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

Environmental management of groundwater abstraction from the Gnangara Mound

Triennial compliance report to the Office of the Environmental Protection Authority

July 2009 – June 2012

Looking after all our water needs

Environmental management of groundwater from the Gnangara Mound

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July 2009 to June 2012

Looking after all our water needs

Department of Water

January 2013

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1 Introduction

This triennial report covers the period 1 July 2009 to 30 June 2012 and describes the Department of Water's compliance with conditions and commitments, including water level criteria, given in *Ministerial Statement No. 819* (Government of Western Australia 2009a). The report also outlines the environmental monitoring, management actions, research initiatives and consultation the department undertakes to manage the groundwater resources of the Gnangara system in a sustainable manner.

Ministerial statement No. 819 sets environmental water provisions in the form of water level criteria at 30 sites across the Gnangara Mound, including 14 wetland sites and 16 terrestrial phreatophytic vegetation sites (Figure 1). Ministerial conditions and commitments were established in 1986 to manage the development of groundwater abstraction for public water supply and expected private abstraction. The conditions and commitments have been revised several times to remove sites where the environmental values identified for protection have been lost due to causes other than abstraction. These causes include the drying climate, land clearing and disturbance related to changing land use. The most recent revision removed seven sites and amended the water level criteria at three sites. Reduced recharge and changes in land use continue to contribute to non-compliance.

The department aims to manage abstraction from the Gnangara groundwater system to meet water level criteria and to minimise environmental impacts associated with abstraction. The department manages abstraction using allocation limits set for each aquifer by groundwater subarea.

Allocation limits and licensing of groundwater abstraction are the main mechanisms the department uses to manage Gnangara groundwater resources. The department also guides the appropriate use of domestic garden bores. Totals of licensed entitlements from groundwater areas within the Gnangara groundwater areas allocation plan (DoW 2009a) boundary, focusing on entitlements from the Superficial aquifer (the Gnangara Mound), are given in this report (Tables 1, 2 and 3).

In 2009–10, there were no additional sites non-compliant with absolute minimum or peak water level criteria compared to the previous year and water levels at most sites were relatively stable. In 2010–11, there were three additional sites non-compliant with absolute minimum or peak water level criteria and declines in water levels at most sites. In 2011–12, the number of sites non-compliant with absolute minimum or peak water level criteria remained unchanged despite water levels at most sites stabilising or improving marginally (Table 1).

The department has previously submitted annual compliance reports for 2009–10 and 2010–11. This triennial report replaces the annual report of the final year of the reporting period.

Table 1 Rainfall, water use from the Superficial aquifer and number of sites non-compliant absolute minimum and peak water level criteria over the reporting period

	Gnangara Mound (Superficial aquifer)		
	2009-10	**2010-11**	**2011-12**
Rainfall (mm) [1]	606.2	552.8	838.0
Public water supply entitlements (GL)	32.80	48.26	41.96
Private licensed entitlements (GL)	110.58	113.08	115.70
Estimated garden bore use (GL) [2]	35.00	27.20	27.00
Non compliance [3]	13/30	16/30	16/30

[1] Rainfall figures are for the months July to June, corresponding with the reporting period. They are taken from Perth Airport BOM station.

[2] Garden bore use is estimated as part of our annual water accounting. Approach to estimating use is covered in section 4.3.

[3] The number of sites non-compliant with absolute summer minimum or absolute minimum spring peak water level criteria (sites non-compliant with both water level criteria are count only once in the table). For full details of compliance see Table 4, Table 5 and Appendix A.

2 The Gnangara groundwater system

The Gnangara system provides water for public open space, horticulture, industry and gardens, and is a vital component of Perth's public water supply. The system comprises four main aquifers:

- the shallow unconfined Superficial (water table) aquifer known as the Gnangara Mound
- the shallow, semi confined Mirrabooka aquifer
- the deeper, partially confined Leederville aquifer
- and the deeper, mostly confined Yarragadee aquifer.

Groundwater levels across the Superficial aquifer have generally declined over the last thirty years due to a combination of a drying climate (less rainfall and recharge), dense vegetation (native bush and pine plantations) limiting recharge and impacts from abstraction for public water supply, private licensed use and garden bores.

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

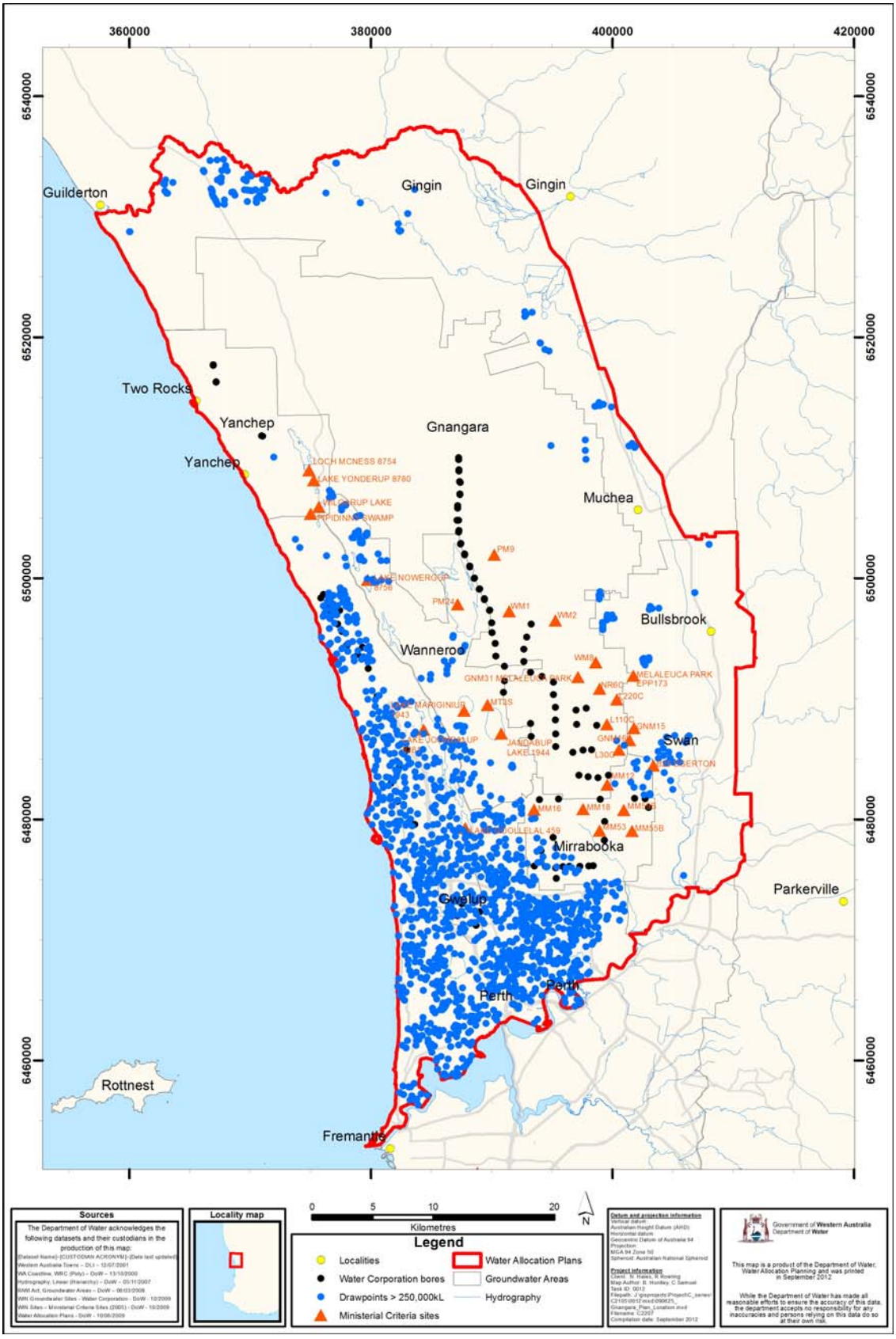

Figure 1 Location of Ministerial sites, public water supply production bores and private licensed entitlements over 250,000 kL from the Superficial aquifer

3 Rainfall and recharge

Across the south-west of Western Australia there has been a general trend of declining annual rainfall since the mid 1970s. A CSIRO investigation of climate change (Bates et al. 2010) predicts a continuation of rainfall reduction in the south-west of Western Australia.

Groundwater levels of the Superficial aquifer depend directly on recharge from rainfall. Comparison of medium term (post July 1975) and short-term average rainfall (post July 1997) for the Perth Airport (BOM site 9021) show further declines since the 1970s (Figure 2).

Over the reporting period, Perth's rainfall was 606.2 mm, 552.8 mm and 838.0 mm in 2009-10, 2010-11 and 2011-12 respectively. In 2010, the wet season rainfall (368.2 mm between May and September) was the lowest on record. This led to the lowest inflow into Water Corporation's reservoirs ever recorded and contributed to groundwater levels across the Superficial aquifer falling to the lowest levels on record. In comparison, wet season rainfall in 2009 was 548.6 mm and 596.6 mm in 2011.

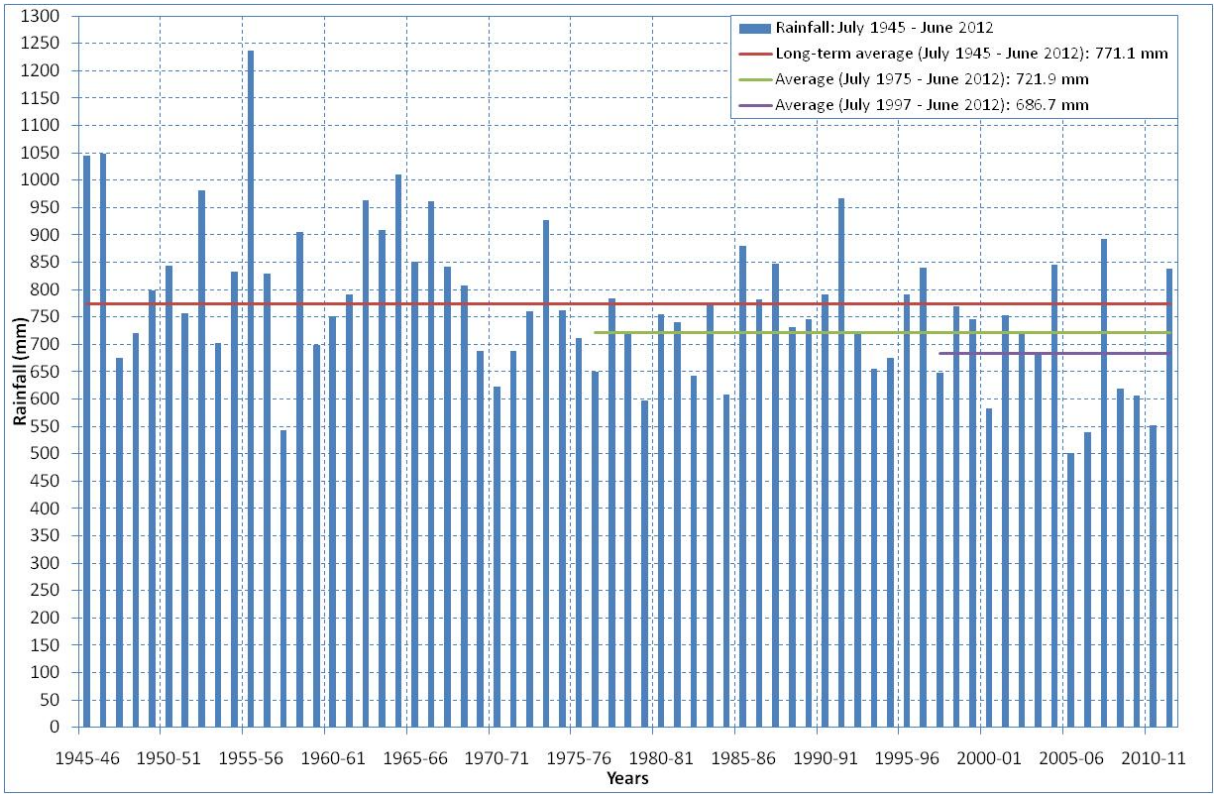

Figure 2 Long-term rainfall by water year (July 1945 – June 2012) for Perth Airport BOM site 9021

Note: Data sourced from the Bureau of Meteorology.

4 Groundwater use

4.1 Public water supply

For public water supply purposes the Gnangara and Jandakot groundwater systems are managed together as part of the Integrated Water Supply Scheme. Licensed entitlements for public water supply are from all aquifers.

Licence entitlements from the Superficial aquifer for the public water supply are within the Gnangara, Gwelup, Mirrabooka, Perth and Yanchep groundwater areas. The volumes of groundwater licensed for public water supply from all aquifers over the reporting period are shown in Table 2. Table 3 shows public supply licensed entitlements from the Superficial aquifer over the reporting period by groundwater subarea. See also section 6.2.3.

4.2 Private licensed use

Most of the groundwater now licensed from the Superficial aquifer is to private users. Groundwater is used for public open space, horticulture, industry, gardens and grounds of institutions and recreation grounds. Over this triennial period private licensed entitlements from all aquifers in the Gnangara groundwater areas remained relatively steady (see Table 2 and section 6.2.4). Table 3 shows volumes of private licensed entitlements from the Superficial aquifer over the reporting period by groundwater subarea.

4.3 Garden bore use

Groundwater is also abstracted from the Superficial aquifer through domestic garden bores that do not require a licence. Garden bore use is estimated using Australian Bureau of Statistics data and Water Corporation household use data. Estimates are verified through data collected from bores that have been metered by the department. Data is provided to the Bureau of Meteorology for inclusion in their national water account.

The estimated volumes of groundwater abstracted from the Superficial aquifer within the *Gnangara groundwater areas allocation plan* boundary are shown in Table 2. Over this triennial period, use has declined due to the introduction of the sprinkler restrictions for garden bore use. See also section 6.2.5.

Table 2 Licensed entitlements from the all aquifers within the Gnangara groundwater areas for public water supply and private use; and estimated garden bore use over the reporting period

Aquifer	Public water supply entitlements (GL)			Private licensed entitlements (GL)			Estimated garden bore use (GL)		
	2009–10	2010–11	2011–12	2009–10	2010–11	2011–12	2009–10	2010–11	2011–12
Superficial	32.80	48.26	41.96	110.58	113.08	115.70	35.00	27.20	27.00
Mirrabooka	0.90	4.24	4.22	2.39	2.26	2.21			
Leederville	35.45	48.09	48.85	11.56	13.09	12.00			
Yarragadee	40.25	50.19	52.28	0.68	0.68	0.68			
TOTAL	**109.39**	**150.78**	**147.31**	**125.21**	**129.11**	**130.59**	**35.00**	**27.20**	**27.00**

Table 3 Licensed entitlements from the Superficial aquifer within the Gnangara groundwater areas for public water supply and private licensed use over the reporting period

Groundwater area	Subarea	Ministerial site present	Allocation limit (GL/yr) [1, 2]		Public water supply licensed entitlements (GL/yr) [3]				Private licensed entitlements (GL/yr) [4]		
			2007	2011	2009-10	2010-11	2011-12	Future water reserve [5]	2009-10	2010-11	2011-12
Gingin [1, 5]	Beermullah Plain South	No	3.00	2.70					3.11	3.14	3.60
	Deepwater Lagoon South	No	3.50	3.50					3.44	2.55	3.46
	Guilderton South	No	11.00	9.92					11.26	10.79	11.09
	Lake Mungala	No	3.40	3.16					2.61	3.04	3.39
Total for Gingin Groundwater area			**20.90**	**19.29**	**0.00**	**0.00**	**0.00**	**Yes**	**20.41**	**19.51**	**21.55**
Gnangara [5]	Reserve	Yes	9.00	8.83	1.45	3.47	1.30		1.24	1.27	1.22
	Wanneroo Wellfield	Yes	12.00	11.85	5.53	10.56	8.04		1.10	2.77	0.50
Total for Gnangara Groundwater area			**21.00**	**20.68**	**6.98**	**14.03**	**9.34**	**Yes**	**2.34**	**4.04**	**1.72**
Gwelup [1, 5]	Gwelup	No	7.95	7.85	3.35	4.76	5.08		1.71	1.46	1.45
Total for Gwelup Groundwater area			**7.95**	**7.85**	**3.35**	**4.76**	**5.08**	**Yes**	**1.71**	**1.46**	**1.45**
Mirrabooka [5]	Ballajura	No	6.00	5.90	1.36	2.45	1.95		1.88	1.27	1.12
	Beechboro	No	1.00	0.90					0.28	0.27	0.27
	Henley Brook	No	1.60	1.57	0.03	0.45	0.44		0.33	0.32	0.33
	Improvement Plan 8	No	5.50	5.48	1.25	2.85	2.00		0.24	0.19	0.19
	Landsdale	Yes	1.40	1.40					1.17	0.80	0.90
	Plantation	No	0.60	0.60					0.53	0.45	0.45
	State Forest	No	1.00	0.90					0.88	0.79	1.04
	Whiteman Park	Yes	1.00	0.99	0.55	0.60	0.25		0.33	0.29	0.52
Total for Mirrabooka Groundwater area			**18.10**	**17.75**	**3.19**	**6.35**	**4.64**	**Yes**	**5.64**	**4.38**	**4.83**
Perth [5]	City of Bayswater	No	2.30	2.30					1.65	1.68	1.68
	City of Fremantle North	No	0.70	0.70					0.14	0.04	0.04
	City of Nedlands	No	2.30	2.30					2.43	3.40	2.35
	City of Perth	No	1.50	1.50					1.49	2.29	3.26
	City of Stirling	No	11.15	11.15	1.34	3.45	3.43		7.77	7.85	7.85
	City of Subiaco	No	1.00	1.00					1.00	1.00	1.30
	Eglington	No	15.45	15.45					2.59	1.83	2.08
	Quinns	No	24.65	24.65	14.30	15.28	15.32		2.63	3.05	2.93
	Shire of Peppermint Grove	No	0.10	0.10					0.08	0.08	0.08
	Shire of Swan North	No	1.00	0.90					1.11	0.64	0.61
	Town of Bassendean	No	0.50	0.45					0.35	0.35	0.37
	Town of Cambridge	No	3.50	3.50					2.33	2.27	2.43
	Town of Claremont	No	0.70	0.70					0.67	0.66	0.70
	Town of Cottesloe	No	0.30	0.30					0.25	0.25	0.25
	Town of Mosman Park	No	0.50	0.50					0.48	0.48	0.48
	Town of Vincent	No	1.00	1.00					1.23	1.49	1.17
	Whitfords	Yes	22.43	21.54	2.25	2.92	2.87		9.53	9.46	9.32
Total for Perth Groundwater area			**89.08**	**88.04**	**17.89**	**21.65**	**21.61**	**Yes**	**35.74**	**36.81**	**36.90**
Swan	Bandy Spring	No	0.35	0.35					0.35	0.33	0.33
	Central Swan	No	1.00	0.92					1.59	1.29	1.34
	Cockman Bluff	No	1.50	1.35					0.44	1.08	1.16
	East Swan	No	0.75	0.68					1.07	1.01	1.01
	Neaves	No	2.00	1.80					0.02	3.43	3.88
	North Swan	Yes	2.00	1.83					3.01	2.73	2.91
	Radar	No	2.00	1.80					2.33	2.31	2.27
	South Swan	No	4.00	3.62					3.95	3.77	3.84
Total for Swan Groundwater area			**13.60**	**12.35**	**0.00**	**0.00**	**0.00**	**No**	**12.76**	**15.96**	**16.76**
Wanneroo	Adams	Yes	1.00	0.91					1.21	1.11	1.12
	Carabooda	No	6.40	5.76					8.08	8.06	8.54
	Carramar	No	1.70	1.55					1.53	1.50	1.50
	Jandabup	No	0.20	0.18					0.21	0.18	0.18
	Joondalup	No	1.50	1.35					1.25	1.20	0.87
	Lake Gnangara	No	7.50	7.50					7.60	7.27	7.32
	Mariginiup	Yes	4.00	3.61					4.71	4.29	4.46
	Neerabup	No	2.65	2.39					2.56	2.59	2.72
	Nowergup	Yes	2.00	1.80					2.79	2.77	3.25
	Pinjar	Yes	0.50	0.45					0.75	0.70	0.70
Total for Swan Groundwater area			**27.45**	**25.51**	**0.00**	**0.00**	**0.00**	**No**	**30.70**	**29.66**	**30.66**
Yanchep [5]	Yanchep	Yes	10.87	10.87	1.40	1.48	1.30		1.28	1.50	1.83
Total for Yanchep Groundwater area			**10.87**	**10.87**	**1.40**	**1.48**	**1.30**	**Yes**	**1.28**	**1.50**	**1.83**
Total for Gnangara Groundwater areas			**208.95**	**202.33**	**32.80**	**48.26**	**41.96**		**110.58**	**113.08**	**115.70**

NOTE: In 2011–12 there were minor administrative changes to how the department accounted for water licensed for public water supply. This report presents licensed entitlement data rather than the combination of estimates of abstraction and licensed entitlement data that have been presented in previous compliance reports. Similarly there were minor administrative changes to accounting for a small group of private licences as part of the streamlining of legislation. Therefore, some of the figures presented will differ slightly to those presented in previous compliance reports.

[1] Allocation limits for the Gnangara groundwater areas were reviewed in 2007. As part of this review, subareas in the Gingin groundwater area (GWA) were amended. Allocation limits were finalised in the *Gnangara groundwater areas allocation plan* (DoW 2009a). Additionally, the Gwelup subarea in the Superficial aquifer was changed from Perth GWA to Gwelup GWA.

[2] Allocation limits for the Gnangara groundwater areas were reviewed again in 2011 (see section 6.2.2).

[3] Source of public water supply data is the Water Resourcing Licensing System and annual reports submitted to the Department of Water by the Water Corporation as a condition of their licence. Annual allocations for public water supply were determined using the Variable Groundwater Abstraction Rule (VGAR). In previous compliance reports the department reported actual volumes of water abstracted, rather than annual licensed entitlements. Therefore, the figures presented above will differ to those presented in previous compliance reports.

[4] Source of private licensed data is the Water Resourcing Licensing System (2009–10 report run on 1 June 2010. 2010–11 report run on 1 June 2011. 2011–12 report run on 1 July 2012). There have been minor administrative changes to accounting for a small group of private licences as part of the streamlining of legislation. Therefore, some of the figures presented will differ slightly to those presented in previous compliance reports.

[5] For subareas containing groundwater reserved for future public water supply, reserve volumes are NOT included in the licensed entitlement figures presented.

Up to date figures on water availability are available from the Swan Avon Regional office. 1 GL = 1 000 000 kL. Figures have been rounded to two decimal places.

5 Compliance

Appendices A and B (the 'Audit Tables') detail the conditions and commitments that the Department of Water is required to comply with on the Gnangara Mound (*Ministerial Statement No. 819*). The EPA/DEC have previously cleared some conditions and commitments and therefore we no longer report against them.

5.1 Compliance with water level criteria

Ministerial Statement No. 819 sets water level criteria at 30 sites across the Gnangara Mound (Figure 1). There are 14 wetland sites and 16 terrestrial phreatophytic vegetation sites. Phreatophytic vegetation is vegetation that utilises groundwater to meet at least part of its water needs. Some sites have more than one water level criterion and can be non-compliant with multiple criteria. Water level criteria include:

- preferred minimum water levels
- absolute minimum water levels
- peak water levels
- water levels allowed between preferred minimum and absolute minimum at a rate of 2 in 6 years to replicate natural drying cycles (referred to as other water level criteria).

As of June 2012, water levels at a number of sites were still declining and a minimum level had not been reached. For these sites the minimum water level recorded for the final year of the reporting period is the water level recorded in June. Non-compliance with absolute minimum water level, which is arguably the most ecologically significant criterion, increased over the reporting period from 12 sites in 2009–10 to 14 in 2010–11 and 2011–12. This increase has been influenced by the extended drying period experienced since 2010.

Further detail on compliance at sites across the Gnangara Mound and the circumstances contributing to non-compliance can be found in Table 4, Table 5 and Appendix A. Table 5 also includes details of the management and mitigation being undertaken at these sites.

Table 4 Sites across the Gnangara groundwater areas non-compliant with water level criteria over the reporting period

Year	Compliance [1]						
	Absolute minimum water level criteria			Peak water level criteria		Other water level criterion	
	Wetlands	Terrestrial vegetation	Total non-compliant	Wetlands	Total non-compliant	Wetlands	Total non-compliant
2009-10	Loch McNess Lake Yonderup Lake Jandabup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173	MM53 MM55B MM59B PM9 WM1	12/30 [2]	Lake Nowergup Lake Wilgarup Pipidinny Swamp	3/5	Lake Joondalup Lake Mariginiup Lake Nowergup Lexia 186	4/8
2010-11	Loch McNess Lake Yonderup Lake Jandabup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173	MM16 MM53 MM55B MM59B PM9 WM1 WM8	14/30 [2]	Lake Mariginiup Lake Nowergup Lake Wilgarup Pipidinny Swamp	4/5	Lake Joondalup Lake Mariginiup Lake Nowergup Lexia 186	4/8
2011-12	Loch McNess Lake Yonderup Lake Jandabup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173	MM53 MM55B MM59B PM9 WM1 WM2 WM8	14/30	Lake Mariginiup Lake Nowergup Lake Wilgarup Pipidinny Swamp	4/5	Lake Joondalup Lake Mariginiup Lake Nowergup Lexia 186	4/8

[1] Sites can be non-compliant with both absolute summer minimum water level and peak water level criteria. Also see Appendix A.

[2] There have been issues with water levels recorded from the staff gauge at Pipidinny Swamp (see table 5). This site was incorrectly reported as compliant with the absolute minimum water level criteria in 2009-10 and 2010-11 in previous compliance reports. The department has notified the OEPA of these errors and updated the relevant compliance reports on our web site.

Table 5 Sites non-compliant with water level and other criteria over the reporting period, circumstances of non-compliance and management and mitigation being undertaken

Site	Relevant criteria	Non-compliance	Circumstances, management and mitigation
Loch McNess	Absolute summer minimum: 6.95 mAHD.	2009–12: non-compliant with absolute summer minimum water levels.	Loch McNess is located in the Yanchep linear suite of wetlands west of the crest of the Gnangara Mound. The wetland is in the Yanchep groundwater area. Lake levels have been non-compliant since 2002–03 and declined rapidly since 2006. Building on the work of the shallow groundwater system investigation, the department recently completed an investigation into the cause of rapidly declining lake levels. This study improved our understanding of the hydrogeology of Loch McNess and surrounding areas including the caves. The report is being finalised and will be available of the department's website in early 2013. The management response arising from this work included: • reducing abstraction to water lawns and grounds in the Yanchep National Park • ceasing abstraction for the Yanchep caves supplementation trial. As part of the Perth shallow groundwater systems investigation, a shallow bore was installed adjacent to the vegetation monitoring transect on the south west side of the lake. This bore improves monitoring of groundwater directly related to the monitored vegetation (Searle 2009a). The investigation determined that a groundwater level of 5.27 mAHD measured at bore MCN_SWC (AWRC ref. 61611844) would meet the minimum groundwater requirements of all wetland vegetation on the southern vegetation transect. The department is using this bore to better relate groundwater levels to the ecological condition of vegetation at the site. Clusters of bores were also installed on the north western and eastern sides of the lake to improve the department's understanding of the lake's hydrogeology. Detailed findings and recommendations from the investigation can be found in DoW 2011a. We are currently assessing groundwater availability along the northwest coastal corridor, considering compliance and ecological condition at the lake.
Lake Yonderup	Absolute summer minimum: 5.9 mAHD.	2009–12: non-compliant with absolute summer minimum water levels.	Lake Yonderup is located in the Yanchep linear suite of wetlands west of the crest of the Gnangara Mound. The wetland is in the Yanchep groundwater area. The lake has been non-compliant since 2007–08 and lake levels have declined since 1998, with the rate of decline increasing since 2006. Lake level fluctuations have increased since 2010. A cluster of bores was installed adjacent to the vegetation monitoring transect as part of the Perth shallow groundwater systems investigation (Searle 2009a). Clusters of bores were also installed on the eastern and western sides of the lake. This additional monitoring infrastructure was installed to understand the hydrological function of the lake and to better relate groundwater levels to wetland vegetation condition at the transect. The investigation determined that a groundwater level of 5.48 mAHD at bore YDP_SC would meet the minimum groundwater requirements of all wetland vegetation on the southern vegetation transect. Detailed findings and recommendations from the investigation can be found in DoW 2011b. The department is also currently assessing groundwater availability along the northwest coastal corridor, considering compliance and ecological condition at the lake.
Lake Joondalup	Minimum water levels must be above preferred minimum four in every six years.	2009–12: minimum water levels were not above preferred minimum for four out of six years.	Lake Joondalup is located in the Yanchep linear suite of wetlands west of the crest of the Gnangara Mound. The wetland is in the Whitfords subarea of the Perth groundwater area. Though the lake has been non-compliant since 1998–99, lake levels have been relatively stable since 1998 despite declining rainfall. Increased local recharge and surface water inflows from urban development surrounding the lake are likely to have contributed to the relatively stable levels. The staff gauge at the lake dries at 16.0 mAHD and cannot be used to determine compliance with the absolute summer minimum criteria which is below this level. The current criteria bore, bore 8281 (AWRC ref. 61610661), is located 100 m up gradient of the lake and may also be inappropriate for determining compliance with criteria levels. A cluster of bores was installed on the western margin of the lake adjacent to the vegetation monitoring transect as part of the Perth shallow groundwater systems investigation (Bourke 2008). Clusters of bores were also installed on the northern and eastern margins of the lake. This infrastructure was installed to understand the hydrological function of the lake and to better relate groundwater levels to wetland vegetation condition at the transect. Analyses conducted as part of the investigation found that groundwater levels at bore JP20C (AWRC ref. 61610629) more closely reflect trends in lake levels than the current criteria bore and that this bore should be used to measure water level criteria. The department will consult with the OEPA as part of the development of the next Gnangara allocation plan on amending the bore used to measure the water level criteria at this site based on the SGS investigation.
Lake Mariginiup	Absolute minimum spring peak: 41.5 mAHD. Peak water levels must be above absolute minimum four in every six years.	2010–12: non-compliant with absolute minimum spring peak water levels. 2009–12: peak water levels were not above absolute minimum for four out of six years.	Lake Mariginiup is located in the Gnangara suite of wetlands on the Gnangara Mound. The wetland is in the Mariginiup subarea of the Wanneroo groundwater area. Surface water levels have not been above the preferred spring peak since 1994 and have not been above the absolute minimum spring peak since 2005. As part of the Perth shallow groundwater systems investigation a cluster of bores were installed adjacent to the vegetation monitoring transect on the western margin of the lake (Bourke 2008). The investigation included the development of a local area model. Details on the model can be found in RPS (2009). Key recommendations relating to the Ministerial water level criteria and the vegetation monitoring transect included: • continue to measure the water criteria level at bore MS10 (AWRC ref. 61610685) when the lake is dry using a revised criteria level of 41.14 mAHD. • measure groundwater levels at the newly installed bore MGP_c (AWRC ref. 61611440) when relating the watertable to the ecological condition of the vegetation transect The department is using bore MGP_c to better relate groundwater levels to the ecological condition of vegetation at this site. Detailed findings and recommendations from the investigation can be found in Searle et al. (2010a). We will consult with the OEPA as part of the development of the next Gnangara allocation plan on amending the bore used to measure the water level criteria at this site based on the SGS investigation.
Lake Jandabup	Absolute summer minimum: 44.3 mAHD	2009–12: non-compliant with absolute minimum spring peak water levels.	Lake Jandabup is located in the Gnangara suite of wetlands on the Gnangara Mound. The wetland is in the Mariginiup subarea of the Wanneroo groundwater area. Water levels at Lake Jandabup are artificially maintained by the Water Corporation to attempt to meet the absolute spring peak. Levels have been relatively stable since 1997, despite declining rainfall. A new shallow bore was installed adjacent to the vegetation monitoring transect on the eastern margin of the lake as part of the Perth shallow groundwater systems investigation (Searle 2009a). The department is using this bore to better relate groundwater levels to the ecological condition of vegetation at this site.

Site	Relevant criteria	Non-compliance	Circumstances, management and mitigation
Lake Nowergup	Absolute minimum spring peak: 16.8 mAHD. Peak water levels must be above absolute minimum four in every six years.	2009–12: non-compliant with absolute minimum spring peak water levels. 2009–12: peak water levels were not above absolute minimum for four out of six years.	Lake Nowergup is located in the Yanchep linear suite of wetlands west of the crest of the Gnangara Mound. The wetland is in the Nowergup subarea of the Wanneroo groundwater area. The department has a Ministerial condition to supplement water levels at Lake Nowergup to meet the absolute spring peak water level criteria and protect ecological values. Water levels have been artificially maintained with groundwater from the Leederville aquifer since 1989. Artificial maintenance at Lake Nowergup has been generally unsuccessful in meeting the Ministerial water level criteria and in maintaining a number of the lake's ecological values, including its vegetation. Lake Nowergup was included in the Perth shallow groundwater systems investigation. Detailed findings and recommendations can be found in Bourke (2008) and Searle et al. (2010b). The investigation included the development of a local area model. Details on the model developed can be found in SKM (2009a). Key recommendations relating to the Ministerial water level criteria and the vegetation monitoring transect included: • the current managed rise and fall artificial maintenance regime should be continued. • lake levels should be measured at the new telemetered site (AWRC ref. 616139) as levels less than 16 mAHD cannot be measured at the current staff gauges. • a revised spring peak criteria of 16.2 m AHD is recommended. The spring peak should be gradually reduced to this level from the 2009 peak of 16.5 mAHD. • groundwater levels should be measured at bore LN2-89 (AWRC ref. 61611247) when relating the watertable to the ecological condition of the vegetation transect. We are using bore LN2-89 to better relate groundwater levels to the ecological condition of vegetation at this site. We will consult with the OEPA as part of the development of the next Gnangara allocation plan on amending the bore used to measure the water level criteria at this site based on the SGS investigation. We are also currently assessing groundwater availability along the northwest coastal corridor, considering compliance and ecological condition at the lake.
Lake Wilgarup	Absolute summer minimum: 4.5 mAHD. Absolute minimum spring peak: 5.65 mAHD.	2009–12: non-compliant with absolute summer minimum water levels. 2009–12: non-compliant with absolute minimum spring peak water levels.	Lake Wilgarup is located in the Yanchep linear suite of wetlands to the west of the crest of the Gnangara Mound. The wetland is in the Yanchep groundwater area. No surface water has been present in the lake since 1998 and groundwater levels have declined steadily since that time. Groundwater levels were first non-compliant with the absolute minimum criteria in 2006–07 and have been non-compliant since. The groundwater related ecological values at Lake Wilgarup have also been significantly impacted fire and acidification, and management objectives for the lake may have been irreversibly compromised. The department is assessing groundwater availability along the northwest coastal corridor, considering compliance and ecological condition at the lake.
Pipidinny Swamp	Absolute summer minimum: 1.6 mAHD Absolute minimum spring peak: 2.40 mAHD	2010–12: unable to determine compliance with absolute summer minimum – assuming and reporting as non-compliance. 2009–12: non-compliant with absolute minimum spring peak water levels.	Pipidinny Swamp is located in the Yanchep linear suite of wetlands to the west of the crest of the Gnangara Mound. The wetland is in the Yanchep groundwater area. From 2004 to 2010, water levels below 2.0 mAHD could not be measured at the staff gauge at Pipidinny Swamp. This meant the staff gauge could not be used to determine if water levels were non-compliant with the absolute summer minimum criteria. In 2010, an extra staff gauge plate was fixed underneath the existing plate to allow levels to be measured to 1.0 mAHD, allowing non-compliance with the absolute summer minimum criteria to be determined. Issues around the recording of water levels from the different plates resulted in the swamp being incorrectly reported as compliant with the absolute minimum water level criteria in 2009-10 and 2010-11 in previous compliance reports. The department has notified the OEPA of these errors and updated the relevant compliance reports on our website. A new bore was installed as part of the Perth shallow groundwater system investigation (Searle 2009b). Levels at this bore need to be correlated with the staff gauge at the swamp so that it can be used to measure compliance with absolute summer minimum criteria. A longer time series of data is required for this correlation than what is currently available. The department is also currently assessing groundwater availability along the northwest coastal corridor, considering compliance and ecological condition at the swamp.
Lexia 186 (GNM15)	Absolute summer minimum: 47.2 mAHD Minimum water levels must be above preferred minimum four in every six years.	2009–12: non-compliant with absolute summer minimum water levels. 2009–12: non-compliant with absolute minimum spring peak water levels.	Lexia 186 is located in the Jandakot suite of wetlands to the east of the crest of the Gnangara Mound. The wetland is in the North Swan subarea of the Swan groundwater area. Water levels have been non-compliant with the absolute summer minimum water level criteria since 1997. Clusters of bores were installed on the eastern and western sides of the Lexia wetlands as part of the Perth shallow groundwater system investigation. The investigation found that poor water quality is probably the most immediate threat to the system. Detailed findings are published in DoW (2011c). The investigation included the development of a local area model. Details on the model developed can be found in SKM (2009b). Modelling demonstrated that a combination of harvesting pine plantations and a reduction in abstraction for public water supply in this area may result in some recovery of groundwater levels.
Melaleuca Park EPP173 (GNM14)	Absolute summer minimum: 50.2 mAHD	2009–12: non-compliant with absolute summer minimum water levels.	Melaleuca Park EPP173 is located in the Muchea suite of wetlands to the east of the crest of the Gnangara Mound. The wetland is in the Wanneroo Wellfield subarea of the Gnangara groundwater area. Water levels have been non-compliant with absolute summer minimum water levels since before 1995. One bore was installed adjacent to GNM14 (AWRC ref. 61613213) as part of the Perth shallow groundwater systems investigation (Searle 2009a). The department is using this bore to better relate groundwater levels to the ecological condition of vegetation at this site.
MM16	Absolute summer minimum: 38.8 mAHD	2010–11: non-compliant with absolute summer minimum water levels.	MM16 is located in the Landsdale subarea of the Mirrabooka groundwater area. Water levels recovered marginally with improved rainfall in 2011–12 so that the site was compliant.
MM53	Absolute summer minimum: 33.3 mAHD	2009–12: non-compliant with absolute summer minimum water levels.	MM53 is located in the Whiteman Park subarea of the Mirrabooka groundwater area. Water levels recovered marginally with improved rainfall in 2011–12.
MM55B	Absolute summer minimum: 29.5 mAHD	2009–12: non-compliant with absolute summer minimum water levels.	MM55B is located in the Whiteman Park subarea of the Mirrabooka groundwater area. Water levels recovered marginally with improved rainfall in 2011–12.
MM59B	Absolute summer minimum: 36.3 mAHD	2009–12: non-compliant with absolute summer minimum water levels.	MM59B is located in the Whiteman Park subarea of the Mirrabooka groundwater area. Water levels recovered marginally with improved rainfall in 2011–12.
PM9	Absolute summer minimum: 56.3 mAHD	2009–12: non-compliant with absolute summer minimum water levels.	PM9 is located in the Reserve subarea of the Gnangara groundwater area. In 2010 there was no evidence of recharge at this site and water levels declined significantly over the reporting period.
WM1	Absolute summer minimum: 55.7 mAHD	2009–12: non-compliant with absolute summer minimum water levels.	WM1 is located in the Wanneroo Wellfield subarea of the Gnangara groundwater area. In 2010 there was very little recharge at this site and water levels declined significantly over the reporting period.

Site	Relevant criteria	Non-compliance	Circumstances, management and mitigation
WM2	Absolute summer minimum: 66.5 mAHD	2011–12: non-compliant with absolute summer minimum water levels.	WM2 is located in the Wanneroo Wellfield subarea of the Gnangara groundwater area. In 2010 there was very little recharge at this site and water levels declined significantly over the reporting period.
WM8	Absolute summer minimum: 64.8 mAHD	2010–12: non-compliant with absolute summer minimum water levels.	WM8 is located in the Wanneroo Wellfield subarea of the Gnangara groundwater area. In 2010 there was no evidence of recharge at this site and water levels declined significantly over the reporting period.

5.1.1 Predicted non-compliance with water level criteria

The department uses previous water levels and average summer weather conditions (rainfall and temperature) to predict the number of sites that may be non-compliant with absolute summer minimum water level criteria in the coming reporting period.

These predictions help to inform management to prevent non-compliance, primarily through working with the Water Corporation on the annual distribution of abstraction for the public water supply. As required, the department informs the OEPA regularly of predicted compliance with water level and other criteria. The number of sites predicted to be non-compliant with absolute summer minimum water level criteria in 2012–13 is sixteen (Table 6).

Table 6 Predictions and actual numbers of sites non-compliant with absolute summer minimum water level criteria for the Gnangara Mound for the years 2009–13.

Year	Predicted non-compliant sites					
	Predicted non-compliance with absolute summer minimum water level criteria			Actual non-compliance with absolute summer minimum water level criteria		
	Wetland sites	Terrestrial vegetation	Total	Wetland sites	Terrestrial vegetation	Total
2009–10	Loch McNess Lake Yonderup Lake Jandabup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173	MM53 MM55B MM59B PM9 WM1	12/30	Loch McNess Lake Yonderup Lake Jandabup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173	MM53 MM55B MM59B PM9 WM1	12/30
2010–11	Loch McNess Lake Yonderup Lake Jandabup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173	MM16 MM53 MM55B MM59B PM9 WM1 WM2 WM8	15/30	Loch McNess Lake Yonderup Lake Jandabup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173	MM16 MM53 MM55B MM59B PM9 WM1 WM8	14/30
2011–12	Loch McNess Lake Yonderup Lake Jandabup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173 Melaleuca Park Dampland 78	MM53 MM55B MM59B PM9 WM1 WM2 WM8	15/30	Loch McNess Lake Yonderup Lake Jandabup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173	MM53 MM55B MM59B PM9 WM1 WM2 WM8	14/30

Year	Predicted non-compliant sites					
	Predicted non-compliance with absolute summer minimum water level criteria			Actual non-compliance with absolute summer minimum water level criteria		
	Wetland sites	Terrestrial vegetation	Total	Wetland sites	Terrestrial vegetation	Total
2012–13	Loch McNess Lake Yonderup Lake Jandabup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park EPP173 Melaleuca Park Dampland 78	MM53 MM55B MM59B PM9 WM1 WM2 WM8 L220C	16/30			

6 Environmental monitoring, management actions, research initiatives and consultation

6.1 Environmental monitoring

The department engages expert environmental consultants to undertake an environmental monitoring program in line with the commitments in *Ministerial Statement No. 819*. The monitoring program was reviewed in 2009 (see Appendix D). It includes monitoring of:

- wetland and terrestrial vegetation
- wetland aquatic macroinvertebrates and water quality
- cave and spring macroinvertebrates and water quality
- wetland frogs.

Ecological condition is affected by a number of factors that influence water levels, including abstraction. The department uses environmental monitoring to manage abstraction at priority locations where it is identified that reduced abstraction can have a positive effect on ecological condition. A summary of compliance with Ministerial water level criteria and changes in ecological condition for the reporting period is given in Table 7.

Wetland vegetation

Over the reporting period wetland vegetation was monitored in spring (September/October) at 13 sites (Wilson and Froend 2012; Wilson and Froend 2011 and Wyse et al. 2009). Eight sites were monitored annually and five were monitored once over the reporting period (as part of a suite of sites that are monitored triennially).

The monitoring highlighted a number of wetlands of concern, where significant declines in ecological condition in relation to falling groundwater levels were observed. These wetlands included Lake Nowergup, Loch McNess, Lake Yonderup, Lake Wilgarup and Lake Mariginiup. Water levels at these sites (except Lake Mariginiup) were non-compliant with water level criteria over the entire reporting period. Levels at Lake Mariginiup were non-compliant in the last two years of the reporting period.

Triennial terrestrial vegetation

In 2011, triennial terrestrial vegetation monitoring was undertaken at 11 transects on the Gnangara Mound (Mattiske Consulting Pty Ltd 2012). These transects were established in the late 1960s and most are not directly related to Ministerial sites. Compared to the 2006-09 reporting period, general declines in condition were observed in tree and understorey species at all transects. A general decline in tree abundance was also recorded. Declines in condition of species with a wide tolerance of water tolerances were observed.

Wetland aquatic macroinvertebrates and water quality

Eleven wetlands were monitored over the reporting period for macroinvertebrate family richness, assemblages and water quality (Judd and Horwitz 2012; Judd and Horwitz 2011 and Judd and Horwitz 2010). Monitoring was undertaken in spring (September/October) to coincide with peak water levels.

In 2009–10, species richness generally increased from the previous year, despite peak water levels decreasing at a number of sites. In 2010–11 there were no discernable trends observed in relation to species richness patterns, despite lower peak water levels and shorter periods of inundation at all sites. In 2011–12, species richness was again similar to the previous year at most sites sampled despite lower peak water levels at some sites.

Wetlands nutrient concentrations were relatively stable over the reporting period with consistently high ammonium levels observed at a number of sites including Lake Mariginiup and Lake Goollelal. Elevated sulphate, total iron, total aluminium, and ammonium were recorded at Lake Mariginiup over the reporting period indicating that the acidification at the lake may be permanent. At Lake Goollelal, Lake Yonderup and Loch McNess the oxidation of sulphidic sediments is increasing acidification risks. The potential for declining water levels leading to the exposure of acid sulphate soils was also identified as a risk at Melaleuca Park.

Cave and spring macroinvertebrates and water quality

Nine caves in the Yanchep area, and three springs in the Lexia/Bullsbrook area were monitored over the reporting period for macroinvertebrates and water quality (Knott et al. 2012; Knott et al. 2011 and Knott and Storey 2010). Monitoring was undertaken in spring (September/October) to coincide with peak water levels.

Water levels in the caves continued to decline throughout the reporting period to the point where many of the caves were dry and could not be sampled in 2011–12. When sufficient water was present to sample, water quality was relatively consistent across all caves and between years. The declining water levels resulted in low macroinvertebrate species richness throughout the reporting period.

Flow at Egerton and Gaston Road springs generally reduced over the reporting period and flow at Sue's Spring was variable. Measured pH at the springs was variable throughout the reporting period. Elevated concentrations of nitrogen were recorded at all sites. Across the reporting period macroinvertebrate species richness and composition remained similar at the three springs.

Wetland frogs

Frog populations were monitored at five Ministerial wetland sites in the Lexia area over the reporting period. Aural surveys were conducted at all sites and trapping was undertaken at two sites. Aural surveys were also conducted at a number of other sites identified through the Gnangara Sustainability Strategy. Generally, the numbers of calling frogs were considered to be low across the survey years. The exceptions corresponded with high spring water levels are important for frog breeding. Numbers of captured frogs varied over the reporting period (Bamford and Everard 2011). Annual variations in the numbers of frogs calling and captured related to changes rainfall, water levels and changes in the annual inundation of wetlands.

Table 7 Summary of compliance and ecological condition at Ministerial sites on the Gnangara Mound where monitoring occurred across the triennial reporting period

Site	Compliance (absolute minimum / spring peak water level criteria)			Wetland vegetation (canopy vigour / exotic cover / species composition)			Macroinvertebrates (species richness / species assemblages)			Water quality (pH / DO / salinity / nutrients)		
	2009–10	2010–11	2011–12	2009–10	2010–11	2011–12	2009–10	2010–11	2011–12	2009–10	2010–11	2011–12
Lake Goollelal	✓	✓	✓	NM 09–10	NM 10–11	= / – /	+ / =	– / =	= / =	– / – / + / =	+ / = / – / =	– / + / = / –
Loch McNess	X	X	X	– / = / –	# + / – / =	# + / – / +	+ / –	= / =	– / –	= / – / + / –	= / = / – / –	= / – / = / –
Lake Yonderup	X	X	X	– / – / –	+ / = / =	+ / – / –	NM 09–10	= / =	= / =	= / – / + / =	= / = / – / =	= / + / = / =
Lake Joondalup	✓	✓	✓	= / – / =	NM 10–11	NM 11–12	NM 09–10	– / =	– / =	= / = / – / =	= / = / = / =	– / – / + / =
Lake Mariginiup	✓	X	X	– / – / –	NM 10–11	NM 11–12	– / –	NM 10–11	NM 11–12	+ / – / + / –	+ / = / – / =	NM 11–12
Lake Jandabup	X	X	X	– / – / =	= / – / =	– / + / –	+ / =	= / =	– / =	= / = / = / =	+ / = / – / =	– / + / + / =
Nowergup Lake	X	X	X	– / – / =	– / + / =	– / – / –	– / =	– / =	= / –	+ / = / – / =	– / = / – / =	– / + / + / =
Lake Wilgarup	X	X	X	# – / – / –	# + / + / =	# + / – / –	#	#	#	#	#	#
Pipidinny Swamp	X	X	X	NM 09–10	NM 10–11	NM 11–12	NM 09–10	NM 10–11	NM 11–12	+ / = / – / =	= / = / – / +	NM 11–12
Lexia 86	✓	✓	✓	– / = / +	= / = / –	– / – / +	#	#	#	#	#	#
Lexia 186	X	X	X	NM 09–10	– / + / =	NM 11–12	#	#	#	#	#	#
Melaleuca Park (EPP 173)	X	X	X	= / – / =	– / = / =	= / – / –	+ / =	– / =	= / =	+ / = / + / =	– / = / – / =	= / = / = / =
Egerton Spring *	✓	✓	✓	NM 09–10	NM 10–11	NM 11–12	NM			– / = / – / –	– / = / + / –	– / = / – / =

✓ compliant
x non-compliant
= no change from previous monitoring
+ improvement in condition from previous monitoring
– decline in condition from previous monitoring

NM not monitored
lake dry at time of monitoring

6.2 Management actions

The department's primary approach is to manage abstraction in environmentally sensitive areas where this would lead to improvements in compliance and ecological condition at Ministerial sites.

6.2.1 Gnangara groundwater areas allocation plan

The *Gnangara groundwater areas allocation plan* was released in November 2009 (DoW 2009a). It describes how the department manages the allocation of groundwater resources of the Gnangara groundwater system. The objectives of the plan are to:

1. Reduce the total volume of water abstracted from the Gnangara system towards a level that better reflects the current recharge from rainfall.
2. Optimise the use of water through water use efficiency and demand management measures.
3. Protect groundwater-dependent ecosystems from direct impacts associated with abstraction.
4. Protect the quality of groundwater for public and self-supply from impacts associated with abstraction and land use.
5. Adapt management of the water resource based on the results of monitoring programs and the condition of the resource.

The Gnangara groundwater system is now almost fully allocated across all groundwater areas, meaning there is only a small amount of additional water available for licensing. Through the plan, the department encourages trading, where the transferred entitlement does not result in increased impacts to environmentally sensitive areas.

6.2.2 Gnangara groundwater areas allocation plan – evaluation statement 2009-2011

Part of the reporting period aligned with the first evaluation of the *Gnangara groundwater areas allocation plan*. The evaluation reviews the department's management and the extent to which the objectives of the plan were met since its release in November 2009 until December 2011. The evaluation also identifies how the department will continue to adapt its management to meet the objectives.

Since developing the plan and through the evaluation the department has initiated a number of management responses to improve performance against the objectives including:

- Reviewing appropriateness of allocation limits in the Superficial aquifer across all subareas in the context of declines in rainfall and recharge since the plan was prepared.
- Working with local government, other agencies and urban developers to reduce demand, optimise use of groundwater and identify alternatives for urban expansion, particularly for public open parkland.

- Continuing to recoup unused entitlements to manage risk.
- Continuing to focus compliance activities in high use and high environmental risk areas and follow up with enforcement action on over use identified through metering data and compliance surveys.
- Continuing to undertake research into managing groundwater dependent ecosystems in a drying climate, to minimise environmental impacts associated with abstraction.
- Continuing to investigate additional confined aquifer capacity and aquifer connectivity.
- Triggering a new allocation plan to be commenced in 2013.

6.2.3 Managing public water supply

The proportion of groundwater licensed for public water supply from the deeper aquifers has increased in the last ten years. This is line with the strategy developed by the department and the Water Corporation to limit impacts by reducing abstraction from environmentally sensitive areas of the Superficial aquifer where it would benefit water levels and ecological condition at Ministerial sites.

As outlined in the *Gnangara groundwater areas allocation plan,* the addition of the Southern Seawater Desalination Plant to the scheme triggered a change in how groundwater for the public water supply is allocated. In line with the plan, from 2012–13, the Water Corporation's groundwater allocation from Gnangara and Jandakot for the Integrated Water Supply Scheme has been reduced from 145 GL to 120 GL (from existing infrastructure). The Water Corporation is committed to achieving an average abstraction of 120 GL over the five year licence period from 2012–13 to 2017–18. Under the 120 GL allocation, the licensed volume from the Superficial aquifer has been reduced from 42.70 GL to 29.60 GL. This reduction was targeted to environmentally sensitive areas where it would benefit water levels and ecological condition at Ministerial sites.

The department updated the environmental sensitivity classifications of public water supply production bores based on the groundwater level trends, ecological condition and compliance measured for this report. This update resulted in a significant number of production bores being reclassified to a more sensitive classification and will help to distribute abstraction for the public water supply to limit impacts at Ministerial sites.

6.2.4 Managing private licensed use

Most of the groundwater now licensed from the Superficial aquifer is to private users. Activities in progress or scheduled to manage private licensed use include on-ground compliance inspections, meter audits and water use surveys. This work checks that water use is within entitlements and that site activities are authorised.

The 2005–2010 government funded metering program maintains and reads meters on bores for licences between 5000–500 000 kL/yr in the Gnangara plan area. The department uses and maintains this program for collecting metering data (in conjunction with privately submitted meter readings) to better understand patterns of

use, support efficiency improvements and for compliance purposes. As more metering data is collected and analysed, the department uses the data to:

- compare actual water use to groundwater level changes
- compare actual water use to licensed entitlements
- focus efficiency measures and more intensive compliance monitoring
- identify where enforcement action is required.

The department's compliance and enforcement activities have been prioritised to respond to performance against water level criteria and ecological condition at Ministerial sites. This included expanding the scope of the *State Compliance Monitoring Plan* to consider conditions and commitments at Ministerial sites, and forms part of the department's work to reduce levels of non-compliance. Other ways the department works to optimise the use of water by private licensees include:

- The department works with local governments and other licensees using large volumes to improve water use efficiency. Of the 17 local government authorities that use water from Gnangara system, 16 have completed and implemented a water conservation strategy.
- The department updated the water trading policy and listed a web-based register of licensees in 2010 to facilitate water trades as a way to optimise water use.

6.2.5 Managing garden bore use

The efficient use of water from garden bores reduces demand on the scheme water and is appropriate in some areas. A new garden bore use guideline was developed in 2011, emphasising water conservation and efficiency, and an updated garden bore suitability map is now accessible on the Perth Groundwater Atlas (accessed through the department's website). Garden bores are not encouraged in areas that are unsuitable due to the risk of acid sulphate soils, poor water quality or low yields. These areas are identified in the Atlas.

The government updated the 2007 water efficiency measures legislation for garden bores in November 2011 under the Water Agencies (Water use) by-laws 2010. This limits their use to three days per week over summer and applies a total use-ban during winter.

6.3 Research initiatives

6.3.1 Hydrogeological investigations and modelling

The department, with research partners, is completing a number of major projects to focus management effort on those areas which will show the most benefit from changes to abstraction. This work will inform the next Gnangara allocation plan.

- The Perth regional aquifer modelling system (PRAMS) is currently being updated. The system will be used for detailed modelling studies, including modelling of scenarios to examine interactions between climate, land use and groundwater abstraction, which will support the management of the groundwater resources of the Gnangara groundwater system.

- Investigations to more thoroughly understand the hydrogeology of the Leederville and Yarragadee aquifers. This will be used to determine the sustainability of current abstraction, and whether there is potential for future public water supply, across different parts of the aquifers.
- Perth shallow groundwater system investigation reports have been published for Lake Mariginiup, Loch McNess, Lexia Wetlands, Lake Yonderup, Egerton Seepage, Tangletoe Swamp, Lake Muckenburra, Lake Nowergup and Lake Gwelup. These studies improved 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 investigations to better relate water levels to ecological condition and will consult with the OEPA as part of the development of the next Gnangara allocation plan on amending how the water level criteria are measured at some sites.
- The department commissioned Edith Cowan University to develop a model to determine ecological risk to groundwater dependent vegetation on the Gnangara Mound in a drying climate. The model is based on 30 years of ecological and hydrological monitoring data. It will be an important management tool for assessing the impact of future land and water use scenarios and for revising allocation limits as part of the next phase of planning for the Gnangara groundwater resources.

6.4 Consultation

The department engages with the community through public seminars, conferences, workshops and community meetings. The department provides ongoing advice to local government and other agencies that refer proposed developments to us for review, and works with other agencies to minimise the impacts of proposed developments on groundwater dependent ecosystems.

The *Better urban water management framework* is used to supply local government authorities and other land development agencies with advice on water management in urban areas to minimise the effects of drainage and stormwater on shallow groundwater in the plan area.

The department also provides specific advice to local and state government agencies on water supply, including for public open space, for development proposals as required.

Appendices

Appendix A — Water level monitoring results for Ministerial sites on the Gnangara Mound, 2000–2012

Sites non-compliant with water level criteria and other criteria are highlighted in **RED.** See also Table 5 for further information about the circumstances of non-compliance and mitigation actions.

Table 1 Wetland sites

Wetland	AWRC Ref.	Water level criteria (mAHD)				Water level (mAHD)												Comments on compliance in 2011–12
		Spring peak		End of summer minimum														
		Pref	Abs	Pref	Abs		2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12	
Lake Goollelal	6162517			* 26.2	26.0	max	27.5	27.4	27.4	27.5	27.4	27.6	27.3	27.2	27.4	27.4	27.2	27.1	**Compliant.**
						min	26.7	26.7	26.6	26.6	26.6	26.8	26.6	26.5	26.7	26.6	26.4	26.5	
Loch McNess	6162564				6.95	max	7.10	7.06	7.05	7.05	7.03	7.04	7.02	6.94	6.85	6.80	6.64	6.43	**Non-compliant with absolute summer minimum.** The lake has been non-compliant since 2002–03. Lake levels have declined rapidly since 2006. Building on the work of the shallow groundwater system investigation, the department recently completed an investigation into the cause of rapidly declining levels in Loch McNess. This study improved our understanding of the hydrogeology of the lake and surrounding areas including the caves. The report is being finalised and will be available of the department's website in early 2013. In line with recommendations from the report, the department has reduced local abstraction in Yanchep National Park and turned off the abstraction bores for the Yanchep caves supplementation trial which were found to be impacting on lake levels. The department is also assessing groundwater allocations along the northwest coastal corridor, considering compliance and ecological condition at the lake.
						min	6.97	6.96	**6.90**	**6.92**	**6.93**	**6.91**	**6.74**	**6.63**	**6.61**	**6.45**	**6.25**	**6.17**	
Lake Yonderup	6162565				5.9	max	6.0	6.0	5.9	6.0	6.0	5.9	6.0	5.9	5.9	5.9	5.9	5.9	**Non-compliant with absolute summer minimum.** The lake has been non-compliant since 2007–08. Lake levels have declined since 1998, with the rate of decline increasing since 2006. Lake level fluctuations have increased since 2010**.** The department is currently assessing groundwater allocations along the northwest coastal corridor, considering compliance and ecological condition at the lake.
						min	5.9	5.9	5.9	5.9	5.9	5.9	5.9	**5.8**	**5.8**	**5.8**	**5.7**	**5.7**	
Lake Joondalup	6162572 (8281 staff)			* 16.2	15.8	max	17.0	17.0	16.9	17.0	16.8	17.1	16.9	16.8	17.0	17.0	16.8	16.8	**Compliant with absolute summer minimum.** **Non-compliant with other criterion.** The lake has been non-compliant since 1998–99. Lake levels have been relatively stable since 1998, despite declining rainfall. The staff gauge dries at 16.0 mAHD and cannot be used to determine compliance with the absolute summer minimum criteria when lake levels fall below this level. The monitoring bore, which is located 100 m up gradient of the lake, may also be inappropriate for determining compliance with criteria levels. Analyses conducted as part of the shallow groundwater systems investigation found that groundwater levels at bore JP20C (AWRC ref. 61610629) more closely reflect trends in lake levels than the current criteria bore and that this bore should be used to measure water level criteria. The department will consult with the OEPA as part of the development of the next Gnangara allocation plan on amending the bore used to measure the water level criteria at this site to JP20C.
						min	16.1 **4/6 yr**	16.1 **4/6 yr**	16.0 **4/6 yr**	16.0 **4/6 yr**	16.1 **4/6 yr**	16.4 **4/6 yr**	16.0 **4/6 yr**	16.0 **4/6 yr**	16.2 **4/6 yr**	16.2 **4/6 yr**	16.0 **4/6 yr**	16.0 **4/6 yr**	
	61610661 (8281 bore)					max	18.7	18.6	18.6	18.6	18.5	18.8	18.5	18.5	18.7	18.9	18.7	18.6	
						min	17.7	17.9	17.8	17.8	17.8	18.1	17.8	17.9	18.1	18.3	17.9	18.0	
Lake Mariginiup	6162577 (1943 staff)	* 42.1	41.5			max	41.9	41.8	41.7	41.8	41.5	41.7	**41.4**	**41.4**	41.5	41.5	**41.3**	**41.2**	**Non-compliant with absolute spring minimum peak.** Water levels have not been above the preferred spring peak since 1994 and have not been above the absolute minimum spring peak since 2005. The department will consult with the OEPA as part of the development of the next Gnangara allocation plan on amending the water level criteria at this site to a level of 41.14 mAHD measured at bore MS10 (AWRC ref. 61610685) when the lake is dry (as per findings from the shallow groundwater systems investigation at this site). **Non-compliant with other criterion.**
						min	41.3 **4/6 yr**	41.3 **4/6 yr**	41.3 **4/6 yr**	41.2 **4/6 yr**	41.3 **4/6 yr**	41.3 **4/6 yr**	41.3 **4/6 yr**	41.2 **4/6 yr**	41.2 **4/6 yr**	41.3 **4/6 yr**	41.1 **4/6 yr**	41.0 **4/6 yr**	
	61610685 (MS10 bore)					max	41.5	41.4	41.3	41.4	41.1	41.3	41.1	41.0	41.3	41.1	40.8	40.9	
						min	40.5	40.5	40.5	40.4	40.3	40.4	40.0	40.2	40.2	40.2	40.0	40.1	
Lake Jandabup	6162578 (1944 staff)	* 44.7	44.2		44.3	max	44.9	44.9	44.8	44.9	44.7	45.0	44.6	44.7	44.8	44.8	44.5	44.7	**Non-compliant with absolute summer minimum.** Lake levels are artificially maintained by the Water Corporation to attempt to meet the absolute spring peak water level criteria. Levels have been relatively stable since 1997, despite declining rainfall.
						min	44.3	44.3	**44.2**	**44.2**	44.3	44.4	**44.2**	**44.1**	44.3	**44.2**	**44.1**	**44.2**	
Lake Nowergup	6162567 (staff)	* 17.0	16.8			max	**16.6**	17.0	**16.6 4/6 yr**	**16.3 4/6 yr**	**16.4 4/6 yr**	**16.7 4/6 yr**	16.8 **4/6 yr**	17.2 **4/6 yr**	**16.5 4/6 yr**	**16.5 4/6 yr**	**16.2 4/6 yr**	**16.1 4/6 yr**	**Non-compliant with absolute spring minimum peak.** Lake levels have been non-compliant in most years since 1996 despite water levels being artificially maintained by the department since 1989. Lake levels were recorded above the preferred spring peak criteria in 2007–08 for the first time since 2001–02. The department is currently assessing groundwater allocations along the northwest coastal corridor, considering compliance and ecological condition at the lake. **Non-compliant with other criterion.**
						min	15.9	16.0	16.0	16.0	16.0	16.3	16.1	16.5	16.2	16.0	16.0	15.9	

Wetland	AWRC Ref.	Water level criteria (mAHD)					Maximum (Spring)/Minimum (Autumn) water levels (mAHD)											Comments on compliance in 2011–12
		Spring peak		End of summer minimum														
		Pref	Abs	Pref	Abs		2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12	
Lake Wilgarup	6162623 (staff)	6.10	5.65	4.8	4.5	max	**6.00**	**6.00**	**6.00**	**6.00**	**6.00**	**6.00**	**6.00**	**6.00**	**6.00**	**6.00**	**6.00**	**6.00**	**Non-compliant with absolute spring minimum peak.** No surface water has been present in the lake since 1998. . **Non-compliant with absolute summer minimum.** Groundwater levels have declined steadily since 1998. Groundwater levels were first non-compliant with the absolute minimum criteria in 2006–07 and have been non-compliant since. The department is currently assessing groundwater allocations along the northwest coastal corridor, considering compliance and ecological condition at the site.
						min													
	61618500 (bore)					max	5.48	5.38	5.16	5.26	4.99	5.32	4.88	4.77	4.77	4.64	4.47	4.38	
						min	4.73	4.66	4.53	4.51	4.53	4.62	**4.34**	**4.18**	**4.08**	**4.02**	**3.80**	**3.84**	
Pipidinny Swamp	6162624 (staff)	2.70	2.40		1.6	max	2.8	2.8	2.4	2.7	**2.2**	2.9	**2.3**	**2.1**	**2.1**	**2.0**	**2.0**	**1.6**	**Non-compliant with absolute summer minimum.** There have been issues with water levels recorded from the staff gauge at Pipidinny Swamp (see table 5 in report). This site was incorrectly reported as compliant with the absolute minimum water level criteria in 2009-10 and 2010-11 in previous compliance reports. The department has notified the OEPA of these errors and updated the relevant compliance reports on our web site. **Non-compliant with absolute spring minimum peak.** Spring peak levels have been non-compliant since 2005–06.
						min	1.7	2.0	1.8	**1.5**	2.0	2.0	2.0	2.0	2.0	**1.3**	**1.0**	**1.0**	
Lexia 86 (GNM16)	61613215			* 47.3	47.0	max	48.6	48.4	48.4	48.7	48.4	48.6	48.1	48.2	48.4	48.2	47.7	47.9	**Compliant.** Water levels have declined since 2005 but have not fallen below absolute minimum criteria.
						min	47.5	47.5	47.5	47.5	47.4	47.6	47.4	47.4	47.3	47.3	47.1	47.2	
Lexia 186 (GNM15)	61613214			* 47.5	47.2	max	48.0	47.8	47.8	48.0	47.7	48.0	47.5	47.5	47.6	47.5	47.0	47.1	**Non-compliant with absolute summer minimum.** Water levels have been non-compliant with the absolute summer minimum water level criteria since 1997. **Non-compliant with other criterion.** Water levels have not been recorded above the preferred summer minimum water level criteria since before 1995.
						min	**47.0 4/6 yr**	**47.0 4/6 yr**	**47.0 4/6 yr**	**47.1 4/6 yr**	**46.9 4/6 yr**	47.2 4/6 yr	**46.8 4/6 yr**	**46.9 4/6 yr**	**46.8 4/6 yr**	**46.8 4/6 yr**	**46.5 4/6 yr**	**46.5 4/6 yr**	
Melaleuca Park EPP173	6162628 (staff)				50.2	max	51.1	51.0	51.0	51.1	51.0	51.1	51.0	51.1	51.0	51.0	50.5	50.7	**Non-compliant with absolute summer minimum.** Water levels have been non-compliant with absolute summer minimum water levels since before 1995. The staff gauge dries at 50.4 mAHD and minimum water levels are recorded at the monitoring bore.
						min	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	
	61613213 (GNM14 bore)					max	51.0	50.6	50.5	50.9	50.4	50.9	50.3	50.7	50.9	50.5	49.5	50.0	
						min	**49.0**	**49.1**	**49.1**	**49.1**	**49.0**	**49.2**	**48.9**	**49.1**	**48.9**	**48.9**	**48.6**	**# 48.8**	
Melaleuca Park Dampland 78 (GNM31)	61613231			* 65.4	65.1	max	66.5	66.1	66.0	66.1	65.9	66.1	65.9	66.0	66.0	65.9	65.5	65.3	**Compliant.** Water levels have declined significantly since 2008 and were equal to the absolute summer minimum in 2010–11 and 2011–12.
						min	65.9	65.8	65.7	65.7	65.5	65.8	65.5	66.0	65.6	65.5	65.1	65.1	
Egerton Spring (B25)	61618607				39.29	max	39.82	39.66	39.58	39.81	39.83	40.00	39.87	40.03	40.22	40.15	40.01	40.05	**Compliant.** Water levels have been compliant since 2003. Water levels have risen over the past 10 years, probably in response to increased recharge from runoff due from surrounding urban development.
						min	39.45	39.42	**39.26**	39.43	39.42	39.69	39.50	39.54	39.72	39.72	39.49	39.70	

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

\# As of June 2012, water levels were still declining. The minimum water level reported is the minimum water level recorded during the 2011–12 water year.

Table 2 Terrestrial phreatophytic vegetation sites

Groundwater monitoring bore	ARWC Ref.	End of summer absolute minimum (mAHD)	Water levels (mAHD)												Comments on compliance in 2011–12
				2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	
MM16	61610835	38.8	max	40.1	40.0	40.0	40.0	39.8	40.2	39.4	39.4	39.8	39.9	39.4	39.6	**Compliant.**
			min	38.8	39.1	38.9	38.8	38.8	39.0	**38.6**	38.8	39.0	39.0	**38.6**	# 38.9	
MM18	61610918	38.6	max	40.4	40.2	39.6	39.8	39.8	40.0	39.4	39.3	40.0	39.8	39.3	39.5	**Compliant.**
			min	39.2	39.2	38.7	39.0	38.9	39.1	38.6	38.8	39.0	39.0	38.7	# 38.9	
MM53	61610493	33.3	max	34.5	34.3	34.2	34.4	34.3	34.4	33.8	33.9	34.1	33.9	33.3	33.8	**Non-compliant with absolute summer minimum.** Water levels have generally declined since 2005 but recovered marginally with improved rainfall in 2011–12.
			min	33.3	33.4	33.3	33.3	**33.2**	33.3	**33.1**	**33.2**	**33.1**	**33.0**	**32.8**	**# 33.0**	
MM55B	61610559	29.5	max	31.1	30.9	30.7	31.1	30.8	30.9	30.3	30.6	31.0	30.8	30.1	30.3	**Non-compliant with absolute summer minimum.** Water levels have generally declined since 2008 but recovered marginally with improved rainfall in 2011–12.
			min	29.6	29.6	**29.4**	29.5	**29.4**	29.5	**29.4**	**29.4**	**29.4**	**29.3**	**29.0**	**29.3**	
MM59B	61611025	36.3	max	37.7	37.2	36.8	37.1	36.8	37.0	36.2	36.4	36.8	36.6	36.0	36.1	**Non-compliant with absolute summer minimum.** Water levels have declined since 2000 but recovered marginally with improved rainfall in 2011–12.
			min	**36.2**	**36.2**	**35.9**	**36.0**	**35.9**	**35.8**	**35.6**	**35.8**	**35.8**	**35.7**	**35.3**	**# 35.5**	
MT3S	61610745	43.0	max	45.2	45.1	44.9	45.1	44.7	45.4	44.6	44.7	44.9	44.8	44.3	44.4	**Compliant.**
			min	43.2	44.6	44.1	44.1	44.0	44.2	43.7	43.9	44.0	43.9	43.5	43.6	
NR6C	61610982	58.5	max	60.7	60.2	60.0	60.2	59.8	60.2	59.7	59.7	60.0	60.1	59.9	59.7	**Compliant.**
			min	59.6	59.5	59.3	59.4	59.3	59.4	59.1	59.1	59.2	59.4	58.9	# 59.0	
PM9	61610804	56.3	max	57.7	57.3	57.0	57.2	56.8	57.0	56.4	56.3	56.1	55.9	55.9	55.0	**Non-compliant with absolute summer minimum.** Water levels have declined significantly since 1996 and were first non-compliant in 2006-07. Water levels have continued to decline since.
			min	57.1	56.9	56.5	56.5	56.4	56.3	**56.0**	**55.8**	**55.6**	**55.4**	**54.9**	**# 54.8**	
PM24	61610697	40.5	max	43.1	42.9	42.6	43.1	43.0	43.1	42.4	42.7	43.0	42.5	42.1	42.4	**Compliant.**
			min	41.4	41.5	41.4	41.4	41.4	41.4	41.2	41.3	41.2	41.2	41.0	41.1	
WM1	61610833	55.7	max	56.8	56.2	56.0	56.2	55.9	56.5	55.6	55.6	55.7	55.4	54.8	54.8	**Non-compliant with absolute summer minimum.** Water levels have been non-compliant since 2001-02 and have declined since 2005.
			min	55.7	**55.5**	**55.3**	**55.4**	**55.2**	**55.4**	**55.0**	**55.0**	**54.9**	**54.8**	**54.4**	**# 54.3**	
WM2	61610908	66.5	max	68.3	67.9	67.7	68.0	67.7	68.2	67.6	67.5	67.6	67.5	66.9	66.8	**Non-compliant with absolute summer minimum.** 2011–12 was the first year the site was non-compliant with water level criteria.
			min	67.5	67.5	67.2	67.3	67.2	67.5	67.1	67.0	66.9	66.9	66.5	**# 66.4**	
WM8	61610983	64.8	max	66.2	65.8	65.8	66.0	65.6	66.0	65.5	65.4	65.5	65.4	65.5	64.9	**Non-compliant with absolute summer minimum.** Water levels have declined since 2005 and were non compliant for the first time in 2010–11.
			min	65.6	65.4	65.4	65.5	65.3	65.5	65.1	65.1	65.1	65.1	**64.7**	**# 64.7**	
MM12	61610989	42	max	45	44	43	44	43	44	43	43	43	43	43	43	**Compliant.**
			min	43	43	43	43	43	43	42	42	43	43	42	42	
L30C	61611010	47.2	max	49.2	49.1	48.9	49.2	48.8	49.5	48.4	48.6	48.7	48.9	48.1	48.2	**Compliant.**
			min	48.6	48.5	48.3	48.5	48.3	48.4	48.0	48.0	48.2	48.1	48.0	47.7	
L110C	61611011	55.7	max	59.0	58.6	58.4	58.6	58.1	58.5	57.8	57.7	57.8				**Compliant.** Minimum levels can not currently be measured at the Ministerial criteria bore as it is blocked. This bore is scheduled for maintenance.
			min	58.1	58.0	57.7	57.8	57.6	57.7	57.3	57.2	57.5				
L220C	61611018	52.2	max	54.3	54.2	53.9	54.1	53.8	54.2	53.7	53.7	53.5	53.6	52.8	53.2	**Compliant.**
			min	53.3	53.0	53.0	52.9	52.9	52.8	53.1	52.7	52.6	52.6	52.3	# 52.4	

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*. To ensure a more accurate reporting of compliance in future years the department has requested an amendment of all criteria water levels to two decimal places.

As of June 2012, water levels were still declining. The minimum water level reported is the minimum water level recorded during the 2010-12 water year.

Appendix B — Environmental conditions, procedures and commitments, Gnangara Mound groundwater resources (including groundwater resources allocation, East Gnangara, City of Swan)

Proponent: Department of Water

Period: 1 July 2009 to 30 June 2012

Text in blue represents Conditions/Proponent Commitments for which the Department of Water seeks 'Clearance' from DEC/EPA

Ministerial conditions and procedures

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: M 1-1	Implementation	The proponent shall implement the proposals as documented in "Section 46 Review of Environmental Conditions on Management of the Gnangara and Jandakot Mounds – Stage 1 Proposal for Changes to Conditions" (August 2004), as modified and documented in Environmental Protection Authority Bulletin 1155.	Implement proposals given in EPA Bulletin 1155 and Ministerial Statement No. 819.	Compliance report	Minister for the Environment		Overall		**Partly compliant.** Partly compliant with majority of Ministerial conditions – refer to 'Status' column of this Audit Table (Appendix B). Further amendments are likely to be proposed in the next Gnangara groundwater areas allocation plan.
819: M 2-1	Proponent Commitments	The proponent shall implement the environmental management commitments, as revised in May 2009, and documented in schedule 1 of Statement No. 819, to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority.	Implement Commitments given in Schedule 1 of EPA Bulletin 1324 and Ministerial Statement No. 819.	Compliance report	Minister for the Environment	EPA	Overall		**Partly compliant.** Compliant with majority of Proponent Commitments – refer to 'Status' column of this Audit Table (Appendix B).
819: M 3-1	Proponent Nomination & 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 Department of Environment and Conservation of any change in proponent details. Compliance report.	Minister for the Environment	EPA	Overall		**N/A at this time.**
819: M 3-2	Proponent Nomination & Contact Details	If the proponent wishes to relinquish the nomination, the proponent shall apply for the transfer of proponent and provide a letter with a copy of this statement endorsed by the proposed replacement proponent that the proposal will be carried out in accordance with this statement. Contact details and appropriate documentation on the capability of the proposed replacement proponent to carry out the proposal shall also be provided.	Follow procedure given in 'Action'.	Letter notifying the Chief Executive Officer of the Department of Environment and Conservation of any change in proponent details.	Minister for the Environment		Overall		**N/A at this time.**
819: M 3-3	Proponent Nomination & Contact Details	The nominated proponent shall notify the Chief Executive Officer of the Department of Environment and Conservation of any change of contact name and address within 60 days of such change.	Follow procedure given in 'Action'.	Letter notifying the Chief Executive Officer of the Department of Environment and Conservation of any change in proponent details.	CEO		Overall	60 days of change	**N/A at this time.**
819: M 4-1 1	Compliance Audit & Performance Review	The proponent shall prepare an audit program and submit compliance reports to the Chief Executive Officer of the Department of Environment and Conservation which address: 1. evidence of compliance with the conditions and commitments.	Detail in Annual/Triennial reports. Compliance report will include: 1. evidence of compliance with the conditions and commitments.	Audit program	CEO		Overall	Annually	**Compliant.** Summarised in compliance report and 'Status' column of this Audit Table (Appendix B).

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: M 4-1 2	Compliance Audit & Performance Review	The proponent shall prepare an audit program and submit compliance reports to the Chief Executive Officer of the Department of Environment and Conservation which address: 2. the performance of the environmental management plans and programs.	Detail in Annual/Triennial reports. Compliance report will include: 2. the performance of the environmental management plans and programs.	Compliance report	CEO			Annually	**Compliant.** Environmental management plans and programs are on-going and include: 1. The final *Gnangara groundwater areas allocation plan* was released in November 2009 (DoW 2009a). The plan will be evaluated regularly to assess whether objectives are being achieved. The final year of the reporting period aligned with the first evaluation of the Gnangara groundwater areas allocation plan. This evaluated the department's management of Gnangara groundwater resources and the extent to which the objectives of the Gnangara plan have been met since its release in November 2009 until December 2011. The statement will be available on the department's website in late 2012. 2. The draft *Gnangara Sustainability Strategy* was released for public comment in July 2009 (Government of Western Australia 2009b).
819: M 4-2 1	Compliance Audit & Performance Review	The proponent shall submit a performance review report by 1 December each year and more detailed reports by 1 February every three years, to the requirements of the Chief Executive Officer of the Department of Environment and Conservation, which address: 1. compliance with the conditions.	The performance review will address: 1. 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 found in 'Status' column of Audit Tables (Appendix B).
819: M 4-2 2	Compliance Audit & Performance Review	The proponent shall submit a performance review report by 1 December each year and more detailed reports by 1 February every three years, to the requirements of the Chief Executive Officer of the Department of Environment and Conservation, which address: 2. the achievement of environmental objectives set for the proposal.	The performance review will address: 2. 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 objectives is given by 'Evidence' & 'Status' columns of this Audit Table (Appendix B).
819: M 4-2 3	Compliance Audit & Performance Review	The proponent shall submit a performance review report by 1 December each year and more detailed reports by 1 February every three years, to the requirements of the Chief Executive Officer of the Department of Environment and Conservation, which address: 3. stakeholder and community consultation about environmental performance and the outcomes of that consultation, including a report of any on-going concerns being expressed.	The performance review will address: 3. 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.	**Partly Compliant.** A series of community forums were held during the development of the draft *Gnangara Sustainability Strategy*. The draft *Gnangara Sustainability Strategy* was released for public comment in July 2009 (Government of Western Australia 2009b). The final *Gnangara groundwater areas allocation plan* was released in November 2009. The accompanying *Gnangara groundwater areas allocation plan statement of response* (DoW 2009b) sets out how we have responded to issues raised by the public in finalising the plan and how we are working towards managing these issues when the plan is implemented. The final year of the reporting period aligned with the first evaluation of the Gnangara groundwater areas allocation plan. This evaluated the department's management of Gnangara groundwater resources and the extent to which the objectives of the Gnangara plan have been met since its release in November 2009 until December 2011. The statement will be available on the department's website in late 2012.
819: M 4-2 4	Compliance Audit & Performance Review	The proponent shall submit a performance review report by 1 December each year and more detailed reports by 1 February every three years, to the requirements of the Chief Executive Officer of the Department of Environment and Conservation, which address: 4. proposed environmental management over the next three years to comply with conditions and environmental objectives set for the proposal.	The performance review will address: 4. 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.** Section 6.2 describes management actions and research initiatives the department is undertaking to limit impacts of abstraction on groundwater dependent ecosystems.
819: M 4-3	Compliance Audit & 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 Department of Environment and Conservation.	Available on Department of Water's website.	Reports made available on the Department of Water's website.	CEO		Overall	After OEPA acknowled-gement letter being received. Department of Water website.	**Compliant.** The following Gnangara compliance reports have been formally audited or commented on by DEC or the OEPA and can be found on the department's website: • 2003–06 triennial (DoW 2007) • 2006–07 annual (DoW 2008a) • 2006–09 triennial (DoW 2010a) The following Gnangara compliance reports that haven't been formally audited or commented on can also be found on the department's website: • 2007–08 annual (DoW 2009c) • 2009–10 annual (DoW 2010b). • 2010–11 annual (DoW 2011d).

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: M 4-4	Compliance Audit & Performance Review	The proponent shall report any breach or anticipated breach of the environmental criteria set out in Tables 1 and 2 or environmental objectives to the Chief Executive Officer of the Department of Environment and Conservation immediately it becomes evident to the proponent.	Report in regular summaries sent to the Chief Executive Officer of the Environmental Protection Authority.	Letter to the Chief Executive Officer of the Office of the Environmental Protection Authority reporting non compliances with water level and other criteria as required. Compliance report.	CEO		Overall	Immediately as it becomes evident.	**Compliant.** Over the reporting period, the department reported regularly to DEC (now the Office of the EPA) on non-compliance with criteria water levels and other criteria: • DG DoW to DG DEC 2009–10 Q3 (CEOW157/10) • DG DoW to GM OEPA 2009–10 Q4 (CEOW391/10) • DG DoW to GM OEPA 2010–11 Q1 (CEOW583/10) • DG DoW to GM OEPA 2010–11 Q2 (CEOW58/11) • DG DoW to GM OEPA 2010–11 Q3 (CEOW274/11) • DG DoW to GM OEPA 2010–11 Q4 (CEOW436/11) • DG DoW to GM OEPA 2011–12 Q2 (CEOW36/12)
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 concept of sustainable yield using PRAMS modelling was applied in the calculation allocation limits for the *Gnangara groundwater areas allocation plan* (DoW 2009a). This plan provides the basis for water management decisions on the Gnangara Mound. The department recognises that sustainable yield has diminished as recharge has decreased in recent years (e.g. from PRAMS modelling).
819: M 5-2	Management of the Water Resource	The proponent shall subject to review, every three years, the basis for groundwater management decisions, including groundwater allocations and licences, and the criteria specified for conservation of the environment and the groundwater resource of the Gnangara Mound, to the requirements of the Environmental Protection Authority on advice of the Department of Environment and Conservation.	Present relevant material in Annual/Triennial reports. Refer draft groundwater management planning reports to the Office of Environmental Protection Authority, the Department of Environment and Conservation for comment. Make compliance reports publicly available (on the Department of Water's website).	Compliance report. Draft groundwater management documents sent to DEC/EPA for comment. Reports made available on Department of Water's website.	EPA	DEC	Overall	Subject to regular review every three years.	**Compliant.** The 'basis for groundwater management decisions' are the department's water licensing policies. These policies undergo a regular cycle of review which is detailed in a specific section of the policies (e.g. Statewide policies reviewed every 5 years). The *Gnangara groundwater areas allocation plan* provides the foundation for water allocation decision-making on the Gnangara Mound. The department regularly evaluates whether the management strategies in the plan are working to achieve the objectives of the plan. The final year of the reporting period aligned with the first evaluation of the Gnangara groundwater areas allocation plan. This evaluated the department's management of Gnangara groundwater resources and the extent to which the objectives of the Gnangara plan have been met since its release in November 2009 until December 2011. The draft *Gnangara Sustainability Strategy* (Government of Western Australia 2009b) indicates the association of other factors (e.g. land uses) with water management decisions on the Gnangara Mound. The following Gnangara compliance reports have been formally audited or commented on by DEC or the OEPA and can be found on the department's website: • 2003–06 triennial (DoW 2007) • 2006–07 annual (DoW 2008a) • 2006–09 triennial (DoW 2010a) The following Gnangara compliance reports that haven't been formally audited or commented on can also be found on the department's website: • 2007–08 annual (DoW 2009c) • 2009–10 annual (DoW 2010b) • 2010–11 annual (DoW 2011d)
819: M 6-1	Groundwater Allocation	The proponent shall ensure that the allocation of water to public and private users and the operation of the Pinjar Stages 1, 2 and 3, Wanneroo, Mirrabooka, and Lexia Groundwater Schemes comply with environmental water provisions.	Licensed allocations not to exceed allocation limits for Groundwater Area sub-areas.	Compliance report	Minister for the Environment		Overall		**Compliant.** Under the *Gnangara groundwater areas allocation plan* an allocation of up to 165 GL from Gnangara and Jandakot was considered under exceptional circumstances. In response to record low dam storage in 2010 and 2011, the department and Water Corporation agreed to exceptional circumstances allocations in 2010–11 and 2011–12. These allocations were agreed by the department, after the Corporation met the conditions for exceptional circumstances set out in the plan. These conditions included: • demand management measures for drought circumstances remained in place (Target 60) • contingency measures (additional production from the existing desalination plants) • environmental impact mitigation measures (minimal take from the most environmentally sensitive bores). The department worked with Water Corporation to distribute abstraction to limit impacts at groundwater dependent ecosystems. Allocation limits in the Superficial aquifer across all subareas are being reviewed to account for declines in rainfall and recharge as part of the work leading up to the Gnangara groundwater allocation plan.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
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 Environmental Protection Authority and the Department of Environment and Conservation.	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/ DEC	Overall		**Compliant.** Section 6.1 and Appendix D describe the department's environmental monitoring program (in line with the commitments in Ministerial Statement No. 819). 6.2 describes management actions and research initiatives the department is undertaking 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 Department of Water's website.	Allocation limits made available on the Department of Water's website. Current water availability figures can be obtained from Swan Avon regional office or through the department's water register: http://www.water.wa.gov.au/ags/WaterRegister	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 Swan Avon regional office or through the department's water register: http://www.water.wa.gov.au/ags/WaterRegister
819: M 8-2	Groundwater Availability	The proponent shall update annually the figures published according to the requirements of condition 8-1, with the emphasis on those areas of high allocation relative to sustainable yield of the groundwater resource so that limits to use and development can be clearly seen by all interested parties. The updated figures shall also be widely published.	Detail limits on availability relative to sustainable yield (allocation limits) published on the Department of Water's website.	Allocation limits made available on the Department of Water's website. Current water availability figures can be obtained from Swan Avon regional office or through the department's water register: http://www.water.wa.gov.au/ags/WaterRegister	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 Swan Avon regional office or through the department's water register: http://www.water.wa.gov.au/ags/WaterRegister
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.** In accordance with the *State Water Plan* (Department of Premier and Cabinet 2007), and following extensive consultation with the mining and irrigation industries as well as local government, the department developed and implements *Operational policy no. 1.2 – 'Policy on water conservation and efficiency plans*' (DoW 2009d). The department's Water Recycling and Efficiency Branch undertake projects to reduce water demand and achieve water conservation initiatives. These include implementing *Operational policy no. 1.2 – 'Policy on water conservation and efficiency plans*' (in particular by local government authorities), implementing the permanent winter sprinkler ban and implementing metering programs. Section 6.2 discusses the department's approach to the allocation of groundwater for public water supply and other initiatives aimed to reduce demand on the Gnangara groundwater resources and increase efficiency.
819: M 10-1 1	Research & Monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: 1. clarification of the relationship between groundwater level and rainfall under conditions of declining long-term rainfall to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority and the Department of Environment and Conservation.	Engage in research projects to address this issue, which includes: 1. clarification of the relationship between groundwater level and rainfall under conditions of declining long-term rainfall.	Compliance report	Minister for the Environment	EPA/ DEC	Overall		**Compliant.** The department is using PRAMS modelling to examine the relationship between rainfall and groundwater levels in a drying climate. A number of scenarios have been run using: short-term, 30-year average and dry climate conditions from 2008 to 2031 to examine the impact of the drying climate on groundwater levels. A new version of PRAMS is currently being calibrated and the datasets that feed into the model updated, including the climate dataset. The model will soon be used for detailed modelling studies, including scenarios examining interactions of climate, land use and public and private allocation (including provision of water to the environment).

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: M 10-1 2	Research & Monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: 2. 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 Environmental Protection Authority and the Department of Environment and Conservation.	Engage in research projects to address this issue, which includes: 2. improvement in the understanding of the relationship between groundwater levels and vegetation, including plantations	Compliance report	Minister for the Environment	EPA/ DEC	Overall		**Compliant.** The 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 outcomes and recommendations from the investigations 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 on the Gnangara Mound in a drying climate. The model is based on 30 years of ecological and hydrological monitoring data. It will be an important management tool for assessing the impact of future land and water use scenarios and for revising allocation limits as part of the next phase of planning for the Gnangara groundwater resources. Several projects undertaken as part of the draft *Gnangara Sustainability Strategy* address improving the understanding this relationship. They included: • Fire regimes on the Gnangara Mound – potential for water gain and impacts on biodiversity • Options and implications of continuing plantation forestry on the Gnangara Mound • Biodiversity values on the Gnangara Mound. For further information see sections 4.1.2 & 4.1.3 of the draft *Gnangara Sustainability Strategy* and the department's website.
819: M 10-1 3	Research & Monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: 3. 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 Environmental Protection Authority and the Department of Environment and Conservation.	Engage in research projects to address this issue, which includes: 3. 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/ DEC	Overall		**Compliant.** PRAMS modelling is being used improve the understanding of the relationship between groundwater level and abstraction from unconfined and confined aquifers of the Gnangara Mound. Reductions to both public and private abstraction have been modelled to evaluate storage gains in the Superficial aquifer over the next 20 years. These scenarios have informed the management of allocations and licensing. A new version of PRAMS is currently being calibrated and the datasets that feed into the model updated. The model will soon be doing detailed modelling studies, including scenarios examining interactions of climate, land use and public and private allocation (including provision of water to the environment). 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 outcomes and recommendations from the investigations to limit abstraction impact on groundwater dependent ecosystems.
819: M 10-1 4	Research & Monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: 4. 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 Environmental Protection Authority and the Department of Environment and Conservation.	Engage in research projects to address this issue, which includes: 4. clarification of the relationship between groundwater level and wetland water levels and wetland water quality	Compliance report	Minister for the Environment	EPA/ DEC	Overall		**Compliant.** The department has undertaken hydrogeological investigations at a number of sites across the Gnangara Mound as part of the Perth shallow groundwater systems investigation. To date, nine 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. Local area groundwater flow models for the following areas have been constructed and scenario modelling completed: • East Wanneroo integrated groundwater-lake flow modelling: Predictive scenario modelling to support the draft Gnangara Sustainability Strategy (Bourke 2009) • Local area model of groundwater flows and lake interactions: Lakes Mariginiup and Jandabup (RPS 2009) • Development of Local Area Groundwater Models – Gnangara Mound, Lake Nowergup (SKM 2009a) • Development of Local Area Groundwater Models – Gnangara Mound, Lake Bindiar (SKM 2009c) • Development of Local Area Groundwater Models – Gnangara Mound, Lexia Wetlands (SKM 2009b) These reports were used to support the draft Gnangara Sustainability Strategy. Reports are available on the department's website.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: M 10-1 5	Research & Monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: 5. 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 Environmental Protection Authority and the Department of Environment and Conservation.	Engage in research projects to address this issue, which includes: 5. improvement in the understanding of the relationship between groundwater level and water levels in the Yanchep caves	Compliance report	Minister for the Environment	EPA/ DEC	Overall		**Compliant.** The department's current environmental monitoring program is summarised in Appendix D. The program includes regular monitoring of Yanchep caves and surrounding Superficial aquifer monitoring bores. Monitoring of water quality and invertebrate cave fauna is undertaken annually. Building on the work of the shallow groundwater system investigation, the department recently completed an investigation into the cause of rapidly declining levels in Loch McNess in Yanchep National park. This study improved our understanding of the hydrogeology of Loch McNess and surrounding areas including the caves. The report is being finalised and will be available of the department's website in early 2013.
819: M 10-1 6	Research & Monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: 6. 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 Environmental Protection Authority and the Department of Environment and Conservation.	Engage in research projects to address this issue, which includes: 6. 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/ DEC	Overall		**Compliant.** The conservation value of wetlands issue is a prime responsibility of the DEC. The department undertakes 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 Environmental Protection Authority", the Environmental Protection Authority will prepare the written notice to the proponent.	The Environmental Protection Authority to provide written notice to the proponent (Department of Water).		Minister for the Environment		Overall		**The Department of Water seeks 'Clearance' of this condition.** It is not responsibility of Proponent.
819: M Proced-ure 2		The Environmental Protection Authority may seek advice from other agencies or organisations, as required, in order to provide its advice.	The Environmental Protection Authority to seek advice as required.		EPA	Other agencies as required.	Overall		**The Department of Water seeks 'Clearance' of this condition.** It is not responsibility of Proponent.
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 Department of Environment and Conservation.	Department of Water liaises with advisory body as required.	Liaison with advisory body in compliance report.	EPA	Agencies listed as part of compliance reporting.	Overall		**Compliant.** Refer to Commitments: • 2, 4,6,8,21 = CALM/DEC; • 21 = FPC. Although specific feedback was not sought on each separate condition, advice on relevant issues were obtained as part of the comprehensive interagency network that formed part of the draft *Gnangara Sustainability Strategy*. Also, both the DEC and Forest Products Commission made public submissions to the *Gnangara groundwater areas water management plan,* draft *for public comment* (DoW 2008b) which dealt with similar issues as the conditions.

Proponent environmental management conditions

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: P 1	Gnangara Mound allocations	Sustainable use of groundwater from the Gnangara Mound (Superficial aquifer).	Manage public and private groundwater abstraction to meet objectives and Environmental Water Provisions (EWP) criteria presented in Tables 1 and 2 (Ministerial Statement No. 819).	Meet objectives and Environmental Water Provisions criteria presented in Tables 1 and 2 (Ministerial Statement No. 819).	Compliance report	Minister for the Environment		Overall		**Partly compliant.** Refer to results given in Appendix A – water level monitoring results for Ministerial criteria sites on the Gnangara Mound, 1999-2011. Table 1 (wetlands) and Table 2 (terrestrial phreatophytic vegetation).
819: P 2	Management objectives & 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	DEC	Overall		**Compliant.** The most recent review of management objectives and criteria for the Gnangara mound are outlined in the 2007 *Review of Ministerial Conditions on the Groundwater Resources of the Gnangara Mound* (DoW 2007) and confirmed in *Ministerial Statement No. 819*. Allocation limits were reviewed in 2007 and set to minimise the impacts of groundwater abstraction on the groundwater resource. These were formalised in the *Gnangara groundwater areas allocation plan* released in November 2009 (DoW 2009a). The final year of the reporting period aligned with the first evaluation of the Gnangara groundwater areas allocation plan. This evaluates the department's management of Gnangara groundwater resources and the extent to which the objectives of the Gnangara plan have been met since its release in November 2009 until December 2011. As per the evaluation, allocation limits in the Superficial aquifer across all subareas are being reviewed to account for declines in rainfall and recharge.
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 Department of Water Gnangara Mound monitoring program.	Compliance report	Minister for the Environment	DEC	Overall		**Compliant.** Regular monitoring of Yanchep caves and surrounding Superficial aquifer monitoring bores is ongoing. Monitoring of water quality and invertebrate cave fauna is undertaken annually. Working with DEC, the department has recently reduced local abstraction in the Yanchep National Park. The department is also re-assessing groundwater allocations along the northwest coastal corridor.
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.** During the reporting period the department finalised the following plan dealing with drainage for the area: • *Swan Urban Growth Corridor Drainage and Water Management Plan* (DoW 2009e). See the department's website for more information.
819: P 5 1	Research & investigation program	Improving understanding of: • groundwater-environmental relationships on the Swan Coastal Plain; • the associated management requirements, and • potential management techniques.	Prepare a research and investigation program for submission to the EPA for review and subsequent finalisation of the program to the satisfaction of the EPA. The research and investigation program will be prepared with the objective of improving understanding of: • groundwater – environmental relationships on the Swan Coastal Plain; • the associated management requirements, and • potential management techniques; and will incorporate all relevant aspects of research and investigation work currently committed to under Ministerial Statements 438 and 496.	Prepare a research and investigation program.	Submit research and investigation program to the EPA for approval. Compliance report.	EPA	DEC	Overall	Within four months of a revised statement being issued following the 2004 Stage 1 section 46 review	**Compliant.** The department, with research partners, is completing a number of major pieces of work to focus management effort on those areas which will show the most benefit from changes to abstraction. This work will inform the next Gnangara allocation plan. • The Perth regional aquifer modelling system (PRAMS) is currently being updated. • Investigations to determine whether additional abstraction from the Leederville and/or Yarragadee aquifers could be a viable source option for public water supply. • The Perth shallow groundwater system investigation is complete and reports are being finalised. These studies improved understanding of the interrelationships between wetlands and the Superficial aquifer, and the complex, superimposed impacts of climate change, land use and abstraction. • For the next phase of Gnangara allocation planning, a tool developed by Edith Cowan University will be used to assess risk to groundwater dependent vegetation under different water, land use and climate scenarios. 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 commitment could be 'cleared' upon confirmation from the DEC.
819: P 5 2	Research & investigation program	Administrative	1. Implement the research and investigation program to the satisfaction of the EPA.	Make part of annual Departmental work program.	Compliance report	EPA	DEC	Overall		**Compliant.** The department uses outcomes from the research and investigation program to develop management strategies based on scientific data that promote the sustainable use of the groundwater resources of the Gnangara system.

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: P 5 3	Research & investigation program	To provide for ongoing up-to-date adaptive management.	2. Review and revise the program every six years (coinciding with triennial reports), to the satisfaction of the EPA.	Incorporate review in Triennial reporting in 6 year intervals.	Triennial compliance report	EPA	DEC	Overall	Every six years (coincide with Triennial reports)	**Compliant.** The department's research and investigation program is constantly evolving. The current program includes: updating the Perth regional aquifer modelling system, investigating the Leederville and Yarragadee aquifers as source options for public water supply and ongoing Perth shallow groundwater system investigations.
819: P 6 1	Environmental monitoring program	To enable evaluation of the environmental impact of groundwater abstraction from the Gnangara Mound (Superficial aquifer).	1. Prepare an environmental monitoring program for submission to the EPA for review and subsequent finalisation of the program to the satisfaction of the EPA. The monitoring program will include: • monitoring of groundwater levels in all relevant aquifer systems; • relevant wetland water levels and water quality; • condition of vegetation and fauna associated with groundwater- dependent ecosystems; and • cave water levels.	Prepare an environmental monitoring program.	Submit monitoring program to the EPA for approval. Compliance report.	EPA	DEC	Overall	Within four months of a revised statement being issued following the 2004 Stage 1 section 46 review	**Compliant.** A letter was sent to Director General of the DEC in December 2009, seeking advice and input on amendments to the monitoring program. To date, no response has been received. The monitoring program is set out in Appendix C. The previous environmental monitoring 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 2006–07 compliance report agreed commitment could be 'cleared' upon confirmation from the DEC. Although technically this requirement has been satisfied (monitoring program prepared), the department does not seek a 'Clearance' of this commitment as the program is constantly evolving and modifications are ongoing (with OEPA/DEC approval.
819: P 6 2	Environmental monitoring program	Administrative	2. Implement the approved environmental monitoring plan to the satisfaction of the EPA.	Make part of annual Departmental work program.	Compliance report	EPA	DEC	Overall		**Compliant.** (see P 6 1)
819: P 6 3	Environmental monitoring program	To provide for ongoing up-to-date adaptive management.	3. Review and revise the program every six years (coinciding with triennial reports), to the satisfaction of the EPA.	Incorporate review in Triennial reporting in 6 year intervals.	Triennial compliance report	EPA	DEC	Overall	Every six years (coincide with Triennial report)	**Compliant.** A review of the environmental monitoring program was undertaken in June 2009 in collaboration with the ecologists who undertake the monitoring. A number of amendments were made. A letter was sent to Director General of the DEC in December 2009, seeking advice and input on the amendments. To date, no response has been received. Although stated to be addressed in triennial reports every 6 years, the ecological monitoring program undergoes regular revision as required.
819: P 7	Development advice	Integrated land and water resource planning for enhanced water resource management.	Continue to provide advice to the City of Wanneroo, the Department for Planning and Infrastructure, DEC and other relevant agencies on the impact of land use on groundwater resources.	Liaise with the City of Wanneroo, the Department for Planning and Infrastructure, DEC and other relevant agencies.	Compliance report	Minister for the Environment	City of Wanneroo, Department for Planning, DEC and other relevant agencies	Overall		**Compliant.** The department assesses land use proposals with potential water resource issues referred from local and State government agencies.
819: P 8	Gnangara inter-agency technical advisory group	Integrated land and water resource planning for enhanced water resource management.	Convene and provide ongoing executive support for an inter-agency technical advisory group for water resources planning and management issues on the Gnangara Mound. The group will consider planning and management issues in the context of recommendations of the Select Committee on Metropolitan Development and Groundwater Supplies.	Provide executive duties for the Gnangara Coordinating Committee. Provide executive duties for the Gnangara Consultative Committee (see P 9).	Compliance report. See P 9.	Minister for the Environment		Overall		**Compliant.** (See P 9)
819: P 9	Community consultation	Useful forum for information exchange and advice.	Continue to chair and provide support for the Gnangara Consultative Committee as an ongoing forum for information exchange and advice.	Chair and provide support for the Gnangara Consultative Committee.	Compliance report	Minister for the Environment		Overall		**Partly-compliant.** Although the Gnangara Consultative Committee did not meet during the reporting period, its role was assumed by the Gnangara Coordinating Committee (GCC) that oversaw the Gnangara Sustainability Strategy.

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
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 Water Corporation Operating Strategy.	Compliance report	Minister for the Environment		Overall		**Compliant.** Over the summer of 2010-11 widespread signs of water stress were observed, including large numbers of dead or dying eucalypts and banksias. Both phreatophytic species (that are dependant or partially dependant on groundwater) and non-phreatophytic species were affected, suggesting the cause of the deaths is likely to be a combination of groundwater levels falling below rooting depths and a severe lack of soil moisture. Each public water supply bore is assigned a sensitivity classification determined by proximity to environmentally sensitive areas. The department uses these classifications to distribute public supply abstraction to limit impacts at groundwater dependent ecosystem. The department has recently reviewed the classifications of each bore and amended bore quotas to limit the impacts of abstraction on groundwater dependent vegetation.
819: P 11	Lake Nowergup supplementation	Protect environmental values.	Should EWPs in Lake Nowergup not be met by November, artificial supplementation will be used until the EWP is reached.	Operate Lake Nowergup artificial maintenance facility if EWPs not met by end of November until EWP is reached.	Compliance report	Minister for the Environment		Overall		**Non-compliant.** See Table 5.
819: P 12	Reporting	Assessment of environmental impact(s) from groundwater abstraction for public water supply.	Require the Water Corporation to submit yearly production plans as part of the operating strategy and to report on compliance with environmental commitments made in the operating strategy.	Water Corporation to submit annual production summary and report on compliance with environmental commitments defined in operating strategy.	Compliance report	Minister for the Environment		Overall		**Compliant.** Water Corporation submitted bore abstraction plans that the department reviewed to ensure abstraction was distributed to limit impacts on groundwater dependent ecosystems. The Water Corporation also submitted an *Integrated Water Supply Scheme Water Monitoring Summary* for 2011–12 which reports on compliance with environmental commitments made in the operating strategy.
819: P 13	Vegetation Protection	To minimise environmental and/or significant impact	Establish additional monitoring wells in those areas where suitable wells do not exist to monitor groundwater levels under phreatophytic vegetation.	Review monitoring program and recommend construction of additional monitoring wells as required.	Compliance report	Minister for the Environment		Overall		**Cleared.** A similar Commitment from previous Statement 438: P 2 was stated as 'Cleared' by DEP Environmental Audit Branch 28/10/1997, refer Appendix 7 Gnangara 2000–03 triennial compliance report. However, the department is continuing work in this area. The department completed a management area review (McHugh & Bourke 2007) that summarised the current monitoring and management issues facing particular wetlands on the Gnangara and Jandakot groundwater mounds and identified the information and data required to address these issues. The review recommended sites to be included in the Perth shallow groundwater systems investigation, prioritised by a combination of ecological significance, management issues and geomorphic setting. The investigations redesigned and upgraded the existing monitoring infrastructure and installed new monitoring networks at ecologically important sites.
819: P 14	East Gnangara Wetlands	Offset environmental impact with environmental benefit.	Require the Water Corporation to implement its 2001 wetland mitigation strategy and subsequent approved revision and report to the DoW on implementation.`	Require information in Water Corporation annual production summary and report on compliance with environmental commitments defined in operating strategy.	Compliance report	Minister for the Environment		Overall	Prior to the commiss-ioning of the Lexia scheme	**Partly compliant.** The department has been in discussions with the Water Corporation regarding this issue. In light of the work undertaken by DEC to assess biodiversity values on the Mound (as part of the draft Gnangara Sustainability Strategy) and other investigations outlined in the status against commitment 819: P 51, the department and the Corporation have agreed to include a process for offsetting these wetlands in the next phase of planning for the Gnangara Mound.

Appendix C — Background information

The importance of managing the Gnangara Mound to protect the groundwater-dependent ecosystems was formally recognised in late 1980s. The Environmental Protection Authority (EPA) set the first conditions on abstracting groundwater and protecting the environment on the Gnangara Mound when the former Water Authority of Western Australia (WAWA) published the Gnangara Mound Water Resources Environmental Review and Management Program in 1986 (WAWA 1986). The conditions included Ministerial water level criteria based on environmental knowledge at the time. These were considered by the WAWA to provide a reasonable level of maintenance of values of key elements of the environment. The Ministerial water level criteria took into account expected groundwater abstraction limits for the region, future land use expectations and historical rainfall variations.

In 1995, the WAWA reviewed the Ministerial water level criteria (WAWA 1995). In the review, the importance of climate as a factor affecting groundwater levels was highlighted, as was the difficulty of predicting future groundwater levels given the uncertainty of future climatic conditions.

Section 46 review of Ministerial conditions and commitments

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

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

The second stage of the Section 46 review was to be a more comprehensive review to deliver improvements to management of public and private abstraction. The second stage was to have incorporated ecological information from work underway at the time, however this work has been subsequently outdated by more recent investigations into the shallow groundwater systems and ecological responses to climate. Analysis of this investigative work will be used to focus management effort on those areas which will show the most benefit from changes to abstraction. The

intent of the stage two review will be covered by the next phase of planning for Gnangara groundwater resources.

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

In mid 2009, the department commenced a series of monitoring review workshops in collaboration with the ecologists contracted to carry out the monitoring. The workshops aimed to improve both the effectiveness and efficiency of the monitoring program. In revising the monitoring program we:

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

A second review workshop, held in late April 2010, considered the following two key issues:

- how monitoring results could be presented spatially so that they represent short-term and longer-term trends across an entire groundwater management area
- how modelling results could be used to ensure the monitoring effort is focussed on the correct areas in the longer-term.

The main outcomes and recommendations of this workshop were as follows:

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

The following tables contain a summary of the amended environmental monitoring program for the Gnangara Mound.

Frequency	
✱	Monthly
✓	Annually
◆	Triennially
♦	Episodic (when water is present)

Site	Water levels	Wetland vegetation	Rapid end of summer	Macro-invertebrate	Water quality	Frog	Terrestrial vegetation
Criteria wetlands							
Lake Goollelal	*	◆	✓	✓	✓		
Lake Gnangara	*			✓	✓		
Loch McNess	*	✓	✓	✓	✓		
Lake Yonderup	*	✓	✓	◆	✓		
Lake Joondalup	*	◆	✓	✓	✓		
Mariginiup Lake	*	◆	✓	◆	◆		
Lake Jandabup	*	✓	✓	✓	✓		
Lake Nowergup	*	✓	✓	✓	✓		
Wilgarup Lake	*	✓	✓	♦	♦		
Pipidinny Swamp	*						
Lexia 94 (GNM17a)	*	✓	✓			✓	
Lexia 86 (GNM16)	*	✓	✓	♦	♦	✓	
Lexia 186 (GNM15)	*	◆	✓	♦	♦	✓	
Melaleuca Park (EPP) 173	*	✓	✓	✓	✓	✓	
Melaleuca Park (Dampland) 78	*	◆	✓			✓	
Egerton Swamp	*		✓	✓	✓		
Criteria Monitoring Wells							
MM12	*		✓				
MM16	*		✓				
MM18	*		✓				
MM53	*		✓				
MM55B	*		✓				
MM59B	*		✓				
MT3S	*		✓				
NR6C	*		✓				
PM9	*		✓				
PM24	*		✓				

Site	Water levels	Wetland vegetation	Rapid end of summer	Macro-invertebrate	Water quality	Frog	Terrestrial vegetation
WM1	*		✓				
WM2	*		✓				
WM8	*		✓				
L30C	*		✓				
L110C	*		✓				
L220C	*		✓				
Other sites							
PM6	*		✓				
PM7	*		✓				
NR11C	*		✓				
Lexia 132		◆					
Coogee Springs				♦	♦		
Gaston Road Swamp (Jacquie's Spring)				✓	✓		
ALPACA01 (Sue's Spring south)				✓	✓		
Lake Yakine						✓	
GSS sites						✓ Aural surveys at 23 sites	
Perth SGS investigation sites							
Lake Bindiar	*	✓					
Lake Muckenburra	*	✓		✓	✓		
Quin Brook	*	✓		✓	✓		
Yeal Lake	*	✓		✓	✓		
Tangletoe Swamp	*	✓					
PM4	*	✓					
Lake Bambun	*	◆		✓	✓		
Phreatophytic terrestrial vegetation sites (11/17 sites monitored triennially)							
Tangletoe							◆
Tick Flat							◆
Yeal							◆
Ridges							◆
P50							◆
Yanchep							◆

Site	Water levels	Wetland vegetation	Rapid end of summer	Macro-invertebrate	Water quality	Frog	Terrestrial vegetation
Nowergup							◆
Neaves							◆
Joondalup							◆
Jandabup							◆
South Kendall							◆
West Gironde							◆
Whiteman Park							◆
Melaleuca Park							◆
Bell							◆
Maralla							◆
Bombing Range							◆
Yanchep Caves							
YN99 (Boomerang Cave)	*			♦	♦		
YN31 (Cabaret Cave)	*			♦	♦		
YN18 (Carpark Cave)				♦	♦		
YN565 (Spillway Cave)				♦	♦		
YN27 (Gilgie Cave)				♦	♦		
YN555 (Lot 51)				♦	♦		
YN61 (Mire Bowl)				♦	♦		
YN256 (Orpheus Cave)				♦	♦		
YN81 (Fridge Grotto)				♦	♦		
YN1 (Crystal Cave)	*						
YN11 (Water Cave)	*						

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