



Department of Water
Government of Western Australia



Denham North and Denham South (D7-7) Water Reserves Drinking Water Source Protection Plan



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Denham Town Water Supply

Department of Water

Water Resource Protection Series

Report WRP 68

May 2007

Department of Water

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May 2007

ISSN 1326-7442

Subject of cover photograph

Denham's Water Tanks, taken by Tran Huynh

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Preface

The Department of Water has prepared this Drinking Water Source Protection Plan to report on the activities and risks to water quality within the Denham North and Denham South (D7-7) Water Reserves, and to recommend management strategies to address these.

A safe drinking water supply is critical to the well-being of the community and catchment protection is necessary to help avoid, minimise or manage risks to water quality. The Department is committed to protecting Denham's drinking water sources to ensure the continued supply of 'safe, good quality drinking water' to consumers.

The Australian Drinking Water Guidelines recommend multiple barrier a risk based approach to protect public drinking water sources. Protection of drinking water catchments is the 'first barrier', with subsequent barriers implemented at the water storage, treatment and distribution stages of a water supply system. Catchment protection includes understanding the catchment, the hazards and hazardous events that can compromise drinking water quality, and developing and implementing preventive strategies and operational controls to ensure the safest possible water supply from our groundwater aquifers.

This plan details the location and boundary of the drinking water reserve which provides potable water to the town of Denham. It describes the water supply system, discusses existing and future usage of the water source, identifies risks and recommends management approaches to maximise protection of the catchment.

This plan should be used to guide State and local government land use planning decisions. It should be recognised in the Shire of Shark Bay 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 proposed Denham North Water Reserve and the gazetted Denham South (D7-7) 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 received.
4	Release Draft Drinking Water Source Protection Plan	Draft Plan released for a six week public consultation period.
5	Publish Drinking Water Source Protection Plan	Final Plan published after considering advice received in submissions. Includes recommendations on how to protect the catchment.

Summary

Denham is located approximately 830 kilometres (km) north of Perth. The Denham Water Reserves are Denham's only existing public water supply. Most properties have dual water supply services, a desalinated service and a brackish service. There are two production bores that are used to supply the town, Bores 1/79 (a stand by bore) and 1/97 (the main production bore). The groundwater is drawn from around 500 metres (m) depth.

The aquifer is considered to be confined and with its depth of 500 m, it is not considered vulnerable to contamination from surrounding land uses.

Currently, Denham has two water reserves D7-2 and D7-7 (Denham South which contains bore 1/79). This Plan proposes to deproclaim D7-2 and proclaim a Denham North Water Reserve on which bore 1/97 is located.

The boundaries and priority classification have been determined to provide an appropriate level of protection for Denham's drinking water source.

The following strategies are also recommended:

- The boundary of the Reserves at Denham need to be proclaimed and that information needs to be available to the public to help them protect their drinking water;
- The Water Reserve boundary and proposed Priority 1 (P1) classification need to be recognised in the Shire of Shark Bay's Town Planning Scheme and other applicable schemes and strategies;
- The management principles outlined in this plan should be incorporated into the Shire of Shark Bay's Town Planning Scheme and other applicable land use planning schemes and strategies; and
- Best management practices for existing or future bore construction in close proximity to the water reserves should be implemented.

In order to protect water quality of this groundwater source, best management practices at design, construction and operational stages is 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.

1 Drinking water source overview

1.1 Existing water supply system

Denham is located approximately 830 kilometres (km) north of Perth (see Figure 1). The town has a permanent population of about 1375 (Australian Bureau of Statistics 2001) and is the centre for local fishing and tourism industries.

The Denham wellfields consist of Artesian Bores 1/97 and 1/79. Bore 1/97 is located within the proposed Denham North Water Reserve and Bore 1/79 within the Denham South (D7-7) Water Reserve (see Figure 2).

Bore 1/97 replaced Bore 1/66 which was located in Denham Water Reserve D7-2 (see Figure 2) but has since been decommissioned. Bore 1/97 provides brackish water which is either desalinated for potable use or left brackish for non-potable use. Bore 1/79 is used for standby emergency.

There are no known significant alternative reserves of potable surface water or groundwater near Denham. Accordingly the town's water is sourced from the brackish artesian bores. A reverse osmosis (RO) plant commissioned in 1977 provides Denham residents with a reticulated potable water supply. The balance is supplied as brackish for non-potable use via the towns dual supply system. In September 2006 there were 700 water services in Denham (Water Corporation 2006a).

1.2 Water treatment

Brackish water is pumped from the bores to a 1500 kilolitre (kL) ground storage tank via an aerator and sand filter. During aeration and filtration, the water is also dosed with potassium permanganate to help remove manganese and iron. From the tank, brackish water either gravitates to the lower level brackish reticulation system or is pumped to a 43 kL high level storage tank for distribution to the brackish reticulation system in the higher areas of the town. The 43 kL tank also supplies water to the desalination plant.

Brackish water is desalinated for potable supply by the RO plant, which operates up to 22 hours per day during the peak demand period. After chlorination, desalinated water is stored in two 225 kL ground storage tanks from where it either gravitates to the low level potable reticulation system or is pumped to a high level storage tank for distribution to the potable reticulation system in the higher areas of town.

1.3 Catchment details

1.3.1 Physiography

Denham lies on the Peron Peninsula and is characterised by mobile and fixed calcareous dunes and sand plains located in the Gascoyne Sub Basin of the Carnarvon Basin. From the Denham waterfront the land rises rapidly along an alignment that parallels the coast to a height of about 12 metres Australian Height Datum (AHD) where a series of small dunes tending northwards create a rolling variable landscape over which the town has developed.

At the southern end of the town, a steep limestone scarp about 6 metres in height tapers in from the sea edge and encloses a relatively flat undeveloped section of beach land. Above the scarp, overlaying the limestone are brown, calcareous dune sands with dunes of up to 28 metres AHD. Beyond these dunes the landform changes to the rolling transverse and longitudinal dunes and sand plains that are typical of the Peron Peninsula. These dunes of red quartz sand rise up from deep interdune depressions to heights of up to 50 metres AHD.

1.3.2 Climate

The climate at Denham is semi arid with an average annual rainfall of 225.7 millimetres (mm) associated with winter cold fronts and occasional summer cyclonic activity. Over the period of 1990 to 2005 annual rainfall ranges between 105 mm and 371 mm with an average of 243.2 mm per annum. A major rainfall event was recorded in March 2000 associated with Tropical Cyclone Steve. The mean maximum temperature ranges from 32°C in February to 21.7°C in July, while the mean minimum temperature ranges from 22.5°C in February to 12.4°C in July.

1.3.3 Hydrogeology

The Gascoyne Sub Basin of the Carnarvon Basin is a sequence of Phanerozoic sediments up to 6000 m thick. The artesian bores draw water from the Cretaceous Birdrong Sandstone at around 500 m depth (Water Corporation 2004). The Birdrong Sandstone is recharged by leakage from superficial formations and younger Cretaceous sediments in an area 100 to 120 km east of Denham. Groundwater flow is to the northwest. The confined nature of the aquifer and its depth of around 500 m are sufficient to consider it not to be vulnerable to contamination from inappropriate land uses. There is an upward artesian pressure on the production wellheads, which must be contained to prevent local flooding. This is achieved by placing a gate valve to the wellheads to allow controlled flow. The recharge area for the Denham source is approximately 100 – 120 km to the east of the wellfield (Water Corporation 2004).

1.4 Future water supply requirements

The current source is considered adequate to meet future demand.

1.5 Protection and allocation

1.5.1 Existing water source protection

Denham D7-2 and D7-7 Water Reserves were proclaimed in 1992 under the *Country Areas Water Supply Act 1947* for the purpose of protecting the public drinking water source from potential contamination. Denham D7-7 will be known for the purpose of this plan as Denham South. They are shown in Figure 2.

The Denham North Water Reserve has not yet been proclaimed under the *Country Areas Water Supply Act 1947*.

Current measures that are undertaken by Water Corporation to ensure water source protection include a surveillance program and bore maintenance as well as placing signs around the bore compound to alert the public about the presence of the drinking water bores.

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 water and groundwater is vested with the Crown. This Act requires licensing of groundwater abstraction within proclaimed groundwater areas.

The Denham groundwater resource lies within the Gascoyne Groundwater Area, which was proclaimed in 1990 under the *Rights in Water and Irrigation Act 1914*.

The Water Corporation is licensed to draw 300 000 kL (Groundwater Well Licence 62151(2)) per annum from the Denham wellfield for public water supply purposes. Abstraction in 2005/2006 was 221 062 kL, from bore 1/97. There was no abstraction in 2005/2006 from the standby bore 1/79.

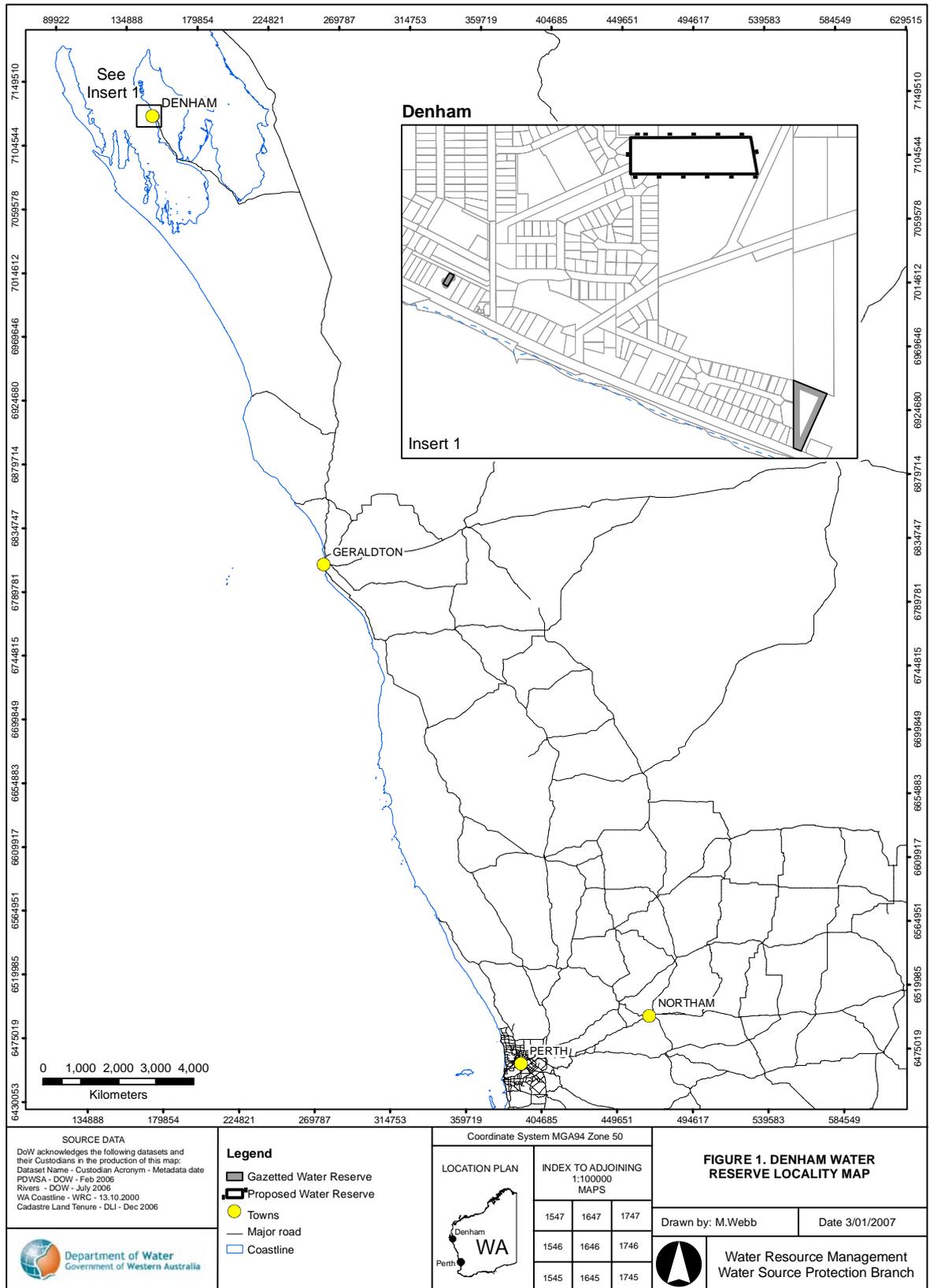


Figure 1 Denham North and Denham South (D7-7) Water Reserves locality map

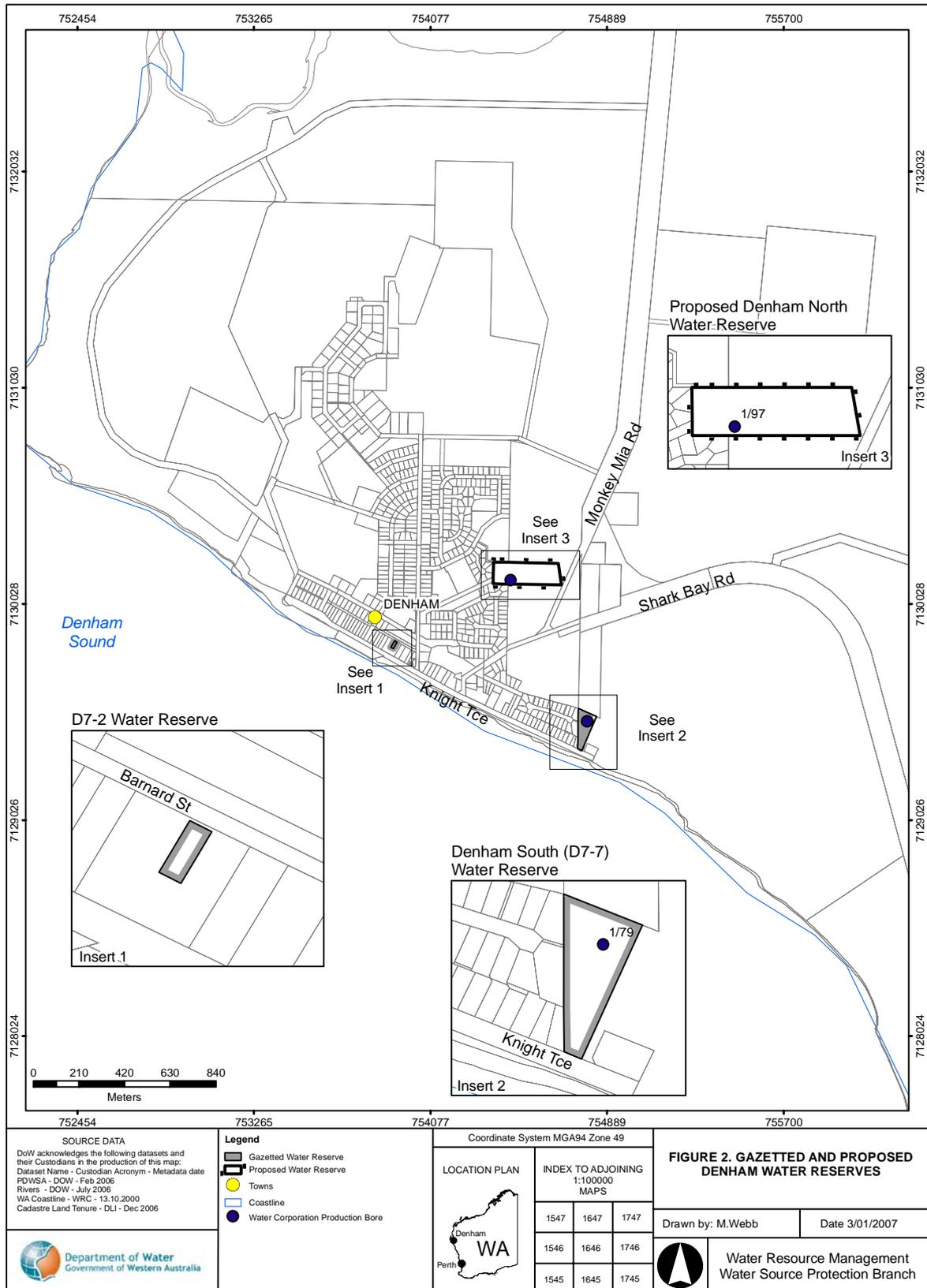


Figure 2 Denham North and Denham South (D7-7) Water Reserves

2 Water quality

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 (untreated) water quality from Denham's borefields for microbiological contamination, health related chemicals and aesthetic characteristics in accordance with the ADWG (NHMRC & ARMCANZ 2004). The results of this monitoring are then 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 Denham wellfields from January 2002 to April 2007 is presented in Appendix B and described below. 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 > Downloads > most recent Annual Report.

It should be noted that testing is conducted on raw water, and that all Australian Drinking Water Guideline limits are met following treatment before supply to consumers.

2.1 Microbiological contaminants

Microbiological contaminants were detected at low levels for 4.5% of samples in the raw water from Denham borefields between 2001 and 2002. There have been no detections since 2002. The source of earlier detections is unclear given the confined nature of the aquifer.

2.2 Health related chemicals

The concentrations of all elements detected did not exceed the health guideline of the Australian Drinking Water Guidelines (ADWG). All detected health related chemical parameters are at levels that pose no health concern.

2.3 Aesthetic characteristics

Aesthetically, the raw water from Denham borefield is brackish with high levels of salinity and hardness. Levels for chloride, sodium, sulphate, turbidity, iron and Total Filterable Solids by Summation (TFSS) also exceed ADWG values.

Following treatment all aesthetic guideline levels in the reticulated supply comply with the 1996 ADWG.

3 Land use and contamination risk

3.1 Potential water quality risks

Under the provisions of section 26D and 5C of the *Rights in Water and Irrigation Act 1914*, a licence is required to construct a bore or extract water within a proclaimed groundwater area. The proposed Denham North and Denham South (D7-7) Water Reserves and surrounding areas are within the Gascoyne Groundwater Area. It should be noted that any future bores drilled in close proximity to a drinking water source bore have the potential to contaminate the drinking water source. Through the Department of Water's bore application/assessment process it is important to ensure that private bores are appropriately located and constructed in order to prevent contamination and other impacts on the public drinking water source. All bores should be constructed in accordance with *Minimum Construction Requirements for Water Bores in Australia* (National Minimum Bore Specifications Committee 2003). The Department of Water's database indicate that there are no bores in close proximity to Bores 1/97 and 1/79.

3.2 Existing land uses

Denham South (D7-7) Water Reserve is located on vacant Crown land vested in the Water Corporation (see Figure 3). This land is zoned as "Public Purpose Water Supply" under the Shire of Shark Bay Town Planning Scheme No. 2, as amended. Surrounding land is primarily zoned residential and Crown reserve with the exception of a quarry to the north. The proposed Denham North Water Reserve is located on land owned freehold by the Water Corporation zoned for "Public Purposes".

3.3 Proposed land uses

Land use zonings and activity levels in and around both Water Reserves are not expected to change in the near future. A new Town Planning Scheme was due for finalisation in March 2006 and has now closed for public comment. It is expected to be finalised within the next few months (mid 2007) and is not expected to affect the Water Reserves.

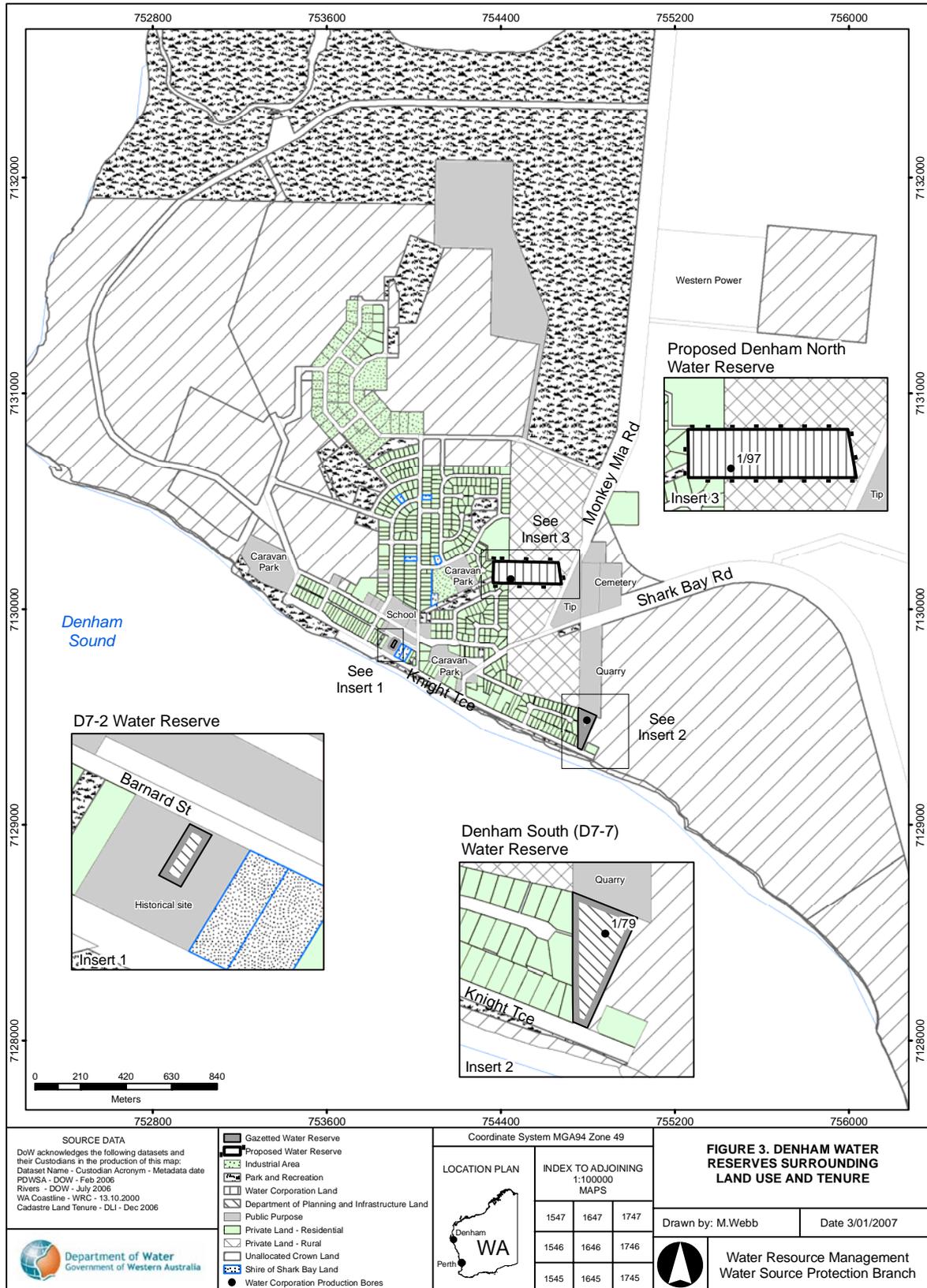


Figure 3 Land use and tenure surrounding the proposed Denham North and Denham South (D7-7) Water Reserves.

4 Catchment protection strategy

4.1 Protection objectives

The objective of this plan is to protect the drinking water source to ensure safe drinking water is supplied to the town of Denham. Existing approved land uses around the Reserve can continue.

The boundaries for the proposed Denham North and Denham South (D7-7) Water Reserves have been assigned to ensure consistency with this Department's current framework for public drinking water source protection. The boundaries of each Water Reserve reflect the land tenure, the strategic importance of the water source, land use and zoning.

4.2 Proclaimed area

Denham D7-7 (South) Water Reserve was proclaimed on 8 September 1992 under the *Country Areas Water Supply Act 1947* for the purpose of protecting the public drinking water source from potential contamination.

The proposed Denham North Water Reserve (containing bore 1/97) is proposed to be proclaimed under the *Country Areas Water Supply Act 1947* for the purpose of protecting the public drinking water source from potential contamination.

Denham D7-2 Water Reserve was also proclaimed under the *Country Areas Water Supply Act 1947* on 8 September 1992, it is proposed to abolish (deproclaim) this area as there is no production bore in the Water Reserve and therefore protective measures are not required.

4.3 Priority classifications

The risk of contamination from existing and proposed land uses is negligible as a result of the depth to the aquifer (500 m), depth and construction of the bores, and the confined nature of the aquifer. Accordingly a Wellhead Protection Zone (WHPZ) is not proposed. It is proposed that there will be a Priority 1 (P1) classification within the proposed Denham North and existing Denham South (D7-7) Water Reserves. This classification recognises the current land use and tenure surrounding the Water Reserves (see Figure 4).

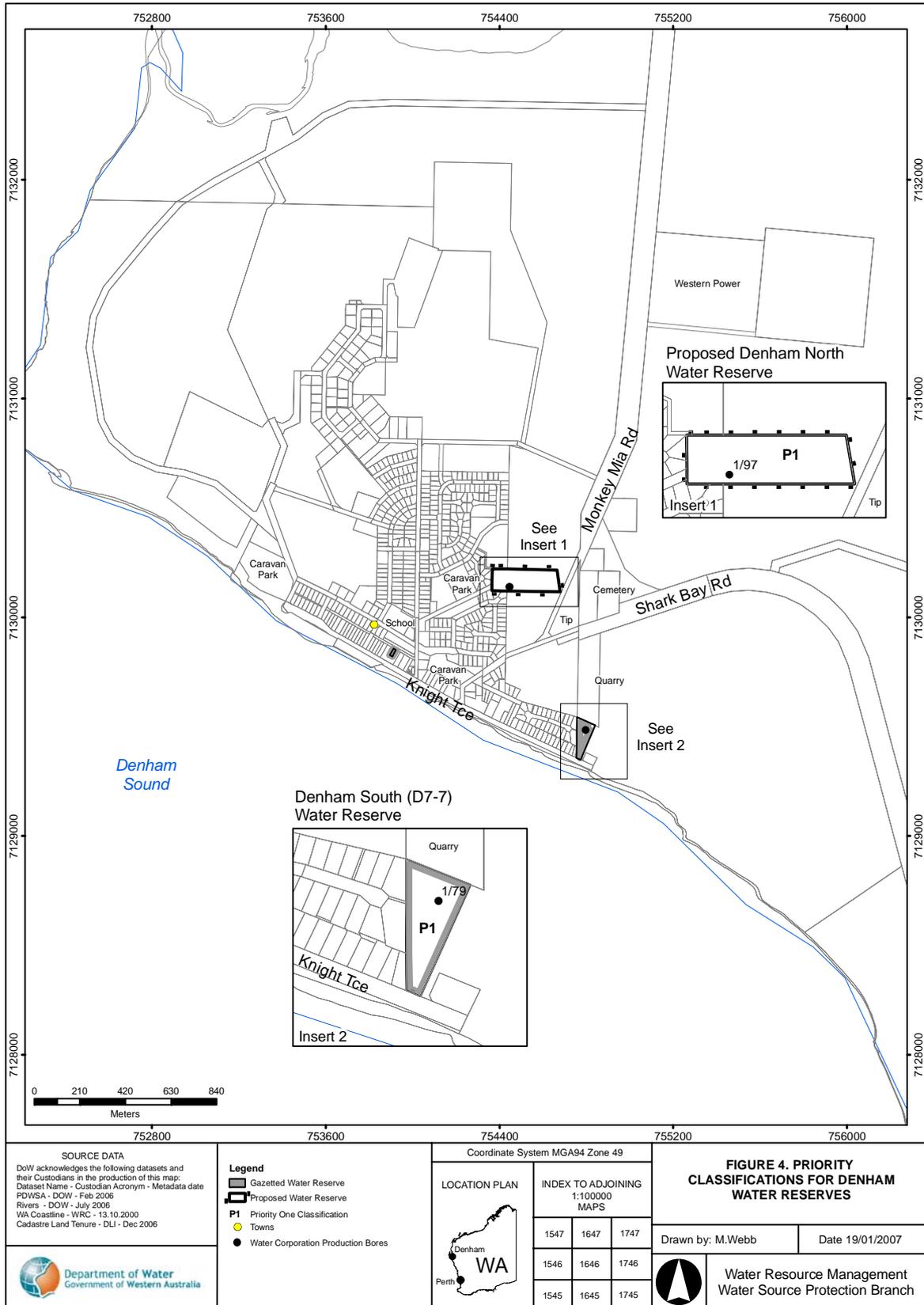


Figure 4 Priority classifications for the proposed Denham North and Denham South (D7-7) Water Reserves.

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 ensure 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 therefore appropriate that the proposed Denham North and Denham South (D7-7) Water Reserves and their priority classification be recognised in the Shire of Shark Bay's Town Planning Scheme. Any development proposals within the Denham Water Reserves that are inconsistent with the Department of Water's Water Quality Protection Note – *Land Use Compatibility in Public Drinking Water Source Areas* should be referred to the Department of Water for advice and recommendations.

4.5 Best management practices

The adoption of best management practices for land uses will continue to be encouraged to help protect the State's water resources. On freehold land, the Department of Water aims to work with landowners to achieve best management practices for water quality protection through the provision of management advice, and assistance to seek funding if required.

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. The guidelines help managers reduce the risk of their operations causing unacceptable environmental impacts. They are recommended as best practice for water quality protection.

Education and awareness (eg signage and information material) is a key mechanism for water quality protection, especially for those people visiting the area who are unfamiliar with the proposed Denham North and Denham South (D7-7) Water Reserves. A brochure will be produced once this Plan is endorsed, describing the proposed Denham North and Denham South (D7-7) Water Reserves, their location and the main threats to water quality protection. This brochure will be made available to the community and will serve to inform people in simple terms about the drinking water source and its protection.

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 on-ground surveillance of land use activities in Public Drinking Water Source Areas as an important water quality protection mechanism.

Signs are erected around PDWSAs to educate the public and to advice of activities that are prohibited or regulated. This Plan recommends that delegation of surveillance and By-law enforcement to the Water Corporation is continued.

4.7 Emergency response

Escape of chemicals during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The Shire of Shark Bay's Local Emergency Management Advisory Committee (LEMAC) through the Mid West-Gascoyne Emergency Management District should be familiar with the location and purpose of the proposed Denham North and Denham South (D7-7) Water Reserves. A locality plan should be provided to the Fire and Rescue Services headquarters for the Hazardous Materials Emergency Advisory Team (HAZMAT). The Water Corporation should have an advisory role to any HAZMAT incident in the proposed Denham North and Denham South (D7-7) Water Reserves.

Personnel who deal with WESTPLAN – HAZMAT (Western Australian Plan for Hazardous Materials) incidents within the area should have access to a map of the proposed Denham North and Denham South (D7-7) Water Reserves.

4.8 Recommended protection strategies

Due to the confined nature of the aquifer, existing and future land uses surrounding the proposed Denham North and existing Denham South (D7-7) Water Reserves should have a negligible effect on the public drinking water source. The recommended protection strategy for these Water Reserves is to assign a P1 classification and to implement best management practices in maintaining existing bores and construction of any future bores.

5 Recommendations

- 1 The boundary of the proposed Denham North Water Reserve should be proclaimed under the *Country Areas Water Supply Act 1947 (Department of Water)*.
- 2 Denham D7-2 Water Reserve should be deproclaimed under the provisions of the *Country Areas Water Supply Act 1947 (Department of Water)*.
- 3 The Shire of Shark Bay's Town Planning Scheme should incorporate this Plan and reflect the identified Denham North and Denham South (D7-7) Water Reserves boundaries and their Priority 1 classification (*Shire of Shark Bay*).
- 4 Applications to construct a bore and/or extract groundwater in close proximity to the proposed Denham North and Denham South (D7-7) Water Reserves 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*).
- 5 Incidents covered by WESTPLAN – HAZMAT in the proposed Denham North and Denham South (D7-7) Water Reserves should be addressed through the following:
 - The Mid West-Gascoyne LEMAC should be aware of the location and purpose of the proposed Denham North and Denham South (D7-7) Water Reserves.
 - The locality plan for the proposed Denham North and Denham South (D7-7) Water Reserves is provided to the Fire and Rescue headquarters for the HAZMAT Emergency Advisory Team.
 - The Water Corporation continues to provide an advisory role during incidents in the proposed Denham North and Denham South (D7-7) Water Reserves.
 - Personnel dealing with WESTPLAN – HAZMAT incidents in the area have ready access to a locality map of the proposed Denham North and Denham South (D7-7) Water Reserves.

(*Department of Water, Water Corporation*)
- 6 The surveillance program should be maintained to identify incompatible land uses or any potential threats to the proposed Denham North and Denham South (D7-7) Water Reserves (*Water Corporation*).
- 7 Signs located along the boundary of the proposed Denham North and Denham South (D7-7) Water Reserves should be maintained to define the location and promote awareness of the need to protect drinking water quality. (*Water Corporation*).
- 8 A full review of this Plan should be undertaken after five years (*Department of Water*).

Appendices

Appendix A - Summary of submissions

The following table is a summary of the submissions received from the 2007 release of the Draft Plan, the current status of that issue, and how they have been addressed in this current Plan.

Summary of submissions from the 2007 release of the Draft Plan

Issue raised	Current Status	Response in Plan/Comment
That the identification of Water Treatment Plant buffer zones be included within the DWSPP	The buffer area for the Denham North Water Reserve relates to the chlorine dosing plant at the site. It is a hazardous chemical storage buffer for the purpose of assessing advising land uses within a defined zone for town planning purposes. It doesn't relate to the water source protection address by the Draft Drinking Water Source Protection Plan.	No change in plan.
What plans have been made to accommodate future growth within the Shire and within the treatment plant to accommodate fluoridation?	The current source is considered adequate to meet the future demand. There is no likelihood of fluoridation of the Denham Town Water Supply until the town size grows to the trigger level and the Department of Health sets the requirement subsequent to pressure from the community which is usually sponsored by dentists.	Future growth of the Shire has been addressed in Section 1.4. No change in Plan in regards to fluoridation.
Clarification of the Denham North Water Reserve area and buffer zone requirements.	The Denham North Water Reserve is limited to the boundary of the Water Corporation property – Lot 39 Monkey Mia Road. The buffer area for the dosing plant is a defined area determined relative to the location and size/type of the dosing plant.	No change in Plan.
Consideration to be given to relocating the site of the Water Reserve to the east side of Monkey Mia Road given the possible impact on private land.	No plans to relocated water reserve. Water Corporation owns the land for a Treatment Plant and tank compound, bore 1/97 is located within this land. The elevated site is also essential to provide reticulation pressure to meet the Water Corporations standards to satisfy their Customer Charter. No impact on private land in regards to the Water Reserve as all current land uses can continue.	No change in Plan.

Issue raised	Current Status	Response in Plan/Comment
Clarification of the status of the D7-2 Water Reserve given this site is portion of the Shark Bay World Heritage Discovery Centre block.	Proposing to deproclaim the D7-2 Water Reserve due to the fact that there is no longer a production bore being used in the Water Reserve and therefore no protective measures are needed.	Already stated in Section 4.2 and Recommendation 2.

Appendix B - Water quality

The Water Corporation has monitored the raw (source) water quality from Denham in accordance with the Australian Drinking Water Guidelines (ADWG) and interpretations agreed to with the Department of Health. The raw water is regularly monitored for:

- a. aesthetic related characteristics – (Non-Health Related)
- b. health related characteristics
 - health related chemicals; and
 - microbiological contaminants.

Following is data representative of the quality of raw water from Denham borefield. 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 customers 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. For more information on the quality of drinking water supplied to Denham refer to the most recent Water Corporation Drinking Water Quality Annual Report at <www.watercorporation.com.au> > Publications > Annual Reports > Drinking Water Quality Annual Report.

Aesthetic related characteristics

Aesthetic water quality analyses for raw water from Denham borefield are summarised in the following table.

The values are taken from ongoing monitoring for the period January 2002 to April 2007. All values are in milligrams per litre (mg/L) unless stated otherwise. Any water quality parameters that have been detected are reported, those that have on occasion exceeded the ADWG are shaded.

Aesthetic related detections for Denham borefield.

Parameter	Units	ADWG Aesthetic Guideline Value*	Range of Monitored Values		
			Min-Max Med		Borefield Raw Source
			Bore 1/97	Bore 3 (1/79)	
Aluminium unfiltered	mg/L	-	<0.008 <0.008	<0.008 <0.008	<0.008 - 0.018 <0.008
Chloride [†]	mg/L	250	2280 - 2490 2370	1930 - 2450 2080	2270 - 2400 2335
Colour - True	TCU	15	<1 - 4 <1	<1 - 2 <1	<1 - 12 1
Hardness as CaCO ₃ [†]	mg/L	200	980 - 1060 1000	815 - 1080 879	981 - 1020 1000.5
Iron unfiltered	mg/L	0.3	1.4 - 2.2 1.8	0.36 - 2.2 1.6	<0.003 - 2.6 1.8
Manganese unfiltered	mg/L	0.1	0.065 - 0.08 0.07	0.075 - 0.101 0.085	<0.002 - 0.085 0.075
Sodium [†]	mg/L	180	1270 - 1420 1380	1140 - 1460 1400	1280 - 1420 1350
Sulphate [†]	mg/L	250	655 - 735 665	605 - 785 710	650 - 665 657.5
TFSS [†]	mg/L	500	4880 - 5200 5040	4280 - 5340 4660	4880 - 5100 4990
Turbidity	NTU	5	5.2 - 33 31	4.4 - 33 24	<0.1 - 60 25.5
pH	NOUNIT	6.5 - 8.5	6.9 - 7.01 6.94	6.91 - 7.49 7.19	6.84 - 7.79 6.955
Conductivity @ 25°C	mS/m	-	711 - 870 806	698 - 780 747	680 - 870 830

* 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 5 or less sampling occasions

Health related characteristics

Health parameters

Raw water from Denham borefield is analysed for health related chemicals including inorganics, heavy metals, industrial hydrocarbons and pesticides. Health related water quality parameters that have been measured at detectable levels in the source between January 2002 and April 2007 are summarised in the following table. Any parameters that have on occasion exceeded the ADWG are shaded.

Health related detections for Denham borefield.

Parameter	Units	ADWG Aesthetic Guideline Value*	Range of Monitored Values [†]		
			Min-Max Med		Borefield Raw Source
			Bore 1/97	Bore 3 (1/79)	
Barium	mg/L	0.7	-	-	0.04 - 0.045 0.0425
Boron	mg/L	4	-	-	1.4 - 1.6 1.5
Molybdenum	mg/L	0.05	-	-	0.003 0.003
Nitrate as nitrogen	mg/L	11.29	-	-	<0.002 - 0.022 <0.012
Nitrite as nitrogen	mg/L	0.91	-	-	<0.002 - 0.008 <0.005
Nitrite plus nitrate as N	mg/L	11.29	<0.05 <0.05	<0.002 - 0.19 <0.05	0.007 0.007
Fluoride	mg/L	1.5	-	-	0.8 - 0.85 0.8

* A health guideline value is the concentration or measure of a water quality characteristic that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHRMC & ARMCANZ, 1996).

[†] All water quality data observed from 5 or less sampling occasions

Microbiological contaminants

Microbiological testing of raw water samples from Denham borefield is currently conducted on a monthly basis. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw water from warm-blooded animals. A detection of *Escherichia coli* in raw water abstracted from any bore may indicate possible contamination of faecal material through ingress in the bore, or recharge through the aquifer (depending on aquifer type).

During the review period of January 2002 to April 2007, positive *Escherichia coli* counts were recorded in 4.5 per cent of samples. This low occurrence of *Escherichia coli* detections is indicative of minimal contamination of the groundwater from faecal sources.

Appendix C - Photographs



Photo 1 Bore 1/79 located in Denham South (D7-7) Water Reserve



Photo 2 Bore 1/97 located in the proposed Denham North Water Reserve

Glossary

Abstraction	The pumping of groundwater from an aquifer.
ADWG	The Australian Drinking Water Guidelines, outlining guideline criteria for the quality of drinking water in Australia.
Aesthetic guideline	NHMRC guideline level ascribed to acceptable aesthetic qualities of drinking water such as taste, smell, colour and temperature.
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 licence, usually specified in kilolitres per year (kL/a).
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.
Confined aquifer	An aquifer that is confined between non-porous rock formations (such as shale and siltstone) and therefore contains water under pressure.
GL	Gigalitres (1000 000 000 litres)
HAZMAT	Hazardous Materials
Hydrogeology	The study of groundwater, especially relating to the distribution of aquifers, groundwater flow and groundwater quality.
kL	Kilolitres (1000 litres)
km	Kilometres (1000 metres)
km²	Square kilometres (a measure of area)
LEMAC	Local Emergency Management Advisory Committee

m	Metres
mg/L	Milligrams per litre (0.001 grams per litre)
ML	Megalitres (1 000 000 litres)
mm	Millimetres
MPN	Most probable number (a measure of microbiological contamination).
NHMRC	National Health and Medical Research 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.
Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.
Public Drinking Water Source Area (PDWSA)	Includes all underground water pollution control areas, catchment areas and water reserves constituted under the <i>Metropolitan Water Supply Sewerage and Drainage Act 1909</i> and the <i>Country Areas Water Supply Act 1947</i> .
Recharge	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.
TCU	True colour units are a measure of colour in water.
TDS	Total dissolved salts, a measurement of ions in solution, such as salts in water.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes including drinking and discharge to the environment.
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 a 300 m or a 500 m protection zone 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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