



Department of Water
Government of Western Australia

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Brookton Happy Valley Water Reserve drinking water source protection plan

Brookton town water supply



Department of **Water**
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Brookton Happy Valley Water Reserve Drinking Water Source Protection Plan

Brookton Town Water Supply

Department of Water

Water Resource Protection Series

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Department of Water

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Preface

The Department of Water has prepared this Draft Drinking Water Source Protection Plan to report on the activities and risks to water quality within the Brookton Happy Valley Water Reserve and to recommend management strategies to address these risks.

The Australian Drinking Water Guidelines recommend a risk based, multiple barrier 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 surface water reservoirs and groundwater aquifers.

This plan details the location and boundary of the drinking water reserve, which provides potable water to the Brookton Town Water Supply. It describes the water supply system, discusses existing and future usage of the water source, identifies risks and recommends management approaches to protect water quality.

This plan should be used to guide State and local government land use planning decisions. It should be recognised in the Shire of Brookton Town Planning Scheme No 3, 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 Brookton Happy Valley 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	Assessment document prepared following water reserve survey and preliminary information gathering from government agency stakeholders.
2	Conduct stakeholder consultation	Advice sought from key stakeholders using the assessment as a tool for background 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 for public comment	Draft Plan released for a six week public consultation period.
5	<i>Publish Drinking Water Source Protection Plan</i>	<i>Final Plan published after considering advice received in submissions. Includes recommendations on how to protect the water reserve.</i>

Summary

Brookton Happy Valley Water Reserve is located approximately 138 km east - south east of Perth and about 8 km north of the town of Brookton. The town of Brookton services local rural industries that are based on sheep, cattle and wheat farming, and is the administrative centre for the Shire of Brookton. The Shire of Brookton has a population of approximately 600 residents.

This plan has been developed to protect drinking water quality for public health. The plan:

- identifies potential drinking water quality contamination risks from land use activities within the water reserve; and
- recommends strategies to manage these potential risks whilst recognising current land use rights.

The Happy Valley Water Reserve is one of two local water sources operated by the Water Corporation, which augments the public drinking water supply provided by the Great Southern Town Water Supply to the town of Brookton. The Brookton Happy Valley Water Reserve has 2 production bores (1/95 and 2/95) and 1 monitoring bore (3/78) located on privately owned land. Water Corporation has an agreement with the landholders for easement over the road accessing the bores, allowing Water Corporation officers access to the bore compounds for servicing and monitoring purposes. Bore 1/95 is located on freehold land, Avon location Lot 8523 and bore 2/95 and bore 3/78 are located on freehold land, Avon location Lot 10793.

The Brookton Happy Valley Water Reserve was proclaimed in 1982 under the *Country Areas Water Supply Act 1947* to ensure protection of the water source from potential contamination. The Happy Valley Groundwater Area was proclaimed in 1979 under the *Rights in Water and Irrigation Act 1914* to allocate groundwater resources within its boundaries to manage its sustainable use. Proclamation of a redefined boundary for the Brookton Happy Valley Water Reserve is proposed for this plan to more accurately reflect the hydrogeological boundary of the Brookton Happy Valley Water Reserve.

All of the land within the Brookton Happy Valley Water Reserve is in private ownership, animal grazing and broad hectare cropping are the dominant land uses. The following parcels of privately owned freehold land (Lot 10793, 8523, 6239 and 6384 (164)) are proposed to be managed for Priority 1 (P1) source protection. The management objective for P1 land is to maintain and preserve the highest water quality within the public drinking water source area, through (where reasonable) avoiding potentially contaminating land uses. However, existing approved land uses are allowed to continue with the expectation that best management practices will be adopted. Proposed future intensification of land uses will generally be considered incompatible with the objectives of P1 source protection.

The remainder of privately owned farming land within the water reserve is proposed to be classed Priority 2 (P2) source protection. Existing land uses are generally considered “Acceptable” under P2 classification. Future low intensity development consistent with farming practice is “Compatible with conditions”, the conditions of which include best management practices that are encouraged by the Department of Water.

1 Drinking water supply system

1.1 Existing water supply system

The Brookton Happy Valley Water Reserve (BHVWR) currently consists of 2 production bores and a monitoring bore that draw water from this locally recharged shallow, unconfined aquifer system (Figure 1). The bores are used to augment the water supply during the period of increased demand experienced during the summer months and usually operate between November and April. Water from BHVWR is pumped into Brookton Reservoir for storage before being piped to the Wabbing Hill transfer pump station and supplied to the town of Brookton. Supply from the BHVWR supplements the main town supply from Harris Reservoir, part of the Great Southern Town Water Supply (GSTWS). Winter surface water runoff flows into Brookton Reservoir are also used to augment the town water supply (Figure 2).

1.2 Water treatment

The raw water is chlorinated at the wellfield and re-chlorinated at Wabbing Hill transfer pump station before entering the Brookton reticulation system.

It should be recognised that although disinfection is an essential barrier used to ensure a safe, good quality drinking water supply, catchment management and water source protection are fundamental 'first barriers' for the protection of water quality. This approach is endorsed by the Australian Drinking Water Guidelines (ADWG) 2004 (NHMRC & ARMCANZ, 2004) and reflects a risk based, 'catchment to consumer' multiple barrier approach for the provision of safe drinking water to consumers.

1.3 Water Reserve details

1.3.1 Physiography

The BHVWR is contained within the Darling Range, which forms part of the Archaean Shield that is composed largely of granite with some linear belts of metamorphosed sedimentary and volcanic rocks, some isolated occurrences of which remain (Schofield, 1991). Thin dolerite intrusions occur abundantly in the basement rock.

Deep V-shaped valleys occur close to the Scarp, with thin soils and frequent rock outcrops. Further inland, valleys are broader and more U-shaped. Happy Valley is a typical example of the broader U-shaped valleys, which are poorly drained, often resulting in the presence of soaks in the valley bottoms.

The soil profile of the Darling Scarp consists of a typical weathered profile. The granite basement is overlain by matted to white kaolinitic clays which are in turn covered by a weathered laterite hard cap, shallow sands over sheet laterite, gravelly

duplex soils and grey sands often overly the laterite hard cap. Upland slopes comprise sandy loams in a gravel matrix with the gravels becoming finer grained down slope, sometimes grading into sandy yellow earths at the base of the slope. Happy Valley comprises soils that are valley infill deposits of sandy colluvium and alluvium.

1.3.2 Climate

Brookton experiences a Mediterranean style climate, characterised by warm, dry summers and cool, wet winters.

The long-term average annual rainfall for the water reserve is 460 mm. Most rain results from winter cold front systems that cross the south west of Western Australia between May and August.

1.3.3 Hydrogeology

The sandy colluvium and alluvium deposits at Happy Valley are of Tertiary to Quaternary age and overly a sequence of sandy clay and clayey sand formed through the total weathering of the Archaean basement (Haydon, 1990).

The aquifer is unconfined and comprises of alluvial sand deposited at the foot of the slope and extending up the slope into colluvial and alluvial sands. The town water supply bores draw groundwater from the sandy deposits on the northern side of the valley.

Production bore 1/95 was drilled to 12.83m below the surface and it is screened between 6.0 and 11.5m. Production bore 2/95 was drilled to 16m metres below the surface and is screened at a depth between 8.5 and 14.5. Bore 3/78 is currently used as a monitoring bore, it is located in close proximity to bore 2/95 and is drilled to a depth of 16.7m below the surface and screened between 9m to 15m.

Recharge occurs on the upper sandy slopes and results from direct infiltration of rainfall through the sands to valley sediments and as run-off from nearby slopes. Groundwater flows towards the streamline where it discharges in a west – north westerly direction into the swampy areas of the valley bottom.

The aquifer is unconfined and shallow which makes it highly vulnerable to contamination from land uses within BHVWR. Drainage from the southern part of the originally gazetted water reserve is saline and several of the small dams and excavations near bore 1/95 have become salty.

1.4 Future water supply requirements

There are no current plans to extend the Happy Valley wellfield or increase the capacity of Brookton Reservoir. A 3.0 megalitre (ML) water storage tank has been completed and will act as an enclosed storage facility for the GSTWS and Happy

Valley water supplies. Water from the tank will be pumped to the Wabbing Hill transfer station where it will be chlorinated and pumped into town for local supplies. The Water Corporation has determined that current supply from the GSTWS can meet existing and future increases in demand with current levels of supplementation from the two local sources.

It may be necessary at some stage to upgrade the GSTWS pipeline or construct a booster pump station if demand exceeds the current capacity of the Harris Reservoir delivery main. Bore 3/78 is currently being used as a monitoring bore, however, it is equipped and has the potential to be used as a production bore in the future if required. The plan recognises the potential for 3/78 to become a production bore and has allocated a WHPZ to protect the bore for future use.

1.5 Protection and allocation

1.5.1 Existing water source protection

The BHVWR was proclaimed in 1982 under the *Country Areas Water Supply (CAWS) Act 1947* to ensure protection of the water source from potential contamination. The Water Reserve is shown in Figure 3.

There is no existing priority protection classification assigned to the BHVWR, this plan proposes to allocate P1 and P2 source protection classification to protect the water source from potential contaminants associated with existing and proposed land uses.

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 (RIWI) Act 1914*. Under this Act, the right to use and control surface and groundwater is vested with the Crown. This Act requires a licence to draw water from surface water and groundwater areas proclaimed under the Act (except for domestic and stock use) and all artesian wells throughout the State.

The Brookton Happy Valley Groundwater Area was proclaimed in 1979 under the *RIWI Act 1914* to allocate groundwater resources within its boundaries and to manage its sustainable use. The Water Corporation is licensed by the Department to draw 85 megalitres/year from bore 1/95 and 3/78 and 25 megalitres/year from bore 2/95, for public water supply purposes. The Water Corporation can exceed this level of extraction in a year provided the average consumption over three years does not exceed the limit set by this Department. The current number of water services in Brookton is 338 and total scheme consumption in 2002/03 was 137 megalitres. Draw from the BHVWS in 2002/03 was close to 65 megalitres.

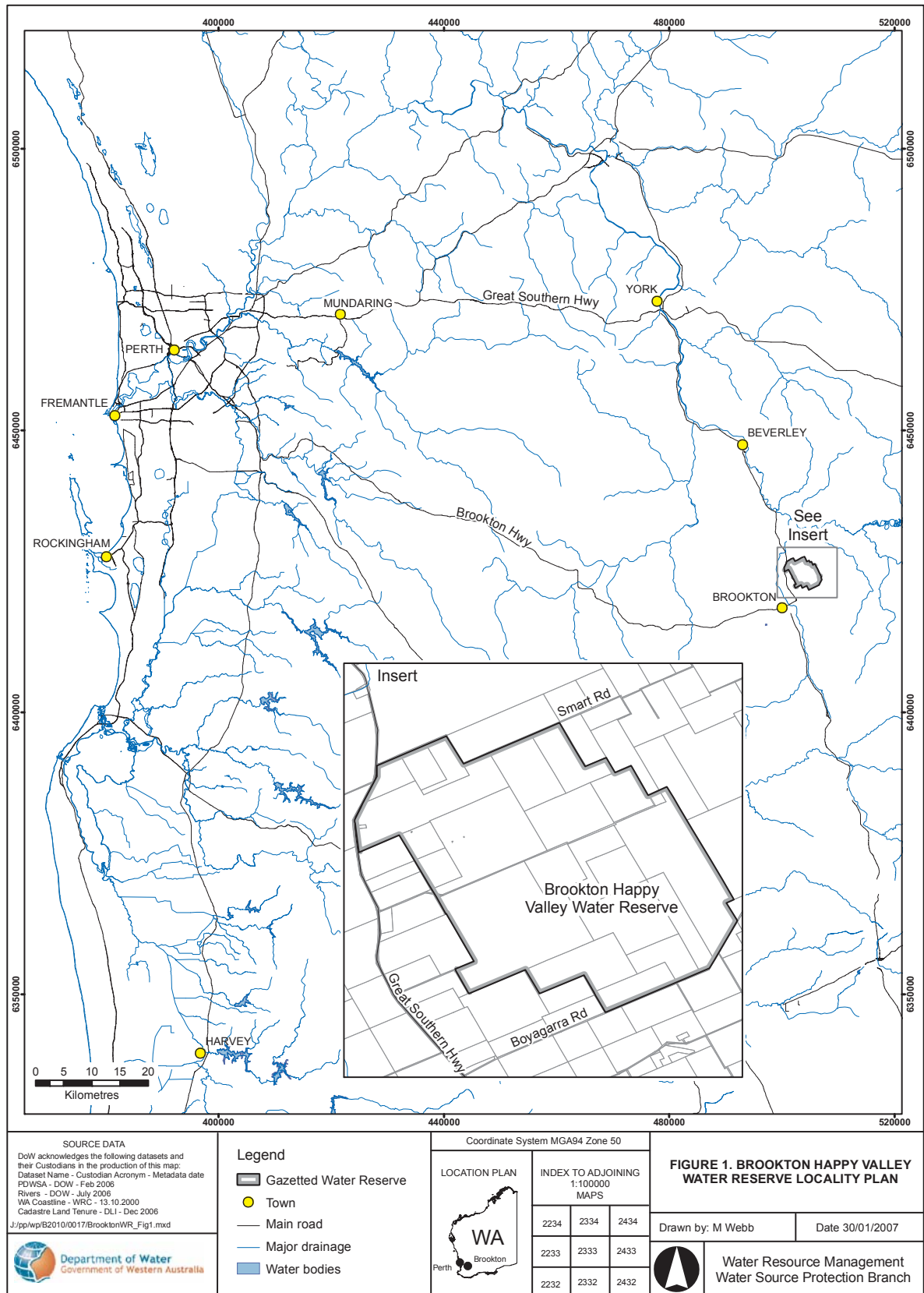


Figure 1 Brookton Happy Valley Water Reserve locality map

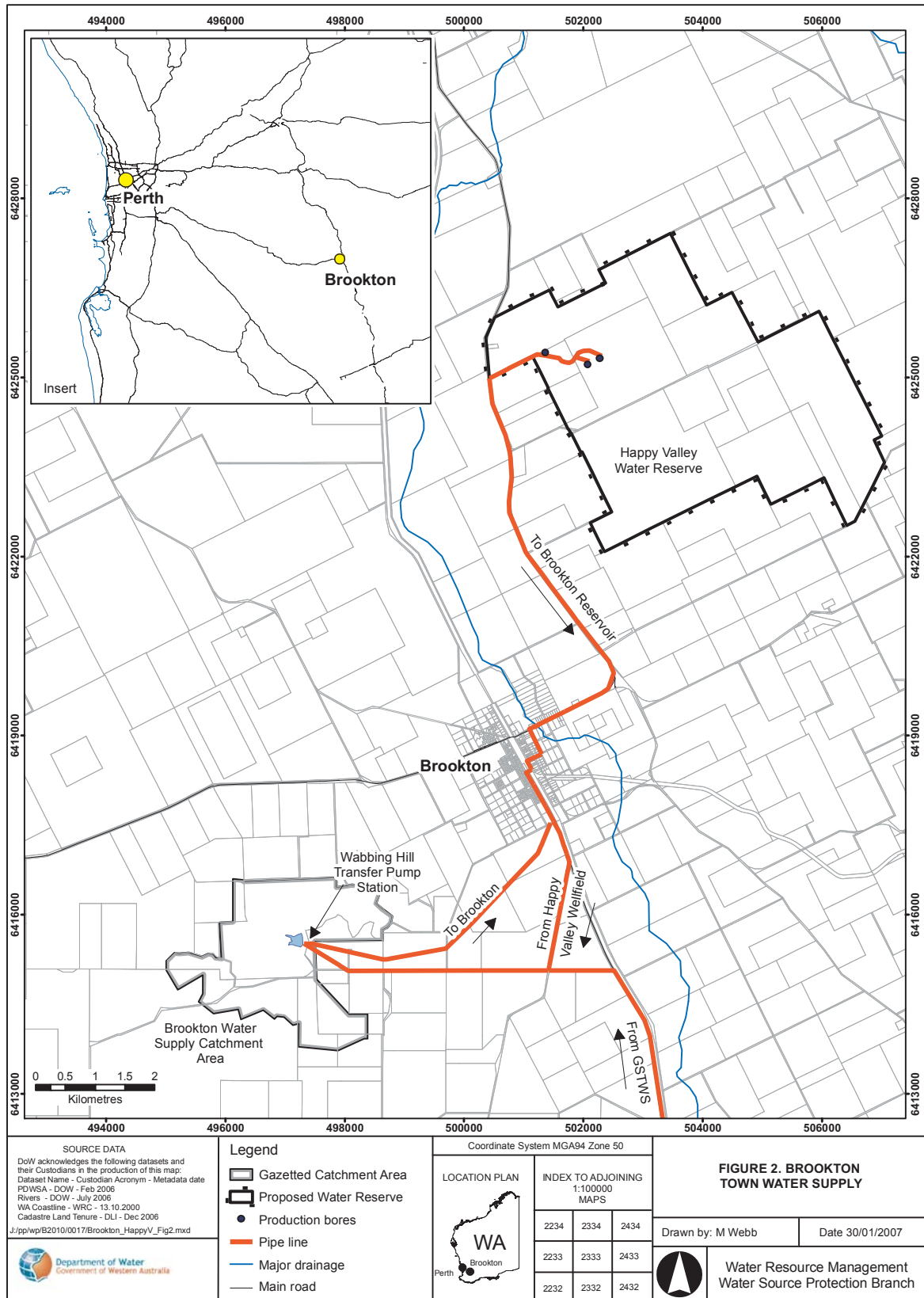


Figure 2 Brookton Town Water Supply Scheme

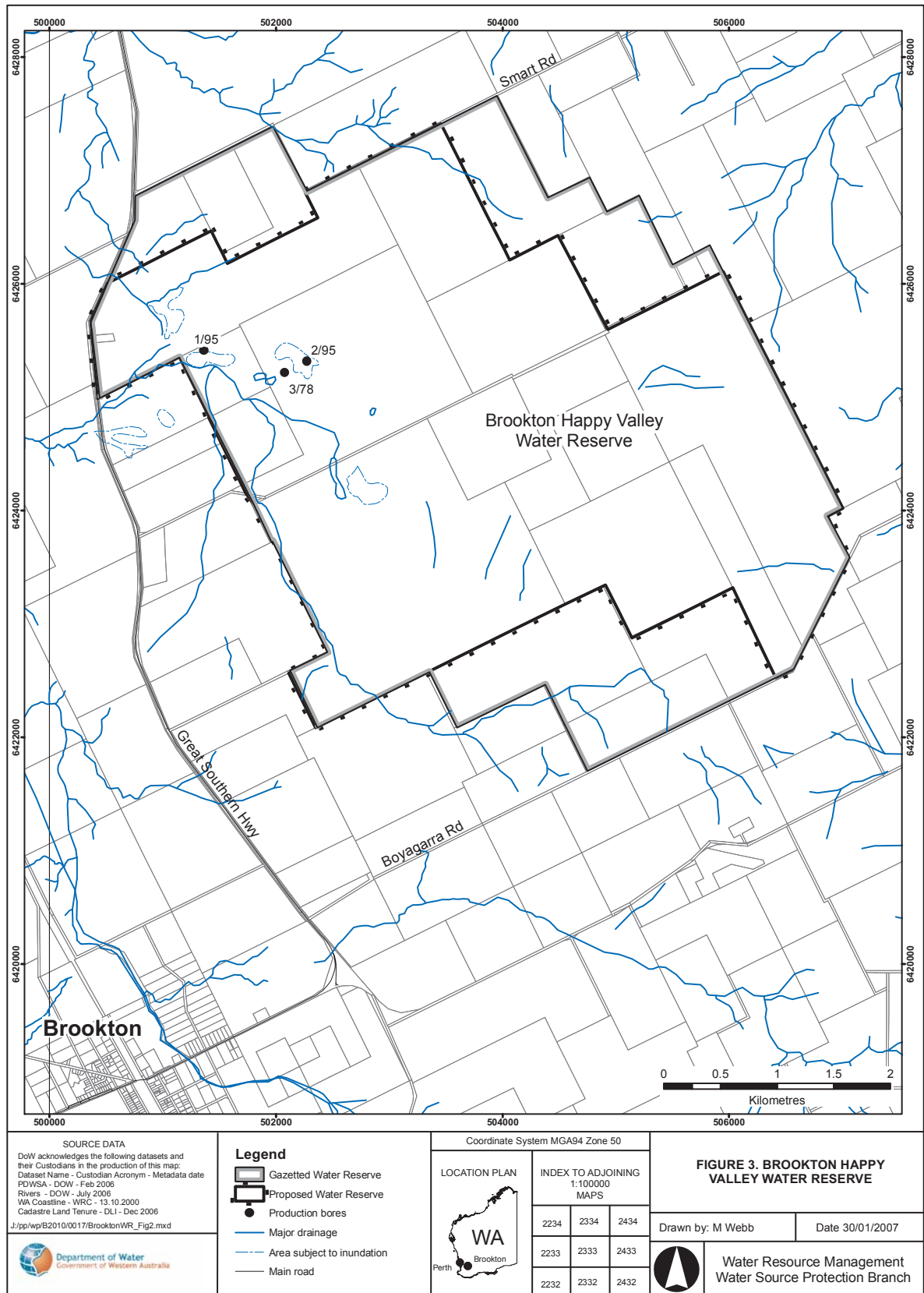


Figure 3 Brookton Happy Valley Water Reserve

2 Water quality monitoring and contamination risks

The Water Corporation regularly monitors the raw water quality from the BHVWR for microbiological contamination, health related and aesthetic (non-health related) characteristics in accordance with the ADWG and the program set out in the Brookton Town Water Supply Water Resource Management Operation Strategy (Kolman, 2003). 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 BHVWR from January 2002 to February 2007 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 > Downloads > most recent Annual Report.

Contamination risks relevant to the BHVWR are described below.

2.1 Microbiological contaminants

Pathogens are types of micro-organisms that are capable of causing diseases. These include bacteria (such as *Escherichia coli*), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses. In water supplies the pathogens of concern that can cause illness, such as stomach upset, diarrhoea and even death, are mostly found in the faeces of humans and domestic animals. Thermotolerant coliform 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 (ie humans and domestic animals, such as dogs or cattle); their subsequent transfer to and movement in the water source; and the ability of the pathogen to survive in the water source.

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), primarily through the transfer of faecal material (even a very small amount can cause contamination), or indirectly through their presence.

There are a number of pathogens that are commonly known to contaminate water supplies worldwide. These include bacteria (eg *Salmonella*, *Escherichia coli* and *Cholera*), parasites (eg *Cryptosporidium*, *Giardia*) and viruses. 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).

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 & ARMCANZ, 2004).

The effects of pathogen contamination in drinking water varies significantly, ranging from illness to death, as was the case in Walkerton, Canada in 2000 where seven people died due to contamination by *Escherichia coli* and *Campylobacter* in the town water source and supply. Preventing the introduction of pathogens into the water source is the most effective barrier in avoiding this public health risk.

During the reviewed period of January 2002 to February 2007, positive *Escherichia coli* counts were recorded in < 3% of samples collected from the borefield. The low occurrence of *Escherichia coli* detections may be indicative of minimal contamination of the groundwater from faecal sources (refer to Appendix A).

2.2 Health-related characteristics

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, rodenticides and miticides. Contamination of a drinking water source by pesticides may occur as a result of accidental spills, incorrect or over use and leakage from storage areas. In such cases, prompt action is required to notify relevant authorities and clean up the spill. No pesticides have been detected in the bores within the BHVWR to date.

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 3 months old being most susceptible (NHMRC & NRMMC, 2004).

Hydrocarbons (fuels, oils, solvents) 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 associated with but not limited to; vehicle accidents, refuelling and leakage from storage areas. There have been no hydrocarbons detected in groundwater within the BHVWR to date.

2.3 Aesthetic characteristics

Impurities in drinking water can affect the aesthetic qualities of water such as 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 & NRMCC, 2004).

Iron and dissolved organic matter can affect the colour and appearance of water, and salinity can affect the taste. The ADWG 2004 set guideline values for water quality characteristics to meet aesthetic requirements of consumers.

Some properties such as pH can contribute to the corrosion and encrustation of pipes. The ADWG 2004 also sets out aesthetic guidelines for these types of water quality characteristics.

Raw water samples taken from BHVWR during January 2002 – February 2007 indicate that the pH is slightly below the ADWG 2004 aesthetic guidelines recommended range of 6.5 - 8.5, with median values from bore's 1/95 and 2/95 of 5.955 – 5.96 respectively. Some of the chloride, sodium and Total Filtered Suspended Solids (TFSS) values have their upper range slightly higher than is recommended in the ADWG 2004 aesthetic guidelines (non health related).

2.4 Groundwater bores

Under the provisions of sections 26D and 5C of the *RIWI Act 1914*, 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 P1 source area of the BHVWR is located within the Brookton Happy Valley 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 nearby, it may abstract 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 1914*.

All bores should be constructed in accordance with *Minimum Construction Requirements for Water Bores in Australia* (National Minimum Bore Specifications Committee 2003).

3 Land use and contamination risk

3.1 Existing land uses

The BHVWR is located on rural zoned private land, which is used for cereal cropping and sheep and cattle grazing. There are several dams throughout the wellfield (Figure 4) that have been excavated for use as stock watering dams. One dam is located approximately 25 metres downstream of production bore 2/95 and another is approximately 10 metres upstream of bore 1/95. These dams represent a high management priority due to the shallow nature of the aquifer, regular use by cattle and proximity to the bores. The dams are excavated soaks and are therefore expressions of the groundwater.

The uncontrolled movement of cattle around the wellfield poses a high risk of pathogen and nutrient contamination. Accumulated deposition of animal faeces within the capture zones of the production bores provides the greatest long-term risk to the source. Cereal cropping also occurs close to the bores. Water quality monitoring indicates that nitrate levels are within guideline values and there is no evidence of pesticides being present in the raw water quality data.

A farm house located approximately 500 metres south of bore 1/95 and 500 metres north of bore 2/95 is used intermittently by the landowner for temporary lodgings on his visits to the property. The farm house includes ablution and toilet facilities connected to a septic disposal system. Adjoining the house is a farm shed containing some farming machinery and farm chemical storage and equipment. In addition, there is a stockyard that is used for loading cattle ready for transport to market and weaning of young animals. Although the stockyard, shed and house are only transiently used, their close proximity to the production bores and shallow depth to the groundwater table result in these land uses being classified as a high risk to water quality.

There are natural wetlands immediately downstream of bore 1/95, 2/95 and 3/78 that are reflective of the lands natural drainage (see figure 4). The streamline within the wetland downstream of bore 1/95 has been excavated to drain the wetland and increase the flow of fresh water from the aquifer. This has resulted in the increased flow of fresh water across the land from the Water Reserve into adjoining private land. The wetlands in question have been referred to the Department of Environment and Conservation for assessment, to determine the appropriate environmental value and protection classification of the wetlands.

Adjacent and downstream of bore 1/95 are a series of 20 dams that were originally established for aquaculture approximately ten years ago (Figure 4). The dams were designed to intercept surface water flow from a creek line that drains water from the southern section of the water reserve.

The distance from the bore to the closest dam is approximately 150 metres and approximately 600 metres away from the furthest dam.

The dams were also designed so that fresh water flowing out of the aquifer could pass through the dams and discharge to rejoin the natural flow path of the stream line, therefore, maintaining fresh water within the dams. Modifications of the stream drainage line has resulted in only salt water entering the dams as fresh water is now diverted across the land and away from the dams. As a consequence the dams act as evaporation basins storing and accumulating salt. The drainage of the wetland has increased the discharge from the aquifer and increased the potential risk of contaminating the aquifer through dredging activities. This has the potential to compromise the water quality in the aquifer through enhancing direct infiltration of salt, nutrients and pathogens.

The dams present a high risk to the aquifer as they are excavations into the groundwater system (soaks) and are accumulating salt. The close proximity to bore 1/95 increases the risk of contamination during pumping which may result in the movement of saline water towards the bore.

Land planning should ensure that further intensification of the farmland within the Brookton Happy Valley Water Reserve is consistent with rural zoned private land under the town planning scheme. Best management practices should be adopted to minimise contamination risks posed by current land uses. Advice and recommended protection strategies proposed to manage the risks posed by existing land uses are provided in Table 1.

3.2 Proposed land uses

Recently, a large number of tagasaste (200 Ha, 200,000 plants) were planted within Lot 10793 upstream of bore 2/95. This is considered to be a high risk management priority for the protection of the water quality within the aquifer. Tagasaste is used as a fodder for cattle and livestock and provides a highly nutritious food source. However, tagasaste is also known to significantly lower the water table and has the potential to increase nitrate concentrations in the groundwater.

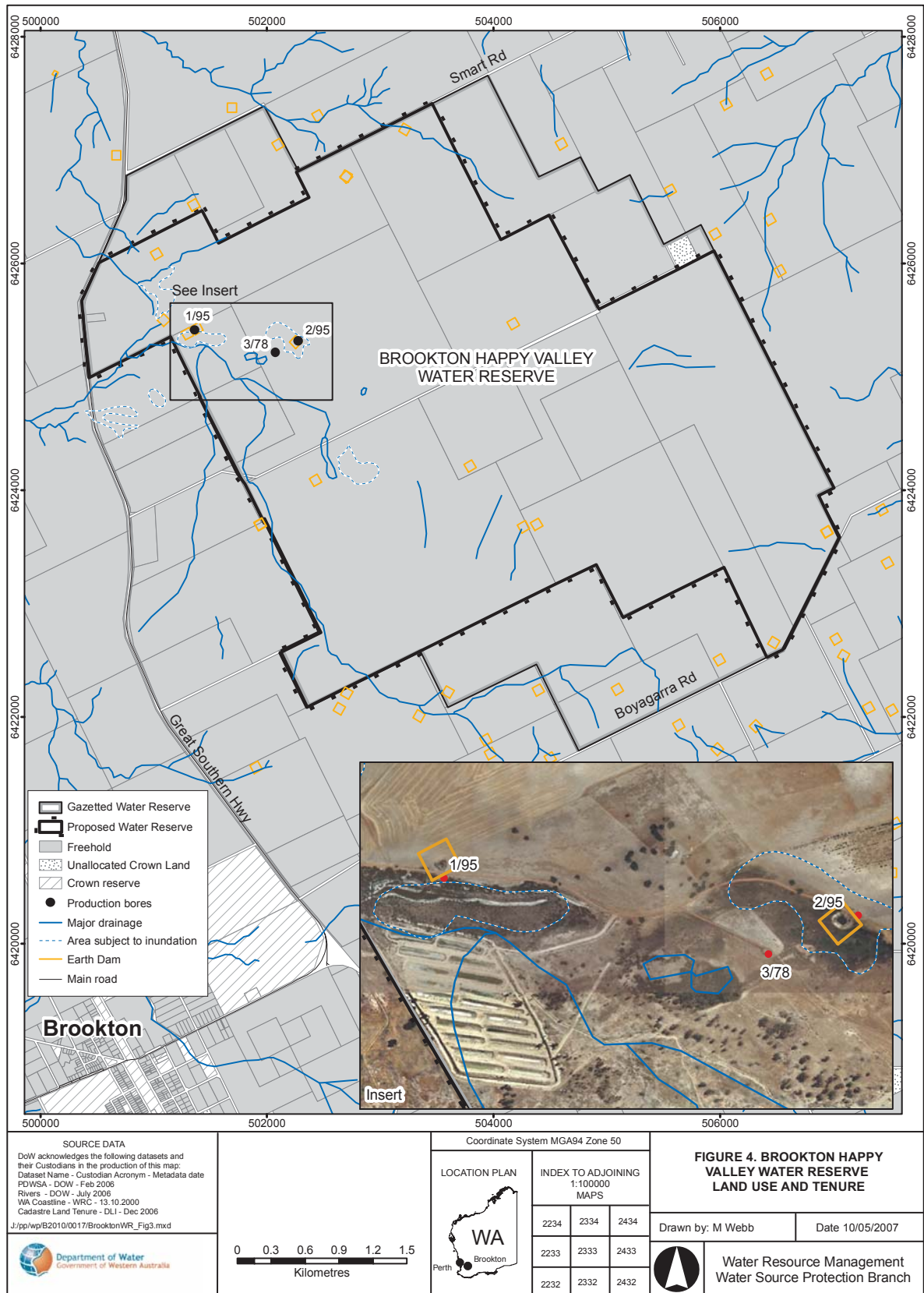


Figure 4 Land use and activities in the Brookton Happy Valley Water Reserve

4 Catchment protection strategy

4.1 Protection objectives

The protection of a PDWSA by the Department of Water requires the development of a drinking water protection plan for the source, consistent with government policy.

The preparation of this Drinking Water Source Protection Plan (DWSPP) forms part of the 'multiple barrier' approach for the protection of public drinking water sources from potential contamination. The strategies used to protect PDWSAs in this Plan recognise the rights of existing and approved land uses and activities. The management of existing land uses within the water reserve should aim to maintain and where possible improve water quality standards for the benefit of the local drinking water supply.

4.2 Proclaimed area

The current BHVWR was proclaimed in 1982 under the *CAWS Act 1947* to ensure protection of the water source from potential contamination. A review of the boundary has been undertaken and a reduced Water Reserve that will reflect the groundwater recharge area for the Brookton Happy Valley Water reserve is shown in Figure 3.

4.3 Priority classifications

An explanation of priority classifications and the land use compatibility associated with each priority classification can be viewed on the Departments website and follow the links: <http://www.water.wa.gov.au> > Drinking Water > Publications > Water Quality Protection Notes.

There are no existing priority classification assigned to the Water Reserve. This DWSPP has assigned priority classification to areas that are within the direct drainage line of the BHVWR (see Figure 4).

The BHVWR is located over separately owned private land parcels. Lot 10793, 8523, 6239 and 6384 are proposed to be classed priority 1 source protection with the objective of avoiding all risks to the water source. These land parcels will be given a higher priority classification as they are located within the direct recharge area of the aquifer. Priority 1 source protection is the highest level of protection that can be placed on private land and will enable the Department to consider purchasing the land in the future to preserve and protect the water source.

There is a Water Corporation easement on the access roads to the bores and around the bore compounds, that allows Water Corporation access to the bores.

The remainder of private farm land within the Water Reserve is proposed to be classified for Priority 2 source protection to minimise contamination risks to the water source from existing rural land uses.

4.4 Protection zones

A 500m wellhead protection zone will be established around all three bores in the BHVWR see Figure 5.

The protection zones will ensure the value of water for public drinking water supply is properly recognised. Best management practice of land use activities in these zones will be recommended. The Department of Water and Water corporation will work with land owners to achieve this objective. As discussed above, the Department has approached the land owners under the proposed P1 source area to determine if they are willing to enter into land purchase negotiations. As of the date of this publication, negotiation with the private landowners is continuing.

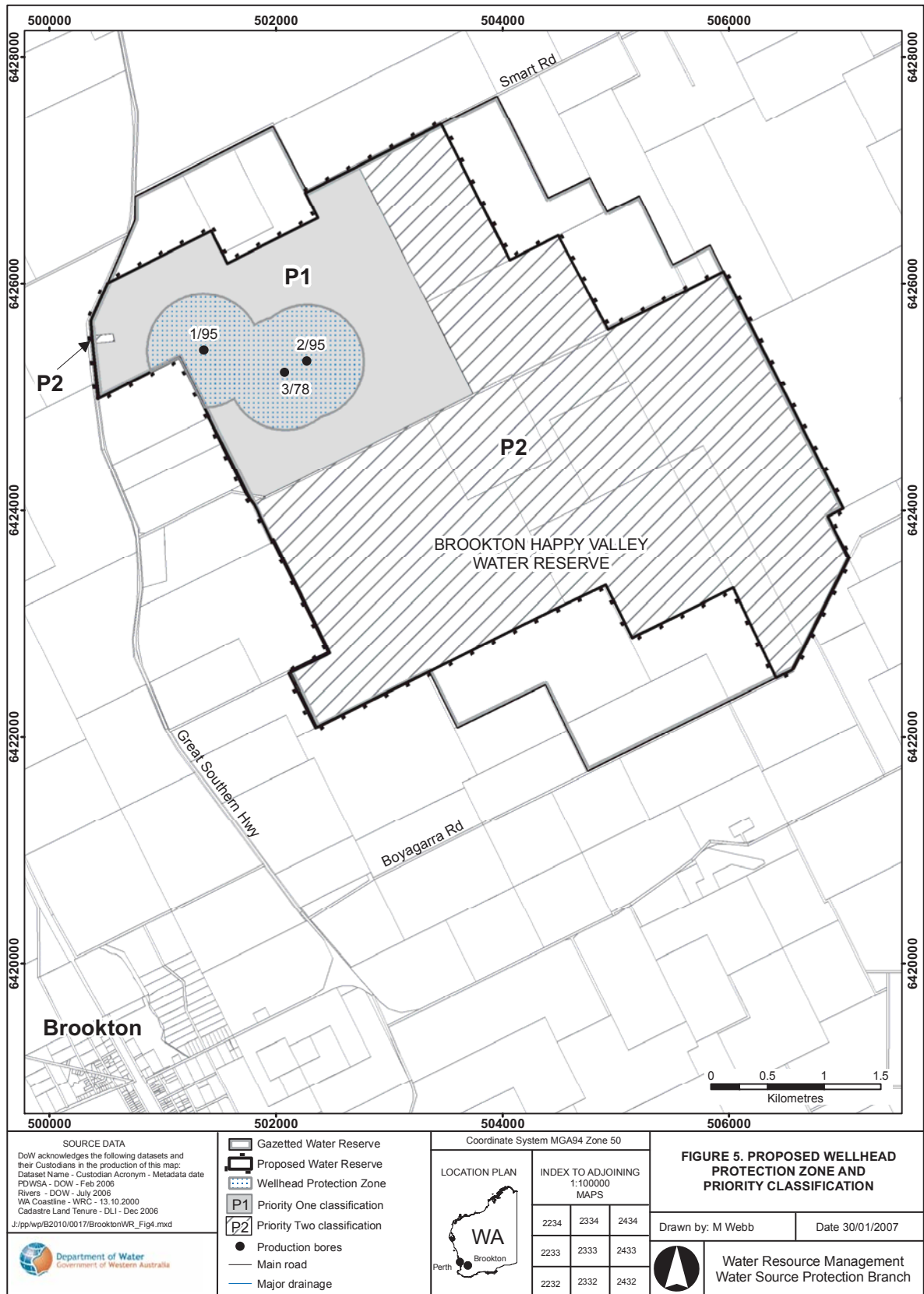


Figure 5 Priority classifications and protection zones for Brookton Happy Valley Water Reserve

4.5 Land use planning

It is recognised under the State Planning Strategy (Western Australian Planning Commission, 1997) that the establishment of appropriate protection mechanisms in statutory land use planning processes is necessary to secure the long-term protection of drinking water sources. As outlined in *Statement of Planning Policy No.2.7: Public Drinking Water Source Policy* (Western Australian Planning Commission, 2003) it is therefore appropriate that the BHVWR Well Head Protection Zones and priority classifications be recognised in the Shire of Brookton's Town Planning Scheme No 3. Any development proposals that are inconsistent with the Land Use Compatible Table or by-laws applicable to the water reserve should be referred to the Department of Water for assessment.

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 protection of water quality. 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.

There are guidelines 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 *WQPN Land Use Compatibility in Public Drinking Water Source Areas*, *WQPN 1 Agriculture: dryland crops near sensitive water resources* and *WQPN 80 Stockyards*, which are listed in the references and recommended reading section. 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 BHVWR. A brochure will be produced once this Plan is published, describing the BHVWR, its 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 *CAWS 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 PDWSA as an important water quality protection

mechanism. Surveillance is also important in raising the general level of awareness of the need to protect water quality.

Signs are erected 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 Brookton Local Emergency Management Committee (LEMC) through the Shire of Brookton's Emergency Management District should be familiar with the location and purpose of the BHVWR. The designation of local governments to LEMCs as it currently stands is listed in the Western Australian Emergency Management Arrangements Policy Statement No. 7

When regulations are approved, there might be a small change. The regulations can be found at <http://www.slp.wa.gov.au/index.html>. 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 BHVWR.

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

4.8 Implementation of this plan

Table 1 identifies the potential water quality risks associated with existing land uses in the BHVWR and recommends protection strategies to minimise these risks.

Following publication of the final BHVWR Drinking Water Source Protection Plan, an Implementation Strategy will be drawn up based on the recommendations in Table 1. It will describe time frames for the recommended protection strategies and identify the responsible stakeholders. This is reflected in the Recommendations section of this plan.

Table 1 Land use, potential water quality risks and recommended strategies

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
<p>Broad Acre Intensive grazing on P1 land:</p> <ul style="list-style-type: none"> Cattle 	<ul style="list-style-type: none"> Pathogens from animal faeces. Nutrients associated with pesticides, herbicides, animal faeces and animal feeds. Hydrocarbons associated with machinery used for feeding and transporting stock. 	<p>High</p> <p>Medium</p> <p>Low</p>	<p>Pre-existing land use.</p> <p>Cattle have unrestricted access to land overlying the direct recharge area for the aquifer.</p> <p>Shallow depth to groundwater table. Groundwater is being extracted less than 10m from the surface.</p> <p>Stocking rates above Department of Agriculture and Food recommended stocking rates.</p> <p>Cattle excrement is a potential source of <i>E.coli</i>, <i>Cryptosporidium</i> and <i>Giardia</i>.</p> <p>Old bore casing next to 2/95 has not been sealed adequately.</p>	<ul style="list-style-type: none"> Water quality monitoring CAWS Act 1947, by-laws. Fencing around bore compound to prevent stock access to bore 1/95, 2/95 & 3/78. 	<ul style="list-style-type: none"> Establish a WHPZ surrounding the bores. Investigate ways to improve stock management, to reduce the risk of contamination to the water supply. Create a watering point for stock outside of the WHPZ. (investigate water supply options for cattle down gradient of the production bores) Follow Department of Agriculture and Food recommended stocking rates. Consider planting a vegetated (low water use) native buffer around the bore within the WHPZ to increase filtration of potential contaminants.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			<p>The soaks near production bores 1/95 & 2/95 are expressions of groundwater and possible windows of contamination for the groundwater.</p> <p>The wetland and soak adjacent to bore 1/95 is another possible window for contamination to groundwater.</p> <p>Stock have unrestricted access to the soaks and wetlands.</p>		<ul style="list-style-type: none"> Employ best management practice outlined in the Department's, water quality protection note (WQPN) 06 <i>Vegetation buffers to sensitive waters</i> & WQPN 80 <i>Stockyards</i>. Department to look at land purchase of P1 classified land (especially land with a designated WHPZ contained on it).
<p>Intensive cropping (proposed)</p> <ul style="list-style-type: none"> tagasaste 	<ul style="list-style-type: none"> Pathogens from animals feeding within the plantation. Nutrient contamination from pesticides, herbicides and fertilizers. 	<p>High</p> <p>Medium</p>	<p>Shallow depth to groundwater.</p> <p>Stock access to tagasaste crops is dependent on the age of the crops and grazing technique to promote an increased yield.</p> <p><i>WQPN Pastoral activities</i></p>	<ul style="list-style-type: none"> <i>CAWS Act 1947, By-laws.</i> Fencing around bore compound to prevent stock access to bore 1/95, 2/95 & 3/78. 	<p>Monitor impact of Tagasaste crop.</p> <ul style="list-style-type: none"> Investigate improvements to stock management such as the harvesting of tagasaste within the WHPZ to minimise contamination risks. Pesticides should be used in

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
	<ul style="list-style-type: none"> Nutrient fixing in the soil and groundwater from <i>tagasaste</i> and rotting leaf litter on the surface of the ground. Hydrocarbons from vehicle usage. 	<p>Medium</p> <p>Low</p>	<p><i>within rangelands, WQPN 01 Agriculture – dryland crops, WQPN 06 Vegetation buffers to sensitive waters and WQPN 33 Nutrient and irrigation management plans.</i></p>	<ul style="list-style-type: none"> Statement of Planning Policy 2.7 and 2.9 	<p>accordance with Public Sector Circular (PSC) 88 and Statewide Planning Policy 2: <i>Pesticide use in Public Drinking Water Source Areas.</i></p> <ul style="list-style-type: none"> Employ best management practices see WQPN 01 <i>Agriculture - dryland crops near sensitive water resources</i> , WQPN 06 <i>Vegetation buffers to sensitive waters</i> and WQPN 33 <i>Nutrient and irrigation management plans.</i> Department to look at land purchase of P1 classified land (especially land with a designated wellhead protection zone contained on it).
Broadacre cropping on P1 land	<ul style="list-style-type: none"> Nutrient and pesticide contamination from crops, plantations, and inadequate 	Medium	<p>Shallow depth to the groundwater table.</p> <p>Pre-existing land use.</p>	<ul style="list-style-type: none"> Water quality monitoring CAWS Act 1947, by-laws. 	<ul style="list-style-type: none"> Ensure water quality protection objectives are recognised in the Shire of Brookton Town Planning Scheme.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
	<p>storage and disposal of chemicals.</p> <ul style="list-style-type: none"> Hydrocarbon contamination through fuel spills from chemical storage, refuelling and mechanical servicing. Increased salinity from land clearing causing a rise in the water table and salt accumulation. 	<p>Low</p> <p>Low</p>	<p>Further intensification is not supported and best management practices are encouraged.</p>		<ul style="list-style-type: none"> Encourage landholders to prepare a nutrient and irrigation management plan. Employ best management practices see WQPN 01 <i>Agriculture – dryland crops near sensitive water resources</i>, WQPN 06 <i>Vegetation buffers to sensitive waters and WQPN 33 Nutrient and irrigation management plans</i>. Department to look at land purchase of P1 classified land (especially land with a designated wellhead protection zone contained on it).
Stockyard	<ul style="list-style-type: none"> Pathogen contamination from animal faeces. Nutrient contamination from 	<p>High</p> <p>Medium</p>	<p>Shallow depth to groundwater table.</p> <p>Pre-existing land use.</p> <p><i>CAWS Act 1947, Division 2 –</i></p>	<ul style="list-style-type: none"> Water quality monitoring <i>CAWS Act 1947, By-laws.</i> 	<ul style="list-style-type: none"> Employ best management practices see WQPN 80 <i>Stockyards</i> Establish water storage point for cattle outside WHPZ.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
	stock feeding practices and pesticide application.		<i>Prevention of pollution in water reserves and catchment areas, 10, 12 and 13</i> prohibits the accumulation of waste (dung or manure), including animal holding buildings ie outbuildings for cattle, used or constructed to be permitted < 300 metres from any production bore.		<p>(investigate water supply options for cattle down gradient of the production bores)</p> <ul style="list-style-type: none"> Establish fencing around WHPZ to prevent stock access within 500m of the bore compounds. Investigate ways to relocate stock yard outside of WHPZ and down gradient bores. Department to look at land purchase of P1 classified land (especially land with a designated wellhead protection zone contained on it).
Farm Infrastructure (shed).	<ul style="list-style-type: none"> Hydrocarbons from chemical and fuel storage and servicing machinery. Nutrients from cleaning agents, 	<p>Medium</p> <p>Medium</p>	<p>Shallow depth to groundwater.</p> <p>Pre-existing land use.</p> <p>Storage of farm machinery and equipment occurs on Lot 10793. Shed areas are</p>	<ul style="list-style-type: none"> Water quality monitoring CAWS Act 1947, by-laws. 	<ul style="list-style-type: none"> Inspect farm sheds for contaminant sources consistent with CAWS Act 1947 by-laws 12(1), 12(2) and 12(3). Implementing safe practices for storage of chemicals and

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
	<p>chemicals and pesticides.</p> <ul style="list-style-type: none"> Pathogens from rubbish disposal. 	High	<p>potentially contaminated from past and current farming activities, machinery maintenance, cleaning activities, chemical storage, refuelling and rubbish disposal etc.</p>		<p>other hazardous materials.</p> <ul style="list-style-type: none"> Department of Water WQPN 07 <i>Chemical blending</i>, WQPN 28 <i>Mechanical servicing and workshops</i>, WQPN 65 <i>Toxic and hazardous substances &</i> WQPN 68 <i>Mechanical equipment washdown</i>.
House (temporary lodging Lot 10793)	<ul style="list-style-type: none"> Pathogens and nutrients from septic tank system and rubbish disposal. Nutrients from cleaning agents and chemical storage. Hydrocarbons from vehicle storage and transport. 	<p>High</p> <p>Medium</p> <p>Low</p>	<p>Shallow depth to groundwater. It is possible that the leach drains from the septic tanks are discharging waste water directly into the groundwater.</p> <p>Pre-existing land use.</p> <p>House and facilities are temporarily visited.</p> <p>Located within 500 m of bore compound 2/95.</p>	<ul style="list-style-type: none"> Water quality monitoring <i>CAWS Act 1947</i>, By-laws. 	<p>Department of Water and Water Corporation to encourage landholder to undertake best management practices.</p> <ul style="list-style-type: none"> Decommissioning old septic systems or upgrading to alternative systems when due for replacement; Correct maintenance of onsite wastewater treatment systems; Developing processes for collecting hazardous household wastes; and Ensuring chemical storage

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
					areas are correctly maintained and bunded.
Aquaculture (excavations)	<ul style="list-style-type: none"> Salt accumulation through the storage of saltwater within the dams and a lack of fresh water flow through the dams. Increase the risk of pathogens and nutrients that may be transported, stored and infiltrate into the groundwater through the dams. 	<p>Medium</p> <p>Medium</p>	<p>Shallow depth to groundwater. Excavations were initially constructed over 10 years ago.</p> <p>Located downstream of the bores.</p> <p><i>RIWI Act 1914</i>, prohibits taking water from any watercourse, wetland or underground water source to which section 5, 9 and 26 of the <i>Act</i> apply.</p>	<ul style="list-style-type: none"> Downstream of bores Water quality monitoring <i>CAWS Act 1947</i>, By-laws. 	<ul style="list-style-type: none"> Prevent salt water from being stored and allowed to evaporate within excavations; Excavations to be back filled by the Department subject to successful acquisition of P1 land. Plant salt tolerant species around excavations to increase salt uptake from groundwater and surface water flow.
Monitoring bore	3/78 is downstream of abstraction bores	High	Is currently downstream of the production bores, therefore, no forewarning of		Establish a new monitoring bore upstream of bore 1/95 and 2/95.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			<p>contaminants reaching the production bores is possible.</p> <p>This bore could possibly become a production bore for future town water supply requirements.</p> <p>The old bore casing within the compound of bore 2/95 has not been sealed and could act as a pathway for contamination.</p>		<ul style="list-style-type: none"> Establish a 500m WHPZ around bore 3/78 to protect it from potential contamination, in case it is required for future town water supply. Adequately seal the old bore casing to prevent contamination risk.
Wetland (clearing and stock access)	<p>Pathogens from animal access</p> <p>Nutrients from animal urine.</p> <p>Hydrocarbons from machinery used to drain the wetland.</p>	<p>High</p> <p>Medium</p> <p>Low</p>	<p>A licence needs to be obtained from DEC prior to any clearing or drainage of the wetland under the <i>Environmental Protection (Clearing of Native Vegetation) Regulations 2004</i>.</p>	<p><i>Environmental Protection Act 1986</i>.</p>	<ul style="list-style-type: none"> Wetland should be fenced off to prevent stock access. Conservation value of the wetland should to be investigated by the Department of Environment and Conservation, and if necessary have it listed under the <i>Wetlands Conservation Policy Western Australia 1997</i> and the <i>South West Agricultural Zone Wetlands Environmental Protection</i>

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
					<i>Policy 1998.</i>
Stock watering dams adjacent to 1/95 and 2/95.	<p>Pathogens from animal faeces.</p> <p>Nutrients from animal faeces.</p>	<p>High</p> <p>Medium</p>	<p>The most highly used stock watering dam is less than 30 metres downstream of production bore 2/95.</p> <p>The dams are expressions of the groundwater and act as a direct pathway for contamination.</p> <p>Another stock watering point is less than 20m upstream of bore 1/95.</p>	<ul style="list-style-type: none"> Water quality monitoring 1/95 is located downstream of the bore. 	<ul style="list-style-type: none"> Prevent stock access to the soaks and bore compound. (investigate water supply options for cattle down gradient of the production bores) Establish as far as possible from the bores, a watering point outside of WHPZ. Carry out further water quality investigation and sampling of dam water quality in conjunction with Water Corporation, to determine the impact and relationship between the dams and groundwater quality.
<p>General broad acre farming on P2 land:</p> <ul style="list-style-type: none"> Animal grazing 	<ul style="list-style-type: none"> Pathogens associated with animal activity. Nutrients 	<p>Medium</p> <p>Low</p>	<p>The existing land uses of broad acre cropping and grazing are compatible with conditions in P2 areas.</p>	<ul style="list-style-type: none"> Water quality monitoring Statement of Planning Policy 	<p>Existing land uses are acceptable with best management practices.</p> <ul style="list-style-type: none"> Encourage landowners to adopt best management

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
and, <ul style="list-style-type: none"> • Cereal cropping 	<ul style="list-style-type: none"> • associated with fertiliser and pesticide application • Hydrocarbons associated with vehicle traffic. 	Low		2.7	practices, particularly with regards to fertiliser and pesticide application and stream buffers. For the Department's description for best management practices see WQPN 01 <i>Agriculture – dryland crops near sensitive water resources</i> <ul style="list-style-type: none"> • Follow Department of Agriculture and Food recommended stocking rates for the soil type.
Permanent house (Lot 1 on diagram 80139) (within Lot 6384)	<ul style="list-style-type: none"> • Pathogens and nutrients associated with septic tanks. • Nutrients from cleaning products. • Hydrocarbons associated with vehicle use and maintenance. 	Medium Low Low	The distance from the production bores lowers the land use risks associated with the house.	<ul style="list-style-type: none"> • Water quality monitoring. • Statement of Planning Policy 2.7 	The Department of Water and Water Corporation to encourage landholders to undertake best management practices. This may include: <ul style="list-style-type: none"> • Decommissioning old septic systems or upgrading to alternative systems when due for replacement; • Correct maintenance of onsite wastewater treatment

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
					systems; <ul style="list-style-type: none"> • Developing processes for collecting hazardous household wastes; and • Ensuring chemical storage areas are correctly maintained and banded.

5 Recommendations

- 1 Implement the recommended protection strategies as detailed in *Table 1: Land use, potential water quality risks and recommended strategies* of this plan (*Applicable stakeholders*).
- 2 The amended boundary of the BHVWR should be proclaimed under the *CAWS Act 1947 (Department of Water)*.
- 3 Prepare an implementation strategy for this plan describing responsible stakeholders and indicative, time frames for the recommended protection strategies (*Department of Water*).
- 4 The Shire of Brookton's Town Planning Scheme No 3 should incorporate this plan and reflect the identified Brookton Happy Valley Water Reserve boundary and the Priority 1 and 2 classifications and wellhead protection zones (*Shire of Brookton*).
- 5 All development proposals within the Brookton Happy Valley Water Reserve that are likely to impact on water quality and/or quantity, or are inconsistent with Water Quality Protection Note – *Land use compatibility in public drinking water source areas* or Statement of planning policy – *Public Drinking Water Source Policy or by-laws applicable in proclaimed water reserves* should be referred to the Department of Water for advice and recommendations (*Department for Planning and Infrastructure, Shire of Brookton*).
- 6 Determine with landowners, options for best practice management or purchase of P1 land (especially with a WHPZ)
- 7 Investigate ways to prevent cattle entering the WHPZ to ensure that contaminants are kept away from the point of extraction for the bores.
- 8 Establish off-site watering troughs for cattle to reduce exposing the aquifer to pathogens from faecal matter.
- 9 Filling in the dam/stock watering point near Bore 2/95 to reduce the potential for contamination and evaporation of the aquifer.
- 10 Develop a monitoring programme to establish the relationship between the water quality within the stock watering dams and the groundwater quality.
- 11 Incidents covered by WESTPLAN – HAZMAT in the Brookton Happy Valley Water Reserve should be addressed through the following:
 - The *Shire of Brookton* LEMAC are familiar with the location and purpose of the Brookton Happy Valley Water Reserve.
 - The locality plan for the Brookton Happy Valley Water Reserve is provided to the Fire and Rescue headquarters for the HAZMAT emergency advisory team.
 - The Water Corporation provides an advisory role during incidents in the Brookton Happy Valley Water Reserve.
 - Personnel dealing with WESTPLAN – HAZMAT incidents in the area have ready access to a locality map of the Brookton Happy Valley Water Reserve and training to understand the potential impacts of spills on drinking water quality (*Department of Water, Water Corporation*).

- 12 A surveillance program should be implemented to identify any incompatible land uses or potential threats within the Brookton Happy Valley Water Reserve. Pursuant to Section 13(1) of the *Water and Rivers Commission Act 1995*, the Department of Water should delegate responsibility for the surveillance and enforcement to the Water Corporation (*Water Corporation*).
- 13 Signs should be erected along the boundary of the Brookton Happy Valley 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*).
- 14 A review of this plan should be undertaken after five years or in the event of a significant change to the landuses and associated risks to Happy Valley Water Reserve (*Department of Water*).

Appendices

Appendix A - Water quality

The Water Corporation has monitored the raw (source) water quality from Brookton Happy Valley Bore field 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
- Microbiological Contaminants

Following is data representative of the quality of raw water in Brookton Happy Valley Borefield. In the absence of specific guidelines for raw water quality, the results have been compared with ADWG values set for drinking water, which defines the quality requirements at the customers tap. Results that exceed 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 ADWG. For more information on the quality of drinking water supplied to Brookton refer to the most recent Water Corporation Drinking Water Quality Annual Report at http://www.watercorporation.com.au/W/waterquality_annualreport.cfm?uid=2377-9937-9579-7091.

Aesthetic Related Characteristics

Aesthetic water quality analyses for raw water from Brookton Happy Valley Borefield are summarised in Table 1.

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

Table 2 Aesthetic related detections for Brookton Happy Valley Borefield

Parameter	Units	ADWG Aesthetic Guideline Value*	Brookton Bore 1/95		Brookton Bore 2/95	
			Range	Median	Range	Median
Aluminium unfiltered	mg/L	NA	<0.008 - 0.075	<0.008	<0.008 - 0.095	<0.008
Chloride	mg/L	250	195 - 310	245	235 - 310	250
Colour - True	TCU	15	<1 - 3	<1	<1	<1
Conductivity (25°C)	mS/m	NA	75 - 120	93.5	87 - 120	95
Hardness as CaCO ₃	mg/L	200	55 - 89	70	67 - 90	75
Iron unfiltered	mg/L	0.3	<0.003 - 0.24	0.004	<0.003 - 0.9	<0.003
Manganese unfiltered	mg/L	0.1	<0.002 - 0.004	<0.002	<0.002 - 0.044	<0.002
pH	-	6.5 - 8.5	5.76 - 6.44	5.955	5.72 - 6.4	5.96
Sodium	mg/L	180	120 - 190	145	130 - 190	155
Sulphate	mg/L	250	18 - 26	19	17 - 26	20
TFSS	mg/L	500	405 - 622	492	466 - 625	507
Turbidity	NTU	5	<0.1 - 3.6	0.15	<0.1 - 8.4	<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 Brookton Happy Valley 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 February 2007 are summarised in the Table 2. Any parameters that have on occasion exceeded the ADWG are shaded.

Table 3 Health related detections for Brookton Happy Valley Bore field

Parameter	Units	ADWG Health Guideline Value*	Brookton Bore 1/95		Brookton Bore 2/95	
			Range	Median	Range	Median
Barium [†]	mg/L	0.7	0.035	0.035	0.035	0.035
Boron [†]	mg/L	4	0.02 - 0.03	0.025	0.02 - 0.04	0.03
Fluoride	mg/L	1.5	<0.10 - 0.15	<0.1	<0.10	<0.1
Manganese unfiltered	mg/L	0.5	<0.002 - 0.004	<0.002	<0.002 - 0.044	<0.002
Nitrite plus nitrate as N	mg/L	11.29	4.1 - 4.8	4.3	4.2 - 5.4	4.2
Sulphate	mg/L	500	18 - 26	19	17 - 26	20

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

[†] Water quality results taken from two sampling occasions at each sample point

Microbiological Contaminants

Microbiological testing of raw water samples from Brookton Happy Valley Bore field 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 a bore may indicate possible contamination of faecal material through ingress in the bore, or recharge through to the aquifer (depending on aquifer type).

During the reviewed period of January 2002 to February 2007, positive *Escherichia coli* counts were recorded in < 3% of samples collected from the borefield. This low occurrence of *Escherichia coli* detections is indicative of minimal contamination of the groundwater from faecal sources.

Appendix B- Photographs



Photo 1 Bore 2/95



Photo 2 Bore 2/95 and stock watering point



Photo 3 Stock watering point



Photo 4 Faeces in stock watering point



Photo 5 Evidence of land clearing in wetland adjacent to bore 1/95



Photo 6 Stock accessing wetland through cleared areas adjacent to Bore 1/95



Photo 7 Aquaculture excavations and salt accumulation within dams

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.
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.
ARI	Average Recurrence Interval (measure of storm frequency)
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.
Augment	To increase the available water within a storage reservoir by pumping back water from a secondary storage/reservoir dam.
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.
CFU	Coliform forming units is a measure of pathogen contamination in water.
Confined aquifer	An aquifer that is confined between non-porous rock formations (such as shale and siltstone) and therefore contains water under pressure.
Diffuse source	Pollution originating from a widespread area eg urban stormwater runoff, agricultural infiltration.
Effluent	The liquid, solid or gaseous wastes discharged by a process, treated or untreated.

GL	Gigalitres (1000 000 000 litres)
GSTWS	Great Southern Town Water Supply
ha	Hectares (a measure of area)
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)
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.
m	Metres
mg/L	Milligrams per litre (0.001 grams per litre)
ML	Megalitres (1 000 000 litres)
mm	Millimetres
NHMRC	National Health and Medical Research Council.
NTU	Nephelometric turbidity units are a measure of turbidity in water.
Nutrient load	The amount of nutrient reaching the waterway over a given timeframe (usually per year) from it's catchment area.
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.
Perched	An unconfined aquifer, often ephemeral or seasonal, perched on top of an impermeable horizon near the land surface and separated from deeper groundwater by an unsaturated zone.
Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.

Point source pollution	Pollution originating from a specific localised source, eg sewage or effluent discharge, industrial waste discharge.
Pollution	Water pollution occurs when waste products or other substances, eg 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.
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 it's distribution. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface.
Reservoir	A reservoir, dam, tank, pond or lake that forms part of any public water supply works
Run-off	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 of private company and supplied via a distribution network to customers for urban, industrial or irrigation use.
Stormwater	Rainwater which has run off the ground surface, roads, paved areas etc. and is usually carried away by drains.
TDS	Total dissolved solids, a measurement of ions in a solution.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes including drinking and discharge to the environment.
Unconfined aquifer	An aquifer in which the upper surface of water is lower than the top of the aquifer itself. The upper surface of the groundwater within the aquifer is called the watertable.

Wastewater	Water that has been used for some purpose and would normally be treated and discarded. Wastewater usually contains significant quantities of pollutant.
Water quality	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.
Watertable	The upper saturated level of the unconfined groundwater.
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 (WPZ) is usually declared around wellheads in drinking water areas to protect the water source from contamination.

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