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

Gnangara

groundwater allocation plan

draft for public comment

Water resource allocation
and planning series
Report no. 76
November 2021

This plan is part of the State Government's 2019–2021 *Waterwise Perth Action Plan* which sets the direction for Perth's transition to a waterwise city. Our ambition is for Perth to be cool, liveable, green and sustainable – a place where people want to live, work and spend their time.

The *Gnangara groundwater allocation plan* helps deliver Action 14 of the *Waterwise Perth Action Plan*: Review groundwater allocation plans for Gnangara, Perth South and Jandakot, Cockburn and Serpentine to manage groundwater levels for wetlands, urban trees and irrigation of green spaces. The plan also contributes to achieving the 2030 target of 10 per cent less groundwater use across the region.

The Department of Water and Environmental Regulation acknowledges the Whadjuk and Yued Noongar peoples as the traditional owners and custodians of the lands and waters covered by this plan. We pay our respects to their elders past and present.

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Cover photograph: Looking south above Lake Goollelal to the Perth city skyline, by Ashley Ramsay.

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Have your say

Our consultation process so far shows that groundwater users broadly recognise the need to respond to climate change by reducing groundwater take to better match recharge from rainfall. We are now seeking comments on the plan to achieve this.

This plan is open for public comment until 28 February 2022. We encourage you to discuss the plan with your peak industry body.

You can make a formal submission on the plan in several ways:

- online at our Consultation Hub consult.dwer.wa.gov.au
- by email to: gnangara.planning@dwer.wa.gov.au
- by post to:

  Manager Water Allocation Planning
  Department of Water and Environmental Regulation
  Locked Bag 10
  Joondalup DC, WA 6919

We won't identify individuals but may quote directly from your comments, unless you clearly state you do not wish us to do so.

We will review and consider each of the comments we receive to inform the final *Gnangara groundwater allocation plan*.

Please send your comments on the plan to us by 5 pm Monday, 28 February 2022.

For general licensing queries contact our Swan Avon regional office on 08 6250 8000

Summary

Purpose of the plan

The Gnangara groundwater system is Perth's largest and most important water resource. This plan sets out how the Department of Water and Environmental Regulation will manage the system to continue adapting to climate change.

The department is responsible for the sustainable allocation of Gnangara groundwater both to benefit the community and protect the environment that depends on it.

This plan replaces the *Gnangara groundwater areas allocation plan* (DoW 2009a) and is an outcome of the *Waterwise Perth Action Plan* (Government of Western Australia 2019b).

In the 2009 plan we reduced groundwater use for public water supply and capped growth in licensed self-supply groundwater use, while avoiding direct reductions to the entitlements of licensees. We kept domestic bore abstraction in check by using daytime sprinkler restrictions, the sprinkler roster and the winter sprinkler ban. Even with these changes, groundwater levels were the lowest on record by the end of summer 2016.

Climate change has caused average annual rainfall to decline 15 per cent since 1975 (Perth Airport rainfall station). This decline, combined with groundwater abstraction, has lowered groundwater levels across the Gnangara groundwater system. As a result, the health of groundwater-dependant wetlands and vegetation is suffering, groundwater quality is reducing in some areas, and the long-term sustainability of the resource is under threat.

The Gnangara groundwater system's wetlands are drying. Lower groundwater levels have caused the drying of cave pools and wetlands in Yanchep National Park, such as Crystal Cave, Loch McNess (Wagardu[1]) and Lake Wilgarup. Lower levels have also contributed to the loss of the unique invertebrate communities in the cave pools. Further to the south, lower groundwater levels have caused visible drying and health declines in wetlands such as lakes Nowergup, Gnangara, Mariginiup and Jandabup.

Elsewhere, along the Swan River (Derbarl Yerrigan) and the coast, declining groundwater recharge has caused saline water to move inland and reduced water quality in some bores. Acid-forming soils have been exposed above the watertable, making lakes Mariginiup and Gnangara acidic and increasing the acidity in Mussel Pool in Whiteman Park.

[1] Where possible in this plan, we have included the Noongar place name beside the European name for the site. In many cases, the names of Gnangara wetlands already reflect the original Noongar name for the area, such as lakes Joondalup, Goollelal etc. Note that the spelling of Noongar words can vary, reflecting the slight variations in pronunciation of the language.

To protect the Gnangara groundwater system from further impacts, we need new measures to narrow the gap between groundwater abstraction, and reduced rainfall and recharge projected under climate change.

Approach for managing the Gnangara groundwater system

This groundwater allocation plan sets out the system's water resource management objectives and how we will use water licensing and other measures to:

- maintain or increase groundwater levels to avoid further damage to water quality and environmental health at important locations
- reduce the rate of groundwater level decline in other locations
- maintain a reliable water supply.

To achieve these objectives, we need to reduce the annual groundwater abstraction rate by 54 gigalitres during the next decade. This is about a 19 per cent change in total annual abstraction across the Gnangara groundwater system.

Our extensive groundwater modelling and analysis show that a reduction of this size is necessary across the plan area to measurably improve groundwater levels in critical areas and protect environmental and resource values more broadly. Managing groundwater resources and keeping water in our unique wetlands will not only protect habitat for local flora and fauna, but also continue to provide local amenity, opportunities for recreation and learning, and health and wellness benefits for the community.

We expect that reduced abstraction will stabilise or improve groundwater levels at wetlands around East Wanneroo, Whiteman Park and Ellenbrook. Urban developments are underway in these locations, which will increase demand for the amenity the wetlands provide.

We also expect the changes to abstraction will benefit wetlands in urban areas such as Perry Lakes and Carine Swamp, and maintain or improve some of the iconic and culturally significant wetlands in Yanchep National Park[2], one of the most popular national parks in the state.

The Gnangara groundwater system is a shared resource. The abstraction reductions in this plan will be shared across Gnangara groundwater users. For most licensed users this will be a 10 per cent reduction from 2028, although the reduction for public water supply will be 27 per cent. The sprinkler roster for domestic garden bore use in the Perth/Mandurah area will be aligned with the two-days-a-week sprinkler roster for scheme water users.

Reducing abstraction, as outlined in this plan, will help repair some of the detrimental effects of the rapid growth in groundwater use before 2009. These reductions will help to implement the targets set in the government's *Waterwise Perth Action Plan*.

[2] The name Yanchep comes from the Noongar word *yandjip* or *yanget*, meaning bullrush (*Typha orientalis*). The bullrush was common around the area's wetlands and an important food source for the Noongar people.

This plan also outlines how we will continue to monitor water levels, water quality and ecological health against the water resource objectives and environmental protection criteria to ensure the delivery of real outcomes.

Allocation and licensing for the Gnangara groundwater system

Adjusting licensed water entitlements granted under the *Rights in Water and Irrigation Act 1914* (WA) is the primary mechanism to reduce groundwater take. This plan clarifies the scale, timing and process of changes to annual water entitlements for groundwater licences in the plan area. The licence duration for self-supply water users will remain at 10 years.

We will change the system's ~2600 water licences when we receive a licence application, in most cases when a self-supply user applies for a licence renewal. At this time, unless there is an exception outlined in this plan, we will:

1. assess metering and water use information
2. recoup unused water and adjust the entitlement where appropriate
3. (a) before 1 July 2028 add a condition that will reduce the adjusted entitlement volume by 10 per cent at the start of the first water year after 1 July 2028 or

   (b) from 1 July 2028 reduce the adjusted entitlement by 10 per cent when the licence is reissued.

This process will see all licences adjusted between 2028 and 2032.

Changes to the abstraction of groundwater by sector will be:

- a 27 per cent reduction for the Water Corporation for the Integrated Water Supply Scheme (30 GL/year)
- a 10 per cent reduction for the agriculture and horticulture sectors (5.4 GL/year)
- a 10 per cent reduction for licences for irrigating parks, gardens and other recreational green space (3.4 GL/year)
- a 10 per cent reduction for most other licensed water use such as industry and mining (1.4 GL/year)
- a reduction to domestic garden bore water use achieved by aligning the garden bore sprinkler roster with the scheme roster in the Perth/Mandurah area from September 2022 (savings of up to 13.6 GL/year by changing to a two-days-a-week roster between 1 September to 31 May).
- no reductions for schools and hospitals, as well as a small number of other specified purposes and locations.

To support water users to adjust to using less water the State Government will:

- invest $750,000 in targeted programs in North Wanneroo to support the horticulture industry
- advise land developers in Perth's new growth areas on opportunities to access tradeable water entitlements, water sensitive urban design and, where needed, options for additional water supplies
- launch a new waterwise irrigation training program for Gold status Waterwise Councils in partnership with Water Corporation and Irrigation Australia Limited Western Australia
- help schools, businesses, local government and the community through targeted Waterwise programs
- assist the community to improve water literacy and reduce water use through public education campaigns
- provide advice to all water use sectors on water use efficiency
- adjust groundwater subarea boundaries in the Swan Valley and establish water trading rules to support priority agriculture
- provide assistance to householders to make their gardens more waterwise, including incentives to invest in smart irrigation technology and spring sprinkler system check-ups.

1 Plan context and scope

Climate change means that Perth must become even more waterwise. Our city needs to adjust to using less groundwater to achieve the same productivity and amenity benefits we are used to. The amount of water being taken from the Gnangara groundwater system exceeds the amount of water recharging the system. Reducing abstraction will have long-term benefits for water users and help protect important wetlands and native bushland, making them more resilient to climate change.

The Department of Water and Environmental Regulation has made this plan to address this water imbalance and secure the Gnangara groundwater system as a long-term sustainable water resource that supports a healthy environment for Perth.

1.1 Purpose of the plan

This plan continues the aims of the *Gnangara groundwater areas allocation plan* (DoW 2009a) to manage the Gnangara groundwater system in line with the impact climate change is having across south-west Western Australia.

Actions in the *Gnangara groundwater areas allocation plan* slowed the rate of groundwater level decline, mainly by reducing groundwater use for public water supply and capping licensed, self-supply groundwater use. Sprinkler restrictions for garden bores supported these actions. We did not reduce licensed, self-supply groundwater abstraction at the time.

This plan is the next step in adapting to the long-term decline in rainfall from climate change. Our overall goal is to rebalance the water being taken out of the groundwater system with the recharge to groundwater from rainfall. This is to make sure the water quality remains suitable for irrigation and other uses and the water quantity maintains water levels to support groundwater-dependent wetlands and vegetation.

Key features of this plan are new groundwater level objectives, a more sustainable allocation of groundwater across the system, and a pathway to reduce the amount of groundwater being used over the next decade. The plan focuses on bringing groundwater abstraction back into balance with climate by adjusting most water licences and reducing garden bore watering.

Reducing the amount of groundwater being taken from the system will stabilise and reverse some of the past groundwater declines, as well as improve the climate resilience of valuable wetlands and bushland reserves. We will help groundwater users by promoting innovative water projects, building capacity in water efficiency, sharing research and exploring new water supply options with water users.

New science and research completed since the last allocation plan in 2009 (Section 1.5) has informed this plan, along with feedback from groundwater users, including the Water Corporation.

1.2 Plan area

Location

This plan covers about 2,200 km^2 of the Swan coastal plain, extending north from the Swan River (Derbarl Yerrigan) in Perth, Western Australia. The plan area is bound by the Swan River (Derbarl Yerrigan) to the south, the Moore River and Gingin Brook to the north, the Darling Scarp to the east, and the Indian Ocean to the west (Figure 1). The plan covers the aquifer system known as the Gnangara groundwater system.

This plan includes aquifers of the Gingin groundwater area south of Gingin Brook and Moore River. However, we will establish their management through a Gingin water allocation plan, to be developed after this plan is completed (see details in Section 5.2).

Proclamation

This plan covers part or all of eight groundwater areas proclaimed under Section 26B of the *Rights in Water and Irrigation Act 1914* (WA) (Figure 1):

- Gnangara groundwater area – gazetted on 16 February 1996
- Gwelup groundwater area – gazetted on 16 February 1996
- Mirrabooka groundwater area – gazetted on 16 February 1996
- Perth groundwater area (north of the Swan River) – gazetted on 1 December 1989
- Swan groundwater area – gazetted on 26 September 1975
- Wanneroo groundwater area – gazetted on 26 March 1982
- Yanchep groundwater area – gazetted on 30 January 1987
- Gingin groundwater area (south of Moore River and Gingin Brook) – gazetted on 26 September 1975.

Proclamation means that you need a water licence to take groundwater in these areas. A licence is also required to construct or alter wells unless an exemption under Section 26C of the *Rights in Water and Irrigation At 1914* applies. Exemptions for a water licence may apply (see Chapter 4 for more details).

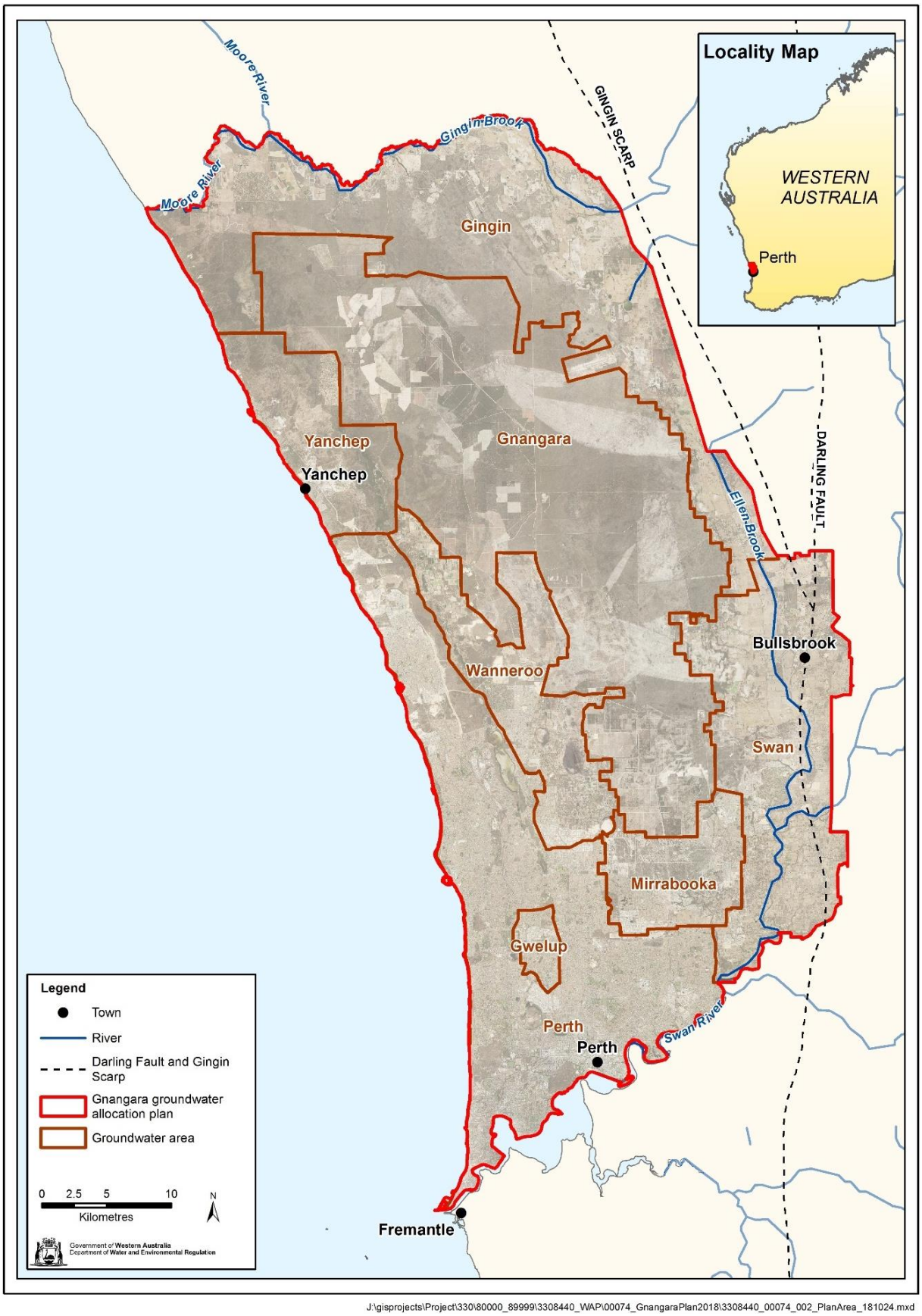


Figure 1 The Gnangara groundwater allocation plan area and proclaimed groundwater areas

1.3 The importance of groundwater for Perth

The Gnangara groundwater system is Perth's largest source of low-cost, good-quality water. It provides almost half of all the water used in the Perth metropolitan area each year, supplying drinking water, water for agriculture and water for irrigating parks, ovals and gardens.

Perth's lakes, wetlands, cave systems and bushlands also depend on the Gnangara groundwater system. At present, 275 gigalitres of water each year (GL/year) is allocated from the Gnangara groundwater system, as authorised through water licences and for purposes exempt from licensing.

Gnangara groundwater has a variety of uses. The Water Corporation uses about 40 per cent of the water abstracted to supply the Integrated Water Supply Scheme, servicing most of the households and businesses in the Perth and Peel regions, as well as Kalgoorlie and the towns along the pipeline. The other 60 per cent of the water is abstracted by licensed self-supply users, unlicensed stock and domestic bores and garden bore users (Figure 2). Under the current growth rate, we estimate that domestic garden bore use would increase to about 43 GL/year by 2030.

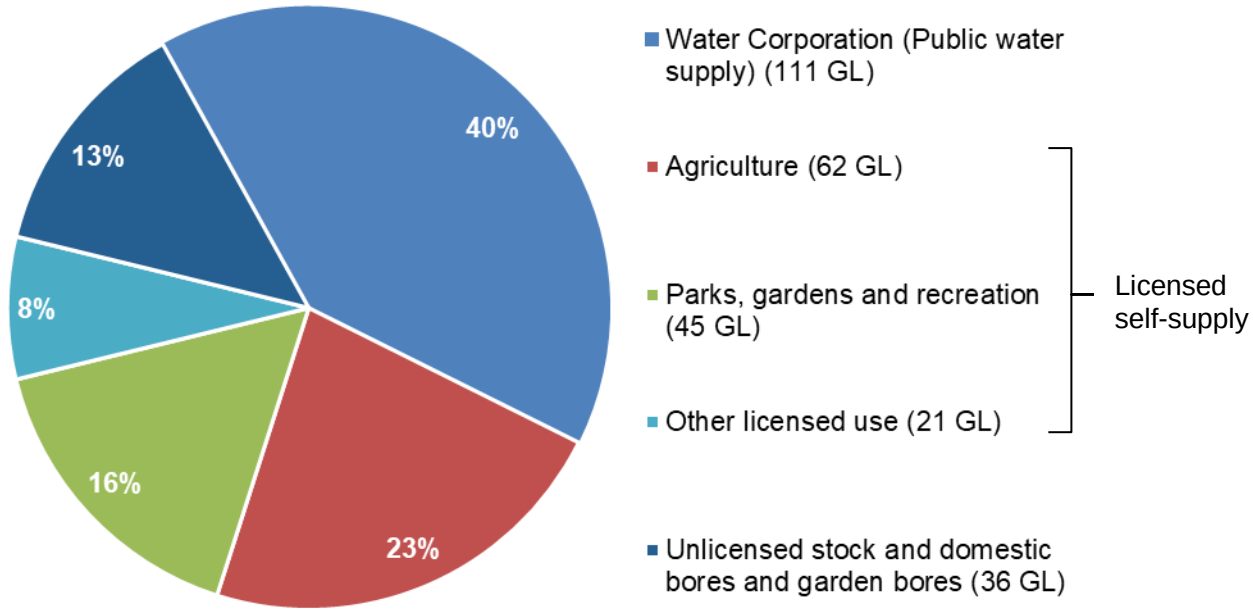


Figure 2 Proportion of water abstracted in 2019–20 for different water uses from all aquifers in the Gnangara groundwater system

1.4 The groundwater system and changes over time

The Gnangara groundwater system's hydrogeology is well studied and there are three main aquifers that we abstract from (Figure 3):

- the shallow, unconfined Superficial aquifer (including the less extensive Mirrabooka aquifer) – 186 GL/year
- the deep, partly confined Leederville aquifer – 44 GL/year
- the deep, mostly confined Yarragadee aquifer – 45 GL/year.

The central and most elevated part of the Superficial aquifer is known as the Gnangara Mound. The term 'Superficial aquifer' is used throughout this plan rather than the Gnangara Mound. The Mirrabooka aquifer is also present in the Gnangara groundwater system, but it is not as extensive as the other aquifers (about 6 GL/year is abstracted). It sits below, and in parts is connected to, the Superficial aquifer. Minor fractured rock aquifers exist along the plan area's eastern boundary but are not connected to the Gnangara aquifers.

The Leederville (up to 550 metres thick) and Yarragadee (up to 2,000 metres thick) are large, deep aquifers present across almost the entire Perth region. These are used mainly for public water supply. Latest research shows the Superficial aquifer is more widely connected to the deeper aquifers than previously thought (DWER 2021a).

The term 'Gnangara groundwater system' refers to all these aquifers in the area north of the Swan River (Derbarl Yerrigan) to Gingin Brook, and west of the Darling Scarp to the Indian Ocean. See the *Gnangara groundwater allocation plan methods report* (DWER 2021b) for more information about the aquifers of the Gnangara groundwater system.

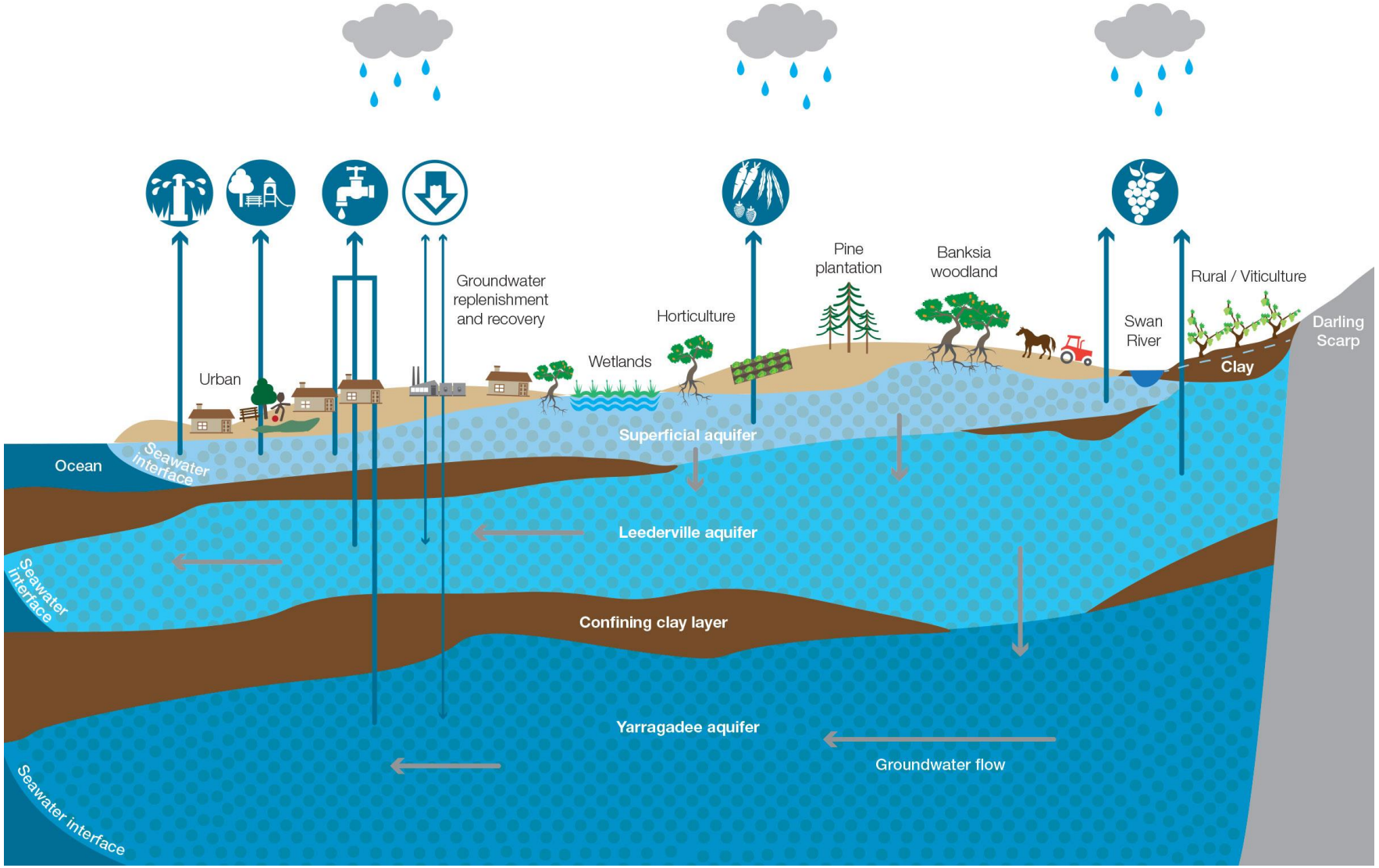


Figure 3 Typical cross-section of the Gnangara groundwater system and how it is used

Impacts of climate change and abstraction

Climate change has caused a significant reduction in Perth's rainfall. Average annual rainfall has declined by about 15 per cent since 1975 at the Perth Airport rainfall station – from 841 mm/year (1945–1974) to 708 mm/year (1975–2020). As a result, rainfall recharge to the groundwater system is now much less than it was.

Combined with groundwater abstraction, this has caused the loss of large volumes of groundwater from the system (Figure 4). Despite a small recovery in storage after 2016 (because of higher rainfall in 2017 and 2018), low rainfall in 2019 and 2020 re-established the overall downward trend in storage volumes.

Declines in hydraulic pressure in the Leederville and Yarragadee aquifers (measured as pressure head in mAHD) has accelerated since the 1980s as groundwater abstraction from them, mostly for public water supply, has increased. Where the deep aquifers are connected to the Superficial aquifer, the reduced pressures have exacerbated declines in Superficial aquifer levels.

Climate change and groundwater abstraction are drying the Gnangara groundwater system's wetlands. In the past 40 years, groundwater levels in the Superficial aquifer have fallen across most of the Gnangara plan area, most notably in the north. This has caused drying of the cave pools and wetlands in Yanchep National Park, such as Crystal Cave, Loch McNess (Wagardu) and Lake Wilgarup. Unique invertebrate communities in the cave pools have been lost. Large areas of wetland peat were burnt in the Yanchep fire in late 2019 (Blake et al. 2021). Further to the south, wetlands such as lakes Nowergup, Gnangara, Mariginiup and Jandabup have visibly dried and suffered health declines as a result of low groundwater levels.

Elsewhere, along the Swan River (Derbarl Yerrigan) and the coast, lower groundwater recharge has caused saline water to move inland, making some bores more saline. Acid-forming soils have been exposed above the watertable, making lakes Mariginiup and Gnangara acidic and increasing acidity in Mussel Pool in Whiteman Park.

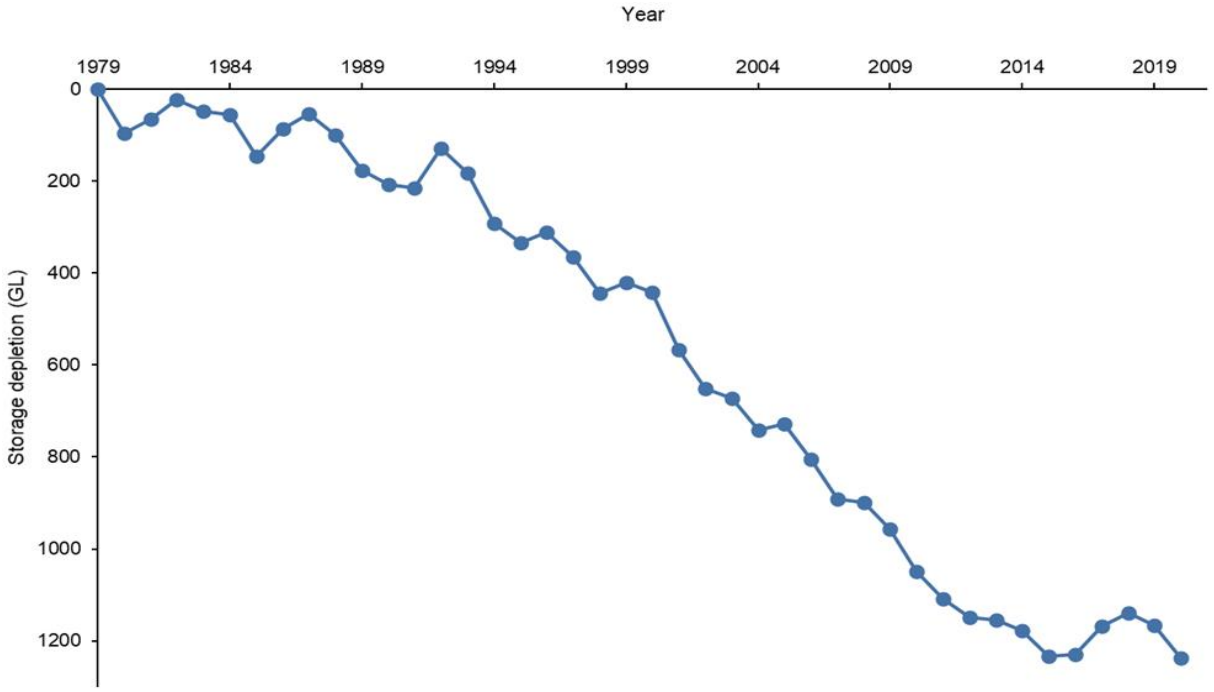


Figure 4 *More than 1,000 gigalitres of groundwater storage has been lost from the Superficial aquifer since 1980*

Managing Gnangara groundwater up to now

For more than two decades the Western Australian water sector has had to contend with the effects of climate change. Dramatic decreases in streamflow and dam storage have occurred at the same time as increasing demand for water from a growing population. We have managed the Gnangara groundwater system in this context of competing needs.

With less water filling Perth's dams, groundwater helped make up the gap in public (scheme) water supply from the 2000s, giving us time to develop new climate-independent water sources. During the same period, the allocation of groundwater was guided by environmental conditions set under Part IV of the *Environmental Protection Act 1986* (WA). This included water level criteria for 30 representative wetland and bushland sites across the plan area (see Section 6.1). The *State water strategy 2003* also helped improve water efficiency, leading to initiatives such as the Waterwise Councils program.

The previous *Gnangara groundwater areas allocation plan* (DoW 2009a) drove reductions in the use of groundwater for public water supplies. It reduced the average amount of groundwater available to the Water Corporation in 2013 after the Southern Seawater Desalination Plant was expanded (Figure 5).

The 2009 plan also capped growth in licensed, self-supply groundwater abstraction, but avoided direct reductions to the entitlements of licensees. Domestic bore abstraction was kept in check by daytime sprinkler restrictions, the three-day sprinkler roster for autumn, summer and spring and the winter sprinkler ban.

Even with these changes, by the end of summer in 2016, groundwater levels were the lowest on record, and water levels at 18 of the 30 representative wetland and bushland sites were below the minimum water level criteria.

We now need further measures to narrow the gap between groundwater abstraction and the reduced rainfall and recharge projected under climate change. These will help protect groundwater-dependent ecosystems and ensure the long-term sustainability of the resource. We have proposed new minimum water level thresholds at some of the 30 water level criteria sites, in line with what is possible under a drier climate and a reduced groundwater abstraction regime (see also Chapter 7 and Appendix G).

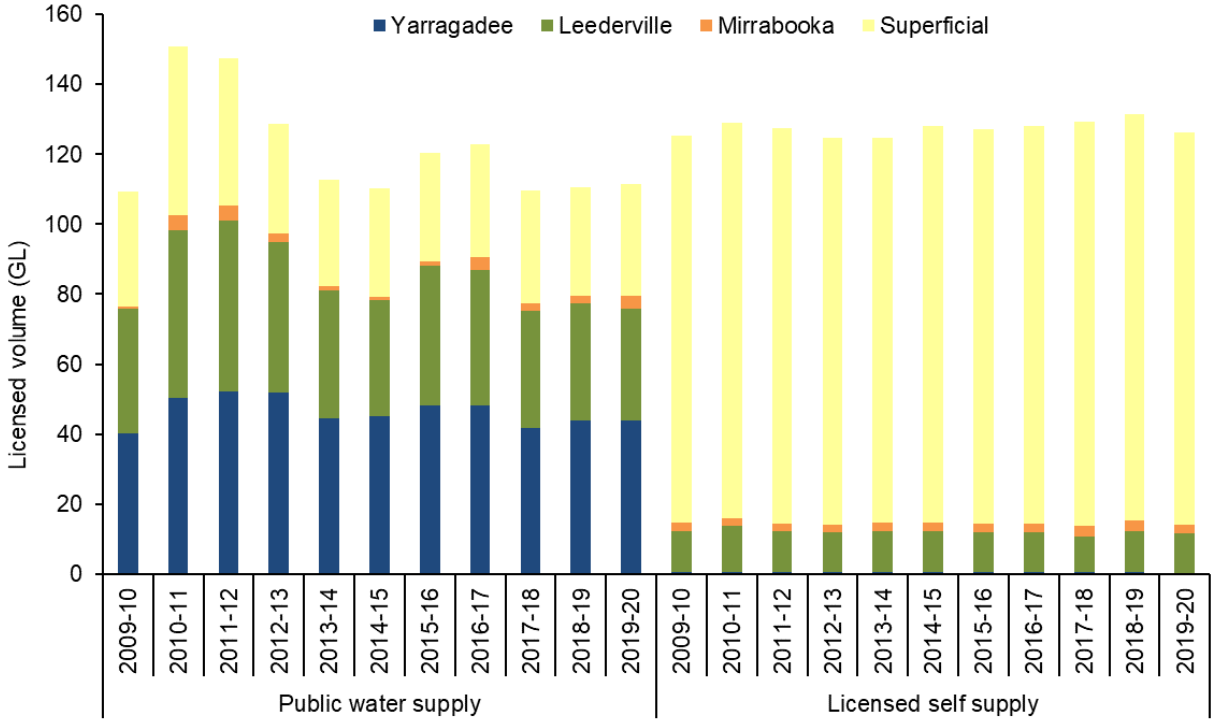


Figure 5 Changes in licensed groundwater volumes over time for each aquifer

1.5 How we developed the plan

We evaluated the *Gnangara groundwater areas allocation plan* (DoW 2009a) twice – see DoW (2013) for the 2009–11 timespan and DoW (2015a) for 2012–14. In these statements we reported on how we were tracking to meet the 2009 plan's objectives, with the second evaluation confirming the need to replace the plan.

This plan builds on the 2009 plan but uses updated scientific information, including:

- An update of the Perth Regional Aquifer Modelling System (PRAMS 3.5) – this updated model uses findings from new hydrogeological studies. We have used it to assess the future impacts of climate change, abstraction and land use changes on groundwater levels (CyMod Systems Pty Ltd 2014).
- The Perth regional confined aquifer capacity study (PRCAC) – this study combined established scientific approaches with the results of innovative

research to improve our understanding of the deep Leederville and Yarragadee aquifers in the Perth region (DWER 2021a).

- Shallow groundwater system investigations – these studies improved our understanding of the hydrogeology of important wetlands and the interactions and connectivity of surface waterbodies and groundwater. Wetlands studied included: Lake Mariginiup (Searle et al. 2010), Lake Nowergup (Searle et al. 2011), Lake Yonderup (DoW 2011a), the Lexia wetlands (DoW 2011b), Loch McNess (DoW 2011c), Tangletoe Swamp (DoW 2011d), Egerton Seepage (McHugh et al. 2011), Lake Gwelup (Clohessy 2012), Lake Muckenburra (Degens et al. 2012) and at the North Yeal wetlands (Degens et al. 2021).
- Detailed studies of the causes of water level declines at the high-value wetlands Loch McNess (Kretschmer & Kelsey 2016) and Lake Nowergup (Global Groundwater 2015) – these showed where abstraction should be reduced to improve the water levels and ecological condition of these lakes.
- Long-term monitoring of significant wetlands and other groundwater-dependent ecosystems – for decades we have observed changes in ecological condition related to water level and water quality trends. Expert consultants monitor the condition of the environment for us, including the status of wetland vegetation, wetland macroinvertebrates and water quality, mound spring macroinvertebrates and water quality, and wetland frogs. Summaries of annual monitoring are included in compliance reporting required by the EPA. These reports are published on our website (DWER 2020a).

See Chapter 3 for more detail on how we developed this plan and set the allocation limits, as well as the separate *Gnangara groundwater allocation plan methods report* (DWER 2021b). We developed this plan consistent with our approach to allocation planning, described in *Water allocation planning in Western Australia* (DoW 2011e).

1.6 Stakeholder interests

From 2016 we began consulting with different interest groups about a new plan. The brochure *Our groundwater future in Perth: Securing Gnangara groundwater and adapting to climate change* (DWER 2018) and a new Gnangara groundwater website <gnangara.dwer.wa.gov.au> helped to keep water licensees and the wider community informed.

The brochure was posted to 2,100 individual licensees in 2018 with a letter to advise them that Gnangara planning work was underway. The letter also described the likely changes to their groundwater licences and let them know they could formally comment on the plan during a three-month public comment period.

As part of developing this plan, we have held more than 100 workshops and meetings with groups and individuals across different water use sectors, including the Water Corporation, local governments, agricultural organisations and environmental groups (see Appendix A). The consultation followed three main phases:

1. *Science update* – beginning in 2016 we shared the latest science and research with stakeholders, including groundwater modelling of the past effects and future projections of groundwater abstraction, climate and land use change.
2. *Licensing strategy* – we then asked representatives from the major water use sectors for their input, including how they thought their industry would respond to reduced groundwater availability.
3. *Option assessment* – from late 2017 onwards our discussions with representatives from the major water use sectors, other agencies and groups interested in Gnangara groundwater planning began to focus on potential water allocation options and underlying licensing approaches.

Since 2019 we have worked with key stakeholders and agencies to consider approaches for each sector to transition and adapt to reduced water use because of climate change. See Chapter 5 for a discussion about these approaches.

1.7 Related plans and strategies

Waterwise approaches and water sensitive urban design

In October 2019, the State Government released the *Waterwise Perth Action Plan* as part of its response to climate change. The plan sets the groundwork for a 10-year program to ensure Perth remains beautiful, green and liveable by becoming a leading waterwise city (Government of Western Australia 2019b).

The *Waterwise Perth Action Plan* has nine targets to be achieved by 2030, one of which is to reduce groundwater use by 10 per cent across the Perth-Peel region. Delivery of a new *Gnangara groundwater allocation plan* is also an action under the *Waterwise Perth Action Plan*.

Being waterwise as a city is about sustainable, resilient and productive communities and businesses in the face of reducing rainfall and increasing demand for water. Being waterwise involves integrating approaches to water allocation, drainage and waterway management, supply planning, land use planning, design of urban and the built form, and efficient household and industry use.

We provide leadership by sharing our expertise in the water science and planning disciplines, actively working with other organisations, and influencing and advising government planning processes to enable water sensitive urban design. We supported and partnered with the former Cooperative Research Centre for Water Sensitive Cities and continue to work with Water Sensitive Cities Australia. This provides a shared platform to research urban water problems, align water-related policy and demonstrate practical water sensitive solutions.

We also partner with the Water Corporation for the Waterwise Councils and Waterwise Schools programs to increase water awareness and reduce water use. We work with the Golf Course Superintendents Association of Western Australia to deliver the Waterwise Golf Course Program and raise the industry's capacity to operate best irrigation practice and reduce the water used on golf courses.

Each of these Waterwise programs have been extended during the past 18 months under the *Waterwise Perth Action Plan*. We also partner with Irrigation Australia WA to build waterwise capacity through training, certification, waterwise irrigation programs and industry-led demonstrations.

In keeping with the aims of the *Waterwise Perth Action Plan*, this plan supports a liveable, sustainable, productive and resilient Perth for the long-term by maintaining groundwater for wetlands, bushland, neighbourhood trees and public open spaces. These places keep our city green and cool and provide urban amenity and social benefits.

Perth and Peel@3.5 million

The State Government's *Perth and Peel@3.5 million* (DPLH and WAPC 2018) land use planning and infrastructure frameworks give a strategic view of where new homes and jobs will be located to make best use of existing and proposed infrastructure, while also considering how important environmental assets will be protected.

The North West, North East and part of the Central subregional frameworks cover the Gnangara plan area. We have used the detailed land use described in these frameworks to inform groundwater modelling for this plan. Land use is a critical factor for understanding and determining groundwater recharge.

We have also used the land use planning and infrastructure frameworks to determine the region's long-term water demands for a projected population of 3.5 million by 2050. We considered demand information when deciding on future groundwater availability and where alternative water sources should be explored.

The subregional frameworks were released in March 2018 and are scheduled for review. As part of the review, we will be evaluating potential water demands and supply options for the eight 'planning investigation areas' in the Gnangara plan area.

As part of the *Waterwise Perth Action Plan,* we are working with the Department of Planning, Lands and Heritage (DPLH) and the Water Corporation to help local governments and developers in the plan area see how they can achieve fit-for-purpose and climate-resilient water supplies for future development areas to 2050. See Section 5.4 for more information about this work.

The Gnangara, Pinjar and Yanchep pine plantations

Together with the Department of Biodiversity, Conservation and Attractions (DCBA) and the Forest Products Commission, we are looking at post-harvest land use options for the 23,000 hectares of pine and ex-pine plantations in the plan area. This work aims to balance and support the multiple objectives for the area, which are to:

- meet existing forestry commitments under the *Wood Processing (Wesbeam) Agreement Act 2002*
- conserve important food sources for the endangered Carnaby's cockatoo
- maximise recharge to the Gnangara groundwater system.

Work to date, including groundwater modelling, shows we can balance these competing objectives by having a mixture of replanted pines, pine wildings (pine trees that regrow naturally), low native shrubs and grassland, and banksia and other native revegetation areas. We will work with DCBA to identify revegetation and carbon farming opportunities as part of the Carbon for Conservation Initiative.

See the *Gnangara groundwater allocation plan methods report* (DWER 2021b) for more information about management of the pine plantations.

Western Australian climate policy

In 2020 the State Government released the *Western Australia climate policy* (Government of Western Australia 2020). The policy recognises climate change as a pressing global issue that creates both challenges and opportunities for Western Australia.

All levels of government, along with business and the community, have a role to play in responding to the challenge. Western Australians are already adapting to a drier and warmer climate, particularly because of the decline in rainfall in the state's south-west over several decades. This plan supports Perth's water sectors to continue to adapt to the effects of climate change.

2 What the plan will achieve

The Department of Water and Environmental Regulation is responsible for managing the water resources of Western Australia, including the Gnangara groundwater system, consistent with the objects of the *Rights in Water and Irrigation Act 1914*[3]:

'a To provide for the management of water resources, and in particular –

i. for their sustainable use and development to meet the needs of current and future users

ii. for the protection of their ecosystems and the environment in which water resources are situated, including by the regulation of activities detrimental to them.

b To promote the orderly, equitable and efficient use of water resources.'

Under the *Water Agencies (Powers) Act 1984*[4] the Minister for Water has the general functions and powers to conserve, protect and manage the state's water resources by assessing and planning for the use of water resources. This includes promoting the efficient provision of water services and having regard to water recycling and efficient water use measures when planning to develop new water resources.

This plan is in place to ensure that water resources in the Gnangara groundwater system are licensed and managed consistent with the *Rights in Water and Irrigation Act 1914* and to enable the Minister to make decisions in line with their general functions and powers under the *Water Agencies (Powers) Act 1984*.

2.1 Outcomes and water resource objectives

Outcomes

The outcomes we expect to see from implementing this plan are:

1. Groundwater abstraction from the Gnangara groundwater system is reduced to be **more secure and sustainable** in the long term.
2. Perth's unique groundwater-dependent **wetlands and bushlands are healthier and more resilient** to climate change.
3. Groundwater users and state and local government are **optimising how the Gnangara groundwater system is used** for water supply, storage and reuse.
4. Groundwater users, infrastructure and the environment are **safer from deteriorating water quality**.

[3] Part III, Division 1, section 4 of the *Rights in Water and Irrigation Act 1914*

[4] Part II, Division 1, section 9 of the *Water Agencies (Powers) Act 1984*

Water resource objectives

To meet both the purpose and outcomes of this plan, we have set specific water resource objectives to guide and assess how we regulate and manage Gnangara groundwater.

Water resource objectives (Table 1) describe the physical change to an aquifer (that is, changes in water levels, pressure or water quality).

2.2 Strategies

To meet the water resource objectives, there are four main strategies in this plan:

1. **Reduce groundwater abstraction over the next decade**
    - This plan outlines how we will use changes to water licences, a change to the sprinkler roster for garden bores in the Perth/Mandurah area and other measures to reduce groundwater abstraction.
2. **Encourage efficient use of water, water trading and where appropriate alternative water source options**
    - This plan clearly signals future reductions to groundwater availability and gives a fair and reasonable timeframe for licensees to respond by improving how they use water. It also outlines some actions the government will take to help water users adapt.
3. **Set aside water for the future strategic needs of Perth where it is available and appropriate to do so**
    - Water has been set aside for strategic purposes (for some new public open space, public water supply and strategic basic raw materials extraction).
4. **Use our monitoring network to review our management**
    - We have an extensive monitoring network across the Gnangara groundwater system. We will continue to use this to review our management.

Table 1 Water resource objectives for the Gnangara groundwater system

Objective	Site-specific details	Expected benefits
Water levels		
1. Maintain or increase groundwater levels in the Superficial aquifer:		
a. To maintain a reliable supply to groundwater users.	Maintain groundwater levels at groundwater modelling reference bores across the plan area (see Figure 15 for bore locations and Appendix F for bore details).	• Long-term access to Perth's lowest cost and largest source of good-quality water is secured. • The effects of over-abstraction in different parts of the system are stabilised or reversed. • Modest changes now to secure groundwater resources mean less drastic action may be required in the future. • Less risk of impacts on pumping costs, water quality and neighbouring bores.
b. To maintain or improve the health of groundwater-dependent ecosystems (see Figure 16 for site locations and Appendix G for details on monitoring infrastructure and proposed threshold levels).	Maintain groundwater levels at: • Yellagonga Regional Park wetlands (lakes Joondalup and Goollelal) • Egerton Seepage • Eastern Gnangara wetlands (Lexia 86 and 186) • Lexia bushland • Lake Pinjar.	• Valuable environmental assets that contribute to local amenity, recreation, health and wellness benefits remain an important part of Perth's urban landscape. • The health of ecosystems that previously suffered negative impacts from groundwater level decline is stabilised. • Diversity of habitats for flora and fauna is maintained, with no loss of existing vegetation hydrotypes. • Continual, year-round groundwater discharge at Egerton Seepage is maintained.
	Increase groundwater levels at: • Loch McNess (Wagardu) • Lake Yonderup, Lake Wilgarup and Pipidinny Swamp in Yanchep National Park • Lake Nowergup • Lake Mariginiup • Lake Jandabup • Lake Gnangara • Whiteman Park.	• Artificial supplementation of lakes Nowergup and Jandabup is reduced or ceased. • Ecological values are improved at Yanchep National Park wetlands and lakes Nowergup, Jandabup and Mariginiup. • The risk of peat fires at Yanchep National Park wetlands is reduced. • Visual amenity is improved at Yanchep National Park wetlands, Jandabup Nature Reserve, Lake Mariginiup and Lake Gnangara to support tourism and community values. • The condition of native vegetation is improved at Whiteman Park and the Lexia area west of Ellenbrook.

Objective	Site-specific details	Expected benefits
2. Manage declines in Superficial groundwater levels at a rate and magnitude that presents a lower risk of critical declines in ecological condition (see Figure 16 for site locations and Appendix G for details on monitoring infrastructure and proposed threshold levels).	Reduced rate of decline in groundwater levels at: • some of the Eastern Gnangara wetlands (Melaleuca Park 173 and 78) • northern Melaleuca Park bushland • Pinjar bushland.	• The Eastern Gnangara wetlands and Melaleuca Park and Pinjar bushlands remain important, connected and diverse habitat areas, providing a major vegetation corridor and refuge for native fauna. • Vegetation communities over shallow groundwater will have experienced a slow transition to species preferring drier soil conditions, with no catastrophic loss of species or habitats.
3. Increase pressure heads in the Leederville and Yarragadee aquifers, especially in and near areas connected to the Superficial aquifer:		
a. To support groundwater-dependent ecosystems	Increase deep aquifer pressure heads to help meet objectives at groundwater-dependent ecosystems: • increase water levels in Yanchep National Park wetlands • increase water levels at Lake Nowergup • limit groundwater-level declines at Quin Brook, Gingin Brook and areas of groundwater-dependent Banksia woodland in the Yeal Nature Reserve.	• The health and amenity of ecosystems are stabilised or improved in areas connected to the deeper aquifers that previously suffered negative impacts from groundwater-level decline caused by over-abstraction (such as Yanchep National Park wetlands and Lake Nowergup).
b. To minimise impacts on water users (see Figure 15 and Appendix F for bore locations).	Increase deep aquifer pressure heads to support: • Superficial aquifer users in the North Wanneroo horticultural area • Superficial and Leederville aquifer users in the Swan Valley area.	• Long-term access to Perth's lowest cost and largest source of good-quality water is more secure, especially areas connected to the deep aquifers like Swan Valley and North Wanneroo. • Modest changes now to secure groundwater resources mean less drastic action may be required in the future. • Risk of subsidence is managed in the long-term (subsidence is a very low risk and is explained further in our deep aquifer study [DWER 2021a]).

Objective	Site-specific details	Expected benefits
Water quality		
4. No significant inland movement of saline water along the coast and the Swan River (Derbarl Yerrigan) to maintain suitable water quality for use (see Figure 15 and Appendix F for bore locations).	Salinity risk areas: • along the coast including at Two Rocks, Yanchep, Eglinton and Quinns • along the Swan River (Derbarl Yerrigan) to Caversham • the Mosman, Cottesloe and Nedlands peninsula area.	• The risk of groundwater users being affected by salinity near the coast and along the Swan River (Derbarl Yerrigan) is significantly reduced.
5. Changes in acidity in the Superficial aquifer in potential areas of acid sulfate soils have little or no adverse impacts on significant environmental values and groundwater users.	Acidification risk areas: • at and around wetlands including lakes Jandabup, Mariginiup, Egerton Seepage and Mussel Pool in Whiteman Park • dunes between wetlands, particularly in the localities of Banksia Grove, Jandabup, Mariginiup, Gnangara, Whiteman, Ellenbrook, Melaleuca and west Bullsbrook and the urban areas spanning Bayswater to Ballajura and Dianella to Bassendean.	• The risk of groundwater users and environmental assets being affected by soil acidification is significantly reduced.

3 Water allocation changes across the system

The Department of Water and Environmental Regulation identified the Gnangara groundwater system as over-allocated in the previous *Gnangara groundwater areas allocation plan* (DoW 2009a). The actions of that plan helped to reduce the rate of groundwater level decline. This new plan aims to take the next step to adjust to ongoing climate change by reducing groundwater abstraction to a more sustainable level.

To minimise further damage to water quality and environmental health at important locations, and manage risks to water supply, we will reduce groundwater abstraction by 54 GL/year across the system. A reduction of this size supports achieving the outcomes and meeting the water resource objectives outlined in Chapter 2.

See Section 3.1 for our methods to determine what reductions were needed and Section 3.2 for how the reductions will be shared across water users and each groundwater resource.

3.1 Science to determine reduced abstraction

In this section we outline the science and other critical information we considered to develop this plan and how we decided on the scale of the reductions. See more in sections 1.5, 3.2, 4.2 and Chapter 5, and find the technical details in the *Gnangara groundwater allocation plan methods report* (DWER 2021b).

Groundwater modelling, climate and land use changes

We generated, modelled and assessed a range of reduced abstraction options to test how groundwater levels would respond and how risks would reduce to water supply and groundwater-dependent ecosystems. This modelling included:

- climate change projections
- beneficial changes in recharge from reducing the area of pine plantations
- increasing the area of land developed for housing and other urban purposes.

Groundwater modelling was completed using the Perth Regional Aquifer Modelling System (PRAMS) version 3.5. PRAMS is a sophisticated numerical groundwater flow model that simulates the responses of Perth aquifers to changes in climate, land use and abstraction.

The model has been updated and improved since it was developed in the early 2000s, with PRAMS 3.5 including updated geological, abstraction, climate and land use information. This is documented in *Construction and calibration of the Perth Regional Aquifer Model PRAMS 3.5.2* (CyMod Systems Pty Ltd 2014).

The model meets the calibration targets and performance criteria in the *Australian groundwater flow modelling guidelines* (Barnett et al. 2012) and has been independently reviewed (HydroAlgorithmics 2014). The review found the model was fit to:

- estimate the impact of abstraction on water levels and pressure heads in all aquifers
- provide quantitative estimates of the water resources of the Perth region
- evaluate how future land-use management would affect groundwater levels of the Perth region
- evaluate the impacts of climate change.

See the *Gnangara groundwater allocation plan methods report* (DWER 2021b) for more information about the groundwater modelling that underpins this plan.

Climate change

When the 2009 Gnangara plan was released, allocation limits were based on an average annual rainfall of 729 mm (Perth Airport rainfall station 1975–2008). Since then, the average has declined to 699 mm (1990–2020) and Perth has had three of the driest years on record – 483 mm in 2010, 578 mm in 2015 and 525 mm in 2019.

Groundwater modelling for this plan is based on a climate projection to 2030 that is consistent with the trend in declining rainfall experienced in Perth over the past two decades (Figure 6). Under this projection, the average annual rainfall at 2030 will be 663 mm (Perth Airport rainfall station).

The climate projection used in the groundwater modelling for this plan falls within the range of climate change projections for Australia (Figure 6) released in 2015 by the Australian Government, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation – see www.climatechangeinaustralia.gov.au.

The climate change in Australia projections used global climate models as part of the Coupled Model Intercomparison Project Phase 5 (CMIP5) which were also used as inputs to the Intergovernmental Panel on Climate Change (IPCC) fifth assessment report (AR5) released in 2013. A new CMIP6 ensemble of models is being used to assess climate change processes as part of the sixth IPCC assessment report (AR6). The first instalment of AR6 was release on 9 August 2021 and will be completed in 2022.

Under both CMIP5 and CMIP6 models there is a high confidence that the future climate for south-west Western Australia will be warmer and drier. CMIP6 rainfall projections are similar to CMIP5 but have a narrower range of rainfall change for Southern Australia (Grose et al. 2020).

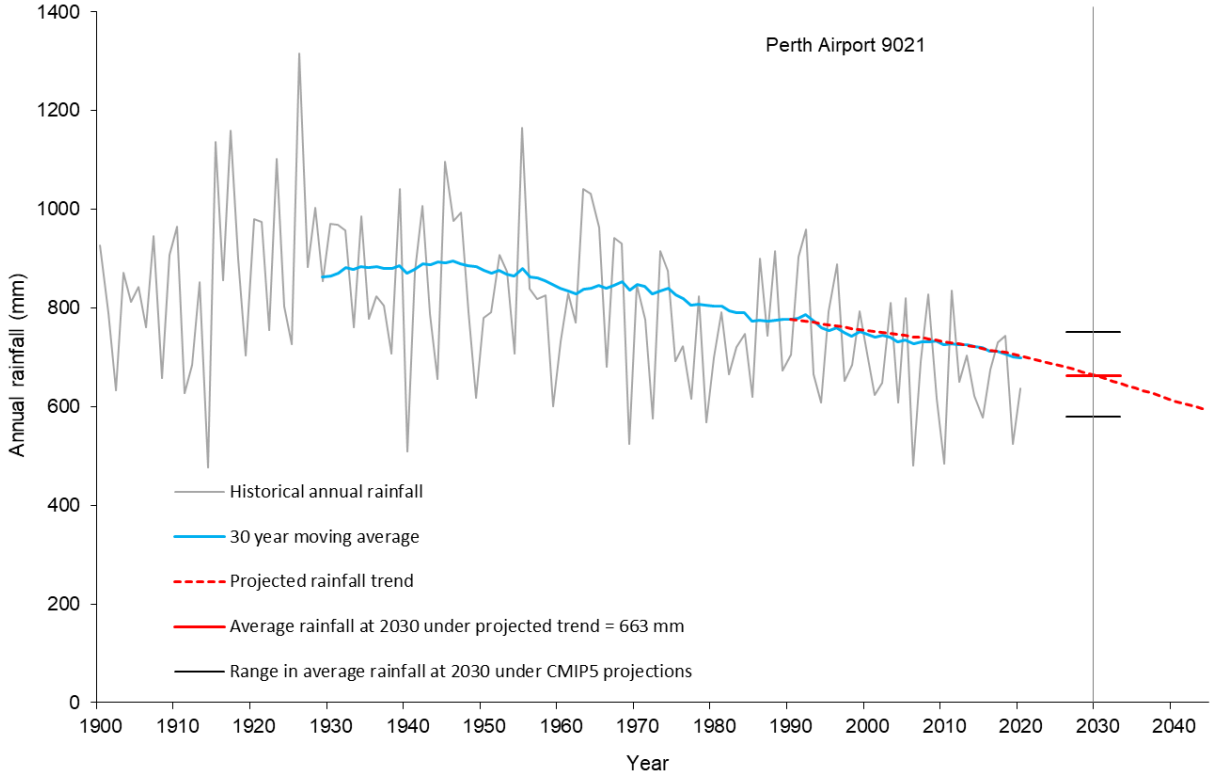


Figure 6 Historical and projected rainfall at the Perth Airport rainfall station

Land use changes

Land use changes as a result of urbanisation and other changes to Perth's footprint have already had, and will continue to have, a significant influence on groundwater recharge and Superficial aquifer water levels. We have observed local water levels rise because of increased recharge in some urban, commercial and industrial development areas.

We have made decisions about water allocation limits for the Gnangara groundwater system based on planned and expected land use changes to 2030. We have modelled the changes in recharge to groundwater that will result from:

- all planned urban and industrial growth likely to occur by 2030, as outlined in the *Perth and Peel @3.5 million* land use planning and infrastructure frameworks (DPLH and WAPC 2018)
- expected changes to land use and groundwater recharge in the Gnangara, Pinjar and Yanchep pine plantations (see Section 1.7).

As described in Section 1.7, we are assessing the water needs of eight 'planning investigation areas' in the Gnangara plan area. This is ahead of the DPLH's review of the *Perth and Peel @3.5 million* subregional frameworks. We have not included the eight 'planning investigation areas' in the modelling for this plan as any land use changes are yet to be confirmed so are beyond the plan's timeframe.

Assessing abstraction reduction

We used outputs generated from PRAMS 3.5 modelling to quantify and assess the risks of different reduced abstraction options to groundwater resources and dependent ecosystems. We also used the outputs to look at the extent to which the groundwater system could be rebalanced and meet the water resource objectives (Section 2.1). See the *Gnangara groundwater allocation plan methods report* (DWER 2021b) for details of the outputs and an assessment of each option against the objectives.

The groundwater modelling demonstrated that a reduced abstraction of 54 GL/year could deliver significant benefits across the aquifer system (Table 2) consistent with the plan's objectives. Smaller reductions would not achieve the plan's objectives and could result in more non-compliance with water level criteria set under Part IV of the *Environmental Protection Act 1986* (WA). The significant community benefits of maintaining wetlands and bushland areas in our city would also not be realised (see Section 6.3).

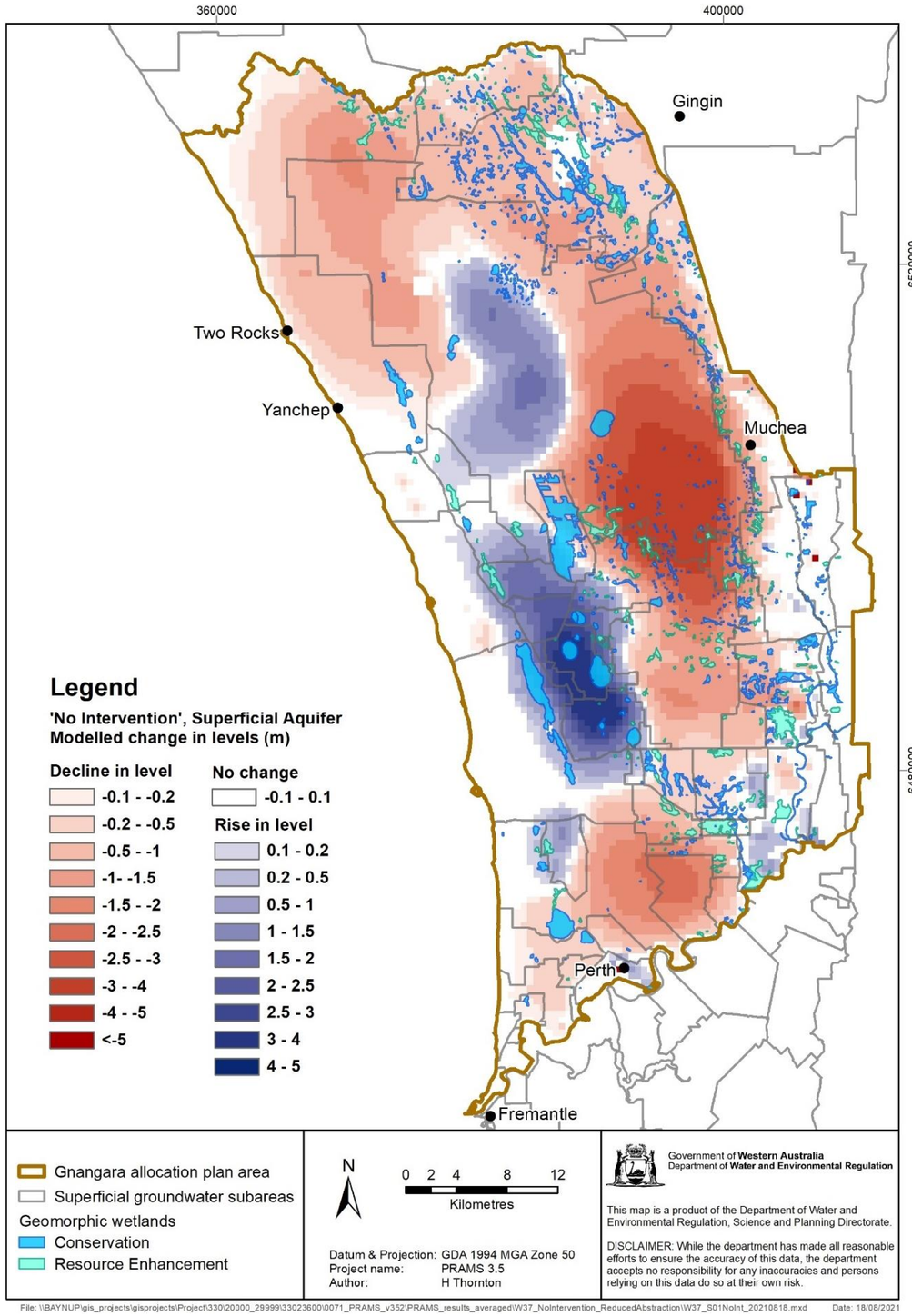
Higher reductions than proposed here, while improving environmental outcomes, would likely be too costly for the additional benefits gained and be impractical for licensees to implement.

The reductions to licensed users will begin in 2028. This timeframe will enable licensees to adjust their businesses and minimise many of the costs associated with adapting to change. Modest changes over this period will mean less drastic action may be required in the future as climate change continues.

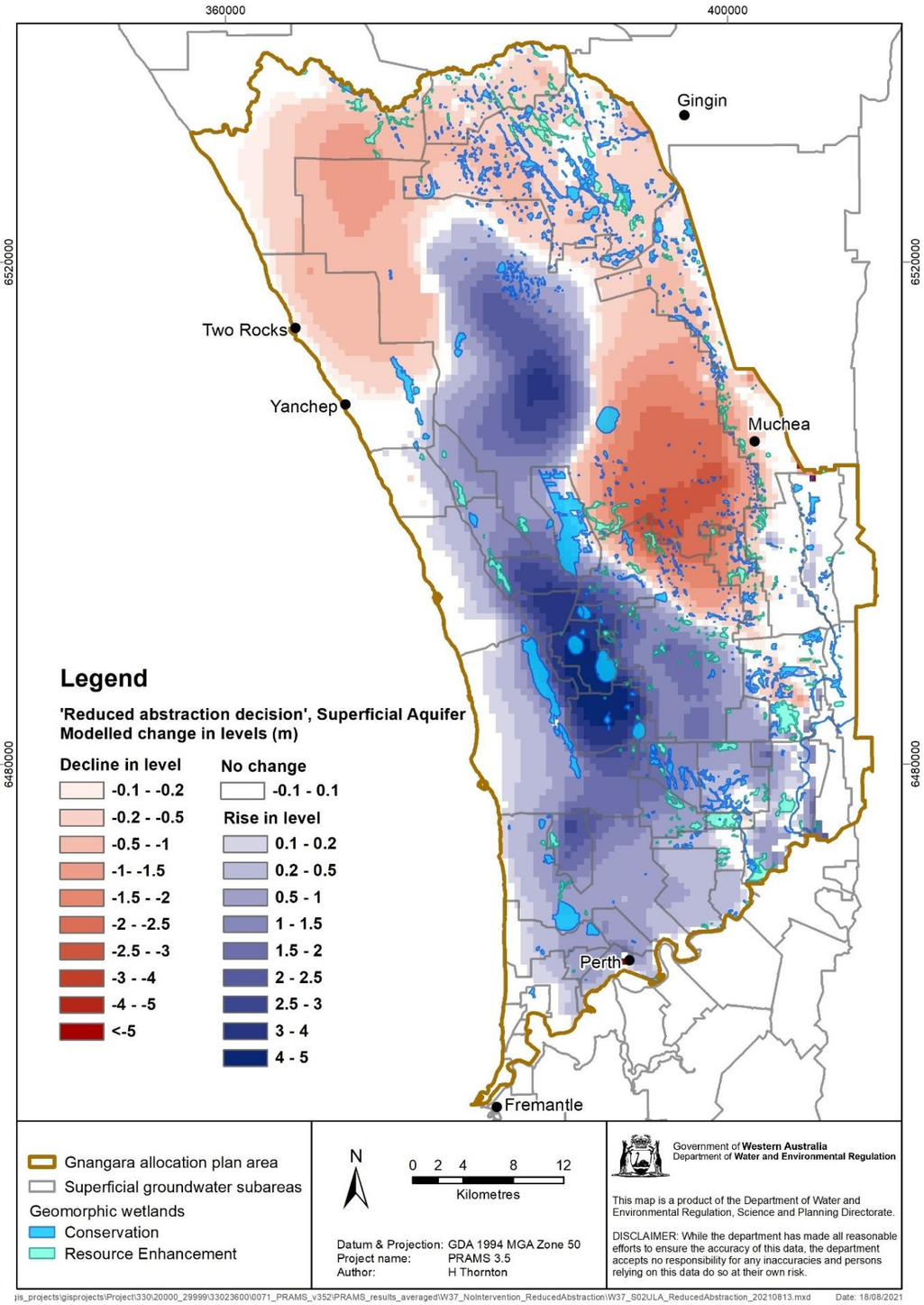
Table 2 Outcomes of reduced abstraction, compared with 'no intervention'

Consideration	No intervention	Abstraction reduction
Reduction to total annual abstraction	No reduction	54 GL
Sites where current condition will be maintained or improved:	• Wetlands and bushland around urbanising areas in East Wanneroo (such as lakes Jandabup, Mariginiup, Joondalup and Goollelal). • Lake Gwelup.	• Wetlands and bushland around Whiteman Park and west of Ellenbrook. • North-west wetlands such as Lake Nowergup (with some supplementation) and wetlands in and around Yanchep National Park (such as Loch McNess (Wagardu) and Lake Yonderup). • Some urban wetlands close to Perth, such as Herdsman Lake (Ngurgenboro).
Number of sites where groundwater modelling showed there was a low risk of breaching the current *Environmental Protection Act 1986* criteria (currently 16 out of 30 compliant):	6/30 (significant additional non-compliance)	16/30 (no additional non-compliance)
Area of healthy groundwater-dependent ecosystems compared with now:	36% less	10% less
Volume of water at risk of acidity or salinity impacts:	13.1 GL	2.8 GL (79% less)

See Figure 7 for the modelled changes to groundwater levels under the 'no intervention' option and the 'reduced abstraction' option. The relative benefits shown will not be fully achieved until the mid-2030s because reduced abstraction and land use changes will occur incrementally.



a) Change in levels under the ‘no intervention’ option



b) Change in levels under the ‘reduced abstraction’ option

Figure 7 Comparison of modelled changes in groundwater levels for the Superficial aquifer projected at 2030 under ‘no intervention’ (a) and ‘reduced abstraction’ (b)

3.2 Sharing reductions

The 54 GL/year reduction will be shared across all users of the Gnangara groundwater system:

- Most of this reduction will come in 2028 from changes to groundwater licensed to the Water Corporation for public water supply for the Integrated Water Supply Scheme, totalling 30 GL/year across all aquifers (a 27 per cent reduction) (Section 5.1).
- Most self-supply licensees will have to reduce abstraction from 2028 by about 10 GL/year from the Superficial, Mirrabooka and Leederville aquifers (a 10 per cent reduction). We explain the exceptions to these reductions in the subsection below.
- A further estimated 13.6 GL/year reduction will come from aligning the current three-days-a-week sprinkler roster for domestic garden bores with the two-days-a-week roster for scheme users in the Perth/Mandurah area.

The Water Corporation is the single largest groundwater user in the plan area. It has geographically widespread infrastructure and a proportionally larger reduction to its abstraction. This provides greater certainty in achieving this plan's outcomes and water resource objectives.

The Water Corporation has a greater ability to bring alternative water sources online than other water users, including desalination and groundwater replenishment and recovery. Making larger changes to the ~2600 individual licences in the Gnangara plan area would be more difficult.

The 10 per cent reduction for licensed self-supply users is modest and realistic. It is likely that most self-supply groundwater licensees can achieve a 10 per cent reduction through better water efficiency and improving the way they use water leading up to 2028. Also, enhanced recharge from land use change will partially offset reduced recharge from rainfall and enable the relatively small-scale reductions to licensed self-supply groundwater users.

Various estimates of residential water use over the last decade, when comparing similar-sized properties, have consistently found that on average households with a garden bore use 3 to 4 times more water on lawns and gardens than households using scheme water. Bringing the domestic garden bore sprinkler roster in line with that of scheme users will mean that all households in the Gnangara plan area would have the same two-days-a-week sprinkler roster, whether using scheme water or bore water and that all users are fairly contributing to the sustainability of the Gnangara groundwater system.

See Chapter 4 for how the reduction will be implemented for licensed users.

Exceptions to reductions

Reduced abstractions will not apply for the following groundwater users (see Chapter 5 for more information):

- *Primary and secondary schools with groundwater licences for irrigating school grounds.* However, we encourage schools to increase their water efficiency to support a more sustainable level of local and total abstraction (target reduction is 10 per cent over the plan's life). Schools will continue to play a valuable role in building awareness and understanding of water, encouraging the next generation to be waterwise.
- *Hospitals irrigating hospital grounds and gardens.* The seven groundwater licences for public and private hospitals total only 0.3 GL/year.
- *Licensees in the North West corridor taking groundwater to develop and irrigate new public open spaces.* The water available to irrigate these new public open spaces was adjusted down in 2014 to account for climate change (DoW 2014).
- *Licensees in the area identified as urban expansion in East Wanneroo.* Groundwater levels are expected to rise here during the plan's life because of planned land use changes and associated water use.
- *Self-supply Yarragadee aquifer licences*. These are mostly for geothermal heating purposes.
- *Temporary licences*, such as for dust suppression and dewatering during construction. These licences cannot be renewed or transferred.
- *All licences associated with Water Corporation's groundwater replenishment scheme or other managed aquifer recharge.* These are linked to recovery of water injected through managed aquifer recharge operations.
- *All licences for fractured rock aquifers.* These are typically located on the Darling Scarp and are not connected to the Gnangara groundwater system.
- *All licences from coastal saline aquifers.* The one licence in the Whitfords subarea is used for aquaculture research.

We will also defer any reductions to groundwater abstraction from the Superficial and Leederville aquifers in the Guilderton South, Beermullah Plain South, Deepwater Lagoon South and SA3 South subareas until we complete a new Gingin water allocation plan (see areas in Figure 8 and details in Section 5.2). This is because groundwater abstraction on both sides of Gingin Brook and the Moore River Estuary influences the flow and health of these systems and needs to be considered together.

3.3 Allocation limits

Groundwater abstraction draws down water levels in our aquifers and can affect water quality, wetlands, vegetation and other groundwater users. To manage these local impacts and ensure they do not become concentrated, the proclaimed areas of the Gnangara plan area are divided into subareas (Figure 8). There are:

- 51 subareas for the shallow Superficial, Mirrabooka, fractured rock and coastal saline aquifers
- eight subareas for the deeper Leederville and Yarragadee aquifers.

We are proposing a new Swan Valley subarea to better align management of the valley's groundwater use with the *Swan Valley Planning Act 2020* (see Figure 8,a) Proposed changes to the Superficial aquifer subareas in the Swan Valley b) Priority agriculture zone in the proposed Swan Valley groundwater subarea

Figure 9 and Section 5.2). The new subarea will replace the Central Swan subarea, and include parts of the North, South and East Swan subareas.

Subareas are further divided into water resources, which are the parts of an aquifer within a subarea. Water allocation limits are set for each water resource (Table 3). Different components within each allocation limit help us account for different water uses and administer water licensing (see Appendix C for more details).

We have set new allocation limits in this plan by applying the 54 GL/year reduction to licence entitlements and estimated unlicensed groundwater use across each resource of the Gnangara groundwater system. These limits also reflect the anticipated changes in abstraction due to land use change in East Wanneroo. They do not include temporary licences.

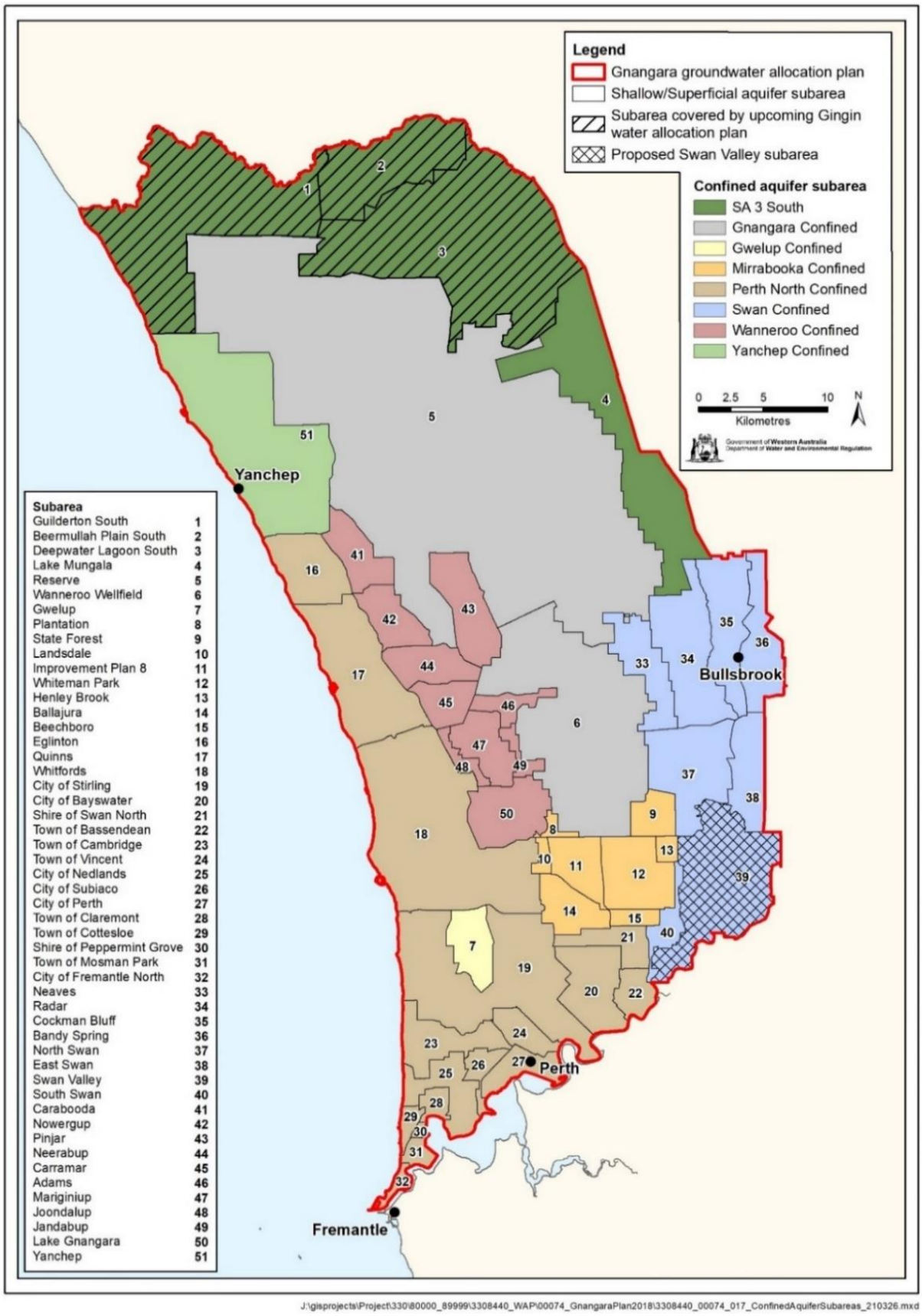


Figure 8 Groundwater subareas in the Gnangara plan area including the proposed Swan Valley subarea

Table 3 Allocation limits for the groundwater resources of the Gnangara plan (kL/year)

Water resource		Allocation limit components							
Subarea	Aquifer	Allocation limit	General licensing	Public open space	Basic raw materials	Public water supply	Public water supply reserve	Exempt	Allocation status and water available for licensing [i]
Gnangara groundwater area									
Reserve	Superficial	1,624,000	1,416,000	0	200,000	0	0	8,000	Available [ii]
Wanneroo Wellfield	Superficial	4,884,000	1,919,000	375,000	200,000	2,390,000	0	0	Available [iii]
Gnangara Confined	Leederville	4,900,000	0	0	0	4,900,000	0	0	Over-allocated
Gnangara Confined	Yarragadee	4,500,000	0	0	0	4,500,000	0	0	Over-allocated
Gwelup groundwater area									
Gwelup	Superficial	5,257,000	989,000	0	0	2,950,000	0	1,318,000	Over-allocated
Gwelup	Mirrabooka	950,000	0	0	0	950,000	0	0	Over-allocated
Gwelup Confined	Leederville	6,050,000	0	0	0	6,050,000	0	0	Over-allocated
Gwelup Confined	Yarragadee	5,750,000	0	0	0	5,750,000	0	0	Over-allocated
Mirrabooka groundwater area									
Plantation	Superficial	339,000	323,000	0	0	0	0	16,000	Over-allocated
State Forest	Superficial	1,154,000	858,000	0	0	0	0	296,000	Over-allocated
Landsdale	Superficial	472,000	423,000	0	0	0	0	49,000	Over-allocated
Improvement Plan 8	Superficial	433,000	70,000	0	0	350,000	0	13,000	Over-allocated
Whiteman Park	Superficial	394,000	231,000	0	0	150,000	0	13,000	Over-allocated
Whiteman Park	Mirrabooka	0	0	0	0	0	0	0	Over-allocated
Henley Brook	Superficial	334,000	211,000	0	0	0	0	123,000	Over-allocated
Ballajura	Superficial	3,865,000	783,000	0	0	1,800,000	0	1,282,000	Over-allocated
Beechboro	Superficial	850,000	284,000	500,000	0	0	0	66,000	Available [iv]
Mirrabooka Confined	Leederville	3,050,000	0	0	0	3,050,000	0	0	Over-allocated
Mirrabooka Confined	Yarragadee	1,850,000	0	0	0	1,850,000	0	0	Fully allocated
Perth groundwater area									
Eglinton	Superficial	5,909,000	823,000	700,000	0	0	4,210,000	176,000	Available [v]
Quinns	Superficial	16,142,000	2,414,000	90,000	0	11,000,000	2,310,000	328,000	Available [v]
Whitfords	Superficial	14,249,000	7,902,000	0	0	2,250,000	0	4,097,000	Over-allocated
Whitfords	Coastal saline	Not set	Not set	Not set	Not set	Not set	Not set	0	Case-by-case [vi]
City of Stirling	Superficial	15,120,000	6,337,000	0	0	2,550,000	0	6,233,000	Over-allocated
City of Bayswater	Superficial	6,235,000	1,627,000	0	0	0	0	4,608,000	Over-allocated
Shire of Swan North	Superficial	1,111,000	444,000	0	0	0	0	667,000	Over-allocated
Shire of Swan North	Mirrabooka	217,000	217,000	0	0	0	0	0	Over-allocated
Town of Bassendean	Superficial	1,210,000	337,000	0	0	0	0	873,000	Over-allocated
Town of Cambridge	Superficial	3,429,000	2,101,000	0	0	0	0	1,328,000	Over-allocated
Town of Vincent	Superficial	1,217,000	650,000	0	0	0	0	567,000	Over-allocated
City of Nedlands	Superficial	3,293,000	2,142,000	0	0	0	0	1,151,000	Over-allocated
City of Subiaco	Superficial	959,000	791,000	0	0	0	0	168,000	Over-allocated
City of Perth	Superficial	1,050,000	1,035,000	0	0	0	0	15,000	Over-allocated
Town of Claremont	Superficial	763,000	571,000	0	0	0	0	192,000	Over-allocated
Town of Cottesloe	Superficial	410,000	251,000	0	0	0	0	159,000	Over-allocated
Shire of Peppermint Grove	Superficial	170,000	69,000	0	0	0	0	101,000	Over-allocated
Town of Mosman Park	Superficial	528,000	434,000	0	0	0	0	94,000	Over-allocated
City of Fremantle North	Superficial	89,000	41,000	0	0	0	0	48,000	Over-allocated
City of Fremantle North	Coastal saline	Not set	Not set	Not set	Not set	Not set	Not set	0	Case-by-case [vi]
Perth North Confined	Leederville	9,045,000	1,245,000	0	0	7,800,000	0	0	Over-allocated
Perth North Confined	Yarragadee	16,430,000	80,000	0	0	16,350,000	0	0	Over-allocated
Swan groundwater area									
Neaves	Superficial	2,950,000	2,906,000	0	0	0	0	44,000	Over-allocated
Radar	Superficial	1,824,000	1,649,000	0	0	0	0	175,000	Over-allocated
Radar	Mirrabooka	193,000	193,000	0	0	0	0	0	Over-allocated
Cockman Bluff	Superficial	996,000	841,000	0	0	0	0	155,000	Over-allocated
Bandy Springs	Superficial	476,000	297,000	0	0	0	0	179,000	Over-allocated
Bandy Springs	Fractured rock	Not set	Not set	Not set	Not set	Not set	Not set	0	Case-by-case [vi]
North Swan	Superficial	2,594,000	2,216,000	0	0	0	0	378,000	Over-allocated
North Swan	Mirrabooka	116,000	116,000	0	0	0	0	0	Over-allocated
East Swan	Superficial	377,000	196,000	0	0	0	0	181,000	Over-allocated
East Swan	Fractured rock	Not set	Not set	Not set	Not set	Not set	Not set	Not set	Case-by-case [vi]
South Swan	Superficial	647,000	263,000	0	0	0	0	384,000	Over-allocated
South Swan	Mirrabooka	109,000	109,000	0	0	0	0	0	Over-allocated
Swan Valley [ix]	Superficial	5,000,000	4,403,000	0	0	0	0	597,000	Over-allocated

Water resource		Allocation limit components							
Subarea	Aquifer	Allocation limit	General licensing	Public open space	Basic raw materials	Public water supply	Public water supply reserve	Exempt	Allocation status and water available for licensing [i]
Swan Valley [ix]	Mirrabooka	1,428,000	1,428,000	0	0	0	0	0	Over-allocated
Swan Valley [ix]	Fractured rock	Not set	Not set	Not set	Not set	Not set	Not set	Not set	Case-by-case [vi]
Swan Confined	Leederville	4,740,000	4,740,000	0	0	0	0	0	Over-allocated
Wanneroo groundwater area									
Carabooda	Superficial	7,161,000	7,076,000	0	0	0	0	85,000	Over-allocated
Nowergup	Superficial	2,493,000	2,475,000	0	0	0	0	18,000	Over-allocated
Pinjar	Superficial	544,000	500,000	0	0	0	0	44,000	Over-allocated
Neerabup	Superficial	2,306,000	2,268,000	0	0	0	0	38,000	Over-allocated
Carramar	Superficial	1,726,000	1,349,000	0	0	0	0	377,000	Over-allocated
Adams	Superficial	1,045,000	996,000	0	0	0	0	49,000	Over-allocated [vii]
Mariginiup	Superficial	1,092,000	842,000	0	0	0	0	250,000	Over-allocated [vii]
Joondalup	Superficial	363,000	338,000	0	0	0	0	25,000	Over-allocated [vii]
Jandabup	Superficial	324,000	178,000	119,000	0	0	0	27,000	Available [vii]
Lake Gnangara	Superficial	2,531,000	1,874,000	0	0	0	0	657,000	Over-allocated [vii]
Wanneroo Confined	Leederville	1,290,000	1,290,000	0	0	0	0	0	Over-allocated
Wanneroo Confined	Yarragadee	5,600,000	600,000	0	0	5,000,000	0	0	Over-allocated
Yanchep groundwater area									
Yanchep	Superficial	15,895,000	786,000	2,110,000	0	1,010,000	11,540,000	449,000	Available [v]
Yanchep Confined	Leederville	288,000	288,000	0	0	0	0	0	Over-allocated
Gingin groundwater area									
Guilderton South [viii]	Superficial	9,116,000	8,719,000	0	0	30,000	0	367,000	Over-allocated
Beermullah Plain South [viii]	Superficial	2,907,000	2,834,000	0	0	0	0	73,000	Over-allocated
Deepwater Lagoon South [viii]	Superficial	2,542,000	2,287,000	0	0	0	0	255,000	Over-allocated
Lake Mungala	Superficial	2,853,000	2,434,000	0	0	0	0	419,000	Over-allocated
Lake Mungala	Mirrabooka	90,000	90,000	0	0	0	0	0	Over-allocated
SA 3 South [viii]	Leederville	3,343,000	2,605,000	0	0	738,000	0	0	Over-allocated
Total		**229,191,000**	**96,204,000**	**3,894,000**	**400,000**	**81,418,000**	**18,060,000**	**29,215,000**	

i The status of a resource and the volume of water available changes based on licensing activity. For live and up-to-date water availability information, please visit our online Water Register <https://www.water.wa.gov.au/maps-and-data/maps/water-register> or contact our Swan Avon Region on 08 6250 8000.

ii Water is only available in the Reserve subarea for suppressing dust generated from the extraction of basic raw materials.

iii Water is only available in the Wanneroo Wellfield subarea for suppressing dust generated from the extraction of basic raw materials and for irrigating new (future) public open space in the South Pinjar urban development area.

iv Water is only available in the Beechboro subarea for irrigating new (future) sports grounds and public open space areas.

v Water is only available in the Eglinton, Quinns and Yanchep subareas for irrigating planned public open space and public water supply as per the *North West corridor water supply strategy* (DoW 2014).

vi Allocation limits are 'not set' for fractured rock aquifers because they are irregular and complex aquifers in which water availability is difficult to quantify (see Table 4). Allocation limits are also 'not set' for coastal saline aquifers. We will assess licence applications for water from these aquifers on a case-by-case basis.

vii Water will be available for planned urban development in the urban expansion area in East Wanneroo (including the Adams, Mariginiup, Joondalup, Jandabup and Lake Gnangara subareas) as existing water licences for agricultural purposes are transferred to new developers and landowners as land use changes over time. Additional water (enough only to meet projected demand in combination with trades and transfers) has been reserved in the Jandabup subarea for irrigating new (future) sports grounds and public open space areas as recovery of groundwater levels in this area will allow its sustainable take. Allocation limits reflect the collaborative work with the City of Wanneroo and the Department of Planning, Lands and Heritage (see Section 5.4).

viii Allocation limits for the Superficial and Leederville aquifers covered by the Guilderton South, Beermullah Plain South, Deepwater Lagoon South and SA3 South subareas are indicative only, based on groundwater modelling for the whole plan area, and will be revised when we complete a new Gingin water allocation plan (see details in Section 5.2).

ix Proposed new Swan Valley subarea.

4 Water licensing

Water licences are required under the *Rights in Water and Irrigation Act 1914* (the Act) to manage and regulate the individual take of water from proclaimed water resources and to promote its sustainable and efficient use. The detailed legislative requirements for groundwater users and licensing are outlined in Appendix D.

To protect the Gnangara groundwater system, the Department of Water and Environmental Regulation needs to make changes to licensed entitlements over the next decade.

We will manage water licences in the Gnangara plan area in line with statewide policy, except where local licensing policies are needed to achieve the plan's objectives. See Table 4 for the local licensing policies.

We have designed a licensing approach which is:

- consistent and fair across licensees
- allows a reasonable timeframe to adapt over the next decade
- minimises the impact on people and businesses.

Through the public comment process, the Department of Water and Environmental Regulation may consider the potential use of regulations to implement elements of the management outlined in this chapter.

4.1 Water Corporation

The Water Corporation has many water licences to abstract groundwater from the Gnangara groundwater system and supply Perth's Integrated Water Supply Scheme. These licences are spread across different subareas and aquifers.

The Water Corporation's total groundwater abstraction will be reduced by 30 GL/year on 1 July 2028. This amount is about 70 per cent of the overall reduction to abstraction under this plan.

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

4.2 Self-supply users

When we receive a licence application from a self-supply user in the Gnangara plan area we will:

1. **Assess metering and water use information**
2. **Recoup unused water and adjust the entitlement where appropriate**
3. **(a) Before 1 July 2028 add a condition that will reduce the adjusted entitlement volume by 10 per cent at the start of the first water year after 1 July 2028 or**

   (b) From 1 July 2028 reduce the adjusted entitlement by 10 per cent when the licence is reissued.

Licence applications refer to the following:

- Licence renewals applications.
- Applications for the trade or transfer of a water entitlement.
- Licensee initiated amendment applications.

See Table 4 for more detail (local licensing policies 2.2 and 2.3).

Recouping unused entitlements

Recouping of unused water entitlements is a standard practice that has been in place since the early 2000s as part of good water resource management.

Metering data shows that most licensees on the Gnangara groundwater system use a high proportion of their entitlement each year. This limits the risk of the activation of unused entitlements impacting on system and its water users. However, we will continue to assess licensee water use and, where appropriate, recoup unused water as per *Policy: Management of unused licensed water entitlements*[5] (DWER 2020b).

We consider an unused entitlement to be all or part of a licensed annual water entitlement that has not been taken for more than three consecutive years. For Gnangara plan area licences, we will look at metered and peak water use information to identify any unused water entitlement. Other information, such as the licensee's history of water use, ongoing and demonstrated demand, and aerial photography may also be used to calculate unused water. If we establish that this volume is consistently unused for three years, we may act to recoup it. The adjusted volume will then have the 10 per cent reduction applied to it (where applicable).

[5] Previously Statewide policy No. 11, published in 2003. The policy was reformatted in 2020 to show how it is classified within the current DWER policy framework but its content was not changed.

Licence tenure and renewing a water licence

We will reissue water licences to licensees in the Gnangara plan area for up to 10 years if their renewal application is successful, unless the licence is for temporary purposes (see section below – Applying for a new water licence).

The tenure of an agreement (temporary transaction – see section 4.4 below) is negotiated between the licensee and a third-party and cannot exceed the expiry date of the parent licence.

Metering

Under Regulation 41C of the *Rights in Water and Irrigation Regulations 2000* (Metering Regulations) and in line with the statewide policy – *Measuring the taking of water* (DoW 2016), all licensees in the plan area with an annual water entitlement equal to or greater than 10,000 kL/year must meter their water use and submit metering data to us through Water Online. Metering in the Gnangara plan area began earlier than the rest of Western Australia because of the challenges facing the resource and its over-allocated status.

Metering abstraction from the Gnangara groundwater system and capturing this data through Water Online will establish, for the first time, a comprehensive measurement of licensed take (more than 10,000 kL/year). Metering, together with other information, such as the licensee's history of water use, ongoing and demonstrated demand, and aerial photography will be used to assess, identify and recoup unused water entitlements (Table 4).

The Metering Regulations, including online data submission, override any pre-existing metering licence conditions. Failure to comply with the Metering Regulations is an offence and can result in a fine of $2,000 and daily penalty of $200 if prosecuted. Incorrect installation or alteration of a meter, such that it does not accurately measure water, or damaging meters, are prosecutable offences.

You can find more information including fact sheets and frequently asked questions at www.water.wa.gov.au/licensing > Metering and Measurement > Metering regulations.

Applying for a new water licence

Almost all the groundwater resources in the Gnangara plan area are over-allocated and will still be over-allocated after 2028. Because of this, we will not be granting new licensed entitlements for private or commercial uses (unless the licence is for an approved temporary use or part of a trade with an existing licensee).

We may approve applications for shorter durations (less than 10 years) as temporary groundwater licences for the following purposes:

- dewatering (if not exempt from licensing)
- dust suppression for temporary works (as may be required under the *Environmental Protection Act 1986*)
- initial establishment of turf and gardens in new public open spaces.

If we issue a temporary licence for groundwater in the Gnangara plan area, it will usually be for two years and have conditions that reflect the plan's local licensing policies (Table 4).

We will not seek to recoup water or apply the 10 per cent reduction to temporary licences. We will also not approve applications to renew, trade or transfer temporary licences.

We will assess new licence applications where water is reserved for strategic purposes, such as for new urban areas or critical basic raw material mining. The water reserved for these purposes is shown in the public open space, basic raw materials and public water supply reserve components in Table 3 (see Appendix C for a description of these allocation limit components).

4.3 Water entitlement transactions

Trades, transfers and agreements allow existing licensees to expand their operations as well as adapt to changing circumstances. We expect that the clear picture of water scarcity and reduced groundwater availability described in this plan will drive increased interest in water transactions.

People seeking water transactions can find details about current water licences and contact details for existing licensees at our online Water Register.

We will assess all trades, transfers and agreements using our normal processes (see *Policy: Water entitlement transactions for Western Australia* (DWER 2020c)[6] and this plan (local licensing policy 2.7).

Trading of water entitlements

Trading of water entitlements allows water users to access additional water entitlements. We strongly encourage this, as it typically results in the water going to its highest-value use.

When someone applies to trade a water entitlement, we will assess the current water use of both parties (the seller and purchaser) to determine if any portion of their water licence entitlement is unused. Any portion of the entitlement that is unused may be recouped (see Recouping unused entitlements in Section 4.2). We will also add a condition, on both licences, for the 10 per cent reduction to the adjusted water entitlement. This condition will apply at the start of the first water year after 1 July 2028.

For applications after 1 July 2028, we will put the 10 per cent reduction on the entitlement directly (after recouping, if appropriate). The new licence will state the adjusted entitlement.

Trades for water entitlements near groundwater-dependent ecosystems may include additional assessment and conditions to minimise the risk to water levels and quality.

[6] Formerly Operational policy 5.13, published in 2010. The policy was reformatted in 2020 to show how it is classified within the current DWER policy framework but its content was not changed.

Trades may be refused if they increase the risk of abstraction impacts on groundwater-dependent ecosystems.

In the proposed Swan Valley subarea (see Section 5.2) new trading rules will apply (see local licensing policy 2.7.3 in Section 4.5) to manage and retain water in the priority agriculture zone (see Figure 9) as identified in the *Swan Valley planning scheme* (DPLH 2021). As part of assessing trades within or into the priority agricultural zone, the department will consider the proximity of abstraction to the river and potential water quality impacts.

Transfers

Water transfers are required when the licensee changes but the location of groundwater take remains the same. This usually occurs when a licensee sells their property to another party. Settlement on a property purchase does not automatically transfer a water licence. Both the seller and purchaser must send us a licence transfer application (Form 4T) before or within 30 days of settlement.

At this time, we will assess the transfer application for unused water and may adjust the licence entitlement accordingly. In some circumstances, the water use changes while a property is for sale (e.g. if the property is on the market for a long time). We will consider this when assessing and deciding on the unused portion of the entitlement.

Agreements

A licensee can agree with another party to temporarily use part or all of their water entitlement for a period within the tenure of the parent licence.

When parties submit an agreement application, we will assess the current water use of the parent licence to determine if any portion of their water licence entitlement is unused. Any portion of the entitlement that is unused may be recouped. We will also add a condition, on the parent licence, for the 10 per cent reduction to the adjusted water entitlement. This condition will apply at the start of the first water year after 1 July 2028.

For applications after 1 July 2028, we will put the 10 per cent reduction on the parent licence's entitlement directly (after recouping, if appropriate).

It is the parent licensee's responsibility to:

- manage the effects of the reduction on the agreement holder
- ensure the agreement holder complies with the licence conditions where appropriate.

4.4 Compliance and enforcement approach

Licensed water users have a legal responsibility to manage their water use according to the terms and conditions of their licence. See our *Compliance and enforcement policy* (DWER 2021c) to find out about our approach to compliance and enforcement.

Across the state, we focus our compliance and enforcement activities in highly allocated areas where there are significant risks to the water resource or dependent values from over-abstraction or non-compliance with licence conditions. The Gnangara plan area is a high priority for our compliance and enforcement activities.

Compliance and enforcement activities

We seek to ensure compliance in various ways, from desktop investigations to site visits. We usually notify the licensee if we intend to visit a site, but this is not compulsory, and our inspectors may conduct a site inspection at any time.

Under Section 71 of the *Water Agencies (Powers) Act 1984*, our officers may enter and re-enter a property to establish if an offence against the relevant Act is being committed.

Water metering is becoming a critical component of compliance and enforcement for the Gnangara groundwater system. It is the most accurate method to find out how much of a water entitlement is being used. Metering also discourages over-use.

Wasting water

Given the limited water availability in the Gnangara area, it is important that people use their water efficiently and responsibly. A licensee who wastes water may be in breach of the *Rights in Water and Irrigation Act 1914*.

We may identify wasteful behaviour in several ways, including conducting surveys and investigations, or responding to concerns raised by members of the community.

Enforcement action for wasting water may include, but is not limited to, the issuing of directions, and prosecution, which may lead to the imposition of a fine.

4.5 Local licensing policies

We will apply the local licensing policies in Table 4 when assessing licence applications and administering them during the tenure of the licence. The table summarises the policy information presented in this plan.

These locally specific policies support this plan's objectives and outcomes and supplement our statewide policies. Statewide policies are updated from time to time and the most recent version will apply – see www.dwer.wa.gov.au. If a local policy in this plan differs from a statewide one, the local licensing policy in this plan prevails.

Table 4 Local licensing policies specific to the Gnangara plan area

No.	Policy detail
1.	**Allocating water**
1.1.	**Allocating water for general licensing purposes**
1.1.1.	The department will not grant new groundwater licences from the general licensing component (See Appendix C for a description of the allocation limit components). Existing licensees or new water users will only be able to access additional water from this component through a water entitlement transaction or for temporary purposes (policy 1.4)
1.2.	**Allocating water for new public open space**
1.2.1.	The department will allocate water for new public open space in the Wanneroo Wellfield, Beechboro, Yanchep, Eglington and Quinns subareas from the public open space component (Table 3).
1.2.2.	Water for new public open space in the East Wanneroo urban expansion area (Section 5.4) will need to be obtained by trading with, or transferring from, existing licensees.
1.2.3.	The department will assess water licence applications for all new public open space based on: • an allocation rate of 6,750 kL/year/ha for the irrigated area (previously 7,500 kL/year/ha) (Section 5.4) • inclusion of waterwise design principles, best-practice irrigation infrastructure, use of soil wetting agents and a commitment to regular maintenance of irrigation infrastructure.
1.3.	**Allocating water from the basic raw material component (dust suppression)**
1.3.1	Water from the basic raw material component (Table 3) in the Reserve and Wanneroo Wellfield subareas is for temporary dust suppression activities to maintain air quality and a safe environment for the public during the excavation of basic raw materials (sand, limestone and clay).
1.3.2	The department will allocate a maximum of 50,000 kL/year per mine site from the Reserve and Wanneroo Wellfield subareas.
1.3.3	Licence applicants will need to demonstrate how they have minimised their planned water use. See *A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities* (DECR 2011).
1.4.	**Allocating water for a temporary purpose licence**
1.4.1	The department may approve applications for temporary groundwater licences for the following purposes (see Section 4.2): • dewatering (where it is not exempt from licensing) • dust suppression for temporary works (as required under the *Environmental Protection Act 1986*) • initial establishment of turf and gardens in new public open space areas • to allow Water Corporation to adjust the annual distribution of abstraction in response to temporary operational constraints or to achieve environmental benefits.
1.4.2	The department will usually issue temporary licences for two years.
1.4.3	The department will not recoup unused water or apply the 10 per cent reduced abstractions to temporary licences.
1.4.4	The department will not approve applications to renew, trade or transfer temporary licences.
1.5.	**Allocating water from the Yarragadee aquifer**
1.5.1.	The department will continue to prioritise groundwater from the Yarragadee aquifer for the Water Corporation to supply drinking water through its Integrated Water Supply Scheme. It is likely that we will refuse to grant new applications and applications to increase existing

No.	Policy detail
	water entitlements from the aquifer unless they are associated with Water Corporation's groundwater replenishment scheme or other managed aquifer recharge.
1.5.2.	The department will continue to support access to the Yarragadee aquifer for geothermal heating. The annual water entitlement for geothermal heating is set at 0 kL/year as the abstracted groundwater does not produce a net loss to the aquifer.
1.6.	**Allocating water from fractured rock and coastal saline aquifers**
1.6.1.	The department will assess applications for groundwater licences within fractured rock and coastal saline aquifers on a case-by-case basis.
2.	**Water licensing approach**
2.1.	**Licence tenure (duration of licence)**
2.1.1.	The department will issue water licences for a 10-year term after: • licence renewals • licensee initiated amendments (where assessment is required) • trades (timeframes may be less than 10 years) • transfers • recouping of unused water. Licensees must demonstrate legal access to the land for the term of the licence and must notify the department if that legal access terminates.
2.1.2.	The tenure of an agreement may be determined by the two parties subject to the department's approval and must not exceed the tenure of the parent licence.
2.2.	**Recouping unused water entitlements**
2.2.1.	The department will assess, identify and may propose to recoup unused water for groundwater applications in the Superficial, Mirrabooka and Leederville aquifers.
2.2.2.	We will calculate unused water as 'the annual water entitlement' less the 'peak recorded annual water abstraction from the preceding three years based on metered data'. We may also use other information to calculate unused water, such as the licensee's history of water use, ongoing and demonstrated demand, and aerial photography.
2.2.3.	We will not recoup unused water entitlements from licences with annual water entitlements less than 10,000 kL/year.
2.2.4.	The small-scale (less than 0.2 ha) stock and domestic component of any licence entitlement (up to 1,500 kL/year) will be exempt from recouping.
2.2.5.	Recouped water will not be made available for licensing.
2.3.	**Reducing groundwater abstraction – self-supply**
2.3.1.	Reductions to self-supply groundwater abstraction will apply to licences and licence applications in the Superficial, Mirrabooka and Leederville aquifers unless otherwise specified in policy 2.5.
2.3.2.	Before 1 July 2028, when we receive a licence application, we will add a condition to the licence to reduce the entitlement volume by 10 per cent at the start of the first water year after 1 July 2028. The 10 per cent reduction will apply to the entitlement after the recouping process (policy 2.2.1) and any proposals to remove unused water.
2.3.3.	From 1 July 2028, when we receive a licence application, we will reduce the adjusted entitlement by 10 per cent when the licence is reissued. The 10 per cent reduction will apply to the entitlement after the recouping process (policy 2.2.1) and any proposals to remove unused water.
2.3.4.	The small-scale (less than 0.2 ha) stock and domestic component of any licence entitlement (up to 1,500 kL/year) will be exempt from reductions as described in policies 2.3.1 to 2.3.3.
2.4.	**Reducing groundwater abstraction – public water supply**
2.4.1.	The Water Corporation's licence entitlements will be reduced by a total of 30 GL/year on 1 July 2028.

No.	Policy detail
2.4.2.	Reductions to public water supply will neither apply to Water Corporation's Groundwater Replenishment Scheme licences nor the public water supply reserves stated in this plan for the Quinns, Eglinton and Yanchep subareas. These subareas were adjusted down to account for climate change in 2014.
2.4.3.	Each year we will review the Water Corporation's borefield abstraction plan to: • distribute abstraction to minimise impacts to water levels at wetland and bushland sites with environmental conditions set under the *Environmental Protection Act 1986* and at other high-value groundwater-dependent ecosystems • stage reductions to abstraction from Water Corporation bores west of Yanchep National Park and Loch McNess (Wagardu) down to 0.21 GL/year by 2025–26.
2.5.	**Exceptions to reduced abstractions**
2.5.1.	The department will not reduce the entitlements (see Section 4.3 and policy 2.3) of the following licensees: • primary and secondary schools with groundwater licences for irrigating grounds • hospitals irrigating grounds and gardens • licensees in the North West urban growth corridor (Quinns, Eglinton and Yanchep subareas) who are developing and irrigating new public open space areas • licensees in the area identified as urban expansion in East Wanneroo in the state government's *North-West sub-regional planning framework* (DPLH 2018) • self-supply Yarragadee aquifer licences, mostly used for geothermal heating • temporary licences • all licences for fractured rock aquifers and coastal saline aquifers.
2.5.2.	Licensees with an exception to reduced abstractions may still have to follow *Policy: Management of unused licensed water entitlements* (DWER 2020b) at any point.
2.6.	**Deferred water reductions**
2.6.1.	The department will defer reducing licensed groundwater abstraction from the Superficial and Leederville aquifers in the geographic area covered by the Guilderton South, Beermullah Plain South and Deepwater Lagoon South subareas until we complete a new Gingin water allocation plan (see Section 5.2).
2.7.	**Water licence transactions (trades, transfers and agreements)**
2.7.1.	If we identify that either party has unused water when we assess an application for a trade, we may recoup it. If we identify unused water in a parent licence when we assess an application for an agreement, we may recoup it. We will consider changes in water use over the sale period when we assess an application for a licence transfer and determine whether there is any unused water.
2.7.2.	For water entitlement transactions near groundwater-dependent ecosystems, we may ask for additional information to complete our assessment of the licence application and apply licence conditions to minimise the risk to these environments. Trades may be refused if they increase the risk of abstraction impacts on groundwater-dependent ecosystems.
2.7.3.	In the proposed Swan Valley subarea (see Section 5.2) the following trading rules will apply to manage and retain water in the priority agriculture zone (see Figure 9) as identified in the *Swan Valley planning scheme* (DPLH 2021): • water can be traded into the priority agriculture zone • water can be traded within the priority agriculture zone • water cannot be traded out of the priority agriculture zone As part of assessments of trades within or into the priority agricultural zone, the department will consider the proximity of abstraction to the river and potential water quality impacts.

No.	Policy detail
2.8.	**Metering**
2.8.1.	Licensees must comply with the metering requirements under Regulation 41C of the *Rights in Water and Irrigation Regulations 2000* and the *Rights in Water and Irrigation (Approved Meters) Order 2009*.
3.	**Managing the impacts of groundwater abstraction**
3.1.	**Water licence conditions**
3.1.1.	The department may include any condition on a 5C licence that supports this plan's outcomes and objectives. This may include, but is not limited to conditions that: • minimise impacts to groundwater-dependent ecosystems • require monitoring in line with *Operational policy no. 5.12 – Hydrogeological reporting associated with a groundwater well licence* (DoW 2009b) • require an operating strategy or other strategies in line with *Policy: Use of operating strategies in the water licensing process* (DWER 2019) • restrict use of water.
3.2.	**Managed aquifer recharge**
3.2.1.	The department will assess applications for water licences relating to managed aquifer recharge in line with *Policy: Managing aquifer recharge in Western Australia* (DWER 2021d).

5 Changes to groundwater abstraction for different water uses

The Department of Water and Environmental Regulation aims to bring the Gnangara groundwater system back to a better, more sustainable condition by reducing total abstraction by 54 GL/year. This chapter provides further context and details about how each sector might adapt to reduced water availability (Table 5).

Table 5 Overview of groundwater use and reductions by sector (licence data across all aquifers)

Water use category	Total water use GL/year (% of total)	Notable water use sector or planning area	No. of licences	Total licensed GL/year	Overall reduction GL/year
Public water supply	111 GL (40%)	Integrated Water Supply Scheme and other public water supply	**22**	**110.8**	**30.1**[1]
Agriculture	62 GL (23%)	North Wanneroo	188	12.7	1.3
		East Wanneroo	526	9.8	0.2[2]
		Swan Valley	700	9.8	1.0
		Gingin[3]	96	14.3	1.4
		Other	310	15.5	1.5
		Total for agriculture	**1,820**	**61.9**	**5.4**
Parks, gardens and recreation	45 GL (16%)	Local government including public golf courses	64	25.0	2.0[4]
		Private golf courses	17	5.3	0.5
		Schools and educational institutions	98	6.0	0.1[5]
		Other (e.g. sports clubs, commercial and hospital gardens)	232	8.3	0.8
		Total for parks, gardens and recreation	**411**	**44.6**	**3.4**
Other licensed use	21 GL (8%)	Commercial, industrial, construction, mining, and licensed stock and domestic use	**370**	**20.9**	**1.4**[6]
Total for licensed users			**2,623**	**238.2**	**40.3**
Unlicensed stock and domestic use	36 GL (13%)	Urban garden bores and rural stock and domestic bores exempt from licensing – projected 43 GL by 2030	–	–	13.6
Total reductions for all use by 2028					**53.9**

1 Includes 30 GL reduction to Integrated Water Supply Scheme and 10 per cent reduction to other public water supply (0.1 GL reduction).

2 Outside the East Wanneroo urban expansion area (which is an exception to reductions) in the Adams, Mariginiup, Jandabup, Joondalup and Lake Gnangara subareas, there is about 2.2 GL/year of licensed groundwater that will be reduced by 10 per cent. In the expansion area, licences will be traded, transferred or retired as urbanisation occurs.

3 We are signalling future reductions for these Gingin water resources but may revise the extent of reductions in a Gingin water allocation plan (see Section 5.2).

4 The City of Wanneroo's licences to irrigate public open space in the North West urban growth corridor will not be reduced as these have already been adjusted for climate change. Temporary establishment licences are not renewable and therefore will also not be reduced.
5 Includes reductions to educational facilities other than schools (e.g. universities) but does not include the reductions to primary and secondary schools.
6 There are at least 160 temporary and non-renewable licences totalling about 7 GL/year for dewatering and dust suppression associated with construction and mining activities that will not be reduced.

5.1 Public water supply

The largest amount of groundwater taken from the Gnangara groundwater system is for public water supply. The Water Corporation is currently licensed to take a baseline volume of 110 GL/year from the Gnangara groundwater system. This is to supply Perth's Integrated Water Supply Scheme (IWSS). This volume does not include water licensed as part of the groundwater replenishment scheme.

Within the Gnangara groundwater system, a small volume of licensed groundwater is taken from the Leederville aquifer for the Woodridge town water supply (0.1 GL in 2019–20) and for the Moore River South development (0.7 GL in 2019–20). These volumes do not form part of the IWSS and are licensed separately.

Abstraction reductions for public water supply

The Water Corporation's abstraction from the Gnangara groundwater system for the IWSS will be reduced by 30 GL/year in 2028. To supplement this reduction, the Water Corporation may need to bring forward a new water source and distribution infrastructure from 2032.

To reduce risks to Loch McNess (Wagardu) in Yanchep National Park – one of the most valuable wetlands in the plan area from a social perspective – the Water Corporation will step down abstraction from its bores west of the park before 2028, to reach a volume of 0.21 GL/year by 2025–26.

We will consider abstraction to supply drinking water for Woodbridge (Water Corporation) and Moore River South (Moore River Company) in the plan area's north and near the Gingin Brook in a new Gingin water allocation plan (see Section 5.2).

Ongoing management of groundwater for public water supply

The Water Corporation's abstraction from all aquifers is closely monitored, reviewed and adjusted each year to minimise impacts on other water users and the environment. This includes moving deep aquifer abstraction away from areas connected to the Superficial aquifer.

We anticipate the Water Corporation will not require access to contingency groundwater in the coming decade as an adequate buffer of water is available in the dams at present and there is enough time to plan for new sources.

We have reserved groundwater for future public water supply in the North West urban growth corridor (see Table 3 and Appendix C), which is yet to be developed. We assessed this for the *North West corridor water supply strategy* (DoW 2014), and again for this plan, to account for climate change and other water users in the corridor.

Groundwater replenishment scheme

We work closely with the Water Corporation to assess options to meet demand for the IWSS and better manage water resources. Through this work, we have supported the Water Corporation to develop its groundwater replenishment scheme, a climate-independent water source.

Groundwater replenishment involves treated wastewater being further treated to drinking water standards and then recharged into aquifers for later use as public water supply. After a successful three-year trial in 2012, we authorised water licences for 14 GL for Stage 1 of the scheme. Starting in 2017 water was recharged into the Leederville and Yarragadee aquifers.

In 2016, we supported a proposal from the Water Corporation to expand the scheme to 28 GL. Our Perth regional confined aquifer capacity study – *Studying Perth's deep aquifers to improve groundwater management* (DWER 2021a) – guided the Water Corporation on suitable locations for Stage 2 recharge and abstraction. These locations support full recovery of the volume of water being recharged and provide improved water resource and environmental outcomes. Stage 2 should be completed in 2021.

5.2 Agricultural water supply

The second-largest amount of groundwater taken from the Gnangara groundwater system is for agriculture. About 61.9 GL/year, mostly from the shallow Superficial aquifer, is licensed for a variety of agricultural uses. This water underpins a range of benefits to the community including fresh local produce, export income and, in areas like the Swan Valley, a landscape and diverse economy that supports tourism and recreation. Other agricultural areas are North Wanneroo, East Wanneroo and Gingin.

Agricultural water users in the plan area will need to reduce their groundwater abstraction by 10 per cent from 2028, the same percentage as other self-supply licensees.

In this sector, over-abstraction and climate change may cause negative effects on neighbouring users, water quality and nearby local wetlands. Climate change means that changes in water use are inevitable and improving the resilience of agriculture to hotter and drier periods will benefit the whole sector. We anticipate that agricultural water users will adapt by making a range of business, water use and crop adjustments to improve the way they use water. Additional water will have to be obtained through trading.

Agricultural water use in North Wanneroo

The North Wanneroo area – comprising the Carabooda, Nowergup and Neerabup subareas – is important for local food production and agricultural enterprise. Horticultural producers, poultry farmers, turf growers and nurseries in the area rely on self-supplied groundwater, primarily from the Superficial aquifer.

In North Wanneroo, licensees abstract up to 12.7 GL/year of groundwater across 188 licences. This high concentration of water use (high volume of abstraction in a relatively small area), combined with climate change, has resulted in local groundwater levels declining by about 2 metres during the past decade.

Local wetlands such as lakes Nowergup, Carabooda and Neerabup have declined, and water quality issues such as increasing acidity and seawater intrusion downstream at the coast are ongoing risks.

Uncertainty about agriculture's future in North Wanneroo is a long-standing issue. In 2017 the State Government established the North Wanneroo Agriculture and Water Taskforce. It considered a range of matters, including:

- potential reductions in groundwater availability of up to 25 per cent
- impacts of climate change
- changing land uses
- ways to support new horticultural development
- the future of agricultural production.

The taskforce reported back in August 2018. One of the State Government's responses to the taskforce findings was to propose a 10 per cent reduction to groundwater abstraction in North Wanneroo. This reduction will contribute to the local water level objectives when combined with changes to recharge from urbanisation in East Wanneroo and pine removal, and reductions to local Water Corporation abstraction.

The State Government also asked the Department of Primary Industries and Regional Development (DPIRD) to set up a water use efficiency program in North Wanneroo. In 2019, DPIRD set up two demonstration sites showing water efficient techniques and best-practice irrigation, and commissioned Irrigation Australia to assess the irrigation efficiency of 22 on-farm systems.

The results found opportunities for growers to become more water efficient by modernising their irrigation systems. To support growers to do this, in 2021 the State Government established a $600,000 water efficiency infrastructure and technology grants program. The program will help growers improve the design of water systems, implement soil and crop sensor technology, and apply soil amendments to increase soil-moisture holding capacity.

DPIRD will continue to investigate future land and water supply options. It is looking at treated wastewater to provide a fit-for-purpose water supply for irrigated agriculture. If feasible, this additional source would be developed to support and potentially grow the North Wanneroo agricultural precinct as a supplement

groundwater. In addition to the water efficiency program, the State Government has committed another $150,000 to support the City of Wanneroo's local planning processes to maintain and protect agriculture in North Wanneroo.

Agricultural water use in East Wanneroo

Agricultural licences in the East Wanneroo urban expansion area (see Section 5.4) will be exempt from reductions because water use will go down over the plan period as urbanisation occurs. All licences outside the urban expansion area will be reduced by 10 per cent.

Agricultural water use in the Swan Valley

Widely known as a viticulture area, the Swan Valley also supports a range of agricultural and rural enterprises. More than a third of groundwater abstraction in the Swan Valley is for pasture and agistment purposes. It includes the South Swan and Central Swan subareas and parts of the East Swan and North Swan subareas.

Licensees in the valley use up to 9.8 GL/year from the Superficial, Mirrabooka and Leederville aquifers, across more than 700 licences. As the Superficial aquifer in this area is relatively low yielding, much of the abstraction is from the Leederville aquifer.

In the Swan Valley over-abstraction and climate change are impacting on groundwater levels and fresh groundwater flows into the Swan River (Derbarl Yerrigan). With declines of up to 2 meters in the Superficial aquifer and larger declines of up to 8 metres in the deeper but connected Leederville aquifer, saline intrusion is already affecting some groundwater users along the river. Over-abstraction is also affecting local wetlands and bushland in Whiteman Park.

A 10 per cent reduction for agricultural users in this area, from all aquifers, will stabilise fresh groundwater flows to the river and reduce salinity risk along the river. In doing so, this plan will help secure a reduced but more sustainable groundwater supply for the Swan Valley.

Growers in the valley are well-placed to adapt to climate change and modest reductions to water use during the next decade. The valley's character and location support opportunities to:

- grow agri-tourism
- diversify products
- adapt grape varietals
- capitalise on high visitation and the Swan Valley brand.

In addition, and despite a significant transition to drip irrigation, there are water efficiency measures that may still be taken.

The State Government has considered the independent *Swan Valley planning review* (Kobelke 2018) and released the *Swan Valley action plan: Protecting the Swan Valley's unique character* (Government of Western Australia 2019a). The action plan says what the government will do to support the long-term vision for the Swan Valley.

As part of our response to the action plan, we propose to realign groundwater subarea boundaries in the Swan groundwater area to the Swan Valley statutory planning area (see Figure 9). This will ensure that water supporting the valley's unique agricultural character stays within a new Swan Valley subarea. Existing subarea boundaries will change and the Central Swan subarea will no longer exist.

We have developed new trading rules to align with the priority agriculture zone identified in the *Swan Valley planning scheme* (DPLH 2021) gazetted 6 August 2021 (see local licensing policy 2.7.3 in Section 4.5). These trading rules will help ensure water is retained in, and prioritised for, the priority agriculture zone (Figure 9).

We have funded a new hydrogeological investigation across the North East corridor which will further our local understanding of increases in groundwater salinity in some bores in the Swan Valley (see additional information in Section 5.4).

Agricultural water in the Gingin area

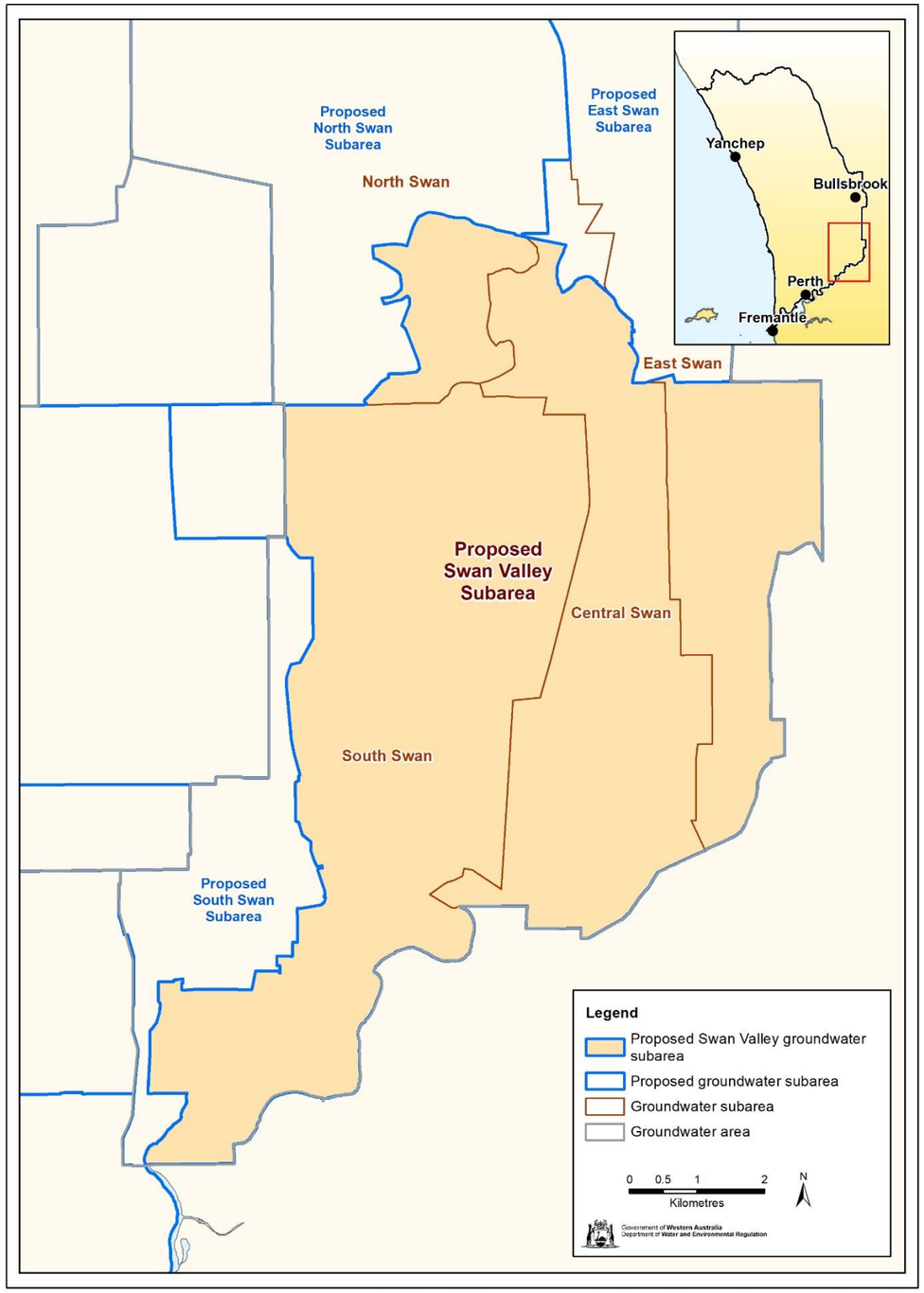
In the northern parts of the plan area, along the southern side of Gingin Brook and Moore River, groundwater is used to grow pasture, fruit, vegetables, nursery plants and turf. For this plan, the Gingin area refers to Superficial and Leederville aquifer abstraction in the geographic area covered by the Guilderton South, Beermullah Plains South and Deepwater Lagoon South subareas (see Figure 8 and Section 3.2). This includes the portion of the SA3 South subarea covered by these three subareas. About 14 GL/year across almost 100 licences is abstracted in the Gingin area.

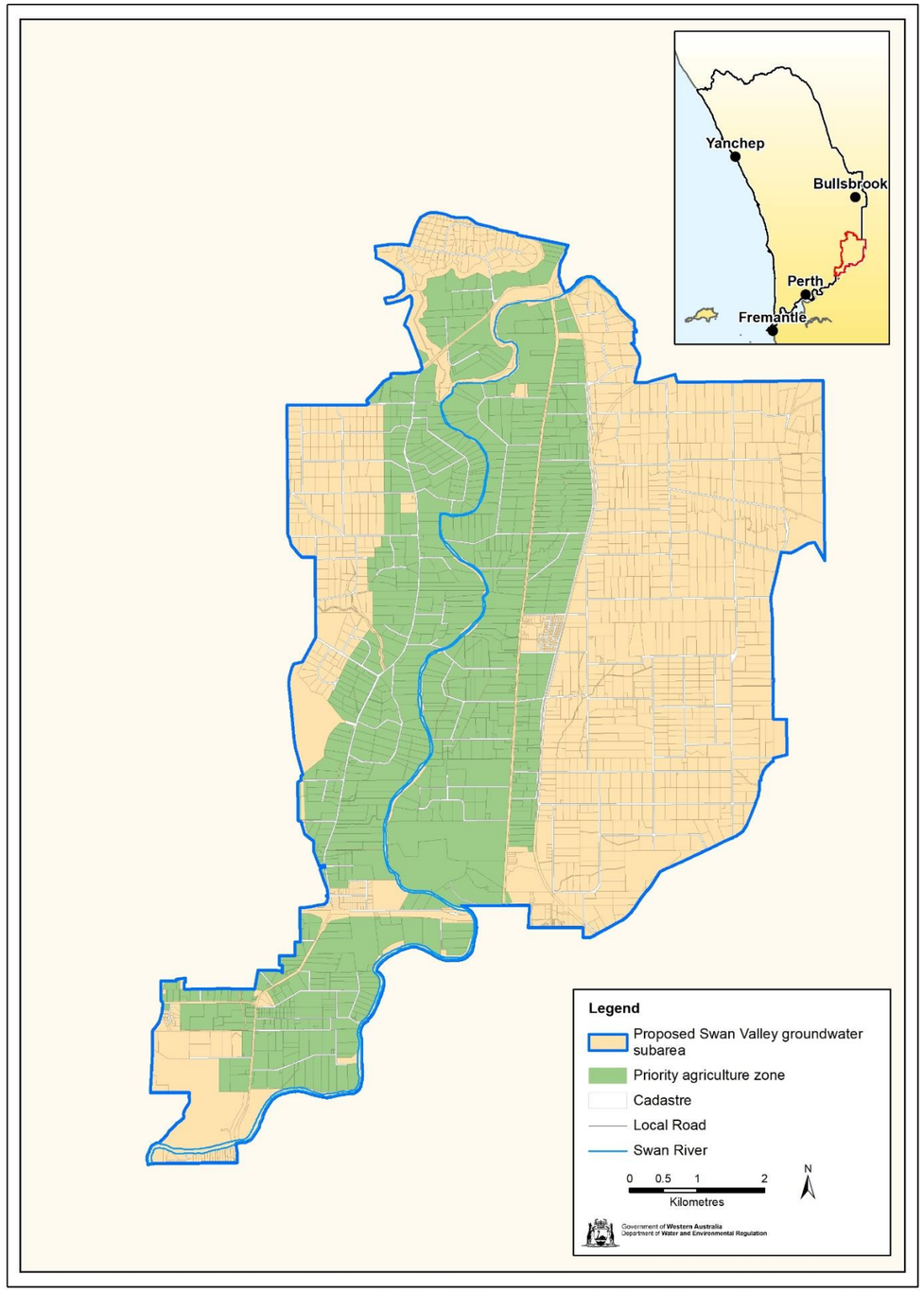
Local abstraction, together with climate change and regional scale abstraction from the deeper aquifers, has reduced flows in Gingin Brook and negatively affected wetlands and groundwater-dependent banksias in the area. Local groundwater level declines vary but 1 to 2 metre declines during the past decade have been common.

As part of this plan, we are signalling our intent to reduce groundwater abstraction in the Gingin area. However, we will not reduce licensed abstraction (as described in Chapter 4) until we confirm an approach in a new Gingin water allocation plan. This is because groundwater abstraction to the north of Gingin Brook impacts streamflow in a similar manner as abstraction to the south and a consistent approach to groundwater use will be needed on both sides of the brook.

Water licences in the Lake Mungala subarea (Superficial aquifer) as well as licences in the portion of SA3 South subarea (Leederville aquifer) that are geographically covered by the Lake Mungala subarea, will be subject to the reductions outlined in this plan. This is because abstraction in this area does not affect flows in Gingin Brook and won't be included in the new Gingin water allocation plan.

We will establish a comprehensive and fair approach to managing the values of Gingin Brook and Moore River Estuary in the new Gingin water allocation plan, which we are aiming to complete by 2025. The new plan will combine and replace both the *Gingin groundwater allocation plan* (DoW 2015b) and *Gingin surface water allocation plan* (DoW 2011f).





a) Proposed changes to the Superficial aquifer subareas in the Swan Valley b) Priority agriculture zone in the proposed Swan Valley groundwater subarea

Figure 9 Proposed Swan Valley groundwater subarea (a) and priority agriculture zone (b)

Other agricultural areas

Other agricultural areas covered by this plan include:

- subareas along the eastern margin of the plan area such as Neaves, Radar, Cockman Bluff, Bandy Springs and Lake Mungala – licensees include horticultural growers, nurseries, turf farms, poultry farms and vineyards
- central subareas such as Landsdale, Plantation and Henley Brook – licensees include nurseries and vegetable and pasture growers.

Agricultural users in these areas take over 15 GL/year of groundwater. We anticipate that these users will respond to the 10 per cent reduction in the same way as growers in the other areas, through a range of business, water use and crop adjustments.

5.3 Irrigating parks, gardens and recreational areas

Parks, gardens and recreational areas are an integral part of the Perth lifestyle and are important for active and healthy communities. Local governments, urban developers, schools and sporting clubs typically access the Superficial aquifer to irrigate these areas. In 2019–20 this sector took the third-largest amount of groundwater from the Gnangara groundwater system – about 45 GL/year of licensed water.

Except for schools and hospitals, this sector's licensed water users will need to reduce their groundwater abstraction by 10 per cent from 2028 to contribute to bringing total and local abstraction from the Gnangara groundwater system down to a more sustainable level.

In many cases, these licensees can find water savings and adapt to using less groundwater in the future through:

- ongoing programs to maintain irrigation systems and improve practices
- waterwise design such as hydro-zoning and eco-zoning
- efficiency upgrades to irrigation infrastructure and use of soil wetting agents.

Many actions in the *Waterwise Perth Action Plan* (see Section 1.7) focus on creating waterwise and climate-resilient public open space and recreational areas. We have been working with agencies such as the Department of Local Government, Sport and Cultural Industries and the Water Corporation to identify groundwater supply and demand gaps for green space areas.

This work is showing that in most cases, waterwise practices will mean existing groundwater supplies will be adequate to meet green space irrigation demand. In some cases, alternative water sources such as subsurface drainage, stormwater harvesting, recycled wastewater or scheme supply may be needed, but only after the options above have been fully explored.

Groundwater use by local governments

Most of the groundwater used to irrigate public open spaces is licensed to local governments. Of the 16 urban councils and two rural shires covering the plan area, 17 are licensed to abstract a total of about 25 GL, mainly to irrigate parks, road and river reserves, and sporting grounds such as ovals and public golf courses.

Some local governments will have flexibility in how they respond to the 10 per cent reduction because their water licences cover total take across a groundwater subarea. This means they can choose which parks, road reserves or sporting grounds to redesign or irrigate less. Sports ovals that have shared use arrangements with schools will not be subject to reductions. The abstraction reductions from 2028 allows time for park redesign and irrigation upgrades in asset renewal programs, and for planning additional water supply if needed.

Although the approach to adaptation will vary, urban local governments are starting to adjust to climate change and a future with less available groundwater. Of the 16 urban councils in the Gnangara plan area, all but one are part of the Waterwise Councils Program. This program is a joint initiative of the Water Corporation and the department, which is supporting local governments to improve the way they use water and build waterwise communities.

To extend the Waterwise Councils Program, in 2021 the government launched new waterwise irrigation training to encourage local governments to achieve and retain the program's 'gold' endorsement. The irrigation training will equip local government staff with the skills and knowledge to ensure best practice in efficient water use, through improved irrigation design, installation and maintenance.

The cost of the training will be fully subsidised for participating local government parks and irrigation staff and will run each year for the next three years. To be eligible for access to the training, a local government must have, or be working towards gold status in the Waterwise Council Program.

See Section 5.4 for more information on water allocation approaches for new public open space in urban development areas.

Groundwater use by private golf clubs

In addition to the nine golf courses managed by local governments, there are 12 private golf clubs or golf resorts across the Gnangara plan area. Private golf clubs are collectively licensed to take about 5.3 GL/year, mainly to irrigate the greens and surrounding gardens, and to artificially maintain lake levels.

As with other groundwater users in the plan area, golf clubs will need to reduce their groundwater use by 10 per cent from 2028 as part of adapting to climate change and a future with less available groundwater.

Use of best-practice design and irrigation efficiency varies between golf courses. We encourage golf courses to join the Waterwise Golf Program, a joint initiative of the Golf Course Superintendents Association of Western Australia and the department. The program supports golf courses to improve water efficiency and resilience to

climate change by focusing on training, design, efficient irrigation, water budgeting, soil management and alternative water supplies to maintain high-amenity golf courses that use less water.

Irrigation of school, college and university grounds

Various government and private educational institutions are licensed to abstract about 6 GL/year to irrigate school, college and university grounds. About 280 of these are in the Gnangara plan area. Quality sports ovals and green spaces for play are essential for education and community wellbeing.

Primary and secondary schools are exempt from reductions in groundwater abstraction. This includes sports ovals where shared-use arrangements with a local government are in place. However, we encourage them to reduce their groundwater use in a way that avoids affecting outdoor education and recreation. Other educational institutions will need to reduce their groundwater use by 10 per cent from 2028.

Many schools across the plan area participate in the Water Corporation's Waterwise Schools Program and are finding ways to save water. We will work with the government and private sectors to use groundwater more efficiently through the Waterwise Schools Program, as well as with irrigation and turf management specialists. We have already begun work on providing school groundskeepers with educational material, with an initial focus on metering.

Irrigation of other parks and grounds, sports clubs, businesses and hospitals

Sports clubs, other parks and grounds, and commercial businesses are licensed to take about 8.3 GL/year of groundwater for a range of uses. Sports clubs use groundwater to irrigate tennis courts, cricket pitches and bowling greens. Some commercial businesses use groundwater to irrigate their landscaped gardens and turf. These licensees will also need to reduce their groundwater use by 10 per cent from 2028.

Hospitals in the Gnangara plan area use a small amount of groundwater (0.3 GL/year in total) to irrigate their grounds. Water licences for hospitals are exempt from reductions in groundwater abstraction as part of this plan.

5.4 Water for public open spaces in developing areas

The *Perth and Peel@3.5 million* planning frameworks (Section 1.7) identify three main areas for urban expansion across the Gnangara plan area:

1. North West urban growth corridor (north along the coast from Quinns to Two Rocks)
2. North East urban growth corridor (north of Midland to Bullsbrook)
3. East Wanneroo urban expansion area

We have accounted for the changes in water demand and groundwater recharge from land use changes when assessing water availability for these growth areas. Our work as part of the *Waterwise Perth Action Plan* has found that in most cases, waterwise practices will mean existing groundwater supplies (including trades and transfers) will be adequate to meet green space irrigation demand. In some cases, alternative water sources may be needed. Where local groundwater cannot meet demand in full, we will continue to work with local governments and state planning agencies to find other ways to secure water for public open space purposes, depending on the local situation.

North West urban growth corridor

The North West urban growth corridor is an area of about 9,000 hectares that extends along Perth's coastline from Quinns to Two Rocks. It covers three groundwater subareas – Quinns, Eglinton and Yanchep. This area will be progressively developed in the coming decades.

Demand is being managed so that local groundwater is available for developing and irrigating new public open spaces across the North West urban growth corridor. The approach for allocating groundwater in this area was established in the *North West corridor water supply strategy* (DoW 2014). This strategy accounted for climate change, increased recharge from urbanisation, and use of best-practice design and irrigation standards for new public open space development.

Because changes to water allocation have already been made, the use of groundwater by the City of Wanneroo, urban developers, schools and other licensees to irrigate new public open spaces in this area will not be reduced. The strategy sets aside water for developing and irrigating new public open space areas through a 'public open space component' of the allocation limit (see Appendix C and Table 3).

Any other pre-2014 licensed use in these subareas, such as for agriculture, other commercial uses and public open space, have not had allocations adjusted for climate change. These groundwater users will need to reduce their groundwater take by 10 per cent from 2028, as outlined in this plan. In doing so, they will help bring total and local abstraction from the Gnangara groundwater system down to a more sustainable level.

North East corridor

The North East corridor, from north of Midland to Bullsbrook, is zoned for development and will slowly become urbanised by 2050. Land is being developed east of Whiteman Park at present, with the development front generally moving north over the coming decades. As this happens, the groundwater currently being used on agricultural and lifestyle lots for self-supply water uses may shift to public open space irrigation and other commercial uses.

Our initial supply planning projections found there would not be enough groundwater to irrigate new public open space in the North East corridor. More recent and detailed modelling (which focused on the Swan urban growth corridor) found enough

groundwater may become available in some areas as the land uses change and trades and transfers of existing licences take place.

However, this potential availability depends on the amount and design of the green spaces in these new developments. Development proposals to date have included varying amounts of public open space and consequently a wide range of projected water use for irrigation. We will continue to work with the City of Swan and advise developers on options to meet green space watering requirements in new urban developments. We will encourage them to:

- seek opportunities to acquire groundwater entitlements as land uses change
- make water savings through redesign and efficiency improvements to existing public open space areas
- explore the viability of alternatives to using groundwater such as subsurface drainage, stormwater harvesting or recycled wastewater.

Some water (0.5 GL/year) has been set aside in the Superficial aquifer in the Beechboro subarea, where very little abstraction has occurred to date, to meet some of the future demand for public open space.

Existing licensees in the North East corridor will need to reduce their groundwater take by 10 per cent from 2028 to contribute to bringing total and local abstraction from the Gnangara groundwater system down to a more sustainable level. This change has been built into our groundwater modelling of the public open space watering demand for the urban growth corridor. Changes in land use will increase recharge and help improve water levels in the corridor but these will not be enough to meet water resource objectives.

To inform future groundwater management in the North East corridor we have funded a hydrogeological investigation through the State Groundwater Investigation Program. It aims to better understand faulting, aquifer connectivity and groundwater flow in the region, and help identify potential areas for managed aquifer recharge – a potential alternative water source option in the future. The investigation involves airborne geophysical survey, drilling and installing groundwater monitoring bores, groundwater chemistry and isotope sampling and analysis of data to develop a conceptual model.

Urban growth in East Wanneroo

The State Government has identified East Wanneroo for urban expansion in the *North-West sub-regional planning framework* (DPLH 2018). Most of the urban expansion area shown in Figure 10, roughly 2,200 hectares, has now been rezoned to ‘urban deferred’ in the Metropolitan Region Scheme.

We expect the increase in recharge and decrease in local water demand as the area transitions from rural agriculture to urban land use – combined with the local topography – will result in a rise in Superficial aquifer levels. To manage the risk that local groundwater level rises will impact on wetlands and future urban form in the area, the *East Wanneroo district water management strategy* (Urbaqua 2021)

proposes a concept to control groundwater via subsoil drains and a pumping scheme to remove water from the area. The concept will need to go through further pre-feasibility and feasibility studies (Urbaqua 2021).

Water demand for new public open space in East Wanneroo can be met through the transfer or trade of existing agricultural licences as properties are bought by urban developers (Figure 10). The volume of groundwater licensed for agriculture at present (about 10 GL/year and 90 per cent of licences) will exceed the City of Wanneroo's water demand for public open space, which is less than 2.5 GL/year.

Agricultural water entitlements that are not transferred or traded to urban developers for public open space will be retired to the department and not made available for general licensing. The allocation limits in the area reflect collaborative work done with the City of Wanneroo and the Department of Planning, Lands and Heritage.

The urban expansion area in East Wanneroo partially covers five groundwater subareas – Adams, Mariginiup, Jandabup, Joondalup and Lake Gnangara.

Additional water (enough only to meet projected demand in combination with trades and transfers) has been reserved in the Jandabup subarea for irrigating new (future) sports grounds and public open space areas. Recovery of groundwater levels in this area will allow this reserved volume of water to be taken sustainably.

Licensees within the area zoned as urban expansion in East Wanneroo are exempt from reduced abstractions because the water resource objectives will be achieved through the expected rise in water levels.

Outside the urban expansion area, but within the five subareas, groundwater has a range of uses such as existing public open space, industry and other commercial operations (about 2.2 GL/year in total). These licensees will need to reduce their groundwater use by 10 per cent from 2028 to contribute to bringing the total and local abstraction from the Gnangara groundwater system down to a more sustainable level.

Directly to the north of the urban expansion area, the South Pinjar area has been identified as a potential site for urban development (Figure 10). Water levels are also projected to rise here as a result of the land use changes in East Wanneroo.

The *East Wanneroo district water management strategy* (Urbaqua 2021) estimates that a total of 375,000 kL/year will be needed to develop public open space in the South Pinjar development area. This volume has been set aside as a public open space component of the allocation limit for the Wanneroo Wellfield subarea (Appendix C). Access to this water is subject to land use planning approvals and those of the relevant district and local water management plans.

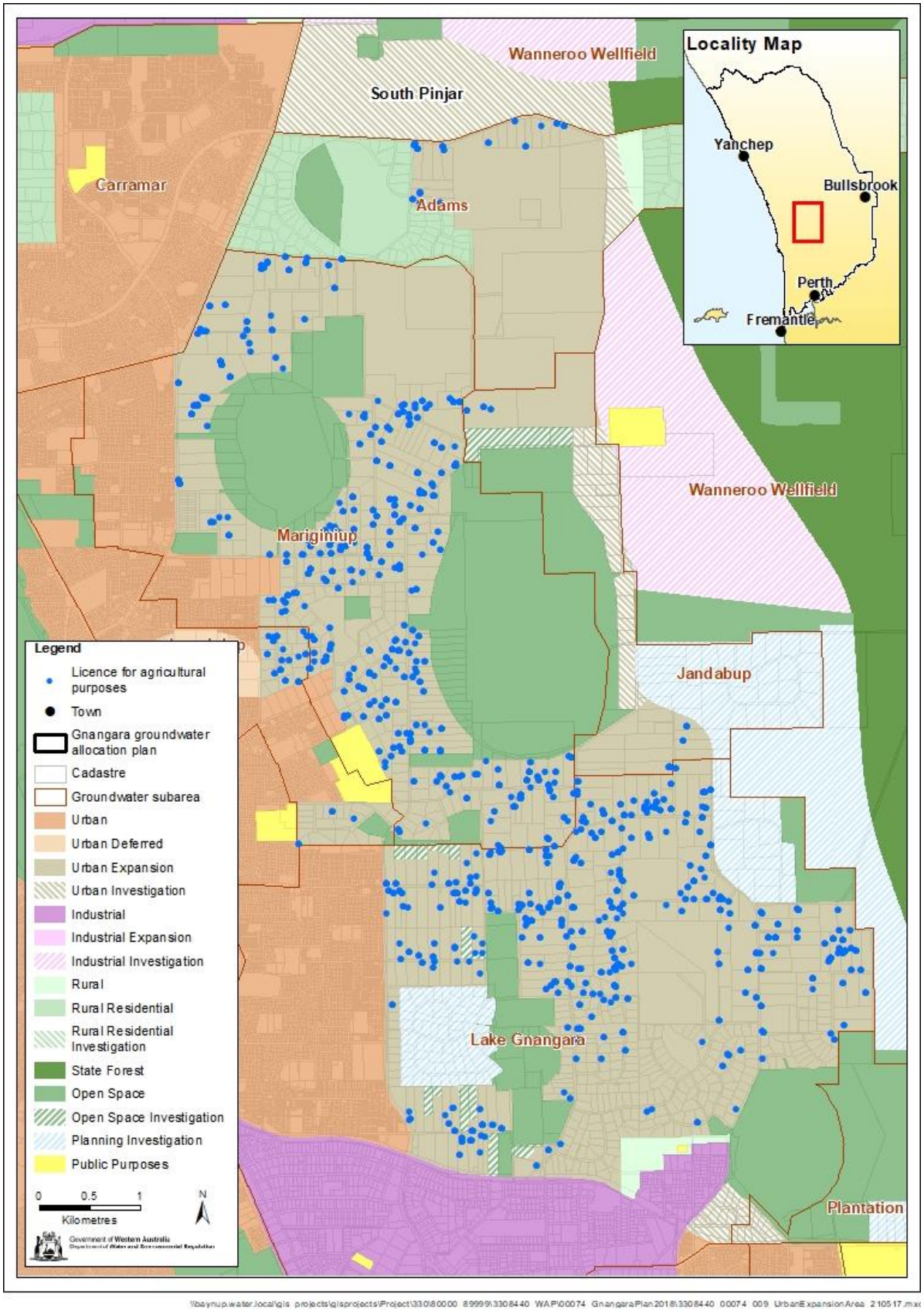


Figure 10 Identified urban expansion areas in East Wanneroo and current groundwater licences for agricultural purposes (90 per cent of all licences)

5.5 Other licensed use

Other licensed users have an allocation of 20.9 GL/year in total, mostly for commercial and industrial operations, construction and mining, and licensed stock and domestic purposes. Licensees taking groundwater for these purposes will need to reduce their groundwater abstraction by 10 per cent from 2028, as described in this plan. Licensees temporarily taking groundwater during construction and mining activities are exempt from reduced abstractions.

We expect that individuals and organisations will make a range of business and water use adjustments similar to other sectors to reduce water demand and improve irrigation efficiency. Some will explore other sources.

Construction and mining

To create a safe environment during major construction and mining activities, temporary abstraction of groundwater for short-term dust suppression and dewatering may be required. At present, 160 temporary and non-renewable licences have an allocation totalling 7 GL/year. Licences to take groundwater temporarily for construction and mining activities are exempt from reduced abstractions.

The extraction of sand and other raw building materials is needed to support Perth's growth and development. These activities generally need water for short-term dust suppression. We have accounted for these strategic needs and their water requirements by including a basic raw materials component (see Appendix C) in the allocation limit for the Reserve and Wanneroo Wellfield subareas.

We expect applicants for temporary dust suppression licences to demonstrate how they will minimise watering demands. They need to apply the guidelines for managing dust impacts (DECR 2011).

Licensed stock and domestic use from artesian bores

About 6 GL/year of groundwater is licensed for stock and domestic use from artesian bores, which can be divided into two broad categories:

1. Small-scale domestic garden watering, household use and water for non-intensive stock on rural properties not connected to scheme water (less than 0.2 hectares).
2. Larger-scale private garden and pasture watering (greater than 0.2 hectares).

Groundwater for small-scale stock and domestic use is exempt from licensing when taken from the watertable aquifer (the Superficial aquifer – see Appendix D). We estimate that these activities use 1,500 kL/year. We include this volume on a licence within the annual water entitlement when it is abstracted from a bore which is also used for commercial purposes (e.g. for irrigating vegetable crops).

This component of a water entitlement will be exempt from reductions and cannot be traded (see Table 4).

Larger-scale stock and domestic use will be subject to reductions, but like licences for other commercial purposes, this volume can be traded.

5.6 Garden bores and stock and domestic bores

Garden bores are an important part of Perth's water supply and today, across Perth and Peel, about one in four households have a garden bore. In the Gnangara area, we estimate that households use about 36 GL/year of groundwater for garden, stock and domestic watering purposes. This is abstracted across an estimated 65,000 garden bores and a further 4,000 bores on properties used for stock and domestic purposes. All of these uses are exempt from licensing (see exempt uses in appendices C and D). Under the current growth rate with no intervention, we estimate that domestic garden bore use will increase to about 43 GL/year by 2030.

Although garden bores were once promoted as a good way to reduce the need for new scheme water supplies, the effects of climate change mean that it is now necessary to use garden bores more carefully than before and that the overall amount of groundwater used to water gardens should be reduced. Reducing this use of groundwater will help slow and reverse declining groundwater levels; reducing the risk of bores going dry, the death of street trees and the salinisation or acidification of groundwater in vulnerable locations.

Various estimates of residential water use over the last decade, when comparing similar-sized properties, have consistently found that on average households with a garden bore use 3 to 4 times more water on lawns and gardens than households using scheme water. In part, this is a consequence of the extra watering day that garden bore users have under the current sprinkler restrictions.

Managing bores exempt from licensing

The *Waterwise Perth Action Plan* set the target of reducing groundwater use across Perth and Peel by 10 per cent by 2030. As part of this we started the Be Groundwater Wise education and awareness campaign which encouraged waterwise behaviour and asks householders to use their garden bores more efficiently and effectively.

To lock in these behaviour changes and maintain a long-term reduction in groundwater use for garden watering, we are now aiming to amend the garden bore sprinkler roster to remove the additional watering day in Area 3 Perth/Mandurah (Figure 11). No changes are being made to sprinkler rosters in Area 2 South Area (Figure 11) also located in the Gnangara plan area as there is a very limited number of garden bores in this area. The use of urban garden bores and domestic bores is managed under the provisions of the Water Agencies (Water Use) By-Laws 2010 which we will seek to amend and implement by Spring 2022.

This will mean that all households in Perth and Mandurah have the same two-days-a-week sprinkler roster, whether using scheme water or bore water. Although this will be a significant change for garden bore users, it will mean that all groundwater users

are contributing to the sustainability of the Gnangara groundwater system and Perth's aquifers as a whole.

The community has generally supported sprinkler restrictions, helping to preserve groundwater resources and encourage water use efficiency in garden irrigation. Failure to follow the restrictions can result in an infringement being issued. In addition to enforcing sprinkler restrictions on garden bores, we have a guide to where new bores can be installed. This is to manage risks to water quality or environmentally sensitive areas, such as wetlands.

To support the planned change to the sprinkler roster for garden bores we are:

- providing assistance to householders to make their gardens more waterwise, including incentives to invest in smart irrigation technology and spring sprinkler system check-ups.
- continuing to implement a community education and awareness campaign through the Be Groundwater Wise website
- updating our garden bore suitability map to represent the over-allocation status of the Gnangara groundwater system
- using new information to improve how we account for garden bores in urban areas and stock and domestic bores in rural areas.

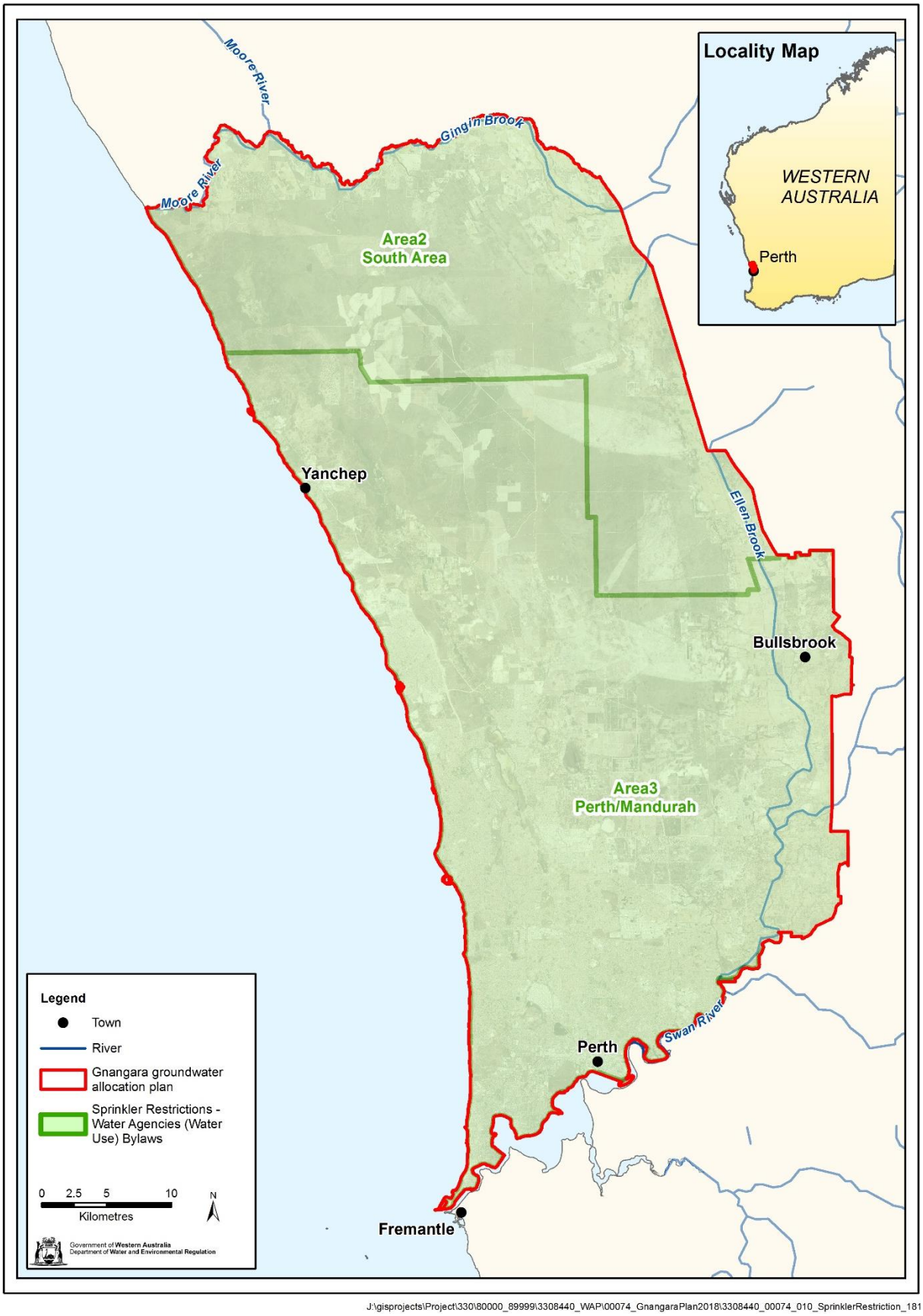


Figure 11 Changes to the sprinkler roster for garden bores outlined in Section 5.6 will be made to Area 3 Perth/Mandurah

6 The benefits of taking less from the Gnangara groundwater system

This chapter explains the benefits of taking less groundwater from the Gnangara groundwater system to protect:

- groundwater-dependent ecosystems (Section 6.1)
- water quality (Section 6.2)
- community and cultural values (Section 6.3).

A rapid increase in groundwater use, combined with a significant decline in rainfall, has altered the natural cycle of recharge and discharge in the Gnangara groundwater system.

Perth has relied on Gnangara groundwater as a source of public water supply since the 1970s. Perth's groundwater use tripled to about 150 GL/year between the mid 1970s and late 1980s, and doubled again to about 300 GL/year by the early 2000s. This has caused groundwater levels in the Superficial aquifer to fall across most of the plan area and, over time, has negatively affected groundwater-dependent values and processes (Appendix B summarises the impacts observed in each subarea).

Actions to reduce groundwater abstraction – both in the previous 2009 plan and this plan – will support ecosystems, the groundwater resource, and community and cultural values for current and future generations.

6.1 Groundwater-dependent ecosystems

The natural areas remaining on the Swan coastal plain are critically important, given most of the native bushland and more than 80 per cent of the original wetlands have been lost through clearing and draining since European settlement. The Gnangara groundwater system sustains these and other valuable areas including wetlands, mound springs, cave systems and large areas of bushland that overlie shallow groundwater (Figure 12).

Many of these features:

- have conservation significance and are recognised and protected under state and federal legislation[7]
- are some of the most biologically diverse and ecologically productive parts of Perth's environment north of the Swan River (Derbarl Yerrigan).

[7] In 2016 the Banksia Woodlands of the Swan coastal plain ecological community was listed as 'endangered' under Australia's national environment law, the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth). As most of the groundwater-dependent native vegetation in the Gnangara plan area is Banksia woodland, this listing signals a significant increase in the level of legal protection for much of the area shown in Figure 12. Banksia woodlands provide vital habitat for more than 20 nationally threatened species, including the Carnaby's black cockatoo.

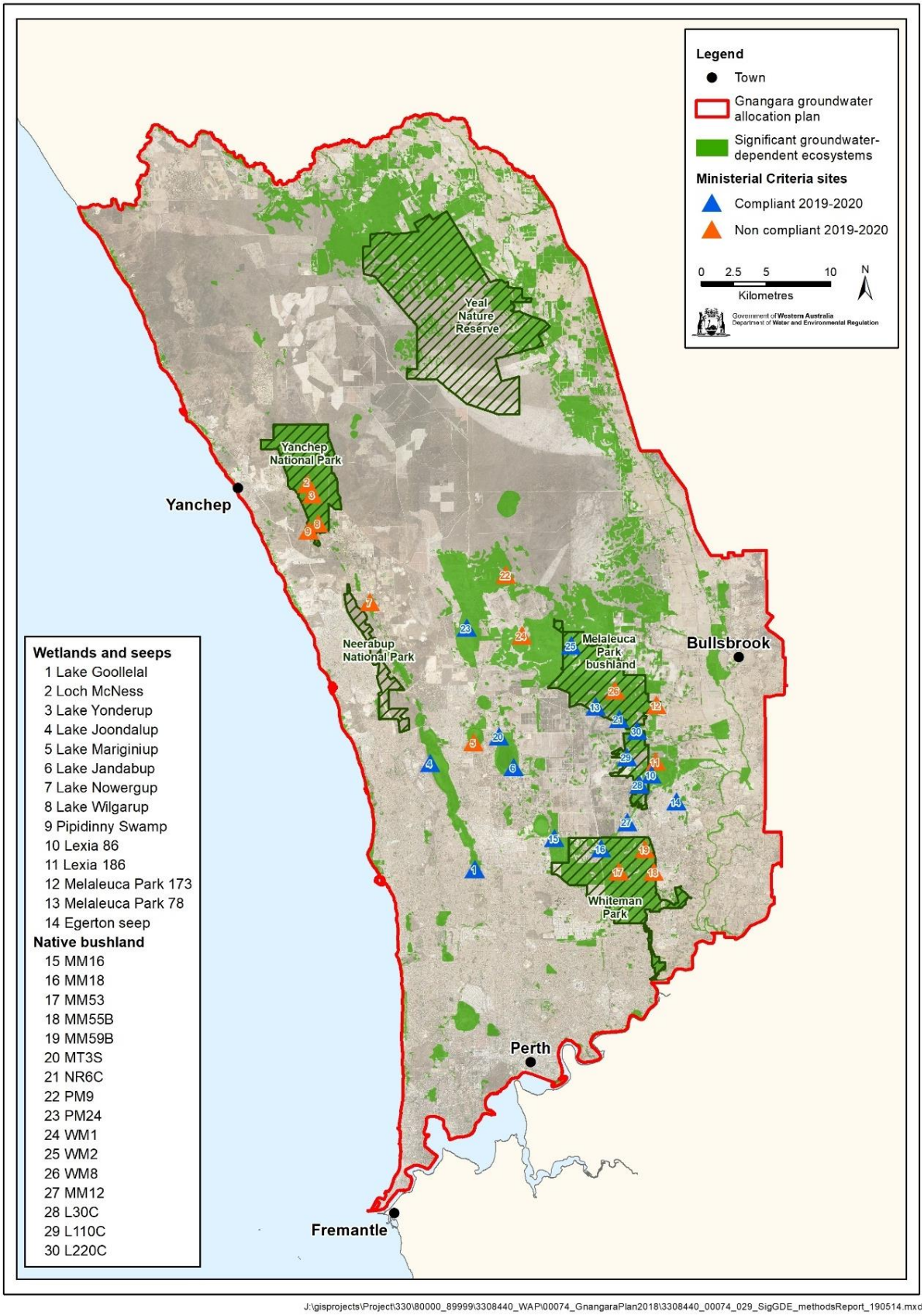


Figure 12 Significant groundwater-dependent ecosystems in the Gnangara plan area, and compliance against minimum water level criteria in 2019–20 for 30 representative wetlands and bushland sites

As part of managing Gnangara groundwater resources, the Department of Water and Environmental Regulation is responsible for meeting conditions set under the *Environmental Protection Act 1986* and detailed in Ministerial Statement no. 819 (Environmental Protection Authority 2009). Some of these conditions are minimum water level criteria that we must meet at 30 representative wetland and bushland sites in the Gnangara plan area (Figure 16, Section 7.1). These water level criteria are scientifically based and designed to protect the key ecological and community values of groundwater-dependent ecosystems.

Minimum water level criteria have been exceeded at an increasing number of sites as groundwater abstraction has increased and the climate has dried. Gnangara groundwater levels were the lowest on record in 2016, with water levels below minimum criteria levels at 18 of the 30 representative wetland and bushland sites. Ecological monitoring at many sites confirmed that sustained, low groundwater levels had resulted in real impacts, including:

- drying of wetlands
- declining vegetation health and tree deaths
- vegetation species changing to those preferring drier conditions
- increasing soil and water acidity
- reductions in frog and macroinvertebrate diversity.

Three sites have met the minimum criteria levels (i.e. become compliant) in the past two to three years because of some improved annual rainfall (including two large summer rainfall events). There are now 14 non-compliant sites. If we don't take action to reduce abstraction, compliance will fall again and damage to ecosystems will worsen as climate change continues to reduce rainfall and increase temperatures.

Our long-term monitoring datasets on water levels and ecology are invaluable for how we manage groundwater. These have provided key information about the relationship between water levels and ecosystem health. This has been and continues to be fundamental to how we manage the take of Gnangara groundwater to limit impacts on important ecosystems as the climate dries.

How this plan supports groundwater-dependent ecosystems

The reduction to abstraction will help maintain or restore ecological values at many sites that have been affected by falls in groundwater levels, and limit further loss of values at other sites. Groundwater modelling shows that water levels are likely to improve or stabilise at most of the 30 representative sites. This will reduce the risk of exceeding the current level of non-compliance with existing minimum water level criteria and have a positive effect on the health of Gnangara's groundwater-dependent ecosystems overall.

Modelling of the system shows it is not possible to restore all the values of the ecosystems affected by falls in groundwater levels, even with reductions to groundwater abstraction.

We should see water levels and ecological condition stabilise or improve across 41 per cent of the area covered by significant groundwater-dependent ecosystems (Figure 12).

The reduction to abstraction will help stabilise and possibly improve water levels in some of the iconic and culturally significant wetlands in Yanchep National Park, one of the most popular national parks in the state. Because of its significance, we are continuing to investigate options for managing abstraction within and around the national park to improve certainty around water level recovery.

Further to the south, the ecology of lakes Gnangara, Jandabup and Mariginiup is expected to improve as increasing recharge from the East Wanneroo urban expansion area begins to contribute to groundwater-level rises. This will also improve local water quality, which has been impacted by increasing acidity in the past. Improved water levels will also help to maintain or improve the scenic appeal of these wetlands for a growing local population and the wider community. Our groundwater modelling shows that reducing garden bore use would be particularly beneficial to the water tables in residential suburbs of the Gnangara area and would provide environmental benefits to Perry Lakes, Herdsman Lake, Carine Swamp, Inglewood Triangle bushland and Star Swamp.

Although groundwater modelling shows water levels will improve over large parts of the plan area, water levels in other areas are still expected to decline because of climate change (Figure 7b, Section 3.1). In the northern central parts of the plan area, increased recharge from pine plantation harvesting and careful management of post-harvest land use will help mitigate these declines and support habitat in the Gnangara–Moore River State Forest and Yeal Nature Reserve.

Modelling shows the effects of climate change will continue to be the most pronounced in central eastern parts of the plan area (best seen in Figure 7). Reductions to abstraction across the Gnangara groundwater system will contribute to slowing the rate of decline in this area and help to limit the risk of significant impacts to ecological values. While positive, these improvements are generally far smaller than the water-level falls that have occurred during the past few decades.

We have proposed new minimum water level thresholds at some of the representative wetland and bushland sites that have criteria set in Ministerial Statement no. 819 (Section 7.1 and Appendix G). These changes consider what is likely to be achievable given the effects of climate change and will be assessed by the Environmental Protection Authority (EPA).

Once it has completed its assessment, including consideration of public comments, the EPA will provide its recommendations to the Minister for Environment. Following approval by the Minister, any revisions to existing environmental conditions and water level criteria in Ministerial Statement no. 819 will form part of a new statement

and will also be published in the final Gnangara groundwater allocation plan. The Gnangara groundwater allocation plan methods report (DWER 2021b) has more detail about how we developed the new threshold levels.

6.2 Water quality

Groundwater flowing through aquifers and discharging to the Indian Ocean and Swan River (Derbarl Yerrigan) maintains good groundwater quality and holds back the inland movement of saline water into aquifers. Saline water intrusion is influenced by groundwater recharge and climatic and seasonal variability in rainfall and sea levels. This causes a natural ebb and flow movement of the saline water wedge along the coastline and river.

Groundwater abstraction in the Superficial aquifer can draw saline water further inland, affecting the quality of groundwater pumped from bores near the coast and along the river. Rising salinity has been recorded adjacent to the coast in the Yanchep, Quinns and Town of Cottesloe subareas, and in subareas adjacent to the Swan River (Derbarl Yerrigan), including the Swan Valley (Appendix B).

At present, seawater intrusion in the deep aquifers is restricted to offshore parts of the aquifer and there is a generally low risk of seawater moving inland in the Leederville and Yarragadee aquifers. However, the risk of seawater intrusion limits deep aquifer abstraction near the coast, close to Mindarie, where the Leederville aquifer is connected to the Superficial aquifer (DWER 2021a).

Water quality can also deteriorate inland in the Superficial aquifer if pumping draws the watertable down to expose acid sulfate soils. These soils are commonly located around wetlands but can also occur beneath the watertable in the areas between wetlands. Low groundwater levels have already caused acidification and associated ecological impacts at some of the wetlands we monitor.

Lakes Gnangara and Mariginiup have become acidic, and Lake Jandabup has experienced intermittent acidification (Sommer & Horwitz 2009) – although it has since recovered after supplementation improved water levels at the lake. Acidity is also affecting Mussel Pool in Whiteman Park.

Decline in the watertable between wetlands has exposed acid sulfate soils in upper parts of the Superficial aquifer, causing acidification of over 380 km^2 of the shallow aquifer (Degens & Thornton 2018). If this continues, it will eventually limit the use of shallow groundwater in these areas. While pumping from greater depth may avoid drawing acidified groundwater, it can also draw the acidic shallow water deeper into the aquifer – which occurred in the Mirrabooka borefield (Appleyard & Cook 2008).

How this plan supports water quality objectives

The reduction to abstraction will minimise further inland movement of saline water along the coast and Swan River (Derbarl Yerrigan) and prevent significant acidification of groundwater.

The groundwater modelling for this plan showed that if no action is taken to reduce current abstraction volumes, about 13.1 GL of the water drawn by licensed and garden bore users could become degraded in the future and may be unusable because of increased acidity or salinity.

Under reductions, this volume is reduced by 79 per cent to 2.8 GL. Of this total, the volume at risk of impacts from acidity is reduced by 90 per cent to 1.1 GL, and the volume at risk of impacts from salinity is reduced by 19 per cent to 1.7 GL.

The water quality risk map below shows areas at risk of deteriorating groundwater quality in the Superficial aquifer, either through saline water intrusion or acidification (Figure 13). This map will help groundwater users identify whether their bore may be affected by poor water quality in the future, and to manage and monitor their groundwater use accordingly.

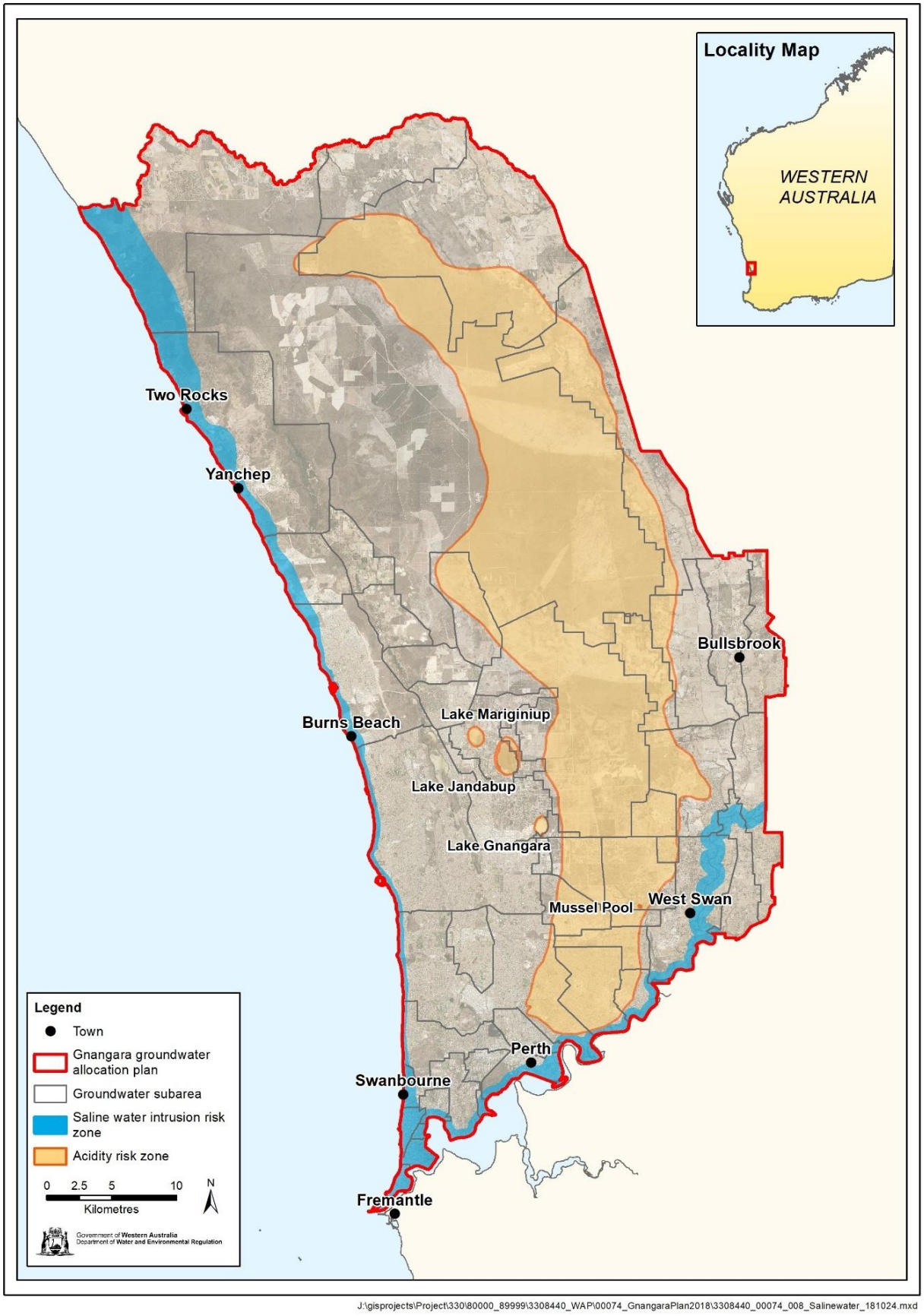


Figure 13 Groundwater quality risk map for the Gnangara plan area

6.3 Community and cultural values

Aboriginal people value the many lakes, wetlands and springs in the plan area and used these places for hunting, gathering and performing ceremonies, as well as for campsites, burial sites, birthplaces and totemic places. Indigenous artefacts have been found in several wetland areas. Many of these places are registered as Aboriginal heritage sites. See the *Gnangara groundwater allocation plan methods report* (DWER 2021b) for more information on the significance of Gnangara groundwater to the Noongar people.

There is a strong preference in the community for maintaining wetlands, as highlighted by research for the *Gnangara sustainability strategy: draft for public comment* (Government of Western Australia 2009). In a study by Estill & Associates (2005), Aboriginal representatives identified the need for 'wetlands to be maintained and flows to be restored wherever possible'.

Preventing further degradation and loss of groundwater-dependent ecosystems is as important for people as it is for wildlife. These ecosystems are the greener, wetter parts of the landscape that the community uses for recreation and amenity. These are the areas that help to counteract increased temperatures in built-up parts of our city and suburbs (known as the urban heat island effect).

Where the watertable is shallow, groundwater also helps to sustain the shady trees in our streets and parks that further help cool urban areas. Residential properties close to wetlands and bushland areas have also been found to attract a price premium compared with those further away (Tapsuwan et al. 2007).

Not only do these waterbodies and green spaces provide attractive places to visit and enjoy – which support people's physical and mental health and wellness – they provide important ecosystem services to the community such as retaining nutrients from drainage and flood mitigation. They also have important scientific and educational value.

How this plan supports community and cultural values

By reducing abstraction through this plan, the health of Gnangara groundwater-dependent ecosystems will improve, in turn supporting the cultural values associated with these ecosystems and benefitting the community. Although lower rainfall conditions caused by climate change now prevent historical water regimes from being restored, water levels will improve at many wetlands because of this plan.

Communities near wetlands in and around the urban expansion area in East Wanneroo will benefit from increasing water levels in lakes Gnangara, Jandabup and Mariginiup – their visual amenity and social value will be much improved. The community around the popular lakes Gwelup, Joondalup and Goollelal will continue to enjoy these urban green spaces because lake levels will be maintained.

In between these zones, urban street trees over shallow groundwater will also be supported as groundwater levels rise, helping to keep our suburbs cool and liveable as the climate continues to get hotter and drier (Figure 14). Further north, small

improvements in water levels are projected around Yanchep National Park, helping to protect its value as a destination for tourism and recreation.

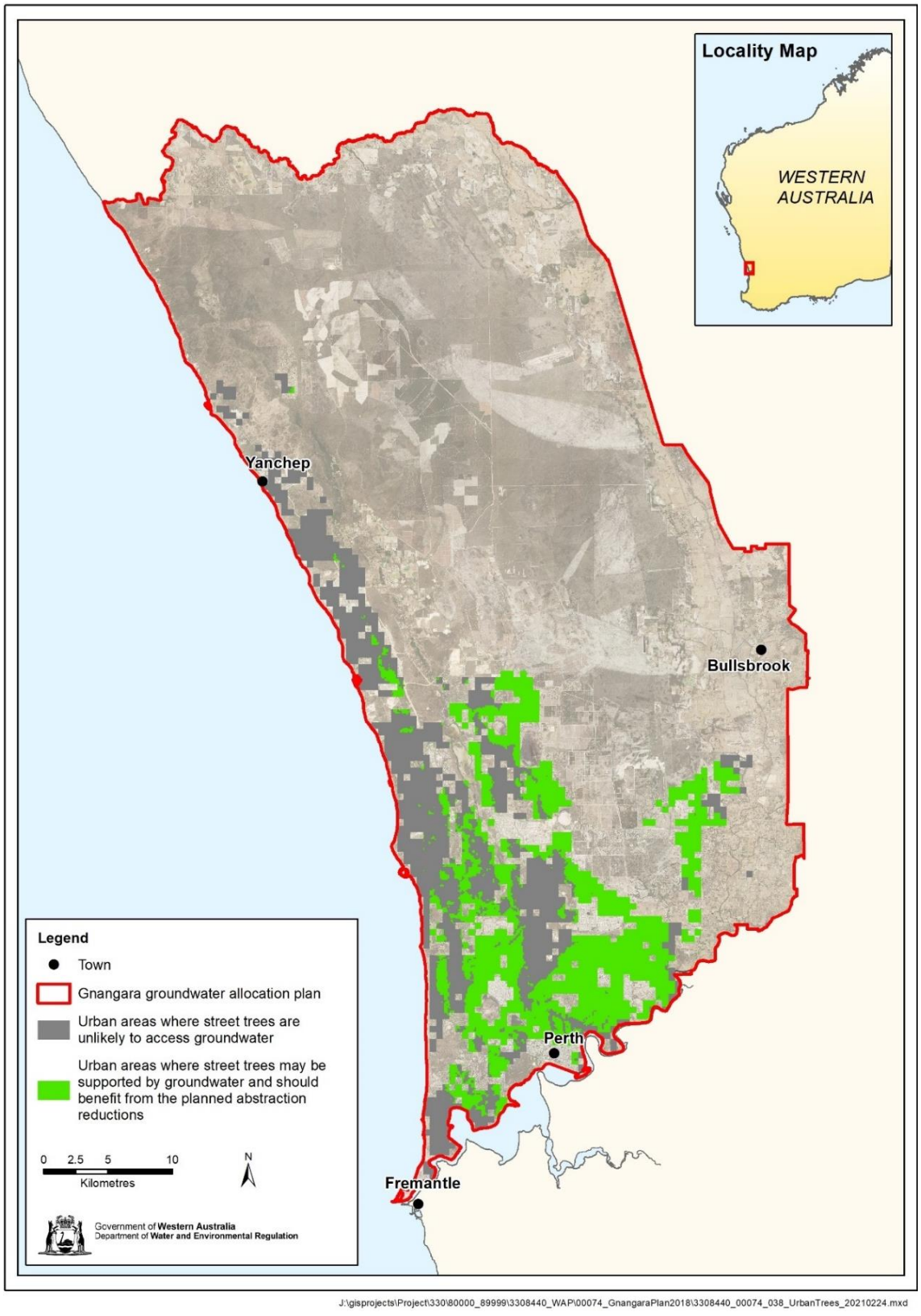


Figure 14 Areas where street trees should benefit from the plan and reductions to abstraction

7 Monitoring program for the Gnangara groundwater system

7.1 Current monitoring

The Department of Water and Environmental Regulation operates an extensive network of more than 700 monitoring bores and 30 staff gauges to monitor the Gnangara groundwater system and the ecosystems that depend on it (Table 6).

Table 6 Total number of monitoring sites for the Gnangara groundwater system

Type of site	Number of sites	Monitoring frequency	Approximate number of measurements each year
Staff gauge	30	Monthly to bimonthly	300
Superficial aquifer bore	553	Monthly to yearly	3,266
Mirrabooka aquifer bore	31	Monthly to yearly	372
Leederville aquifer bore	71	Monthly to yearly	732
Yarragadee aquifer bore	49	Monthly to yearly	364
Total	**734**		**5,034**

We regularly take measurements at these sites to assess changes in groundwater levels, hydraulic pressure and, in some cases, water quality (salinity). While we consider measurements from all sites, we will focus on a series of representative sites to assess the performance of the water resource against this plan's objectives (see also Figure 15 and Appendix F).

Water level monitoring

Most monitoring bores in the plan area measure levels in the Superficial aquifer. This aquifer's condition is especially important to the Gnangara groundwater system because it:

- sustains groundwater-dependent ecosystems
- is the groundwater source most people use for self-supply
- is the most likely to be adversely affected by climate change
- is the most likely to be adversely affected by changes to water quality from saline water intrusion or acid sulfate soils.

We will continue to publish the average groundwater level graph on our website each month – gnangara.dwer.wa.gov.au/status – using the 42 representative groundwater level bores in Figure 15. This graph is an important tool for us to communicate how the groundwater resource is broadly responding over time to fluctuations in rainfall and changes to land use and abstraction. Note, however, that water levels at individual monitoring sites can vary significantly from those shown in the average graph.

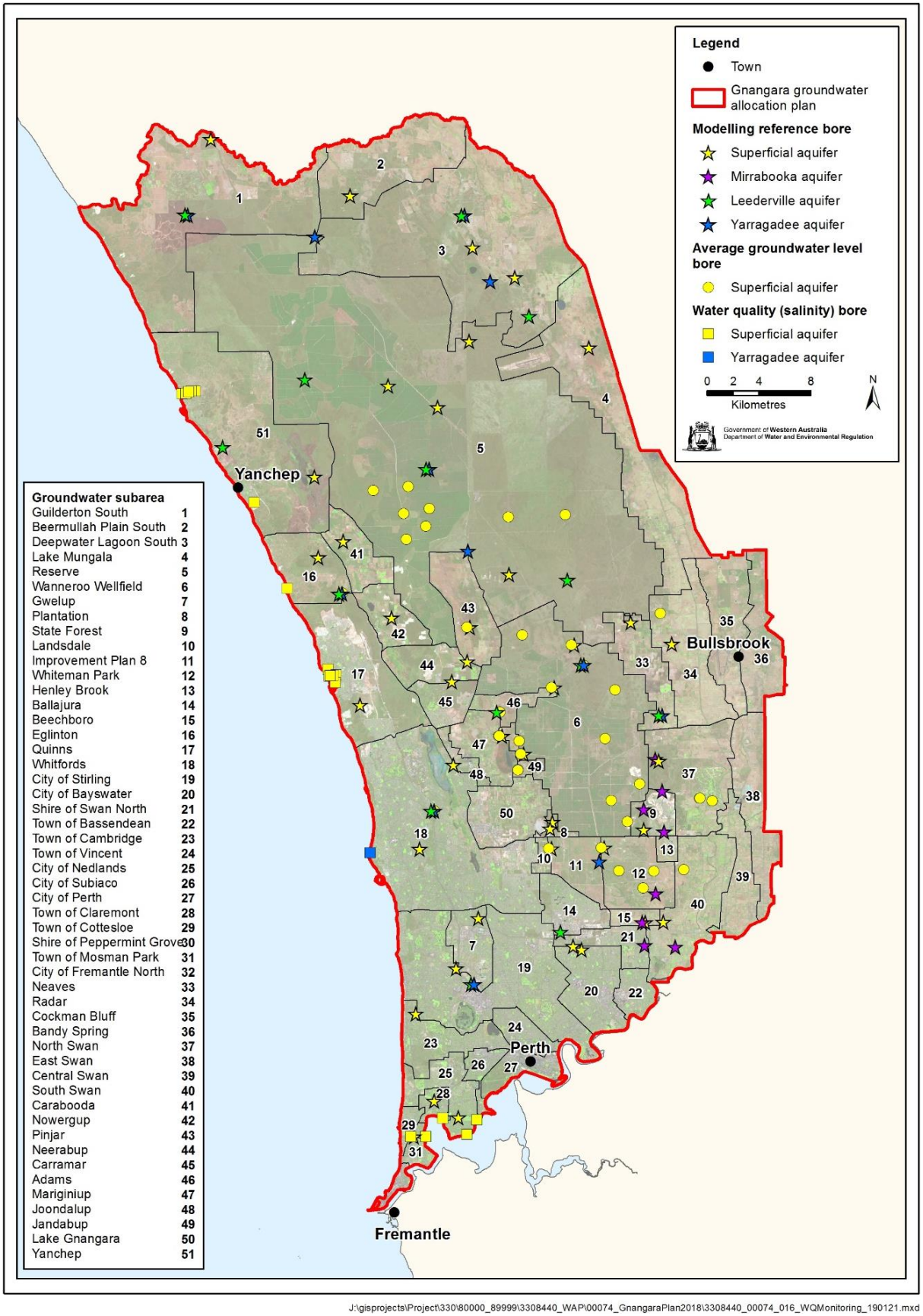


Figure 15 Representative monitoring sites for modelling, our average groundwater level graph and water quality

We will also continue to monitor 75 modelling reference bores to provide data for our Perth Regional Aquifer Modelling System (Figure 15). This helps us assess the performance of the resource and project water level and hydraulic pressure changes into the future. The sites include:

- 41 bores in the Superficial aquifer
- 8 bores in the Mirrabooka aquifer
- 14 bores in the Leederville aquifer
- 12 bores in the Yarragadee aquifer.

Water quality monitoring

In the Superficial aquifer, we monitor water quality (salinity) at 17 seawater intrusion bores across six locations along the coast and 25 saline water intrusion bores across five locations along the Swan River (Derbarl Yerrigan) (Figure 15). These bores track the location of the boundary between fresh groundwater discharging into the ocean and saline water coming in from the ocean and Swan River (Derbarl Yerrigan). This monitoring is important to help manage and prevent water quality decline along the coast and river (Section 6.2).

In the Yarragadee aquifer, we have installed a water quality (salinity) bore in the suburb of Hillarys (Figure 15). This bore was constructed for induction logging in both the Leederville and Yarragadee aquifers and has provided evidence that confirms the seawater interface is offshore in both the aquifers. We will continue to monitor the seawater interface at this location to track any inland movement.

Most water level monitoring bores in acidification risk areas are not specifically designed for routine monitoring of acidity but are used for periodic surveys of water quality status. We used the most recent survey to identify current areas of acidity, and the extent of the risk zone for future acidification impacts (see Figure 13). This survey gives us a point of comparison for future surveys of water quality to track trends in acidity over time.

Monitoring against environmental conditions in Ministerial Statement no. 819

In addition to monitoring and tracking general water level and quality trends in all aquifers, we must also meet specific monitoring and reporting commitments in the environmental conditions set out in Ministerial Statement no. 819 (see Section 6.1). These include monitoring against water level criteria at wetlands and in areas of bushland over shallow groundwater, and ecological monitoring of vegetation, vertebrates and invertebrates. At present we are responsible for monitoring against water level criteria at 14 wetland sites and 16 bushland sites (see Figure 16).

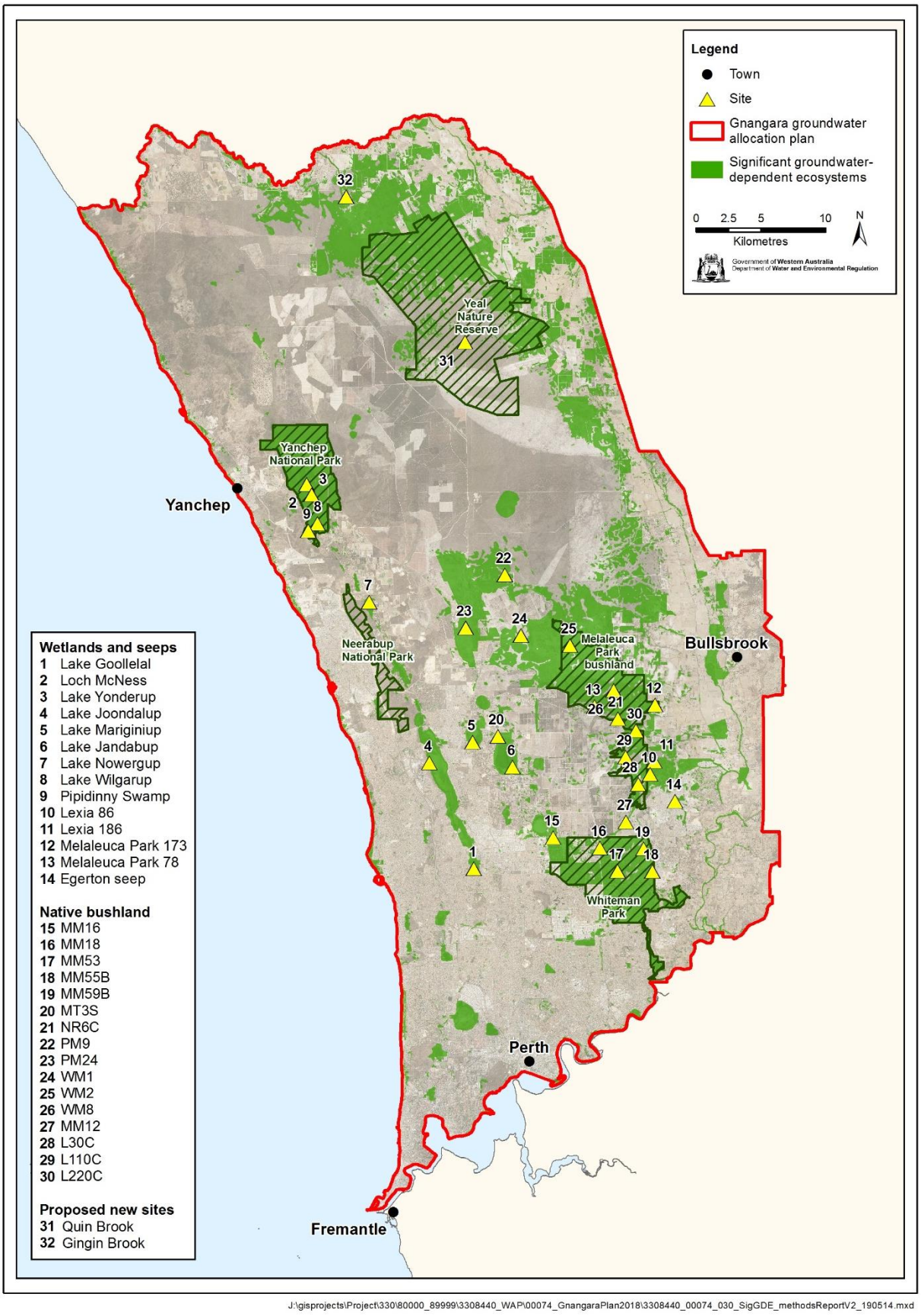


Figure 16 Existing and proposed representative wetland and bushland sites in the Gnangara plan area with new water level criteria proposed

We will be requesting amendments to some of the minimum water level criteria (see Appendix G, Table G1) under Section 46 of the *Environmental Protection Act 1986* as a result of our investigations, water level projections and proposed management outlined in this plan.

To support the requested adjustments, we will submit this plan and supporting documentation to the EPA for assessment. We will include any revisions to water level criteria or other environmental conditions, as approved by the Minister for Environment, in the final *Gnangara groundwater allocation plan*.

The proposed water level thresholds (previously referred to as criteria) will apply to all but one[8] of the 30 representative wetland and bushland sites. We have also proposed levels at two new sites (Quin Brook and Gingin Brook) to manage public water supply abstraction and to inform the development of a Gingin water allocation plan (see Section 5.2).

To determine the proposed minimum water level thresholds, we considered:

- past and current water levels and the relationship between water levels and ecological health
- ecological water requirements
- the hydrogeology of wetlands and the interactions and connectivity of surface waterbodies and groundwater
- modelled projections of what water resource outcomes can likely be achieved once reductions to abstraction are in place
- consultation with key stakeholders, including the Department of Biodiversity, Conservation and Attractions, on site management objectives.

We have documented the proposed thresholds as applying from 2028. Although land use changes will continue to contribute to water level improvements in some areas, actual reduced abstractions will only start to come into effect from 2028. The total effect of these changes on the watertable may not be fully realised at some sites until the mid-2030s.

Ecological monitoring

As part of the commitments for Ministerial Statement no. 819, we conduct ecological condition monitoring at representative wetland and bushland sites (see Figure 16). This monitoring provides critical information about the system's overall health and the effects of short- and long-term changes in water levels on ecosystem values.

[8] The existing site that we are not proposing a water level threshold for is PM9 (see Appendix G).

The current program (Appendix F) involves monitoring:

- wetland vegetation – 18 transects, of which 10 to 12 are monitored each year
- macroinvertebrates and water quality at wetlands and groundwater seepages – 14 regular sites, with up to 10 monitored each year
- frogs – 15 wetland sites, annual and opportunistic pit trapping and aural monitoring
- groundwater-dependent bushland – 16 transects, with 7 to 10 transects monitored every three years.

We will continue to conduct a comprehensive ecological monitoring program into the future.

7.2 Evaluating against water resource objectives

We will continuously monitor and evaluate the water resource after the plan is finalised and released. In 2030 we will formally assess the results of the monitoring program against the performance indicators to:

- determine whether the plan's objectives are being met (see Table 7)
- decide whether the plan needs to be replaced after 2032.

Data from the representative monitoring sites (see Figure 15 and Appendix F) will be the focus of our assessment against the performance indicators. However, we will consider all available groundwater monitoring data, including data from licensees, to comprehensively assess the causes and effects of changing groundwater levels as we implement this plan.

We will continue to comply with reporting requirements related to Ministerial Statement no. 819 or a revised statement following the assessment under Section 46 of the *Environmental Protection Act 1986* (see Section 6.1).

Table 7 Performance indicators to assess the plan's water resource objectives

Objective	Performance indicators	Monitoring	Assessment
Water levels			
1. Maintain or increase groundwater levels in the Superficial aquifer.			
a. To maintain a reliable supply to groundwater users.	Water levels in the Superficial aquifer are consistent with projected levels.	Actual water levels at the groundwater modelling reference bores shown in Figure 15 and detailed in Appendix F and Table F1.	Track changes in Superficial aquifer water levels and compare against projected levels. Undertake detailed formal review in 2030.
b. To maintain or improve the health of groundwater-dependent ecosystems.	Water levels are tracking towards thresholds for groundwater-dependent ecosystems (Table G1).	Monthly water level monitoring at ecological sites shown in Figure 16 and detailed in Appendix G and Table G1.	Annually assess water levels against thresholds and report to the EPA. Consider results of relevant ecological monitoring to determine whether there has been a measurable effect of water level change on ecosystem health.
2. Manage declines in Superficial groundwater levels at a rate and magnitude that presents a lower risk of critical declines in ecological condition.	Water levels are tracking towards thresholds for groundwater-dependent ecosystems (Table G1).	Monthly water level monitoring at ecological sites shown in Figure 16 and detailed in Appendix G and Table G1.	Annually assess water levels against thresholds and report to the EPA. Consider results of ecological monitoring to determine whether there is evidence of a threshold response in the ecosystem.
3. Increase pressure heads in the Leederville and Yarragadee aquifers, especially in and near areas connected to the Superficial aquifer:			
a. To support groundwater-dependent ecosystems.	Pressure heads in the Leederville and Yarragadee aquifers are consistent with modelled heads.	Actual pressure heads at groundwater modelling reference bores, measured monthly and detailed in Appendix F and Table F2.	Annually assess changes in Leederville and Yarragadee aquifer pressure heads, compare against projected heads and report to the EPA. Undertake detailed formal review in 2030.
b. To minimise impacts on water users.	Pressure heads in the Leederville and Yarragadee aquifers are consistent with modelled heads.	Actual pressure heads measured monthly at groundwater modelling reference bores shown in Figure 15 and detailed in Appendix F and Table F2.	Track changes in Leederville and Yarragadee aquifer pressure heads and compare against projected heads. Undertake detailed formal review in 2030.
4. No significant inland movement of saline water along the coast and the Swan River (Derbarl Yerrigan) to maintain suitable water quality for use.	Salinity levels at seawater intrusion monitoring sites and along the Swan River (Derbarl Yerrigan) do not significantly increase compared with historical recorded levels.	Salinity monitoring at Superficial monitoring bores shown in Figure 15 and detailed in Appendix F and Table F1.	Track trends in salinity in the Superficial aquifer. Undertake detailed formal review in 2030.
	Seawater interface remains offshore in the Leederville and Yarragadee aquifers.	Salinity monitoring of the Yarragadee bore, near Hillarys, detailed in Appendix F and Table F2.	Track trends in salinity in the Leederville and Yarragadee aquifers. Undertake detailed formal review in 2030.
5. Changes in acidity in the Superficial aquifer in potential areas of acid sulfate soils have little or no adverse impacts on significant environmental values and groundwater users.	Acidity at monitored wetlands does not increase beyond known tolerance levels of the invertebrate fauna. There should be no acidification events at lakes Jandabup, Nowergup, Goollelal, Joondalup and Egerton Seepage and acidity levels at Lake Mariginiup should decline over the plan period.	Water quality (acidity) monitoring at wetland and mound spring sites detailed in Appendix F, Table F3 and Table F4.	Annually assess changes in acidity at monitored wetlands and mound springs and report to the EPA.
	The extent of the acidification risk area does not increase. There should be a declining trend in the number of reports of acidification problems by shallow groundwater users in Banksia Grove, Jandabup, Mariginiup, Gnangara, Whiteman, Ellenbrook, Melaleuca and west Bullsbrook and the urban areas spanning Bayswater to Ballajura and Dianella to Bassendean.	Before 2030, survey water quality at previous survey sites within the acidification risk area.	In 2030 map the extent of the acidification risk area based on survey data and compare this with extent of previous mapping.

8 Implementing and reviewing the plan

This chapter sets out what actions the Department of Water and Environmental Regulation will take to implement and review this plan, and the reporting we plan to do.

8.1 Plan timeframe

This *Gnangara groundwater allocation plan* will remain in effect until it is replaced by a new water allocation plan, amended or revoked by the Minister for Water. To adapt our management to ongoing climate change, we will continue to monitor and evaluate the resource and publish progress reports. We will formally review whether this plan's outcomes and objectives are being met in 2030 and determine whether the plan needs replacing at the end of the 2032. Figure 17 summarises the timeline for development, implementation and review of this plan.

8.2 Implementing the plan

We will implement this plan by following the strategies outlined in Section 2.2. In addition to these strategies, we will take a number of actions to help implement the plan and meet its outcomes and objectives (Table 8).

Progress reports

So that we remain transparent and accountable to our stakeholders, we will publish progress reports every two years. These short reports will provide updates on water licensing and plan actions, including:

- licensing statistics, such as number of licences assessed, and volume of water recouped in the previous year/s
- average water levels
- the status of any plan actions due
- status of work with key stakeholders and industry partners.

These progress reports will be available on our website. We will continue to comply with any reporting the EPA requires after its assessment of this plan under Section 46 of the *Environmental Protection Act 1986*. These reports will also be available on our website.

You can access our monitoring networks at any time via the Water Information Reporting portal on our website.

Table 8 Additional actions to implement this plan

	Action	Timeline
1	Continue to support the 'Be groundwater wise' community education campaign to encourage garden bore users to implement waterwise behaviours and reduce their abstraction.	2019–24
2	Amend garden bore regulations and implement	September 2022
3	Continue to work with the Water Corporation to optimise abstraction from its existing borefields and support its source development investigations.	Ongoing
4	Consistent with the *Waterwise Perth Action Plan,* partner with industry, other agencies and researchers to promote innovative water projects, build capacity in water efficiency and explore new water supply options with water users.	Ongoing
5	Consistent with the *Waterwise Perth Action Plan,* work with the Water Corporation to continue to extend the Waterwise Councils, Golf and Schools programs.	Ongoing
6	Consistent with the *Waterwise Perth Action Plan,* continue to undertake integrated water planning, including: • guide DPLH and WAPC on water supply-demand gaps and supply options for the irrigation of green space in development zones, planning investigation areas, and as part of the review of the subregional planning frameworks • support the Water Corporation to identify where a strategic approach to alternative (non-drinking water) supply options may be needed to meet supply-demand gaps for the irrigation of green spaces.	Ongoing
7	Consistent with the *Waterwise Perth Action Plan,* continue to investigate improvements to monitoring garden bore use, bore installation rates, and the outcomes of the education and awareness campaigns and regulatory changes.	Ongoing
8	Continue to work with the City of Swan to complete an integrated water management strategy for the North East urban growth corridor that considers alternative water source options.	2021
9	Continue to work with DPIRD and other stakeholders on the commitments made by government in response to the North Wanneroo Agriculture and Water Taskforce recommendations, including: • implement a water efficiency infrastructure and technology grants program • support the City of Wanneroo's local planning processes to maintain and protect agriculture in North Wanneroo.	Ongoing Start of water efficiency program TBD
10	Continue to work with the DPLH to implement the *Swan Valley action plan: Protecting the Swan Valley's unique character* (Government of WA 2019a)	Ongoing
11	Review and replace the *Gingin groundwater allocation plan* (DoW 2015b) and *Gingin surface water allocation plan* (DoW 2011f) with a new Gingin water allocation plan.	By 2025

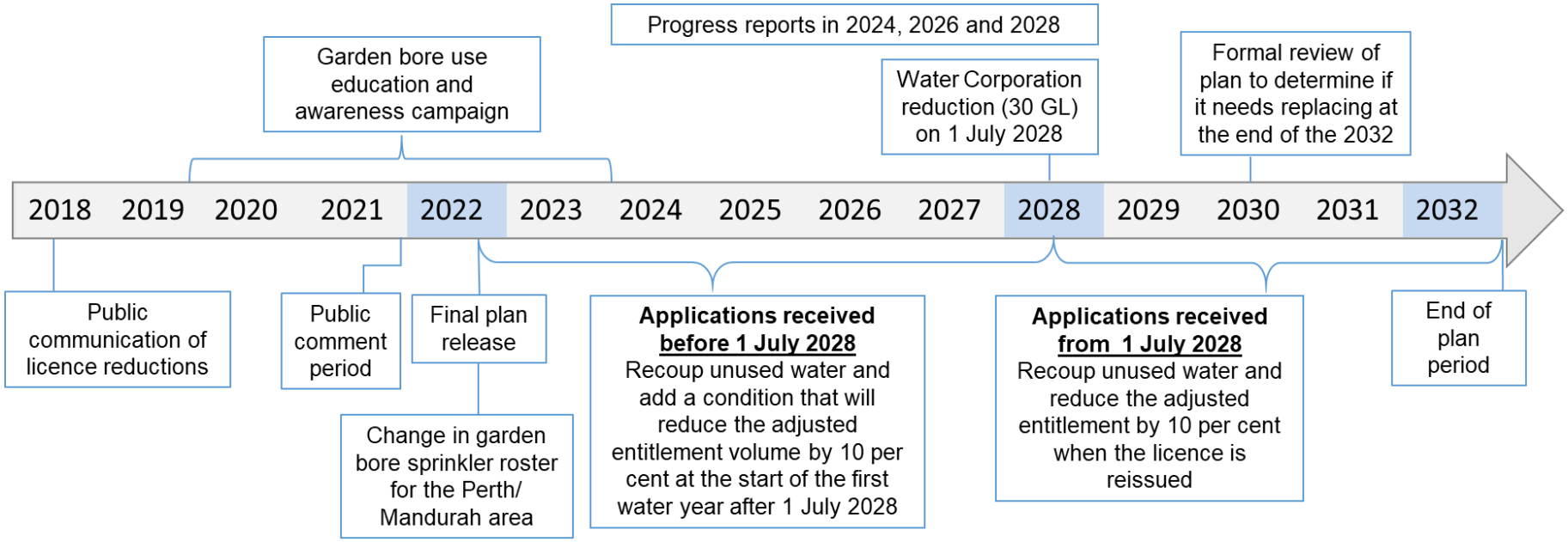


Figure 17 Timeline for the development, implementation and review of this plan

Appendices

Appendix A — Stakeholders we consulted to develop this plan

The Department of Water and Environmental Regulation (and as the former Department of Water) consulted stakeholders on the new Gnangara plan from early 2016 to late 2018. We attended or held more than 100 meetings and workshops with interest groups and individuals during this time.

Table A1 *Stakeholders we met with to develop the* Gnangara groundwater allocation plan: for public comment*, excluding individuals*

Water use sector	Stakeholder
Public water supply	• Water Corporation (including the Water Corporation Board) • Senior Officers Group for Water Supply Planning
Public open space – schools	• Department of Education • Catholic Education WA • Association of Independent Schools of WA • Outer metropolitan chief executive officers
Public open space – others	• Local government park managers • Nursery and Gardens Association • Sports Turf Association (WA) • Golf Superintendents Association • Turf industry • Green Space Alliance • Water Corporation's Garden Industry Reference Group • WA Local Government Association
Agriculture and growers	• Vegetables WA • North Wanneroo Agriculture and Water Taskforce • Carabooda growers • Turf growers • Perth NRM (Woodridge and Gingin) • Strawberry Growers Association of WA • Carabooda Lawn • Benara Nurseries • City of Wanneroo
Swan Valley	• Swan Valley Ratepayers Association • Swan Valley and Regional Winemakers Association • Grape Growers Association • Swan Valley Planning Committee • City of Swan
Gingin	• Gingin Water Group
Environment and culture	• South West Aboriginal Land and Sea Council (SWALSC) • Ecologists • Urban Bushland Council • Conservation Council WA • World Wildlife Fund Australia (WWF)

Water use sector	Stakeholder
	• Birdlife Australia
Consultants and others	• Groundwater Consulting Services Pty Ltd • Landholders around Lake Nowergup
Other agencies	• Department of Biodiversity, Conservation and Attractions • Department of Local Government, Sport and Cultural Industries • Department of Treasury • Department of Jobs, Tourism, Science and Innovation • Department of Premier and Cabinet • Department of Primary Industries and Regional Development • Department of Planning, Land and Heritage

Appendix B – Local impacts and risks map

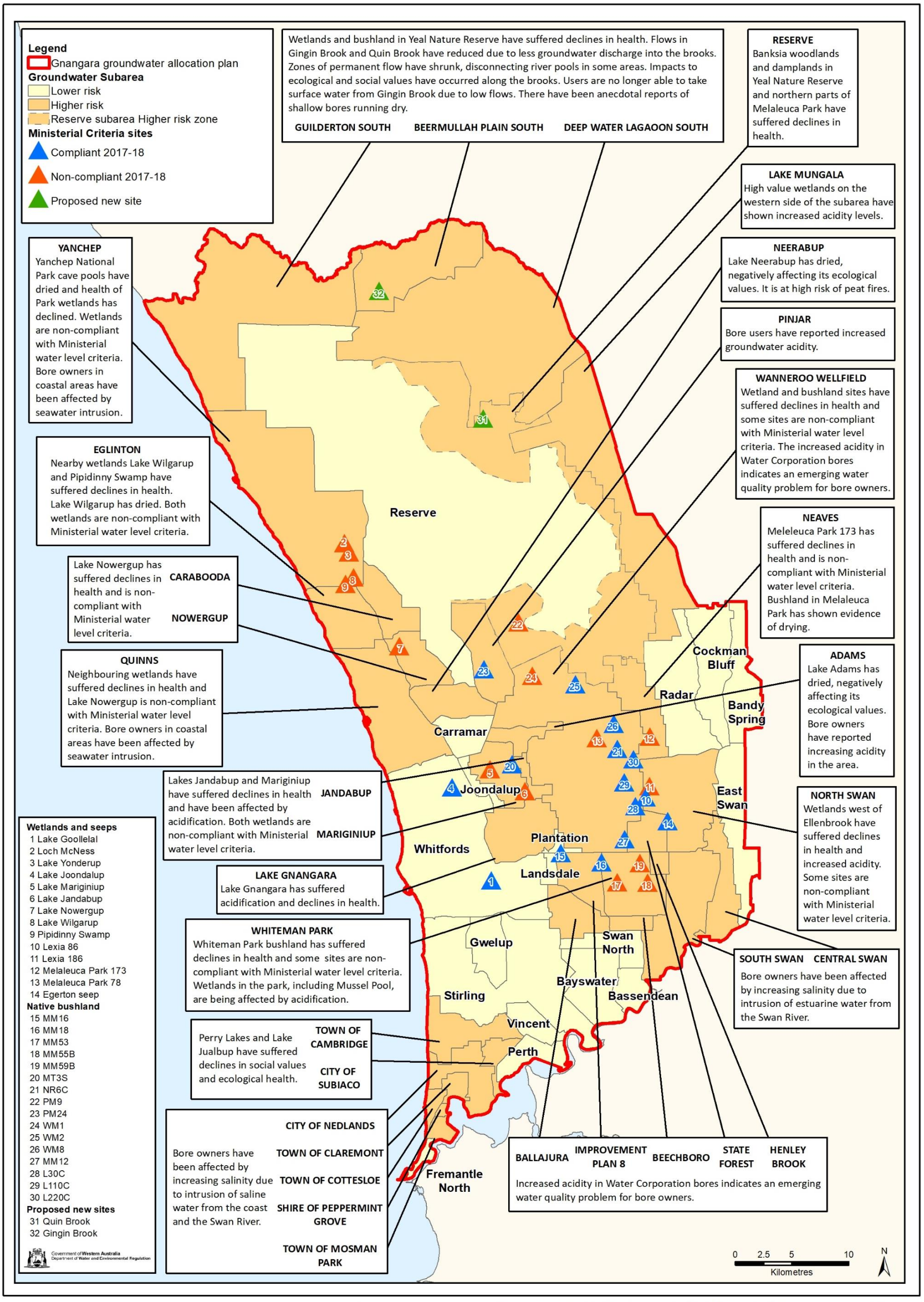


Figure B1 Summary of the impacts on groundwater in each subarea

Appendix C – Allocation limit components

To account for different water uses and administer water licensing, we divide allocation limits into different components. In the Gnangara plan area, we have six components (Figure C1). Five of the components are used for water licensing and one account is used for unlicensed use (water uses exempt from licensing). Not all the components are present in each subarea (see Table 3 and Section 3.2).

The recovery of groundwater injected through managed aquifer recharge operations (such as Water Corporation's groundwater replenishment scheme) is licensed under a managed aquifer recharge component that is outside the allocation limit. The volume and locations of groundwater licensed under the managed aquifer recharge component are linked to the volume and location of the injected water (DWER2021d).

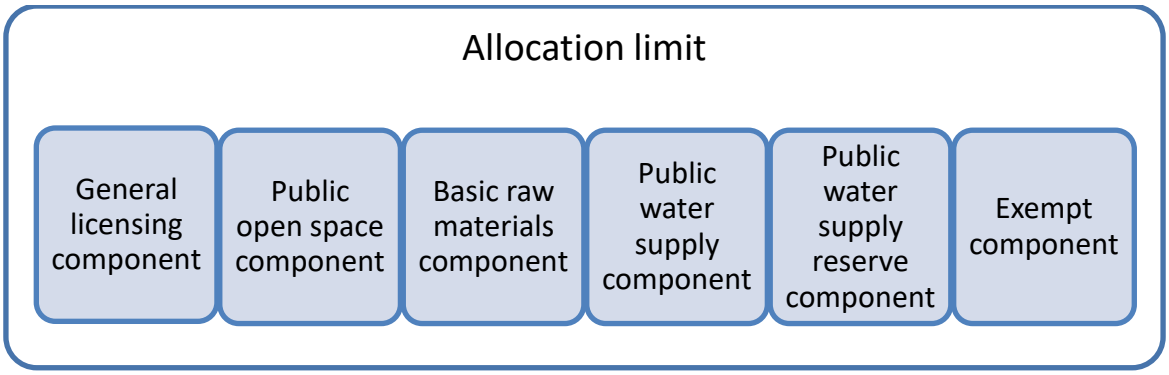


Figure C1 Components of the allocation limit in the Gnangara plan area

General licensing component

The general licensing component is the volume of groundwater that can be licensed for most water uses. In the Gnangara plan area, the general licensing component includes water licensed to:

- growers and other agricultural producers
- local governments for irrigating existing public open spaces, parks and gardens
- schools and other institutions for irrigating ovals and grounds
- sports clubs for irrigating ovals, pitches, grounds and golf courses
- businesses and commercial water users for manufacturing and delivery of services
- mining and construction companies for dust suppression and processing.

Public open space component

The public open space component is the volume of water for licensing the irrigation of new public open spaces in specified locations. This component has been applied in subareas of the three main growth areas in the plan area – the North West and North East urban growth corridors and the area identified as urban expansion in East

Wanneroo. Additional information about these growth areas is provided in Section 5.4 of this plan. A public open space component has also been included in the Wanneroo Wellfield subarea for potential urban development in the South Pinjar development area.

Water from this component is or will be allocated to developers, schools and local governments to establish and irrigate new parks and gardens, sports ovals and public open spaces. The component volume is based on the water required once turf and garden areas have been established (long-term requirements).

Any licence issued for temporary establishment of turf and garden areas will have a reduced licence tenure and include conditions that mean the licence cannot be transferred to other uses or water users and will not be renewed (see Chapter 4 and Table 4 for more information on water licensing for new public open spaces).

Basic raw materials component

The basic raw material component is the volume of water set aside for licensing dust suppression required under the *Environmental Protection Act 1986* during the extraction of basic raw materials, such as limestone and sand (see Chapter 4 and Table 4 for more information on water licensing for basic raw materials).

This component is set for the Superficial aquifer in subareas that overlap areas identified:

- as priority resource locations in *State Planning Policy 2.4 – Basic raw materials* (WAPC 2000)
- as a high priority area shown in the 2018 North East, North West, and Central subregional planning frameworks as part of the *Perth and Peel @ 3.5 million* (DPLH and WAPC 2018)

Public water supply component

The public water supply component is the volume of water licensed for public water supply abstractions. In the Gnangara plan area, the public water supply component accounts for groundwater from all aquifers that is licensed to the Water Corporation for Perth's Integrated Water Supply Scheme and the town water supply system for Woodridge and the Moore River South development.

Public water supply reserve component

Public water supply reserves are the volume of water reserved for planned public water supply needs. These reserves were initially established in the 1980s and 90s and have now either been allocated or impacted by climate change, so have largely been removed from the Gnangara area as part of setting allocation limits for this plan. Public water supply reserves now only remain in the North West urban growth corridor, where water resources are yet to be developed for public supply.

In developing this plan, the department and the Water Corporation reassessed public water supply reserves in the Superficial aquifer along the North West urban growth

corridor. We considered climate change, planned urban developments and risks to nearby wetlands in Yanchep National Park and Lake Nowergup. The total volume reserved decreased from a total of 23.1 GL to 18.1 GL/year, with most of it only being accessible in the northern parts of the Yanchep subarea. Significant investigation and assessment work will be needed to demonstrate the long-term sustainability of these volumes.

Exempt component

Since the previous Gnangara plan (DoW 2009), we have developed ways of accounting for exempt uses within the allocation limit. The exempt component accounts for groundwater used for purposes that do not require a water licence under:

- *Rights in Water and Irrigation Exemption (Section 26C) Order 2011*
- *Rights in Water and Irrigation Exemption (Section 26C) (Dewatering) Order 2010*
- section 52(i) of the Commonwealth Constitution.

This includes water taken by:

- private garden, and stock and domestic bores for domestic purposes
- Commonwealth-owned bores, such as the Department of Defence.

Garden, stock and domestic bores

A large share of water used from the Gnangara groundwater system is from urban garden bores and rural stock and domestic bores. This use is likely to increase as the population grows and urbanisation spreads (Table C1). In urban areas, about one in four households have a garden bore.

Table C1 Current and projected garden, stock and domestic bores

Date of estimated or projected use	Volume kL/year
Estimated use at 2014 Our baseline estimate for garden bore use.	35,950,000
Projected use at 2030 under the current three-days-a-week sprinkler roster (autumn, summer and spring) Our estimate of the volume of garden bore use in the future under the current sprinkler roster. It is based on our 2014 estimate with a 1% a year growth in the installation of bores.	42,802,000
Projected use at 2030 under the proposed two-days-a-week sprinkler roster (autumn, summer and spring) Our estimate of the volume of garden bore use in the future if the garden bore sprinkler roster was aligned with the scheme roster to remove the additional watering day for households with garden bores.	29,215,000

We use the best-available information to estimate exempt uses. This is subject to change over time as we get better information on the rates of instalment and average water use per bore in urban and rural areas. You can find further information on how we calculated levels of exempt use in the *Gnangara groundwater allocation plan methods report* (DWER 2021b).

Good information on the rate of new bore installation in urban areas across Perth is available – data from on-the-ground surveys by the Water Corporation; surveys by the Australian Bureau of Statistics in 2003, 2006 and 2009; and independent phone surveys conducted for us in 2012, 2016 and 2018. This data shows that the rate of garden bore installation has dropped since the bore rebate scheme ended in 2009. The number of urban garden bores is increasing by about 1 per cent a year compared with 2 per cent before 2009. Average water use per bore has also decreased in urban areas because of the three-day sprinkler restrictions for garden bores (from about 800 to 430 kL/year).

Average water use per bore was estimated for our domestic bore metering project (which operated from 2009–2012) and was updated in 2016. The phone surveys conducted in 2016 and 2018 confirmed our assumptions that more bores were being installed across Perth.

Commonwealth exemption

Groundwater abstracted for Department of Defence activities on Commonwealth land is not subject to licensing under the *Rights in Water and Irrigation Act 1914* due to the operation of section 52(i) of the Commonwealth Constitution. A total of 50,000 kL/year accounts for use of the Superficial aquifer in the City of Nedlands subarea.

We have a memorandum of understanding with the Department of Defence and its abstraction is managed according to best practice, through a water resource management operating strategy. The operating strategy is the same as those we apply to licences issued under the *Rights in Water and Irrigation Act 1914* and includes abiding by daytime and winter sprinkler restrictions, implementing best practice irrigation, monitoring groundwater levels and water quality, metering actual levels of use and reporting to us annually.

Appendix D – Legislative requirements

Rights in Water and Irrigation Act 1914

The *Rights in Water and Irrigation Act 1914* (the Act) establishes the legislative framework for managing and allocating water in Western Australia. The Gnangara plan area consists of eight groundwater areas proclaimed under the Act between 1975 and 1996 (see Section 1.2, Figure 1).

Water licences

Water users in the area require a licence under section 5C of the Act to lawfully take groundwater, unless otherwise exempt (see exemptions section below). A licence issued under section 26D of the Act is also required to construct or alter a well (bore) unless exempt. This includes replacing collapsed bores or decommissioning abandoned bores.

When assessing any application to take water, the department does so in accordance with clause 7(2) of Schedule 1 of the Act, any relevant allocation plan and operational policies and guidelines. In granting a new licence, reissuing or renewing a licence, the department may apply terms, conditions and restrictions to the licence under clause 15 of Schedule 1 of the Act.

Our powers under Schedule 1 of the Act also allow the alteration of any licence term, condition or restriction. The rights of licensees are covered under clause 26. A person who is aggrieved by a decision made on a licence application may be able to apply for a review of the decision by the State Administrative Tribunal.

Exemptions

Stock, domestic and garden bore exemptions and use

Under the *Rights in Water and Irrigation Exemption (Section 26C) Order 2011*, some uses of water do not require licensing in proclaimed areas. This applies to water taken from non-artesian wells where:

- the only water that can be taken from the well is from the water table aquifer (the Superficial aquifer in Gnangara); and
- the water is only used for:
  - fire-fighting purposes
  - watering of cattle or stock, other than those raised under intensive conditions
  - garden and lawn irrigation less than 0.2 hectares
  - other ordinary domestic uses.

Groundwater users are responsible for ensuring the groundwater taken is suitable for the proposed use and does not pose any health or environmental risks. We support the Department of Health's advice that bore water should be regularly tested and, if necessary, treated to ensure it is suitable for its intended use. Bore water should never be used for drinking, bathing, filling swimming and paddling pools, food preparation or cooking unless it has been professionally tested and, if necessary, treated.

Dewatering

The *Rights in Water and Irrigation Exemption (Section 26C) (Dewatering) Order 2010* applies in the plan area. Under this exemption order, sections 5C and 26B (3) to (6) of the Act do not apply in relation to a non-artesian (Superficial aquifer) well for dewatering purposes, when:

- the only water that can be taken from the well is from the water table aquifer
- water is taken from the well or excavation solely for removing groundwater to facilitate construction or other activity (that is, dewatering)
- the water is taken at a pump rate not exceeding 10 litres per second over a period of less than 30 consecutive days
- the volume of water taken over the period does not exceed 25,000 kL.

Other exemptions

Certain activities on Commonwealth land are exempt from licensing under the *Rights in Water and Irrigation Act 1914*. Examples of this in the Gnangara plan area include the Irwin and Campbell Barracks in the City of Nedlands.

In addition, under the *Rights in Water and Irrigation Exemption (Section 26C) Order 2012*, a licence is not required to take water from (for sampling), or to construct or alter, a non-artesian well solely used to monitor water levels and/or water quality.

Aligning with other legislation

It is important all licence applicants consult with us to make sure their application complies with other legislation and regulatory processes. We will work with the responsible agencies to streamline the regulatory approvals process.

Appendix E – Monitoring sites

Table F1 Monitoring sites for water levels and water quality in the Superficial and Mirrabooka aquifers

Subarea	Aquifer	Bore name	ID number	Purpose
Gingin groundwater area				
Guilderton South	Superficial	YY10 (I)	61710014	PRAMS modelling reference bore
Beermullah Plain South	Superficial	GB13	61710078	PRAMS modelling reference bore
Deepwater Lagoon South	Superficial	GC4	61710105	PRAMS modelling reference bore
Deepwater Lagoon South	Superficial	GB19	61710098	PRAMS modelling reference bore
Lake Mungala	Superficial	GC14	61610953	PRAMS modelling reference bore
Lake Mungala	Mirrabooka			No sites
Gnangara groundwater area				
Reserve	Superficial	Y60	61710055	PRAMS modelling reference bore
Reserve	Superficial	GC11	61710060	PRAMS modelling reference bore
Reserve	Superficial	YY4(i)	61710046	PRAMS modelling reference bore
Reserve	Superficial	PM28	61610595	Average groundwater level graph
Reserve	Superficial	P300	61610617	Average groundwater level graph
Reserve	Superficial	P320	61610619	Average groundwater level graph
Reserve	Superficial	PM15	61610622	Average groundwater level graph
Reserve	Superficial	PM19	61610644	Average groundwater level graph
Reserve	Superficial	PM17	61610645	Average groundwater level graph
Reserve	Superficial	PM4	61610805	Average groundwater level graph
Reserve	Superficial	PM6	61610756	Average groundwater level graph
Reserve	Superficial	GN30 (I)	61610915	Average groundwater level graph
Wanneroo Wellfield	Superficial	WM2	61610908	PRAMS modelling reference bore
Wanneroo Wellfield	Superficial	JB10A	61610768	Average groundwater level graph
Wanneroo Wellfield	Superficial	JB10B	61610769	Average groundwater level graph
Wanneroo Wellfield	Superficial	WM1	61610833	Average groundwater level graph
Wanneroo Wellfield	Superficial	WM2	61610908	Average groundwater level graph
Wanneroo Wellfield	Superficial	GN12	61610933	Average groundwater level graph
Wanneroo Wellfield	Superficial	GN29 (O)	61610944	Average groundwater level graph
Wanneroo Wellfield	Superficial	GN29 (I)	61610945	Average groundwater level graph
Wanneroo Wellfield	Superficial	WM32	61610978	Average groundwater level graph
Wanneroo Wellfield	Superficial	WM8	61610983	Average groundwater level graph
Wanneroo Wellfield	Superficial	MM12	61610989	Average groundwater level graph
Wanneroo Wellfield	Superficial	L30C	61611010	Average groundwater level graph
Gwelup groundwater area				
Gwelup	Superficial	GM6	61610107	PRAMS modelling reference bore
Gwelup	Mirrabooka			No sites
Mirrabooka groundwater area				
Plantation	Superficial	MM9	61610843	PRAMS modelling reference bore
State Forest	Superficial	GLW7A	61611001	PRAMS modelling reference bore
State Forest	Mirrabooka	MM65	61611006	PRAMS modelling reference bore
Landsdale	Superficial	MM16	61610835	PRAMS modelling reference bore
Landsdale	Superficial	MM16	61610835	Average groundwater level graph

Subarea	Aquifer	Bore name	ID number	Purpose
Improvement Plan 8	Superficial	MM18	61610918	Average groundwater level graph
Whiteman Park	Superficial	MM18	61610918	PRAMS modelling reference bore
Whiteman Park	Superficial	MM53	61610493	Average groundwater level graph
Whiteman Park	Superficial	MM49B	61610525	Average groundwater level graph
Whiteman Park	Superficial	MM55B	61610559	Average groundwater level graph
Whiteman Park	Mirrabooka	MM71A	61618443	PRAMS modelling reference bore
Henley Brook	Superficial			No sites
Henley Brook	Mirrabooka	AM30C	61615096	PRAMS modelling reference bore
Ballajura	Superficial			No sites
Beechboro	Superficial	MM46	61610511	PRAMS modelling reference bore
Beechboro	Mirrabooka	MM46A	61610512	PRAMS modelling reference bore
Perth groundwater area				
Eglinton	Superficial	EL 6-89	61611673	PRAMS modelling reference bore
Eglinton	Superficial	JP15	61610584	Average groundwater level graph
Eglinton	Superficial	JP22	61611092	Water quality (Seawater intrusion)
Eglinton	Superficial	EF 3-89	61611669	Water quality (Seawater intrusion)
Eglinton	Superficial	EF 4-89	61611670	Water quality (Seawater intrusion)
Quinns	Superficial	QJ 17-89	61611656	PRAMS modelling reference bore
Quinns	Superficial	ES 30-89	61611681	Water quality (Seawater intrusion)
Quinns	Superficial	ET 31-89	61611683	Water quality (Seawater intrusion)
Quinns	Superficial	QB 27-89	61611666	Water quality (Seawater intrusion)
Quinns	Superficial	SIM 2-90	61611702	Water quality (Seawater intrusion)
Quinns	Superficial	SIM 9	61611707	Water quality (Seawater intrusion)
Quinns	Superficial	SIM 1-90	61611701	Water quality (Seawater intrusion)
Quinns	Superficial	SIM 3-90	61611703	Water quality (Seawater intrusion)
Quinns	Superficial	SIM 6-90	61611706	Water quality (Seawater intrusion)
Quinns	Superficial	SIM 4-90	61611704	Water quality (Seawater intrusion)
Quinns	Superficial	JP3DA	61615184	Average groundwater level graph
Whitfords	Superficial	WF12	61620111	PRAMS modelling reference bore
Whitfords	Superficial	WH100	61610627	Average groundwater level graph
City of Stirling	Superficial	8525	61610032	PRAMS modelling reference bore
City of Bayswater	Superficial	MM67	61610283	PRAMS modelling reference bore
City of Bayswater	Mirrabooka			No sites
Shire of Swan North	Superficial	649	61610284	PRAMS modelling reference bore
Shire of Swan North	Mirrabooka	MM44A	61610509	PRAMS modelling reference bore
Town of Bassendean	Superficial			No sites
Town of Cambridge	Superficial	GD4	61610006	PRAMS modelling reference bore
Town of Vincent	Superficial			No sites
City of Nedlands	Superficial	8279	61610020	PRAMS modelling reference bore
City of Nedlands	Superficial	GE1	61610016	Water quality and levels (seawater intrusion)
City of Nedlands	Superficial	IF9 (3M)	61611785	Water quality (Salinity)
City of Nedlands	Superficial	IF9 (6M)	61611786	Water quality (Salinity)
City of Nedlands	Superficial	IF9 (9M)	61611787	Water quality (Salinity)
City of Nedlands	Superficial	IF9 (22M)	61611788	Water quality (Salinity)
City of Nedlands	Superficial	IF9 (25M)	61611789	Water quality (Salinity)
City of Nedlands	Superficial	IF9 (29.6M)	61611790	Water quality (Salinity)
City of Nedlands	Superficial	IF8 (3M)	61611779	Water quality (Salinity)

Subarea	Aquifer	Bore name	ID number	Purpose
City of Nedlands	Superficial	IF8 (7M)	61611780	Water quality (Salinity)
City of Nedlands	Superficial	IF8 (10M)	61611781	Water quality (Salinity)
City of Nedlands	Superficial	IF8 (13M)	61611782	Water quality (Salinity)
City of Nedlands	Superficial	IF8 (16M)	61611783	Water quality (Salinity)
City of Nedlands	Superficial	IF8 (21M)	61611784	Water quality (Salinity)
City of Subiaco	Superficial			No sites
City of Perth	Superficial			No sites
Town of Claremont	Superficial	142	61610015	PRAMS modelling reference bore
Town of Claremont	Superficial	IF7 (3M)	61611773	Water quality (Salinity)
Town of Claremont	Superficial	IF7 (8.5M)	61611774	Water quality (Salinity)
Town of Claremont	Superficial	IF7 (14M)	61611775	Water quality (Salinity)
Town of Claremont	Superficial	IF7 (17M)	61611776	Water quality (Salinity)
Town of Claremont	Superficial	IF7 (22M)	61611777	Water quality (Salinity)
Town of Claremont	Superficial	IF7 (25M)	61611778	Water quality (Salinity)
Town of Cottesloe	Superficial	IF16	61611833	PRAMS modelling reference bore
Town of Cottesloe	Superficial	GE2	61610005	Water quality and levels (Seawater intrusion)
Shire of Peppermint Grove	Superficial	IF16 (14M-26M)	61611833	Water quality (Salinity)
Shire of Peppermint Grove	Superficial	IF6 (4M)	61611767	Water quality (Salinity)
Shire of Peppermint Grove	Superficial	IF6 (7M)	61611768	Water quality (Salinity)
Shire of Peppermint Grove	Superficial	IF6 (10M)	61611769	Water quality (Salinity)
Shire of Peppermint Grove	Superficial	IF6 (16M)	61611770	Water quality (Salinity)
Shire of Peppermint Grove	Superficial	IF6 (23M)	61611771	Water quality (Salinity)
Shire of Peppermint Grove	Superficial	IF6 (27M)	61611772	Water quality (Salinity)
Town of Mosman Park	Superficial			No sites
City of Fremantle North	Superficial			No sites
Swan groundwater area				
Neaves	Superficial	NR2C	61611021	PRAMS modelling reference bore
Radar	Superficial	1-98	61618558	PRAMS modelling reference bore
Radar	Superficial	GN24	61611043	Average groundwater level graph
Radar	Mirrabooka			No sites
Cockman Bluff	Superficial			No sites
Bandy Spring	Superficial			No sites
North Swan	Superficial	GNM15	61613214	PRAMS modelling reference bore
North Swan	Superficial	L80A	61611063	Average groundwater level graph
North Swan	Superficial	L80C	61611064	Average groundwater level graph
North Swan	Superficial	L90A	61611075	Average groundwater level graph
North Swan	Superficial	L90C	61611076	Average groundwater level graph
North Swan	Mirrabooka	L132 (1-85)	61611115	PRAMS modelling reference bore
North Swan	Mirrabooka	L50A	61611032	PRAMS modelling reference bore
East Swan	Superficial			No sites
Central Swan	Superficial			No sites

Subarea	Aquifer	Bore name	ID number	Purpose
South Swan	Superficial	MM47A	61610547	PRAMS modelling reference bore
South Swan	Superficial	MM57	61610576	Average groundwater level graph
South Swan	Mirrabooka	14-85	61619614	PRAMS modelling reference bore
Wanneroo groundwater area				
Carabooda	Superficial	CG4-90	61611303	PRAMS modelling reference bore
Nowergup	Superficial	PM33	61610601	PRAMS modelling reference bore
Pinjar	Superficial	PM24	61610697	PRAMS modelling reference bore
Pinjar	Superficial	PM24	61610697	Average groundwater level graph
Neerabup	Superficial	GN19	61610696	PRAMS modelling reference bore
Carramar	Superficial	WM4	61610665	PRAMS modelling reference bore
Adams	Superficial	WM6	61610860	PRAMS modelling reference bore
Adams	Superficial	GN15	61610789	Average groundwater level graph
Adams	Superficial	WM6	61610860	Average groundwater level graph
Mariginiup	Superficial	MT3S	61610745	PRAMS modelling reference bore
Mariginiup	Superficial	MT3I	61610743	Average groundwater level graph
Mariginiup	Superficial	MT3D	61610744	Average groundwater level graph
Mariginiup	Superficial	MT3S	61610745	Average groundwater level graph
Joondalup	Superficial	8281	61610661	PRAMS modelling reference bore
Jandabup	Superficial	JB9C	61610822	PRAMS modelling reference bore
Jandabup	Superficial	JB10A	61610768	Average groundwater level graph
Jandabup	Superficial	JB10B	61610769	Average groundwater level graph
Jandabup	Superficial	JB12B	61610764	Average groundwater level graph
Jandabup	Superficial	JB12C	61610765	Average groundwater level graph
Jandabup	Superficial	JB9A	61610820	Average groundwater level graph
Jandabup	Superficial	JB9C	61610822	Average groundwater level graph
Lake Gnangara	Superficial	8386	61618440	PRAMS modelling reference bore
Yanchep groundwater area				
Yanchep	Superficial	YN5	61612104	PRAMS modelling reference bore
Yanchep	Superficial	TR13	61619464	Water quality (Seawater intrusion)
Yanchep	Superficial	TR7	61619462	Water quality (Seawater intrusion)
Yanchep	Superficial	TR7A	61619463	Water quality (Seawater intrusion)
Yanchep	Superficial	TR4	61619461	Water quality (Seawater intrusion)
Yanchep	Superficial	TR12	61619455	Water quality (Seawater intrusion)
Yanchep	Superficial	TR8	61619406	Water quality (Seawater intrusion)
Yanchep	Superficial	YSI-1	61618603	Water quality (Seawater intrusion)
Yanchep	Superficial	GA33	61710117	Water quality and levels (Seawater intrusion)

Table F2 Monitoring sites for hydraulic pressure levels and water quality in the Leederville and Yarragadee aquifers

Subarea	Aquifer	Bore name	ID number	Purpose
Gingin groundwater area				
SA 3 South	Leederville	AM10A	61715017	PRAMS modelling reference bore
SA 3 South	Leederville	AM6A	61715015	PRAMS modelling reference bore
SA 3 South	Leederville	AM2C	61715033	PRAMS modelling reference bore
SA 3 South	Yarragadee	AM2B	61715046	PRAMS modelling reference bore
SA 3 South	Yarragadee	AM6	61715014	PRAMS modelling reference bore
SA 3 South	Yarragadee	NG9A	61710563	PRAMS modelling reference bore
Gnangara groundwater area				
Gnangara Confined	Leederville	AM13A	61715005	PRAMS modelling reference bore
Gnangara Confined	Leederville	AM25	61615089	PRAMS modelling reference bore
Gnangara Confined	Leederville	AM17A	61615067	PRAMS modelling reference bore
Gnangara Confined	Leederville	AM22A	61615088	PRAMS modelling reference bore
Gnangara Confined	Yarragadee	AM17	61615066	PRAMS modelling reference bore
Gnangara Confined	Yarragadee	AM25A	61615108	PRAMS modelling reference bore
Gnangara Confined	Yarragadee	AM5	61715008	PRAMS modelling reference bore
Gwelup groundwater area				
Gwelup Confined	Leederville	AM36A	61615011	PRAMS modelling reference bore
Gwelup Confined	Yarragadee	AM36	61615012	PRAMS modelling reference bore
Mirrabooka groundwater area				
Mirrabooka Confined	Leederville	AM34	61615040	PRAMS modelling reference bore
Mirrabooka Confined	Yarragadee	AM30Y	61615127	PRAMS modelling reference bore
Perth groundwater area				
Perth North Confined	Leederville	AM27A	61615064	PRAMS modelling reference bore
Perth North Confined	Leederville	AM20A	61615060	PRAMS modelling reference bore
Perth North Confined	Yarragadee	AM27	61615063	PRAMS modelling reference bore
Perth North Confined	Yarragadee	AM20	61615059	PRAMS modelling reference bore
Perth North Confined	Yarragadee	AM75	61615179	Water quality (Seawater intrusion)
Swan groundwater area				
Swan Confined	Leederville	AM29A	61615098	PRAMS modelling reference bore
Swan Confined	Yarragadee	AM29	61615097	PRAMS modelling reference bore
Wanneroo groundwater area				
Wanneroo Confined	Leederville	AM24A	61615077	PRAMS modelling reference bore
Wanneroo Confined	Yarragadee	AM21	61615071	PRAMS modelling reference bore
Yanchep groundwater area				
Yanchep Confined	Leederville	AM12	61715019	PRAMS modelling reference bore
Yanchep Confined	Yarragadee	–	–	–

Table F3 Ecological monitoring sites – Ministerial criteria sites

Site name	Surface water/ groundwater (AWRC ref.)	Monitoring				
		Wetland vegetation	Macroinvertebrate and water quality	Mound springs macroinvertebrate and water quality	Frogs	Terrestrial vegetation
Lake Goollelal/ GSS 48, GSS 49	6162517 (staff 459) 61610112 (bore 459)	Triennial	Annual	–	Annual (aural)	–
Loch McNess	6162564 (staff 8754) 61640108 (bore BH-LM2)	Annual	Annual	–	–	–
Lake Yonderup	6162565 (staff 8780) 61611840 (bore YDP_SC)	Annual	Annual	–	–	–
Lake Joondalup/ GSS 46, GSS 47	6162572 (staff 8281) 61610661 (bore 8281)	Triennial	Annual	–	Annual (aural)	Triennial
Lake Mariginiup	6162577 (staff 1943) 61610685 (bore MS10)	Triennial	Annual (water quality) Triennial (macroinvertebrates)	–	–	–
Lake Jandabup/ GSS 44/ West Gironde	6162578 (staff 1944) 61610765 (bore JB12B)	Annual	Annual	–	Annual (pit trapping and aural)	Triennial
Lake Nowergup	6162567 (staff 8756) 61611247 (bore LN2-89)	Annual	Annual	–	–	Triennial
Lexia 86 (GMN16)	61613215 (bore GMN16)	Annual	–	–	Annual (pit trapping and aural)	–
Lexia 186 (Emu Sump GNM15)/ Maralla	61613214 (bore GNM15)	Triennial	–	–	Annual (aural)	Triennial
Melaleuca Park EPP173 (GNM14)/ NV01	6162628 (staff) 61613213 (bore GNM14)	Annual	Annual	–	Annual (pit trapping and aural)	–
Melaleuca Park Dampland 78 (GNM31)	61613231 (bore GNM31)	Triennial	–	–	–	–
Egerton Spring (B25, B25A)	61618607 (bore B25)	–	–	Annual	–	–
WM2/GSS25a	61610908 (bore WM2)	–	–	–	Annual (pit trapping and aural)	–

Table F4 Ecological monitoring sites – other sites

Site name	Surface water/ groundwater (AWRC ref.)	Monitoring				
		Wetland vegetation	Macroinvertebrate and water quality	Mound springs macroinvertebrate and water quality	Frogs	Terrestrial vegetation
Lake Gwelup	6162504 (staff 465) 61611876 (bore GLP_EC)	–	Triennial	–	–	–
Lake Gnangara	6162597 (staff 8386) 61618440 (bore 8386)	–	Annual (water quality)	–	–	–
Yeal Lake/ GSS 6	6171326 (staff YL_SG) 6171330 (staff YL_SG2) 61710494 (bore YL_c) 61710097 (bore GB22)	–	Triennial	–	Annual (aural)	–
Lake Bambun	6171322 (staff BBN_SG) 61710483 (bore BBN_Wc)	–	Triennial	–	–	–
Quin Brook/GSS 5	61710480 (bore CYW_C) 61710589 (bore QUNWc)	–	–	–	Annual (aural)	–
Sue's Spring/ Alpaca Spring	61611043 (GN24)	–	–	Annual	–	–
Gaston Road Spring	61611043 (GN24)	–	–	Annual	–	–
Edgecombe Seepage	61618606 (B10)	–	–	Annual	–	–
PM4 (High Hill Road East)/ Bombing Range	61611861 (bore HHW_EC) 61610868 (bore PM3) PM4 (AWRC ref. 61610805)	–	–	–	–	Triennial
Bell	61613201 (bore GNM2) 61613215 (bore GNM16)	–	–	–	–	Triennial
Melaleuca	61613231 (bore GNM31)	–	–	–	–	Triennial
Neaves	61613225 (bore WM6)	–	–	–	–	Triennial
P50	61610804 (bore PM9)	–	–	–	–	Triennial
Ridges	61613210 (bore GNM11A) 61613210 (bore GA3)	–	–	–	–	Triennial
South Kendall	61618440 (bore 8386)	–	–	–	–	Triennial
Tangletoe	61710078 (bore GB13)	–	–	–	–	Triennial
Tick Flat	61710065 (bore GA22)	–	–	–	–	Triennial
Whiteman Park	61610493 (bore MM53)	–	–	–	–	Triennial
Yanchep	61612105 (bore YN6) 61612106 (bore YN7)	–	–	–	–	Triennial
Yeal	61710053 (bore GA10)	–	–	–	–	Triennial
Neaves Road Nature Reserve/GSS 36		–	–	–	Annual (pit trapping and aural)	–
Tuscany Park/GSS 41		–	–	–	Annual (aural)	–

Appendix F – Proposed ecological threshold levels

Table G1 *Proposed ecological threshold levels at groundwater-dependent ecosystems in the plan area (sites with proposed changes to current water level criteria set under the* Environmental Protection Act 1986 *are shown in red text).*

Site name	Site management objectives	Bore or staff gauge where criteria and threshold are measured (*primary measurement site)	Current absolute minimum criteria under EP Act 1986	Threshold level mAHD
Lake Goollelal	*1b) Maintain health* Maintain groundwater levels to: • maintain permanent surface water for fauna habitat and visual amenity • maintain fringing vegetation • minimise risk of acidification and nuisance midge proliferation.	6162517 (staff 459)	26.0	26.4
Loch McNess	*1b) Improve health* Improve groundwater levels to: • increase surface area of permanent water for fauna habitat and visual amenity • maintain healthy, intact fringing vegetation • maintain diverse habitat types and excellent water quality.	6162564 (staff 8754)	6.95	6.2
Lake Yonderup	*1b) Improve health* Improve groundwater levels to: • increase surface area of permanent water for fauna habitat • maintain intact, undisturbed fringing vegetation • maintain diverse habitat types and excellent water quality.	6162565 (staff 8780)	5.9	5.7
Lake Joondalup	*1b) Maintain health* Maintain groundwater levels to: • maintain permanent water for fauna habitat and for visual amenity • maintain diverse aquatic plants and fringing vegetation • minimise risk of acidification.	6162572 (staff 8281)* [61610661 (bore 8281)	15.8	16.2
Lake Mariginiup	*1b) Improve health* Improve groundwater levels to: • increase wading bird habitat • maintain the rich aquatic macroinvertebrate community • reduce lake acidity to beneficial levels for fauna.	6162577 (staff 1943)* 61610685 (bore MS10)	41.5 (minimum peak)	42.1 (minimum peak)
Lake Jandabup	*1b) Improve health* Improve groundwater levels to: • increase wading bird habitat • maintain the rich aquatic macroinvertebrate community • minimise risk of acidification.	6162578 (staff 1944)	44.2 (minimum peak)	Remove criteria
		6162578 (staff 1944)	44.3	44.3
Lake Nowergup	*1b) Improve health* Improve groundwater levels to: • increase area of permanent deep-water habitat for fauna • maintain fringing vegetation to support macroinvertebrate diversity and nutrient retention.	6162567 (staff 8756)	16.8 (minimum peak)	16.0 (absolute minimum)
Lake Wilgarup	*1b) Improve health* Improve groundwater levels to maintain soil moisture and minimise risk of acidification.	61618500 (Wilgarup Lake bore)	4.5	3.2
Pipidinny Swamp	*1b) Improve health* Improve groundwater levels to: • increase area of water habitat for fauna • maintain fringing vegetation to support a range of habitat types for macroinvertebrates.	6162624 (staff)* 61611872 (bore PIP_C)	1.6	1.1
Lexia 86	*1b) Maintain health* Maintain groundwater levels to maintain fringing vegetation to support a range of habitat types for macroinvertebrates and vertebrates.	61613215 (bore GNM16)	47.0	47.0
Lexia 186	*1b) Maintain health* Maintain fringing and wetland vegetation to support a range of habitat types.	61613214 (bore GNM15)	47.2	47.0
Melaleuca Park 173	*2) Manage declines in groundwater levels to reduce risk to ecological health* Limit declines in health of fringing and wetland vegetation to support a range of habitat types.	61613213 (bore GNM14)* [6162628 (staff)	50.2	49.0
Melaleuca Park 78	*2) Manage declines in Superficial groundwater levels to reduce risk to ecological health* Limit declines in health of wetland vegetation.	61613231 (bore GNM31)	65.1	65.5 (minimum peak)
Egerton Seepage	*1b) Maintain health* To maintain the mound spring threatened ecological community (EG01), intact fringing vegetation and invertebrate habitat.	61618607 (bore B25) 61672233 (B25A – replacement bore for B25)*	39.3	39.3
MM16 Whiteman Park West	*1b) Maintain health* Maintain or improve the condition of intact dependent vegetation and threatened Banksia woodland community (SCP 20a).	61610835 (bore MM16)	38.8	38.8
MM18 Whiteman Park Central	*1b) Maintain health* Maintain or improve the condition of intact dependent vegetation and potential Banksia woodland threatened community.	61610918 (bore MM18)	38.6	38.6
MM53 Whiteman Park Central	*1b) Improve health* Improve groundwater levels to improve the condition of intact dependent vegetation and potential Banksia woodland threatened community.	61610493 (bore MM53)	33.3	33.3
MM55B Whiteman Park East	*1b) Improve health* Improve groundwater levels to improve the condition of dependent Melaleuca woodland.	61610559 (bore MM55B)	29.5	29.5
MM59B Whiteman Park East	*1b) Improve health* Improve groundwater levels to improve the condition of dependent vegetation and potential Banksia woodland threatened community.	61611025 (bore MM59B)	36.3	36.2
MT3S East Wanneroo	*1b) Maintain health* Maintain groundwater levels to maintain or improve the condition of intact dependent vegetation and potential Banksia woodland threatened community.	61610745 (bore MT3S)	43.0	43.0

Site name	Site management objectives	Bore or staff gauge where criteria and threshold are measured (*primary measurement site)	Current absolute minimum criteria under EP Act 1986	Threshold level mAHD
NR6C Melaleuca Park	*1b) Maintain health* Maintain or improve the condition of intact dependent vegetation and potential Banksia woodland threatened community.	61610982 (bore NR6C)	58.5	58.5
PM9 Pinjar North		61610804 (bore PM9)	56.3	Remove criteria
PM24 Lake Pinjar	*1b) Maintain health* To maintain or improve the condition of regionally significant bushland, including Pinjar vegetation complex.	61610697 (bore PM24)	40.5	40.5
WM1 Pinjar	*2) Manage declines in Superficial groundwater levels to reduce risk to ecological health* To avoid significant impacts to habitat values of the Banksia woodland community as it transitions to be less groundwater-dependent	61610833 (bore WM1)	55.7	53.7
WM2 Melaleuca Park North	*2) Manage declines in Superficial groundwater levels to reduce risk to ecological health* To avoid significant impacts to habitat values of the Banksia woodland community as it transitions to be less groundwater-dependent	61610908 (bore WM2)	66.5	64.7
WM8 Melaleuca Park	*2) Manage declines in Superficial groundwater levels to reduce risk to ecological health* To avoid significant impacts to habitat values of the Banksia woodland community as it transitions to be less groundwater-dependent	61610983 (bore WM8)	64.8	63.7
MM12 Lexia	*1b) Maintain health* Maintain or improve the condition of intact dependent vegetation and potential Banksia woodland threatened community.	61610989 (bore MM12)	42.0	42.0
L30C Lexia	*1b) Maintain health* Maintain or improve the condition of intact dependent vegetation and potential Banksia woodland threatened community	61611010 (bore L30C)	47.2	47.2
L110C Lexia	*1b) Maintain health* Maintain or improve the condition of intact dependent vegetation and potential Banksia woodland threatened community.	61611011 (bore L110C	55.7	55.7
L220C Melaleuca Park South	*1b) Maintain health* Maintain or improve the condition of intact dependent vegetation and potential Banksia woodland threatened community.	61611018 (bore L220C)	52.2	52.2
Quin Brook	To be confirmed in the Gingin water allocation plan (draft expected by 2025).	61710060 (bore GC11)		55.0
Gingin Brook	To be confirmed in the Gingin water allocation plan (draft expected by 2025).	61710078 (bore GB13)		37.3

Appendix G – Map information

Datum and projection information

Vertical datum: Australian Height Datum (AHD)

Horizontal datum: Geocentric Datum of Australia 94

Projection: MGA 94 Zone 50

Spheroid: Australian National Spheroid

Project information

Client: Emily Harrington

Map author: Hisayo Thornton

File path: J:\gisprojects\Project\330\80000_89999\33 08440_WAP\00074_GnangaraPlan2018

Compilation date: October 2018 – April 2019

Disclaimer

These maps are a product of the Department of Water and Environmental Regulation, Water Assessment and Allocation Division. These maps were produced with the intent that they be used for information purposes at the scale as shown when printed.

While we have made all reasonable efforts to ensure the accuracy of this data, we accept no responsibility for any inaccuracies and persons relying on this data do so at their own risk.

Sources

We acknowledge the following datasets and their custodians in the production of this map:

Acidity Risk Zone – DWER 2018

Allocation plan areas – DWER 2016

Aquifer Connectivity – DWER 2015

Bush Forever – DPLH 2018

Cadastre – Landgate 2018

Darling Fault – DWER 2005

DBCA Legislated Lands and Waters – DBCA 2018

Geomorphic Wetlands – DBCA 2018

Gnangara Jandakot Significant GDEs – DWER 2018

Groundwater monitoring bores – DWER 2018

Groundwater areas – DWER 2018

Groundwater subareas – DWER 2018

Imagery – Landgate 2016

Rivers – Geoscience Australia 2001

Seawater Intrusion Zone – DWER 2018

Sprinkler Restrictions – Water Agencies (Water Use) Bylaws – DWER 2012

Towns – Western Australia – DWER 2013

Urban expansion area – DPLH 2018

WA Coastline – DWER 2000

Water level change data – DWER 2019

WIN Sites – DWER 2018

WIN Sites – Ministerial Criteria – DWER 2005

Yeal Nature Reserve Banksia TEC reserve – DWER 2017

Shortened forms

AHD	Australian height datum
BoM	Bureau of Meteorology
CMIP3	Coupled Model Intercomparison Project Phase 3
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cwlth	Commonwealth of Australia
DBCA	Department of Biodiversity, Conservation and Attractions
DEC	Department of Environment and Conservation (now Department of Biodiversity, Conservation and Attractions)
DECR	Department of Environment and Conservation Regulation
DER	Department of Environmental Regulation (now DWER)
DoW	Department of Water (now DWER)
DPC	Department of the Premier and Cabinet
DPIRD	Department of Primary Industries and Regional Development
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
EPA	Environmental Protection Authority
GDE	Groundwater-dependent ecosystem
GL	Gigalitre
IWSS	Integrated Water Supply Scheme
PRAMS	Perth regional aquifer modelling system
PRCAC	Perth regional confined aquifer capacity study
RIWI	Rights in Water and Irrigation
SWALSC	South West Aboriginal Land and Sea Council
TEC	Threatened ecological community
WA	Western Australia
WAPC	Western Australian Planning Commission
WWF	World Wildlife Fund
WIN	Water Information Network
WRC	Water and Rivers Commission

Volumes of water

One litre	1 litre	1 litre	(L)
One thousand litres	1000 litres	1 kilolitre	(kL)
One million litres	1 000 000 litres	1 Megalitre	(ML)
One thousand million litres	1 000 000 000 litres	1 Gigalitre	(GL)

Glossary

Commonly used terms in relation to water resource management in the plan area are listed below.

Abstraction	Withdrawal of water from any groundwater source of supply.
Acid sulfate soils	Sediments that contain sulfuric acid stored below the watertable (and in wetlands) as the mineral pyrite that is released and starts to leach when exposed to air.
Allocation limit	Annual volume of water set aside for use from a water resource.
Ecological values	The natural ecological processes occurring within water-dependent ecosystems and the biodiversity of these systems.
Groundwater area	The boundaries proclaimed under the *Rights in Water and Irrigation Act 1914* (WA) and used for water allocation planning and management.
Groundwater-dependent ecosystem	An ecosystem that is at least partially dependent on groundwater for its existence and health.
Licence (or licensed entitlement)	A formal permit which entitles the licensee to take water from a watercourse, wetland or underground source under the *Rights in Water and Irrigation Act 1914.*
Metering	Refers to the measurement of water that is taken from a water resource using a water meter.
Non-artesian well or bore	A well, including all associated works, from which water does not flow, or has not flowed, naturally to the surface but has to be raised, or has been raised, by pumping or other artificial means.
Over-allocation	A situation where licensed water entitlements, together with exempt uses and public water supply reserves, exceed the allocation limit set for a water resource.
Over-abstraction	A situation where the total volume of water actually abstracted by licensed and exempt water users exceeds the allocation limit set for a water resource.
Public water supply	Water taken by public water suppliers to supply water to homes and businesses, generally at drinking water quality and through a metropolitan or town water supply scheme.
Public water supply reserve	The volume of water reserved for planned public water supply needs.
Recharge	Water that infiltrates into the soil to replenish an aquifer.

Saline water intrusion	An increase in the area where dense salty water from the ocean, along our coastlines and saline parts of rivers, has reached into the bottom of the aquifer.
Self-supply water use (private use)	Water diverted from a source by a private individual, company, or public body for their own individual requirements.
State Agreement	A State Agreement is a legal contract between the Western Australian Government and an applicant of a major project within the boundaries of Western Australia. State Agreements detail the rights, obligations, terms, and conditions for the development of the specific project. In some circumstances the agreement contains clauses regarding water supply and this can affect what is required under the *Rights in Water and Irrigation Act 1914*.
Subarea	A subdivision, within a surface or groundwater area, defined to better manage water allocation. Subarea boundaries are not proclaimed and can therefore be amended without being gazetted.
Temporary licence	A licence issued under section 5C of the *Rights in Water and Irrigation Act 1914* for a duration shorter than the maximum 10 years for a temporary use. Justification for a temporary licence may include type of works and risk to resource.
Unused water entitlement	That part, or all, of a licensed annual water entitlement that has not been taken for three consecutive years. For the Gnangara plan area, the department will calculate the amount of unused water as the annual water entitlement less the recorded peak water use, where peak water use is the largest recorded volume used during the previous three years.
Vegetation hydrotype	A grouping of plants based on their ‘water tolerance’ and determined by where they are found in the landscape in relation to topography and groundwater depth (Sommer & Froend 2010).
Water level criteria	Water levels and thresholds committed to as conditions set under the *Environmental Protection Act 1986* in Ministerial Statement no. 819 (Environmental Protection Authority 2009).

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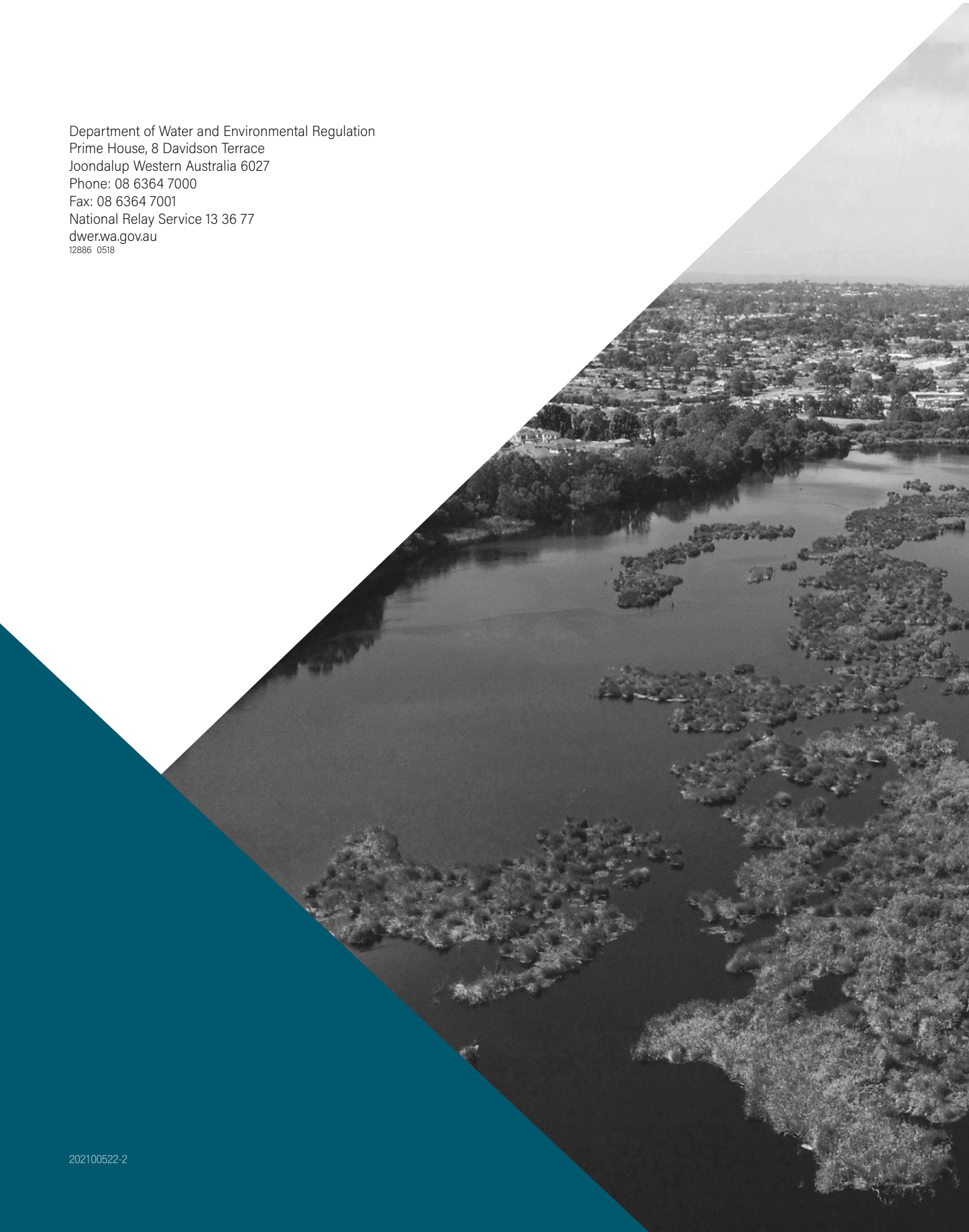

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