



Important information

The Department of Water's *Hopetoun water reserves drinking water source protection plan* (2009, WRP no. 106) was reviewed in 2016.

Please ensure you also read the *Hopetoun Water Reserve drinking water source protection review* (2016, WRP no.157) alongside the 2009 plan to obtain all of the information about this drinking water source.

The 2016 review considers changes that have occurred in and around the Hopetoun Water Reserve (Springdale wellfield) since the completion of the 2009 plan. Additional recommendations have been prepared to ensure the ongoing protection of this public drinking water source area, including:

- New land ownership by the Water Corporation is reflected with a new priority 1 (P1) area around the Springdale wellfield bores.
- The radius of the wellhead protection zones around the Springdale wellfield bores has changed from 300 m to 500 m to reflect the change in priority area. The wellhead protection zones are contained within the boundary of the P1 land.
- The need for the Water Corporation to improve the protection around these production bores has been flagged.

You can find the 2016 *Hopetoun Water Reserve drinking water source protection review* at www.water.wa.gov.au > publications or by contacting the Department of Water on +61 8 6364 7600 or drinkingwater@water.wa.gov.au.



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

Looking after all our water needs



Hopetoun water reserves
drinking water source protection plan
Hopetoun Town Water Supply

Hopetoun water reserves drinking water source protection plan for public comment

Hopetoun town water supply

Looking after all our water needs

Department of Water

Water resource protection series

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All maps in this publication were produced by the Department of Water with the intent that they be used for the Hopetoun DWSPP at the scale shown on the maps.

While the Department of Water has made all reasonable efforts to ensure the accuracy of data in this report, no responsibility is accepted for any inaccuracies, and persons relying on them do so at their own risk.

For more information about this report, contact the Department of Water (Water Source Protection Branch) on +61 8 6364 7600 or send your enquiry to <drinkingwater@water.wa.gov.au>.

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Preface

The Department of Water has prepared this drinking water source protection plan to review the existing Hopetoun groundwater protection plan 1995, and to reassess risks to water quality within the Hopetoun water reserves and to recommend management strategies to avoid, minimise or manage those risks. The department is committed to protecting drinking water sources to meet public health requirements and ensure the supply of a reliable, safe, good quality drinking water to consumers.

The *National water quality management strategy: Australian drinking water guidelines 6, 2004* (NHMRC & NRMCC 2004a) recommends a risk-based, multiple-barrier approach to protect public drinking water sources. Catchment protection is the first barrier against contamination, with subsequent barriers implemented at the water storage, treatment and distribution stages of a water supply system. Catchment protection requires an understanding of the catchment and hazards that can compromise drinking water quality. It then requires the development of preventative strategies and operational controls to ensure the safest possible water is supplied to consumers.

This plan details the location and boundary of the drinking water source, providing potable water to the Hopetoun town water supply system. It discusses existing and future use of the water source, describes the water supply system, identifies risks and recommends management approaches to address these risks and protect the water source.

This plan has been prepared to guide state and local government land-use planning and development decisions. It should be recognised in the Shire of Ravensthorpe's *local planning scheme*, consistent with the Western Australian Planning Commission's Statement of planning policy 2.7: *Public drinking water source policy*. Other stakeholders should use this document as a guide for protecting the quality of water in the gazetted Hopetoun water reserves.

The stages involved in the preparation of this drinking water source protection plan were:

Stages in development of a plan		Comment
1	Prepare drinking water source protection assessment document. (2004)	Prepared after initial catchment survey and preliminary information gathering. This assessment considered information available in the Hopetoun groundwater protection plan, 1995.
2	Conduct stakeholder consultation. (July 2008 to April 2009)	Advice sought from key stakeholders using the assessment document as a tool for information and discussion.
3	Prepare draft drinking water source protection plan. (July 2008 to April 2009)	Draft protection plan developed taking into account input from stakeholders and any additional advice.
4	Release draft drinking water source protection plan. (April 2009)	Draft protection plan released for a six-week public consultation period.
5	Publish approved drinking water source protection plan. (June 2009)	Final protection plan published after considering submissions. Includes recommendations on how to protect water quality. Proclamation of public drinking water source area can now occur.

Summary

Hopetoun is located in the Great Southern region of Western Australia within the Shire of Ravensthorpe, approximately 585 kilometres south-east of Perth and about 50 kilometres south of the administrative centre of Ravensthorpe.

A groundwater protection plan for the Hopetoun water reserves was first prepared by Holmes in June 1995. That plan established the boundaries of the current water reserves and set priority areas within them. This protection plan updates the information available for the Hopetoun water reserves.

The current boundaries of the Hopetoun water reserves (i.e. Town and Springdale wellfields) were proclaimed in July 2001 under the *Country Areas Water Supply Act 1947* for the purpose of protecting water quality. This protection plan proposes amendments to the current gazetted Hopetoun (Town wellfield) water reserve boundary. These amendments will result in a reduction in the size of the existing water reserve and remove potential land-use constraints on some private land. These changes are based on additional hydrogeological information now available to the department and reflect a more accurate water reserve boundary. No changes are proposed to the Springdale wellfield at this time. However, based on landowner feedback, the department will reconsider the priority areas in this water reserve to determine if they are still appropriate.

The Hopetoun water reserves are located mainly over privately owned land, Water Corporation-owned land, and pockets of crown land along Jerdacuttup River in the Springdale wellfield. Land uses and activities within the proposed water reserves include pastoral and farming activities, rural residential subdivision, production bores, sites of Aboriginal significance, public recreation, and crown land reserved for protection of fauna and flora.

The Hopetoun water reserves are the sole water supply for the Hopetoun community. The production bores in the water reserves are screened in a shallow unconfined aquifer, making them vulnerable to contamination from land use activities, and potential increases in salinity from over-extraction.

Land owned by the Water Corporation in the Town wellfield is managed for priority 1 water source protection. All crown land in the Hopetoun water reserves are proposed to be reclassified from priority 2 to priority 1 source protection to maximise the protection of water quality. Most of the private land is zoned rural and managed for priority 2 source protection to ensure the main recharge area of the wellfields is protected from incompatible land uses. The additional hydrogeological information also lead to proposing a priority 3 classification (currently priority 2) to a small portion of land west of the Hopetoun–Ravensthorpe Road, just south of the caravan park. But the larger portion of land (now zoned rural conservation) remains assigned as a P2 area. The existing Krystal Park Estate residential development was assigned a

priority 3 classification as a result of an historical development approval that was granted before 1995. In the Town wellfield, one larger privately owned lot and a number of smaller private lots are located within wellhead protection zones of production bores. This land is considered to be of strategic importance to the wellfield, and it is proposed to reclassify the larger lot (Lot 201 Banksia Road) from P3 to P1 for the purpose of water source protection. Liaison with the affected land owners, the Shire of Ravensthorpe and Department of Water has been initiated to determine how the quality of the water source below this land can be best protected. In relation to Lot 201 Banksia Road, the department recently agreed the purchase of this property to maximise the protection of water quality.

Recommended protection strategies have been outlined in this protection plan for each of the land uses and identified activities within the water reserves. These strategies aim to avoid, minimise or manage risks to water quality.

This plan has been developed with input from the Water Corporation and Shire of Ravensthorpe, and in consultation with landowners and other relevant state government departments and stakeholders.

This plan makes the following key recommendations:

- The boundary of the amended Hopetoun (Town wellfield) water reserve should be reproclaimed under the *Country Areas Water Supply Act 1947*. No change has been proposed to the boundary of the Springdale wellfield.
- An implementation strategy should be prepared for this plan to identify timeframes and stakeholders responsible for recommended protection strategies.
- The Shire of Ravensthorpe's local planning scheme should reflect the proposed amended Hopetoun water reserves boundary, priority 1, 2, and 3 areas and protection zones as a special control area.
- All development proposals within the Hopetoun water reserves that are inconsistent with the Department of Water's water quality protection note: *Land use compatibility in public drinking water source areas* or recommendations in this plan should be referred to the Department of Water for advice and recommendations.
- Best-management practices for current and approved land uses within the water reserves should be implemented
- The Department of Water should continue to liaise with landowners with properties within the water reserves' wellhead protection zones to determine how water quality can best be protected.

1 Drinking water source overview

Hopetoun is located in the Great Southern region of Western Australia within the Shire of Ravensthorpe approximately 585 kilometres south-east of Perth and about 50 kilometres south of the administrative centre of Ravensthorpe.

In the past few years, the town's population growth was associated with the BHP–Billiton open-cut mine project, scheduled to produce nickel and cobalt hydroxide by the end of 2007 for a period of 25 years for packaging and shipping via Esperance (Western Australia) to Townsville (Queensland). The town has grown from a small retirement and holiday centre and farming community with a residential population of about 350 in 2001 to a mining orientated town with a population of more than 590 in 2006 (Australian Bureau of Statistics, 2006), and more than 1100 people in December 2008. This population growth and associated land development pressures placed a high demand for special rural subdivision and water on the Hopetoun water reserves. However, in January 2009 BHP–Billiton announced that it would close the mine and the future of the town's expansion has become uncertain.

By 2009, new housing estates, health and childcare centres, schools, businesses, an airport, road upgrades and expansion of the local utilities (e.g. diesel-gas turbine, wastewater treatment plant and other infrastructure) were already on their way or completed to support the town's growing population.

1.1 Existing water supply system

The public drinking water supply for Hopetoun is obtained from two groundwater wellfields operated by the Water Corporation, located north of the townsite. The potable groundwater resources in Hopetoun are limited and the water reserves (Town wellfield and Springdale wellfield) are the sole water supply for the Hopetoun community (Figure 1). The need to protect these wellfields from potential contamination is, therefore, imperative.

Groundwater is drawn from a shallow unconfined regional groundwater system making the source vulnerable to contamination from surface land uses.

The original Town wellfield, located about 3 km north-west of the town, was commissioned in 1979 and currently comprises six production bores (bores 3/05 (redrill of 1/66); 2/05 (redrill of 2/67), 1/77, 1/05 (redrill of 4/77), 4/05 (redrill of 6/77) and 21/01. Production bores 2/77 and 3/77 were decommissioned in 1992 as a result of high salinity levels and are now used as monitoring bores. However, these bores will be redrilled in the near future and reused for supplying water to the town water supply scheme.

The water service provider has identified seven potential future bores (including bores considered to be redrilled) in the Town wellfield to assist in meeting the town's drinking water demand.

A second wellfield, the Springdale wellfield (also known as the Oldfield wellfield), about 15 km north-east of the town was commissioned in 1990 and currently uses six production bores (bores 9/88, 10/88, 14/88, 15/88 in the eastern part of the wellfield and bores 17/05 and 18/05 in the western part of the wellfield). In 1994 and 1995, bores 9/88 and 10/88 were not used for the drinking water supply as a result of high salinity. However, installation of a water treatment plant has allowed them to be used again. Bores 17/05 and 18/05 were only commissioned in 2007–08. This wellfield requires careful management of abstraction rates to minimise increases in salinity.

At present, bores 10/88 and 14/88 provide the core drinking water supply from the Springdale wellfield. Groundwater from the Springdale wellfield is diverted to a small scale water treatment plant at the Town wellfield for reducing the levels of dissolved salts. The water from both wellfields is then pumped into a common delivery main, where the blended supply is distributed directly into the reticulation system or stored in the elevated service tank at Table Hill, depending on demand.

One potential future production bore (bore H) has been identified in the Springdale wellfield and may be commissioned in the near future (Figure 2).

1.2 Water treatment

A small scale water treatment plant (reverse osmosis) was installed at the Town wellfield in 2006. The saline groundwater from the Springdale wellfield is diverted to the plant, where the water diffuses through a membrane under high pressure, removing the dissolved salts and impurities to ensure the water is suitable for drinking and complies with the Australian drinking water guidelines. The water from both wellfields is then blended and pumped into a common delivery main. The water is chlorinated using an automatic in-line injector system before being supplied to the town via a pipeline alongside Springdale Road and Hopetoun–Ravensthorpe Road.

The concentrated waste discharge from the desalination treatment process, commonly known as brine, is discharged to an infiltration basin between Culham Inlet and the ocean.

It should be recognised that although treatment and disinfection are essential barriers against contamination, management of the wellfields is the first step in protecting water quality and ensuring a safe, quality drinking water supply. This approach is endorsed by the *National water quality management strategy: Australian drinking water guidelines 6, 2004* (ADWG) (NHMRC & NRMCC 2004a) and reflects a risk-based, multiple-barrier approach, for providing safe drinking water to consumers. This combination of catchment protection and water treatment will deliver more reliably safe, lower cost, drinking water to consumers than either approach could achieve individually.

1.3 Catchment details

1.3.1 Physiography

Hopetoun is located on a small sandy peninsula where a narrow belt of sand dunes has been formed. The country rises gradually north to an old peneplain with a gently undulating topography that becomes more rugged around Kundip, with pronounced hills extending past Ravensthorpe. The most significant elevated landforms are the Mt Barren and Eyre ranges about 10 km west of Hopetoun, within the Fitzgerald River National Park (Hirschberg 1980).

The main drainage systems are the Steere and Jerdacuttup rivers, which flow intermittently southwards. The Steere River flows into the Culham Inlet and the Jerdacuttup River flows to wetlands within the coastal dune system. Small perched lakes and swamps have formed inland on the peneplain, receiving enhanced recharge with the clearing of land for farming (Smith and Davidson 1987).

1.3.2 Climate

Hopetoun experiences a Mediterranean–climate, characterised by warm, dry summers and cool, wet winters.

The long-term average annual rainfall is about 500 millimetres. Most rain results from winter cold front systems that cross the coast between May and October.

Average daily temperatures range between 5°C and 16°C in winter and between 15°C and 25°C in summer.

1.3.3 Hydrogeology

Hopetoun is located within the Albany–Fraser Orogen. The silty and clayey sand of the Quaternary superficial sediments form a thin discontinuous veneer in the depressions of the widespread sandplain deposits of the Late Tertiary. The sandplain deposits range from sand through to a base of loam and clay that unconformably overlies shale, lignite and coarse-grained sandstone of the Werillup Formation. The basement comprises Proterozoic migmatites, which have been extensively weathered in their upper margins. The Quaternary limestone hills along the coast consist of shelly sandstone and grit, overlain by dune sand (Smith and Davidson 1987).

The Hopetoun town water supply draws on groundwater from two sites. Bores in the original Town wellfield are drilled into a freshwater sequence in the coastal sand and limestone sediments which form a discontinuous belt along the coastline (Hirschberg 1980). Bores in the Springdale wellfield draw on groundwater within the sandplain deposits and the underlying weathered and fresh basement rocks (Smith and Davidson 1987). Both sources form part of a regional unconfined flow system that is recharged by direct infiltration of rainfall and discharges into drainage systems and

coastal wetlands such as Jerdacuttup River and lakes, or to the ocean. The lowest salinity is found in small areas at the top of the groundwater flow system, which generally occurs beneath the topographical divides. The major part of the groundwater system is brackish to saline, requiring pumping rates to be limited to minimise salinisation of freshwater sequences. Depth to the groundwater table is generally less than 10 metres, where the groundwater level in the Town wellfield ranges from 3.75 m (2/77) to 12.7 m (3/77) below natural surface. Groundwater levels measured in bores in the Springdale wellfield range from 4.5 m (10/88) to 8.5 m (15/88) below natural surface. The shallow depth to the groundwater table makes the very few freshwater sequences in the unconfined aquifer vulnerable to contamination from incompatible land uses.

The safe draw for the currently used wellfields has recently been set at 295 000 kL/year, with the Springdale West subarea to 75 000 kL/year, Springdale East subarea to 150 000 kL/year and the Town subarea to 70 000 kL/year to preserve potability of the source.

The direction of groundwater flow in the Town wellfield is generally to the south and south-west with groundwater recharge to the ocean, and partial discharge to the Culham Inlet. Local variations in groundwater flow occur around bedrocks and about incised drainages.

Groundwater flow in the Springdale wellfield is to the south-west with groundwater discharge to the Jerdacuttup River and the coastal wetlands.

In general, low salinity (less than 1000 mg/L total dissolved solids (TDS)) groundwater occurs along the groundwater divides as a result of direct rainwater infiltration. The salinity of groundwater then increases to more than 1500 mg/L TDS in the direction of groundwater flow.

Further information relating to the hydrogeology of Hopetoun can be obtained from the report *Hydrogeology of the Ravensthorpe 1:250 000 Sheet* that was prepared by S.L. Johnson in 1998 (Bibliography section).

1.4 Future water supply requirements

The groundwater resources in the Hopetoun area suitable for potable water supplies are limited by the lack of major aquifer systems and the wide extent of high groundwater salinity.

A number of options were considered and investigated for meeting future demand for Hopetoun, and subsequently additional bores were commissioned in the Springdale wellfield (west of the Jerdacuttup River) and in the Town wellfield (Lot 1 on plan 16591). Potential future bores were also identified in both wellfields to meet the future water demand of the community (Figure 2).

1.5 Existing drinking water source protection

Hopetoun water reserve was originally proclaimed in 1984 under the *Country Areas Water Supply Act 1947* for the purpose of public drinking water protection, then consisting only of the Town wellfield. The water reserve boundary was amended to include the Springdale wellfield in July 2001 as an outcome of the 1995 groundwater quality protection plan. Further boundary changes are now proposed to the currently gazetted Hopetoun water reserves. This amendment is based on additional hydrogeological investigations and information now available to the department and will reflect a more accurate water reserves boundary (Figure 2). This is discussed in more detail in section 3.2. Proposed land uses and activities.

By-laws created under the *Country Areas Water Supply Act 1947* enable the Department of Water to control some potentially contaminating activities and take some necessary steps to prevent or clean up pollution.

The groundwater quality protection plan prepared by Holmes in 1995 provided details on water quality issues and contaminant risks to the Hopetoun water reserves. The plan established the currently gazetted water reserve boundaries and assigned priority areas for water source protection within the water reserves.

The Town wellfield in the immediate area of the production bores is managed for priority 1 source protection. A priority 2 area was assigned over the surrounding farmland and priority 3 over the existing special rural subdivision and land immediate south of production bores 3/05 and 2/05 that abuts Hopetoun– Ravensthorpe Road. The land area within the Springdale wellfield is managed for priority 2 source protection.

The 1995 groundwater quality protection plan set out recommendations and responsibilities for effective implementation of groundwater protection. Progress with the implementation of these recommendations is described in section 4.9.

In 2004, the Water Corporation prepared a Hopetoun water reserve drinking water source protection assessment. This document provides an update to the risks to water quality from land uses and activities in the Hopetoun water reserves. This drinking water source protection plan builds upon and replaces the groundwater quality protection plan (1995) and the drinking water source protection assessment (2004).

The Shire of Ravensthorpe's local planning scheme recognises the Hopetoun water reserves as a special control area; therefore, the types of development supported are described in the Department of Water's water quality protection note: *Land use compatibility in public drinking water sources areas*.

1.6 Department of Water management

1.6.1 Current allocation licence

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 surface and groundwater is vested with the Crown. This Act requires licensing of groundwater abstraction (pumping water from a bore, spring or soak) within groundwater areas proclaimed under the Act and all artesian wells throughout the state.

The Hopetoun groundwater area was proclaimed in 1974 under the *Rights in Water and Irrigation Act 1914* to allocate groundwater resources and to manage sustainable use in the area around the original Town wellfield. The groundwater area was expanded in 1978 to incorporate the area around the 1977 production bores. It was then amended in 2001 to include the area north-east of Hopetoun, centred on the new Springdale wellfield.

The Water Corporation is licensed by Department of Water to draw 295 000 kL/year from the Hopetoun wellfields for public water supply purposes. The current number of water services is 703 and annual production in 2007–08 was just above 267 000 kL/year. As a result of the BHP-Billiton mine closure at Ravensthorpe, the number of services and water consumption is expected to decrease.

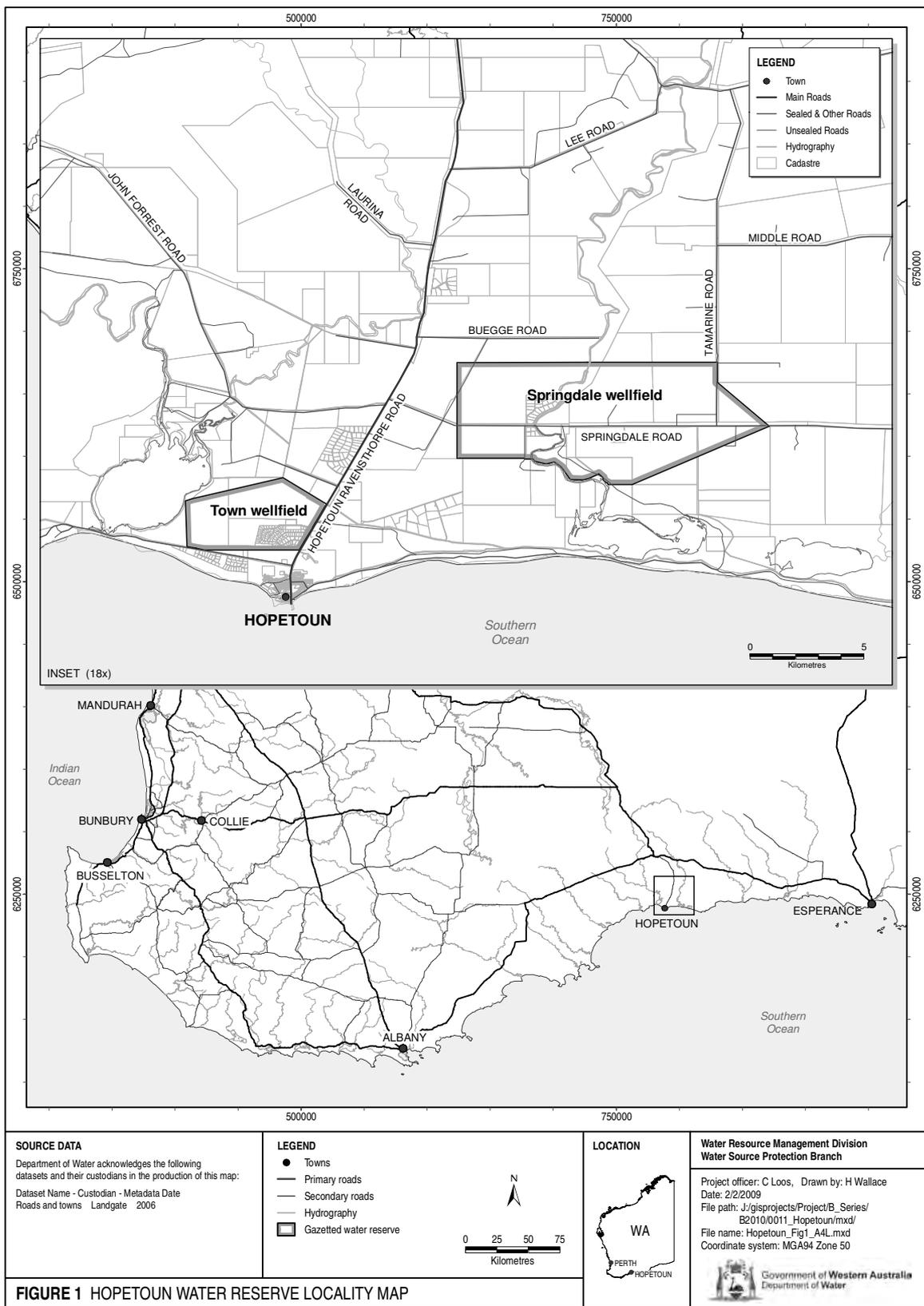


FIGURE 1 HOPETOON WATER RESERVE LOCALITY MAP

Figure 1 Hopetoun Water Reserves locality map

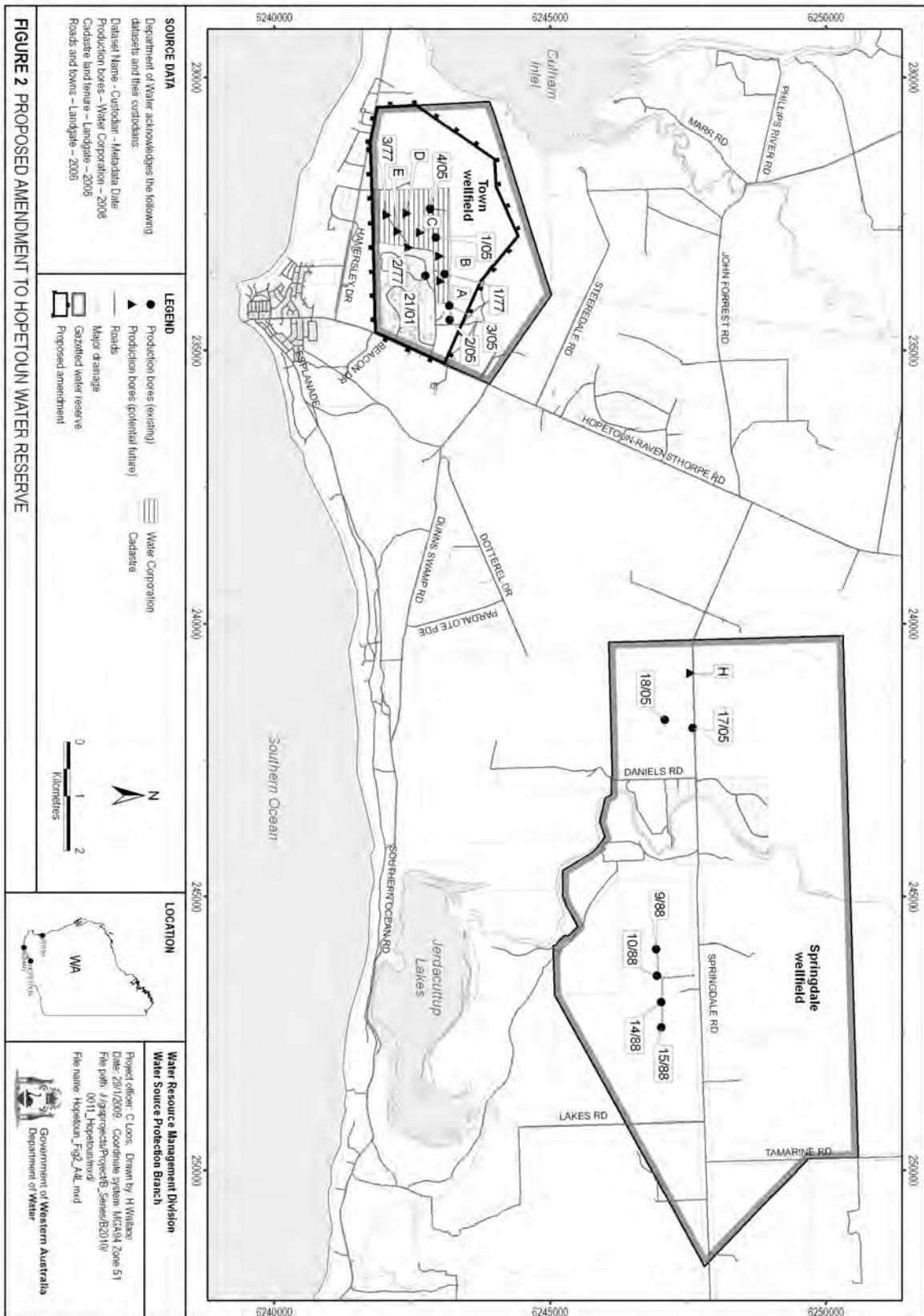


Figure 2 Proposed amendment to Hopetoun Water Reserve

2 Water quality monitoring and contamination risks

A wide range of chemical, physical and microbiological factors can impact on water quality and therefore affect the provision of a reliable, safe, good quality drinking water to consumers.

The Water Corporation regularly monitors the quality of raw water from the Hopetoun (Town and Springdale wellfields) water reserves for microbiological, health-related and aesthetic (non health-related) characteristics. This data shows the quality of water in the Hopetoun water reserves. An assessment of the drinking water quality received by consumers once treated is also made against the ADWG to ensure safe, good quality drinking water is available to consumers. This assessment is made by an intergovernmental committee called the Advisory Committee for the Purity of Water that is chaired by the Department of Health.

A water quality summary for the Hopetoun water reserves from January 2002 to January 2008 is presented in Appendix A. For more information on water quality, see the Water Corporation's most recent drinking water quality annual report at www.watercorporation.com.au Water > Water quality > Latest report > Drinking water quality annual report.

Typical contamination risks relevant to drinking water sources are described below.

2.1 Microbiological

Pathogens are types of micro-organisms that are capable of causing disease. These include bacteria, protozoa and viruses. In water supplies, pathogens that can cause illness to humans are mostly found in the faeces of humans and domestic animals (such as dogs and cattle).

There are a number of pathogens that are commonly known to contaminate water supplies worldwide. These include bacteria (for example, salmonella, *Escherichia coli* and cholera), protozoa (for example, Cryptosporidium, Giardia) and viruses. *Escherichia coli* counts may be used as an indicator of faecal contamination.

Pathogen contamination of a drinking water source is influenced by many factors such as the existence of pathogen carriers (e.g. 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 effect on people consuming drinking water that is contaminated with pathogens varies considerably, ranging from mild illness (such as stomach upset or diarrhoea) to hospitalisation and sometimes even death. In 2000, in Walkerton, Canada seven people died due to contamination of the town water source and supply by a pathogenic strain of *Escherichia coli* and campylobacter (NHMRC & NRMMC 2004b). Where possible, avoiding the introduction of pathogens into a water source is the most effective way to protect public health.

On several occasions between January 2002 and January 2008, the raw water from the Hopetoun water reserves tested positive for low counts of *Escherichia coli*, particularly the water from the Springdale wellfield. The bores at this wellfield are located on private land currently used for cattle grazing and broadacre farming. Cattle grazing in proximity to production bores may contribute to higher counts of *Escherichia coli* in a water source, particularly when these bores draw water from a shallow, unconfined aquifer.

Further investigation into these elevated *Escherichia coli* counts and potential sources of contamination is required to determine the need for additional catchment management barriers.

2.2 Health related

Land- and water-based uses and activities within a catchment can directly impact on water quality and treatment. For example, off-road driving contributes to erosion and the uprooting of vegetation which can increase turbidity in water. The effectiveness of treatment processes, particularly chlorine disinfection, can be reduced by increased turbidity.

Chemicals attached to suspended material, such as soil particles, can occur in drinking water sources. This could occur as a result of natural leaching from mineral deposits or from different land uses (NHMRC & NRMMC 2004a). 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 such cases, prompt notification of relevant authorities and clean up of the spill is required.

Drinking water supplies can also be contaminated by nutrients such as nitrogen from fertiliser application, faulty septic systems, leach drains and from domestic animal faecal matter that washes through or over soil and into a water source. Nitrate and nitrite can be toxic to humans at high levels, with infants younger than three months being most susceptible (NHMRC & NRMMC 2004a).

Hydrocarbons (e.g. fuel; oils) are potentially toxic to humans, and potentially harmful chemical by-products may be formed when they are combined with chlorine in the water-treatment processes. Hydrocarbons can occur in water supplies as a result of spills and leakage from vehicles.

Low levels of dissolved metals have been detected in Springdale wellfield bores 10/88 and 14/88, but concentrations are below ADWG. The most likely explanation is that these metals are naturally occurring, because there are no obvious local activities that are likely to be a source of contamination. Monitoring of these and other health parameters is ongoing. Detailed investigation should be undertaken if trends show increasing levels during routine monitoring.

2.3 Aesthetic

Impurities in drinking water can affect the aesthetic qualities of water such as its appearance, taste, smell and feel. Such impurities are not necessarily hazardous to human health; for example, water that is cloudy and has a distinctive odour or has a strong taste is not necessarily harmful to health, while clear, pleasant-tasting water may still contain harmful micro-organisms (NHMRC & NRMCC 2004b).

Iron and dissolved organic matter can affect the colour and appearance of water, and salinity can affect the taste. Some properties such as pH (a measure of acidity or alkalinity) can contribute to the corrosion and encrustation of pipes.

Water provided to Hopetoun has been of acceptable quality, generally meeting ADWG values, but salinity has been close to the guideline value of 1 000 mg/L Total Dissolved Solids (TDS) and the water is naturally hard. This is now addressed by the water treatment plant at the Town wellfield.

Groundwater quality in the Springdale wellfield is better than the Town wellfield. Hardness and iron are significantly higher in the Town wellfield, generally exceeding ADWG values. Salinity from the Town wellfield has been variable depending on the state of aquifer recharge. Salinity from Springdale has been more consistent and was below the guideline value.

The ADWG sets aesthetic water quality criteria to meet the aesthetic requirements of consumers and to protect water supply infrastructure (such as pipes).

A summary of water quality monitoring data from the Hopetoun water reserves is provided in Appendix A.

2.4 Groundwater bores

The Hopetoun water reserves are located within the Hopetoun groundwater area which is proclaimed under the *Rights in Water and Irrigation Act 1914*. Under the provisions of sections 26D and 5C of the *Rights in Water and Irrigation Act 1914*, a licence is required to construct a bore or extract water within a proclaimed groundwater area, (unless exempt under the Rights in Water and Irrigation Exemption and Repeal (Section 26C) Order 2001).

Drinking water bores are operated in the Hopetoun water reserves by the Water Corporation. If bores for other purposes (i.e. irrigation, private household use) are drilled near to a public drinking water supply bore, they can cause contamination of the drinking water source. For example, a poorly constructed private 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 in order to prevent contamination impacts on the public drinking water source. This issue will be addressed through the Department of Water's 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 Minimum Bore Specifications Committee 2003).

3 Land-use assessment

3.1 Existing land uses and activities

The Hopetoun water reserves are located over a mixture of crown and privately owned land. Current land uses and activities are outlined below. This information has been summarised in Table 1 at the end of this section. This table also identifies a recommended management priority for different hazards. Appendix B of this plan uses data in this section and Table 1 to recommend protection strategies for consideration by key stakeholders.

The Shire of Ravensthorpe's Town Planning Scheme (Ayton, Taylor & Burrell 2001) shows both areas of the water reserves as special control areas on the scheme map. Special provisions apply to development of the underlying zones or reserves for the purpose of protecting the town water supply.

There are a range of existing land uses and activities within the proposed water reserves that have the potential to impact on water quality. These include:

- private land (rural and special rural)
- Crown land
- drinking water treatment plant
- quarry site (existing quarry area falls now outside the proposed boundary of the Town wellfield, but could encroach onto the water reserve in the future)
- general agriculture (pasture and broadacre cropping)
- café (small restaurant)
- permaculture (herb nursery)
- recreational activities along Jerdacuttup River (part that is located in Springdale wellfield)
- sites of Aboriginal significance
- Infrastructure
- roads and tracks

These land uses and activities are illustrated in Figure 3 and some photographs are provided in Appendix C.

The caravan park (park homes), in the northern portions of Lot 6382 and Lot 1 (Lot 1 on plan 13741) Hopetoun–Ravensthorpe Road, is no longer within the proposed Hopetoun (Town wellfield) water reserve and not discussed further in this plan.

The limestone quarry on Lot 6382 Hopetoun – Ravensthorpe Road is also located outside the proposed boundary of the Hopetoun (Town wellfield) water reserve,

however, it could encroach on the proposed water reserve in the future. Therefore, water source protection strategies for quarry activities are discussed in section 3.1.1.2.

3.1.1 Hopetoun (Town wellfield) water reserve

Within the proposed Hopetoun (Town wellfield) water reserve land is zoned for two purposes. The south-east corner is zoned *rural conservation* and provides for special rural lots while the remainder of land is zoned *rural agriculture*.

3.1.1.1 Private land

Rural land

Large parcels of private land exist within the proposed water reserve. There is increased pressure for this land to be developed for rural residential properties due to its proximity to Hopetoun.

The provision of advice and guidance on land use or rezoning applications is a high priority issue for water quality protection. Careful consideration of any proposed change in land use (or zoning) is required to protect the quality of water in the Hopetoun (Town wellfield) water reserve. The Department of Water's advice on appropriate land uses is based on its existing zoning, land tenure, strategic importance of the land or water source, and existing approved land uses. This approach is explained in the department's water quality protection note *Land use compatibility in public drinking water source areas*. This land use compatibility table is also called up in the Western Australian Planning Commission's Statement of planning policy 2.7: *Public drinking water source policy*.

A large portion of land in the northern part of the Town wellfield was recently rezoned from *general agriculture* to *rural conservation*. A detailed hydrogeological study for this site was undertaken to ensure the water quality of the water reserve is not compromised. Any subdivision guide plans need to be referred to the Department of Water for advice and recommendations. These land uses are considered to be a medium management priority for water quality protection.

One *general agriculture* zoned private lot is located entirely within the wellhead protection zones of production bores 2/05 and 3/05. This lot is considered to be strategically important for protecting the water quality of the Town wellfield. The protection of this lot is considered to be a high management priority.

Special rural subdivision - Krystal Park Estate

In the early 1990s, approval of the Krystal Park Estate special rural subdivision immediately east of the wellfield, influenced the level of aquifer protection given to the area in the 1995 protection plan. A classification of priority 3 was assigned to recognise use of the land for special rural purposes.

At the time of approval, there was concern about activities in the subdivision impacting on aquifer yield. Consequently, the keeping of stock and private groundwater abstraction have not been supported as a condition of development, in order to preserve the integrity of this limited freshwater resource. The use of approved, alternative effluent disposal system (e.g. aerobic treatment units) were also recommended for on-site wastewater treatment systems.

Other stages of the existing Krystal Park Estate residential development (special rural area) were developed even closer to production bores than the existing estate and with smaller one hectare lots. Although the development is compatible with a priority 3 classification, it is likely to increase pathogen and nutrient input to the aquifer with an increase in septic tank numbers, fertiliser and other chemical use. The subdivision is located within the local planning scheme's special control area for protecting the town water supply and more than 25 lots are within the wellhead protection zone of bores 2/77 and 21/01. Bore 2/77 is currently not used, but may be redrilled this year and reused for supplying the town water supply. The subdivision poses a risk to groundwater quality because there is potential for some of the recharge over this area to be drawn into the capture zone of production bores. Conditions were applied to the development to minimise impacts, with limitations placed on the keeping of animals and storage and collection of fuels, chemicals and pesticides. These conditions need to be adhered to, in order, to minimise the risks to groundwater quality. The department recommends that in situations where residential development is approved near drinking water bores, any on-site wastewater treatment system must be at least 100 m away from the production bores.

Activities associated with the special rural subdivision of Krystal Park Estate have the potential to threaten quality within the Town wellfield and are rated a high management priority.

Water Corporation land

The production bores in the Town wellfield are located on freehold land owned by the water service provider (Water Corporation). This parcel of land is surrounded by private land zoned *rural agriculture* and *special rural*, traditionally used for broadacre farming. An access way (crown land) leads from Hopetoun–Ravensthorpe Road (via Banksia Road and north of Lot 201 Banksia Road) to production bores 2/05 and 3/05 to assist the water service provider to maintain these bores. A limestone quarry is located to the north-east of the wellfield.

Portions of the land on which the production bores are located have been regenerating to natural bush and pose little risk to groundwater quality.

These activities are considered to be a low management priority for water quality protection.

3.1.1.2 Quarry

A limestone quarry near the north-eastern part of the wellfield falls outside the proposed northern boundary of the water reserve. However, if the quarry is expanded to the south, it could encroach on the water reserve and could be a potential risk to water quality if not managed appropriately.

The greatest risk to water quality from quarry operations is fuel spill contamination from excavating machinery. The Department of Water's water quality protection note *Extractive industries* and the Department of Industry and Resources' *Environmental management of quarries, development, operation and rehabilitation guidelines 1994* outline best-management practices to address this water quality risk.

An above-ground fuel storage tank located at this site should be fitted with appropriate bunding to capture any spills and the refuelling area should be protected by a concrete apron. Details on the design and best-management practices can be obtained from the department's *water quality protection note Tanks for elevated chemical storage*.

At this stage this activity is considered to be a low management priority for water quality protection.

3.1.1.3 Pastoral activities

Current activities associated with broadacre farming to the north and west of the wellfield are considered a medium management priority because of the need to ensure there is no further land use intensification.

3.1.1.4 Roads and tracks in the Town wellfield

The Hopetoun–Ravensthorpe Road, which runs along the eastern boundary of the Town wellfield, and the road system traversing Krystal Park Estate, can potentially have an impact on water quality if fuel or chemical spills occur as a result of a road accident. Accordingly an emergency response plan needs to be put in place under the responsibility of the regional emergency management district.

Any road design in a public drinking water source area should consider the recommendations provided in the department's water quality protection note *Roads near sensitive water resources*.

This activity is considered to be a low management priority for water quality protection.

3.1.2 Hopetoun (Springdale wellfield) water reserve

A major portion of the Springdale area of the water reserve has remained as broadacre farming and is currently zoned for *general agriculture*. Small pockets of

crown land about the Jerdacuttup River within this water reserve and are considered to have significant biodiversity values for the south coast region. The Hopetoun (Springdale wellfield) water reserve is used for stock grazing with surrounding lots outside the water reserve being used for cereal and canola cropping, and stock grazing. An area west of Jerdacuttup River within the water reserve has been rezoned to *rural conservation* and subdivided.

3.1.2.1 Private land

Rural land

Large parcels of private land exist within the Hopetoun (Springdale wellfield) water reserve. Any land use and activity (including rezoning) within the water reserve needs to consider the Department of Water's water quality protection note: *Land use compatibility in public drinking water source areas* (see <www.water.wa.gov.au>water quality>publications>water quality protection notes for latest version). This land use compatibility table is called up in the Western Australian Planning Commission's Statement of planning policy 2.7: *Public drinking water source policy*.

A small herb nursery (permaculture) was recognised as a non-conformity land use in the 1995 groundwater protection plan.

More recently, a café was approved on a rural property in a priority 2 classification area of the Springdale wellfield by the Shire of Ravensthorpe. Restaurants, cafés and taverns are considered to be an incompatible land use in a priority 2 classification area. This land use may pose a potential contamination risk to the wellfield mainly as a result of the loads of the wastewater treatment system (e.g. pathogens, degradable organic matter, nutrients and cooking oils), runoff from car parks, landscaped surrounding areas (e.g. fertiliser use; pesticide residues), and the disturbance to native vegetation.

An expansion or more intensive use of the café would not be supported by the Department of Water.

Special rural subdivision - west of Jerdacuttup River

An area west of Jerdacuttup River has been rezoned to *rural conservation* and is subdivided into an average of 4 ha special rural lots (total of 29 lots). The lots will be supplied with drinking water from 92 000 litre rainwater storage tanks. Private groundwater abstraction has not been allowed (as a condition of development) in order to preserve the integrity of this limited freshwater resource. A foreshore management plan was prepared for this subdivision that was endorsed by the Shire of Ravensthorpe in 1995 (Stephens 1995). This subdivision was approved prior to finalising the original drinking water protection plan in 1995.

The special rural subdivision to the west of Jerdacuttup River is not likely to impact on the quality of the existing wellfield because groundwater beneath these properties

discharges along the western fringe of the river. The production bores draw on a part of the aquifer with a different flow system. All lots of this subdivision are located outside the wellhead protection zones (bores 17/08, 18/08 and H).

3.1.2.2 Crown land

Unallocated crown land and 8 crown reserves abut or are close to the Jerdacuttup River. The crown reserves (CR) are listed below and were created for:

CR 40156 – the purpose of conservation of flora and fauna, vested in the National Parks and Nature Conservation Authority (Department of Environment and Conservation).

CR 31760 – park and protection of river and foreshore, currently not vested

CR 8456 – parkland and recreation, vested in the Shire of Ravensthorpe

CR 45425 – public recreation, vested in the Shire of Ravensthorpe

CR 49159 – recreation, vested in the Shire of Ravensthorpe

CR 49207 – bushfire protection, vested in the Shire of Ravensthorpe

CR 49209 – right of way, vested in the Shire of Ravensthorpe

CR 8457 – water, vested in the Water Corporation.

Crown reserve 40156 is located along the southern boundary of the Springdale wellfield, and is managed by the Department of Environment and Conservation for the purpose of fauna and flora protection under the *Conservation and Land Management Act 1984*.

As part of the approval for the subdivision west of Jerdacuttup River (Oldfield Location 203), a foreshore reserve of 30 metres was added to the unallocated crown land that abuts the Jerdacuttup River. This portion of land has been designated for the use of passive recreation (e.g. walkway).

A pathway was constructed south of Springdale Road to allow access to the river via a granite outcrop. Otherwise there is limited access to the crown reserves.

Recreational activities such as canoeing and fishing were reported in the foreshore management plan that was prepared for the subdivision west of Jerdacuttup River (endorsed by the Shire of Ravensthorpe) in 1995.

The Department of Water is proposing to recognise these non-conforming, historical land use activities, as the linkage between the river water and groundwater is considered to be minimal. Therefore, it is unlikely that the Jerdacuttup River will have an impact on the quality of the existing production bores.

Jerdacuttup Spring is located on crown reserve 8456. A wetland survey is currently being undertaken by the Department of Water's regional office in the Hopetoun regional area. The survey identified a stand of native rush around the spring.

A large portion of the nature reserve is part of the Jerdacuttup lakes suite that is considered a significant wetland in the south coast region and is nationally registered.

The current level of activity seems to pose a low water quality risk, and the activity is considered overall to be a low management priority for water quality protection.

3.1.2.3 *General agriculture (pastoral activities)*

Pastoral activities on private land on the Springdale wellfield are typically sheep and cattle grazing. Uncontrolled movement of stock around the production bores pose a high risk of pathogen and nutrient contamination. Accumulated deposition of animal faeces within the capture zones of the production bores provide a long-term risk to the source. Over the last six years water quality monitoring indicates that the nutrient levels are within the guideline values. However, on several occasions increased counts of *Escherichia coli* were detected in the raw water of the production bores. This indicates the need for additional catchment management barriers to be adopted for stock management.

This activity around the wellfield is considered a high risk to groundwater quality. Maintaining an acceptable level of stocking of cattle and sheep and grazing stock away from the production bores is an efficient way to protect water quality.

This activity is considered overall to be a high management priority for water quality protection.

3.1.2.4 *General agriculture (broadacre cropping)*

Broadacre cropping is undertaken on private land in the Hopetoun (Springdale wellfield) water reserve. This activity provides varying risks to water quality through application of fertilisers and pesticides. Use of best-management practices for this type of activity in accordance with the Department of Water's Statewide policy No. 2: *Pesticide use in public drinking water source areas (2000)* and other policies should assist in managing potential risks.

Herbicides listed in the Department of Health's Circular PSC 88 can be used in water reserves in accordance with the label description and best-management practices, however non-chemical measures are preferred if they are available.

This activity is considered overall to be a medium management priority for water quality protection if best-management practices are applied and the land use is not intensified. However, if pesticide is applied in wellhead protection zones, this activity is considered to be a high management priority for water source protection.

3.1.2.5 Roads and tracks in Springdale wellfield

Springdale Road traverses through the Springdale wellfield and three wellhead protection zones (17/05, 18/05 and H), and smaller roads are associated with the subdivision west of the Jerdacuttup River. The land owner, local farmers, supply vehicles and general traffic use these roads.

There is potential for fuel or chemical spills that may result from a road accident on Springdale Road or the minor roads, to impact on groundwater quality in the Springdale wellfield. Although the likelihood is low, Springdale Road and the other public roads should be included in a local emergency response plan.

Any road design in a public drinking water source area should consider the recommendations provided in the department's water quality protection note *Roads near sensitive water resources*.

This activity is considered to be a low management priority for water quality protection.

3.1.3 Native title and Aboriginal sites of significance

Native title is a form of land title that recognises the unique ties some Aboriginal groups have to land. Native title exists where Aboriginal people have maintained a traditional connection to their land and waters, since sovereignty, and where Acts of government have not removed it.

There are two native title claims within the gazetted Hopetoun water reserves – from the Southern Noongar (WAD6134_98) and Wagyl Kaip (WAD6286/98) people.

Aboriginal sites of significance are those areas which 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. In Western Australia, the *Aboriginal Heritage Act 1972* protects all Aboriginal sites.

There are two Aboriginal sites of significance within the gazetted Hopetoun water reserves. Those sites are *Gnamma Hole (Location G)* and *Jerdacuttup River (WO1175)*.

3.2 Proposed land uses and activities

Future development proposals within the Hopetoun water reserves need to fully consider risks to water quality. Guidance on this land use planning issue is available in the Western Australia's Planning Commission's Statement of planning policy 2.7

Public drinking water source policy and the Department of water's Water quality protection note *Land use compatibility in public drinking water source areas*.

The Shire of Ravensthorpe's local planning scheme will need to incorporate the new boundary of the Hopetoun water reserve and its priority areas and protection zones, and the management principles as set out in this drinking water source protection plan.

3.2.1 Private land

Rural subdivision

Large parcels of private land exist within the proposed water reserves. There is therefore the potential for land uses to be intensified, or considered for rezoning to allow the development of rural residential properties.

Any development or rezoning proposal that is inconsistent with the department's water source protection policies and strategies needs to be referred to the Department of Water for consideration and guidance consistent with Western Australia's Planning Commission's Statement of planning policy 2.7: *Public drinking water source policy* and the Department of Water's water quality protection note *Land use compatibility in public drinking water source areas*. The department will provide advice and make recommendations appropriate to these proposals and the protection of Hopetoun's drinking water.

The Department of Water has recently considered a rezoning proposal within the Hopetoun (Town wellfield) water reserve. This rural land was subsequently rezoned from *general agriculture* to *rural conservation* in the Shire of Ravensthorpe's local planning scheme. The land has been assigned for priority 2 water source protection. New hydrogeological information that became available during the assessment of this proposal was used to create a more accurate boundary for a reduced water reserve (Figure 2). The subdivision guide plans required for this proposal will need to be referred to the Department of Water for further advice and recommendations.

In similar subdivision proposals the Department of Water has recommended minimum lot sizes of four hectares on similar P2 land which is highly vulnerable to contamination. It also recommended that conditions apply that include alternative treatment units for each lot, clearing to be minimised for new subdivision approvals (only allowing for defined building blocks, water tank storage, access ways and fencing), and prohibiting new bores and carrying of livestock.

The department recommends that in situations where residential development are approved near drinking water bores, on-site wastewater treatment systems must be at least 100 m away from the production bores.

Rural agriculture land – private land

A major portion of the Springdale wellfield area of the water reserve has remained as broadacre farming and is currently zoned for general agriculture. Most of this land is used for pasture and stock grazing, but broadacre cropping (e.g. canola) is being proposed to be undertaken on land west of Jerdacuttup River. Three production bores and their 300 m radius wellhead protection zones are located on this priority 2 property. Landowners will not be prevented from using their land for rural agricultural land uses that are supported by the Shire of Ravensthorpe's local planning scheme. However, best-management practices are encouraged for any land uses in public drinking water source areas to help protect the water quality and quantity.

Herbicides that are listed in the Public Service Circular PSC 88 are recommended for use in PDWSAs. This circular was prepared by the Department of Health for government agencies and their contractors; however, as a guide PSC88 includes the types of herbicides that are recommended for use in drinking water areas and importantly for the protection of the local groundwater supply.

It is not recommended that pesticides be used in wellhead protection zones without first seeking advice from the Department of Water, as within these zones contamination leaching from the ground surface could migrate rapidly into the water abstracted for the town water supply.

3.2.2 Existing mining project

Land uses and activities in the Hopetoun water reserves are expected to change as a direct result of the closure of the BHP–Billiton open-cut mine project.

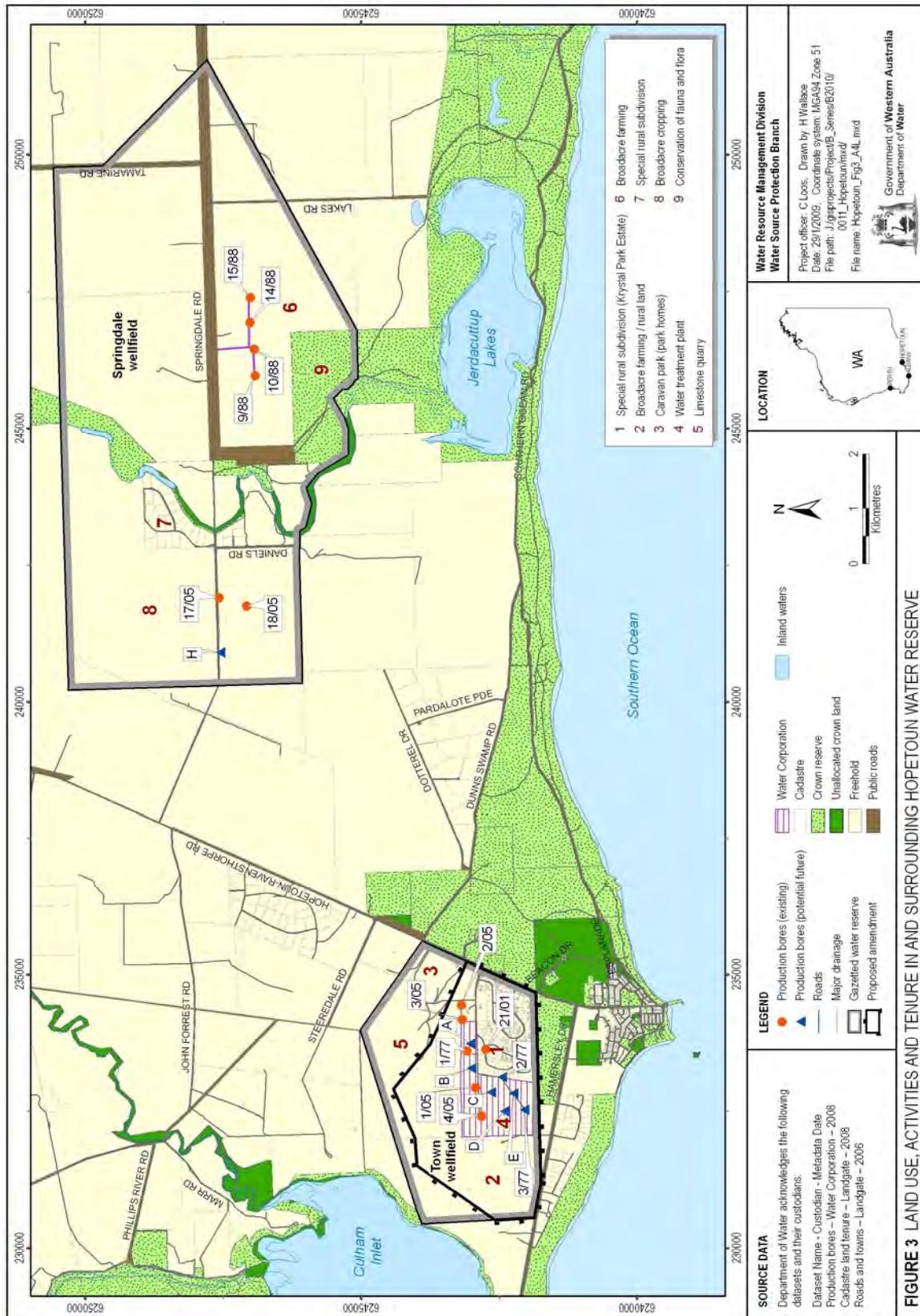


Figure 3 Land use, activities and tenure in and surrounding Hopetoun Water Reserves

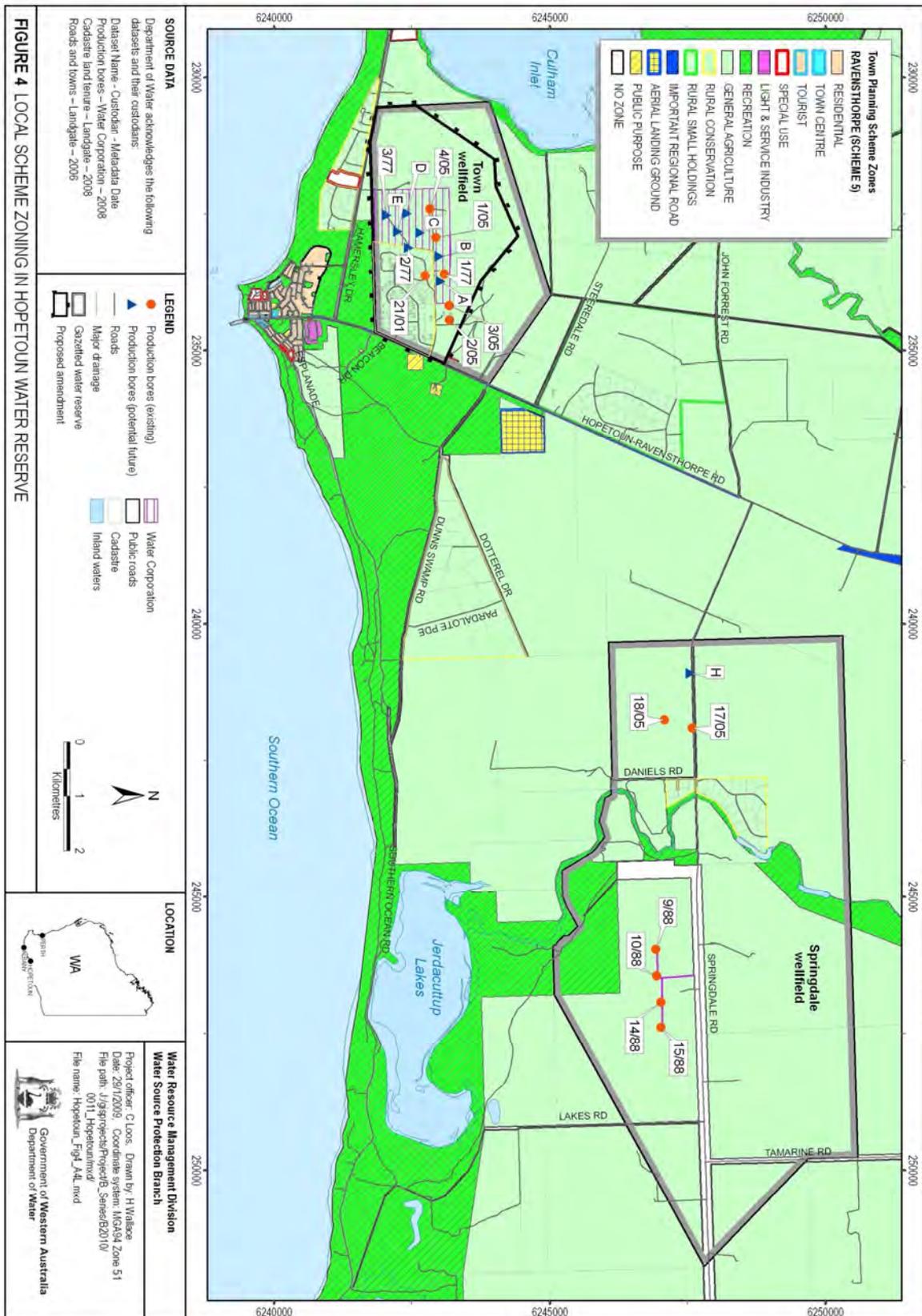


Figure 4 Shire of Ravensthorpe local scheme zoning in Hopetoun Water Reserves

Table 1 Land use and potential water quality

Land use/activity	Hazard	Management priority	Compatibility of land use/activity
Private land (Rural zoned land)	<ul style="list-style-type: none"> • Pathogens from animals and on-site wastewater disposal systems • Nutrients from on-site wastewater disposal systems and fertiliser use • Pesticides from pest control • Hydrocarbons and chemicals from fuel and chemical spills • Rubbish dumping (such as car bodies, furniture and household goods) 	High Medium Medium/high Low/medium Low/medium	Rural land uses are compatible with conditions in a priority 2 (P2) PDWSA
Existing Special Rural lots (Krystal Park Estate in Town wellfield and special rural subdivision in Springdale wellfield – both historical approved land uses)	<ul style="list-style-type: none"> • Pathogens from animals and on-site wastewater disposal systems • Nutrients from on-site wastewater disposal systems and fertiliser use • Pesticides from pest control • Hydrocarbons and chemicals from fuel and chemical spills 	High High Low/medium Low	These special rural subdivisions are historical land uses
Lot 201 Banksia Road in Town wellfield (Located in wellhead protection zones of bores 2/05 and 2/03)	<ul style="list-style-type: none"> • Potential risks as above 	High	The Department of Water proposes to reclassify Lot 201 Banksia Road from a P3 to a P1 PDWSA due to its proximity to the production bores, and strategic importance to the wellfield. Liaison between the affected landowner and the Department of Water has been initiated to determine how this area can best be protected

Land use/activity	Hazard	Management priority	Compatibility of land use/activity
Water treatment plant in Town wellfield	<ul style="list-style-type: none"> • High salt (brine) from treatment process. 	Low	Water treatment plants are compatible with conditions in a P1 PDWSA
Limestone quarry (existing quarry falls outside the proposed boundary of the Town wellfield area, but could encroach onto the wellfield in future)	<ul style="list-style-type: none"> • Hydrocarbons and chemicals from fuel and chemical spills from vehicles and machinery 	Low	Extractive industries are compatible with conditions in a P2 PDWSA
Pastoral grazing in Town and Springdale wellfields <ul style="list-style-type: none"> • sheep • cattle 	<ul style="list-style-type: none"> • Pathogens contamination from domestic animal excreta and carcasses • Nutrients from excreta originating from domestic animals • Pesticides from pest control • Fuel and chemical spills from fuel from vehicles and machinery 	High Low/medium Medium/high Low	Pastoral activities are compatible with conditions in a P2 PDWSA
General agriculture (including broadacre cropping)	<ul style="list-style-type: none"> • Nutrients from animals, fertiliser use and household wastewater disposal systems • Pathogens from animals and household wastewater disposal systems • Pesticides from pest control • Hydrocarbons and chemicals from fuel and chemical spills • Rubbish dumping (such as car bodies, furniture and household goods) 	Medium High Medium/high Low/medium Low/medium	Agricultural activities are compatible with conditions in a P2 PDWSA

Land use/activity	Hazard	Management priority	Compatibility of land use/activity
Crown land and reserves (limited recreational activities occur at the Springdale wellfield)	<ul style="list-style-type: none"> • Nutrients from native animals • Pathogens from native animals • Rubbish dumping (such as car bodies, household goods, and any unwanted materials) 	<p>Low</p> <p>Low</p> <p>Low/medium</p>	Crown land is a compatible land use in a P1 PDWSA
Roads traversing Town and Springdale wellfields	<ul style="list-style-type: none"> • Hydrocarbons and chemicals from fuel and chemical spills from vehicles and machinery • Pesticides from weed spraying along edges of roads • Nutrients from accidents or leaks 	<p>Low</p> <p>Low</p> <p>Low</p>	Roads are compatible with conditions in P2 and P3 PDWSAs
<p>Infrastructure maintenance</p> <ul style="list-style-type: none"> • power lines • pipelines • associated tracks • production bores and associated fixtures/structures 	<ul style="list-style-type: none"> • Hydrocarbons and chemicals from fuel and chemical spills from vehicles and machinery • Pesticides from weed spraying along edges of roads, pipelines and other structures 	<p>Low</p> <p>Low</p>	Infrastructure corridors are compatible with conditions in P2 and P3 areas, and occasionally approved with conditions in P1 areas where it can be demonstrated alternative siting is impractical or vital to the state's interest

4 Catchment protection strategy

The main objective of this plan is to protect the Hopetoun water reserves in the interest of providing safe drinking water to the community. In addition, this plan aims to balance water quality protection, social needs and the expectations of land owners.

A 'catchment to consumer' multiple barrier risk-based management approach is used to protect drinking water quality in Western Australia, consistent with the *National water quality management strategy: Australian drinking water guidelines 6 2004* (NHMRC & NRMCC 2004a).

The protection of Hopetoun water reserves by the Department of Water is in accordance with government legislation and policy and involves three key elements:

- The water reserves are proclaimed under the *Country Areas Water Supply Act 1947*. Proclamation of these water reserves ensures the location of the water source is known to statutory land use planning decision-makers and the general public.
- 'Priority areas' have been assigned to the land within the water reserves to guide land-use planning and development and to protect the water quality.
- Wellhead protection zones have been determined around existing and proposed production bores within the water reserves to identify these areas clearly. Specific by-laws apply to these zones to protect water quality.

4.1 Protection objectives

The objective of water source protection is to preserve water quality at its current level, and where practical, achieve an improvement in water quality.

Where water reserves remain covered with native vegetation, with little human activity occurring, the risk of contamination is low. However, contamination risks increase with human activity and development.

This plan recognises the right of existing approved land uses to continue to operate in the Hopetoun water reserves. However, these existing approved land uses should be managed with best-management practices to reduce risk to water quality. The avoidance, minimisation and management of risks to water quality for public supply is imperative for the protection of public health.

4.2 Proclaimed area

The original Hopetoun water reserve was proclaimed in 1984 under the *Country Areas Water Supply Act 1947* for the purpose of protecting the public drinking water

source of the Town wellfield. The boundary of the water reserve was amended in 2001 to provide protection for the Springdale wellfield.

The boundary of the gazetted Hopetoun (Town wellfield) water reserve has recently been revised by the Department of Water to reflect new hydrogeological data. The department has recommended amending the boundary to reduce the area of the Town wellfield and maintaining the boundary of the Springdale wellfield (Figure 2).

4.3 Priority areas

The protection of PDWSAs relies on statutory and non-statutory measures available in legislation and policies for water resource management and land-use planning. The Department of Water's policy for the protection of PDWSAs includes three risk-based priority areas:

- Priority 1 (P1) areas have the fundamental water-quality objective of risk avoidance.
- Priority 2 (P2) areas have the fundamental water-quality objective of risk minimisation.
- Priority 3 (P3) areas have the fundamental water-quality objective of risk mitigation.

The determination of priority areas is based on the strategic importance of the land or water source, the local planning scheme zoning, the form of land tenure and existing approved land uses or activities. For further detail, please refer to the Department of Water's water quality protection note: *Land use compatibility in public drinking water sources areas*.

The 1995 water source protection plan established the current protection boundaries of the Hopetoun water reserves and assigned priority areas within both wellfields.

Most of the current priority areas applied to the Hopetoun water reserves are in accordance with current Department of Water policy, except the priority area currently assigned to Lot 201 Banksia Road and the majority of the crown land. Changes to the proposed areas are described below and displayed in Figure 5 and 6. The department's water quality protection note: *Land use compatibility in public drinking water source areas* outlines activities that are acceptable, compatible with conditions or incompatible within the different priority areas. For an explanation of the background and support for protection of PDWSAs, refer to water quality protection note: *Protecting public drinking water source areas*.

The Shire of Ravensthorpe's local planning scheme No. 5 notes both wellfields of the gazetted Hopetoun water reserves as special control areas on the scheme map.

4.3.1 Priority areas in the Hopetoun (Town wellfield) water reserve

The existing Town wellfield has priority 1, 2 and 3 areas within its boundary. Priority 1 applies to land owned by the Water Corporation, where the production bores are

located. Priority 2 was assigned to the surrounding farmland (rural agriculture) and priority 3 to the special rural subdivision (existing Krystal Park Estate) that abuts the Hopetoun–Ravensthorpe Road. More than 25 residential lots (lot sizes range between one and two hectares) are situated in wellhead protection zones (section 4.4). Best management practices and adherence to the conditions of subdivision approval are imperative to ensure the quality of the water source in these zones is protected (Table 1).

New hydrogeological information was used to propose a more accurate water reserve boundary and lead to proposing a priority 3 area (currently priority 2) to a small portion of land west of the Hopetoun–Ravensthorpe Road, just south of the caravan park. But the larger portion of land (now zoned rural conservation) remains assigned as a priority 2 area (Figure 5).

The caravan park (park homes), the northern portions of Lot 6382 and the north-western portion of Lot 1 (Lot 1 on plan 13741) Hopetoun–Ravensthorpe Road, and the existing limestone quarry are now located outside the proposed Hopetoun (Town wellfield) water reserve.

A small area of privately owned land (Lot 201 Banksia Road) zoned *rural agriculture* and assigned as P3 area in the 1995 plan is located within the wellhead protection zones of bores 2/05 and 3/05 (Figure 5). This land has been identified to be highly vulnerable and of strategic importance to the wellfield. The Department of Water proposes to reclassify this lot from a P3 to a P1 area due to its proximity to the production bores. Liaison between the affected landowner and this department has been initiated to determine how this area can best be protected. One option that could be considered is the sale of this land to the Department of Water. Other approaches may need to be negotiated to maximise the quality of water from this area (e.g. establishing native vegetation buffers and limited fertiliser use).

The access way to production bores 2/05 and 3/05 from Hopetoun–Ravensthorpe Road (via Banksia Road and north of Lot 201 Banksia Road) is crown land (CR 34474) and was not identified in the 1995 plan. The department proposes to assign a P1 area to this strip of land.

4.3.2 Priority areas in Hopetoun (Springdale wellfield) water reserve

The existing farmland in the Springdale wellfield was assigned for priority 2 water source protection. The crown land along Jerdacuttup River was not identified in the figures of the 1995 protection plan, but crown land in general was discussed as priority 1 in this 1995 plan. It is proposed to assign the crown land for the objectives of priority 1 source protection (Figure 6).

All other priority areas will remain as assigned in the Hopetoun groundwater plan (1995).

The classifications for the Town and Springdale wellfields are appropriate for the following reasons:

- Water from this source constitutes a strategic supply to the town of Hopetoun and it should be afforded a high level of protection.
- The wellfields represent the groundwater recharge area of the current sole water supply source for Hopetoun.
- The sources are vulnerable to contamination from incompatible land uses.
- The private land located within the WHPZ is considered of strategic importance because:
 - it overlies a shallow aquifer which is vulnerable to contamination from inappropriate land uses
 - development is undesirable given the proximity of production bores.
- Existing land uses on the crown land are considered compatible with P1 source protection objectives.
- Existing land uses and tenures (on farmland) are generally considered compatible with P2 source protection.
- Existing land uses in the wellfields can be managed for P1, P2 and P3 source protection objectives by implementing best-management practices for relevant compatible land uses.
- The special rural subdivisions (Krystal Park Estate (P3) and the subdivision just west of Jerdacuttup River (P2)) were established in the early 1990s prior to finalising the original protection plan in 1995.

The Department of Water in cooperation with Water Corporation has identified P2 land in the Springdale wellfield that is of strategic importance to the drinking water source. The land contains four production bores and is used for cattle grazing. On several occasions between January 2002 and January 2008 these bores have tested positive for low counts of *Escherichia coli*. Cattle grazing in proximity to production bores may contribute to higher counts of *Escherichia coli* in a water source, particularly when these bores draw water from a shallow, unconfined aquifer. The Department of Water has spoken to the landowner and advised that it will consider the issues that have been raised about the operation of the bores, and the option of changing the priority of this land (in whole or in part) from P2 to P1.

4.4 Protection zones

In addition to P1, P2 and P3 areas, specific protection zones are defined to protect drinking water sources from contamination in the immediate vicinity of water extraction facilities. Specific conditions may apply within these zones such as restrictions on the storage of chemicals.

Wellhead protection zones (WHPZ) are generally circular (unless information is available to determine a different shape or size) with a 500-metre radius around each production bore in a P1 area and a 300-metre radius around each production bore in P2 and P3 areas. WHPZ do not extend outside the boundary of the water reserves.

For further details on WHPZ refer to the departments water quality protection notes *Land use compatibility in public drinking water source areas*.

4.4.1 Wellhead protection zones in Town wellfield

The Town wellfield has production bores on land that is managed for priority 1, 2 and 3 source protection. Circular 500 m and 300 m radius WHPZ exist around each production bore. The water service provider identified six potential future production bores (this includes redrilling of existing bores) in the immediate wellfield that may be used in the near future. The proposed WHPZ for these future bores are displayed in Figure 5.

Additionally, a 200 m protection zone to the north and east of the Water Corporation's land (Town wellfield, Lot 1 on plan 16591) has been proposed by the Department of Water (Figure 5). This 200 m zone will assist in protecting any potential future production bores along the northern and eastern boundary of Lot 1 on plan 16591 (Water Corporation's land) from incompatible land use developments or intensification. Any building envelope should be located outside this zone.

Two additional production bores (bores A and B) are proposed to be commissioned along the northern boundary of the Town wellfield in the near future. These bores will assist the Water Corporation in meeting the community's drinking water needs (Figure 5).

Future development and expanding approved land uses and activities in these zones should be assessed carefully to address immediate water quality risks.

4.4.2 Wellhead protection zones in Springdale wellfield

The Springdale wellfield has production bores on land that is managed for the objective of priority 2 drinking water source protection. Therefore, circular 300 m radius WHPZ exist around each production bore. The Water Corporation identified another potential future production bore (bore H) in the western part of the Springdale wellfield that will be commissioned in the near future. The proposed WHPZ for this future bore is displayed in Figure 6.

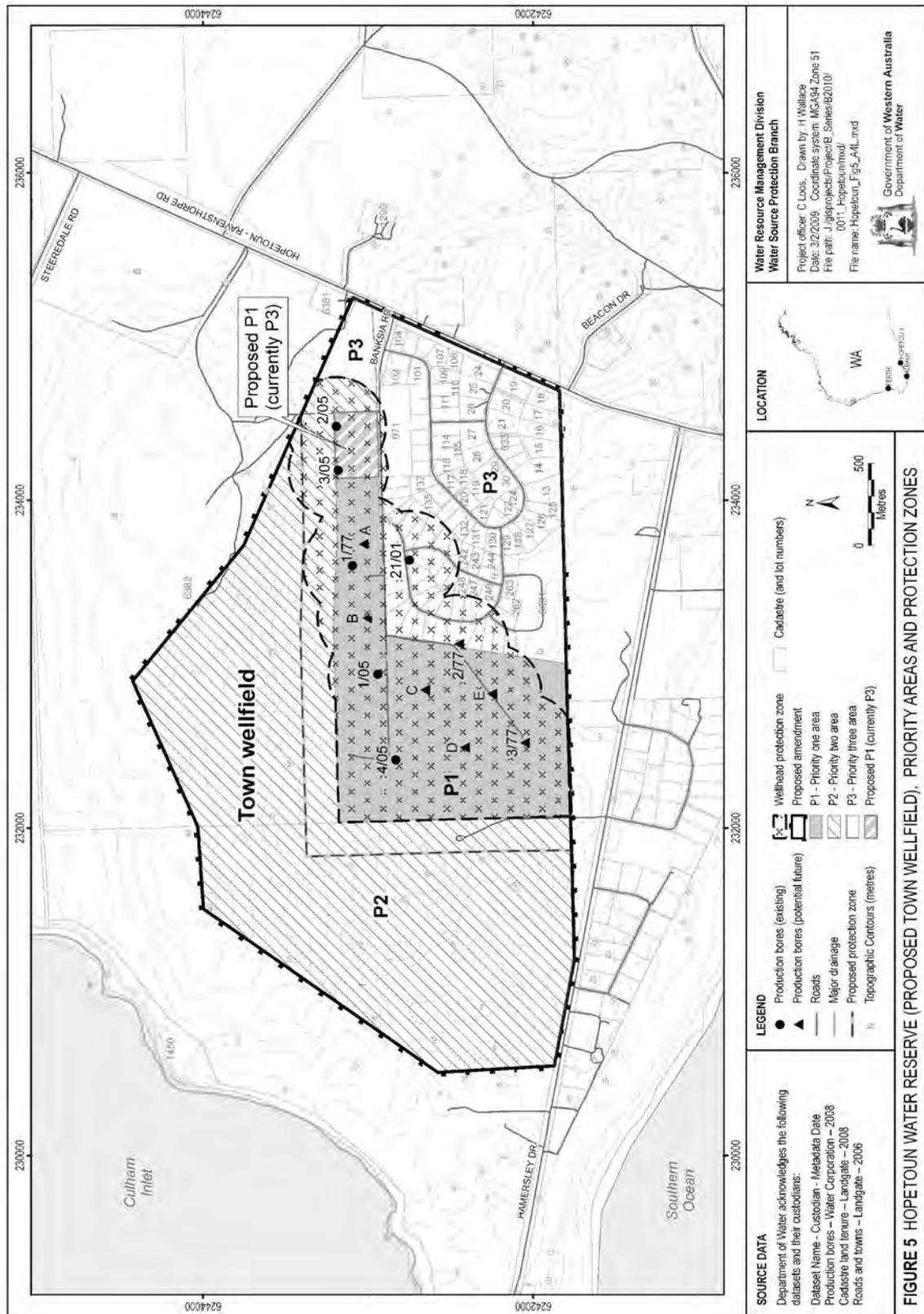


Figure 5 Hopetoun (proposed Town wellfield) water reserve, priority areas and protection zones

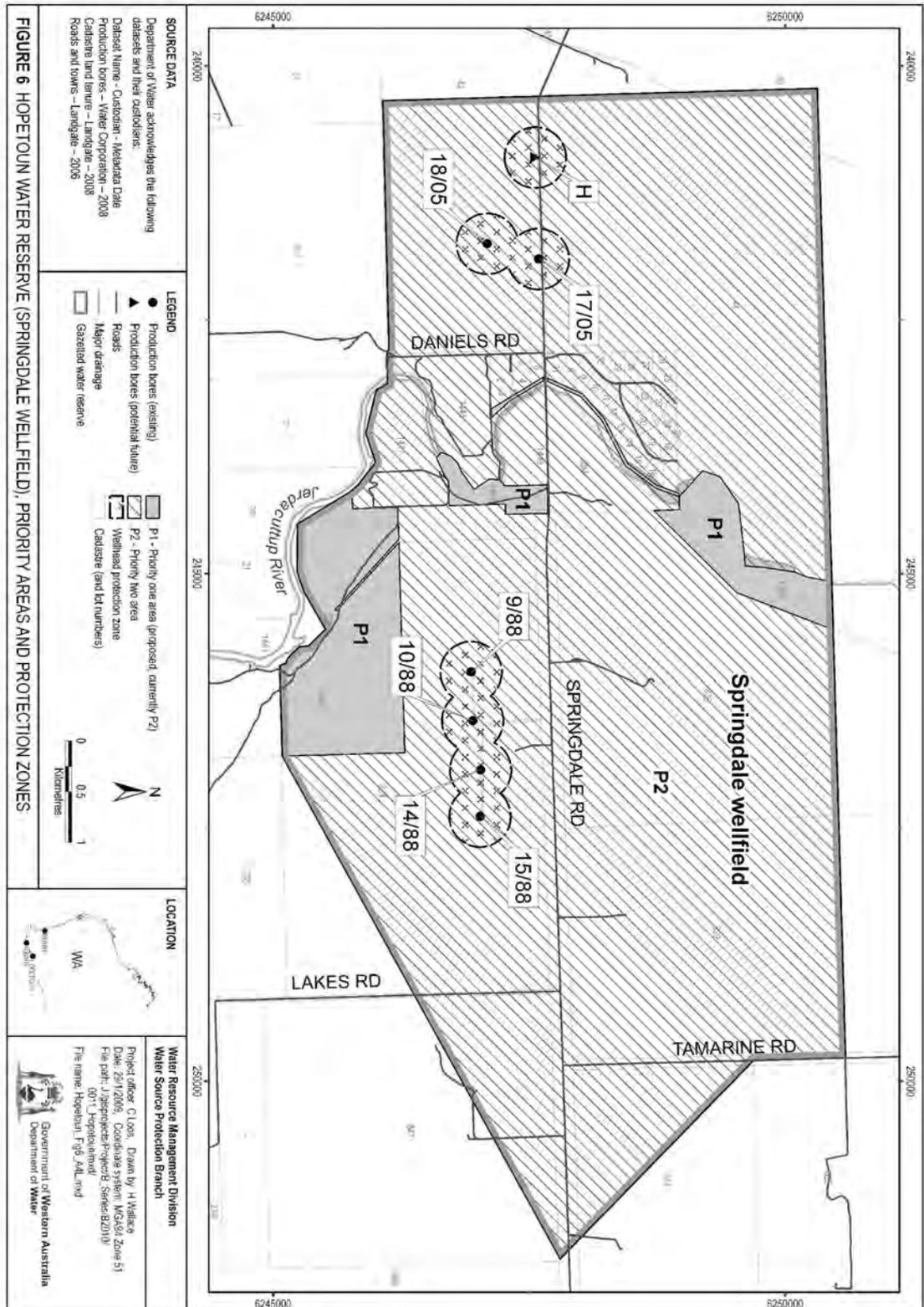


Figure 6 Hopetoun (Springdale wellfield) water reserve, priority areas and protection zones (The P2 status of some land in this water reserve is proposed to be reviewed to determine if it should be P1)

4.5 Land-use planning

It is recognised under the *State planning strategy* (Western Australian Planning Commission 1997) that the establishment of appropriate protection mechanisms in statutory land-use planning processes is necessary to secure the long-term protection of drinking water sources. As outlined in Statement of planning policy: *Public drinking water source policy* (Western Australian Planning Commission 2003) it is appropriate that the Hopetoun water reserves, priority areas and protection zones be recognised in the Shire of Ravensthorpe local planning scheme. Any development proposals within the Hopetoun water reserves that are inconsistent with advice in the Department of Water's water quality protection note: *Land use compatibility in public drinking water source areas* or recommendations in this plan, should be referred to the Department of Water for advice.

For further information on the integration of land-use planning and water source protection, please refer to the Department of Water's water quality protection note: *Protecting public drinking water source areas*.

The department's protection strategy for public drinking water source areas provides for lawfully established and operated developments to continue despite their location or facilities posing a level of risk to water quality which would not be accepted for new developments. The department will provide advice to landowners/operators on measures to improve these facilities and reduce water quality contamination risks.

In strategically significant areas the department has developed a policy that allows it to approach land owners with a view to purchase P1 land or negotiate water contamination risk reduction measures. Given the strategic significance of some water sources, and possible public health risks, a compulsory purchase option also exists.

4.6 Best management practices

There are opportunities to significantly reduce water contamination risks by carefully considering design and management practices. The adoption of best-management practices for land uses will continue to be encouraged to help protect water sources.

There are guidelines for many land uses available in the form of industry codes of practice, environmental guidelines and water quality protection notes. These have been developed in consultation with stakeholders such as industry groups, agricultural producers, state government agencies and technical advisers. Examples include:

- *Contaminate spills – emergency response*
- *Extractive industries within public drinking water source areas*

- *Vegetation buffers to sensitive water resources*
- *Toxic and hazardous substances – storage and use*
- *Tanks for elevated chemical storage*
- *Subdivision and rezoning in public drinking water source areas*
- *Rural restaurants, cafés and taverns*

These documents are listed in the Bibliography section of this document. The guidelines help managers reduce the water quality impacts of their operations and are the recommended practice to ensure the protection of water quality.

Education and awareness (e.g. signage and information) are also key mechanisms for protecting the quality of water, especially for those people visiting the area. A brochure will be produced once this plan is finalised, describing the Hopetoun water reserves, their location and the main threats to water quality. This brochure will be available to the community and will inform people in simple terms of the drinking water source and the need to protect it.

4.7 Surveillance and by-law enforcement

The quality of public drinking water sources within country areas of the state is protected under the *Country Areas Water Supply Act 1947*. Proclamation of PDWSAs allows existing 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, as an important mechanism to protect water quality. Routine surveillance conducted under an operational surveillance plan is undertaken by Water Corporation personnel.

Signs will be erected on the boundaries of these water reserves to educate and to advise the public of activities that are prohibited or regulated. This plan recommends that the delegation of surveillance and by-law enforcement to the Water Corporation be continued.

4.8 Emergency response

The escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The Ravensthorpe local emergency management committee (LEMC), through the Goldfields–Esperance emergency management district, should be familiar with the location and purpose of the Hopetoun water reserves. A locality plan should be provided to the fire and rescue services headquarters for the hazardous materials (HAZMAT) emergency advisory team. DEC is the lead agency for wildfire control management for the majority of the water reserves that is outside of the gazetted fire emergency

response. The Water Corporation should have an advisory role to the HAZMAT team for incidents in the Hopetoun water reserves.

Personnel who deal with WESTPLAN–HAZMAT (Western Australian plan for hazardous materials) incidents within the area should have access to a map of the Hopetoun water reserves. These personnel should have an adequate understanding of the potential impacts of spills on this water resource.

4.9 Implementation of the 1995 and this plan

The 1995 Hopetoun groundwater protection plan provided a list of 15 recommendations for implementation. Fourteen of the 15 recommendations have been effectively actioned. The outstanding recommendation related to developing an appropriate emergency response plan.

The most significant of the achieved tasks from the 1995 plan were:

- gazettal of water reserves and priority protection areas
- adoption of protection areas and zones in the Shire of Ravensthorpe Town Planning Scheme
- application of priority classifications and assessment of development proposals for conformity
- communication of protection strategies to landowners.

Although the town rubbish tip is outside the Hopetoun (Town wellfield) water reserve it is located about 1 km east of Town wellfield. It was considered prudent that the operation of this tip be improved to reduce risk of contamination of groundwater from liquid wastes and oil wastes. Better control of inputs to the tip and separation of potentially contaminating materials was recommended and implemented.

The cemetery is located a similar distance from Town wellfield but was considered not to be of significant threat to warrant its relocation. In determining future land uses on the nearby land reserves, the 1995 plan stated that it may be beneficial to consider an alternative use for the cemetery site that would pose less of a threat to local groundwater quality.

Action is still required to prepare a suitable emergency response plan to ensure the quality of the water reserves is protected now and in future.

Actions identified in the 1995 plan that were not implemented and still apply to the water reserves have been incorporated in this Hopetoun water reserves drinking water source protection plan (DWSPP). The status of the 1995 groundwater protection plan recommendations is provided in Appendix D.

Implementing of the drinking water source protection plan 2009

Table 1 identifies the potential water quality risks associated with existing land uses in the Hopetoun water reserves. Further information and recommended protection strategies to deal with those risks are also outlined in Appendix B.

Following completion of the final Hopetoun water reserves drinking water source protection plan, an implementation strategy will be drawn up based on the recommendations in Table 1 (Appendix B).

It is essential that existing preventive and management strategies be continued and protection measures identified in this plan be implemented to ensure the ongoing availability of good quality drinking water to the consumers in Hopetoun.

5 Recommendations

The following recommendations apply to the entire Hopetoun water reserves (i.e. Town and Springdale wellfields). The bracketed stakeholders are known to have an interest in implementation of the relevant recommendation.

- 1 The boundary of the amended Hopetoun (Town wellfield) water reserve should be reproclaimed under the *Country Areas Water Supply Act 1947* as shown in Figure 2. (Department of Water)
- 2 An implementation strategy should be developed for the recommendations of this plan (including the recommended protection strategies as detailed in Appendix B) showing responsible stakeholders and planned timeframes. (Department of Water; applicable stakeholders)
- 3 The *Shire of Ravensthorpe's local planning scheme* should incorporate this plan and reflect the amended Hopetoun water reserves boundaries (as specified control areas), priority 1, 2 and 3 areas and protection zones in accordance with Statement of planning policy 2.7: *Public drinking water source policy*. (Shire of Ravensthorpe)
- 4 The Department of Water to continue liaising with landowners with properties within the wellhead protection zones to determine how water quality can best be protected in those areas. Potential purchase of strategically important P1 land may be considered. (Department of Water)
- 5 The Department of Water is to investigate the need to change some or all of the P2 land in the Springdale wellfield to P1 after consulting landowners and the Water Corporation. (Department of Water)
- 6 Any subdivision guidance plans for development/rezoning proposals within the water reserves should be referred to the Department of Water for advice and recommendations. (Department for Planning and Infrastructure; Shire of Ravensthorpe; and proponents of proposals)
- 7 Any future building envelopes to the north and west boundary of Lot 1 on Plan 16591 (Water Corporation's wellfield) should be 200 m away from the dividing boundary, extending north and westwards onto the adjoining properties for the purpose of water source protection (Figure 5). (Department of Water; Shire of Ravensthorpe)
- 8 All development proposals within the Hopetoun water reserves that are inconsistent with the Department of Water's water quality protection note: *Land use compatibility in public drinking water source areas* or recommendations in this plan should be referred to the Department of Water for advice and recommendations. (Department for Planning and Infrastructure; Shire of Ravensthorpe; proponents of proposals)
- 9 Incidents covered by WESTPLAN–HAZMAT in the Hopetoun water reserves should be addressed by ensuring that:
 - the Shire of Ravensthorpe LEMC should be aware of the location and purpose of the Hopetoun water reserves

- the locality plan for the Hopetoun water reserves is provided to the Fire and Emergency Services Authority headquarters for the HAZMAT emergency advisory team
- the Water Corporation acts in an advisory role during incidents in the Hopetoun water reserves
- personnel dealing with WESTPLAN–HAZMAT incidents in the area have ready access to a locality map of the Hopetoun water reserves and information to help them recognise the potential impacts of spills on drinking water quality.

(All Department of Water and Water Corporation)

- 10 The existing groundwater monitoring program should be maintained to identify any incompatible land uses or potential threats within the Hopetoun water reserves. (Department of Water; Water Corporation)
- 11 Signs should be erected along the boundary of the Hopetoun water reserves to define the location and promote awareness of the need to protect drinking water quality. Signs should include an emergency contact telephone number. (Water Corporation)
- 12 The elevated micro-biological counts in the water samples taken from the Town and Springdale wellfields should be further investigated to determine and remove the source(s) of contamination.
- 13 Vesting should be sought for the unallocated crown land along Jerdacuttup River for the purpose of waterways, or flora and fauna protection by the relevant government agency. (Department of Water or Department of Environment and Conservation)
- 14 Liaison with the South West Aboriginal Land and Sea Council should occur prior to seeking vesting for the unallocated crown land along Jerdacuttup River. (Department of Water or Department of Environment and Conservation)
- 15 A brochure describing the Hopetoun water reserves, its location and main threats to water quality should be prepared.
- 16 A review of this plan should be undertaken after five years. (Department of Water)

Appendices

Appendix A Water quality data

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

The Water Corporation has monitored the raw (source) water quality from Hopetoun borefield and Hopetoun Springdale borefield in accordance with the Australian drinking water guidelines (ADWG) and interpretations agreed to with the Department of Health. The raw water is monitored regularly for:

a. aesthetic related characteristics– (non health-related)

b. health-related characteristics

–health related chemicals

–microbiological contaminants

Following is data representative of the quality of raw water in the Hopetoun borefield and Hopetoun Springdale borefield. In the absence of specific guidelines for raw water quality, the results have been compared with ADWG values set for drinking water, which defines the water quality requirements at the customer's tap. Results that exceed ADWG are shaded red to give an indication of potential raw water quality issues associated with this source.

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, to name a few, exist downstream of the raw water to ensure it meets the requirements of ADWG. For more information on the quality of drinking water supplied to Hopetoun refer to the most recent Water Corporation drinking water quality annual report at

<http://www.watercorporation.com.au/W/waterquality_annualreport.cfm?uid=2377-9937-9579-7091>.

Aesthetic-related characteristics

Aesthetic water quality analyses of raw water from Hopetoun borefield and Hopetoun Springdale borefield are summarised in Table 1.

The values are taken from ongoing monitoring for the period January 2002 to January 2008. All values are in milligrams per litre (mg/L) unless stated otherwise. Any water quality parameters that have been detected are reported, those that have on occasion exceeded the ADWG are shaded red.

Table 2 Aesthetic related detections for Hopetoun

Parameter	Units	ADWG aesthetic guideline value*	Hopetoun bore 1/77 SP		Hopetoun Springdale bore 14/88 SP	
			Range	Median	Range	Median
Aluminium unfiltered	mg/L	NA	<0.008 - 0.1	0.018	<0.008 - 0.02	<0.008
Chloride	mg/L	250	225 - 360	330	86 - 450	410
Colour - true	TCU	15	<1 - 4	<1	<1 - 5	<1
Conductivity at 25°C	mS/m	na	120 - 165	140	135 - 195	160
Copper [‡]	mg/L	1	<0.002	<0.002	0.004 - 0.03	0.017
Hardness as CaCO ₃	mg/L	200	183 - 245	223	99 - 146	109
Iron unfiltered	mg/L	0.3	0.9 - 10	4.6	0.004 - 1.4	0.014
Manganese unfiltered	mg/L	0.1	0.055 - 0.38	0.134	<0.002 - 0.024	0.016
pH	NOUNIT	6.5 - 8.5	6.96 - 7.38	7.14	5.5 - 6.13	5.8
Sodium	mg/L	180	165 - 220	185	230 - 285	250
Sulphate	mg/L	250	42 - 60	52.5	42 - 55	48
TFSS	mg/L	500	762 - 922	863	761 - 904	827
Turbidity	NTU	5	9.2 - 170	55	<0.1 - 5.2	0.1
Zinc [‡]	mg/L	3	0.18	0.18	0.04 - 0.1	0.07

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

[‡] Water quality data observed from 3 or less sampling occasions.

Health-related characteristics

Health parameters

Raw water from Hopetoun borefield and Hopetoun Springdale borefield is analysed for health-related chemicals including inorganics, heavy metals, industrial hydrocarbons and pesticides. Health-related water quality parameters that have been measured at detectable levels in the source between January 2002 and January 2008 are summarised in Table 2. Any parameters that have, on occasion, exceeded the ADWG are shaded.

Table 3 Health-related detections for Hopetoun borefield and Hopetoun Springdale borefield

Parameter	Units	ADWG health guideline value*	Hopetoun bore 1/77 SP		Hopetoun Springdale bore 14/88 SP	
			Range	Median	Range	Median
Arsenic[†]	mg/L	0.007	<0.002	<0.002	<0.002 - 0.005	<0.0035
Barium[†]	mg/L	0.7	0.045	0.045	0.019 - 0.02	0.0195
Boron[†]	mg/L	4	0.14	0.14	0.32	0.32
Cadmium[†]	mg/L	0.002	<0.0002	<0.0002	<0.0002 - 0.0002	<0.0002
Chromium[†]	mg/L	0.05	<0.0005	<0.0005	0.0025 - 0.04	0.02125
Lead[†]	mg/L	0.01	<0.002	<0.002	<0.002 - 0.01	<0.006
Molybdenum[†]	mg/L	0.05	<0.0005	<0.0005	<0.0005 - 0.003	<0.00175
Nickel[†]	mg/L	0.02	<0.002	<0.002	0.007 - 0.035	0.021
Nitrite plus nitrate as N	mg/L	11.29	0.31 - 1.3	0.69	<0.05 - 0.22	0.11
Uranium[†]	mg/L	0.02	<0.001	<0.001	<0.001 - 0.001	<0.001

* 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, 1996).

[†] Water quality data observed from 3 or less sampling occasions.

Microbiological contaminants

Microbiological testing of raw water samples from Hopetoun borefield and Hopetoun Springdale borefield 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 *Escherichia coli* in raw water abstracted from any bore may indicate possible contamination of faecal material through ingress in the bore, or recharge through to the aquifer (depending on aquifer type).

During the reviewed period of January 2002 to January 2008, positive *Escherichia coli* counts were recorded in less than two per cent of samples from Hopetoun borefield and approximately 18 per cent of samples from Hopetoun Springdale borefield.

Hopetoun Springdale borefield is located on private property currently used for cattle grazing and broadacre farming. High *Escherichia coli* levels are likely to be associated with cattle in proximity to bores which are drawing from a shallow, unconfined aquifer.

Appendix B Recommended water source protection strategies

Land use, potential water quality risks and recommended protection strategies

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Land uses/activities in Town and Springdale wellfields					
Private land (Rural-zoned land)	<p>The potential risks associated with rural areas are:</p> <ul style="list-style-type: none"> • Pathogens from animals and on-site wastewater disposal systems • Nutrients from on-site wastewater disposal systems and fertiliser use • Pesticides from pest control • Hydrocarbons and chemicals from fuel and chemical spills • Rubbish dumping (such as car bodies, furniture and household goods) 	<p>High</p> <p>Medium</p> <p>Medium/high</p> <p>Low/medium</p> <p>Low/medium</p>	<ul style="list-style-type: none"> • Land planning zoning provisions limit clearing of natural vegetation • The land uses and activities on rural lots in the water reserves may intensify as a result of land being close to Hopetoun. This may compromise the quality of the water reserves under pressure • There are two registered Aboriginal sites of significance in the Hopetoun water reserves 	<ul style="list-style-type: none"> • Water quality monitoring • Land planning controls recognise importance of protecting drinking water supply 	<p>Rural land uses are compatible with conditions in a priority 2 (P2) area</p> <ul style="list-style-type: none"> • Any land uses and activities should be in accordance with the WA Planning Commission's Statement of planning policy No 2.7: <i>Public drinking water source policy</i>, and this department's water quality protection note <i>Land use compatibility in public drinking water source areas</i>. • Vegetation buffers should be maintained along the drainage lines in the water reserves in accordance with the department's water quality protection note: <i>Vegetation buffers</i> • Bores should be assessed to determine the level of risk to water quality

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Existing Special Rural lots (Krystal Park Estate (P3) in Town wellfield and special rural subdivision (P2) in Springdale wellfield – both are historical approved land uses)	<p>The potential risks associated with residences are:</p> <ul style="list-style-type: none"> • Pathogens from animals and on-site wastewater disposal systems • Nutrients from on-site wastewater disposal systems and fertiliser use • Pesticides from pest control • Hydrocarbons and chemicals from fuel and chemical spills 	<p>High</p> <p>High</p> <p>Low/moderate</p> <p>Low</p>	<ul style="list-style-type: none"> • In the Town wellfield, there are more than 25 lots located in wellhead protection zones, as a result of an historical land use planning decision • No deep sewer line is currently available to serve this housing estate • There is a potential for private bores to affect availability of water to wellfield, and its quality • Stock management • Pesticide and fertiliser use • Access to production bores is provided by a pathway zoned Crown land 	<ul style="list-style-type: none"> • Water quality monitoring • Land planning controls recognise importance of protecting drinking water supply • The construction of bores or wells is not permitted as a condition of the planning approval in the special rural zoning • Animal control, pesticide use, retention of native vegetation, and similar controls were incorporated in the Shire of Ravensthorpe town planning scheme • A foreshore management plan for the subdivision (Oldfield Location 203, Hopetoun) in the Springdale wellfield was endorsed by the Shire of Ravensthorpe in 1995 	<p>These special rural subdivisions are historical land uses</p> <ul style="list-style-type: none"> • Ensure stormwater management is implemented that takes into consideration water source protection objectives and proximity to production bores • Ensure conditions of subdivision approval are adhered to. Residential development can pose high risks of groundwater contamination • Encourage landowners to adopt best-management practices (allowed activities). • Oppose intensification of land use through planning approval process • Support changes within existing approvals that reduce groundwater contamination risks

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
<p>Continued (Krystal Park Estate (P3) in Town wellfield and special rural subdivision (P2) in Springdale wellfield – both historical approved land uses)</p>			<ul style="list-style-type: none"> Unsewered lots in special rural-zoned land create a subdivision density that may compromise scheme water quality Land planning zoning provisions limit clearing of natural vegetation 		<ul style="list-style-type: none"> Shire of Ravensthorpe to encourage connection to deep sewerage (once available) through planning approval process Promote water quality protection, particularly by use of priority areas and wellhead protection zones Private bores should be assessed to determine the level of risk to water quality.
<p>Lot 201 Banksia Road in Town wellfield</p>	<ul style="list-style-type: none"> Potential risks as per Lot 6382 Hopetoun–Ravensthorpe Road (if intensified) 	High	<ul style="list-style-type: none"> This lot (9.8 ha) is private land located in a wellhead protection zone that was assigned for P3 water source protection in the 1995 plan The land is considered to have a high potential to impact the production bores, if the land use on this lot is intensified. This could put the quality of the water reserves under pressure 	<ul style="list-style-type: none"> Water quality monitoring Pesticide is currently not used on the land Limited fertiliser use No stock is kept at the property Residence is located greater than 100 m away from the production bores Land planning controls 	<ul style="list-style-type: none"> The Department of Water proposes to reclassify Lot 201 Banksia Road from a P3 to a P1 area due to its proximity to the production bores, and strategic importance to the wellfield. The purchase of this strategic important parcel of land is currently in progress. After finalising the purchase, this land will be assigned for P1 water source protection.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Water treatment plant in Town wellfield	<p>The potential risks associated with the treatment plant are:</p> <ul style="list-style-type: none"> • High salt (brine) from treatment process. 	Low	<ul style="list-style-type: none"> • The Water Corporation's small scale water treatment plant is located on the northern side of the Town wellfield and close to several production bores • Access to production bores and treatment plant is provided by a pathway zoned Crown land 	<ul style="list-style-type: none"> • Water quality monitoring • The brine is discharged to an infiltration basin between Culham Inlet and the ocean 	<p>Water treatment plants are compatible with conditions in a P1 area</p> <ul style="list-style-type: none"> • Continue with appropriate best- management practices for the handling of brine in accordance with the Department of Water's requirements

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Limestone quarry (existing quarry falls just outside the proposed boundary of the Town wellfield area, but could encroach onto the wellfield in future)	<p>The potential risks associated with the use and maintenance of a limestone quarry and machinery are:</p> <ul style="list-style-type: none"> • Hydrocarbons and chemicals from fuel and chemical spills from vehicles and machinery 	Low	<ul style="list-style-type: none"> • The limestone quarry is now located outside the water reserve. This land use is considered compatible with conditions in a P2 area. Conditions may relate to fuel and chemical storage, the depth of excavation relative to the watertable and also rehabilitation criteria • Quarries used for building materials and road maintenance require effective site management to reduce risks to water quality • Chemical storage and bunding were not assessed • All mechanical servicing of machinery to be undertaken outside the water reserves 		<p>Extractive industries are compatible with conditions in a P2 PDWSA</p> <ul style="list-style-type: none"> • Basic raw material extraction should be in accordance with water quality protection guidelines No.1: <i>Water quality management in mining and mineral processing – An overview</i> (WRC et al. 2000) and WQPN: <i>Extractive industries within public drinking water source areas</i> (Department of Water various dates) and Statewide policy No. 1: <i>Policy and guidelines for construction and silica sand mining in public drinking water source areas</i> (WRC 1999) • Chemical storage should be in accordance with this department's water quality protection note <i>Tanks for elevated chemical storage</i> • Any abandoned quarry should be rehabilitated, once depleted

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Pastoral grazing in Town and Springdale wellfields <ul style="list-style-type: none"> • sheep • cattle 	The potential water quality risks associated with pastoral activities are: <ul style="list-style-type: none"> • Pathogen contamination from domestic animal excreta and carcasses • Nutrients from excreta originating from domestic animals • Pesticides from pest control • Fuel and chemical spills from vehicles and machinery 	High Low/medium Medium/high Low	<ul style="list-style-type: none"> • Although in the main recharge area, current protection classification recognises the right of landowners to continue current land use. Further intensification should not be supported • Sheep and cattle grazing are generally secondary land uses to cropping in the area and stocking rates are usually low • Stocking rates should be in accordance with the Department of Agriculture and Food's guidelines • Access to production bores is provided via Springdale Road 	<ul style="list-style-type: none"> • Water quality monitoring • Land planning controls • Water treatment (e.g. chlorination). • Signage 	Pastoral activities are compatible with conditions in P2 PDWSA <ul style="list-style-type: none"> • Maintain water quality monitoring program • Ensure stock is fenced and kept at least 100 m away from the production bores • Maintain stock watering points for grazing animals. Stock watering points should be located 100 m away and down-slope of the production bores • Water Corporation should ensure all bores are constructed in accordance with the Minimum construction requirements for water bores in Australia (National Minimum Bores Specifications Committee 2003) • Pesticide use should be in accordance with Statewide policy No 2: <i>Pesticide use in public drinking water source areas</i> (WRC 2000) and the Public Service Circular 88 (PSC88).

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
General agriculture (including broadacre cropping)	<p>The potential risks associated with general farming are:</p> <ul style="list-style-type: none"> • Nutrients from animals, fertiliser use and household wastewater disposal systems • Pathogens from animals and household wastewater disposal systems • Pesticides from pest control • Hydrocarbons and chemicals from fuel and chemical spills • Rubbish dumping (such as car bodies, furniture and household goods) 	<p>Medium</p> <p>High</p> <p>Medium/high</p> <p>Low/medium</p> <p>Low/medium</p>	<ul style="list-style-type: none"> • General agricultural activities on private land are typically cropping and low density sheep and cattle grazing • Canola cropping occurs in the Springdale wellfield. Farms apply nitrogen and phosphorous to the soil with soil and plant testing often used to optimise application rates. No-tillage farming is becoming more common • Herbicides used in the Hopetoun area include glyphosate, atrazine and others, with application usually occurring at seeding and 4 to 8 weeks later (if required). Atrazine is a widely used herbicide in Australian agriculture; however, it has the potential to contaminate groundwater 	<ul style="list-style-type: none"> • There are pockets of native vegetation on privately owned land that act as a vegetation buffer • Best-practice management as in <i>WQPN Agriculture – dryland crops near sensitive water resources</i> and Department of Agriculture and Food's Farm note series • Water quality monitoring • Water treatment (e.g. chlorination) 	<p>Agricultural activities are compatible with conditions in a P2 PDWSA</p> <ul style="list-style-type: none"> • Encourage landholders to undertake best-management practices according to the relevant industry guidelines, Department of Agriculture and Food's Farmnote series and Department of Water's water quality protection notes • Ensure stocking levels are in accordance with the Department of Agriculture and Food's stocking rate guidelines and consistent with the P2 source protection area objective • Refer development proposals that are likely to impact on water quality to this department for advice and recommendation • This department recommends that bio-solids are not applied to or stockpiled on this land

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Continued General agricultural activities (including broadacre cropping)			<ul style="list-style-type: none"> • The risks associated with these activities can be managed through education and the adoption of best-management practices • Further intensification of this land use is undesirable 		<ul style="list-style-type: none"> • Pesticide use should be in accordance with Statewide policy No 2: <i>Pesticide use in public drinking water source areas</i> (WRC 2000) • Herbicides that are listed in the Public Service Circular 88 are recommended for use in PDWSAs. This circular was prepared by the Department of Health for government agencies and their contractors, however, as a guide PSC88 includes the types of herbicides recommended for use in drinking water areas and importantly for the protection of the local groundwater supply • Landholders should inform the relevant agency of any spills or accidents in the water reserves with the potential to contaminate the groundwater source • Existing bores should be assessed to determine the level of risk to the water quality

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Crown land and reserves	<p>The potential risks associated with crown land are:</p> <ul style="list-style-type: none"> • Nutrients from native animals • Pathogens from native animals • Rubbish dumping (such as car bodies, household goods, and any unwanted materials) 	<p>Low</p> <p>Low</p> <p>Low/medium</p>	<ul style="list-style-type: none"> • Bushland (north of Springdale Road) with very little activity evident • Land and water based recreational activities (e.g. canoeing, walking, and fishing) occur along Jerdacuttup River • A registered Aboriginal site of significance is located in vicinity of West Bank Close/Daniels Road and along Jerdacuttup River. A 5 km section of the river traverses the gazetted Hopetoun (Springdale wellfield) water reserve. • Reserve 40156 is managed by the Department of Environment and Conservation for the purpose of flora and fauna protection 	<ul style="list-style-type: none"> • Water quality monitoring • Land planning controls 	<p>Crown land is a compatible land use in a P1 PDWSA</p> <ul style="list-style-type: none"> • Vesting for unallocated crown land along Jerdacuttup River (approximately 5 km section) should be sought for the protection of waterways, or flora and fauna by relevant agency • Relevant agency should liaise with South West Aboriginal Land and Sea Council prior to seeking vesting (management order) for the unallocated crown land • The Department of Water proposes to recognise the recreational activities (e.g. walking, fishing and canoeing) that occur along Jerdacuttup River (the portion within the water reserve) as a non-conforming, historical land use activity

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Continued Crown land and reserves			<ul style="list-style-type: none"> The land area in the gazetted Hopetoun water reserves are subject to registered native title claims The bushland is an important corridor to the Jerdacuttup lake system 		
Roads traversing Town and Springdale wellfields	<p>The potential risks associated with roads and tracks are:</p> <ul style="list-style-type: none"> Hydrocarbons and chemicals from fuel and chemical spills from vehicles and machinery Pesticides from weed spraying along edges of roads Nutrients from accidents or leaks 	<p>Low</p> <p>Low</p> <p>Low</p>	<ul style="list-style-type: none"> Hopetoun–Ravensthorpe Rd runs along the east side of the Town wellfield Springdale Road and some minor public roads in the special rural subdivision run through Springdale wellfield Springdale Road traverses through 3 wellhead protection zones (bores 17/05, 18/05 and H) in the western portion of the Springdale wellfield area 	<ul style="list-style-type: none"> Water quality monitoring HAZMAT emergency response 	<p>Roads are compatible with conditions in P2 and P3 PDWSAs.</p> <ul style="list-style-type: none"> Ensure adequate gates and signage to prevent access to private property within WHPZ Ensure road siting, construction and management complies with WQPN: <i>Roads in sensitive environments</i> (Department of Water) Ensure sumps and run-off control measures are adequate and away from production bores Ensure contingency plans are in place for any spills resulting from accidents

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			<ul style="list-style-type: none"> These roads can potentially have a high impact on water quality if fuel or chemical spills occur as a result of a road accident 		<ul style="list-style-type: none"> Use pesticides for verge/road treatment in accordance with Statewide policy No. 2 <i>Pesticide use in public drinking water source areas</i> (WRC 2000) and <i>Public Sector Circular 88: Herbicide use in water catchment areas</i> (Department of Health 2007)

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
<p>Infrastructure maintenance</p> <ul style="list-style-type: none"> • power lines • pipelines • associated tracks • production bores and associated fixtures/structures 	<p>The potential risks associated with infrastructure and maintenance are:</p> <ul style="list-style-type: none"> • Hydrocarbons and chemicals from fuel and chemical spills from vehicles and machinery • Pesticides from weed spraying along edges of roads, pipelines and other structures 	<p>Low</p> <p>Low</p>	<ul style="list-style-type: none"> • Maintenance is necessary for the operation of the infrastructure. However, the risks to water quality associated with maintenance need to be managed, particularly close to the production bores • The Department of Water's Statewide policy No. 2 <i>Pesticide use in public drinking water source areas</i> should be considered when dealing with these hazards • There are also restrictions on the use of pesticides in PDWSAs reflected in Public Service Circular 88 	<ul style="list-style-type: none"> • Water quality monitoring • HAZMAT emergency response 	<p>Infrastructure corridors are compatible with conditions in P2 and P3 areas, and occasionally approved with conditions in P1 areas where it can be demonstrated alternative siting is impractical or vital to the state's interest</p> <ul style="list-style-type: none"> • Ensure that all agencies with responsibilities (and their maintenance contractors) are aware of the location of the water reserves, and that appropriate best-management practices are followed while within the PDWSA • Encourage adherence to Department's water quality protection note <i>Infrastructure corridors near sensitive water resources</i>.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
<p>Continued</p> <p>Infrastructure maintenance</p> <ul style="list-style-type: none"> • power lines • pipelines • associated tracks • production bores and associated fixtures/structures 					<ul style="list-style-type: none"> • Encourage adherence to the Department's Statewide policy No. 2 <i>Pesticide use in public drinking water source areas</i> and Public service circular No 88 (Department of Health 2006)

Appendix C Photographs



Photo 1 Production bore in the Town wellfield



Photo 2 View over the Town wellfield



Photo 3 Water treatment plant -Town wellfield



Photo 4 Cattle grazing at Springdale wellfield



Photo 5 Cropping at Springdale Road



Photo 6 Jerdacuttup River intersecting the Springdale wellfield

Appendix D Review of recommendations of 1995 groundwater protection plan

The tasks listed in this table have been taken directly from the 1995 *Hopetoun groundwater protection plan* and refer to the branches and personnel positions that existed within the agencies at that time. For further information please see the 1995 *Hopetoun groundwater protection plan*.

Recommendations made in 1995 protection plan		Status of implementation
1	Groundwater and Environment Branch will commence action to gazette the revised water reserves following the completion of the public consultation process.	<ul style="list-style-type: none"> The revised Hopetoun water reserves were gazetted in July 2001.
2	The priority classification areas within the water reserves should then become effective immediately.	<ul style="list-style-type: none"> The Hopetoun water reserves have been managed in accordance with the priority classifications.
3	All development proposals within the water reserves will be initially referred by DPUD to the Water Authority for comment in the normal manner. Any proposal could be initially be referred by the Shire to the Water Authority's Regional Water Resource Officer in Albany for comment. This could alleviate delays in the processing of proposals	<ul style="list-style-type: none"> Development proposals for the Hopetoun water reserves are referred by the Shire of Ravensthorpe to the South Coast Regional office (DoW) for comment.
4	The Groundwater and Environment Branch and the Shire should provide advice to affected land owners and detail the implications of the Protection of Drinking Water Supplies policy.	<ul style="list-style-type: none"> The Shire is aware of the land use constraints associated with the water reserves and the priority (1, 2 and 3) areas. The boundaries of the water reserves were incorporated in the Shire of Ravensthorpe local planning strategy. (Emma Monk 2001)
5	The Groundwater and Environment Branch and the Shire should facilitate a public meeting to detail the groundwater protection plan to the local community prior to report finalisation.	<ul style="list-style-type: none"> A public meeting was held following the release of the protection plan in 1995. (Emma Monk 2001)
6	The Regional Water Resources Officer in Albany should arrange for the erection of signs that clearly describe the water reserves, the priority source area classifications and the groundwater areas.	<ul style="list-style-type: none"> Signs were erected.
7	The Shire in conjunction with the local emergency services should be familiar with procedures detailed in the WAHMEMS manual in order to address any accidental spillages from road transport within the water reserves. Source Operations Section of Headworks and Treatment Branch (Perth) should be consulted in the identification of these emergency measures.	<p>Status needs to be confirmed</p> <ul style="list-style-type: none"> Letters were sent to FESA and WA Police Service in September 2001 to advise of the key recommendation made in the 1995 protection plan.
8	The Regional Manager (Albany) should ensure that Water Authority personnel who	<ul style="list-style-type: none"> Letters were sent to FESA and WA Police Service in September 2001 to

	have been designated to respond to any WAHMEMS request are adequately trained. The designated personnel should be made aware of the location of the water reserves and have an understanding of the procedures that should be employed in the event of a spill that may threaten the Hopetoun groundwater supply.	advice of the key recommendation made in the 1995 protection plan.
9	The Shire in conjunction with the Office of Waste Management and the Health Department should identify a site for the disposal of liquid waste (septage) from Hopetoun.	<ul style="list-style-type: none"> • A wastewater treatment plant is currently being constructed north of the Hopetoun (Town wellfield). • Implementation of recommendation was led by Department of Environmental Protection (now DEC), Department of Health and Shire of Ravensthorpe. • Status still needs to be followed up
10	The Shire should coordinate a programme for the collection of waste oils from Hopetoun.	<ul style="list-style-type: none"> • Waste oils are now collected in a waste oil unit at the local tip site (this site is outside the water reserves) and appeared to be well managed.
11	The Shire should initiate action to control the input to the tip site. Measures to isolate (separate) potentially contaminating materials should be established.	<ul style="list-style-type: none"> • The tip site is located outside the water reserves. • Still needs to be followed up
12	The Groundwater and Environment Branch should initially review implementation of the groundwater protection measures defined in this report on an annual basis.	<ul style="list-style-type: none"> • Undertaken by WRC South Coast Regional Officer (now Dow) in cooperation with head office.
13	The Shire should monitor land use activities in the water reserves on a regular basis. The Shire Environmental Health Officer (EHO) or Shire Ranger should be considered to carry out these inspections. The EHO or ranger could report any potentially contaminating activities to the Shire or the Regional Water Resource Officer in Albany.	<ul style="list-style-type: none"> • The Hopetoun water reserves were delegated to Water Corporation for undertaking surveillance and by-law enforcement.
14	The Groundwater and Environment Branch should assess the feasibility of developing a subroutine within the SWRIS database to flag when action levels are breached and an appropriate response plan.	<ul style="list-style-type: none"> • Compliance subject to normal assessment and surveillance procedures.
15	The basis of the land planning requirements of this report should be consistent with the limited rural strategy.	<ul style="list-style-type: none"> • South Coast Regional officer worked with the Shire of Ravensthorpe on the Local Planning Strategy. The boundaries of the water reserves were incorporated into the strategy.

Acronyms

ADWG	<i>Australian drinking water guidelines</i>
AHD	Australian height datum
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
CFU	colony forming units
DEC	Department of Environment and Conservation
EC	electrical conductivity
GL	gigalitre
ha	hectare
HAZMAT	hazardous materials
kL	kilolitre
km	kilometre
km²	square kilometre
LEMC	local emergency management committee
m	metres
mg/L	milligram per litre
mL	millilitre
ML	megalitre
mm	millimetre
MPN	most probable number
mSv	millisievert
mS/m	millisiemens per metre
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	nephelometric turbidity units

PSC 88	Public Service Circular No. 88
PDWSA	public drinking water source area
TCU	true colour units
TDS	total dissolved solids
TFSS	total filterable solids by summation
WHPZ	wellhead protection zone
WESTPLAN- HAZMAT	Western Australian plan for hazardous materials

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. For example, micro-organisms can adsorb onto soil particles.
Australian drinking water guidelines	The <i>National water quality management strategy: Australian drinking water guidelines 6 2004</i> (NHMRC & NRMMC 2004a) (ADWG) outline acceptable criteria for the quality of drinking water in Australia (see <i>Bibliography</i> section).
Aesthetic guideline value	Is the concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer, e.g. appearance, taste and odour (NHMRC & NRMMC 2004a).
Australian height datum	Australian height datum is the height of land in metres above mean sea level. For example, the AHD is +0.026 m at Fremantle.
Allocation	The quantity of water permitted to be abstracted by a licensee is their allocation, usually specified in kilolitres per annum (kL/a).
Anisotropic	Having different properties in different directions. For example, an aquifer with variations in hydraulic conductivity horizontally and vertically, or different grain sizes in all directions.
Aquifer	An aquifer is a geological formation or group of formations able to receive, store and transmit significant quantities of water.
Augment	Augment means to increase the available water supply. For example, pumping back water from a secondary storage/reservoir dam.
Bore	A bore is a narrow, lined hole drilled into the ground to monitor or draw groundwater.
Bore field	A group of bores to monitor or withdraw groundwater is referred to as a bore field (also see <i>wellfield</i>).
Colony forming units	Colony forming units are a measure of pathogen contamination in water.
Confined aquifer	An aquifer that is confined between non-porous rock formations (such as shale and siltstone) and therefore contains water under pressure.

Department of Environment and Conservation	The Department of Environment and Conservation was established on 1 July 2006, bringing together the Department of Environment and the Department of Conservation and Land Management.
Diffuse source	A diffuse source of pollution originates from a widespread non-specific area (e.g. urban stormwater runoff; agricultural infiltration) as opposed to a particular point source (see <i>Point source pollution</i>).
Effluent	Effluent is treated or untreated liquid, solid or gaseous waste discharged by a process such as through a septic tank and leach drain system.
Electrical conductivity	This estimates the volume of TDS or the total volume of dissolved ions in a solution (water) corrected to 25 ⁰ Celsius. Measurement units include millisiemens per metre and microsiemens per centimetre.
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. Fractured rock aquifers are highly susceptible to contamination from land-use activities when aquifers crop-out or sub-crop close to the land surface.
Gigalitre	A gigalitre is equivalent to 1 000 000 000 litres or one million kilolitres.
Hectare	A hectare is a measurement of area, equivalent to 10 000 square metres.
Health guideline value	Is 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 & NRMCC 2004a).
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 a total dissolved solid in a solution.
Most probable number	Most probable number is a measure of microbiological contamination.
Millisievert	A millisievert is a measure of annual radiological dose, with a natural dose equivalent to 2 mSv/yr.
Millisiemens per metre	Millisiemens per metre is a measure of electrical conductivity of a solution or soil and water mix that provides a measurement of salinity.
Nephelometric turbidity units	Nephelometric turbidity units are a measure of turbidity in water.
Nutrient load	The amount of nutrient reaching the waterway over a given timeframe (usually per year) from its catchment area.
Nutrients	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.
Pathogen	A disease-producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as <i>Escherichia coli</i>), protozoa (such as <i>Cryptosporidium</i> and <i>Giardia</i>) and viruses.
Perched	An unconfined aquifer, often ephemeral or seasonal, perched on top of an impermeable horizon near the land surface and separated from deeper groundwater by an unsaturated zone.
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.
Point source pollution	Pollution originating from a specific localised source, e.g. sewage or effluent discharge; industrial waste discharge.

Pollution	Water pollution occurs when waste products or other substances (effluent, litter, refuse, sewage or contaminated runoff) change the physical, chemical or biological properties of the water, adversely affecting water quality, living species and beneficial uses.
Production bore	See Bore
Public Service Circular No. 88	A state government circular produced by the Department of Health providing guidance on appropriate herbicide use within water catchment areas.
Public drinking water source area	Includes all underground water pollution control areas, catchment areas and water reserves constituted under the <i>Metropolitan Water Supply Sewerage and Drainage Act 1909</i> and the <i>Country Areas Water Supply Act 1947</i> .
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. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface.
Runoff	Water that flows over the surface from a catchment area, including streams.
Semi-confined aquifer	A semi-confined or leaky aquifer is saturated and bounded above by a semi-permeable layer and below by a layer that is either impermeable or semi-permeable.
Stormwater	Rainwater which has run off the ground surface, roads, paved areas etc, and is usually carried away by drains.
True colour units	True colour units are a measure of degree of colour in water.
Total dissolved solids	Total dissolved solids consist of inorganic salts and small amounts of organic matter that are dissolved in water. Clay particles, colloidal iron and manganese oxides, and silica fine enough to pass through a 0.45 micrometer filter membrane can also contribute to total dissolved solids. Total dissolved solids comprise sodium, potassium, calcium, magnesium, chloride, sulfate, bicarbonate, carbonate, silica, organic matter, fluoride, iron, manganese, nitrate (and nitrite) and phosphate (NHMRC & NRMCC 2004a).

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.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.
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.
Wastewater	Water that has been used for some purpose and would normally be treated and discarded. Wastewater usually contains significant quantities of pollutant.
Water quality	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 <i>Country Areas Water Supply Act 1947</i> or the <i>Metropolitan Water Supply Sewerage and Drainage Act 1909</i> for the purposes of protecting a drinking water supply.
Watertable	The upper saturated level of the unconfined groundwater is referred to as the watertable.
Wellfield	A wellfield is a group of bores located in the same area used to monitor or withdraw groundwater.
Wellhead	The top of a well (or bore) used to draw groundwater is referred to as a wellhead.
Wellhead protection zone	A wellhead protection zone (WHPZ) 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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