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

Looking after all our water needs

Fitzroy Crossing Water Reserve drinking water source protection plan

Fitzroy Crossing town water supply

Water resource protection series

REPORT NO. 94
June 2008

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Cover photograph: *Bore 2/89 and compound* (photo by B. Jago, Water Corporation)

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Preface

The Department of Water has prepared this drinking water source protection plan to assess risks to water quality within the Fitzroy Crossing Water Reserve 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 safe, good quality drinking water to consumers.

The *Australian drinking water guidelines* recommend a risk-based, multiple-barrier approach to protect public drinking water sources. Catchment protection is the first barrier, 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, the hazards and hazardous events that can compromise drinking water quality, and development of preventative strategies and operational controls to ensure the safest possible water supply.

This plan details the location and boundary of the drinking water catchment, which provides potable water to the Fitzroy Crossing town water supply. 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 maximise protection of the water reserve.

This plan should be used to guide state and local government land-use planning decisions. It should be recognised in the Shire of Derby – West Kimberley's final Fitzroy futures town plan, consistent with the Western Australian Planning Commission's *Statement of Planning Policy – Public drinking water source policy*. Other stakeholders should use this document as a guide for protecting the quality of water in the recommended Fitzroy Crossing Water Reserve.

The stages involved in preparing this drinking water source protection plan were:

Stages in development of a plan		Comment
1	Prepare drinking water source protection assessment	Prepared following catchment survey and preliminary information gathering.
2	Conduct stakeholder consultation	Advice sought from key stakeholders using the assessment as a tool for information and discussion.
3	Prepare draft drinking water source protection plan	Draft plan developed taking into account input from stakeholders and any additional advice received.
4	Release draft drinking water source protection plan	Released for public consultation through the 2004 draft *Fitzroy futures town plan*.
5	**Publish approved drinking water source protection plan**	**Final plan published after considering advice received in submissions. Includes recommendations on how to protect water quality.**

Summary

The town of Fitzroy Crossing is in the Shire of Derby – West Kimberley, 262 km south-east of Derby in the Kimberley Region of Western Australia. It services pastoral, tourism and extractive industries in surrounding areas.

The Fitzroy Crossing town water supply is sourced from four production bores (1/74, 1/82, 2/82 and 2/89) installed in hard cemented sandstone located at the north-western side of the town. The aquifer is unconfined and fractured, allowing groundwater to flow through fractures and joints. Recharge is via direct rainfall infiltration and river flows from Brooking Creek and the Fitzroy River.

The Fitzroy Crossing Water Reserve was gazetted in 1975 under the *Country Areas Water Supply Act 1947*. It is proposed to modify the existing boundaries of the water reserve to include potential future bore sites for the town water supply (Figure 1) and a larger part of the recharge area. The amended water reserve boundaries and Priority areas outlined in this plan have already been recognised in the draft *Fitzroy futures town plan* (2004). These boundaries as well as the Wellhead Protection Zones (Figure 4) should be included in the final town plan.

The proposed Fitzroy Crossing Water Reserve covers the immediate bore field area (Crown Reserve 35090, designated for water supply), a small part of Crown Reserve 9656 (vested in the Aboriginal Lands Trust), and unallocated crown land, residential, commercial and light industry areas, public open space and land set aside for public purposes in the town itself. Figure 3 illustrates the different land tenures in the proposed Fitzroy Crossing Water Reserve.

This drinking water source protection plan aims to protect the quality of this public drinking water supply. This will be achieved through the identification of potential contamination risks associated with land-use practices in and around the water reserve and the recommendation of protection strategies to ensure these are effectively managed.

Signs indicating the location of the Fitzroy Crossing Water Reserve should be erected and development proposals within the water reserve should be assessed for impact on water quality and in accordance with the *Statement of Planning Policy*: *Public drinking water source policy* and the Department of Water's Land Use Compatibility Table (refer water quality protection note: *Land use compatibility in public drinking water source areas*). Landowners and managers within the proposed water reserve should be encouraged to apply best management practices to reduce the risk of contamination to this water source.

The site of the old power station should be assessed to determine what is required to deal with any potential risks to groundwater quality and the disused wastewater treatment ponds should be removed and rehabilitated.

1 Drinking water source overview

1.1 Existing water supply system

The number of services supplied in Fitzroy Crossing by the Water Corporation bore field is approximately 218. The groundwater resource to the north of the existing bore field is utilised by the Junjuwa Aboriginal Community and to the south of the bore field by the hospital, but these sources are not covered in this plan.

The water supply for Fitzroy Crossing is obtained from four production bores (1/74, 1/82, 2/82 and 2/89) located at the north-west end of town that access an unconfined aquifer system in hard cemented sandstone. Bores 1/82, 2/82 and 2/89 are the duty bores and bore 1/74 is operated as a stand-by bore. All existing production bores except 2/89 are located within the current water reserve boundaries (Figure 2).

The bore field is located on Fallon Road near the old power station. Water from the bore field is collected in a 600kL ground tank before being pumped to a 200kL elevated tank located on the same site. From the elevated tank, water is supplied to the reticulation system and consumers by gravity.

All bores are controlled by the levels in the storage tank. Therefore, at any particular time the source of the raw water can be any combination of the working bores. Over the operating period 1 April 2006 to 31 March 2007 more than half of the extraction came from bore 2/82, with most of the remainder taken from bores 2/89 and 1/82.

The existing control system does not allow automatic management of water quality under different demand scenarios. In addition, there is no operator based in town to carry out regular manual adjustment to the system to achieve optimum water quality.

1.2 Water treatment

The groundwater from these bores is chlorinated prior to it being pumped to an elevated tank that distributes water to the town. Chlorination is undertaken to disinfect the water.

It should be recognised that although treatment and disinfection are essential barriers to ensure a safe, good quality drinking water supply, catchment management is the fundamental first barrier for protecting water quality. This approach is endorsed by the *Australian drinking water guidelines* (ADWG) (NHMRC & NRMMC 2004a) and reflects a risk-based, catchment-to-consumer, multiple-barrier approach for providing safe drinking water to consumers. The combination of catchment protection and treatment delivers a safer drinking water source than either barrier could achieve individually.

1.3 Catchment details

1.3.1 Physiography

The Fitzroy-Lennard floodplains occur along the courses of the Fitzroy River and its main tributaries, Christmas Creek and Margaret River. The plains contain many anabranches, natural levees and billabongs, which are mainly underlain by extensive black soil. The dune fields contain low, isolated outcrops of Jurassic rocks in the valleys between the longitudinal dunes. The dunes are orientated east-south-east, indicating that they were formed by east-south-east prevailing winds. Drainage in the area is limited to a few floodways.

1.3.2 Climate

The Fitzroy Crossing area experiences a hot, rainy monsoonal summer and a cool to warm, dry winter. Rainfall averages 540.5 mm per annum and is extremely variable. Rainfall generally occurs in the summer months as a result of cyclonic activity and can range between a recorded minimum of 188.6 mm and a recorded maximum of 930.7 mm per annum (Bureau of Meteorology 2008). Average potential evaporation is approximately 3400mm (Department of Environment 2004).

1.3.3 Hydrology

Fitzroy Crossing is located on early Permian sandstones of the Grant Formation protruding from the floodplain of the Fitzroy River. Extensive black soils overlie these in the west. The Grant Formation sandstone is believed to dip to the east and south from the town site to the river. The sandstone is overlain by alluvial deposits near the Fitzroy River, which extend to around 1 km west and 10 to 15 km east of the Fitzroy River in this area. A depth of approximately 30 m of alluvial sand and shingle is believed to exist under the riverbed.

The Grant Group comprises interbedded sandstone and minor siltstone and is an extensive but low yielding aquifer. The Grant Formation sandstones, from which the town water supply well field obtains groundwater, are red and white, hard and, in places, highly jointed. The aquifer is unconfined and fractured and groundwater flows through fractures and joints. Those areas free of joints and fractures are mostly impermeable.

Recharge to the Grant formation is via direct rainfall infiltration and river flows from Brooking Creek and the Fitzroy River. Groundwater flow directions in the vicinity of Fitzroy Crossing are affected by major flood events and probably vary accordingly. Groundwater flow during dry periods is likely to be toward the Fitzroy River. Groundwater elevation contours at the bore field indicate groundwater flows in a north-westerly direction. During flood events, flow will occur away from the river, toward the south-west into the central part of the Canning Basin, in the process recharging the aquifer.

The depth to water table is about 20 to 23 m and production bores range from about 30 m to 60 m deep. Production bores are located in hard cemented sandstone on joints or faults within the sandstone. Bores that are not located on joints or faults within the sandstone, may be unsuccessful.

1.4 Future water supply requirements

Groundwater from the aquifer to the north of the well field is utilised by the Junjuwa Aboriginal Community and to the south of the well field by the hospital. It is considered that current levels of abstraction are not likely to seriously deplete the aquifer.

Most of the future growth at Fitzroy Crossing is expected over the holdings of Aboriginal community land. Over the operating period 1 April 2006 to 31 March 2007 abstraction was about 91% of the licensed allocation of 250 ML per annum, which may not be sufficient to meet future water needs. Assuming the unaccounted water use remains at current levels of 18%, an increase in allocation may be required before the next review of the source. The fairly high figure of unaccounted water use may be either due to water distribution issues (for example, leakage) or behavioural issues (for example, leaving taps running). If it is due to behavioural issues, an education program may be of benefit.

The 2004 draft *Fitzroy futures town plan* lists three potential options for alternative drinking water sources that may be considered for Fitzroy Crossing:

1) extending the existing bore field with expansion north toward Brooking Creek,
2) abstraction from bores on Jubilee Downs Station;

   or

3) abstraction from bores near the Fitzroy River.

Option 1 was the preferred option as it is believed that the existing source will be able to meet *Australian drinking water guidelines* and cater for future demand. Options 2 and 3 would involve extensive site investigation to validate the sources at Jubilee Downs Station and near the Fitzroy River. Past experience in the Fitzroy Crossing area suggests that bores with a reasonable yield are generally difficult to find. The Water Corporation is planning a review of the current source in the near future, which may include a more detailed investigation of potential alternative sources.

1.5 Protection and allocation

1.5.1 Existing water source protection

The Fitzroy Crossing Water Reserve was gazetted in 1975 under the *Country Areas Water Supply Act 1947*. All existing production bores except one (2/89) are located within the current water reserve boundaries (Figure 2).

The amended water reserve boundaries as outlined in this plan have already been recognised in the draft *Fitzroy futures town plan* (2004) prepared by the Shire of Derby – West Kimberley, Bunuba Inc. and the Western Australian Planning Commission.

Proposed land-use developments are being assessed by the Shire of Derby – West Kimberley in accordance with the WA Planning Commission's *Statement of Planning Policy – Public drinking water source policy* and referred to the Department of Water for comment.

The Water Corporation's bore compounds, storage tanks and treatment facilities are fenced (see Photo 1 for an example) and inspected regularly by Water Corporation staff.

1.5.2 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* (the RiWI Act). Under the Act, the right to use and control surface and groundwater is vested with the Crown. This Act requires licensing of groundwater abstraction within proclaimed groundwater areas.

The Groundwater Well Licence Number is 65334 and the licence is due for renewal on 30 June 2008. The Water Corporation is licensed by the Department of Water to draw 250 ML/annum from the Fitzroy Crossing well field for public water supply purposes. The current number of services is 218 and annual production in 2006/07 was just over 228 ML.

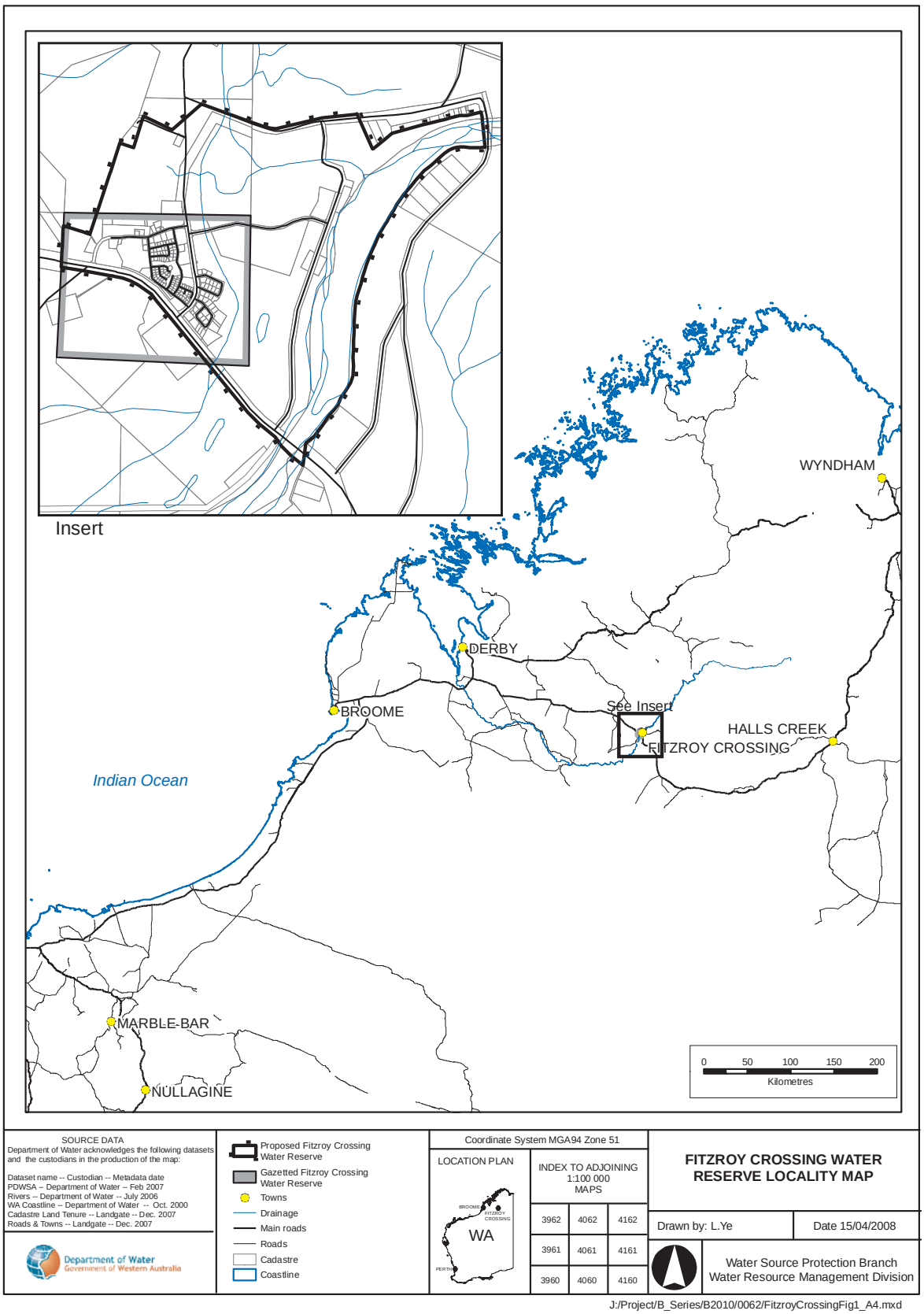

Figure 1 Fitzroy Crossing Water Reserve locality map

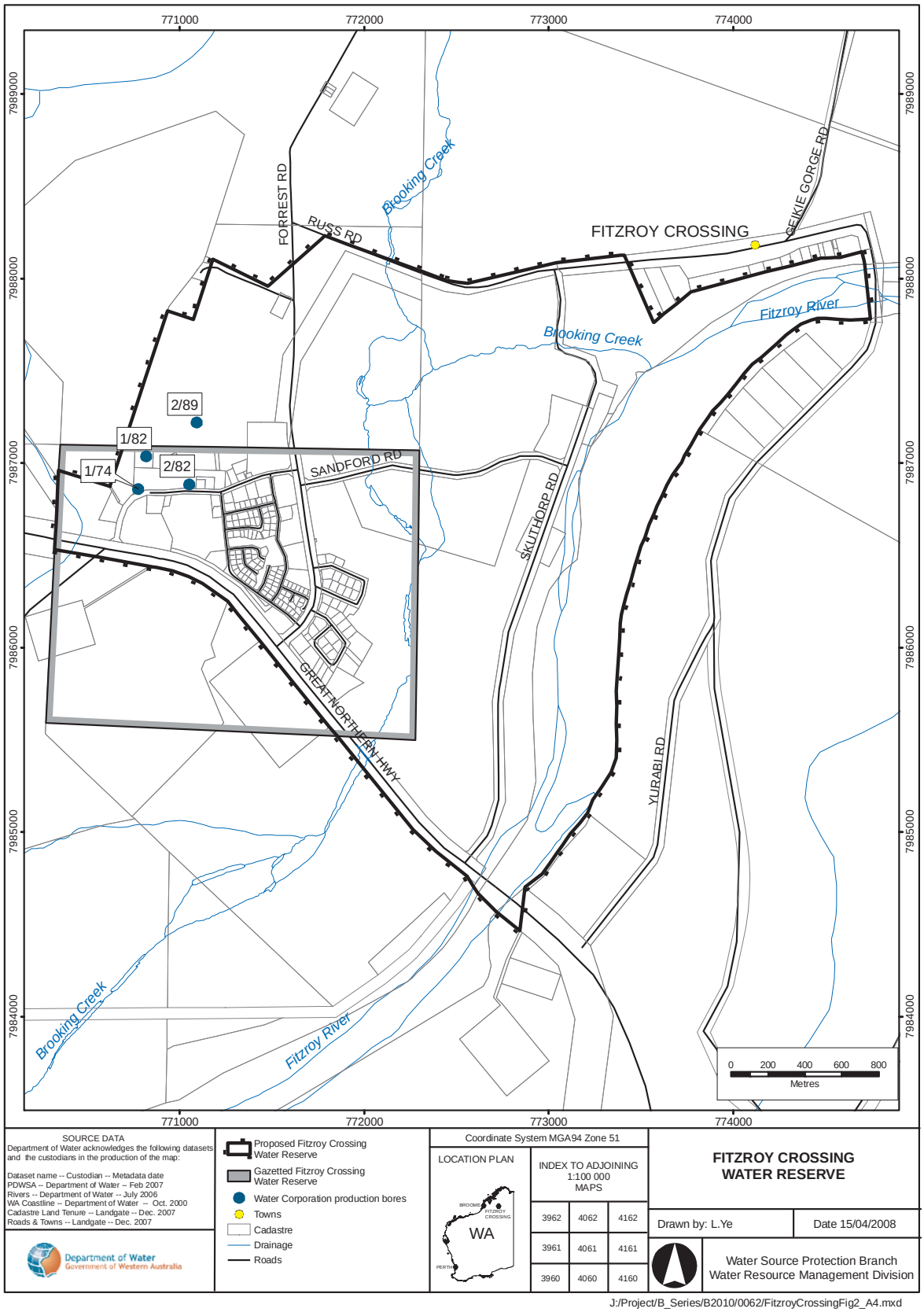

Figure 2 Fitzroy Crossing Water Reserve

2 Water-quality monitoring and contamination risks

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

The Water Corporation regularly monitors the raw-water quality from the Fitzroy Crossing Water Reserve for microbiological contamination, health-related and aesthetic (non-health related) characteristics in accordance with the ADWG. Monitoring results are reviewed by an intergovernmental committee, chaired by the Department of Health, called the Advisory Committee for the Purity of Water.

A water-quality summary for the Fitzroy Crossing Water Reserve from May 2003 to May 2008 is presented in Appendix A. For more information on the quality of drinking water supplied to Fitzroy Crossing see the most recent Water Corporation *Drinking water quality annual report* at <www.watercorporation.com.au> > Publications > Water Quality > Annual Reports.

Contamination risks relevant to the Fitzroy Crossing Water Reserve are described below.

2.1 Microbiological contaminants

Pathogens are types of micro-organisms that are capable of causing diseases. These include bacteria, protozoans and viruses. In water supplies, pathogens that can cause illness are mostly found in the faeces of humans and domestic animals.

There are a number of pathogens that are commonly known to contaminate water supplies worldwide. These include bacteria (for example, salmonella, *Escherichia coli [E. coli]* and cholera), protozoans (for example, cryptosporidium, giardia) and viruses. *E. coli* counts are a way of measuring these pathogens and are an indicator of faecal contamination.

Pathogen contamination of a drinking water source is influenced by the existence of pathogen carriers (that is, humans and domestic animals such as dogs or cattle), their transfer to and movement in the water source and the ability of the pathogen to survive in the water. The percentage of humans in the world that carry various 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).

Pathogens may enter a water source through activities involving direct contact of people and domestic animals with the main water body or its tributaries (such as fishing, marroning and swimming). This primarily occurs through the direct transfer of

faecal material (even a very small amount can cause contamination), or indirectly through runoff moving faecal material into the water.

The ability of pathogens to survive in surface water differs between species. For example, *Salmonella* may be viable for two to three months, *Giardia* may still infect after one month in the natural environment (Geldreich 1996) and *Cryptosporidium* oocysts (cells containing reproductive spores) may survive weeks to months in freshwater (NHMRC & NRMMC, 2004b).

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 death. This was the case in Walkerton, Canada in 2000, where seven people died due to contamination by a pathogenic strain of *E. coli* and *Campylobacter* in the town water source and supply (NHMRC & NRMMC 2004b; Hrudey and Hrudey 2004). Preventing the introduction of pathogens into the water source is the most effective barrier in avoiding this public health risk.

As recharge of the Fitzroy Crossing groundwater source is partially from surface waters (river flows from Brooking Creek and the Fitzroy River), the occurrence of *E. coli* detections can be expected to be higher than would typically be seen in a groundwater source. During the period May 2003 to May 2008 positive *E. coli* counts were recorded in approximately 14% of raw water samples collected from the Fitzroy Crossing bore field.

Less than 2% of positive samples were > 20 most probable number (MPN) per 100 mL. A count less than 20 MPN/100 mL is typically associated with low levels of faecal contamination of the surface water (World Health Organisation 1996).

2.2 Health-related characteristics

Land-use activities within a catchment can directly influence the effectiveness of water treatment. For example, off-road driving and driving on unauthorised tracks contributes to erosion and the uprooting of vegetation.

Erosion results in the mobilisation of soil particles, which are released into the air and tributaries, increasing the turbidity of the main water body. Pathogens can adsorb onto these soil particles and may be shielded from the effects of disinfection. Increased turbidity also impacts upon other environmental constituents, for example, smothering riparian vegetation and reducing the transfer of light within the water column, which affects plant growth.

A number of chemicals (organic and inorganic) are of concern in drinking water from a health perspective because they are potentially toxic to humans. Chemicals usually occur in drinking water sources attached to suspended material, such as soil particles, and may result from natural leaching from mineral deposits or from different land uses (NHMRC & NRMMC 2004b).

Pesticides include agricultural chemicals such as insecticides, herbicides, nematicides (used to control nematodes or worms), rodenticides and miticides (used to control mites). Contamination of a drinking water source by pesticides may occur as a result of accidental spills, incorrect or overuse and leakage from storage areas. In such cases, prompt action is required to notify relevant authorities and clean up the spill.

Nutrients (such as nitrogen) can enter drinking water supplies from leaching of fertiliser, septic tanks, and from faeces of domestic animals (such as cattle grazing on the land). Nitrate and nitrite (ions of nitrogen) can be toxic to humans at high levels, with infants less than three months old being most susceptible (NHMRC & NRMMC 2004a).

Hydrocarbons (for example, fuels, oils) are potentially toxic to humans, and harmful by-products may be formed when they are combined with chlorine in water treatment processes. Hydrocarbons can occur in water supplies from pollution events from vehicle accidents, refuelling and leakage from storage areas.

The pesticide dieldrin is present in water sourced from the Fitzroy Crossing bore field, at concentrations below the *Australian drinking water guidelines* (ADWG). Although dieldrin manufacture in Australia has ceased and it is no longer registered for use in Australia, this pesticide is likely to be present due to construction works in the area and the historic use of dieldrin to control termite infestations. Unfortunately dieldrin is a very persistent chemical in soils and water and may continue to be leached from soils for some time.

When detections were noted the Water Corporation reviewed its bore field operating strategy to ensure minimal impact. Samples have been taken monthly for several years and confirm that the dieldrin concentrations are stable and less than 6% of the ‘Health Guideline Value’ in the ADWG. The results of the monitoring are reported to the Departments of Health and Water and are kept under review by the Advisory Committee for the Purity of Water (Chaired by the Department of Health).

2.3 Aesthetic characteristics

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 colour may not be harmful (NHMRC & NRMMC 2004b).

Iron and dissolved organic matter can affect the colour and appearance of water, and salinity can affect the taste. The ADWG have set limits on water-quality characteristics to meet the aesthetic requirements of consumers.

Some properties such as pH (a measure of acidity or alkalinity) can contribute to the corrosion and encrustation of pipes. The ADWG also sets out aesthetic guidelines for these types of water-quality characteristics.

Water quality is within the guideline limits except for iron and turbidity. Generally the turbidity and iron levels obtained from the Fitzroy Crossing bores are below the guideline values and only on isolated occasions are the monitored levels high enough that the guideline values are exceeded.

2.4 Groundwater bores

Under the provisions of sections 26D and 5C of the RiWI Act, a licence is required to construct a bore or extract water (unless exempt under the RiWI Exemption and Repeal (Section 26C) Order 2001) within a proclaimed groundwater area. The Fitzroy Crossing Water Reserve is located within the Canning Kimberley Groundwater Area.

Any bores drilled near to a public drinking water supply bore have the potential to contaminate the drinking water source. For example, a poorly constructed bore may introduce contaminants through surface leakage down the outside of the bore casing into an otherwise uncontaminated aquifer. If a public drinking water source bore is being used nearby, it may abstract some of the contaminated water.

It is important to ensure that any bores are appropriately located and constructed in order to prevent contamination and other impacts on the public drinking water source. This will be assessed through the Department of Water's water licensing process where applicable under the RiWI Act.

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 immediate bore field area is within Crown Reserve 35090, which is vested in the Minister for Water Resources and designated for water supply. All existing production bores except one (2/89) are located within this reserve (Figure 2). The vegetation cover is scrubland and the land is managed by the Water Corporation. Bore 2/89 (cover photo) is located to the north of the current bore field in Crown Reserve 9656, which is vested in the Aboriginal Lands Trust.

Figure 3 illustrates the different land tenures in the proposed Fitzroy Crossing Water Reserve. The areas to the south-west, west, north and north-east of the bore field are used for rural purposes and are also largely covered by scrubland. The airport is located to the north-west of the bore field adjacent to the proposed water reserve. Areas to the south and south-east are occupied by the hospital and by sewered urban lots. Several potentially contaminating land uses exist within the proposed water reserve, and are discussed below and in Table 1.

3.1.1 Urban and special rural/residential land

The majority of the lots near the Fitzroy Crossing bore field have been connected to the town sewerage system, thereby removing a significant contaminant threat to the unconfined aquifer system. However, many dwellings located away from the main urban areas are unsewered. Septic tanks in these areas are potential sources of harmful bacteria and viruses, which may contaminate drinking water supplies. They are also a source of nitrates and phosphorus, which can contribute to groundwater contamination. In addition, septic tanks provide a ready pathway to the subsurface for any chemicals or toxic substances that are disposed of via this system.

Stormwater runoff is another potential threat to groundwater quality. With greater residential development proposed for the area north of the bore field the risks from stormwater runoff may increase further.

3.1.2 Wastewater treatment ponds

The Junjuwa wastewater treatment ponds are located approximately one kilometre north of the existing Fitzroy Crossing bore field. They are disused but have not been removed. The ponds serviced the Junjuwa Aboriginal community, which is located one kilometre north of the Fitzroy Crossing centre. Treated effluent was discharged directly into the upper reaches of Brooking Creek.

One of the proposals for future bore field development is toward the north and east of the existing bore field. Groundwater in this area may have been contaminated with bacteriological organisms and may have elevated nitrate levels as a result of the effluent discharge.

An active wastewater treatment pond is situated to the south-west of the town site, outside the proposed water reserve boundaries. Treated wastewater is discharged from this pond into the Fitzroy River, downstream of Fitzroy Crossing town site.

3.1.3 Commercial and municipal infrastructure

Commercial activities involving the storage, handling or disposal of chemicals, other toxic substances and wastes can result in significant impacts to groundwater quality. An industry or business with underground or aboveground bulk fuel storage tanks poses a threat to the water quality of an unconfined aquifer due to the potential for leakage or spillage of the stored product. Fuel storage facilities similar to those at an airport constitute such a threat.

Several municipal infrastructure sites potentially pose a threat to the quality of the groundwater. These include the council depot and the cemetery. These sites have the potential to leach contaminants such as nutrients, hydrocarbons, heavy metals and pesticides into the groundwater.

3.1.4 Power station

The old power station is located on Fallon Road and is immediately adjacent to production bore 2/82 (Photo 2). Staining on the ground surface around the fill point area suggests past spillages of fuel. The fuel fill points are located within close proximity of bore 2/82. There are also signs of spillage of hydrocarbons on the ground surface within the power station compound. Even minor spills of hydrocarbons can cause significant groundwater contamination.

A new power station (located outside the proposed water reserve boundaries south of Great Northern Highway) has been brought on-line recently. On decommissioning the old power station, an investigation into the needs for a clean up and rehabilitation program for the site should be undertaken to limit continued leaching of hydrocarbons and other chemicals and protect the quality of the groundwater.

Some of the buildings associated with the old power station may be offered to corporate entities representing local traditional owners.

3.1.5 Hospital

The hospital is within close proximity to the bore field on the south side of Fallon Road. Most of the hospital site lies within the wellhead protection zones (WHPZ) shown in Figure 4. Potential threats to the groundwater from the hospital include storage of chemicals, use of cleaning agents, stormwater runoff and bio-hazardous waste.

3.1.6 Sporting oval and associated facilities

Potential threats to the groundwater from the oval include leaching of chemicals and nutrients from herbicide, pesticide and fertiliser application.

3.2 Proposed land uses and activities

The planned growth of Fitzroy Crossing is constrained by the availability of suitable land above the flood line. Increasing pressure will be applied to develop within the Water Reserve. Fitzroy Crossing does not have a town planning scheme; instead the Fitzroy Futures town planning project is underway to provide a strategic framework for development throughout Fitzroy Crossing.

The *Fitzroy Crossing Water Reserve Drinking Water Source Protection Assessment* (Department of Environment 2004) assisted in the development of the draft *Fitzroy futures town plan* (WAPC 2004), which gives consideration to drinking water protection issues. This drinking water source protection plan reflects the draft *Fitzroy futures town plan*, the drinking water source assessment and their recommendations.

The draft *Fitzroy futures town plan* proposes a new residential development in the northern area of the proposed water reserve and the development of a new road alignment for Forrest Road. The decommissioning of the old power station and the relocation of the local school to a site adjacent to the town oval are progressing. The new school is due to be completed by February 2009 and will be connected to the town sewerage system. Some of the old power station and school buildings may be offered for use to corporate entities representing local traditional owners.

The state government recently announced the allocation of funding to build and operate a swimming pool at Fitzroy Crossing. Such a facility has recognised social benefits for the local community. Public swimming pools and aquatic centres are considered to be land uses that are ‘compatible with conditions’ (water quality protection note: *Land use compatibility in public drinking water source areas*) in the water reserve’s Priority 3 area (see Figure 4). This department’s water quality protection note: *Swimming Pools* should be used as a guide in determining the site and design of this facility.

The Shire of Derby – West Kimberley currently uses the draft *Fitzroy futures town plan* and the *Statement of Planning Policy – Public drinking water source policy* to guide its land-use development decisions.

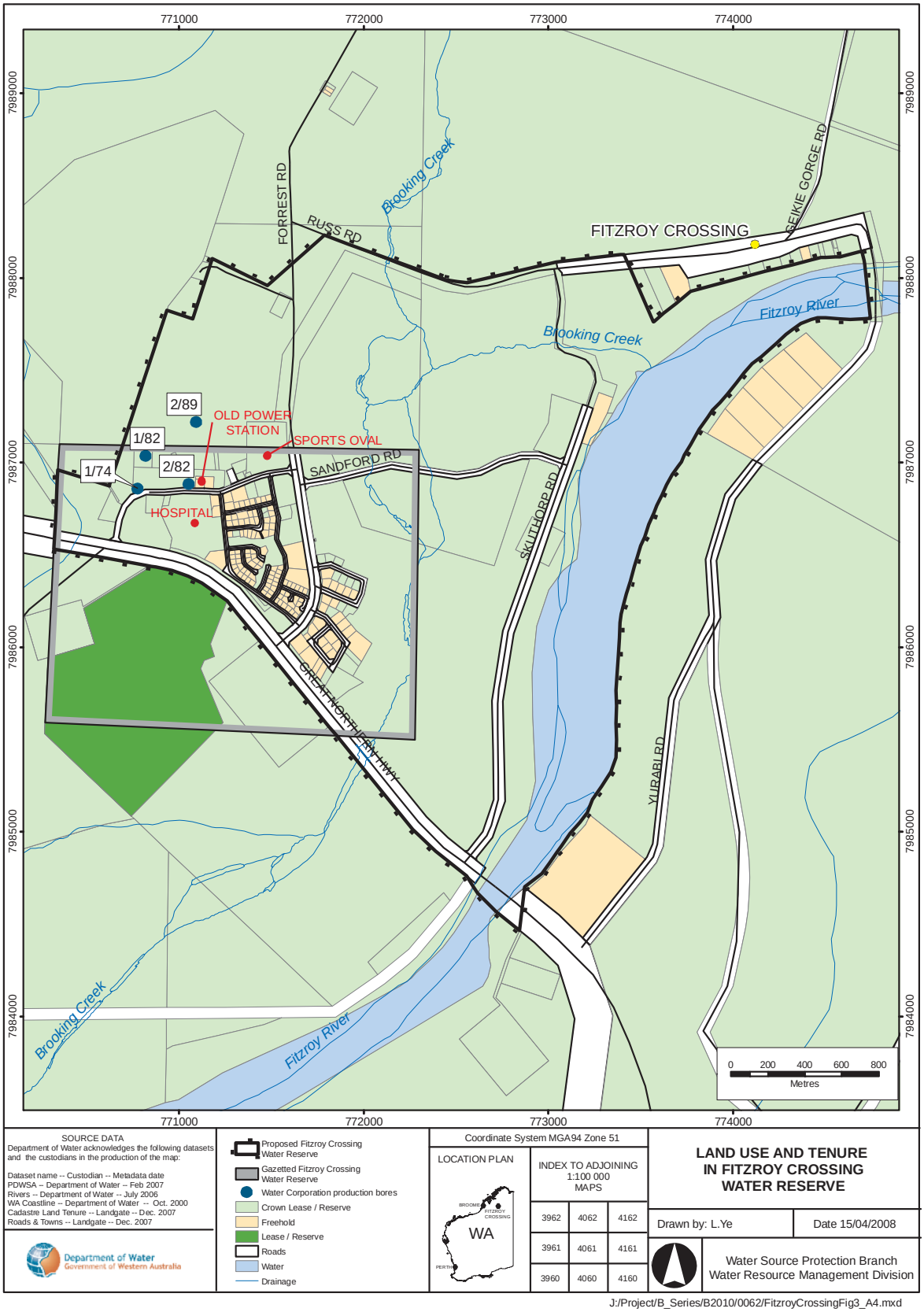

Figure 3 Land-use and tenure in the Fitzroy Crossing Water Reserve

Table 1 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**			
Residential land	Nutrients and pathogens from septic tanks and fertiliser applications Contamination from fuels, chemicals and pesticides	High Medium	Residential use of private land is an existing approved land-use. Further intensification or changes in land-use are possible. Urban residential areas to the south and south-east are sewered.	The Shire of Derby – West Kimberley currently uses the draft *Fitzroy futures town plan*, which considers drinking water source protection, and *Statement of Planning Policy – Public drinking water source policy* (WAPC 2003) to guide its land-use development decisions. Water quality is monitored regularly by the Water Corporation.	*Existing land uses are acceptable with Best Management Practices.* Development proposals should be referred to the Department of Water for assessment and advice to ensure that water-quality protection requirements are met. Restrict intensification of land-use through the planning approval process and consistent with SPP 2.7. Ensure pesticide use follows the Department of Health (DoH) PSC-88 (2007) and the Statewide Policy No.2 *Pesticide use in public drinking water source areas* (Water and Rivers Commission 2000).
Indigenous cultural activities	Pathogen contamination from people remaining in the water reserve for extended periods.	Medium	The water reserve lies within registered Aboriginal sites of significance and native title claims exist immediately west of the water reserve and over part of the Priority 2 area.	Visitors are likely to stay in near-by residential communities. Water quality is monitored regularly by the Water Corporation.	*Existing land uses are acceptable with Best Management Practices.* See 'Residential land' above.

Land-use/activity	Potential water-quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Rural land	Nutrients and pathogens from septic tanks and fertiliser application Contamination from fuels, chemicals and pesticides Pathogen contamination from animal excreta Turbidity from erosion	High Low Medium Low	Unsewered lots of 1–2 ha create a subdivision density that may compromise scheme water quality. Land planning zoning provisions limit clearing of natural vegetation. Commercial operations related to horticulture and keeping of animals are not permitted.	The Shire of Derby – West Kimberley currently uses the draft *Fitzroy futures town plan*, which considers drinking water source protection, and SPP 2.7 (WAPC 2003) to guide its land-use development decisions. Water quality is monitored regularly by the Water Corporation.	*Existing land uses are acceptable with Best Management Practices.* Encourage and provide advice on the adoption of Best Management Practices (i.e. stock management, drainage, domestic on-site septic systems and chemical use and storage). Development proposals should be referred to the Department of Water for assessment and advice to ensure that water-quality protection requirements are met. Restrict intensification of land-use through the planning approval process and consistent with SPP 2.7. Ensure pesticide use follows PSC-88 (Department of Health 2007) and SP 2 (Water and Rivers Commission 2000).

Land-use/activity	Potential water-quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Commercial, Light Industry and Tourism	Nutrients and pathogens from ablution facilities and septic tanks Contamination from fuels and chemicals	High Medium	The risks associated with most of these activities can be managed through education and the adoption of Best Management Practices; however, intensification of these land uses is undesirable.	The Shire of Derby – West Kimberley currently uses the draft *Fitzroy futures town plan*, which considers drinking water source protection, and SPP 2.7 (WAPC 2003) to guide its land-use development decisions. Water quality is monitored regularly by the Water Corporation. Bulk fuel storage over 2500L requires Department of Industry and Resources approval.	*Existing land uses are acceptable with Best Management Practices.* Encourage and provide advice on the adoption of Best Management Practices (i.e. runoff management, domestic on-site septic systems and chemical use and storage). Development proposals should be referred to the Department of Water for assessment and advice to ensure that water-quality protection requirements are met. Restrict intensification of land-use through the planning approval process and consistent with SPP 2.7. Ensure pesticide use follows PSC-88 (Department of Health 2007) and SP 2 (Water and Rivers Commission 2000).

Land-use/activity	Potential water-quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Roads and infrastructure corridors	Fuel and chemical spills from vehicles, machinery, and their loads. Pathogens from litter Pesticides from weed control	Medium Medium Medium	Roads and infrastructure corridors are necessary for transport and utility provision. However, it is essential they are well designed and maintained to minimise the risks from erosion and hazardous goods spills, to reduce the impact on water quality. Accidents and spills are rare. The Local Emergency Management Committee responds to incidents.	The Shire of Derby – West Kimberley currently uses the draft *Fitzroy futures town plan*, which considers drinking water source protection, and SPP 2.7 (WAPC 2003) to guide its land-use development decisions.	*Accepted as necessary with Best Management Practices.* Best management practice as recommended in this department's WQPN *Roads near sensitive water resources*. Ensure pesticide use follows PSC-88 (Department of Health 2007) and SP 2 (Water and Rivers Commission 2000)

Land-use/activity	Potential water-quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Community Purpose / Public Utility and Landscaped Open Space					
• Power station	Contamination from fuels, chemicals and pesticides	High	The old power station will soon be decommissioned. The new power station is located outside the water reserve. Some buildings at the old power station site may be offered to corporate entities representing local traditional owners.	Water quality is monitored regularly by the Water Corporation.	Investigate the need for a clean up and rehabilitation program for the site of the old power station to limit continued leaching of hydrocarbons and other chemicals and protect the quality of the groundwater. Ensure pesticide use follows PSC-88 (Department of Health 2007) and SP 2 (Water and Rivers Commission 2000)
• Hospital	Contamination from fuels, chemicals and bio-hazardous waste	High	Most of the hospital site lies within the WHPZs for bores 1/74 and 2/82. The risks associated with the hospital can be managed through the implementation of Best Management Practices.	Water quality is monitored regularly by the Water Corporation.	*Existing land uses are acceptable with Best Management Practices.* Encourage and provide advice on the implementation of Best Management Practices (i.e. bio-hazard and runoff management, domestic on-site septic systems and chemical use and storage).

Land-use/activity	Potential water-quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
• Depots (used and disused)	Contamination from fuels, chemicals and pesticides	Medium	The risks associated with depots can be managed through the implementation of Best Management Practices.	The Shire of Derby – West Kimberley currently uses the draft *Fitzroy futures town plan*, which considers drinking water source protection, and SPP 2.7 (WAPC 2003) to guide its land-use development decisions. Water quality is monitored regularly by the Water Corporation.	*Existing land uses are acceptable with Best Management Practices.* Encourage and provide advice on the implementation of Best Management Practices (i.e. runoff management, domestic on-site septic systems and chemical use and storage). Ensure pesticide use follows PSC-88 (Department of Health 2007) and SP 2 (Water and Rivers Commission 2000).
• Wastewater treatment ponds	Contamination from nutrients, pathogens, fuels and chemicals	High	The disused Junjuwa wastewater treatment ponds located approximately 1 km north of the bore field may have caused contamination of the groundwater in the vicinity.	The quality of the water drawn from the existing production bores is monitored regularly by the Water Corporation.	The disused wastewater treatment ponds should be removed and the site rehabilitated. Groundwater quality should be tested through both the wet and dry seasons before bore field extension into this area is considered.

Land-use/activity	Potential water-quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
• Sporting oval	Nutrients and pathogens from ablution facilities and septic tanks Nutrients and chemicals from fertiliser and herbicide applications	Medium Medium	The risks associated with sporting facilities can be managed through the implementation of Best Management Practices.	The Shire of Derby – West Kimberley currently uses the draft *Fitzroy futures town plan*, which considers drinking water source protection, and SPP 2.7 (WAPC 2003) to guide its land-use development decisions. Water quality is monitored regularly by the Water Corporation.	*Existing land uses are acceptable with Best Management Practices.* Encourage and provide advice on the implementation of Best Management Practices (i.e. runoff management, domestic on-site septic systems and chemical use and storage). Ensure pesticide use follows PSC-88 (Department of Health 2007) and SP 2 (Water and Rivers Commission 2000).

Land-use/activity	Potential water-quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
• Existing school • New school	Nutrients and pathogens from septic tanks and fertiliser applications Contamination from fuels, chemicals and pesticides	High Medium	Some buildings at the old school site may be offered to corporate entities representing local traditional owners. A portion of the new school site falls within the WHPZ for bore 2/82. The risks associated with the school can be managed through the implementation of Best Management Practices.	The Shire of Derby – West Kimberley currently uses the draft *Fitzroy futures town plan*, which considers drinking water source protection, and SPP 2.7 (WAPC 2003) to guide its land-use development decisions. The new school will be connected to the town sewerage system. Water quality is monitored regularly by the Water Corporation.	*Acceptable with conditions.* Encourage adoption of best management practice such as that recommended in this department's WQPN *Wastewater treatment – onsite domestic systems.* Ensure pesticide use follows PSC-88 (Department of Health 2007) and SP 2 (Water and Rivers Commission 2000).

4 Catchment protection strategy

4.1 Protection objectives

The objective of this plan is to protect the Fitzroy Crossing Water Reserve to provide safe drinking water to the town of Fitzroy Crossing, while recognising the rights of existing approved land-uses to continue.

4.2 Proclaimed area

It is proposed to amend the area of the current proclaimed Fitzroy Crossing Water Reserve (Figure 2) to the boundaries shown in Figure 4 and proclaim this entire area under the *Country Areas Water Supply Act 1947*. This will increase the area under management. The north-west corner of the current water reserve has been removed to exclude the airport. The rest of the water reserve is proposed to be extended to the southern edge of the Great Northern Highway, east to the far bank of the Fitzroy River (as far as Yurabi Road), north-east to the boundary of the rural area and north to include the Junjuwa Aboriginal Community living area.

The extended boundary will include the block in which production bore 2/89 is located. The boundary also incorporates more of the recharge area for the existing bore field and the areas with a high potential for future bore field development.

4.3 Priority areas

Priority classification areas applied within the Fitzroy Crossing Water Reserve are outlined in Figure 4. The land immediately surrounding the bore field and north to the airport has been classified as a Priority 1 (P1) source protection area. P1 areas are defined to ensure that there is no degradation of the water source, and are declared over land where the provision of the highest quality public drinking water is the prime beneficial land use. Existing approved land-uses are recognised. P1 areas are managed in accordance with the principle of risk avoidance. Intensification of land uses on P1 land is not supported in order to protect water quality.

The area covered by the Fitzroy River bed has been classified a Priority 2 (P2) source protection area. P2 areas are managed in accordance with the principle of risk minimisation and some development is allowed under specific guidelines. P2 areas are declared over land where low intensity development (such as rural) already exists.

Protection of public water supply sources is a high priority in these areas. P2 is considered appropriate as this area has the potential for use in the future as a bore field and its zoning is compatible with P2 water-quality objectives (that is, most of it is either crown land or is set aside for foreshore purposes). The potential water source in this area would be abstracted from a thick sequence of riverbed sands. These

areas, by their nature, are vulnerable to contamination and should be afforded greater protection.

The remainder of the Fitzroy Crossing Water Reserve has been classified as a Priority 3 (P3) source protection area as the land uses are not compatible with P2. P3 areas are defined to manage the risk of pollution to the water source. P3 source protection areas are declared over land where drinking water source protection needs to co-exist with other land uses. A P3 classification is considered appropriate to protect groundwater in this area. This classification will guide the Shire of Derby-West Kimberley in regulating land uses according to P3 'risk management' objectives.

4.4 Protection zones

Circular wellhead protection zones with a radius of 500 m in P1 areas and 300 m in P2 and P3 areas should be established around each production bore to manage activities within close vicinity to the bores (Figure 4). The activities/land uses that occur in these zones should be consistent with this department's Land Use Compatibility Table (water quality protection note: *Land use compatibility in public drinking water source areas*) and other relevant water quality protection notes regarding the management, storage and use of chemicals and fuels.

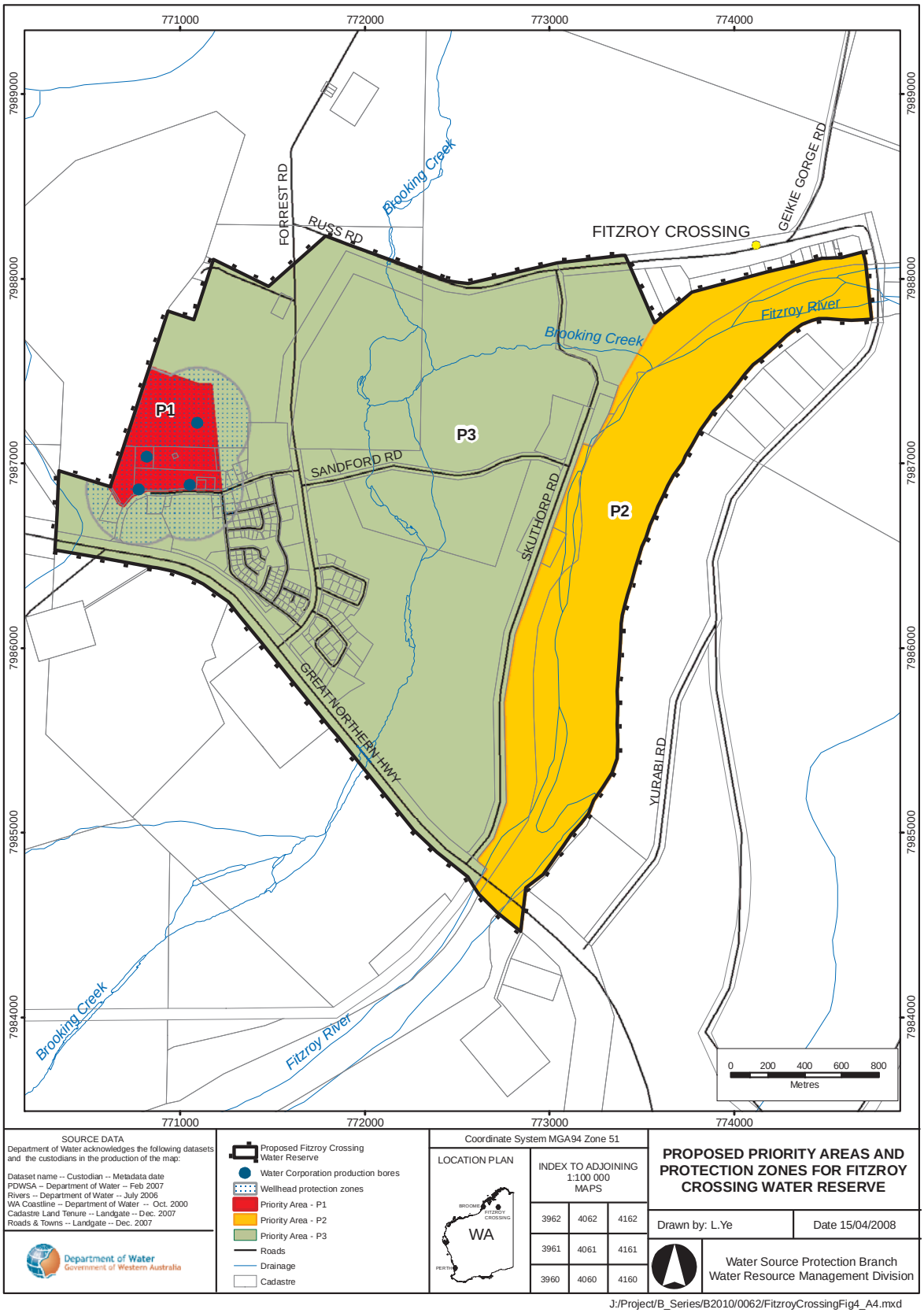

Figure 4 Priority areas and protection zones for the Fitzroy Crossing Water Reserve

4.5 Land-use planning

It is recognised under the *State planning strategy* (WA 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* (WA Planning Commission 2003) it is appropriate that the Fitzroy Crossing Water Reserve, priority classifications and protection zones be recognised in the final Fitzroy futures town plan. Any development proposals within the water reserve that are inconsistent with advice within this department's water quality protection note: *Land use compatibility in public drinking water source areas* or the recommendations in this plan, should be referred to the Department of Water.

The department's protection strategy for public drinking water source areas (PDWSA) such as water reserves 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 may negotiate with landowners/operators on measures to improve these facilities or processes to lessen the level of water contamination risk.

In critical areas close to water sources, the department may offer to purchase land or development rights where the level of contamination risk is considered significant enough to have the potential to compromise the quality of water resources.

4.6 Best management practices

Opportunities exist to significantly reduce risks to water quality 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 quality. On freehold land, the department aims to work with landowners to achieve best management practices for water-quality protection by providing management advice.

Guidelines are available for many land uses in the form of industry codes of practice, environmental guidelines or water quality protection notes (WQPN). These have been developed in consultation with stakeholders such as industry groups, producers, state government agencies and technical advisers. Examples include WQPNs *Contaminant spills – emergency response*, *Light industry near sensitive waters*, *Rural restaurants, cafes and taverns near sensitive water resources*, *Service stations*, and various WQPNs dealing with the storage of fuels, chemicals and other hazardous substances. These WQPNs are listed in the references section of this document. Guidelines and WQPNs help managers reduce the risk of their operations causing unacceptable water-quality impacts. They are recommended as best practice for water-quality protection.

Education and awareness (for example, signage and information) are key mechanisms for water-quality protection, especially for people visiting the area who

are unfamiliar with the Fitzroy Crossing Water Reserve. A brochure has been produced, describing the Fitzroy Crossing Water Reserve, its location and the main threats to water quality. This brochure will be available to the community and will inform people in simple terms about 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*. Declaration (proclamation) of these areas 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.

Signs are erected around PDWSA boundaries to educate the public and to advise of activities that are prohibited or regulated. This plan recommends delegation of surveillance and by-law enforcement to the Water Corporation.

4.8 Emergency response

Escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The Shire of Derby – West Kimberley Local Emergency Management Committee (LEMC) through the Kimberley Emergency Management District should be familiar with the location and purpose of the Fitzroy Crossing Water Reserve. A locality plan should be provided to the fire and rescue services headquarters for the Hazardous Materials (HAZMAT) Emergency Advisory Team. The Water Corporation and/or the Department of Water should have an advisory role to any HAZMAT incident in the Fitzroy Crossing Water Reserve.

Personnel who deal with WESTPLAN – HAZMAT (Western Australian Plan for Hazardous Materials) incidents within the area should have access to a map of the Fitzroy Crossing Water Reserve. These personnel should have an adequate understanding of the potential impacts of spills on this water resource.

4.9 Implementation of this plan

Table 1 identifies the potential water-quality risks associated with existing land uses in the Fitzroy Crossing Water Reserve and recommends protection strategies to minimise these risks.

Following publication of this drinking water source protection plan, an implementation strategy will be drawn up based on the recommendations in Table 1. It will describe timeframes for the recommended protection strategies and identify responsible stakeholders and sources of funding.

5 Recommendations

1 The boundary of the Fitzroy Crossing Water Reserve should be amended and proclaimed under the *Country Areas Water Supply Act 1947*. *(Department of Water)*

2 Prepare an implementation strategy including the recommended protection strategies as detailed in Table 1: *Land use, potential water quality risks and recommended strategies* of this plan showing responsible stakeholders and planned time frames. *(Department of Water in consultation with applicable stakeholders)*

3 The final Fitzroy futures town plan should incorporate this plan and reflect the identified Fitzroy Crossing Water Reserve boundary, priority 1, 2 and 3 areas and protection zones in accordance with *Statement of Planning Policy – Public drinking water source policy. (Shire of Derby – West Kimberley, WA Planning Commission)*

4 All development proposals within the Fitzroy Crossing Water Reserve 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 Derby – West Kimberley, Proponents of proposals*)

5 Incidents covered by WESTPLAN – HAZMAT in the Fitzroy Crossing Water Reserve should be addressed through the following:

- the Shire of Derby – West Kimberley LEMC should be aware of the location and purpose of the Fitzroy Crossing Water Reserve
- the locality plan for the Fitzroy Crossing Water Reserve is provided to the Fire and Rescue headquarters for the HAZMAT Emergency Advisory Team
- the Water Corporation and/or Department of Water provide an advisory role during incidents in the Fitzroy Crossing Water Reserve
- personnel dealing with WESTPLAN – HAZMAT incidents in the area have ready access to a locality map of the Fitzroy Crossing Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality.

(*Department of Water; Water Corporation)*

6 Pursuant to Section 13(1) of the *Water and Rivers Commission Act 1995*, the Department of Water should consider delegating responsibility for surveillance and enforcement measures of the Fitzroy Crossing Water Reserve to the Water Corporation. (*Water Corporation*)

7 Signs should be erected along the boundary of the Fitzroy Crossing Water Reserve 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)*

8 A full review of this plan should be undertaken after five years. (*Department of Water*)

9 A monitoring program should be maintained for the water supply and account for risks identified in this Plan and the work undertaken to implement Recommendation 6 above. (*Water Corporation*)

10 On decommissioning and relocation of the old power station a thorough assessment of the site should be undertaken to determine what is required to deal with any potential risks to groundwater quality. *(Horizon Power)*

11 Disused wastewater treatment ponds should be removed and rehabilitated. *(Relevant stakeholders)*

12 The location, design, construction, operation and maintenance of the proposed public swimming pool should be guided by the Department of Water's water quality protection note: *Swimming Pools* and should include water quality protection considerations. *(Shire of Derby – West Kimberley, Water Corporation, relevant stakeholders)*

Appendices

Appendix A: water quality

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

The Water Corporation has monitored the raw (source) water quality from Fitzroy Crossing bore field 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:

- aesthetic characteristics (non-health related)
- health-related characteristics including
    1) health-related chemicals
    2) microbiological contaminants

Following is data representative of the quality of raw-water from the Fitzroy Crossing bore field. In the absence of specific guidelines for raw-water quality, the results have been compared with the ADWG values set for drinking water, which defines the quality requirements at the customer's tap. Results that on occasion have exceeded the ADWG have been shaded 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 exist downstream of the raw-water to ensure it meets the requirements of the ADWG. For more information on the quality of drinking water supplied to Fitzroy Crossing refer to the most recent Water Corporation *Drinking water quality annual report* at <www.watercorporation.com.au> > Publications > Water Quality > Annual Reports.

Aesthetic characteristics

Aesthetic water-quality analyses for raw water from Fitzroy Crossing borefield are summarised in Table A1.

The values are taken from ongoing monitoring for the period May 2003 to May 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 highlighted.

Table A1 Aesthetic related detections for the Fitzroy Crossing bore field

Parameter	Units	ADWG Aesthetic Guideline Value*	SP Fitzroy Crossing Tank Site Raw Water	
			Range	Median
Aluminium unfiltered	mg/L	NA	<0.008 - 0.67	<0.008
Conductivity at 25ºC	mS/m	NA	37 - 50	42
Iron unfiltered	mg/L	0.3	<0.003 - 0.34	<0.003
Manganese unfiltered	mg/L	0.1	<0.002 - 0.065	<0.002
pH	NOUNIT	6.5 - 8.5	6.75 - 7.07	6.91
Turbidity	NTU	5	<0.1 - 6.6	<0.1

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

Health-related characteristics

Health parameters

Raw water from the Fitzroy Crossing bore field 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 May 2003 and May 2008 are summarised in Table A2. Any parameters that have on occasion exceeded the ADWG are highlighted.

Table A2 Health-related detections for the Fitzroy Crossing bore field

Parameter	Units	ADWG Health Guideline Value*	SP Fitzroy Crossing Tank Site Raw Water	
			Range	Median
Barium†	mg/L	0.7	0.095	0.095
Boron†	mg/L	4	0.1	0.1
Dieldrin	µg/L	0.3	<0.001 - 0.02	0.008
Fluoride	mg/L	1.5	0.2 - 0.25	0.25
Nitrate as nitrogen†	mg/L	11.29	0.63 - 0.75	0.7
Nitrite as nitrogen†	mg/L	0.91	<0.002 - 0.005	<0.002
Uranium†	mg/L	0.02	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 (NHMRC & ARMCANZ 2004a).

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

Microbiological contaminants

Microbiological testing of raw water samples from Fitzroy Crossing 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 *E. 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 May 2003 to May 2008, positive *E. coli* counts were recorded in approximately 14% of samples collected from Fitzroy Crossing borefield. This groundwater source is under the direct influence of surface water, resulting in the higher occurrence of *E. coli* detections than would typically be seen for a groundwater source.

Less than 2% of positive samples were > 20 most probable number (MPN) per 100 mL. A count less than 20 MPN/100 mL is typically associated with low levels of faecal contamination of the surface water and is used as a microbiological contamination benchmark of the raw water (World Health Organisation 2006).

Appendix B – Photographs

Photo 1 Fenced compound of bore 1/74 (Photo by B. Jago, Water Corporation)

Photo 2 Fenced compound of bore 2/82 (Photo by B. Jago, Water Corporation)

Glossary

abstraction	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.
adsorb	Accumulate on the surface.
ADWG	The Australian drinking water guidelines, outlining acceptable criteria for the quality of drinking water in Australia.
Aesthetic guideline	A water-quality criteria in the ADWG associated with acceptability of water to the consumer for example, appearance, taste and odour (NHMRC & NRMMC, 2004).
allocation	The quantity of water permitted to be abstracted by a licencee, usually specified in kilolitres per annum (kL/a).
aquifer	A geological formation or group of formations able to receive, store and transmit significant quantities of water.
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand.
bore	A narrow, lined hole, also known as a well, drilled to monitor or draw groundwater.
bore field	A group of bores to monitor or withdraw groundwater.
catchment	The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
confined aquifer	An aquifer that is confined between non-porous rock formations (such as shale and siltstone) and therefore contains water under pressure.
effluent	The liquid, solid or gaseous wastes discharged by a process, treated or untreated.
ha	Hectare (a measure of area).
HAZMAT	Hazardous materials.
Health guideline	A water-quality criteria in the ADWG associated with human health that, based on present knowledge, does not result in any significant risk to the consumer over a lifetime of consumption (NHMRC & NRMMC 2004).

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.
kL	Kilolitre (1,000 litres) or one cubic metre.
km	Kilometre (1,000 metres).
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.
LEMC	Local Emergency Management Committee.
m	Metres.
mg/L	Milligram per litre (0.001 grams per litre) as a measurement of a total dissolved solid in a solution.
mL	Millilitre
ML	Megalitre (1,000,000 litres = one million litres).
mm	Millimetre.
MPN	Most probable number (a measure of microbiological contamination).
mS/m	MilliSiemens per metre is a measure of electrical conductivity of a solution or soil and water mix that provides a measurement of salinity.
NHMRC	National Health and Medical Research Council.
NRMMC	Natural Resource Management Ministerial Council.
NTU	Nephelometric turbidity units are a measure of turbidity in water.
nutrients	Minerals dissolved in water, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) which provide nutrition (food) for plant growth. Total nutrient levels include the inorganic forms of an element plus any bound in organic molecules.

pathogen	A disease producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as *Escherichia coli*), protozoans (such as *cryptosporidium* and *giardia*) and viruses).
PDWSA (Public Drinking water Source Area)	Includes all underground water pollution control areas, catchment areas and water reserves constituted under the *Metropolitan Water Supply Sewerage and Drainage Act 1909* and the *Country Areas Water Supply Act 1947*.
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.
pollution	Water pollution occurs when waste products or other substances, for example, effluent, litter, refuse, sewage or contaminated runoff, change the physical, chemical, biological or thermal properties of the water, adversely affecting water quality, living species and beneficial uses.
PSC 88	A state government circular produced by the Department of Health providing guidance on appropriate herbicide use within water catchment areas.
recharge	Water infiltrating 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.
RiWI Act	*Rights in Water and Irrigation Act 1914*
runoff	Water that flows over the surface from a catchment area, including streams.
stormwater	Rainwater which has run off the ground surface, roads, paved areas etc, and is usually carried away by drains.
treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.

turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.
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.
WQPN	Water quality protection note
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	The physical, chemical and biological measures of water.
Water Reserve	An area proclaimed under the *Country Areas Water Supply Act 1947* or the *Metropolitan Water Supply Sewerage and Drainage Act 1909* for the purposes of protecting a drinking water supply.
watertable	The upper saturated level of the unconfined groundwater.
well field	A group of bores to monitor or withdraw groundwater.
wellhead **WHPZ**	The top of a well (or bore) used to draw groundwater. A wellhead protection zone (WHPZ) is usually declared around wellheads in drinking water areas to protect the water source from contamination.
WESTPLAN HAZMAT	Western Australian Plan for Hazardous Materials.

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