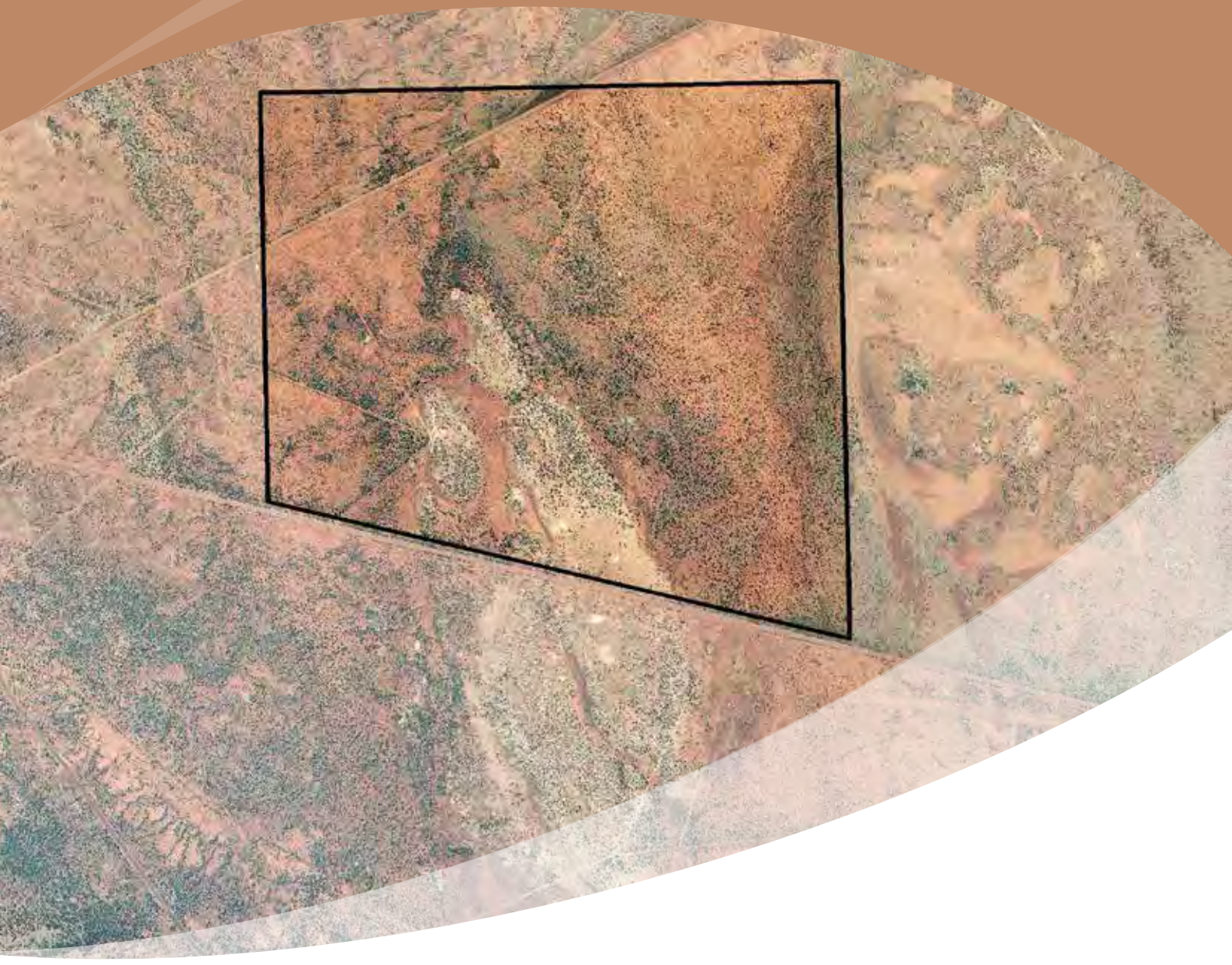
Government of **Western Australia**
Department of **Water**

Wiluna Water Reserve

Drinking water source protection plan

Wiluna town and Bondini Aboriginal community water supply



Securing Western Australia's water future

Water resource protection series
Report WRP 165
November 2016

Wiluna Water Reserve drinking water source protection plan

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Wiluna is located in the Mid West Gascoyne region of Western Australia, approximately 950 km north-east of Perth and 175 km north of Leinster by road. Wiluna is a service centre for the surrounding agricultural and mining areas. The town of Wiluna has a population of 291 residents (ABS 2011). The Bondini Aboriginal community is located 4 km east of Wiluna. The population is estimated to be around 90 people, but this can increase significantly at various times throughout the year (Department of Planning 2012).

The Water Corporation supplies water to the town of Wiluna and the Bondini Aboriginal community from three production bores – 6/01, 10/01 and 24/04 – located on a parcel of Crown reserve approximately 7 km east of the Wiluna townsite.

These bores draw water from a shallow, calcrete aquifer, at depths ranging from 3 m to 21 m. The aquifer is deemed to be unconfined and therefore the drinking water source is vulnerable to contamination from land uses and activities within the Wiluna Water Reserve. Establishing wellhead protection zones around the bores and assigning the Wiluna Water Reserve as a priority 1 area will reduce this contamination risk.

The Wiluna Water Reserve was first proclaimed under the *Country Areas Water Supply Act 1947* in 1992.

Key recommendations of this plan are:

- Incorporate the findings of this plan and location of the Wiluna Water Reserve (including its priority area and protection zones) in the Shire of Wiluna's local planning scheme in accordance with the Western Australian Planning Commission's State planning policy no. 2.7: *Public drinking water source policy*.
- Refer development proposals within the Wiluna Water Reserve that are inconsistent with the Department of Water's Water quality protection note no.25: *Land use compatibility tables for public drinking water source areas* or recommendations in this plan to the Department of Water's Swan Avon regional office for advice.
- Water Corporation should continue the current regime of water quality monitoring, maintenance of fencing, inspections and by-law enforcement.
- Ensure all abandoned wells and bores within the Wiluna Water Reserve are appropriately decommissioned to prevent the introduction of contaminants into the drinking water source.
- Conduct a groundwater assessment to improve the accuracy of the Wiluna Water Reserve boundary. Include updated boundary into the next review. (Department of Water)

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

This document has been prepared in consultation with stakeholders, including the Water Corporation, Shire of Wiluna and the Bondini Aboriginal community.

The following table shows important information about the Wiluna Water Reserve.

Key information about the Wiluna Water Reserve	
Status of this report	This report has been prepared based on information for the 2014/15 financial year
Local government authority	Shire of Wiluna
Locations supplied	Wiluna town and Bondini Aboriginal community
Water service provider	Water Corporation
Aquifer type	Unconfined (needs to be confirmed via future hydrogeological investigations)
Licensed abstraction	120 000 kL/year
Number of bores	3
Bore names and GPS coordinates	6/01 (E 230 636, N 7 054 316, zone 50) 10/01 (E 230 637, N 7 054 498, zone 50) 24/04 (E 230 713, N 7 054 257, zone 50)
Date of drinking water source protection reports	2004 – Wiluna Water Reserve drinking water source protection assessment (Water Corporation) 2016 – Wiluna Water Reserve drinking water source protection plan (this document)
Consultation	2014 – Consultation with stakeholders including the Water Corporation, Shire of Wiluna and the Bondini Aboriginal community via a representative of Midwest Employment & Economic Development Aboriginal Corporation (MEEDAC)
Proclamation status	Proclaimed on 26 June 1992 under the *Country Areas Water Supply Act 1947*

1 Overview

1.1 The drinking water supply system

Wiluna is located in the Mid West Gascoyne region of Western Australia, approximately 950 km north-east of Perth and 175 km north of Leinster by road (Figure A1). Wiluna is a service centre for surrounding agricultural and mining areas and there are 291 people who live in the town of Wiluna (ABS 2011).

The Bondini Aboriginal community is located 4 km east of Wiluna (Figure A1). The population is estimated to be around 90 people, but this can increase significantly at various times throughout the year (Department of Planning 2012).

The Water Corporation supplies water to the Wiluna scheme and Bondini Aboriginal community's drinking water from three bores – 6/01, 10/01 and 24/04 – located in a bore field 7 km east of Wiluna (Figure A5). These bores draw water from a shallow, calcrete aquifer, at depths ranging from 3 m to 21 m. The production bores are not contained in fenced compounds (Figure C1).

The aquifer is considered to be unconfined because recharge to the aquifer is thought to be, in part, from direct rainfall. Therefore the drinking water source is managed as an unconfined aquifer, which is highly vulnerable to contamination from land uses and activities within the Wiluna Water Reserve.

In addition to the production bores, the bore field contains two monitoring bores (5/01 and 7/01), and one monitoring well (Well 111) which are used by the Water Corporation to monitor water quality within the Wiluna Water Reserve. Two other observation wells within the bore field have been abandoned (Well 117 and Well 112).

The water levels in the production bores (6/01 and 10/01) fluctuate around 494 m AHD without showing any specific trend. The water levels in the monitoring wells (111, 112, 117 and 5/01) remain stable, but water levels in monitoring bore 7/01 vary seasonally around the same level as the production bores – 494 m AHD.

Prior to treatment, groundwater from the production bores is pumped to a 100 kL storage tank located in the bore field.

In 2009, the Water Corporation built an electrodialysis reversal (EDR) water treatment plant to improve the water quality for Wiluna and the Bondini Aboriginal community by reducing dissolved salts and nitrates. This treatment plant has now been doubled in capacity to treat raw water from all three bores, before being blended with a small percentage of raw water.

The water then undergoes chlorination to disinfect the water and ensure microbiological quality for consumers. The water treatment plant and associated discharge brine beds are located within the water reserve. The treatment plant and brine beds are surrounded by fencing and signage (figures C3 and C4 respectively).

After treatment, the water is pumped to two 500 kL storage tanks located on Tank Hill, approximately 2 km north-east of Wiluna. These tanks distribute the water via gravity to the Wiluna town scheme and the Bondini Aboriginal community.

Raw water quality in the Wiluna Water Reserve exceeds values in the *Australian drinking water guidelines* (ADWG) (NHMRC & NRMMC 2011) for the aesthetic parameters of total filterable solids, silicon and hardness; and the health-related parameters of nitrite and nitrate.

It should be recognised that although treatment and disinfection are essential barriers against contamination, public drinking water source area (PDWSA) management is the first step in protecting water quality and ensuring a safe drinking water supply. This approach is endorsed by the ADWG (NHMRC & NRMMC 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 PDWSAs, read Appendix F.

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 Wiluna refer to the most recent Water Corporation drinking water quality annual report at watercorporation.com.au.

1.2 Water management

1.2.1 Licence to take water

Water resource use and conservation in Western Australia is administered by the Department of Water in accordance with the *Rights in Water and Irrigation Act 1914*. Under this act, the right to use and control water is vested with the Crown. This means that a licence is required for drilling bores and abstracting groundwater (pumping water from a bore, spring or soak) within proclaimed groundwater areas throughout the state. Some exemptions apply such as abstracting water for domestic purposes only.

The Wiluna Water Reserve is located within the East Murchison Groundwater Area (in the Meekatharra subarea) which is proclaimed under the *Rights in Water and Irrigation Act 1914*. The Water Corporation is licensed by the Department of Water to abstract water from the Wiluna Water Reserve for the purpose of public water supply.

Water Corporation's groundwater allocation licence for these bores was last renewed in 2013, and is due to expire in March 2018. The licence allows the Water Corporation to draw 120 000 kL of water from the combined fractured rock aquifer to

supply Wiluna and the Bondini Aboriginal community's drinking water from the three production bores.

1.2.2 Water planning

In 2011, the Department of Water published the *Capacity of Water resources in the Mid West to meet mining and industrial growth*. This report is an addendum to the *Mid West Minerals Province – groundwater resource appraisal* (Department of Water 2006). The original report and the addendum summarise current information on the availability of water resources in the Mid West region, in the context of expected mining and industrial growth.

In 2015, the Department of Water published the *Mid West regional water supply strategy, A long-term outlook of water demand and supply*. The strategy considers a range of water demand scenarios for mining, industry, agriculture and towns in the region and identifies water supply options to meet demand well into the future. Five strategies guide how government, industry and the community can work together to ensure water is available to meet future demand in the Mid West region.

1.2.3 Future water needs

The Water Corporation had plans to install a reverse osmosis (RO) water treatment plant to improve the quality of water supplied to Wiluna. This treatment upgrade would have involved the commissioning of additional production bores (expected to be located within the existing water reserve) to supply the increased demand of a RO plant. However, in 2009, an electrodialysis reversal (EDR) water treatment plant was built for Wiluna instead. As EDR water treatment has a higher water recovery rate than RO systems, no additional bores were required to meet current water demands.

The Australian Bureau of Statistics data has shown that in 2001, the estimated population of Wiluna was 211 (ABS 2001) and in 2006 this reduced slightly to 202 (ABS 2006). Then in 2011 it increased again to an estimated 291 (ABS 2011).

The water needs of the Bondini Aboriginal community are variable depending on the population of the community at any given time. Calculations estimate that the permanent population of Bondini is increasing at a rate of 1 per cent, meaning that there will be an estimated population of 100 people by 2021 (Department of Planning 2012).

1.3 Characteristics of the catchment

1.3.1 Physical environment

The Wiluna Water Reserve is in the Mid West Gascoyne region of Western Australia. The landscape is dominated by large areas of flat sand plains, with scattered areas of higher bedrock and laterite. The drainage in the area is intermittent and has salt lakes at its base levels (Water Corporation 2004).

The topography within the water reserve is mostly flat with a very gentle southern slope. The drainage in the area is non-perennial and flows in a southerly direction.

The water reserve is covered by native vegetation, sparse low woodlands and open shrub-lands. The native vegetation can be seen in figures C1, C2, C5, and C7.

1.3.2 Climate

The climate of Wiluna is semi-arid, with typically hot summers and warm to mild winters. Since 1901, the average monthly maximum temperature has ranged from 19.4 ^{o}C in July to 37.9 ^{o}C in January, and the average monthly minimum temperature has ranged from 5.4 ^{o}C in July to 22.9 ^{o}C in January (Bureau of Meteorology 2014).

Average annual rainfall (since 1898) is 259.8 mm, mostly occurring during the summer months (Bureau of Meteorology 2014).

1.3.3 Hydrogeology

The Wiluna Water Reserve is situated on the north-eastern part of the Archaean Yilgarn Block.

The production bores abstract groundwater from the East Wiluna aquifer that occupies the lower portions of the Negrara and Kukabubba creeks drainage systems. Within the water reserve, the East Wiluna aquifer is made up of lateritic alluvium and massive calcrete, overlaying weathered and fractured Archaean greenstone and granite.

Recharge to the aquifer is thought to be from direct rainfall onto the calcrete and through indirect recharge from intermittent flow within the Negrara and Kukabubba creeks drainage system with groundwater flow to the south.

As the aquifer is considered to be unconfined, this makes it vulnerable to contamination from land uses and activities.

The current water reserve boundary has not been confirmed with groundwater modelling for the production bores. Due to the limited availability of hydrogeological information for this area, it is recommended that, when possible, groundwater modelling or further investigations be undertaken to confirm the nature of the aquifer and the accuracy of the PDWSA boundary.

1.4 How is this drinking water source currently protected?

The Wiluna Water Reserve was proclaimed in 1992 under the *Country Areas Water Supply Act 1947*. Proclamation identifies the location of the water reserve and ensures that its drinking water value is considered in land use planning decisions. It also allows by-laws to be applied for the protection of water quality.

The Water Corporation regularly patrols and surveys the water reserve to identify risks to water quality and enforce the by-laws where required. To find out more about by-laws, please see section 3.6: *Enforcing by-laws and surveying the area*. Water

Corporation's site operator conducts weekly production bore surveillance and inspections, and a Water Corporation catchment ranger conducts bi-annual surveillance of the production bores and water reserve.

In 2004, the Water Corporation prepared the *Wiluna Water Reserve drinking water source protection assessment.* It has information about the catchment, identifies risks to water quality and recommends strategies to manage those risks. This document replaces it, as it provides more up-to-date information and has been consulted with stakeholders.

This plan recommends that the Shire of Wiluna's local planning scheme recognises the Wiluna Water Reserve as a special control area – therefore the types of development supported should be guided by the Department of Water's Water quality protection note (WQPN) no.25: *Land use compatibility in public drinking water source areas*. This note is linked to the Western Australian Planning Commission's State planning policy no. 2.7: *Public drinking water source policy*, which addresses development in PDWSAs.

The Department of Water has formally delegated the enforcement of by-laws to the Water Corporation, for the management of this water reserve. This plan recommends that the Water Corporation continue by-law enforcement under the existing delegation arrangement. This also includes:

- erecting and maintaining signs in accordance with *S111 Source protection signage* (Water Corporation 2013)
- maintaining security and fencing
- ongoing regular surveillance and inspections.

1.5 Other water management information

1.5.1 Other groundwater bores in the area

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).

Apart from the Water Corporation production bores, there are five other production bores within the Wiluna Water Reserve, all licensed to the Wiluna Gold mine. There are four more production bores for this same licensee less than 500 m south of the water reserve.

Appropriate decommissioning of bores in accordance with *Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee 2012) is important as incorrectly decommissioned bores and wells can cause contamination of the drinking water source. Incorrectly decommissioned bores and wells provide a potential contamination pathway as they reduce the time available for contaminants to naturally degrade before potentially entering the aquifer.

Within the Wiluna Water Reserve there are at least eight decommissioned wells and bores. These should be appropriately managed so that they don't pose a risk to the water source. This includes a number of abandoned bores previously licensed to the Wiluna Gold mine that have not been appropriately decommissioned. One of these abandoned unsealed bores is shown in Figure C6. It is the responsibility of the Proprietor of Wiluna Gold mine – Apex Gold Pty Ltd – to decommission these bores in accordance with the *Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee 2012).

2 Contamination risks in this drinking water source

2.1 Water quality

The Water Corporation regularly monitors the quality of raw water from the Wiluna Water Reserve for microbiological, health-related and aesthetic (non-health related) characteristics. This data shows the quality of water in the PDWSA. An assessment of the drinking water quality once treated is also made against the ADWG. Any significant issues identified in this assessment is reported to an intergovernmental committee called the Advisory Committee for the Purity of Water, chaired by the Department of Health.

A water quality summary for the Wiluna Water Reserve from February 2009 to January 2014 is presented in Appendix B. For more information on water quality, see the Water Corporation's most recent drinking water quality annual report at www.watercorporation.com.au.

2.2 Land uses and activities

The Wiluna Water Reserve is mostly located on Crown reserve with one small cross-section that is a privately owned road (Research Station Road). This road provides access to a nearby mine and passes through the north-western corner of the water reserve. A buried gas pipeline also intersects the north-western corner and a road within the water reserve (refer to Figure A4).

The eastern half of the water reserve is covered by mining leases, however activity in these areas is minimal, with no active mines.

Current land uses and activities and their risks to the drinking water source are described below. Table 1, at the end of this section, summarises this information in an easy-to-read format. Appendix D displays a more detailed risk assessment, and includes recommended protection strategies to address water quality risks.

The current land uses in the Wiluna Water Reserve are limited. Some illegal recreation occurs such as hunting, camping and off-road vehicle use. A limited amount of prospecting also occurs.

There are a number of open bores and wells within the Wiluna Water Reserve.

There is no pastoral lease over the Wiluna Water Reserve but the water reserve is almost completely surrounded on all sides by the Millbillillie Station. However, stocking rates on the station are low.

2.2.1 Roads and tracks

There are a number of unsealed tracks and roads within the Wiluna Water Reserve. These tracks pose a risk to the water reserve by providing access to the production

bores. Vandalism of the production bores can result in hydrocarbon contamination from spills or leaks from vehicles, or pathogen contamination from human access.

There is a privately owned road (Research Station Road), which crosses the north-western corner of the water reserve. Vehicles within the water reserve pose a hydrocarbon contamination risk to the water source from leaks, spills or accidents. This risk can be reduced by ensuring that all unused bores are sealed and that the production bores have restricted access.

2.2.2 Unsealed wells

Abandoned wells and bores that have not been sealed correctly can pose a water source contamination risk (see section 1.5.1). Livestock and wild fauna may stray into the wells or their faeces may wash down into the well or bore, providing a direct pathway for pathogen contamination. An example of an unsealed abandoned bore within the Wiluna Water Reserve is shown in Figure C6.

2.2.3 Unauthorised recreation

Some illegal recreation occurs in the Wiluna Water Reserve. The recreation activities include camping, hunting and off-road vehicle use. The main water quality risks related to illegal recreation include spills of hydrocarbons and other chemicals from vehicles, and pathogen contamination from human access. This activity is difficult to control within the water reserve because of the high number of small access tracks and easy off-road access within the water reserve. The Water Corporation has a limited ability to monitor the reserve for illegal recreation but recreation levels are low due to the small population of the area. To reduce this risk it is recommended that signage is erected at entry points and along the boundary of the Wiluna Water Reserve to educate and advise the public that they are within the water reserve and about activities that are prohibited or regulated. The signage should include an emergency contact telephone number, in accordance with the Water Corporation's *S111 Source protection signage.*

2.2.4 Mining tenements

Mining and exploration tenements cover the eastern half of the Wiluna Water Reserve. Any proposed exploratory drilling requires a program of works, and any proposed mining activity requires a mining proposal. If either of these activities are proposed within the Wiluna Water Reserve boundary, these documents need to be referred to the Department of Water so that the drinking water source can be considered in licensing conditions. Also, the Department of Mines and Petroleum has a memorandum of understanding with the Department of Water for managing mining activities that may affect the state's water resources.

Exploration drilling poses a risk to aquifers as they can be cross-contaminated through poor drilling techniques and uncapped drill holes can provide a pathway for surface contaminants to reach the aquifer.

In addition, abandoned mine shafts provide a potential pathway for contamination to enter the aquifer through the accidental or deliberate action of people (such as illegal dumping) and through fauna access (including livestock). Decomposing animal carcasses pose a potentially significant risk of introducing pathogens into the water source.

2.2.5 Gas pipeline

A buried gas pipeline crosses the Wiluna water reserve (Figure A4). The gas pipeline is an existing land use and as the pipeline is transporting hydrocarbons as a gas rather than in liquid form, it poses a low hydrocarbon contamination risk to the water reserve. The highest contamination risk associated with the pipeline is access for maintenance and repair. All maintenance and repairs of the pipeline should be done in accordance with best management practices.

2.2.6 Aboriginal sites of significance and native title claims

Aboriginal sites of significance are those areas that Aboriginal people value as important and significant to their cultural heritage. The sites are significant because they link Aboriginal culture and tradition to place, land and people over time. These areas form an integral part of Aboriginal identity and the heritage of Western Australia. The *Aboriginal Heritage Act 1972* protects all Aboriginal sites in the state.

There are no Aboriginal sites of significance within the Wiluna Water Reserve, but there are a number of sites nearby.

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 is one native title claim within the Wiluna Water Reserve. This is the Wiluna claim (WAD6164_98).

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.

2.2.7 Surrounding pastoral lease

There is a pastoral lease which surrounds most of the Wiluna Water Reserve. As the water reserve is not fenced, stock from the surrounding Millbillillie Station can access the water reserve. Livestock grazing can present a risk of nutrient and pathogen contamination to the drinking water source. This risk is considered low in the Wiluna Water Reserve given that stocking rates are low and stock are not intentionally drawn into the water reserve. However to reduce this risk, production bores should be contained within fenced compounds.

2.2.8 Water treatment plant and brine beds

The Wiluna water treatment plant includes an electrodialysis reversal (EDR) water treatment unit and associated discharge brine beds. The EDR unit discharges brackish water into the brine beds while it is running. The brine beds are lined, which

means they are impervious, and store and evaporate the discharge water. The EDR unit discharges approximately 48 m^3 of brackish water into the brine beds per day if the plant runs 3–4 hours each day.

Water quality samples of the discharge water have been taken from the brine beds. Analysis of these samples indicates that the discharge water contains various salts including calcium, magnesium, chloride and nitrates.

The brine beds will be desludged when required. Modelling suggests that desludging will be required every 25 years. The sludge will be disposed of outside the Wiluna Water Reserve, at an approved landfill site.

The brine bed walls are well above ground level, and their capacity has been designed to take into account any flooding. As there has been no history of flooding in the area of the water treatment plant, it is unlikely that the brine beds would be compromised by flooding.

The brine beds pose a contamination risk to the local groundwater and surface water, mainly resulting from the constituents of the water. However, as the brine beds are lined and visually monitored by the Water Corporation, the water quality contamination risk that they pose is considered to be medium.

The use of machinery and vehicles at the water treatment plant poses a risk to groundwater quality from hydrocarbon spills or leaks.

2.3 Possible future contamination risks

The land uses and activities identified in this plan are not expected to change in the short term. Future land uses should be guided by this protection plan and recognise that the Wiluna Water Reserve is protected under the *Country Areas Water Supply Act 1947* (WA). This Act may restrict or prevent some land uses from occurring in the water reserve to help protect water quality and public health. The Water Corporation, the Shire of Wiluna and the Department of Water need to coordinate land-use assessment and approvals in the water reserve. Future land uses within the water reserve are expected to be in accordance with the Department of Water's WQPN no. 25: *Land use compatibility in public drinking water source areas*. Further information on development application referrals, the PDWSA water source protection framework, special control areas and relevant by-laws can be found in the Department of Water's WQPN no. 76: *Land use planning in public drinking water source areas*.

As part of this plan, we have conducted a new assessment of water quality contamination risks to the Wiluna drinking water source, in accordance with the ADWG. Table 1 shows a summary of the assessment of the risks to water quality.

Table 1 Summary of potential water quality risks and best management practices

Land use/activity	**Hazard**	**Management priority**	**Comments**	**Best management practice guidance[1]**
Roads and tracks	Hydrocarbons	Low	Existing roads are acceptable. Access to roads and tracks should be managed.	WQPN no. 44: *Roads near sensitive water resources*
Recreation and illegal recreation activities such as: • hunting • camping • off-road driving	Pathogens from human access	Medium	Levels of recreation are low. Most recreational activities within the water reserve, including camping, hunting and off-road driving, are inconsistent with Operational policy no.13: *Recreation within public drinking water source areas on Crown land*.	Operational policy no.13: *Recreation within public drinking water source areas on Crown land*
Mineral exploration and mining	Hydrocarbon and chemical spills from machinery and vehicles	Low	Mining is compatible with conditions in P1 areas. Mineral exploration and mining activities are subject to licensing and reviews by the departments of Mines and Petroleum and Environmental Regulation.	Water quality protection guidelines series: *Mining and mineral processing* Mining tenement conditions for the protection of water quality on tenement leases

Land use/activity	Hazard	Management priority	Comments	Best management practice guidance[1]
Gas pipeline	Hydrocarbons from repairs and maintenance	Low	The pipeline is an existing land use. The pipeline is buried 1–2 m underground.	WQPN no. 83: *Infrastructure corridors near sensitive water resources*
Stock access from neighbouring pastoral lease	Pathogens and nutrients from animal excrement	Medium	There is no fence surrounding the production bores or the water reserve so stock access is possible.	WQPN no. 35: *Pastoral activities within rangelands*
Open wells	Pathogen contamination from animal waste and carcasses	Medium	These wells can provide a direct route for animals and their waste to contaminate the groundwater with pathogens.	*Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee 2012)
Water treatment plant and EDR brine beds	Hydrocarbons from vehicles and machinery Saline and chemical contamination from leaking brine beds	Medium	The brine beds are close to production bores 6/01 and 24/04. Drinking water treatment plants are compatible with conditions in P1 areas.	WQPN no. 27: *Liners for containing pollutants using synthetic liners* WQPN no.65: *Toxic and hazardous substances: storage and use*

[1]Water quality protection notes (WQPNs) are available drinkingwater.water.wa.gov.au.

3 Protecting Wiluna's drinking water source

The objective of this plan is to preserve water quality at its current level, and where practical achieve an improvement, to ensure the continued supply of safe, good quality drinking water to residents of Wiluna and the Bondini Aboriginal community.

3.1 Proclaiming public drinking water source areas

Wiluna Water Reserve was proclaimed under the *Country Areas Water Supply Act 1947* in 1992.

Proclamation of a PDWSA does not change the zoning of land. All existing, approved land uses and activities in a proclaimed area can continue. However, we recommend that best management practices are employed in PDWSAs to protect the quality of the drinking water source. New developments or expansion of existing land uses or activities need to consider the recommendations in this plan. As a general guide, the Department of Water does not recommend land use intensification in a PDWSA because of the increased risks to water quality and public health.

For more guidance on appropriate land uses and activities please refer to our WQPN no. 25: *Land use compatibility tables for public drinking water source areas*.

3.2 Defining priority areas

The protection of PDWSAs relies on statutory and non-statutory measures for water resource management and land-use planning.

The determination of priority areas is based on the strategic importance of the land or water source including risks to water quality and quantity, the local planning-scheme zoning, the form of land tenure and existing approved land uses or activities. For further detail, please refer to our WQPN no. 25: *Land use compatibility tables for public drinking water source areas*.

The proposed priority area for the Wiluna Water Reserve has been determined in accordance with current Department of Water policy. This area is described below and displayed in Figure A5. Our WQPN no.25: *Land use compatibility tables for public drinking water source areas* outlines activities that are 'acceptable', 'compatible with conditions' or 'incompatible' within different priority areas. For an explanation of the background and support for protection of PDWSAs, please refer to WQPN no. 36: *Protecting public drinking water source areas*.

We propose to assign the Crown land and the privately owned road reserve in the Wiluna Water Reserve as priority 1 (P1) because:

- water from this source is the only supply available to Wiluna and the Bondini Aboriginal community
- current land uses on the private and Crown land are considered 'acceptable' in P1 areas.

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

3.3 Defining protection zones

In addition to priority areas, protection zones are defined in PDWSAs to protect water from contamination in the immediate vicinity of water extraction facilities (i.e. bores or dams). Specific conditions may apply within these zones such as restrictions on the storage of chemicals or prohibition of public access.

Wellhead protection zones (WHPZs) are generally circular (unless information is available to determine a different shape or size), with a 500 m radius around each production bore in a P1 area and a 300 m radius around each production bore in P2 and P3 areas. WHPZs do not extend outside the boundary of the water reserve and they adopt the priority area of the land over which they occur.

There are three production bores in the Wiluna Water Reserve and each bore is protected by a 500 m WHPZ (Figure A5).

3.4 Planning for future land uses

Appropriate protection mechanisms in statutory land-use planning processes are necessary to secure the long-term protection of drinking water sources. As outlined in the WAPC's State planning policy no. 2.7: *Public drinking water source policy* (2003) it is appropriate that the Wiluna Water Reserve, its priority area and protection zones be recognised in the Shire of Wiluna's local planning scheme. Any development proposals in the Wiluna Water Reserve that are inconsistent with advice in our WQPN no.25: *Land use compatibility tables for public drinking water source areas* or recommendations in this plan, need to be referred to our nearest regional office for advice.

For further information on the integration of land-use planning and water source protection, please refer to our WQPN no.36: *Protecting public drinking water source areas*. This note describes the findings of Parliamentary Committee reviews instrumental in the integration of water quality protection and land use planning in WA. The Parliamentary Committees all advocated protection over a reliance on costly water treatment or the cleanup of contaminated sources required in other parts of the world.

The department's protection strategy for PDWSAs provides for approved developments to continue even if those facilities would not be supported under current water quality protection criteria. In these instances, the department can provide advice to landowners or operators on measures they can use to improve their facilities and reduce water quality contamination risks (see section *3.5: Using best management practices*).

3.5 Using best management practices

There are opportunities to reduce water contamination risks by carefully considering design and management practices. To help protect water sources, the Department of Water will continue to encourage the adoption of best management practices.

Guidelines on best management practices for many land uses are available in the form of industry codes of practice, environmental guidelines and WQPNs. They recommend practices to help managers reduce their impacts upon water quality. These guidelines have been developed in consultation with stakeholders such as industry groups, agricultural producers, state government agencies and technical advisers. Examples relevant to the Wiluna Water Reserve include WQPN no. 44: *Roads near sensitive water resources* and Water quality protection guideline series: *Mining and mineral processing*) (see *Further reading*).

Education and awareness-raising (such as through providing information on signs) are key mechanisms for protecting water quality, especially for people visiting the area.

3.6 Enforcing by-laws and surveying the area

The quality of water in PDWSAs within country areas of the state is protected under the *Country Areas Water Supply Act 1947*. Proclamation of PDWSAs allows by-laws to be applied to protect water quality.

The Department of Water considers by-law enforcement, through surveillance of land-use activities in PDWSAs, to be an important mechanism to protect water quality.

Signs will be erected on the boundaries of this water reserve to educate and advise the public about activities that are prohibited or regulated. This plan recommends that the Water Corporation continue surveillance and by-law enforcement under the existing delegation arrangement.

3.7 Responding to emergencies

The escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The Shire of Wiluna local emergency management committee, through the Mid West Gascoyne emergency management district, should be familiar with the location and purpose of the Wiluna Water Reserve. A locality plan will be provided to the fire and rescue services headquarters for the hazardous materials (HAZMAT) emergency advisory team. The Water Corporation should have an advisory role to the HAZMAT team for incidents in the Wiluna Water Reserve.

Personnel who deal with Westplan–HAZMAT (Western Australian plan for hazardous materials) incidents within the area should have access to a map of the Wiluna Water Reserve. These personnel should have an adequate understanding of the potential impacts of spills on this drinking water source.

3.8 Implementing and updating this plan

Table 1 (Section 2) identifies the potential water quality risks associated with existing land uses in the Wiluna Water Reserve. Further information and the recommended protection strategies to deal with those risks are outlined in Appendix D.

4 Recommendations

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

1. Incorporate the findings of this plan and location of the Wiluna Water Reserve (including its priority area and protection zones) in the Shire of Wiluna's 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 Wiluna)
2. Refer development proposals within the Wiluna 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 plan to the Department of Water's Swan Avon regional office for advice. (Department of Planning, Shire of Wiluna, proponents of proposals)
3. Ensure incidents covered by Westplan–HAZMAT in the Wiluna Water Reserve are addressed by ensuring that:
    - the Shire of Wiluna local emergency management committee is aware of the location and purpose of the Wiluna Water Reserve
    - the locality plan for the Wiluna 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 Wiluna Water Reserve
    - personnel dealing with Westplan–HAZMAT incidents in the area have ready access to a locality map of the Wiluna Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality.

    (Water Corporation)
4. Erect signs at entry points and along the boundary of the Wiluna Water Reserve including an emergency contact telephone number, in accordance with the Water Corporation's *S111 Source protection signage* (2013). (Water Corporation)
5. Water Corporation should continue the current regime of water quality monitoring, maintenance, inspections and by-law enforcement. (Water Corporation)
6. Ensure all abandoned wells and bores within the Wiluna Water Reserve are appropriately decommissioned. (Water Corporation, Apex Gold Pty Ltd –Proprietor of Wiluna Gold mine)
7. Ensure all production bores are contained within fenced compounds. (Water Corporation)

8. Conduct a groundwater assessment to improve the accuracy of the Wiluna Water Reserve boundary. Include updated boundary into the next review.
   (Department of Water)
9. Update this plan within seven years.
   (Department of Water)

Appendices

Appendix A — Figures

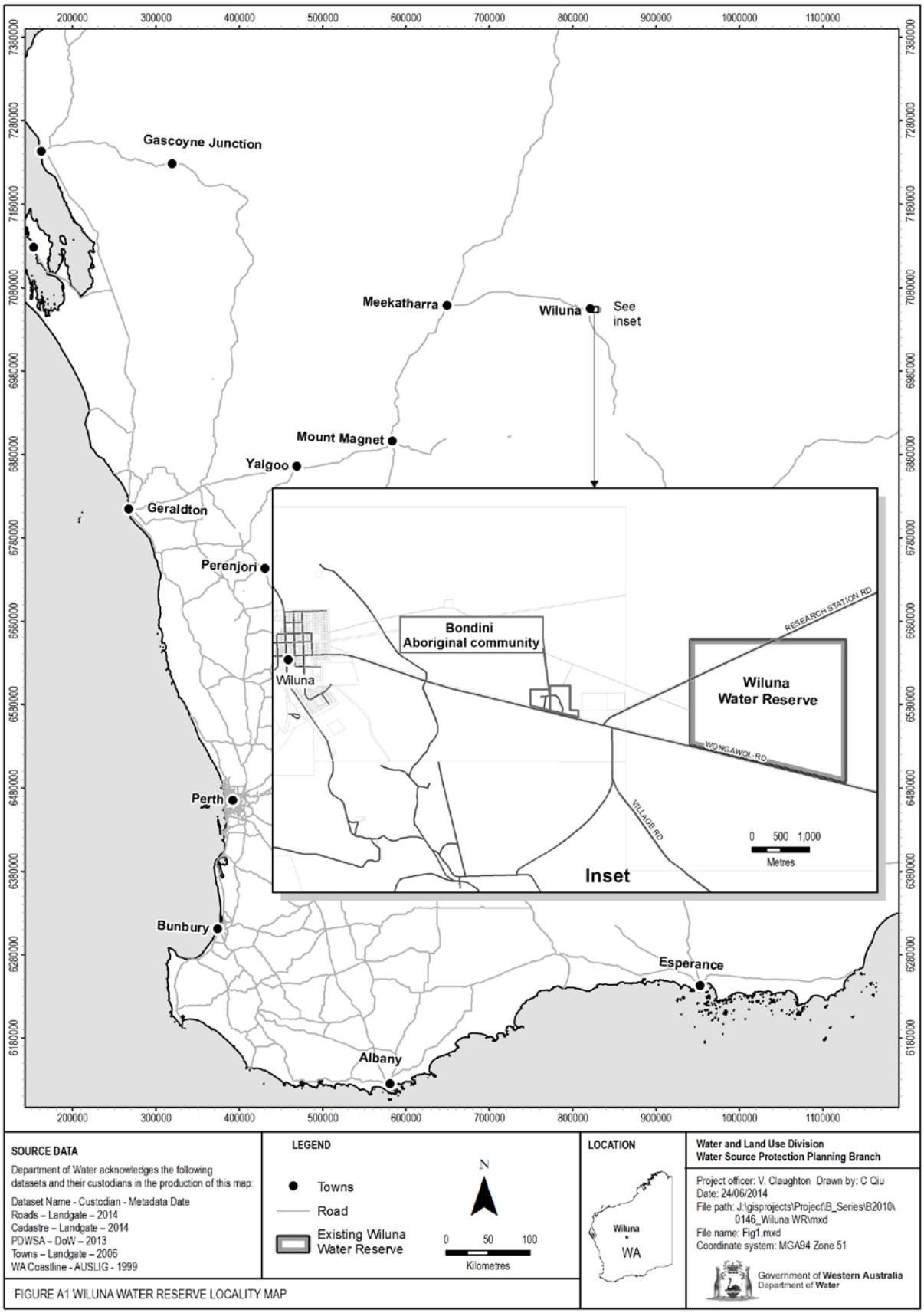
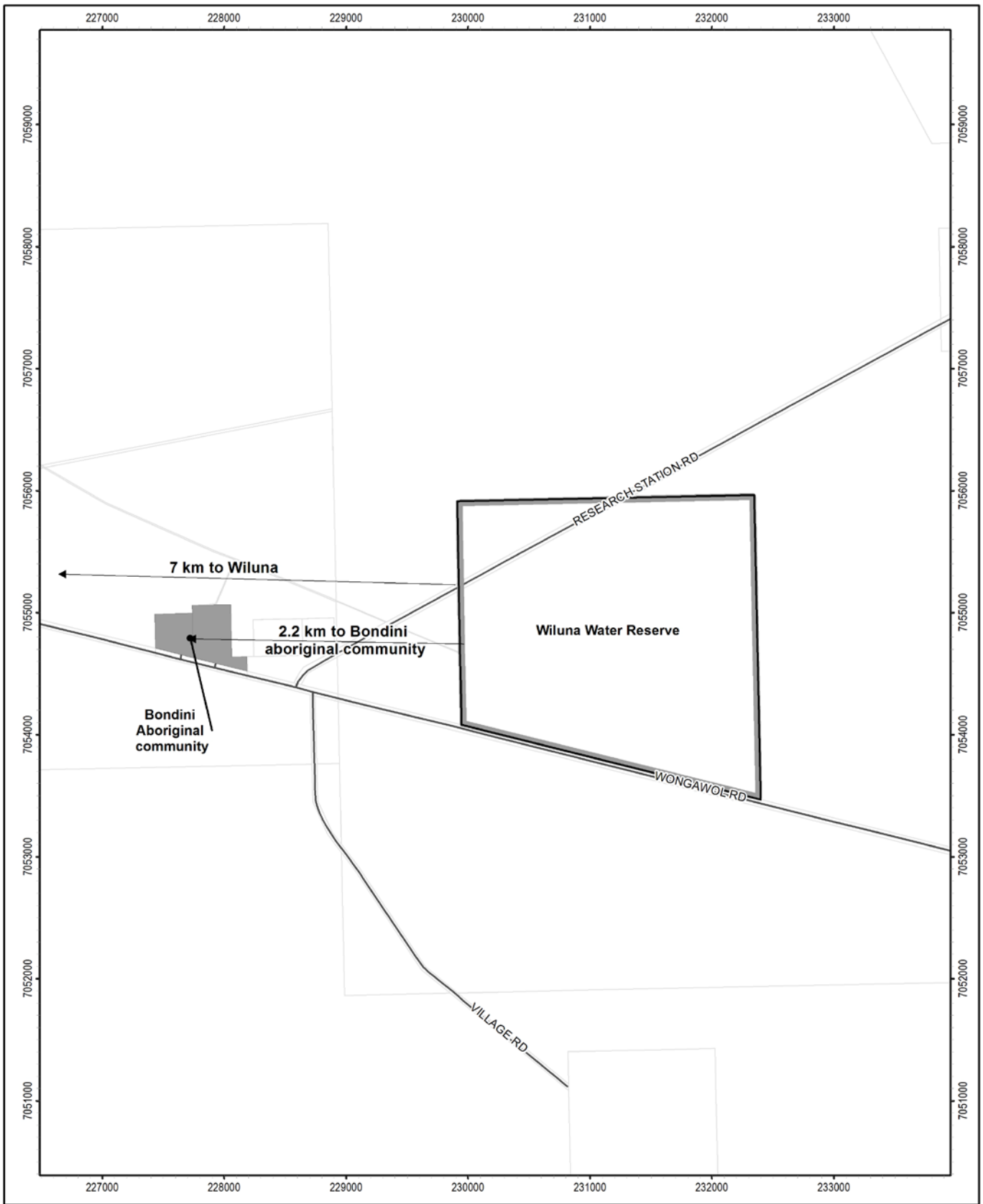


FIGURE A1 WILUNA WATER RESERVE LOCALITY MAP



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2014
Cadastre – Landgate – 2014
PDWSA – DoW – 2013
WA Petroleum Pipelines – DMP – 2014
Towns – Landgate – 2006

LEGEND

- Roads
- Wiluna Water Reserve
- Cadastre
- Bondini Aboriginal community

N

0 250 500

Metres

LOCATION

Wiluna

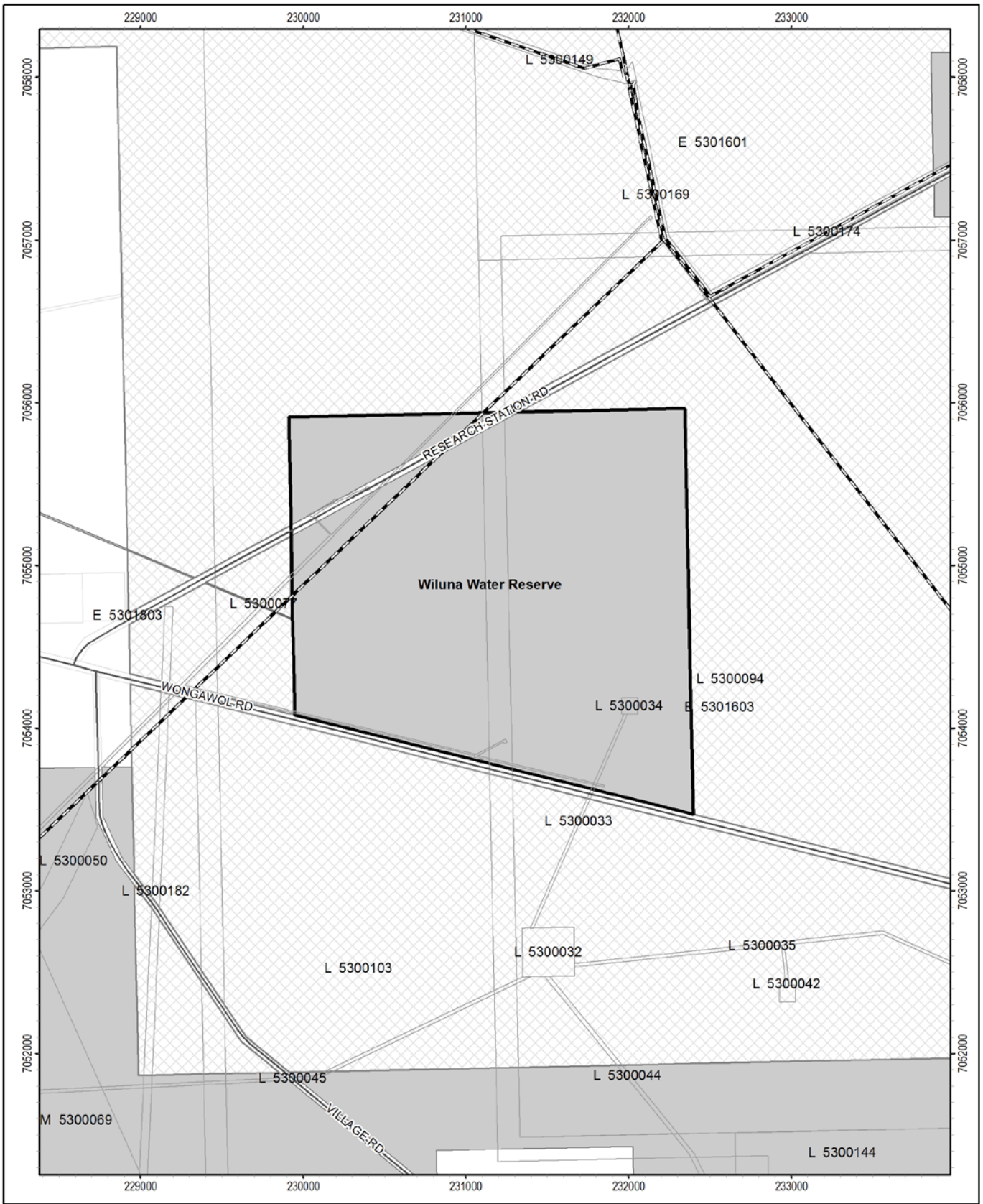
WA

Water and Land Use Division
Water Source Protection Planning Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 18/03/2015
File path: J:\gisprojects\Project\B_Series\B2010\0146_Wiluna WR\mxd
File name: Fig2P.mxd
Coordinate system: MGA94 Zone 51

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

FIGURE A2 EXISTING WILUNA WATER RESERVE BOUNDARY



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2014
Cadastre – Landgate – 2014
PDWSA – DoW – 2013
WA Petroleum Pipelines – DMP – 2014
Mining tenements - DMP - 2014

LEGEND

- Gas pipelines
- Roads
- Wiluna Water Reserve
- Crown Lease
- Crown Reserve
- Mining tenements

N

0 250 500
Metres

LOCATION

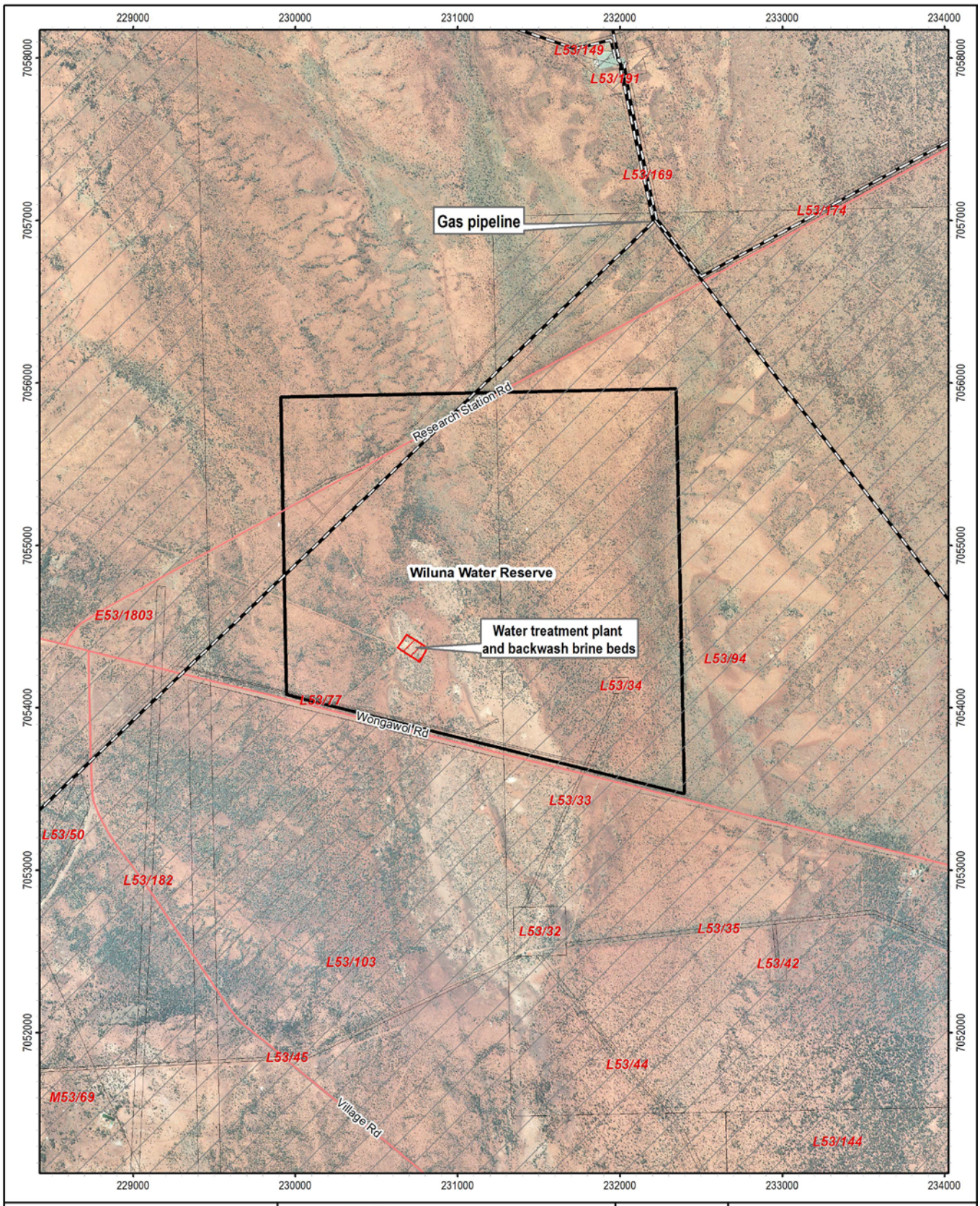
Wiluna
WA

Water and Land Use Division
Water Source Protection Planning Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 24/06/2014
File path: J:\gisprojects\Project\B_Series\B2010\0146_Wiluna WR\mxd
File name: Fig3.mxd
Coordinate system: MGA94 Zone 51

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

FIGURE A3 LAND USE, ACTIVITIES AND TENURE IN AND AROUND THE WILUNA WATER RESERVE



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2014
Cadastre – Landgate – 2015
PDWSA – DoW – 2013
Wiluna_2008_80cm_z51 – Landgate – 2008
Towns – Landgate – 2006
WA Petroleum Pipelines – DMP – 2014

LEGEND

- Gas pipelines
- Roads
- Water treatment plant and backwash brine beds
- Wiluna Water Reserve
- Mining Tenements

N

0 250 500
Metres

LOCATION

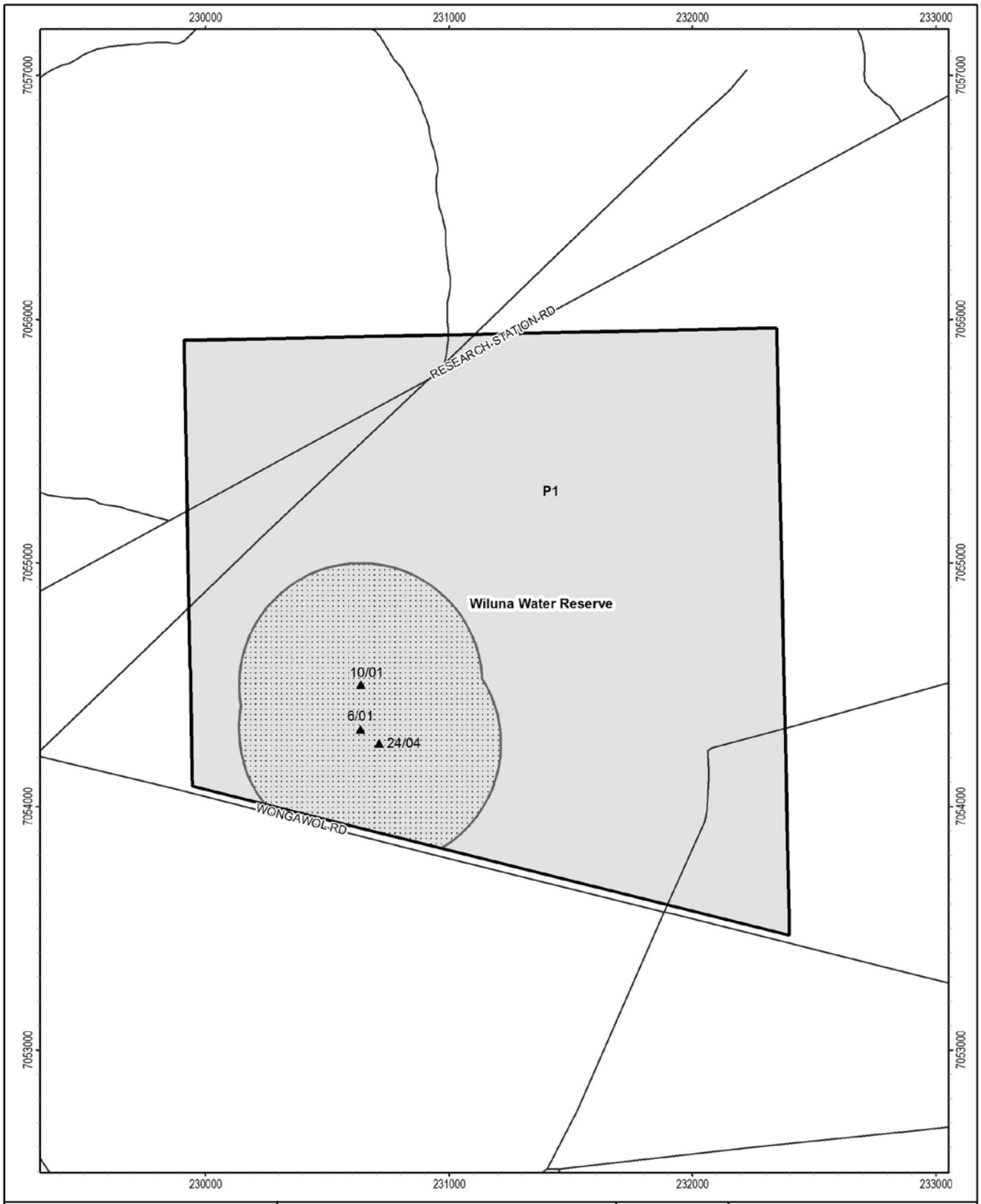
Wiluna
WA

Water and Land Use Division
Water Source Protection Planning Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 18/03/2015
File path: J:\gisprojects\Project\B_Series\B2010\0146_Wiluna WR\mxd
File name: Fig4P.mxd
Coordinate system: MGA94 Zone 51

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

FIGURE A4 AERIAL PHOTOGRAPHY AND LAND USES IN THE WILUNA WATER RESERVE



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2014
PDWSA – DoW – 2013
Towns – Landgate – 2006

LEGEND

- Production bores
- Roads
- Wiluna Water Reserve
- Proposed Wellhead Protection Zone
- Proposed Priority one (P1) area

N

0 250 500
Metres

LOCATION

Water and Land Use Division
Water Source Protection Planning Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 29/7/2014
File path: J:\gisprojects\Project\B_Series\B2010\0146_Wiluna WR\mxd
File name: Fig5A.mxd
Coordinate system: MGA94 Zone 51

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

FIGURE A5 PROPOSED BOUNDARY, PRIORITY AREAS AND WELLHEAD PROTECTION ZONES FOR THE WILUNA WATER RESERVE

Appendix B — Water quality data

The Water Corporation has monitored the raw (source) water quality from Wiluna in accordance with the requirements of the *Australian drinking water guidelines* (ADWG) (NHMRC & NRMMC 2011) and interpretations agreed to with the Department of Health. This data shows the quality of water in the water reserve. The raw water is regularly monitored 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 Wiluna 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 February 2009 to January 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 Wiluna refer to the most recent Water Corporation drinking water quality annual report at watercorporation.com.au.

Aesthetic

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

Aesthetic detections for Wiluna

Parameter	**Units**	**ADWG aesthetic guideline value***	**Wiluna bore field raw water – post EDR and Bore 10/01**		**Wiluna bore field raw water – bores 6/01 and 24/04**	
			Range	**Median**	**Range**	**Median**
Chloride	mg/L	250	55–155	112.5	155–170	165
Hardness as CaCO3	mg/L	200	130–***350***	***210***	150–***400***	***360***
Iron (unfiltered)	mg/L	0.3	<0.003–0.01	<0.003	<0.003–0.05	<0.003
Silicon as SiO2	mg/L	80	75–***110***	***85***	***80–90***	***85***
Sodium	mg/L	180	64–87	73	78–89	82
Sulfate	mg/L	250	44–125	71	23–156	107
Total filterable solids by summation	mg/L	600	415–***827***	***609.5***	***655–902***	***829***
Turbidity	NTU	5	<0.1–0.3	<0.1	<0.1–1.3	<0.1
pH measured in laboratory	no unit	8.5	7.39–7.97	7.65	7.55–7.98	7.72
Copper	mg/L	1	0.045–0.045	0.045	-	-
Zinc	mg/L	3	0.02–0.02	0.02	-	-

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

Health-related

Health-related chemicals

Raw water from Wiluna 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 Wiluna

Parameter	**Units**	**ADWG health guideline value***	**Wiluna bore field raw water – post EDR and Bore 10/01**		**Wiluna bore field raw water – bores 6/01 and 24/04**	
			Range	**Median**	**Range**	**Median**
Nitrite plus nitrate as N	mg/L	11.29†	4.4–***23.3***	***14.2***	11–***33.7***	***22.95***
Sulfate	mg/L	500	44–125	71	23–156	107
Barium	mg/L	0.7	0.025–0.025	0.025	0.05–0.05	0.05
Boron	mg/L	4	0.5–0.5	0.5	0.5–0.5	0.5
Chromium	mg/L	0.05	0.0035–0.0035	0.0035	0.007–0.007	0.007
Copper	mg/L	2	0.045–0.045	0.045	-	-
Fluoride laboratory measurement	mg/L	1.5	0.25–0.3	0.25	0.3–0.4	0.3

* 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 (NHRMC & ARMCANZ 2011).

† The 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 Wiluna 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 any bore may indicate contamination of faecal material through ingress into the bore, or recharge through to the aquifer (depending on aquifer type).

During the review period, no positive *E. coli* counts were recorded.

Appendix C — Photographs

Figure C1 Wiluna Water Reserve production bore 10/01, photograph by M. Sawyer, Water Corporation, reproduced with permission

Figure C2 Signage within the Wiluna Water Reserve, photograph by M. Sawyer, Water Corporation, reproduced with permission

Figure C3 Wiluna Water Reserve drinking water treatment plant, photograph by M. Sawyer, Water Corporation, reproduced with permission

Figure C4 Wiluna Water Reserve discharge brine beds, photograph by M. Sawyer, Water Corporation, reproduced with permission

Figure C5 A decommissioned bore within the Wiluna Water Reserve, photograph by M. Sawyer, Water Corporation, reproduced with permission

Figure C6 Unsealed abandoned bore within the Wiluna Water Reserve, photograph by H. Merrett, Water Corporation, reproduced with permission

Figure C7 Unsealed road within the Wiluna Water Reserve, photograph by M. Sawyer, Water Corporation, reproduced with permission

Figure C8 Stock tracks within the Wiluna Water Reserve, photograph by M. Sawyer, Water Corporation, reproduced with permission

Appendix D — Land use, potential water quality risks and recommended protection strategies

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	Management priority			
Roads and tracks	Hydrocarbon contamination from fuel spills and leaks	Low	There are a number of unsealed roads in the water reserve.	• water quality monitoring • Water Corporation surveillance	• Use signs to inform people that they are within the Wiluna Water Reserve and of the need to protect water quality: signage should include an emergency contact number. • Investigate installing gates on unnecessary roads that currently provide public access. • Maintain HAZMAT emergency response. • Ensure adherence to WQPN no. 44: *Roads near sensitive water resources* and WQPN no. 10: *Contaminant spills – emergency response*.

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Mineral exploration and mining	Hydrocarbon and other chemical spills and leaks from machinery and vehicles	Low	Mining is compatible with conditions in P1 areas. Proposed exploratory drilling and mining activity requires a program of works or a mining proposal to be referred to the Department of Water for comment.	• water quality monitoring • sealed bores • Water Corporation surveillance • Department of Mines and Petroleum (DMP) licensing and reviews	• Ensure adherence to the Water quality protection guideline series: *Mining and mineral processing.* • Ensure compliance with DMP mining tenement conditions and endorsements.
	Pathogens from human activity	Medium			
	Chemicals from mineral processing	Low			
Stock access from neighbouring pastoral lease	Pathogens and nutrients from animal excrement	Medium	As the production bores are not within fenced compounds and there is no fence surrounding the water reserve, stock can access the production bores.	• water quality monitoring • sealed bores • Water Corporation surveillance	• Contain production bores within fenced compounds. • If required, and if funding is available, fence the water reserve to prevent stock access. • Surrounding pastoral lease owner not to encourage stock movement into the water reserve, and to adhere to best management practices.

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Recreational and illegal recreation • camping • hunting • off-road vehicles	Pathogens from human activity	Medium	Occasional recreational activity occurs within the water reserve. There are a number of tracks that provide access to the water reserve. Most recreational activities within the water reserve, including camping, hunting and off-road driving, are inconsistent with Operational policy no. 13. The current level of activity is low.	• water quality monitoring • sealed bores • Water Corporation surveillance	• Increase monitoring of the water reserve if practical. • Contain production bores within fenced compounds. • Use signs to inform people that they are within the Wiluna Water Reserve and of the need to protect water quality: signage should include an emergency contact number. • Investigate closing or installing gates on unnecessary roads that provide public access. • Recreation should be consistent with Operational policy no.13: *Recreation within public drinking water source areas on Crown land*.
	Hydrocarbon contamination from vehicles, fuel spills, leaks or accidents	Low			

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Maintenance and repairs of the gas pipeline	Hydrocarbon and other chemical spills and leaks from machinery and vehicles	Low	The gas pipeline is an existing land use. The pipeline is buried underground. The company responsible for the pipeline is aware of the Wiluna Water Reserve and of DoW best practice guidance documents.	• water quality monitoring • sealed bores • Water Corporation surveillance • DMP licensing and reviews	• Ensure adherence to WQPN no. 83: *Infrastructure corridors near sensitive water resources.* • Ensure compliance with DMP mining tenement conditions and endorsements.
	Pathogens from human activity	Medium			

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Open bores and wells	Pathogen contamination from animal wastes and carcasses Livestock and wild animals falling into the wells and decomposing or their faeces washing into the bores and wells	Medium	Old open bores and wells provide a potential contamination pathway as they reduce the time available for contaminants to naturally degrade before potentially entering the aquifer.	• water quality monitoring • Water Corporation surveillance	• Ensure bores and wells have been appropriately decommissioned.
Electrodialysis reversal (EDR) water treatment plant and discharge brine beds	Saline and chemical contamination from salts and chemicals accumulated in brine beds	Medium	The water treatment plant and brine beds are less than 50 m from production bores 6/01 and 24/04.	• brine beds are lined and designed to cope with flooding • brine beds will be desludged when	• Continue to monitor water quality of the bores and brine beds. • Implement a monitoring program to check for leaks in the brine beds.

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
	Fuel and chemical spills from vehicles and machinery	Medium	The brine beds have been lined and the brine bed walls are well above ground level and would not be likely to be impacted by flooding. Chemical components of the brine beds are calcium, magnesium, chloride and nitrates.	necessary • desludged waste will be disposed of outside the Wiluna Water Reserve at an appropriate waste disposal facility	• Undertake maintenance of the water treatment plant on a regular basis. • No chemicals should be stored at the water treatment plant, apart from the chemicals used while operating the plant. • Adhere to WQPN no. 27: *Liners for containing pollutants using synthetic liners* and WQPN no. 65: *Toxic and hazardous substances: storage & use*.

Appendix E— 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 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 & NRMMC 2011). Contaminants can also interfere with water treatment processes, and damage water supply infrastructure (such as iron corroding pipes).

The ADWG (NHMRC & NRMMC 2011) outlines 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. These include bacteria, protozoa and viruses. In drinking water supplies, pathogens are commonly found in the faeces of humans and domestic animals (such as dogs and cattle).

Pathogens can enter drinking water supplies from faecal contamination in the water reserve. 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 the length of time it normally takes to decay) and the groundwater properties (including flow rate, permeability, 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.

When people consume drinking water contaminated with pathogens the consequences vary considerably, ranging from mild illness (such as stomach upset or diarrhoea) to hospitalisation and sometimes even death. During 2000, seven people died in Walkerton, Canada, because the town's water supply was contaminated by a pathogenic strain of *E. coli* and *Campylobacter* (NHMRC & NRMMC 2011).

Given the wide variety of pathogens, the differences in how they act 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). 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 can adsorb onto soil particles and may be shielded from the effects of disinfection. Chemicals can also attach to suspended soil particles.

Some physical properties of water such as pH (a measure of acidity or alkalinity) can contribute to the corrosion and encrustation of pipes. Other properties such as iron and dissolved organic matter can affect the colour and smell of water. Although not necessarily harmful to human health, coloured or 'hard' water will not be as appealing to consumers. Salinity can affect the taste of drinking water.

Chemical risks

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

Pesticides include agricultural chemicals such as insecticides, herbicides, nematicides (used to control worms), rodenticides and miticides (used to control 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, and harmful chemical by-products may be formed when they are combined with chlorine during the water-treatment process. Hydrocarbons can occur in water supplies as a result of spills and leakage from vehicles.

Drinking water sources can also be contaminated by nutrients (such as nitrogen) from fertiliser, septic systems, and faecal matter from domestic or feral animals that washes through or over soil and into a water source. Nitrate and nitrite (forms of nitrogen) can be toxic to humans at high levels, with infants younger than three months being most susceptible (NHMRC & NRMMC 2011).

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

Appendix F— How do we protect public drinking water source areas?

The *Australian drinking water guidelines* (ADWG) (NHMRC & NRMMC 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.

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.

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 Gnangara, Jandakot and Middle Helena.

If you would like more information about the ADWG and how we protect drinking water in Western Australia, visit drinkingwater.water.wa.gov.au or refer to our Water quality protection note (WQPN) no. 36: *Protecting public drinking water source areas*. 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 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	Up to 3 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 (DWSPP)	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 change in land and water factors and implementation of previous recommendations. Sometimes prepared to consider specific issues in a PDWSA.	Key stakeholders	Up to 3 months	Prepared from recommendations in the DWSPA or DWSPP.	

Appendix G— 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. These planning policies recognise the importance of PDWSAs for the protection of water quality and public health.

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 equals risk (see risk matrix below).

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. Further, no previous detection of contamination is not proof that the risk is acceptable.

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

List of shortened forms

ADWG	*Australian drinking water guidelines*
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
EDR	electrodialysis reversal
HAZMAT	hazardous materials
kL	kilolitre
km	kilometre
LEMC	local emergency management committee
m	metres
mg/L	milligram per litre
mm	millimetre
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	nephelometric turbidity units
PDWSA	public drinking water source area
RO	reverse osmosis
WAPC	Western Australian Planning Commission
Westplan–HAZMAT	Western Australian plan for hazardous materials
WHPZ	wellhead protection zone
WQPN	water quality protection note

Glossary

Abstraction	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.
Adsorb	Adsorb means to accumulate on the surface of something.
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	Is the volume of water that a licensee is permitted to abstract, usually specified in kilolitres per annum (kL/a).
Aquifer	An aquifer is a geological formation or group or formations able to receive, store and transmit significant quantities of water.
Australian drinking water guidelines	The *National water quality management strategy: Australian drinking water guidelines 6*, 2011 (NHMRC & NRMMC 2011) (ADWG) outlines acceptable criteria for the quality of drinking water in Australia (see this plan's References).
Bore	A bore is 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 is referred to as a bore field.
Catchment	The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
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.
Fractured rock	An aquifer where groundwater is present in the fractures, joints, solution cavities, bedding planes and zones of weathering igneous, metamorphic and deformed sedimentary rocks. Fractures rock aquifers are highly susceptible to contamination from land-use activities when aquifers crop-out or sub-crop close to the land surface.
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 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.
mg/L	A milligram per litre (0.001 grams per litre) is a measurement of something (such as salinity) in a solution.
Nephelometric turbidity units	Nephelometric turbidity units are a measure of turbidity in water.
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 *Escherichia coli*), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses.
Permeability	The ability of a porous medium to transmit a fluid.
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 seven indicates an acidic solution and above seven indicates an alkaline solution.
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 *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* or the *Country Areas Water Supply Act 1947*.
Recharge	Recharge is 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.
Runoff	Water that flows over the surface from a catchment area, including streams.
Total filterable solids by summation	Total filterable solids by summation is 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 (TDS). 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.
Unconfined aquifer	An aquifer in which the upper surface of water is lower than the top of the aquifer itself. The upper surface of the groundwater within the aquifer is called the watertable. This is also known as a superficial aquifer.
Water quality	Water quality is the collective term for the physical, aesthetic, chemical and biological properties of water.
Water reserve	A water reserve is an area proclaimed under the *Country Areas Water Supply Act 1947* or the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* for the purposes of protecting a drinking water supply.
Wellhead	The top of a well (or bore) used to draw groundwater is referred to as a wellhead.
Wellhead protection zone	A wellhead protection zone is usually declared around wellheads in public drinking water source areas to protect the groundwater from immediate contamination threats in the nearby area.

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