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

# Environmental management of groundwater from the Gnangara Mound

Triennial compliance report to the Office of the Environmental Protection Authority

July 2012 - June 2015

*Securing Western Australia's water future*

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Department of Water

February 2016

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**Disclaimer**

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# 1 Summary

This report describes the Department of Water's compliance with Ministerial conditions and commitments for the Gnangara Mound for the period 1 July 2012 – 30 June 2015. These conditions and commitments, including water level criteria, were set by the Minister for Environment in *Ministerial statement no. 819* (Government of Western Australia 2009a).

This report presents total licensed water entitlements covered by the *Gnangara groundwater areas allocation plan* (DoW 2009a) (Figure 1), focusing on entitlements from the Superficial aquifer (Table 1, 2 and 3). It also outlines the environmental monitoring, management, research and consultation the department is doing to sustainably manage the Gnangara groundwater system.

Over the three year reporting period, the number of sites that were non-compliant with absolute minimum or peak water level criteria reduced from 17 in 2012–13, to 16 sites in 2013–14 and 2014–15. Although compliance improved slightly for absolute minimum level and peak water level criteria, there were increased breaches of other criteria over the reporting period due to continuing water level declines in some areas (see section 5).

In response to this and previous non-compliance, we are implementing strategies to reduce abstraction towards a sustainable level and reduce impacts on environmentally important sites (see section 6.2). Many of these strategies are in the *Gnangara groundwater areas allocation plan* (DoW 2009a), which has been a key step in reducing groundwater use in the context of a drier climate. The department is currently working on the next Gnangara groundwater allocation plan, which will include new strategies to return the system to balance by setting levels of abstraction that match the drying climate.

*Table 1 Rainfall, licensing totals and compliance with Ministerial criteria for the Gnangara Mound*

| | **Gnangara Mound (Superficial aquifer)** | | |
|---|---|---|---|
| | **2012–13** | **2013–14** | **2014–15** |
| Rainfall | 584.8 mm | 721.2 mm | 652.8 mm |
| Public water supply entitlements | 31.42 GL | 30.37 GL | 30.80 GL |
| Private licensed entitlements | 110.56 GL | 109.99 GL | 113.45 GL |
| Estimated garden bore use[1] | 30 GL | 30 GL | 36 GL |
| No. of non-compliant sites | 17 out of 30 | 16 out of 30 | 16 out of 30 |

[1] Garden bore use is estimated using data collected through surveys, data from the Australian Bureau of Statistics and records of household use from the Water Corporation. In 2014 the Department of Water reviewed domestic garden bore use. The increase from 30 to 36 GL is due to improved information to account for use in semi-rural and rural areas.

# 2 Background

## 2.1 Ministerial statement no. 819

*Ministerial statement no. 819* sets environmental water provisions in the form of water level criteria at 30 sites across the Gnangara Mound – 14 wetland sites and 16 terrestrial phreatophytic vegetation sites (Figure 1). Phreatophytic vegetation is vegetation that uses groundwater to meet at least part of its water needs.

Ministerial conditions and commitments were established in 1986 to manage how groundwater was abstracted for public water supply and the expected growth in private licensed use at the time. Since then, the conditions and commitments have been revised several times to remove sites where environmental values have been lost due to causes other than abstraction (see Appendix C). These causes include the drying climate, land clearing and disturbance related to changing land use. The most recent revision in 2008 removed seven sites and amended the water level criteria at three sites. Increased rainfall variability and reduced recharge to groundwater associated with the drying climate in south-west Western Australia continues to contribute to non-compliance with water level criteria.

## 2.2 Allocation limits and licensing

The department uses allocation limits, licensing of groundwater abstraction and monitoring as the main mechanisms to manage groundwater resources. An allocation limit is the annual volume of water set aside for consumptive use from a water resource. This includes:

- water that is available for licensing
- water we account for that is exempt from licensing, including water used by domestic garden bores
- water we set aside for future public water supply.

Water for the environment is not included in the allocation limit. This is because it is left in the system and considered a non-consumptive use. Allocation limits are set considering recharge estimates, modelling, environmental objectives and benefits of groundwater use. The limits guide water availability for individual licence assessments. The department also guides the appropriate use of domestic garden bores through sprinkler restrictions and identifying the areas that are unsuitable for the installation of new bores.

The department reviewed allocation limits for the Gnangara groundwater areas in 2007 and these were finalised in the *Gnangara groundwater areas allocation plan* (DoW 2009a). We reviewed allocation limits again in 2011 to account for reduced rainfall and recharge, and in 2014 finalised a review of allocation limits for subareas in the North West urban growth corridor. The current allocation limits for Superficial aquifer resources are shown in Table 3.

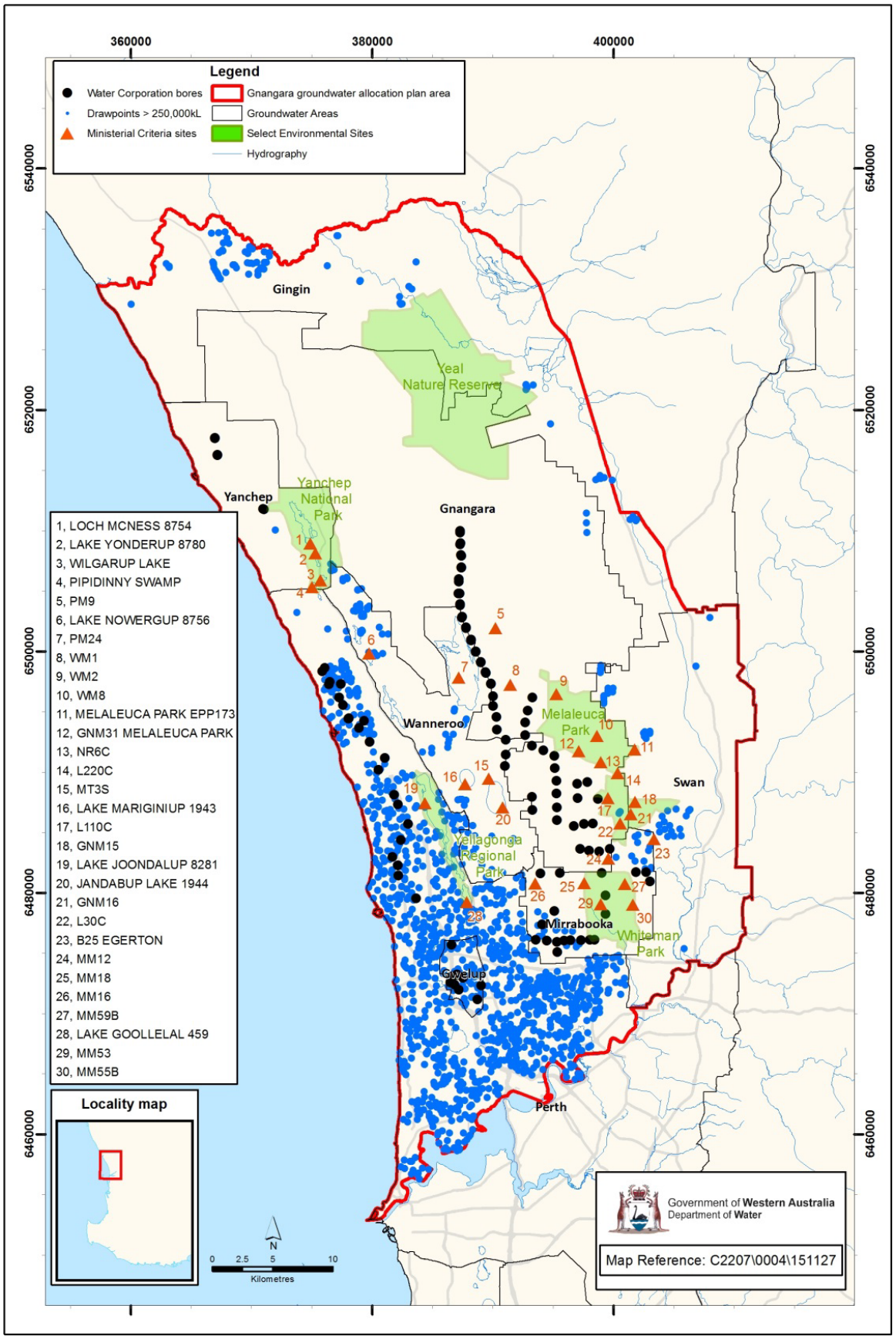


*Figure 1 Location of Gnangara Ministerial sites, public water supply production bores and private licensed drawpoints*

## 2.3 The Gnangara groundwater system

The Gnangara groundwater system is located on the Swan Coastal Plain, extending from the Swan River in the south to Moore River and Gingin Brook in the north, covering an area of about 2200 $km^2$. The system comprises four main aquifers:

- the shallow, unconfined Superficial (watertable) aquifer known as the Gnangara Mound
- the shallow, semi-confined Mirrabooka aquifer
- the deep, partially-confined Leederville aquifer
- the deep, mostly-confined Yarragadee aquifer.

Environmental impacts from abstraction and reduced recharge occur where ecosystems are directly supported by the Superficial aquifer. Impacts can occur from abstraction within the Superficial aquifer itself or through abstraction from deeper aquifers where they are directly or indirectly connected to the Superficial aquifer.

Many parts of the Gnangara system are currently over-allocated and water levels in the system have declined over the last 40 years because of:

- groundwater abstraction for public water supply and private use
- the drying climate (less rainfall and recharge)
- pine plantations limiting recharge to groundwater.

These declines have meant that important wetlands and other groundwater-dependent ecosystems on Gnangara are under significant pressure, and in many cases at risk of further decline in health and ecological function.

# 3 Rainfall

Groundwater levels in the Superficial aquifer depend on recharge from rainfall. Across south-west Western Australia there has been a general trend of declining annual rainfall since the mid 1970s. CSIRO's investigation of climate change (Bates et al. 2010), as well as relevant global climate change models, predict continued rainfall reduction in the region.

Annual rainfall at Perth Airport Bureau of Meteorology (BoM) station was 548.8 mm in 2012–13, 721.2 mm in 2013–14 and 652.8 mm in 2014–15 (Figure 2). This meant that over the 2012–2015 reporting period, rainfall was lower than the short-term (10-year) average in two out of the three years (Figure 2).

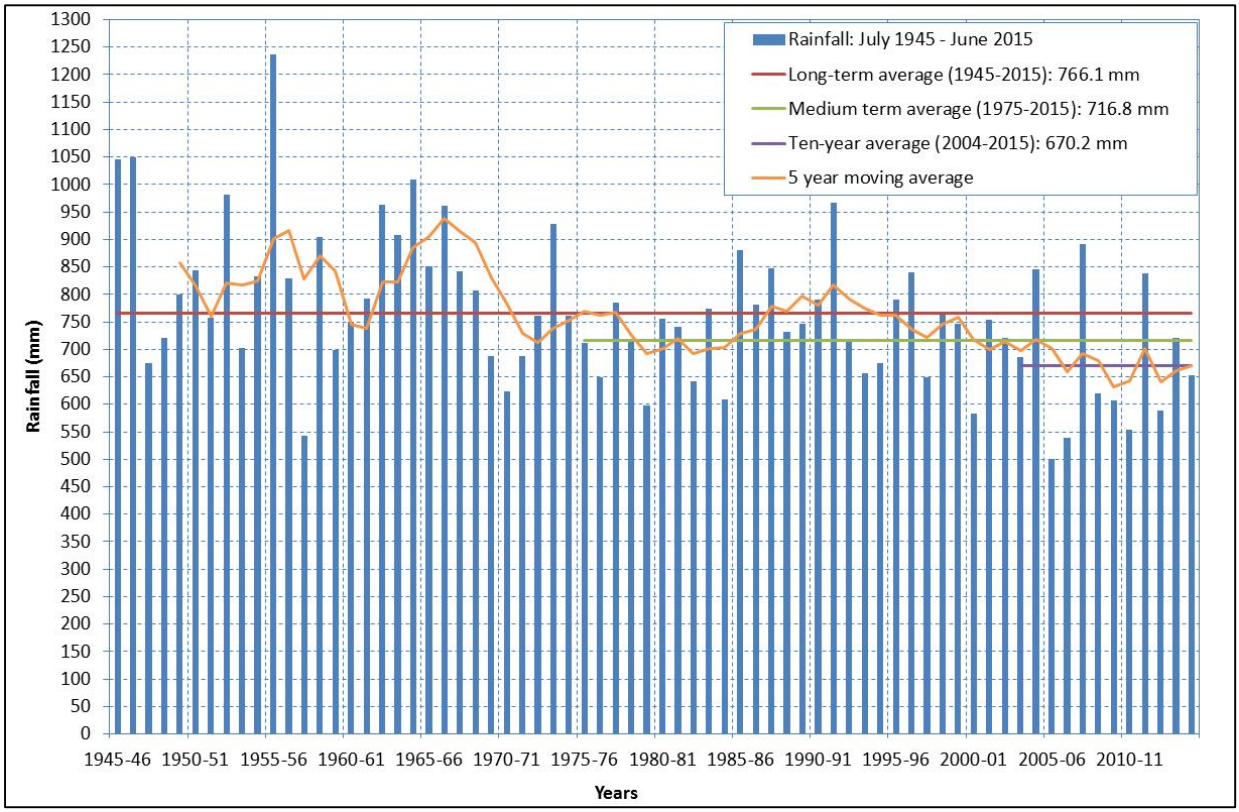


*Figure 2 Annual and average rainfall over time by water year for Perth Airport (BOM site 9021)*

# 4 Groundwater use

The Gnangara groundwater system is Perth's largest water source. It provides almost half of all the water used in Perth each year for agriculture, parks, ovals, gardens and public water supply.

## 4.1 Public water supply

The Department of Water licenses the Water Corporation to take groundwater from the Gnangara and Jandakot groundwater systems for Perth's public water supply. Groundwater from these systems forms a crucial component of Perth's Integrated Water Supply Scheme. Within the Gnangara system, there is also a small volume of groundwater licensed for the Woodridge town water supply. This volume does not form part of the Integrated Water Supply Scheme.

Licensed entitlements for public water supply are from all aquifers of the Gnangara system. In the Superficial aquifer, licensed entitlements for public water supply are within the Gnangara, Gwelup, Mirrabooka, Perth, Yanchep and Gingin groundwater areas (Figure 1). The impacts of public water supply abstraction on high value wetlands are managed by apportioning abstraction to lower risk areas, including the deeper confined aquifers.

The volumes of groundwater licensed for public water supply from all aquifers decreased from 129.04 GL in 2012–13 to 110.81 GL in 2014–15 (Table 2). The reduction is primarily because a temporary licence for 17.85 GL was issued to the Water Corporation in 2012–13 to meet demand from the Integrated Water Supply Scheme. Additional volumes of 1.3 GL and 2.8 GL were licensed in 2012–13 and 2013–14 respectively as part of the groundwater replenishment scheme (managed aquifer recharge).

Licensed entitlements for public water supply are further broken down into groundwater subareas for the Superficial aquifer in Table 2 (section 4.3).

## 4.2 Private licensed use

About 80 per cent of groundwater licensed from the Superficial aquifer is for private use. This includes groundwater for agriculture and groundwater licensed to local government for the irrigation of public open space such as parks and sporting grounds.

Over the 2012–2015 reporting period, private licensed entitlements remained similar from the Leederville and Yarragadee aquifers and increased from the Superficial aquifer. The increase in 2014–15 from the Superficial aquifer (by around 3.50 GL) is due to temporary over-allocation in the North West urban growth corridor for dust suppression and establishment of public open space, as well as some increases in allocation for general purposes in subareas where water was available for licensing (Table 2, section 4.3). Table 3 (section 4.3) shows private licensed entitlements from the Superficial aquifer by groundwater subarea.

## 4.3 Use that is exempt from licensing

When we review allocation limits, we estimate and account for groundwater that is exempt from licensing. The main type of this use from Gnangara is from domestic garden bores which are used for irrigating lawns and gardens in urban areas and for non-commercial stock and domestic purposes in rural areas. When accounting for this volume we estimate the number of bores and the average water use per bore.

The number of bores are estimated through data from the Australian Bureau of Statistics, ground surveys conducted by the Water Corporation and local government plans and land zoning.

The average water use per bore is estimated based on:

- the 2009–2011 Perth garden bore metering project
- information on the size of blocks
- water use surveys and local knowledge.

In 2014–15, the department reviewed domestic garden bore use as part of the allocation limit review for the next Gnangara groundwater allocation plan. We now estimate that 36 GL per year is abstracted for domestic garden use. The increase from our previous estimate of 30 GL per year is mainly because of better accounting for stock and domestic garden bore use on semi-rural and rural blocks.

*Table 2 Public water supply, private use and use that is exempt from licensing from all aquifers in the Gnangara groundwater system over the reporting period*

| Aquifer | Public water supply entitlements[1] GL | | | Private licensed entitlements GL | | | Estimated use that is exempt from licensing GL | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2012–13 | 2013–14 | 2014–15 | 2012–13 | 2013–14[2] | 2014–15 | 2012–13 | 2013–14 | 2014-15 |
| Superficial | 31.42[3] | 30.37 | 30.80 | 110.56 | 109.99 | 113.45 | 30 | 30 | 36 |
| Mirrabooka (and fractured rock)[2] | 2.65 | 1.17 | 1.10 | 2.24 | 2.52 | 2.39 | - | - | - |
| Leederville | 43.18[4] | 36.51[4] | 33.29[4] | 11.13 | 11.58 | 11.68 | - | - | - |
| Yarragadee | 51.79 | 45.57[5] | 45.62[5] | 0.68 | 0.68 | 0.68 | - | - | - |
| **TOTAL** | **129.04** | **113.61** | **110.81** | **124.61** | **124.77** | **128.20** | **30** | **30** | **36** |

[1] Public water supply volumes include groundwater licensed to the Water Corporation for both the Integrated Water Supply Scheme and the Woodridge town water supply.

[2] From 2013–14 onwards, the Mirrabooka volumes are a combination of licensed entitlements for the Mirrabooka and fractured rock aquifers.

[3] This figure has been updated from the 31.52 GL reported in 2012–13 because it incorrectly included 0.1 GL of water licensed from Leederville aquifer. The Leederville volume has also been updated.

[4] A total of 1.30 GL and 2.80 GL was licensed as part of the groundwater replenishment trial in 2012–13 and 2013–14 respectively. No water was licensed for this purpose in 2014–15 because the stage 1 scheme is under construction.

[5] Yarragadee volumes include 1 GL in 2013–14 and 0.65 GL in 2014–15 from bore MR17, which is located outside of the Gnangara plan boundary in the Perth South Groundwater Area.

*Table 3 Licensed entitlements from the Superficial aquifer in subareas of the Gnangara groundwater areas allocation plan*

| Groundwater area | Subarea | Ministerial criteria site present? | Current allocation limit (GL)[1] | Public water supply licensed entitlements (GL)[2] | | | | Private licensed entitlements (GL)[3] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2012–13 | 2013–14 | 2014–15 | Future water reserve[4] | 2012–13 | 2013–14 | 2014–15 |
| Gingin | Beermullah Plain South | No | 2.70 | | | | | 3.13 | 2.83 | 2.80 |
| | Deepwater Lagoon South | No | 3.50 | | | | | 3.38 | 3.08 | 3.03 |
| | Guilderton South | No | 9.92 | 0.03 | 0.03 | 0.03 | | 9. 88 | 9.72 | 9.88 |
| | Lake Mungala | No | 3.16 | | | | | 2.90 | 2.90 | 2.85 |
| **Total for Gingin Groundwater Area** | | | **19.29** | **0.03** | **0.03** | **0.03** | **Yes** | **19.30** | **18.53** | **18.55** |
| Gnangara | Reserve | Yes | 8.83 | 0.17 | 0.35 | 0.49 | | 1.22 | 1.42 | 1.42 |
| | Wanneroo Wellfield | Yes | 11.85 | 5.92 | 5.97 | 6.05 | | 0.50 | 2.04 | 2.04 |
| **Total for Gnangara Groundwater Area** | | | **20.68** | **6.09** | **6.32** | **6.54** | **Yes** | **1.72** | **3.46** | **3.46** |
| Gwelup | Gwelup | No | 7.85 | 2.65 | 2.49 | 3.20 | | 1.11 | 1.12 | 1.17 |
| **Total for Gwelup Groundwater Area** | | | **7.85** | **2.65** | **2.49** | **3.20** | **Yes** | **1.11** | **1.12** | **1.17** |
| Mirrabooka | Ballajura | No | 5.90 | 1.94 | 1.60 | 1.64 | | 0.91 | 0.89 | 0.89 |
| | Beechboro | No | 0.90 | | | | | 0.25 | 0.25 | 0.25 |
| | Henley Brook | No | 1.57 | 0.55 | 0.50 | 0.55 | | 0.27 | 0.27 | 0.27 |
| | Improvement Plan 8 | No | 5.48 | 1.45 | 1.25 | 1.01 | | 0.14 | 0.14 | 0.13 |
| | Landsdale | Yes | 1.40 | | | | | 0.75 | 0.66 | 0.71 |
| | Plantation | No | 0.60 | | | | | 0.40 | 0.36 | 0.36 |
| | State Forest | No | 0.90 | | | | | 1.07 | 0.99 | 1.03 |
| | Whiteman Park | Yes | 0.99 | 0.15 | 0.15 | 0.15 | | 0.54 | 0.32 | 0.64 |
| **Total for Mirrabooka Groundwater Area** | | | **17.75** | **4.09** | **3.50** | **3.35** | **Yes** | **4.33** | **3.88** | **4.29** |
| Perth | City of Bayswater | No | 2.30 | | | | | 1.72 | 1.73 | 1.81 |
| | City of Fremantle North | No | 0.70 | | | | | 0.04 | 0.04 | 0.04 |
| | City of Nedlands | No | 2.30 | | | | | 2.35 | 2.35 | 2.38 |
| | City of Perth | No | 1.50 | | | | | 3.26 | 2.15 | 2.68 |
| | City of Stirling | No | 11.15 | 3.08 | 2.73 | 2.70 | | 7.76 | 8.59 | 7.79 |
| | City of Subiaco | No | 1.00 | | | | | 1.12 | 1.07 | 0.98 |
| | Eglinton | No | 7.05 | | | | | 2.02 | 2.62 | 2.92 |
| | Quinns | No | 16.56 | 11.75 | 11.65 | 11.00 | | 2.84 | 3.03 | 3.67 |
| | Shire of Peppermint Grove | No | 0.10 | | | | | 0.08 | 0.08 | 0.08 |
| | Shire of Swan North | No | 0.90 | | | | | 0.53 | 0.55 | 0.60 |
| | Town of Bassendean | No | 0.45 | | | | | 0.34 | 0.34 | 0.36 |
| | Town of Cambridge | No | 3.50 | | | | | 2.43 | 2.43 | 2.43 |
| | Town of Claremont | No | 0.70 | | | | | 0.70 | 0.70 | 0.70 |
| | Town of Cottesloe | No | 0.30 | | | | | 0.25 | 0.25 | 0.25 |
| | Town of Mosman Park | No | 0.50 | | | | | 0.48 | 0.48 | 0.48 |
| | Town of Vincent | No | 1.00 | | | | | 1.82 | 0.77 | 1.70 |
| | Whitfords | Yes | 21.54 | 2.51 | 2.27 | 2.60 | | 9.27 | 9.13 | 9.02 |
| **Total for Perth Groundwater Area** | | | **71.54** | **17.34** | **16.65** | **16.30** | **Yes** | **37.03** | **36.32** | **37.89** |
| Swan | Bandy Spring | No | 0.35 | | | | | 0.33 | 0.33 | 0.29 |
| | Central Swan | No | 0.92 | | | | | 1.31 | 1.32 | 1.27 |
| | Cockman Bluff | No | 1.35 | | | | | 1.18 | 1.18 | 1.26 |
| | East Swan | No | 0.68 | | | | | 1.08 | 0.94 | 0.78 |
| | Neaves | No | 1.80 | | | | | 3.43 | 3.29 | 3.28 |
| | North Swan | Yes | 1.83 | | | | | 2.91 | 2.88 | 3.41 |
| | Radar | No | 1.80 | | | | | 2.27 | 1.86 | 1.85 |
| | South Swan | No | 3.62 | | | | | 3.74 | 3.64 | 3.62 |
| **Total for Swan Groundwater Area** | | | **12.35** | **0.00** | **0.00** | **0.00** | **No** | **16.24** | **15.44** | **15.76** |
| Wanneroo | Adams | Yes | 0.91 | | | | | 1.11 | 1.09 | 1.10 |
| | Carabooda | No | 5.76 | | | | | 8.01 | 7.99 | 8.02 |
| | Carramar | No | 1.55 | | | | | 1.49 | 1.50 | 1.50 |
| | Jandabup | No | 0.18 | | | | | 0.18 | 0.18 | 0.18 |
| | Joondalup | No | 1.35 | | | | | 0.87 | 0.86 | 0.86 |
| | Lake Gnangara | No | 6.79 | | | | | 7.15 | 7.09 | 6.83 |
| | Mariginiup | Yes | 3.61 | | | | | 4.25 | 4.19 | 4.17 |
| | Neerabup | No | 2.39 | | | | | 2.56 | 2.57 | 2.57 |
| | Nowergup | Yes | 1.80 | | | | | 2.77 | 2.70 | 2.73 |
| | Pinjar | Yes | 0.45 | | | | | 0.62 | 0.61 | 0.60 |
| **Total for Swan Groundwater Area** | | | **24.79** | **0.00** | **0.00** | **0.00** | **No** | **29.01** | **28.78** | **28.55** |
| Yanchep | Yanchep | Yes | 20.48 | 1.22 | 1.38 | 1.38 | | 1.81 | 2.46 | 3.79 |
| **Total for Yanchep Groundwater Area** | | | **20.48** | **1.22** | **1.38** | **1.38** | **Yes** | **1.81** | **2.46** | **3.79** |
| **Total for Gnangara groundwater allocation plan area** | | | **194.73** | **31.42** | **30.37** | **30.80** | | **110.56** | **109.99** | **113.45** |

[1] The department reviewed allocation limits for the Gnangara groundwater allocation plan area in 2007 and these were finalised in the *Gnangara groundwater areas allocation plan* (DoW 2009a). The department reviewed allocation limits again in 2011 to account for reduced rainfall and recharge and in 2014 finalised a review of allocation limits for subareas in the North West urban growth corridor (Quinns, Eglinton and Yanchep Superficial resources).

[2] Public water supply information is from both the department's Water Resources Licensing System and annual reports submitted to the department as a condition of the Water Corporation's licences.

[3] The source of private licensed entitlement data is the Water Resources Licensing System (2012–13 report run on 1 July 2013, 2013–14 report run on 30 June 2014, 2014–15 report run on 1 July 2015).

[4] Where groundwater is reserved for future public water supply, the reserve volumes are not included in the licensed entitlement figures presented. The reserved volumes do not consider the drying climate and are likely to be removed when allocation limits are reviewed for the next Gnangara groundwater allocation plan.

Also note: Up-to-date figures on water availability are available from the Department of Water's Swan–Avon Region office or through the department's water register: <www.water.wa.gov.au/maps-and-data/maps/water-register>.

1 GL = 1 000 000 kL.

Figures have been rounded to two decimal places.

# 5 Compliance

The conditions and commitments that the Department of Water is required to comply with from *Ministerial statement no. 819* are outlined in Appendices A and B (the 'audit tables').

## 5.1 Compliance with water level criteria

Ministerial statement no. 819 sets water level criteria at 30 sites across the Gnangara Mound (Figure 1). Some sites have more than one water level criterion and can be non-compliant with multiple criteria. Water level criteria include:

- absolute minimum levels and peak water levels – these are used as the main indicator for compliance from year to year
- levels allowed to fall between a preferred minimum and the absolute minimum in two out of six years to replicate natural drying cycles – these are referred to as 'other' water level criteria in this report and provide information on water level trends.

The number of sites non-compliant with absolute minimum or peak water level criteria reduced from 17 sites in 2012–13 to 16 sites in 2013–14 and 2014–15 (Table 4). Different sites were non-compliant in these years – Melaleuca Park Dampland 78 was compliant in 2013–14 but non-compliant in 2014–15 and MM55B was non-compliant in 2013–14 but compliant in 2014–15 (Table 4).

Two additional sites were non-compliant with 'other' criteria during 2013–14 and 2014–15 because levels fell between the preferred minimum and absolute minimum levels for more than two of the last six years. We use these criteria to show longer term trends in water levels. Although compliance slightly improved for absolute minimum levels and peak water levels for this period, the increase in breaches of other criteria show that water levels are continuing to decline. If these trends continue there will be further non-compliance in the future.

Our management and mitigation actions in response to non-compliance are described in Section 6. Details for individual sites can be found in the 'audit tables' in Appendix A.

*Table 4 Summary of non-compliance with Ministerial criteria for the Gnangara Mound*

| Year | Compliance[1] | | | | |
|---|---|---|---|---|---|
| | Absolute minimum or peak water level criteria | | | Other water level criteria | |
| | Wetlands | Terrestrial vegetation | Total non-compliant | Wetlands | Total non-compliant |
| 2012–13 | Loch McNess<br>Lake Yonderup<br>Lake Jandabup<br>Lake Wilgarup<br>Pipidinny Swamp<br>Lexia 186<br>Melaleuca Park-EPP173<br>Melaleuca Park-Dampland 78<br>Lake Mariginiup<br>Lake Nowergup | MM53<br>MM55B<br>MM59B<br>PM9<br>WM1<br>WM2<br>WM8 | 17 out of 30 | Lake Joondalup<br>Lake Mariginiup<br>Lake Nowergup<br>Lexia 186 | 4 out of 8 |
| 2013–14 | Loch McNess<br>Lake Yonderup<br>Lake Jandabup<br>Lake Wilgarup<br>Pipidinny Swamp<br>Lexia 186<br>Melaleuca Park-EPP173<br>Lake Mariginiup<br>Lake Nowergup | MM53<br>MM55B<br>MM59B<br>PM9<br>WM1<br>WM2<br>WM8 | 16 out of 30 | Lake Joondalup<br>Lake Mariginiup<br>Lake Nowergup<br>Lexia 86<br>Lexia 186<br>Melaleuca Park-Dampland 78 | 6 out of 8 |
| 2014–15 | Loch McNess<br>Lake Yonderup<br>Lake Jandabup<br>Lake Wilgarup<br>Pipidinny Swamp<br>Lexia 186<br>Melaleuca Park-EPP173<br>Melaleuca Park-Dampland 78<br>Lake Mariginiup<br>Lake Nowergup | MM53<br>MM59B<br>PM9<br>WM1<br>WM2<br>WM8 | 16 out of 30 | Lake Joondalup<br>Lake Mariginiup<br>Lake Nowergup<br>Lexia 86<br>Lexia 186<br>Melaleuca Park-Dampland 78 | 6 out of 8 |

[1] Refers to the number of sites that were non-compliant. A site can be non-compliant with both absolute summer minimum and peak water level criteria but are only counted as one site. Also see Appendix A.

# 6 Environmental monitoring, management, research and consultation

## 6.1 Environmental monitoring

Expert environmental consultants undertake environmental monitoring for the department in line with the commitments in *Ministerial statement no. 819*. The department reviewed the monitoring program in 2009 and 2013 (see Appendix D) to improve cost effectiveness and efficiency.

The program includes monitoring of:

- wetland vegetation
- terrestrial (phreatophytic) vegetation
- wetland macroinvertebrates and water quality
- cave and mound spring macroinvertebrates and water quality
- wetland frogs.

Ecological condition is affected by a number of factors that influence water levels, such as groundwater abstraction, fire, disease and disturbance from changing land use. We use environmental monitoring to continually improve our understanding of the relationship between water levels and ecological condition. We also use the information to manage abstraction at priority locations, where reduced abstraction is likely to improve ecological condition.

### 6.1.1 Wetland vegetation

Vegetation monitoring in 2012–13 identified a number of wetlands where ecological condition declined because of falling groundwater levels. These included Lake Nowergup, Loch McNess, Lake Yonderup, Lake Wilgarup and Lake Mariginiup (Wilson, McGuinness & Froend 2013). Water levels at these sites were non-compliant with water level criteria.

In 2013–14 canopy condition improved at a number of wetlands, including Quin Swamp and Lake Bindiar in the Yeal Nature Reserve (Figure 1), which was associated with increases in peak water levels. Notable changes in vegetation and hydrological conditions compared to previous monitoring were seen at Yeal Lake and Lake Yonderup (Wilson and Froend 2014). Water levels at Lake Yonderup were non-compliant with water level criteria. Yeal Lake is not a Ministerial site but is monitored as part of our environmental program as a representative site in the northern Gnangara area.

In 2014–15 canopy condition declined at Loch McNess, Melaleuca Park EPP173, Quin Brook, Lake Gwelup, Lake Goollelal and Lexia 94 but increased at Lexia 86, Lake Bindiar, Quin Swamp, Yeal Lake and Dampland 78. Species composition continued to change at Loch McNess, Lake Goollelal, Melaleuca Park EPP173, Lexia 86, Dampland 78, Lexia 94, Quin Swamp and Yeal Lake. Declining groundwater

levels are likely to be contributing to these changes (Wilson, French & Froend 2015). Notable changes in vegetation condition were again seen at Yeal Lake.

### 6.1.2 Terrestrial vegetation

Triennial monitoring of terrestrial vegetation in 2014–15 showed:

- a shift from tree species that prefer moister soils to tree species that tolerate drier soil conditions
- general declines in numbers and condition of tree species and in particular the larger and older trees
- continuing declines in understorey species that prefer moister soil conditions
- decreases in the density of understorey species
- increases in introduced species.

### 6.1.3 Wetland macroinvertebrates and water quality

In 2012–13 macroinvertebrate family richness was the lowest since monitoring began at lakes Gnangara and Mariginiup. Richness was also low at Melaleuca Park EPP173 and lakes Jandabup and Nowergup. Richness increased from the previous year at lakes Goollelal and Joondalup, and was relatively high at Loch McNess compared to historical levels (Judd and Horwitz 2013).

In 2013–14 macroinvertebrate family richness increased at a number of wetlands where peak water levels were higher, including Lake Jandabup, Loch McNess and Melaleuca Park EPP173. However, family richness at Lake Nowergup was the lowest since monitoring began, with some sampling sites being inaccessible because of low water levels (Sampey et al. 2014).

In 2014–15, macroinvertebrate family richness:

- decreased at most of the wetlands being monitored – Lake Goollelal, Lake Joondalup, Melaleuca Park EPP 173, Yeal Lake and Lake Yonderup
- was above mean richness at Lake Jandabup, Lake Joondalup and Loch McNess
- was below mean richness at other monitored wetlands – Lake Goollelal, Lake Yonderup, Melaleuca Park EPP 173 and Yeal Lake.

Wetland nutrient concentrations and pH were generally within historical ranges during the reporting period. pH values at Lake Jandabup and Lake Goollelal were relatively low over the reporting period but increased slightly in 2014–15. Lake Mariginiup and Melaleuca Park EPP173 continued to be the most acidic of the wetlands monitored (Sampey et al. 2014).

### 6.1.4 Cave and mound spring macroinvertebrates and water quality

We monitored macroinvertebrates and water quality in nine caves in the Yanchep area in 2012–13, which have a Threatened Ecological Community referred to as the 'Aquatic root mat community of caves of the Swan Coastal Plain' (Knott et al. 2013). Threatened root mat communities are no longer found in the areas we could access,

but they may exist in undiscovered or inaccessible parts of the caves. Water levels in most of the caves have declined to the point where most are too dry to be sampled. In the two caves that could be sampled, water quality was similar to previous years but low water levels resulted in low macroinvertebrate species richness. We ceased to monitor the caves in 2013–14 because of the low water levels. However, we continue to monitor groundwater levels in the Superficial aquifer that relate to cave water levels and have been implementing changes to abstraction with the aim to improve levels in the caves (see section 6.2.1 and 6.2.2).

In 2012–13, all three springs monitored had reduced flows compared to previous years. pH was relatively low at all sites, especially at Gaston Road Spring. Low water quality conditions at Egerton Spring, including low dissolved oxygen levels, was reflective of the low flow. Despite the lower flows, macroinvertebrate richness was the highest on record at Gaston Road and Sue's springs. Richness at Egerton Spring declined from previous years (Knott et al. 2013).

In 2013–14, flows increased at all three springs compared to the previous year. Again, pH was relatively low at all sites. Macroinvertebrate species richness at Gaston Road and Sue's springs was within historical ranges and richness at Egerton Spring declined despite the improved flow (WRM 2014).

In 2014–15 flow at Egerton and Sue's springs remained relatively constant. Gaston Road Spring continued to sustain a shallow swamp despite reduced flow. pH was still low at all sites, with Egerton and Sue's springs slightly acidic and Gaston Road strongly acidic. Dissolved oxygen levels improved at all sites. Macroinvertebrate richness was the highest since 2008 at Egerton and was the highest on record at the other two sites. Several high conservation taxa were recorded at the springs monitored, including two that are currently undescribed (WRM 2015).

### 6.1.5 Wetland frogs

Frog populations were monitored using trapping and aural surveys of calling males. Generally, the numbers of frogs trapped and calling over the reporting period was considered to be low compared to previous years. The number of frogs calling and captured each year is affected by changes in rainfall, water levels and the annual inundation of wetlands (Everard and Bamford 2013, Huang and Bamford 2014). Trapping frogs has also shown that annual rainfall and periods of surface water inundation are important for successful breeding.

Some frog species have disappeared at a number of sites, likely because of shorter periods of surface water inundation. Despite these disappearances, it seems frogs are recolonising some wetlands, which suggests that frogs may be able to disperse widely from scattered breeding sites. This would explain the persistence of frogs at sites where breeding seems unlikely and could mean that populations over large areas may only rely on a few breeding sites (Everard and Bamford 2015).

## 6.2 Management actions

In response to the level of non-compliance identified in this and previous reports, the department is implementing strategies to reduce abstraction towards a sustainable level and reduce impacts on environmentally important sites. Many of these strategies are outlined in the *Gnangara groundwater areas allocation plan* (DoW

2009a), which has been a key step in adjusting groundwater management in the context of a drier climate.

By implementing the Gnangara plan, we have:

- significantly reduced abstraction for public water supply
- increased licensing compliance and enforcement activities
- increased the protection of groundwater-dependent ecosystems by moving public water supply abstraction to lower risk areas, including the deeper Leederville and Yarragadee aquifers.

We have identified and implemented other strategies through evaluating the plan (DoW 2013b and DoW 2015a). We will use the evaluation findings to develop the next Gnangara groundwater allocation plan, which will include new strategies to return the system to balance and aim to set levels of abstraction that match the drying climate.

### 6.2.1 Managing public water supply use

As outlined in the *Gnangara groundwater areas allocation plan,* the addition of the Southern Seawater Desalination Plant to the Integrated Water Supply Scheme triggered a change in how groundwater for public water supply is allocated. In line with the plan, the department reduced the Water Corporation's groundwater allocations for the scheme from 145 GL to 120 GL per year from existing infrastructure from the Gnangara and Jandakot systems. As part of the reduced allocation the licensed volume from the Superficial aquifer was reduced in areas that most benefit water levels and ecological condition at non-compliant Ministerial sites.

Every water year we review how to distribute the Water Corporation's entitlements based on compliance and water level trends. This aims to further reduce the impacts of abstraction on Ministerial sites where water levels are or may become non-compliant with water level criteria. In 2013–14 we reduced abstraction from Leederville aquifer bores in the Pinjar bore field and Superficial aquifer bores in the Quinns bore field to reduce impacts on water levels at Loch McNess, Yanchep caves and Lake Nowergup. These changes were based on recommendations from a recent hydrogeological study for a review of allocation limits in the North West urban growth corridor.

In 2014–15 we further reduced abstraction from the Superficial and Leederville aquifers in the Quinns bore field, aiming to further reduce impacts at Lake Nowergup. We also changed the abstraction pattern in the Lexia bore field to limit risks of increased non-compliance in the area.

#### *Groundwater replenishment scheme*

The department is working with the Water Corporation to progress the groundwater replenishment scheme at Beenyup Wastewater Treatment Plant. Increased use of Perth's wastewater resources is now a critical strategy to meet increasing demands for water in our growing city.

As part of the groundwater replenishment scheme, we licensed the Water Corporation to abstract 1.3 GL and 2.8 GL of water injected at the Beenyup site in 2012–13 and 2013–14 respectively. Because of the success of the groundwater

replenishment trial, and to reduce costs, the Water Corporation have brought forward their planned expansion of the scheme to 14 GL per year. There were no licences issued in 2014–15 because new injection bores were being constructed for the 14 GL expansion. The scheme will have the potential to deliver up to 28 GL per year in future stages of expansion.

### 6.2.2 Managing private licensed use

The department monitors private licensed use through on-ground compliance inspections, meter audits and water use surveys. We use this work to check that groundwater use is within licensed entitlements and that site activities are authorised. Over the 2012–2015 reporting period the department prosecuted three individuals for illegal activities. This included:

- in December 2012 a Wanneroo grower was convicted for tampering with their water meter and water theft – taking more water than they were entitled to
- in May 2013 a Gnangara grower was convicted for water theft – taking more water than they were entitled to
- in July 2013 a commercial driller was convicted and fined for constructing two illegal bores on separate properties.

The department has prioritised its licence compliance and enforcement activities to consider the conditions and commitments set in *Ministerial statement no. 819*. This included expanding the scope of our licensing compliance plan to focus on areas potentially affecting non-compliant Ministerial sites.

The department also manages the use of groundwater by private licensees in other ways:

- In 2013–14 we reviewed allocation limits in the North West urban growth corridor (along the coast between Quinns and Two Rocks). Demand for groundwater from both the Water Corporation and developers is high in this area, to supply about 9000 ha of urban development. The department worked with the Water Corporation, the City of Wanneroo and developers on a water supply strategy to apportion available water across the whole corridor and improve water efficiency and public open space design.
- In 2013–14 we started working with the City of Swan to develop a similar water supply strategy for the North East urban growth corridor (the area between Midland and Bullsbrook). Groundwater resources in these areas are limited or over-allocated and there will likely be a need to transition to alternative water sources over time. This will reduce pressure on Ministerial sites in the area.
- We worked with the Department of Parks and Wildlife to reduce abstraction impacts on Loch McNess by reducing groundwater abstraction in Yanchep National Park and ceasing the Yanchep caves supplementation program. This program was not meeting success criteria for the occurrences of the Threatened Ecological Community and was found to be negatively impacting water levels at Loch McNess. These changes were based on recommendations from recent, local hydrogeological investigations.

- The department continues to work with local governments, urban developers and other licensees that use large volumes to improve water use efficiency, reduce demand for groundwater and assess water needs and supply options. The Waterwise Council program began in 2009 and continues to grow. Twelve of the 16 councils that abstract Gnangara groundwater are accredited Waterwise councils and three are working towards endorsement. In 2012 the department co-founded the Waterwise Golf Course Program, with the Lake Karrinyup Country Club and Wembley Golf Course achieving gold accreditation.
- The department continues to work with peak bodies, as well as directly with horticulturalists in the Carabooda and Wanneroo areas, to focus on water use efficiency, compliance with licence conditions and options to reduce total water use in the future.
- The department maintains a web-based register of licensees to facilitate water trades as a way to optimise water use.

### 6.2.3 Managing groundwater use exempt from licensing

Domestic garden bores are generally encouraged (where suitable and used efficiently) because they reduce demand on the Integrated Water Supply Scheme. To help manage this abstraction, the department developed a garden bore use policy in 2011 (DoW 2011e) that emphasises water conservation and efficiency and includes a garden bore suitability map, which is also available in the department's online Perth Groundwater Atlas. Garden bores are not encouraged in areas identified as unsuitable in the bore suitability map, where there is a risk of acid sulfate soils, poor water quality or low yields.

To help preserve water resources and encourage water use efficiency by the community, water restrictions on the use of garden bores were initiated in 2007 under the Rights in Water and Irrigation Exemption (Section 26C) Order 2007. In 2010, the total winter sprinkler ban also came into effect under the Water Agencies (Water Use) By-laws 2010. Restrictions that apply to domestic garden bore users across Gnangara are:

- daytime (9am to 6pm) sprinkler ban
- three-day-a-week sprinkler restriction
- permanent winter sprinkler ban (1 June – 31 August).

The annual winter sprinkler ban is now in its sixth year and has become an accepted part of the community's water use calendar, as shown by a strong reduction in the number of infringements for using garden bores during the reporting period.

### 6.2.4 Updating the 2009 *Gnangara areas groundwater allocation plan*

The 2009 *Gnangara groundwater areas allocation plan* was a strong first step in adjusting our groundwater management in a context of a drier climate. At the time, we identified that the plan would need review and further refinement to continue to adapt our management approach.

We are now preparing for the next allocation plan, with the aim to set levels of abstraction that match a drier climate to 2030. Developing the plan will involve environmental, social and economic assessment and continued consultation with key stakeholder groups during the planning process.

Our key stakeholders have been working with us for many years to face the challenge of adapting water use to a drier climate and growing population. The Water Corporation, horticultural industry and a number of local and state government agencies will be strong partners in the next Gnangara allocation plan.

We will begin more focused stakeholder engagement towards the second half of 2015–16 and aim to release the plan for public comment in 2017.

### 6.2.5 Strategic Assessment of the Perth and Peel regions

The Western Australian Planning Commission's *Draft Perth and Peel@3.5million* (WAPC 2015) and sub-regional planning frameworks detail how we will accommodate 3.5 million people in the Perth and Peel regions. The *Perth and Peel Green Growth Plan for 3.5 million: Draft Strategic Conservation Plan for the Perth and Peel Regions* (GGP) (DPC 2015) will complement this by streamlining the environmental approvals needed for future urban, industrial and infrastructure development and significantly reducing the costs of this development.

A significant part of the GGP for the Gnangara Mound has been the potential impacts of different scenarios of pine plantation management on groundwater levels, groundwater-dependent ecosystems and future groundwater availability. To do this the department used the Perth Regional Aquifer Modelling System (PRAMS) to simulate groundwater levels under various land use and climate scenarios.

Despite the GGP identifying that 5000 hectares of pines needs to be replanted in the Yanchep plantation as an important conservation measure for Carnaby's black cockatoo, the location will also minimise the impacts to a majority of Ministerial sites and groundwater users.

## 6.3 Research initiatives

The department, together with research partners, is completing a number of major projects that will help us develop the next Gnangara groundwater allocation plan and help focus management effort on the areas that will show the most benefit from changes to abstraction.

### 6.3.1 Perth Regional Aquifer Modelling System

The department recently updated the Perth Regional Aquifer Modelling System (PRAMS) and is using it to examine the interactions between climate, land use and groundwater abstraction for the next Gnangara allocation plan. The model has and will continue to be used to assess:

- scenarios for the *Perth and Peel Green Growth Plan for 3.5 million* (draft, DPC 2015)
- groundwater licence applications for the Integrated Water Supply Scheme

- scenarios for the Perth Regional Confined Aquifer Capacity project (section 6.3.3)
- future scenarios that will be used to develop the next Gnangara allocation plan.

### 6.3.2 Future climate tool

The department has developed a future climate tool that helps us better consider rainfall in our drying climate. The peer-reviewed tool was built using global climate models that perform well in Western Australia. It ensures that we use robust, up-to-date and defensible climate science in our decision making. An internal report outlining how we developed the climate tool has been completed – *Selection of future climate projections for Western Australia* (DoW 2015b). We are using the climate tool in PRAMS modelling to develop the next Gnangara allocation plan.

### 6.3.3 Perth Regional Confined Aquifer Capacity project

The department began the four-year Perth Regional Confined Aquifer Capacity (PRCAC) project in 2012. The project is investigating the best locations and depth for sustainable abstraction from the Leederville and Yarragadee aquifers and for groundwater replenishment (managed aquifer recharge). The $7 million project will make sure that decisions about abstraction from the deep, mostly confined aquifers are based on robust, transparent science and collaboration with key stakeholders.

The project combines conventional hydrogeological investigations, innovative science from partnerships with leading research institutions, and ongoing collaboration with the Water Corporation. The project will help identify whether additional abstraction from these deeper aquifers is a viable water source option for public water supply into the future. Of particular interest is how managed aquifer recharge could be used to maximise abstraction from these aquifers while protecting groundwater-dependent ecosystems and managing seawater intrusion.

As part of the PRCAC project, we initiated a study to improve our understanding of the relative influence of different types of groundwater abstraction (public water supply, private and supplementation) on declining lake and groundwater levels at Lake Nowergup. An important component of the study is to assess the effects of pumping from the Leederville aquifer on the Superficial aquifer at the lake. The outcomes of this and other work will also inform the next Gnangara allocation plan.

## 6.4 Consultation

The department regularly engages with the community through public seminars, conferences, workshops and community meetings. We also work with peak bodies and horticulturalists in the Carabooda and Wanneroo areas on water use efficiency and licensing.

To minimise the impacts on groundwater-dependent ecosystems, the department provides advice to local and state government agencies on water supply, including water for public open space, and on development proposals as required. For example, the department has provided significant input to the *Perth and Peel Green Growth Plan for 3.5 million* (draft, DPC 2015) during the reporting period.

The department also uses the framework described in *Better urban water management* (WAPC 2008) to provide advice to local government authorities and other land development agencies on water management in urban areas to minimise the effects of drainage and stormwater on shallow groundwater in the plan area. The *Better urban water management* framework sets out how water resources should be considered at each planning stage by identifying the various actions and investigations required to support decisions at each level of planning.

Our level of engagement has recently increased as we move forward with developing the next Gnangara allocation plan.

# Appendices

# Appendix A — Water level monitoring results for Ministerial sites on the Gnangara Mound for 2000–2015

Bold text refers to compliance with water level criteria and other criteria, with **black bold text** for compliant sites and **red bold text** for non-compliant sites.

*Table A 1 Wetland sites*

| Wetland | AWRC reference number | Water level criteria (mAHD) | | | | Water level (mAHD) | | | | | | | | | | | | | | Comments on compliance during the triennial reporting period (1 July 2012 – 30 June 2015) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Spring peak | | End of summer minimum | | | | | | | | | | | | | | | | |
| | | Pref | Abs | Pref | Abs | | 2000–01 | 2001–02 | 2002–03 | 2003–04 | 2004–05 | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | 2012–13 | 2013–14 | 2014–15 | |
| Lake Goollelal | 6162517 | | | 26.2* | 26.0 | Max | 27.5 | 27.4 | 27.4 | 27.5 | 27.4 | 27.6 | 27.3 | 27.2 | 27.4 | 27.4 | 27.2 | 27.1 | 27.2 | 27.3 | 27.2 | Compliance:<br>**Compliant with absolute summer minimum and other criteria.** |
| | | | | | | Min | 26.7 | 26.7 | 26.6 | 26.6 | 26.6 | 26.8 | 26.6 | 26.5 | 26.7 | 26.6 | 26.4 | 26.5 | 26.5 | 26.5 | 26.6 | |
| **Loch McNess** | 6162564 | | | | 6.95 | Max | 7.10 | 7.06 | 7.05 | 7.05 | 7.03 | 7.04 | 7.02 | 6.94 | 6.85 | 6.80 | 6.64 | 6.43 | 6.40 | 6.39 | 6.25 | Compliance and trends:<br>**Non-compliant with absolute summer minimum criterion.**<br>The lake has been non-compliant since 2002–03 and lake levels have fallen rapidly since 2006. The staff gauge at the lake is now dry.<br><br>Management and mitigation:<br>Work completed as part of the Perth shallow groundwater systems investigation found that a groundwater level of 5.27 mAHD at bore BH-LM2 (AWRC ref. 61640108) would meet the minimum groundwater requirements of wetland vegetation. The department is using levels at BH-LM2 to better relate groundwater levels to the ecological condition of vegetation at Loch McNess. The minimum groundwater level at the bore did not meet the minimum groundwater requirement of wetland vegetation over the reporting period.<br>Clusters of bores were also installed on the north western and eastern sides of the lake to improve the department's understanding of the lake's hydrogeology. Detailed findings and recommendations from the investigation can be found in the Loch McNess report (DoW 2011a).<br>Building on this work, the department recently completed a study into the cause of rapidly declining levels in Loch McNess. This study improved our understanding of the hydrogeology of the lake and surrounding areas, including the Yanchep caves nearby. Based on the findings of the study the department has:<br>• reduced Superficial aquifer abstraction in Yanchep National Park<br>• ceased the Yanchep caves supplementation trial<br>• reduced public supply abstraction from the Leederville aquifer in the Pinjar bore field.<br>The department has recently updated allocation limits in the Superficial aquifer along the North West urban growth corridor, considering compliance and ecological condition at Loch McNess. |
| | | | | | | Min | 6.97 | 6.96 | **6.90** | **6.92** | **6.93** | **6.91** | **6.74** | **6.63** | **6.61** | **6.45** | **6.25** | **6.17** | **6.10** | **6.25** | **6.25#** | |
| **Lake Yonderup** | 6162565 | | | | 5.9 | Max | 6.0 | 6.0 | 5.9 | 6.0 | 6.0 | 5.9 | 6.0 | 5.9 | 5.9 | 5.9 | 5.9 | 5.9 | 5.8 | 5.8 | 5.8 | Compliance and trends:<br>**Non-compliant with absolute summer minimum criterion.**<br>The lake has been non-compliant since 2007–08 and lake levels have fallen since 1998, with the rate of decline increasing since 2006. The minimum level in 2013–14 was the lowest on record. There was some recovery in 2014–15. |

| Wetland | AWRC reference number | Water level criteria (mAHD) | | | | Water level (mAHD) | | | | | | | | | | | | | | Comments on compliance during the triennial reporting period (1 July 2012 – 30 June 2015) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Spring peak | | End of summer minimum | | | | | | | | | | | | | | | | |
| | | Pref | Abs | Pref | Abs | | 2000–01 | 2001–02 | 2002–03 | 2003–04 | 2004–05 | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | 2012–13 | 2013–14 | 2014–15 | |
| | | | | | | Min | 5.9 | 5.9 | 5.9 | 5.9 | 5.9 | 5.9 | 5.9 | **5.8** | **5.8** | **5.8** | **5.7** | **5.7** | **5.6** | **5.6** | **5.6** | Management and mitigation:<br>Work completed as part of the Perth shallow groundwater systems investigation found that a groundwater level of 5.48 mAHD at bore YDP_SC (AWRC ref. 61611840) would meet the minimum groundwater requirements of wetland vegetation (DoW 2011b). The minimum groundwater level at this bore did not meet the minimum groundwater requirement of wetland vegetation over the reporting period.<br>The department is using levels at YDP_SC to better relate groundwater levels to the ecological condition of vegetation at the lake. In response to declines at the lake we reviewed the distribution of the Water Corporation's licences for 2013–14 and made changes to further reduce the impacts of abstraction at the site.<br>The department has recently updated allocation limits in the Superficial aquifer along the North West urban growth corridor, considering compliance and ecological condition at Lake Yonderup. |
| **Lake Joondalup** | 6162572 (Staff 8281) | | | 16.2* | 15.8 | Max | 17.0 | 17.0 | 16.9 | 17.0 | 16.8 | 17.1 | 16.9 | 16.8 | 17.0 | 17.0 | 16.8 | 16.8 | 16.8 | 17.1 | 17.0 | Compliance and trends:<br>**Compliant with absolute summer minimum criterion.**<br>**Non-compliant with other criterion.**<br>The lake has been non-compliant since 1998–99. Lake levels have been relatively stable since 1998 and the minimum level in 2014–15 was above the preferred minimum for the first time since 2005–06.<br>The staff gauge dries at around 16.0 mAHD and cannot be used to determine compliance with the absolute summer minimum criteria when lake levels fall below this level. The monitoring bore, which is located 100 m up-gradient of the lake, may also be inappropriate for determining compliance with criteria levels.<br><br>Management and mitigation:<br>Work completed as part of the Perth shallow groundwater systems investigation found that groundwater levels at bore JP20C (AWRC ref. 61610629) more closely reflect trends in lake levels than the current criteria bore and that this bore should be used to measure water level criteria. The minimum groundwater level at this bore increased over the reporting period.<br>The department will consult with the OEPA on amending the bore used to measure the water level criteria at this site to JP20C, as part of the developing the next Gnangara allocation plan. |
| | | | | | | Min | 16.1 **4/6 yr** | 16.1 **4/6 yr** | 16.0 **4/6 yr** | 16.0 **4/6 yr** | 16.1 **4/6 yr** | 16.4 **4/6 yr** | 16.0 **4/6 yr** | 16.0 **4/6 yr** | 16.2 **4/6 yr** | 16.2 **4/6 yr** | 16.0 **4/6 yr** | 16.0 **4/6 yr** | 16.0 **4/6 yr** | 16.2 **4/6 yr** | 16.3 **4/6yr** | |
| | 61610661 (Bore 8281) | | | | | Max | 18.7 | 18.6 | 18.6 | 18.6 | 18.5 | 18.8 | 18.5 | 18.5 | 18.7 | 18.9 | 18.7 | 18.6 | 18.6 | 19.0 | 18.9 | |
| | | | | | | Min | 17.7 | 17.9 | 17.8 | 17.8 | 17.8 | 18.1 | 17.8 | 17.9 | 18.1 | 18.3 | 17.9 | 18.0 | 18.0 | 18.2 | 18.3 | |
| **Lake Mariginiup** | 6162577 (Staff 1943) | 42.1* | 41.5 | | | Max | 41.9 | 41.8 | 41.7 | 41.8 | 41.5 | 41.7 | **41.4** | **41.4** | 41.5 | 41.5 | **41.3** | **41.2** | **41.1** | **41.3** | **41.3** | Compliance and trends:<br>**Non-compliant with absolute spring peak criterion.**<br>Water levels have not reached the preferred spring peak since 1994 and have not reached the absolute minimum spring peak since 2005.<br>Peak levels in 2013–14 and 2014–15 were higher than in the two previous years.<br>**Non-compliant with other criterion.**<br><br>Management and mitigation:<br>Work completed as part of the Perth shallow groundwater systems investigation found that:<br>• bore MS10 (AWRC ref. 61610685) should be used to measure water level criteria when the lake is dry using a revised level of 41.1 mAHD<br>• the newly installed bore MGP_C (AWRC ref. 61611440) should be |
| | | | | | | Min | 41.3 **4/6 yr** | 41.3 **4/6 yr** | 41.3 **4/6 yr** | 41.2 **4/6 yr** | 41.3 **4/6 yr** | 41.3 **4/6 yr** | 41.3 **4/6 yr** | 41.2 **4/6 yr** | 41.2 **4/6 yr** | 41.3 **4/6 yr** | 41.1 **4/6 yr** | 41.0 **4/6 yr** | 41.0 **4/6 yr** | 41.0 **4/6 yr** | 41.0 **4/6 yr** | |
| | 61610685 (Bore MS10) | | | | | Max | 41.5 | 41.4 | 41.3 | 41.4 | 41.1 | 41.3 | 41.1 | 41.0 | 41.3 | 41.1 | 40.8 | 40.9 | 40.8 | 41.0 | 41.2 | |

| Wetland | AWRC reference number | Water level criteria (mAHD) | | | | Water level (mAHD) | | | | | | | | | | | | | | Comments on compliance during the triennial reporting period (1 July 2012 – 30 June 2015) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Spring peak | | End of summer minimum | | | 2000–01 | 2001–02 | 2002–03 | 2003–04 | 2004–05 | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | 2012–13 | 2013–14 | 2014–15 | |
| | | Pref | Abs | Pref | Abs | | | | | | | | | | | | | | | | | |
| | | | | | | Min | 40.5 | 40.5 | 40.5 | 40.4 | 40.3 | 40.4 | 40.0 | 40.2 | 40.2 | 40.2 | 40.0 | 40.1 | 40.1 | 40.1 | 40.2 | used to relate changes in the watertable to wetland vegetation condition.<br>Detailed findings and recommendations from the investigation can be found in Searle et al. (2010).<br>We are using MGP_C to better relate groundwater levels to the condition of wetland vegetation. Minimum levels at bores MS10 and MGP_C improved marginally in 2013–14 and 2014–15. As part of developing the next Gnangara allocation plan, the department will consult with the OEPA to amend the water level criteria at this site by considering findings from Searle et al. (2010). |
| **Lake Jandabup** | 6162578 (Staff 1944) | 44.7* | 44.2 | | 44.3 | Max | 44.9 | 44.9 | 44.8 | 44.9 | 44.7 | 45.0 | 44.6 | 44.7 | 44.8 | 44.8 | 44.5 | 44.7 | 44.6 | 44.7 | 44.7 | Compliance and trends:<br>**Non-compliant with absolute summer minimum criterion.**<br>The Water Corporation artificially maintains lake levels to try to meet the absolute spring peak water level criterion and to prevent the lake from acidifying. Although non-compliant since 2009–10, levels have been relatively stable and the artificial maintenance has been relatively successful in preventing it from acidifying.<br><br>Management and mitigation:<br>Work completed as part of the Perth shallow groundwater systems investigation found that bore JB12B (61610764) should be used to relate groundwater levels to the ecological condition of vegetation on the transect. The minimum levels at JB12B were relatively stable over the reporting period. |
| | | | | | | Min | 44.3 | 44.3 | **44.2** | **44.2** | 44.3 | 44.4 | **44.2** | **44.1** | 44.3 | **44.2** | **44.1** | **44.2** | **44.1** | **44.2** | **44.2** | |
| **Lake Nowergup** | 6162567 (Staff) | 17.0* | 16.8 | | | Max | **16.6** | 17.0 | **16.6 4/6 yr** | **16.3 4/6 yr** | **16.4 4/6 yr** | **16.7 4/6 yr** | 16.8 **4/6 yr** | 17.2 **4/6 yr** | **16.5 4/6 yr** | **16.5 4/6 yr** | **16.2 4/6 yr** | **16.1 4/6 yr** | **16.0 4/6 yr** | **16.0 4/6yr** | **16.0 4/6yr** | Compliance and trends:<br>**Non-compliant with absolute spring peak criterion.**<br>Lake levels have been non-compliant in most years since 1996 despite the lake being artificially maintained by the department.<br>**Non-compliant with other criterion.**<br><br>Management and mitigation:<br>From work completed as part of the Perth shallow groundwater systems investigation, Searle, Hammond and Bathols (2010) recommends to:<br>• continue the artificial maintenance regime<br>• revise the spring peak criterion to 16.2 mAHD, which should be done gradually from the 2009 peak of 16.5 mAHD<br>• use groundwater levels at bore LN2-89 (AWRC ref. 61611247) to relate changes in the watertable to wetland vegetation condition. |

| Wetland | AWRC reference number | Water level criteria (mAHD) | | | | Water level (mAHD) | | | | | | | | | | | | | | Comments on compliance during the triennial reporting period (1 July 2012 – 30 June 2015) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Spring peak | | End of summer minimum | | | | | | | | | | | | | | | | |
| | | Pref | Abs | Pref | Abs | | 2000–01 | 2001–02 | 2002–03 | 2003–04 | 2004–05 | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | 2012–13 | 2013–14 | 2014–15 | |
| | | | | | | Min | 15.9 | 16.0 | 16.0 | 16.0 | 16.0 | 16.3 | 16.1 | 16.5 | 16.2 | 16.0 | 16.0 | 15.9 | 16.0 | 16.0 | 16.0 | Despite continued artificial maintenance, lake levels have fallen in recent years. In response, we reviewed how the Water Corporation's licences for 2013–14 and 2014–15 are distributed and made changes that aim to further reduce abstraction impacts at the site.<br>As part of developing the next Gnangara allocation plan, the department will consult with the OEPA to amend water level criteria at this site. We are using bore LN2-89 to better relate groundwater levels to condition of wetland vegetation. The minimum levels at bore LN2-89 have been declining since 2009 but have stabilised over the reporting period.<br>The department recently updated allocation limits in the Superficial aquifer along the North West urban growth corridor, considering compliance and ecological condition at Lake Nowergup.<br>As part of the Perth Regional Confined Aquifer Capacity project, we are undertaking a study to better understand the relative influence of different groundwater abstraction (public supply, private and supplementation) on declining lake and groundwater levels at Lake Nowergup. |
| **Lake Wilgarup** | 6162623 (Staff) | 6.10 | 5.65 | 4.8 | 4.5 | Max | **6.00** | **6.00** | **6.00** | **6.00** | **6.00** | **6.00** | **6.00** | **6.00** | **6.00** | **6.00** | **6.00** | **6.00** | **6.00** | **6.00** | **6.00** | <u>Compliance and trends:</u><br>**Non-compliant with absolute spring peak criterion.**<br>The lake has been dry since 1998.<br>**Non-compliant with absolute summer minimum criterion.**<br>Groundwater levels have declined since 1998 and have been non-compliant with the absolute minimum criteria since 2006–07.<br><br><u>Management and mitigation:</u><br>The department recently updated allocation limits in the Superficial aquifer along the North West urban growth corridor, considering compliance and ecological condition at Lake Wilgarup. |
| | | | | | | Min | | | | | | | | | | | | | | | | |
| | 61618500 (Bore) | | | | | Max | 5.48 | 5.38 | 5.16 | 5.26 | 4.99 | 5.32 | 4.88 | 4.77 | 4.77 | 4.64 | 4.47 | 4.38 | 4.31 | 4.41 | 4.29 | |
| | | | | | | Min | 4.73 | 4.66 | 4.53 | 4.51 | 4.53 | 4.62 | **4.34** | **4.18** | **4.08** | **4.02** | **3.80** | **3.84** | **3.83** | **3.82** | **3.79** | |
| **Pipidinny Swamp** | 6162624 (Staff) | 2.70 | 2.40 | | 1.6 | Max | 2.8 | 2.8 | 2.4 | 2.7 | **2.2** | 2.9 | **2.3** | **2.1** | **2.1** | **2.0** | **2.0** | **1.6** | **1.8** | **2.2** | **1.9** | <u>Compliance and trends:</u><br>**Non-compliant with absolute summer minimum criterion.**<br>We could not confirm compliance with the absolute summer minimum criteria from 2004 to 2010 because levels below 2.0 mAHD could not be measured at the staff gauge at the swamp. In 2010, we fixed an extra staff gauge plate to measure to 1.0 mAHD and any non-compliance. The swamp was incorrectly reported as compliant in 2009–10 and 2010–11 in previous compliance reports because of this issue. The department has notified the OEPA of this error.<br>**Non-compliant with absolute spring peak criterion.**<br>Spring peak levels have been non-compliant since 2005–06.<br><br><u>Management and mitigation:</u><br>A new bore – PIP_C (AWRC ref. 61610764) – was installed as part of the Perth shallow groundwater system investigation (Searle 2009). Levels at this bore are well correlated with the staff gauge and can be used to measure compliance with absolute summer minimum criteria when the staff gauge dries. Levels have been relatively stable at the bore since it was installed in 2009.<br>The department has recently updated allocation limits in the Superficial aquifer along the North West urban growth corridor, considering compliance and ecological condition at the swamp. |
| | | | | | | Min | 1.7 | 2.0 | 1.8 | **1.5** | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | **1.3** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | |
| **Lexia 86 (GNM16)** | 61613215 | | | 47.3* | 47.0 | Max | 48.6 | 48.4 | 48.4 | 48.7 | 48.4 | 48.6 | 48.1 | 48.2 | 48.4 | 48.2 | 47.7 | 47.9 | 47.6 | 47.8 | 47.7 | <u>Compliance and trends:</u><br>**Compliant with absolute summer minimum.** |

| Wetland | AWRC reference number | Water level criteria (mAHD) | | | | Water level (mAHD) | | | | | | | | | | | | | | Comments on compliance during the triennial reporting period (1 July 2012 – 30 June 2015) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Spring peak | | End of summer minimum | | | | | | | | | | | | | | | | |
| | | Pref | Abs | Pref | Abs | | 2000–01 | 2001–02 | 2002–03 | 2003–04 | 2004–05 | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | 2012–13 | 2013–14 | 2014–15 | |
| | | | | | | Min | 47.5 | 47.5 | 47.5 | 47.5 | 47.4 | 47.6 | 47.4 | 47.4 | 47.3 | 47.3 | 47.1 | 47.2 | 47.0 | 47.0<br>**4/6yr** | 47.0<br>**4/6yr** | Water levels have declined since 2005 and are likely to be non-compliant with this criteria in the coming year.<br>**Non-compliant with other criterion.** |
| **Lexia 186 (GNM15)** | 61613214 | | | 47.5* | 47.2 | Max | 48.0 | 47.8 | 47.8 | 48.0 | 47.7 | 48.0 | 47.5 | 47.5 | 47.6 | 47.5 | 47.0 | 47.1 | 46.9 | 47.2 | 47.1 | Compliance and trends:<br>**Non-compliant with absolute summer minimum criterion.**<br>Water levels have been non-compliant with the absolute summer minimum water level criteria since 1997.<br>**Non-compliant with other criterion.**<br>Water levels have not reached the preferred summer minimum water level criteria since 1995.<br><br>Management and mitigation:<br>Work completed as part of the Perth shallow groundwater systems investigation found that poor water quality is potentially the most immediate threat to the wetland (DoW 2011c). |
| | | | | | | Min | **47.0**<br>**4/6 yr** | **47.0**<br>**4/6 yr** | **47.0**<br>**4/6 yr** | **47.1**<br>**4/6 yr** | **46.9**<br>**4/6 yr** | 47.2<br>**4/6 yr** | **46.8**<br>**4/6 yr** | **46.9**<br>**4/6 yr** | **46.8**<br>**4/6 yr** | **46.8**<br>**4/6 yr** | **46.5**<br>**4/6 yr** | **46.5**<br>**4/6 yr** | **46.5**<br>**4/6 yr** | **46.6**<br>**4/6yr** | **46.5**<br>**4/6yr** | |
| **Melaleuca Park EPP173** | 6162628 (Staff) | | | | 50.2 | Max | 51.1 | 51.0 | 51.0 | 51.1 | 51.0 | 51.1 | 51.0 | 51.1 | 51.0 | 51.0 | 50.5 | 50.7 | 50.6 | 50.9 | 50.7 | Compliance and trends:<br>**Non-compliant with absolute summer minimum criterion.**<br>Water levels have been non-compliant with absolute summer minimum criterion since1995.<br><br>Management and mitigation:<br>As part of the transition to 120 GL per year for the Integrated Water Supply Scheme in 2012–13, the department worked with the Water Corporation to reduce groundwater abstraction from the Superficial aquifer in bore fields located close to the crest of the Gnangara Mound. This aimed to reduce abstraction impacts at sites in the area, including Melaleuca Park EPP173. We also review public water supply abstraction annually, considering water level trends and criteria compliance. |
| | | | | | | Min | 50.4 | 50.4 | 50.4 | 50.4 | 50.4 | 50.4 | 50.4 | 50.4 | 50.4 | 50.4 | 50.4 | 50.4 | 50.4 | 50.4 | 50.4 | |
| | 61613213 (Bore GNM14) | | | | | Max | 51.0 | 50.6 | 50.5 | 50.9 | 50.4 | 50.9 | 50.3 | 50.7 | 50.9 | 50.5 | 49.5 | 50.0 | 49.7 | 50.3 | 50.1 | |
| | | | | | | Min | **49.0** | **49.1** | **49.1** | **49.1** | **49.0** | **49.2** | **48.9** | **49.1** | **48.9** | **48.9** | **48.6** | **48.8** | **48.7** | **48.8** | **48.7** | |
| **Melaleuca Park Dampland 78 (GNM31)** | 61613231 | | | 65.4* | 65.1 | Max | 66.5 | 66.1 | 66.0 | 66.1 | 65.9 | 66.1 | 65.9 | 66.0 | 66.0 | 65.9 | 65.5 | 65.3 | 65.2 | 65.3 | 65.2 | Compliance and trends:<br>**Non-compliant with absolute summer minimum criterion.**<br>The site was non-compliant with absolute minimum water level criteria in 2012–13 and 2014–15.<br>**Non-compliant with other criterion.**<br><br>Management and mitigation:<br>A cluster of bores were installed adjacent to GNM31 as part of the Perth shallow groundwater systems investigation (Searle 2009). |
| | | | | | | Min | 65.9 | 65.8 | 65.7 | 65.7 | 65.5 | 65.8 | 65.5 | 66.0 | 65.6 | 65.5 | 65.1 | 65.1 | **64.9** | 65.1<br>**4/6yr** | **64.9**[#]<br>**4/6yr** | |
| Egerton Spring (B25) | 61618607 | | | | 39.29 | Max | 39.82 | 39.66 | 39.58 | 39.81 | 39.83 | 40.00 | 39.7 | 40.03 | 40.22 | 40.15 | 40.01 | 40.05 | 40.04 | 40.17 | 40.12 | Compliance and trends:<br>**Compliant with absolute summer minimum criterion.**<br>Water levels have been compliant since 2003 and have risen over the past 10 years, probably in response to increased localised recharge associated with the surrounding urban development. |
| | | | | | | Min | 39.45 | 39.42 | **39.26** | 39.43 | 39.42 | 39.69 | 39.50 | 39.54 | 39.72 | 39.72 | 39.49 | 39.70 | 39.69 | 39.73 | 39.79 | |

* Water levels are allowed to fall between the preferred minimum and absolute minimum for two out of six years to replicate natural drying cycles.

[#] The minimum water level reported is the minimum water level recorded during the 2014–15 water year. As of June 2015, water levels were still declining.

Note: Pref means preferred water level. Abs means absolute water level.

*Table A 2 Terrestrial phreatophytic vegetation sites*

| Groundwater monitoring bore | AWRC reference number | End of summer absolute minimum (mAHD) | Water levels (mAHD) | | | | | | | | | | | | | | | Comments on compliance during the triennial reporting period (1 July 2012 – 30 June 2015) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2000–01 | 2001–02 | 2002–03 | 2003–04 | 2004–05 | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | 2012–13 | 2013–14 | 2014–15 | |
| MM16 | 61610835 | 38.8 | Max | 40.1 | 40.0 | 40.0 | 40.0 | 39.8 | 40.2 | 39.4 | 39.4 | 39.8 | 39.9 | 39.4 | 39.6 | 39.6 | 40.1 | 40.2 | Compliance:<br>**Compliant with absolute summer minimum criterion.**<br>Peak water levels in 2014–15 were the highest recorded since 2005–06 and minimum levels were the highest since 1994. Water levels have shown a rising trend since 2011. |
| | | | Min | 38.8 | 39.1 | 38.9 | 38.8 | 38.8 | 39.0 | **38.6** | 38.8 | 39.0 | 39.0 | **38.6** | 38.9 | 39.0 | 39.2 | 39.5 | |
| MM18 | 61610918 | 38.6 | Max | 40.4 | 40.2 | 39.6 | 39.8 | 39.8 | 40.0 | 39.4 | 39.3 | 40.0 | 39.8 | 39.3 | 39.5 | 39.6 | 39.9 | 40.0 | Compliance:<br>**Compliant with absolute summer minimum criterion.**<br>Water levels have shown a rising trend since 2011. |
| | | | Min | 39.2 | 39.2 | 38.7 | 39.0 | 38.9 | 39.1 | 38.6 | 38.8 | 39.0 | 39.0 | 38.7 | 38.9 | 39.0 | 38.6 | 39.2 | |
| **MM53** | 61610493 | 33.3 | Max | 34.5 | 34.3 | 34.2 | 34.4 | 34.3 | 34.4 | 33.8 | 33.9 | 34.1 | 33.9 | 33.3 | 33.8 | 33.6 | 34.0 | 34.0 | Compliance and trends:<br>**Non-compliant with absolute summer minimum criterion.**<br>Water levels have generally declined since 2005 but seem to have stabilised since 2011.<br><br>Management and mitigation:<br>As part of the transition to 120 GL per year for the Integrated Water Supply Scheme in 2012–13, the department worked with the Water Corporation to reduce groundwater abstraction from the Superficial aquifer from bores located close to Whiteman Park. This aimed to reduce abstraction impacts at sites in the area, including MM53. We also review public water supply abstraction annually, considering water level trends and criteria compliance. |
| | | | Min | 33.3 | 33.4 | 33.3 | 33.3 | **33.2** | 33.3 | **33.1** | **33.2** | **33.1** | **33.0** | **32.8** | **33.0** | **33.0** | **32.8** | **33.1** | |
| MM55B | 61610559 | 29.5 | Max | 31.1 | 30.9 | 30.7 | 31.1 | 30.8 | 30.9 | 30.3 | 30.6 | 31.0 | 30.8 | 30.1 | 30.3 | 30.3 | 30.5 | 30.5 | Compliance and trends:<br>**Compliant with absolute summer minimum criterion.**<br>Water levels have stabilised since 2011. In 2014–15 the site was compliant for the first time since 2005–06. |
| | | | Min | 29.6 | 29.6 | **29.4** | 29.5 | **29.4** | 29.5 | **29.4** | **29.4** | **29.4** | **29.3** | **29.0** | **29.3** | **29.2** | **29.2** | 29.7 | |
| **MM59B** | 61611025 | 36.3 | Max | 37.7 | 37.2 | 36.8 | 37.1 | 36.8 | 37.0 | 36.2 | 36.4 | 36.8 | 36.6 | 36.0 | 36.1 | 36.2 | 36.3 | 36.3 | Compliance and trends:<br>**Non-compliant with absolute summer minimum criterion.**<br>Water levels have generally declined since 2000 but seem to have stabilised since 2011. As of June 2015 water levels were still declining.<br><br>Management and mitigation:<br>As part of the transition to 120 GL per year for the Integrated Water Supply Scheme in 2012–13, the department worked with the Water Corporation to reduce groundwater abstraction from the Superficial aquifer from bores located close to Whiteman Park. This aimed to reduce abstraction impacts at sites in the area, including MM59B. We also review public water supply abstraction annually, considering water level trends and criteria compliance. |
| | | | Min | **36.2** | **36.2** | **35.9** | **36.0** | **35.9** | **35.8** | **35.6** | **35.8** | **35.8** | **35.7** | **35.3** | **35.5** | **35.5** | **35.5** | **# 35.6** | |
| MT3S | 61610745 | 43.0 | Max | 45.2 | 45.1 | 44.9 | 45.1 | 44.7 | 45.4 | 44.6 | 44.7 | 44.9 | 44.8 | 44.3 | 44.4 | 44.2 | 44.6 | 44.5 | Compliance and trends:<br>**Compliant with absolute summer minimum criterion.**<br>Water levels have generally declined since 1992 but seem to have stabilised since 2011. |
| | | | Min | 43.2 | 44.6 | 44.1 | 44.1 | 44.0 | 44.2 | 43.7 | 43.9 | 44.0 | 43.9 | 43.5 | 43.6 | 43.5 | 43.7 | 43.7 | |
| NR6C | 61610982 | 58.5 | Max | 60.7 | 60.2 | 60.0 | 60.2 | 59.8 | 60.2 | 59.7 | 59.7 | 60.0 | 60.1 | 59.9 | 59.7 | 59.3 | 59.7 | 59.5 | Compliance:<br>**Compliant with absolute summer minimum criterion.** |

| Groundwater monitoring bore | AWRC reference number | End of summer absolute minimum (mAHD) | Water levels (mAHD) | | | | | | | | | | | | | | | Comments on compliance during the triennial reporting period (1 July 2012 – 30 June 2015) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2000–01 | 2001–02 | 2002–03 | 2003–04 | 2004–05 | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | 2012–13 | 2013–14 | 2014–15 | |
| | | | Min | 59.6 | 59.5 | 59.3 | 59.4 | 59.3 | 59.4 | 59.1 | 59.1 | 59.2 | 59.4 | 58.9 | 59.0 | 58.7 | 58.9 | 59.0 | Water levels have generally declined since 1992 and the minimum level in 2012–13 was the lowest on record. Levels have slightly improved over the reporting period. |
| **PM9** | 61610804 | 56.3 | Max | 57.7 | 57.3 | 57.0 | 57.2 | 56.8 | 57.0 | 56.4 | 56.3 | 56.1 | 55.9 | 55.9 | 55.0 | 54.8 | 55.0 | 54.7 | Compliance and trends:<br>**Non-compliant with absolute summer minimum criterion.**<br>Water levels have declined since 1996 and were first non-compliant in 2006–07. In 2013–14 recharge occurred at this site for the first time in two years. Water levels were still declining as of June 2015.<br><br>Management and mitigation:<br>As part of the transition to 120 GL per year for the Integrated Water Supply Scheme in 2012–13, the department worked with the Water Corporation to reduce groundwater abstraction from the Superficial aquifer in bore fields located close to the crest of the Gnangara Mound. This aimed to reduce abstraction impacts at sites in the area, including PM9. We also review public water supply abstraction annually, considering water level trends and criteria compliance. |
| | | | Min | 57.1 | 56.9 | 56.5 | 56.5 | 56.4 | 56.3 | **56.0** | **55.8** | **55.6** | **55.4** | **54.9** | **54.8** | **54.4** | **54.3** | **54.1#** | |
| PM24 | 61610697 | 40.5 | Max | 43.1 | 42.9 | 42.6 | 43.1 | 43.0 | 43.1 | 42.4 | 42.7 | 43.0 | 42.5 | 42.1 | 42.4 | 42.0 | 42.1 | 42.3 | Compliance:<br>**Compliant with absolute summer minimum criterion.**<br>Water levels have generally declined since 1998 but seem to have stabilised since 2011. |
| | | | Min | 41.4 | 41.5 | 41.4 | 41.4 | 41.4 | 41.4 | 41.2 | 41.3 | 41.2 | 41.2 | 41.0 | 41.1 | 41.1 | 41.1 | 41.3 | |
| **WM1** | 61610833 | 55.7 | Max | 56.8 | 56.2 | 56.0 | 56.2 | 55.9 | 56.5 | 55.6 | 55.6 | 55.7 | 55.4 | 54.8 | 54.8 | 54.4 | 54.7 | 54.4 | Compliance and trends:<br>**Non-compliant with absolute summer minimum criterion.**<br>Water levels have been non-compliant since 2001–02 and have declined since 2005. Water levels were still declining as of June 2015.<br><br>Management and mitigation:<br>As part of the transition to 120 GL per year for the Integrated Water Supply Scheme in 2012–13, the department worked with the Water Corporation to reduce groundwater abstraction from the Superficial aquifer in bore fields located close to the crest of the Gnangara Mound. This aimed to reduce abstraction impacts at sites in the area, including WM1. We also review public water supply abstraction annually, considering water level trends and criteria compliance. |
| | | | Min | 55.7 | **55.5** | **55.3** | **55.4** | **55.2** | **55.4** | **55.0** | **55.0** | **54.9** | **54.8** | **54.4** | **54.3** | **54.1** | **54.2** | **54.1#** | |
| **WM2** | 61610908 | 66.5 | Max | 68.3 | 67.9 | 67.7 | 68.0 | 67.7 | 68.2 | 67.6 | 67.5 | 67.6 | 67.5 | 66.9 | 66.8 | 66.4 | 66.7 | 66.5 | Compliance and trends:<br>**Non-compliant with absolute summer minimum criterion.**<br>The site has been non-compliant with water level criteria since 2011–12. In 2013–14 recharge occurred at this site for the first time in two years. |

| Groundwater monitoring bore | AWRC reference number | End of summer absolute minimum (mAHD) | Water levels (mAHD) | | | | | | | | | | | | | | Comments on compliance during the triennial reporting period (1 July 2012 – 30 June 2015) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2000–01 | 2001–02 | 2002–03 | 2003–04 | 2004–05 | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | 2012–13 | 2013–14 | 2014–15 | |
| | | | Min | 67.5 | 67.5 | 67.2 | 67.3 | 67.2 | 67.5 | 67.1 | 67.0 | 66.9 | 66.9 | 66.5 | **66.4** | **66.1** | **66.2** | **66.1** | Management and mitigation:<br>As part of the transition to 120 GL per year for the Integrated Water Supply Scheme in 2012–13, the department worked with the Water Corporation to reduce groundwater abstraction from the Superficial aquifer in bore fields located close to the crest of the Gnangara Mound. This aimed to reduce abstraction impacts at sites in the area, including WM2. We also review public water supply abstraction annually, considering water level trends and criteria compliance. |
| **WM8** | 61610983 | 64.8 | Max | 66.2 | 65.8 | 65.8 | 66.0 | 65.6 | 66.0 | 65.5 | 65.4 | 65.5 | 65.4 | 65.5 | 64.9 | 64.7 | 65.0 | 64.8 | Compliance and trends:<br>**Non-compliant with absolute summer minimum criterion.**<br>Water levels have declined since 2005 and were non-compliant for the first time in 2010–11. In 2013–14 recharge occurred at this site for the first time in two years. Water levels were still declining as of June 2015. |
| | | | Min | 65.6 | 65.4 | 65.4 | 65.5 | 65.3 | 65.5 | 65.1 | 65.1 | 65.1 | 65.1 | **64.7** | **64.7** | **64.4** | **64.7** | **64.3#** | Management and mitigation:<br>As part of the transition to 120 GL per year for the Integrated Water Supply Scheme in 2012–13, the department worked with the Water Corporation to reduce groundwater abstraction from the Superficial aquifer in bore fields located close to the crest of the Gnangara Mound. This aimed to reduce abstraction impacts at sites in the area, including WM8. We also review public water supply abstraction annually, considering water level trends and criteria compliance. |
| MM12 | 61610989 | 42 | Max | 45 | 44 | 43 | 44 | 43 | 44 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | Compliance and trends:<br>**Compliant with absolute summer minimum criterion.**<br>Levels have risen since 2011. |
| | | | Min | 43 | 43 | 43 | 43 | 43 | 43 | 42 | 42 | 43 | 43 | 42 | 42 | 43 | 43 | 43 | |
| L30C | 61611010 | 47.2 | Max | 49.2 | 49.1 | 48.9 | 49.2 | 48.8 | 49.5 | 48.4 | 48.6 | 48.7 | 48.9 | 48.1 | 48.2 | 47.8 | 47.9 | 48.0 | Compliance:<br>**Compliant with absolute summer minimum criterion.**<br>Levels have generally fallen since 2005. Water levels were still declining as of June 2015. |
| | | | Min | 48.6 | 48.5 | 48.3 | 48.5 | 48.3 | 48.4 | 48.0 | 48.0 | 48.2 | 48.1 | 48.0 | 47.7 | 47.5 | 47.5 | 47.7# | |
| L110C | 61611011 | 55.7 | Max | 59.0 | 58.6 | 58.4 | 58.6 | 58.1 | 58.5 | 57.8 | 57.7 | 57.8 | 57.7 | | | | 57.4 | 57.6 | Compliance:<br>**Compliant with absolute summer minimum criterion.**<br>Levels have generally fallen since 1999. Minimum levels could not be measured at the Ministerial criteria bore between March 2010 and July 2013 because of a blockage. Water levels were still declining as of June 2015. |
| | | | Min | 58.1 | 58.0 | 57.7 | 57.8 | 57.6 | 57.7 | 57.3 | 57.2 | 57.5 | 57.5 | | | | 57.1 | 57.3# | |
| L220C | 61611018 | 52.2 | Max | 54.3 | 54.2 | 53.9 | 54.1 | 53.8 | 54.2 | 53.7 | 53.7 | 53.5 | 53.6 | 52.8 | 53.2 | 52.8 | 53.1 | 53.9 | Compliance:<br>**Compliant with absolute summer minimum criterion.**<br>Levels have generally fallen since 1991. Peak water levels in 2014–15 were the highest recorded since 2005. |
| | | | Min | 53.3 | 53.0 | 53.0 | 52.9 | 52.9 | 52.8 | 53.1 | 52.7 | 52.6 | 52.6 | 52.3 | 52.4 | 52.1 | 52.3 | 53.1 | |

# The minimum water level reported is the minimum water level recorded during the 2014–15 water year. As of June 2015, water levels were still declining.

Note: Observed water levels have been rounded to the same number of decimal places as shown in Table 1 and 2 on Ministerial Statement No. 819.

# Appendix B — Audit tables: Environmental conditions, procedures and commitments for the Gnangara groundwater resources

Proponent: Department of Water

Period: 1 July 2011 to 30 June 2015

*Table B 1 Ministerial conditions and procedures*

| Audit code | Subject | Action | How | Evidence | Require-ment of | On advice from | Phase | When/ Where | Status |
|---|---|---|---|---|---|---|---|---|---|
| **819: M 1-1** | Implementation | 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. | Implement proposals given in EPA Bulletin 1155 and *Ministerial Statement No. 819*. | Compliance report | Minister for the Environment | | Overall | | **Partly compliant.** Partly compliant with most Ministerial conditions – refer to the 'status' column of this table. Further amendments are likely to be proposed in the next Gnangara groundwater allocation plan. |
| **819: M 2-1** | Proponent commitments | The proponent shall implement the environmental management commitments, as revised in May 2009, and documented in schedule 1 of Statement No. 819, to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority (EPA). | Implement commitments given in Schedule 1 of EPA Bulletin 1324 and *Ministerial Statement No. 819*. | Compliance report | Minister for the Environment | EPA | Overall | | **Partly compliant.** Compliant with most proponent commitments – refer to the 'status' column of this table. |
| **819: M 3-1** | Proponent nomination and contact details | 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 proposal 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 proposal. | Adhere to conditions, procedures and commitments given in EPA Bulletin 1324 and *Ministerial Statement No. 819*. Maintain responsibility for implementation of proposal. | Letter notifying the Chief Executive Officer of the Office of the Environmental Protection Authority (OEPA) of any change in proponent details. Compliance report. | Minister for the Environment | EPA | Overall | | **N/A at this time.** |
| **819: M 3-2** | Proponent nomination and contact details | 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 proposal 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 proposal shall also be provided. | Follow procedure given in 'action'. | Letter notifying the Chief Executive Officer of the OEPA of any change in proponent details. | Minister for the Environment | | Overall | | **N/A at this time.** |
| **819: M 3-3** | Proponent nomination and contact details | The nominated proponent shall notify the Chief Executive Officer of the OEPA of any change of contact name and address within 60 days of such change. | Follow procedure given in 'action'. | Letter notifying the Chief Executive Officer of the OEPA of any change in proponent details. | CEO | | Overall | 60 days of change | **N/A at this time.** |
| **819: M 4-1 1** | Compliance audit and performance review | The proponent shall prepare an audit program and submit compliance reports to the Chief Executive Officer of the OEPA which address:<br>1. evidence of compliance with the conditions and commitments. | Detail in annual/triennial reports. Compliance report will include:<br>evidence of compliance with the conditions and commitments. | Audit program | CEO | | Overall | Annually | **Compliant.** Summarised in sections 5 and 6 of this report and the 'status' column of this table. |

| Audit code | Subject | Action | How | Evidence | Require-ment of | On advice from | Phase | When/ Where | Status |
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| **819: M 4-1 2** | Compliance audit and performance review | The proponent shall prepare an audit program and submit compliance reports to the Chief Executive Officer of the OEPA which address:<br>2. the performance of the environmental management plans and programs. | Detail in annual/triennial reports. Compliance report will include:<br>the performance of the environmental management plans and programs. | Compliance report | CEO | | | Annually | **Compliant.**<br>Environmental management plans and programs are ongoing and include:<br>1. The final *Gnangara groundwater areas allocation plan* was released in November 2009 (DoW 2009a). The plan has been evaluated regularly to assess whether objectives are being achieved. The second evaluation statement was recently completed (DoW 2015a). The statement evaluates the department's management of Gnangara groundwater resources against the Gnangara plan objectives between 2011–2014. The evaluation statement is available on the department's website.<br>2. Work has started on the next Gnangara groundwater allocation plan which will include new strategies to work towards meeting the following objectives:<br>• reduce the total volume of water abstracted from the Gnangara system towards a level that better reflects the recharge from rainfall under the drying climate<br>• protect groundwater-dependent ecosystems from impacts associated with abstraction. |
| **819: M 4-2 1** | Compliance audit and performance review | 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 Chief Executive Officer of the OEPA, which address:<br>1. compliance with the conditions. | The performance review will address:<br>compliance with the conditions. | Compliance report | CEO | | Overall | By 1 December each year and more detailed reports by 1 February every three years. | **Compliant.**<br>Refer to 819: M 4-1 2.<br>Compliance with conditions can found in the 'status' column of this table . |
| **819: M 4-2 2** | Compliance audit and performance review | 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 Chief Executive Officer of the OEPA, which address:<br>2. the achievement of environmental objectives set for the proposal. | The performance review will address:<br>the achievement of environmental objectives set for the proposal. | Compliance report | CEO | | Overall | By 1 December each year and more detailed reports by 1 February every three years. | **Compliant.**<br>Evidence of achievement of the objectives is given by the 'evidence' and 'status' columns of this table. |
| **819: M 4-2 3** | Compliance audit and performance review | 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 Chief Executive Officer of the OEPA, which address:<br>3. stakeholder and community consultation about environmental performance and the outcomes of that consultation, including a report of any on-going concerns being expressed. | The performance review will address:<br>stakeholder and community consultation about environmental performance and the outcomes of that consultation, including a report of any on-going concerns being expressed. | Compliance report | CEO | | Overall | By 1 December each year and more detailed reports by 1 February every three years. | **Compliant**<br>The final *Gnangara groundwater areas allocation plan* was released in November 2009. The accompanying *Gnangara groundwater areas allocation plan: statement of response* (DoW 2009b) sets out how we responded to issues raised by the public to finalise the plan and how we are working towards managing these issues in implementing the plan.<br>Gnangara plan evaluation statements were completed in 2013 and 2015 (DoW 2013b; DoW 2015a). These statements evaluate the department's management of Gnangara groundwater resources against the Gnangara plan objectives since its release. The evaluation statements are available on the department's website. |
| **819: M 4-2 4** | Compliance audit and performance review | 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 Chief Executive Officer of the OEPA, which address:<br>4. proposed environmental management over the next three years to comply with conditions and environmental objectives set for the proposal. | The performance review will address:<br>proposed environmental management over the next three years to comply with conditions and environmental objectives set for the proposal. | Compliance report | CEO | | Overall | By 1 December each year and more detailed reports by 1 February every three years. | **Compliant.**<br>Sections 6.2 and 6.3 describes the management actions and research initiatives the department is doing to limit impacts of abstraction on groundwater-dependent ecosystems. |

| Audit code | Subject | Action | How | Evidence | Require-ment of | On advice from | Phase | When/ Where | Status |
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| **819: M 4-3** | Compliance audit and performance review | The proponent shall make the reports required by condition 4-2 publicly available, to the requirements of the Chief Executive Officer of the OEPA. | Available on Department of Water's website. | Reports made available on the Department of Water's website. | CEO | | Overall | After OEPA acknowledg-ement letter being received.<br>Department of Water website. | **Compliant.**<br>The following Gnangara compliance reports have been formally audited or commented on by DEC or the OEPA and can be found on the department's website:<br>• 2003–06 triennial (DoW 2007)<br>• 2006–07 annual (DoW 2008a)<br>• 2006–09 triennial (DoW 2010a).<br>The following Gnangara compliance reports haven't been formally audited or commented on but can also be found on the department's website:<br>• 2007–08 annual (DoW 2009c)<br>• 2009–10 annual (DoW 2010b)<br>• 2010–11 annual (DoW 2011d)<br>• 2009–12 triennial (DoW 2013a)<br>• 2012–13 annual (DoW 2014a)<br>• 2013–14 annual (DoW 2014b). |
| **819: M 4-4** | Compliance audit and performance review | 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 Chief Executive Officer of the OEPA immediately it becomes evident to the proponent. | Report in regular summaries sent to the Chief Executive Officer of the OEPA. | Letter to the Chief Executive Officer of the OEPA reporting non compliances with water level and other criteria as required.<br>Compliance report. | CEO | | Overall | Immediately as it becomes evident. | **Compliant.**<br>The department reports regularly to the OEPA on non-compliance with criteria water levels and other criteria. |
| **819: M 5-1** | Management of the water resource | 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). | Base decision on the concept of sustainable yield of resources and maintenance of ecological systems in accordance with the State Conservation Strategy (1987).<br>Present relevant material in annual/triennial compliance reports. | Compliance report | Minister for the Environment | | Overall | | **Compliant.**<br>The department used the concept of sustainable yield and PRAMS modelling to calculate allocation limits for the *Gnangara groundwater areas allocation plan* (DoW 2009a). This plan provides the basis for water management decisions on the Gnangara Mound. The department recognises that sustainable yield has diminished because recharge has decreased since the plan was released. We will reassess allocation limits for Gnangara resources as part of the next Gnangara groundwater allocation plan. |

| Audit code | Subject | Action | How | Evidence | Require-ment of | On advice from | Phase | When/ Where | Status |
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| **819: M 5-2** | Management of the water resource | The proponent shall subject to review, every three years, 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 Department of Parks and Wildlife (DPaW) – formerly the Department of Environment and Conservation (DEC). | Present relevant material in annual/triennial reports.<br>Refer draft groundwater management planning reports to the OEPA and the DPaW for comment.<br>Make compliance reports publicly available (on the Department of Water's website). | Compliance report.<br>Draft groundwater management documents sent to DPaW/OEPA for comment.<br>Reports made available on Department of Water's website. | EPA | DPaW | Overall | Subject to regular review every three years. | **Compliant.**<br>The department's water licensing policies are the 'basis for groundwater management decisions'. We regularly review these policies, which is detailed in the policies (e.g. state-wide policies are reviewed every 5 years).<br>The *Gnangara groundwater areas allocation plan* provides the foundation for water allocation decisions on the Gnangara Mound. We have evaluated the Gnangara plan twice (DoW 2013b; DoW 2015a). These statements evaluate the department's management of Gnangara groundwater resources against the Gnangara plan objectives since its release. The evaluation statements are available on the department's website.<br>The draft *Gnangara sustainability strategy* (Government of Western Australia 2009b) shows how other factors (e.g. land uses) relate to water management decisions on the Gnangara Mound.<br>The following Gnangara compliance reports have been formally audited or commented on by DPaW or the OEPA and can be found on the department's website:<br>• 2003–06 triennial (DoW 2007)<br>• 2006–07 annual (DoW 2008a)<br>• 2006–09 triennial (DoW 2010a).<br>The following Gnangara compliance reports haven't been formally audited or commented on but can also be found on the department's website:<br>• 2007–08 annual (DoW 2009c)<br>• 2009–10 annual (DoW 2010b)<br>• 2010–11 annual (DoW 2011d)<br>• 2009–12 triennial (DoW 2013a)<br>• 2012–13 annual (DoW 2014a)<br>• 2013–14 annual (DoW 2014b). |
| **819: M 6-1** | Groundwater allocation | 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. | Licensed allocations not to exceed allocation limits for Groundwater Area sub-areas. | Compliance report | Minister for the Environment | | Overall | | **Compliant.**<br>As outlined in the *Gnangara groundwater areas allocation plan*, adding the Southern Seawater Desalination Plant to the Integrated Water Supply Scheme triggered a change in how we allocate groundwater for public water supply. In line with the plan, from 2012–13 the Water Corporation's baseline groundwater allocation from Gnangara and Jandakot for the Integrated Water Supply Scheme has been reduced from 145 GL to 120 GL per year (from existing infrastructure).<br>The Water Corporation is committed to achieving an average abstraction of 120 GL per year over the five year licence period from 2012–13 to 2016–17. The department works with the Water Corporation annually to distribute abstraction to limit impacts at groundwater-dependent ecosystems.<br>We will also review public water supply allocations in developing the next Gnangara allocation plan. |
| **819: M 7-1** | Groundwater-dependent ecosystems | The proponent shall ensure that the integrity of all groundwater-dependent ecosystems (GDE) 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 OEPA and the DPaW . | Comply with EPA Bulletin No. 1324 *and Ministerial Statement No. 819*.<br>Undertake a monitoring program to measure integrity of GDEs. | Compliance report | Minister for the Environment | EPA/ DPaW | Overall | | **Compliant.**<br>Section 6.1 and Appendix D describe the department's environmental monitoring program (in line with the commitments in *Ministerial Statement No. 819*). Sections 6.2 and 6.3 describe the management and research initiatives the department is doing to limit impacts of abstraction on groundwater-dependent ecosystems. |

| Audit code | Subject | Action | How | Evidence | Require-ment of | On advice from | Phase | When/ Where | Status |
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| **819: M 8-1** | Groundwater availability | The proponent shall widely publish by the end of October each year the limits on groundwater availability for the Gnangara Mound. | Detail limits on availability on the Department of Water's website. | Allocation limits made available on the Department of Water's website.<br>Current water availability figures can be obtained from Swan Avon regional office or through the department's water register: <www.water.wa.gov.au/ags/WaterRegister> | Minister for the Environment | | Overall | End of October each year | **Compliant.**<br>Current water availability figures are constantly changing. Up-to-date figures are available by contacting the Swan Avon regional office or through the department's water register: <www.water.wa.gov.au/maps-and-data/maps/water-register> |
| **819: M 8-2** | Groundwater availability | The proponent shall update annually the figures published according to the requirements of condition 8-1, with the 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. | Detail limits on availability relative to sustainable yield (allocation limits) published on the Department of Water's website. | Allocation limits made available on the Department of Water's website.<br>Current water availability figures can be obtained from Swan Avon regional office or through the department's water register: <www.water.wa.gov.au/ags/WaterRegister> | Minister for the Environment | | Overall | End of October each year | **Compliant.**<br>Current water availability figures are constantly changing. Up-to-date figures are available by contacting the Swan Avon regional office or through the department's water register: <www.water.wa.gov.au/maps-and-data/maps/water-register> |
| **819: M 9-1** | Water conservation | 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. | Engage in activity that supports water conservation. | Compliance report | Minister for the Environment | | Overall | | **Compliant.**<br>Consistent with the *State Water Plan* (DPC 2007), and after extensively consulting with the mining and irrigation industries and local government, the department developed and implements *Operational policy no. 1.2 – 'Policy on water conservation and efficiency plans'* (DoW 2009d).<br>The department's Water Recycling and Efficiency staff do projects to reduce water demand and achieve water conservation initiatives. These include implementing *Operational policy no. 1.2 – 'Policy on water conservation and efficiency plans'* (in particular by local government authorities), implementing the permanent winter sprinkler ban and implementing metering programs.<br>In 2013–14 the department finalised work with the City of Wanneroo and developers to reduce planned water use in the North West urban growth corridor and developed a water supply strategy (DoW 2014c).<br>Section 6.2 discusses the department's approach to allocating groundwater for public water supply and other initiatives that aim to reduce demand on the Gnangara groundwater resources and increase water use efficiency. |
| **819: M 10-1 1** | Research and monitoring | The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes:<br>1. clarification of the relationship between groundwater level and rainfall under conditions of declining long-term rainfall<br>to the requirements of the Minister for the Environment on advice of the OEPA and the DPaW. | Engage in research projects to address this issue, which includes:<br>clarification of the relationship between groundwater level and rainfall under conditions of declining long-term rainfall. | Compliance report | Minister for the Environment | EPA/ DPaW | Overall | | **Compliant.**<br>The department is using PRAMS modelling to examine the relationship between rainfall and groundwater levels in a drying climate. We have run a number of scenarios using future climate datasets (developed using the department's future climate tool), to examine the impact of the drying climate on groundwater levels. This work will inform our review of allocation limits as part of the next Gnangara allocation plan. |

| Audit code | Subject | Action | How | Evidence | Require-ment of | On advice from | Phase | When/ Where | Status |
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| **819: M 10-1 2** | Research and monitoring | The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes:<br>2. improvement in the understanding of the relationship between groundwater levels and vegetation, including plantations<br>to the requirements of the Minister for the Environment on advice of the EPA and the DPaW. | Engage in research projects to address this issue, which includes:<br>improvement in the understanding of the relationship between groundwater levels and vegetation, including plantations. | Compliance report | Minister for the Environment | EPA/ DPaW | Overall | | **Compliant.**<br>As part of the *Perth and Peel Green Growth Plan for 3.5 million* (draft, DPC 2015), the department has used the Perth Regional Aquifer Modelling System to simulate groundwater levels under various pines, land use and climate scenarios. The results are informing the plan, which was released for public comment in December 2015.<br>Through the Perth shallow groundwater system investigations we have improved our understanding of the interrelationships between wetlands and the Superficial aquifer and the complex, superimposed impacts of climate change, land use and abstraction. We are using the investigation's outcomes to better relate water levels to ecological condition at groundwater-dependent ecosystems.<br>Commissioned by the department, Dr Bea Sommer and Professor Ray Froend of Edith Cowan University developed a model for determining ecological risk to groundwater-dependent vegetation on the Gnangara Mound in a drying climate. The model is based on 30 years of ecological and hydrological monitoring data. It will be an important management tool for the department to assess the impact of future land and water use scenarios and to revise allocation limits for the next Gnangara allocation plan.<br>Several other studies have improved our understanding of the relationships between groundwater levels and vegetation, including:<br>• fire regimes on the Gnangara Mound – potential for water gain and impacts on biodiversity<br>• options and implications of continuing plantation forestry on the Gnangara Mound<br>• biodiversity values on the Gnangara Mound.<br>For further information, see sections 4.1.2 and 4.1.3 of the draft *Gnangara sustainability strategy* and the department's website. |
| **819: M 10-1 3** | Research and monitoring | The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes:<br>3. improvement in the understanding of the relationship between groundwater level and abstraction from unconfined and confined aquifers of the Gnangara Mound<br>to the requirements of the Minister for the Environment on advice of the EPA and the DPaW. | Engage in research projects to address this issue, which includes:<br>improvement in the understanding of the relationship between groundwater level and abstraction from unconfined and confined aquifers of the Gnangara Mound. | Compliance report | Minister for the Environment | EPA/ DPaW | Overall | | **Compliant.**<br>The department is using PRAMS modelling to improve the understanding of the relationship between groundwater levels and abstraction from unconfined and confined aquifers of the Gnangara system. Reductions to both public and private abstraction are being modelled to evaluate storage gains in the Superficial aquifer at 2030. These scenarios will inform an allocation limit review as part of the next Gnangara allocation plan.<br>The department began the four-year Perth Regional Confined Aquifer Capacity project in 2012. The project is investigating the best locations and depth for sustainable abstraction from the Leederville and Yarragadee aquifers and for groundwater replenishment (or managed aquifer recharge).<br>Perth shallow groundwater system investigations have improved the department's understanding of the interrelationships between wetlands and the Superficial aquifer and the complex, superimposed impacts of climate change, land use and abstraction. The department is using the investigation's outcomes to limit abstraction impacts on groundwater-dependent ecosystems. |

| Audit code | Subject | Action | How | Evidence | Require-ment of | On advice from | Phase | When/ Where | Status |
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| **819: M 10-1 4** | Research and monitoring | The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes:<br>4. clarification of the relationship between groundwater level and wetland water levels and wetland water quality<br>to the requirements of the Minister for the Environment on advice of the EPA and the DPaW. | Engage in research projects to address this issue, which includes:<br>clarification of the relationship between groundwater level and wetland water levels and wetland water quality. | Compliance report | Minister for the Environment | EPA/ DPaW | Overall | | **Compliant.**<br>The department has studied hydrogeology at a number of sites across the Gnangara Mound as part of the Perth shallow groundwater systems investigation. To date, ten reports have been completed and are available on the department's website. These reports examine relationships between wetland hydrogeology, chemistry and ecosystem function to provide a basis for improved management strategies that limit abstraction impacts.<br>Local area groundwater flow models have been constructed and used for scenario modelling for the following areas:<br>• *East Wanneroo integrated groundwater–-lake flow modelling: Predictive scenario modelling to support the draft Gnangara Sustainability Strategy* (Bourke 2009)<br>• *Local area model of groundwater flows and lake interactions: Lakes Mariginiup and Jandabup* (RPS 2009)<br>• *Development of local area groundwater models – Gnangara Mound, Lake Nowergup* (SKM 2009a)<br>• *Development of local area groundwater models – Gnangara Mound, Lexia Wetlands* (SKM 2009b).<br>These reports are available on the department's website. |
| **819: M 10-1 5** | Research and monitoring | The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes:<br>5. improvement in the understanding of the relationship between groundwater level and water levels in the Yanchep caves<br>to the requirements of the Minister for the Environment on advice of the EPA and the DPaW. | Engage in research projects to address this issue, which includes:<br>improvement in the understanding of the relationship between groundwater level and water levels in the Yanchep caves. | Compliance report | Minister for the Environment | EPA/ DPaW | Overall | | **Partly compliant.**<br>Water quality and macroinvertebrate monitoring in the Yanchep caves ceased in 2013–14 because of low water levels.<br>Building on the work of the shallow groundwater system investigation, the department recently completed a study on the cause of rapidly declining levels in Loch McNess in Yanchep National Park. This study improved our understanding of the hydrogeology of Loch McNess and surrounding areas, including the nearby caves. We continue to monitor groundwater levels in relation to cave levels and have made management changes that aim to improve levels in the caves (see section 6). |
| **819: M 10-1 6** | Research and monitoring | The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes:<br>6. improvement in understanding of the conservation value of wetland and other groundwater-dependent ecosystems on the Gnangara Mound<br>to the requirements of the Minister for the Environment on advice of the EPA the DPaW. | Engage in research projects to address this issue, which includes:<br>improvement in understanding of the conservation value of wetland and other groundwater-dependent ecosystems on the Gnangara Mound. | Compliance report | Minister for the Environment | EPA/ DPaW | Overall | | **Compliant.**<br>The conservation value of wetlands is a prime responsibility of DPaW. The Department of Water does research and monitoring to determine how conservation values are supported by groundwater and how abstraction can be managed to limit impacts on these values. |
| **819: M Proced-ure 1** | | Where a condition states "to the requirements of the Minister for the Environment on advice of the EPA", the EPA will prepare the written notice to the proponent. | The EPA to provide written notice to the proponent (Department of Water). | | Minister for the Environment | | Overall | | Not the responsibility of the Proponent (Department of Water). |
| **819: M Proced-ure 2** | | The EPA may seek advice from other agencies or organisations, as required, in order to provide its advice. | The EPA to seek advice as required. | | EPA | Other agencies as required. | Overall | | Not the responsibility of the Proponent (Department of Water). |
| **819: M Proced-ure 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 Chief Executive Officer of the OEPA. | Department of Water liaises with advisory body as required. | Liaison with advisory body in compliance report. | EPA | Agencies listed as part of compliance reporting. | Overall | | **Compliant.**<br>Refer to commitments:<br>• 2,4,6,8,21 = CALM/DPaW<br>• 21 = FPC.<br>Although specific feedback was not sought on each separate condition, advice on relevant issues was obtained as part of the comprehensive, interagency network that formed part of the draft *Gnangara Sustainability Strategy*.<br>Also, both the DEC and FPC made public submissions to the *Gnangara groundwater areas water management plan: draft for public comment* (DoW 2008b), which dealt with similar issues as the conditions. |

*Table B 2 The proponent's (Department of Water's) environmental management conditions*

| Audit code | Subject | Objective | Action | How | Evidence | Require-ment of | On advice from | Phase | When/ Where | Status |
|---|---|---|---|---|---|---|---|---|---|---|
| **819: P 1** | Gnangara Mound allocations | Sustainable use of groundwater from the Gnangara Mound (Superficial aquifer). | Manage public and private groundwater abstraction to meet objectives and Environmental Water Provisions (EWP) criteria presented in tables 1 and 2 (*Ministerial Statement No. 819*). | Meet objectives and EWPs criteria presented in tables 1 and 2 (*Ministerial Statement No. 819*). | Compliance report | Minister for the Environment | | Overall | | **Partly compliant.**<br>Refer to the results given in Appendix A – Water level monitoring results for Ministerial sites on the Gnangara Mound, 2000–2015. |
| **819: P 2** | Management objectives and Criteria | To provide for ongoing adaptive management. | Management objectives, criteria and water allocation limits will be regularly reviewed and amended as information becomes available to provide for ongoing adaptive management. | Regularly review management objectives, criteria and water allocation limits.<br>Best examined in triennial reports, which also review long-term trends (most recent triennial for Gnangara: 2006-09). | Compliance report | Minister for the Environment | DEC | Overall | | **Compliant.**<br>Gnangara plan evaluation statements were completed in 2013 and 2015 (DoW 2013b; DoW 2015a). These statements evaluate the department's management of Gnangara groundwater resources against the Gnangara plan objectives since its release. The evaluation statements are available on the department's website.<br>The most recent review of Ministerial conditions and commitments for the Gnangara mound are outlined in the 2007 *Review of Ministerial Conditions on the groundwater resources of the Gnangara Mound* (DoW 2008b) and confirmed in *Ministerial Statement No. 819*.<br>The department will review allocation limits of Gnangara resources for the next Gnangara allocation plan. |
| **819: P 3** | 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. | Interact with state and local agencies to coordinate land and water development activity to promote objective.<br>Incorporate water level and fauna monitoring of caves in Department of Water Gnangara Mound monitoring program. | Compliance report | Minister for the Environment | DEC | Overall | | **Partly compliant.**<br>Water levels in Yanchep caves have been declining for a number of years and most caves are now dry. Also, we can no longer gain access to a number of the caves above because of safety concerns. This informed the decision to discontinue macroinvertebrate and water quality monitoring at Yanchep caves. Monitoring of surrounding Superficial aquifer groundwater bores is ongoing.<br>Building on the work of the shallow groundwater system investigation, the department recently completed a study on the cause of rapidly declining levels in Loch McNess in Yanchep National Park. Working with DPaW, the department has reduced local abstraction in the Yanchep National Park and has also made changes to public water supply abstraction to limit impacts on the caves (see section 6). |
| **819: P 4** | Strategic drainage plans | To minimise environmental and/or significant impact. | Prepare strategic drainage plans for the study area including options for management of higher water levels in lakes Joondalup, Goollelal, Mariginiup, and Jandabup. | Prepare strategic drainage plans for the study area. | Compliance report | Minister for the Environment | | Overall | | **Compliant.**<br>In 2009 the department finalised the *Swan urban growth corridor drainage and water management plan* (DoW 2009e), which provides guidance on drainage management in the area.<br>See the department's website for more information. |

| Audit code | Subject | Objective | Action | How | Evidence | Require-ment of | On advice from | Phase | When/ Where | Status |
|---|---|---|---|---|---|---|---|---|---|---|
| **819: P 5 1** | Research and investigation program | Improving understanding of:<br>groundwater-environmental relationships on the Swan Coastal Plain;<br>the associated management requirements, and<br>potential management techniques. | 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:<br>• groundwater – environmental relationships on the Swan coastal plain;<br>• the associated management requirements, and<br>• potential management techniques;<br>and will incorporate all relevant aspects of research and investigation work currently committed to under Ministerial statements 438 and 496. | Prepare a research and investigation program. | Submit research and investigation program to the EPA for approval.<br>Compliance report. | EPA | DEC | Overall | Within four months of a revised statement being issued following the 2004 Stage 1 section 46 review | **Compliant.**<br>The department, together with research partners, is focussing management effort on the areas that will show the most benefit from changes to abstraction. This work will inform the next Gnangara allocation plan.<br>The department has updated the Perth Regional Aquifer Modelling System. The department began the four-year Perth Regional Confined Aquifer Capacity project in 2012. The project is investigating the best locations and depth for sustainable abstraction from the Leederville and Yarragadee aquifers and for groundwater replenishment (or managed aquifer recharge). The Perth shallow groundwater system investigation is complete, with ten reports available on the department's website. These studies improved our understanding of the interrelationships between wetlands and the Superficial aquifer and the complex, superimposed impacts of climate change, land use and abstraction.<br>For the next Gnangara allocation plan, we will use a tool developed by Edith Cowan University to assess the risk of impacts to groundwater-dependent vegetation under different water, land use and climate scenarios.<br>A previous research and investigation program was produced and submitted to the EPA on 21 December 2005. It was detailed in Appendix 7 of Gnangara Triennial report 2003–06 (DoW 2007). The audit of 2003–06 and 2006–07 compliance reports agreed that the commitment could be 'cleared' upon confirmation from the former DEC. |
| **819: P 5 2** | Research and investigation program | Administrative | Implement the research and investigation program to the satisfaction of the EPA. | Make part of annual Departmental work program. | Compliance report | EPA | DEC | Overall | | **Compliant.**<br>The department uses outcomes from the research and investigation program to develop management strategies based on scientific data and to promote the sustainable use of the groundwater resources of the Gnangara system. |
| **819: P 5 3** | Research and investigation program | To provide for ongoing up-to-date adaptive management. | Review and revise the program every six years (coinciding with triennial reports), to the satisfaction of the EPA. | Incorporate review in Triennial reporting in 6 year intervals. | Triennial compliance report | EPA | DEC | Overall | Every six years (coincide with triennial reports) | **Compliant.**<br>The department's research and investigation program is constantly evolving. The current program includes modelling of climate, land use and abstraction scenarios using the Perth Regional Aquifer Modelling System and the Perth Regional Confined Aquifer Capacity project. |
| **819: P 6 1** | Environmental monitoring program | To enable evaluation of the environmental impact of groundwater abstraction from the Gnangara Mound (Superficial aquifer). | 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:<br>• monitoring of groundwater levels in all relevant aquifer systems;<br>• relevant wetland water levels and water quality;<br>• condition of vegetation and fauna associated with groundwater-dependent ecosystems<br>• cave water levels. | Prepare an environmental monitoring program. | Submit monitoring program to the EPA for approval.<br>Compliance report. | EPA | DEC | Overall | Within four months of a revised statement being issued following the 2004 Stage 1 section 46 review | **Compliant.**<br>A letter was sent to the Director General of the former DEC in December 2009, seeking advice and input on amendments to the monitoring program. To date, no response has been received.<br>The previous environmental monitoring program was produced and submitted to the EPA on 21 December 2005. It was detailed in Appendix 7 of the Gnangara triennial report 2003–06 (DoW 2007). The audit of 2006–07 compliance report agreed commitment could be 'cleared' upon confirmation from the former DEC.<br>Although this requirement has been satisfied technically (the monitoring program was prepared), the department does not seek a 'clearance' of this commitment as the program is constantly evolving and being modified. |
| **819: P 6 2** | Environmental monitoring program | Administrative | Implement the approved environmental monitoring plan to the satisfaction of the EPA. | Make part of annual departmental work program. | Compliance report | EPA | DEC | Overall | | **Compliant.**<br>(see P 6 1) |

| Audit code | Subject | Objective | Action | How | Evidence | Require-ment of | On advice from | Phase | When/ Where | Status |
|---|---|---|---|---|---|---|---|---|---|---|
| **819: P 6 3** | Environmental monitoring program | To provide for ongoing up-to-date adaptive management. | Review and revise the program every six years (coinciding with triennial reports), to the satisfaction of the EPA. | Incorporate review in Triennial reporting in 6 year intervals. | Triennial compliance report | EPA | DEC | Overall | Every six years (coincide with triennial report) | **Compliant.**<br>A review of the environmental monitoring program was completed in June 2009 with the ecologists who do the monitoring. We made a number of amendments. A letter was sent to the Director General of the former DEC in December 2009, seeking advice and input on the amendments. To date, no response has been received.<br>Although the action states that a review must be compiled in triennial reports every 6 years, the ecological monitoring program undergoes regular revisions as required. Recent revisions were made in 2010 and 2013 – see Appendix D.<br>The department will review environmental objectives and monitoring as part of developing the next Gnangara allocation plan. |
| **819: P 7** | Development advice | Integrated land and water resource planning for enhanced water resource management. | Continue to provide advice to the City of Wanneroo, the Department for Planning and Infrastructure, DEC and other relevant agencies on the impact of land use on groundwater resources. | Liaise with the City of Wanneroo, the Department for Planning and Infrastructure, DEC and other relevant agencies. | Compliance report | Minister for the Environment | City of Wanneroo, Department for Planning, DEC and other relevant agencies | Overall | | **Compliant.**<br>The department assesses land use proposals with potential water resource issues that are referred to it from local and state government agencies. |
| **819: P 8** | Gnangara inter-agency technical advisory group | Integrated land and water resource planning for enhanced water resource management. | 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. | Provide executive duties for the Gnangara Coordinating Committee.<br>Provide executive duties for the Gnangara Consultative Committee (see P 9). | Compliance report.<br>See P 9. | Minister for the Environment | | Overall | | **Compliant.**<br>(See P 9) |
| **819: P 9** | Community consultation | Useful forum for information exchange and advice. | Continue to chair and provide support for the Gnangara Consultative Committee as an ongoing forum for information exchange and advice. | Chair and provide support for the Gnangara Consultative Committee. | Compliance report | Minister for the Environment | | Overall | | **Partly compliant.**<br>While there is no formal Gnangara Consultative Committee, the department continues to consult with a range of stakeholders on Gnangara as required.<br>There will be focused consultation to develop the next Gnangara allocation plan. |
| **819: P 10** | Vegetation protection | Limit environmental impact – tree deaths. | Limit potential for tree deaths around production wells to 100 metres radius for normal (average) climate conditions and within 200 metres to extreme conditions. | Considered in the Water Corporation operating strategy. | Compliance report | Minister for the Environment | | Overall | | **Compliant.**<br>The department has classified the sensitivity of each public water supply bore based on proximity to environmentally sensitive areas. We use these classifications to distribute public supply abstraction to limit the impacts at groundwater-dependent ecosystems. In 2012–13 the department reviewed the classifications of each bore and amended bore quotas to limit the impacts of abstraction on groundwater-dependent vegetation. |
| **819: P 11** | Lake Nowergup supplementation | Protect environmental values. | Should EWPs in Lake Nowergup not be met by November, artificial supplementation will be used until the EWP is reached. | Operate Lake Nowergup artificial maintenance facility if EWPs not met by end of November until EWP is reached. | Compliance report | Minister for the Environment | | Overall | | **Non-compliant.**<br>Supplementation occurs at Lake Nowergup though water levels continue to be non-compliant. |
| **819: P 12** | Reporting | Assessment of environmental impact(s) from groundwater abstraction for public water supply. | 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. | Water Corporation to submit annual production summary and report on compliance with environmental commitments defined in operating strategy. | Compliance report | Minister for the Environment | | Overall | | **Compliant.**<br>The department requires and reviews annual bore abstraction plans from the Water Corporation to ensure that abstraction was distributed to limit impacts on groundwater-dependent ecosystems. The Water Corporation also submits annual water monitoring summaries that report on compliance with environmental commitments made in the operating strategy. |

| Audit code | Subject | Objective | Action | How | Evidence | Require-ment of | On advice from | Phase | When/ Where | Status |
|---|---|---|---|---|---|---|---|---|---|---|
| **819: P 13** | 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. | Review monitoring program and recommend construction of additional monitoring wells as required. | Compliance report | Minister for the Environment | | Overall | | **Cleared.**<br>A similar commitment from previous statement 438: P 2 was stated as 'cleared' by the former Department of Environmental Protection's Environmental Audit Branch on 28/10/1997 (refer to Appendix 7 of the Gnangara 2000–03 triennial compliance report). However, the department is continuing work in this area.<br>The department completed a management area review (McHugh and Bourke 2007) that summarised the current monitoring and management issues facing particular wetlands on the Gnangara and Jandakot groundwater mounds and identified the information and data required to address these issues. The review recommended sites to be included in the Perth shallow groundwater systems investigation, prioritised based on ecological significance, management issues and geomorphic setting. As part of the investigation, we redesigned and upgraded existing monitoring infrastructure and installed new monitoring networks at ecologically important sites. |
| **819: P 14** | East Gnangara wetlands | Offset environmental impact with environmental benefit. | Require the Water Corporation to implement its 2001 wetland mitigation strategy and subsequent approved revision and report to the DoW on implementation. | Require information in the Water Corporation annual production summary and report on compliance with environmental commitments defined in operating strategy. | Compliance report | Minister for the Environment | | Overall | Prior to the commiss-ioning of the Lexia scheme | **Partly compliant.**<br>The department has discussed this issue with the Water Corporation. Consistent with the study on biodiversity values on the Mound (as part of the draft *Gnangara sustainability strategy*) and other investigations outlined in the status against commitment 819: P 5 1, the department and the Water Corporation have agreed to review and develop an environmental benefit program to offset the impacts seen on wetlands in the next phase of planning for the Gnangara Mound. |

# Appendix C — History of Ministerial statements for the Gnangara Mound

The importance of managing abstraction from the Gnangara Mound to protect groundwater-dependent ecosystems was formally recognised in the late 1980s. The Environmental Protection Authority (EPA) set the first conditions on Gnangara groundwater abstraction in 1986 when the *Gnangara Mound water resources environmental review and management program* was released (WAWA 1986). The conditions included Ministerial water level criteria based on environmental knowledge at the time. These were considered reasonable by the former Water Authority of WA to maintain key elements of the environment. These Ministerial criteria accounted for expected groundwater abstraction for the region, expected land use changes and historical rainfall variations.

In 1995, the WAWA reviewed Ministerial water level criteria (WAWA 1995). The review highlighted that climate was an important factor affecting groundwater levels, and the difficulty of predicting future groundwater levels given the uncertainty of future climatic conditions.

In 2001, in response to land-use changes and lower rainfall, the EPA endorsed a two-stage approach to review the Ministerial conditions and commitments for the Gnangara and Jandakot mounds under section 46 of the *Environmental Protection Act, 1986*. The first stage was for the Department of Water (former Department of Environment) to review Ministerial conditions and commitments on Gnangara and Jandakot based on existing knowledge (DoE 2005). This review led to *Statement No.687* for Gnangara (Government of Western Australia 2005a) and *Statement No. 688* for Jandakot (Government of Western Australia 2005b).

In 2007, the Department of Water conducted a further review of Ministerial conditions and commitments on Gnangara (DoW 2008c). The purpose of this review was to refine Ministerial criteria to the sites with significant ecological value and where abstraction is the main factor influencing groundwater levels. This review led to *EPA Bulletin 1324* in May 2009, with recommendations to the Minister for Environment on the proposed changes. *Statement No.819* (Government of Western Australia 2009a) for Gnangara was released later that year containing the consolidated and refined conditions and commitments.

The second stage of the Section 46 review was proposed as a more comprehensive review to improve management of public and private abstraction and to incorporate ecological information from work underway at the time. This work has been overtaken by more recent investigations into the shallow groundwater systems and ecological responses to climate. We will use this work to focus management effort on areas that will show the most benefit from changes to abstraction. The intent of the stage two review will be covered by the next Gnangara groundwater allocation plan, which is expected to be released for public comment in 2017.

# Appendix D — Review of environmental monitoring program (819: P 6 3)

In mid 2009, the department started a series of workshops to review monitoring in collaboration with our consultant ecologists. The workshops aimed to improve both the effectiveness and efficiency of the monitoring program. Our review of the monitoring program:

- refocused the program on the relationships between groundwater levels, ecological condition and abstraction
- improved efficiency by reducing the monitoring frequency from annually to every three years, unless annual monitoring is warranted on a management or information-needs basis
- improved the presentation and communication of monitoring data.

In a second review workshop, held in late April 2010, we considered two key issues:

- how monitoring results could be presented spatially to represent short-term and long-term trends across an entire groundwater management area
- how modelling results could be used to make sure the monitoring effort is focussed on the correct areas in the long-term.

There were three main outcomes and recommendations of this second workshop:

- Future monitoring programs should include sites where ecological health and compliance can be improved through managing abstraction (based on modelling).
- The department can make a difference to important areas on the Gnangara Mound by managing abstraction – even minor benefits to groundwater levels can be significant for certain groundwater-dependent ecosystems.
- Where possible, abstraction should be reduced in areas where it would benefit wetlands that still retain some of their key environmental values.

Another review was held in 2013 to further refine the frequency of the monitoring program. The monitoring program will be reviewed again as part of the next Gnangara allocation plan.

# Appendix E — Map information and disclaimer

## 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: M. Hammond

Map Author: T. Fardon

Task ID: 0012

Filepath: J:\gisprojects\Project\C_series\C2207\0004\plt

Filename: 151127_Gnangara_GWA_WCorp_MCrit.pdf

Compilation date: November 2015

## Disclaimer

This map is a product of the Department of Water, Water Allocation Planning Branch and was printed in November 2015.

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.

## Sources

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Western Australia Towns – DLI – 12/07/2001

WA Coastline, WRC (Poly) – DoW – 13/10/2000

Hydrography, Linear (Hierarchy) – DoW – 05/11/2007

RIWI Act, Groundwater Areas – DoW – 06/03/2008

WIN Groundwater Sites – Water Corporation – DoW – 10/2009

WIN Sites – Ministerial Criteria Sites (2005) – DoW – 10/2009

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