Government of **Western Australia**
Department of **Water**

Gnangara

groundwater areas allocation plan

Looking after all our water needs

Water resource allocation
and planning series
Report no. 30
November 2009

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November 2009

ISSN 1327-8428 (print)
ISSN 1834-2620 (online)

ISBN 978-1-921637-69-8 (print)
ISBN 978-1-921637-70-4 (online)

Acknowledgements

The Department of Water would like to acknowledge in particular, the following for their contribution to this publication: the Gnangara groundwater areas project team, project board and regional staff.

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Foreword

The Gnangara groundwater system is the major source of potable water for public water supply in the south-west of Western Australia. It also supports an extensive horticultural industry, urban parks and recreational areas, industrial activities and a range of unique ecological systems.

In the last 30 years, particularly the last decade, there has been less rain to refill dams and recharge groundwater. In this water scarce environment, we need to manage our precious groundwater carefully. This plan presents the Department of Water's management approach for allocating groundwater in the Gnangara groundwater system, and serves as a guide for water users and the wider community. We have trialled the plan since February 2008 and have scheduled the plan to be reviewed and updated by 2012.

Our goal is to optimise water availability within a sustainable limit. To achieve this for Gnangara we have reduced the amount of water available for abstraction and promoted better use of water. We aim for a secure supply of water for public use and for development, while at the same time protecting wetlands and other groundwater-dependent ecosystems from the direct impacts of abstraction.

This plan represents one of the first steps in implementing the Gnangara Sustainability Strategy. In taking a strategic approach to managing water allocation within the Gnangara system, we encourage and support a competitive and innovative water industry, and continue to modernise water management in Western Australia.

Kim Taylor
Director General

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Summary

What is this all about?

The Department of Water is the state government agency responsible for managing Western Australia's water resources. Our role includes deciding how much water is taken from rivers and groundwater systems by developing water allocation plans.

This allocation plan describes in a transparent manner how we manage the allocation of groundwater resources of the Gnangara groundwater areas. This plan reflects the directions of the Gnangara Sustainability Strategy (GSS) by reducing groundwater abstraction, supporting more effective use of water, and limiting the direct impacts of abstraction and use on wetlands and water quality.

The department will review and update the plan by 2012. The 2012 plan will be informed by outcomes of the GSS, together with an increasing body of knowledge being gathered by the department. This work is partly funded by the Australian Government under Water for the Future's – Water Smart Australia program.

Why are we doing this?

The Gnangara system is the largest single source of good quality fresh water in the Perth region and is of vital importance to our continuing social and economic development. However, groundwater levels have declined significantly over the past 30 years.

This decline is the result of a combination of factors including increased water abstraction, changes in land use and lower than average rainfall. Many of the significant environmental features in the area are dependent on groundwater for their survival.

This water allocation plan aims to balance abstraction of groundwater with the need to retain water in the ground to meet ecological, social and cultural needs, and provide for public and private use in the future. This supports our broader goal of maximising water availability within a sustainable limit.

What is the picture for Gnangara and its water resources?

The plan covers the groundwater resources of the Gnangara system including the Superficial Aquifer, commonly known as the Gnangara Mound, and the confined Leederville and Yarragadee aquifers.

There are currently more than 5000 licences to take groundwater across the system. Approximately 60% of groundwater abstracted from the Gnangara system is for self-supply use, including domestic gardens. Most of this water is abstracted from the Superficial Aquifer.

Western Australia's Integrated Water Supply Scheme (IWSS), managed by the Water Corporation, has relied substantially on water pumped from the Gnangara system for many years. Approximately 40% of the groundwater abstracted from the system is for the IWSS, which currently represents approximately half of the total supply of water to the IWSS.

The health of groundwater-dependent ecosystems in areas across the mound is at risk because groundwater levels are declining.

How are we managing the Gnangara groundwater areas?

In response to declining water levels, and with groundwater models predicting further declines, the department has reduced allocation limits for all aquifers. In 2006 we reduced the allocation limits for the confined aquifers to 10% less than the licensed entitlements at the time, and in 2007 we capped or reduced allocation limits for most areas of the Superficial Aquifer.

Through this plan, the department has reduced the amount of water available for abstraction for the IWSS by approximately 12%. We have also reduced the amount of water available from the Superficial Aquifer by 13%, which is mostly accessed for private abstraction. Consequently the Gnangara groundwater system is now almost fully allocated across all areas, meaning there are limited opportunities for new groundwater licence entitlements.

Work carried out for the Gnangara Sustainability Strategy suggests that we will need to reduce allocation limits further in the 2012 allocation plan. We expect that by then we will have mechanisms to enable water abstraction to be more closely in balance with groundwater recharge.

Under this plan, the department will only allocate groundwater up to the allocation limits defined in this plan. Except for small amounts under extenuating circumstances, we will not issue any new groundwater licences that will result in additional demand on any resources across the Gnangara groundwater system that are fully or over-allocated.

In areas that are fully or over-allocated, the plan promotes water trading in line with our current state-wide policy. Water users are encouraged to be more efficient so that others can buy or lease these water efficiency gains to sustain regional development. Recovery of water through licence renewals, efficiency programs and land use change has also started.

Where areas are not fully allocated, the department will assess groundwater licence applications according to the amount of water available at the date of application, and relevant policy described in this plan.

Security of existing licences is assured for the life of this plan provided licensees use the water in accordance with the terms and conditions on the current licence. However, the department will actively recoup unused water entitlements in accordance with state-wide policy. In addition, we expect both current and future water users to conserve water, use groundwater more efficiently and manage the impacts of their water use.

Limiting the total draw of groundwater will help to protect natural systems across the Gnangara groundwater areas. The department has developed high impact zones to manage abstraction near environmentally sensitive areas.

Where possible the department has reserved water for future public water supply purposes.

Where changes to allocation limits before the 2012 plan are necessary, the department will release them through an appropriate mechanism announced by the department at that time.

How did we develop this plan?

The department developed the plan within the current legislative requirements for water use and management in Western Australia, the *Rights in Water and Irrigation Act 1914*.

Over the last few years we have scoped water allocation and use issues, as well as social and environmental issues, with representatives from water service providers, horticulturalists, turf growers, other industry, local authorities, other government authorities, landowners, conservation groups and members of the Indigenous community.

The department used the following information to set the allocation limits in the Gnangara groundwater areas allocation plan:

- data on current use and demand
- results of groundwater modelling
- assessments of groundwater level trends
- current ecological monitoring results and trends.

How have we considered the public's submissions in finalising the plan?

The department has improved the plan by considering the public's submissions received through the draft consultation period.

Please see the department's *Statement of response – Gnangara groundwater areas allocation plan* (Department of Water 2009a) for more information on the department's response to the comments received and how the plan has been updated.

Part one

Gnangara groundwater areas allocation plan

Chapter one

The Gnangara groundwater areas allocation plan

Purpose of the plan

Water allocation planning is the primary means of balancing the amount of water used for consumptive purposes with that needed for the environment, including in situ social, cultural and ecological needs.

This water allocation plan explains the Department of Water's management approach for the taking and use of groundwater resources in the Gnangara groundwater areas. The plan aims to meet the need of current and future water users for clear and consistent direction about water use in areas that are under pressure from increasing abstraction and climate change.

The department has developed this plan in response to the following needs:

- social and economic dependence on the resource
- declining groundwater levels
- high demand for water
- reduced recharge into the system
- protection of groundwater-dependent ecosystems

This plan details:

- the Gnangara groundwater areas allocation planning boundaries by area, subarea and aquifer (resource)
- public drinking water source areas
- environmental considerations within the plan boundary
- current water use
- allocation limits, total licensed allocations and an indication of water availability for each resource
- the department's water management framework, including:
  - the objectives and strategies for water use and management
  - specific actions to manage allocation and the policies to support these strategies
  - how we will implement, evaluate and review the plan.

1.1.1 Department of Water's position

Through this plan the department will support the Gnangara Sustainability Strategy to:

- reduce groundwater abstraction
- support more effective use of water
- limit the direct impacts of abstraction and use on wetlands and water quality.

The department's allocation decisions will be guided by and will be consistent with the department's strategic position, set out in the Perth-Peel Regional Water Plan (Department of Water 2009b).

1.2 The plan area

1.2.1 Location

The Gnangara groundwater system covers an area of approximately 2200 km^2 and is located on the Swan Coastal Plain near Perth, Western Australia (Figure 1).

The plan area is bounded by the Moore River and Gingin Brook to the north, the Swan River to the south, the Darling Scarp, Ellen Brook and Swan Valley to the east, and the Indian Ocean to the west.

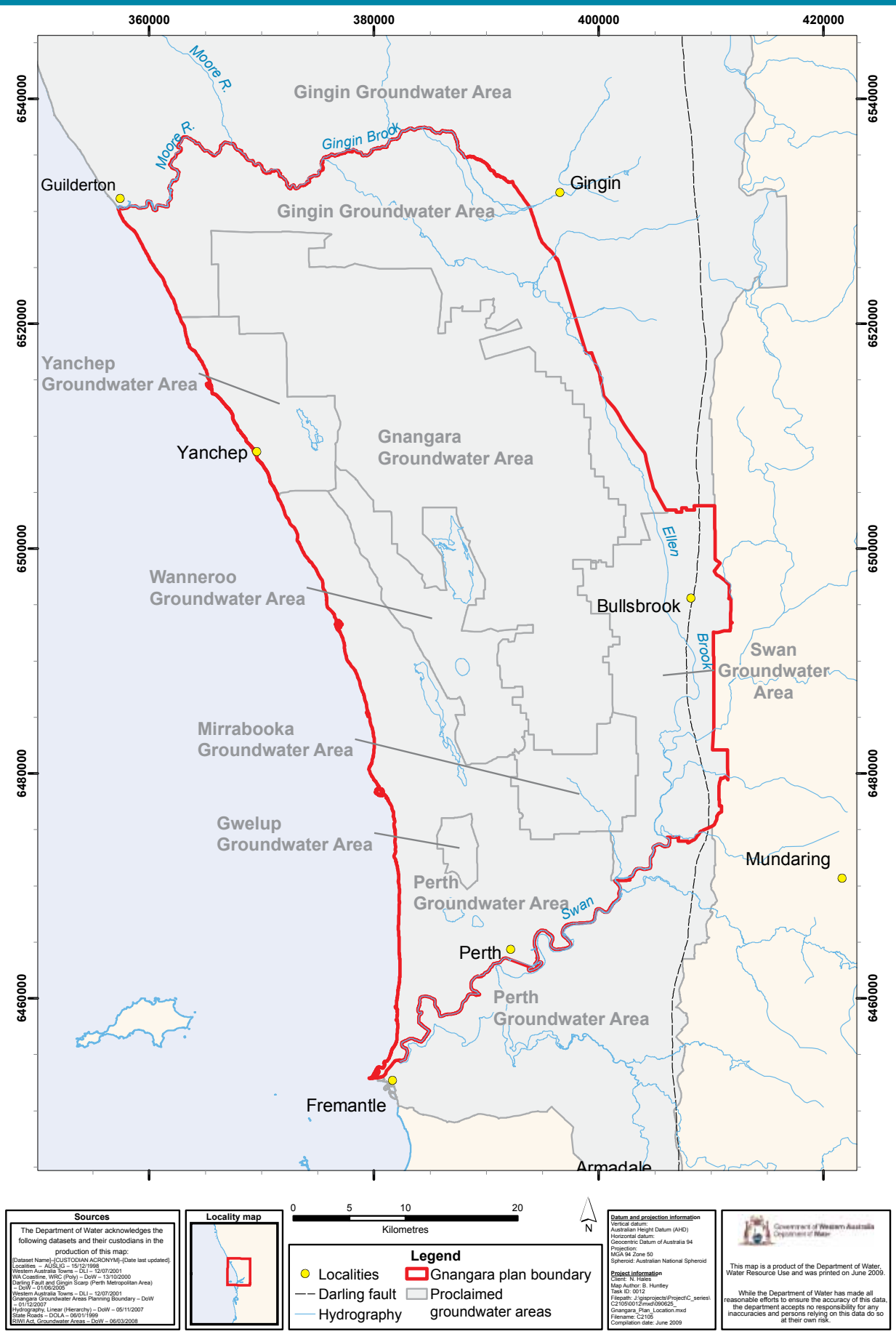

Figure 1
Location of the Gnangara groundwater areas

1.2.2 Proclaimed groundwater areas

The following groundwater areas, proclaimed in accordance with s.26B of the *Rights in Water and Irrigation Act 1914*, are included in this plan (Figure 1):

- Gingin (portion south of Moore River and Gingin Brook)
- Gnangara
- Gwelup
- Mirrabooka
- Perth (portion north of the Swan River)
- Swan
- Wanneroo
- Yanchep.

1.3 Where does this plan fit in?

This allocation plan describes the Department of Water's water resource management relating to the taking and use of water in the Gnangara groundwater areas until 2012.

The Gnangara Sustainability Strategy (see Section 2.8) aims to integrate land use and water planning, and provides direction across government up to 2030. The draft GSS was released for public comment in July 2009.

The department is currently developing the Perth-Peel Regional Water Plan which will be released as a draft for public comment in late 2009. The Perth-Peel plan will set the department's strategic direction for water use and management issues for the area from Gingin to Mandurah up to 2050.

This allocation plan was developed while the GSS and Perth-Peel Regional Water Plan were in preparation, and aligns with the management direction that will be proposed by these documents.

This allocation plan will be replaced in 2012. The next allocation plan for the Gnangara groundwater areas will continue the direction set in this plan. It will be shaped by contemporary water management policy and by the results of research projects that the department is undertaking with the assistance of almost $6 million of funding over three years by the Australian Government, under the Water for the Future's – Water Smart Australia program. The next allocation plan will also be informed by the land and water use recommendations of the GSS, and will align with the department's Perth-Peel Regional Water Plan.

As part of Western Australia's response to the water reform agenda, the *Rights in Water and Irrigation Act 1914* is under review, and is intended to be replaced with new water resources management legislation. New legislation will provide the legal basis for statutory water allocation plans, which may introduce contemporary mechanisms to update the management of water allocation, over-allocation, trading and other water resource management issues.

1.4 Previous plans for the Gnangara groundwater areas

Groundwater management plans have previously been prepared for the Gingin groundwater area (Water and Rivers Commission 2002), the Swan groundwater area (Water and Rivers Commission 1997) and the Wanneroo groundwater area (Water Authority of Western Australia 1993).

This water allocation plan replaces these plans for those areas within the Gnangara groundwater areas planning boundary.

1.5 Existing Local Water Resource Management Committees

The Gingin Dandaragan Water Resource Management Committee is the only Local Water Resource Management Committee within the plan area. This committee exists under Section 26GK of the *Rights in Water and Irrigation Act 1914* and under Section 13 of the *Water and Rivers Commission Act 1986*. The Premier has initiated a review of all government boards and committees. The outcome of this review is expected by the end of 2009.

Chapter two

Considerations for water allocation in Gnangara

2.1 Climate and impacts on water supply

The reliability of the Gnangara groundwater system for water supply depends directly on rainfall. Across the south-west of Western Australia there has been a general trend of decline in annual rainfall since the mid 1970s. This shift to a drier climate represents a decline of approximately 11% of rainfall when compared to the wetter rainfall period prior to the mid-1970s (1914–1975).

Comparison of medium-term (1976–2008) with short-term average rainfall (1997–2008 and 2001–2008) show further declines to those observed since the 1970s. Figure 2 and Figure 3 show total annual rainfall, where available, for Wanneroo site 9105 (1905–2008) and Perth Airport site 9021 (1945–2008) respectively.

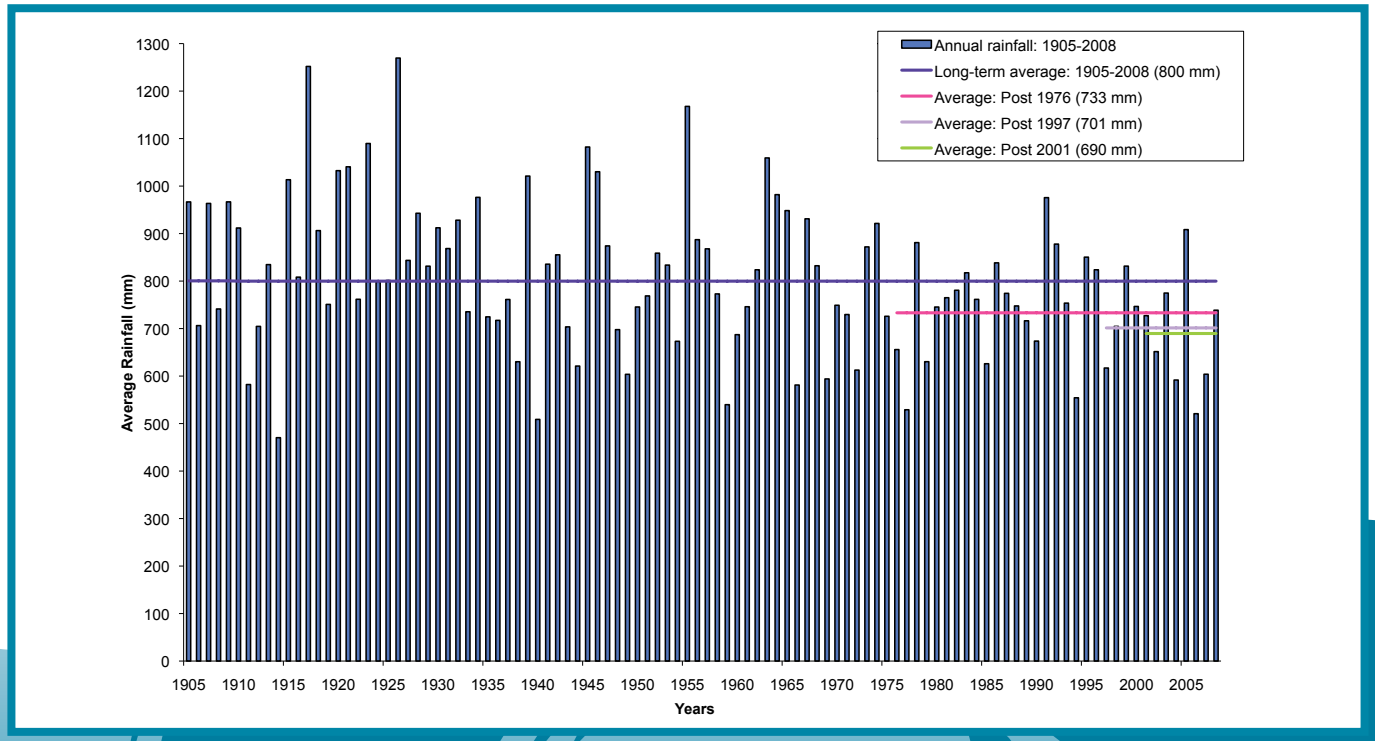

Figure 2
Long-term (1905–2008) annual rainfall for Wanneroo site 9105 including varying rainfall averages

Note: Data sourced from the Bureau of Meteorology. Data for 1905, 1910–11, 1930–1963, 1970–71, 1974–1975 is not available for site 9105. Data presented for these years has been extrapolated from that available from several other rainfall monitoring stations in proximity to site 9105.

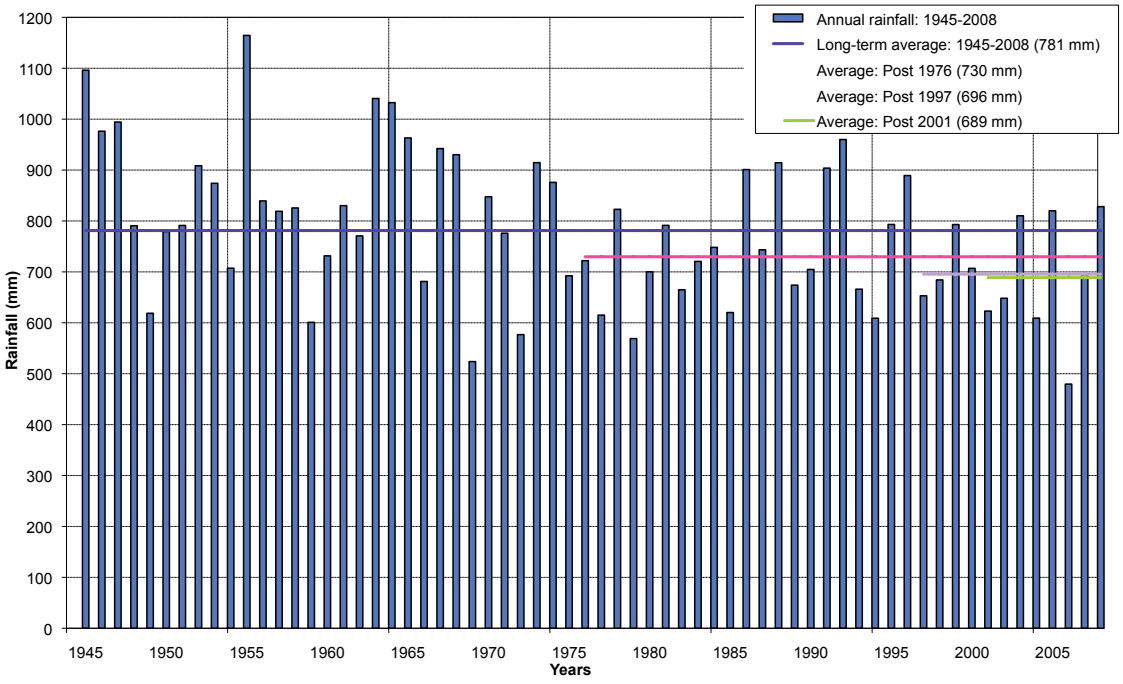

Figure 3
Long-term (1945–2008) annual rainfall for Perth Airport site 9021 including varying rainfall averages

Note: Data sourced from the Bureau of Meteorology.

The future climate of the Perth region is expected to include wet and dry periods due to natural variability, with variations due to climate change. The expectation is for continued warming with increases in mean temperature (Sadler (ed.) 2007; CSIRO 2006; Ryan & Hope (eds) 2006).

Decreases in winter rainfall are also expected, and it is projected that reduced rainfall will drive a significant decrease in streamflow and groundwater recharge (Sadler (ed.) 2007; CSIRO 2006; Ryan & Hope (eds) 2006).

It has only recently been recognised that the shallow groundwater levels in the Gnangara system reflect long-term climatic cycles, rising after 1914 and declining after 1969 (Yesertener 2002).

The shift to a drier climate has implications for the management of the Gnangara system. The department has reviewed the allocation limits with the expectation of the drying climate continuing over the coming years and the corresponding impacts on water availability.

The department will base any review of allocation limits on groundwater modelling of projected climate scenarios based on climate data relevant at that time.

2.2 Hydrogeology

2.2.1 Description

The Gnangara groundwater system comprises several different hydrogeological units or aquifers, including:

- the unconfined Superficial Aquifer
- the semi-confined Mirrabooka Aquifer
- the confined Leederville Aquifer
- the confined Yarragadee North Aquifer.

Small amounts of water may be available from fractured rock occurring east of the Darling Fault. The semi-confined Kings Park aquifer is a minor local aquifer that is not a major source of water and the department has not considered it further in this plan.

For a detailed explanation, please refer to *Hydrogeology and groundwater resources of the Perth region Western Australia* (Davidson 1995).

Figure 4 shows a representative cross-section of the aquifers across the Gnangara Mound.

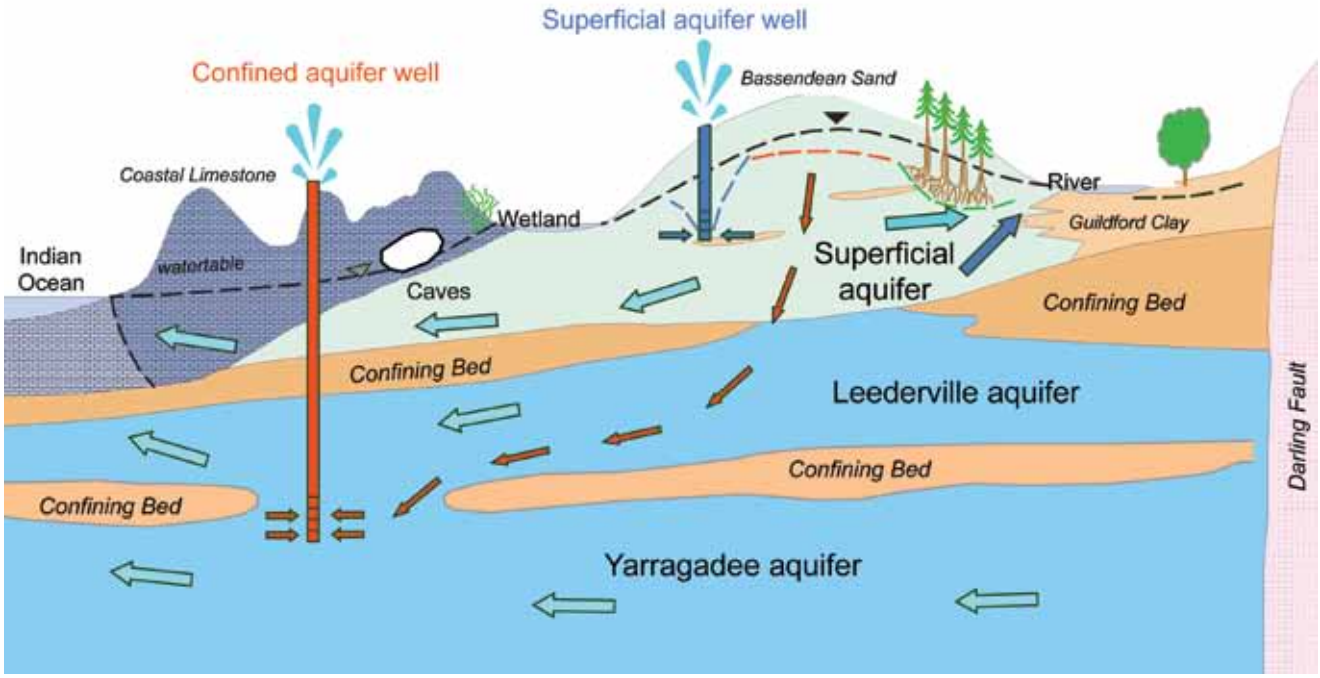

Figure 4
Gnangara system hydrogeological cross-section

Superficial Aquifer

The Superficial Aquifer is a major unconfined aquifer that exists across the entire plan area, and is commonly termed the 'Gnangara Mound'. It has an average thickness of 45 m and a maximum thickness of 75 m.

This aquifer comprises the Quaternary–Tertiary sediments of the coastal plain, and consists of Safety Bay Sand, Becher Sand, Tamala Limestone, Bassendean Sand, Gnangara Sand, Guildford Clay, Yoganup Formation and Ascot Formation.

Mirrabooka Aquifer

The Mirrabooka Aquifer is present mainly in the southern and eastern regions of the plan area. It is a locally important, semi-confined to confined aquifer, and ranges in thickness to a maximum of 160 m. Due to its variability in thickness it cannot be relied upon to draw large volumes of water.

This aquifer comprises the Cretaceous Poison Hill Greensand, Gingin Chalk, Molecap Greensand and Mirrabooka Member of the Osborne Formation.

Leederville Aquifer

The Leederville Aquifer is a major confined aquifer that extends from Lancelin in the north to the Scott Coastal Plain in the south-west. It is present across the entire plan area except beneath the deeper parts of the Kings Park Formation, and ranges in thickness to a maximum of 550 m.

This aquifer comprises the Cretaceous Osborne Formation (Henley Sandstone) and the Leederville Formation (Pinjar Member, Wanneroo Member and Mariginiup Member).

Yarragadee North Aquifer

The Yarragadee North is a major confined aquifer that extends from the Geraldton area to east of Mandurah and is present across the entire plan area. The thickness of the aquifer in the Perth region is greater than 2000 m.

This aquifer comprises the Cretaceous Gage Formation, the Parmelia Formation and the Jurassic Yarragadee Formation.

2.2.2 Connectivity of aquifers – groundwater recharge and discharge

The Superficial Aquifer is recharged directly from rainfall with minor upward recharge from the underlying Leederville and Yarragadee Aquifers in some areas. Groundwater discharge occurs by evaporation from wetlands, transpiration from groundwater-dependent vegetation, leakage into underlying aquifers and by groundwater abstraction from wells. Groundwater in the Superficial Aquifer also discharges to drains and wetlands, Ellen Brook, Gingin Brook, Moore River, and the Indian Ocean and Swan River over a saltwater wedge.

The Mirrabooka Aquifer is recharged from the downward component of groundwater flow from the overlying Superficial Aquifer. Much of the throughflow in the Mirrabooka Aquifer eventually discharges by upward leakage into the Superficial Aquifer, mainly in the north-easterly portion of the Gnangara groundwater system.

Groundwater is recharged to the Leederville Aquifer through the Superficial Aquifer on the crest of the Gnangara Mound, and flows westward to eventually discharge offshore. Some groundwater in the Leederville Aquifer discharges into the Superficial Aquifer where the Kardinya Shale Member is absent and where there are increasing heads with depth and upward hydraulic gradients.

The Yarragadee North Aquifer is recharged on the northern Gnangara Mound by downward leakage of groundwater where it is directly overlain by the Superficial Aquifer. It is also recharged from the Leederville Aquifer where the South Perth Shale is absent, and where a downward hydraulic head prevails. Groundwater discharges from the Yarragadee aquifer into the Leederville Aquifer in areas where there are upward hydraulic head differentials and where the confining South Perth Shale is absent.

2.2.3 Current condition

Since the 1970s, declines in groundwater levels have been observed in the Superficial, Leederville and Yarragadee North Aquifers. This may be attributed to climate variation, abstraction, evapotranspiration and interception by pine plantations (Yesertener 2007).

Superficial Aquifer

The largest change in groundwater levels is at the crest of the Superficial Aquifer in the Gnangara groundwater area (Reserve subarea) where declines of over 0.4 m per year have been observed since the 1970s (Bekesi 2007). This has led to a corresponding decline in groundwater storage.

Figure 5 shows that groundwater storage depletion in the Superficial Aquifer over the last 29 years has been approximately 700 GL.

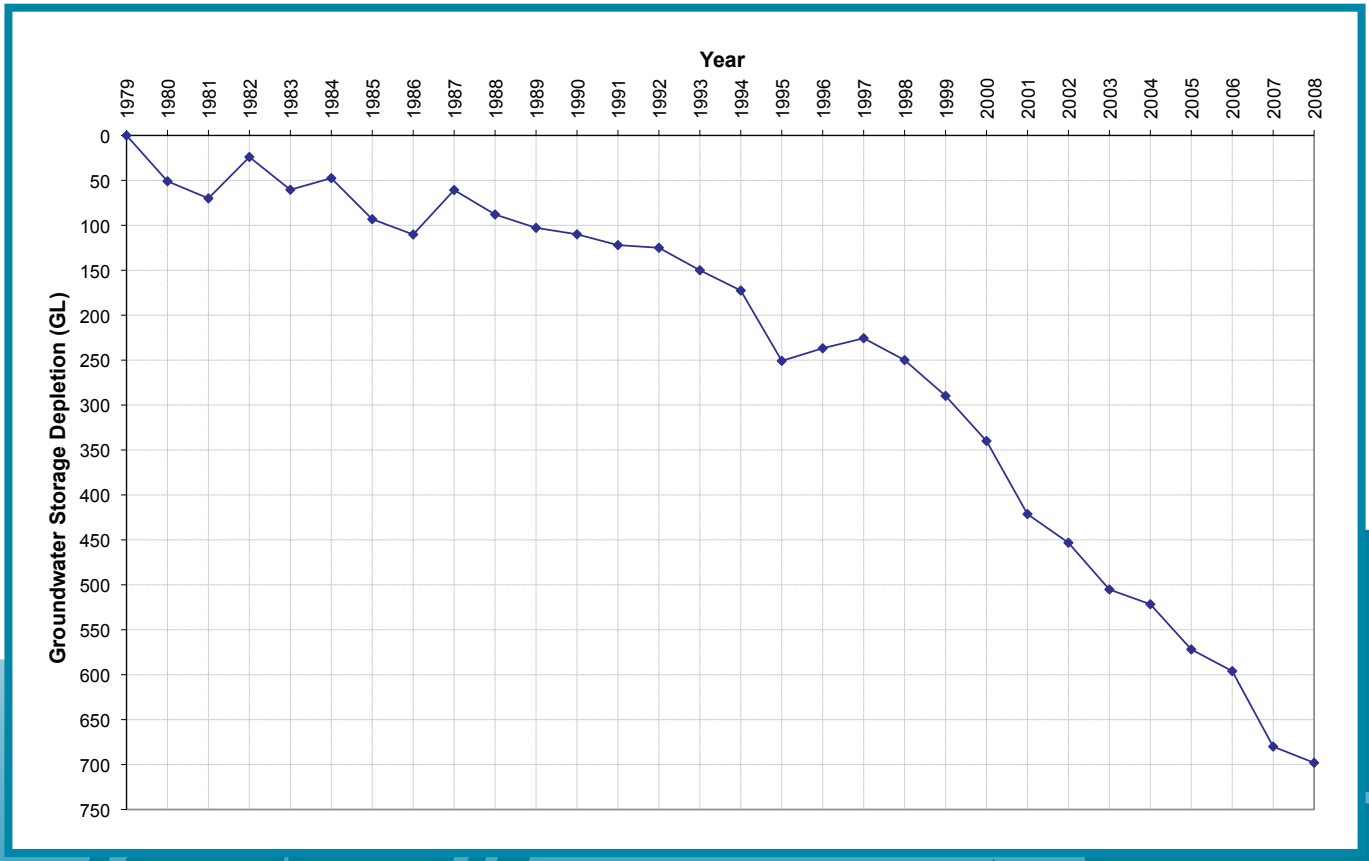

Figure 5
Groundwater storage decline in the Superficial Aquifer for the period 1979–2008

Substantial declines in groundwater levels have been observed between 1998 and 2006 in the coastal subareas (City of Stirling, Gwelup, Whitfords, Carramar, Quinns Rocks, Yanchep and Guilderton). Smaller declines have been observed in the Wanneroo and Gwelup groundwater areas as well as the Carabooda, Nowergup and Neerabup subareas.

Assessment of declining groundwater levels in the Superficial Aquifer undertaken by Yesertener (2007), showed that:

- Reduced rainfall is the main factor causing the reduction of groundwater levels within the Gnangara groundwater areas since 1969, with falls of up to 4 m noted over the period 1979–2004.
- The long-term cumulative impacts of abstraction in the Gnangara groundwater area are centred on the Pinjar, Wanneroo, Gwelup and Mirrabooka borefields with declines of a maximum of 2.4 m, 2.0 m, 3.0 m and 1.5 m respectively within a 6 km radius of the borefields.
- The Gnangara pine plantation has caused groundwater declines in the order of 3.5 m over the same period in areas where pines were particularly dense.

The declining trend in groundwater levels at the crest of this aquifer has led to reduced discharge to local groundwater-dependent ecosystems.

Mirrabooka Aquifer

Groundwater level monitoring data shows a 1 to 3 m decline in water levels in the Mirrabooka Aquifer since the 1970s. However, during the last ten-year period, groundwater levels have been relatively stable.

Bekesi (2007) noted that groundwater levels are relatively stable in the south-eastern portion of the Gnangara system and that some small, and comparatively insignificant, positive trends were noted in the Mirrabooka and Swan groundwater areas.

The relative stability in groundwater levels in this aquifer may reflect the shallow watertable in the Superficial Aquifer.

Leederville Aquifer

Groundwater potentiometric heads in the Leederville Aquifer are monitored by the department in approximately 20 of the Artesian Monitoring series of bores across the Gnangara system.

Groundwater level decline in the Leederville Aquifer is centred on the Water Corporation production bores in the Wanneroo–Pinjar area where potentiometric head has declined by up to 10 m since 1997, representing a decline rate of approximately 1 m per year.

In the same period, potentiometric head has declined by up to 5 m near the Swan River and 1.5 to 3.5 m near Gingin Brook.

Yarragadee North Aquifer

Groundwater potentiometric heads in the Yarragadee aquifer are monitored in 27 of the Artesian Monitoring series of bores.

During the period 1998–2006, potentiometric head decline has occurred at a rate of between 2 and 6 m per year in this aquifer, particularly in the southern part of the plan area (Bekesi 2007).

Groundwater level decline is centred on the location of bores in Gwelup and Wanneroo, where there is a considerable overall decline of approximately 50 m and 20 m respectively in levels at monitoring sites.

The cone of depression extends to the north of the plan area where declines of approximately 10 m have been observed, and to the southern boundary of the plan area where the declines have been approximately 30 m at the Swan River.

Action 1 – Complete an annual groundwater resource assessment report which includes groundwater level trends.

2.2.4 Research and investigation

The department has developed a research and investigation program to improve our understanding of the groundwater resources.

The department is undertaking this work in conjunction with the Australian Government under the Water for the Future's – Water Smart Australia program. This work includes a shallow groundwater systems investigation, to improve our understanding of the local area wetland hydrology.

We will use the outcomes of the investigation to improve our hydrogeological monitoring networks, to review environmental measures and to support the 2012 plan.

Action 2 – Continue to implement an appropriate research and investigation program.

2.3 Water quality

Groundwater quality varies according to geology and position within the groundwater flow system relative to recharge and discharge. Factors such as land use, groundwater abstraction and climate can also affect the quality of groundwater on the Gnangara Mound.

The department measures various water quality parameters on the mound and in some areas water quality has changed over time.

2.3.1 Salinity

Since 1995 the salinity of the groundwater of the Gnangara Mound has generally remained constant. The lowest salinity groundwater is found on the crest of the mound where it is derived from rainfall.

Groundwater salinity generally increases in the direction of groundwater flow so that it is highest along the discharge areas at the coast and rivers. Since 1995 groundwater has become saline along the coast near Yanchep, which may be an indication of saline intrusion due to abstraction.

Salinity generally increases with depth. In the eastern clay area, particularly along Gingin Brook and Ellen Brook, the groundwater is relatively more saline. Salinity has also increased down-gradient of lakes and wetlands due to the evaporative concentration of salts.

Salinity varies in the Gnangara aquifers (see Appendix A for salinity classifications):

- Groundwater in the Superficial Aquifer ranges from fresh to marginal, with the lowest salinity levels found near the crests of the mound (< 250 mg/L TDS) but can be up to 1000 mg/L TDS.
- Groundwater in the Mirrabooka Aquifer is fresh at less than 350 mg/L TDS.
- Groundwater in the Leederville Aquifer ranges from fresh to saline, with > 3000 mg/L TDS at depth in some parts of the system.
- Groundwater in the Yarragadee aquifer ranges from fresh to saline, with > 3000 mg/L TDS along the eastern margin.

2.3.2 Saltwater interface

A saltwater interface to the freshwater aquifers is present along the coast and adjacent to the Swan River estuary. Abstraction from areas near the river or along the coast may result in salt water being drawn inland and up into the freshwater aquifer. This saltwater intrusion results in the deterioration of water quality in the freshwater aquifers.

Groundwater abstraction near the river and in coastal areas requires specific management.

For further information on saltwater intrusion and implications for licensing contact the Swan Avon regional office on 08 6250 8000.

2.3.3 Nutrients

In natural systems, levels of nutrients such as nitrate and phosphorous are generally very low (< 1 mg/L and 0.2 mg/L respectively). In 1983 nitrate concentrations were generally no greater than 1 mg/L across much of the mound but levels frequently exceeded 20 mg/L in the more urbanised areas closest to Perth. Today, elevated concentrations of nitrate above 1 mg/L across the mound are more widespread. High nitrate levels correspond to intensive horticultural areas (e.g. Carabooda, Nowergup) and near Landsdale where historical land use activities or input from Lake Gnangara might be the cause.

Phosphorous levels in 1981 were generally low (< 0.1 mg/L). Today, phosphorous concentrations in the Superficial Aquifer have increased, particularly in horticultural areas where levels are generally greater than 0.5 mg/L and are as high as 6 mg/L. The application of fertilisers in these areas is the likely cause.

Elevated levels of nutrients have the potential to adversely affect the quality of wetlands and waterways, and may cause health problems in livestock and humans.

For further information on nutrient use and implications for licensing such as potential monitoring requirements, contact the Swan Avon regional office on 08 6250 8000. Information regarding soil nutrient requirements can be obtained from the Department of Agriculture and Food at <www.agric.wa.gov.au>.

2.3.4 Groundwater acidification

The most widely known cause of acidification is acid sulfate soils. Acid sulfate soils are naturally occurring soils that contain iron sulfides, predominantly as pyrite. These soils are not harmful when undisturbed, but the exposure of the pyrite to air by the drainage, dewatering, burning or excavation of soil will cause oxidation and can generate substantial amounts of sulfuric acid.

As a result, the pH of groundwater or rainfall flowing through these soils will be lowered, and dissolved metals (such as iron, aluminium and arsenic) and other ions (such as sulfate) can increase.

Discharge of acidic water into waterways and wetlands can cause fish kills and loss of aquatic biodiversity, and may contaminate

groundwater with acid, metals and other pollutants that are toxic to humans and other biota.

On the Gnangara Mound, groundwater pH ranges from < 4 around acid sulfate soil bearing wetlands that dry during the summer months, to between 4 and 6 in groundwater in Bassendean Sand. pH increases to approximately 8 towards the coast due to the calcareous sediments of the Tamala Limestone.

Further information on acid sulfate soils can be obtained from the Department of Environment and Conservation at <www.dec.wa.gov.au> or the Western Australian Planning Commission Planning (Bulletin 64) at <www.wapc.wa.gov.au>.

Action 3 – Work with the Department of Environment and Conservation to update the current acid sulfate soils risk map and review procedures for addressing identified acid sulfate soil risks when licensing.

2.4 Water quality protection

2.4.1 Public drinking water source areas

There are four proclaimed public drinking water source areas (PDWSAs) within the Gnangara allocation plan boundary (Figure 6):

- Gnangara underground water pollution control area (incorporating Gnangara, Wanneroo and Mirrabooka)
- Gwelup underground water pollution control area
- Perth Coastal underground water pollution control area
- Woodridge Water Reserve.

The department protects and manages drinking water sources in Western Australia using a combination of legislative and non-legislative mechanisms, including:

- proclamation under either the *Metropolitan Water Supply Sewerage and Drainage Act 1909* (MWSSD Act) or *Country Areas Water Supply Act 1947* (CAWS Act) as a water reserve, catchment area or underground water pollution control area (collectively known as 'public drinking water source areas')
- water quality protection measures under the MWSSD by-laws 1981 or CAWS by-laws 1957
- planning controls under the Metropolitan Regional Scheme, or town or local planning schemes
- Western Australian Planning Commission Statement of Planning Policies (SPP), including SPP 2.7 Public Drinking Water Sources, SPP 2.9 Water Resources and SPP 2.2 Gnangara Groundwater Policy
- drinking water source protection plans, including land use and water management strategies.

For land planning and development purposes the department has defined three priority classification areas (P1, P2 and P3) based on strategic importance of land or water source, local planning scheme zoning, approved land uses or activities, and tenure.

Special by-laws apply to wellhead protection zones, which cover the immediate surrounds of water production wells. Because of this, these zones are subject to change.

The department prepares priority areas and protection zones in consultation with state government agencies, landowners, local government, industry and community stakeholders.

2 Considerations for water allocation in Gnangara

The objectives of each priority area are:

- **Priority 1 Area:** Ensure there is no degradation of the water source by preventing the development of potentially harmful activities in these areas. The guiding principle is risk avoidance. This is the most stringent priority classification for drinking water source protection.
- **Priority 2 Area:** Ensure that there is no increased risk of pollution to the water source. These areas are declared over land where low intensity development (such as rural) already exists. The guiding principle is risk minimisation.
- **Priority 3 Area:** Manage the risk of contamination to the water source. These areas are declared over land where water supply sources need to co-exist with other land uses such as residential, commercial and light industrial developments. The guiding principle is risk management.

Wellhead protection zones in a PDWSA are circular (unless information is available to determine a different size and shape) with a radius of 500 metres in P1 areas and 300 metres in P2 and P3 areas. These zones do not extend outside public drinking water source areas.

The level of protection for each PDWSA in the Gnangara groundwater system area is shown in Figure 6 and Table 1.

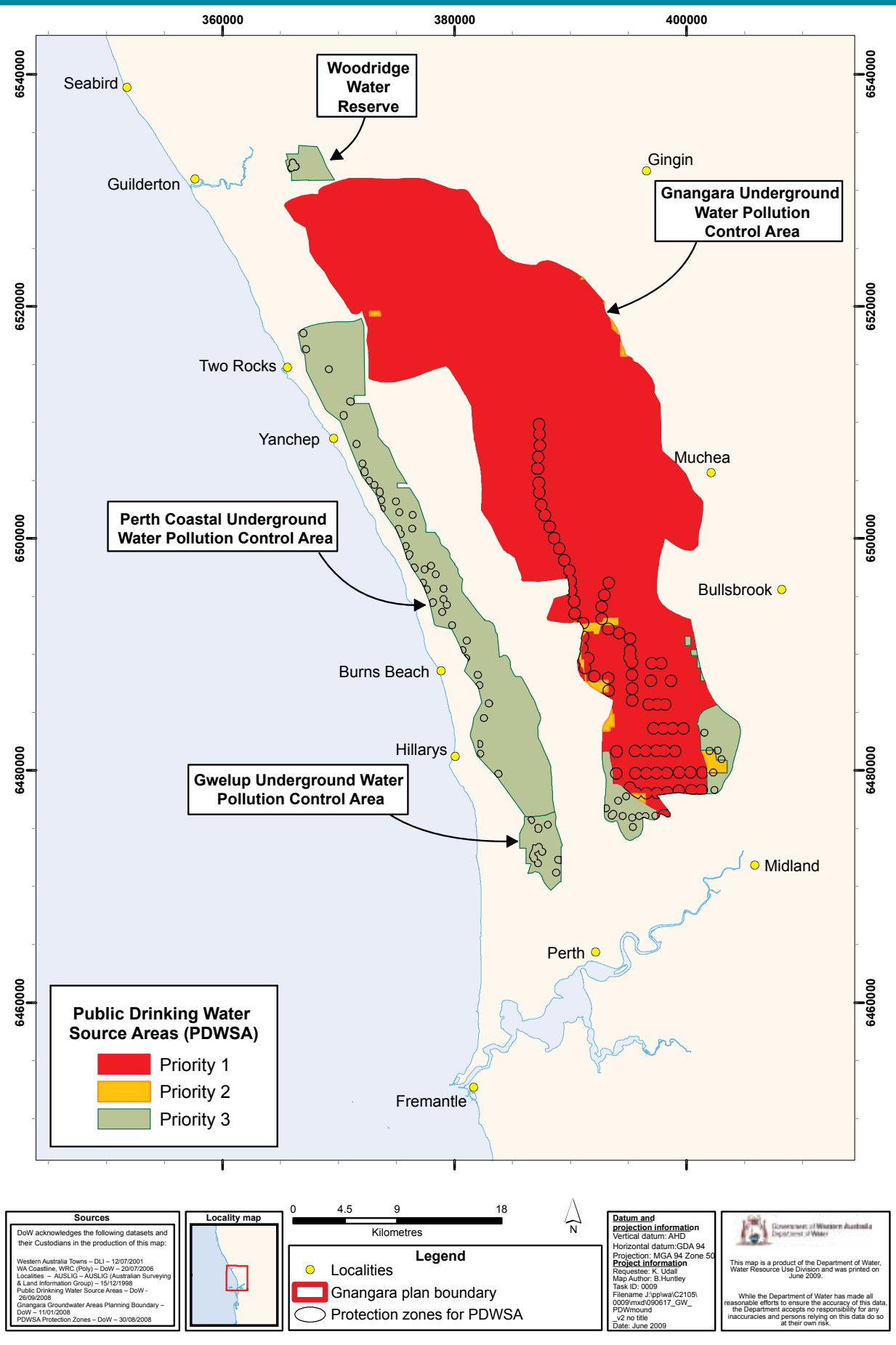

Figure 6
Public drinking water source areas and wellhead protection zones

Table 1
Public drinking water source areas within the Gnangara plan boundary

Area	Classification
Gnangara underground water pollution control area	Priority 1 with some Priority 2 and 3
Perth Coastal underground water pollution control area	Priority 3
Gwelup underground water pollution control area	Priority 3
Woodridge Water Reserve	Priority 3

2.4.2 Protection of water quality in public drinking water source areas

To ensure the quality of drinking water in the Superficial Aquifer is protected, land use within the proclaimed public drinking water source areas should be compatible with the assigned priority classification area (P1, P2 or P3), and consistent with relevant by-laws, planning controls and policies.

The *Gnangara Land Use and Water Management Strategy* (Western Australian Planning Commission 2001) provides the water quality protection objectives and planning controls for a large portion of the Gnangara system. The department currently implements drinking water quality protection in the Gnangara system through its statutory referral process and water allocation licensing process.

To determine compatibility of a proposed land use in a public drinking water source area, refer to the Western Australian Planning Commission's *Statement of Planning Policy 2.7 Public Drinking Water Sources* (2003).

To determine compatibility of a proposed land use in the Gnangara underground water pollution control area, refer to the Western Australian Planning Commission's *Statement of Planning Policy 2.2 Gnangara Groundwater Policy* (2005).

These documents are subject to change, and should be obtained from the department or Western Australian Planning Commission as required. Land-use and risk-management classifications are currently under review as part of the development of the Gnangara Sustainability Strategy.

Documents related to the management of the state's drinking water sources can be obtained from the department or viewed online at <www.water.wa.gov.au>. Please contact the Swan Avon Regional office on 08 6250 8000 for further advice regarding licensing implications for proposed new licences and amendments to existing licences.

Action 4 – Continue to implement water source protection for the public drinking water source areas of the Gnangara system through statutory referral using Statement of Planning Policies 2.2 and 2.7.

NOTE:

All groundwater abstracted for use as public drinking water is treated by the Water Corporation before being made available for consumption. The department does not recommend drinking or using untreated bore water inside the home, unless it has been tested and certified as suitable for these purposes. Drinking water guidelines are available from the Department of Health at <www.health.wa.gov.au>.

Further information on drinking water quality and recommendations for treatment of water collected from lakes, roof-tops, stored stormwater run-off, springs, underground sources or waterways is available in the department's Water Quality Protection Note No. 41 Private drinking water supplies available at <www.water.wa.gov.au>.

2.4.3 Protection of water quality for uses other than public water supply

Protection of water quality is important for many self-supply purposes, including domestic use, industry, stock watering, horticulture and viticulture. Assigning underground water pollution control areas, as outlined in Section 2.4.2, provides a level of protection for these uses.

Throughout the plan area, the department provides advice to the Department for Planning and Infrastructure and local governments to ensure land planning decisions consider possible water quality implications. Also, where necessary, the department ensures existing groundwater users implement appropriate water quality protection measures through conditions on water licences.

The *Future of East Wanneroo – land use and water management in the context of Network City* (Western Australian Planning Commission 2007) recommends the preparation of an integrated management strategy for the Gnangara system that will consider water quality and quantity, as well as planning issues associated with:

- pine plantation management and harvesting
- natural vegetation and fire management
- current and future drinking water protection measures
- possible land use changes from rural to urban deferred and rural living
- possible managed aquifer recharge scheme
- establishing a new horticultural precinct.

Many of these issues will be addressed through the GSS and statutory land or water planning processes.

Action 5 – Continue to respond to development referrals with advice to the Department of Planning and Infrastructure and local governments regarding the compatibility of proposed land uses and associated impacts on water quality across the Gnangara groundwater system.

2.5 Managing water for the environment

2.5.1 Groundwater-dependent ecosystem values

The Superficial Aquifer, or Gnangara Mound, supports a variety of ecosystems that depend, to some degree, on groundwater for their existence and health. These are known as groundwater-dependent ecosystems. Groundwater-dependent ecosystems on the mound can be classified as permanent and seasonal wetlands, groundwater-dependent terrestrial vegetation, mound springs and caves. Some of these groundwater-dependent ecosystems, such as the Yanchep caves and the tumulus mound springs are listed as critically endangered in Western Australia and are found nowhere else in the state (Gibson, Burbidge, Keighery & Lyons 2000). The location of groundwater-dependent ecosystems on the Gnangara Mound is shown in Figure 7.

Some groundwater-dependent ecosystems have high environmental and social value because of the richness of the flora and fauna that they support. The recently completed *Gnangara Sustainability Strategy Situation Statement* (Government of Western Australia 2009a) provides a description of these values, which are summarised below.

Fauna

The reptilian fauna on the Gnangara Mound is highly diverse, represented by approximately 39 genera and 64 species including geckos, dragons, goannas, turtles and snakes (Storr, Harold & Barron 1978; How & Dell 1993; How & Dell 1994; How & Dell 2000). Nine frog species have been recorded in the study area (Department of Environmental Protection 2000).

The critically endangered western swamp tortoise, *Pseudemydura umbrina*, is the only species endemic to the GSS study area. Most reptile species have declined in local distribution and abundance in urban areas since European settlement and now remain in bushland remnants (How & Dell 1994; How & Dell 2000).

Approximately 140 species of birds (excluding seabirds and migrants) have been recorded on the Swan coastal plain (Department of Environmental Protection 2000). Wetland birds have been particularly impacted by large-scale loss of coastal-plain wetlands (How & Dell 1993). Species such as the black bittern (*Ixobrychus flavicollis*), the Australasian bittern (*Botaurus poiciloptilus*) and the whistling kite (*Haliastur sphenurus*) have all suffered major declines, together with most species of raptor (birds of prey).

Carnaby's black cockatoo (*Calyptorhynchus latirostris*) is listed as endangered under the *Environment Protection and Biodiversity Conservation Act 1999*. It breeds in the wheatbelt regions of the South West and migrates to the Swan coastal plain, an important feeding area, in the non-breeding season. The birds feed on proteaceous plants including *Banksia, Dryandra, Hakea* and *Grevillea* (Shah 2006). Losses of feeding and roosting sites due to urban development have been identified as key threatening processes for this species. There are large populations in the pine plantations, and the pines are considered to be a major habitat and food source. Black cockatoos roost in pines and mix pine seed and *Banksia* as major food sources.

A total of 33 native mammal species were documented historically (1839–1907) on the northern Swan coastal plain, but by 1978 only 12 species were recorded (Kitchener, Chapman & Barron 1978). Species, such as the western grey kangaroo (*Macropus fuliginosuos*), are thought to be reasonably common, while others such as the bush rat (*Rattus fuscipes*), water rat (*Hydromys*

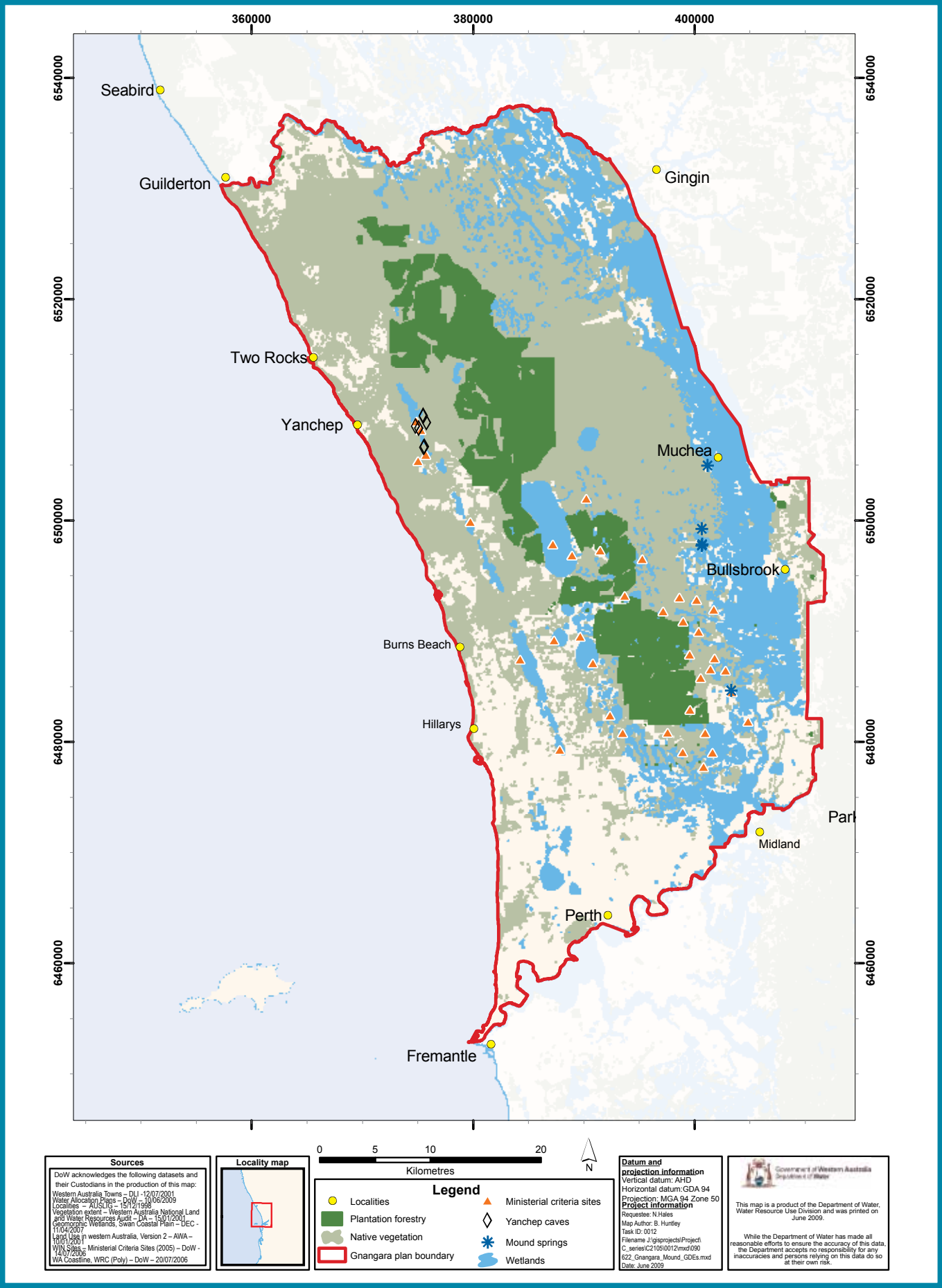

Figure 7
Location of groundwater-dependent ecosystems across the Gnangara system

chrysogaster), brush wallaby (*Macropus irma*), ash-grey mouse (*Pseudomys albocinereus*), honey possum (*Tarsipes rostratus*) and western pygmy possum (*Cercartetus concinnus*) occur only in restricted or isolated populations (Kitchener et al 1978; How & Dell 2000).

There is a rich diversity of invertebrate fauna, although these have not been widely studied. A number of invertebrate taxa found in the Perth metropolitan area are listed as fauna likely to become extinct, four of them as priority fauna. They include the graceful sun moth and two native bee species in the genera *Leiproctus* and *Neopasiphae*. (Department of Environmental Protection 2000; Department of Environment and Conservation 2008 (in prep)).

Wetlands

There are approximately 600 wetlands throughout the study area as shown in Figure 7. Although some may be perched, the majority of these wetlands are hydraulically connected to the Superficial Aquifer. Of these, six are listed as nationally significant (Hill, Semeniuk, Semeniuk & Del Marco 1996).

The wetlands and their fringing vegetation are important ecosystems for many of the fauna listed above.

Vegetation

The Gnangara Mound once supported large areas of groundwater-dependent native woodlands. Prominent species include the tuart (*Eucalyptus gomphocephala*), jarrah (*E. marginata*), marri (*Corymbia calophylla*), the coastal blackbutt (*E. todtiana*) and *Melaleuca* spp. as well as several *Banksia* including the slender banksia (*B. attenuata*), firewood banksia (*B. menziesii*), holly-leaved banksia (*B. ilicifolia*) and swamp banksia (*B. littoralis*).

Although there have been large amounts of clearing for urbanisation and agriculture, the total remnant native woodland in the study area of the Gnangara Sustainability Strategy covers more than 100 000 ha, including the largest continuous area of remnant vegetation on the Swan coastal plain south of the Moore River. The remnant woodland within the GSS study area has significant state biodiversity values, containing as it does a number of threatened species and ecological communities (Government of Western Australia 2009a).

In the south, west and east the majority of remnant vegetation patches are small and highly fragmented, but large intact areas remain in the centre and north in the Department of Environment and Conservation Estate (about 16 000 ha) and Department of Environment and Conservation state forest (about 30 000 ha). Large areas of remnant vegetation also occur within unallocated Crown land in the shires of Gingin and Chittering (approximately 12 000 ha). A further 17 000 ha of remnant vegetation have been identified as regionally significant by Bush Forever (Department of Environmental Protection 2000).

Mound springs

The organic mound springs are permanently wet peat mounds. These springs occur at the junction of the Guildford Clays and Bassendean Sands. Mounds of saturated peat accumulate at the surface, providing a stable, permanently moist series of microhabitats. There are few remaining intact mound springs and these are associated with a rich, healthy fauna, some of which are ancient Gondwanan relicts endemic to each site. The mound spring threatened ecological communities are recognised as critically endangered (Mitchell, Williams & Desmond 2003).

Caves

Extensive karstic limestone systems occur within the Yanchep National Park. Over 400 karst features have been documented with approximately 50 caves known to have (or have had) permanent streams and pools. A number of these are known to contain submerged root mats from overlying Tuart trees, providing a primary food source for Gondwanan relict invertebrate fauna.

The Yanchep Caves are classified as threatened ecological communities by the Department of Environment and Conservation. They are unique within the Gnangara planning boundary, and are critically endangered (Gibson et al 2000).

2.5.2 Providing water for the environment

Environmental water provisions based on ecological water requirements were first developed for the protection of the environmental values associated with groundwater-dependent ecosystems on the Gnangara Mound in 1986. These became Ministerial criteria under the *Environmental Protection Act 1986* in 1988. The current criteria are contained in Ministerial statement 687 released in August 2005 (Appendix B).

Environmental water provisions are usually water level criteria set for representative sites. The department monitors water levels and the ecological condition at these sites to determine compliance with criteria and the ecological impact of changing water levels.

The environmental water provisions have been reviewed a number of times for a variety of reasons:

- our understanding about ecological values and impacts of water level declines have improved
- groundwater abstraction has increased
- there have been administrative changes.

There has not been a detailed review of conditions in the context of reduced rainfall and a drying climate. As lower rainfall is a factor contributing to groundwater decline, the department has initiated research into an approach for determining ecological water requirements in a changing climate. The department is undertaking this work with funding from the Australian Government under Water for the Future's – Water Smart Australia program.

It is recognised that groundwater-dependent ecosystems in Gnangara have adapted to a water regime of winter recharge that supports these ecosystems through typically hot, dry summers. However, overlaying this seasonal variability are climate fluctuations at annual and decadal time scales.

Declining groundwater levels across the mound, combined with the drying climate trend have resulted in a corresponding decline in the health of groundwater-dependent ecosystems. Major impacts have included:

- declining vegetation health, terrestrialisation, poor water and soil quality and declining numbers of macroinvertebrate species at some wetlands
- a shift in the species composition of terrestrial vegetation from species preferring wetter conditions towards species tolerant of drier conditions
- declining water levels in the limestone caves which may result in the loss or possible extinction of a number of unique aquatic invertebrate fauna.

The department submitted the most recent review of Ministerial criteria to the EPA in October 2007 (Department of Water 2007a). The review provided a detailed assessment of water level and ecological trends at each criteria site (Appendix C) over the last ten years. Generally, most criteria sites were showing some ecological decline or risk of ecological decline as a result of declining water levels.

The department made the following recommendations:

- the removal of water level criteria for sites where the review showed the ecological values no longer exist
- the removal of sites where the impacts on water levels were mostly driven by climate and/or land use, which are outside the control of the department.
- improvements to the monitoring program.

It is anticipated that a new Ministerial statement with revised conditions and a reduced number of Ministerial sites will be released within the life of this plan.

Managing to environmental criteria

Groundwater-dependent ecosystems may be directly affected by abstraction from the Superficial Aquifer. These effects can be significant if a groundwater-dependent ecosystem is:

- within the drawdown cone caused by local abstraction
- down-gradient of abstraction.

We use the number of non-compliances with environmental water provision criteria, the rate of groundwater level decline, ecological condition and end of summer water level predictions to manage abstraction for public water supply on an annual basis.

When environmental monitoring indicates that the ecological health of wetlands and other groundwater-dependent ecosystems are in significant decline, remedial action may be taken.

Remedial action often requires the department to integrate its expertise with other organisations for the best management of the ecosystems, including Department of Environment and Conservation and the Water Corporation.

Action 6 – Continue to implement wetland site management including supplementation where appropriate and engage other organisations as required.

2.6 Cultural and social values of the Gnangara groundwater system

Aboriginal heritage sites are sites of significance to Aboriginal people, listed on the Aboriginal Site Register which is held under Section 38 of the state's *Aboriginal Heritage Act 1972*. There are over 800 sites listed within the Gnangara groundwater areas planning boundary.

The Gnangara groundwater system and its associated wetlands, rivers and springs are important to the cultural and spiritual beliefs of the Nyungar people. Details on the cultural sites of significance across the plan area are outlined by Estill and Associates (2005a, 2005b).

The plan is unlikely to have a direct effect on Aboriginal sites, but actions arising from the plan, such as the installation of monitoring equipment, may be affected by Section 17 of the *Aboriginal Heritage Act (1972)*. Section 17 describes a breach as being any action that excavates, destroys, damages, conceals or in any way alters an Aboriginal site.

The department carries out consultative surveys and seeks consent under Section 18 of the *Aboriginal Heritage Act (1972)* for works carried out by us that may affect an Aboriginal site. It is the licensee's responsibility to seek consent to carry out licensed activities if any impact on an Aboriginal heritage site is expected. For further information contact the Department of Indigenous Affairs at <www.dia.wa.gov.au>.

The report by Estill and Associates (2005a) highlights concerns relating to the cultural and environmental impact of declining groundwater levels.

The social value of groundwater-dependent features on the Gnangara Mound typically refers to the recreational and/or aesthetic value of the feature. Social values have been determined through previous public consultation.

Beckwith Environmental Planning (2006) assessed the in situ social value of water use on the Gnangara Mound, and found a variety of values associated with groundwater-dependent ecosystems, including:

- nature-based recreation activities (such as bird-watching, bushwalking and nature observation)
- historical significance
- Aboriginal culture
- aesthetic or amenity
- education and scientific
- intrinsic
- sense of place.

The study also showed that community members do not separate the in situ social value of groundwater-dependent ecosystems from the issue of ecological health and ecological value. For many of the participants, meeting the ecological needs of the groundwater-dependent ecosystems would be adequate to support the in situ social values.

The department has not quantitatively defined the water regime required to support the cultural and social values of groundwater-dependent features on the mound to date. However, the department considers these values through the application of *Statewide policy no. 5 – Environmental water provisions policy for Western Australia* (Water and Rivers Commission 2000a).

2.7 Existing allocation and use of groundwater

The Gnangara system is the largest and most valuable single source of good quality, fresh water in the Perth region. This water source is of vital importance to the continuing social and economic development of the Perth region, and supports a population of approximately 1.5 million people (Australian Bureau of Statistics 2006).

The distribution of water use (including licensed entitlements and estimated unlicensed use) of the groundwater resources as at August 2009 is shown in Table 2. It is estimated that one in three households have access a domestic garden bore. This equates to approximately 72 500 garden bores within the plan area, representing a total groundwater abstraction of 58 GL/yr (Davidson & Yu 2007). This figure is based on an estimated use of 800 kL per bore per year (Water and Rivers Commission 2000b).

Appendix D provides a description of the land use sub-categories within each water use category.

Table 2
Distribution of water use for the Gnangara system

Water use category[1,2]	Volume GL/yr[3,5]	Percentage of total volume used %[5]
Domestic	9	3%
Horticulture and Agriculture	72	22%
Industry and Commercial	15	5%
Parks and Gardens	30	9%
Public Water Supply	136	42%
Unlicensed (estimated garden bore)[4]	58	18%
Other	1	0%
Total	321	100

Notes:

1. Assumes water use corresponds to total of licensed entitlements, except for Unlicensed (see Note 4)
2. Source of licensed entitlement data is Water Resourcing Licensing System, Department of Water, as at 5 August 2009
3. 1 GL = 1 000 000 kL
4. Source is Davidson & Yu (2007)
5. Numbers rounded to whole numbers

Table 3 shows the distribution of licensed entitlements for each groundwater area. This table shows that the main water use in the Gingin, Swan and Wanneroo groundwater areas is for horticulture and agriculture (94%, 76% and 69% respectively).

The main use in all other groundwater areas is public water supply.

Table 3
Distribution of licensed water entitlements (%) by water use category and groundwater area

Water use category	Groundwater area							
	Gingin	Gnangara	Gwelup	Mirrabooka	Perth	Swan	Wanneroo	Yanchep
Domestic	2%	0%	0%	3%	3%	10%	8%	2%
Horticulture and Agriculture	94%	0%	0%	11%	2%	76%	69%	2%
Industry and Commercial	2%	4%	0%	1%	9%	9%	4%	26%
Parks and Gardens	1%	0%	0%	9%	26%	5%	4%	20%
Public Water Supply	1%	96%	100%	76%	60%	0%	15%	49%
Other	0%	0%	0%	0%	0%	0%	0%	2%
Total	100%	100%	100%	100%	100%	100%	100%	100%

Notes:

1. Source of licensed entitlement data is Water Resource Licensing system, Department of Water, as at 5 August 2009.
2. Numbers rounded to whole numbers.

The distribution of licensed water entitlements by aquifer is shown in Table 4 for each groundwater area and for the Gnangara system. Most of the groundwater allocated to the Gnangara system is from the Superficial Aquifer (65%), followed by the Leederville (17%) and Yarragadee North (16%) aquifers. A small amount of water is allocated to the Mirrabooka Aquifer (2%) and fractured rock aquifers (less than 0.01 per cent). See also Table 6 to Table 10 for detail on licensed entitlements at the subarea level.

Table 4
Distribution of licensed water entitlements (%) by aquifer

Aquifer	Groundwater area								Gnangara system
	Gingin	Gnangara	Gwelup	Mirrabooka	Perth	Swan	Wanneroo	Yanchep	
Superficial	88%	40%	0%	61%	71%	68%	80%	93%	65%
Mirrabooka	0%	0%	0%	5%	3%	8%	0%	0%	2%
Leederville	12%	32%	48%	29%	10%	22%	4%	3%	17%
Yarragadee North	0%	28%	52%	6%	16%	2%	16%	4%	16%
Fractured Rock	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Notes:

1. Source of licensed entitlement data is Water Resource Licensing system, Department of Water, as at 5 August 2009.
2. Numbers rounded to whole numbers.

2.7.1 Public water supply

The department regulates the abstraction of water for Western Australia's Integrated Water Supply Scheme, which is managed by the Water Corporation.

Reduced inflow to dams over the last 30 years has seen the Gnangara groundwater system provide increasing volumes of water to the IWSS. At the same time, Perth's population has almost doubled with additional water needs being met from groundwater.

Approximately 40% of groundwater abstracted from the Gnangara system is for the IWSS for public water supply (Table 2), which represents approximately half of the total supply of water to the scheme. Prior to commissioning of the Perth Seawater Desalination Plant in 2007, groundwater comprised approximately two-thirds of supply to the IWSS.

Of the groundwater abstracted for the IWSS from the Gnangara system, approximately one-third is abstracted from the Superficial Aquifer (31%), and two-thirds from the confined Leederville and Yarragadee aquifers (30% and 36% respectively), with a small amount from the semi-confined Mirrabooka Aquifer (3 per cent). The proportion of licensed abstraction for the IWSS from the confined aquifers has increased in the last ten years.

Groundwater from the Gnangara system is also pumped into Mundaring Weir to supply water to the Goldfields and Agricultural Water Supply Scheme. Groundwater will continue to be critical to the security of public water supply before and after commissioning of the next major source, the Southern Seawater Desalination Plant, scheduled for 2012.

2.7.2 Horticultural and agricultural industry

The Gnangara system supports an extensive area of irrigated agriculture that includes vegetables, orchards, vineyards, turf farms and plant nurseries. Approximately 22% of groundwater abstracted from the system is for the horticultural and agricultural industries (see Table 2), comprised of:

- Crops (2.7%)
- Horticulture (14%)
- Pasture (3.8%)
- Viticulture (1.3%)
- Stock (0.7%)

Most of this water is abstracted from the Superficial Aquifer.

Market gardens and orchards are located mostly in the Wanneroo area, the Swan Valley and along the northern margin of the system at Gingin Brook. Vineyards are located in the Swan Valley and north of Wanneroo and turf farms are located mostly in Carabooda with some in North Swan.

In 2006–07 the total value of revenue from horticulture and other agricultural activities based within the Perth area was approximately $646 million (Science Matters and Economic Consulting Services 2008), reflecting the importance of agriculture to the regional economy. The Wanneroo area accounted for 42% of the total metropolitan horticultural production area in 2005-06 and this represented about 5 per cent of the state area (Science Matters and Economic Consulting Services 2008).

2.7.3 State agreements

There are two state agreement acts within the plan area – the *Wood Processing (WESFI) Agreement Act 2000* and the *Wood Processing (Wesbeam) Agreement Act 2002*. These acts govern the management of pine plantations that have been established over 22 000 ha of land in the central and northern portions of the Gnangara system.

The Wood Processing *(WESFI) Agreement Act 2000* commits the state government to supply wood until 2025. The *Wood Processing (Wesbeam) Agreement Act 2002* commits the state government to provide wood to the Laminated Veneer Lumber (LVL) Plant from its plantations on Gnangara until 2029. Harvesting rates, which in turn influence groundwater yields, are stipulated under the acts. The total combined profit of timber production from Wesbeams and LVL is $142.5 million per annum (Government of Western Australia 2009a).

As part of implementing the Gnangara Sustainability Strategy, the Forest Products Commission is investigating the potential of modifying harvesting strategies within the constraints of the acts to assist in increasing recharge to the Gnangara system.

2.8 The Gnangara Sustainability Strategy

The government has recognised the importance of the Gnangara system as a future water source and has invested $7.5 million for the Gnangara Sustainability Strategy to develop a sustainable long-term approach for land use and water resource management for the Gnangara system.

The GSS is a multi-agency approach to integrate land and water management to reduce impacts on the water resources of the Gnangara system.

The following projects have been undertaken as part of the GSS:

- biodiversity values on the mound (Department of Environment and Conservation)
- local and regional area groundwater flow modelling (Department of Water)
- regional planning context and regional planning (Department for Planning and Infrastructure)
- evaluation of a dedicated horticulture precinct on the Gnangara Mound (Department of Agriculture and Food)
- plantation forestry (Forest Products Commission)
- future land uses for Crown land (Department of Environment and Conservation)
- prescribed burning and water recharge (Department of Environment and Conservation)
- quantitative analysis and integration of land-use and water management scenarios (CSIRO)
- six projects by the Water Corporation:

- strategic source options for the Integrated Water Supply System
- abstraction plans
- viability of Eglington, Yanchep–Two Rocks and Barragoon schemes
- winter pumping trial and Leederville Aquifer storage recovery
- hydrological investigations in the Yeal and Pinjar subareas
- groundwater replenishment trial.

The draft *Gnangara Sustainability Strategy* (Government of Western Australia 2009b) was released in July 2009 for public comment and recommends the preferred land use and water management options for the sustainable use of water from the Gnangara system.

The 2012 Gnangara allocation plan will build on the recommendations of the Gnangara Sustainability Strategy. Information on the Gnangara Sustainability Strategy can be obtained from the department or viewed online at <www.gnangara.water.wa.gov.au>.

2.9 Community input into allocation planning

Water allocation planning recognises and seeks community input through existing community and representative groups and through targeted consultation activities. For this plan, the department held targeted consultation through the assessment of social values of water on the Gnangara Mound (Beckwith Environmental Planning 2006). We also made use of knowledge gained through previous consultation processes.

This plan was released as a draft for a public comment. Throughout the public comment period for this plan, the department recorded the major allocation issues raised by the community. We incorporated feedback where relevant to finalise this plan and will address relevant issues through further work for the 2012 plan.

For more information on the comments received through the public review process and the department's responses please see *Statement of response – Gnangara groundwater areas allocation plan* (Department of Water 2009a).

The department is improving the management framework for the Gnangara system. An annual cycle of review against criteria is already in place to inform the annual IWSS abstraction volume and to report to the Environmental Protection Authority on the effect of abstraction on key wetlands. Under this plan, we will broaden and integrate this approach to assess and respond to performance against plan objectives and actions (see Chapter 7).

Action 7 – Develop and implement an integrated annual management review and response framework for the Gnangara system.

Part two

Allocation and management framework

Chapter three

Objectives and strategies

3.1 Objectives

The objectives for managing groundwater levels and abstraction in the Gnangara groundwater areas are based on the considerations in Chapter 2.

Through this plan, the department aims to achieve a reduction in the total abstraction from the Gnangara system to address the trend of declining groundwater levels.

The objectives of this plan are as follows.

1. Reduce the total volume of water abstracted from the Gnangara system towards a level that better reflects the current recharge from rainfall.

2. Optimise the use of water through water use efficiency and demand management measures.

3. Protect groundwater-dependent ecosystems from direct impacts associated with abstraction.

4. Protect the quality of groundwater for public and self-supply from impacts associated with abstraction and land use.

5. Adapt management of the water resource based on the results of monitoring programs and the condition of the resource.

We will develop more specific and measurable objectives for the Gnangara system for the 2012 plan, based on the following:

- recommendations of the *Gnangara Sustainability Strategy*
- the *Perth-Peel Regional Water Plan*
- outcomes of projects the department is undertaking with the assistance of the Water Smart Australia program
- the proposed new water resources management legislation.

3.2 Strategies to meet objectives

The strategies of this plan to meet the objectives are (Table 5):

Table 5
Strategies for the Gnangara groundwater areas allocation plan

Strategies	Objectives
Allocate water up to the allocation limits for each resource	3 and 4
Reduce the allocation to the IWSS	1 and 3
Reserve water for future public water supply	4
Recover water entitlements in over-allocated resources	1
Allow water trading in fully or over-allocated resources	2
Monitor the groundwater resource and dependent ecosystems	3 and 5
Monitor the use of water	2 and 5

Chapter four

Water allocation

4.1 Allocation limits

For this plan, the allocation limit is the total amount of water that can be licensed for use for a particular water resource. The department sets an 'allocation limit' to manage the overall impact of water use. The department sets allocation limits for the Gnangara system to minimise the impacts of the annual groundwater abstraction regime on the groundwater resource (quantity and quality), its dependent ecosystems (such as wetlands and terrestrial vegetation) and its dependent social values.

The department has reviewed allocation limits for each resource (each aquifer in a subarea) across the Gnangara system (Table 6 to Table 10). In defining the allocation limit, the department allowed for estimates of current unlicensed use (see Section 4.5.1).

The allocation limit of a resource may change in the future. The department may increase or decrease limits in this plan based on water level and water quality trends over time. The department will review allocation limits following groundwater assessment and investigation conducted throughout the life of this plan, or when the department deems necessary. The department will release revised allocation limits through an appropriate mechanism announced by the department at that time.

Action 8 – Review allocation limits in this plan and revise if necessary.

4.2 Subareas

The department has divided the proclaimed groundwater areas into subareas for allocation purposes (Figure 8 and Table 6 to Table 10).

Currently groundwater area and subarea boundaries are based primarily on cadastral boundaries. In 2008, the department split the subareas in the Gingin Groundwater area along the hydrogeological boundary defined by Gingin Brook to better achieve water resource management objectives. The southern subareas are included in this plan, while the northern subareas will be included in a future plan for the Gingin Groundwater area.

The department will review proclaimed groundwater areas and respective subareas of the Gnangara system to better align with hydrogeological features and to consider the water management units proposed by the *Gnangara Sustainability Strategy* (Government of Western Australia 2009b).

Action 9 – Review proclaimed groundwater areas and subareas of the Gnangara system.

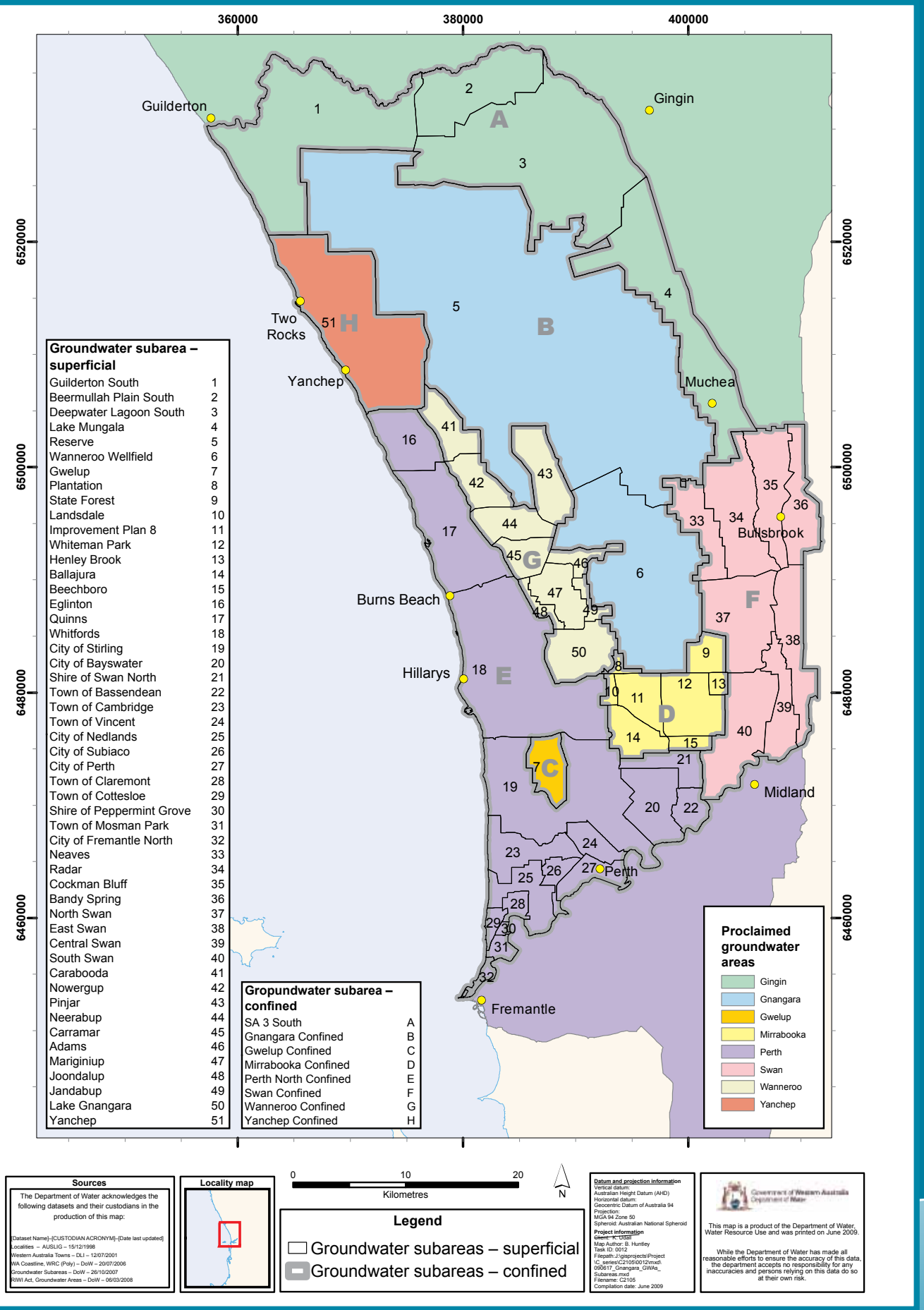

Figure 8
Groundwater areas and subarea in the- plan area

4.3 Water availability

For this plan, water availability at a particular date is the allocation limit minus the total of licensed entitlements (private and public water supply), public water supply reserved (future use) and other commitments (e.g. staged developments).

Table 6 to Table 10 show, for each aquifer, the allocation limits, current licensed entitlements and whether water is available for new licences. The licensed entitlement and water availability data provided in the tables are current as at August 2009. Figures for licensed entitlements and water availability will vary in the future, as licensing and recouping of water is an ongoing activity.

Please contact the department's Swan Avon region on 08 6250 8000 for up-to-date information on water availability.

The department has reserved water for future public water supply in the Superficial, Mirrabooka, Leederville and Yarragadee aquifers (Table 6 to Table 9). This accounts for most of the difference between the total of the allocation limits and the licensed entitlements for the Superficial Aquifer.

Table 6
Superficial aquifer allocation limits, licensed entitlements and water availability for new licences

Groundwater area	Groundwater subarea	Allocation limit kL/a	Licensed entitlements[1] kL/a	Public water supply (reserved)	Water available[2,3]
Gingin	Beermullah Plain South	3 000 000	3 012 825	-	No
	Deepwater Lagoon South	3 500 000	3 453 535	-	Limited
	Guilderton South	11 000 000	11 531 489	-	No
	Lake Mungala	3 400 000	2 641 280	Yes	No
Gnangara	Reserve	9 000 000	4 521 960	Yes	No
	Wanneroo Wellfield	12 000 000	9 600 000	Yes	No
Mirrabooka	Ballajura	6 000 000	3 459 376	Yes	No
	Beechboro	1 000 000	296 719	-	Yes
	Henley Brook	1 600 000	1 033 315	Yes	No
	Improvement Plan 8	5 500 000	2 781 376	Yes	No
	Landsdale	1 400 000	1 285 920	-	Limited
	Plantation	600 000	529 915	-	Limited
	State Forest	1 000 000	861 574	-	Limited
	Whiteman Park	1 000 000	1 103 281	Yes	No
Perth	City of Bayswater	2 300 000	2 187 493	-	Limited
	City of Fremantle North	700 000	41 150	-	Yes
	City of Nedlands	2 300 000	2 339 150	-	No
	City of Perth	1 500 000	1 629 038	-	No
	City of Stirling	11 150 000	9 673 906	Yes	No
	City of Subiaco	1 000 000	894 800	-	Limited
	Eglinton	15 450 000	2 469 850	Yes	Limited
	Gwelup	7 950 000	4 380 288	Yes	No
	Quinns	24 650 000	16 465 069	Yes	Limited
	Shire of Peppermint Grove	100 000	83 900	-	Limited
	Shire of Swan North	1 000 000	628 115	-	Yes
	Town of Bassendean	500 000	448 190	-	Limited
	Town of Cambridge	3 500 000	2 283 725	-	Yes
	Town of Claremont	700 000	693 730	-	Limited
	Town of Cottesloe	300 000	248 400	-	Limited
	Town of Mosman Park	500 000	477 100	-	Limited
	Town of Vincent	1 000 000	718 575	-	Limited
	Whitfords	22 430 000	13 256 379	Yes	No
Swan	Bandy Spring	350 000	349 992	-	Limited
	Central Swan	1 000 000	1 597 896	-	No
	Cockman Bluff	1 500 000	1 262 525	-	Limited
	East Swan	750 000	923 940	-	No
	Neaves	2 000 000	3 427 930	-	No
	North Swan	2 000 000	2 983 563	-	No
	Radar	2 000 000	2 366 365	-	No
	South Swan	4 000 000	3 920 423	-	Limited
Wanneroo	Adams	1 000 000	1 243 423	-	No
	Carabooda	6 400 000	8 099 355	-	No
	Carramar	1 700 000	1 536 390	-	Limited
	Jandabup	200 000	205 580	-	No
	Joondalup	1 500 000	1 307 180	-	Limited
	Lake Gnangara	7 500 000	7 997 342	-	No
	Mariginiup	4 000 000	4 776 392	-	No
	Neerabup	2 650 000	2 575 780	-	Limited
	Nowergup	2 000 000	2 785 665	-	No
	Pinjar	500 000	851 095	-	No
Yanchep	Yanchep	10 870 000	2 726 013	Yes	Limited
TOTAL		208 950 000	155 968 272		

Table 7
Mirrabooka aquifer allocation limits, licensed entitlements and water availability for new licences

Groundwater area	Groundwater subarea	Allocation limit kL/a	Licensed entitlements[1] kL/a	Public water supply (reserved)	Water available[2,3]
Mirrabooka	Beechboro	0	1500	-	No
	Henley Brook	360 000	360 000	Yes	No
	State Forest	200 000	150 000	-	Limited
	Whiteman Park	400 000	306 500	Yes	No
Perth	City of Bayswater	50 000	12 000	-	Yes
	Gwelup	3 600 000	3 350 000	Yes	No
	Shire of Swan North	230 000	167 250	-	Limited
Swan	North Swan	300 000	252 060	-	Limited
	Radar	200 000	151 950	-	Limited
	South Swan	1 600 000	1 462 085	-	Limited
TOTAL		6 940 000	6 213 345		

Table 8
Leederville aquifer allocation limits, licensed entitlements and water availability for new licences

Groundwater area	Groundwater subarea	Allocation limit kL/a	Licensed entitlements[1] kL/a	Public water supply (reserved)	Water available[2,3]
Gingin	SA 3 South	2 600 000	2 964 215	-	No
Gnangara	Gnangara confined	15 100 000	13 100 000	Yes	No
Gwelup	Gwelup confined	5 300 000	7 000 000	-	No
Mirrabooka	Mirrabooka confined	6 000 000	8 201 650	-	No
Perth	Perth North confined	10 700 000	13 706 270	-	No
Swan	Swan confined	5 000 000	5 457 326	-	No
Wanneroo	Wanneroo confined	1 250 000	1 419 840	-	No
Yanchep	Yanchep confined	360 000	320 000	-	Limited
TOTAL		46 310 000	52 169 301		

Table 9
Yarragadee North aquifer allocation limits, licensed entitlements and water availability for new licences

Groundwater area	Groundwater subarea	Allocation limit kL/a	Licensed entitlements[1] kL/a	Public water supply (reserved)	Water available[2,3]
Gnangara	Gnangara confined	5 150 000	14 700 000	-	No
Gwelup	Gwelup confined	7 500 000	7 600 000	-	No
Mirrabooka	Mirrabooka confined	1 580 000	1 300 000	Yes	No
Perth	Perth North confined	21 000 000	19 740 000	Yes	Limited
Swan	Swan confined	500 000	0	Yes	No
Wanneroo	Wanneroo confined	5 000 000	6 400 000	-	No
Yanchep	Yanchep confined	390 000	0	Yes	No
TOTAL		41 120 000	49 740 000		

Table 10
Fractured rock aquifer allocation limits, licensed entitlements and water availability for new licenceses

Groundwater area	Groundwater subarea	Allocation limit kL/a	Licensed entitlements[1] kL/a	Public water supply (reserved)	Water available[2,3]
Gingin	Lake Mungala	100 000	0	-	Yes
Swan	Bandy Spring	100 000	0	-	Yes
	East Swan	100 000	9270	-	Yes
	Central Swan	100 000	0	-	Yes
TOTAL		400 000	9270		

Notes (for Tables 6 to 10):

1 Licensed entitlements includes the total of private and public water supply licensed entitlements as at 5 August 2009.

2 Water availability = allocation limit – total of Licensed Entitlements (private and public water supply), public water supply reserved (future use) and other commitments (e.g. staged developments).

3 Resources less than 100% allocated but over 70% allocated have limited availability.

4 Subject to change due to the water service provider(s) taking contingency actions associated with providing its customers with water (such as bore maintenance and environmental commitments).

4.4 Over-allocated resources

Water resources are over-allocated when the use (total of licensed entitlements) is higher than the allocation limit. The department classifies the resource as being in a C4 resource category (Appendix E). This may occur in exceptional circumstances where the department issues licence entitlements above the allocation limit.

Resources also become over-allocated if the department reduces the allocation limit in areas where use is already high. For the Gnangara system, the department has reduced allocation limits for all resources in the Leederville and Yarragadee North Aquifers (see Section 4.5) and some resources in the Superficial Aquifer, resulting in over-allocated areas.

Since the department revised the allocation limits for the groundwater areas of the resources in the Leederville and Yarragadee North Aquifers, current licensed entitlements as a percentage the allocation limit varies from approximately 110% for some resources (Table 8 and Table 9) as the total licensed entitlements has changed over time. Changes may result from licences expiring and the department issuing additional entitlements (particularly for public water supply as the allocation varies from year to year – see Section 5.4).

In over-allocated groundwater resources in the Gnangara plan area, the department promotes water trading in line with our current state-wide policy (Water and Rivers Commission 2001a). We have also started the recovery of water through the licence renewals process and efficiency programs.

4.5 Methodology used to set allocation limits

Allocation limits are the primary tool the department uses to control the amount of water that water users can take and to restrict the impact of take on in situ needs.

We set allocation limits for each groundwater resource (each aquifer in a subarea) in the Gnangara plan area.

4.5.1 Superficial Aquifer

Allocation limits for the Superficial Aquifer are based on hydrogeological and ecological condition assessments in addition to data on the current use and demand for the resource.

The department developed a water balance for each groundwater area and subarea using the Perth Regional Aquifer Modelling System (PRAMS) model. The aquifer yield was calculated as a percentage of net rainfall recharge to the Superficial Aquifer, based on the PRAMS generated water balance calculation (URS 2008).

We applied a technique known as cumulative deviation from mean rainfall (CDFM) to examine the relative influence of different factors on groundwater levels for a sample of approximately 100 hydrographs across the Gnangara Mound (Yesertener 2007).

We used a groundwater level response management (hydrograph trend analysis) method as a corrective tool for short-term to medium-term management toward achieving long-term sustainability in the context of changing climate and declining groundwater levels (Bekesi 2007). We used the trend analysis to determine a correction factor (increase or decrease) to the allocation limit based on the trends observed in hydrographs across the Gnangara system.

We set allocation limits by using a combination of the hydrograph trend analysis and water balance information provided by PRAMS as the primary hydrogeological information in decision-making. We used the CDFM technique to support decisions made, as it attempts to determine the possible cause of groundwater level decline.

We also used ecological information as part of decision making, including the location and condition of environmental criteria sites and other groundwater-dependent ecosystems within subareas in the plan area. We made more conservative allocation decisions when criteria sites or groundwater-dependent ecosystems were located nearby.

We used total existing water use (licensed and unlicensed) to modify allocation limits. The allocation limits do not include but allow for the estimated unlicensed use. We took unlicensed use into account as part of the water balance and we deducted this volume before setting the allocation limit. We also considered current and potential future land and water use to make allocation limit decisions, including:

- reserving water for public water supply
- recognising existing water use
- allowing for water requirements to support land use change and developments of significant public benefit
- the department's strategic direction in water management.

We set allocation limits based on the management objectives for each groundwater area. We also identified actions to manage impacts during this process.

4.5.2 Mirrabooka Aquifer

The department set allocation limits for the Mirrabooka Aquifer by using the groundwater level response management (hydrograph trend analysis) method. We also considered ecological condition assessments as well as data on the current use and demand for the resource.

4.5.3 Leederville and Yarragadee North Aquifers

In 2006 the department reviewed the internal policy on accessing the confined aquifers (Department of Water 2006c). We made a management decision to cap abstraction for all the confined aquifer resources in the Perth region (excluding the Gingin groundwater area), as scientific assessment showed that abstraction was impacting the groundwater resources. We reduced the allocation limit for each groundwater resource in the Perth region to approximately 10% less than the total licensed entitlements at the time, so that licensed entitlements were approximately 110% of the allocation limit. This meant that all resources were over-allocated (C4 resource category – see Appendix E).

In 2007 the department reviewed the allocation limits for the Gnangara system based on the most current information available at the time. As a result we decided that the allocation limits set for the confined aquifer systems in 2006 were still appropriate. In 2008, the department reapportioned the allocation limits for the Gingin groundwater area, based on the subareas split (see Section 4.2).

We will review this decision when the PRAMS model is upgraded to better model the confined aquifers during the life of this plan and in context of possible changes to resource boundaries (see Action 9).

4.5.4 Fractured Rock Aquifer

The department reviewed the allocation limits for the Fractured Rock Aquifer in 2007 as part of the allocation limit review for the Gnangara system. We made a nominal amount of water available in all subareas where the aquifer is present, as this aquifer is considered to be low yielding and restricted to 3–5 m thickness. The justification for this approach is that a proponent has the opportunity to undertake exploratory work to prove the availability of the resource, relative to their water needs. The department will make allocation decisions based on the results of work that the proponent provides to us.

Chapter five

Allocation and licensing policies

The department develops allocation and licensing policies to ensure we allocate water in an equitable and considered way. Allocation policies provide advice on where and under what circumstances water may be taken, and how water abstraction is managed. They provide advice for water users, as well as guidance for department staff.

All state and Commonwealth legislation relating to water and its use apply to this plan area, including the Rights *in Water and Irrigation Act 1914,* and the Rights in Water and Irrigation Regulations 2000.

We developed the allocation policies in the context of competition for consumptive water, and aim to provide a sound basis for groundwater licensing over the life of the plan. The policies aim to protect all groundwater use and as such cover ecological, social and economic aspects, as well as water quality and quantity.

Licensing decisions should be based on the best available scientific knowledge, and through the decision-making process, take into consideration local and regional scale impacts of abstraction. All licensing decisions must be in line with this plan.

High value groundwater-dependent ecosystems, areas of social or cultural significance, and sites of potential acid sulfate soil risk that may be affected by abstraction may have local area policies applied to them. The department develops these additional requirements to protect high value areas or areas at high risk of impact. Trigger and response criteria may also apply to some sites.

5.1 Groundwater licensing

The department's Swan Avon Regional office administers licensing of groundwater in the plan area (other than for the Integrated Water Supply Scheme).

The licensing process and licence application forms are available on the department's website or at the department's Swan Avon regional office. Applicants should be aware of the licensing policies that may apply to their area before submitting their groundwater licence application to the department.

For further information contact the Swan Avon regional office on 08 6250 8000.

5.1.1 Licensed water entitlements

Groundwater users within the Gnangara plan area need a licence to take water (licence entitlement) from any aquifer, except for those purposes that are exempt from licensing (Section 5.1.3).

Abstraction may be unsuitable in the Gnangara system in areas:

- that are close to groundwater-dependent ecosystems
- where groundwater salinity is brackish to saline
- that are constrained by the local hydrogeology
- where there are potential acid sulfate soils.

5.1.2 Subarea restrictions

Land uses in parts of the following subareas in the Swan groundwater area are subject to planning restrictions stated in the *Swan Valley Planning Act, 1995*:

- North Swan
- South Swan
- East Swan
- Central Swan.

For further information regarding the *Swan Valley Planning Act, 1995* refer to Appendix F.

5.1.3 Exemptions

Under the *RiWI Exemption and Repeal (Section 26C)* Order 2001, groundwater abstraction is exempt from licensing from the Superficial Aquifer for the following purposes only:

- firefighting
- water for cattle or other stock, other than those being raised under intensive conditions
- watering an area of lawn or garden that does not exceed 0.2 ha
- other ordinary domestic uses.

Garden bores

Garden bores reduce demand on the Integrated Water Supply scheme, but they do draw a large amount of water from the Superficial Aquifer in the Perth metropolitan area. As part of water efficiency measures, the government has introduced three-day water restrictions for garden bore use in the Perth region, including the Gnangara Mound.

The department will continue to work with the government to develop other demand management measures in addition to the three-day watering restrictions, to reduce garden bore water use. The department has defined areas suitable and unsuitable for garden bores in the Perth metropolitan region, which we will use to inform future planning. The department is also currently developing a statewide policy to manage unlicensed groundwater use, which includes garden bores.

Action 10 – Continue to work with government to develop other demand measures to reduce garden bore use in addition to the three-day restrictions.

5.2 Policies for water take and use

The department develops allocation policies to ensure that we allocate available water in accordance with the *Rights in Water Irrigation Act 1914*. They provide the structure for the department to assess and issue licences. Policies also guide water allocation in line with ecological, social and economic considerations.

The department has developed policies to manage water take and use across the state (Table 11). The state-wide policies are available on the department's website at <www.water.wa.gov.au>. These policies also apply to the Gnangara plan area unless they conflict with the policies specific to the plan area (Table 12). In this case the policies in Table 12 override the policies in Table 11.

In addition to the policies in Table 11and Table 12, the department will use any other policies approved during the life of this plan that affect allocation of water resources within the Gnangara plan area and make them publicly available where appropriate.

Table 11
Statewide licensing policies for the take and use of water

Policy group & Policy detail	
1.	General policy
The department's *General principles and policy for groundwater licensing in Western Australia* (Water Authority of Western Australia 1990) will be used when assessing licence applications.	
2.	Statewide policies
2.1	The department will allocate and license water in accordance with *Statewide policy no. 3 – Policy statement on water sharing* (Water and Rivers Commission 2000c).
2.2	The department will consider environmental and social needs for water in accordance with *Statewide policy no. 5 – Environmental Water Provisions Policy for Western Australia* (Water and Rivers Commission 2000a)
2.3	The trading of water entitlements will be in accordance with *Statewide policy no. 6 – Transferable (Tradeable) Water Entitlements for Western Australia* (Water and Rivers Commission 2001a).
2.4	The department will grant licences for a future date in accordance with *Statewide policy no. 8 – Giving an undertaking to grant a licence or a permit under the Rights In Water and Irrigation Act, 1914* (Department of Water 2006a).
2.5	The department will issue groundwater licences for periods in accordance with *Statewide policy no. 9 – Water licensing – staged developments* (Water and Rivers Commission 2003a).
2.6	The department will use *Statewide policy no. 10 – Use of operating strategies in the water licensing process* (Water and Rivers Commission 2004) to assess whether a licensee must develop an operating strategy. Licensees will develop operating strategies in accordance with this policy.
2.7	The department will manage unused water entitlements in accordance with *Statewide policy no. 11 – Management of unused licensed water entitlements* (Water and Rivers Commission 2003b).

Table 11
Statewide licensing policies for the take and use of water

Policy group & Policy detail	
2.8	Where required, licensees will develop water conservation plans and efficiency measures in accordance with *Statewide policy no. 16 – Policy on water conservation/efficiency plans* (Department of Water 2008a)
2.9	The department will consider *Statewide policy no. 17 – Timely submission for required further information* (Department of Water 2007b) when assessing licence applications in accordance with the first-in, first-served principle.
2.10	In instances where insufficient information is available to determine the impact of a proposed or existing groundwater abstraction, the department will request the applicant to carry out the necessary work and provide the information in accordance with *Statewide policy no. 19 – Hydrogeological reporting associated with a groundwater well licence* (Department of Water 2006b).

Table 12
Specific licensing policies for the take and use of groundwater in the plan area

Policy group		Policy detail
1. Allocating water		
1.1	Aquifer policy	1.1.1 Superficial Aquifer The department will allocate groundwater from the Superficial Aquifer in preference to deeper aquifers in the following circumstances: • where it is available • where it is environmentally acceptable • where it is of suitable quality • where the abstraction meets the requirements of the *Rights in Water and Irrigation Act 1914.*
		1.1.2 Mirrabooka Aquifer In areas where the Mirrabooka Aquifer is present and where the Superficial Aquifer is not accessible or the water is not of suitable quality, the department will allocate water from the Mirrabooka Aquifer, in preference to the Leederville or Yarragadee North Aquifers.
		1.1.3 Leederville and Yarragadee North Aquifer The Leederville and Yarragadee North Aquifers in the Gnangara system are over-allocated and no further water is available. In areas where the Leederville or Yarragadee North Aquifers are present, the department will manage existing licences in accordance with internal operational policy – *Accessing the Leederville and Yarragadee aquifers in Perth* (Department of Water 2006c) and the Supplementary Note to this policy. Where there are extenuating circumstances and there is a public benefit for the water, the department will consider new applications to take water from these aquifers in accordance with *Accessing the Leederville and Yarragadee aquifers in Perth* (Department of Water 2006c) and Policy 1.2.

Table 12
Specific licensing policies for the take and use of groundwater in the plan area

Policy group		Policy detail
1.2	Applications for water above the allocation limit	The department will only allocate groundwater up to the allocation limits defined in this plan. Where the department decides there are extenuating circumstances to take water in a fully or over-allocated area, the department will assess applications in accordance with internal operational policy – *Extenuating circumstances for granting water entitlements resulting in allocation limits being temporarily exceeded* (Department of Water 2008b).
2.	Public water supply reserves	
2.1	Public water supply reserves	The department has reserved water for future public water supply from all aquifers. The department does not guarantee that this water will be available in future years and reserves the right to amend the reserve at any time.
2.2	Accessing water from public water supply reserves	2.2.1 Where the department has reserved water for the purpose of public water supply, access will be limited to water service providers.
		2.2.2 Applicants must hold a service provider licence or demonstrate that they are exempt and that they will use the water to service the community.
		2.2.3 Applicants must submit documentation to the department, developed in accordance with *Statewide policy no. 19 – Hydrogeological reporting associated with a groundwater well licence* (Department of Water 2006b). This documentation must demonstrate that the licensee can access the water without compromising the resource or groundwater-dependent ecosystems.
		2.2.4 Applicants must submit a source development plan to the department that identifies the need for the water and provides a case as to why they require that source.
		2.2.5 Applications must be consistent with the department's drinking water source protection plan or any land use and water management strategy relevant to a public drinking water source protection area.
		2.2.6 Applicants must develop an operating strategy in accordance with *Statewide policy no. 10 – Use of operating strategies in the water licensing process* (Water and Rivers Commission 2004). Operating strategies must establish a period of review which will include an assessment of the impacts of abstraction on the resource.
		2.2.7 Applicants must develop a drought contingency strategy to document the implementation of drought management and emergency supply options.
		2.2.8 Applicants must develop a water efficiency management plan which identifies how water accessed will be used efficiently. The department anticipates that there would need to be reductions in per capita consumption in all areas supplied by the water prior to the allocation of new water.

Table 12
Specific licensing policies for the take and use of groundwater in the plan area

Policy group		Policy detail
3.	Water quality	
3.1	Drinking water source protection	3.1.1 The department will assess proposed land uses for new licences and amendments to existing licences in public drinking water source areas for compatibility in accordance with *Statement of Planning Policy 2.7 Public drinking water sources* (Western Australian Planning Commission 2003)
		3.1.2 Proposed land uses for new licences and amendments to existing licences in the Gnangara underground water pollution control area will be assessed for compatibility in accordance with *Statement of Planning Policy 2.2 Gnangara groundwater policy* (Western Australian Planning Commission 2005).
3.2	Seawater interface	The department may restrict the volume of water and the rate at which it may be abstracted from existing and proposed new wells in subareas in proximity to the coast or the Swan River to minimise the potential for saltwater intrusion. In addition the department may request monitoring of groundwater salinity as a condition of licence.
4.	Environmental policies	
4.1	Protecting groundwater-dependent ecosystems	4.1.1 In high-risk abstraction areas, the department will assess applications for water in accordance with *Allocation Note – Managing abstraction in areas of declining water levels affecting groundwater-dependent ecosystems on the Gnangara Mound* (Department of Water 2005).
		4.1.2 The department may require new bores in environmentally sensitive areas to be screened at the base of the Superficial Aquifer as a condition of licence.
5.	Water use efficiency	
5.1	Water efficiency measures	5.1.1 The department will ensure that all new licences and renewal of existing licences for non-commercial purposes, include conditions to comply with the state-wide daytime sprinkler bans.
		5.1.2 As part of the assessment process of these and commercial licences, the department will review proposed efficiencies in each application. The department may require applicants to detail efficiency measures via an operating strategy in accordance with *Statewide policy no. 10– Use of operating strategies in the water licensing process* (Water and Rivers Commission 2004) and/ or in accordance with *Statewide policy no. 16 – Policy on water conservation / efficiency plans* (Department of Water 2008a). The department will make any agreed measures a condition of licence.

Table 12
Specific licensing policies for the take and use of groundwater in the plan area

Policy group		Policy detail	
6.	Metering		
6.1	Water efficiency measures	6.1.1	Licences with an entitlement over 500 000 kL will have a condition that the licensees must install privately owned meters to manufacturer's specifications and must adhere to the *RiWI Approved Meters order* (2003) together with manufacturer and departments *Guidelines for water meter installation* (Department of Water 2007c).
		6.1.2	The department may add metering conditions to licences in areas where it is considered necessary. The department generally requires holders of large entitlements to monitor groundwater use and levels as part of their licence conditions. Where required, the department will add metering conditions in accordance with *Allocation note – Licence conditions relating to metering requirements* (Department of Water 2008c).
6.2	Installation and reading of meters	6.2.1	The installation and reading of meters will be consistent with Strategic policy 5.03 – Metering the taking of water (Department of Water 2009c).
		6.2.2	The department requires licensees to record their meter readings monthly, and submit them to the department annually. The department's metering section together with the Swan Avon regional office will review metering data for accuracy and compliance with licence conditions, and will take appropriate enforcement actions when required.
7.	Compliance and enforcement		
7.1	Compliance inspections	The department's Swan Avon regional office conducts inspections to assess compliance with licensed activities and entitlements within the Gnangara system. Priority for compliance inspections is given: • to licences issued in subareas classified as C3 and C4 (70% and above) (refer to Appendix E for description of allocation categories) • where development is due for completion in accordance with the terms and conditions of the licence • where aerial photography fails to identify whether the licensed water entitlement is being used as per the terms and conditions of the licence.	

Table 12
Specific licensing policies for the take and use of groundwater in the plan area

Policy group		Policy detail
8. Trading		
Trading in Western Australia is subject to *Statewide policy no. 6 – Transferable (tradeable) water entitlements in Western Australia* (Water and Rivers Commission 2001a). Trading offers incentive to irrigate efficiently, as water savings resulting from efficient irrigation can be sold or leased by the licensee. The department uses internal policy to manage trading around environmentally sensitive areas (see Policy 4.1.1).		
8.1	General	8.1.1 In fully or over-allocated subareas, water users may purchase or lease water from other licensees within the same groundwater subarea.
		8.1.2 It is not possible to trade unused water entitlements (see *Statewide policy* no. 6).
8.2	Transfer of water entitlements	The transfer of a water entitlement is not automatic with the sale of a property where the vendor holds a water licence. The department must receive applications to transfer a water entitlement to a new owner on the same property within 30 days of settlement. Alternatively the licensee can apply to have the licence extended for a period of up to six months.

5.3 Progress towards meeting plan objectives

5.3.1 Optimise water use

Water efficiency measures

The department has been working with local government authorities to develop Water Conservation Plans to identify actions and measures to improve their groundwater use efficiency. All local governments operating within the plan area have now submitted Water Conservation Plans.

The department is also working with local government authorities and government departments to achieve compliance with the statewide daytime sprinkler bans. This includes amendment of all licences held by local government authorities and government departments to include the daytime sprinkler ban condition.

The department has also implemented additional efficiency measures, such as winter sprinkler bans, which we are jointly trialling with the Water Corporation during the 2009 winter.

Action 11 – Continue to work with local government authorities within the Gnangara planning boundary to assess the implementation of their water conservation plans.

Managed aquifer recharge

The department is currently developing a statewide policy to address water quality and allocation management for water that may become available through the process of managed aquifer recharge.

Action 12 – Develop a statewide policy on managing new water that may become available through managed aquifer recharge.

5.3.2 Metering

The department needs to measure actual groundwater use to accurately understand the impacts of abstraction. The department measures water use by metering bores, and by estimating use from water use surveys and the review of monitoring bore data.

The Gnangara Mound Metering Program started in 2004, with the first meters installed on wells (bores) in March 2005. This program covers the costs of installing government owned meters on all wells for licensed groundwater use between 5000 kL and 500 000 kL in selected high-risk subareas on the Gnangara Mound.

The metering program provides accurate water use data that the department can use to review water allocations and manage the groundwater resource. The department will use data collected through this program to develop the 2012 Gnangara allocation plan.

Action 13 – Continue to implement the Gnangara Mound Metering Program across the Gnangara groundwater system, subject to external funding.

5.3.3 Protecting groundwater-dependent ecosystems

In response to declining groundwater levels across the plan area, the department has developed an internal policy to limit or restrict use of groundwater in environmentally sensitive areas (see Policy 4.1.1 in Section 5.2). This policy helps departmental officers to assess water licence applications in areas where groundwater-dependent ecosystems are at high risk of impact from abstraction

5.4 Allocations for the Integrated Water Supply Scheme

The way the department allocates water to the Integrated Water Supply Scheme is different to allocation for self-supply users. The following policy applies to the allocation of groundwater to the IWSS from both the Gnangara and Jandakot systems. The policies in Section 5.2 also apply unless they are inconsistent with the policy in this section.

For a description of how the department previously allocated groundwater for the IWSS refer to Appendix G.

The department manages Water Corporation licences for the IWSS through the Water Licensing branch in the Perth office.

5.4.1 Allocation 2008–2012

The department has used a revised variable groundwater abstraction rule (VGAR) to set the annual groundwater allocation for the combined Gnangara and Jandakot systems, up to a maximum of 145 GL, for the periods 2008–09, 2009–10, 2010–11 and 2011–12. We will review this allocation following the commissioning of the Southern Seawater Desalination Plant, which is scheduled for 2012.

This rule (Figure 9) has a sliding scale where groundwater allocations are based on the total volume stored in IWSS reservoirs at their peak in October of each year. The dams that supply the IWSS are Canning, Serpentine, Serpentine Pipehead, Victoria, Mundaring Weir, South Dandalup, North Dandalup, Wungong, Stirling and Churchman's Brook.

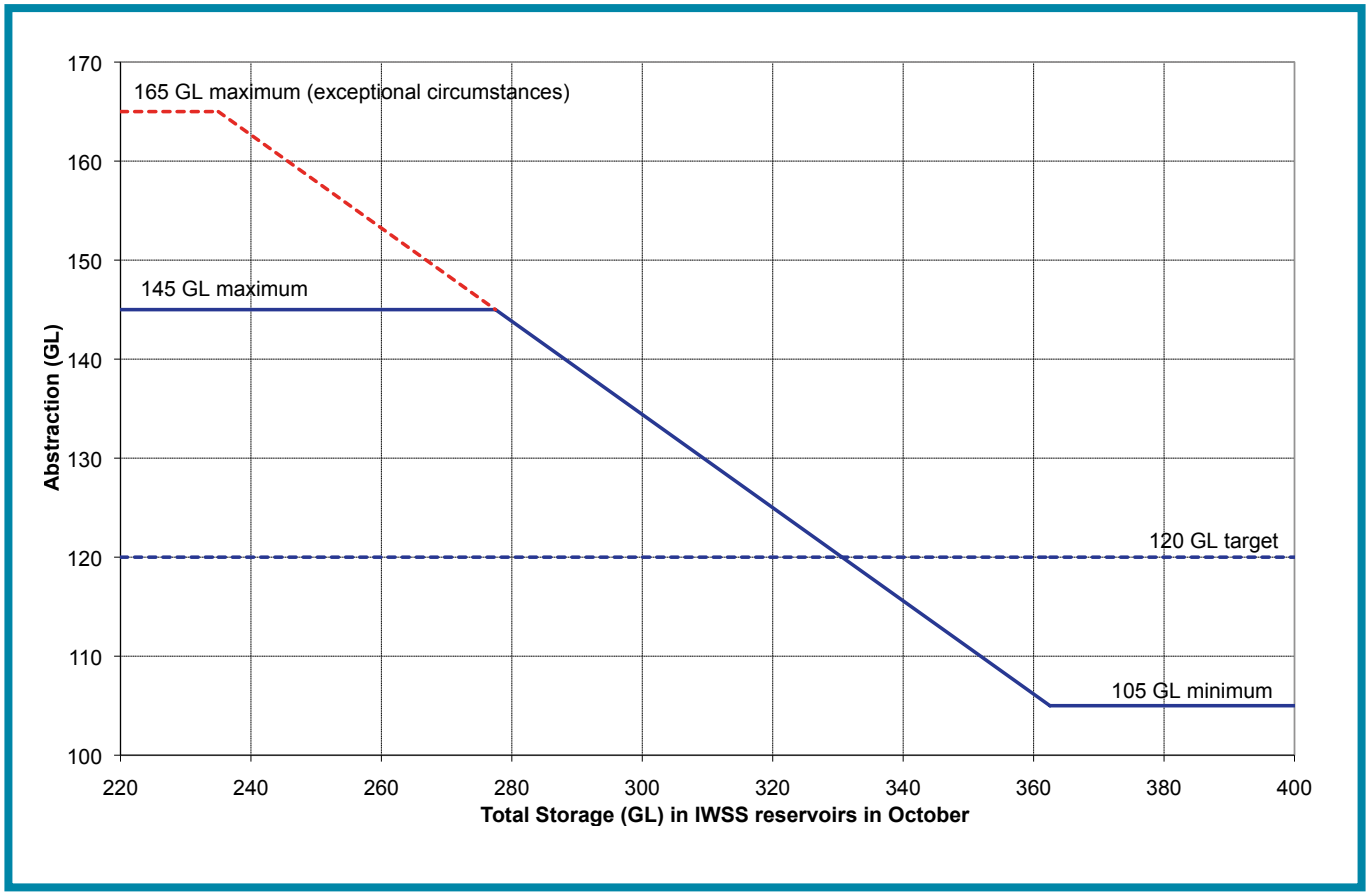

Figure 9
Revised Variable Groundwater Abstraction Rule

Note: Abstraction is from the Gnangara and Jandakot systems.

For this plan, the department revised the VGAR to meet an average sustainable abstraction target of 120 GL per year for the Gnangara and Jandakot systems, which the Water Corporation will aim to achieve by 2012. The revised rule will operate as follows:

- the sustainable allocation target is 120 GL per year
- the maximum allocation is 145 GL per year (165 GL per year under exceptional circumstances)
- the minimum allocation is 105 GL per year.

The rule allows for an allocation of up to 145 GL in years when the reservoir levels are low, and this increased allocation will ideally be offset by reducing allocations in years when there is sufficient water in the reservoirs. As it is unlikely that abstraction will be below the 120 GL target during the life of this plan, the department has not adjusted the previous minimum allocation of 105 GL.

The Water Corporation will increase water efficiency and conservation measures to reduce demand and manage the impacts on the groundwater resources.

As part of the management of allocation to the IWSS, the Water Corporation will prepare the following plans and strategies as part of their licence conditions to abstract groundwater. The department will review and endorse these plans and strategies.

- The Water Corporation will develop an *IWSS Source Development Plan*. This plan will outline forward planning for major source development to meet growth in demand for water supplied by the IWSS. The groundwater source component within this plan will be based on an annual groundwater take of 120 GL from the Gnangara and Jandakot systems.
- The Water Corporation will review and update its *IWSS Operating Strategy* annually. The operating strategy will be consistent with the department's *Statewide policy no. 10 – Use of operating strategies in the water licensing process*. This strategy will outline annual reviews of groundwater abstraction patterns and other measures used by the Water Corporation to ensure protection of groundwater-dependent ecosystems in the vicinity of production wells. The strategy will also to outline contingency sources of water that the Water Corporation can develop and commission in periods prior to the completion of major sources. The Water Corporation should use contingency sources to reduce take from groundwater resources to assist in active recovery of groundwater systems. The department will assess the use of contingency sources to make annual allocation decisions.

To achieve the 120 GL target over the next four years, the Water Corporation must implement the above plans and strategies required by the department.

The department may consider an allocation up to a maximum of 165 GL under exceptional circumstances, subject to the following:

- that all possible efforts have been made to secure alternative (contingency) water supplies
- that demand management measures for drought circumstances are in place
- that the impact of the additional abstraction is more acceptable than increasing the probability of water restrictions
- the department and Water Corporation are able to develop an annual abstraction pattern that does not breach the environmental sensitivity rules in the IWSS Operating Strategy.

In October each year, when the allocation based on the variable groundwater abstraction rule is agreed between the

department and the Water Corporation, the department will advise the Minister for Water Resources of the volume of water to be allocated and will provide advice on the likely impacts of abstracting this volume. This information will be made publicly available, as part of meeting Ministerial condition 9 (see Appendix B).

Action 14 – Continue to make an annual allocation decision for the IWSS and release in October each year.

The department is working with the Water Corporation to investigate opportunities for, and the possible effects of, increasing the proportion of water abstracted from the confined aquifers relative to that abstracted from the Superficial Aquifer in the Gnangara Mound.

The government has introduced permanent restrictions on the use of IWSS water in the Perth region including that taken from the Gnangara system, as a measure to reduce water consumption. The department will continue to inform government decisions on demand management, including restrictions. As part of this role, the department will review the level of permanent restrictions on the use of IWSS water in response to seasonal water use and annual rainfall and advise government when appropriate.

Action 15 – Continue to inform government decisions on demand management and restrictions to reduce abstraction for the IWSS.

5.4.2 Allocation from 2012

The department will review the allocation of groundwater for the IWSS from 2012 following the commissioning of the Southern Seawater Desalination Plant. The review will be informed by the land and water use recommendations of the GSS, including the recommendation that the long-term allocation should be reduced to 110 GL per year, and will align with the department's Perth-Peel Regional Water Plan.

Issues that we need to investigate and research further, prior to developing new policy, include:

- reviewing the variable groundwater abstraction rule in the context of a drier climate and new water sources
- shifting to a lower average use under changing (drier) climatic scenarios
- assessing whether the department should introduce consumptive pools in the Gnangara system (including allocation of public water supply)
- considering new water sources within the plan area, e.g. North West Coastal and additional water from managed aquifer recharge.
- reviewing the availability of water in the Gingin groundwater area
- aligning planning timeframes for allocation and source development
- reviewing the security of supply assumption for total sprinkler bans.

In recent years, the department has been working with the Water Corporation to determine contingency sources of water for the IWSS. Alternative sources will enable the Water Corporation to reduce groundwater abstraction from the Gnangara system in line with the allocations set by the department. They will also ensure that the continued supply of water to the IWSS is not compromised in the period prior to the commissioning of Southern Seawater Desalination Plant. The Water Corporation will use these sources to avoid increased groundwater take through the life of this plan.

Action 16 – Continue to review the Water Corporation's contingency source program and advise government as required.

Chapter six

Monitoring the groundwater resources

6.1 Environmental monitoring

The department has developed environmental water provisions to protect groundwater-dependent ecosystems on the Gnangara Mound. These are water level criteria at representative sites (see Section 2.5.2).

The department's commitment to maintain these provisions has been formalised under the *Environmental Protection Act 1986*. The current Ministerial statement 687 (Appendix B) details Ministerial conditions that the department must meet, including minimum water levels to be maintained at monitoring bores and wetlands. Appendix C shows the location of these criteria sites in the plan area.

Under Ministerial statement 687 the department is committed to undertake an environmental monitoring program to monitor the ecological condition of groundwater dependent ecosystems across the mound. The current program (as at July 2009) is outlined in Appendix H. We are also required to submit annual and triennial compliance reports to the Environmental Protection Authority.

Action 17 – Continue to report annually and triennially to the EPA on compliance.

The department is currently revising the environmental monitoring program in line with commitment 8 in the current statement (Appendix B). The department will also review the program when the new Ministerial statement is released (see Section 2.5.2).

Action 18 – Continue to improve and rationalise the environmental monitoring program to provide the most useful information to manage and protect groundwater-dependent ecosystems.

6.2 Groundwater level monitoring

The department currently collects groundwater level data as discrete field measurements from a large number of monitoring bores across the Gnangara system. This data is sent to the Water Information branch and is stored in the department's water information network database.

The frequency of monitoring of individual bores ranges between monthly and annually, depending on the bore location, the aquifer it is monitoring and statutory obligations. The department is currently reviewing its monitoring strategy.

6 Monitoring the groundwater resources

The department uses groundwater monitoring data to assess changes in groundwater levels and as input into groundwater models.

The department will continue to maintain a graph of annual groundwater levels across the Superficial Aquifer on its website <www.water.wa.gov.au>. We have recorded and averaged groundwater level measurements from over 50 bores to produce a single average figure per month. The graph represents relative groundwater level change across the Gnangara Mound compared to the average highest recorded groundwater level.

Action 19 – Continue to implement the approved groundwater monitoring program and enter data into the department's database.

Chapter seven

Implementing and evaluating the plan

This section sets out how the department will implement, evaluate and review the *Gnangara groundwater areas allocation plan*, to ensure that it is successful.

7.1 Implementing the plan

Actions required to implement this plan are summarised in Table 13. Actions to inform future planning have also been identified and are summarised in Table 16.

Table 13
Action for implementing the plan

Action		Responsibility[1]	Timeline
Resource assessment			
Complete an annual resource assessment report	Action 1	Water Resource Assessment branch and Allocation Planning branch	Annually
Continue to implement an appropriate research and investigation program	Action 2	Water Resource Assessment branch and Swan Avon region	Ongoing
Environmental management			
Work with Department of Environment and Conservation to update the current acid sulfate soils risk map, and review procedures for addressing identified acid sulfate soil risks when licensing	Action 3	Water Resource Assessment branch and Licensing branch	2010 - 11

Table 13
Action for implementing the plan

Action		Responsibility[1]	Timeline
Continue to implement wetland site management including supplementation where appropriate and engage other organisations as required	Action 6	Allocation Planning branch	As required
Continue to report compliance to the EPA	Action 17	Licensing branch and Allocation Planning branch	Annually and triennially
Allocation decisions			
Review groundwater and subarea boundaries	Action 9	Allocation Planning branch	2010 – 11
Review allocation limits in this plan and revise if necessary	Action 8	Allocation Planning branch	As required
Continue to make an allocation decision for the IWSS and release in October each year	Action 14	Licensing branch (licensing support) and Allocation Planning branch	Annually (October)
Licensing Support			
Continue to work with local government authorities to assess the implementation of their water conservation plans	Action 11	Water Recycling and Efficiency branch	Ongoing
Develop a statewide policy on managing new water that may become available through managed aquifer recharge	Action 12	Licensing branch	2009

Table 13
Action for implementing the plan

Action		Responsibility[1]	Timeline
Continue to implement the Gnangara Mound Metering Program across the Gnangara groundwater system, subject to external funding	Action 13	Water Recycling and Efficiency branch	As scheduled
Advice			
Continue to implement public drinking water source protection through statutory referrals	Action 4	Swan Avon Region	Ongoing
Continue to respond to development referrals regarding proposed land uses and impacts on water quality	Action 5	Swan Avon Region	Ongoing
Continue to work with government to develop other demand measures to reduce garden bore use in addition to the three-day restrictions	Action 10	Water Recycling and Efficiency branch	Ongoing
Continue to inform government decisions on demand management and restrictions to reduce abstraction for the IWSS	Action 15	Director, Water Resource Use	Ongoing
Continue to review the Water Corporation's contingency source program and advise government as required	Action 16	Director, Water Resource Use	Ongoing

Table 13
Action for implementing the plan

Action		Responsibility[1]	Timeline
Monitoring program			
Continue to improve and rationalise the environmental monitoring program	Action 18	Allocation Planning branch and Swan Avon Region	As scheduled
Continue to implement the approved groundwater monitoring program	Action 19	Swan Avon Region	As scheduled
Monitoring data management			
Enter groundwater monitoring data into the department's water information network database	Action 19	Water Information branch	As scheduled
Evaluation			
Develop and implement an integrated annual management review and response framework for the Gnangara system	Action 7	Allocation Planning branch	2009
Produce and publicly release the annual evaluation statement	Action 20	Swan Avon Region	Annually

[1] Department of Water branch that is responsible for implementing the actions in the plan area

7.1.1 Performance indicators against objectives

Table 14 summarises the performance indicators that we will use to measure the performance of this plan against its objectives (Section 3.1).

Table 14
Performance indicators against objectives

Performance indicator	Objective/s	How we will assess it
Change in groundwater levels better reflects change in recharge	1 and 5	• monitor water levels and pressure heads across all aquifers • assess groundwater level trends as part of the annual groundwater level review program
Impacts of abstraction on groundwater-dependent ecosystems decreases	3 and 5	• compliance with Ministerial conditions at sites impacted by abstraction • number of these sites where ecological condition improves
Actual use is less than or equal to the licensed entitlement volume	1, 2 and 5	• number and location of meters installed across the mound • compare metered data against licence entitlement for individual licensees • determine actual use for each resource and compare with the total licensed entitlement volume
Licensees comply with licence conditions (and operating strategies)	3 and 4	• number of properties inspected (as a percentage of applications received) to assess compliance with licensed activities and entitlements • review licensee monitoring reports to ensure that users have complied with their licensing conditions and/or operating strategy • number of licensees managing to a water conservation plan
Over-allocated resources are recovered	1, 2, 3 and 4	• quantity of water recouped as unused • number of resources that are over-allocated (C4)

7.1.2 Management triggers and responses

Throughout the life of the plan, the department will need to respond to changes in the status of the groundwater resources in the Gnangara plan area. The department has set triggers for responses that will be necessary when these situations arise (Table 15).

Table 15
Management triggers and responses

Detail	Trigger	Response
Groundwater resources are approaching full allocation	Groundwater resources within a subarea are 70–<100% allocated (C3 category)	• Licence up to 100% of the allocation limit • Recoup unused entitlements in accordance with *Statewide policy no. 11*
Groundwater resources are fully allocated	Groundwater resources within a subarea are 100% allocated (C4 category)	• Refuse applications for new water entitlements • Continue to recoup unused entitlements in accordance with *Statewide policy no. 11* • Establish trading as per *Statewide policy no. 6*
Groundwater resources are over-allocated	Groundwater resources within a subarea are > 100% allocated (C4 category)	• Responses as for fully allocated resources • Focus on efficiency measures, assessing licence renewals and compliance
Allocating water to the IWSS	Water Corporation requests an allocation greater than 145 GL	• Director Water Resource Use considers against criteria in Section 5.4.1
Decreased water availability: impact of drying climate	Declining groundwater levels due to reductions in rainfall recharge	• Review allocation limits and update plan
Increased water availability: land use change	Groundwater recharge increases through urbanisation or removal of pine plantations	• Review allocation limits for affected resources and update plan
Compliance with Ministerial conditions	The department does not meet the Environmental Water Provisions set as Ministerial criteria	• Determine cause of non-compliance. If related to abstraction, address through management actions. If other cause (e.g. climate or land use), document in annual and triennial reporting to the EPA
Improved understanding of the aquifers of the Gnangara Mound	New information and/or resource assessment methods recommend changes to allocation limits	• Review allocation limits and management framework

7.2 Evaluating the success of the plan

7.2.1 Annual evaluation statement

To identify whether the management strategies identified in the plan are working to achieve its objectives, the department will release an evaluation statement annually. The statement will identify:

- the status of water use (using licensed entitlements, metering data, water use surveys and estimates of unlicensed use)
- the status of all actions required in the plan (Table 13)
- performance against the plan objectives (Table 14).
- any triggers that have been reached, and the effectiveness of the responses (as per Table 15).
- any minor changes to the plan.

Action 20 – Produce and publicly release the annual evaluation statement.

7.3 Reviewing the plan

The department will review the plan through the development of the 2012 plan, or earlier if the evaluation statement recommends a review. The plan will be reviewed early if it is not meeting its objectives or if significant new information becomes available.

The Government of Western Australian is currently updating and reviewing its water resource legislation. Any significant changes in legislation that may affect the Gnangara groundwater resources will trigger a review of the plan.

7.4 Future planning in the Gnangara groundwater areas

While this plan sets out the department's water use management approach for the next few years we are also looking ahead and working towards improving and replacing it in 2012.

We have identified actions that will contribute to future planning in the Gnangara groundwater areas (Table 16). We will report progress against their achievement in the annual evaluation statement.

Table 16
Actions for future planning

Action	Responsibility	Timeline
1. Assessment tool development and use		
Use recently upgraded Perth regional aquifer modelling system and local aquifer modelling system in future groundwater scenario modelling	Water Resource Assessment branch	2009–2011
2. Resource investigations and assessments		
Review the existing groundwater monitoring program	Water Resource Assessment branch	2009–2011
Complete work on the: • Perth shallow groundwater systems Investigation • confined aquifer investigations • state groundwater investigation program • Perth metropolitan hydrogeochemistry survey	Water Resource Assessment branch	2009–2011
Undertake a review of groundwater levels in all aquifers and determine acceptable level of decline in the context of a drying climate	Water Resource Assessment branch	2009–2011
Undertake research on estimated unlicensed water use (exempt from licensing)	Water Recycling and Efficiency branch	2009–2011
3. Systems		
Upgrade data management systems to better reflect water reserved for uses other than self-supply	Allocation Planning branch and Water Licensing branch	2009–2011
4. Policy		
Develop additional methods under current or future legislation to reduce private abstraction (self-supply)	Allocation Planning branch and Water Licensing branch	2009–2011
Review need for confined aquifer policy specific to the IWSS	Allocation Planning branch and Water Licensing branch	2009–2011
Review the approach to allocating water to the IWSS post 2012	Allocation Planning branch and Water Licensing branch	2009-2011

Table 16
Actions for future planning

Action	Responsibility	Timeline
Base future planning on outcomes of the Gnangara Sustainability Strategy	Allocation Planning branch, Water Recycling and Efficiency branch, Water Licensing branch and Swan Avon region	2009–2011
Revise *General principles and policy for groundwater licensing in Western Australia* (Water Authority Western Australia 1990)	Allocation Planning branch	2009–2011
Revise existing metering policies	Water Licensing branch, Water Recycling and Efficiency branch	2009–2011
Investigate an alternative approach to the first-in, first-served principle of water allocation	Allocation Planning branch	2009–2011
Develop policy on recovering water in over-allocated areas	Water Licensing branch	2009–2011
5. Environmental investigation		
Continue research into water quality across the mound	Water Assessment branch	2009–2011
Develop a framework for determining ecological water requirements in a drying climate	Allocation Planning branch	2009–2011
Develop comprehensive environmental water provisions for the Gnangara system based on the new ecological water requirements framework	Allocation Planning branch	2009–2011
Review the Ministerial conditions for the Gnangara Mound in the context of a drying climate	Allocation Planning branch	2009–2011

Appendices

Gnangara areas allocation plan

A Appendix
Classification of salinity

Table A1
Salinity threshold categories (Australian Government 2004)

Salinity type	Range mg/L TDS
Fresh	< 500
Marginal	500–1000
Brackish	1000–2000
Moderately saline	2000–5000
Saline	5000–10 000
Highly saline	10 000–35 000
Brine	> 35 000

Statement No.

MINISTER FOR THE ENVIRONMENT; SCIENCE

000687

STATEMENT TO AMEND CONDITIONS APPLYING TO PROPOSALS (PURSUANT TO THE PROVISIONS OF SECTION 46 OF THE ENVIRONMENTAL PROTECTION ACT 1986)

STATEMENT FOR THE WATER AND RIVERS COMMISSION

GNANGARA MOUND GROUNDWATER RESOURCES
[*INCLUDING* GROUNDWATER RESOURCE ALLOCATION, EAST GNANGARA CITY OF SWAN]

Proposals: The management and abstraction of groundwater for public and private water supply from the Gnangara Mound, with provision for environmental water requirements, as documented in this statement.

Proponent: The Water and Rivers Commission (Joint)

Proponent Address: Level 2, 3 Plain Street
EAST PERTH WA 6004

Assessment Number: 1540-1

Previous Assessment Numbers: 041 / 697 / 932

Previous Statement Numbers: Statement No. 021 (Published on 8 March 1988)
Statement No. 437 (Published on 6 February 1997)
Statement No. 438 (Published on 6 February 1997)
Statement No. 496 (Published on 17 February 1999)

Report of the Environmental Protection Authority: Bulletin 1155

Previous Reports of the Environmental Protection Authority: Bulletins 295 / 817 / 904

The implementation and management of groundwater and groundwater allocations for the Gnangara Mound Groundwater Resources is subject to the following conditions and procedures, which replace all previous conditions and procedures applicable to the abovementioned proponent (See note 2 at foot of this statement):

Published on

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1 Implementation

1-1 The proponent shall implement the proposals as documented in "Section 46 Review of Environmental Conditions on Management of the Gnangara and Jandakot Mounds – Stage 1 Proposal for Changes to Conditions" (August 2004), as modified and documented in Environmental Protection Authority Bulletin 1155, which revised the Environmental Review and Management Programme (1986), published in Environmental Protection Authority Bulletin 295 as Appendix D; and which were consolidated in May 1996 and reported on in Environmental Protection Authority Bulletin 817, as revised in November 1996, and also revised in the Public Environmental Review (1997), published in Environmental Protection Authority Bulletin 904 as Appendix 3.

2 Proponent Commitments

2-1 The proponent shall implement the environmental management commitments, as revised in December 2004, and documented in schedule 1 of this statement, to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority.

3 Proponent Nomination and Contact Details

3-1 The proponent for the time being nominated by the Minister for the Environment under section 38(6) or (7) of the *Environmental Protection Act 1986* is responsible for the implementation of the proposals until such time as the Minister for the Environment has exercised the Minister's power under section 38(7) of the Act to revoke the nomination of that proponent and nominate another person as the proponent for the proposals.

3-2 If the proponent wishes to relinquish the nomination, the proponent shall apply for the transfer of proponent and provide a letter with a copy of this statement endorsed by the proposed replacement proponent that the proposals will be carried out in accordance with this statement. Contact details and appropriate documentation on the capability of the proposed replacement proponent to carry out the proposals shall also be provided.

3-3 The nominated proponent shall notify the Environmental Protection Authority of any change of contact name and address within 60 days of such change.

4 Commencement and Time Limit of Approval

4-1 The proponent shall provide evidence to the Minister for the Environment within five years of the date of this statement that the proposals have been substantially commenced or the approvals granted in the statements of 8 March 1988 and 17 February 1999 shall lapse and be void.

5 Compliance Audit and Performance Review

5-1 The proponent shall prepare an audit program and submit compliance reports to the Environmental Protection Authority which address:

1. the status of implementation of the proposals;
2. evidence of compliance with the conditions and commitments; and
3. the performance of the environmental management plans and programs.

Note: Under delegation No. 54 issued on 18 June 2004 and section 48(1) of the *Environmental Protection Act 1986*, the Environmental Protection Authority is empowered to monitor the compliance of the proponent with the statement and should directly receive the compliance documentation, including environmental management plans, related to the conditions, procedures and commitments contained in this statement.

5-2 The proponent shall submit a performance review report by 1 December each year and more detailed reports by 1 February every three years, to the requirements of the Environmental Protection Authority, which address:

1. compliance with the conditions;
2. the achievement of environmental objectives set for the proposal;
3. stakeholder and community consultation about environmental performance and the outcomes of that consultation, including a report of any on-going concerns being expressed; and
4. proposed environmental management over the next three years to comply with conditions and environmental objectives set for the proposal.

5-3 The proponent shall make the reports required by condition 5-2 publicly available, to the requirements of the Environmental Protection Authority.

5-4 The proponent shall report any breach or anticipated breach of the environmental criteria set out in Tables 1 and 2 or environmental objectives to the Environmental Protection Authority immediately it becomes evident to the proponent.

6 Management of the Water Resource

6-1 The proponent shall base decisions affecting the management of groundwater resources of the Gnangara Mound on the concept of sustainable yield of resources and maintenance of ecological systems in accordance with the objectives of the State Conservation Strategy (1987).

6-2 The proponent shall subject to regular review the basis for groundwater management decisions, including groundwater allocations and licences, and the criteria specified for conservation of the environment and the groundwater resource of the Gnangara Mound, to the requirements of the Environmental Protection Authority on advice of the Department of Conservation and Land Management.

7 Groundwater Allocation

7-1 The proponent shall ensure that the allocation of water to public and private users and the operation of the Pinjar Stages 1, 2 and 3, Wanneroo, Mirrabooka and Lexia Groundwater Schemes comply with environmental water provisions.

8 Groundwater-dependent Ecosystems

8-1 The proponent shall ensure that the integrity of all groundwater-dependent ecosystems located on the Gnangara Mound that may be impacted as a result of groundwater abstraction are protected, to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority and the Department of Conservation and Land Management.

9 Groundwater Availability

9-1 The proponent shall widely publish by the end of October each year the limits on groundwater availability for the Gnangara Mound.

9-2 The proponent shall update annually the figures published according to the requirements of condition 9-1, with emphasis on those areas of high allocation relative to sustainable yield of the groundwater resource so that limits to use and development can be clearly seen by all interested parties. The updated figures shall also be widely published.

10 Water Conservation

10-1 The proponent shall actively encourage further reduction in public and private water demand in accordance with the State Water Strategy (2003) and other water conservation initiatives.

11 Research and Monitoring

11-1 The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes:

1. clarification of the relationship between groundwater level and rainfall under conditions of declining long-term rainfall;
2. improvement in the understanding of the relationship between groundwater levels and vegetation, including plantations;

3. improvement in the understanding of the relationship between groundwater level and abstraction from unconfined and confined aquifers of the Gnangara Mound;
4. clarification of the relationship between groundwater level and wetland water levels and wetland water quality;
5. improvement in the understanding of the relationship between groundwater level and water levels in the Yanchep caves; and
6. improvement in the understanding of the conservation value of wetlands and other groundwater-dependent ecosystems on the Gnangara Mound,

to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority and the Department of Conservation and Land Management.

Procedures

1 Where a condition states "to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority", the Environmental Protection Authority will prepare the written notice to the proponent.

2 The Environmental Protection Authority may seek advice from other agencies or organisations, as required, in order to provide its advice.

3 Where a condition lists advisory bodies, it is expected that the proponent will obtain the advice of those listed as part of its compliance reporting to the Environmental Protection Authority.

Notes

1 The Minister for the Environment will determine any dispute between the proponent and the Environmental Protection Authority over the fulfilment of the requirements of the conditions.

2 The conditions and commitments of Statement No. 437 for which the Water Corporation is primarily responsible have not been reviewed during the section 46 consideration which has lead to the amended conditions of this statement.

Dr Judy Edwards MLA
MINISTER FOR THE ENVIRONMENT; SCIENCE

Schedule 1

Proponent's Environmental Management Commitments

December 2004

GNANGARA MOUND GROUNDWATER RESOURCES [*INCLUDING* GROUNDWATER RESOURCE ALLOCATION, EAST GNANGARA]

(Assessment No. 1540-1)

Water and Rivers Commission

Gnangara Mound Groundwater Resources [*Including* Groundwater Resource Allocation, East Gnangara] (Assessment No. 1540-1) December 2004

Note: The term "commitment" as used in this schedule includes the entire row of the table and its six separate parts as follows:

- a commitment number;
- a commitment topic;
- the objective of the commitment;
- the "action" to be undertaken by the proponent;
- the timing requirements of the commitment; and
- the body / agency to provide technical advice to the Environmental Protection Authority.

No.	Topic	Objective	Action	Timing	Advice
1	Gnangara Mound allocations		Manage public and private groundwater abstraction to meet objectives and Environmental Water Provision (EWP) criteria presented in Tables 1 and 2 (attached).	Ongoing	
2	Management objectives and Criteria		Management objectives and criteria and water allocation limits will be regularly reviewed and amended as information becomes available to provide for ongoing adaptive management.	Ongoing	CALM
3	Yeal Groundwater Scheme	To minimise environmental and/or significant impact	Prepare a Water Resources Allocation and Management Plan for the Yeal area to identify groundwater allocations.	Prior to grant of an allocation to the Yeal scheme	
4	Yanchep caves	To minimise environmental and/or significant impact	Continue to develop catchment strategies to minimise change in hydrological regime within the caves of Yanchep National Park. Monitor water levels and cave fauna.	Ongoing	CALM
5	Strategic drainage plans		Prepare strategic drainage plans for the study area including options for the management of high water levels in Lakes Joondalup, Goollelal, Marginiup and Jandabup.	Ongoing	
6	Research and investigation program		1. Prepare a research and investigation program for submission to the EPA for review and subsequent finalisation of the program to the satisfaction of the EPA. The research and investigation program will be prepared with the objective of improving understanding of: • groundwater-environmental relationships on the Swan Coastal Plain; • the associated management requirements; and • potential management techniques; and will incorporate all relevant aspects of research and investigation work currently committed to under Ministerial Statements 438 and 496. 1. Implement the research and investigation program to the satisfaction of the EPA. 2. Review and revise the program every six years (coinciding with triennial reports), to the satisfaction of the EPA.	Within four months of a revised statement being issued following the 2004 Stage 1 section 46 review/ Ongoing	CALM
7	Vegetation protection	To minimise environmental and/or significant impact	Require the Water Corporation, through licence conditions, to phase in production bores closest to phreatophytic vegetation to allow the vegetation to adapt slowly to the drawdown and minimise the overall impacts of drawdown.	Ongoing	
8	Environmental monitoring program		1. Prepare an environmental monitoring program for submission to the EPA for review and subsequent finalisation of the program to the satisfaction of the EPA. The monitoring program will include: • monitoring of groundwater levels in all relevant aquifer systems; • relevant wetland water levels and water quality; • condition of vegetation and fauna associated with groundwater-dependent ecosystems; and • cave water levels. 2. Implement the approved environmental monitoring plan to the satisfaction of the EPA. 3. Review and revise the program every six years (coinciding with triennial reports), to the satisfaction of the EPA.	Within four months of a revised statement being issued following the 2004 Stage 1 section 46 review/ Ongoing	CALM

9	Development advice		Continue to provide advice to the City of Wanneroo, the Department for Planning and Infrastructure, CALM and other relevant agencies on the impact of land use on groundwater resources.	Ongoing	
10	Gnangara inter-agency technical advisory group		Convene and provide ongoing executive support for an inter-agency technical advisory group for water resources planning and management issues on the Gnangara Mound. The group will consider planning and management issues in the context of recommendations of the Select Committee on Metropolitan Development and Groundwater Supplies.	Ongoing	
11	Community consultation		Continue to chair and provide support for the Gnangara Consultative Committee as an ongoing forum for information exchange and advice.	Ongoing	
12	Aboriginal consultation		Liaise with the Swan Valley Nyungah Community regarding the East Gnangara proposal.	Ongoing	
13	Vegetation protection		Limit potential for tree deaths around production wells to 100 metres radius for normal (average) climate conditions and within 200 metres in extreme conditions.	Ongoing	
14	Lake Nowergup supplementation		1 Upgrade the artificial maintenance facility for Lake Nowergup to provide more rapid recharge when it becomes necessary to meet EWPs; and 2 Should EWPs in Lake Nowergup not be met by November 1, artificial supplementation will be used until the EWP is reached.	Ongoing	
15	Dieback protocols		Conduct operations in accordance with proponent protocol for dieback management.	Ongoing	
16	Reporting		Require the Water Corporation to submit yearly production plans as part of the operating strategy and to report on compliance with environmental commitments made in the operating strategy.	Ongoing	
17	Monitoring wells	To minimise environmental and/or significant impact	Request the Water Corporation to establish further monitoring bores for monthly monitoring and more frequently if required within a 200 metre radius of production bores located in phreatophytic vegetation.	Before 5 May 1997	

18	Vegetation protection	To minimise environmental and/or significant impact	Establish additional monitoring wells in those areas where suitable wells do not exist to monitor groundwater levels under phreatophytic vegetation.	Before 5 May 1997	
19	Vegetation monitoring	To minimise environmental and/or significant impact	Select a range of indicator species at transects to determine an acceptable rate of change in vegetation composition. Also calculate similarity indices when monitoring.	By spring 1997	
20	Environmental management plan		Require the Water Corporation to prepare an environmental operations plan to provide specific detail on environmental management of groundwater schemes in the study area, which includes detailed management prescriptions for wellfield operators and water resource managers.	Before 5 August 1997	
21	Pine plantations		Develop a Memorandum of Understanding on pine management regimes with CALM.	By June 1997	CALM and FPC
22	Lexia Groundwater Scheme		Prepare a Water Resources Allocation and Management Plan for the Lexia area (East Gnangara area) to identify groundwater allocations, which includes detailed groundwater modelling to optimise groundwater availability while minimising environmental impacts.	Prior to construction of the Lexia scheme	
23	East Gnangara wetlands		Require the Water Corporation to implement its 2001 wetland mitigation strategy and subsequent approved revisions and report to the Department of Environment on implementation.	Prior to commissioning of Lexia scheme/ Ongoing	
24	East Gnangara wetlands		Determine EWPs for new appropriately located bores in the East Gnangara vegetation corridor.	By 17 February 2002	

Abbreviations

CALM = Department of Conservation and Land Management
EPA = Environmental Protection Authority
EWPs = Environmental Water Provisions
FPC = Forest Products Commission

Gnangara Mound Criteria (2004)

Table 1 – Monitoring Wells

Groundwater Monitoring Well	End of Summer	
	Preferred Minimum (mAHD)	Absolute minimum (mAHD)
MM16	-	38.8
MM18	-	38.6
MM49B	-	24.7
MM53	-	33.3
MM55B	-	29.5
MM59B	-	36.3
MT3	-	43.0
NR6C	-	58.5
PM9	-	56.3
PM24	-	40.5
PM25	-	42.3
WM1	-	55.7
WM2	-	66.5
WM6	-	58.3
WM8	-	64.8
NR11C (G61611042)	-	55
MM12 (G61610989)	-	42
L30C (G61611010)	-	47.2
L110C (G61611011)	-	55.7
L220C (G61611018)	-	52.2

Gnangara Mound Criteria (2004)

Table 2 – Wetlands

Wetlands		End of Summer (mAHD)		Spring (mAHD)	
		Preferred Minimum	Absolute minimum	Preferred Min. peak	Absolute Min. peak
Lake Goollelal	Q6162517	* 26.2	26		
Lake Gnangara	(Q6162591 staff) (G61618440 bore)	42	41.3		
Loch McNess	(Q6162564)	6.95			
Yonderup	(Q6162565)	5.9			
Lake Joondalup	(Q6162572 staff) (G61610661 bore)	* 16.2	15.8		
Mariginiup Lake	(Q6162577 staff) (peak levels recorded) (G61610685 bore)			* 42.1	41.5
Lake Jandabup Artificially maintained	(Q6162578)		44.3	* 44.7	44.2
Nowergup Lake Artificially maintained	(Q6162567) (peak levels recorded)			* 17	16.8
Wilgarup	(Q6162623 staff) (61618500 bore)		4.8	6.10	5.65
Pipidinny Swamp	(Q6162624)		1.6	2.70	2.40
Lexia 94	(GNM17a) G61613216	* 45.8	45.5		
Lexia 86	(GNM16) G61613215	* 47.3	47		
Lexia 186	(GNM15) G61613214	* 47.5	47.2		
Melaleuca Park (EPP) 173	(GNM14) Q6162628 staff Bore G61613213		50.2		
Melaleuca Park (Dampland) 78	(GNM31) G61613231	* 65.4	65.1		
Edgecombe	(B10) (G61618606)		14.35		
Egerton	(B25) (G61618607)		39.29		

* water levels allowed between minimum and absolute minimum at a rate of 2 in 6 years to replicate natural drying cycles.

Appendix C

Location of Ministerial criteria sites within the Gnangara plan area

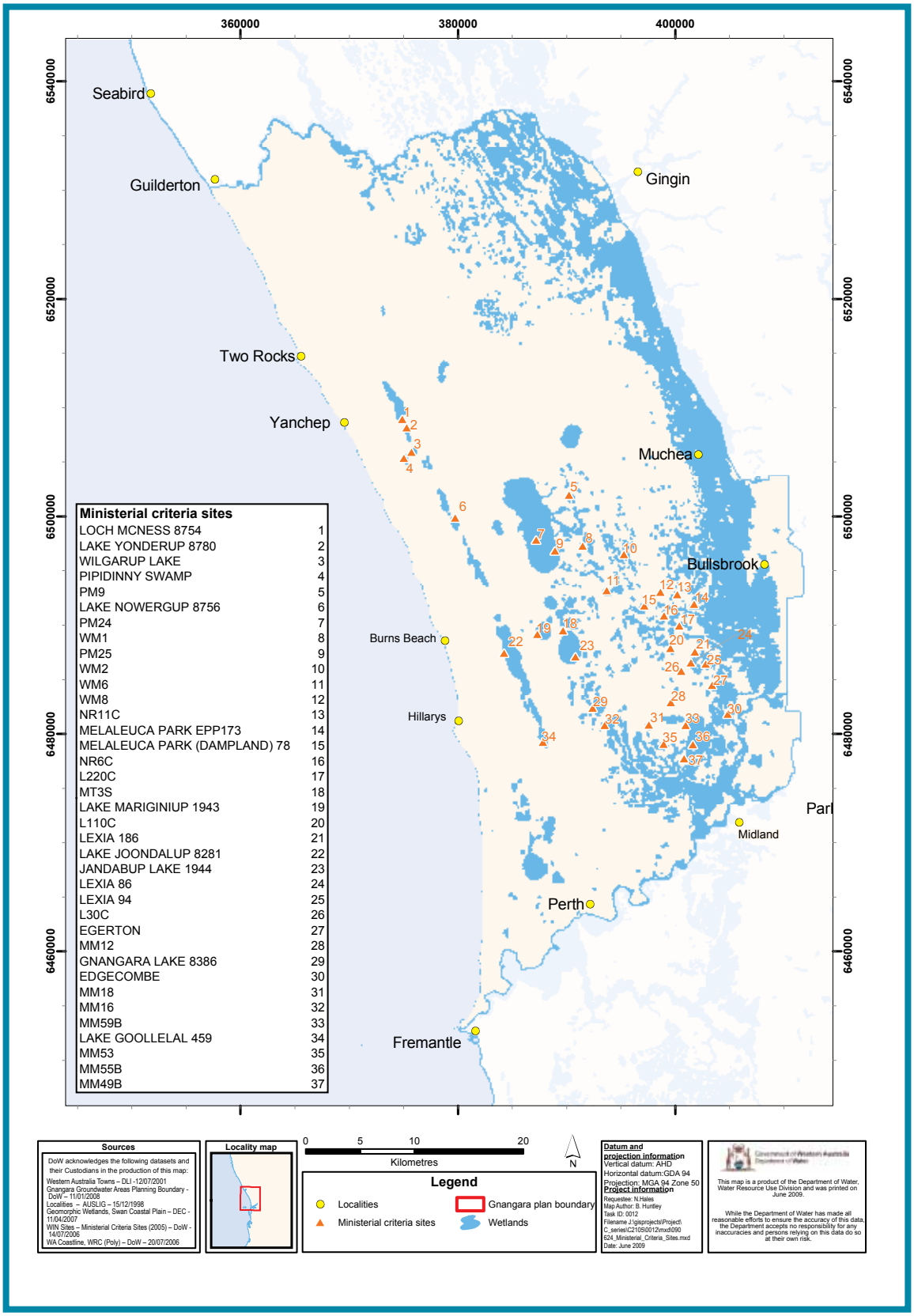

Figure C1

D Appendix
Water use categories and sub-categories

Table D1
Land use description for each water use category and sub-category for licensed entitlements

Water use category	Water use sub-category	Description
Horticulture and Agriculture	Crops	Cultivation of mostly annual crops including cereals, oil seeds, sugar, cotton, rice, and fodder crops including lucerne
	Horticulture	Irrigation water used in intensively cultivated situations and orchards. Includes vegetables, citrus, nuts, bananas, fruits and vines
	Pasture	Irrigation use for cultivation of pastures
	Stock	Commercial stock rearing
	Viticulture	Water used for irrigation of grapes and winery processes
Industry and Commercial	General commercial	Use by commercial establishments, retail stores, restaurants and offices, as well as government, local government, and other institutions such as hospitals and schools
	General industrial & power - thermal	Large and small industrial use, as a primary factor of production. Use for cooling purposes in thermal power stations
	Mining/ processing	Use in mines and plants carrying out basic processing of ores and minerals
Domestic	Domestic urban	Private domestic/residential purposes in an urban setting, including inside use and garden watering
	Domestic rural	Private domestic/residential purposes in a rural setting, including private gardens and private animal husbandry. Use for public parks, gardens, and recreation areas in a rural setting
Parks and Gardens	Park/garden	Public parks, gardens, and recreation areas in an urban setting
Public Water Supply	Public water supply	The drawing of groundwater for public supply purposes
Other	Other	Includes supply system losses, firefighting, roadworks, cave supplementation

Appendix E
Resource classification

A resource classification was proposed as part of the National Land and Water Resources Audit: Water Availability and Use Theme (Water and Rivers Commission 2000d) based on the proportion of the total water used (licensed and unlicensed use) in an area as a percentage of the sustainable yield. The required management response category should correspond to the level of use or allocation.

The department has adopted a classification based on the original classification, where the classification category is based on use (licensed entitlements) as a percentage of the allocation limit (Table E1).

The department uses the classification and response categories to assess the status of water resources, and to plan and manage the resource.

Table E1
Resource categories according to level of use

Classification category	Use as a percentage of allocation limit[1]	Level of use	Required response category
C1	0 to <30	Low	R1
C2	30 to <70	Medium	R2
C3	70 to <100	High	R3
C4	>=100	Fully or over-allocated	R4

[1] Assumes water use corresponds to the total of licensed entitlements in the department's Water Resources Licensing system

F

Appendix
Subarea restrictions

Land uses in parts of the following subareas are subject to planning as stated in the *Swan Valley Planning Act, 1995* (Figure F1):

- North Swan
- South Swan
- East Swan
- Central Swan.

The *Swan Valley Planning Act (1995)* makes specific reference to the alignment of land use planning decisions and groundwater usage in these subareas. However, it is the responsibility of those agencies implementing the *Planning and Development Act 2005* (i.e. the Western Australian Planning Commission, Department for Planning and Infrastructure and relevant local government authority) to make decisions relating to approval of land use on particular land holdings. These agencies may seek comment from the Department of Water before making land use decisions.

The department will assess applications to take groundwater in the above subareas subject to water availability and relevant department policy at the time of application.

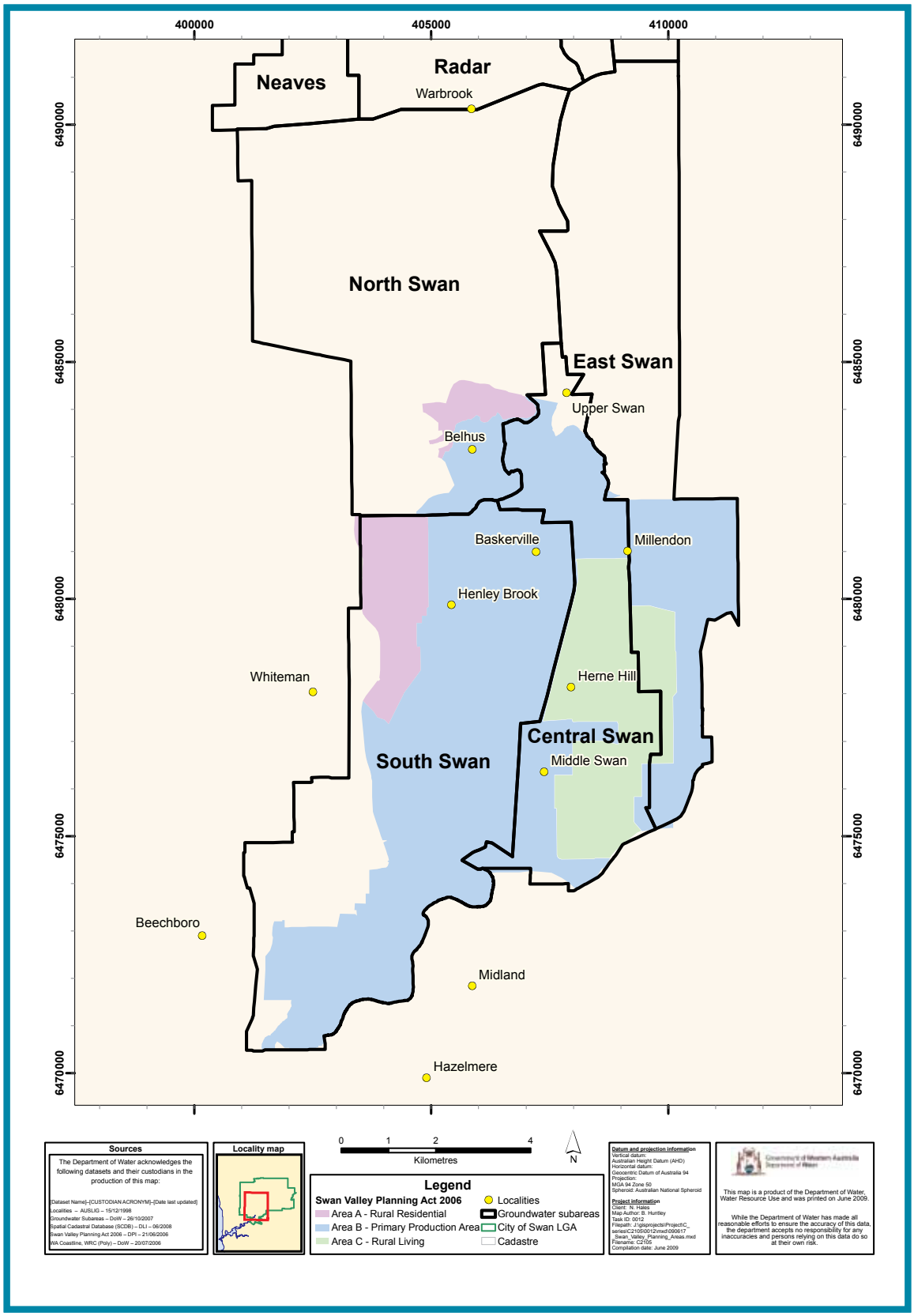
400000
405000
410000
6490000
6485000
6480000
6475000
6470000
Neaves
Radar
Warbrook
North Swan
East Swan
Upper Swan
Belhus
Baskerville
Millendon
Henley Brook
Whiteman
Herne Hill
Central Swan
South Swan
Middle Swan
Beechboro
Midland
Hazelmere
Sources
The Department of Water acknowledges the following datasets and their custodians in the production of this map:
[Dataset Name]–[CUSTODIAN ACRONYM]–[Date last updated]
Localities – AUSLIG – 15/12/1998
Groundwater Subareas – DoW – 26/10/2007
Spatial Cadastral Database (SCDB) – DLI – 06/2008
Swan Valley Planning Act 2006 – DPI – 21/06/2006
WA Coastline, WRC (Poly) – DoW – 20/07/2006
Locality map
0 1 2 4
Kilometres
N
Legend
Swan Valley Planning Act 2006
Area A - Rural Residential
Area B - Primary Production Area
Area C - Rural Living
Localities
Groundwater subareas
City of Swan LGA
Cadastre
Datum and projection information
Vertical datum: Australian Height Datum (AHD)
Horizontal datum: Geocentric Datum of Australia 94
Projection: MGA 94 Zone 50
Spheroid: Australian National Spheroid
Project information
Client: N. Hales
Map Author: B. Huntley
Task ID: 0012
Filepath: J:\gis\projects\Project\C_series\C2105\0012\mxd\090617_Swan_Valley_Planning_Areas.mxd
Filename: C2105
Compilation date: June 2009
This map is a product of the Department of Water, Water Resource Use and was printed on June 2009.
While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.

Figure A5

Appendix
Historical allocations for the Integrated Water Supply Scheme

The Water Corporation historically held a groundwater entitlement for 177.49 GL from the Gnangara and Jandakot systems for the IWSS. This figure was adjusted as allocations to public water supply were determined for each new borefield.

Although the Water Corporation held an entitlement for this figure, the actual volume of groundwater that was allocated to the IWSS for public water supply was determined on an annual basis. Since 2002, this determination has been made using the variable groundwater abstraction rule.

This rule has a sliding scale where groundwater allocations are based on the total volume stored in IWSS dams at their peak in October of each year. The dams that supply the IWSS are Canning, Serpentine, Serpentine Pipehead, Victoria, Mundaring Weir, South Dandalup, North Dandalup, Wungong, Stirling and Churchman's Brook. The variable groundwater abstraction rule was reviewed in 2004. This review resulted in the version shown in Figure G1.

The criteria upon which the variable groundwater abstraction rule was originally developed and operated were:

- The average sustainable groundwater use was assumed to be 135 GL per year.
- The maximum groundwater abstraction target was set at 165 GL.
- The minimum groundwater abstraction target was set at 105 GL.
- Groundwater abstraction would need to be lower than the minimum abstraction target, before the water restrictions introduced in 2001 would be lifted (Stage 4 restrictions). Restrictions were not to be eased until dam storage reached 362.5 GL.
- Groundwater abstraction would need to reach the maximum abstraction target, before more severe water restrictions would be implemented. Increased restrictions were to apply when dam storage reached 235 GL.

The minimum groundwater abstraction target was set recognising that annual groundwater abstraction could not continue indefinitely at a rate above the average sustainable abstraction rate of 135 GL and was to be counter balanced by a 30 GL reduction in use to allow for recovery of the groundwater system.

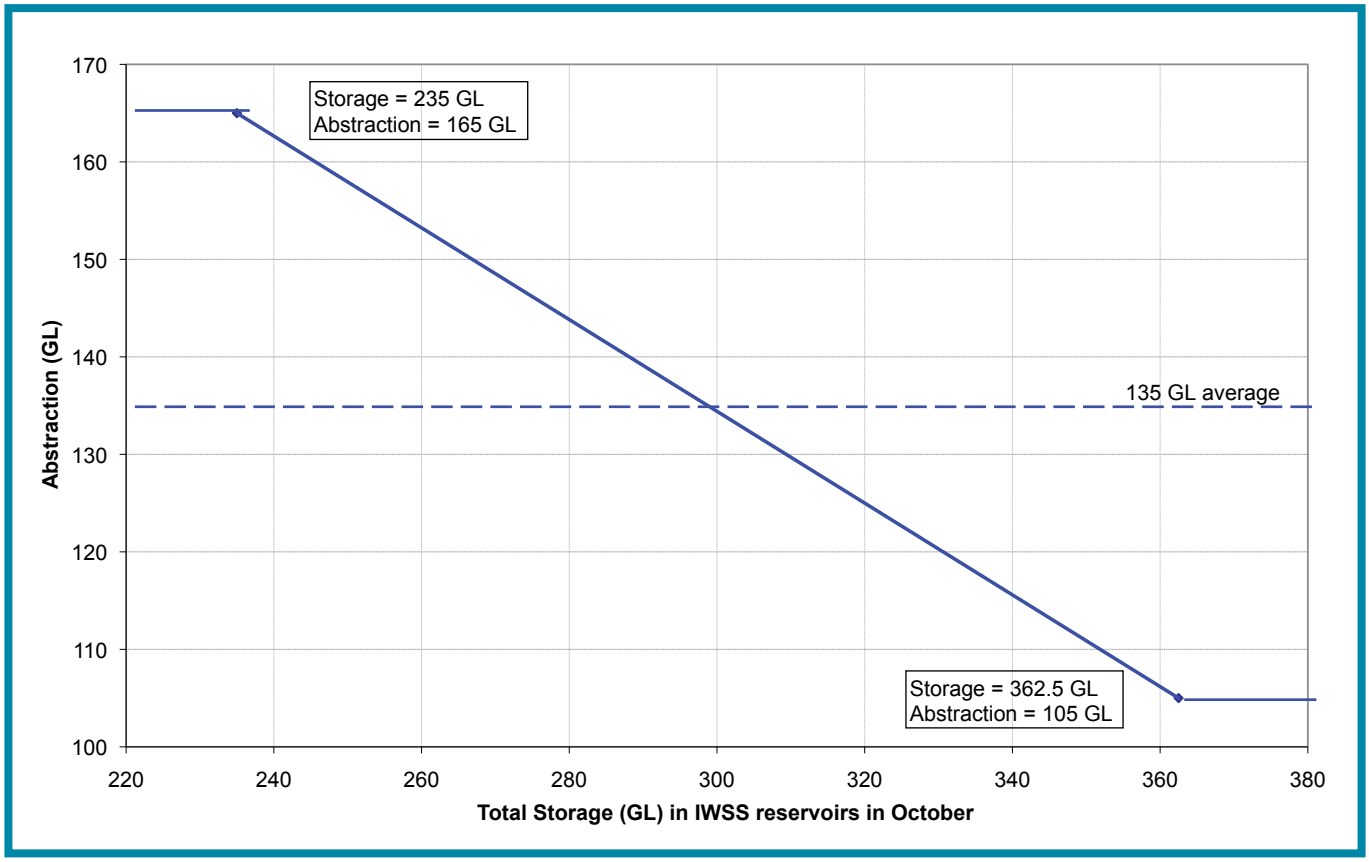

Figure G1
Variable Groundwater Abstraction Rule (2004 version)

Note: Abstraction is from the Gnangara and Jandakot systems.

H Appendix
Environmental monitoring program

Table H1
Monitoring sites, type and frequency of monitoring program

Ministerial criteria sites	**Wetlands** Lake Goollelal, Lake Gnangara, Loch McNess, Lake Yonderup, Lake Joondalup, Lake Jandabup, Lake Mariginiup, Lake Nowergup, Lake Wilgarup, Pipidinny Swamp, Lexia 94, Lexia 86, Lexia 186, Melaleuca Park EPP173, Melaleuca Park Dampland 78, Edgecombe Seepage, Egerton Seepage **Monitoring wells** MM16, MM18, MM49B, MM53, MM55B, MM59B, MT3S, NR6C, PM9, PM24, PM25, WM1, WM2, WM6, WM8, NR11C, MM12, L30C, L110C, L220C
Non-ministerial criteria sites	**Wetlands** Lexia Wetland 132, Lake Yakine, Coogee Springs **Monitoring wells** PM6, PM7, JB5
Water level monitoring (monthly)	**Wetlands** Lake Goollelal, Lake Gnangara, Loch McNess, Lake Yonderup, Lake Joondalup, Lake Jandabup, Lake Mariginiup, Lake Nowergup, Lake Wilgarup, Pipidinny Swamp, Lexia 94, Lexia 86, Lexia 186, Melaleuca Park EPP173, Melaleuca Park Dampland 78, Edgecombe Seepage, Egerton Seepage **Monitoring wells** MM16, MM18, MM49B, MM53, MM55B, MM59B, MT3S, NR6C, PM9, PM24, PM25, WM1, WM2, WM6, WM8, NR11C, MM12, L30C, L110C, L220C
Water level monitoring (continuous)	YN102 (Onychopora), YN14 (Carpark Cave), YN1 (Crystal Cave), YN99 (Boomerang Gorge), Cabaret Cave, YN11 (Water Cave)
Water level monitoring (other)	YN354 (8 times per year)
Wetland vegetation (annually)	Lake Goollelal, Loch McNess, Lake Yonderup, Lake Joondalup, Lake Jandabup, Lake Mariginiup, Lake Nowergup, Lake Wilgarup, Lexia 94, Lexia 86, Lexia 186, Melaleuca Park EPP173, Melaleuca Park Dampland 78, Lexia Wetland 132
Water quality and macroinvertebrate (biannually)	**Wetlands** Lakes Goollelal, Lake Gnangara, Loch McNess, Lake Yonderup, Lake Joondalup, Lake Jandabup, Lake Mariginiup, Lake Nowergup, Lake Wilgarup, Pipidinny Swamp, Lexia 86, Lexia 186, Melaleuca Park EPP173, Edgecombe Seepage, Egerton Seepage, Coogee Springs **Yanchep Caves** YN99, YN31, YN194, YN18, YN27 OR YN11, YN555, YN61, YN256, YN81,
Phreatophytic terrestrial vegetation (triennially)	Tangletoe, Tick Flat, Yeal, Ridges, P50, Yanchep, Nowergup, Neaves, Joondalup, Jandabup, South Kendall, West Gironde, Whiteman Park, Melaleuca Park, Bell, Maralla, Bombing Range
Wetland frogs (biannually)	Lexia 94, Lexia 86, Melaleuca Park EPP173, Melaleuca Park Dampland 78, Lake Yakine
End of summer condition assessment (annually)	**Wetlands** Lake Gnangara, Loch McNess, Lake Yonderup, Lake Joondalup, Lake Jandabup, Lake Mariginiup, Lake Nowergup, Lake Wilgarup, Pipidinny Swamp, Lexia 94, Lexia 86, Lexia 186, Melaleuca Park EPP173, Egerton Seepage **Monitoring wells** MM16, MM18, MM53, MM55B, MM59B, MT3S, NR6C, PM6, PM7, PM9, PM24, WM1, WM2, WM8, NR11C, MM12, L30C, L110C, L220C, JB5

Note: Environmental monitoring program current as of July 2009. This may change as a result of the review that is currently underway (see section 6.1)

Glossary[1]

Gnaragra groundwater areas allocation plan

Abstraction	The permanent or temporary withdrawal of water from any source of supply, so that it is no longer part of the resources of the locality.
Allocation limit	Annual volume of water set aside for licensed use from a water resource.
Aquifer	A geological formation or group of formations capable of receiving, storing and transmitting significant quantities of water.
Australian height datum (m AHD)	The datum used for the determination of elevations in Australia. The determination used a national network of bench marks and tide gauges, and set mean sea level as zero elevation.
Bore	A narrow, normally vertical hole drilled in soil or rock to monitor or withdraw groundwater from an aquifer. *See Well.*
Borefield	A group of bores to monitor or withdraw groundwater. *See Wellfield.*
Confined aquifer	An aquifer lying between confining layers of low permeability strata (such as clay, coal or rock) so that the water in the aquifer cannot easily flow vertically.
Ecological values	The natural ecological processes occurring within water dependent ecosystems and the biodiversity of these systems.
Environmental water provision (EWP)	The water regimes that are provided as a result of the water allocation decision-making process taking into account ecological, social, cultural and economic impacts. They may meet in part or in full the ecological water requirements.
Ecological water requirements (EWR)	The water regime needed to maintain the ecological values (including assets, functions and processes) of water dependent ecosystems at a low level of risk.
Ecosystem	A community or assemblage of communities of organisms, interacting with one another, and the specific environment in which they live and with which they also interact, e.g. lake, to include all the biological, chemical and physical resources and the interrelationships and dependencies that occur between those resources.
Entitlement	The quantity of groundwater permitted to be abstracted by a well licence, usually specified in kilolitres/year (kL/year).
Evaporation	Loss of water from the water surface or from the soil surface by vaporisation due to solar radiation.

Evapotranspiration	The combined loss of water by evaporation and transpiration. It includes water evaporated from the soil surface and water transpired by plants.
First-in, first-served	A process by which groundwater entitlements are allocated consistent with the order in which licence applications are received by the Department of Water.
Gigalitre (GL)	A measure equal to one thousand megalitres, one million kilolitres, or one billion litres.
Groundwater	The water that occurs in pore spaces and fractures in rocks beneath the ground surface. Also see aquifer, confined aquifer and unconfined aquifer.
Groundwater area	All the boundaries that are proclaimed under the *Rights in Water and Irrigation Act (1914)*, and used for water allocation planning and management.
Groundwater-dependent ecosystem	An ecosystem that is dependent on groundwater for its existence and health.
Groundwater mound	Mound-shaped formation developed when the vertical infiltration of rainfall exceeds the rate of horizontal groundwater flow through the aquifer.
Groundwater subarea	Areas defined by the Department of Water within a groundwater area, used for water allocation planning and management.
Hectare (ha)	A surface measure of area equal to 10 000 square metres or approximately 2.47 acres.
Hydrogeology	The hydrological and geological science concerned with the occurrence, distribution, quality and movement of groundwater, especially relating to the distribution of aquifers, groundwater flow and groundwater quality.
Hydrograph	A graph showing the height of a water surface above an established datum plane with respect to time.
Kilolitre (kL)	A unit of volume in the metric system, equal to 1000 litres.
Leakage	The flow of water from one aquifer to another.
Licence	A formal permit which entitles the licence holder to 'take' water from a watercourse, wetland or underground source.
Managed aquifer recharge	Purposeful recharge of an aquifer under controlled conditions, in order to store the water for later abstraction or to achieve environmental benefits. It may involve the passive treatment of water within the aquifer.
Megalitre (ML)	A unit of capacity (volume) in the metric system equal to one million litres, a thousand kilolitres or a thousand cubic metres.
Policy	A guideline that interprets the intent of the legislation to inform operational or strategic decisions.
Potentiometric level	An imaginary surface representing the total head of groundwater and defined by the level (surface) to which water will rise in a well.
Priority use	The current or future uses for a water resource that have priority over other potential uses because of their regional significance to the community.

Public water supply reserve (PWS)	A volume of groundwater that has been reserved for town water supply purposes (drinking water for human consumption) and, where appropriate, to satisfy the water requirements for developments of state significance under State Agreements to which the *Government Agreements Act 1979* applies.
Recharge	Water that infiltrates into the soil to replenish an aquifer.
Salinity	The measure of total soluble salt or mineral constituents in water. Water resources are classified based on salinity in terms of total dissolved solids (TDS) or total soluble salts (TSS). Measurements are usually in milligrams per litre (mg/L) or parts per thousand (ppt).
Social values	A particular in situ quality, attribute or use that is important for public benefit, welfare, state or health (physical and spiritual).
Subarea	A smaller area determined by the Department of Water within a proclaimed area used for water allocation planning and management purposes. The boundaries of which are based on the location of the resource.
Sustainable groundwater yield	The amount of water that can be abstracted over time from a water resource while maintaining the ecological values (including assets, functions and processes).
Unconfined aquifer	The aquifer nearest the surface, having no overlying confining layer. The upper surface of the groundwater within the aquifer is called the watertable. An aquifer containing water with no upper non-porous material to limit its volume or to exert pressure.
Water efficiency	The minimisation of water use through adoption of best management practices.
Water entitlements	The quantity of water that a person is entitled to take on an annual basis in accordance with the Rights in Water and Irrigation Act 1914 (1914) or a licence.
Water resource	A watercourse, wetland or underground water source to which Section 5C of the *Rights in Water and Irrigation Act (1914*) applies.
Water regime	A description of the variation of flow rate or water level over time. It may also include a description of water quality.
Water reserve	An area proclaimed under the Metropolitan Water Supply, Sewerage and Drainage Act 1909 or Country Areas Water Supply Act 1947 to allow the protection and use of water on or under the land for public water supplies.
Watertable	The saturated level of the unconfined groundwater. Wetlands in low-lying areas are often seasonal or permanent surface expressions of the watertable.
Well	An opening in the ground made or used to obtain access to underground water. This includes soaks, wells, bores and excavations. See Bore.
Wellfield	A group of wells to monitor or withdraw groundwater, including for scheme supply. See Borefield.
Wetland	For the purposes of this plan (unless otherwise specified) the department adopts the Ramsar Convention definition of a wetland *as an area that is permanently, seasonally or intermittently waterlogged or inundated with water that may be fresh, saline, flowing or static, including areas of marine water of which the depth at low tide does not exceed six metres.*

Volumes of water			
One litre	1 litre	1 litre	(L)
One thousand litres	1 000 litres	1 kilolitre	(kL)
One million litres	1 000 000 litres	1 Megalitre	(ML)
One thousand million litres	1 000 000 000 litres	1 Gigalitre	(GL)

Shortened forms	
AHD	Australian height datum (in metres)
CAWS Act	*Country Areas Water Supply Act 1947*
CDFM	Cumulative deviation from mean rainfall
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEC	Department of Environment and Conservation
DIA	Department of Indigenous Affairs
DoW	Department of Water
DPC	Department of Premier and Cabinet
DPI	Department for Planning and Infrastructure
EPA	Environmental Protection Authority
EWP	Environmental water provision
EWR	Ecological water requirement
GDE	Groundwater-dependent ecosystems
GSS	Gnangara Sustainability Strategy
IWSS	Integrated water supply scheme

Shortened forms	
MWSSD Act	*Metropolitan Water Supply Sewerage and Drainage Act 1990*
PDWSA	Public drinking water supply area
PRAMS	Perth regional aquifer modelling system
PWS	Public water supply
SPP	Statement of planning policies
TEC	Threatened Ecological Community
TDS	Total dissolved solids
TSS	Total soluble salts
VGAR	Variable groundwater abstraction rule
WAPC	Western Australian Planning Commission
WC	Water Corporation
WRC	Water and Rivers Commission

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