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

Horrocks Beach Water Reserve

drinking water source protection review

Horrocks Beach town water supply

Water resource protection series
Report WRP 176
April 2018

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Cover photograph: Aerial photo of Horrocks Beach Water Reserve

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Summary

This drinking water source protection review considers changes that have occurred in and around the Horrocks Beach Water Reserve since the *Horrocks Beach Water Reserve drinking water source protection assessment* (Water Corporation 2004) was released. The assessment still contains relevant information, so it is important that these documents are read in conjunction. Both are available on the Department of Water and Environmental Regulation's website or by contacting the department.

Horrocks Beach is a small tourist and fishing town about 75 km north of Geraldton in the Shire of Northampton (Figure A1). The Water Corporation supplies drinking water to 165 residential properties from two bores about 4 km north-east of town (1/92 and 2/92). The bores draw water from a confined source, meaning that they are protected from surface contamination from surrounding land uses. They are located in secure compounds on private farming land (Figure A3).

The current Horrocks Beach Water Reserve boundary is quite large, covering approximately 4.5 km^2 (Figure A2). Given that the aquifer is confined and the bores will meet the town's water needs for the foreseeable future, a large boundary is not required. The source will be adequately protected by a smaller boundary that covers the bore compounds. Department of Water and Environmental Regulation will arrange to reduce this boundary and assign a priority 2 (P2) area (Figure A4).

The main changes since the 2004 assessment are:

- the boundary is being reduced to reflect current policy and exclude private land
- bore 7/90 is no longer used due to rising salinity.

The Department of Water and Environmental Regulation prepared this document in consultation with key stakeholders, including land owners, the Water Corporation, Department of Health, Department of Planning (Department of Planning, Lands and Heritage as of 1 July 2017) and the Shire of Northampton.

This review helps implement the *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 2011), State planning policy no. 2.7: *Public drinking water source policy* (Western Australian Planning Commission 2003) and Strategic policy: *Protecting public drinking water source areas in Western Australia* (Department of Water 2016a).

Important information about the Horrocks Beach Water Reserve is in Table 1.

Table 1 Key information about the Horrocks Beach Water Reserve

Horrocks Beach Water Reserve	
Local government authority	Shire of Northampton
Location supplied	Horrocks Beach
Water service provider	Water Corporation
Aquifer type	confined
Licensed abstraction	100 000 kL per year
Number of bores	2
Bore details	1/92 (E 250 365, N 6 862 413, zone 50) 1992, 108 m deep 2/92 (E 250 270, N 6 862 835, zone 50) 1992, 108 m deep
Dates of drinking water source protection reports	2004 – *Horrocks Beach Water Reserve drinking water source protection assessment* (Water Corporation) 2017 – *Horrocks Beach Water Reserve drinking water source protection review* (this document)
Consultation	2017 – consultation with key stakeholders including landowners
Gazettal history and status	Gazetted on 28 July 1992 under the *Country Areas Water Supply Act 1947* Department of Water and Environmental Regulation proposes to significantly reduce this boundary via an amendment under the *Country Areas Water Supply Act 1947* when this report is finalised
Reference documents	*Australian drinking water guidelines* (NHMRC & NRMMC 2011) State planning policy no. 2.7: *Public drinking water source policy* (Western Australian Planning Commission 2003) *Mid West regional water supply strategy* (Department of Water 2015)

1 Review of Horrocks Beach's drinking water source protection assessment

1.1 Boundary, priority areas and protection zones

The Horrocks Beach Water Reserve was gazetted in 1992 under the *Country Areas Water Supply Act 1947* (Figure A2).

In 2004, the Water Corporation prepared a drinking water source protection assessment for the source, which discussed the need to maintain a large water reserve boundary for future alternative water sources. Projections show that the current source will meet Horrocks Beach's needs for the foreseeable future (Department of Water 2015).

Horrocks Beach's drinking water bores draw water from the Tumblagooda aquifer (Department of Water 2017), which is overlain by the Kockatea Shale, a confining unit. This means that water in the aquifer is protected from surface contamination risks.

These two factors have led the Department of Water and Environmental Regulation to propose a significant reduction of the water reserve boundary (Figure A2). The proposed boundary incorporates only the bore compounds and will be assigned a priority 2 (P2) area to reflect the rural zoning (figures A3 and A4). Wellhead protection zones are not considered necessary for the Horrocks Beach Water Reserve due to the confined nature of the water source, the depth of the bores and the fenced compound.

The Department of Water and Environmental Regulation will arrange for the constitution of the new Horrocks Beach Water Reserve boundary under the *Country Areas Water Supply Act 1947* (see section 3, recommendation 1 and Figure A4).

The boundary, priority areas and protection zones have been determined in accordance with Strategic policy: *Protecting public drinking water source areas in Western Australia* (Department of Water 2016a).

Please read Appendix E for more information about how we protect drinking water sources in Western Australia.

1.2 Special control area

The existing Horrocks Beach Water Reserve is recognised in the Shire of Northampton's *Local planning scheme no. 10* (Department of Planning 2012) as *Special control area no. 3*, meaning that the shire gives it special consideration in land use planning decisions to ensure protection of the drinking water source. The scheme also refers to the department's Water quality protection note (WQPN) no. 25: *Land use compatibility tables in public drinking water source areas* (Department of Water 2016b).

When the water reserve is amended under the *Country Areas Water Supply Act 1947*, the Department of Water and Environmental Regulation recommends that the Shire of Northampton reduce *Special control area no. 3* accordingly (see section 3, recommendation 2).

1.3 Update on water supply scheme

Horrocks Beach's drinking water comes from two bores (1/92 and 2/92, see Appendix C for photos) about 4 km north-east of town (Figure A2). The bores are 108 m deep and draw water from the Tumblagooda aquifer, which is confined (Department of Water 2017). They are connected to mains power.

Bore 7/90 is no longer used due to rising salinity. It is unequipped, and the bore hole has been closed with a steel plate.

The Department of Water and Environmental Regulation licenses the Water Corporation to draw 100 000 kL of groundwater per year from the Kalbarri/Eurady subarea of the Gascoyne groundwater area to supply Horrocks Beach with drinking water. There are 165 residential properties connected to the supply. Peak demand occurs in December and January, coinciding with the tourist season. Total abstraction for April 2015 – March 2016 was 41 505 kL and the licence expires in 2023 (no. 108574). The average annual growth rate for scheme water demand in the Mid West region is expected to be 1–3 per cent over the next thirty years (Department of Water 2015). Therefore the current bores are expected to meet future demand for Horrocks.

Water abstracted from the bores is pumped to a water treatment plant, about 2 km from the town. Raw water is treated to reduce iron, manganese and turbidity levels through pre-chlorination to oxidise and precipitate these minerals, caustic dosing, filtration through a single Dynasand continuous moving sand bed filter followed by chlorination for disinfection. Treated water is then transferred to a 1000 kL storage tank for gravity supply to the distribution system.

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 *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 2011) and is based on preventive risk and multiple barriers 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, and the Department of Water and Environmental Regulation's approach based on preventive risk, read Appendix E.

1.4 Aboriginal sites of significance and native title claims

Aboriginal sites of significance are important places with special cultural connections to Aboriginal people. They are important because they link Aboriginal cultural tradition to place, land and people over time. These sites are integral to the lives of Aboriginal people, and are found in urban, rural and remote areas. They are most common near rivers, lakes, swamps, hills and the coast. The *Aboriginal Heritage Act 1972* protects all Aboriginal places and objects that are culturally important to Aboriginal people. It is against the law to disturb a site or to remove artefacts.

There are two sites of significance within the existing water reserve boundary (Grey Gorge and White Water burial site) but none are within the proposed smaller boundary.

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 over the proposed Horrocks Beach Water Reserve. These are the Mullewa Wadjari community (WAD6119/1998) and the Hutt River claim (WAD6001/2000).

The Department of Water and Environmental Regulation 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.

1.5 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 3, recommendation 6). This includes:

- erecting and maintaining signs in accordance with *S111 Source protection signage* (Water Corporation 2013), see section 3, recommendation 5
- maintaining security and fencing surrounding the bores
- ongoing regular surveillance and inspections.

1.6 Update on water quality risks

As part of this review, the Department of Water and Environmental Regulation has conducted an updated assessment of water quality contamination risks to Horrocks Beach's drinking water source, in accordance with the ADWG.

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.

1.6.1 Land uses

As Horrocks Beach's drinking water is drawn from a confined groundwater source there is little potential for contamination from surrounding land uses. This is because the source is adequately protected from surface contamination by the considerable depth to the groundwater and the presence of a confining layer of rock that sits above the groundwater. This confining layer acts as a barrier to contamination.

The bores are located on land zoned 'general rural' in the Shire of Northampton's *Local planning scheme no. 10* (Department of Planning 2012). Farming is the main surrounding land use (Figure A4).

1.6.2 Bore compounds

The two public drinking water supply bores are in secure compounds, located on private land. There has been no evidence of problems with vandalism, or people or animals accessing the bore compounds. The drinking water bores are adequately constructed to prevent contaminated surface water from entering directly into the aquifer through the production bores, with concrete bases around the headworks.

To further protect Horrocks Beach's drinking water source, the Department of Water and Environmental Regulation recommends that the Water Corporation investigate the feasibility of formalising access to the bore compounds, such as formal access arrangements, leasing or purchasing (see section 3, recommendation 7).

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 and Environmental Regulation'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). It is important that GIS coordinates for all bores are recorded correctly, to ensure proper assessment of the risk to drinking water bores.

The nearest licensed users are approximately 4 km away, in the Horrocks Beach town site.

1.6.4 Shale and tight gas

The Horrocks Beach Water Reserve is within the Carnarvon basin, a prospective shale and tight gas area. Therefore any proposals for the extraction of shale or tight gas within the Horrocks Beach Water Reserve or within 5 km of any drinking water bore should be referred to the Department of Water and Environmental Regulation

for comment. This is consistent with the *Administrative agreement between the Department of Mines and Petroleum and Department of Water for onshore petroleum and geothermal activities in WA* (Department of Water and Department of Mines and Petroleum 2015).

Oil or gas exploration and production is to be managed in accordance with this administrative agreement, as well as government's response to *Report 42: Implications for Western Australia of hydraulic fracturing for unconventional gas* (Legislative Council Standing Committee on Environment and Public Affairs 2015) and *Guide to the regulatory framework for shale and tight gas in WA: A whole-of-government approach* (Government of Western Australia 2015) (see section 3, recommendation 8).

The proposed boundary and priority area amendments will not require any change to the way the administrative agreement and regulatory framework are implemented.

1.7 Water quality information

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

Iron, manganese and turbidity levels are naturally high, however it is important to appreciate that this raw-water data 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 (see section 1.3).

2 Consultation

The Department of Water and Environmental Regulation consulted with Shire of Northampton, Water Corporation, the departments of Health and Planning and the Yamatji Marlpa Aboriginal Corporation to prepare this review. Comments made on draft copies of the review were discussed and incorporated where appropriate.

The department sent a letter to private landowners within the proposed, reduced water reserve boundary, inviting them to contribute to the review process.

No contentious issues were raised in the consultation.

3 Recommendations

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

1. After this report is published, the Department of Water and Environmental Regulation will arrange constitution of the amended boundary of the Horrocks Beach Water Reserve as per Figure A4 under the *Country Areas Water Supply Act 1947*. (Department of Water and Environmental Regulation)
2. Update *Special control area no. 3* in *Local planning scheme no. 10* to reflect the updated boundary of the Horrocks Beach Water Reserve as per Figure A4. (Shire of Northampton)
3. Refer development proposals within the Horrocks Beach Water Reserve that are inconsistent with the Department of Water and Environmental Regulation's WQPN no.25: *Land use compatibility tables for public drinking water source areas* or recommendations in this review to the Department of Water and Environmental Regulation regional office for advice. (Department of Planning, Lands and Heritage, Shire of Northampton, proponents of proposals)
4. Ensure incidents covered by Westplan–HAZMAT in the Horrocks Beach Water Reserve are addressed by ensuring that:
    - Shire of Northampton local emergency management committee is aware of the location and purpose of the Horrocks Beach Water Reserve
    - the locality plan for the Horrocks Beach Water Reserve is provided to the Department of Fire and Emergency Services headquarters for the HAZMAT emergency advisory team
    - Water Corporation acts in an advisory role during incidents in the Horrocks Beach Water Reserve
    - personnel dealing with Westplan–HAZMAT incidents in the area have ready access to a locality map of the Horrocks Beach 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 of Horrocks Beach Water Reserve, including an emergency contact telephone number, in accordance with the Water Corporation's *S111 Source protection signage* (2013). (Water Corporation)
6. Continue the current regime of water quality monitoring, maintenance of fencing, inspections and by-law enforcement. (Water Corporation)
7. Water Corporation should investigate options for formalising access to the bore compounds. (Water Corporation)

8. Oil or gas exploration and production should be managed in accordance with government's response to Report 42: *Implications for Western Australia of hydraulic fracturing for unconventional gas,* the *Administrative agreement between the Department of Mines and Petroleum and Department of Water for onshore petroleum and geothermal activities in WA* and *Guide to the regulatory framework for shale and tight gas in WA: A whole-of-government approach.* (Department of Mines, Industry Regulation and Safety, Department of Water and Environmental Regulation)
9. This report should be reviewed after seven years or in response to changes in water quality contamination risks. (Department of Water and Environmental Regulation)

Appendices

Appendix A — Figures

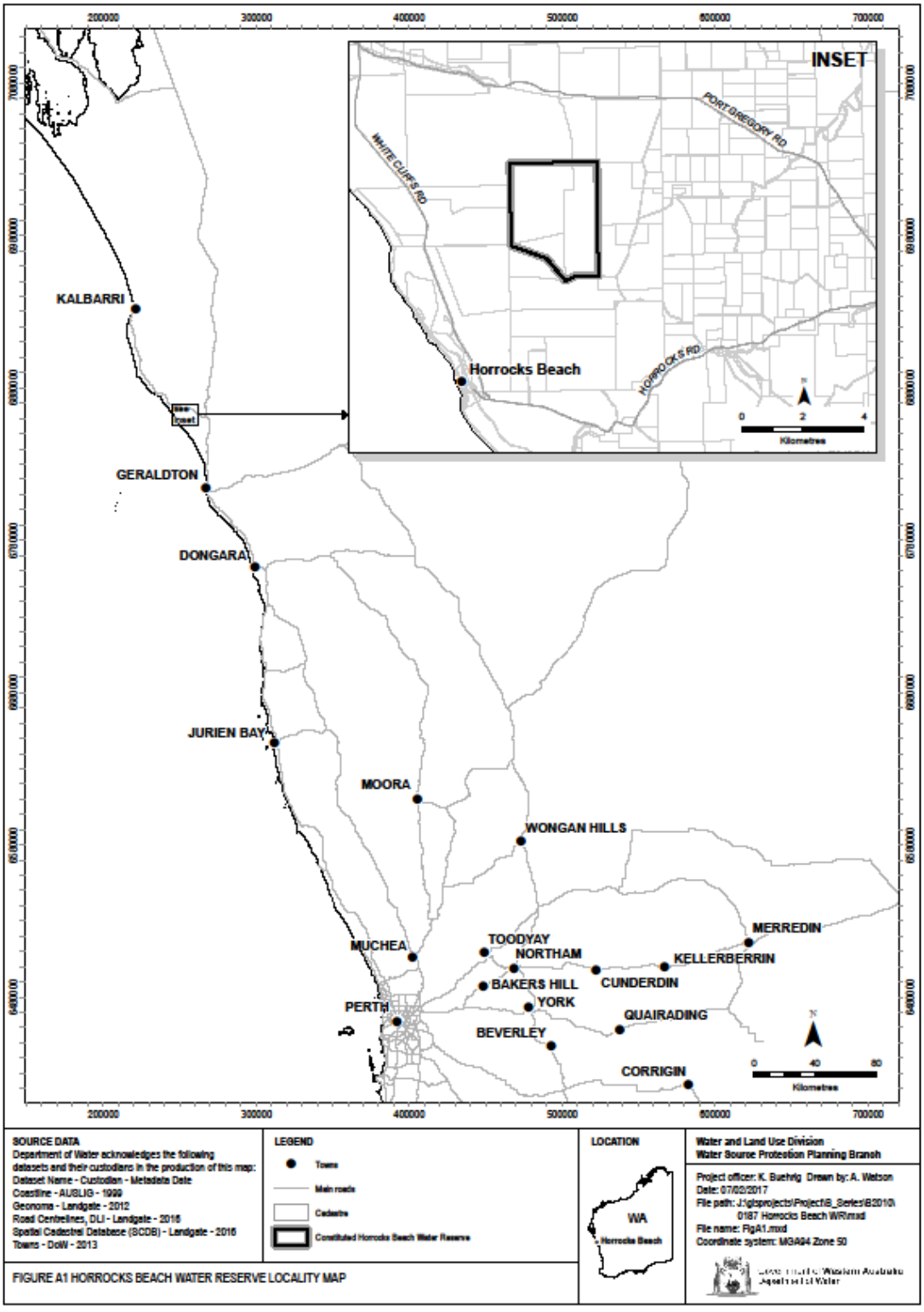

Figure A1 Horrocks Beach Water Reserve locality map

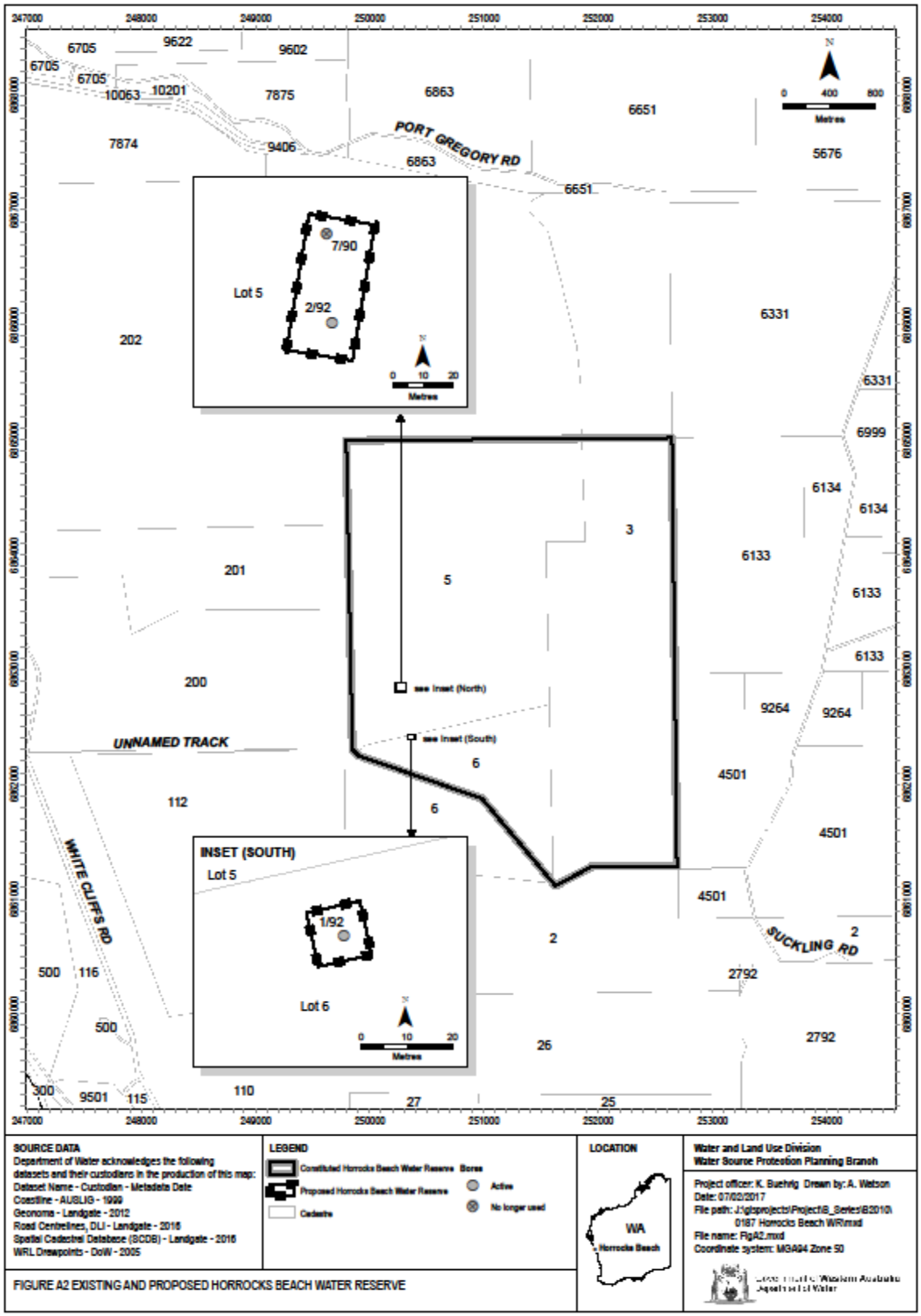

Figure A2 Existing and proposed Horrocks Beach Water Reserve

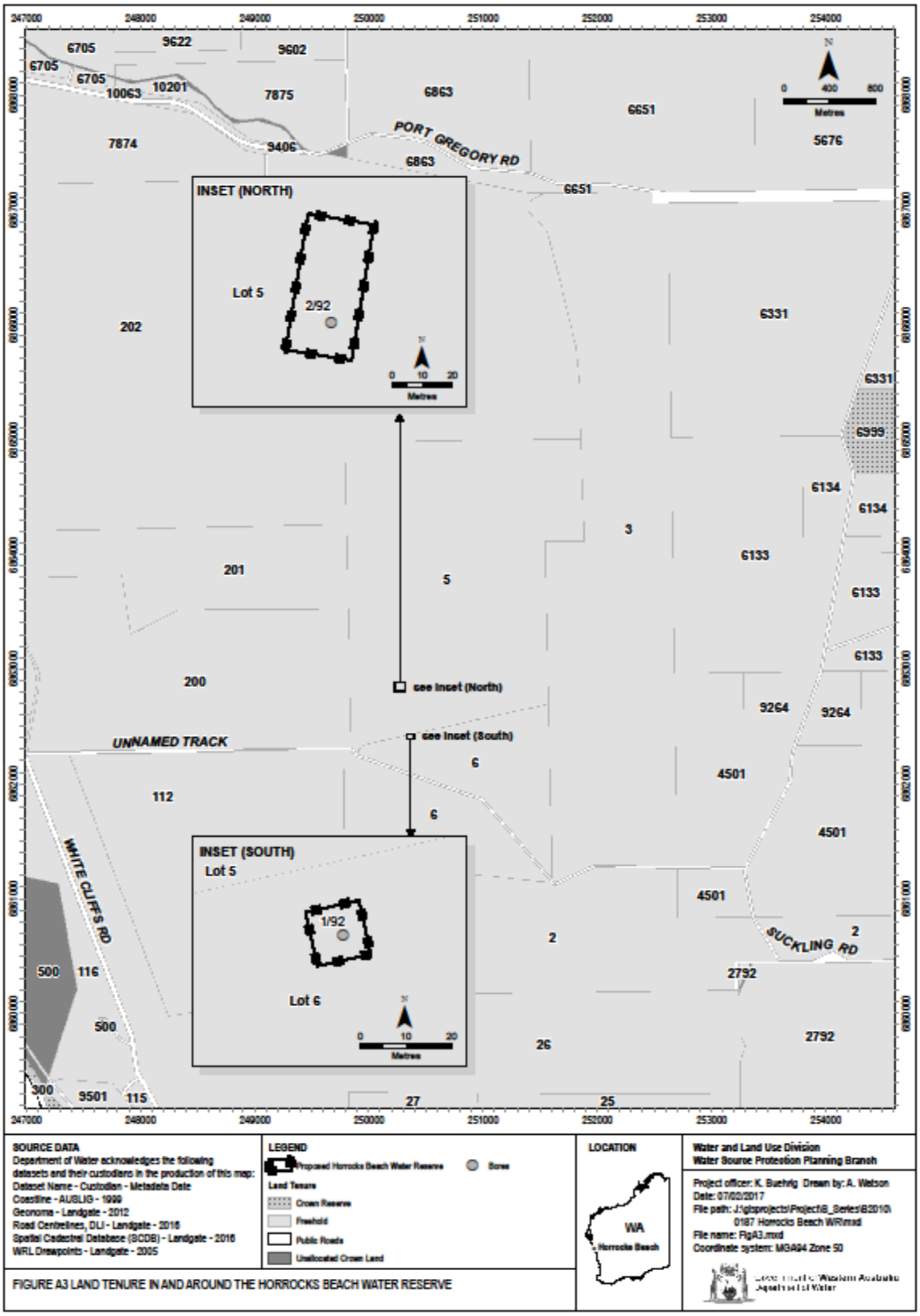

Figure A3 Horrocks Beach Water Reserve land tenure

Figure A4 Horrocks Beach Water Reserve aerial photo, proposed boundary and priority areas

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 Horrocks bore field 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 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 the Horrocks 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 2012 to February 2017.

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 Horrocks Beach, refer to the most recent Water Corporation drinking water quality annual report at <watercorporation.com.au> What we do > Water quality > Water quality publications > Most recent *Water quality annual report*.

Aesthetic characteristics

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

Aesthetic detections for Horrocks bore field

Parameter	**Units**	**ADWG aesthetic guideline value[1]**	**Horrocks bore field**	
			Range	**Mean**
Chloride	mg/L	250	***555–600***	***578.75***
Hardness as $CaCO_3$	mg/L	200	120–130	127.5
Iron (unfiltered)	mg/L	0.3	***0.48–11***	***7.069***
Manganese (unfiltered)	mg/L	0.1	***0.28–0.9***	***0.677***
Silicon as SiO_2	mg/L	80	14–17	15.625
Sodium	mg/L	180	***355–375***	***366.875***
Sulfate	mg/L	250	85–97	91.313
Total filterable solids by summation	mg/L	600	***1130–1197***	***1163.75***
Turbidity	NTU	5	0.6–***65***	***26.427***
pH measured in laboratory	no units	6.5–8.5	***5.67–6.28***	***5.963***

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

Health-related chemicals

Raw water from Horrocks bore field is analysed for chemicals that are harmful to human health, including inorganics, heavy metals, industrial hydrocarbons and pesticides. Those that have been detected in the source are summarised in the following table.

Health-related detections for Horrocks bore field

Parameter	**Units**	**ADWG health guideline value[2]**	**Horrocks bore field**	
			Range	**Mean**
Manganese (unfiltered)	mg/L	0.5	*0.28–**0.9***	***0.677***
Flouride (lab measured)	mg/L	1.5	0.35–0.4	0.358
Iodide	mg/L	0.5	n/a[3]	0.18

[2] 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 & NRMMC 2011).

[3] Only one sample was taken during the reporting period.

Microbiological contaminants

Microbiological testing of raw-water samples from Horrocks Beach 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 may indicate contamination of faecal material.

During the reviewed period, no samples had a positive *E. coli* count.

Appendix C — Photographs

Figure C1 Horrocks bore 1/92, photograph by M. Sawyer, Water Corporation

Figure C2 Horrocks bore 2/92, photograph by M. Sawyer, Water Corporation

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 the soil. A wide range of microbiological, chemical and physical contamination risks can impact on water quality and therefore, affect the provision of 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 & NRMMC 2011). Contaminants can also interfere with water treatment processes and damage infrastructure.

The *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 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 *Escherichia coli* and *Campylobacter* (NHMRC & NRMMC 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 & NRMMC 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 & NRMMC 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 & NRMMC 2011) outline how we should protect drinking water in Australia. The ADWG recommends a 'catchment to consumer' framework that uses an approach based on preventive risk and multiple barriers. 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.

An approach based on preventive risk 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 risk-based approach is often suggested as a way to address risks to water quality in a public drinking water source area (PDWSA; the area from which water is captured to supply drinking water). However, a risk-based approach is not the same as an approach based on preventive risk. A risk-based approach is inadequate for addressing risks to public health, and is not recommended by the ADWG.

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 PDWSA. 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.

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 report is important. We should not forget that ultimately it's about safeguarding your health by protecting water quality now and for the future.

An additional benefit from PDWSA protection is that it complements the state's conservation initiatives.

In Western Australia, the Department of Water and Environmental Regulation 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 legislative tools to protect water quality for PDWSAs. These Acts and the associated by-laws 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 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. Our Strategic policy: *Protecting public drinking water source areas in Western Australia* (Department of Water 2016a) describes how we do this. It is available on the website www.dwer.wa.gov.au.

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.

Our Water quality protection note (WQPN) no. 25: *Land use compatibility tables for public drinking water source areas* (Department of Water 2016b) outlines appropriate development and activities within each of the priority areas (P1, P2 and P3).

With more than 120 constituted 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 addressing different needs. The following table shows the differences between them.

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 Environmental Regulation) 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 www.dwer.wa.gov.au. You can also contact the Department of Water and Environmental Regulation's Water source protection planning section on +61 8 6364 7600 or email drinkingwater@dwer.wa.gov.au.

Drinking water source protection reports produced by the Department of Water and Environmental Regulation

Drinking water source protection report	**Scope and outcome**	**Consultation**	**Time to prepare**	**Implementation table**	**Gazettal**
Drinking water source protection assessment (DWSPA)	Desktop assessment of readily available information	Preliminary	Up to 3 months	No	Arrange for the constitution and gazettal of the source under legislation. This helps protect water quality and guides land use planning. All types of consulted drinking water source protection reports can recommend to constitute a source's boundary under legislation.
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 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 DWSPP	

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 program has resulted in the development of four Western Australian Planning Commission state planning policies (SPPs), recognising the importance of PDWSAs for the protection of water quality and public health:

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

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

Risk-based assessments normally focus on the acceptability of risks after mitigation (residual risks). For drinking water sources, an assessment based on preventive risk 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).

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	*Australian drinking water guidelines*
ANZECC	Australian and New Zealand Environment Conservation Council
HAZMAT	hazardous materials
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
P1, P2, P3	priority 1, priority 2, priority 3
PDWSA	public drinking water source area
WQPN	water quality protection note

Units of measurement

ha	hectares	A measure of area, 1 ha equals 10 000 m^2
km	kilometres	A measure of distance, 1 km equals 1000 m
km^2	square kilometres	A measure of area
m	metres	A measure of distance
m^2	square metres	A measure of area
mg/L	milligrams per litre	A measure of concentration of a substance in a solution
NTU	nephelometric turbidity units	A measure of turbidity in water
pH		A logarithmic scale for expressing the acidity or alkalinity of a solution; a pH below 7 indicates an acidic solution and above 7 indicates an alkaline solution

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).
Aquifer	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* (ADWG; NHMRC & NRMMC 2011) outlines acceptable criteria for the quality of drinking water in Australia (see *References*).
Bore	A narrow, lined hole drilled into the ground to monitor or draw groundwater (also called a well).
Bore field	A group of bores located in the same area used to monitor or withdraw groundwater.
Catchment	The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Confined aquifer	An aquifer that is overlain by relatively impermeable rock or clay that limits movement of water into and out of the aquifer. Confined aquifers are usually deeper under the ground than unconfined aquifers. Groundwater in a confined aquifer is under pressure and will rise up inside a bore hole that is drilled into the aquifer.
Constitute	Define the boundaries of any catchment area or water reserve by Order in Council under the *Country Areas Water Supply Act 1947* or by Proclamation under *the Metropolitan Water Supply, Sewerage and Drainage Act 1909*.
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.
Gazette	Publication within the Government Gazette of Western Australia of the Order in Council or Proclamation defining the boundaries of any catchment area or water reserve.
Health guideline value	The concentration or measure of a water quality characteristic, based on current knowledge, that 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.
Maximum risk	This is the level of risk in the absence of any preventive measures being installed in the system, or assuming that preventive measures have failed. Assessing maximum risk is useful for identifying high priority risks, determining where attention should be focused and preparing for emergencies (NHRMC & NRMMC 2011).
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.
Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.

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.
Proclamation	Made under the Governor of Executive Council and published in the Government Gazette to constitute or abolish a water reserve, catchment area or underground water pollution control area under section 13 and 57A of the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909.*
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*.
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 *risk avoidance*, priority 1 (P2) areas is *risk minimisation* and priority 3 (P3) areas is *risk management*.
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.
Residual risk	This is the level of risk after considering preventive measures that are applied in the drinking water supply system, such as fencing to keep cattle away from drinking water bores, or surveillance to identify people accessing protected areas. Residual risk provides an indication of how effective preventive strategies are or the need for additional preventive measures (NHRMC & NRMMC 2011).
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.

Sole supply	The only source of drinking water for a given town or community. These sources are important to protect as there are no other current options to supply drinking water for that location.
Stormwater	Rainwater that has runoff the ground surface, roads, paved areas etc., and is usually carried away by drains.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.
Water quality	Collective term for the physical, aesthetic, chemical and biological properties of water.
Water reserve	An area constituted 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.
Watertable	The upper saturated level of the unconfined 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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