



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

Greenbushes Catchment Area

drinking water source protection review



Water resource protection series
Report WRP186
June 2019

Greenbushes Catchment Area drinking water source protection review

Department of Water and Environmental Regulation

Water resource protection series

Report no. 186

June 2019

Department of Water and Environmental Regulation
Prime House, 8 Davidson Terrace
Joondalup Western Australia 6027
Telephone +61 8 6364 7000
Facsimile +61 8 6364 7001
National Relay Service 13 36 77
www.dwer.wa.gov.au

© Government of Western Australia

June 2019

This work is copyright. You may download, display, print and reproduce this material in unaltered form only (retaining this notice) for your personal, non-commercial use or use within your organisation. Apart from any use as permitted under the *Copyright Act 1968*, all other rights are reserved. Requests and inquiries concerning reproduction and rights should be addressed to the Department of Water and Environmental Regulation.

ISSN 1835-3924 (online)

FIRST 115401

Acknowledgements

The following people contributed to this publication: Vivien Claughton, Brendan Kelly, Andrew Watson and Stephen Watson (DWER); and Louise Holbrook, Emma Plant and Steve Collins (Water Corporation).

For more information about this report, contact the Water Source Protection Planning team on +61 8 6364 7000 or drinkingwater@dwer.wa.gov.au

Cover photograph: Aerial photo of Greenbushes Catchment Area

Disclaimer

This document has been published by the Department of Water and Environmental Regulation. Any representation, statement, opinion or advice expressed or implied in this publication is made in good faith and on the basis that the Department of Water and Environmental Regulation and its employees are not liable for any damage or loss whatsoever which may occur as a result of action taken or not taken, as the case may be in respect of any representation, statement, opinion or advice referred to herein. Professional advice should be obtained before applying the information contained in this document to particular circumstances.

This publication is available at our website www.dwer.wa.gov.au or for those with special needs it can be made available in alternative formats such as audio, large print or Braille

Contents

Summary	v
1 Review of Greenbushes Catchment Area drinking water source protection assessment	1
1.1 Boundary, priority areas and protection zones.....	1
1.2 Water supply scheme	1
Licence to take water.....	1
1.3 Physical environment	2
1.4 How is this drinking water source currently protected?.....	2
Risk management.....	2
Local planning scheme.....	3
Legislation	3
Recreation policy	3
1.5 Native title claims.....	4
1.6 Update on water quality risks	4
1.7 Water quality information.....	9
2 Recommendation	10
Appendices.....	11
Appendix A — Figures.....	11
Appendix B — Water quality data	16
Appendix C — Photographs.....	20
Appendix D — Typical contamination risks in surface water	23
Microbiological risks.....	23
Physical risks	24
Chemical risks	25
Appendix E — Understanding risks to drinking water quality	26
Shortened forms	28
Glossary	30
References	33
Further reading	35

Tables

Table 1	Key information about the Greenbushes Catchment Area	v
---------	--	---

Summary

This drinking water source protection review considers changes that have occurred in and around the Greenbushes Catchment Area since the 2004 *Greenbushes Catchment Area drinking water source protection assessment* (Water Corporation 2004) was released.

The most significant change is that Greenbushes' drinking water supply is now sourced from the Water Corporation's Warren–Blackwood Regional Water Supply Scheme.

After considering advice from key stakeholders and given that this catchment is no longer being used for drinking water, the Department of Water and Environmental Regulation (DWER) is proposing to abolish the Greenbushes Catchment Area under the *Country Areas Water Supply Act 1947*. If this occurs, water from this catchment could still be used for other non-drinking water uses, such as irrigation or recreation.

Dumpling Gully Dam 1 and Dam 2 collectively form the Greenbushes Catchment Area, which was gazetted in 1974 under the *Country Areas Water Supply Act 1947* to protect it as a source of drinking water.

In early 2017, the Water Corporation stopped using Dumpling Gully Dam 1 and Dam 2 to supply drinking water to Greenbushes due to water quality issues. This included regular *Escherichia coli* recordings as shown in samples taken from 2013 to 2018 where *E.coli* was recorded in 53 per cent of samples from dam 1 and in 77 per cent of samples from dam 2. The Greenbushes Catchment Area is an example of how a water source can be rendered unsuitable for drinking water supply when activities and land uses are not managed appropriately.

DWER prepared this document in consultation with key stakeholders:

- Department of Biodiversity Conservation and Attractions (DBCA)
- Department of Planning Lands and Heritage
- Water Corporation
- South West Aboriginal Land and Sea Council
- Shire of Bridgetown-Greenbushes.

Important information about the Greenbushes Catchment Area is in Table 1.

Table 1 Key information about the Greenbushes Catchment Area

Greenbushes Catchment Area	
Local government	Shire of Bridgetown-Greenbushes
Location supplied	None Previously town of Greenbushes

Greenbushes Catchment Area	
Water service provider to the town	Water Corporation
Dam capacities	Dumpling Gully Dam 1 has a capacity of 95 megalitres (ML) Dumpling Gully Dam 2 has a capacity of 98 ML
Licensed abstraction	None Previously, the Water Corporation held a licence to abstract 170 000 kilolitres per year (kL/yr)
Date of dams completion	Dumpling Gully Dam 1 was completed in 1962 Dumpling Gully Dam 2 was completed in 1987
Date/s of drinking water source protection reports	2004 – <i>Greenbushes Catchment Area drinking water source protection assessment</i> (Water Corporation) 2019 – <i>Greenbushes Catchment Area drinking water source protection review</i> published (this document)
Consultation	2018–19 – consultation with key stakeholders, including the Shire of Greenbushes-Bridgetown, Water Corporation, South West Aboriginal Land and Sea Council and the Department of Biodiversity Conservation and Attractions
Gazettal history	Gazetted on 10 May 1974 under the <i>Country Areas Water Supply Act 1947</i> DWER is proposing to abolish the Greenbushes Catchment Area
Reference documents	<i>Australian drinking water guidelines</i> (NHMRC & NRMCC 2011) State planning policy no. 2.7: <i>Public drinking water source policy</i> (Western Australian Planning Commission 2003)

1 Review of Greenbushes Catchment Area drinking water source protection assessment

1.1 Boundary, priority areas and protection zones

The Greenbushes Catchment Area was gazetted on 10 May 1974 under the *Country Areas Water Supply Act 1947* to protect it as a source of drinking water. The catchment was not assigned priority areas or protection zones, but the Department of Water and Environmental Regulation (DWER) manages it in accordance with our current policy, which states that Crown land is priority 1 and private land is priority 2 or 3.

The 2004 *Greenbushes Catchment Area drinking water source protection assessment* (Water Corporation) recommended a reduced boundary based on a hydrological assessment. Both the 1974 gazetted boundary and 2004 proposed reduced boundary are shown in Figure A2.

The Greenbushes Catchment Area is no longer used for drinking water supply (see section 1.2). Given this and advice from key stakeholders, DWER is proposing to abolish the Greenbushes Catchment Area under the *Country Areas Water Supply Act 1947* (see recommendation in section 2). If it is abolished, this would mean that by-laws for drinking water source protection would no longer apply, and the catchment could be used for a greater variety of land uses and activities (subject to relevant approvals).

1.2 Water supply scheme

The Water Corporation now supplies Greenbushes with drinking water from the Warren–Blackwood Regional Water Supply Scheme, which consists of nine surface water sources and one groundwater bore. Up until early 2017, Greenbushes was supplied from Dumpling Gully dams 1 and 2, with supplementation from Mt Jones Dam and mine voids. However, due to water quality issues, these sources stopped being used and the tanks have been decommissioned (see Figure C4).

Water Corporation is considering the future management of Dumpling Gully dams 1 and 2, including possible options for transferring management to the Shire of Bridgetown-Greenbushes. This would allow the water to be used for non-drinking purposes such as irrigation or recreation. This was considered in the department's decision to propose the abolition of the Greenbushes Catchment Area.

Licence to take water

The Greenbushes Catchment Area is located within the Norilup Brook Surface Water Subarea which is proclaimed under the *Rights in Water and Irrigation Act 1914*. The department licenses water abstraction under this act.

The Water Corporation was licensed to abstract 170 000 kL of water per year for public water supply until 31 December 2022. However, the Water Corporation ceased to take water from this resource in early 2017.

If the Water Corporation transfers its infrastructure and assets in the Greenbushes Catchment Area to another party, this will not automatically mean that the licence to take water from the dams will also be transferred. Any other party intending to use the dams will need to apply for a licence from the department to take water.

1.3 Physical environment

The Greenbushes Catchment Area is located within the undulating Yilgarn Craton. Soils are generally gravels, with pale orange soils, occasional block laterite outcrops and sandy loams in some elevated areas. In deeper valleys, soils are heavier alluvials.

The catchment area contains forested areas consisting of jarrah and marri as well as wetland vegetation.

The catchment includes a number of disused mine voids of varying depths which are also used for water storage.

1.4 How is this drinking water source currently protected?

Risk management

Public drinking water source area (PDWSA) management is the first step in protecting water quality and ensuring a safe drinking water supply. Although treatment and disinfection are essential barriers against contamination, catchment protection is the most important, as advocated by the *Australian drinking water guidelines* (ADWG; NHMRC & NRMCC 2011). The ADWG is based on preventing risks and installing multiple barriers for providing safe drinking water to consumers. This combination of catchment protection and water treatment delivers a safer, more reliable and lower cost drinking water to consumers than either approach could achieve individually.

This approach was not appropriately implemented within the Greenbushes Catchment Area, as can be observed from increased water quality and public health risks. Ongoing evidence of these increased risks led the Water Corporation to deem the source as no longer appropriate for drinking water.

This situation demonstrates how important it is to protect drinking water sources as a key part of the multiple barrier approach in the ADWG.

For more information on how DWER protects PDWSAs and our preventive risk management approach, read Appendix E.

Local planning scheme

The department recommends that PDWSAs are recognised as special control areas in planning schemes so that drinking water quality and public health are considered in land use planning decisions. The Shire of Bridgetown-Greenbushes *Town planning scheme no. 4* (Department of Planning, Lands and Heritage 2018) does not recognise the Greenbushes Dam Catchment Area as a special control area, however as the department is proposing to abolish this catchment, it will not need to be recognised in the scheme.

Until it is abolished, the types of development supported in the catchment by the shire should be guided by the department's Water quality protection note (WQPN) no.25: *Land use compatibility in public drinking water source areas*.

Legislation

Under the *Country Areas Water Supply Act 1947* by-laws exist to protect drinking water sources. However, the department has found through this review that surveillance and enforcement of the by-laws were not sufficient to protect this source from activities that were causing water quality impacts and posing a significant public health risk.

Recreation policy

The department's Operational policy 13: *Recreation within public drinking water source areas on Crown land* outlines how to manage recreation activities and facilities within PDWSAs on Crown land, such as state forest. This policy applies to the state forest and other Crown land within the Greenbushes Catchment Area.

The policy's intent is to protect drinking water quality and public health by managing recreation. It aims to deliver a consistent, equitable and integrated approach to recreation management in PDWSAs on Crown land and increase awareness of public health, water quality protection and recreation matters.

The policy applies to the reservoir protection zone (RPZ) and outer catchment of a PDWSA and defines where and what types of recreation can occur. Within RPZs, the policy prohibits public access consistent with legislation and other department policies, (except on public roads), however there is no defined RPZ in the Greenbushes Catchment Area. Given the proposal to abolish this PDWSA there is no plan to define one.

The policy supports existing, approved recreation facilities. New and enhanced recreation should be developed outside PDWSAs. Within the Greenbushes Catchment Area there are a number of existing approved trails as described in Section 1.6.

If the Greenbushes Catchment Area is abolished, this policy will no longer apply.

1.5 Native title claims

Native title is the recognition in Australian law that some Aboriginal people continue to hold native title rights and interests in lands and waters.

The Greenbushes Catchment Area lies within the Wagyl Kaip Southern Noongar, Gnaala Karla Booja and South West Boojarah #2 claim areas. These three claims are all within the South West Settlement Area (see Figure A5).

The State Government of Western Australia and the Noongar native title claimants have negotiated a South West Native Title Settlement. This settlement recognises the Noongar people as the traditional owners of land in the South West Settlement Area, which includes the Greenbushes Catchment Area.

The settlement includes six identical Indigenous Land Use Agreements (ILUAs). The agreements enable some types of land-based customary activities to be undertaken by Noongar people in PDWSAs within the South West Settlement Area. On 8 June 2016, the department amended two sets of by-laws (Metropolitan Water Supply, Sewerage and Drainage By-laws 1981 and the Country Areas Water Supply By-laws 1957) to enable Noongar people undertake those customary activities. These amended by-laws apply within the Greenbushes Catchment Area until it is abolished.

The ILUAs are available via the Department of Premier and Cabinet, see www.dpc.wa.gov.au. Refer to Water quality information sheet 39: *Aboriginal customary activities in public drinking water source areas in the South West Native Title Settlement Area* (DoW 2017).

DWER is committed to working with Aboriginal people in its planning and management activities. The department recognises that native title is an important framework for water management.

If the Greenbushes Catchment Area is abolished, it will become available for increased opportunities for customary activities, tourism and recreation.

1.6 Update on water quality risks

As part of this review, DWER has assessed the water quality contamination risks that resulted in the Greenbushes Catchment Area being abandoned by the Water Corporation as a drinking water source.

The Greenbushes Catchment Area contains a small area of residential and rural land but it is predominantly state forest. Due to its proximity to the town, there is unauthorised recreation occurring within the catchment. This poses a risk of pathogen, nutrient and hydrocarbon contamination.

Ongoing evidence of these increased risks led the Water Corporation to deem the source as no longer appropriate for drinking water, because the risk to public health was too high.

This situation demonstrates how activities and land uses within PDWSAs can have a significant impact on water quality and public health. It shows how important it is to

protect drinking water sources as a key part of the multiple barrier approach in the ADWG.

Further information on land uses and activities in this catchment can be found in the *Greenbushes Catchment Area drinking water source protection assessment* (Water Corporation 2004).

Refer to Appendix D for information about typical contamination risks in PDWSAs.

Unauthorised activities

Swimming

There have been reports of people swimming within the dams and disused mine voids within the Greenbushes Catchment Area, particularly during the summer season. Body contact with water in a drinking water catchment poses a high risk of pathogen contamination, which poses a drinking water public health risk. Read Appendix D for more information about pathogens.

Fishing and marroning

Evidence of marroning has been observed in Dumpling Gully Dam 1 (see Figure C3) and the mine voids within the Greenbushes Catchment Area.

Marroning leads to direct body contact with water, increasing the risk of pathogen contamination. Additionally, baits used for marroning can include animal carcasses and chicken pellets and these increase the risk of pathogen and nutrient contamination.

Risks such as turbidity and fuel and chemical spills are also posed by vehicles that are used to access the dam for fishing and marroning.

Camping and picnicking

Evidence of camping and picnicking has been observed in close proximity to the dams and the mine voids.

The risk of pathogen contamination from people remaining in the catchment for extended periods is high. Camping also poses risks to water quality from associated activities such as fishing and rubbish dumping.

Wildfires may also result from the lighting of camp fires.

Off-road vehicle use

Unauthorised off-road vehicle use has been observed within the Greenbushes Catchment Area, including four wheel drives and motorbikes in close proximity to the dams. The number of tracks and associated activities have been increasing, particularly the creation of new 'single' motorbike tracks.

Off-road driving damages vegetation and poses a risk of turbidity and hydrocarbon contamination from fuel leaks and spills. It also can result in the spread of forest disease such as dieback. Pathogen contamination from humans within the catchment is also a risk.

There is a powerline access track within the catchment that has been used for recreational off-road vehicle pursuits. The track has been observed to become a source of turbidity during stormwater runoff, which is exacerbated by erosion caused by off-road driving. The eroded soil runs down slope and can enter the dam.

Firewood collection

Illegal firewood collection occurs within the Greenbushes Catchment Area, despite there being designated firewood collection points elsewhere in the region.

Risks include pathogen contamination from the increased presence of people and turbidity from off-road driving and the degradation and removal of vegetation.

Rubbish dumping

The catchment is close to town and it has been subject to rubbish dumping and illegal waste disposal. Examples include disposing of general household waste, camping rubbish and dumped car bodies. Dumping within the Greenbushes Catchment Area has become more prevalent.

Rubbish dumping poses a number of risks including contamination from nutrients, chemicals, heavy metals and fuel from domestic, building or industrial waste and tyres.

Hunting

Hunting within the catchment poses a risk of pathogen contamination from people, dogs and feral animal carcasses. The risk increases when people and dogs remain in the catchment for extended periods.

Hunters have been known to introduce feral animals into catchments in the south-west where the Greenbushes Catchment Area is located, to increase stock for hunting. This further increases the risks posed by feral animals such as pathogens from faeces and turbidity from feral pig rooting.

Disused mine voids

There are a number of disused mine voids in the north-eastern part of the Greenbushes Catchment Area. The mine voids are now used for water storage and are often accessed for recreation such as swimming, camping, picnicking and marroning. Direct contact with water in a drinking water catchment poses a high risk of pathogen contamination, in addition to the other associated risks posed by these unauthorised activities.

Horse riding

Horse riding sometimes occurs within the Greenbushes Catchment Area because the catchment covers state forest and residential areas in a rural setting.

Horse riding poses a risk of pathogen contamination from animal faeces and humans. It also poses an increased risk of turbidity and can encourage the spread of exotic plant species.

Vandalism

Vandalism has occurred within the Greenbushes Catchment Area, mostly to gain access into restricted areas. Gates have been rammed or smashed off using heavy equipment such as block splitters and sledge hammers, and locks have been cut or even shot apart. Some people have forced tracks around gates through bushland and cut fences.

State forest

The Greenbushes Catchment Area is located in state forest which is vested in the Conservation Commission of Western Australia and managed by the Department of Biodiversity, Conservation and Attractions (DBCA) under the *Conservation and Land Management Act 1984*. The *Forest Management Plan 2014–2023* (Conservation Commission 2013) outlines the operation and management of resources within state forests. DBCA manages indigenous state forest and timber reserves according to the plan.

The purpose of state forest and timber reserves as outlined in the plan includes conservation, recreation, timber production on a sustainable yield basis, water catchment protection and other purposes prescribed by the Conservation and Land Management Regulations 2002 (e.g. beekeeping).

DBCA is obligated under the act to prepare its management plans in consultation with DWER and Water Corporation and submit them to the Minister for Water.

Bushwalking

Bushwalking occurs within the Greenbushes Catchment Area because it covers state forest and residential areas in a rural setting, making it easily accessible. The catchment area also includes popular bushwalking trails such as the New Zealand Gully Trail, the Greenbushes Loop heritage trail and the Bibbulmun Track Connection which connects with the Bibbulmun Track outside of the catchment area. The trails are maintained and promoted by the local Eco-Cultural Discovery Centre, which provides walkers with information regarding protection of water quality.

These trails and tracks pass alongside both dams and their feeder streams, increasing the likelihood of body contact with the water in the dams. This poses a risk of pathogen contamination. The trails also pose a risk of turbidity, and further increase the risk of other unauthorised activities that may occur in association with the bushwalking, such as vehicle access and littering.

Roads and tracks

There are several fire management tracks in the state forest. DBCA maintains these on a regular basis to ensure adequate access in the event of a bushfire. There is also a powerline access track used for maintenance purposes that has been used for recreational off-road vehicle pursuits. The powerline track has been observed to be a source of turbidity, particularly during stormwater runoff, where eroded soil can flow down the slope of the track and into the dam.

The South West Highway, a major transport route, dissects the Greenbushes Catchment Area.

Water quality contamination risks from roads and tracks include fuel and chemical spills and leaks from vehicles and turbidity from erosion. Turbidity decreases the effectiveness of water treatment. There is a risk of chemical contamination from the use of herbicides for weed control along road verges. Vehicle movements also encourage the spread of forest diseases such as dieback. Roads and tracks provide increased access to the catchment and its water bodies, which further increases the risk of unauthorised activities and the associated contamination.

Silviculture

Timber growing and harvesting occurs within the Greenbushes Catchment Area, and is managed consistent with the *Forest management plan 2014–2023* (Conservation Commission 2013) and its associated guidelines, and the *Code of practice for timber plantations in Western Australia* (Forest Industries Federation 2014).

Water quality contamination risks from silviculture include hydrocarbons from fuel spills or leaks from vehicles and machinery as well as chemical contamination from fertiliser and pesticide application during plantation establishment and maintenance. Increased turbidity during plantation establishment, and via runoff from cleared areas and construction and use of roads and tracks is also a risk. In addition there is a pathogen risk from the increased recreational access via plantation access roads and tracks.

Mining

There are a number of mining tenements and mine sites within the Greenbushes Catchment Area, predominantly for lithium and tin mining. Talison Greenbushes Pty Ltd, Talison Lithium Australia Pty Ltd and Greenbushes Ltd are the three tenement holders within the Greenbushes Catchment Area.

Mining poses a risk of hydrocarbon contamination from fuel via spills and leaks from vehicles and machinery, turbidity from soil erosion and chemicals from mining activities. Mining activities are subject to a State Administrative agreement or similar, and have strict monitoring and compliance controls and conditions put on them for the protection of water quality and public health as well being subject to high penalties and consequences.

Land for public purposes

There is a community recreation area within the Greenbushes Catchment Area. It is located less than 600 m from Dumpling Gully Dam 1 and less than 100 m from Dumpling Gully Dam 2 (see Figure C5). It includes an oval, a playing field, ablution facilities, a dog exercise area and a vehicle parking area. These facilities are mostly used on weekends.

The playing fields are fertilised and irrigated, which poses a risk of nutrient contamination to the dams. Although dog waste collection bags are provided, this

activity still poses a risk of pathogen contamination. The ablutions are connected to a septic system, which poses a risk of pathogen and nutrient contamination. There is the potential for the septic system to overflow during periods of high use and high rainfall. During this time, there is a very high level of risk for pathogen contamination due to the close proximity of the septic system to the dams.

Private land

The private land in the Greenbushes Catchment Area is a mix of residential and rural. A small area of the town site is within the upper section of the catchment. There is also some rural land that has been developed since the 2004 assessment.

The risks posed by these land uses include nutrients and pathogens from septic systems and animal wastes, chemical contamination from fertilisers and pesticides and hydrocarbon contamination from vehicles and machinery.

1.7 Water quality information

The Water Corporation has provided updated water quality information for the Greenbushes Catchment Area. This is shown in Appendix B.

The detections for colour, iron unfiltered, manganese unfiltered, turbidity and pH all exceeded ADWG aesthetic guideline levels.

The detections for manganese unfiltered exceeded ADWG health-related guideline levels.

Dam 1 had positive *Escherichia coli* counts detected in 53 per cent of samples and of these, 5 per cent of samples had *E. coli* counts greater than 20 most probable number per 100 millilitres (MPN/100mL) and the maximum detection was 71 MPN/100mL. Dam 2 had positive *E. coli* counts detected in 77 per cent of samples and of these, 35 per cent of samples had *E. coli* counts greater than 20 MPN/100mL and the maximum detection was 390 MPN/100mL.

These consistent and high detection levels of *E. coli* were likely due to the amount of human activities within the catchment area.

Given these water quality results, in 2017, the Water Corporation stopped using the Greenbushes Catchment Area to supply drinking water to the town of Greenbushes, due to the risks posed to public health. Water Corporation established a new drinking water source for the town.

It is important to appreciate that this raw-water quality data did not represent the quality of drinking water distributed to the public at that time. Barriers such as storage and water treatment existed downstream of the raw water to ensure it met the requirements of the ADWG.

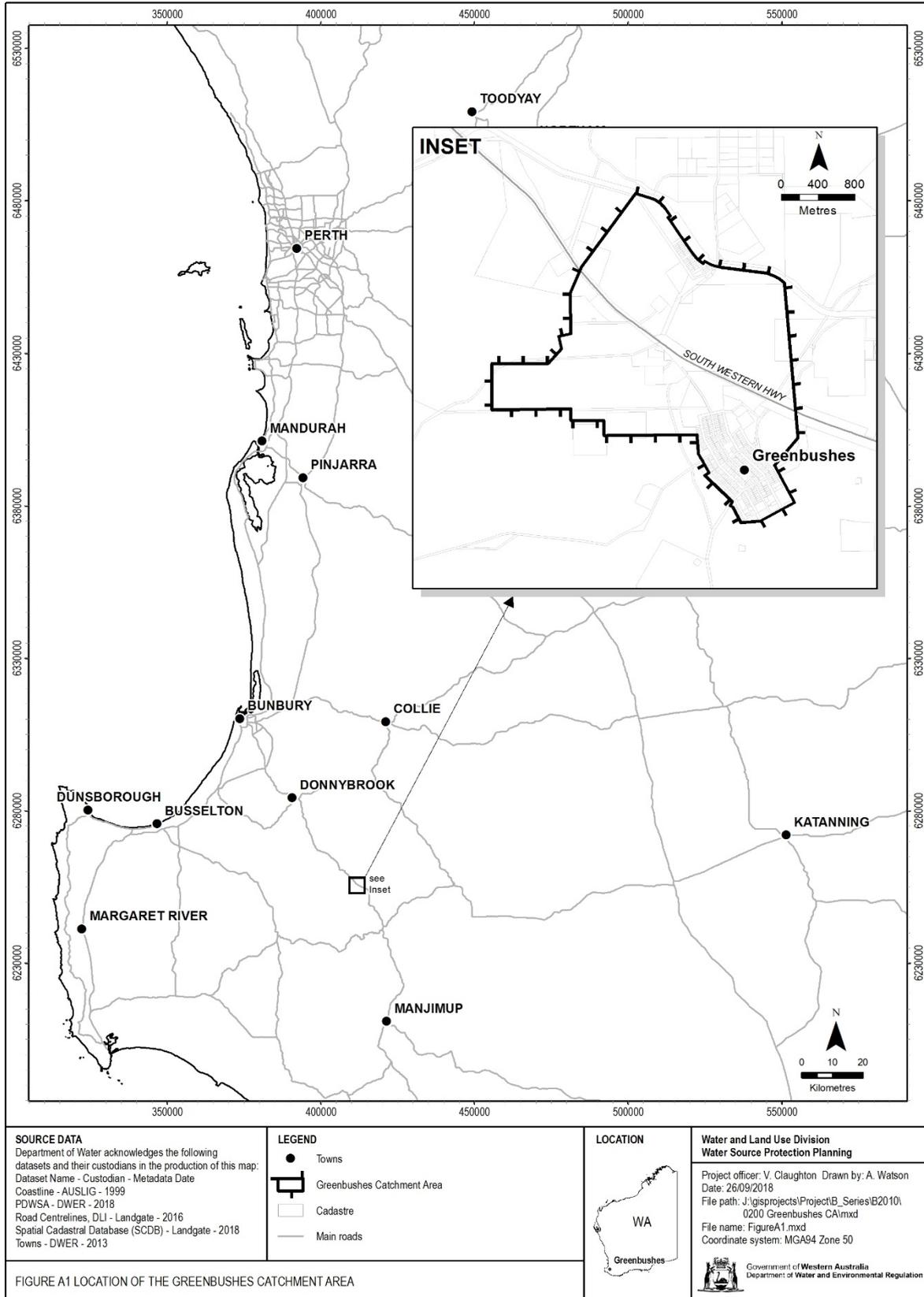
2 Recommendation

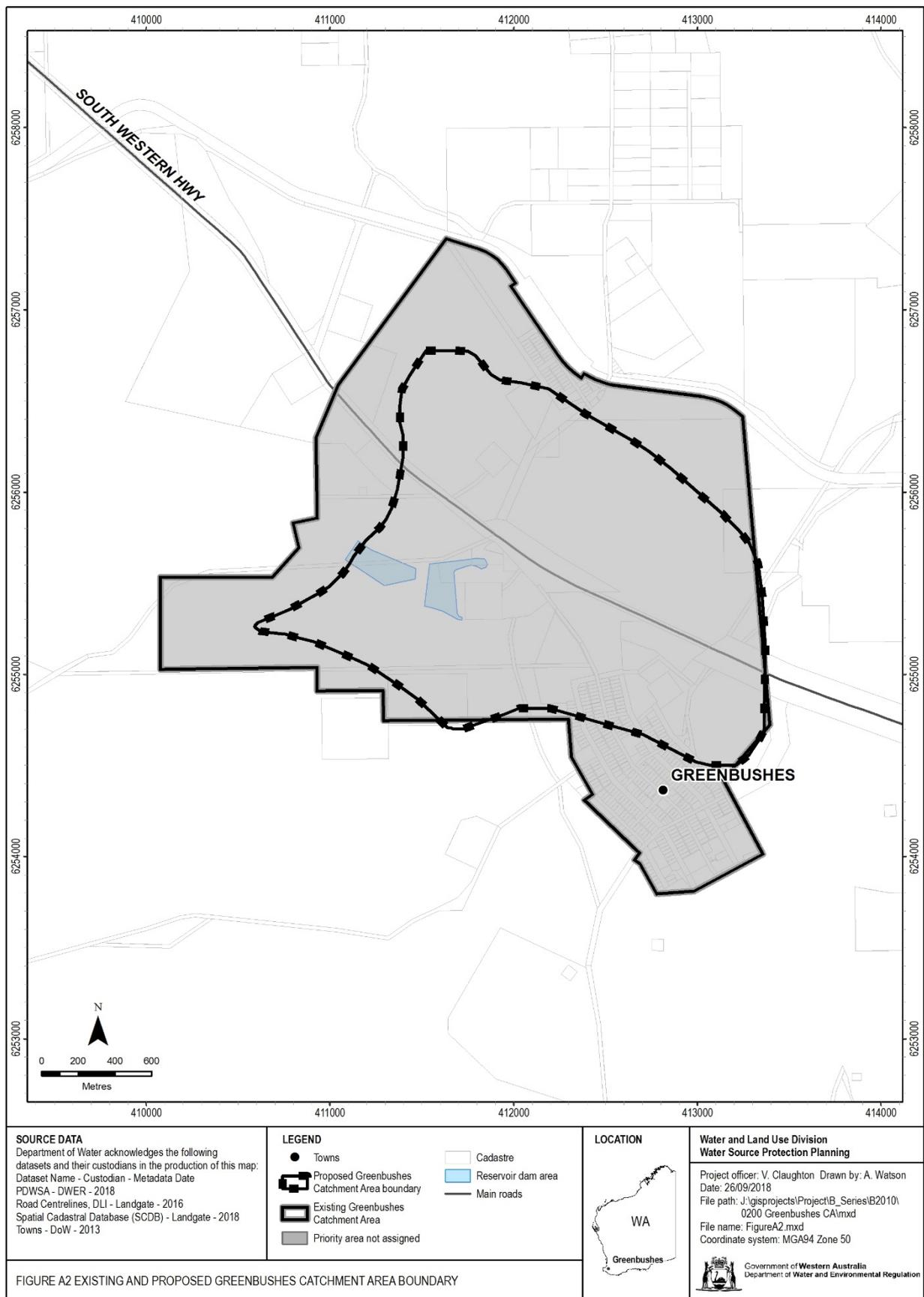
Based on the findings of this review, the following recommendation will now be applied to the Greenbushes Catchment Area. The stakeholders listed in brackets are responsible for, or have an interest in, implementing that recommendation.

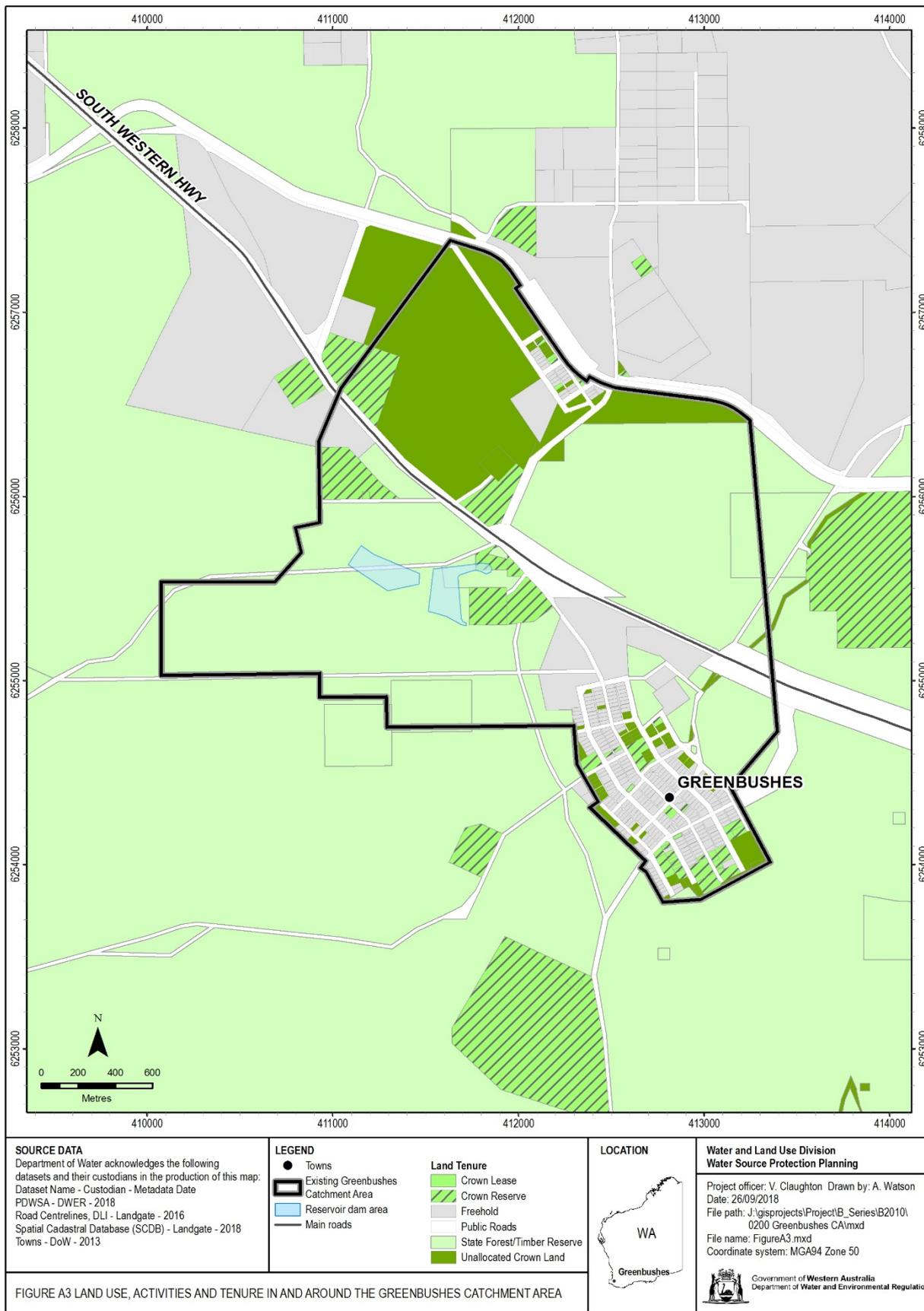
1. Abolish the Greenbushes Catchment Area under the *Country Areas Water Supply Act 1947*, which will make the catchment available for increased recreation, tourism and customary activities. (Department of Water and Environmental Regulation)

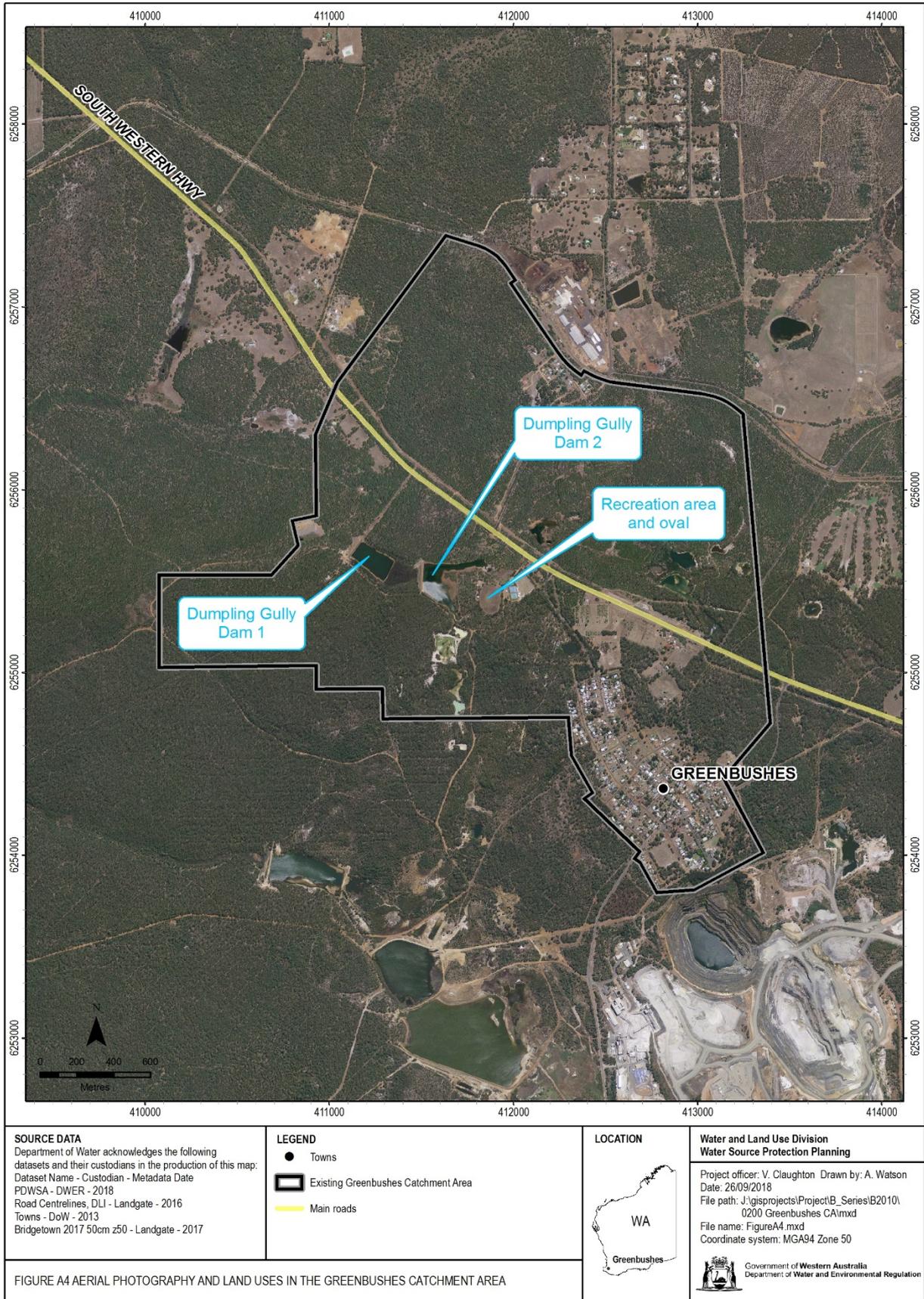
Appendices

Appendix A – Figures









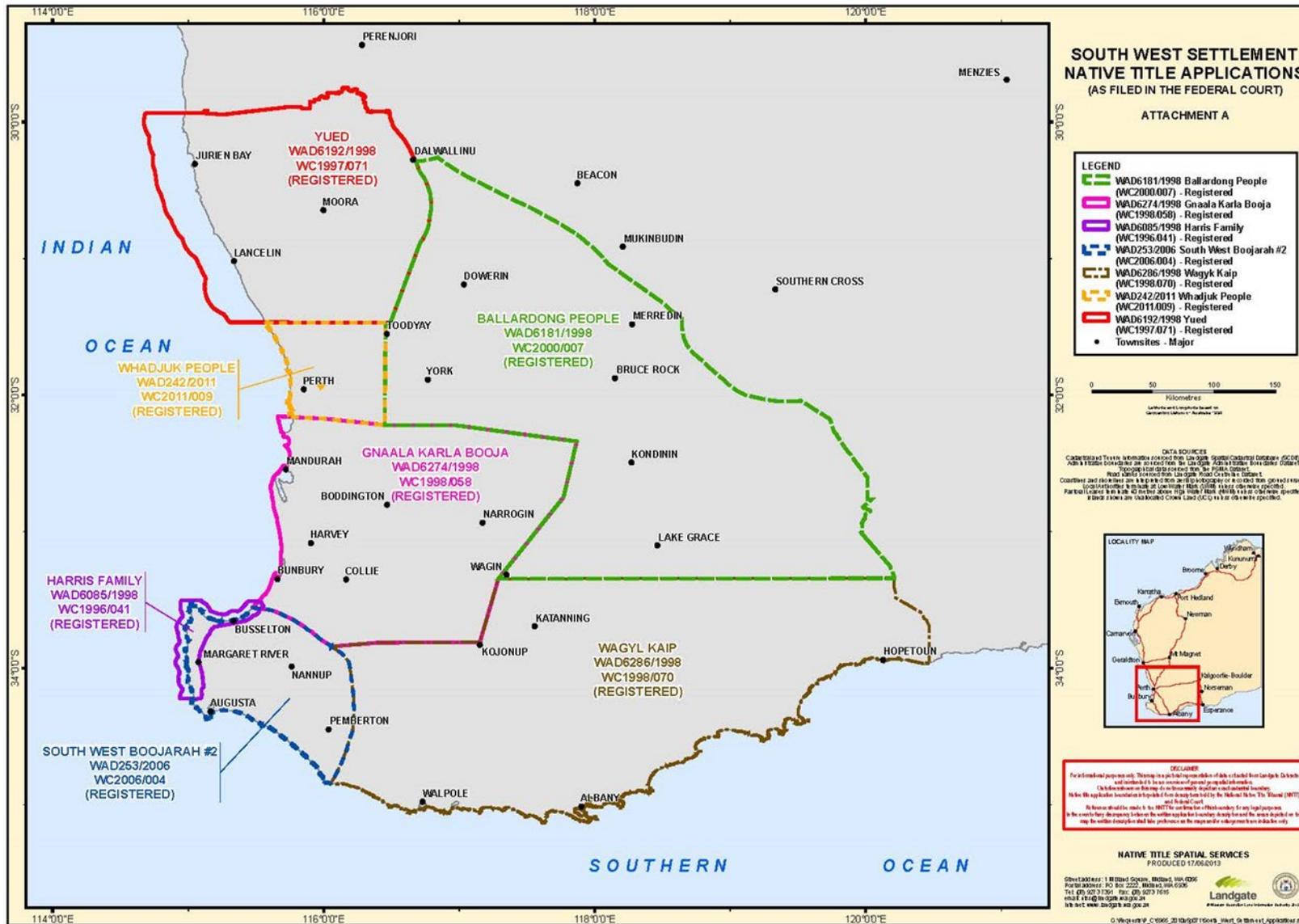


Figure A5 South West Native Title Agreement area (source: Department of Premier and Cabinet)

Appendix B – Water quality data

The information provided in this appendix has been supplied by the Water Corporation.

The Water Corporation has monitored the raw (source) water quality from Dumpling Gully (Greenbushes) Dams 1 and 2 in accordance with the requirements of the *Australian drinking water guidelines* (ADWG; NHMRC & NRMCC 2011) and interpretations agreed to with the Department of Health. This data shows the quality of water in the public drinking water source area (PDWSA). The raw water is monitored regularly for:

- aesthetic characteristics (non-health-related)
- health-related characteristics including:
 - health-related chemicals
 - microbiological contaminants.

The following data represents the quality of raw water from Dumpling Gully (Greenbushes) Dams 1 and 2. In the absence of specific guidelines for raw-water quality, the results have been compared with the ADWG values set for drinking water, which defines the quality requirements at the customer's tap. Any water quality parameters that have been detected are reported; those that on occasion have exceeded the ADWG are in ***bold and italics*** to give an indication of potential raw-water quality issues associated with this source. The values are taken from ongoing monitoring for the period November 2013 to October 2018.

It is important to appreciate that the raw-water data presented does not represent the quality of drinking water distributed to the public. Barriers such as storage and water treatment exist downstream of the raw water to ensure it meets the requirements of the ADWG.

For more information on the quality of drinking water supplied to the Warren Blackwood Regional Supply Scheme refer to the most recent Water Corporation drinking water quality annual report at www.watercorporation.com.au

Aesthetic characteristics

The aesthetic quality analyses for raw water from Dumpling Gully (Greenbushes) Dams 1 and 2 are summarised in the following table.

Aesthetic detections for Dumpling Gully (Greenbushes) Dams 1 and 2

Parameter	Units	ADWG aesthetic guideline value ¹	Dumpling Gully Dam 1		Dumpling Gully Dam 2	
			Range	Mean	Range	Mean
Chloride	mg/L	250	90–170	123.75	70–200	121.47
Colour (true)	TCU	15	0– 24	6.47	2–11	4.7
Hardness as CaCO ₃	mg/L	200	47–75	59.38	40–88	58.47
Iron unfiltered	mg/L	0.3	0.045– 0.74	0.216	0.05–0.22	0.11
Manganese unfiltered	mg/L	0.1	0.002– 7.5	0.169	0.007–0.035	0.015
Silicon as SiO ₂	mg/L	80	1.5–6.6	3.63	0.8–5.1	3.5
Sodium	mg/L	180	54–98	73.13	46–120	72.71
Sulfate	mg/L	250	13–20	16.25	16–24	20.18
Total filterable solids by summation	mg/L	600	232–381	295.13	193–434	289.59
Turbidity	NTU	5	0.3– 5.6	1.22	0.3– 11	2.4
pH measured in laboratory	no units	6.5–8.5	7.37– 9	8.07	7.15–8.17	7.71
Ammonia as nitrogen	mg/L	0.41	0–0.044	0.013	–	–

¹ An aesthetic guideline value is the concentration or measure of a water quality characteristic that is associated with good quality water

Health-related chemicals

Raw water from Dumpling Gully (Greenbushes) Dams 1 and 2 is analysed for chemicals that are potentially harmful to human health, including inorganics, heavy metals, industrial hydrocarbons and pesticides. Health-related parameters that have been detected in the source are summarised in the following table.

Health-related detections for Dumpling Gully (Greenbushes) Dams 1 and 2

Parameter	Units	ADWG health guideline value ¹	Dumpling Gully Dam 1		Dumpling Gully Dam 2	
			Range	Mean	Range	Mean
Barium	mg/L	2	0.009–0.017	0.014	–	–
Boron	mg/L	4	0.03–0.04	0.035	–	–
Manganese unfiltered	mg/L	0.5	0.002– 7.5	0.169	0.007–0.035	0.015
Nitrite plus nitrate as N ²	mg/L	11.29 ³	0–0.068	0.013	0–0.29	0.046
Sulfate	mg/L	500	13–20	16.25	16–24	20.176

¹ A health guideline value is the concentration or measure of a water quality characteristic that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHMRC & NRMCC 2011).

² This is reported as nitrate as nitrogen, whereas the ADWG uses nitrate as nitrate, with a health guideline value of 50 mg/L. This has been converted to 11.29 mg/L so as to compare with the nitrate as nitrogen values that were sampled.

³ A guideline value of 11.29 mg/L (as nitrogen) has been set to protect bottle-fed infants less than three months of age. Up to 22.58 mg/L (as nitrogen) can be safely consumed by adults and children over three months of age.

Microbiological contaminants

Microbiological testing of raw-water samples from Dumpling Gully (Greenbushes) Dam 1 was conducted on a weekly basis when it was being used. Microbiological testing of raw-water samples from Dumpling Gully (Greenbushes) Dam 2 was conducted on a monthly basis when it was being used. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw water from warm-blooded animals.

A detection of *E. coli* in raw water may indicate contamination of faecal material.

During the reviewed period, positive *E. coli* counts were recorded in 53 per cent of samples from Dam 1. Of these, 5 per cent of samples from Dam 1 had *E. coli* counts greater than 20 MPN/100 mL and the maximum detection was 71 MPN/100 mL.

Positive *E. coli* counts were recorded in 77 per cent of samples from Dam 2. 35 per cent of samples from Dam 2 had *E. coli* counts greater than 20 MPN/100 mL and the maximum detection was 390 MPN/100 mL.

Appendix C – Photographs

Photographs by V. Cloughton, Department of Water and Environmental Regulation



Figure C1 Dumpling Gully Dam 2 within Greenbushes Catchment Area



Figure C2 Spillway from Dumpling Gully Dam 2, overflowing



Figure C3 *Dumpling Gully Dam 2 within the Greenbushes Catchment Area*



Figure C4 *Dumpling Gully Dam 1 showing decommissioned water supply tanks due to the source being no longer used by the Water Corporation*



Figure C5 Recreation and dog exercise area within the Greenbushes Dam Catchment Area



Figure C6 Parking area and ablution block at the recreation area within the Greenbushes Dam Catchment Area

Appendix D – Typical contamination risks in surface water

Land development and land- or water-based activities within a catchment area can directly affect the quality of drinking water and its treatment. Contaminants can reach drinking water sources through runoff over the ground and infiltration through soil. A wide range of microbiological, chemical and physical contamination risks can impact on water quality and therefore affect the provision of safe, good quality drinking water to consumers.

Some contaminants in drinking water can affect human health resulting in illness, hospitalisation or even death. Other impurities can affect the water's aesthetic qualities, including its appearance, taste, smell and 'feel' but are not necessarily hazardous to human health. For example, cloudy water with a distinctive odour or strong taste may not be harmful to health, but clear, pleasant-tasting water may contain harmful, undetectable microorganisms (NHMRC & NRMCC 2011). Contaminants can also interfere with water treatment processes, and damage water supply infrastructure (such as iron corroding pipes).

The *Australian drinking water guidelines* (ADWG; NHMRC & NRMCC 2011) outline criteria for acceptable drinking water quality to protect human health, manage aesthetics and maintain water supply infrastructure.

Some commonly seen contamination risks relevant to surface water drinking water sources are described below.

Microbiological risks

Pathogens are types of microorganisms that are capable of causing illness and include bacteria, protozoa and viruses. When people consume drinking water that is contaminated with pathogens, the consequences vary considerably, ranging from mild illness (such as stomach upset or diarrhoea) to hospitalisation and in some cases even death. For example, seven people died and about 2500 people became ill in Walkerton, Canada, during 2000, because the town's water supply was contaminated by a pathogenic strain of *Escherichia coli* and *Campylobacter* (NHMRC & NRMCC 2011).

The types of pathogens that are likely to cause harm to people are commonly found in the faeces of humans and domestic animals (such as dogs and cattle). These pathogens can enter drinking water supplies from faecal contamination in the catchment area, either directly or indirectly.

Directly: When people or domestic animals come into contact with a body of water, pathogens may enter that water source. This occurs through the direct transfer of faecal material into the water such as while fishing, marroning or swimming.

Indirectly: Pathogens can wash over or infiltrate into the soil, and find their way into water supplies, such as from septic tanks or animal manure deposited in paddocks.

A number of pathogens are commonly known to contaminate water supplies worldwide. These include bacteria (for example *Salmonella*, *Escherichia coli* and cholera), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses. Monitoring for the presence of *E. coli* in water supplies provides an indication of the level of recent faecal contamination.

Pathogen contamination of a drinking water source is influenced by many factors including the existence of pathogen carriers (humans and domestic animals), the transfer to and movement of the pathogen in the water source and its ability to survive in the water.

The percentage of humans in the world that carry pathogens varies. For example, it is estimated that between 0.6 to 4.3 per cent of people are infected with *Cryptosporidium* worldwide, and 7.4 per cent with *Giardia* (Geldreich 1996).

The ability of pathogens to survive in surface water differs between species. *Salmonella* may be viable for two to three months, *Giardia* may still infect after a month in the natural environment (Geldreich 1996) and *Cryptosporidium* oocysts (cells containing reproductive spores) may survive weeks to months in fresh water (NHMRC & NRMCC 2011).

Unlike chemicals, which dissipate and dilute when they enter a water source, pathogens can multiply under the right conditions, increasing the likelihood of contamination. Therefore it is important to understand both the groundwater and surface water systems to be able to protect the drinking water source from pathogens.

Given the wide variety of pathogens, their behaviour in the environment and the potential consequences of consuming contaminated water, the most effective way to protect public health and reduce water treatment costs is to avoid the introduction of pathogens into a water source.

Physical risks

Turbidity is the result of soil or organic particles becoming suspended in water (cloudiness). Erosion from activities such as off-road driving and clearing of vegetation can cause turbidity in surface water sources. Increased turbidity can result in cloudy or muddy-looking water, which is not aesthetically appealing to consumers. Turbidity can also reduce the effectiveness of treatment processes (such as disinfection). This is because pathogens and chemicals can attach onto soil particles and become more difficult to remove during disinfection and treatment processes. High levels of turbidity in a water body can also affect the environment. Suspended particles smother riparian vegetation and reduce the ability of light to penetrate the water column. This affects plant growth which in turn can affect water quality.

Other physical properties of water can affect water supply infrastructure, or the aesthetics of the drinking water. For example, pH can contribute to the corrosion and encrustation of pipes; iron and dissolved organic matter can affect the colour and smell of water; and salinity levels can affect its taste. Although not necessarily

harmful to human health, water with properties like this will be less appealing to customers.

Chemical risks

Chemicals can occur in drinking water as a result of natural leaching from mineral deposits or from different land uses (NHMRC & NRMCC 2011). A number of these chemicals (organic and inorganic) are potentially toxic to humans.

Pesticides include agricultural chemicals used to control weeds (herbicides) and pests (insecticides, rodenticides, nematicides (for worms) and miticides (for mites)). Contamination of a drinking water source by pesticides (and other chemicals) may occur as a result of accidental spills, incorrect use or leakage from storage areas. In these cases, the relevant authorities should be notified promptly and the spill cleaned up to prevent contamination of the drinking water source.

Hydrocarbons such as fuels and oils are potentially toxic to humans. Harmful chemical by-products may be formed when hydrocarbons are combined with chlorine during the water treatment process. Hydrocarbons can occur in water supplies as a result of spills and leaks from vehicles and machinery.

Drinking water sources can also be contaminated by nutrients such as nitrogen and phosphorus. Nutrients can be introduced into a catchment via the application of fertiliser, from septic systems, and from animal faecal matter deposited in the catchment that washes over soil and down waterways and into the water supply. Nitrate and nitrite are two forms of nitrogen that can be toxic to humans at high levels, with infants younger than three months being most susceptible (NHMRC & NRMCC 2011).

Other chemicals and heavy metals can be associated with land uses such as industry and landfill. These may enter groundwater and could be harmful to human health if consumed.

Appendix E – Understanding risks to drinking water quality

The existing integrated land use planning and public drinking water source area (PDWSA) protection program is based on the findings of three parliamentary committee reports in 1994, 2000 and 2010 (see *Further reading*). Since 1995, this program has resulted in the development of four Western Australian Planning Commission state planning policies (SPPs), recognising the importance of PDWSAs for the protection of water quality and public health:

- SPP no. 2.2: Gnangara groundwater protection
- SPP no. 2.3: Jandakot groundwater protection
- SPP no. 2.7: Public drinking water source policy
- SPP no. 2.9: Water resources.

This integrated program relies upon a risk assessment process based on preventing risk in each PDWSA through the development of drinking water source protection reports. It is important to understand how risks are assessed to appreciate the impact of development within PDWSAs.

Risk-based assessments normally focus on the acceptability of risks after mitigation (residual risks). For drinking water sources, we use an assessment based on preventing risks, which considers both the maximum risk (before installing barriers) and the residual risk (after installing barriers). This means that in some cases, the maximum risks from land uses will still be considered unacceptable, even after mitigation (installing barriers) has reduced the risk. We need this more conservative approach to protect the health of consumers; those that are drinking the water.

Water quality risks are evaluated by considering the type and scale of a potential contamination event (consequence), together with the probability/frequency of that event occurring (likelihood). An understanding of this relationship will prevent the common misunderstanding that probability equals risk (see risk matrix below).

Table E1 Risk matrix: Level of risk (NHRMC & NRMCC 2011)

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Moderate	High	Very high	Very high	Very high
Likely	Moderate	High	High	Very high	Very high
Possible	Low	Moderate	High	Very high	Very high
Unlikely	Low	Low	Moderate	High	Very high
Rare	Low	Low	Moderate	High	High

For example, just because a drinking water contamination incident has not occurred for many years (low likelihood) does not mean that the risk is low. This is because we also need to consider the consequence of that contamination when determining risk. Furthermore, no previous detection of contamination is not proof that the risk is acceptable.

Drinking water quality is a public health issue. When development and increased activity occurs in a PDWSA, the risk of water quality contamination increases, because there are more sources of contamination i.e. people, animals, houses, roads, infrastructure. For example, an urban area (priority 3) poses a higher risk than a rural area (priority 2), and a rural area poses a higher risk than state forest (priority 1) (see Table E2 below).

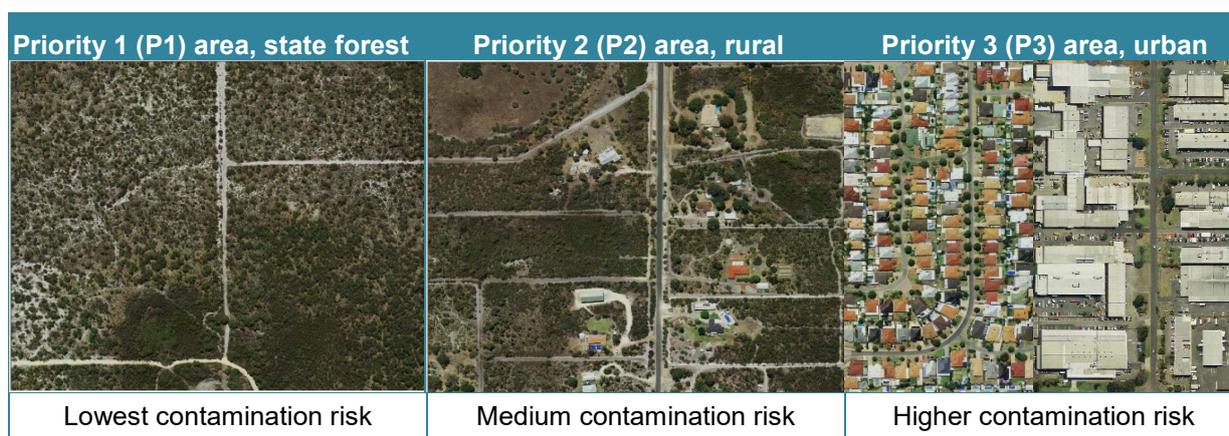


Table E2: Different risk profile that occur within a public drinking water source area.

Shortened forms

List of shortened forms

ADWG	<i>Australian drinking water guidelines</i>
DBCA	Department of Biodiversity, Conservation and Attractions
DWER	Department of Water and Environmental Regulation
ILUA	Indigenous land use agreement
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
P1, P2, P3	priority 1, priority 2, priority 3
PDWSA	public drinking water source area
RPZ	reservoir protection zone
SPP	state planning policy
WQPN	water quality protection note
yr	year

Units of measurement

m	metre	A measure of distance.
mg/L	milligrams per litre	A measure of concentration of a substance in a solution.
mL	millilitre	A measure of volume.
MPN	most probable number	A method used to measure the occurrence of microbes in a sample of water. The procedure uses tubes or microtitre plates and presence/absence tests (WHO 2011).
NTU	nephelometric turbidity units	A measure of turbidity in water.
pH		A logarithmic scale for expressing the acidity or alkalinity of a solution; a pH below 7 indicates an acidic solution and above 7 indicates an alkaline solution.
TCU	true colour units	A measure of degree of colour in water.

Volumes of water

One thousand litres	1000 litres	1 kilolitre	(KL)
One million litres	1 000 000 litres	1 megalitre	(ML)

Glossary

Abstraction	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.
Aesthetic guideline value	The concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer, for example appearance, taste and odour (NHMRC & NRMMC 2011).
Australian drinking water guidelines	The <i>National water quality management strategy: Australian drinking water guidelines 6</i> (ADWG; NHMRC & NRMMC 2011) outlines acceptable criteria for the quality of drinking water in Australia (see <i>References</i>).
Catchment	The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Catchment area	An area constituted under the <i>Country Areas Water Supply Act 1947</i> or the <i>Metropolitan Water Supply, Sewerage, and Drainage Act 1909</i> for the purposes of protecting a drinking water supply.
Constitute	Define the boundaries of any catchment area or water reserve by Order in Council under the <i>Country Areas Water Supply Act 1947</i> or by proclamation under <i>the Metropolitan Water Supply, Sewerage and Drainage Act 1909</i> .
Contamination	A substance present at concentrations exceeding background levels that presents – or has the potential to present – a risk of harm to human health, the environment, water resources or any environmental value.
Drinking water source protection report	A report on water quality hazards and risk levels within a public drinking water source area; includes recommendations to avoid, minimise, or manage those risks for the protection of the water supply in the provision of safe drinking water supply.
Gazette	Publication within the Government Gazette of Western Australia of the Order in Council or proclamation defining the boundaries of any catchment area or water reserve.
Health guideline value	The concentration or measure of a water quality characteristic that, based on current knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHMRC & NRMMC 2011).

Hydrocarbons	A class of compounds containing only hydrogen and carbon, such as methane, ethylene, acetylene and benzene. Fossil fuels such as oil, petroleum and natural gas all contain hydrocarbons.
Leaching/leachate	The process by which materials such as organic matter and mineral salts are washed out of a layer of soil or dumped material by being dissolved or suspended in percolating rainwater. The material washed out is known as leachate. Leachate can pollute groundwater and waterways.
Maximum risk	This is the level of risk in the absence of any preventive measures (barriers) being installed in the system, or assuming that preventive measures have failed. Assessing maximum risk is useful for identifying high priority risks, determining where attention should be focused and preparing for emergencies (NHRMC & NRMCC 2011).
Nutrients	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.
Order in Council	Made under the Governor of Executive Council and published in the Government Gazette to constitute or abolish a catchment area or water reserve under section 9 of the <i>Country Areas Water Supply Act 1947</i> .
Pathogen	A disease-producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as <i>Escherichia coli</i>), protozoa (such as <i>Cryptosporidium</i> and <i>Giardia</i>) and viruses.
Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.
Public drinking water source area	The area from which water is captured to supply drinking water. It includes all underground water pollution control areas, catchment areas and water reserves constituted under the <i>Metropolitan Water Supply, Sewerage, and Drainage Act 1909</i> or the <i>Country Areas Water Supply Act 1947</i> .
Priority 1, 2 and 3	Three different priority areas are assigned within PDWSAs to guide land use decisions. The objective of priority 1 (P1) areas is <i>risk avoidance</i> , priority 2 (P2) areas is <i>risk minimisation</i> and priority 3 (P3) areas is <i>risk management</i> .

Reservoir protection zone	A buffer measured from the high water mark of a drinking water reservoir, and inclusive of the reservoir (usually 2 km). This is referred to as a prohibited zone under the Metropolitan Water Supply, Sewerage, and Drainage Act By-laws 1981.
Residual risk	This is the level of risk after considering preventive measures (barriers) that are applied in the drinking water supply system, such as fencing to keep cattle away from drinking water bores, or surveillance to identify people accessing protected areas. Residual risk provides an indication of how effective preventive strategies are, or the need for additional preventive measures (NHRMC & NRMCC 2011).
Runoff	Water that flows over the surface from a catchment area, including streams.
Stormwater	Rainwater that has run off the ground surface, roads, paved areas etc., and is usually carried away by drains.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.
Wastewater	Water that has been used for some purpose and would normally be treated and discarded. Wastewater usually contains significant quantities of pollutant.
Water quality	Collective term for the physical, aesthetic, chemical and biological properties of water.

References

- Conservation Commission of Western Australia 2013, *Forest Management Plan 2014–2023*, Conservation Commission of Western Australia, Perth, available www.dbca.wa.gov.au.
- Department of Planning, Lands and Heritage 2018, *Shire of Bridgetown-Greenbushes Town Planning Scheme No. 4*, Government of Western Australia, Perth available www.dplh.wa.gov.au.
- Department of Water 2012, Operational policy no.13: *Recreation within public drinking water source areas on Crown land*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.
- 2016, Water quality protection note no. 25: *Land use compatibility tables for public drinking water source areas*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.
- 2017, Water quality information sheet 39: *Aboriginal customary activities in public drinking water source areas in the South West Native Title Settlement Area*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.
- Geldreich, EE 1996, 'Pathogenic agents in freshwater resources', *Hydrological Processes*, vol. 10, pp. 315-333.
- Government of Western Australia 1914, *Rights in Water and Irrigation Act*, State Law Publisher, Perth, available www.slp.wa.gov.au.
- 1947, *Country Areas Water Supply Act*, State Law Publisher, Perth, available www.slp.wa.gov.au.
- 1957, *Country Areas Water Supply By-laws*, State Law Publisher, Perth, available www.slp.wa.gov.au.
- 1981, *Metropolitan Water Supply, Sewerage and Drainage By-laws*, State Law Publisher, Perth, available www.slp.wa.gov.au.
- 1984, *Conservation and Land Management Act*, State Law Publisher, Perth, available www.slp.wa.gov.au.
- 2002, *Conservation and Land Management Regulations*, State Law Publisher, Perth, available www.slp.wa.gov.au.
- Forest Industries Federation (WA) Inc 2014, *Code of Practice for timber plantations in Western Australia*, Australian Government Publishing Service, Bentley, available www.fpc.wa.gov.au.
- National Health and Medical Research Council (NHMRC) & Natural Resource Management Ministerial Council (NRMMC) 2011, National water quality management strategy: *Australian drinking water guidelines*, Australian Government, Canberra, available www.nhmrc.gov.au.

Water Corporation 2004, *Greenbushes Catchment Area drinking water source protection assessment*, Greenbushes Town Water Supply, Water Corporation, Leederville.

—2009, *SG097 Source protection operations manual*, unpublished corporate manual, Water Corporation, Leederville.

Western Australian Planning Commission 2003, State planning policy no. 2.7: *Public drinking water source policy*, Government of Western Australia, Perth, available www.planning.wa.gov.au.

Further reading

- Department of Water & Department of Health 2008, *Risks from pathogenic microorganisms in public drinking water source areas*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.
- Department of Water 2011, *Living and working in public drinking water source areas*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.
- Department of Water, *Water quality protection notes (WQPNs)*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.
- 2006, WQPN no. 44: *Roads near sensitive water resources*
- 2009, WQPN no. 36: *Protecting public drinking water source areas*
- 2016, WQPN no. 25: *Land use compatibility tables for public drinking water source areas*
- Hrudey, SE & Hrudey, EJ 2004, *Safe drinking water – Lessons from recent outbreaks in affluent nations*, IWA Publishing, London.
- Standing Committee on Public Administration 2010, *Report 11: Recreation activities within public drinking water source areas*, Legislative Council, Perth, available www.parliament.wa.gov.au.

Department of Water and Environmental Regulation
Prime House
8 Davidson Terrace Joondalup
Western Australia 6027

Locked Bag 10, Joondalup DC WA 6919

Phone: 08 6364 7000
Fax: 08 6364 7001
National Relay Service 13 36 77
dwer.wa.gov.au