Government of **Western Australia**
Department of **Water and Environmental Regulation**

Environmental management of groundwater from the Gnangara Mound groundwater resources

Annual compliance assessment report July 2021–June 2022

June 2023

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Summary

This report describes the Department of Water and Environmental Regulation's (the department) compliance with Ministerial conditions and commitments under *Ministerial statement no. 819 – Gnangara Mound groundwater resources [including East Gnangara Shire of Swan]* (Government of Western Australia 2009) for the period 1 July 2021 to 30 June 2022, under Part IV of the *Environmental Protection Act 1986* (EP Act).

The report presents total licensed groundwater entitlements covered under the *Gnangara groundwater allocation plan* (DWER 2022a) 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.

Under *Ministerial statement no. 819*, the department must manage the groundwater system to comply with water level criteria set at 30 groundwater-dependent wetland and terrestrial vegetation sites across the Gnangara groundwater system. The number of sites where water levels were non-compliant with absolute minimum or peak water level criteria in 2021–22 was 14, compared with 16 in 2020–21. Lake Mariginiup and MM55B became compliant in 2021–22, with the marginally improved rainfall received over the 2021–22 period, together with ongoing land use change, likely contributing to the increased water levels at the sites.

Rainfall at Perth Airport BoM station (no. 9021) over the reporting period was 689 mm which was well below the long-term (75 year) average of 756 mm and similar to the short-term (10 year) average of 672 mm (Table 1 and Figure 3).

Public water supply entitlement volumes, licensed to Water Corporation primarily for the Integrated Water Supply Scheme (IWSS), remained similar in 2021–22 to the previous reporting period (Table 1). 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).

Over the 2021–22 reporting period, the volumes of water licensed, injected and abstracted as part of Water Corporation's groundwater replenishment scheme for the IWSS was similar to 2020–21 (Table 1).

Private licensed entitlements increased across the Gnangara Mound by 2.14 GL compared with 2020–21 (Table 1).

To rebalance the Gnangara groundwater system in response to climate change, in June 2022 the department released the *Gnangara groundwater allocation plan* (DWER 2022a). The plan, developed over five years and following extensive stakeholder consultation, provides water users with certainty of ongoing supply and helps ensure the long-term environmental sustainability of the Gnangara groundwater system.

Table 1 Rainfall, licensed entitlement totals from all aquifers, and compliance summary

	2020–21	2021–22
Rainfall[1]	658.0 mm	688.8 mm
Public water supply entitlements (IWSS baseline licences, Town of Woodridge [ToW] and Moore River South development [MRSD])[2]	112.52 GL	111.47 GL
Public water supply entitlements (IWSS groundwater replenishment)[3]	27.15 GL	27.90 GL
Injected (actual)	*15.24 GL*	*15.02 GL*
Abstracted (actual)	*12.33 GL*	*10.48 GL*
Private licensed entitlements	127.38 GL	129.52 GL
Estimated garden bore and stock and domestic use[4]	36.00 GL	36.00 GL
No. of sites non-compliant with absolute minimum or peak water level criteria[5]	16 out of 30	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 2021–22 this consists of 110.65 GL licensed to Water Corporation for the IWSS (including 0.78 GL for bore MR17 which is located outside of the Gnangara allocation plan boundary, but within the Perth South Groundwater Area), 0.13 GL for the ToW and 0.69 GL for the MRSD.
In 2020–21 this consists of 111.7 GL licensed to Water Corporation for the IWSS (including 0.78 GL for bore MR17), 0.13 GL for the ToW and 0.69 GL for the MRSD.

3 For full details of IWSS groundwater replenishment (GWR) entitlements, injection and abstraction see section 3.1 and Table 2.

4 Garden bore and stock and domestic use is from the Superficial aquifer only. It is estimated using data collected through surveys, data from the Australian Bureau of Statistics and records of household use from Water Corporation.

5 For full details of compliance with absolute minimum or peak water level criteria see Table 4 and Appendix A.

The plan outlines strategies to reduce overall annual groundwater use from the Gnangara resources by 54 gigalitres (GL), or about 19 per cent. In doing so the plan aims to maintain or increase groundwater levels in important locations and reduce the rate of groundwater decline in other locations to avoid further impacts to the health of groundwater-dependent ecosystems. The plan also proposes changes to water level criteria at some sites, and the Environmental Protection Authority (EPA) is currently inquiring into whether these implementation conditions should be changed under section 46 of the EP Act.

Following the EPA's inquiry, the Minister for Environment will review its recommendations. If the Minister decides the implementation conditions should be changed, a new Ministerial Approval Statement will be issued. The department will continue to comply with monitoring and reporting requirements under *Ministerial statement no. 819* until a new statement is issued.

1 Background

1.1 Ministerial statement no. 819

Ministerial statement no. 819: Gnangara Mound groundwater resources [including East Gnangara Shire of Swan] (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 must comply with and report on the conditions to the EPA each year.

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

Some of the key conditions in *Ministerial 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 EP Act and since then they have been revised several times to include additional criteria sites or to remove sites where environmental values have been lost because of causes other than abstraction (Appendix C). These causes include reduced rainfall because of climate change, land clearing and disturbance related to changing land use.

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 groundwater system.

The new *Gnangara groundwater allocation plan* (DWER 2022a), released in June 2022, proposes changes to some water level criteria. The EPA is inquiring into the proposed changes under section 46 of the EP Act. After reviewing the EPA's recommendations, if the Minister for Environment decides that implementation conditions in *Ministerial statement no. 819* should be changed then a new Ministerial Approval Statement will be issued. The department will then comply with reporting conditions in the new Statement.

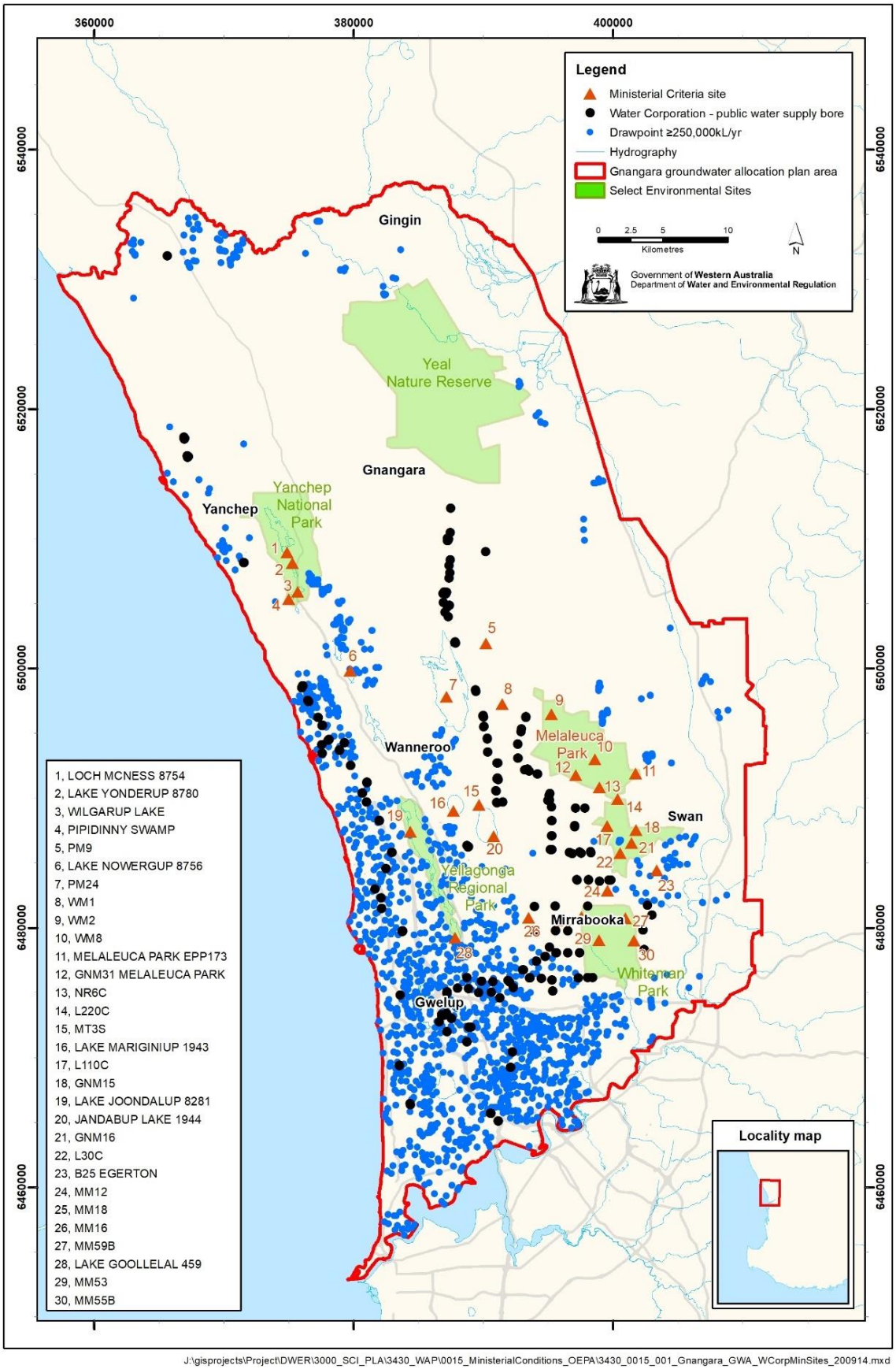

Figure 1 Location of Gnangara water level criteria sites, public water supply production bores and drawpoints of private licences with larger entitlements

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 currently over-allocated and overused. A reduction in rainfall and an increase in groundwater use have contributed to water level declines over the past 40 years. These have, in turn, 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). Private users of groundwater most often take water from the Superficial aquifer, while Water Corporation is the dominant user of the deeper Leederville and the Yarragadee aquifers for public water supply purposes.

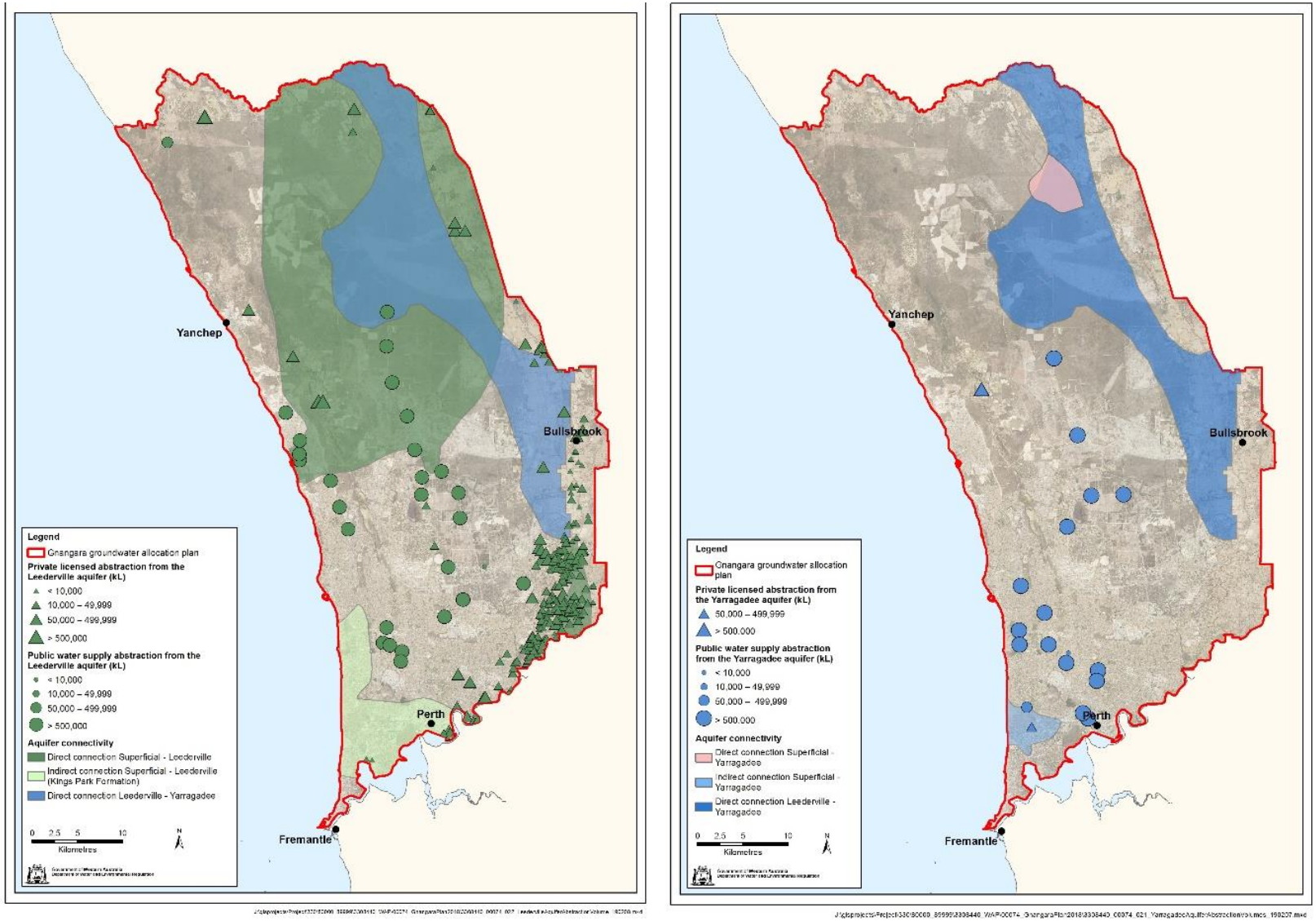

Figure 2 Groundwater connectivity of the Leederville (left) and Yarragadee (right) aquifers, with abstraction locations and volumes

1.3 Allocation limits and licensing

The department uses allocation limits, licensing of groundwater abstraction and monitoring of water levels, water quality and ecological values 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.

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 environmental, cultural and community values. The water level criteria set at high value wetland and bushland sites on the Gnangara groundwater system in *Ministerial statement no. 819* serve to restrict the amount of water that can be allocated from the system. This helps ensure there is sufficient water left in the system to meet environmental needs. If criteria are not met this indicates that there is a risk of impacts to ecological values. Breaches or impending breaches of criteria trigger management actions, including further investigations or, ultimately, changes to groundwater management and reductions to groundwater use.

Ongoing and increasing breaches of water level criteria set in *Ministerial statement no. 819* led to the development and release of the new *Gnangara groundwater allocation plan* (DWER 2022a), published in June 2022. The new Gnangara plan reduces groundwater use and establishes new allocation limits for the Gnangara groundwater resources.

The new allocation limits were 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 applied climate science, hydrogeological modelling and environmental assessments in setting the new allocation limits. See the *Gnangara groundwater allocation plan: Methods* (DWER 2022c) for more information.

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. This trend is predicted to continue with outputs from new state-of-the-art climate models under the Coupled Model Inter-comparison Project phase 5 (CMIP5) and 6 (CMIP6) projecting that the future climate for south-west Western Australia will continue to become warmer and drier (Grose et al. 2020).

Rainfall at the Perth Airport BoM station over the reporting period was 688.8 mm. An unusually large monthly rainfall of 262.8 mm was received in July 2022, the highest since records started in 1945. Despite this, rainfall was well below the long-term (75 year) average of 756 mm and similar to the short-term (10 year) average of 671.5 mm (Figure 3).

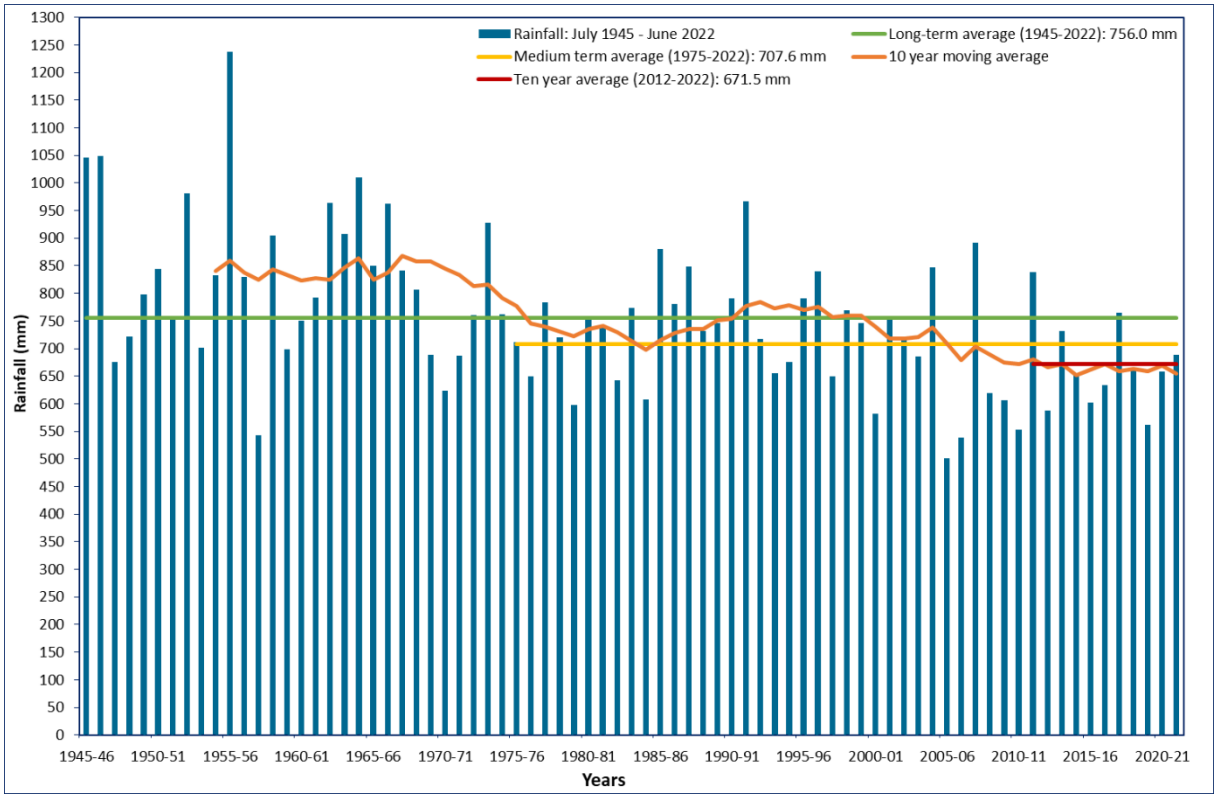

Figure 3 Annual and average water-year (July–June) rainfall at Perth Airport (BoM site no. 9021)

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 as well as 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 groundwater allocation plan area for the reporting period.

3.1 Public water supply entitlements

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 groundwater system, there is also a small volume of groundwater licensed from the Leederville aquifer for the Woodridge town water supply (ToW) and for the Moore River South development (MRSD). 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 111.47 GL in 2021–22 compared with 112.52 GL in 2020–21. See Table 2 for the distribution of licences by all aquifers and Table 3 for the distribution of licences across Superficial aquifer subareas. We continue to work with Water Corporation 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 *Ministerial 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 groundwater system. Licensed volumes are reported separately from other volumes licensed for public water supply. Water abstracted is balanced by water reinjected.

Groundwater replenishment is a form of managed aquifer recharge. At Beenyup Wastewater Treatment Plant in Craigie, water is treated to drinking water quality standard and recharged (or injected) into the Leederville and Yarragadee aquifers. In 2021–22 15.02 GL was injected, compared with 15.24 GL in 2020–21.

An equivalent amount of water is then available for abstraction from aquifers across the Gnangara groundwater system, and from one Yarragadee bore (MR17) located in the Perth South groundwater area, south of the Gnangara plan area. These are subject to a groundwater licence. The distribution of GWR licensing considers IWSS operating constraints while aiming to limit overall impacts to groundwater-dependent

ecosystems. See Table 2 for the distribution of licences, GWR injection volumes and GWR abstraction by aquifer.

3.2 Private licensed entitlements

Groundwater licensed for private use from the Gnangara groundwater 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 2009 *Gnangara groundwater allocation plan* (DoW 2009a), which capped private entitlements in most subareas (Tables 2 and 3).

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 the Gnangara groundwater system 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 the Gnangara area we estimate a total of 36 GL is abstracted from about 65,000 garden bores and 4,000 stock and domestic bores each year.

We use the best information available to estimate exempt uses. Estimates are updated over time as we get better information on the rates of instalment and average water use per bore in urban and rural areas.

Average water use per bore was estimated as part of our domestic bore metering project, which operated from 2009–2012. Average water use per bore decreased from about 800 kL/year to 430 kL/year in urban areas after the three-day-per-week sprinkler roster and the winter sprinkler ban were introduced in 2010.

From 1 September 2022, the rostered watering days for domestic garden bore use changed from three days to two days per week, which is the same roster as scheme water users. See Section 5.2 for more information.

Table 2 Licensed entitlements and estimates of garden bore use 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)	
	Baseline entitlements (IWSS + ToW + MRSD)[2]		IWSS GWR									
			Entitlements		Injected		Abstracted					
	2020–21	2021–22	2020–21	2021–22	2020–21	2021–22	2020–21	2021–22	2020–21	2021–22	2020–21	2021–22
Superficial	31.90	32.53	1.62	1.90	-	-	1.58	1.05	112.75	114.33	36.00	36.00
Mirrabooka[3]	3.50	3.48	0.80	0.80	-	-	0.74	0.09	2.52	2.41	-	-
Leederville	32.32	31.50	18.58	15.81	11.50	10.68	7.85	5.93	11.44	11.52	-	-
Yarragadee[3]	44.80	43.15	6.15	9.50	3.74	4.34	2.15	3.41	0.68	0.68	-	-
Fractured rock[4]	-	-	-	-	-	-	-	-	0.58	0.58	-	-
Total	**112.52**	**111.47**	**27.15**	**27.90**	**15.24**	**15.02**	**12.33**	**10.48**	**127.38**	**129.52**	**36.00**	**36.00**

1 Public water supply volumes include groundwater licensed to Water Corporation for the IWSS, the ToW and the MRSD.

2 In 2021–22 the IWSS baseline licence from the Gnangara groundwater system (including bore MR17) was 110.65 GL. In 2020-21 it was 111.70 GL. In both 2021–22 and 2020–21 the ToW entitlement was 0.13 GL and the MRSD entitlement was 0.69 GL (both from the Leederville aquifer).

3 Yarragadee public water supply entitlement volumes include: 0.78 GL in 2021-22 and 0 2020–21 from bore MR17 which is located outside of the Gnangara allocation plan boundary, but within the Perth South groundwater area.

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

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 system

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			
			2020–21	2021–22	2020–21	2021–22	2020–21	2021–22
Gingin	Beermullah Plain South	No	-	-	-	-	3.11	3.14
	Deepwater Lagoon South	No	-	-	-	-	2.90	2.88
	Guilderton South	No	-	-	-	-	9.49	9.78
	Lake Mungala	No	-	-	-	-	2.70	2.70
Total for Gingin Groundwater Area			**0.00**	**0.00**	**0.00**	**0.00**	**18.20**	**18.51**
Gnangara	Reserve	Yes	0.65	0.65	-	-	1.57	1.57
	Wanneroo Wellfield	Yes	6.05	6.10	-	-	2.15	2.11
Total for Gnangara Groundwater Area			**6.70**	**6.75**	**0.00**	**0.00**	**3.72**	**3.68**
Gwelup	Gwelup	No	3.30	3.30	0.10	0.10	1.19	1.10
Total for Gwelup Groundwater Area			**3.30**	**3.30**	**0.10**	**0.10**	**1.19**	**1.10**
Mirrabooka	Ballajura	No	2.00	2.00	0.05	0.05	0.97	1.36
	Beechboro	No	-	-	-	-	0.35	0.65
	Henley Brook	No	0.50	0.45	-	-	0.29	0.30
	Improvement Plan 8	No	1.55	1.60	-	-	0.16	0.16
	Landsdale	Yes	-	-	-	-	0.47	0.34
	Plantation	No	-	-	-	-	0.36	0.36
	State Forest	No	-	-	-	-	0.99	1.12
	Whiteman Park	Yes	0.10	0.08	-	-	0.63	0.72
Total for Mirrabooka Groundwater Area			**4.15**	**4.13**	**0.05**	**0.05**	**4.23**	**5.01**
Perth	City of Bayswater	No	-	-	-	-	2.22	2.50
	City of Fremantle North	No	-	-	-	-	0.05	0.05
	City of Nedlands	No	-	-	-	-	2.38	2.52
	City of Perth	No	-	-	-	-	1.86	1.49
	City of Stirling	No	2.80	2.80	0.30	0.30	7.83	7.83
	City of Subiaco	No	-	-	-	-	1.06	1.14
	Eglinton	No	-	-	-	-	3.43	3.39
	Quinns	No	10.85	11.05	0.25	0.25	3.61	3.49
	Shire of Peppermint Grove	No	-	-	-	-	0.08	0.08
	Shire of Swan North	No	-	-	-	-	0.73	0.73
	Town of Bassendean	No	-	-	-	-	0.37	0.37
	Town of Cambridge	No	-	-	-	-	2.37	2.33
	Town of Claremont	No	-	-	-	-	0.66	0.63
	Town of Cottesloe	No	-	-	-	-	0.28	0.28
	Town of Mosman Park	No	-	-	-	-	0.48	0.48
	Town of Vincent	No	-	-	-	-	0.82	0.72
	Whitfords	Yes	2.80	3.00	0.93	1.20	8.96	9.36
Total for Perth Groundwater Area			**16.45**	**16.85**	**1.48**	**1.75**	**37.21**	**37.38**
Swan	Bandy Spring	No	-	-	-	-	0.33	0.33
	Central Swan	No	-	-	-	-	1.26	1.27
	Cockman Bluff	No	-	-	-	-	0.80	0.85
	East Swan	No	-	-	-	-	0.78	0.80
	Neaves	No	-	-	-	-	3.23	3.23
	North Swan	Yes	-	-	-	-	2.73	2.66
	Radar	No	-	-	-	-	1.79	1.90
	South Swan	No	-	-	-	-	3.81	3.65
Total for Swan Groundwater Area			**0.00**	**0.00**	**0.00**	**0.00**	**14.73**	**14.68**
Wanneroo	Adams	Yes	-	-	-	-	1.04	1.04
	Carabooda	No	-	-	-	-	7.83	8.00
	Carramar	No	-	-	-	-	1.60	1.60
	Jandabup	No	-	-	-	-	0.18	0.18
	Joondalup	No	-	-	-	-	0.73	0.73
	Lake Gnangara	No	-	-	-	-	6.01	6.28
	Mariginiup	Yes	-	-	-	-	4.12	4.10
	Neerabup	No	-	-	-	-	2.52	2.52
	Nowergup	Yes	-	-	-	-	2.74	2.74
	Pinjar	Yes	-	-	-	-	0.58	0.58
Total for Wanneroo Groundwater Area			**0.00**	**0.00**	**0.00**	**0.00**	**27.33**	**27.76**
Yanchep	Yanchep	Yes	1.30	1.30	-	-	6.13	6.21
Total for Yanchep Groundwater Area			**1.30**	**1.30**	**0.00**	**0.00**	**6.13**	**6.21**
Total for Gnangara groundwater allocation plan area			**31.90**	**32.53**	**1.62**	**1.90**	**112.75**	**114.33**

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 2020–21 report was run on 1 July 2021. The 2021–22 report was run on 1 July 2022. All reports were run 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* (Government of Western Australia 2009) under Part IV of the EP Act 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:

- annual absolute minimum levels and minimum peak water levels
- annual 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 decreased to 14 in 2021–22 compared with 16 in 2020–21 (Table 4). In 2021–22 peak water levels at Lake Mariginiup increased from 41.3 to 41.6 mAHD, making the site compliant for the first time since 2018–19. Minimum water levels also increased from 29.28 to 29.52 mAHD at MM55B in Whiteman Park, making the site compliant for the first time since 2017–18. The marginally improved rainfall in 2021–22, together with ongoing land use change, likely contributed to the increased water levels at both sites.

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**
2020–21				
Loch McNess Lake Yonderup Lake Mariginiup Lake Jandabup Lake Nowergup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173	MM53 MM55B MM59B PM9 WM1 WM2 WM8	16 out of 30	Lake Mariginiup Lake Nowergup Lexia 86 Lexia 186 Melaleuca Park Dampland 78	5 out of 8
2021–22				
Loch McNess Lake Yonderup Lake Jandabup Lake Nowergup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173	MM53 MM59B PM9 WM1 WM2 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.

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 groundwater system over time and includes:

- wetland vegetation – paused in 2021–22 for transect maintenance[1]
- wetland macroinvertebrates and water quality
- mound spring macroinvertebrates and water quality
- wetland frogs.

Ecological condition of groundwater-dependent ecosystems is affected by several 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 public supply abstraction at priority locations, by reducing abstraction from nearby production bores where monitoring indicates there have been adverse changes in ecological condition and water stress is a likely contributing factor.

The department is required to update the monitoring program every six years and submit it to the EPA. This is in line with commitment 6.3 in *Ministerial statement no. 819* (Government of Western Australia 2009). The monitoring program is reviewed internally annually. A formal update will be submitted to the EPA in 2022 as part of the proposed changes to implementation conditions prompted by the new *Gnangara groundwater allocation plan* (DWER 2022a).

[1] Transect maintenance involves updating transect coordinates, re-staking transects and plots and tagging/re-tagging overstorey species

Wetland macroinvertebrates and water quality

Over the reporting period macroinvertebrates and water quality were monitored in spring to coincide with peak water levels at Loch McNess, Lake Yonderup, Lake Nowergup, Lake Joondalup, Lake Jandabup, Lake Mariginiup, Lake Goollelal, Melaleuca Park EPP173, Lake Gwelup and Lake Gnangara. The surveys showed:

- a risk of acidification at lakes Jandabup, Mariginiup, Gwelup and Gnangara
- high nutrient levels at lakes Jandabup and Nowergup (despite supplementation of water levels), Lake Mariginiup, Lake Gwelup, Lake Gnangara and Loch McNess (note, for lakes Gwelup, Goollelal and Joondalup high nutrient levels are more likely to be attributed to urban runoff)
- 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 and at lakes Yonderup, Nowergup, Jandabup and Gnangara
- localised extinction of the native fish *Galaxiella nigrostriata* from Melaleuca Park EPP173. Macroinvertebrate richness has also declined because of habitat loss resulting from lower water levels.

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 (WRM 2022).

Higher peak groundwater levels led to discharge and surface water expression remaining similar to, or improved from, previous years.

Water quality remained relatively stable across the reporting period. 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 2022). At some sites several species have stopped calling for an extended period, suggesting that these populations have died out. Disappearances of frog species from wetlands relate mostly to declining hydroperiods – periods of surface water presence – which can be related to declining groundwater levels. The disappearances of frogs 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). Annual variation in rainfall and surface water levels also impact on breeding success.

The monitoring suggests that current groundwater regimes at the monitored wetlands 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

(three to five years), with the greatest declines in the middle and north of the Gnangara plan 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 were outlined in the 2009 *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.

New Gnangara groundwater allocation plan

The department released the *Gnangara groundwater allocation plan: draft for public comment* (DWER 2021a) on 19 November 2021. We invited comments by advertising in state and local newspapers, and sending about 2,000 letters to groundwater licensees and 120 letters and/or emails to other stakeholders. We received 197 public submissions on the draft plan and our responses are detailed in the *Gnangara groundwater allocation plan: Statement of response* (DWER 2022b). We used these submissions to modify and finalise the plan which was release in June 2022.

The *Gnangara groundwater allocation plan* (DWER 2022a) details how groundwater abstraction will be reduced by about 54 GL per year from the Gnangara groundwater system over the next decade. The plan aims to stabilise or improve groundwater levels in key areas of environmental significance, and to reduce the rate of groundwater level decline in other areas where climate is driving the changes.

The plan includes adjustments to most licensed water users' entitlements that will better align the amount of groundwater abstracted with rainfall recharge under a drying climate. This will help ensure that Perth's groundwater-dependent environments are more resilient to climate change, and that the city's most important water source is secure and sustainable in the long term.

Managing public water supply use

Under the *Gnangara groundwater allocation plan* (DWER 2022a) Water Corporation's abstraction from the Gnangara groundwater system for the IWSS will be reduced by 30 GL/year in 2028. To supplement this reduction, a third seawater desalination plant at Alkimos to the north of Perth is expected to be operational by 2028 and will provide an additional, long-term, climate-independent drinking water source for Perth.

To reduce risks to Loch McNess in Yanchep National Park, Water Corporation will step down abstraction from its bores west of the park before 2028, to reach a volume of 0.21 GL/year by 2025–26.

The department will review the abstraction for Woodbridge town water supply and Moore River South development in the Gnangara plan area's north and near the Gingin Brook in a new Gingin water allocation plan.

Every 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 is done to reduce the impact 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. Stages 1 and 2 of the Groundwater Replenishment Scheme at Beenyup, with a combined capacity of 28 GL, have been commissioned, with Stage 2 due to reach full operation in 2022.

Water injected through Stage 2 of the Groundwater Replenishment Scheme will provide broader benefits to the groundwater system, including to connected wetlands in the northern half of the Gnangara plan area. The locations of the injection bores constructed as part of Stage 2 were informed by *Perth Regional Confined Aquifer Capacity study* (DWER 2021b) completed by the department to inform the sustainable use of Perth's deep aquifers.

Managing private licensed use

The *Gnangara groundwater allocation plan* (DWER 2022a) applies a reduction in groundwater use of 10 per cent to most private licence holders from 2028. The lead time before implementation of the reductions allows licensees time to improve their irrigation systems and/or adapt their business model so that the impact of the change on individuals and businesses is reduced. Schools, hospitals, commercial nurseries and tree farms, and community gardens are among the few exceptions to the 10 per cent reductions.

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.

The department conducts compliance monitoring events across licences taking water from the Gnangara groundwater system. They assess for incidents of suspected non-compliance, particularly those relating to alleged exceedance of annual water entitlements. The department's response to any alleged non-compliances ranges

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*.

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 (during this reporting period 14 of the 16 urban local councils across Gnangara are endorsed as 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

The use of domestic garden bores is managed under the provisions of the *Water Agencies (Water Use) By-Laws 2010*. Permanent water efficiency measures are ongoing and cover most of the Gnangara groundwater allocation plan area. They include:

- a total winter sprinkler switch off between 1 June and 31 August each year (unless delayed by the Minister because of low rainfall)
- a daytime sprinkler ban between 9am and 6pm
- sprinkler watering day rosters applying to scheme and domestic garden bore sprinkler use.

From 1 September 2022, the rostered watering days for domestic garden bore use changed from three days to two days per week, which is the same roster as scheme water users. The State Government is supporting garden bore users to adopt waterwise practices by promoting waterwise products and activities. For example, Water Corporation is providing a rebate for waterwise products, including smart irrigation controllers, and endorsing garden designers, landscapers, garden centres and nurseries which can assist households in watering efficiently and provide advice on waterwise plants.

Waterwise Perth action plan

The *Waterwise Perth action plan* was released in October 2019 to help transition Perth to a leading waterwise city (Government of Western Australia 2019). The 2019 action plan was a two-year plan in a 10-year program. The Waterwise program aims to achieve responsible and sustainable use of water from all sources, including

groundwater, and well-designed private and public green spaces to make the most of the Perth and Peel region's limited water resources.

The second phase of the program, *Kep Katitjin – Gabi Kaadadjan – Waterwise Perth action plan* 2, was launched in October 2022 (Government of Western Australia 2022). The department continues to work with local government, industry and the broader community to fulfil (among others) the following action plan commitments:

- reduce Perth and Peel groundwater use by 10 per cent by 2030
- Waterwise Gold status achieved by all Perth and Peel councils
- best practice waterwise policies integrated into all state urban water policies, guidelines and technical advice notes
- 100 per cent of irrigated open space audited and adopting waterwise management practices.

Be Groundwater Wise

The Be Groundwater Wise community education initiative was part of the 2019 *Waterwise Perth action plan* and continues in *Kep Katitjin – Gabi Kaadadjan – Waterwise Perth action plan* 2 (Government of Western Australia 2022). In collaboration with Water Corporation, the department has developed the Be Groundwater Wise website begroundwaterwise.wa.gov.au. It provides a central location for the community to learn about our precious groundwater and how to use groundwater wisely, such as through developing waterwise gardens and implementing waterwise use of garden bores.

5.3 Research initiatives

The department, together with research partners, has completed several 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 compliance reports and are also documented in the *Gnangara groundwater allocation plan* (DWER 2022a) and the *Gnangara groundwater allocation plan: Methods* (DWER 2022b).

5.4 Consultation

There was extensive stakeholder consultation over the reporting period in the finalisation of the *Gnangara groundwater allocation plan* (DWER 2022a). The department focused on working with water users, their industry reference groups and other government agencies to identify a practical pathway to bring the system back into balance, prepare for a future with less groundwater availability and help build climate resilient organisations and businesses. During the public consultation period for the draft plan between November 2021 and February 2022, the department held two major public information sessions for licensees, and many stakeholder meetings and presentations. The department received 197 submissions on the draft plan which were used to finalise the plan. The department's responses to the key issues raised are documented in the *Gnangara groundwater allocation plan: Statement of response* (DWER 2022b).

Appendices

Appendix A — Water level monitoring results for Ministerial sites for the Gnangara Mound Groundwater Resources for 2012–2022

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)										Status and comments on compliance during the 2021–22 annual reporting period
		Spring peak		End of summer minimum												
		Pref	Abs	Pref	Abs		2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22
Lake Goollelal	6162517			26.2*	26.0	Max	27.2	27.3	27.2	27.1	27.3	27.3	27.2	27.5	27.3	27.6
						Min	26.5	26.5	26.6	26.4	26.8	26.9	26.9	26.7	26.7	26.8
Loch McNess	6162564				6.95	Max	6.40	6.39	6.25	6.25	6.25	6.25	6.25	6.02	6.03	6.01
						Min	**6.10**	**6.25**	**6.25**	**6.07**	**6.25**	**6.25**	**6.25**	**5.89**	**5.94**	**5.85**

Compliance:

Compliant with absolute summer minimum and other criteria.

Since monitoring started, water levels at Lake Goollelal have never been non-compliant with the absolute summer minimum water level criterion.

Groundwater modelling projections indicate that the ongoing urbanisation of East Wanneroo could lead to increases in the surface water levels of Lake Goollelal in the coming years.

Compliance and trends:

Non-compliant with absolute summer minimum criterion.

The lake has been non-compliant since 2002–03. Lake levels fell rapidly from 2006 with some easing in the rate of decline evident in recent years. The original staff gauge at the lake is no longer inundated and a new staff gauge was installed in a deeper part of the wetland in 2019. Water levels are now measured from the new staff 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 monitoring 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 (DoW 2011a) 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 has not met the minimum groundwater requirement of wetland vegetation since 2006. Monitored peak and minimum levels in BH-LM2 have remained relatively stable since 2015.

In 2016 the department completed a further 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.

Under the *Gnangara groundwater allocation plan* (DWER 2022a), groundwater abstraction will be reduced in areas that are affecting Superficial aquifer levels in the vicinity of Yanchep National Park. This action should help to stabilise and slightly improve water levels at Loch McNess in coming years.

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)										Status and comments on compliance during the 2021–22 annual reporting period
		Spring peak		End of summer minimum												
		Pref	Abs	Pref	Abs		2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22	
Lake Yonderup	6162565				5.9	Max	5.8	5.8	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. Peak and minimum levels declined from about 2006, although peak levels were relatively stable from 2014 to 2021. Minimum levels have continued to decline, particularly from 2011 onwards, and this trend continued over the reporting period. 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 (DoW 2011b) 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. The minimum groundwater level at this bore has remained more than one metre below this level for over a decade, including over the reporting period. Water levels in YDP_SC have been stable from 2016 onwards. Under the new *Gnangara groundwater allocation plan* (DWER 2022a), groundwater abstraction will be reduced in areas that are affecting Superficial aquifer levels in the vicinity of Yanchep National Park. This action should help to stabilise and slightly improve water levels at Lake Yonderup in coming years.
						Min	**5.6**	**5.6**	**5.6**	**5.5**	**5.6**	**5.5**	**5.5**	**5.6**	**5.5**	**5.4**	
Lake Joondalup	6162572 (Staff 8281)			16.2*	15.8	Max	16.8	17.1	17.0	16.9	17.1	17.3	17.6	17.5	17.4	17.8	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. Groundwater modelling projects that water levels at Lake Joondalup are likely to rise further as result of the ongoing urbanisation of East Wanneroo. High water levels may be having an impact on the health of fringing *Melaleuca rhaphiophylla* adjacent to the lake. This will be further assessed during annual ecological monitoring.
						Min	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	16.7	17.0	
	61610661 (Bore 8281)					Max	18.6	19.0	18.9	18.7	19.0	19.2	19.4	19.4	19.2	19.5	
						Min	18.0	18.2	18.3	18.1	18.5	18.6	18.7	18.6	18.6	18.8	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)										Status and comments on compliance during the 2021–22 annual reporting period
		Spring peak		End of summer minimum			2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22	
		Pref	Abs	Pref	Abs												
Lake Mariginiup	6162577 (Staff 1943)	42.1*	41.5			Max	**41.1**	**41.3**	**41.3**	**41.1**	**41.4**	41.5	41.6	**41.4**	**41.3**	41.6	Compliance and trends: **Compliant with absolute minimum spring peak criterion.** Peak levels have shown an increasing trend over the past decade and this trend continued over the reporting period. Lake levels were compliant with the absolute spring peak criterion for the first time since 2018–19. Groundwater modelling projects that water levels at Lake Mariginiup are likely to rise in the future because of increasing urbanisation of the East Wanneroo area and a corresponding decrease in groundwater abstraction from agricultural land uses. **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. Minimum groundwater levels have slowly been increasing since 2011. Management and mitigation: Work completed as part of the Perth shallow groundwater systems investigation (Searle et al. 2010a) 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 • bore MGP_C (AWRC ref. 61611440) should be used to relate changes in the watertable to wetland vegetation condition. 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 increased marginally over the reporting period. Groundwater modelling projections indicate that the ongoing urbanisation of East Wanneroo is likely to lead to an increase in surface water levels of Lake Mariginiup in the coming years.
						Min	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**	41.0 **4/6 yr**	41.0 **4/6 yr**	
	61610685 (Bore MS10)					Max	40.8	41.0	41.2	40.8	41.1	41.1	41.2	41.1	40.9	41.2	
						Min	40.1	40.1	40.2	40.0	40.4	40.4	40.3	40.2	40.2	40.4	
Lake Jandabup	6162578 (Staff 1944)	44.7*	44.2		44.3	Max	44.6	44.7	44.7	44.6	44.7	44.8	45.0	44.8	44.6	44.9	Compliance and trends: **Compliant with absolute spring peak criterion.** **Non-compliant with absolute summer minimum criterion.** Water Corporation supplements lake levels to meet the absolute spring peak water level criterion and to prevent the lakebed from drying and oxidising, causing acidification upon rewetting. Over the reporting periods 780 ML was supplemented into the lake. 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 because of excessive drying of the lakebed is high if water levels decline and the lakebed is exposed. However, groundwater modelling projects that water levels at Lake Jandabup are likely to rise in the future because of increasing urbanisation of the East Wanneroo area and a corresponding decrease in groundwater abstraction from agricultural land uses. This should reduce the need for artificial supplementation of the lake. Management and mitigation: Work completed as part of the Perth shallow groundwater systems investigation found that bore JB12B (AWRC ref. 61610764) should be used to relate groundwater levels to the ecological condition of vegetation on the transect. Groundwater modelling projections indicate that the ongoing urbanisation of East Wanneroo is likely to lead to an increase in surface water levels of Lake Jandabup in the coming years.
						Min	**44.1**	**44.2**	**44.2**	**44.1**	44.3	**44.2**	44.3	44.3	**44.29**	**44.2**	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)										Status and comments on compliance during the 2021–22 annual reporting period
		Spring peak		End of summer minimum			2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22	
		Pref	Abs	Pref	Abs												
Lake Nowergup	6162567 (Staff) 616145 (telemetered site)	17.0*	16.8			Max	**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**	**15.7 4/6 yr**	**15.6 4/6 yr**	**15.6 4/6 yr**	**15.7 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 artificially maintained by the department. Since 2018 the department has used a telemetered site to monitor levels at the lake (AWRC ref. 616145). 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) recommended: • the continuation of the supplementation regime • the use of groundwater levels at bore LN2-89 (AWRC ref. 61611247) to relate changes in the watertable to wetland vegetation condition. Minimum levels at bore LN2-89 declined from 2007 to 2016 but rose about 1.5 m in 2017-18 and water levels have been stable over the past few years. The department investigated the causes of groundwater level declines at Lake Nowergup and results 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). The *Gnangara groundwater allocation plan* (DWER 2022a) includes reductions in both public and private licensed entitlements across Gnangara resources, including in the vicinity of Lake Nowergup, which modelling projects should, with continued supplementation, help to stabilise water levels at the lake and buffer the lake against the effects of climate change.
						Min	16.0	16.0	16.0	16.0	16.0	16.0	15.1	15.0	15.0	15.1	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)										Status and comments on compliance during the 2021–22 annual reporting period
		Spring peak		End of summer minimum			2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22	
		Pref	Abs	Pref	Abs												
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**	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. Ecological condition Vegetation composition at Lake Wilgarup has shifted from one dominated by wetland species such as *Baumea articulata* to a terrestrial community dominated by *Eucalyptus gomocephala*. Bushfire events have also led to the significant loss of peat from the wetland. Management and mitigation: Given the location of Lake Wilgarup just to the east of Loch McNess, the department's management actions to improve water levels at Loch McNess also aim to benefit groundwater levels at Lake Wilgarup. However, groundwater modelling results indicate that the improvement in groundwater levels will not be sufficient to produce surface water at Lake Wilgarup and therefore the vegetation is likely to remain dominated by terrestrial species.
						Min											
	61618500 (Bore)					Max	4.31	4.41	4.29	4.21	4.34	4.29	3.64	3.43	3.32	3.58	
						Min	**3.83**	**3.82**	**3.79**	**3.66**	**3.88**	**3.75**	**2.99**	**2.86**	**2.83**	**2.90**	
Pipidinny Swamp	6162624 (Staff)	2.70	2.40		1.6	Max	**1.8**	**2.2**	**1.9**	**1.6**	**2.0**	**2.0**	**2.2**	**1.4**	**0.9**	**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. 61611872) – 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. Under the *Gnangara groundwater allocation plan* (DWER 2022a), groundwater abstraction will be reduced in areas that are affecting Superficial aquifer levels in the vicinity of Yanchep National Park. This action should help to stabilise and slightly improve water levels at Pipidinny Swamp in coming years.
						Min	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**<0.7**	**<0.7**	**<0.7**	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)										Status and comments on compliance during the 2021–22 annual reporting period
		Spring peak		End of summer minimum			2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22	
		Pref	Abs	Pref	Abs												
Lexia 86 (GNM16)	61613215			47.3*	47.0	Max	47.6	47.8	47.7	47.3	47.7	47.9	48.2	48.2	47.8	47.9	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. Under the *Gnangara groundwater allocation plan* (DWER 2022a), groundwater abstraction will be reduced in areas that are affecting Superficial aquifer levels in the vicinity of the Lexia wetlands. This action should help to maintain levels at Lexia 86.
						Min	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	47.1 4/6 yr	47.1 4/6 yr	
Lexia 186 (GNM15)	61613214			47.5*	47.2	Max	46.9	47.2	47.1	46.7	47.0	47.3	47.5	47.6	47.3	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. Under the *Gnangara groundwater allocation plan* (DWER 2022a), groundwater abstraction will be reduced in areas that are affecting Superficial aquifer levels in the vicinity of the Lexia wetlands. This action should help to maintain levels at Lexia 186.
						Min	**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	**46.7** 4/6 yr	**46.8** 4/6 yr	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)										Status and comments on compliance during the 2021–22 annual reporting period
		Spring peak		End of summer minimum			2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22	
		Pref	Abs	Pref	Abs												
Melaleuca Park EPP173	6162628 (Staff)				50.2	Max	50.6	50.9	50.7	50.4	50.8	51.0	51.1	50.8	50.6	50.8	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Water levels have been non-compliant with absolute summer minimum criterion since water level monitoring began in 1995. The spring peak and summer minimum levels in 2021-22 were higher than in 2020–21. Ecological condition: Groundwater declines since the mid-2000s have contributed to the wetland species *Baumea articulata* and *Pericalymma ellipticum* almost disappearing from the transect. Despite lower water levels *B. articulata* is still present in very low abundances. Other tree species remain in good health. Declines have also contributed to the degradation and loss of aquatic habitat for macroinvertebrates and a decline in macroinvertebrate richness. The native fish *Galaxiella nigrostriata* has also become locally extinct. Management and mitigation: Under the *Gnangara groundwater allocation plan* (DWER 2022a), groundwater abstraction will be reduced in areas that are affecting Superficial aquifer levels in the vicinity of Melaleuca Park. Modelling indicates that this action should limit declines in groundwater levels at Melaleuca Park EPP173.
						Min	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.7	50.4	50.4	
	61613213 (Bore GNM14)					Max	49.7	50.3	50.1	49.3	50.2	50.3	50.8	50.1	49.8	50.3	
						Min	**48.7**	**48.8**	**48.7**	**48.5**	**49.0**	**48.8**	**48.7**	**48.7**	**48.6**	**48.8**	
Melaleuca Park Dampland 78 (GNM31)	61613231			65.4*	65.1	Max	65.2	65.3	65.2	64.9	65.1	65.2	65.4	65.5	65.4	65.6	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. However, groundwater levels have been on a rising trend since 2016. 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). Under the *Gnangara groundwater allocation plan* (DWER 2022a), groundwater abstraction will be reduced in areas that are affecting Superficial aquifer levels in the vicinity of Melaleuca Park. Modelling indicates that this action should limit declines in groundwater levels at Melaleuca Park Dampland 78.
						Min	**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**	65.1 **4/6 yr**	65.2 **4/6 yr**	
Egerton Spring (B25)/ Egerton Spring (B25A)	61618607/ 61672233				39.29	Max	40.04	40.17	40.12	39.97	40.10	40.20	40.26	40.15	40.07	40.86	Compliance and trends: **Compliant with absolute summer minimum criterion.** Water levels have been compliant since 2003 and since then there has been a rising trend in response to increased localised recharge associated with the surrounding urban development. Additional information: The department was unable to continue monitoring at bore B25 because of access and safety issues. The department now uses B25A (AWRC ref. 61672233), located nearby, to measure water level criteria. Modelling completed as part of the *Gnangara groundwater allocation plan* (DWER 2022a) indicates groundwater levels can be maintained at Egerton Spring.
						Min	39.69	39.73	39.79	39.58	39.84	39.84	39.76	39.71	39.77	40.28	

* 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)										Status and comments on compliance during the 2021–22 annual reporting period
				2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22	
MM16	61610835	38.8	Max	39.6	40.1	40.2	40.1	40.3	40.7	41.1	41.0	40.7	41.0	Compliance and trends: **Compliant with absolute summer minimum criterion.** Minimum water levels have been stable in recent years. Modelling completed as part of the *Gnangara groundwater allocation plan* (DWER 2022a) indicates groundwater levels can be maintained at MM16.
			Min	39.0	39.2	39.5	39.3	39.5	39.8	40.0	40.0	40.0	40.1	
MM18	61610918	38.6	Max	39.6	39.9	40.0	39.6	40.0	40.2	40.6	40.6	40.2	40.5	Compliance and trends: **Compliant with absolute summer minimum criterion.** Minimum water levels have been stable in recent years. Modelling completed as part of the *Gnangara groundwater allocation plan* (DWER 2022a) indicates groundwater levels can be maintained at MM18.
			Min	39.0	38.9	39.2	39.1	39.2	39.4	39.6	39.6	39.5	39.6	
MM53	61610493	33.3	Max	33.6	34.0	34.0	33.5	33.7	34.0	34.3	34.1	33.7	34.1	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 MM53. The department reviews public water supply abstraction annually, considering water level trends and criteria compliance. Modelling completed as part of the *Gnangara groundwater allocation plan* (DWER 2022a) indicates groundwater levels can be improved at MM53.
			Min	**33.0**	**32.8**	**33.1**	**32.9**	**33.1**	**33.1**	**33.27**	**33.2**	**33.1**	**33.2**	
MM55B	61610559	29.5	Max	30.3	30.5	30.5	30.3	30.4	30.6	30.8	30.7	30.2	30.7	Compliance and trends: **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, 2017–18 and 2021–22. Modelling completed as part of the *Gnangara groundwater allocation plan* (DWER 2022a) indicates groundwater levels can be improved at MM55B.
			Min	**29.2**	**29.2**	29.7	**29.2**	**29.4**	29.55	**29.46**	**29.3**	**29.3**	29.52	
MM59B	61611025	36.3	Max	36.2	36.3	36.3	36.0	36.1	36.4	36.7	36.5	36.0	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. Modelling completed as part of the *Gnangara groundwater allocation plan* (DWER 2022a) indicates groundwater levels can be improved at MM59B.
			Min	**35.5**	**35.5**	**35.6**	**35.4**	**35.5**	**35.6**	**35.8**	**35.6**	**35.5**	**35.6**	
MT3S	61610745	43.0	Max	44.2	44.6	44.5	44.3	44.6	44.9	45.0	44.8	44.5	44.9	Compliance and trends: **Compliant with absolute summer minimum criterion.** Minimum water levels have been stable in recent years. Groundwater modelling projections indicate that the ongoing urbanisation of East Wanneroo is likely to lead to increases in groundwater levels at MT3S in the coming years.
			Min	43.5	43.7	43.7	43.6	44.0	44.1	44.0	44.0	43.9	44.0	

Groundwater monitoring bore	AWRC reference number	End of summer absolute minimum (mAHD)	Water levels (mAHD)										Status and comments on compliance during the 2021–22 annual reporting period
				2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22	
NR6C	61610982	58.5	Max	59.3	59.7	59.5	59.1	59.5	60.0	59.9	59.7	59.5	59.6	Compliance and trends: **Compliant with absolute summer minimum criterion.** Minimum water levels have been stable in recent years. Modelling completed as part of the *Gnangara groundwater allocation plan* (DWER 2022a) indicates groundwater levels can be maintained at NR6C.
			Min	58.7	58.9	59.0	58.7	58.8	59.0	59.0	59.0	58.8	58.9	
PM9	61610804	56.3	Max	54.8	55.0	54.7								Compliance and trends: **Non-compliant with absolute summer minimum criterion.** The bore is not currently being monitored because of 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. The department is proposing to remove the water level criteria at PM9 in the *Gnangara groundwater allocation plan* (DWER 2022a).
			Min	**54.4**	**54.3**	**54.1**	**51.8**							
PM24	61610697	40.5	Max	42.0	42.1	42.3	42.1	42.2	41.6	42.5	42.2	42.0	42.0	Compliance and trends: **Compliant with absolute summer minimum criterion.** Water levels have been stable since 2011. No water level recording occurred between August and November as the site and access track were inundated. Peak water levels would have been higher than 42.0mAHD (recorded in December). This also occurred during the 2017–18 and 2018–19 reporting periods. Modelling completed as part of the *Gnangara groundwater allocation plan* (DWER 2022a) indicates groundwater levels can be maintained at PM24.
			Min	41.1	41.1	41.3	41.0	41.4	41.0	41.1	41.0	40.9	41.0	
WM1	61610833	55.7	Max	54.4	54.7	54.4	54.5	55.1	55.6	55.9	55.6	55.2	55.4	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Until 2020–21 water levels had been showing 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 WM1. The department reviews public water supply abstraction annually, considering water level trends and criteria compliance. Under the *Gnangara groundwater allocation plan* (DWER 2022a), groundwater abstraction will be reduced in areas that are affecting Superficial aquifer levels in the vicinity of WM1. Modelling indicates that this action should limit declines in groundwater levels at the site.
			Min	**54.1**	**54.2**	**54.1**	**54.1**	**54.3**	**54.7**	**54.9**	**54.9**	**54.6**	**54.6**	

Groundwater monitoring bore	AWRC reference number	End of summer absolute minimum (mAHD)	Water levels (mAHD)										Status and comments on compliance during the 2021–22 annual reporting period
				2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22	
WM2	61610908	66.5	Max	66.4	66.7	66.5	66.6	67.2	67.3	67.5	67.0	66.6	66.7	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Until 2020–21 water levels had been showing 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. Under the *Gnangara groundwater allocation plan* (DWER 2022a), groundwater abstraction will be reduced in areas that are affecting Superficial aquifer levels in the vicinity of WM2. Modelling indicates that this action should limit declines in groundwater levels at the site.
			Min	**66.1**	**66.2**	**66.1**	**66.3**	**66.4**	66.7	66.7	66.52	**66.2**	**66.2**	
WM8	61610983	64.8	Max	64.7	65.0	64.8	64.3	64.7	65.2	65.6	65.5	64.7	65.0	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Until 2020–21 water levels had been showing a general rising trend after reaching a record low in 2015–16 and 2016–17. 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. Under the *Gnangara groundwater allocation plan* (DWER 2022a), groundwater abstraction will be reduced in areas that are affecting Superficial aquifer levels in the vicinity of WM8. Modelling indicates that this action should limit declines in groundwater levels at the site.
			Min	**64.4**	**64.7**	**64.3**	**64.1**	**64.1**	64.9	65.0	**64.7**	**64.4**	**64.4**	
MM12	61610989	42	Max	43	43	43	43	43	43	44	44	43	44	Compliance and trends: **Compliant with absolute summer minimum criterion.** Minimum water levels have been stable in recent years. Modelling completed as part of the *Gnangara groundwater allocation plan* (DWER 2022a) indicates groundwater levels can be maintained at MM12.
			Min	43	43	43	43	43	43	43	43	43	43	
L30C	61611010	47.2	Max	47.8	47.9	48.0	47.7	47.9	48.1	48.6	48.9	48.2	48.4	Compliance and trends: **Compliant with absolute summer minimum criterion.** Water levels in 2015–16 and 2016–17 were the lowest on record. They have been stable since then. Modelling completed as part of the *Gnangara groundwater allocation plan* (DWER 2022a) indicates groundwater levels can be maintained at L30C.
			Min	47.5	47.5	47.7	47.3	47.3	47.6	48.0	48.0	47.8	47.8	
L110C	61611011	55.7	Max		57.4	57.6	57.4	57.6	57.8	57.9	57.7	57.3	57.5	Compliance and trends: **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. Modelling completed as part of the *Gnangara groundwater allocation plan* (DWER 2022a) indicates groundwater levels can be maintained at L110C.
			Min		57.1	57.3	57.1	57.1	57.3	57.3	57.2	57.0	57.0	
L220C	61611018	52.2	Max	52.8	53.1	53.9	53.4	53.8	54.1	54.4	54.3	54.1	54.5	Compliance and trends: **Compliant with absolute summer minimum criterion.** Water levels in 2015–16 levels were the lowest on record. Water levels rose again in 2017 and have been stable since then. Modelling completed as part of the *Gnangara groundwater allocation plan* (DWER 2022a) indicates groundwater levels can be maintained at L220C.
			Min	52.1	52.3	53.1	52.8	53.1	53.2	53.3	53.3	53.2	53.4	

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 2022

Table B 1 Ministerial conditions and procedures

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status and further information for the 2021–22 annual reporting period
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		**Non-compliant** Strategies have been implemented to reduce impacts on environmentally important sites. These were outlined in the *Gnangara groundwater allocation plan* (2009a) and included: • significantly reducing abstraction for public water supply • increasing licence compliance and enforcement activities • capping abstraction for private licensed water supply Further amendments are outlined in the *Gnangara groundwater allocation plan* (DWER 2022a) and these are being assessed by the EPA under section 46 of the EP Act. Compliance monitoring and reporting results were used to support the development of the plan. The plan includes new strategies to return the system to balance and reduce groundwater use in line with climate change. The plan supports one of the targets of the State Government's 2019 *Waterwise Perth Action Plan* (Government of Western Australia 2019) and the *Kep Katitjin – Gabi Kaadadjan – Waterwise Perth action plan* 2 (Government of Western Australia 2022), which is a 10 per cent reduction in groundwater use across Perth and Peel by 2030.
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 *Ministerial 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		**Non-compliant** Refer to the results given in Appendix A – water level monitoring results for Ministerial sites on the Gnangara Mound. A number of sites were non-compliant with the absolute minimum and/or peak water level criteria identified in Schedule 1 of *Ministerial statement no. 819*. Fourteen sites were non-compliant in 2021–22 compared with 16 sites in 2020–21.
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		**Not required at this time** No change to proponent was made over the reporting period.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status and further information for the 2021–22 annual reporting period
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		**Not required at this time** No change to proponent was made over the reporting period.
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	**Not required at this time** No change to proponent was made over the reporting period.
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.** Performance and compliance with water level criteria, management activities and research initiatives are summarised in sections 4 and 5 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.** The department has recently finalised the *Gnangara groundwater allocation plan* (DWER 2022a). It includes strategies to work towards meeting the following objectives: • reducing the total volume of water abstracted from the Gnangara groundwater system towards a level that better reflects the recharge from rainfall because of climate change. • protecting groundwater-dependent ecosystems from impacts associated with abstraction. It also proposes some changes to Conditions in *Ministerial statement no. 819*, which are being assessed by the EPA under section 46 of the EP Act. The department is preparing a Groundwater Monitoring and Management Plan as part of its proposed changes to implementation conditions. Until such time as a new Ministerial Approval Statement is issued, the department continues to comply with the reporting requirements in *Ministerial statement no. 819*.
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.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status and further information for the 2021–22 annual reporting period
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 allocation plan* (DWER 2022a) was finalised and released in June 2022. A summary of consultation that has occurred to date as part of its development is contained within this report. The accompanying *Gnangara groundwater allocation plan: Statement of response* (DWER 2022b) 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 2013a; DoW 2015). These statements evaluated the department's management of Gnangara groundwater resources against 2009 *Gnangara groundwater areas allocation plan* (DoW 2009) objectives since its release. The evaluation statements are available on the department's website.
819: M 4-2 4	Compliance audit and performance review	The proponent shall submit a performance review report by 1 December each year and more detailed reports by 1 February every three years, to the requirements of the 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, management activities and research initiatives. The department has implemented a number of management actions and research initiatives such as upgrading the Perth Regional Aquifer Modelling System (PRAMS) model and completing the Perth Regional Confined Aquifer Capacity (PRCAC) project to help understand and 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 Acknowledge-ement letter being received. Department of Water and Environmental Regulation website.	**Compliant.** Gnangara annual and triennial compliance reports are available on the department's website.
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 help calculate allocation limits for the new *Gnangara groundwater allocation plan* (DWER 2022a). The department recognises that sustainable yield has diminished because recharge has decreased since the 2009 plan was released and has reassessed future allocation of Gnangara resources as part of the development of the *Gnangara groundwater allocation plan* (DWER 2022a).

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status and further information for the 2021–22 annual reporting period
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 the Department of Biodiversity, Conservation and Attractions (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. statewide policies are reviewed every five years). The *Gnangara groundwater allocation plan: draft for public comment* (DWER 2021) was released or public comment in November 2021. The plan was finalised and released in June 2022 (DWER 2022a). The accompanying *Gnangara groundwater allocation plan: Statement of response* (DWER 2022b) 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 2013a; DoW 2015). These statements evaluated the department's management of Gnangara groundwater resources against 2009 *Gnangara groundwater areas allocation plan* objectives since its release. The evaluation statements are available on the department's website. Gnangara annual and triennial compliance reports are also available on the department's website.
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		**Non-compliant.** The addition of the Perth and Southern desalination plants and the Groundwater Replenishment scheme to the Integrated Water Supply Scheme has reduced the pressure on the Gnangara groundwater system for public water supply. 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 remains non-compliant with about 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 *Gnangara groundwater allocation plan* (DWER 2022a) outlines proposals for further reductions in licensed groundwater entitlements along with other 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		**Non-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.
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 .	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.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status and further information for the 2021–22 annual reporting period
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.	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.
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. The cross-agency *Waterwise Perth Action Plan* (Government of Western Australia 2019) was initiated to help transition Perth to become a leading waterwise city. The plan advocates responsible and sustainable use of water from all sources, including groundwater, and sets a target of a 10 per cent reduction in groundwater use across Perth and Peel by 2030. 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. In autumn 2021, under the Be Groundwater Wise initiative, the department ran digital campaigns to educate garden bore owners on the importance of groundwater and how to use it wisely – knowing how to have a water-efficient bore and irrigation system and a waterwise garden.
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 PRAMS modelling to examine the relationship between rainfall and groundwater levels as climate changes as part of our review of future allocation for the *Gnangara groundwater allocation plan* (DWER 2022a). The PRAMS model is currently undergoing another version update.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status and further information for the 2021–22 annual reporting period
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 the *Gnangara groundwater allocation plan* (DWER 2022a), 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 (Sommer & Froend 2010). 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 the draft 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 PRCAC 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, 10 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 and further information for the 2021–22 annual reporting period
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		**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 DBCA, 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		**Non-compliant.** 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		**Non-compliant.** 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 the Department of Environment and Conservation [DEC]) • 21 = Forest Products Commission (FPC). Both the FPC and the then DEC made public submissions to the *Gnangara groundwater areas water management plan: draft for public comment* (DoW 2008a), 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 and further information for the 2021–22 annual reporting period
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		**Non-compliant.** Refer to the results given in Appendix A – water level monitoring results for Ministerial sites on the Gnangara Mound. A number of sites were non-compliant with the absolute minimum and/or peak water level criteria identified in Schedule 1 of *Ministerial statement no. 819*. Sixteen sites were non-compliant in 2020–21 and 14 sites in 2021–22.
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 2013a; DoW 2015). These statements evaluated the department's management of Gnangara groundwater resources against the objectives in the 2009 *Gnangara groundwater areas allocation plan* (DoW 2009). The evaluation statements are available on the department's website. Gnangara plan evaluation statements were completed in 2013 and 2015 (DoW 2013a; DoW 2015). These statements evaluated the department's management of Gnangara groundwater resources against the objectives in the 2009 *Gnangara groundwater areas allocation plan* (DoW 2009). 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 reviewed the management objectives and allocation limits of Gnangara resources as part of the development of the *Gnangara groundwater allocation plan* (DWER 2022a). The plan proposes some changes to environmental conditions and water level criteria, which are being assessed by the EPA in 2022.
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		**Non-compliant.** Water levels in Yanchep Caves have been declining for many 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 the 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 cave water levels. Building on the work of the shallow groundwater system investigation, the department 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. It 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 entitlements in line with the recommendations in Kretschmer and Kelsey (2016). Further reductions in licensed groundwater entitlements are outlined in the *Gnangara groundwater allocation plan* (DWER 202a2), which also aim to improve groundwater levels in the vicinity of Yanchep National Park and the Yanchep Caves.

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status and further information for the 2021–22 annual reporting period
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 • proposed urban development does not result in adverse impacts to water resources and the environment. During the reporting period the department worked with the Department of Planning, Lands and Heritage (DPLH), City of Wanneroo and Urbaqua to complete the District Water Management Strategy for East Wanneroo. The existing environmental conditions set on lakes Mariginiup and Jandabup were significant considerations for the establishment of Controlled Groundwater Levels and overall drainage designs for future urban development in the East Wanneroo area.
819: P 5 1	Research and investigation program	Improving understanding of: • groundwater-environmental relationships on the Swan Coastal Plain • the associated management requirements • 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 It will incorporate all relevant aspects of research and investigation work currently committed to under *Ministerial statement nos. 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 reports agreed that the commitment could be 'cleared' upon confirmation from the DEC (now DBCA). The department, together with research partners, is focusing management effort on the areas that will show the most benefit from changes to abstraction. This work has informed the *Gnangara groundwater allocation plan* (DWER 2022a) and includes: • updates to the PRAMS • completion of the PRCAC studies that investigated the best locations and depth for sustainable abstraction from the Leederville and Yarragadee aquifers and for groundwater replenishment (or managed aquifer recharge) • completion of the Perth shallow groundwater system investigations (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 • a conceptual model of vegetation water requirements developed by Edith Cowan University being used in the draft plan, 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 six-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 PRAMS.

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status and further information for the 2021–22 annual reporting period
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 (EMP). The previous environmental monitoring program was produced and submitted to the EPA on 21 December 2005. It was detailed in Appendix 7 of the Gnangara triennial report 2003–06 (DoW 2007). The audit of 2006–07 compliance report agreed commitment could be 'cleared' upon confirmation from the 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.
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 819: P 6 1)
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 six-year intervals.	Triennial compliance report	EPA	DBCA	Overall	Every six years (coincide with triennial report)	**Compliant.** Although the action states that a review must be compiled in triennial reports every six years, the EMP 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 based on water level and ecological condition trends. The department has also reviewed environmental objectives and monitoring as part of developing the *Gnangara groundwater allocation plan* (DWER 2022a) and is producing a Groundwater Monitoring and Management Plan as part of its request to change some of the implementation conditions in statement no. 819 under the EP Act.
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, 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, DPLH, DBCA and other relevant agencies.	Compliance report	Minister for 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 Environment		Overall		**Not required at this time.** (See M19: 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 Environment		Overall		**Not required at this time.** The Gnangara GCC at the time of the Gnangara Sustainability Study provided a cross-government approach to the sustainable management of Gnangara groundwater resources. While it hasn't been reinstated, the department continues to consult with a range of stakeholders on sustainable use of Gnangara groundwater. To develop the *Gnangara groundwater allocation plan* (DWER 2022a) we consulted extensively with water users on how to adjust to climate change.

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status and further information for the 2021–22 annual reporting period
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 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 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.
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 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 Environment		Overall		**Compliant.** A similar commitment from previous *Ministerial statement no. 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 monitoring and management issues facing 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 Environment		Overall	Before the commissioning of the Lexia scheme	**Partially compliant.** Water Corporation has developed a wetland offset strategy, but it has not been fully finalised or implemented. Production from the Lexia borefield never reached full capacity because of environmental concerns and under the new *Gnangara groundwater allocation plan* (DWER 2022a), abstraction from the borefield is likely to be reduced further or ceased altogether. The department has proposed a change to this implementation condition as part of its request for changes to implementation conditions under section 46 of the EP Act.

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 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 Western Australia (WAWA) 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.

After further research on wetland water requirements, in 1995 WAWA reviewed the Ministerial water level criteria (WAWA 1995). The review highlighted that climate was an important factor affecting groundwater levels, and it was difficult to predict future groundwater levels given the uncertainty of future climatic conditions. Following the release of this report in 1996 the water service provision and water management arms of WAWA were separated to form Water Corporation and Water and Rivers Commission. A new Ministerial statement (statement no. 438) with revised conditions was issued to the Water and Rivers Commission in 1997. With the addition of Water Corporation's new Lexia Borefield in the late 1990s another set of Ministerial conditions were established on the Water and Rivers Commission for the East Gnangara area in 1999 (statement no. 496).

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, East Gnangara and Jandakot mounds under section 46 of the EP Act. The first stage of the review led to *Ministerial statement no. 687* for Gnangara/East Gnangara (Government of Western Australia 2005a) and *Ministerial statement no. 688* for Jandakot (Government of Western Australia 2005b).

In 2007, the Department of Water conducted a further review of Ministerial conditions and commitments on Gnangara (DoW 2008b). Its purpose was to remove Ministerial criteria from sites where ecological values had been lost because of reasons other than groundwater level change, and from sites where analysis showed that abstraction was not the main factor influencing groundwater levels. This review eventually led to a revised *Ministerial statement no.819* being released in 2009, which as of December 2021 is the current set of environmental conditions under which the Gnangara groundwater resources is managed (Government of Western Australia 2009).

The second stage of the Section 46 review proposed in 2001 was meant to be 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 was overtaken by more recent investigations into the shallow groundwater

systems and ecological responses to climate. The results of these and other investigations has been used to develop the new *Gnangara groundwater allocation plan* (DWER 2022a). The plan was finalised in June 2022 after a three-month public comment period. The plan also proposes changes to water level criteria at some sites that will require assessment by the EPA under the EP Act and so a section 46 review process has been initiated. If the Minister for Environment, after reviewing the EPA's recommendations, determines that the implementation conditions should be changed, a new Ministerial Approval Statement will be issued, and an addendum will be added to the plan.

References

Bamford M & Everard C 2021, *Frog Monitoring on the Gnangara Mound: 2003 – 2020,* Prepared for the Department of Water and Environmental Regulation, MJ & AR Bamford, Consulting Ecologists, Kingsley, Western Australia.

Bates BC, Chandler RE, Charles SP & Campbell EP 2010, *Assessment of apparent nonstationarity in time series of annual inflow, daily precipitation, and atmospheric circulation indices: A case study from southwest Western Australia*, Water Resources Research, vol. 46, W00H02, doi:10.1029/2010WR009509.

Blake D, Horwitz P & Zwickl K 2021, *Wildfire in Yanchep National Park wetlands: post-fire effects, water chemistry and macroinvertebrate response,* prepared for the Department of Water and Environmental Regulation, Centre for Ecosystem Management, Edith Cowan University, Joondalup.

Department of Environment 2005, *Section 46 review of environmental conditions on management of the Gnangara and Jandakot Mounds: Section 46 progress report – State of the Gnangara Mound*, Department of Environment, Government of Western Australia, Perth.

DoE – see Department of Environment

Department of Water 2007, *Environmental management of groundwater allocation from Gnangara groundwater mound – triennial compliance report to the Environmental Protection Authority, July 2003–June 2006*, Department of Water, Government of Western Australia, Perth.

——2008a, *Gnangara groundwater areas allocation plan: for public comment*, Department of Water, Government of Western Australia, Perth.

——2008b, *Review of Ministerial conditions on the groundwater resources of the Gnangara Mound*, Department of Water, Government of Western Australia, Perth.

——2009a, *Gnangara groundwater areas allocation plan*, Department of Water, Government of Western Australia, Perth.

——2009b, *Gnangara groundwater areas allocation plan: Statement of response*, Department of Water, Government of Western Australia, Perth.

——2011a, *Perth Shallow Groundwater Systems Investigation: Loch McNess,* Hydrogeological Record no. HG 43, Department of Water, Government of Western Australia, Perth.

——2011b, *Perth Shallow Groundwater Systems Investigation: Lake Yonderup,* Hydrogeological Record no. HG 51, Department of Water, Government of Western Australia, Perth.

——2013b, *Gnangara groundwater areas allocation plan: Evaluation statement 2009–2011*, Department of Water, Government of Western Australia, Perth.

——2015, *Gnangara groundwater areas allocation plan: Evaluation statement 2011–2014*, Department of Water, Government of Western Australia, Perth.

DoW – see Department of Water

Department of Water and Environmental Regulation 2021a, *Gnangara groundwater allocation plan: draft for public comment*, Department of Water and Environmental Regulation, Government of Western Australia, Perth.

——2021b, Studying Perth's deep aquifers to improve their management: Findings and recommendations from the Perth Region Confined Aquifer Capacity study, Hydrogeological Record series report no. 67, Department of Water and Environmental Regulation, Perth.

——2022a *Gnangara groundwater allocation plan*, Department of Water and Environmental Regulation, Government of Western Australia, Perth.

——2022b, *Gnangara groundwater allocation plan: Statement of response*, Department of Water and Environmental Regulation, Perth.

——2022c, *Gnangara groundwater allocation plan: Methods*, Water resource and allocation planning report no. 77, Department of Water and Environmental Regulation, Perth.

DWER – see Department of Water and Environmental Regulation

Global Groundwater 2015, *Lake Nowergup: Factors in declining lake and groundwater levels,* prepared for the Department of Water, Government of Western Australia, Perth.

Government of Western Australia 2005a, *Statement to amend conditions applying to proposals – Gnangara Mound groundwater resources, Ministerial statement 687*, Minister for Environment, Government of Western Australia, Perth.

——2005b, *Ministerial statement no. 688: Jandakot Mound groundwater resources*, Government of Western Australia, Perth.

——2009, *Statement to amend conditions applying to proposals – Gnangara Mound groundwater resources, Ministerial statement 819*, Minister for Environment, Government of Western Australia, Perth.

——2019, *Waterwise Perth Action Plan*, Government of Western Australia, Perth.

——2022, *Kep Katitjin – Gabi Kaadadjan – Waterwise Perth action plan* 2, Government of Western Australia, Perth.

Kretschmer P & Kelsey P 2016, *Loch McNess hydrogeology and causes of water level decline*, *Hydrogeological* record series, HG60, Department of Water, Western Australia.

Lette E & Horwitz P 2021, *Annual report for the Gnangara Mound environmental monitoring programme - macroinvertebrate and water quality wetland monitoring for spring 2020*, Centre for Ecosystem Management, Edith Cowan University, Joondalup.

Mattiske Consulting Pty Ltd 2021. Monitoring the effects of groundwater abstraction on native vegetation on the norther Swan Coastal Plain. Unpublished report by Mattiske Consulting Pty Ltd to Department of Water & Environmental Regulation.

MacTiernan A (Minister for Agriculture and Food) 2019, *Minister for Agriculture and Food Response to North Wanneroo Agriculture and Water Taskforce Recommendations 30 January 2019*, available at www.agric.wa.gov.au/sites/gateway/files/Response-to-taskforce-report.pdf (accessed 22/12/2021)

McHugh SL & Bourke SA 2007, *Management area review: shallow groundwater systems on Gnangara and Jandakot mounds*, HG25, Department of Water, Government of Western Australia.

North Wanneroo Agriculture and Water Taskforce (NWAWT) 2018, *Recommendations to the Hon. Alannah MacTiernan, MLC Minister for Agriculture and Food – Thursday 16 August 2018*, available at www.agric.wa.gov.au/sites/gateway/files/Taskforce-report_1.pdf (accessed 22/12/2021)

Searle JA 2009, *Bore completion report for Perth shallow groundwater systems: investigation – stage 2,* Hydrogeology Report no. HR 276, Department of Water, Government of Western Australia, Perth.

Searle JA, McHugh SL, Paton AC & Bathols GR 2010a, *Perth shallow groundwater systems investigation: Lake Mariginiup*, Hydrogeological Record no. HG 36, Department of Water, Government of Western Australia, Perth.

Searle JA, Hammond MJ & Bathols G 2010b, *Perth Shallow Groundwater Systems Investigation: Lake Nowergup,* Hydrogeological Record no. HG 40, Department of Water, Government of Western Australia, Perth.

Sommer B & Froend R 2010, *Gnangara Mound ecohydrological study*, prepared for the Department of Water and Environmental Regulation, Centre for Ecosystem Management, Edith Cowan University, Joondalup.

Water Authority of Western Australia 1986, *Gnangara Mound groundwater resources – environmental review and management*, Water Authority of Western Australia, Government of Western Australia, Perth.

——1995, *Review of proposed changes to environmental conditions, Gnangara Mound groundwater resources (Section 46)*, Water Authority of Western Australia, Government of Western Australia, Perth.

WAWA – see Water Authority of Western Australia

WRM 2021, *East Gnangara Mound Springs: Invertebrate monitoring, spring 2020 survey*. Unpublished report by Wetland Research & Management to Department of Water & Environmental Regulation.

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