource planning is needed to determine water available for potential public supply to Perth after taking account of environmental, social and local needs. If done properly, a statutory planning process, involving community involvement to avoid conflict, provides certainty for all and is the basis for water planning in other states. But it will require additional resources to make this happen in Western Australia.

The need for increased planning is highlighted by the following:

- the rapid rise in licences for water (100 GL/yr) as shown in Figure 2.2;
- the number of groundwater aquifers that are apparently over-allocated (Figure 4.2);
the increased time taken to bring on new water resources, resulting in more expensive sources being developed if they are more certain of delivery on time (e.g. desalination compared with the SW Yarragadee); 

the need to adjust Allocation Limits to reflect more recent rainfall patterns; 

the need to involve communities more in decision making, often as a legislative requirement; and 

source being lost due to inappropriate land uses in potential wellfields or surface catchments

**Figure 13.1** Sequence used to plan and manage water resources (DoE, 2005)

### 13.3 Integrated Resource Planning

The government has committed to “utilise the Integrated Resource Planning approach within the allocation and licensing process to drive appropriate consideration of, and appropriate investment in, conservation measures” (Government of WA, 2003).

Integrated resource planning is a process whereby the water service provider examines a series of water supply options and calculates which option will, at the least total cost, provide their customers with the *water-related services* they need, rather than the water itself (WRC, 2002). This allows options that reduce scheme demand (e.g. leak reduction, retrofitting showerheads and subsidising domestic bores) to be compared on an equal footing with options that increase supply. Such comparisons should be carried out by considering the total costs and benefits to the water service provider and the customers and the general community rather than from the perspective of the water service provider alone.
To date Total Resource Cost tests have not been applied in Western Australia although the analyses carried out in Perth’s Water Future (WAWA, 1995) and WRC (1997) were leading examples of what could be done at that time.

Currently the government is investing in education to achieve water savings targets (ca. $200,000 per GL saved), subsidies which are, with one exception, cheaper than the marginal cost of the next major source (Figure 11.1) and using restrictions which are more equitable than price in distributing a scarce essential service. Price may be used to affect non-essential water use and to encourage investment in water conservation practices and devices, and make re-use more viable.

Cost is only one consideration in balancing the demand and supply equation. The reliability with which a saving can be assured and the volume of the saving can mean that developing a new source is the next best option. In addition, Perth is growing rapidly and a new source will be required at some stage, even if the climate returns to a wetter sequence than the past eight years.

Western Australia is probably well placed to undertake Integrated Resource Planning for all major users of water, not just public water suppliers. The requirement for licence applicants to provide evidence that they have a real need for the water, and to submit a water conservation plan when applying for a new licence or at licence renewal, is a step towards this aim.
14. CONCLUSIONS

It can be concluded that groundwater resources in the Perth Basin are far from exhausted although the full impact of the drier climate still requires more investigation, as does the impact of abstraction regimes, land use changes and land management.

There is an urgent need to improve our knowledge of the Basin’s groundwater resources as they are the most important water resources in the state for both private and public supplies, as well as supporting valuable ecosystems.

The fact that licensed applications are greatly exceeding expected rates of growth made only five years ago is an indication of the pressure that the groundwater system is under. The increase in the number of apparently over-allocated resources since 2000 is another. Management response is currently not keeping pace with changes in the demand status of the aquifers and there is a likelihood of poor resource development as a result.

Unlike other major Australian cities, Perth and its associated water supply schemes (which services over 70% of the state’s population) have a multiple number of surface and groundwater sources which can be linked in a number of ways to provide water supplies with defined levels of quality and security. Desalination provides a third source and a supply from the Kimberley would be yet another.

The diverse nature of this system provides resilience against the loss of any one source (e.g. through water quality, variable seasonal supply, climate change). However, it is difficult to evaluate all possible options without a better knowledge of system performance and the opportunities and threats to the system, especially those arising from rapidly growing demand for both the private and public sectors in a drying climate.

The relative short and longer term roles of surface water, shallow groundwater, confined aquifers and desalination in the public water supply system could be better defined than at present. Drought management strategies need to indicate which reserves are to recover in wet years so supply buffers are maintained in the long term.

Developed groundwater resources have allocation limits which are more likely to be close to their sustainable yield. In this regard it is interesting to note that the water resources in the Perth region have the highest yields of any demand area in the Perth Basin. This may be due to a number of factors:

- the city being fortuitously located in a water-rich environment;
- the allocation limits being set too high;
- induced yield due to development (i.e. increased recharge and decreased discharge); or
- the allocation limits for less developed areas being set too low.

Almost certainly, groundwater yield estimates in some aquifers are too low. For example, the Blackwood Demand Region (Figure 9.2) currently only includes 27 GL of groundwater in its
total but this is under review. This is also possible in the demand regions north of Perth that clearing of native vegetation is resulting in rising groundwater levels in some areas. However, more investigative work would be required to confirm this.

As rainfall declines, the amount of groundwater that is shared between water users and the environment (via EWPs) needs to be clear, otherwise it is very difficult to plan the orderly development of new sources. The extreme policy positions that can be adopted are:

- the environment continues to receive its full allocation and all reductions are made to public and private water supplies; or
- water supplies are maintained because the environmental values will be lost as a result of climate change anyway.

More realistically, both allocations may be reduced and/or augmentation of key environmental areas may occur. In the event of no or slow decisions being made, the environmental values may decline and be lost anyway.

Development of public water resources has in the past been mainly concentrated on building new dams and wellfields to augment growth in the amount and reach of the supply system. Recently, non-traditional sources have become more important as new source development options have become more expensive – trading, reuse, water conservation subsidies, catchment management, etc. Integrated Resource Planning is one way to ensure that the mix of measures will achieve clearly stated aims in terms of reliability of supply, equity between user groups, return on capital, cost efficiency, and adequate lead time to develop new sources.

Western Australia has been innovative in many ways. This includes the early introduction of metering and pay-for-use, transferring and mixing water of different qualities to improve system resilience, protection of water source catchments against inappropriate development, a conservative approach to setting Allocation Limits, recharging stormwaters for use in irrigating open space, and the strategic use of confined groundwater resources.

The state has also adapted to major climate change with relatively small social impact.

It the past it has not required great sophistication to manage the state’s water resources as their level of commitment was low and rainfall was reliable. The rapid growth in water demand and climate change has altered this situation and much more management needs to be applied if water resources are to be developed in an orderly manner. Otherwise expensive solutions will be the only ones that will be able to deliver on time because the required background work has not been done to prove up supply, reuse or demand alternatives.

Sharing water between private and public uses requires better definition of property rights and responsibilities, as well as a good understanding of system responses to development and trades. Implementing the recommendations in the Irrigation Review Steering Committee report will address some of these issues.

The availability of so many options to manage the water resources of the South West for private and public benefit is both an asset and a liability because there are many possible scenarios that can be evaluated and pursued. However, all have a significant lag time to
allow investigations, analyses, community consultation and approval before being implemented.

The limited amount of work done on comparing the relative cost of demand management and new source development in this report (Figure 11.1) shows that there is still scope for savings in public water supplies. However given the drying climate and continued growth in population in Perth, new water sources will be required immediately to avert the need for complete sprinkler bans. If the eight year climate regime continues, another new source will be required, as well as very active demand management, better management of existing sources, trading and reuse. Such a diverse approach to water management has become common around Australia in the past 3 to 5 years. The balance between private (especially regional) and public (especially urban) water needs will require good policy, procedures and planning to get the right outcome.
REFERENCES


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http://www.ourwaterfuture.com.au

http://www.ourwaterfuture.com.au

Water Corporation, (2005). Data provided by the Water Corporation for the purposes of this report.

APPENDIX 1: DETAILED COMMENTS ON RIVER BASINS SHOWN IN FIGURE 3.2 AND MENTIONED IN TABLE 2 (DOE, MARCH 2005)

INTRODUCTION

This appendix describes the basis of the estimates of surface water resources availability presented in Table 2, includes descriptions of the main resources in question and highlights key issues with their potential development.

The appendix includes tabulations of the average stream discharge, the available fresh and marginal resource, the amount of the fresh and marginal resource already committed and the remaining resource potentially available for development. These are presented for each River Basin draining to the coast between Perth and Albany.

Following each tabulation, brief descriptions are provided of the Basin’s main river systems and their salinities, contributions to the available resource, current developments and usage, and comments on possible further developments in each Basin. The comments describe ways that the unused resources are most likely to be developed, and include discussion of issues to be resolved before such developments could proceed. Comments on the potential for water entitlement trading to occur are also provided in Basins where this is likely to be significant in the short to medium term.

SOURCES OF INFORMATION

The resource information is based on data collated for the Western Australia Water Assessment 2000, which formed part of the 2000 National Water Audit. The methodology used to estimate Sustainable Yields for the 2000 Water Assessment is described at the end of this appendix (page 24). The Sustainable Yields quoted are inventory estimates only and based primarily on notional estimates of EWPs at likely development sites. Where specific Environmental Water Provisions (EWPs) have been established and sustainable yields updated, or other significant changes to water availability have occurred, revised figures have been used (see footnotes to Table 2). The licensed allocations are based on the Commission’s Water Resources Licensing Data Base in mid February 2005. Estimates of unlicensed use are based on the figures collated for the 2000 Water Assessment.

As inventory estimates only, the sustainable yields quoted do not represent approved allocations. Before any large scale development could proceed, comprehensive EWPs need to be determined, and licensed entitlements issued. Where the environmental impact is potentially significant, full environmental impact assessment would also be required.

The 2000 Water Assessment estimates of sustainable yields in the Perth to Albany region were based on streamflow data recorded from the early 1960s to the mid 1990s. No one period was used throughout, as hundreds of data sets were needed and periods of available data varied across the region. However, the period from 1962 to 1995 inclusive is considered representative of the many periods used. This period has been used to help interpret the 2000 Water Assessment results, in the light of the streamflow declines observed since the mid 1970s. Average streamflows over two periods (1975 to date and 1997 to date) are presented for selected rivers throughout the region. These are expressed as percentages of the average recorded for the representative period, and discussed on pages 22 and 23.
BASIN DETAILS

<table>
<thead>
<tr>
<th>River Basin</th>
<th>Swan Coastal</th>
<th>Water Region</th>
<th>South West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Flow</td>
<td>683.0 GL/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustainable Yield</td>
<td>125.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total licensed</td>
<td>104.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectively committed</td>
<td>115.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potentially available</td>
<td>9.3</td>
<td></td>
<td></td>
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<table>
<thead>
<tr>
<th>Amount allocated for</th>
<th>Public Water Supply</th>
<th>Other purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>102.6 GL/yr</td>
<td>2.0 GL/yr</td>
</tr>
</tbody>
</table>

Mean Annual Flow and Sustainable yield

The northern part of the Swan Coastal River Basin drains cleared private land where average rainfalls range from below 600 mm/yr to 1000 mm/yr. The Brockman River, Wooroloo Brook and Ellen Brook are the main tributaries of the Swan-Avon River in this area. Brockman River and Wooroloo Brook are brackish; a result of past clearing causing additional groundwaters to transport salts, previously stored in their catchment’s soil profiles, to watercourses. The clayey sub-soils of the Darling Range, formed from underlying granitic or gneissic rocks, hold large stores of salts, especially in areas where the annual rainfall is less than 900 mm/yr. Ellen Brook is of marginal salinity, as most of its catchment drains coastal plain soils of sedimentary origin where less salt has accumulated. The Basin’s mean annual flow is dominated by the brackish flow of the Avon River and its tributaries.

The main rivers of the southern parts of the Basin are the Helena and Canning Rivers and Wungong Brook. Their catchments are predominantly State forest or conservation reserves. Private land occurs in the upper reaches of the Helena River (average rainfall < 900mm/yr) and along the valleys of high rainfall tributaries of the Swan, Helena and Canning Rivers. The Canning River and Wungong Brook are fresh. The Helena River is of marginal salinity; a result of less than 5% of its upper catchment being cleared for agriculture. These three river systems provide about 90% of the Basin’s fresh and marginal sustainable yield.

Current allocation and estimated unlicensed use

Mundaring Weir, Canning and Wungong Dams and related pipehead/pump-back facilities harness most of the Basin’s sustainable yield. Following chlorination at the source, connecting mains provide the water to the Perth Integrated Water Supply Scheme (IWSS). About 10% of water use occurs as small scale diversions (mostly unlicensed) from tributaries of the lower Avon, Helena and Canning Rivers. These support orchards and other small farms in the Perth hills and surrounding areas.

Potential developments and constraints

The catchments of the potentially available resource contain significant private ownership and are partially cleared. Hence, their salinity is marginal and other water quality poor. While pipehead diversions of up to 6 GL/yr for public supplies from Susannah and Jane Brook are possible, their relatively small yields and the costs and complexity of the treatment needed before they could be used to supply the IWSS, has made them unattractive to the
Water Corporation. Further development is most likely to be more small scale private diversions that support small farms and rural living in areas surrounding Perth.

There is scope to increase the streamflow yield into existing reservoirs by thinning areas of dense forest (over-stocked stands) within their catchments. A 12 year trial of thinning in the Wungong Dam Catchment is currently being planned by Water Corporation. It is expected to generate an average additional inflow to Wungong Dam of 4 to 6 GL/yr (depending on the climatic conditions assumed) at a cost to the Water Corporation about 23 cents/kL. For the yield increment to be permanent, subsequent non-commercial thinnings will be periodically required to achieve a low average leaf area index in perpetuity.

Considerable effort has been applied towards the determination of Ecological Water Requirements (EWRs) for the Canning and Wungong systems. These are yet to be finalised. Current estimates are beyond the capacity for release given infrastructure constraints. These EWR estimates are being revised. Environmental Water Provisions (EWP) could be expected to be implemented as a trial in Summer 05/06 and thereafter once an EWP is finalised.

EWRs have been determined for Churchman, Bickley and Munday Brooks, but EWPs have not been finalised. These systems are not proclaimed.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>614</th>
<th>Murray River</th>
<th>Water Region</th>
<th>South West</th>
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<tr>
<td>Mean Annual Flow</td>
<td>897.0</td>
<td>GL/yr</td>
<td>Public Drinking Supplies</td>
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<tr>
<td>Effectively committed</td>
<td>121.4</td>
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<tr>
<td>Potentially available</td>
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</table>

**Mean Annual Flow and Sustainable yield**

The Murray River Basin drains from 450 mm/yr average rainfall country in the east (from Pingelly, and just west of Wickepin and Narrogin), westward through the high rainfall parts of the Darling Range around Dwellingup (average rainfall 1300 mm/annum) to discharge into the Peel Estuary near Mandurah. The two main rivers draining the eastern wheat-belt parts of the Basin are the Hotham and Williams Rivers. Both are saline (average salinity >3000mg/L TSS). They join to form the Murray River near Mt Saddleback (average rainfall 800 mm/yr). The Murray River then flows through forested high rainfall parts of the Darling Range, being diluted by fresh inflows from tributaries along the way, to emerge from the hills as a brackish river near Pinjarra (average salinity about 2,100 mg/L TSS). The Basin also includes the Serpentine and Dandalup River systems. These flow from the Darling Ranges to the north of the Murray River, with the Serpentine River discharging direct to the Peel Inlet and Dandalup River joining the Murray downstream of Pinjarra. These river systems are not as long as the Murray, rising in State forest areas within the Darling Ranges. As only small areas of permanent clearing exist in the higher rainfall parts of these catchments (>1100 mm/yr) stream salinities are fresh.
The Serpentine and Dandalup River systems form the bulk of Basin’s sustainable yield. The main Murray River and its tributaries lie in the Lane Pool Reserve and are unavailable for development.

**Current use and commitments**

The allocations to public drinking supplies (109 GL/yr) consist of licensed diversions from the Serpentine, North and South Dandalup Rivers and Conjurunup Creek at existing dams and pipe-heads that supply the IWSS. The other allocations are primarily for Alcoa’s processing of bauxite ore at its Pinjarra refinery (~ 9GL/yr), with the remaining being for small self supply use mainly taken from the lower Murray and Serpentine Rivers.

The total licensed use quoted above (121.4 GL/yr) is for fresh and marginal resources only. An additional 9.6 GL/yr of brackish to saline water is licensed for diversion from the Hotham River for use in processing Gold ores near Boddington.

**Potential developments and constraints**

With over 90% of the Basin’s fresh and marginal resource already committed the remaining possible developments are limited. Sustainable yields of between 2 and 5 GL/yr are considered possible from developments on Dirk, Marrinup and Davies Brooks. The catchments include some private land and if developed as public drinking water sources, actions would be required to reduce the water quality risks or treat the water before injection into the IWSS. While there is also potential to pump back water from below the Serpentine Falls, any such development would have to be consistent with continued public access to the falls in the existing National Park.

While further allocations are likely to be limited to small self supply developments, some larger allocations are possible from coastal plain watercourses, provided the diversions are limited to times of high flow rates during winter and downstream environmental flows are established. As water quality will be poor and off-stream storage required, such coastal plan resources are likely to be limited to use in industrial processes and to industries where sufficient coastal plain storage can be provided.

However, there is potential to extend the proposed forest thinning trial in the Wungong Dam Catchment (Basin 616) to other water supply catchments with dense forest stands such as the South Dandalup Dam. A potential yield increase of up to 40GL/yr has been estimated as achievable by thinning dense forests across the IWSS catchments within Basins 616 and 614.

No EWRs have been determined or EWPs set below the South Dandalup and Serpentine Dams. These can be expected to be determined within the next 3-5 years.

EWRs have been determined for the North Dandalup system.
Mean Annual Flow and Sustainable yield

The Harvey River Basin is unusual in that it only drains high rainfall areas of the Darling Range. Average rainfall is greater than 1200 mm/yr over much of the hills portion of the Basin, with the upper reaches of the Basin having an average rainfall of a high 1100 mm/yr. Streamflow yields are high, exceeding 250mm per year in many parts of the Basin, especially where forest density is low. The Harvey River is the main water resource of the Basin. The smaller watercourses of Clarke, Logue, Bancell’s and Drakes Brooks flow from the Darling Range to the north of the Harvey River, while Wellesley Creek flows from the hills to the south. The land tenure in the Darling Range is predominantly State forest or conservation reserve, although some private land extends into the hills in the catchments of Wellesley Creek and the lower parts of the Harvey River catchment. All streamflow is fresh; a reflection of the high rainfall of the Basin.

The sustainable yield of the Basin has contributions from the main Harvey River (62%), the northern watercourses (~30%) and the watercourses to the south of the Harvey River (8%). The 149 GL/yr total is a high 70% of the Basin’s estimated mean annual flow and reflects the high level of development in the Basin. While it is engineeringly possible to harness more water from the northern streams of the Basin, such as Bancell’s and Clarke Brooks, these streams were identified as providing important environmental flows to the lower Harvey River and Estuary.

Current use and commitments

The resources are effectively fully developed by storage dams on Drakes, Samson, and Logue Brooks and two (Stirling and the new Harvey Dam) on Harvey River, smaller or pipe-head dams on Bancell’s, Yalup and Black Tom’s and Wokalup Brooks and additional diversions for other small supply use. Of the licensed diversions, 30% are for public water supply, 63% are to enable the supply of irrigation water to the Waroona and Harvey Irrigation Districts, 6% is for mineral processing of bauxite at Alcoa’s Wagerup Refinery and 1% is for self supply use.

Potential developments and constraints

With the possible exception that licensing of some winter diversions from coastal plain streams could be approved, no new large diversions from the hills are considered likely.

However, a shift of water entitlements from the irrigation sector to the public water supply sector is expected. Initial trades are expected in relation to water saved by piping the irrigation supply in the Waroona Irrigation District (~2 GL/yr) and in the Harvey Irrigation
Districts (–15 GL/yr). Full piping of the Harvey Irrigation District will take about three years to complete. Any trade will be phased with the construction program. Further investment in on-farm efficiency could see at least an additional 10 GL/yr be traded in the longer term. Factors likely to contribute to this delay include the current reluctance of irrigators to trade on-farm entitlements and the need to fully treat the additional water before it could be supplied to the IWSS.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>612</th>
<th>Collie River</th>
<th>Water Region</th>
<th>South West</th>
<th>GL/yr</th>
<th>Mean Annual Flow</th>
<th>Sustainable Yield</th>
<th>Total Licensed</th>
<th>Effectively Committed</th>
<th>Potentially available</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Mean Annual Flow and Sustainable yield

The Collie River rises in cleared and partly re-forested land to the east of Bowelling and west of Darkan (average rainfall 600 mm/yr), flows westward through forested parts of the Darling Range, passing the edge of the Collie Coal Basin and through the town of Collie (1000 mm/yr). From Collie the river has cut a deep valley through the highest rainfall parts of the Basin (1200 mm/yr) to flow from the Darling Range near Roelands and discharge to the Leschenault Estuary, north of Bunbury. The River is saline in its upper reaches, but is progressively diluted by fresher tributaries that drain the higher rainfall and more forested parts of the Basin. Important tributaries include the fresh Harris River, which drains State forest and national park (average rainfall 750-1100 mm/annum) to enter from the north, upstream of Collie, and the brackish South Branch, which rises in cleared private land (700 mm/annum) to the south, near Boyup Brook, and flows to the north west through State forest and the western edge of the Coal Basin’s Cardiff Sub-basin, to join the main river just south of Collie. The fresh Brunswick River drains mainly forested private land in the western high rainfall parts of the Darling Range (1100 to 1200 mm/yr), emerging from the hills in cleared farmland to flow across the coastal plain and join the Collie River from the north, six kilometres before the Leschenault Estuary. The fresh Henty Brook drains predominantly undulating cleared land near the Darling Scarp (1000 – 1100 mm/annum) to the south, and joins the main River on the coastal plain near Burekup.

The Basin’s sustainable yield (165 GL/yr) makes provision for current and potential developments on the Collie River (~120 GL/yr), potential new developments on the Brunswick River (~35 – 40 GL/yr), and current and potential new small storage developments on Henty Brook (~ 5 – 10 GL/yr).

### Current use and commitments

Harris River Dam, located about 7 kilometres upstream of the confluence with the Collie River, provides the storage on Harris River to enable up to 16 GL/yr to be diverted for drinking water purposes (11 GL/yr for the Great Southern Town Water Supply Scheme (GSTWSS) and up to 5 GL/yr for the IWSS). Wellington Dam located about 35 kilometres downstream of Collie, and provides storage and regulates the downstream flow of the Collie
River. Harvey Water hold entitlements to divert water from the Collie River at the Burekup Weir, about 12 kilometres downstream, based on releases of 68 GL/yr from Wellington Reservoir. This is used for irrigation in the Collie River Irrigation District. The average salinity of this supply is marginal (less than 1000 mg/L TSS. However, in years when inflows are below average, as have been common in recent years, supply salinities exceed 1000 mg/L TSS (brackish). Supply salinities are kept to a minimum by scouring surplus brackish water from the base of the reservoir during winter months. Catchment management actions designed to improve the inflow salinity to Wellington Dam commenced in the 1970s and are continuing. Additional strategies are being developed based on diverting brackish and saline inflows into temporary storage in old mine voids in the Coal Basin. The aim is to use the stored water as part of the water supply for new power stations proposed in the area or divert it from the catchment. Currently Wesfarmers Coal are licensed to divert up to 7.2 GL/yr of brackish inflow from the South Branch of the Collie River to fill mine voids in the Cardiff Sub-basin.

The other major licensed diversion occurs from the upper reach of the Brunswick River where 2.1 GL/yr is harnessed by Worsley Alumina for mineral processing purposes. Small scale licensed diversions also occur in the lower Brunswick catchment and in the Henty Brook catchment to the south of the Collie River.

**Potential developments and constraints**

Approximately 17 GL/yr of additional water can be allocated from the Collie River at Wellington Dam. Water Corporation have made application for this water on the basis of supplying 5 GL/yr for cooling water in the Collie Basin and supplying the remainder to the IWSS via the Harvey River and the Stirling Dam Trunk Main. Issues relating to public drinking water quality protection measures have delayed final decisions on their application.

A further 15 to 20 GL/yr could also be harnessed from the lower reaches of the Collie River downstream of the new Wellington National Park. While likely to be relatively expensive to develop (for geo-technical, land, and water treatment cost reasons), there would be benefits to integrate any such development with proposals to extend the piping of irrigation supplies to the Collie River Irrigation District. Although twice the cost of piping the Harvey Irrigation District, investment in a piped irrigation supply to customers in the Collie River Irrigation District would secure access to about 20 GL/yr of water at an effective trading price of about 12 cents per kL.

Consequently, between 35 to 40 GL/yr of water could be available from the lower Collie River if investments in new storage, diversion, treatment and irrigation distribution infrastructure were undertaken. Provided the costs to harness and treat the water, and to transmit it to the main centre of IWSS demand, were below 70 cents/kL, the investment would be cost competitive with more distance sources such as South-west Yarragadee groundwater. If there were cost advantages the 12 GL/yr, currently planned to be supplied to the IWSS from the Collie River at Wellington Dam via Harvey River and the Stirling Dam Trunk Main, could be supplied to the IWSS via the lower Collie re-development.

The timing of any decisions to invest in piped irrigation distribution infrastructure, and new diversion and water treatment facilities in the lower Collie River area will be influenced by the speed with which current proposals to reduce the salinity of inflow to Wellington
Reservoir are finalised and approved. Such investments are unlikely to occur until actions are being implemented to ensure that the salinity of supply from the lower Collie River will remain below 1000 mg/L, even in dry years.

There is also the potential to harness up to about 35 GL/yr of fresh water from the lower reaches of the Brunswick River. Environmental concerns related to the effect of reduced flows to the Leschenault Estuary are likely to limit the scale and amount of water able to be diverted. The upper limit of about 35 GL/yr includes provision for 10 to 12 GL/yr to be released from storage each year to meet notional downstream environmental water provisions. Thorough environmental assessment and considerations of alternatives such as pipehead developments and off-stream storage options with less environmental impact would need to be assessed before any development could proceed. This would include consideration of the cumulative effect on the Leschenault Estuary of proposed diversions on both the lower Collie or lower Brunswick Rivers.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>611</th>
<th>Preston River</th>
<th>Water Region</th>
<th>South West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Flow</td>
<td>145.0</td>
<td>GL/yr</td>
<td>Public Drinking Supply</td>
<td>Other purposes</td>
</tr>
<tr>
<td>Sustainable Yield</td>
<td>50.0</td>
<td></td>
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<td>GL/yr</td>
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<tr>
<td>Total Licensed</td>
<td>6.3</td>
<td></td>
<td>6.3</td>
<td>GL/yr</td>
</tr>
<tr>
<td>Effectively Committed</td>
<td>6.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potentially available</td>
<td>43.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mean Annual Flow and Sustainable yield**

The Preston River and the main tributaries of the Ferguson River, Thompson River and Joshua Brook are the main water resources of the Basin. As dam sites are limited and generally of poor quality, the sustainable yield is low relative to the mean annual flow. The Preston River can only be developed as a pipehead diversion (~10 to 15 GL/yr) and potential dam sites on the tributaries occur well up in the catchment (potential yields totalling ~35 to 40 GL/yr). The area is substantially cleared for agriculture, except for the upper reaches where the land tenure is typically State forest. As most clearing has occurred in areas with rainfalls in excess of 1000 mm/yr, the resources are classified as fresh. However, Thompson Brook has an average salinity just in the fresh range (<500 mg/L TSS) and salinities at the high end of the marginal range (1000 mg/L TSS) in drought years.

**Current use and commitments**

Current licensed use supports private irrigation in the Preston, Ferguson and Thompson valleys. Mixed horticulture and apple orchards are the dominant land use water use. Glen Mervyn Dam at the upper end of the Preston valley is the largest storage and provides water to customers of the Preston Valley Irrigation Co-operative (~1.5 GL/yr).

**Potential developments and constraints**

Dam sites on Ferguson River and Thompson Brook could each yield over 10 GL/yr and on Joshua Brook about 4 GL/year but are unlikely to be developed to this level. Current self supply licensed use, either from existing surface water diversions or groundwater bores, is providing sufficient supplies to maintain current agricultural production in the area. It is
unlikely, therefore, that large developments of 5 to 10 GL/yr will be required for irrigation purposes. Development as potential public drinking water sources is possible but of low priority relative to alternatives because of size, location and water treatment costs.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>610</th>
<th>Busselton Coast</th>
<th>Water Region</th>
<th>South West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Flow</td>
<td>599.0</td>
<td>GL/yr</td>
<td>Amount committed to</td>
<td></td>
</tr>
<tr>
<td>Sustainable Yield</td>
<td>135.0</td>
<td>Public Drinking Supply</td>
<td>1.0</td>
<td>GL/yr</td>
</tr>
<tr>
<td>Total Licensed</td>
<td>3.0</td>
<td>Other purposes</td>
<td>2.0</td>
<td>GL/yr</td>
</tr>
<tr>
<td>Effectively Committed</td>
<td>6.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potentially available</td>
<td>128.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mean Annual Flow and Sustainable yield**

The Basin has seven moderate sized rivers and numerous brooks that drain directly to the Indian Ocean. The two largest rivers, Capel River in the north-east and Margaret River in the south west of the Basin, provide about one third of the Basin’s mean annual flow. Streams draining north have headwaters in State forest or national parks, and flow across the coastal plain, through cleared and artificially drained land, to coastal wetlands and Geographe Bay. Westward draining streams rise in either State forest or private cleared land and flow through partially cleared and undulating landscapes before discharging directly to the Indian Ocean. Dam sites are limited to the upper reaches of the northern flowing streams, while dam sites occur in the lower reaches of the larger westward flowing streams. The Basin’s sustainable yield assumes most of the Basin’s sustainable yield (over 55%) is expected to be harnessed by small self-supply dam developments distributed across the Basin. Two larger potential developments on Margaret River (~40 GL/yr) and Willyabrup Brook (~15 to 20 GL/yr) account for the remaining 45%. Salinities are generally fresh, although streams that drain cleared land containing soils derived from granitic or gneissic rocks, where salts have accumulated, have marginal salinities, especially in dry years. Examples include the Capel River and Willyabrup Brook. In the South West, salts invariably accumulate in landscapes with granitic or gneissic basement rocks and where average rainfall is less than 1100 mm/yr.

**Current use and commitments**

The Capel and Margaret River systems are currently proclaimed and public consultation over extending licensing to other parts of the Basin is in progress. Current licensed use (3 GL/yr) is limited to small scale self supply use (mainly for viticulture) and public water supply (mainly for the town of Margaret River). Estimated self supply use in the unlicensed areas is estimated to be a further 3.5 GL/yr and would be licensed when these areas are proclaimed. Total commitments are therefore about 6.5 GL/yr.

**Potential developments and constraints**

In the short term further expansion of viticulture in the region will see a growth in self supply use. Sufficient water is available in the Basin to support this growth, although difficulties in finding sufficient storage within properties and managing competition for water on specific tributaries is expected.
In the short to medium term, Margaret River Town Water Supply is expected to be expanded to serve other centres in the Cape to Cape region. The supply is currently based on Ten Mile Brook, a tributary of Margaret River, and is designed to be augmented by a pump-back facility from Margaret River. This is likely to meet demand for at least five to ten years. In the longer term, there is potential to establish a large storage on the Margaret River (~40 GL/yr) to supply the Cape to Cape region and demand further north. Any such development is unlikely to proceed before the sustainable draw is being taken from the South-west Yarragadee groundwater and surface water developments in the Blackwood and Donnelly River Basin developments. If however, environmental factors substantially constrained the water available from these resources, development of the Margaret River would become a high priority.

Full environmental assessment would be required before the development could proceed. Costs to augment the IWSS from this source are likely to high but marginally less than desalination. Costly land purchase, comprehensive water treatment and moderate to high transmission costs are expected. The notional sustainable yield of 40 GL/yr provides for existing self supply use, a notional 10 GL/yr for releases to maintain the downstream EWP regime, and limits the dam height to avoid inundating the upstream Rapids Conservation Park. At the downstream end, the boundary for the new Bramley National Park has been defined to exclude the potential reservoir area from the national park.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>609 Blackwood River</th>
<th>Water Region South West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Flow</td>
<td>1046 GL/yr</td>
<td>Amount committed to Public Drinking Supply Other purposes</td>
</tr>
<tr>
<td>Sustainable Yield</td>
<td>112.0 GL/yr</td>
<td>1.1 GL/yr - 1.1 GL/yr</td>
</tr>
<tr>
<td>Total Licensed</td>
<td>112.1 GL/yr</td>
<td>-</td>
</tr>
<tr>
<td>Effectively Committed</td>
<td>13.6 GL/yr</td>
<td>-</td>
</tr>
<tr>
<td>Potentially available</td>
<td>98.4 GL/yr</td>
<td>-</td>
</tr>
</tbody>
</table>

**Mean Annual Flow and Sustainable yield**

The Blackwood River Basin extends from the central parts of the Western Australian wheat-belt east of Dumbleyung to the south-west corner of the State to its outlet at the Hardy Inlet and Southern Ocean, near Augusta. The headwater tributaries and upper reaches of the Blackwood River are saline (commonly >3000mg/L TSS). While parts of this landscape included naturally occurring salt lakes, wheat-belt clearing has substantially increased the areas of salt affected land and greatly increased the export of salts down the river system. Average salinities of the Blackwood River at Winnejup (between Boyup Brook and Bridgetown) are 4300 mg/L TSS, where the main forest parts of the Basin commence (average rainfall 700 mm/yr). The River is progressively diluted by fresher tributaries that enter downstream, reaching an average of 2980 mg/L TSS by Nannup (average rainfall 1000 mm/yr), and 1800 mg/L by Twinems Bend and the Hardy Inlet (1100mm/yr). This brackish Blackwood River discharge forms about 90% of the Basin’s discharge to the Hardy Inlet. The remaining 10% comes from the fresh Scott River. The Basin’s sustainable yield is a combination of yields from a range of potential developments on the higher rainfall tributaries of the Blackwood and Scott Rivers where salinities are either fresh or marginal. Typical developments provided yields of between 1 and 10 GL/yr depending on catchment area, location and whether pipehead or storage dam developments were assumed. Two larger
pipehead developments were also identified, on St John’s Brook and Scott River, which combined contributed to about 40% of the Basin’s Sustainable yield.

**Current use and commitments**

The only proclaimed areas in the Basin are the source catchments for the Town Water Supply Schemes of Nannup, Bridgetown-Boyup Brook, Greenbushes-Balingup, Hester and Kirup. The licensed allocations total 1.1 GL/yr. Irrigation and stock water use in non-proclaimed parts the Basin is about 12.5 GL/yr.

**Potential developments and constraints**

In the short term, Water Corporation is planning to develop new storages on Gregory Brook and Camp Creek, small tributaries of the Blackwood River, about 40 kilometres downstream of Bridgetown (1000 mm/annum rainfall) to supplement its current supply from Millstream. This is to establish a more reliable regional water supply scheme to service the towns of Bridgetown and Boyup Brook east as currently, and extend the scheme north to include Greenbushes, Balingup, Hester and Kirup. Based on figures prior to correction for the drier climate, these developments would provide a yield increment of 2 to 3 GL/yr. The boundary of the new Dalgarup National Park was adjusted to accommodate the potential development of Gregory Brook.

The Water Corporation is also assessing the potential of developing St John’s Brook as a pipehead dam (Yield of ~15 GL/yr) to complement their development of the South-west Yarragadee aquifer. The pipehead proposal would be brought forward if significant constraints were identified that limited the sustainable diversion limits of the South-west Yarragadee aquifer. The St John’s pipehead development is located in the new St John’s Brook Conservation Park. Negotiations with CALM are proceeding to ensure that the management plan for the new Park makes provision for the development.

Developments on other tributaries of the Blackwood River, upstream from St John’s Brook, are more remote from future IWSS trunk mains planned to transport water northward from other southern sources in the region. They are therefore unlikely to be developed in the short to medium term. The Scott River pipehead (PhS 13), while having a high nominal yield of over 20 GL/yr, is even more remote from known centres of demand. It is only likely to be developed if mineral processing associated with sand mining occurred in the area.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>608</th>
<th>Donnelly River</th>
<th>Water Region</th>
<th>South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Flow</td>
<td>331.0</td>
<td>Public Drinking Supply</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustainable Yield</td>
<td>91.0</td>
<td>Other purposes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Licensed</td>
<td>9.3</td>
<td>GL/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectively Committed</td>
<td>9.3</td>
<td>GL/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potentially available</td>
<td>81.7</td>
<td>GL/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount committed to</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mean Annual Flow and Sustainable yield**

The headwaters of Donnelly River rise in flat poorly drained land of the southern Darling Ranges to the north-east of Manjimup. The river flows south and east through an
increasingly incised valley of high rainfall Karri and Jarrah Marri forests to reach coastal heaths and sand dunes to the west of the Darling fault, before discharging to the Southern Ocean. The main tributaries of Barlee, Carey and Fly Brooks also rise and flow from the Darling Ranges to join with the main watercourse in its lower reaches just before its outflow to the Southern Ocean. The Basin is predominantly State forest or national park. However, the headwaters of the main river and Manjimup Brook (an upper tributary) are substantially cleared. While increased salinity is apparent in these upper parts of the Basin, the relatively small amount of clearing and fresh runoff from the high rainfall parts of the Basin ensures that main resources of the Basin are all fresh. Pockets of clearing also exist on private land in the lower parts of Beedelup, Carey and Fly Brooks. The sustainable yield is based on the potential development of a large storage on the Donnelly River (Dam Site 40) contributing about 67% (over 60 GL/yr) of the Basin’s sustainable yield, provision for self supply diversions on upstream and downstream tributaries (~ 15 GL/yr), possible pipehead development on the lower reach of the Donnelly River or alternative storage development on Barlee Brook (10 to 15 GL/yr).

Current use and commitments

The current licensed allocations are for existing small scale dams providing water for irrigated horticulture and stock (~7 GL/yr in the upper catchment and ~2 GL/yr in the lower tributaries).

Potential developments and constraints

Major dam developments on the Donnelly River were identified in earlier water resource inventories (1975 and 1985). The 2000 Water Audit confirmed that the Donnelly River as the largest undeveloped fresh surface water resource in the south of the State. A 60 GL/yr diversion at Dam Site 40 provides for a storage release of ~ 15 GL each year to meet (notional) downstream EWP needs and limits the diversion to ~ 50% of the average flow at the site. However, the river and its associated Karri forest valley also have high conservation values. While efforts have been made (in 1987, 1992, 1997-8, 2003-4) to ensure that potential conservation reserves would not conflict with potential reservoir developments along the valley, in late 2004 Parliament created a Class A reserve over the preferred reservoir site to form the Greater Beedelup National Park. This was one of 30 new or extended national parks being created to implement the Gallop Government’s Old Growth Forests Policy. Before any water supply development can now proceed, a future Parliament will have to excise the area needed from the National Park. Excisions of areas for public water supply purposes were acknowledged in the Minister’s second reading speech on the Bill (Hansard 24/06/04) that established the Class A reserve. CALM is to also include this potential in its Management Plan for the Park. Hence large reservoir developments on the Donnelly River remain possible. However, obtaining the necessary approvals will be difficult, require long lead times and contain considerable uncertainties. Thorough environmental assessment, approval by the Environment Minister, and support of Parliament for the excision is required before any project could proceed past the planning phase. Total source and transport costs of water from the Donnelly River are expected to be around 90 to 100 cents per kL and therefore slightly cheaper than current estimates of desalination costs.

If environmental factors precluded a major dam in the main valley, small pipehead dams on the lower Donnelly River and Barlee Brook, located in State Forest, could be developed to
provide a combined sustainable yield of about 40 GL/yr. The Water Corporation see the Barlee Brook site (DS25) as a possible compliment to their South-west Yarragadee well-field if the sustainable aquifer draw proves to be limited (see also Basin 609). There is potential for a further 5 GL/yr to be allocation for further small farm dams on private land in the Basin.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>Warren River</th>
<th>Water Region</th>
<th>South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Flow</td>
<td>411.0 GL/yr</td>
<td>Amount committed to</td>
<td></td>
</tr>
<tr>
<td>Sustainable Yield</td>
<td>207.0</td>
<td>Public Drinking Supply</td>
<td></td>
</tr>
<tr>
<td>Total Licensed</td>
<td>30.6</td>
<td>Other purposes</td>
<td></td>
</tr>
<tr>
<td>Effectively Committed</td>
<td>30.6</td>
<td>1.9 GL/yr</td>
<td></td>
</tr>
<tr>
<td>Potentially available</td>
<td>176.4</td>
<td>28.7 GL/yr</td>
<td></td>
</tr>
</tbody>
</table>

**Mean Annual Flow and Sustainable yield**

The Warren River Basin rises in cleared land about 15 kilometres south of Kojonup, and extents through mixed farming and forested areas to the south-west, reaching the Southern Ocean near Pemberton. The Tone and Perup River tributaries drain the inland upper reaches of the Basin and are brackish. The Warren River, like the Blackwood, is diluted by fresher tributaries as it flows through progressively higher rainfall and forested areas of the Basin and is of marginal salinity when it discharges to the sea. The sustainable yield estimated for the 2000 Water Audit was made up of yields from a large storage on the main River upstream of Lefroy Brook at Dam Site 55 (~ 100 GL/yr of marginal salinity), a large storage on Dombakup Brook (Dam site 1.6), a high rainfall tributary south of Pemberton (~30 GL/yr of fresh water), an associated pump-back diversion (Ph18) from the lower Warren (~25 GL/yr of marginal salinity), and small farm dams and town water supply dams developments in the mid and lower parts of the Basin (~50 GL/yr of marginal or fresh salinity depending on their location).

**Current use and commitments**

The current commitments are related to the existing Town Water Supply Scheme for Manjimup and Pemberton, the Pemberton Trout Hatchery and small farm dam developments that provide water for irrigated horticulture and stock in the Basin.

**Potential developments and constraints**

While remote from current demands and existing services, the large undeveloped resources of the Warren River Basin remain strategically important to meet medium to long term water demand growth in the Perth to Busselton region. The expected total costs per kilolitre to harness and transmit these resources to the main IWSS demand centre (Perth) will be similar to the costs of desalination (~ $1.10/kilolitre). However, the energy needed will be much lower (probably about one third) and have consequent greenhouse gas emission advantages. The costs will be cheaper and greenhouse gas emission advantages greater if most of the water is used in the Bunbury Region and not transferred the full distance to Perth.

Their development would logically follow after the available resources of the Donnelly River Basin were fully harnessed. Their development could be phased with the Dombakup Brook Dam, and the lower Warren River pump-back (at Ph18) being the most likely to be
constructed first. The capacity of the pump back could be increased progressively as demand grew to reach a maximum of 70 to 80 GL/yr. The combined scheme would provide about 100 to 110 GL/yr, before the upstream dam on the main Warren River (DS 55) would be required. Most of the Dombakup Brook reservoir area would flood young karri regrowth forest of lower commercial and aesthetic value relative to more mature stands. However, the development will impact on small areas (from 75 to 200 hectares depending on the final dam design chosen) of the new Greater Hawke National Park. Approval of the Minister for the Environment and Parliament, to excise the areas from the national park, would be required.

Sufficient water is available for some small scale dam developments on private land in the Basin. However, limits have been reached on some tributaries.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>606</th>
<th>Shannon River</th>
<th>Water Region</th>
<th>South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Flow</td>
<td>GL/yr</td>
<td>708.0</td>
<td>Sustainable Yield</td>
<td>58.1</td>
</tr>
<tr>
<td>Total Licensed</td>
<td>Effectively Committed</td>
<td>GL/yr</td>
<td>GL/yr</td>
<td>Other purposes</td>
</tr>
<tr>
<td>Effectively Committed</td>
<td>GL/yr</td>
<td>4.8</td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td>Potentially available</td>
<td>GL/yr</td>
<td>53.3</td>
<td>GL/yr</td>
<td></td>
</tr>
</tbody>
</table>

**Mean Annual Flow and Sustainable yield**

The Walpole, Deep, Shannon and Gardner River systems form the Shannon River Basin. The headwaters of the Deep and Shannon Rivers arise near Lake Muir and flow south reaching the Nornalup and Broke Inlets respectively before discharging into the Southern Ocean. Rainfall ranges from 800 mm/annum in the headwaters of the Deep River to over 1400 mm/annum near the coast. Their catchments are fully forested and lie within the greater Walpole Wilderness Area. All streamflow is fresh. The shorter Walpole River, to the east of the Deep River, rises in 1200 mm/annum rainfall and discharges to the Walpole Inlet and onto the Nornalup Inlet. While predominantly in the Walpole Wilderness Area it contains some private land in its lower reaches. The Gardner River and its tributaries drain the western third of the Basin, discharging directly to the Southern Ocean due south of Northcliffe. The catchment rises in 1200 mm/annum rainfall and contains a patchwork of cleared and forested land. As the clearing occurs in areas of high rainfall, stream salinities remain fresh.

The Basin’s sustainable yield (58.1 GL/yr) is 4.9 GL/yr lower than the 2000 Water Audit estimate. This reduction reflects the loss of a potential pipehead development on the Weld River, a tributary of the Deep River, because of the establishment of the new Deep-Ordnance (Mt Frankland South) National Park that forms part of the Walpole Wilderness Area. The new national park, together with the existing Shannon River National Park, means that no developments are now considered possible on the Deep or Shannon Rivers. The Basin’s sustainable yield is, therefore, restricted to contributions from small dam developments on private land (~ 20 GL/yr), pipehead developments on Canterbury and Walpole Rivers, and Buldania and Collier Creeks (~25 GL/yr), and a storage development on Boorara Creek (10-15GL/yr).
Current use and commitments

No areas in the Basin have been proclaimed so there are no licensed allocations. Current use is estimated to be about 4.8 GL/yr and consists mainly of water use from private farm dams in the cleared areas of the Gardner River catchment. Armstrong Spring provides a small Town Water Supply to Northcliffe (0.03 GL/yr) and a small pipehead diversion on the Walpole River provides the source for the Walpole Town Water Supply (0.08 GL/yr).

Potential developments and constraints

As these resources are remote from current centres of demand, it is unlikely that they will be developed for many years, if at all. However, if new demands develop in the region, related to mineral processing or industries based on the timber industry for example, they would become important. The only potential development with sufficient storage to meet such demands is on Boorara Creek at Dam Site 2. However, the reservoir from this development would flood about 150 ha (~1.5%) of the new Boorara Gardner National Park. Environmental approval and excision of the inundation area from the National Park would be required before the development could proceed.

Given Water Corporation’s current facilities, the Walpole River is not a reliable source of supply to Walpole Town in dry years. Insufficient base flows continue through the last months of Summer and Autumn to maintain the supply. While sufficient water is available from the resource, additional storage (and better catchment management to protect water quality) is required in the near future, if past supply problems are to be avoided.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>605</th>
<th>Franklin River</th>
<th>Water Region</th>
<th>South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Flow</td>
<td>GL/yr</td>
<td>205</td>
<td>Amount committed to Public Drinking Supply Other purposes</td>
<td></td>
</tr>
<tr>
<td>Sustainable Yield</td>
<td>6.0</td>
<td>GL/yr</td>
<td>GL/yr</td>
<td></td>
</tr>
<tr>
<td>Total Licensed</td>
<td>-</td>
<td>0.1</td>
<td>GL/yr</td>
<td></td>
</tr>
<tr>
<td>Effectively Committed</td>
<td>1.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potentially available</td>
<td>4.9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean Annual Flow and Sustainable yield

The Frankland River Basin rises in the southern wheat-belt near Broomehill, and drains flat poorly drained areas to the south and west before reaching better drained mixed farming areas around Rocky Gully. In this upper part of the Basin average rainfall ranges between 450 to 750 mm/annum and stream runoff is low and highly saline. The Basin narrows to the west and south of Rocky Gully, as the Frankland River drains south through higher rainfall areas of the CALM estate (the Walpole Wilderness Area). The river emerges from this forested zone to drain small areas of cleared private land (rainfall 1200+ mm/annum) in the last 20 kilometres of its passage to Nornalup Inlet.

The Frankland River is the only outlet from the Basin. Hence the Basin’s mean annual flow is effectively the average flow of Frankland River as it discharges to Nornalup Inlet. Classified as brackish, the Frankland River is one of the most saline river systems in the south-west of WA. This is a consequence of the limited amount of fresh water, provided
from the small forested and high rainfall parts of the Basin, to dilute the saline flows from the much larger cleared areas of the upper parts of the Basin.

The sustainable yield of the Basin is therefore based on small scale developments on tributaries in cleared private land around Rocky Gully (~5 GL/yr with marginal quality) and Walpole (~1 G/yr of fresh quality)

**Current use and commitments**

No areas are proclaimed in the Basin, so no licensed allocations have been granted. However, small scale self supply use in the area around Rocky Gully was estimated to be about 1 GL/yr and is used primarily for viticulture irrigation and stock watering. Because of salinity problems in valleys, storages are sometimes placed high in the landscape and off-stream, to enable fresher water during high flows in winter to be harnessed and stored without contamination from saline groundwater. Around Walpole private use was estimated to be 0.1 GL/yr and used mainly to water stock.

Minor sources from roaded and bitumen catchments (at Tambellup and Frankland) and a Rocky Gully Tributary (at Rocky Gully) contribute to local town water supplies (total use ~0.1 GL/yr).

**Potential developments and constraints**

No large scale resources is available for development. The number of small scale diversions/developments may grow but total use is unlikely to reach the estimated sustainable yield of ~ 5 GL/yr.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>604 Kent River</th>
<th>Water Region</th>
<th>South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Flow</td>
<td>GL/yr</td>
<td>170</td>
<td>Amount committed to</td>
</tr>
<tr>
<td>Sustainable Yield</td>
<td>20</td>
<td>Public Drinking Supply</td>
<td></td>
</tr>
<tr>
<td>Total Licensed</td>
<td>-</td>
<td>Other purposes</td>
<td></td>
</tr>
<tr>
<td>Effectively Committed</td>
<td>0.6</td>
<td>GL/yr</td>
<td></td>
</tr>
<tr>
<td>Potentially available</td>
<td>19.4</td>
<td>GL/yr</td>
<td></td>
</tr>
</tbody>
</table>

**Mean Annual Flow and Sustainable yield**

The upper parts of the Kent River Basin rise in mixed farming areas south of Cranbrook, west of Mt Barker and east of Frankland. Although the area has reliable rainfall (average of 600 mm/annum), the natural drainage is poor and characterised by ill defined watercourses that connect shallow salt affected lakes. These lake systems rarely overflow and only contribute salt and water to the lower part of the Basin in years when winter rains are well above average. To the south, as average rainfall reaches 700 mm/year, the landscape becomes more dissected and better drained, with runoff contributing to the main Kent River every year. The Kent river then flows to the south-west through progressively higher rainfall areas to reach the northern edge of the Walpole Wilderness Area (average rainfall ~800 mm/yr). The River then flows south, to emerge from the Walpole Wilderness Area into cleared private where the Styx River enters from the east. This tributary drains forest in the Walpole Wilderness area with average rainfall in the 900 to 1000 mm/annum range, before
flowing through partly cleared private land (1050 mm/annum) to join the Kent River. From the confluence, the Kent River continues south through a patchwork of cleared and forested land before discharging to the Irwin Inlet (average rainfall 1200 mm/annum). Fresh inflows from the forested and higher rainfall cleared parts of the Basin dilute the salinity of the main Kent River in its lower reaches. From the late 1970s constraints on broad acre clearing, and the purchase and replanting of some farmland in the upper part of the Basin was undertaken to limit the salinity deterioration of Kent River. While the potential deterioration was limited, the Kent River remains a brackish water resource. The Kent River contributes about 72% to the discharge to Irwin Inlet. The Bow River and Karri Creek provide the remaining 28% of the discharge to Irwin Inlet. This direct inflow to Irwin Inlet is fresh. The Bow River rises in 1150 mm rainfall forested within the Walpole Wilderness area and contains small areas of private cleared land on tributaries that join the River in their lower reaches.

The Kent River Basin also includes the catchment of Parry Inlet, a small estuary to the east of Irwin Inlet. Kordabup River is the main inflow to Parry Inlet. Its catchment drains cleared private land with average rainfall of between 1100 and 1200 mm/annum rainfall and the inflow fresh. Total inflow to Parry Inlet is estimated to be about 10% of the total inflow to Irwin Inlet.

With the main Kent River being brackish, the Basin’s sustainable yield consists primarily of potential developments on the Bow and Styx Rivers (~16 GL/yr). The remaining ~4 GL/yr reflects further potential for small scale developments on the two arms of Kordabup River.

Current use and commitments

No areas in the Basin have been proclaimed under the RIWI Act. Hence no licensed allocations have been made. Current estimated use is based on small scale self supply developments on tributaries in the mid Kent River catchment (~0.1 GL/yr), the high rainfall tributaries of the Kent River (~0.2 GL/yr) and the tributaries of the lower Bow River (~0.3 GL/yr).

Potential developments and constraints

The available resources of this basin are most likely to be used to meet medium to long term demand for public drinking water supplies in the Peaceful Bay to Walpole south coast region.

Any proposed development in the Walpole Wilderness Area will require thorough environmental review and the approval of the Environment Minister, for it to proceed. The potential developments on the Bow and Styx Rivers, while falling within the greater Walpole Wilderness Area, have not become national parks. Southern parts of the Walpole Wilderness Area, including the potential developments are to remain State forest, but classified as a “forest conservation area”, where timber removal is not permitted. The CALM Act 1984 and the 2004–2013 Forest Management Plan provide for permits to be issued that enable the diversion of water, including establishing the related infrastructure, to occur in State forest. However, as no timber can be removed from a “forest conservation area”, a water supply development that required timber removal could not proceed until the area required is excised from the “forest conservation area”. Proposals to change the boundary of a “forest conservation area” have to be laid before Parliament for two weeks and are subject to a disallowance motion by members. This additional process, while not as uncertain as
obtaining Parliamentary approval to excise an area from a national park (or other Class A Reserve), will extend the lead time for obtaining the necessary approvals to develop these resources.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>Denmark River</th>
<th>Water Region</th>
<th>South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Flow</td>
<td>210 GL/yr</td>
<td>Sustainable Yield</td>
<td>36.9 GL/yr</td>
</tr>
<tr>
<td>Total Licensed</td>
<td>-</td>
<td>Effectively Committed</td>
<td>1.0 GL/yr</td>
</tr>
<tr>
<td>Potentially available</td>
<td>35.9 GL/yr</td>
<td>Amount committed to Public Drinking Supply</td>
<td>0.4 GL/yr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other purposes</td>
<td>0.6 GL/yr</td>
</tr>
</tbody>
</table>

Mean Annual Flow and Sustainable yield

The headwaters of the Hay and Denmark Rivers form the upper part of the Denmark River Basin. These are mixed farming areas that lie to the south and west of Mt Barker where with average rainfall is 700 mm per annum. The Denmark River drains the western portion of the basin, flowing through mainly forested higher rainfall land to discharge to Wilson Inlet at Denmark (only about 12% of the catchment to Wilson Inlet is cleared) where average rainfall is over 1100 mm/yr. Important fresh tributaries of the lower Denmark River include Scotsdale Brook (on the west) and Quickup Brook (on the east). The Denmark River is of marginal salinity today, in part because of the protection of remnant vegetation since the 1970s and reforestation of significant areas of cleared land in the upper catchment. In contrast, the Hay River is brackish. It drains the eastern portion of the Basin where rainfall is lower and clearing greater (~ 40% cleared to Wilson Inlet), before also discharging into Wilson Inlet. Although private tree plantations have also been established in its catchment in the last decade, the average salinity remains above 1000 mg/L.

The Denmark (~35%) and Hay (~43% ) Rivers contribute 88% of the mean annual discharge to Wilson Inlet. The remaining 22% comes from smaller fresh streams that drain the cleared coastal plain areas around the Inlet. These include the Sleeman and Cuppup Rivers from the east and the Little River to the west.

The River Basin also includes Marbellup Brook and drained coastal plain areas that discharge to Torbay Inlet, east of Wilson Inlet. Average rainfall ranges from 900 to 1050 mm. However, the soils are mostly sandy and runoff is fresh. Marbellup Brook provides over 60% of the total inflow to Torbay Inlet entering from the east. The remainder comes from drained coastal areas on the west of Torbay Inlet. Overall the inflow to Torbay Inlet represents about 21% of the total discharge from the Basin.

Contributions to the sustainable yield of the Basin come from potential diversions at existing dams on the Denmark River (DS9) and Quickup Brook (DS3) totalling ~1GL/yr, small scale private developments totalling ~5 to 10 GL/yr (mainly from Scotsdale Brook and Sleeman River self supply areas) in high rainfall parts of the Basin, moderate scale pipehead developments totalling up to ~ 10 GL/yr (primarily Marbellup Book at PHS1- ~6 GL/yr), and large storage developments on the lower Denmark River that could yield between 15 and 20 GL/yr, depending on the site developed.
Current use and commitments

No areas are proclaimed in the Basin. Hence there are no licensed allocations. However, 0.4 GL/yr is committed from the Quickup (0.25 GL/yr) and Denmark Rivers (0.15 GL/yr) for the Denmark Town Water Supply. The remaining 0.6 GL/yr is estimated self supply use from the higher rainfall parts of the Basin.

Potential developments and constraints

The undeveloped resources of the Basin are most likely to be used to meet medium term growth in water demand on the Denmark and Lower Great Southern Town Water Supply (LGSTWS) Schemes. Proposals to divert water from Marbellup Brook for direct supply to Albany, or to recharge the aquifer used as a source to the LGSTWS Scheme are currently being investigated by the Water Corporation. Large increments in water demand (> 5 GL/yr) are possible if new industries are attracted to the region. The lower Denmark River is the only resource in the region capable of meeting such large demand increments. The task of obtaining the approvals for a large storage development on the lower Denmark River has been made easier by the creation of a miscellaneous reserve created for the purposes of conservation, recreation, future reservoir and water infrastructure by the Reserves (National Parks, Conservation Parks, and Other Reserves) Act 2004. The reserve will be managed by CALM (under section 5(1) (h) of the CALM Act 1984 until it is needed for water supply development. Any large dam proposal in the reserve will require environmental approval before it could proceed. However, Parliament will not also need to approve the reclassification of Class A reserved land for the development to proceed.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>602</th>
<th>Albany Coast</th>
<th>Water Region</th>
<th>South West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Flow</td>
<td>GL/yr</td>
<td>330</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustainable Yield</td>
<td>19.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Licensed</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectively Committed</td>
<td>3.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potentially available</td>
<td>15.9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean Annual Flow and Sustainable yield

The Basin includes watercourses that drain to Princess Royal and Oyster Harbour at Albany in the west and all those that drain to the Southern Ocean to the east up to and including the Hamersley River, east of Jerramungup. Apart from the Bolganup River, King River (a tributary of the Kalgan River), the rivers and streams that drain the sand plain country to the north of the Two Peoples Bay area, and Waychinicup Brook (to the east of the Mt Many Peaks Range), all other rivers in the basin are either brackish or saline.

The Basin’s Sustainable Yield are therefore limited to these fresh or marginal resources. The main contributions to the sustainable Yield are existing licensed diversions for the LGSTWSS (~ 2 GL/yr), a possible pipehead development on the King River [at PHS9 (~7.5 GL/yr)], and other small pipehead diversions totalling the about ~10 GL/yr. Of the potential pipehead developments the main ones are Waychinicup Brook (~2.5 GL/yr),
Chelgiup Creek (~2 GL/yr) and Goodga River (~2GL/yr). These are of marginal salinity. Willyung Creek (~ 2GL/yr), an upper tributary of the King river, is fresh.

**Current use and commitments**

The Public Water Supply allocations include the diversion of Bolganup River, in the Poronourups Range near Mt Barker (0.2 GL/yr) and Angove River, near Two Peoples Bay (1.6 GL/yr). Both are sources used for the LGSTWSS. The remaining unlicensed use is estimated as being small scale diversions for stock watering and minor irrigation activities across the Basin.

**Potential developments and constraints**

With over 15 GL/yr of water potentially available, there appears little shortage of water in the Basin, given that current total demands in the region are no more than about 5 to 6 GL/yr (with the LGSTWSS being 4 to 5 GL/yr). However, many of the possible developments have limitations as new sources of public drinking water. Most are of marginal salinity. While the sands and limestone geology of the area north of Two Peoples Bay suggests that salt stores are unlikely to be high, the full effect of past clearing on groundwater discharge and stream salinity may not have been reached. Moreover, as the pipe-head catchments contain cleared land, the turbidity, colour and bacterial quality of the raw water will be generally poor and highly variable. Comprehensive and sophisticated treatment plants (to manage the variable raw water quality) will be required if the pipehead developments are to be used as new sources for the LGSTSS. In particular, the small rural holdings in the lower King River catchment, pose an increased risk of contamination and is unlikely to be developed as a drinking water source. Similarly, Willyung Creek includes some urban land, the Albany Airport and is subject to continuing urban pressures. The Waychinicup Brook pipehead is remote from current demand centres and within the existing Waychinicup National Park, the resource could be developed upstream. The diversion limit ultimately approved is likely to be lower than 2.6 GL/yr estimated in the 2000 Water Audit.

The available water from the Basin is also based entirely on pipehead diversions. While some catchments have extended base flows the bulk of the water will be diverted during the winter and spring months. Either additional off-stream storage or conjunctive development with additional groundwater wellfields is expected to be necessary.

Given the above, the amount available to augment the LGSTSS in the medium term from this Basin is unlikely to be more than about 5 GL/yr. This could only be developed in increments of 2 GL/yr or less.
CONCLUDING REMARKS

Declining streamflows and climate change

While debate continues about the degree to which the decline in observed streamflow data since 1975 is a result of climate change or just natural variability, there is general agreement that the high streamflows recorded during the 1960s and early 1970s, are unlikely to be repeated in the coming decade.

Until further research provides a more definitive means of characterising future streamflows, the Water and Rivers Commission has decided to base its future surface water allocation decisions on hydrologic studies that use the Standard Period of 1 May 1975 to 30 April 2003. This period reflects the decline streamflows observed since 1975, and is sufficiently long to provide reasonable definition of the natural variability of streamflows expected over the next decade. By reflecting this variability in simulations of future reservoir operations, appropriate operating rules can be determined and included in licence conditions. This approach effectively considers that the recent sequence of very low streamflows since 1997, is a sequence has the same underlying statistical distributions as the Standard Period, albeit with a low probability of occurrence. While accounting for the natural variability of the Standard Period is necessary for licensing purposes, when planning future source developments it is prudent to consider the implications of the lower average streamflows observed since 1997. This approach is being taken by the Water Corporation.

The following table indicates the decline in mean annual flows observed in long term streamflow data sets of selected river systems throughout the South West region. The mean annual flows for two periods, from 1975 to 2003, and from 1997, have been expressed as a percentage of the mean annual flow for the 2000 Water Assessment representative data period of 1962 to 1995. The declines in individual data sets were grouped by river basins, to assist the interpretation of the estimates of water availability estimates presented in this appendix.

Table 6  Mean streamflows for the Standard Period and from 1997 – expressed as a % of the mean for period 1962 to 1995 (representative of data used in the 2000 Water Audit)

<table>
<thead>
<tr>
<th>River basin</th>
<th>1975 to 2003</th>
<th>From 1997¹,</th>
<th>Data sets used</th>
</tr>
</thead>
<tbody>
<tr>
<td>616</td>
<td>62.6%</td>
<td>43.8%</td>
<td>Inflows to IWSS Dams in the Swan Coastal River Basin</td>
</tr>
<tr>
<td>614</td>
<td>65.6%</td>
<td>48.5%</td>
<td>Inflows to IWSS Dams in the Murray River Basin</td>
</tr>
<tr>
<td>613</td>
<td>87.5%</td>
<td>67.5%</td>
<td>Harvey River, Samson and Wokalup Brooks,</td>
</tr>
<tr>
<td>612</td>
<td>77.8%</td>
<td>71.9%</td>
<td>Harris and Brunswick Rivers</td>
</tr>
<tr>
<td>611</td>
<td>86.0%</td>
<td>77.1%</td>
<td>Thompson River</td>
</tr>
<tr>
<td>610</td>
<td>81.7%</td>
<td>68.7%</td>
<td>Margaret River</td>
</tr>
<tr>
<td>609</td>
<td>81.2%</td>
<td>72.5%</td>
<td>Blackwood River</td>
</tr>
<tr>
<td>608</td>
<td>83.0%</td>
<td>68.8%</td>
<td>Donnelly River</td>
</tr>
<tr>
<td>607</td>
<td>85.2%</td>
<td>75.7%</td>
<td>Lefroy Brook, Warren River</td>
</tr>
<tr>
<td>606</td>
<td>84.7%</td>
<td>77.2%</td>
<td>Weld River</td>
</tr>
<tr>
<td>605</td>
<td>89.0%</td>
<td>77.3%</td>
<td>Frankland River</td>
</tr>
<tr>
<td>604</td>
<td>90.8%</td>
<td>66.9%</td>
<td>Kent River</td>
</tr>
<tr>
<td>603</td>
<td>96.1%</td>
<td>69.7%</td>
<td>Yate Flat Ck, Denmark R</td>
</tr>
<tr>
<td>602</td>
<td>99.8%</td>
<td>69.0%</td>
<td>Goodga River</td>
</tr>
</tbody>
</table>

¹ Based on the eight years from 1997 to 2004 inclusive, except for Basins 616 and 614 where data for the six water years from 1997/6 to 2002/3 were used
The declines have been greatest in the northern river basins near Perth, where the surplus of rainfall over evaporation is small and streamflow yields tend to be low. The rivers that contribute to the IWSS in the Swan Coastal and Murray River Basins recorded average streamflows from 1975 to 2003 of between 35% and 40% lower than for the 1962 to 1995 period. Similar reductions can be expected in licensed entitlements when the Water and Rivers Commission adjusts the licensed entitlements for the Standard Period.

The reductions in average streamflows are not as great in Basins where high streamflow yields are high (the Harvey River Basin, for example) and where the surplus of rainfall over evapo-transpiration is greater (the southern and South Coast basins). If streamflow trends continue and the quantities recorded since 1997 become the norm, the undeveloped southern rivers will become extremely important in meeting future water needs in the region in two ways. As their streamflows are unlikely to decline as rapidly as rivers to the north, they provide important options to complement existing sources to maintain current demands as streamflows decline. Even if declines in streamflow continue, the larger southern river resources will remain able to contribute significantly to demand growth in the region in the medium term.

**SUSTAINABLE YIELD METHODOLOGY**

The methodology used to establish sustainable yields for the 2000 Water Audit is described below.

The Sustainable Yield of any surface water development or set of developments is defined as the amount that can be reliably diverted from the surface water resource(s) being harnessed, while sufficient water is maintained in the watercourse(s) to meet all environmental water provisions specified for the resource(s) in question. These environmental water provisions are flow regimes chosen to maintain defined ecological and social values of the resource, considered important to protect into the future. Environmental water provisions are now determined as part of the assessment of all significant new surface water license applications and often require specific studies to be undertaken. For broad scale inventory purposes such specific studies are unwarranted. The following generalised methodology was developed to account for the needs of the environment for the purposes of the 2000 Water Audit.

Previous surface water resource inventories (in 1975 and 1985) based the amount of available water solely on that which could be practically diverted, from an engineering perspective. The “Divertible Yield” was based on estimating the amount of water that could be reliably diverted from rivers at existing dams and identified sites where new dams could be constructed to practical engineering limits. That is, the divertible yield is the practical upper limit of the amount of water that can be diverted from a watercourse without any environmental constraints. The difference between the sustainable and divertible yields at a particular site reflects the yield forgone in providing water for the environment.

For the purposes of the inventory, notional estimates of environmental water provisions were required for each potential dam and pipehead diversion site in the State. The nominal environmental water provision in each case was depended on the water resource management objective adopted for defined sub areas of each River Basin. The four broad objectives used and the range of adopted water provisions associated with each objective are listed below:
Table 7 Management objectives for sub-areas of river basins

<table>
<thead>
<tr>
<th>No.</th>
<th>Management objective for sub-areas of river basins</th>
<th>Notional environmental water provision – as % of Divertible Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>Environment pre-eminent - development highly constrained</td>
<td>80% to 100%</td>
</tr>
<tr>
<td>M2</td>
<td>Water development sensitive to defined environmental values</td>
<td>20% to 40%</td>
</tr>
<tr>
<td>M3</td>
<td>Water development pre-eminent – low environmental values</td>
<td>10% to 30%</td>
</tr>
<tr>
<td>M4</td>
<td>Little development potential or recognised environmental ranking</td>
<td>0% to 10%</td>
</tr>
</tbody>
</table>

The River Basin sub-areas were identified to include water resources that had similar management issues and environmental constraints associated with their potential development. Factors influencing this definition included the location and types of potential developments, known environmental constraints, existing land tenure, catchment land use and water quality considerations. For example, existing national parks within River Basins were established as sub-areas where the environment was pre-eminent and assigned the M1 objective. If a potential dam site was located in the sub-area, the nominal environmental water provision was set as 100% of the Divertible Yield, the Sustainable Yield therefore became zero and the development site was effectively forgone. Sub-areas that were located upstream of high conservation areas and were mainly forested were usually assigned the management objective M2. Areas of private land where clearing was predominant were usually assigned either objective M3 or M4 depending on the rainfall zone and the salinity of the streams of the area. Where interim environmental water provisions had been proposed or set in allocation plans these were used in preference. No provision was made in the case of existing dams where licensed allocations had been issued prior to 2000, without making provisions for the environment. After an initial pass through all sites, management objectives and nominal water provisions for particular areas were fine-tuned based on accumulated knowledge of planning decisions current at the time and the final set of sustainable yields were adopted.

An indication of how the planning for new water sources has changed in the past ten years can be gauged by comparing the water source development plans developed by the Water Authority of WA (1995) with those developed in early 2001 (immediately before a low runoff period) and in early 2005.

In 1995 there was concern expressed that the lower runoff that had been recorded since about 1970 may be part of climate change. This report preceded a major capital works program which greatly increased supply capacity in the next eight years. Planning of water resources in areas such as the Harvey Basin expedited the development of later sources (e.g. Samson, Wokalup). In many ways this comprehensive form of planning was visionary by incorporating many of the principles espoused in Integrated Resource Planning, with the use of social studies to underpin demand management, introduce water saving devices, etc.

Table 8 shows that each plan has used successively shorter periods of runoff record, lower assumptions about per capita consumption, and reduced likelihood of restrictions, reflecting an increased emphasis on demand management and stronger consumer preference to avoid severe restrictions as service industries become more dependent on a reliable water supply.

Table 8 Assumptions used in developing sources plans since 1995 (WAWA, 1995; Water Corporation, 2001; Water Corporation, 2005)

<table>
<thead>
<tr>
<th>Year of plan development</th>
<th>Stream record used</th>
<th>Per capita assumption used kL/person/yr</th>
<th>Restrictions probabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>1934 – 1974</td>
<td>180-240 (without Water Use Efficiency measures) 180-210 (with Water Use Efficiency measures)</td>
<td>10% mild restrictions 5% severe restrictions</td>
</tr>
<tr>
<td>2001</td>
<td>1975 – 2000</td>
<td>185</td>
<td>10% mild restrictions 3% severe restrictions</td>
</tr>
<tr>
<td>2005</td>
<td>1997 - 2004</td>
<td>155</td>
<td>10% mild restrictions 0.5% severe restrictions</td>
</tr>
</tbody>
</table>

Table 9 shows the recommended sources and their timeframes for development form each plan.

In 1995, extensions of the existing groundwater wellfields on Gnangara and new surface water sources were the main new sources expected up until 2021. High and low demand scenarios impacted on the timing of each development. Forest management, reuse of drainage water and wastewater reuse were all promising areas for research and development which showed a lot of foresight.

Developing the South West Yarragadee was a source to be developed between 2010 and 2050 at a cost of about $0.91/kL. Desalination was thought to be very long term (beyond 2050) reflecting the high relative cost of this technology at that stage ($1.70/kL). Tankering water from the Kimberleys ($3.00/kL) was estimated to be cheaper than piping ($3.50/kL).
Table 9 How sources have changed in each plan since 1995

<table>
<thead>
<tr>
<th>Year of plan development</th>
<th>Source</th>
<th>Yield (GL/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>Quinns groundwater</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Whitfords groundwater</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Lower Serpentine pumpback</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Lexia groundwater</td>
<td>11.1</td>
</tr>
<tr>
<td></td>
<td>Eglinton groundwater</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Yanchep/Two Rocks groundwater</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Partial raise Mundaring Weir</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Jane Brook pumpback to raised Mundaring Weir</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>Pinjar Stage 2 groundwater</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>Pinjar Stage 3 groundwater</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td>New Harvey Dam</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Wellesley Creek pumpback to new Harvey Dam</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Barragooon Stage 3 groundwater</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>Barragooon Stage 1 groundwater</td>
<td>8.7</td>
</tr>
<tr>
<td></td>
<td>Barragooon Stage 2 groundwater</td>
<td>9.1</td>
</tr>
<tr>
<td>2001</td>
<td>Samson pipehead</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Harris pumpback</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Mirrabooka borefield upgrade</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Wellesley Creek pumpback</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>Eglinton groundwater</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Pinjar conventional or Yarragadee</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Wellington</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Logue Brook Dam</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Barragooon Stage 3 groundwater</td>
<td>3.9</td>
</tr>
<tr>
<td>2005</td>
<td>Seawater desalination plant 1</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Water trading in the Harvey and Waroona Irrigation Areas</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>South West Yarragadee groundwater</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Seawater desalination plan 2 (alternative to SWY groundwater)</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Wungong Catchment management</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Eglinton groundwater</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Wellington pumpback</td>
<td>12</td>
</tr>
</tbody>
</table>

The cost of supporting water efficiency practices and appliances was compared with new water sources. Leak reduction, efficient toilets, efficient showerheads and efficient washing machines were the cheapest options estimated to save up to 50 GL/yr by 2020.

In summary, the 1995 plan was very well researched and anticipated many of the issues that followed.

By the 2001 plan, some of the initiatives in the 1995 plan had been implemented or initiated (e.g. new Harvey Dam) and the emphasis was continuing to be on relatively small surface and groundwater sources which extended and complemented the existing infrastructure.

Because of the very poor runoff year in 2001, a number of these were fast tracked which greatly increased capacity over the next 18 months (e.g. Samson, Wellesley – which became Wokalup, west Mirrabooka). A contingency plan identified six deep Yarragadee bores that could be developed in the western suburbs, three of which were installed in 2002/03.
The 2005 plan assumes that a seawater desalination plant will be built and the emphasis is more on future large sources (e.g. South West Yarragadee, a second desalination plant) than multiple small sources.

In summary, the three source development plans have shown that many initiatives have been foreshadowed but the rapidly drying climate has required many to be fast-tracked (e.g. desalination, South West Yarragadee) and others to be discarded as likely to be affected by climate change (e.g. further wellfields on the upper flank of Gnangara Mound, raising dam walls).

It is probably timely that the Perth’s Water Future report be updated to ensure that the correct balance between new sources, reuse and demand management is achieved.