

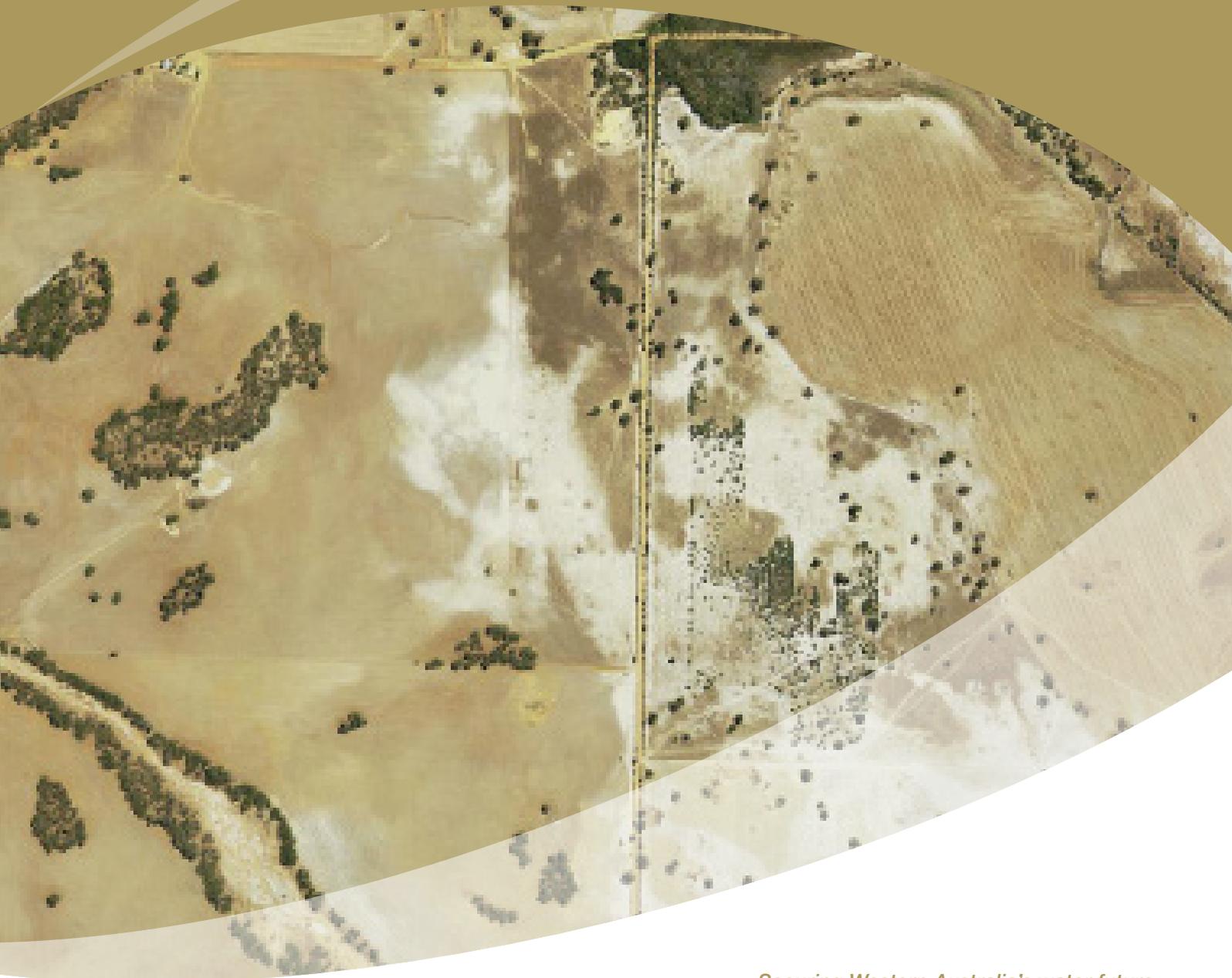


Government of Western Australia
Department of Water

Calingiri Water Reserve

Drinking water source protection review

Calingiri town water supply



Securing Western Australia's water future

Water resource protection series
Report WRP 159
June 2016

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Department of Water
168 St Georges Terrace
Perth Western Australia 6000
Telephone +61 8 6364 7600
Facsimile +61 8 6364 7601 National relay service 13 36 77
www.water.wa.gov.au

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For more information about this report, contact
Water Source Protection Planning on +61 8 6364 7600 or drinkingwater@water.wa.gov.au.

Cover photograph: Aerial photo of Calingiri Water Reserve

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Summary

Calingiri is located in the mid-west region of Western Australia, approximately 140 km north-east of Perth (see Figure A1). It has a population of 111 (2006 Census) and is located in the valley of Scully Brook, a tributary of Fletcher Brook, which flows into the Moore River.

Water Corporation operates Calingiri's drinking water supply, drawing groundwater from the Yenart bore field located 11 km west of the town, to supply 86 properties (Water Corporation 2014a). There are four bores in the Yenart bore field, all located within about 300 m of each other (see Figure A2). The bores range in depth from 18.5 m to 34 m, and draw water from a shallow, unconfined aquifer, meaning that Calingiri's drinking water source is vulnerable to contamination from overlying land uses.

The bores are surrounded by private farming land, mainly used for broadacre cropping and sheep grazing (see figures A3 and A4). The main risks to Calingiri's drinking water source from surrounding land uses include pathogens from grazing animals, nutrients from fertilisers, pesticides, and hydrocarbons from farm machinery and vehicles.

This drinking water source protection review considers changes that have occurred in and around the Calingiri Water Reserve since completion of the *Calingiri Water Reserve water source protection plan* (Water and Rivers Commission 1999). These documents should be read in conjunction and both are available on our website or by contacting us.

We prepared this document in consultation with key stakeholders, including land owners, the Water Corporation and the Shire of Victoria Plains.

The main changes since the 1999 plan are:

- The Department of Water has replaced the Water and Rivers Commission.
- The Calingiri Water Reserve boundary was proclaimed in 2006.
- The wellhead protection zones of bores 1/72 and 2/72 do not need to extend outside of the Calingiri Water Reserve boundary.
- There is no longer a diesel pump within one of the wellhead protection zones, which reduces the risk of contamination of the drinking water source.
- Recommendations from the 1999 plan have been completed or require ongoing implementation. A consolidated list of recommendations has been provided in this review (see section 2.2).

This review is consistent with the *Australian drinking water guidelines* (ADWG; NHMRC & NRMCC 2011) and State planning policy no. 2.7: *Public drinking water source policy*.

Table 1 shows important information about the Calingiri Water Reserve.

Table 1 Key information about the Calingiri Water Reserve

Calingiri Water Reserve	
Local government authority	Shire of Victoria Plains
Location supplied	Calingiri (86 properties), plus carting to Yerecoin (if required)
Water service provider	Water Corporation
Aquifer type	Unconfined groundwater
Licensed abstraction	80 000 kL per year
Number of bores	Four in the Yenart bore field
Bore names and GPS coordinates	1/72 (E 437205, N 6557648, zone 50) 2/72 (E 437190, N 6557646, zone 50) 1/81 (E 437387, N 6557728, zone 50) 4/81 (E 437247, N 6557460, zone 50)
Date of bore completion	1/72 and 2/72 – 1972 1/81 and 4/81 – 1981
Dates of drinking water source protection reports	1999 – <i>Calingiri Water Reserve water source protection plan</i> (Water and Rivers Commission) 2016 – <i>Calingiri Water Reserve drinking water source protection review</i> (this document)
Consultation	1999 – consultation as part of the water source protection plan 2005 – consultation with landowners prior to the proclamation process 2015 – consultation with key stakeholders for this document
Proclamation status	Proclaimed on 10 February 2006 under the <i>Country Areas Water Supply Act 1947</i>
Reference documents	<i>Australian drinking water guidelines</i> (NHMRC & NRMCC 2011) <i>State planning policy no. 2.7: Public drinking water source policy</i>

1 Review of Calingiri's drinking water source protection plan

Calingiri is located in the mid-west region of Western Australia, approximately 140 km north-east of Perth, with a population of 111 (2006 Census). The town is about 260 m above sea level and is located in the valley of Scully Brook, a tributary of Fletcher Brook, which flows into the Moore River. The town supports the surrounding agriculture which is mainly cropping and sheep grazing, and also houses the Shire of Victoria Plains office and local school.

1.1 Boundary, priority areas and protection zones

The Calingiri Water Reserve was proclaimed in 2006 under the *Country Areas Water Supply Act 1947*. The current boundary was determined via consultation prior to the proclamation process in 2006. The boundary provides protection for the Yenart bore field. The water reserve was assigned a priority 2 (P2) area, and included wellhead protection zones (WHPZs) of 300 m in radius around each of the bores (see Figure A2).

The wellhead protection zones of bores 1/72 and 2/72 currently extend outside of the Calingiri Water Reserve boundary (see Figure A2). The current Department of Water approach is that wellhead protection zones do not extend outside the boundary of water reserves. This will be amended as part of this review (section 2.2, recommendation no. 1).

There will be no other changes to the boundary or the priority areas as a result of this review.

If you require more information about how we protect public drinking water sources, please read Appendix E.

1.2 Update on water supply scheme

There are four production bores in the Yenart bore field (1/72, 2/72, 1/81 and 4/81) ranging in depth from 18.5 m to 34 m, drawing water from a shallow, unconfined aquifer. They are all located within about 300 m of each other. Bores 1/72 and 2/72 are close to each other, therefore are not operated simultaneously.

Operation of the bores is controlled via a float valve from a 225 kL reinforced concrete storage tank (Goudge Road tank), and the water is distributed to an elevated 200 kL steel storage tank in the town (Water Corporation 2013a). There are currently 86 domestic services/units (Water Corporation 2014a). Water is chlorinated for disinfection before distribution to the town.

Water is also carted from Calingiri to augment the town water supply at Yerecoin as required (Water Corporation 2013a).

1.2.1 Groundwater abstraction licence

Calingiri's drinking water is sourced from the Yenart subarea of the Yenart Groundwater Area. This aquifer is not fully allocated.

The Water Corporation is licensed by the Department of Water to abstract up to 80 000 kL of groundwater per year for public drinking water supply (licence no. 64111 expires in 2019). The total abstraction for Calingiri's drinking water supply (October 2013 to September 2014) was 60 163 kL (Water Corporation 2014a), well within the Water Corporation's licensed allocation limit, and this includes water carting to Yerecoin.

The current allocation is expected to be sufficient to meet demand over the next five years (Water Corporation 2014b), but should water be required in emergency situations, it would be carted from other nearby sources (Water Corporation 2013a).

1.3 Aboriginal native title claims

Native title is the recognition in Australian law that some Aboriginal people continue to hold native title rights to lands and water arising from their traditional laws and customs.

There are two native title claims within the Calingiri Water Reserve. These are the Yued claim (WAD6192/1998), accepted for registration and the Single Noongar Claim (Area 1), not accepted for registration.

The State Government of Western Australia and the Noongar native title claimants are negotiating an agreement called an Indigenous Land Use Agreement (ILUA). This agreement will recognise the Noongar people as the traditional owners of land in the South West Settlement Area, which extends from a point south of Dongara on the west coast, approximately east to a point north of Moora and then south-easterly to a point midway between Albany and Esperance (see Figure A5). It will enable some types of land-based customary activities to be undertaken by Noongar people in public drinking water source areas (PDWSAs) within the South West Settlement Area. Some of the proposed land-based activities include:

- entry to registered Aboriginal sites in reservoir protection zones
- designated camping sites for Noongar people (outside reservoir protection zones and wellhead protection zones)
- gathering invertebrates and eggs, lighting fires and gathering flora for customary purposes.

The ILUA is available via the Department of Premier and Cabinet, see <www.dpc.wa.gov.au/lantu/Claims/Pages/SouthWestSettlement>.

As all the land within the Calingiri Water Reserve is privately owned, this will not affect the PDWSA.

The Department of Water 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.

1.4 Enforcing by-laws, surveying the area and maintenance

This review recommends that the Water Corporation continue by-law enforcement under the existing delegation arrangement (see section 2.2, recommendation no. 6). This also includes:

- erecting and maintaining signs in accordance with *S111 Source protection signage* (Water Corporation 2013b)
- maintaining security and fencing surrounding the bore compounds and access roads
- ongoing regular surveillance and inspections.

1.5 Other Department of Water work

In 2010 the Department of Water prepared an *Emergency farmland water response plan* for the Shire of Victoria Plains (Department of Water 2010).

The Calingiri community water supply consists of two 225 000 kL storage tanks and a standpipe, located on the Calingiri sports ground. This community emergency source is drawn from a bore on Lot 2764, approximately 1.8 km south-south-east of the drinking water bores, just inside the Calingiri Water Reserve. See section 1.6.3 for more information about bores within the water reserve.

1.6 Update on water quality risks

As part of this review, the Department of Water has conducted a new assessment of water quality contamination risks to Calingiri's drinking water source in accordance with the ADWG. This section discusses the risks, and Table 2 shows a summary.

Refer to Appendix D for information about typical contamination risks in PDWSAs. Refer to Appendix F to gain a greater understanding about the risk assessment process we use.

The bores that supply Calingiri's drinking water draw from an unconfined and shallow aquifer, meaning that the water source is vulnerable to contamination from surrounding land uses. Surrounding land uses are shown in an aerial photo in Figure A4.

1.6.1 Bore compounds

All of Calingiri's drinking water bores are located within secure compounds, on small lots of land owned by the Water Corporation. These small lots are surrounded by private farming land, so there is limited public access. Hence, there is no history of vandalism or break-ins at the compounds. The wellhead protection zones extend beyond the compounds (see Figure A4).

1.6.2 Farming

Private farming land surrounds Calingiri's drinking water bore compounds (see Figure A3). The main land uses include grazing, cropping and private farm residences.

Water quality risks associated with farming include pathogens from livestock (that are able to graze up to the bore compounds) and from septic tanks from farm residences. The closest residence is approximately 150 m away from the bores. Pathogen risks from cattle and septic tanks have been assigned a high management priority due to the unconfined nature of the aquifer, and proximity of the potential sources of contamination to the bores. Refer to Appendix D for more information about pathogen contamination risk.

Nutrients from fertilisers and cattle are another risk posed to Calingiri's drinking water source. Fertilisers should be applied in accordance with best management practices (see Table 2). This has also been assigned a high management priority.

Chemicals (such as pesticides) can pose a risk to water quality if they are spilled, stored incorrectly or applied in excess. Correct storage of chemicals in weatherproof conditions will help prevent spills and leaks. Herbicides recommended for use are those specified in PSC 88: *Use of herbicides in water catchment areas* (Department of Health 2007). All chemicals should be used with best management practices (see Table 2).

Farm machinery and vehicles can pose a risk to Calingiri's drinking water quality via hydrocarbon contamination from fuel or oil spills and leaks, or vehicle accidents. Any fuel storage should be in accordance with best management practices, and contingency plans should be in place in case of accidents. See Table 2 for relevant documents.

The 1999 plan reported that a diesel pump was operating within the wellhead protection zone of bore 1/81. This farm pump has now been replaced by an electric pump, so the risk of hydrocarbon contamination from this pump is now eliminated.

Landowners should continue to use best management practices for cropping and grazing to help protect Calingiri's drinking water quality (see Table 2).

1.6.3 Other groundwater bores

Bores drilled near a public drinking water supply bore (such as for irrigation or private purposes) can cause contamination of the drinking water source. For example, a poorly constructed bore may introduce contaminants from surface leakage down the outside of the bore casing into an otherwise uncontaminated aquifer.

It is therefore important to ensure that any bores are appropriately located and constructed to prevent contamination of the public drinking water source. This will be assessed through Department of Water's water licensing process where applicable under the *Rights in Water and Irrigation Act 1914*. All bores should be constructed in accordance with *Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee 2012).

There are three other licensed users within 2 km of Calingiri's drinking water bores. Two of these are also within the Yenart Groundwater Area (Department of Water, 2015).

One of these bores is the community emergency source, located within the Calingiri Water Reserve, operated by the Shire of Victoria Plains (see section 1.5). The pump is electric, which means there is no risk of hydrocarbon contamination from this pump.

Table 2 Summary of potential water quality risks, land use compatibility and recommended best management practices

Land use/activity	Hazard	Management priority	Comments	Best management practice guidance ¹
Grazing	Pathogens Nutrients	High	Rural land uses such as cropping and grazing are compatible with conditions in P2 areas.	WQPN no. 35: <i>Pastoral activities within rangelands</i>
Cropping	Nutrients Pesticides Chemicals	High		WQPN no. 1: <i>Agriculture – dryland crops near sensitive water resources</i> WQPN no. 104: <i>Aerial spraying of crops with pesticides</i> PSC 88: <i>Use of herbicides in water catchment areas</i> (Department of Health 2013) <i>A guide to the use of pesticides in Western Australia</i> (Department of Health 2007)
Residences	Pathogens	High		WQPN no. 70: <i>Wastewater treatment and disposal – domestic systems</i>
Sheds and machinery	Hydrocarbons Chemicals	Medium		Brochure: <i>Liquid chemicals on agricultural land</i> WQPN no. 65: <i>Toxic and hazardous substances – storage and use</i> WQPN no. 29: <i>Mobile mechanical servicing and cleaning</i>
Roads and tracks	Hydrocarbons	Medium		Bore access roads are secured. WQPN no. 44: <i>Roads near sensitive water resources</i> WQPN no. 10: <i>Contaminant spills – emergency response</i>

¹ Water quality protection notes (WQPNs) are available www.water.wa.gov.au or see *Further reading*.

1.7 Water quality information

The Water Corporation has provided updated water quality information for the Calingiri Water Reserve. This is shown in Appendix B.

In the past five years, water quality has exceeded aesthetic guideline levels for calcium, hardness, iron, sodium, total filterable solids by summation and turbidity; however these are all naturally occurring in the groundwater and not linked to surrounding land uses (Water Corporation 2013a).

Salinity is increasing, which has been attributed to:

- bore 1/72 drawing saline water from below the freshwater lens
- periods of high abstraction coinciding with low rainfall
- saline upconing from below the freshwater lens during low rainfall events
- drawdown interference
- iron crustation on bore 1/81 (Worley Parsons 2010).

Water Corporation addresses the salinity by ongoing water quality monitoring and abstraction management.

Nitrate concentrations continue to be monitored (annually), as the bores are vulnerable to contamination from surrounding agricultural land uses.

It should be recognised that although treatment and disinfection are essential barriers against contamination, PDWSA management is the first step in protecting water quality and ensuring a safe drinking water supply. This approach is endorsed by the *Australian drinking water guidelines* (ADWG; NHMRC & NRMCC 2011) and reflects a preventive risk-based, multiple-barrier approach for providing safe drinking water to consumers. This combination of catchment protection and water treatment will deliver a more reliable, safer and lower cost drinking water to consumers than either approach could achieve individually.

For more information on why it is so important to protect our catchments, read Appendix E.

2 Implementation of Calingiri's drinking water source protection plan

2.1 Status of previous recommendations

Table 3 outlines recommendations from the 1999 plan and their current status.

Table 3 Implementation status for Calingiri Water Reserve

No.	Recommendation	Comments
1	The Calingiri Water Reserve should be gazetted under the <i>Country Areas Water Supply Act 1947</i> .	In response to consultation with landowners, a boundary that is different to the 1999 plan was proclaimed under the <i>Country Areas Water Supply Act 1947</i> in 2006 (see Figure A2).
2	Planning strategies should incorporate the management principles outlined in WQPN no. 25: <i>Land use compatibility in PDWSAs</i>	The Shire of Victoria Plains' <i>Local planning scheme no. 5</i> does not currently incorporate the Calingiri Water Reserve. This recommendation will be carried forward (section 2.2, recommendation no. 2).
3	All development proposals in the water reserve that are likely to impact on water quality should be referred to the Department of Water (formerly Water and Rivers Commission).	Guidelines have been provided through the WQPNs series. Development proposals within all PDWSAs are referred to the Swan Avon Region office of the Department of Water. This has been continued as a recommendation of this review (section 2.2, recommendation no. 3).
4	Signs should be erected along the boundaries of the water reserve to define the reserve and promote public awareness of the need to protect water quality.	Signs are in place on the bore compounds and access roads into the water reserve. Maintenance of these signs has been continued as a recommendation of this review (section 2.2, recommendation no. 5).
5	A process should be put in place to address spillage of pollutants within the water reserve.	Emergency response protocols rest with Westplan-HAZMAT and the local emergency management committee (LEMC). This has been continued as a new recommendation of this review (section 2.2, recommendation no. 4).

No.	Recommendation	Comments
6	A surveillance program should be established to identify incompatible land uses or potential contamination threats within the water reserve.	Water Corporation undertakes regular surveillance within the water reserve. This has been continued as a recommendation of this review (section 2.2, recommendation no. 6).
7	Nutrient and pesticide levels should be monitored to ensure drinking water quality is not compromised. Also, cooperation with landowners should be sought to ensure fertiliser application rates are not excessive and fuel storage and management do not compromise water resources.	Water Corporation undertake regular water quality monitoring to ensure the water meets the ADWG (Water Corporation 2013a). An ongoing recommendation of this review is that landowners continue to adopt best management practices including appropriate fertiliser and pesticide application and fuel and chemical storage (section 2.2, recommendation no. 6).
8	Implementation of these recommendations should be reviewed one year after this plan is endorsed. A full review of this protection plan should be undertaken approximately every five years.	This is the first review of the 1999 plan. Further reviews should be undertaken every seven years or as required (section 2.2, recommendation no. 8).

2.2 Consolidated recommendations

Based on the findings of this review, the following recommendations will now be applied to the Calingiri Water Reserve. The bracketed stakeholders are those expected to have a responsibility for, or an interest in, the implementation of that recommendation.

1. Amend the wellhead protection zone of bores 1/72 and 2/72 so it no longer extends outside of the Calingiri Water Reserve boundary. (Department of Water)
2. Incorporate the findings of this review and the location of the Calingiri Water Reserve (including its priority area and protection zones) in the Shire of Victoria Plains' local planning scheme in accordance with the Western Australian Planning Commission's State planning policy no. 2.7: *Public drinking water source policy*. (Shire of Victoria Plains)
3. Refer development proposals (i.e. scheme amendments, structure plans and subdivision and development applications) within the Calingiri Water Reserve that are inconsistent with the Department of Water's WQPN no. 25: *Land use*

compatibility tables for public drinking water source areas or recommendations in this review to the Department of Water regional office for advice. (Department of Planning, Shire of Victoria Plains, proponents of proposals)

4. Ensure incidents covered by Westplan–HAZMAT in the Calingiri Water Reserve are addressed by ensuring that:
 - the Shire of Victoria Plains LEMC (Wheatbelt Emergency Management District) is aware of the location and purpose of the Calingiri Water Reserve
 - the locality plan for the Calingiri Water Reserve is provided to the Department of Fire and Emergency Services headquarters for the HAZMAT emergency advisory team
 - the Water Corporation acts in an advisory role during incidents in the Calingiri Water Reserve
 - personnel dealing with Westplan–HAZMAT incidents in the area have ready access to a locality map of the Calingiri Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality.(Water Corporation)
5. Maintain signs on the bore compounds and access roads into the Calingiri Water Reserve, including an emergency contact telephone number, in accordance with the Water Corporation's *S111 Source protection signage* (2013b). (Water Corporation)
6. Water Corporation should continue the current regime of water quality monitoring, maintenance of fencing, inspections and by-law enforcement. (Water Corporation)
7. Landowners should continue to use best management practices when undertaking grazing and cropping activities, including chemical and hydrocarbon management and disposal, to help manage the risk to Calingiri's drinking water source. (landowners)
8. Update this review within seven years. (Department of Water)

3 Consultation

3.1 Stakeholder consultation process

Key stakeholders consulted in the development of this report included landowners with property in the Calingiri Water Reserve boundary, Shire of Victoria Plains, Water Corporation, Department of Health, Department of Planning, Department of Mines and Petroleum and the South West Aboriginal Land and Sea Council.

These stakeholders were given opportunity to input into the development of the plan by written communication.

3.2 Issues raised in consultation

The following table provides a summary of the issues raised during consultation of the *Calingiri Water Reserve drinking water source protection review* and the Department of Water's response. Individual stakeholders have not been identified in order to protect their privacy. Issues that are very specific or are not related to this review have not been listed, but have been explained or resolved directly with the affected stakeholder(s).

Table 4 Key issues raised during consultation for Calingiri Water Reserve

Issue raised	Response
Can the water reserve boundary be extended to increase protection for the drinking water source?	The final report recommends to continue with the currently proclaimed boundary, due to the following: <ul style="list-style-type: none"> Landowners agreed to the current boundary after negotiation (in 2006).
Can the portion of the WHPZ that extends outside of the water reserve boundary be retained, and the boundary extended to incorporate it?	<ul style="list-style-type: none"> Current land zoning in the water reserve and surrounding area is all rural – therefore land uses are unlikely to change. Having a WHPZ extend outside of water reserve boundary is in contradiction to Department of Water policy. The section will be removed as it appears to be an anomaly. <p>The boundary will be re-assessed with the next review of the Calingiri drinking water source protection report, in approximately 7 years, or as required (section 2.2, recommendation no. 8).</p>
Recommendations do not appear to adequately address the high priority risks.	The recommendations address risks as far as is practical. Landowners have been sent guidance information on how to undertake best management practices to help protect Calingiri's drinking water source.

Issue raised	Response
Add pesticide management and disposal to Recommendation 7.	This has been added to the final report, however 'chemical and hydrocarbon' has been written to incorporate more potential contaminants than just pesticides.
Amend Recommendation 3 to include all planning proposals.	It is Department of Water's preference that only proposals that are inconsistent with our Water quality protection note no. 25: <i>Land use compatibility tables for public drinking water source areas</i> are referred. Recommendation 3 has retained this reference but also now includes examples of the types of referrals.

Appendices

Appendix A – Figures

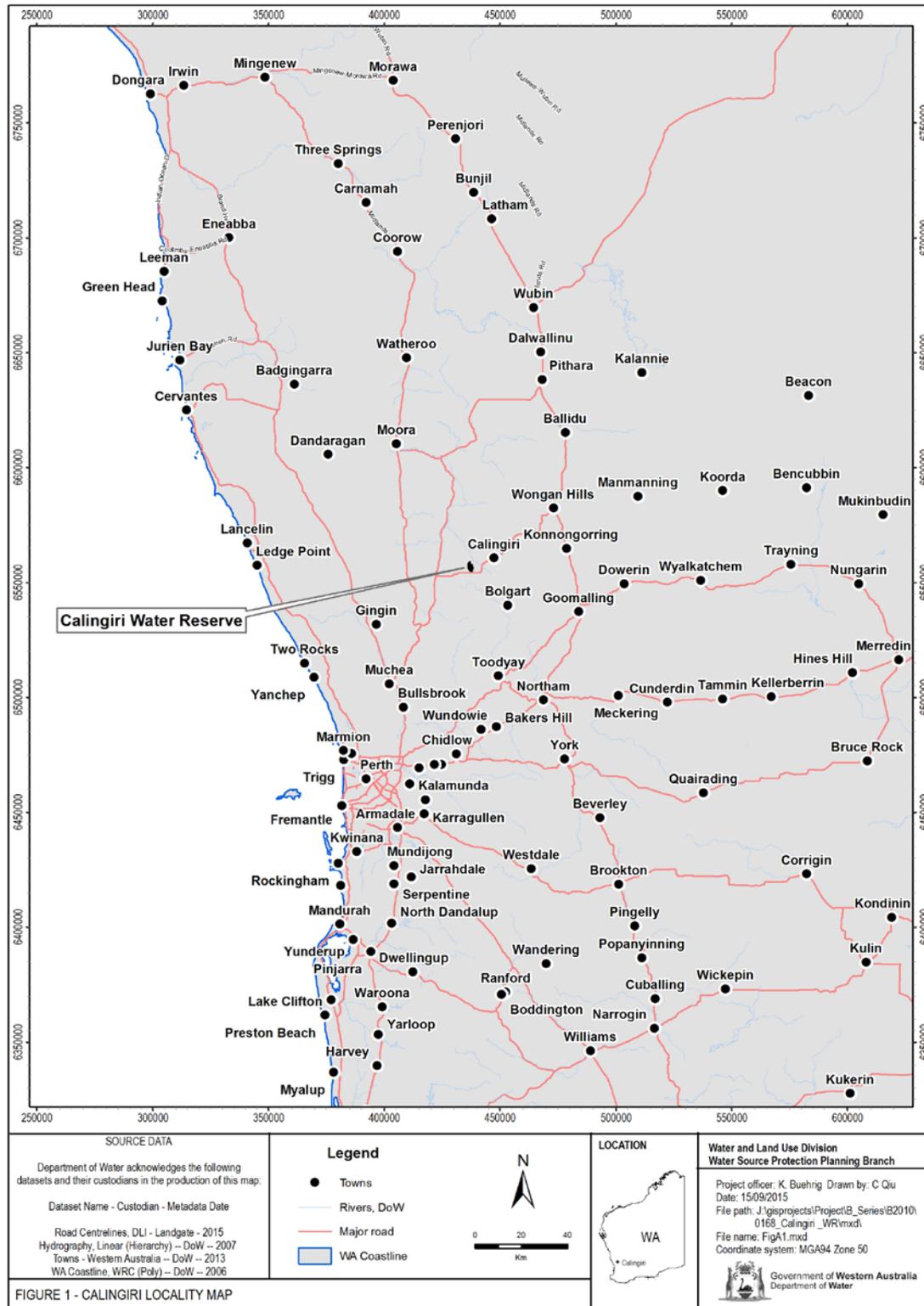


Figure A1 Calingiri Water Reserve locality map

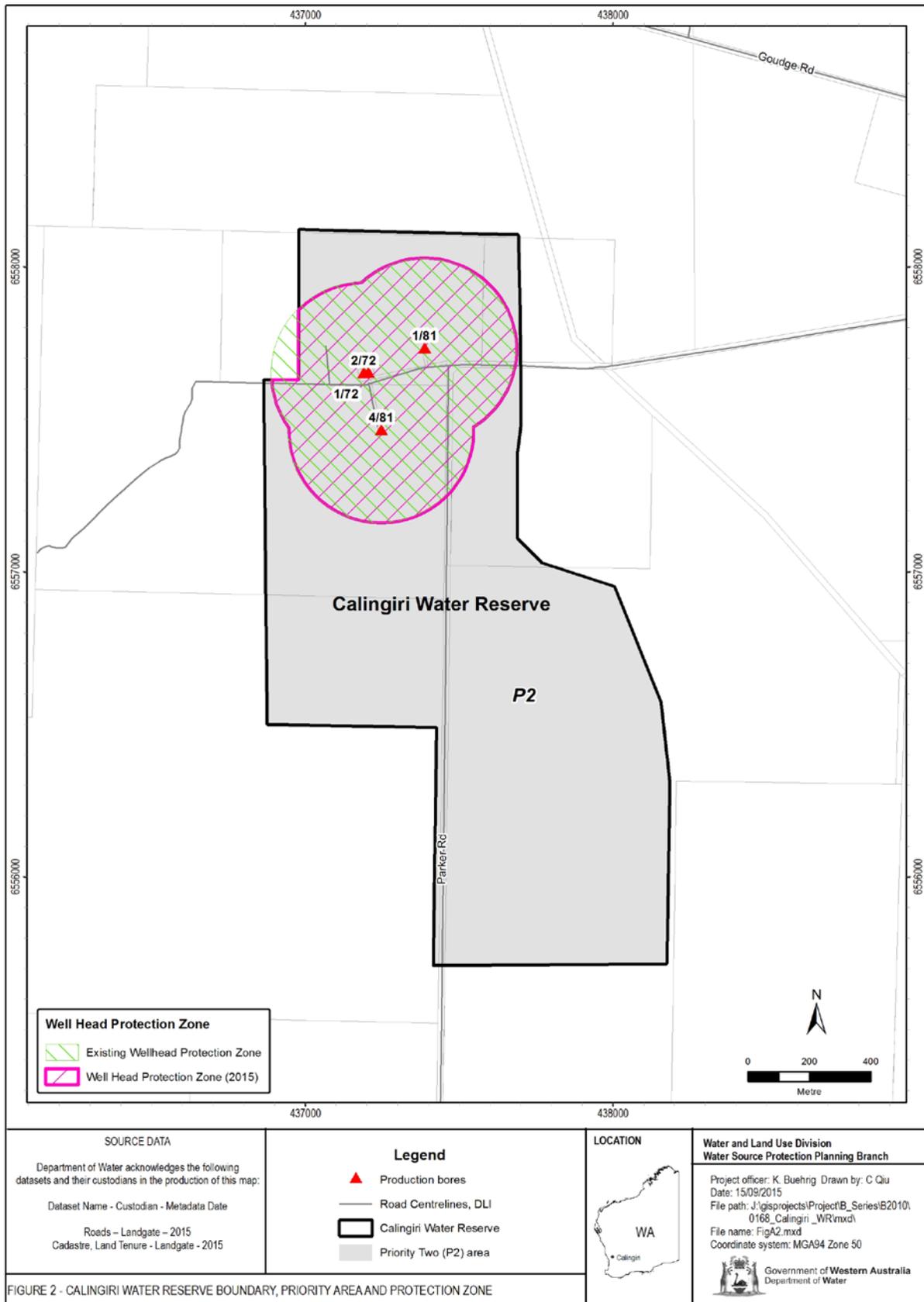


Figure A2 Calingiri Water Reserve boundary, priority area and protection zones

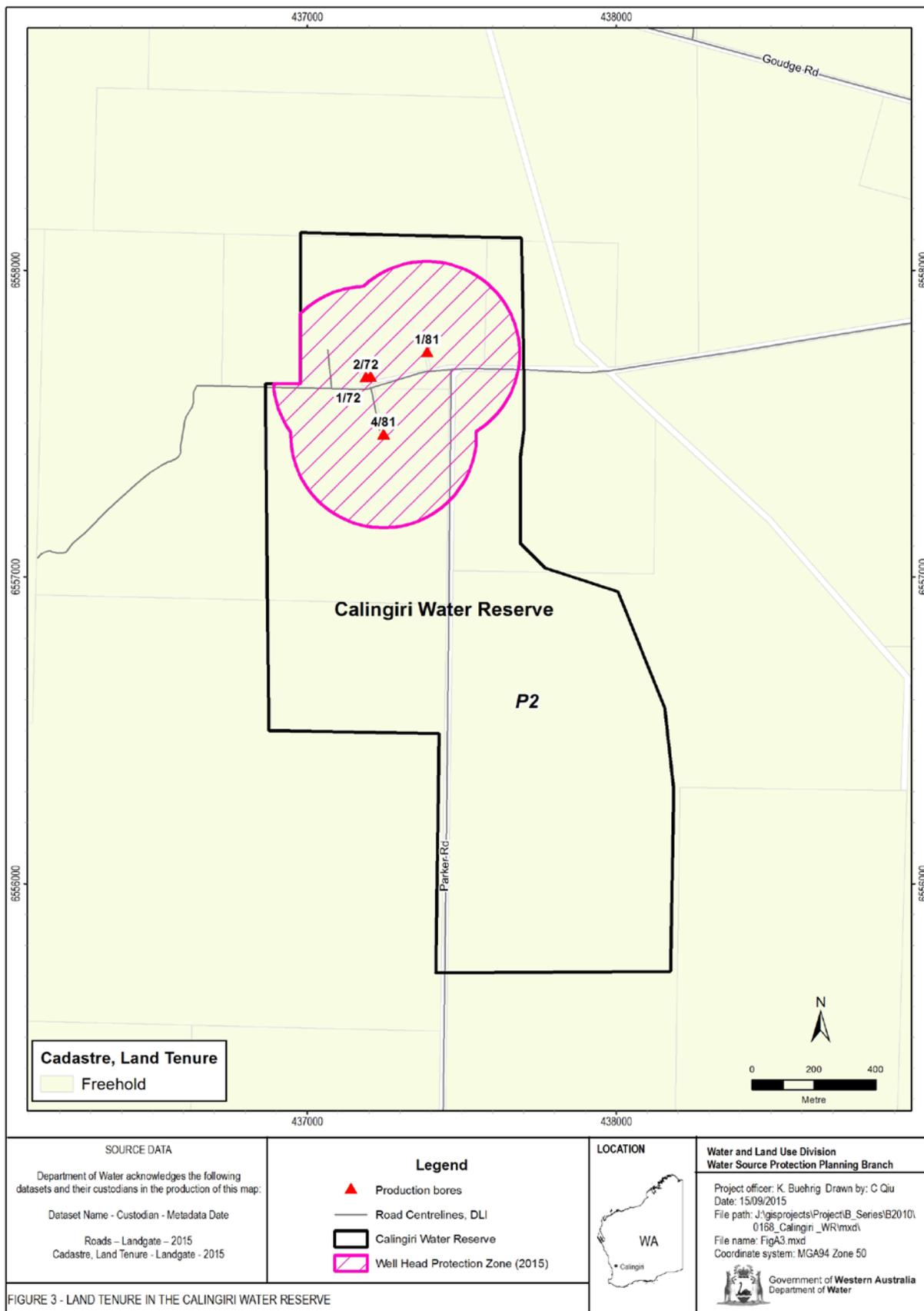


Figure A3 Calingiri Water Reserve land tenure

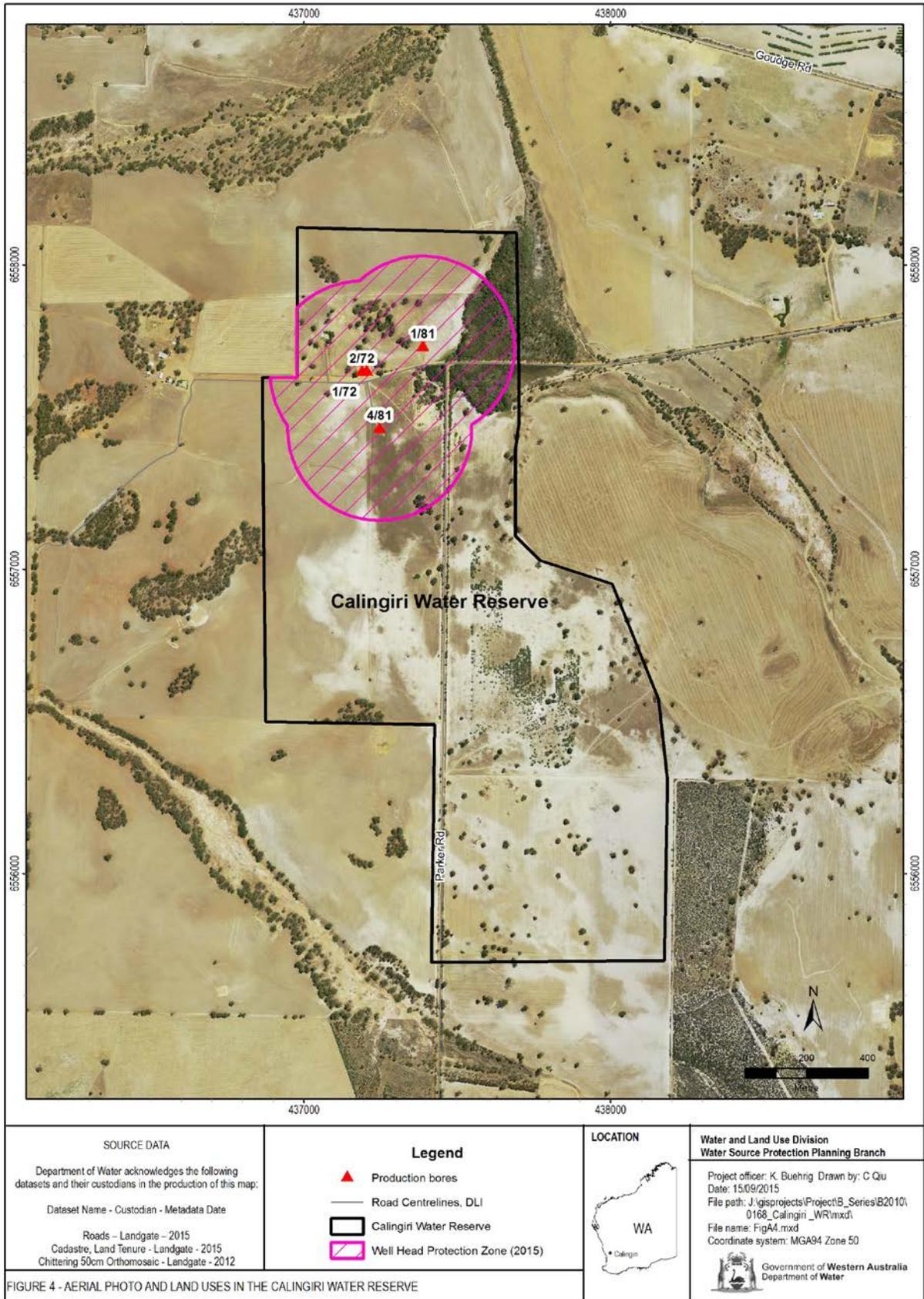


Figure A4 Calingiri Water Reserve aerial photo showing land uses

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 the Yenart bore field (Calingiri) 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 Yenart bore field. 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 March 2009 to March 2014.

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 mid-west region refer to the most recent Water Corporation drinking water quality annual report at <watercorporation.com.au>.

Aesthetic characteristics

The aesthetic quality analyses for raw water from the Yenart bore field are summarised in the following table.

Aesthetic detections for Calingiri

Parameter	Units	ADWG aesthetic guideline value*	Yenart bore field (raw water)	
			Range	Median
Chloride	mg/L	250	200– 605	235
Colour – True	TCU	15	<1–1	<1
Copper	mg/L	1	0.045–0.045	0.045
Hardness as CaCO ₃	mg/L	200	60– 200	85
Iron unfiltered	mg/L	0.3	<0.003 – 0.32	0.008
Manganese unfiltered	mg/L	0.1	<0.002 – 0.014	<0.002
pH (lab)	pH units	6.5–8.5	5.55–6.23	5.74
Silicon as SiO ₂	mg/L	80	13–19	17
Sodium	mg/L	180	110– 290	155
Sulfate	mg/L	250	17–45	24
Total filterable solids by summation	mg/L	600	397– 1057	528
Turbidity	NTU	5	<0.1–0.6	0.2
Zinc	mg/L	3	<0.02–0.04	<0.03

* 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 Yenart bore field is analysed for chemicals that are 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 Calingiri

Parameter	Units	ADWG health guideline value*	Yenart bore field (raw water)	
			Range	Median
Annual radiation dose	mSv	1	0.173 [#]	0.173 [#]
Barium	mg/L	2	0.009–0.02	0.0145
Boron	mg/L	4	0.03–0.04	0.035
Copper	mg/L	2	0.045–0.045	0.045
Lead	mg/L	0.01	0.003–0.004	0.0035
Manganese unfiltered	mg/L	0.5	<0.002–0.014	<0.002
Nitrate as nitrogen	mg/L	11.29 [†]	4.9–5.6	4.9
Nitrite plus nitrate as N	mg/L	11.29 [†]	2.8–6	5.1
Radon-222	Bq/L	100	12.5 [#]	12.5 [#]
Sulfate	mg/L	500	17–45	24

* 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).

† 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.

Based on only one sample taken at this source.

Microbiological contaminants

Microbiological testing of raw-water samples from the Yenart bore field is currently conducted on a monthly basis. *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 abstracted from a bore may indicate contamination of faecal material through ingress into the bore, or recharge through to the aquifer (depending on aquifer type).

During the reviewed period (March 2009 to March 2014), positive *E. coli* counts were recorded in 1.5 per cent of samples.

Appendix C – Photographs



Figure C1 Main Water Corporation compound at Yenart bore field, showing the treatment works and bore 1/72, by A. Kern, Department of Water



Figure C2 Fencing and sign at Yenart bore field, by K. Buehrig, Department of Water



Figure C3 Secure compound for bore 4/81, with surrounding farmland, by A. Kern, Department of Water



Figure C4 Grazing land use surrounding the Yenart bore field, by K. Buehrig, Department of Water

Appendix D – Typical contamination risks in groundwater sources

Land development and land- or water-based activities within a water reserve 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 a reliable, 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 microorganisms that are undetectable by sight, taste or smell. (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 groundwater 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 became ill in Walkerton, Canada, during 2000, because the town's water supply was contaminated by a pathogenic strain of *E. 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.

In groundwater sources, this occurs indirectly. Faecal material can infiltrate through the soil and into the groundwater. For example, contamination can occur from septic tanks or grazing animals.

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 survival and movement of pathogens in groundwater is influenced by the characteristics of the pathogen (such as its size and inactivation rate) and the groundwater properties (including flow rate, porosity, amount of carbon in the soil, temperature and pH). Inactivation rate (the time it normally takes a pathogen to decay) is one of the most important factors governing how far pathogens may migrate. Typical half-lives of pathogens range from a few hours to a few weeks. For example, some reported migration distances of bacteria in groundwater are:

- 600 m in a sandy aquifer
- 1000–1600 m in channelled limestone
- 250–408 m in glacial silt-sand aquifers (Robertson & Edbery 1997).

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 surface water and groundwater 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. 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, make them more difficult to remove during disinfection and treatment processes.

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 that washes through soil and into the groundwater. 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 – How do we protect public drinking water source areas?

The *Australian drinking water guidelines* (ADWG; NHMRC & NRMCC 2011) outline how we should protect drinking water in Australia. The ADWG recommends a 'catchment to consumer' framework that uses a preventive risk-based and multiple-barrier approach. A similar approach is recommended by the World Health Organization.

The catchment to consumer framework applies across the entire drinking water supply system – from the water source to the taps in your home. It ensures a holistic assessment of water quality risks and solutions to ensure the delivery of a reliable and safe drinking water to supply your home.

A preventive risk-based approach means that we look at all the different risks to water quality. We determine what risks can reasonably be avoided and what risks need to be minimised or managed to protect public health. This approach means that the inherent risks to water quality are as low as possible. A multiple-barrier approach means that we use different barriers against contamination at different stages of a drinking water supply system.

The first and most important barrier is protecting the public drinking water source area (PDWSA) (the area from which water is captured to supply drinking water). If we get this barrier right, it has a flow-on effect that can result in a lower cost, safer drinking water supply. Other barriers against contamination include storage of water to help reduce contaminant levels, disinfecting the water (for example chlorination to inactivate pathogens), maintenance of pipes and testing of water quality. Another community benefit from PDWSA protection is that it complements the state's conservation initiatives.

Research and experience shows that a combination of catchment protection and water treatment is safer than relying on either barrier on its own. That's why this drinking water source protection plan is important. We should not forget that ultimately it's about protecting your health by protecting water quality now and for the future.

In Western Australia, the Department of Water protects PDWSAs by implementing the ADWG, writing reports, policies and guidelines, and providing input into land use planning.

This drinking water protection report achieves elements 2 and 3 of the 12 elements in the ADWG recommended for protecting drinking water. It shows the PDWSA's location, its characteristics, existing and potential water quality contamination risks, and makes recommendations to deal with those risks.

The *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* and the *Country Areas Water Supply Act 1947* provide us with important tools to protect water quality in proclaimed PDWSAs. These Acts allow us to assess and manage the water quality contamination risks from different land uses and activities. The department works

cooperatively with other agencies and the community to implement this legislation and develop drinking water source protection reports. For example, the Western Australian Planning Commission has developed a number of state planning policies to help guide development in public drinking water source areas (PDWSAs).

An important step in maximising the protection of water quality in PDWSAs is to define their boundaries, priority areas and protection zones to help guide land use planning and to identify where legislation applies. There are three different priority areas. The objective of priority 1 (P1) areas is risk avoidance – ensuring there is no degradation of the water quality (for example over Crown land). The objective of priority 2 (P2) areas is risk minimisation – maintaining or improving water quality (for example over rural-zoned land). The objective of priority 3 (P3) areas is risk management – maintaining the water quality for as long as possible (for example, urban- or commercial-zoned land). Protection zones surround drinking water abstraction bores and surface water reservoirs so that the most vulnerable areas are protected from contamination.

The Department of Water's Water quality protection note (WQPN) no. 25: *Land use compatibility table for public drinking water source areas* outlines appropriate development and activities within each of the priority areas (P1, P2 and P3).

With 129 proclaimed PDWSAs across Western Australia, the department prioritises the update of drinking water source protection reports (such as this document). Our aim is to update each report every seven years. In some locations, more frequent updates may be required to address changing water quality risks and land uses. These updates allow us to make changes to the PDWSA boundary, priority areas and protection zones if required. They also allow solutions to new water quality risks to be considered.

There are three different types of drinking water source protection report – each providing for different needs. The following table shows the differences between the types of reports.

There is a fourth type of report – land use and water management strategy – that performs the same functions as a drinking water source protection report. However, these strategies are prepared by the Western Australian Planning Commission (with input from the Department of Water) and are strategic documents that integrate land use planning with water management. There are currently land use and water management strategies for Gngangara, Jandakot and Middle Helena.

If you would like more information about the ADWG and how we protect drinking water in Western Australia, visit <<http://drinkingwater.water.wa.gov.au>> or refer to our WQPN no. 36: *Protecting PDWSAs*. You can also contact the Department of Water's Water source protection planning branch on +61 8 6364 7600 or email drinkingwater@water.wa.gov.au.

Drinking water source protection reports produced by the Department of Water

Drinking water source protection report	Scope and outcome	Consultation	Time to prepare	Implementation table	Proclamation
Drinking water source protection assessment (DWSPA)	Desktop assessment of readily available information.	Targeted	3–6 months	No	Proclamation to protect water quality and guide land use planning can occur as a result of any type of drinking water source protection report.
Drinking water source protection plan (DWSP)	Full investigation of risks to water quality building on information in the DWSPA.	Public	6–12 months	Prepared from recommendations in the DWSPA and/or information from public consultation.	
Drinking water source protection review (DWSPR)	Review changes in land and water factors and implementation of previous recommendations. Sometimes prepared to consider specific issues in a PDWSA.	Key stakeholders	3–6 months	Prepared from recommendations in the DWSPA or DWSP.	

Appendix F – 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 integrated 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 preventive risk-based assessment process 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, a preventive risk-based assessment that considers both the maximum and residual risks is required. This means that in some cases, the maximum risks from land uses will still be considered unacceptable, even after mitigation has reduced the risk. This is a more conservative approach needed to protect the health of consumers.

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 (likelihood) equals risk (see risk matrix below).

Risk matrix: Level of risk (from the Australian drinking water guidelines 2011)

Likelihood	Consequences				
	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, 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.

Shortened forms

List of shortened forms

ADWG	<i>Australian drinking water guidelines</i>
ANZECC	Australian and New Zealand Environment Conservation Council
HAZMAT	hazardous materials
LEMC	local emergency management committee
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	nephelometric turbidity units
P1, P2, P3	priority 1, priority 2, priority 3
PSC 88	Public sector circular number 88
PDWSA	public drinking water source area
TCU	true colour units
Westplan– HAZMAT	Western Australian plan for hazardous materials
WHPZ	wellhead protection zone
WQPN	water quality protection note

Units of measurement

Bq/L	becquerel per litre
ha	hectare
mSv	millisievert
m	metres
mg/L	milligram per litre
mm	millimetre
km	kilometre
km²	square kilometre

Volumes of water

One millilitre	0.001 litre	1 millilitre	(mL)
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

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).
Allocation	The volume of water that a licensee is permitted to abstract, usually specified in kilolitres per annum (kL/a).
Aquifer	A geological formation or group of formations able to receive, store and transmit significant quantities of water.
Australian drinking water guidelines	The <i>National water quality management strategy: Australian drinking water guidelines 6, 2011</i> (NHMRC & NRMMC 2011) (ADWG) outlines acceptable criteria for the quality of drinking water in Australia (see <i>References</i>).
Becquerel	A measure of radioactivity, as per the International System of Units.
Bore	A narrow, lined hole drilled into the ground to monitor or draw groundwater (also called a well).
Bore field	A group of bores to monitor or withdraw groundwater (also see <i>wellfield</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.
Dissipate	To become scattered or dispersed.
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.
Gigalitre	A gigalitre is equivalent to 1 000 000 000 litres or one million kilolitres.
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.
Hydrogeology	The branch of geology that deals with the occurrence, distribution and effects of groundwater. It is the study of groundwater, especially relating to the distribution of aquifers, groundwater flow and groundwater quality.
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.
Nephelometric turbidity units	A measure of turbidity in water.
Nutrient load	The amount of nutrient reaching the waterway over a given timeframe (usually per year) from its catchment area.
Nutrients	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.
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.
Permeability	Also referred to as hydraulic conductivity, this is the ability of a rock or soil unit to transmit fluids. Its magnitude depends on the size of the pore spaces (see porosity) and the degree to which they are interconnected.
Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.
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.
Pollution	Water pollution occurs when waste products change the physical, chemical or biological properties of the water, adversely affecting water quality, the ecosystem and beneficial uses of the water.
Porosity	The ratio of water (or air) filled pore spaces to the total volume of the rock or soil, expressed as a percentage or fraction.

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 1 (P2) areas is <i>risk minimisation</i> and priority 3 (P3) areas is <i>risk management</i> .
Public sector circular number 88	A state government circular produced by the Department of Health providing guidance on appropriate herbicide use within water catchment areas.
Recharge	The action of water infiltrating through the soil/ground to replenish an aquifer.
Recharge area	An area through which water from a groundwater catchment percolates to replenish (recharge) an aquifer. An unconfined aquifer is recharged by rainfall throughout its distribution. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface.
Runoff	Water that flows over the surface from a catchment area, including streams.
Scheme supply	Water diverted from a source or sources by a water authority or private company and supplied via a distribution network to customers for urban and industrial use or for irrigation.
Soak	An area where water naturally seeps into a depression in the landscape, directly from groundwater or an ephemeral stream. Sometimes this area is dug out to maximise the water availability.
Superficial aquifer	Shallow (near to the surface) aquifers which are easily recharged and can be readily accessed by bores.
Total filterable solids by summation	A water quality test which is a total of the following ions: Na (sodium), K (potassium), Ca (calcium), Mg (magnesium), Cl equivalent (chloride), alkalinity equivalent, SO ₄ equivalent (sulfate) or S (sulfur) in grams, Fe (iron), Mn (manganese), and SiO ₂ (silicon oxide). It is used as a more accurate measure than total dissolved solids. The higher the value, the more solids that are present and generally the saltier the taste.

Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
True colour units	A measure of degree of colour in water.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.
Unconfined aquifer	An aquifer where the upper boundary is the water table and therefore is in contact with the atmosphere through the pore spaces in the unsaturated zone. Typically (but not always) it is the shallowest aquifer at a given location.
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.
Water reserve	An area proclaimed 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.
Watertable	The upper saturated level of the unconfined groundwater.
Wellfield	A group of bores located in the same area used to monitor or withdraw groundwater.
Wellhead	The top of a well (or bore) used to draw groundwater.
Wellhead protection zone	Usually declared around wellheads in public drinking water source areas to protect the groundwater from immediate contamination risks.
Westplan–HAZMAT	State emergency management plan for hazardous materials emergencies.

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Department of **Water**

168 St Georges Terrace, Perth, Western Australia

PO Box K822 Perth Western Australia 6842

Phone: 08 6364 7600

Fax: 08 6364 7601

www.water.wa.gov.au