Department of Water
Government of Western Australia

Laverton Water Reserve and Catchment Area Drinking Water Source Protection Plan

Laverton Town Water Supply

REPORT NO. 74
June 2007

Water Resource Protection Series

Government of Western Australia
Department of Water and Environmental Regulation

Important information

The *Laverton Water Reserve and Catchment Area drinking water source protection plan* (2007, WRP no. 74) was reviewed in 2021.

Please read the updated *Laverton Water Reserve and Catchment Area drinking water source protection review* (2021, WRP no. 194) alongside the 2007 plan to obtain all of the information about this drinking water source.

The 2021 review considers changes that have occurred in and around the Laverton Water Reserve and Catchment Area since the completion of the 2007 plan. Additional recommendations have been prepared to ensure the ongoing protection of this public drinking water source area:

- update the reservoir and wellhead protection zone of the Laverton Water Reserve and Catchment Area to protect a new bore.
- no mineral exploration should occur within the protection zones of the Laverton Water Reserve and Catchment Area.

You can find the 2021 *Laverton Water Reserve and Catchment Area drinking water source protection review* at www.dwer.wa.gov.au or by contacting the Department of Water and Environmental Regulation on +61 8 6364 7000 or drinkingwater@dwer.wa.gov.au.

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Report No. WRP 74

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Cover photograph
Wedge Pit, taken by Christa Loos

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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 Laverton Public Drinking Water Source Area 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 drinking water sources to ensure the continued supply of 'safe, good quality drinking water' to consumers.

The Australian Drinking Water Guidelines recommend a multiple barrier 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 surface water dams and groundwater aquifers.

This plan details the location and boundary of the drinking water catchment, which provides potable water to the Laverton Town Water Supply. It discusses existing and future usage of the water source, describes the water supply system, 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 Laverton's Town Planning Scheme, consistent with the Western Australian Planning Commission's *Statement of Planning Policy No. 2.7 - Public Drinking Water Source Policy*. Other stakeholders should use this document as a guide for protecting the quality of water in the proposed Laverton Public Drinking Water Source Area (PDWSA).

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 catchment 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	**Publish approved Drinking Water Source Protection Plan**	**Final Plan published after considering advice received in submissions. Includes recommendations on how to protect the catchment.**

Summary

Laverton is located in the Shire of Laverton in the Goldfields region of Western Australia, approximately 690 kilometres (km) north east of Perth and 250 km north east of Kalgoorlie.

The Laverton Town Water Supply is currently obtained from the Beasley Creek and Wedge Pit (mine void) borefields that draw groundwater from an unconfined aquifer of alluvium and fractured rock. The aquifer is recharged directly from surface water entering Wedge Pit and Beasley Creek. The water source is highly vulnerable to contamination from land uses in the proposed Public Drinking Water Source Area (PDWSA).

The water source is managed by Water Corporation and is strategically important to the Laverton community as it is the town's sole supply of drinking water.

The Laverton PDWSA was declared a Water Reserve in 1970 under the *Country Areas Water Supply Act (CAWS) 1947* to protect the quality of the groundwater source. The boundary of this PDWSA has recently been revised by the Department to reflect the actual topological and hydro-geological catchment area of the PDWSA. This has resulted in a major reduction in the size of the PDWSA recommended in this Plan.

In this Drinking Water Source Protection Plan it is recommended that the reduced boundary be re-gazetted as the Laverton Water Reserve and Catchment Area under the CAWS Act 1947 to ensure improved water source protection to the surface water entering Wedge Pit that is used for replenishing Laverton groundwater.

This amendment will mean that land use constraints that may have previously been applied - for source protection purposes - to activities in the current gazetted Water Reserve may not apply if the land use falls outside of the proposed PDWSA boundary.

Land uses and tenures in the proposed PDWSA includes pastoral lease activities and mining, including historical mine workings. Most land uses are compatible with the Priority 1 source protection proposed for the Laverton PDWSA .

Two minor mineral processing operations at Lancefield (M3800037) and major transport routes that exist in the proposed PDWSA are viewed as incompatible land activities in a P1 priority classification area, but will be allowed to continue at their present approved level, provided they operate lawfully and apply best management practices.

The small scale – non-conforming - mineral processing operation is ameliorating an area of degraded historical tailings storage.

There is some recreation activity around Wedge Pit, including picnicking and swimming in the pit. Swimming (direct body contact) poses a significant risk for introducing pathogens into the water resource and should not occur in the pit for reasons of water source protection and general safety.

Potential water quality risks associated with existing land uses in the proposed Laverton PDWSA have been identified and protection strategies to manage these risks are recommended in this Plan.

The major recommendations include:

- the proclamation of the proposed Laverton PDWSA;
- Crown land to be managed for Priority 1 source protection;
- five hundred metres Wellhead Protection Zones to be created around Beasley Creek and Wedge Pit production bores;
- a Reservoir Protection Zones (using the shape of the WPZ area resulting from the four bores at Wedge Pit) to be created around Wedge Pit;
- Environmental Management Plans for the old tailing dam and minor mineral processing operation at M3800037 to be prepared and implemented;
- Skull Creek and Telegraph Shaft borefields to be decommissioned and/or filled in; and
- an implementation strategy for this Plan describing responsible stakeholders, timeframes and funding sources for the recommended protection strategies to be prepared.

The DWSPP has been developed in consultation with the Water Corporation, Department of Industry and Resources, Department of Environment and Conservation, Department of Health, Shire of Laverton and the relevant mining companies through the Laverton Mining Liaison Forum.

1 Drinking water source overview

1.1 Introduction

Laverton is located in the Shire of Laverton in the Goldfields region of Western Australia, approximately 690 kilometres (km) north east of Perth and 250 km north east of Kalgoorlie (see Figure 1). It is a service centre for the surrounding mining and pastoral industries and has an estimated permanent population of about 1200 with an additional itinerant population (Australian Bureau of Statistics, 2005).

The Laverton township developed following the discovery of gold in 1892. Mining for gold and nickel-cobalt is still occurring in the Laverton area. Numerous abandoned open cut mines, historical shafts and underground workings in the area are evident in Laverton Water Reserve.

The currently gazetted Water Reserve comprises of an area of 2 640 square kilometres (km^2) that includes the Laverton town-site, mining tenements, pastoral leases, and the Beasley Creek , Wedge Pit, Telegraph Shaft, and Skull Creek borefields and the recharge areas associated with the borefields. The Skull Creek and Telegraph borefields have recently been abandoned and will be not be used for supplying public drinking water to the Laverton Town Water Supply. Therefore, the potential water quality risks addressed in the Laverton Water Reserve Drinking Water Source Protection Assessment (Water Corporation, 2004) relating to Telegraph Shaft and Skull Creek borefields will not be further discussed in this Plan.

The Department of Water (the Department) reviewed the boundaries of the Laverton Water Reserve and recommends:

- to amend the boundaries of the Water Reserve to protect that part of the Beasley Creek surface water catchment that recharges the groundwater sourced from the Beasley Creek and Wedge Pit borefields area (see Figure 2). This amendment will result in a major reduction in the size of the PDWSA and will avoid potential water source protection land use restrictions from the land in the current gazetted Laverton Water Reserve that will no longer be required to be within the proposed Laverton PDWSA; and
- to proclaim the proposed Laverton PDWSA under the *Country Areas Water Supply(CAWS) Act 1947* for the purpose of protecting the public drinking water source from potential contamination. The Laverton PDWSA will be proclaimed as both a Water Reserve and a Catchment Area under the *CAWS Act, 1947*.

1.2 Existing water supply system

The public drinking water supply for Laverton is obtained from Beasley Creek bore 1/90 and the Wedge Pit borefield (Bores 2/99, 3/99, 2/03 and 3/03), which are located about 12 kilometres (km) north-west of the town.

The Wedge Pit bores were intentionally located in close proximity to the pit in order to source enhanced groundwater recharge associated with water body in Wedge Pit which is augmented from seasonal flows from a nearby creek line that has been diverted into the pit.

The bores at Telegraph Shaft (Bores 1 and 2) have been not in operation since January 2003 and September 2005, respectively, as result of poor water quality and their close positioning to the edge of Telegraph Shaft. Production bores 1 and 2 will be decommissioned as soon as Water Corporation sees it practicable. The power to the site (Bore 1 and 2) has been disconnected. The locations of the borefields are shown in Figure 2.

Beasley Creek bore 1/90 has a static water level of about 20 m below natural surface and is screened between 10 and 70 m. The Wedge Pit bores have a static water level of about 12.6 to 14 m below natural surface and are screened between 30 and 85 m. Telegraph Shaft has a static water level of about 19 m with the pump set at 108 m.

Wedge Pit borefield is the main drinking water source with Beasley Creek the stand-by source, used for emergency supply and occasional peak demand supplementation during summer. Water from Wedge Pit is pumped to the Laverton town tank site via the Beasley Creek borefield site after being treated at the Water Treatment Plant at Beasley Creek. The Laverton reticulation system is gravity supplied from a 183 kilolitre (kL) elevated tank and a 4550 kL ground tank (see Appendix B, Photo 1).

Skull Creek borefield has been abandoned and will not be used anymore for supplying public drinking water to the Laverton Town Supply. The potential water quality risks relating to Skull Creek borefield that have been identified in the Laverton Water Reserve Drinking Water Source Protection Assessment (Water Corporation, 2004) will not be further discussed in this Plan.

1.3 Water treatment

The Water Corporation commenced operation of two new bores at Wedge Pit (Bores 2/03 and 3/03) and water treatment plant at Beasley Creek in 2005. The raw water from the four bores at Wedge Pit is treated at Beasley Creek Water Treatment Plant to ensure the water quality characteristics comply with the Australian Drinking Water Guidelines (ADWG), particularly arsenic (that is naturally occurring in the ground). The treated water is dosed with Calgon™ to mitigate hardness levels, and then

chlorinated before being supplied to the town via the storage tanks. Chlorination provides a disinfection barrier against possible microbiological contamination.

The water treatment plant was installed to reduce the levels of arsenic in the town water supply. This water treatment process is currently being modified to reduce the nitrate levels.

The Department of Health have granted this scheme an exemption from compliance with the Australian Drinking Water Guidelines for nitrate.

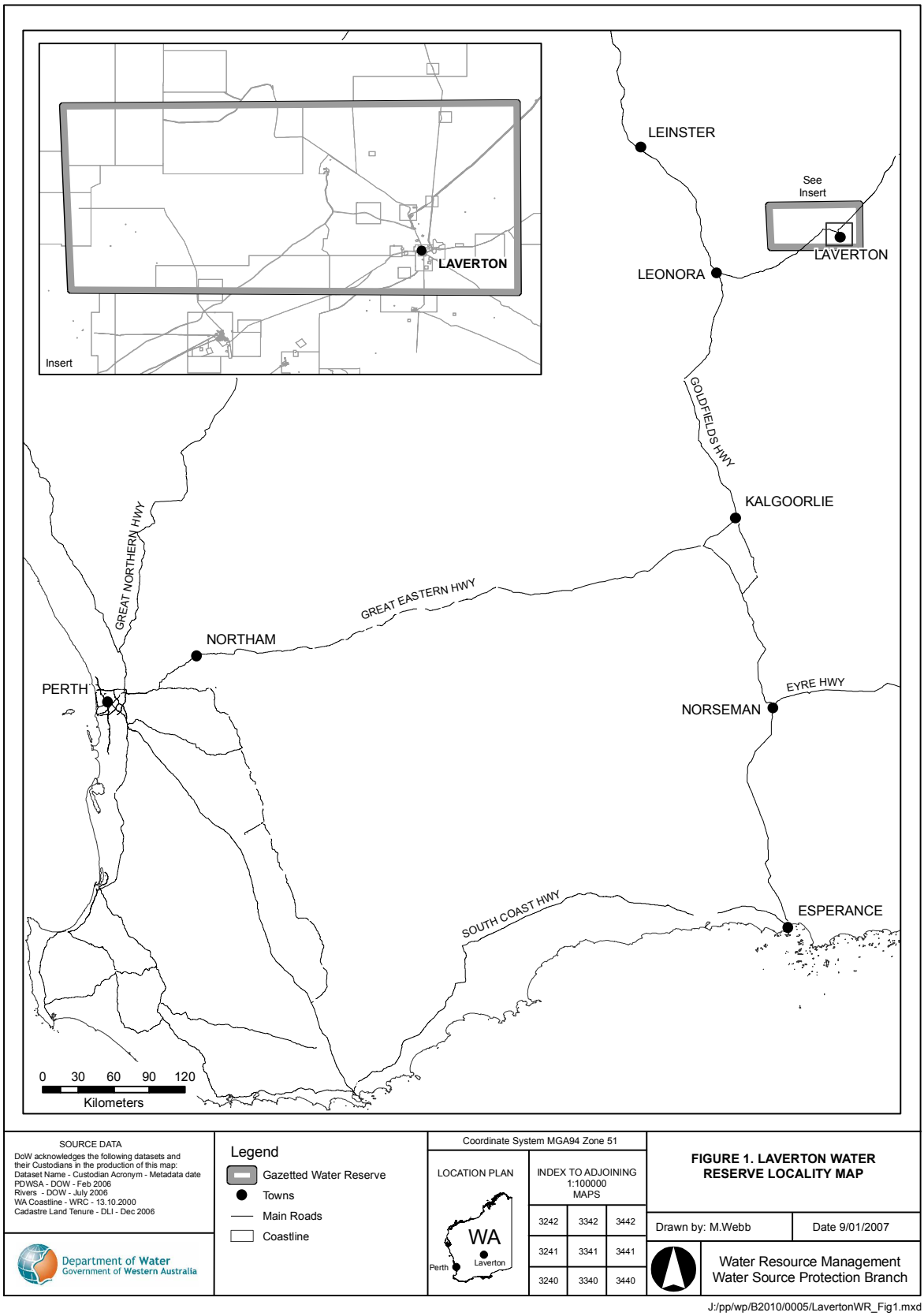

Figure 1 Laverton Water Reserve locality map

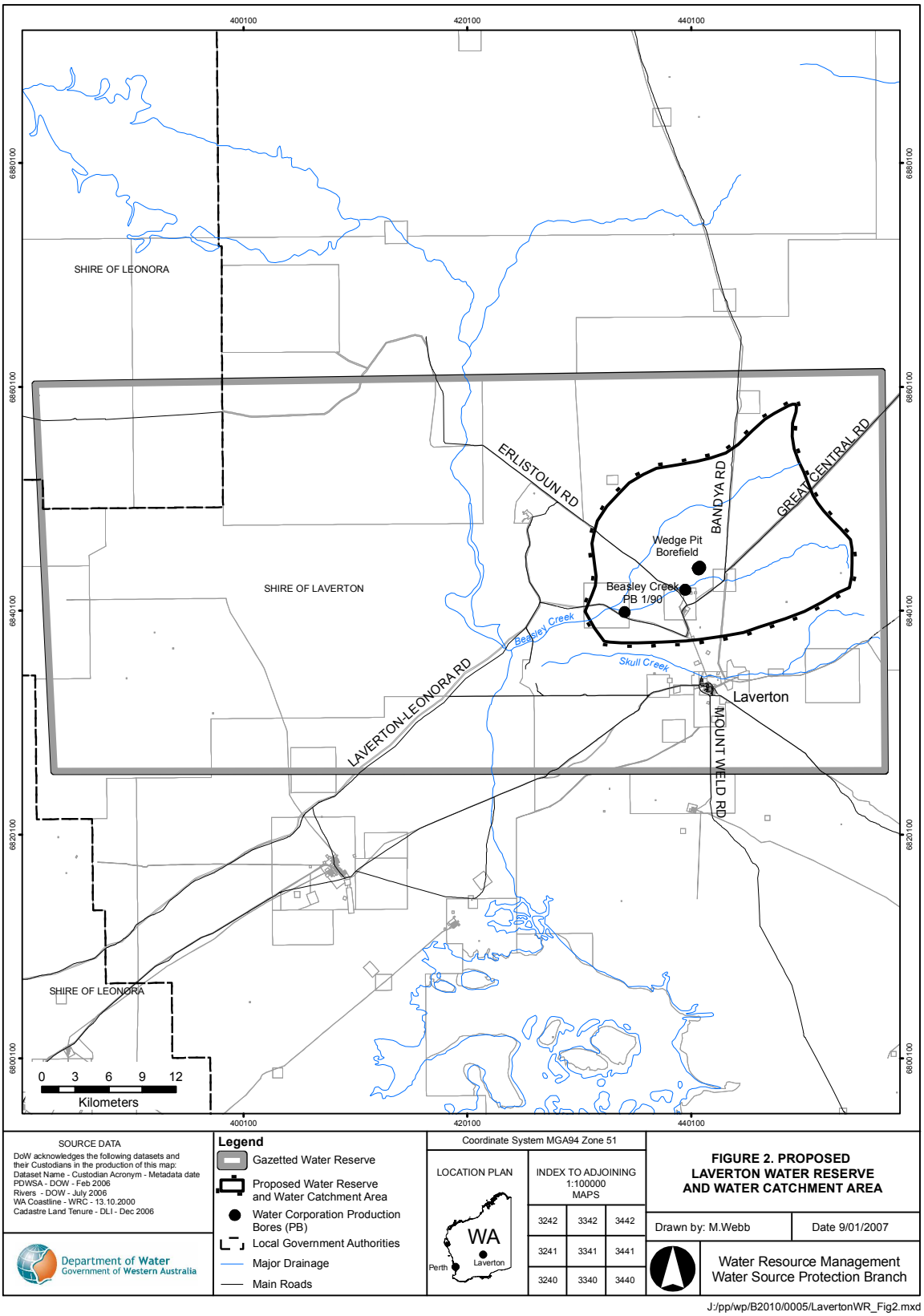

Figure 2 Proposed Laverton Water Reserve and catchment area

1.4 Catchment details

1.4.1 Physiography

Laverton is situated on the Meekatharra Plateau, close to the western boundary of the Great Victoria Desert Dunefields. The area contains generally low areas of outcrop and colluvial slopes and some prominent hills and ridges, transected by surface drainages. Beasley Creek is located north of Laverton, and flows from east to west towards the saline Lake Carey, south-west of Laverton.

Deformed and metamorphosed bedrocks consisting of Archaean greenstone rocks intruded by granitic rocks underlie the area. The rocks have been cut by numerous quartz veins, which have been intruded along zones of weakness or infill joints and fractures. Superficial units of colluvium, alluvium, eluvium and aeolian deposits overlie bedrocks over much of the area along with chemically precipitated limonite, calcrete and silcrete.

1.4.2 Climate

Laverton has a semi-arid climate with hot dry summers and cold to mild winters.

The annual average rainfall is 220 millimetres (mm) however, it is inconsistent and has been as low as 65 mm in 1928 and as high as 452 mm in 1963. Rainfall occurs more frequently during the winter months and the summer months are often dry. However, rainfall does occur in the summer months as a result of the passage of rain bearing depressions usually, from tropical cyclone remnants.

1.4.3 Hydrography/Hydrogeology

The superficial units are mostly thin, of limited areal extent and do not form major aquifers. The major aquifers in the Laverton area are thick sections of weathered and fractured bedrocks. Prospective fractured rock aquifers occur in the more siliceous rocks such as chert, banded iron and quartz veins. Ultramafic rocks are also commonly silicified in the weathered zone and thus have good potential as fractured rock aquifers. Creeks have formed along the fractures or fracture zones, and in Beasley Creek fractures in bedrocks extend to a depth of at least 80 metres.

The aquifers are recharged directly by infiltration of rainfall, from runoff along creeks where the fractured bedrocks (fractured chert) outcrop in the creek beds, and in areas of permeable alluvium. The production bores in the Laverton scheme exploit groundwater from fractured bedrocks overlain by alluvium. They are located in the vicinity of drainage lines in the Beasley Creek catchment area. The Wedge Pit and Telegraph Shaft borefields are located close to disused mine pits which act as permanent water bodies that assist in recharging the local aquifer. The Department believes that there is a hydraulic connection between the bores via fractured rock to the surface water due to the proximity of the bores to the mining voids. The surface water entering the voids has the potential to be directly extracted from the open pits via the production bores without an adequate retention time, and be fed into the water supply scheme after treatment.

The production bores are screened in bedrocks underlying alluvium and colluvium making the aquifer vulnerable to contamination.

Further information relating to the hydrogeology of Laverton can be obtained from the report *Hydrogeology of the Laverton 1:250 000 Sheet* that was prepared by S. L. Johnson in 2004 (see Reference section).

1.5 Future water supply requirements

Two new bores at Wedge Pit and a water treatment plant at Beasley Creek were commissioned in 2005 and are currently used for supplying drinking water to the Laverton Town Water Supply. This drinking water resource is considered to be sufficient for supplying drinking water to the town for the foreseeable future.

1.6 Alternative water sources

Alternative water sources for Laverton are not being investigated as the current water supply scheme is expected to meet demands into the future.

1.7 Protection and allocation

1.7.1 Existing water source protection

Laverton Water Reserve was proclaimed in 1970 under the *Country Areas Water Supply Act 1947* for the purpose of protecting the public drinking water source from potential contamination.

1.7.2 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 the 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 Goldfields Groundwater Area that includes the Laverton groundwater resource was proclaimed in 1990 under the *Rights in Water and Irrigation Act 1914* to allocate groundwater resources within its boundaries and manage its sustainable use.

The Water Corporation is licensed by the Department of Water to draw 300,000 kilolitres (kL) per annum from the Laverton Groundwater Scheme for public supply purposes. The current number of services supplied with drinking water is 406. Abstraction in 2003 was 211 742 kL.

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 the Laverton Water Reserve for microbiological contamination, health related chemicals and aesthetic characteristics in accordance with the Australian Drinking Water Guidelines (ADWG) (NHMRC & ARMCANZ, 2004) and the program set out in the Laverton Water Resource Management Operation Strategy (Water Corporation, 2000). The results of this monitoring are reviewed by the Water Corporation to ensure a safe drinking water supply to Laverton is maintained. An intergovernmental committee, chaired by the Department of Health, called the Advisory Committee for the Purity of Water, oversees this process.

A water quality summary for the Laverton Water Reserve from January 2001 to January 2007 is presented in Appendix A and described below. This data is representative of current water quality trends for the Laverton Water Reserve. 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 Guidelines limits, apart from nitrate, are met following treatment before supply to consumers.

The Department of Health have granted this scheme an exemption from compliance with the ADWG for nitrate. However, the water treatment plant process is currently modified to reduce the naturally occurring nitrate levels in the drinking water to achieve the levels outlined in the Australian Drinking Water Guidelines.

Telegraph Shaft Bore 1 and 2 have not been in operation since January 2003 and September 2005, respectively, and will be decommissioned as soon as possible by the Water Corporation. No water quality data has been provided for these bores.

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. *Escherichia coli* counts are a way of measuring these pathogens and are an indicator of faecal contamination.

Microbiological testing of raw water samples from the Laverton borefields is currently undertaken on a monthly basis. During the reviewed period of January 2001 to January 2007, positive *Escherichia coli* counts were recorded in 14 per cent of raw water samples collected from Beasly Creek borefield. Approximately 11 per cent of these samples had *Escherichia coli* counts greater than 20 colony forming units (cfu) per 100 millilitres (ml). A detection of *Escherichia coli* in raw water abstracted from a groundwater source may indicate possible contamination of faecal material through ingress in the bore, or recharge through to the aquifer (depending on aquifer type). *Escherichia coli* counts greater than 20 cfu per 100 ml can seriously impede on the ability to ensure a safe drinking water supply through disinfection alone.

Micro-organisms have the potential to enter the groundwater via recharge from contaminated surface water or via open mining pits. This connection was shown in the regular detection of faecal pathogens in the groundwater extracted by the bores at Telegraph Shaft. This and other related water quality issues resulted in the subsequent closure of the Telegraph borefield (Bores 1 and 2). Wedge Pit has a similar risk of microbiological contamination unless land use restrictions and protective strategies, such as creating a Reservoir Protection Zone (RPZ) around Wedge Pit, are adopted and implemented for protecting the proposed PDWSA.

2.2 Health related chemicals

The raw water samples taken from the Beasley Creek and Wedge Pit borefields indicate that the majority of health related parameters, with the exception of nitrate (as nitrogen) and arsenic are within the ADWG values.

The level of nitrate (as nitrogen) in raw water from Beasley production bore (1/90) ranges from 2.3 - 24 mg/L. The Australian Drinking Water Guidelines sets a guideline value of 11.29 mg/l. Currently, the nitrate levels exceed the guideline value.

Nitrate levels are naturally high in this area possibly due to nitrate-fixing vegetation and nitrate-fixing bacteria and associated with soil crusts and termite mounds (Jacobson, 1993). This natural phenomenon is outside the influence of this water source protection planning process, but has been addressed through improved water treatment.

Arsenic is a naturally occurring element in the ground in the Laverton area. This element can be introduced to the water source through the dissolution of minerals and ores (NHMRC & ARMCANZ, 1996).

In 2005 Water Corporation commenced operating two new bores at Wedge Pit and a water treatment plant at Beasley Creek. Treating the blended raw water at the Beasley Creek water treatment plant ensures that the Laverton drinking water complies with the ADWG.

2.3 Aesthetic characteristics

At Beasley Creek Borefield the total dissolved solids (TDS), chloride, and hardness concentrations have exceeded the ADWG aesthetic guideline values.

The water is treated with calgon™ at the Beasley Water Treatment Plant to mitigate water hardness.

Raw water from the Wedge Pit bores is typically of better quality than from the Beasley Creek bore with iron, colour (true), pH and turbidity concentrations just above ADWG aesthetic guidelines.

3 Land use and contamination risk

The risks to water quality associated with activities in and around the Laverton PDWSA include contamination from pathogens, pesticides, nutrients, chemicals and hydrocarbons. Pathogens pose the most significant risk to public health.

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) and the opportunity for their subsequent transfer into the surface and groundwater source, the ability of the pathogen to survive and the concentration required to cause illness. Pathogens may enter a groundwater source through infiltration of water containing faecal material. A surface water source may be accessed by pathogens through activities involving the direct contact of human and domestic animals with the water body or tributaries (ie illegal fishing, swimming), primarily through the transfer of faecal material, or indirectly through the presence of humans or domestic animals near the water body and its tributaries (ie runoff transferring faecal material).

There are a number of pathogens that are commonly known to contaminate water supplies worldwide. These include bacteria (eg *Salmonella*, *Escherichia coli* and *Cholera*), protozoa (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 asymptomatic infection to death, as was the case in Walkerton, Canada in 2000 where seven people died due to contamination of a pathogenic strain of *Escherichia coli* 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.

Pesticides are toxic and some are potentially carcinogenic. Nutrients (nitrates) from fertiliser and some natural occurring biological processes are toxic to humans at high levels, with infants less than 3 months old being most susceptible. Hydrocarbons (fuels, oils, solvents) and organic chemicals are potentially toxic and carcinogenic, and harmful by-products may be formed when they are combined with chlorine.

The mining industry also adds various substances (eg cyanide, carbon and/or zinc for processing gold ore) to the environment during their mineral processing operations. The fate of these substances is relatively complex and they may be

released to the environment through a number of pathways (eg. volatilisation, seepage, and spillages).

Under the provisions of sections 26D and 5C of the *Rights in Water and Irrigation Act 1914,* a licence is required to construct a bore or extract water within a proclaimed groundwater area. The proposed Laverton PDWSA is situated within the Goldfield 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).

There are a number of activities and land uses that have the potential to impact upon water quality of the proposed Laverton Water Reserve and Catchment Area (see Figure 3).

3.1 Existing land uses

Land uses and tenures in the proposed Laverton PDWSA are situated on Crown land and include:

- Wedge Pit and Beasley Creek borefields
- Water treatment plant and sedimentation basins
- Mining (including abandoned open cut mines, historical shafts and underground workings; outbuildings and a caretaker residence)
- Low impact mining processing operations
- Pastoral leases
- Major transport routes

These land uses and tenures are discussed in more detail below.

3.1.1 Crown reserved land

3.1.1.1 Wedge Pit

Wedge pit is a disused open cut mine that is now used for replenishing Laverton groundwater with surface water. A surface water diversion (open drain) has been constructed at the northern end of Wedge Pit that allows freshwater from the upper catchment area to enter the pit (see Appendix B, Photo 2).

There is some recreation activity around Wedge Pit, including picnicking and swimming in the pit. Swimming (direct body contact) poses a significant risk by introducing pathogens into the water resource and should not occur in the pit for the reasons of water source protection and general safety. Proclaiming the proposed

Public Drinking Water Source Area as a Catchment Area under *Country Areas Water Supply (CAWS) Act 1947* will ensure that the CAWS Act By-Laws that apply to catchment areas can make swimming in Wedge Pit a prohibited activity.

There is direct access via an old mining decline to the water edge in Wedge Pit. This pathway provides access to vehicles, pedestrians, wildlife and goats, and poses a significant risk for chemical (eg hydrocarbons), nutrient and microbiological contamination. Fencing the pathway should minimise the access to the edge of Wedge Pit and reduce the contamination threat.

Within mine pits the oxidation of sulfides can result in the acidification of groundwater and elevated arsenic and heavy metal levels (Gerrad, 2002). In addition evaporation of water can lead to rising groundwater salinity in the vicinity of the pits. Diversion of freshwater into pits is believed to be an option for off-setting evaporation and helping to maintain the quality of water of the local groundwater supply.

3.1.1.2 Water treatment plant and Beasley Creek borefield

The water treatment plant is located in close proximity, but downstream of Beasely Creek (Bore 1/90) (see Appendix B, Photo 3). The plant was commissioned by Water Corporation in 2005 and has the capacity to treat 2000 cubic metre (m^3) of water per day.

The water treatment plant's filters are backwashed after every 24 hours of operation discharging approximately 40 m^3 of water into two impervious lined evaporation ponds. Sampling of the backwash water taken from the ponds indicated an arsenic concentration of 0.050 mg/l in pond 1 and 0.045 mg/l in pond 2. The highest arsenic concentration that was detected in the backwash water in pond 1 is only slightly higher than the maximum arsenic concentration (0.045 mg/l) reported in the raw water from Beasley Creek Bore 1/90. The evaporation ponds will be desluged when required and the sludge be disposed of at an approved landfill site.

Beasley Creek only flows once or twice a year, but has the potential to flood the local area. The evaporation ponds have been designed to cope with a 1 in 20 year flood. The water treatment plant and evaporation ponds pose a contamination risk to the local groundwater and surface water, mainly resulting from the arsenic in the backwash water. Existing infrastructure may also be lost and the water treatment process be affected if flooded. Water Corporation is in process of preparing provisions for a contingency plan to address potential flooding events at the Beasley Creek water treatment plant and borefield.

The production bores and plant are powered by electricity sourced from the Laverton main power supply.

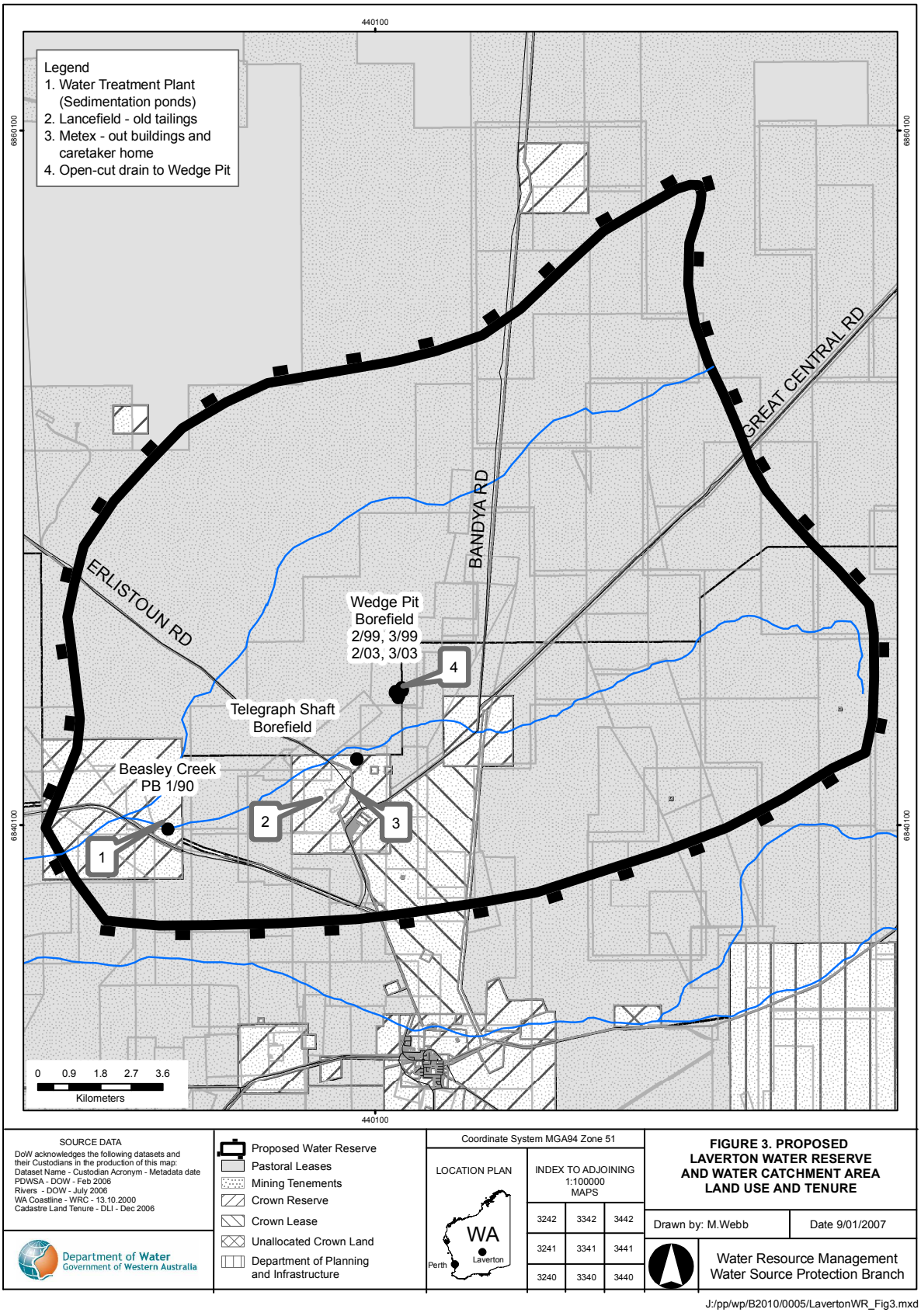

Figure 3 Land use and tenures in the proposed Laverton Water Reserve and catchment area

3.1.1.3 Mining tenements

The dominant land use in the proposed PDWSA is mining, with numerous abandoned open cut mines (Telegraph Shaft, Wedge Pit and other unnamed pits), historical mine shafts, and underground workings at Lancefield gold mine, which also has an old tailing dam (see Appendix B, Photos 4 and 5). The old tailing dam is currently reworked by Doveridge Investments Pty (Department of Industry and Resources' Licences to Treat Tails 38/56 and 38/150 that have been recently joined to one licence). This operation is further discussed in subsection 3.1.1.4. There are currently no operating mines in the proposed PDWSA, however, there is scope for future development. Mining activity in the area is dynamic and new sites are constantly being investigated.

Mineral exploration through the alluvial sediments into the fractured rock underneath provides a potential for contamination through direct application of drilling fluids and oils, plus any fuel and oil spills around the drilling rig. Drilling fluid sumps may also act as point sources for contamination.

It is understood, however, that most polymers and foams used in the mining industry are now biodegradable and a biodegradable hammer oil based on canola oil is now in use.

Metex Ltd currently holds tenement M3800037 that is located within the proposed PDWSA. This area still has mining potential. The caretaker residence at this mine is serviced with drinking water from the Wedge Pit borefield and has an on-site effluent disposal system. This mine included open pit and underground mining, waste storage, workshop facilities, dewatering, mineral processing, explosive operations, tailing dams and other outbuildings (see Figure 3 and Appendix B, Photos 6 and 7).

There are a number of abandoned mine shafts in the proposed PDWSA. These shafts provide a potential pathway for contamination of the aquifers through accidental or deliberate action of people, such as illegal dumping and fauna (including livestock). Decomposing animal carcasses pose a potentially significant risk for introducing pathogens (disease causing micro-organisms) into the water resource.

Interagency guidelines for Mining and Mineral Processing (WQPG 1-11) have been produced to provide the mining industry with information about water quality issues that need to be addressed when preparing Notices of Intent and for gaining environmental approval for mining operations (see Reference section).

3.1.1.4 Mine tailings processing operation

Two small scale, low impact mining processing operations exists in the proposed PDWSA at tenement M3800037 (Lancefield Gold Mine) that are located south of Beasley Creek (see Appendix B, Photos 8 to 11).

Potential risks associated with the management and maintenance of these minor tailings processing operations may arise from:

- Tailings storage facility management (broken bunds, wind erosion);
- process plant liquid and solid waste management;
- mechanical servicing of plant and equipment;
- bulk storage of chemicals;
- stormwater management;
- acid rock drainage management; and
- tailing dam rehabilitation.

One of the mineral mining operation re-processes existing tailings for extracting gold residues from the old tailing dam at M3800037. Cyanide and carbon is added to the tailings to facilitate the extraction of the gold residues. The consolidated tailings (waste products) from this process are stored in a separated, managed area on the old tailing dam assisting in the improvement of the present condition of the dam. The existing tailings may contain some mercury due to the historical use of mercury based gold extraction processes. Other substances may also be present in the tailings as a result of previous attempts to use alternative technologies (eg large vat leach pads, 'turbo-leach' process and other treatment techniques) to extract gold residues from the old tailings. The protective bund surrounding the old tailings storage area is broken in several locations, posing a potential risk of the old tailings to be washed or wind-blown into the Beasley Creek catchment system.

Doveridge Investments Pty in conjunction with the Department of Industry and Resources (DoIR) is in process of preparing an environmental and rehabilitation management plan for parts of the old tailing dam site. This will minimise the potential for surface water and groundwater contamination from the historical operations and current low impact gold processing operation, and subsequently improve protection of the PDWSA.

3.1.1.5 Pastoral leases

There are three pastoral leases in the existing Laverton Water Reserve (ie Laverton Downs, Minara and Mt Weld Stations). Laverton Downs Station, covering the northern portion of the proposed PDWSA is the largest. Dry land grazing occurs in close proximity of the borefields and Wedge Pit, and goats have also been observed in the area. However, the risk of nutrient and pathogen contamination is considered to be low. It appears that there are no plans for more intensive development on the pastoral leases in the proposed PDWSA.

3.1.1.6 Major transport routes

Major transport routes (ie Laverton-Leonora Road, Erlistoun Road, Bandya Road and Great Central Road) that link the major towns in the region, traverses the proposed PDWSA. Supply vehicles and general traffic predominantly use these roads. Beasley Creek Bore (1/90) is within 500 metres radius of Laverton-Leonora Road, but the road is located downstream of the bore. Acute events such as road accidents and spills of fuel or other chemicals are a potentially significant risk to the water source.

3.2 Proposed land uses

Land uses and activities in the proposed Laverton PDWSA are not expected to change significantly.

Future land uses should be conducted in accordance with the Western Australian Planning Commission's Statement of Planning Policy No 2.7 – *Public Drinking Water Source Policy,* and the Department of Water's Water Quality Protection Note *Land use compatibility in Public Drinking Water Source Areas* (see Reference section).

Further advice on PDWSA issues is available from the Water Corporation, Department of Health and Department of Water.

4 Protection strategy

The protection of PDWSA by the Department of Water is consistent with government policy and involves three key elements:

- The proclamation of the PDWSA;
- the determination of 'priority classification areas' for land within the PDWSA; and
- the establishment of Wellhead and Reservoir Protection Zones within the PDWSA.

The preparation of this Drinking Water Source Protection Plan 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.

4.1 Protection objectives

The objective of water source protection is to preserve water quality at its current level, and where practical, achieve an improvement to protect water quality for the safe distribution to the Laverton Town Water Supply.

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

4.2 Proclaimed and proposed area

The current Laverton Water Reserve was gazetted under the *Country Areas Water Supply Act 1947* in 1970.

The boundary of the gazetted Laverton Water Reserve has recently been revised by the Department of Water to reflect the actual topological and hydro-geological catchment of the PDWSA. The Department is now recommending to amend the Reserves' boundary to protect the PDWSA borefields, surface water catchment and the related Wedge Pit water body from contamination (see Figure 2). This amendment will result in a major reduction in the size of the PDWSA and will avoid potential water source protection land use restrictions from the land outside the proposed PDWSA that is currently within the gazetted PDWSA.

The Laverton PDWSA will be proclaimed as both a Water Reserve and a Catchment Area under the *CAWS Act, 1947*.

Proclaiming the PDWSA as a catchment area under the CAWS Act 1947 will provide improved water source protection to the surface water entering Wedge Pit that is used for replenishing Laverton groundwater.

4.3 Priority classifications

Land within PDWSAs is allocated one of three priority classifications (1, 2 or 3). The classification attempts to prioritise areas for the protection of water quality and has been defined using present land use information, existing or approved land zoning, ownership, the importance of the water source, and the vulnerability of the water body. Each priority classification allows different levels of activity according to the degree of risk to the water quality of the water resource. Additional constraints may also apply in zones closest to the point where drinking water is harvested or stored. These areas are known as Wellhead Protection Zones (WPZ) or Reservoir Protection Zones (RPZ).

An explanation of the priority classification and the protection approach, and details of land use compatibility with each priority classification can be obtained from the Department's Water Quality Protection Notes *Land Use Compatibility in PDWSA (*see Reference section).

The proposed Laverton PDWSA should be classified for Priority 1 source protection (see Figure 4). This classification is appropriate because:

- Water from this source constitutes a strategic supply to the town of Laverton and it should be afforded the highest feasible level of protection;
- it represents the surface catchment and groundwater recharge area of the current sole water supply source for Laverton;
- the sources are highly vulnerable to contamination from incompatible land uses;
- Crown land is generally managed for Priority 1 source protection; and
- existing land uses and tenures (mining leases and pastoral leases, with the exception of mineral processing) are generally considered compatible with P1 source protection.

The land uses and tenures in the proposed PDWSA should be managed to ensure there is no degradation of water quality. A P1 priority classification area has the fundamental water quality objective of risk avoidance.

The Beasley Creek and Wedge Pit borefields are currently the only drinking water supply for Laverton, and if contaminated or polluted, is very expensive, sometimes impossible, to remediate.

4.4 Protection zones

Special purpose protection zones, such as Wellhead Protection Zones (WPZ) and Reservoir Protection Zones (RPZ) are generally declared around wellheads (production bores) and reservoirs in PDWSA to protect the water source from contamination. Within these zones, by-laws prohibit, restrict and regulate land use and human activities to prevent water source contamination. For further details on Wellhead and Reservoir Protection Zones refer to the Department's Water Quality Protection Notes *Land Use Compatibility in PDWSA* (see Reference section).

The Department encourages land activities such as fuel and chemical storage being sited outside the Wellhead and Reservoir Protection Zones.

4.4.1 Wellhead Protection Zones

Wellhead Protection Zones are defined around each bore (500 metres radius in Priority 1 areas and 300 metres radius in Priority 2 and 3 areas) in which activities are to be managed to maximise protection against contamination in the immediate vicinity of the production bores. These zones do not extend outside the boundary of the proposed PDWSA.

The Beasley Creek and Wedge Pit borefields are proposed to be managed for Priority 1 source protection. Therefore, circular 500 m radius WPZs should be created around each production bore at Wedge Pit (Bores 2/99, 3/99, 2/03 and 3/03) and Beasley Creek (Bore 1/90) borefields (see Figure 4).

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

4.4.2 Reservoir Protection Zones (RPZ)

In PDWSAs Reservoir Protection Zones (also known as Prohibited Zone) are recommended to be created around reservoirs and water bodies used for supplying water to Town Water Supplies to ensure sufficient protection of the water source from being contaminated by incompatible land use and activities. A 2 kilometres (km) wide buffer area from the top water level of the reservoir that also includes the reservoir itself is generally recommended. The Department is currently considering a provision for RPZ buffer area of less than 2 km, and creation of consistent by-laws for country and Perth PDWSAs.

A reduced RPZ buffer area is recommended around Wedge Pit to ensure the water source is protected from incompatible land uses and activities. The total area and shape that is created by the WPZ around the four production bores at Wedge Pit will be used as the pit's RPZ (see Figure 4).

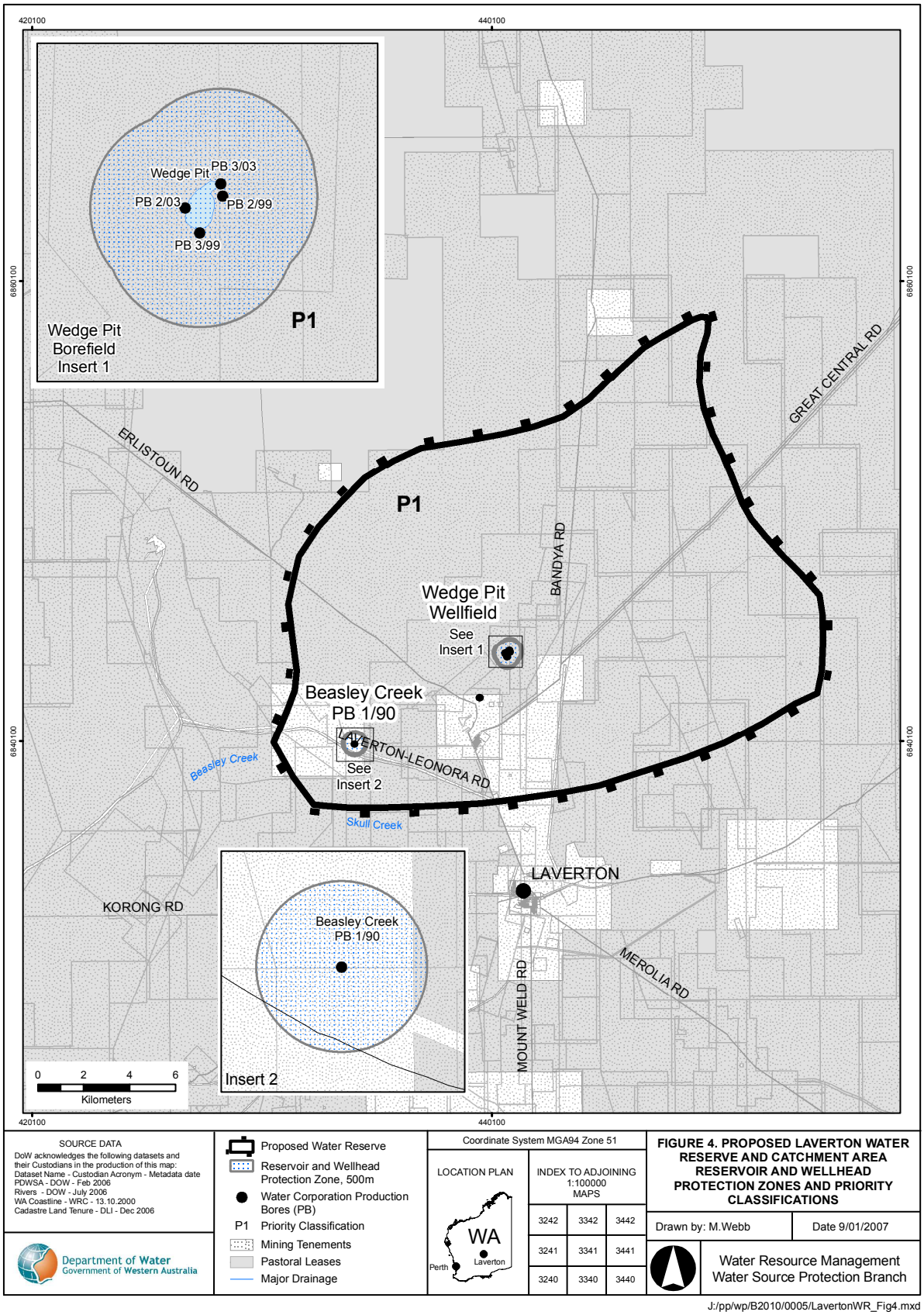

Figure 4 Priority classifications and protection zones for Laverton PDWSA

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 proposed PDWSA, protection zones and priority classifications be recognised in the Shire of Laverton's Town Planning Scheme. Any development proposals located within this area, or deemed likely to affect the protection objectives of the Laverton Water Reserve and catchment area should be referred to the Department of Water for advice and recommendations.

4.6 Best management practices

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

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 Guidelines for Mining and Mineral Processing (WQPG 1-11), 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 Laverton PDWSA. A brochure was produced describing the Laverton PDWSA, 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.

4.7 Surveillance and by-law enforcement

The quality of public drinking water sources within country areas of the State is protected under the *Country Areas Water Supply Act (1947)*. Declaration 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 PDWSAs 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.

4.8 Emergency response

Escape of chemicals during unforeseen incidents and use of chemicals during emergency responses can result in water contamination. The Shire of Laverton's Local Emergency Management Advisory Committee (LEMAC) through the Goldfield-Esperance Emergency Management District should be familiar with the location and purpose of the Laverton PDWSA. 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 Laverton PDWSA.

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

4.9 Recommended protection strategies

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

Following publication of the final Laverton PDWSA Drinking Water Source Protection Plan, an Implementation Strategy will be drawn up based on the recommendations in Table 1. It will describe timeframes and potential funding sources for the recommended protection strategies and identify 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**			
Crown land					
Swimming	The potential risks associated with swimming include: Pathogen contamination associated with swimming, through direct contact with the water body.	High	Dogs and people have been observed swimming in Wedge Pit, contaminating the surface water with pathogens. Wedge Pit can be accessed via the old mine decline (access pathway). The surface water in Wedge Pit recharges the surrounding fractured rock aquifer providing a direct contamination pathway for pathogens. The production bores are located within metres of the edge of Wedge Pit.	Water quality monitoring in bores and of raw water in Wedge Pit. Signs are provided to indicate that swimming is not permitted in Wedge Pit, and an emergency contact phone number for use in an emergency is displayed.	*Unacceptable activity in a surface water body that is used for a public drinking supply.* The proposed Laverton PDWSA should be proclaimed as a Water Reserve and Catchment Area. Swimming is a prohibited activity in a catchment area under the CAWS Act (1947) by-laws. Continue to use signs and prepare and distribute brochures to ensure public awareness that swimming is prohibited in Wedge Pit.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Swimming (continued)			Some general litter was noted in the vicinity of Wedge Pit. Generally swimming is a prohibited activity in a catchment area under the *Country Areas Water Supply (CAWS) Act 1947* by-laws. General safety to swim in an old mining pit.		Close or restrict access to old mine decline at Wedge Pit to prevent people, animals and vehicles accessing the pit. Compliance with the Department of Water's Statewide Policy No 13 *Policy and Guidelines for Recreation within Public Drinking Water Source Areas on Crown Land 2003* (see Reference section). Undertake surveillance with by-law enforcement, once the PDWSA is proclaimed as Catchment Area.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Picnicking at Wedge Pit (access of Wedge Pit via an old decline)	The potential risks associated with picnicking include: Pathogens contamination from people and potentially their pets (dogs), particularly close to the water body. Rubbish dumping. Hydrocarbons and Chemicals from vehicular access to Wedge Pit. Turbidity as result of vegetation loss (eg through human activity or grazing) around pit and wildfires.	 High Low/medium Low/medium Low/medium	There is evidence of picnicking around Wedge Pit which is located 10 km north of Laverton. Human activity has the potential to contaminate the surface water. The Beasley Creek and Wedge Pit bores are fenced, restricting access, however Wedge Pit is not fenced. General litter was noted in the vicinity of Wedge Pit. There is a potential of wildfires as a result of people having camp fires around Wedge Pit. Beer bottles and general rubbish was evident at the pit.	Water quality monitoring in bores and of raw water in Wedge Pit. Fencing of all bores. Signs to indicate Wedge Pit is a Public Drinking Water Source Area. Emergency contact number is displayed.	*Acceptable activity at designated sites.* Ensure designated picnic areas are provided. Designated picnic areas should be sited outside the proposed RPZ and include appropriate facilities with no access to water bodies or tributaries. Close old mine decline (access path) to Wedge Pit to prevent people, animals and vehicles accessing the pit. Use and maintain signs and brochures to advertise the importance of protection drinking water quality.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Camping (undesignated camping)	The potential risks associated with picnicking include: Pathogens contamination from people and potentially their pets (dogs), particularly close to the water body. Rubbish dumping. Hydrocarbons and Chemicals from vehicular access to Wedge Pit. Turbidity as result of vegetation loss around pit and wildfires.	 High Low/medium Low/medium Low/medium	Human activity has the potential to contaminate the surface water. The Beasley Creek and Wedge Pit bores are fenced, restricting access, however Wedge Pit is not fenced. There are no designated camp sites in this PDWSA. Undesignated camping poses a significant risk to water quality, as appropriate facilities are not available, particularly close to Wedge Pit. General litter was noted in the vicinity of Wedge Pit. Loss of Water Corporation's infrastructure.	Water quality monitoring in bores and of raw water in Wedge Pit. Fencing of all bores. Signs to inform people that they are in a Public Drinking Water Source Area. Emergency contact number is displayed.	*Unacceptable land activity in the PDWSA.* Maintain signs and prepare/distribute brochures to ensure the public is aware that camping is prohibited in the PDWSA and advertise the importance of protecting drinking water quality. Close or restrict access to old mine decline at Wedge Pit to prevent people, animals and vehicles accessing the pit. Water Corporation to undertake surveillance with CAWS Act 1947 by-law enforcement.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Recreation • Hunting • Off-road vehicles	The potential water quality risks are: Fuel and chemical spills from vehicles and machinery. Pathogen contamination from increased human activity in the PDWSA and possible decomposing animal carcasses.	 Medium High	Low levels of general recreational activity including hunting and off-road vehicles are reported to occur in the area. Some general litter was noted in the vicinity of Wedge Pit. An unfenced decline (old mine decline) provides direct access to people and animals to Wedge Pit.	Water quality monitoring. The production bores, located at Wedge Pit are sealed and fenced, but Wedge Pit is currently unfenced making unauthorised access possible (via old mine decline). Signs to inform people that they are in a Public Drinking Water Source Area. Emergency contact number is displayed.	*Hunting and recreational off-road vehicles are prohibited land activities in a PDWSA.* Maintain water quality monitoring program. Water Corporation should consider fencing Wedge Pit. Restrict access to old decline to Wedge Pit to prevent people, animals and vehicles accessing the pit. Use signs and brochures to ensure the public is aware that these land activities are prohibited in the PDWSA and advertise the

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Recreation (continued) • Hunting • Off-road vehicles					importance of protecting drinking water quality. Compliance with the Department of Water's Statewide Policy No 13 *Policy and Guidelines for Recreation within Public Drinking Water Source Areas on Crown Land 2003* (refer to Reference section). Undertake surveillance with *Country Areas Water Supply Act 1947* by-law enforcement.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Recreation • Prospecting	The potential water quality risks are: Fuel and chemical spills from vehicles and machinery. Pathogen contamination from increased human activity in the PDWSA	Medium High (at Wedge Pit), low (outside RPZ)	Low levels of general recreational activity including prospecting are reported to occur in the area. Some general litter was noted in the vicinity of Wedge Pit.	Water quality monitoring. The production bores, located at Wedge Pit are sealed and fenced, but Wedge Pit is currently unfenced making unauthorised access possible (via old mine decline)	*Acceptable with conditions in a PDWSA.* Under the Statewide Policy No 13 *Policy and Guidelines for Recreation within Public Drinking Water Source Areas on Crown Land 2003*, prospecting is a prohibited land activity in Wellhead and Reservoir Protection Zones. Policy No 13 is available via the Department's webpage from www.water.wa.gov.au, select policies. Close or limit access (old mine decline) to Wedge Pit to prevent people and vehicles accessing the pit.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Recreation (continued) • Prospecting					Maintain water quality monitoring program.
Fauna	The major risk to water quality is: Pathogen contamination from excreta and feral animal carcasses.	High	An unfenced decline (old mine decline) provides direct access to Wedge Pit by animals. Herding of kangaroos into the pit has occurred in the past, with dead animals observed in the pit. Hunting was also reported in the PDWSA. Surface water runoff into Wedge contributes to the pathogen load. The surface water in Wedge recharges the surrounding fractured rock aquifers providing a direct contamination pathway for pathogens. Bores at	Water quality monitoring in bores and of raw water in Wedge Pit. All production bores are fenced off to limit animal access to the bores. Stock watering points are provided at Wedge Pit borefield (see Appendix B, Photo 12).	*Best management practice should be followed to minimise contamination risks to water quality.* Maintain stock watering points down slope of Wedge Pit. Fencing of Wedge Pit may be considered as a possible strategy to keep animals away from the water source. Close or restrict access (old mine decline) to Wedge Pit to prevent people, animals and vehicles accessing the pit.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Fauna (continued)			Wedge Pit are located within metres of the edge of the pit.		
Water Corporation's water treatment pant and sedimentation ponds	The major risks associated with these activities include: Chemical substances (eg arsenic) accumulating in evaporation ponds. Fuel and chemical spills from vehicles and machinery and maintenance work	Low Low/medium	The water treatment plant is located 10 km north-west of Laverton townsite. The evaporation ponds are lined and have been designed to the requirement to withstand a 1 in 20 year flood. The arsenic levels in the ponds were reported to be slightly higher than the maximum arsenic concentration in the water of Bore 1/90.	Evaporation ponds are lined. Beasley Creek is only flowing once or twice a year. The evaporation ponds have been designed to cope with a 1 in 20 year flood.	*Acceptable with conditions in the PDWSA.* Continue to monitor water quality of bores and evaporation ponds. Maintain water treatment plant on a regular basis. Desludge evaporation ponds on a regular interval, or as seen necessary.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Water Corporation's water treatment pant and sedimentation ponds (continued)			The water treatment plant removes the arsenic from the raw water prior to feeding the drinking water into the Laverton Town Water Supply. The water treatment plant and sedimentation ponds are located downstream from Beasley Creek bore. There is a potential of flooding in the area, and loss of Water Corporation's infrastructure. Water Corporation is in process of preparing a contingency plan for the Beasley Creek water treatment plant and evaporation ponds for the event of flooding.		No chemicals should be stored at the water treatment plant, apart from the chemicals used while operating the plant. Water Corporation to prepare contingency plan for the Beasley Creek Water Treatment Plant (including evaporation ponds) to ensure the water quality of the water source is not compromised.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Mining activities (this includes existing and past activities – disused pits and shafts) (The small scale tailing processing operation is discussed separately, see below).	The potential water quality risks associated with mining activities are: Chemicals eg cyanide, carbon and mercury (historically been used for gold processing). Hydrocarbons and Chemicals Pathogen contamination from increased human activity in the PDWSA, particularly in close proximity of Wedge Pit.	 Medium Medium High	There are currently no operating mines in the proposed PDWSA. Past activities include open-cut and underground workings. Historical heap leaching activities have not been identified in the vicinity of the current borefields however, one does occur in another part of the proposed PDWSA.	Water quality monitoring in bores and of raw water in Wedge Pit. HAZMAT Emergency Response.	*Mining activities (excluding tailing dams and mineral processing) are acceptable with conditions in the PDWSA.* All development proposals within the Laverton PDWSA 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 No.2.7 – Public Drinking Water Source Policy* should be referred to the Department of Water

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Mining activities (continued)			There is the potential for future development of additional mining operations. Potential contamination from fuels and chemicals would be minimised by appropriate storage, use and transportation practices. There are a number of abandoned open pits and mine shafts in the proposed PDWSA. Animals can easily access open pits and shafts, and contaminate the aquifer with pathogens.		for advice and recommendations. Mining activities are subject to Department of Environment and Conservation and Department of Industry and Resources licensing and reviews. New mineral processing operations are not compatible in the PDWSA, and will not be supported by the Department of Water.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Mining activities (continued)			Contaminated surface water may also directly recharge the aquifer via the open shafts and pits, particularly Wedge Pit.	Water Quality Monitoring.	Ensure best management practices are followed. Relevant details are provided in the Department's Water Quality Protection Guidelines No (Nos. 1-11), *Mining and Mineral Processing*, 2000 (see Reference section). Continue and maintain adequate water quality monitoring programs at Beasley Creek and Wedge Pit borefields, Wedge Pit and the old tailing dam.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Minor mineral processing operations on M3800037	The potential water quality risks associated with mining activities are: Chemicals, eg mercury has historically been used for gold processing, cyanide is still used for re-processing the old tailings to extract gold residues at Lancefield. Fuel and chemical spills from vehicles and machinery.	High High	Some mineral processing is occurring south-west of Wedge Pit borefield and south of Beasley Creek borefield. This non-conforming, historical activity is considered to be a minor mineral processing operation. The old tailings from the historical tailing dams on M3800037 are re-processed for the extraction of gold residues. The consolidated tailings (waste products) resulting from this operation are stored in a designated, lined area that is viewed to improve the environmental conditions of the historical tailing dam.	The consolidated tailings (waste products) resulting from this minor operation are stored in a designated, lined area.	*Manage existing minor mineral processing operation as non-conforming land activity.* Water Corporation to continue water quality monitoring in bores at Beasley Creek and Wedge Pit, and the raw water in Wedge Pit. Water testing should also include water quality parameters (eg cyanide, mercury or similar chemicals) to monitor any potential contamination resulting from mining activities. The Department of Industry and Resources should liaise with relevant licence holder to:

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Minor mineral processing operations on M3800037 (continued)			Bunds that surround the old tailing dam are in need of repair. Several gaps currently exist in the bund, having the potential for the tailing to be dispersed in the Beasley Creek catchment. The old tailings (fine dust) have the potential to be wind-blown into the Beasley Creek catchment that may have a potential impact on the water quality of the Beasley Creek borefield.		Maintain internal and external stormwater control measures to minimise embankment erosion. Repair bunds surrounding the old tailing dam. Water proof bunds should be established around the old tailings (particularly along the northern and westerly boundaries) to retain the tailings in the old tailing dam area and to avoid any dispersal of the old tailings into the Beasley Creek catchment area. Cap old tailings that are unlikely to be re-processed with waste rocks or other

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Minor mineral processing operations on M3800037 (continued)			Further information for monitoring cyanide is provided in the National Pollutant Inventory: Emission estimation technique manual for gold ore processing (refer to Reference section).		suitable material to avoid wind-blown dust. Doveridge Investments Pty to prepare and implement an Environmental Management Plan, considering suitable drinking water source protection strategies for parts of the old tailing site to the satisfaction of the Department of Industry and Resources and Department of Water. This management plan should include monitoring provisions for cyanide and other substances that have been used on the site.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Minor mineral processing operations on M3800037 (continued)					New mineral processing operations are not compatible in the PDWSA, and will not be supported by the Department of Water. The site is subject to the Department of Environment and Conservation and Department of Industry and Resources licensing and review process. Consider alternative options under the Contaminated Site *Act 2004* to address the old tailing dam.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Outbuilding and caretaker residence for gold mine on M3800037 (gold mine not in operation)	The potential water quality risks are: Fuel and chemical spills from vehicles and machinery. Pathogens from on-site effluent disposal system.	 Low Low	An above ground chemical storage tank is located next to the outbuildings. The tank is located in a bund.	unknown	*Acceptable with best management practices.* Maintain bund and tank in a good condition to avoid any spillages and leakage into the groundwater. Maintain on-site effluent disposal system.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Exploration Activities	The potential water quality risks are: Fuel and chemical spills from vehicles and machinery. Hydrocarbon transport and storage Pathogen contamination from increased human activity in the PDWSA, particularly in close proximity of Wedge Pit.	 Low Low High (at Wedge Pit), low outside RPZ	Exploration activity occurs in the proposed PDWSA, but not in the immediate area where the bores are situated.	Water quality monitoring	*Acceptable activity with conditions in the PDWSA.* (see mining activities).

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Pastoral Activities	The potential water quality risks associated with pastoral activities are: Pathogens contamination from excreta and domestic animal carcasses Fuel and chemical spills from vehicles and machinery.	 Low Low	A pastoral lease covers a large area in the north of the proposed PDWSA. Stocking levels are typically 1 sheep per 50 acres. The bores are sealed, significantly reducing the potential for pathogen contamination from stock. Fuel and chemical storage would be limited and be more than 10 km away from the borefields. Stock watering points are provided at Wedge Pit (Bore 3/03). Stock watering points should be located down slope of the bores and Wedge Pit.	Water quality monitoring. Sealed bores. Stock watering points for grazing animals are provided.	*Acceptable with conditions in the PDWSA.* Maintain water quality monitoring Program. Encourage adherence to the Department's Water Quality Protection Note *Stockyards* (refer to Reference section). Maintain stock watering points for grazing animals. Stock watering points should be located down-slope of the bores and Wedge Pit. Water Corporation should relocate stock watering point at Wedge Pit down-gradient of the

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Pastoral Activities (continued)					proposed RPZ. Also keep livestock down-slope of the proposed RPZ and WPZ.
Roads	The potential risks to water quality include: Hydrocarbons/ and chemicals from vehicles and their loads. Pathogens imported by litter and dead wildlife.	Medium Low	The Leonora-Laverton Road, a major transport route, passes through the proposed PDWSA approximately 500 m downstream (south) of the Beasley Creek borefield. Road trains frequent the road carrying hydrocarbons and chemicals in bulk quantities with two significant spills reported over the last 2 years. There are also a number of minor roads in the reserve. Major incidents initiate a	Water quality monitoring HAZMAT emergency response. Sealed bores.	*Manage as a non-conformity use with best management practices.* Review road network to identify tracks that are not required for transport thoroughfare and maintaining existing infrastructure. Restrict development of new roads through the proposed PDWSA.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Roads (continued)			HAZMAT emergency response. Litter and dead wildlife along roads is a potential source of contamination during flood events. Maintaining sealed bores significantly reduces the risk.		Use and maintain signs along roads to inform that they are in a public drinking water source area, and display the emergency contact number. Encourage adherence to the Department's Water Quality Protection Note *Roads near Sensitive water resources* (refer to Reference section) Maintain HAZMAT emergency response.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Infrastructure maintenance • Power lines • Pipelines • Associated tracks • Production bores and associated fixtures/ structures	The major risks associated with these activities include: Turbidity. Pesticides (herbicides for weed control). Fuel and chemical spills from vehicles and machinery.	 Low Medium/low Medium/low	Maintenance is necessary for the operation of the infrastructure. However, the risks to water quality associated with maintenance need to be managed, particularly in close proximity to Wedge Pit and Beasley Creek's tributaries. The Department of Water's Statewide Policy Number 2 *Pesticide Use in Public Drinking Water Source Areas* should be considered when dealing with these hazards. There are also restrictions on the use of pesticides in catchment areas reflected in PSC88.	Water quality monitoring. HAZMAT emergency response. Sealed bores.	Best management practices should be followed for all maintenance work in the catchment. Ensure that all agencies with responsibilities and their maintenance contractors are aware of the location of the PDWSA, and that appropriate best management practices are followed whilst within the PDWSA. Encourage adherence to Department's Water Quality Protection Note *Infrastructure corridors near sensitive water resources* (refer to Reference section).

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Infrastructure maintenance (continued)					Encourage adherence to the Department's Statewide Policy Number 2 *Pesticide Use in Public Drinking Water Source Areas* and Public Service Circular No 88 (PSC88) (Department of Health, 2006) (refer to Reference section).

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Fire Management (this includes controlled burning and wildfires)	The potential risks to water quality at Wedge Pit include: Increased turbidity. Carbon and nutrient contamination from airborne and eroded ash. Fuel spills from vehicles and machinery. Pathogens from direct contact of firefighters with water bodies.	 Low Low Low Low	Fire management through fire pre-suppression and suppression. Recreational activities, such as picnicking, camping and similar activities should be kept out of the proposed WPZ and RPZ to reduce the risk of wildfires.	Fire is managed through the Goldfield-Esperance Emergency Management District.	*Acceptable activity with best management practices.* Liaise closely with the Council's Local Emergency Management Advisory Committee (LEMAC) through the Goldfield-Esperance Emergency Management District. The committee should be familiar with the location and purpose of the Laverton PDWSA. Provide a locality plan to the Fire and Rescue Services headquarters for the Hazardous Materials Emergency Advisory Team (HAZMAT).

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 boundary of the existing Laverton Water Reserve should be de-proclaimed and the recommended, reduced boundary be proclaimed under the *Country Areas Water Supply Act 1947as a Water Reserve and Catchment* Area (see Figure 2) *(Department of Water).*

3 Prepare an implementation strategy for this Plan describing responsible stakeholders, timeframes and funding sources for the recommended protection strategies *(Department of Water).*

4 Skull Creek and Telegraph Shaft borefields should be decommissioned and/or filled in *(Water Corporation).*

5 The Shire of Laverton's Town Planning Scheme should incorporate this Plan and reflect the identified Laverton Water Reserve and catchment area boundaries, Priority 1 classification area, and Wellhead and Reservoir Protection Zones *(Shire of Laverton).*

6 All development proposals within the Laverton 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 No.2.7 – Public Drinking Water Source Policy* should be referred to the Department of Water for advice and recommendations (*Department for Planning and Infrastructure, Shire of Laverton).*

7 Incidents covered by WESTPLAN – HAZMAT in the Laverton Water Reserve should be addressed through the following:

- The Goldfield-Esperance Emergency Management District LEMAC are familiar with the location and purpose of the Laverton Water Reserve.
- The locality plan for the Laverton 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 Laverton Water Reserve.
- Personnel dealing with WESTPLAN – HAZMAT incidents in the area have ready access to a locality map of the Laverton Water Reserve and training to understand the potential impacts of spills on drinking water quality

(*Department of Water, Water Corporation).*

8 A surveillance program should be implemented to identify any incompatible land uses or potential threats within the Laverton Water Reserve and catchment area. 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*).

9 Signs should be erected and maintained along the boundary of the proposed Laverton Water Reserve and water catchment 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*).

10 Wedge Pit should be fully or partly fenced around the old mine decline to restrict unauthorised access (Water Corporation).

11 The elevated micro-biological counts in the water samples taken from Wedge Pit should be further investigated with attempts to determine and remove the source of contamination (Water Corporation).

12 An environmental management plan considering drinking water source protection should be prepared and implemented for the minor mineral processing operation and old tailing dam at M3800037; and be forwarded to the Department of Industry and Resources for approval. The Department of Water should be invited to provide advice and comments prior to finalising the management plan). This management plan should include monitoring provisions for chemicals that have been used on the site (Doveridge Investments Pty, Department of Industry and Resources, and Department of Water).

13 A review of this Plan should be undertaken after five years (*Department of Water*).

Appendices

Appendix A - Water quality

The Water Corporation has monitored the raw (source) water quality from Laverton wellfields 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 the Laverton wellfields, Wedge Pit and Beasley. 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 Laverton 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 the Laverton wellfields (Wedge Pit and Beasley) are summarised in Table 1.

The values are taken from ongoing monitoring for the period January 2001 to January 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.

Table 2 Aesthetic related detections for Laverton Wedge Pit and Beasley wellfields

Parameter	Units	ADWG Aesthetic Guideline Value*	Range of Monitored Values Min-Max Med		
			Wedge Pit Raw	Beasley 1/90	Beasley Raw¥
Aluminium unfiltered	mg/L	NA	0.038 - 0.91 0.215	<0.008 <0.008	<0.008 - 0.055 <0.008
Chloride†	mg/L	0 - 250	3.7 - 6.4 4.4	415 - 465 440	100 - 425 262.5
Colour - True	TCU	0 - 15	3 - 28 11	<1 <1	<1 - 5 <1
Conductivity (25ºC)	mS/m	NA	5 - 9 6	39 - 250 235	25 - 250 88.5
Hardness ($CaCO_3$) †	mg/L	0 - 200	11.6 - 12.1 11.7	406 406	101 - 392 246.5
Iron unfiltered	mg/L	0 - 0.3	0.102 - 0.55 0.24	<0.003 - 0.01 <0.003	<0.003 - 0.38 0.015
Manganese unfiltered	mg/L	0 - 0.1	<0.002 - 0.05 0.006	<0.002 <0.002	<0.002 - 0.08 <0.002
pH	-	6.5 - 8.5	6.72 - 9.63 7.76	7.46 - 7.84 7.48	7.37 - 7.99 7.685
Sodium†	mg/L	0 - 180	5 - 6 5.5	330 330	100 - 305 202.5
Sulphate†	mg/L	0 - 250	1.4 - 2.2 1.6	205 - 210 207.5	51 - 200 125.5
TFSS†	mg/L	0 - 500	54 - 57 57	1480 - 1520 1500	481 - 1520 1000.5
Turbidity	NTU	0 - 5	3.4 - 150 7	<0.1 - 0.2 <0.1	<0.1 - 2 0.15

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

† Water quality data extracted from 3 or less sampling occasions.

¥ All aesthetic water quality data reported for Beasley Raw SP is extracted from 3 or less sampling occasions, with the exception of Conductivity (25ºC).

Health Related Characteristics

Health Parameters

Raw water from Laverton wellfields (Wedge Pit and Beasley) 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 2001 and January 2007 are summarised in the Table 2. Any parameters that have on occasion exceeded the ADWG are shaded.

Table 3 Health related detections for Laverton Wedge Pit and Beasley wellfields

Parameter	Units	ADWG Health Guideline Value*	Range of Monitored Values Min-Max Med		
			Wedge Pit Raw	Beasley 1/90	Beasley Raw
Arsenic	mg/L	0 - 0.007	<0.002 - 0.03 <0.002	<0.002 - 0.045 <0.002	0.003 - 0.035 0.02
Fluoride	mg/L	0 - 1.5	<0.10 <0.10	0.75 - 0.9 0.8	0.45 - 1.2 0.8
Nitrate as nitrogen	mg/L	0 - 11.29	0.006 - 1.7 0.335	2.3 - 24 20.5	NA
Nitrite as nitrogen	mg/L	0 - 0.91	<0.002 <0.002	<0.002 - 0.003 <0.002	NA

* 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).

NA – Not available.

Microbiological Contaminants

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

than 20 MPN per 100mL can seriously impede on the ability to ensure of a safe drinking water supply with disinfection alone.

During the reviewed period of January 2001 to January 2007, positive *Escherichia coli* counts were recorded in 14 per cent of samples collected from the borefield. Approximately 11 per cent of these samples had *Escherichia coli* counts greater than 20 MPN per 100mL. This high occurrence of *Escherichia coli* detections from a groundwater source is indicative of significant contamination of the groundwater from faecal sources, and is due to direct recharge from surface water sources mitigating the soil removal barrier often afforded to groundwater sources.

Appendix B - Photographs

Photo 1 Water Storage Tank at Laverton

Photo 2 Open surface drain discharging into Wedge Pit

Photo 3 Water Treatment Plant at Beasley Creek

Photo 4 Open pit in Laverton Public Drinking Water Source Area

Photo 5 Disused mine shaft in Laverton proposed PDWSA

Photo 6 Caretaker residence and outbuildings at Metex site

Photo 7 Chemical storage in bunded area at Metex site

Photo 8 Minor mineral processing operation at old tailing dam

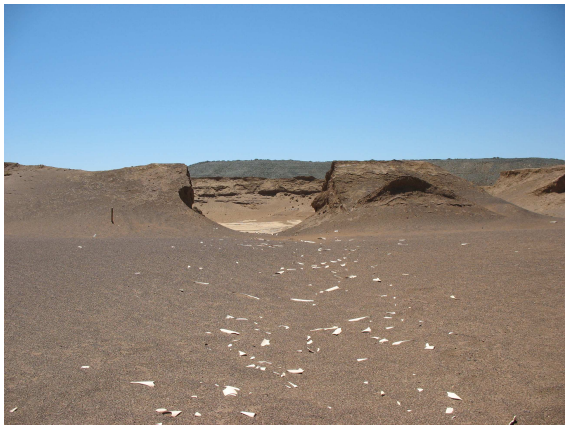

Photo 9 Damaged bund at old tailing dam

Photo 10 Storage area for re-processed tailings from minor mineral processing operation

Photo 11 Open mine pit at Lancefield

Photo 12 Stock watering point at Wedge Pit borefield

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.
Catchment	The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
CFU	Colony 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.
Effluent	The liquid, solid or gaseous wastes discharged by a process, treated or untreated.
GL	Gigalitres (1000 000 000 litres)
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)
km^2	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 its 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	Includes all underground water pollution control areas, catchment

Water Source Area (PDWSA)	areas and water reserves constituted under the *Metropolitan Water Supply Sewerage and Drainage Act 1909* and the *Country Areas Water Supply Act 1947*.
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.
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.
Storage reservoir	A major reservoir of water created in a river valley by building a dam.
Reservoir Protection Zone (RPZ)	Reservoir Protection Zone - a 2 km buffer measured from the high water mark of a drinking water reservoir, and inclusive of the reservoir. Referred to as a 'Prohibited Zone' under the *Metropolitan* Water Supply, Sewerage and Drainage By-laws 1981.
Stormwater	Rainwater which has run off the ground surface, roads, paved areas etc. and is usually carried away by drains.
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.
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 *Country Areas Water Supply Act 1947* or the *Metropolitan Water Supply Sewerage and Drainage Act 1909* for the purposes of protecting a drinking water supply.
Watertable	The upper saturated level of the unconfined groundwater.
Well field	A group of bores to monitor or withdraw groundwater.
Wellhead	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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