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Department of **Water and Environmental Regulation**

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Environmental management of groundwater from the Gnangara Mound groundwater resources

Annual compliance assessment report July 2019–June 2020

December 2020

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Summary

This report describes the Department of Water and Environmental Regulation's compliance with Ministerial conditions and commitments under *Ministerial statement no. 819 – Gnangara Mound groundwater resources [including East Gnangara Shire of Swan]* for the period 1 July 2019 to 30 June 2020 under Part IV of the *Environmental Protection Act 1986* (Government of Western Australia 2009).

The report presents total licensed groundwater entitlements covered by the *Gnangara groundwater areas allocation plan* (DoW 2009a) from all aquifers of the Gnangara groundwater system (Figure 1, Table 1). The report also outlines environmental monitoring, management, research and consultation by the department to manage abstraction from the Gnangara groundwater system.

Many of these strategies are detailed in the *Gnangara groundwater areas allocation plan* (DoW 2009a). The development of the 2009 plan was a key step towards adapting to climate change as it reduced the amount of water available for abstraction, both for public water supply and private use, and it flagged that allocation limits would likely be further reduced in the next allocation plan.

In October 2019 the Government released the *Waterwise Perth Action Plan*, committing to a target of a 10 per cent reduction in groundwater use across the greater Perth area by 2030. The next Gnangara groundwater allocation plan is currently being developed and it will outline further strategies towards achieving the targets in the Action Plan and improving the ecological outcomes for key sites that have been affected by declining groundwater levels.

The number of sites across the Gnangara plan area that were non-compliant with absolute minimum or peak water level criteria in *Ministerial statement no. 819* increased from 12 in 2018–19 to 14 in 2019–20. One site was incorrectly reported as being non-compliant with absolute summer minimum water levels in 2018–19 due to a water level reporting error. Although non-compliances increased, this is lower than the 18 non compliances recorded in 2015-16.

Rainfall at Perth Airport BoM station over the reporting period was 562 mm, below the long-term (75 years) average of 760 mm and the short-term average (10 years) of 652 mm (Figure 3). The low rainfall contributed to the decrease in compliance over the period (Table 1).

Public water supply entitlements for the Integrated Water Supply Scheme (IWSS) from all aquifers remained similar to the previous year, with 111.59 GL licensed in 2019–20. We continued to work with Water Corporation to distribute groundwater abstraction for public water supply in response to groundwater level trends and to move abstraction away from non-compliant sites (Table 1).

In 2019–20, 13.30 GL was licensed from the Gnangara system as part of Stage 1 of Water Corporation's groundwater replenishment scheme and 12.74 GL was injected and 9.42 GL abstracted (Table 1).

Private licensed entitlements across the Gnangara Superficial aquifer were slightly less than in 2018–19 (Table 1).

Table 1 Rainfall, licensing totals from all aquifers and compliance summary

	2018–19	**2019–20**
Rainfall[1]	662.0 mm	561.8 mm
Public water supply entitlements (IWSS baseline licences, Town of Woodridge and Moore River South development)[2]	111.47 GL	111.59 GL
Public water supply entitlements (IWSS groundwater replenishment)	13.30 GL	13.30 GL
Injected (actual)	*3.45 GL*	*12.74 GL*
Abstracted (actual)	*1.24 GL*	*9.42 GL*
Private licensed entitlements	131.59 GL	127.86 GL
Estimated stock and domestic garden bore use[3]	36.00 GL	36.00 GL
No. of non-compliant sites with absolute minimum or peak water level criteria[4]	12 out of 30[5]	14 out of 30

1 Rainfall figures are for July to June (water year) and are measured at Perth Airport (BoM site no. 9021).

2 In 2019-20 this consists of 110.77 GL licensed to Water Corporation for the IWSS (including 0.83 GL for bore MR17), 0.13 GL for Woodbridge town supply and 0.69 GL for the Moore River Scheme development.

3 Stock and domestic garden bore use is from the Superficial aquifer only and is estimated using data collected through surveys, data from the Australian Bureau of Statistics and records of household use from the Water Corporation.

4 For full details of compliance see Table 4 and Appendix A.

5 Melaleuca Park Dampland 78 was incorrectly reported as being non-compliant with absolute summer minimum water levels in 2018–19 due to a water level reporting error. The correct number of sites non-compliant with absolute minimum water level criteria in 2018–19 was 12 out of 30.

1 Background

1.1 Ministerial statement no. 819

Ministerial statement no. 819: Gnangara Mound groundwater resources (Government of Western Australia 2009) establishes the environmental conditions and commitments associated with the allocation of groundwater from the Gnangara groundwater resources north of Perth for public and private use. As the proponent, the Department of Water and Environmental Regulation (the department) must comply with and report on the conditions to the Environmental Protection Authority each year.

Some of the key conditions in *Statement no. 819* are environmental water provisions set as water level criteria at 30 representative sites across the Gnangara groundwater resources – 14 wetland sites and 16 terrestrial phreatophytic vegetation sites (Figure 1). Phreatophytic vegetation uses groundwater to meet at least part of its water needs. On the Swan Coastal Plain, native vegetation that occurs within 10.5 m depth to groundwater is considered likely to be phreatophytic.

The conditions and commitments on Gnangara groundwater resources were first established in 1988 under Part IV of the *Environmental Protection Act 1986* to manage how groundwater was abstracted for public water supply and private licensed use. Since then, the conditions and commitments have been revised several times to include additional criteria sites or to remove sites where environmental values have been lost due to causes other than abstraction (Appendix C). These causes include reduced rainfall due to climate change, land clearing and disturbance related to changing land use.

The most recent revision in 2008 resulted in the removal of seven sites and amended water level criteria at three sites. The water level criteria at the current 30 sites have been developed to protect the important environmental values of groundwater-dependent ecosystems from significant impact caused by water use from the Gnangara system.

Since the merging of the Department of Water, Department of Environment Regulation and the Office of the Environmental Protection Authority in July 2017, the Department of Water and Environmental Regulation has become the proponent of *Ministerial statement no. 819.* To ensure there is no possible apprehension of bias, the Director General of the department is not involved in monitoring compliance with the Statement. The Executive Director, Compliance and Enforcement has been formally delegated to exercise the compliance duties under the *Environmental Protection Act 1986*.

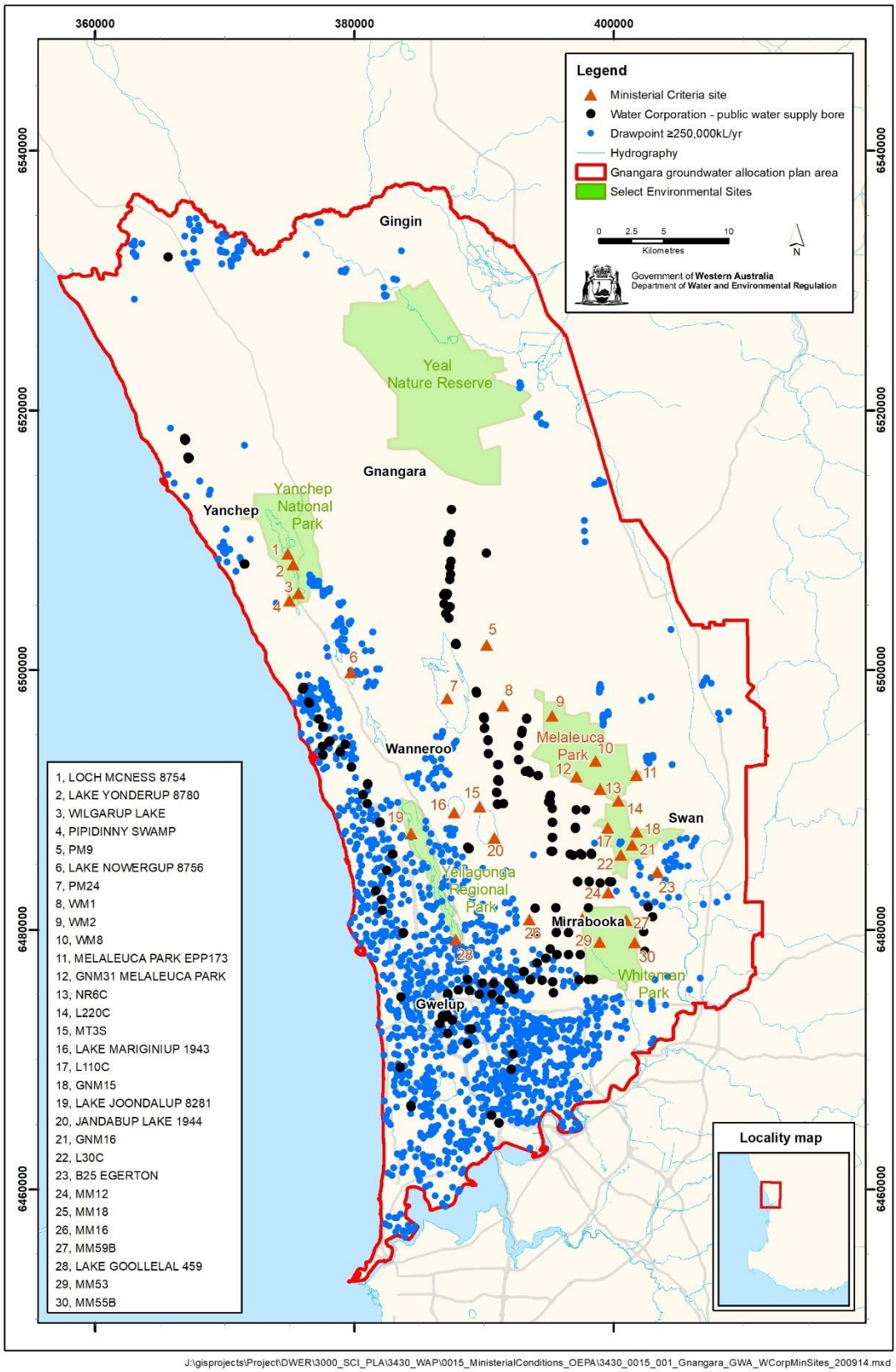

Figure 1 Location of Gnangara Ministerial sites, public water supply production bores and drawpoints of private licences with larger entitlements

1.2 The Gnangara groundwater system

The Gnangara groundwater system is located on the Swan Coastal Plain. It extends from the Swan River in the south to Moore River and Gingin Brook in the north, and from the coast to close to the Darling Scarp in the east. It covers an area of about 2,200 km^2 (Figure 2). The system comprises four main aquifers:

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

The Gnangara groundwater system is now over-allocated and overused. This has contributed to water level declines over the last 40 years, which have impacted on important wetlands and other groundwater-dependent ecosystems. Water level declines are the result of:

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

Environmental impacts to ecosystems from groundwater level decline can occur where those ecosystems are directly supported by the regional watertable. In the Gnangara area, the main watertable aquifer is the Superficial aquifer. Impacts can occur by pumping from the Superficial aquifer itself or through abstraction from deeper aquifers where they are directly or indirectly connected to the Superficial aquifer. Such connections exist in the northern half of the Gnangara plan area (Figure 2).

1.3 Allocation limits and licensing

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

Groundwater abstracted as part of a managed aquifer recharge scheme (including Water Corporation's Groundwater Replenishment Scheme – see section 3.1) is licensed, but accounted for outside the allocation limit as there is no net deficit from the groundwater resource.

Water for the environment is not included as part of the allocation limit, as it is left in the groundwater system to support non-consumptive benefits. The water level criteria set at high value wetland and bushland sites on the Gnangara groundwater system serve to restrict the amount of water that can be allocated from the system. This ensures there is sufficient water left in the system to meet environmental needs.

Allocation limits are set following comprehensive assessments of the state of the groundwater resource, hydrogeological capacity of the system and risks of abstraction to the resource, existing users and the environment. The department applies climate science, hydrogeological modelling and environmental assessments when setting and reviewing allocation limits. The department also uses science and monitoring along with licensing policy to manage licences.

Although domestic garden bores are exempt from licensing, they are still accounted for in setting allocation limits. They are managed by identifying areas unsuitable for their installation, through groundwater awareness and water use efficiency messaging targeted at domestic gardens, and through the winter sprinkler shut off and three day/week sprinkler roster.

Current allocation limits for the Gnangara groundwater resources are being reviewed as part of the development of the next Gnangara groundwater allocation plan. The plan will propose new strategies towards meeting the government's *Waterwise Perth Action Plan's* target of a 10 per cent reduction in groundwater use across the Perth region by 2030 (Government of Western Australia 2019).

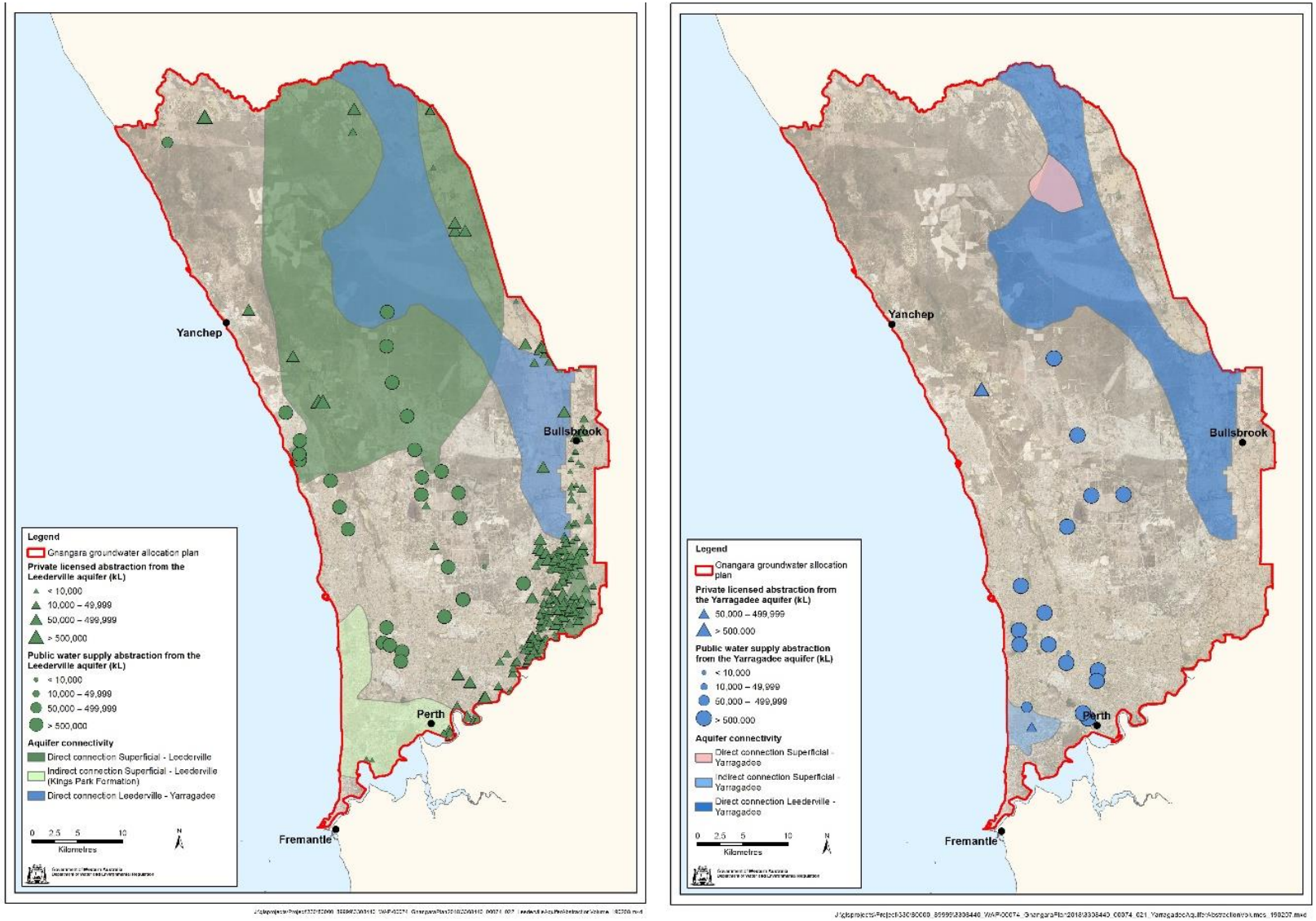

Figure 2 Groundwater connectivity of the Leederville (left) and Yarragadee (right) aquifers, with abstraction locations and volumes.

2 Rainfall

Groundwater is recharged by rainfall. How much groundwater levels rise and fall each year is affected by the amount of rainfall that falls in the catchment, but also by how it falls (timing, pattern and intensity). Recharge is also affected by temperature – warmer weather will increase evaporation and allow less rainfall to reach the aquifer.

The climate across south-west Western Australia is changing. There has been a general trend of declining annual rainfall since the mid-1970s. Average temperatures have also risen. CSIRO's climate change research (Bates et al. 2010), as well as relevant global climate change models, project continued rainfall reduction in the region.

Rainfall at Perth Airport BoM station over the reporting period was 562 mm, below the long-term (75 years) average of 760 mm and the short-term average (10 years) average of 652 mm (Figure 3).

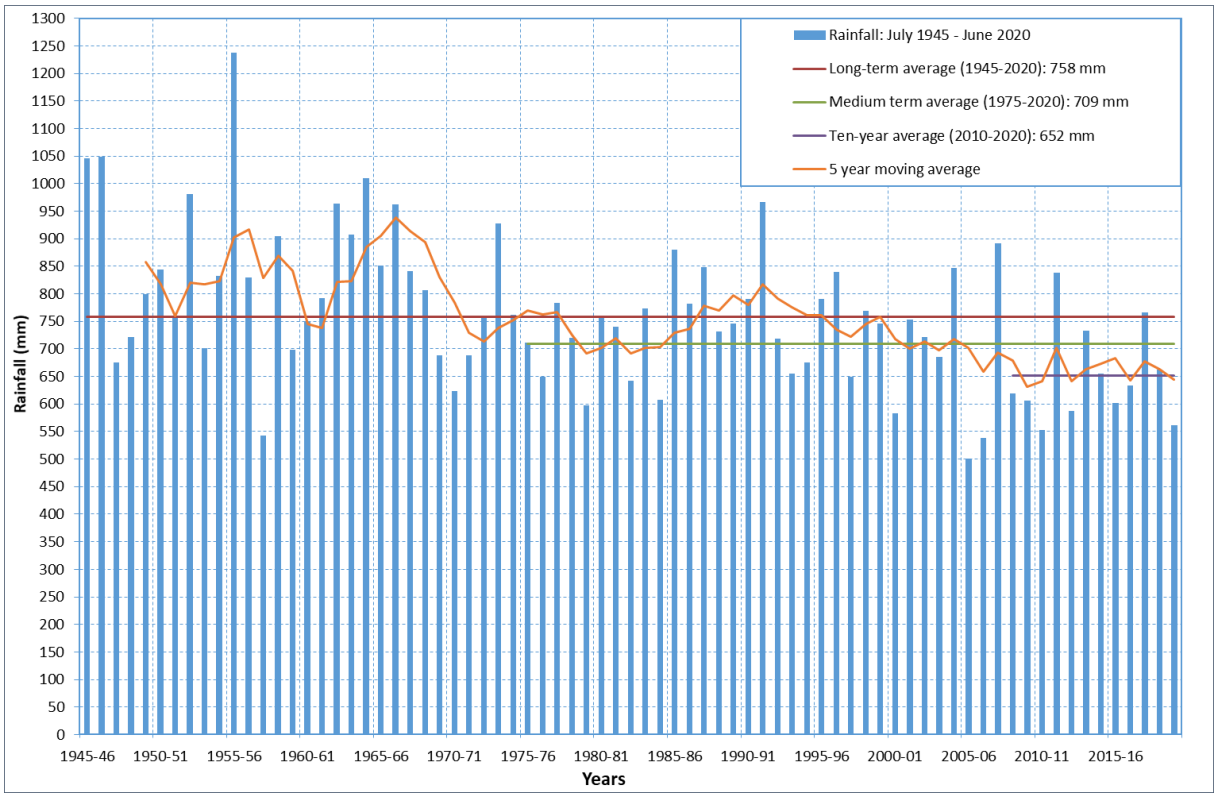

Figure 3 Annual and average water-year (July–June) rainfall at Perth Airport (BoM site no. 9021)

3 Groundwater use

The Gnangara groundwater system is the Perth region's largest source of easily accessible, low cost, good quality water. It provides almost half of Perth's public water supply. It also provides water for public open spaces, for local horticulture and viticulture, and for domestic garden bores.

This section summarises licensed entitlements and estimates of use that are exempt from licensing within the Gnangara allocation plan area.

3.1 Public water supply

The department licenses 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 (IWSS). Within the Gnangara system, there is also a small volume of groundwater licensed from the Leederville Aquifer for the Woodridge town water supply and for the Moore River South development. These volumes do not form part of the IWSS and are licensed separately.

The volume of groundwater licensed for public and town water supply from all aquifers was 111.59 GL over the 2019–20 reporting period. See Table 2 for the distribution of licences by aquifer.

We continue to work with Water Coporation to distribute public water supply abstraction in response to groundwater level trends, and to move abstraction away from sites where levels are non-compliant with water level criteria in Statement no. 819.

Groundwater replenishment scheme

The licensing of groundwater associated with Water Corporation's groundwater replenishment and recovery scheme (GWR) is managed outside the allocation limits set for the Gnangara system because water abstracted is balanced by water reinjected. Licensed volumes are reported separately from other volumes licensed for public water supply.

Groundwater replenishment is a form of managed aquifer recharge. At Beenyup Wastewater Treatment Plant in Craigie, water is treated to drinking standard and recharged (or injected) into the Leederville and Yarragadee aquifers onsite. An equivalent amount of water is then abstracted from aquifers across the Gnangara or Jandakot groundwater systems, and this is subject to a groundwater licence.

In 2019–20 13.30 GL was licensed from the Gnangara system as part of Stage 1 of Water Corporation's GWR scheme (see Table 2 for the distribution of licences by aquifer). Only 9.42 GL of the 13.30 GL licensed in 2019–20 was abstracted.

The groundwater abstracted or 'recovered' from the aquifer as part of Stage 1 of the Beenyup GWR scheme, is pumped from bores that are part of the existing IWSS

network. Abstraction locations are distributed to limit overall impacts to groundwater-dependent ecosystems supported by the Gnangara groundwater system.

Construction of Stage 2 of the GWR scheme was completed in 2019, with commissioning and testing continuing through 2020. Stage 2 injection of treated wastewater into the Leederville and Yarragadee aquifers will occur further north, in Wanneroo and Neerabup. This location will provide broader benefits to groundwater-dependent ecosystems, including wetlands, as there is greater connection between the deep and Superficial aquifers in this area. This was one of the major reasons why this injection location was chosen for Stage 2 of the scheme.

New Leederville and Yarragadee production bores will be constructed in the Whitfords, Quinns and Gwelup borefields to ensure that abstraction of groundwater for Stage 2 of the GWR scheme does not affect wetlands or other groundwater-dependent ecosystems. Once commissioning and testing of Stage 2 of the GWR scheme is complete the overall scheme capacity will increase to 28 GL.

3.2 Private licensed use

Groundwater licensed for private use from the Gnangara system mostly comes from the Superficial aquifer. It is mainly used for the purposes of irrigation of public open spaces, agriculture, industry and commercial uses.

Private licensed entitlements have remained relatively steady since the department implemented the *Gnangara groundwater areas allocation plan* (DoW 2009a), which capped private entitlements in most subareas (Tables 2 and 3). The reduction between 2018–19 and 2019–20 is due to the expiry of short term licences associated with development activities like dewatering and dust suppression.

3.3 Use that is exempt from licensing

The department estimates and accounts for groundwater that is exempt from licensing. The main types of exempt water use from Gnangara are garden bores used in urban areas and stock and domestic bores used in rural areas where there is often no scheme water connection. In 2014 we estimated that a total of 36 GL/year was abstracted from about 65,000 garden bores and 4,000 stock and domestic bores.

There is good information on the number of garden bores in urban areas across Perth. This includes data from on-the-ground surveys by Water Corporation, surveys by the Australian Bureau of Statistics in 2003, 2006 and 2009, and independent phone surveys conducted in 2012, 2016 and 2018.

Average water use per bore was estimated from the department's domestic bore metering project which operated from 2009–2012 and was updated in 2016. Department estimates on exempt use are updated over time as we get new data on rates of instalment and average water use per bore in urban and rural areas. Under the *Waterwise Action Plan* the Department is working with Water Corproation to improve ways of measuring and estimating garden bore usage.

Table 2 Licensed and garden bore water entitlements from all aquifers in the Gnangara groundwater system

Aquifer	Public water supply entitlements[1] (GL)								Private licensed entitlements (GL)		Garden and stock/ domestic bore use exempt from licensing (GL) (estimated)	
	Baseline licences (IWSS + Town of Woodridge + Moore River South)[2]		Groundwater replenishment (GWR)									
			Entitlements[5]		Injected[6]		Abstracted[7]					
	2018–19	2019–20	2018–19	2019–20	2018–19	2019–20	2018–19	2019–20	2018–19	2019–20	2018–19	2019–20
Superficial	30.95	32.05	1.00	1.00	-	-	-	0.69	116.19	112.13	36.00	36.00
Mirrabooka[3]	1.60	3.50	0.80	0.80	-	-	-	0.55	3.08	2.50	-	-
Leederville	33.82	32.02	8.45	8.45	2.65	9.59	1.24	5.84	11.64	11.57	-	-
Yarragadee[4]	45.10	44.02	3.05	3.05	0.80	3.15	-	2.34	0.68	1.55	-	-
Fractured rock	0.00	0.00	0.00	0.00	-	-	-	-	0.09	0.10	-	-
Total	**111.47**	**111.59**	**13.30**	**13.30**	**3.45**	**12.74**	**1.24**	**9.42**	**131.59**	**127.86**	**36.00**	**36.00**

1 Public water supply volumes include groundwater licensed to Water Corporation for the IWSS and Woodridge town water supply and the Moore River South development.

2 For the 2019–20 reporting period the IWSS baseline licence from the Gnangara groundwater system (including bore MR17) was110.77 GL. The Woodbridge town water supply entitlement is 0.13 GL (Leederville) and the Moore River South development entitlement is 0.69 GL (Leederville).

3 Mirrabooka and fractured rock aquifer volumes, previously reported together, have been separated out in compliance assessment reports.

4 For the 2019–20 reporting period Yarragadee public water supply entitlement volumes include 0.83 GL bore MR17 which is located outside of the Gnangara plan boundary in the Perth South Groundwater Area.

5 0.3 GL of the 13.30 GL licensed for groundwater replenishment is licensed from bore MR17.

6 Water is injected into the Leederville and Yarragadee aquifers via four bores.

7 Of the 13.30 GL licensed for groundwater replenishment 9.42 GL was abstracted abstracted by Water Corporation during the 2019–20 reporting period. This includes water abstracted from MR17.

1 GL = 1 000 000 kL. Figures have been rounded to two decimal places.

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

Groundwater area	Subarea	Ministerial criteria site present?	Public water supply entitlements[1] (GL)				Private licensed entitlements[2] (GL)	
			Baseline licences (IWSS + Town of Woodridge)		Groundwater replenishment		2018–19	2019–20
			2018–19	2019–20	2018–19	2019–20		
Gingin	Beermullah Plain South	No	-	-	-	-	3.13	3.13
	Deepwater Lagoon South	No	-	-	-	-	2.97	2.53
	Guilderton South	No	0.03	-	-	-	9.79	9.59
	Lake Mungala	No	-	-	-	-	2.87	2.70
Total for Gingin Groundwater Area			**0.03**	**0.00**	**0.00**	**0.00**	**18.72**	**17.95**
Gnangara	Reserve	Yes	0.65	0.65	-	-	1.55	1.57
	Wanneroo Wellfield	Yes	6.10	6.10	-	-	2.41	2.15
Total for Gnangara Groundwater Area			**6.75**	**6.75**	**0.00**	**0.00**	**3.96**	**3.72**
Gwelup	Gwelup	No	3.20	3.30	-	-	1.10	1.10
Total for Gwelup Groundwater Area			**3.20**	**3.30**	**0.00**	**0.00**	**1.10**	**1.10**
Mirrabooka	Ballajura	No	1.80	2.00	0.05	0.05	1.20	0.89
	Beechboro	No	-	-	-	-	0.34	0.29
	Henley Brook	No	0.50	0.50	-	-	0.25	0.23
	Improvement Plan 8	No	1.05	1.55	-	-	0.66	0.12
	Landsdale	Yes	-	-	-	-	0.48	0.45
	Plantation	No	-	-	-	-	0.36	0.36
	State Forest	No	-	-	-	-	1.30	1.00
	Whiteman Park	Yes	0.15	0.10	-	-	1.21	1.40
Total for Mirrabooka Groundwater Area			**3.50**	**4.15**	**0.05**	**0.05**	**5.82**	**4.74**
Perth	City of Bayswater	No	-	-	-	-	2.26	3.17
	City of Fremantle North	No	-	-	-	-	0.05	0.05
	City of Nedlands	No	-	-	-	-	2.33	1.58
	City of Perth	No	-	-	-	-	1.85	1.57
	City of Stirling	No	2.70	2.80	0.30	0.30	7.98	7.83
	City of Subiaco	No	-	-	-	-	0.99	0.87
	Eglinton	No	-	-	-	-	2.79	3.46
	Quinns	No	10.65	11.05	0.25	0.25	2.96	3.09
	Shire of Peppermint Grove	No	-	-	-	-	0.08	0.08
	Shire of Swan North	No	-	-	-	-	1.52	0.61
	Town of Bassendean	No	-	-	-	-	0.39	0.37
	Town of Cambridge	No	-	-	-	-	1.84	2.43
	Town of Claremont	No	-	-	-	-	0.67	0.54
	Town of Cottesloe	No	-	-	-	-	0.27	0.28
	Town of Mosman Park	No	-	-	-	-	0.48	0.48
	Town of Vincent	No	-	-	-	-	0.76	0.82
	Whitfords	Yes	2.60	2.60	0.40	0.40	8.85	8.81
Total for Perth Groundwater Area			**15.95**	**16.45**	**0.95**	**0.95**	**36.07**	**34.60**
Swan	Bandy Spring	No	-	-	-	-	0.33	0.33
	Central Swan	No	-	-	-	-	1.23	1.27
	Cockman Bluff	No	-	-	-	-	1.22	1.02
	East Swan	No	-	-	-	-	0.71	0.71
	Neaves	No	-	-	-	-	3.24	3.23
	North Swan	Yes	-	-	-	-	3.12	2.73
	Radar	No	-	-	-	-	2.88	2.13
	South Swan	No	-	-	-	-	3.77	3.86
Total for Swan Groundwater Area			**0.00**	**0.00**	**0.00**	**0.00**	**16.51**	**15.28**
Wanneroo	Adams	Yes	-	-	-	-	1.08	1.03
	Carabooda	No	-	-	-	-	8.04	7.85
	Carramar	No	-	-	-	-	1.49	1.50
	Jandabup	No	-	-	-	-	0.18	0.16
	Joondalup	No	-	-	-	-	0.80	0.77
	Lake Gnangara	No	-	-	-	-	6.48	6.19
	Mariginiup	Yes	-	-	-	-	4.17	4.09
	Neerabup	No	-	-	-	-	2.54	2.53
	Nowergup	Yes	-	-	-	-	2.74	2.74
	Pinjar	Yes	-	-	-	-	0.56	0.56
Total for Wanneroo Groundwater Area			**0.00**	**0.00**	**0.00**	**0.00**	**28.06**	**27.40**
Yanchep	Yanchep	Yes	1.55	1.40	-	-	5.95	5.58
Total for Yanchep Groundwater Area			**1.55**	**1.40**	**0.00**	**0.00**	**5.95**	**1.58**
Total for Gnangara groundwater allocation plan area			**30.95**	**32.05**	**1.00**	**1.00**	**116.19**	**112.13**

1 Public water supply information is from COMPASS as well as annual reports submitted to the department as a condition of Water Corporation's licences.
2 The 2018–19 report was run on 1 July 2019 and the 2019-20 report was run on 1 July 2020, both using COMPASS.

Up-to-date figures on water availability are available from the department's website or through the Swan–Avon regional office.

1 GL = 1 000 000 kL. Figures have been rounded to two decimal places.

4 Compliance

The conditions and commitments that the department is required to comply with from *Ministerial statement no. 819: Gnangara groundwater resources* under Part IV of the *Environmental Protection Act 1986* (Government of Western Australia 2009) are shown in Appendices A and B (the 'audit tables').

4.1 Compliance with water level criteria

Ministerial statement no. 819 sets water level criteria at 30 sites across the Gnangara Mound. There are 14 wetland sites and 16 terrestrial (phreatophytic) vegetation sites. 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
- preferred minimum water levels – set at some wetlands to allow water levels to fall between the 'preferred' level and the absolute minimum level in two out of six years (replicating natural drying cycles). Preferred minimum water levels are referred to as 'other' water level criteria in this report.

The number of sites that were non-compliant with absolute minimum or peak water level criteria increased from 12 in 2018–19 to 14 in 2019–20. Water levels at WM8 declined and were non-compliant with absolute minimum water level criteria for the first time since 2016–17. The peak level at Lake Mariginiup fell and was non-compliant after being compliant in 2018–19. Water levels at Melaleuca Park Dampland 78 increased slightly making the site compliant with water absolute minimum water level criteria (Table 4). Levels here were incorrectly reported as non-compliant in 2018–19 due to a water level recording error. The correct number of sites non-compliant with absolute minimum water level criteria in 2018–19 was 12 out of 30.

Management and mitigation actions implemented by the department in response to non-compliance are described in Section 5. Details for individual sites can be found in the 'audit tables' in Appendix A.

Table 4 Summary of non-compliance with water level criteria for Gnangara groundwater resources for the reporting period

Non-compliant sites[1]				
Absolute minimum or peak water level criteria			Other water level criteria	
Wetlands	**Terrestrial vegetation**	**Total non-compliant**	**Wetlands**	**Total non-compliant**
2018–19				
Loch McNess Lake Yonderup Lake Nowergup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173 ~~Melaleuca Park Dampland 78~~[2]	MM53 MM55B MM59B PM9 WM1	~~13~~12[2] out of 30	Lake Joondalup Lake Mariginiup Lake Nowergup Lexia 86 Lexia 186 Melaleuca Park Dampland 78	6 out of 8
2019–20				
Loch McNess Lake Yonderup Lake Mariginiup Lake Nowergup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173	MM53 MM55B MM59B PM9 WM1 WM8	14 out of 30	Lake Mariginiup Lake Nowergup Lexia 86 Lexia 186 Melaleuca Park Dampland 78	5 out of 8

1 In the event that a site is non-compliant with both absolute summer minimum and peak water level criteria within the same year, it is only counted as a single incidence of non-compliance i.e. the site is not double-counted. See also Appendix A.

2 Melaleuca Park Dampland 78 was incorrectly reported as being non-compliant with absolute summer minimum water levels in 2018–19 due to a water level reporting error. The correct number of sites non-compliant with absolute minimum water level criteria in 2018–19 was 12 out of 30.

5 Environmental monitoring, management, research and consultation

5.1 Environmental monitoring

Expert environmental consultants undertake environmental monitoring of groundwater-dependent ecosystems for the department in line with the commitments in *Ministerial statement no. 819: Gnangara Mound groundwater resources* (Government of Western Australia 2009). This long-term monitoring program provides a representative indication of changes in the overall health of the Gnangara system over time and includes:

- wetland vegetation
- wetland macroinvertebrates and water quality
- mound spring macroinvertebrates and water quality
- wetland frogs.

Ecological condition of groundwater-dependent ecosystems is affected by a number of factors of which the water regime is just one. Other factors include fire, insect attack, disease, weed invasion, pollution and disturbance from changing land use. Similarly, groundwater abstraction is just one factor that can affect the water regime of an ecosystem. Others include changes in rainfall patterns, fire and land use changes such as urbanisation.

The department uses the results of environmental monitoring, carried out each spring in the reporting period, to continually improve our understanding of the relationship between water levels and ecological condition. The information is also used to manage abstraction at priority locations, reducing abstraction where it is likely to improve ecological condition.

Wetland vegetation

The condition of wetland vegetation was monitored at the following sites during the reporting period: Lake Jandabup, Lake Mariginiup, Loch McNess, Lake Wilgarup, Lake Yonderup, Lake Nowergup, Lake Goollelal Melaleuca Park EPP173, Melaleuca Park Dampland 78, Lexia 86, Lexia 186 and Quin Brook (Buller et al. 2020).

The increases in groundwater levels seen over the 2018–19 reporting period continued at some sites in 2019–20, including Melaleuca Park Dampland 78, Lexia 86, Lexia 186 and Lake Nowergup. Only minor changes in tree health were recorded. The largest decrease in health was at Lake Yonderup with declines in condition of *Melaleuca rhaphiophylla* and *Eucalyptus rudis* due to a bushfire in December 2019. The largest improvement in vegetation health was observed at Quin Brook.

There are several wetlands where monitoring shows that long-term declines in groundwater levels have contributed to declines in health of overstorey species, and/or the disappearance or decline in condition and abundance of some key wetland species. Some of these sites have been identified as being at potential risk of, or have experienced a threshold change in ecohydrological state. These wetlands include:

- Loch McNess – declines in groundwater levels since 2004 have contributed to the loss of the key wetland sedge, *Baumea articulata,* declines in health of *Melaleuca rhaphiophylla* and, since 2017, declines in abundance of *Lepidosperma longitudinale,* also a sedge species. Impacts of a fire over the reporting period are being investigated and will be reported on in the 2020–21 compliance assessment report.
- Lake Yonderup – lower groundwater levels have contributed to poor health of most *M. rhaphiophylla* and deaths of mature trees. Impacts of a fire over the reporting period are being investigated and will be reported on in the 2020–21 compliance assessment report.
- Lake Wilgarup – steady declines in water levels over many years, coupled with a severe fire in 2005/06, have resulted in a change to terrestrial species, although some mature *M. rhaphiophylla* are still persisting.
- Lake Mariginiup – water level declines since 1997 contributed to the poor health of wetland vegetation. The health of *Eucalyptus rudis* has been in decline for much of the long-term monitoring period. The vegetation monitoring transect will be realigned to capture where native wetland vegetation is still present.
- Lake Nowergup – water level declines have led to deaths of mature trees, including widespread mortality of *M. rhaphiophylla*. There has been a drastic loss of native species including the sedge *B. articulata* which is now absent from the transect.
- Melaleuca Park EPP173 – groundwater declines since the mid-2000s have contributed to the wetland species *B. articulata* and *Pericalymma ellipticum* disappearing from the transect.

Over the longer term, most monitored wetlands show declines in tree health and species similarity, and a general increase in the cover and abundance of exotic species.

Wetland macroinvertebrates and water quality

The following sites were surveyed for aquatic macroinvertebrates and water quality in 2018-19: Lake Jandabup, Lake Mariginiup, Loch McNess, Lake Yonderup, Pipidinny Swamp, Lake Nowergup, Lake Joondalup, Melaleuca Park EPP173, Lexia 86, Lake Goollelal, Lake Gwelup and Lake Gnangara (Lette et al. 2020).

The surveys showed that low water levels continue to contribute to:

- risk of acidification at Lake Jandabup, Lake Mariginiup and Lake Gnangara (though acidity results improved at Lake Jandabup over the reporting period)
- high nutrient levels at Lake Jandabup, Lake Nowergup (despite supplementation of water levels), Lake Mariginiup, Lake Gnangara and Loch McNess
- degradation and loss of aquatic habitat at Loch McNess, Lake Nowergup, Lake Yonderup and Melaleuca Park EPP173
- changes in macroinvertebrate assemblages and loss of key taxa at Loch McNess, Lake Yonderup, Lake Nowergup, Lake Jandabup and Lake Gnangara
- localised extinction of the native fish *Galaxiella nigrostriata* from Melaleuca Park EPP173.

Impacts of a fire on wetland vegetation over the reporting period at Loch McNess and Lake Yonderup are being investigated and will be reported on in the 2020–21 compliance assessment report.

Mound spring macroinvertebrates and water quality

Five springs along the eastern edge of the Gnangara groundwater allocation plan area were monitored for aquatic macroinvertebrates and water quality during the reporting period: Egerton Spring, Edgecombe Spring, Gaston Road Spring, Sue's Spring and Bernard Spring (WRM 2020).

Increased peak groundwater levels over the past few years due to good rainfall contributed to surface water flow improving at all sites. Water quality remained relatively stable and the springs continue to support highly diverse assemblages of aquatic and semi-aquatic invertebrates, including several rare, regionally endemic and/or undescribed groundwater-dependent species.

Wetland frogs

Frog populations were monitored during the reporting period using trapping and aural surveys of calling males (Bamford & Everard 2020). At some sites a number of species have stopped calling for an extended period, suggesting that these populations have died out. Disappearances from wetlands relate mostly to declining hydroperiods – periods of surface water presence, which can be related to declining groundwater levels. The disappearances are most marked at sites where falling

groundwater has resulted in a significant reduction in surface water area and duration of wetting (e.g. Lexia 86 and Lexia 186).

The monitoring suggests that current groundwater regimes are not sufficient to maintain frog distributions. Unless groundwater levels rise, it is likely that the local distribution of some frog species will contract in the short term (3–5 years), with the greatest declines in the middle and north of the Gnangara area.

Frog assemblages remain intact at some of the urban wetlands, such as Lake Joondalup and Lake Goollelal, where groundwater levels have been relatively stable.

5.2 Management actions

In response to the changes described in section 5.1 and the level of non-compliance identified in this and previous reports, the department has implemented strategies to reduce impacts on environmentally important sites. Many of these strategies are outlined in the *Gnangara groundwater areas allocation plan* (DoW 2009a), including:

- significantly reducing abstraction for public water supply
- increasing licence compliance and enforcement activities
- capping abstraction for private licensed water supply.

The department is also using compliance monitoring and reporting results to support development of the next Gnangara groundwater allocation plan. The plan will include new strategies to return the system to balance and reduce groundwater use in line with climate change.

In October 2019 the Government released the *Waterwise Perth Action Plan*, committing to a target of a 10 per cent reduction in groundwater use across the greater Perth area by 2030. The new Gnangara groundwater allocation plan will include strategies to enable implementation of this target reduction.

Managing public water supply use

Every water year the department reviews the distribution of Water Corporation's entitlements and wherever possible moves abstraction away from bores in the environmentally sensitive areas of the Superficial aquifer and from bores in the deeper Leederville and Yarragadee aquifers where they are connected to the Superficial aquifer. This minimises the impacts of Water Corporation's abstraction on Ministerial sites where water levels are non-compliant or are at risk of becoming non-compliant with water level criteria.

Groundwater Replenishment Scheme

Recycling of Perth's wastewater will become a bigger part of the total water supply mix to meet increasing water demands without negative impacts to groundwater levels. Stage 1 of the Groundwater Replenishment Scheme at Beenyup, with a capacity of 14 GL has been commissioned.

Water recharged through Stage 2 of the groundwater replenishment scheme, currently being commissioned, will provide broader benefits to the groundwater system including to connected wetlands. The locations of the recharge bores to be constructed as part of Stage 2 were determined following a study completed by the department into the sustainable use of Perth's groundwater system. Of the locations investigated, environmental objectives were shown to be best met at selected locations in Wanneroo and Neerabup. Once Stage 2 of the GWR scheme is fully commissioned the scheme capacity will increase by 14 GL to a total of 28 GL.

Managing private licensed use

The department monitors private licensed use through on-ground compliance inspections, meter audits, water use surveys and standard checks as part of the licence renewal process. Through this work the department verifies that groundwater use is within licensed entitlements and that site activities are authorised.

Over the reporting period the department conducted 1298 compliance monitoring events across licences taking water from the Gnangara groundwater system. A total of 1301 incidents of suspected non-compliance were detected, with 195 of these relating to alleged exceedance of annual water entitlements. The department's response to these alleged non-compliances ranged from educational letters and warning notices, to statutory direction and infringement notices.

When prioritising licence compliance and enforcement activities the department considers the conditions and commitments set in *Ministerial statement no. 819*. This includes expanding the scope of the department's licensing compliance plan to include areas potentially affecting non-compliant Ministerial sites.

The department also manages groundwater used by private licensees in other ways, by continuing to work with:

- Local governments, urban developers, schools, golf clubs and other licensees that use large volumes, to improve water use efficiency, reduce demand for groundwater and assess water needs and alternative water supply options.
- Water Corporation as our partner in the Waterwise Council program, to encourage the participation of local councils in a program which began in 2009 and for this reporting period included all but one of the 16 urban local councils across Gnangara as endorsed Waterwise Councils.
- Peak bodies, as well as directly with horticulturalists to focus on improving water use efficiency, compliance with licence conditions and options to reduce total water use in the future.

Managing groundwater use exempt from licensing

Responsible and efficient use of domestic garden bores as a fit-for-purpose source of water helps reduce use of highly treated drinking water from scheme supply for the purpose of irrigating lawns and gardens. Garden bores not only reduce demand on the scheme, but spread the impacts of water abstraction through localised pumping

of small volumes across many thousands of drawpoints, rather than the alternative of pumping large volumes from distant public supply bores and importing the water to urban areas. However, there are now a significant number of garden bores and they are not always used sparingly.

The use of domestic garden bores is managed under the provisions of the *Water Agencies (Water Use) By-Laws 2010*. These specify permanent sprinkler restrictions that apply to Area 3 Perth/Mandurah, covering most of the Gnangara groundwater allocation plan area.

The following permanent sprinkler restrictions have applied to garden bores since 2010:

- A total winter sprinkler shut off between 1 June and 31 August each year (unless extended by the Minister due to low rainfall).
- Sprinkler use is limited to once a day on three rostered days a week between 1 September and 31 May each year.
- Daytime sprinkler ban between the hours of 9am and 6pm.

These sprinkler restrictions are generally supported by the community, helping to preserve groundwater resources and encouraging water use efficiency in garden irrigation. Failure to adhere to restrictions can result in an infringement being issued.

The department guides where new bores can be installed without increasing the risk of impacting the quality of the water resource or environmentally sensitive areas, such as wetlands. The department's garden bore suitability map was updated in 2011 and will be updated again when the new Gnangara groundwater allocation plan is finalised, to reflect the over-allocated status of the Gnangara plan area.

The department also undertook digital education campaigns in 2019 to increase garden bore owners' awareness of groundwater as a limited and shared resource and to encourage waterwise use of garden bores. This is part of the department and Water Corporation's "Be groundwater wise" campaign and contributes to implementation of the *Waterwise Perth Action Plan*. The expanded Be Groundwater Wise website provides one location for garden bore and waterwise advice: begroundwaterwise.wa.gov.au

Waterwise Perth Action Plan

The *Waterwise Perth Action Plan* was released in October 2019 to help transition Perth to a leading waterwise city. The strategy advocates responsible and sustainable use of water from all sources, including groundwater, and well-designed private and public green spaces to make the most of Perth's limited water resources. To deliver the plan the department will work with local government, industry and the broader community to fulfil (amongst others) the following commitments:

- reduce Perth groundwater use by 10 per cent by 2030
- manage groundwater levels to sustain wetlands and urban trees, and reducing irrigation of green spaces
- extend and enhance the Waterwise Council and Waterwise Golf Course programs
- assist schools, universities and other institutions to reduce groundwater use through the Waterwise Grounds program.

5.3 Research initiatives

The department, together with research partners, has completed a number of major projects that assist with planning for a drier future and focus management effort on the areas that will deliver the most benefit from changes to abstraction. Recent research initiatives have been outlined in previous reports and the department is currently using the results of this work to support the development of the new Gnangara allocation plan. Impacts of a fire on wetland vegetation over the reporting period are being investigated and will be reported on in the 2020–21 compliance report.

5.4 Consultation

There has been extensive stakeholder consultation over the reporting period in the continuing development of a new Gnangara groundwater allocation plan. The department has focussed on working with water users, their industry reference groups and other government agencies to find practical pathways to bring the system back into balance, prepare for a future with less groundwater availability and build climate resilient organisations and businesses. The department has held well over a 100 stakeholder meetings and workshops since 2016 across all water use sectors.

Appendices

Appendix A — Water level monitoring results for Ministerial sites for the Gnangara Mound Groundwater Resources for 2007–2019

Bold text refers to compliance with water level and other criteria. **Black bold text** indicates sites compliant with water level and other criteria. **Red bold text** indicates sites non-compliant with water level criteria. **Blue bold text** indicates sites non-compliant with other criteria.

Table A 1 Wetland sites

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)											Comments on compliance during the reporting period
		Spring peak		End of summer minimum													
		Pref	Abs	Pref	Abs		2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	
Lake Goollelal	6162517			26.2*	26.0	Max	27.4	27.2	27.1	27.2	27.3	27.2	27.1	27.3	27.3	27.2	27.5	Compliance: **Compliant with absolute summer minimum and other criteria.** Water levels at Lake Goollelal are projected to rise as result of the urbanisation of East Wanneroo.
						Min	26.6	26.4	26.5	26.5	26.5	26.6	26.4	26.8	26.9	26.9	26.7	
Loch McNess	6162564				6.95	Max	6.80	6.64	6.43	6.40	6.39	6.25	6.25	6.25	6.25	6.25	6.02	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** The lake has been non-compliant since 2002–03 and lake levels have fallen rapidly since 2006 with some stabilisation evident in recent years. The original staff gauge at the lake is now dry and a new staff gauge was installed in a deeper part of the wetland in 2019. Levels reported are now taken from the new gauge. Ecological condition: Long-term monitoring has shown declines in the health of *Melaleuca rhaphiophylla*; changes in species composition to more terrestrial species and increases in abundance of exotic species. Declines in groundwater levels have also contributed to the loss of the key wetland macrophyte *Baumea articulata* at the transect and the degradation and loss of aquatic habitat for macroinvertebrates. Management and mitigation: 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. The minimum groundwater level at the bore did not meet the minimum groundwater requirement of wetland vegetation over the reporting period and declined over the period. Detailed findings and recommendations from the investigation can be found in the Loch McNess report (DoW 2011a). The department completed a study into the cause of rapidly declining levels in Loch McNess (Kretschmer & Kelsey 2016). 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: • reduced Superficial aquifer abstraction in the Yanchep National Park • ceased the Yanchep caves supplementation trial • reduced public supply abstraction from the Leederville Aquifer in the Pinjar borefield. Impacts of a fire over the reporting period on wetland vegetation are being investigated and will be reported on in the 2020–21 compliance report.
						Min	**6.45**	**6.25**	**6.17**	**6.10**	**6.25**	**6.25**	**6.07**	**6.25**	**6.25**	**6.25**	**5.89**	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)											Comments on compliance during the reporting period
		Spring peak		End of summer minimum													
		Pref	Abs	Pref	Abs		2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	
Lake Yonderup	6162565				5.9	Max	5.9	5.9	5.9	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** The lake has been non-compliant since 2007–08. Levels have been relatively stable in recent years. Ecological condition: Water level declines have contributed to reduced condition of *Melaleuca rhaphiophylla* and recent deaths of mature trees. They are also contributing to the degradation and loss of aquatic habitat for macroinvertebrates. Management and mitigation: 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. Given the location of Lake Yonderup just to the south of Loch McNess, the department's management actions following the study into the cause of declining levels at Loch McNess, also aim to benefit levels at Lake Yonderup. Impacts of a fire over the reporting period on wetland vegetation are being investigated and will be reported on in the 2020–21 compliance report.
						Min	**5.8**	**5.7**	**5.7**	**5.6**	**5.6**	**5.6**	**5.5**	**5.6**	**5.5**	**5.5**	**5.6**	
Lake Joondalup	6162572 (Staff 8281)			16.2*	15.8	Max	17.0	16.8	16.8	16.8	17.1	17.0	16.9	17.1	17.3	17.6	17.5	Compliance and trends: **Compliant with absolute summer minimum criterion.** **Compliant with other criterion.** Levels have been above the preferred minimum since 2016–17 and have risen in recent years. Water levels at Lake Joondalup are projected to rise as result of the urbanisation of East Wanneroo.
						Min	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 4/6 yr	16.1 4/6 yr	16.5 4/6 yr	16.6 4/6 yr	16.8 4/6 yr	16.7	
	61610661 (Bore 8281)					Max	18.9	18.7	18.6	18.6	19.0	18.9	18.7	19.0	19.2	19.4	19.4	
						Min	18.3	17.9	18.0	18.0	18.2	18.3	18.1	18.5	18.6	18.7	18.6	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)											Comments on compliance during the reporting period
		Spring peak		End of summer minimum													
		Pref	Abs	Pref	Abs		2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	
Lake Mariginiup	6162577 (Staff 1943)	42.1*	41.5			Max	41.5	**41.3**	**41.2**	**41.1**	**41.3**	**41.3**	**41.1**	**41.4**	41.5	41.6	**41.4**	Compliance and trends: **Non-compliant with absolute minimum spring peak criterion.** Peak levels decreased over the reporting period and were non-compliant with the absolute spring peak criterion. **Non-compliant with other criterion.** Water levels have not reached the preferred spring peak since 1994. Ecological condition: Groundwater declines have contributed to the lake being one of the poorest sites in terms of vegetation health. Management and mitigation: Work completed as part of the Perth shallow groundwater systems investigation found that: • 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 • the newly installed bore MGP_C (AWRC ref. 61611440) should be used to relate changes in the watertable to wetland vegetation condition. Detailed findings and recommendations from the investigation can be found in Searle et al. (2010a). The department is using MGP_C to better relate groundwater levels to the condition of wetland vegetation. Minimum levels at bores MS10 and MGP_C improved marginally over the reporting period. Water levels at Lake Mariginiup are projected to increase in the future due to increasing urbanisation of the catchment and a corresponding decrease in groundwater abstraction from agricultural land uses.
						Min	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**	41.0 **4/6 yr**	41.0 **4/6 yr**	41.0 **4/6 yr**	41.0 **4/6 yr**	41.3 **4/6 yr**	
	61610685 (Bore MS10)					Max	41.1	40.8	40.9	40.8	41.0	41.2	40.8	41.1	41.1	41.2	41.1	
						Min	40.2	40.0	40.1	40.1	40.1	40.2	40.0	40.4	40.4	40.3	40.2	
Lake Jandabup	6162578 (Staff 1944)	44.7*	44.2		44.3	Max	44.8	44.5	44.7	44.6	44.7	44.7	44.6	44.7	44.8	45.0	44.8	Compliance and trends: **Compliant with absolute spring peak criterion.** **Compliant with absolute summer minimum criterion.** Minimum water levels recorded were above the absolute minimum criterion before being rounded to one decimal place. Water Corporation supplements lake levels to meet the absolute spring peak water level criterion and to prevent the lake from acidifying. Recently, levels have been relatively stable and the supplementation has been successful in preventing the lake from acidifying. Ecological condition: Long-term vegetation monitoring has shown declines in canopy condition, changes in species composition to more terrestrial species and increases in abundance of exotic species. The risk of acidification is still high if water levels decline. However, Lake Jandabup water levels are expected to increase in the future due to increasing urbanisation of the catchment and a corresponding decrease in groundwater abstraction from agricultural land uses. Management and mitigation: 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 level at JB12B remained relatively stable over the reporting period. Water levels at Lake Jandabup are projected to increase in the future due to increasing urbanisation of the catchment and a corresponding decrease in groundwater abstraction from agricultural land uses. This is expected to reduce the need for supplementation of the lake.
						Min	**44.2**	**44.1**	**44.2**	**44.1**	**44.2**	**44.2**	**44.1**	44.3	**44.2**	44.3	44.3	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)											Comments on compliance during the reporting period
		Spring peak		End of summer minimum													
		Pref	Abs	Pref	Abs		2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	
Lake Nowergup	6162567 (Staff)	17.0*	16.8			Max	**16.5 4/6 yr**	**16.2 4/6 yr**	**16.1 4/6 yr**	**16.0 4/6 yr**	**16.0 4/6 yr**	**16.0 4/6 yr**	**16.0 4/6 yr**	**16.0 4/6 yr**	**16.0 4/6 yr**	**16.0 4/6 yr**	**16.0 4/6 yr**	Compliance and trends: **Non-compliant with absolute spring peak criterion.** Lake levels have been non-compliant in most years since 1996 despite water levels being supplemented and artificially maintained by the department. The department now uses a telemetry site to monitor levels at the lake. Levels recorded at the site have been relatively stable since 2018. **Non-compliant with other criterion.** Ecological condition: Water levels have led to the deaths of mature trees and declines in the abundance of the key wetland macrophyte *Baumea articulata*. Low water levels are also contributing to the risk of acidification. Management and mitigation: From work completed as part of the Perth shallow groundwater systems investigation, Searle, et al. (2010b) recommends to: • continue the supplementation regime • revise the spring peak criteria to 16.2 mAHD, which should be done gradually from the 2009 peak of 16.5 mAHD • use groundwater levels at bore LN2-89 (AWRC ref. 61611247) to relate changes in the watertable to wetland vegetation condition. The department is using bore LN2-89 to better relate groundwater levels to condition of wetland vegetation. Minimum levels at bore LN2-89 declined from 2007 to 2016 but have recovered mariginally in the last few years. The department recently studied the causes of groundwater level declines at Lake Nowergup. The study showed that local Superficial aquifer use for horticulture had the greatest impact on lake levels, followed by reduced rainfall, then Leederville Aquifer pumping from Quinns and Pinjar borefields (Global Groundwater 2015). This study is informing planning and management.
						Min	16.0	16.0	15.9	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	
Lake Wilgarup	6162623 (Staff)	6.10	5.65	4.8	4.5	Max	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	Compliance and trends: **Non-compliant with absolute spring peak criterion.** The lake has been dry since 1998. **Non-compliant with absolute summer minimum criterion.** Groundwater levels have declined since 1998 and have been non-compliant with the absolute minimum criteria since 2006–07. Management and mitigation: Given the location of Lake Wilgarup just to the east of Loch McNess, the department's management actions following the study into the cause of declining levels at Loch McNess, also aim to benefit levels at Lake Wilgarup.
						Min												
	61618500 (Bore)					Max	4.64	4.47	4.38	4.31	4.41	4.29	4.21	4.34	4.29	3.64	3.43	
						Min	**4.02**	**3.80**	**3.84**	**3.83**	**3.82**	**3.79**	**3.66**	**3.88**	**3.75**	**2.99**	**2.86**	
Pipidinny Swamp	6162624 (Staff)	2.70	2.40		1.6	Max	**2.0**	**2.0**	**1.6**	**1.8**	**2.2**	**1.9**	**1.6**	**2.0**	**2.0**	**2.0**	**2.0**	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Levels at the swamp have been non-compliant since 2009–10. **Non-compliant with absolute spring peak criterion.** Spring peak levels have been non-compliant since 2005–06. Management and mitigation: 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.
						Min	**1.3**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**<0.7**	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)											Comments on compliance during the reporting period
		Spring peak		End of summer minimum													
		Pref	Abs	Pref	Abs		2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	
Lexia 86 (GNM16)	61613215			47.3*	47.0	Max	48.2	47.7	47.9	47.6	47.8	47.7	47.3	47.7	47.9	48.2	48.2	Compliance and trends: **Compliant with absolute summer minimum criterion.** 2015–16 was the first and only year that the site was non-compliant with absolute summer minimum water levels. **Non-compliant with other criterion.** Ecological condition: Long-term monitoring has shown reduced frog numbers, declines in canopy condition, changes in species composition to more terrestrial species and increases in abundance of exotic species. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound with the intention of reducing abstraction impacts at sites in the area, including Lexia 86. The department also reviews public water supply abstraction annually, considering water level trends and criteria compliance.
						Min	47.3	47.1	47.2	47.0	47.0 **4/6 yr**	47.0 **4/6 yr**	**46.9** **4/6 yr**	47.1 **4/6 yr**	47.1 **4/6 yr**	47.3 **4/6 yr**	47.2 **4/6 yr**	
Lexia 186 (GNM15)	61613214			47.5*	47.2	Max	47.5	47.0	47.1	46.9	47.2	47.1	46.7	47.0	47.3	47.5	47.6	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Water levels have been non-compliant with the absolute summer minimum water level criteria since 1997. The spring peak in 2015–16 was the lowest on record. Water levels have shown a general rising trend since 2015–16. **Non-compliant with other criterion.** Minimum water levels have not been above the preferred summer minimum criteria since 1995. Ecological condition: Long-term monitoring has shown reduced frog numbers, declines in canopy condition, changes in species composition to more terrestrial species and increases in abundance of exotic species. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound with the intention of reducing abstraction impacts at sites in the area, including Lexia 186. The department also reviews public water supply abstraction annually, considering water level trends and criteria compliance.
						Min	**46.8** **4/6 yr**	**46.5** **4/6 yr**	**46.5** **4/6 yr**	**46.5** **4/6 yr**	**46.6** **4/6 yr**	**46.5** **4/6 yr**	**46.3** **4/6 yr**	**46.5** **4/6 yr**	**46.6** **4/6 yr**	**46.8** **4/6 yr**	**46.8** **4/6 yr**	
Melaleuca Park EPP173	6162628 (Staff)				50.2	Max	51.0	50.5	50.7	50.6	50.9	50.7	50.4	50.8	51.0	51.1	50.8	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Water levels have been non-compliant with absolute summer minimum criterion since 1995. The spring peak in 2015–2016 was the lowest on record. Ecological condition: Groundwater declines have contributed to wetland species *Baumea articulata* and *Pericalymma ellipticum* disappearing from the wetland. Declines have also contributed to the degradation and loss of aquatic habitat for macroinvertebrates. The native fish *Galaxiella nigrostriata* has also become locally extinct. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound with the intention of reducing abstraction impacts at sites in the area, including Melaleuca Park EPP173. The department reviews 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	50.7	
	61613213 (Bore GNM14)					Max	50.5	49.5	50.0	49.7	50.3	50.1	49.3	50.2	50.3	50.8	50.1	
						Min	**48.9**	**48.6**	**48.8**	**48.7**	**48.8**	**48.7**	**48.5**	**49.0**	**48.8**	**48.7**	**48.7**	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)											Comments on compliance during the reporting period
		Spring peak		End of summer minimum													
		Pref	Abs	Pref	Abs		2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	
Melaleuca Park Dampland 78 (GNM31)	61613231			65.4*	65.1	Max	65.9	65.5	65.3	65.2	65.3	65.2	64.9	65.1	65.2	65.4	65.5	Compliance and trends: **Compliant with absolute summer minimum criterion.** **Non-compliant with other criterion.** Minimum water levels have not been above the preferred summer minimum criteria since 2013–14. This site was incorrectly reported as non-compliant in 2018–19 (64.8mAHD) due to a reporting measurement error. Ecological condition: Long-term monitoring has shown reduced frog numbers, declines in tree health, changes in species composition to more terrestrial species and increases in abundance of exotic species. Management and mitigation: A cluster of bores were installed adjacent to GNM31 as part of the Perth shallow groundwater systems investigation (Searle 2009).
						Min	65.5	65.1	65.1	**64.9**	65.1 **4/6 yr**	**64.9** **4/6 yr**	**64.7** **4/6 yr**	**64.7** **4/6 yr**	**65.0** **4/6 yr**	65.2 **4/6 yr**	65.2 **4/6 yr**	
Egerton Spring (B25)	61618607				39.29	Max	40.15	40.01	40.05	40.04	40.17	40.12	39.97	40.10	40.20	40.26	40.15	Compliance and trends: **Compliant with absolute summer minimum criterion.** Water levels have been compliant since 2003 and have risen over the past 10 years in response to increased localised recharge associated with the surrounding urban development.
						Min	39.72	39.49	39.70	39.69	39.73	39.79	39.58	39.84	39.84	39.76	39.71	

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

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 reporting period
				2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	
MM16	61610835	38.8	Max	39.9	39.4	39.6	39.6	40.1	40.2	40.1	40.3	40.7	41.1	41.0	Compliance: **Compliant with absolute summer minimum criterion.** Water levels have shown a general rising trend since 2011.
			Min	39.0	**38.6**	38.9	39.0	39.2	39.5	39.3	39.5	39.8	40.0	40.0	
MM18	61610918	38.6	Max	39.8	39.3	39.5	39.6	39.9	40.0	39.6	40.0	40.2	40.6	40.6	Compliance: **Compliant with absolute summer minimum criterion.** Water levels have shown a general rising trend since 2011.
			Min	39.0	38.7	38.9	39.0	38.6	39.2	39.1	39.2	39.4	39.6	39.6	
MM53	61610493	33.3	Max	33.9	33.3	33.8	33.6	34.0	34.0	33.5	33.7	34.0	34.3	34.1	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** In 2018–19 minimum water levels recorded were below the absolute minimum criterion before being rounded to one decimal place. Minimum water levels have been stable in recent years. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer from bores located close to Whiteman Park, with the intention of reducing abstraction impacts at sites in the area, including MM53. The department reviews public water supply abstraction annually, considering water level trends and criteria compliance.
			Min	**33.0**	**32.8**	**33.0**	**33.0**	**32.8**	**33.1**	**32.9**	**33.1**	**33.1**	**33.3**	**33.2**	
MM55B	61610559	29.5	Max	30.8	30.1	30.3	30.3	30.5	30.5	30.3	30.4	30.6	30.8	30.7	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** The site has been non-compliant with absolute summer minimum water level criteria in all years, except 2014–15. In 2017–18 and 2018–19 minimum water levels recorded were below the absolute minimum criterion before being rounded to one decimal place.
			Min	**29.3**	**29.0**	**29.3**	**29.2**	**29.2**	29.7	**29.2**	**29.4**	**29.5**	**29.5**	**29.3**	
MM59B	61611025	36.3	Max	36.6	36.0	36.1	36.2	36.3	36.3	36.0	36.1	36.4	36.7	36.5	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Minimum water levels have been stable in recent years. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer from bores located close to Whiteman Park with the intention of reducing abstraction impacts at sites in the area, including MM59B. The department reviews public water supply abstraction annually, considering water level trends and criteria compliance.
			Min	**35.7**	**35.3**	**35.5**	**35.5**	**35.5**	**35.6**	**35.4**	**35.5**	**35.6**	**35.8**	**35.6**	
MT3S	61610745	43.0	Max	44.8	44.3	44.4	44.2	44.6	44.5	44.3	44.6	44.9	45.0	44.8	Compliance and trends: **Compliant with absolute summer minimum criterion.** Since 2011 water levels have increased and been table in recent years.
			Min	43.9	43.5	43.6	43.5	43.7	43.7	43.6	44.0	44.1	44.0	44.0	
NR6C	61610982	58.5	Max	60.1	59.9	59.7	59.3	59.7	59.5	59.1	59.5	60.0	59.9	59.7	Compliance: **Compliant with absolute summer minimum criterion.** Water levels in 2015–16 were the lowest on record. Minimum water levels have since increased and been stable in recent years.
			Min	59.4	58.9	59.0	58.7	58.9	59.0	58.7	58.8	59.0	59.0	59.0	

Groundwater monitoring bore	AWRC reference number	End of summer absolute minimum (mAHD)	Water levels (mAHD)											Comments on compliance during the reporting period
				2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	
PM9	61610804	56.3	Max	55.9	55.9	55.0	54.8	55.0	54.7						Compliance and trends: **Non-compliant with absolute summer minimum criterion.** The bore is not currently being monitored due to safety issues associated with its location in a rifle range. Water levels at the site are now greater than 10.5 m depth to groundwater, and it is unlikely vegetation in the vicinity is accessing groundwater. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound with the intention of reducing abstraction impacts at sites in the area, including PM9. The department reviews public water supply abstraction annually, considering water level trends and criteria compliance.
			Min	**55.4**	**54.9**	**54.8**	**54.4**	**54.3**	**54.1**	**51.8**					
PM24	61610697	40.5	Max	42.5	42.1	42.4	42.0	42.1	42.3	42.1	42.2	41.6	42.5	42.2	Compliance: **Compliant with absolute summer minimum criterion.** Water levels have been stable since 2011.
			Min	41.2	41.0	41.1	41.1	41.1	41.3	41.0	41.4	41.0	41.1	41.0	
WM1	61610833	55.7	Max	55.4	54.8	54.8	54.4	54.7	54.4	54.5	55.1	55.6	55.9	55.6	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Water levels have been showing a rising trend in recent years and in 2018–19 and 2019–20 the site recorded its highest minimum water level since 2008–09. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound, with the intention of reducing abstraction impacts at sites in the area, including WM1. The department reviews public water supply abstraction annually, considering water level trends and criteria compliance.
			Min	**54.8**	**54.4**	**54.3**	**54.1**	**54.2**	**54.1**	**54.1**	**54.3**	**54.7**	**54.9**	**54.9**	
WM2	61610908	66.5	Max	67.5	66.9	66.8	66.4	66.7	66.5	66.6	67.2	67.3	67.5	67.0	Compliance and trends: **Compliant with absolute summer minimum criterion.** Minimum water levels recorded were above the absolute minimum criterion before being rounded to one decimal place. In 2017–18 this site was compliant for the first time since 2010–11. Water levels have shown a general rising trend. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound with the intention of reducing abstraction impacts at sites in the area, including WM2. The department also reviews public water supply abstraction annually, considering water level trends and criteria compliance.
			Min	66.9	66.5	**66.4**	**66.1**	**66.2**	**66.1**	**66.3**	**66.4**	66.7	66.7	66.5	
WM8	61610983	64.8	Max	65.4	65.5	64.9	64.7	65.0	64.8	64.3	64.7	65.2	65.6	65.5	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** In 2019–20 the site was non-compliant for the first time since 2016–17. Water levels were still declining in June. In 2017–18 this site was compliant for the first time since 2009–10. Water levels have shown a general rising trend. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound with the intention of reducing abstraction impacts at sites in the area, including WM8. The department also reviews public water supply abstraction annually, considering water level trends and criteria compliance.
			Min	65.1	**64.7**	**64.7**	**64.4**	**64.7**	**64.3**	**64.1**	**64.1**	64.9	65.0	**64.7**	

Groundwater monitoring bore	AWRC reference number	End of summer absolute minimum (mAHD)	Water levels (mAHD)											Comments on compliance during the reporting period
				2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	
MM12	61610989	42	Max	43	43	43	43	43	43	43	43	43	44	44	Compliance and trends: **Compliant with absolute summer minimum criterion.** Water levels have shown a general rising trend since 2011.
			Min	43	42	42	43	43	43	43	43	43	43	43	
L30C	61611010	47.2	Max	48.9	48.1	48.2	47.8	47.9	48.0	47.7	47.9	48.1	48.6	48.9	Compliance: **Compliant with absolute summer minimum criterion.** Water levels generally fell from 2005 to 2016 and are now showing a general rising trend.
			Min	48.1	48.0	47.7	47.5	47.5	47.7	47.3	47.3	47.6	48.0	48.0	
L110C	61611011	55.7	Max	57.7				57.4	57.6	57.4	57.6	57.8	57.9	57.7	Compliance: **Compliant with absolute summer minimum criterion.** Minimum levels could not be measured at the Ministerial criteria bore between March 2010 and July 2013 because of a blockage.
			Min	57.5				57.1	57.3	57.1	57.1	57.3	57.3	57.2	
L220C	61611018	52.2	Max	53.6	52.8	53.2	52.8	53.1	53.9	53.4	53.8	54.1	54.4	54.3	Compliance: **Compliant with absolute summer minimum criterion.** Levels have generally fallen since 1991 and the 2015–16 levels were the lowest on record. Water levels have shown a general rising trend.
			Min	52.6	52.3	52.4	52.1	52.3	53.1	52.8	53.1	53.2	53.3	53.3	

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 and Environmental Regulation (formerly Department of Water)

Period: 1 July 2018 to 30 June 2019

Table B 1 Ministerial conditions and procedures

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status 2018–19
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 new Gnangara groundwater allocation plan when it is released.
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		**Partly compliant.** The Department of Water and Environmental Regulation was established by the Government of Western Australia on 1 July 2017. It is a result of the amalgamation of the Department of Environment Regulation, Department of Water and the Office of the Environmental Protection Authority.
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 any change in proponent details.	Minister for the Environment		Overall		**Partly compliant.** The Department of Water and Environmental Regulation was established by the Government of Western Australia on 1 July 2017. It is a result of the amalgamation of the Department of Environment Regulation, Department of Water and the Office of the Environmental Protection Authority.
819: M 3-3	Proponent nomination and contact details	The nominated proponent shall notify the Chief Executive Officer of the EPA 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 any change in proponent details.	CEO		Overall	60 days of change	**Partly compliant.** The Department of Water and Environmental Regulation was established by the Government of Western Australia on 1 July 2017. It is a result of the amalgamation of the Department of Environment Regulation, Department of Water and the Office of the Environmental Protection Authority.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status 2018–19
819: M 4-1 1	Compliance audit and performance review	The proponent shall prepare an audit program and submit compliance reports to the EPA which address: • evidence of compliance with the conditions and commitments.	Detail in annual/triennial reports. Compliance report will include: • 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.
819: M 4-1 2	Compliance audit and performance review	The proponent shall prepare an audit program and submit compliance reports to the EPA which address: • the performance of the environmental management plans and programs.	Detail in annual/triennial reports. Compliance report will include: • the performance of the environmental management plans and programs.	Compliance report	CEO			Annually	**Compliant.** Environmental management plans and programs are ongoing and include: 1. the *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 evaluation statements are available on the department's website. 2. the new *Gnangara groundwater allocation pla*n when released will include new strategies to work towards meeting the following objectives: • reduce the total volume of water abstracted from the Gnangara system towards a level that better reflects the recharge from rainfall due to climate change. • 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 EPA, which address: • compliance with the conditions.	The performance review will address: • compliance with the conditions.	Compliance report	CEO		Overall	By 1 December each year and more detailed reports by 1 February every three years.	**Compliant.** Refer to 819: M 4-1 2. 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 EPA, which address: • the achievement of environmental objectives set for the proposal.	The performance review will address: • 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.** 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 EPA, which address: • 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: • 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.** The *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. Gnangara plan evaluation statements were completed in 2013 and 2015 (DoW 2013b; DoW 2015). These statements evaluated 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. A summary of consultation that has occurred to date as part of the new Gnangara groundwater allocation plan is contained within this report.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status 2018–19
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 EPA, which address: • proposed environmental management over the next three years to comply with conditions and environmental objectives set for the proposal.	The performance review will address: • 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.** The department submits annual and triennial compliance reports that are performance review reports on compliance with water level criteria and management activites and research initiatives. The department has implemented a number of management actions and research initiatives such as upgrading the PRAMS model and completing the Perth Regional Confined Aquifer Capcity project to help limit impacts of abstraction on groundwater-dependent ecosystems.
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 EPA.	Available on Department of Water and Environmental Regulation website.	Reports made available on the Department of Water's website.	CEO		Overall	After EPA acknowledg-ement letter being received. Department of Water and Environmental Regulation website.	**Compliant.** The following Gnangara compliance assessment reports have been formally audited or commented on by the then Department of Environmental Conservation (DEC) or the then OEPA and can be found on the department's website: • 2003–06 triennial (DoW 2007) • 2006–07 annual (DoW 2008a) • 2006–09 triennial (DoW 2010a). The following Gnangara compliance assessment reports have not been formally audited or commented on, but can also be found on the department's website: • 2007–08 annual (DoW 2009c) • 2009–10 annual (DoW 2010b) • 2010–11 annual (DoW 2011c) • 2009–12 triennial (DoW 2013a) • 2012–13 annual (DoW 2014a) • 2013–14 annual (DoW 2014b) • 2012–15 triennial (DoW 2016) • 2015–16 annual (DoW 2017) • 2016–17 annual (DWER 2017) • 2015–18 triennial (DWER 2020a) • 2018–19 annual (DWER 2020b)
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 immediately it becomes evident to the proponent.	Report in regular summaries sent to the Chief Executive Officer.	Letter to the Chief Executive Officer reporting non compliances with water level and other criteria as required. Compliance report.	CEO		Overall	Immediately as it becomes evident.	**Compliant.** The department reports annually to the EPA on non-compliance with water level 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). Present relevant material in annual/triennial compliance reports.	Compliance report	Minister for the Environment		Overall		**Compliant.** The department used the concept of sustainable yield and PRAMS modelling to calculate allocation limits for the *Gnangara groundwater areas allocation plan* (DoW 2009a). The department recognises that sustainable yield has diminished because recharge has decreased since the plan was released and has reassessed future allocation of Gnangara resources as part of the development of a new Gnangara groundwater allocation plan.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status 2018–19
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 EPA on advice of DBCA (formerly Department of Parks and Wildlife (DPaW)).	Present relevant material in annual/triennial reports. Refer draft groundwater management planning reports to the EPA and the DBCA for comment. Make compliance reports publicly available (on the Department of Water and Environmental Regulation's website).	Compliance report. Draft groundwater management documents sent to DBCA/EPA for comment. Reports made available on Department of Water (now Department of Water and Environmental Regulation) website.	EPA	DBCA	Overall	Subject to regular review every three years.	**Compliant.** The department's water licensing policies are the 'basis for groundwater management decisions'. We regularly review these policies (e.g. state-wide policies are reviewed every 5 years). The 2009 *Gnangara groundwater areas allocation plan* provides the foundation for water allocation decisions on the Gnangara Mound. We have issued two evaluation statements for the 2009 plan (DoW 2013b; DoW 2015). 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. The following Gnangara compliance assessment reports have been formally audited or commented on by the then DEC or the then OEPA and can be found on the department's website: • 2003–06 triennial (DoW 2007) • 2006–07 annual (DoW 2008a) • 2006–09 triennial (DoW 2010a). The following Gnangara compliance assessment reports have not been formally audited or commented on, but can also be found on the department's website: • 2007–08 annual (DoW 2009c) • 2009–10 annual (DoW 2010b) • 2010–11 annual (DoW 2011c) • 2009–12 triennial (DoW 2013a) • 2012–13 annual (DoW 2014a) • 2013–14 annual (DoW 2014b) • 2012–15 triennial (DoW 2016) • 2015–16 annual (DoW 2017) • 2016–17 annual (DWER 2018) • 2015–18 triennial (DWER 2020a) • 2018–19 annual (DWER 2020b)
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.** As outlined in the *Gnangara groundwater areas allocation plan 2009*, 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 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). The department recognises that it is non-compliant with approximately half of the environmental water provision criteria for the Gnangara groundwater resources proposal, and that, in line with climate change, further management strategies are required in order to reduce pressure on groundwater-dependent ecosystems, including reducing groundwater abstraction. The new Gnangara groundwater allocation plan when released will outline proposed strategies to help bring Gnangara groundwater resources back into balance.
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 EPA and the DBCA (formerly DPaW).	Comply with EPA Bulletin No. 1324 *and Ministerial Statement No. 819*. Undertake a monitoring program to measure integrity of GDEs.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		**Compliant.** Section 6.1 and Appendix C describe the department's environmental monitoring program (in line with the commitments in *Ministerial Statement No. 819*). The department undertakes management and research initiatives 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 2018–19
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 (now Department of Water and Environmental Regulation) website.	Allocation limits made available on the (now Department of Water and Environmental Regulation) website. Current water availability figures can be obtained from the department's Swan Avon regional office or through the department's water register: <www.water.wa.gov.au/maps-and-data/maps/water-register>	Minister for the Environment		Overall	End of October each year	**Compliant.** Current water availability figures are constantly changing. Up-to-date figures are available by contacting the department's Swan–Avon regional office or through the 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 and Environmental Regulation's website.	Allocation limits made available on the now Department of Water and Environmental Regulation website. Current water availability figures can be obtained from Swan Avon regional office or through the department's water register: <www.water.wa.gov.au/maps-and-data/maps/water-register>	Minister for the Environment		Overall	End of October each year	**Compliant.** Current water availability figures are constantly changing. Up-to-date figures are available by contacting the department's Swan Avon regional office or through the 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.** The Department has worked with local governments to investigate conceptual water supply and demand management options for North East Corridor urban expansion and Swan Valley agriculture, North Wanneroo agriculture and Western Suburbs Regional Organisation of Councils greenspaces. A cross-agency Waterwise Perth Action Plan has been initiated to help transition Perth to become a leading water wise city. The plan advocates responsible and sustainable use of water from all sources, including groundwater, and well-designed private and public green spaces are key to making the most of Perth's limited water resources. The Waterwise Council Program, a partnership between the Department of Water and Environmental Regulation and Water Corporation, fosters a cooperative working relationship with local government agencies to build demand management capability and improve water efficiency, climate resilience and liveability in their operations and their communities. An awareness campaign in spring 2019 enhanced garden bore owners' awareness of groundwater as a limited resource and to encourage waterwise use of garden bores.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status 2018–19
819: M 10-1 1	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: • clarification of the relationship between groundwater level and rainfall under conditions of declining long-term rainfall • to the requirements of the Minister for the Environment on advice of the EPA and the DBCA (formerly DPaW).	Engage in research projects to address this issue, which includes: • clarification of the relationship between groundwater level and rainfall under conditions of declining long-term rainfall.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		**Compliant.** The department used Perth Regional Aquifer Modelling System (PRAMS) modelling to examine the relationship between rainfall and groundwater levels as climate changes as part of our review of future allocation for a new Gnangara allocation plan.
819: M 10-1 2	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: • improvement in the understanding of the relationship between groundwater levels and vegetation, including plantations • to the requirements of the Minister for the Environment on advice of the EPA and the DBCA (formerly DPaW).	Engage in research projects to address this issue, which includes: • improvement in the understanding of the relationship between groundwater levels and vegetation, including plantations.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		**Compliant.** As part of the development of a new Gnangara allocation plan, the department used PRAMS modelling to simulate groundwater levels under various pines, land use and climate scenarios. 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. The department commissioned Dr Bea Sommer and Professor Ray Froend of Edith Cowan University to develop a model for determining ecological risk to groundwater-dependent vegetation across the Gnangara groundwater system as the climate changes. The model is based on 30 years of ecological and hydrological monitoring data. It has been an important management tool for assessing the impact of future land and water-use scenarios and for reviewing allocation limits for a new Gnangara allocation plan.
819: M 10-1 3	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: • improvement in the understanding of the relationship between groundwater level and abstraction from unconfined and confined aquifers of the Gnangara Mound • to the requirements of the Minister for the Environment on advice of the EPA and the DBCA (formerly DPaW).	Engage in research projects to address this issue, which includes: • 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/ DBCA	Overall		**Compliant.** The department is using PRAMS modelling to improve understanding of the relationship between groundwater level and abstraction from unconfined and confined aquifers of the Gnangara system. The Perth Regional Confined Aquifer Capacity study used robust and established science coupled with innovative research to improve our understanding of the deep Leederville and Yarragadee aquifers in the Perth region. 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.
819: M 10-1 4	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: • clarification of the relationship between groundwater level and wetland water levels and wetland water quality • to the requirements of the Minister for the Environment on advice of the EPA and the DBCA (formerly DPaW).	Engage in research projects to address this issue, which includes: • clarification of the relationship between groundwater level and wetland water levels and wetland water quality.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		**Compliant.** The department has studied hydrogeology at a number of sites across the Gnangara groundwater system 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.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status 2018–19
819: M 10-1 5	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: • improvement in the understanding of the relationship between groundwater level and water levels in the Yanchep caves • to the requirements of the Minister for the Environment on advice of the EPA and the DBCA (formerly DPaW).	Engage in research projects to address this issue, which includes: • improvement in the understanding of the relationship between groundwater level and water levels in the Yanchep caves.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		**Partly compliant.** Water quality and macroinvertebrate monitoring in the Yanchep caves ceased in 2013–14 because of low water levels and cave safety issues. Water loggers have been installed in some caves to monitor water levels. As water levels in caves reflect the surrounding groundwater levels the department uses nearby monitoring bores to monitor caves water levels. The department has a good understanding of the relationship between groundwater levels and cave water levels. Building on the work of the shallow groundwater system investigation, the department recently completed a study on the cause of rapidly declining levels at Loch McNess in Yanchep National Park (Kretschmer and Kelsey 2016). 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. We have worked with Water Corporation to reduce public water supply abstraction near the Yanchep National Park and further reductions are proposed. Reductions in abstraction, both public and private, and removal of pine plantations to the east will assist in improving groundwater levels in the vicinity of the Yanchep Caves.
819: M 10-1 6	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: • improvement in understanding of the conservation value of wetland and other groundwater-dependent ecosystems on the Gnangara Mound • to the requirements of the Minister for the Environment on advice of the EPA the DBCA (formerly DPaW).	Engage in research projects to address this issue, which includes: • 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/ DBCA	Overall		**Compliant.** The conservation value of wetlands is a prime responsibility of the Department of Biodiversity, Conservation and Attractions (formerly DPAW). The department 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, now Department of Water and Environmental Regulation).		Minister for the Environment		Overall		Not the responsibility of the Proponent (Department of Water and Environmental Regulation).
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 and Environmental Regulation).
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 EPA.	Department of Water and Environmental Regulation liaises with advisory body as required.	Liaison with advisory body in compliance report.	EPA	Agencies listed as part of compliance reporting.	Overall		**Compliant.** Refer to commitments: • 2,4,6,8,21 = DBCA (formerly DEC) • 21 = FPC. Both the FPC and the then DEC 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. The Department is working directly with these two advisory bodies on future management of the Gnangara, Pinjar and Yanchep pine plantations given the multiple objectives of the area – pine harvesting, Carnaby’s Cockatoo conservation and groundwater recharge.

Table B 2 The proponent's (Department of Water, now Department of Water and Environmental Regulation) environmental management conditions

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status 2018–19
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.** Refer to the results given in Appendix A – water level monitoring results for Ministerial sites on the Gnangara Mound.
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. Best examined in triennial reports, which also review long-term trends (most recent triennial for Gnangara: 2006-09).	Compliance report	Minister for the Environment	DBCA	Overall		**Compliant.** Gnangara plan evaluation statements were completed in 2013 and 2015 (DoW 2013b; DoW 2015). These statements evaluated 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. 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 2008c) and confirmed in *Ministerial Statement No. 819*. The department is reviewing the management objectives and allocation limits of Gnangara resources as part of the development of a new Gnangara allocation plan in preparation.
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. Incorporate water level and fauna monitoring of caves in the Department of Water and Environmental Regulation's Gnangara Mound monitoring program.	Compliance report	Minister for the Environment	DBCA	Overall		**Partly compliant.** Water levels in Yanchep Caves have been declining for a number of years and accessible caves are now dry. We can no longer gain access to a number of caves 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. We have also installed loggers in some of the bores in the caves to monitor groundwater levels. 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 (Kretschmer and Kelsey 2016). Working with DBCA, 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 and adjoining Loch McNess. There have been reductions to some northern Superficial and Leederville licence entitlemetns in line with the recommendations in Kretschmer and Kelsey (2016).
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.** The department assesses water management strategies and plans against our legislation, policies and guidelines to ensure that: • water management opportunities and issues are addressed at the appropriate planning and design stages of urban development and • proposed urban development does not result in adverse impacts to water resources and the environment. During the reporting period the department advised the Department of Planning, Land and Heritage that the East Wanneroo Structure Plan area will require a Drainage and Water Management Plan. The department is contributing with DPLH, City of Wanneroo and Urbaqua to complete the district water management strategy for East Wanneroo. It will propose new maximum water level criteria/thresholds for Lakes Mariginiup and Jandabup. These will be used as part of the subsoil drainage designs for future urban development in the East Wanneroo area.

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status 2018–19
819: P 5 1	Research and investigation program	Improving understanding of: • groundwater-environmental relationships on the Swan Coastal Plain; • the associated management requirements, and • 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: • groundwater – environmental relationships on the Swan coastal plain; • the associated management requirements, and • potential management techniques; • and will incorporate all relevant aspects of research and investigation work currently committed to under Ministerial statements 438 and 496.	Prepare a research and investigation program.	Submit research and investigation program to the EPA for approval. Compliance report.	EPA	DBCA	Overall	Within four months of a revised statement being issued following the 2004 Stage 1 section 46 review	**Compliant.** 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 assessment reports agreed that the commitment could be 'cleared' upon confirmation from the DEC. 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 is informing a new Gnangara allocation plan: • The department has updated the Perth Regional Aquifer Modelling System (PRAMS). • The department has completed the Perth Regional Confined Aquifer Capacity (PRCAC) that investigated 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 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. • For the new Gnangara allocation plan, we have used 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.
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	DBCA	Overall		**Compliant.** The department uses outcomes from the research and investigation program to develop management strategies based on scientific data, 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	DBCA	Overall	Every six years (coincide with triennial reports)	**Compliant.** 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 (PRAMS).
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: • monitoring of groundwater levels in all relevant aquifer systems; • relevant wetland water levels and water quality; • condition of vegetation and fauna associated with groundwater-dependent ecosystems • cave water levels.	Prepare an environmental monitoring program.	Submit monitoring program to the EPA for approval. Compliance report.	EPA	DBCA	Overall	Within four months of a revised statement being issued following the 2004 Stage 1 section 46 review	**Compliant.** A letter was sent to the Director General of the then DEC in December 2009, seeking advice and input on amendments to the environmental monitoring program. 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 assessment report agreed commitment could be 'cleared' upon confirmation from the then DEC. 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. The new Gnangara groundwater allocation plan will include an updated monitoring program.
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	DBCA	Overall		**Compliant.** (see P 6 1)

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status 2018–19
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	DBCA	Overall	Every six years (coincide with triennial report)	**Compliant.** A review of the environmental monitoring program was completed in June 2009 with ecologists who monitor on the department's behalf. We made a number of amendments. 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 and have been previously reported. We assess the monitoring program each year to ensure that the right sites are being monitored on the basis of water level and ecological condition trends. The department is reviewing environmental objectives and monitoring as part of developing a new 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 of Planning, Lands and Heritage (DPLH) (formerly Department of Planning and Infrastructure), DBCA (formerly DEC) and other relevant agencies on the impact of land use on groundwater resources.	Liaise with the City of Wanneroo, the DPLH, DBCA and other relevant agencies.	Compliance report	Minister for the Environment	City of Wanneroo, DBCA and other relevant agencies	Overall		**Compliant.** 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. Provide executive duties for the Gnangara Consultative Committee (see P 9).	Compliance report. See P 9.	Minister for the Environment		Overall		**Compliant.** (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.** The Gnangara GCC at the time of the GSS provided a cross government approach to the the sustainable management Gnangara groundwater resources. Whilst it hasn't been reinstated, the department continues to consult with a range of stakeholders on sustainable use of Gnangara groundwater. To develop the new Gnangara allocation plan we are consulting extensively with water users on how to adjust to climate change.
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.** The department has classified the sensitivity of each public water supply bore based on its proximity to environmentally sensitive areas and uses these classifications to distribute public supply abstraction to limit impacts at groundwater-dependent ecosystems.
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.** Supplementation of water levels continues to occur at Lake Nowergup all year round, but water levels continue to be non-compliant.

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status 2018–19
819: P 12	Reporting	Assessment of environmental impact(s) from groundwater abstraction for public water supply.	Require 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.** The department requires and reviews annual bore abstraction plans from Water Corporation to ensure that abstraction is distributed to limit impacts on groundwater-dependent ecosystems. Water Corporation also submits annual water monitoring summaries that report on compliance with environmental commitments made in its operating strategy.
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.** A similar commitment from previous statement 438: P 2 was stated as 'cleared' by the then 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. 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 Water Corporation to implement its 2001 wetland mitigation strategy and subsequent approved revision and report to the then DoW (now Department of Water and Environmental Regulation) 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 commissioning of the Lexia scheme	**Partly compliant.** The department has discussed this issue with 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. To date no further actions have been taken.

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) proposed conditions on Gnangara groundwater abstraction in 1986 when the Gnangara Mound water resources environmental review and management program was released (WAWA 1986). The conditions, released in March 1988 under Statement 021, included Ministerial water level criteria based on environmental knowledge at the time. These were considered reasonable by the then 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 then 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 then Department of Water conducted a further review of Ministerial conditions and commitments on Gnangara (DoW 2008c). Its purpose 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 the *EPA Bulletin 1324* in May 2009, with recommendations to the Minister for Environment on the proposed changes. *Statement No.819* for Gnangara (Government of Western Australia 2009) 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 new Gnangara groundwater allocation plan (currently in preparation).

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