



Department of Water
Government of Western Australia

Looking after all our water needs



Quindalup Water Reserve drinking water source protection plan

Dunsborough, Yallingup and Quindalup town water supplies



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Department of Water

Water resource protection series

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Department of Water

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Cover photo: Production bore 1_98, taken by Kathryn Buehrig.

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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 Quindalup 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 National water quality management strategy: *Australian drinking water guidelines* recommends 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 Dunsborough, Yallingup and Quindalup town water supplies. 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 Busselton’s town planning scheme, consistent with the Western Australian Planning Commission’s Statement of Planning Policy No. 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 Quindalup Water Reserve.

The stages involved in preparing a Drinking Water Source Protection Plan are:

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.
4	Release draft drinking water source protection plan	Draft plan released for a six week public consultation period.
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

Dunsborough is a coastal resort town located about 250 km south of Perth on Geographe Bay. Yallingup is a coastal resort town on the western side of Cape Naturaliste Peninsula, 7 km south-west of Dunsborough. Quindalup is a coastal resort town approximately 7 km south-east of Dunsborough.

The town water supply for Dunsborough, Yallingup and Quindalup is derived from nine Water Corporation production bores.

Five of the bores abstract water from the Leederville Aquifer and four draw from the Sue Coal Measures. These aquifers are recharged directly from rainfall on the Blackwood plateau. There is very low risk of contamination from land uses surrounding the wellfields because of the confined nature of the aquifers.

The boundaries and priority areas have been determined to provide an appropriate level of protection for Dunsborough, Yallingup and Quindalup's drinking water source.

The following major protection strategies are recommended:

- The land in the Water Reserve is managed for Priority 1 (P1) water source protection.
- The Water Reserve boundary and P1 classification need to be recognised in the Shire of Busselton's town planning scheme and other applicable schemes and strategies.
- Best management practices for existing or future bore construction in close proximity to the water reserve should be implemented.
- Best management practices should be employed for existing land uses within the area of the production bores.

In order to protect water quality of this groundwater source, best management practices at design, construction and operational stages are recommended for existing and future land use developments. Guidance on best management practices is available on the Department of Water's website, see <www.water.wa.gov.au> and select Water quality.

This plan replaces the *Dunsborough and Yallingup Town Water Supplies Water Source Protection Plan* produced by the Water and Rivers Commission in 1999. The main source of drinking water at that time was the Butterworth Springs. This source is no longer in use and as such land use constraints that were placed upon Lots 454, 455, 1302 and 1303 from the original plan are no longer applicable. Therefore, a new plan has been developed for the Quindalup wellfield.

1 Drinking water source overview

1.1 Existing water supply system

The public drinking water supply for Dunsborough, Yallingup and Quindalup is obtained from groundwater abstracted from Water Corporation wellfields. The wellfields that supplies these towns is called the Quindalup Water Reserve and is located approximately 7 km south-east of Dunsborough (see Figure 1). It consists of nine equipped production bores (1/86, 1/91, 1/92, 1/93, 2/96, 1/98, 2/98, 3/98, 4/98) (see Figure 2). The production bores draw from the Leederville (confined) aquifer and in a minor way from the Sue Coal Measures (bore 1/92).

1.2 Water treatment

The raw water quality in the production bores sourced from the Leederville aquifer often exceeds guideline values for iron and turbidity, and it is therefore treated for iron removal before entering the Dunsborough–Quindalup reticulation system.

The raw water quality in the production bores sourced from the Sue Coal Measures often exceeds guideline values for fluoride, and it is therefore treated for fluoride removal before entering the Dunsborough/Quindalup reticulation system.

All raw water is chlorinated before it is sent into the reticulation system.

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 National water quality management strategy: *Australian drinking water guidelines* (ADWG) (NHMRC & NRMCC 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 area is bounded by Geographe Bay in the north, the Leeuwin Block in the west and the Whicher Scarp in the south and south-east. Much of this region is low-lying and the coastal strip is subject to inundation.

1.3.2 Climate

Dunsborough, Yallingup and Quindalup experience a Mediterranean-type climate, characterised by cool wet winters and warm dry summers. The closest rainfall station to Dunsborough is that at Cape Naturaliste which received a mean annual rainfall of

816.8 mm/yr. The mean maximum temperature ranges from 26.5 °C in February to 16.7 °C in July and August (information from 1970 – 2000, Bureau of Meteorology 2008).

1.3.3 Hydrogeology

The Dunsborough Fault defines the western margin of the Southern Perth Basin and the eastern margin of the Leeuwin Block, and it transects the Dunsborough and Quindalup townships. The Busselton Fault subdivides the Southern Perth Basin into the Bunbury Trough to the east and the Vasse Shelf to the west. The Vasse Shelf is thought to be underlain by Precambrian basement at a depth of less than 2 km. The Wirring Fault further subdivides the Vasse Shelf. The Quindalup Water Reserve is found east of the Wirring Fault on the Vasse Shelf.

The superficial deposits of the Vasse Shelf are comprised of Tertiary and Quaternary sediments with a thickness of up to 15 m. This groundwater aquifer is generally utilised for livestock, as yields are often limited by high clay content and water quality can be brackish.

The Tertiary and Quaternary sediments unconformably overlie the Leederville Formation which contains the best quality groundwater in the area. The Leederville Formation is an interbedded, multilayered aquifer consisting of fine-to-medium grained quartz sandstone and interbedded grey shale. Its thickness on the Vasse Shelf ranges from approximately 50 m to 250 m. The direction of groundwater flow in the Leederville Formation around the production bores is north. Recharge to the Leederville aquifer is by direct rainfall infiltration on the remote Blackwood Plateau, and by downward leakage from the superficial aquifer near the Whicher Scarp.

There are also other areas of potential downward leakage from the superficial formation to the upper Leederville aquifer south of Caves Road (Hirschberg 1987). However, the confining layers between the upper and lower Leederville limits the leakage.

Discharge from the Leederville aquifer generally occurs near the coast into creeks and swamps, over an area that extends several kilometres inland and by upward leakage into the superficial formations. The lower Leederville contains water of potable quality but that in the upper Leederville near the coast has a high salt content and is therefore not used as a drinking water supply.

The Leederville Formation unconformably overlies the Sue Coal Measures west of the Wirring Fault at depths greater than -150 m Australian Height Datum (AHD). East of the Wirring Fault the Leederville Formation unconformably overlies the Cockleshell Gully Formation. The Sue Coal Measures are Permian in age, and consist of multicoloured shale, moderately consolidated fine to coarse-grained quartz sandstone, with accessory feldspars, pyrite and carbonaceous materials. The Sue Coal Measures contain water of potable quality but, to date, bores drilled into this

formation have been low yielding. Discharge occurs from the Sue Coal Measures to the Leederville aquifer by upward leakage. Recharge occurs by downward leakage from sandier areas of the overlying Leederville aquifer higher in the flow path.

Bores 1/86, 1/91, 1/93, 2/96 and 2/98 extract from the lower Leederville Formation (approximately 40 m below the ground) or deeper. As the Leederville Formation in this area is stratified, flat-lying and predominantly shaly, downward leakage from the superficial aquifer to the lower Leederville Formation is not regarded as significant, and the Leederville aquifer is therefore not considered vulnerable to contamination from land uses around the borefields.

1.4 Future water supply requirements

The current source (Sue Coal Measures and Leederville aquifer) is considered adequate to meet future demand. The Water Corporation is also investigating future supply increases to be sourced from the south-west Yarragadee via the Busselton Water Board.

1.5 Protection and allocation

1.5.1 Existing water source protection

Quindalup Water Reserve was proclaimed in 2008 under the *Country Areas Water Supply Act 1947* for the purpose of protecting the public drinking water source from potential contamination.

Current measures that are undertaken by the Water Corporation to ensure water source protection include fencing of the bore compound and bore maintenance.

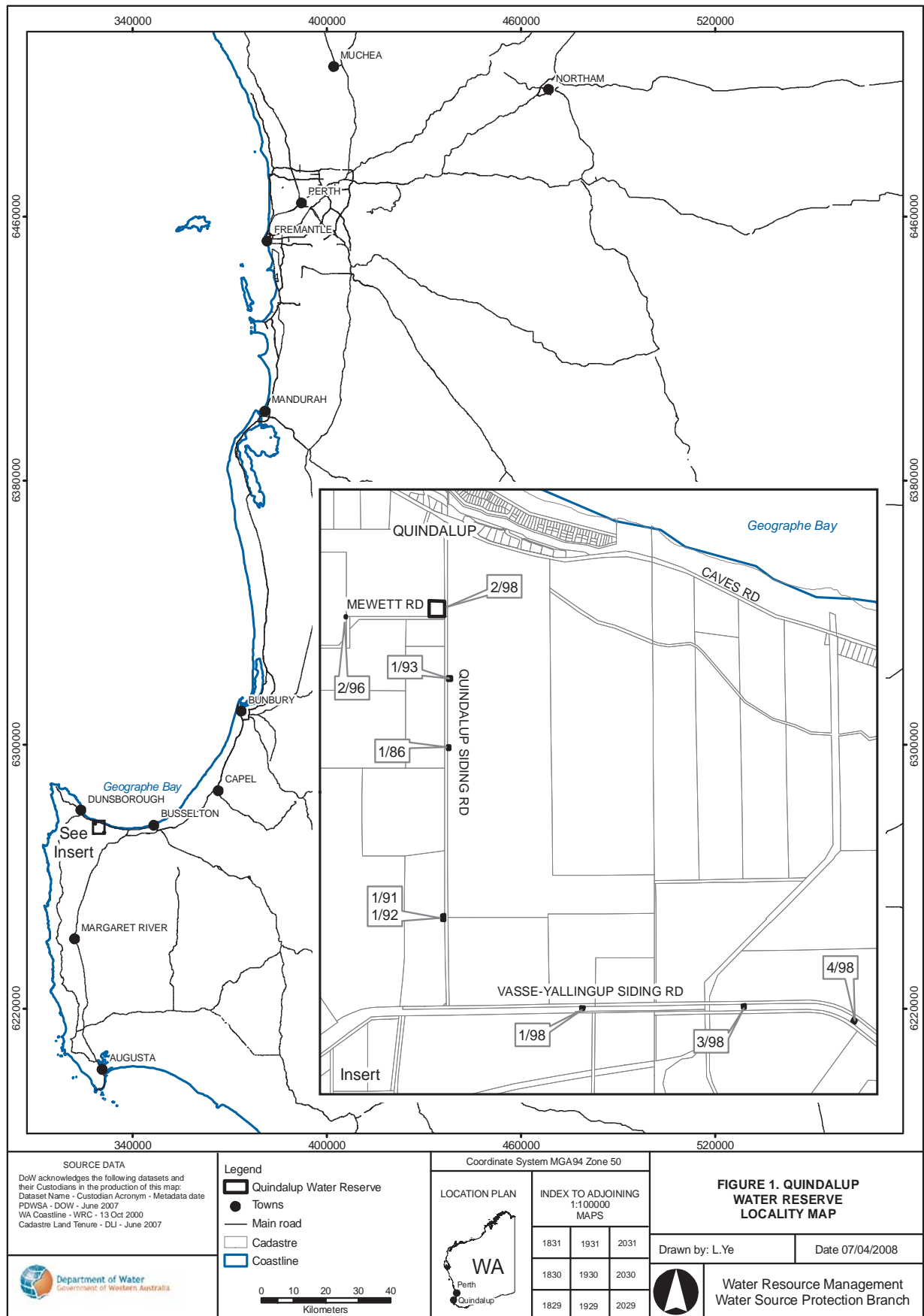
1.5.2 Current allocation licence

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*. 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 proclaimed groundwater areas.

The Quindalup groundwater resource lies within the Busselton-Capel Groundwater Area, which was proclaimed in 1984 under the *Rights in Water and Irrigation Act 1914*.

The Water Corporation is licensed to draw 750 000 kL/yr from the Leederville aquifer and 700 000 kL/yr from the Sue Coal Measures for public water supply purposes.

The Water Corporation and the Department of Water will be negotiating over the exceeded abstraction from the Leederville aquifer. The Water Corporation is investigating future supply sources as mentioned in Section 1.4 above.



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Figure 1 Quindalup Water Reserve locality map

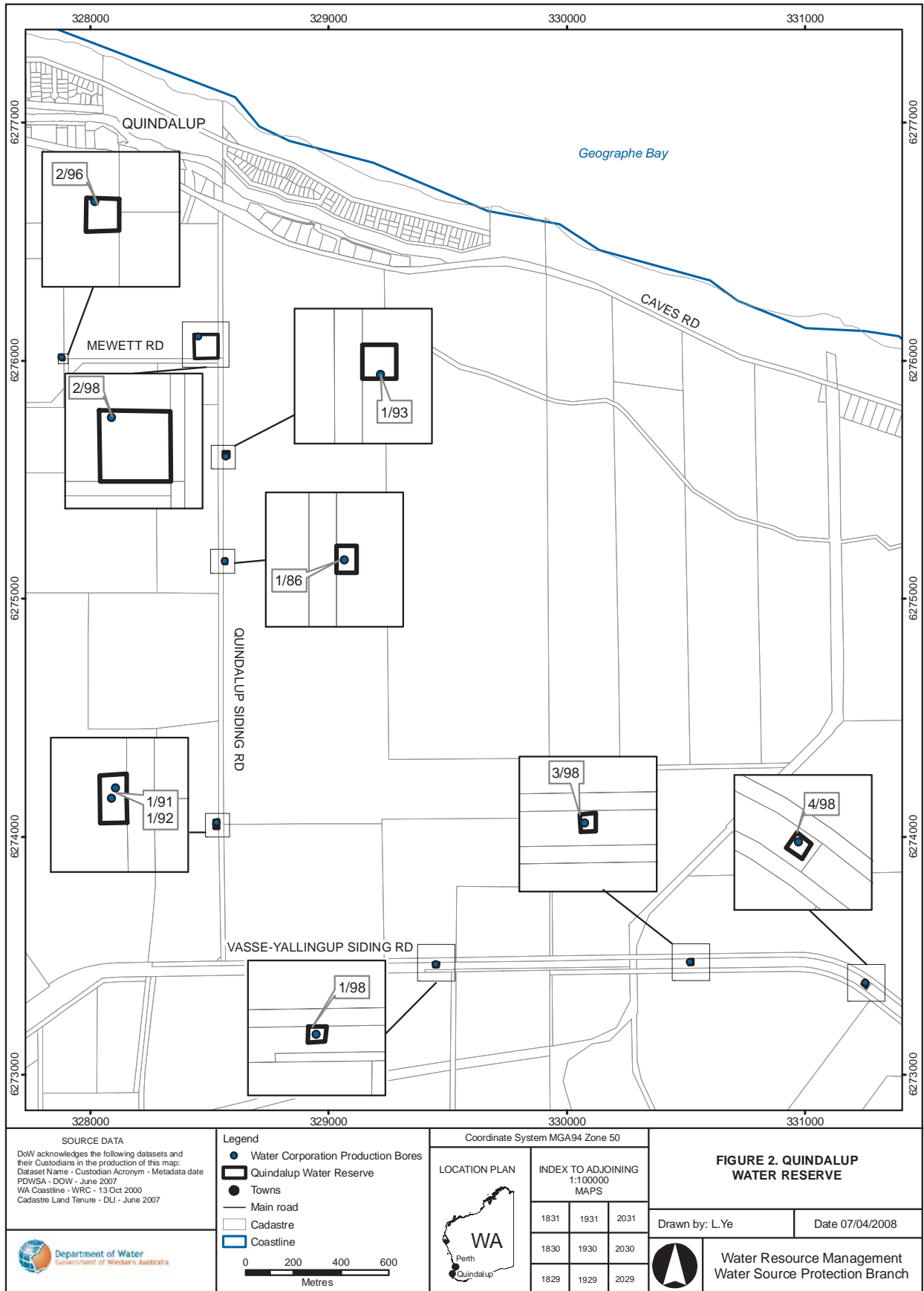


Figure 2 Quindalup Water Reserve

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 Quindalup borefields 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 Quindalup borefields 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.

Contamination risks relevant to the Quindalup Water Reserve are described below.

2.1 Microbiological

Pathogens are types of micro-organisms that are capable of causing diseases. These include bacteria, protozoa 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* and cholera), protozoa (for example, cryptosporidium, giardia) and viruses. *Escherichia coli* counts are a way of measuring these pathogens and are an indicator of faecal contamination.

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

Positive counts of *Escherichia coli* were recorded in less than per cent of the Quindalup Water Reserve raw water samples. Quindalup Water Reserve is considered to be at low risk from microbiological contamination due to the confined nature of the aquifers.

2.2 Health related

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, rodenticides and miticides). Contamination of a drinking water source by pesticides may occur as a result of accidental spills, incorrect use 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.

With the exception of fluoride, none of the health related water quality parameters exceed health guideline values. However, treatment is in place to reduce fluoride levels in the raw water before it reaches the reticulation. These parameters will continue to be routinely monitored.

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 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 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 set out aesthetic guidelines for these types of water quality characteristics.

The measured raw water quality slightly exceeds the aesthetic guidelines for iron, pH, sodium, TFSS and turbidity. These are naturally occurring variations. The raw water is treated for iron removal before entering the reticulation system.

2.4 Groundwater bores

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 (unless exempt under the *Rights in Water and Irrigation Exemption and Repeal (Section 26C) Order 2001*) within a proclaimed groundwater area. The Quindalup Water Reserve is located within the Busselton-Capel 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 *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).

2.5 Mineral exploration bores

Exploration drilling should be located outside the Quindalup Water Reserve bore compounds and downstream of the production bores. All drilling undertaken in close proximity to the Water Reserve must be appropriately backfilled and sealed in order to prevent contamination of the water source.

3 Land-use assessment

3.1 Existing land uses and activities

The Quindalup Water Reserve bore compounds are located on freehold land owned by the Water Corporation with the exception of the compound containing Bore 2/98 (corner of Quindalup Siding Road and Mewitt Road) which is located on Crown land vested in the Minister for Water Resources. All of the bore compounds are zoned as Public Purpose (Figure 3) under the Shire of Busselton's Town Planning Scheme (Western Australian Planning Commission 2007).

Land surrounding the Quindalup Reserve is currently zoned agricultural under the Shire of Busselton's Town Planning Scheme.

The Water Corporation's wastewater treatment plant and woodlot is located at Lot 150 Anniebrook Road Anniebrook, about 1 km away from the closest bore (bore 1/98). It was commissioned in 2000 to replace the old Dunsborough wastewater treatment plant. Treatment is in accordance with Water Services Authority of Australia standards and is to tertiary level. Given the high level of treatment, irrigation onto the treelot and the confined nature of the aquifer, there is negligible contamination risk to the public drinking water supply bores.

3.2 Proposed land uses and activities

Land use zonings and activity levels in and around the Quindalup Water Reserve are not expected to change significantly in the future.

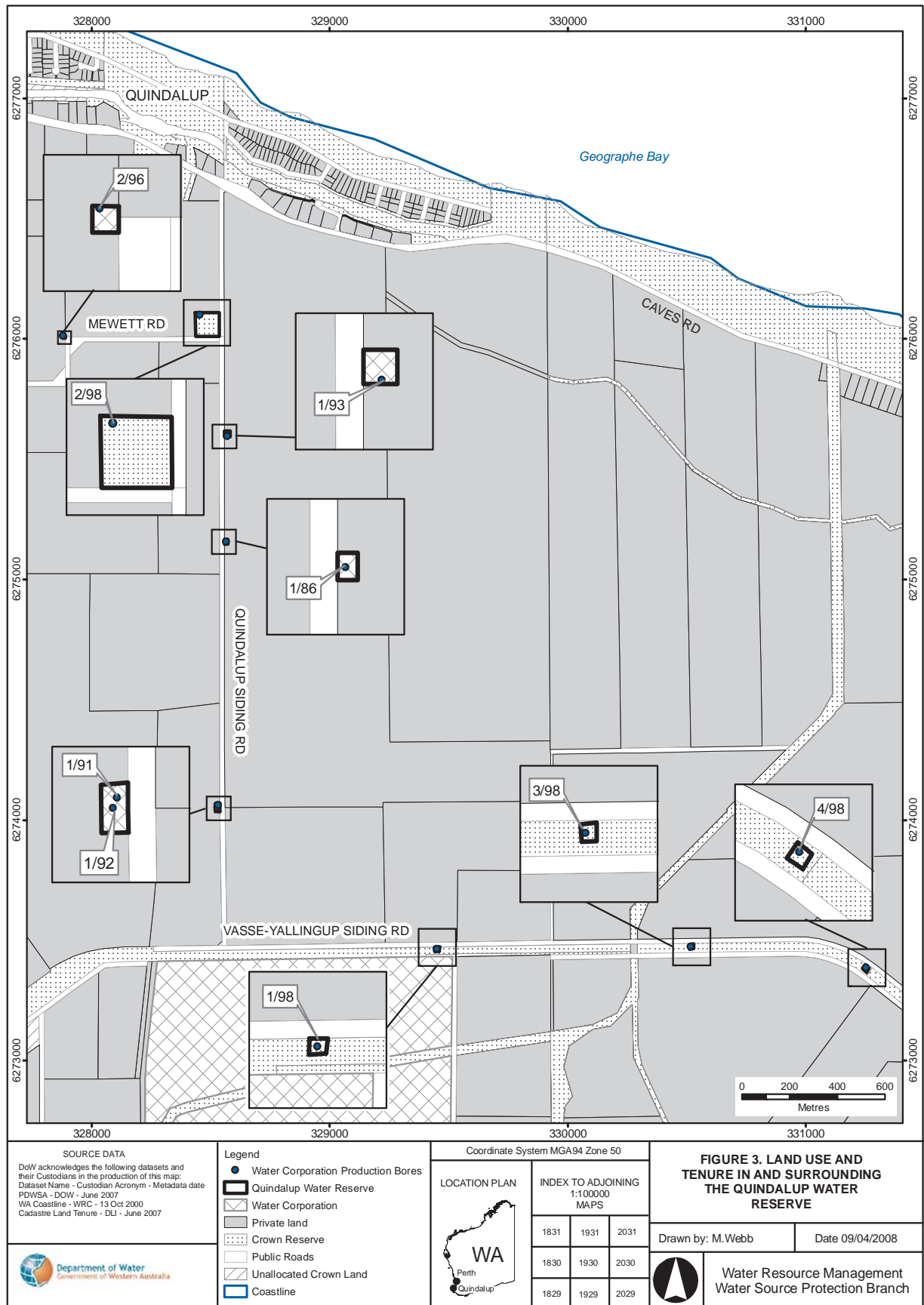


Figure 3 Land-use and tenure surrounding the Quindalup Water Reserve.

4 Catchment protection strategy

4.1 Protection objectives

The objective of this plan is to protect the drinking water source in order to supply safe drinking water to the towns of Dunsborough, Yallingup and Quindalup. Existing approved land uses around the Quindalup Water Reserve can continue.

The boundaries of the Quindalup Water Reserve have been assigned to ensure consistency with this department's current framework for public drinking water source protection. The boundaries reflect the land tenure, the strategic importance of the water source, land use and zoning and consider the low vulnerability of the aquifer to contamination.

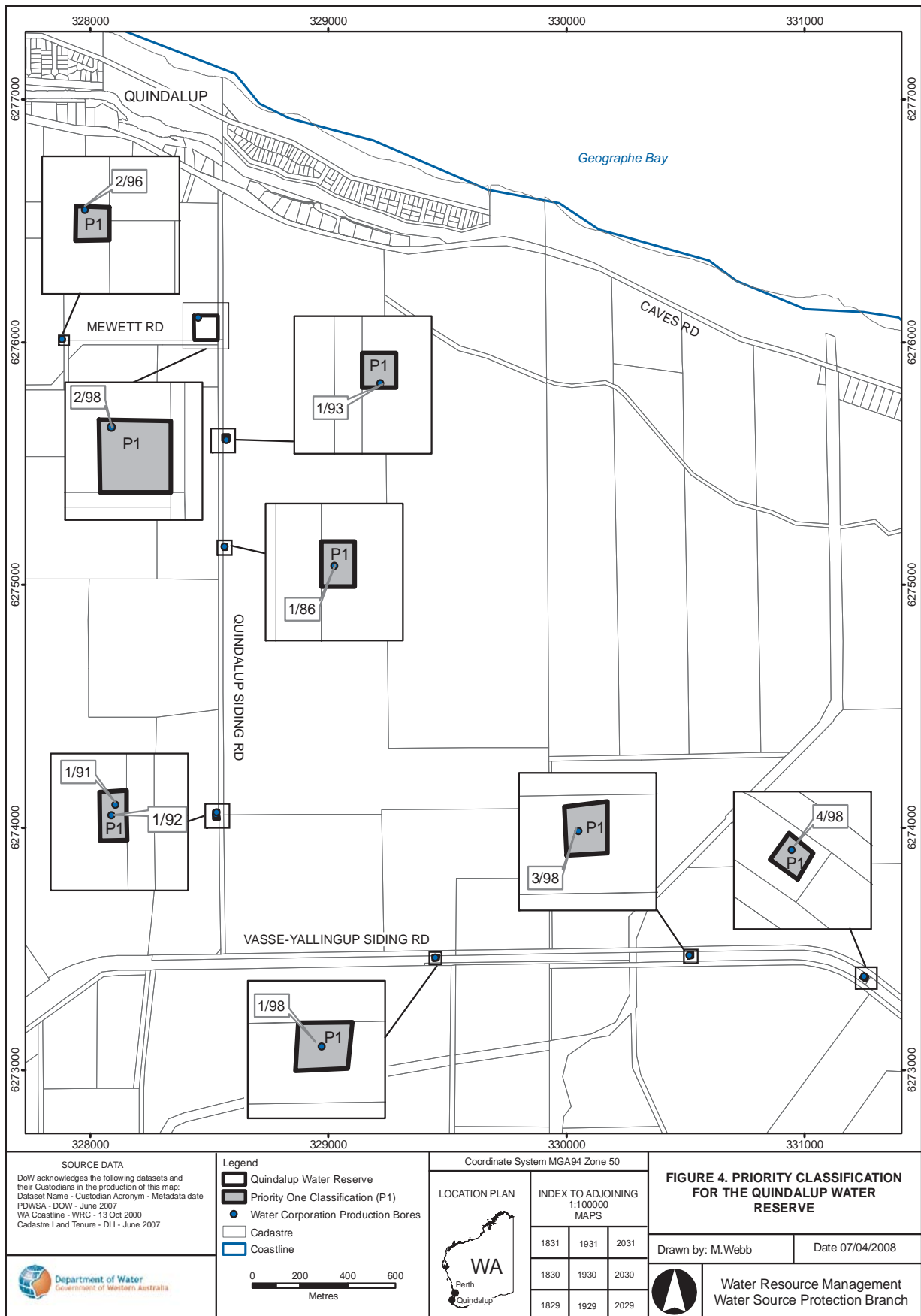
Due to the confined nature of the aquifer, existing and future land uses surrounding the Quindalup Water Reserve should have a negligible effect on the public drinking water source. The recommended protection strategy for this water reserve is to continue managing the area as P1 and to implement best management practices in maintaining existing bores and construction of any future bores.

4.2 Proclaimed area

Quindalup Water Reserve was proclaimed on 11 January 2008 under the *Country Areas Water Supply Act 1947*. By-laws can now be applied within the water reserve for the purpose of protecting the public drinking water source from potential contamination.

4.3 Priority areas

The risk of contamination from existing and proposed land uses is negligible due to the confined nature of the aquifer. Accordingly, a Wellhead Protection Zone is not required. The land is currently managed for Priority 1 (P1) in accordance with land use and tenure of the water reserve. It is proposed that the P1 management is continued (see Figure 4).



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Figure 4 Priority areas for the Quindalup Water Reserve

4.4 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 No. 2.7: *Public drinking water source policy* (Western Australian Planning Commission 2003) it is appropriate that the Quindalup Water Reserve and its priority areas are recognised in the Shire of Busselton's town planning scheme. Any development proposals within the Quindalup Water Reserve that are inconsistent with advice in the 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.

The department's protection strategy for PDWSA 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.

4.5 Best management practices

There are opportunities 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 of Water aims to work with landowners to achieve best management practices for water quality protection by providing management advice.

There are guidelines available for many land uses in the form of industry codes of practice, environmental guidelines or Water quality protection notes. These have been developed in consultation with stakeholders such as industry groups, producers, state government agencies and technical advisers. Examples include *Land use compatibility in Public Drinking Water Source Areas*, *Land use planning in Public Drinking Water Source Areas* and *Protecting public drinking water source areas*, which are listed in the references section of this document. The guidelines 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 those people visiting the area who are unfamiliar with the Quindalup Water Reserve. A brochure will be produced, describing the Quindalup 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.

4.6 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 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 PDWSA, 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.

4.7 Emergency response

Escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The Shire of Busselton's Local Emergency Management Committee (LEMC) through the South West Emergency Management District should be familiar with the location and purpose of the Quindalup Water Reserve. A locality plan should be provided to the fire and rescue services headquarters for the Hazardous Materials (HAZMAT) Emergency Advisory Team. Water Corporation should have an advisory role to any HAZMAT incident in the vicinity of the Quindalup 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 Quindalup Water Reserve. These personnel should have an adequate understanding of the potential impacts of spills on this water resource.

5 Recommendations

The following recommendations apply to the entire Quindalup Water reserve. The bracketed agencies have a direct interest in implementation of the relevant recommendation.

- 1 The Shire of Busselton's Town Planning Scheme should incorporate this plan and reflect the identified Quindalup Water Reserve boundary and P1 area in accordance with Statement of Planning Policy No. 2.7: *Public drinking water source policy (Shire of Busselton)*.
- 2 Applications to construct a bore and/or extract groundwater in close proximity to the Quindalup Water Reserve should be assessed to ensure that the bores are appropriately located. Best management practices should be recommended for the maintenance and construction of new or existing bores to prevent potential contamination or reduction in water availability to the public drinking water source bores (*Department of Water*).
- 3 All development proposals within the Quindalup 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 Busselton, Proponents of proposals*).
- 4 Incidents covered by WESTPLAN – HAZMAT in the Quindalup Water Reserve should be addressed through the following:
 - the *South West* LEMC should be aware of the location and purpose of the Quindalup Water Reserve
 - the locality plan for the Quindalup Water Reserve is provided to the Fire and Rescue headquarters for the HAZMAT Emergency Advisory Team
 - the Department of Water provides an advisory role during incidents in the Quindalup Water Reserve
 - personnel dealing with WESTPLAN – HAZMAT incidents in the area have ready access to a locality map of the Quindalup Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality.

(*Department of Water; Water Corporation*)
- 5 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 Quindalup Water Reserve to the Water Corporation (*Department of Water; Water Corporation*).
- 6 Signs should be erected along the boundary of the Quindalup Water Reserve bore compounds to define the location and promote awareness of the need to protect drinking water quality. Signs should include an emergency contact telephone number (*Department of Water; Water Corporation*).
- 7 A review of this plan should be undertaken after five years (*Department of Water*).

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 the Quindalup borefields 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
 - health related chemicals
 - microbiological contaminants

The following data is representative of the quality of raw water from Quindalup borefields. 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 exceed 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, to name a few, exist downstream of the raw water to ensure it meets the requirements of the ADWG. 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 on occasion have exceeded the ADWG are shaded.

For more information on the quality of drinking water supplied to Dunsborough, Yallingup and Quindalup refer to the most recent Water Corporation *Drinking Water Quality Annual Report* at <www.watercorporation.com.au> > Water > Water quality > Latest report > Drinking water quality annual report.

Aesthetic characteristics

Aesthetic water quality analyses for raw water from Quindalup borefields are summarised in the following table.

Aesthetic detections for Quindalup borefields

Parameter	Units	ADWG Aesthetic Guideline Value*	Dunsborough Wtp Leederville Raw Water SP		Dunsborough Wtp Sue Coal Raw Water SP	
			Range	Median	Range	Median
Aluminium acid soluble	mg/L	0.2	<0.008	<0.008	<0.008–0.012	<0.008
Aluminium unfiltered	mg/L	-	<0.008–0.26	<0.008	<0.008–0.075	0.008
Chloride [†]	mg/L	250	99–135	117	84–140	112
Colour - True	TCU	15	<1–4	<1	<1–4	<1
Conductivity at 25 °C	mS/m	-	50–91	57	51–98	85
Copper [†]	mg/L	1	0.006	0.006	0.007	0.007
Hardness as CaCO ₃ [†]	mg/L	200	72–84	78	15.6–25	20.3
Iron unfiltered	mg/L	0.3	0.006–2.8	0.4	<0.003–2	0.004
Manganese unfiltered	mg/L	0.1	<0.002–0.05	0.02	<0.002–0.026	<0.002
pH	No Unit	6.5–8.5	7.27–8.45	7.71	7.55–8.81	8.44
Sodium [†]	mg/L	180	80–100	90	145–195	170
Sulphate [†]	mg/L	250	10	10	36–50	43
TFSS [†]	mg/L	500	396–437	416.5	521–627	574
Turbidity	NTU	5	<0.1–17	1.6	<0.1–8	<0.1

* 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 three or less sampling occasions

Health related characteristics

Health parameters

Raw water from Quindalup borefields is analysed for health related chemicals including inorganics, heavy metals, industrial hydrocarbons and pesticides. Health related water quality parameters are summarised in the following table.

Health related detections for Quindalup borefields

Parameter	Units	ADWG Health Guideline Value*	Dunsborough Wtp Leederville Raw Water SP		Dunsborough Wtp Sue Coal Raw Water SP	
			Range	Median	Range	Median
Arsenic	mg/L	0.007	<0.002	<0.002	<0.002–0.003	<0.002
Barium	mg/L	0.7	0.035–0.055	0.04	0.03–0.06	0.0425
Boron	mg/L	4	0.18–0.66	0.3	0.28–0.74	0.59
Fluoride	mg/L	1.5	0.35–2.4	0.475	0.45–2.6	1.9
Mercury	mg/L	0.001	<0.0005–0.0006	<0.0005	<0.0005–0.0006	<0.0005
Molybdenum	mg/L	0.05	<0.0005–0.002	<0.0005	<0.0005–0.002	0.0015
Nitrite as nitrogen [‡]	mg/L	0.91	0.004	0.004	<0.002	<0.002
Nitrite plus nitrate as N [‡]	mg/L	11.29	0.039–0.06	0.0495	<0.05	<0.0375

* A health guideline value is the concentration or measure of a water quality characteristic that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHMRC & NRMCC 2004a)

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

Microbiological contaminants

Microbiological testing of raw water samples from Quindalup borefield is currently conducted monthly. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw water from warm-blooded animals. A count of less than 20 MPN (most probable number) per 100 mL sample is typically associated with low levels of faecal contamination and is used as a microbiological contamination benchmark of the raw-water (World Health Organisation 1996). As such, counts less than 20 MPN are seen as being an indication of raw water that has not been recently contaminated with faecal material.

During the reviewed period, positive *Escherichia coli* counts were recorded in less than one per cent of samples. The low occurrence of *Escherichia coli* detections is indicative of minimal contamination of the groundwater from faecal sources.

Appendix B: Photographs



Photo 1 Bore 2/98 sourced from the Leederville aquifer



Photo 2 Bore 3/98 sourced from the Sue Coal Measures

Glossary

Abstraction	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body
ADWG	The <i>Australian Drinking Water Guidelines</i> , 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 e.g. appearance, taste and odour (NHMRC & NRMCC 2004a)
AHD	Australian Height Datum is the height of land in metres above mean sea level. For example, this is +0.026 m at Fremantle.
Allocation	The quantity of water permitted to be abstracted by a licensee, usually specified in kilolitres per year (kL/yr)
ANZECC	Australian and New Zealand Environment Conservation Council
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
Borefield	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
DEC	The Department of Environment and Conservation was established on 1 July 2006, bringing together the Department of Environment (DoE) and the Department of Conservation and Land Management (CALM).
Effluent	The liquid, solid or gaseous wastes discharged by a process, treated or untreated

EC	Electrical conductivity. This estimates the volume of total dissolved solids (TDS), or the total volume of dissolved ions in a solution (water) corrected to 25 °C. Measurement units include milliSiemens per metre and microSiemens per centimetre.
GL	Gigalitre (1,000,000,000 litres) or one million kilolitres
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 & 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
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
mg/L	Milligram per litre (0.001 grams per litre) as a measurement of a total dissolved solid in a solution
mL	Millilitre
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 <i>Escherichia coli</i>), protozoa (such as cryptosporidium and giardia) and viruses.
Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms
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, e.g. 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
PDWSA (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> .
Quaternary	Relates to the most recent period in the Cainozoic era from two million years ago to present
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.

Runoff	Water that flows over the surface from a catchment area, including streams
Scheme supply	Water diverted from a source or sources by a water authority or private company and supplied via a distribution network to customers for urban, industrial or irrigation use
TCU	True colour units (a measure of degree of colour in water)
TFSS	Total filterable solids by summation
Tertiary	The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient
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
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 <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
Wellfield	A group of bores to monitor or withdraw groundwater
Wellhead	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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