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

Looking after all our water needs

Newman Water Reserve drinking water source protection plan

Newman town water supply

Water resource protection series

REPORT NO. 97
June 2009

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

Important information

The *Newman Water Reserve drinking water source protection plan* (2009, WRP no.97) was reviewed in 2014.

Please ensure you read the *Newman Water Reserve drinking water source protection review* (2014, WRP no.146) alongside the 2009 plan to obtain all of the information about this drinking water source.

The 2014 review considers changes that have occurred in and around the Newman Water Reserve since the completion of the 2009 plan. The review reflects the new groundwater source for Newman that will be developed by BHP Billiton – the Homestead bore field – approximately 5 to 10 km north of Newman.

You can find the 2014 *Newman Water Reserve drinking water source protection review* at www.water.wa.gov.au > publications > find a publication > drinking water source protection reviews or by contacting the Department of Water on +61 8 6364 7600 or drinkingwater@water.wa.gov.au.

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All maps in this publication were produced by the Department of Water (for the Water Resource Management Division) with the intent that they be used for the Newman Water Reserve at the scale shown on the maps.

While the Department of Water has made all reasonable efforts to ensure the accuracy of data in this report, it accepts no responsibility for any inaccuracies, and persons relying on them do so at their own risk.

For more information about this report, contact the Department of Water, Water Source Protection Branch on +61 8 6364 7600 or send your enquiry to drinkingwater@water.wa.gov.au.

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Preface

The Department of Water has prepared this drinking water source protection plan to assess risks to water quality within the Newman Water Reserve and to recommend management strategies to avoid, minimise or manage those risks. The department is committed to protecting drinking water sources to meet public health requirements and ensure the supply of safe, reliable, good quality drinking water to consumers.

The *National water quality management strategy: Australian drinking water guidelines 6, 2004* (NHMRC & NRMMC 2004a) recommends a risk-based, multiple-barrier approach to protect public drinking water sources. Catchment protection is the first barrier against contamination, with subsequent barriers implemented at the water storage, treatment and distribution stages of a water supply system. Catchment protection requires an understanding of the catchment and hazards that can compromise drinking water quality. It then requires the development of preventative strategies and operational controls to ensure the safest possible water is supplied to consumers.

This plan details the location and boundary of the drinking water source providing potable water to the Newman town water supply. It discusses existing and future use of the water source, describes the water supply system, identifies risks and recommends management approaches to address these risks and protect the water source.

This plan has been prepared to guide state and local government land-use planning decisions. It should be recognised in the *Shire of East Pilbara town planning scheme*, consistent with the Western Australian Planning Commission's *Statement of planning policy 2.7: Public drinking water source policy*. Other stakeholders should use this document as a guide for protecting the quality of water in the recommended Newman Water Reserve.

The stages involved in preparing a drinking water source protection plan are:

Stages in development of a plan		**Comment**
1	Prepare drinking water source protection assessment document.	Prepared after initial catchment survey and preliminary information gathering. This document may not be required if a drinking water source protection plan already exists or alternative documents provide suitable information.
2	Conduct stakeholder consultation.	Advice sought from key stakeholders using the assessment document as a tool for information and discussion.
3	Prepare draft drinking water source protection plan.	Draft protection plan developed taking into account input from stakeholders and any additional advice.
4	Release draft drinking water source protection plan (17/04/2009).	Draft protection plan released for a six-week public consultation period.
5	**Publish approved drinking water source protection plan (June 2009).**	**Final protection plan published after considering submissions. Includes recommendations on how to protect water quality. Proclamation of public drinking water source area can now occur.**

Summary

Newman is located approximately 1200 km north-east of Perth on the Great Northern Highway, close to where the highway intersects the Tropic of Capricorn. The town is in the upper reaches of the Fortescue River catchment, to the west of where the Ophthalmia Dam is built across the Fortescue.

The town was built by the Mt Newman Mining Company to service the surrounding mining industry and today has population of approximately 7000 people. Newman also provides a stopping-off point for visitors to regional attractions such as the Karijini National Park. It is also the administrative centre for the Shire of East Pilbara.

Newman's connection with the mining industry has meant the development of a water supply system that is part of the mining activities. This has resulted in mining related land uses occurring in closer proximity to the drinking water supply production bores than would otherwise be recommended. This is an unusual situation in Western Australia; however, it can be managed to supply safe drinking water to consumers.

The town water supply is drawn from a number of bores drilled into in-filled paleovalleys north-east and west of the town. BHP Billiton operates the bores and treats the water, while the Water Corporation operates the reticulated supply scheme and is the licensed water service provider. The Newman Water Reserve was proclaimed in 1983 to protect the water source. This plan proposes a significant reduction in the eastern area of the existing water reserve.

The bores are most vulnerable to contamination from mining operations within the catchment. Water quality may also be affected by faecal waste from grazing cattle, particularly where uncapped, abandoned drill holes or other surface disturbances allow surface-water flows to connect to the aquifer. The different land uses associated with the town also pose a contamination risk.

The following strategies are recommended to protect water quality within the Newman Water Reserve:

- all Crown land outside the gazetted Newman town site should be managed for Priority 1 source protection and the Newman town site managed for Priority 3 source protection
- the boundaries of the water reserve should be amended to reflect the physical boundaries of the surface water catchments of Whaleback and Homestead creeks which recharge the superficial aquifer from which the bores draw water.
- all activities that pose a high contamination risk to water quality, which are within wellhead protection zones, should be relocated outside of these zones

1 Drinking water source overview

1.1 Existing water supply system

Newman's town water supply comes from the Ophthalmia Dam borefield, with an additional production bore (known as V18) close to Mt Whaleback. The borefield was commissioned in the early 1970s and is part of an extensive system of production and monitoring bores that are also used for dewatering the mine pits that surround the town. As well as supplying the town, the system is also used to provide potable water to BHP Billiton mine sites in the area. The location of the existing water reserve that covers the borefield is shown in Figure 1 and Figure 2.

Potable water from the borefield has historically come from two different lines of bores: the H-line and E-line. The H-line bores are situated just off the main channel of Homestead Creek, near Orebody 25. The E-line bores are just below Ophthalmia Dam and are currently not used for drinking water supply due to water quality concerns.

BHP Billiton owns and operates the water supply headworks (including borefield pumps and supply mains to the raw-water treatment plant and Ophthalmia Dam). This is part of an extensive system that allows for water obtained from the mine dewatering process to be used for different purposes. BHP Billiton provides bulk treated water to the Water Corporation, which is then responsible for reticulating the water to the town. BHP Billiton and the Water Corporation have a memorandum of agreement in place to manage the water supply system. The Water Corporation (and not BHP Billiton) is the licensed water service provider for the system.

It should be noted that Newman was established to service the surrounding mining industry. This has resulted in the development of a water supply system that is connected with local mining activities. This is an unusual situation that means drinking water source protection must recognise the mining activities. As such, some land uses occur in closer proximity to drinking water supply production bores than would otherwise be recommended. However, this situation can still be managed to supply safe drinking water to consumers.

1.2 Water treatment

BHP Billiton's water treatment plant stores raw water and then treats it using Calgon dosing (to prevent scaling due to raw-water hardness), resin ion exchange (for water softening), carbon dioxide stripping and chlorine disinfection. The treated water is then transferred to a storage tank, from which the Water Corporation draws the water and reticulates it throughout the town and mine sites.

It should be recognised that although treatment and disinfection are essential barriers against contamination, catchment management is the first step in protecting water quality and thus ensuring a safe drinking water supply. This approach is endorsed by

the *National water quality management strategy: Australian drinking water guidelines 6, 2004* (ADWG) (NHMRC & NRMMC 2004a) and reflects a risk-based, catchment-to-consumer, multiple-barrier approach for providing safe drinking water to consumers. The combination of catchment protection and water treatment delivers a more reliably safe drinking water to consumers than either could achieve individually.

1.3 Catchment details

1.3.1 Physiography

The Newman Water Reserve is flanked by the Hamersley and Ophthalmia ranges to the north. Mt Whaleback lies to the town's west and is currently subject to mining for iron ore.

The Fortescue River flows north-east across the water reserve into the Ophthalmia Dam and then down through Ethel Gorge. The water reserve is in the upper reaches of the Fortescue River catchment. A number of creeks run through the water reserve: the major ones are the Whaleback and Homestead creeks. Flows in these watercourses generally coincide with periods of heavy rainfall from cyclonic activity and tropical storms.

1.3.2 Climate

Newman has an arid climate characterised by hot summers with periodic heavy rain and mild winters with occasional rainfall. The average monthly maximum temperature varies from 38.8^{o}C in January to 22.2^{o}C in July.

Newman averages about 300 mm of rainfall a year, most of which results from tropical thunderstorms and cyclonic activity during summer. There can be significant variation in rainfall from year to year. Newman can experience heavy rainfall over short periods, with watercourses in the area generally flowing after these events.

1.3.3 Hydrogeology

The Ophthalmia Dam borefield abstracts groundwater from alluvial and chemical sediments that have in-filled paleovalleys associated with the Fortescue River and its tributaries. Some bores also draw water from the Wittenoom Formation (an extensive carbonate, shale and minor epiclastic unit that overlies the Marra Mamba Iron Formation and passes conformably upward into the Mt Sylvia Formation), which has some hydraulic connection with the overlying sedimentary units. Aquifers are found in the calcrete and underlying sand and gravel. These are generally separated by a sequence of clays that act as a confining layer.

Recharge occurs mostly by leakage from stream beds during runoff and to a lesser extent by direct infiltration of rain over the surface. The potable water supply bores are drawing from a superficial aquifer system – so water quality and quantity is

heavily influenced by the quality and quantity of surface water. Groundwater flow direction generally mimics the direction of surface-water flows.

An aquifer recharge system has been constructed below Ophthalmia Dam and comprises four excavated recharge ponds, two river basins and an open-earth canal, which can be flooded as required from Ophthalmia Dam. If monitoring data indicates that groundwater abstraction from the Ophthalmia borefield is approaching or is projected to exceed the sustainable yield of the aquifer, then the aquifer recharge scheme can be brought into action.

Water levels in the Ophthalmia borefield show no long-term reduction in groundwater storage in the aquifer. Before 1981 groundwater levels had been falling as a result of unsustainable draw from the aquifer. The construction of Ophthalmia Dam in 1981 has seen groundwater levels stabilise. Leakage through the floor of the dam has been sufficient to maintain high aquifer levels in recent years. Because of this leakage, the aquifer recharge system has yet to be used.

1.4 Future water supply requirements

It is anticipated that the quantity of water required to satisfy Newman's potable and non-potable requirements will significantly increase. This is due to the town's growing population as well as an expansion of mining operations such as the BHP Billiton Iron Ore Rapid Growth Project 4 (which is discussed in more detail in Section 3.2). The quantity of water currently available in the existing supply system is thought to be sufficient to meet this future demand, particularly with planned upgrades to existing water supply infrastructure.

1.5 Existing drinking water source protection

The existing 840 km^2 Newman Water Reserve was proclaimed in 1983 under the *Country Areas Water Supply Act 1947* (WA) for public drinking water source protection. By-laws created under this Act enable the Department of Water to control potentially polluting activities, to regulate land use, inspect premises and take the necessary steps to prevent or clean up pollution.

Other source protection measures currently in place include:

- a memorandum of understanding between the Water Corporation and BHP Billiton that provides for weekly updates and discussions about the water source, including source protection issues such as surveillance.
- fencing of the bore compounds to provide limited protection of the bores (see Appendix B, Figure B1).

The Department of Water has delegated surveillance powers and by-law enforcement to the Water Corporation for some public drinking water source areas (PDWSAs). However to date, surveillance and by-law enforcement powers for the

Newman Water Reserve have not been delegated to the Water Corporation. Please refer to Section 4.7 for more information.

1.6 Department of Water management

1.6.1 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* (WA). Under the Act, the right to use and control surface water and groundwater is vested with the Crown. The Act requires licensing of surface-water abstraction (removing water from a waterway) within proclaimed surface-water areas and groundwater abstraction (pumping water from a bore, spring or soak) within proclaimed groundwater areas.

The licences under which potable water is abstracted for Newman also provide for the abstraction of water for mineral ore processing, dewatering and dust suppression. Future demand for water as a result of growth in Newman may require an increase in the licensed allocation.

1.6.2 Pilbara regional water plan

The *Pilbara regional water plan* sets the overall strategic direction for water resource management in the Pilbara. The regional water plan has a planning view to 2030 and identifies priority actions for implementation during the next five years. One of those priority actions is that drinking water source protection plans are prepared for all sources across the Pilbara.

Once this Newman DWSPP is completed, then source protection plans will have been completed for all sources that are currently harnessed in the Pilbara region, except for the Marble Bar Water Reserve DWSPP, which is due for completion in 2010. Existing DWSPP are due for review five years after they are completed. DWSPP for future and existing unused sources will be completed when these sources begin to be utilised.

1.6.3 Pilbara water in mining policy

The Department of Water is developing a policy that aims to facilitate good water management practices in mining operations across the Pilbara, as well as achieve the best-possible water resource, environmental and economic management outcomes.

The policy is needed because the amount of mining below the watertable has significantly increased. To avoid long-term impacts, it is important that water security, together with environmental and cultural values, are recognised and managed.

Part of the policy will be to ensure that mining operations consider fit-for-purpose water use, so that the chosen water source will be appropriate for the different purposes and needs within the mining operations. For example, as far as practical, the best-quality water with the greatest source protection should be used for drinking water supplies. The policy also requires that mining operations within PDWSAs recognise the potential impacts of their operations on drinking water sources and develop strategies to protect the water quality.

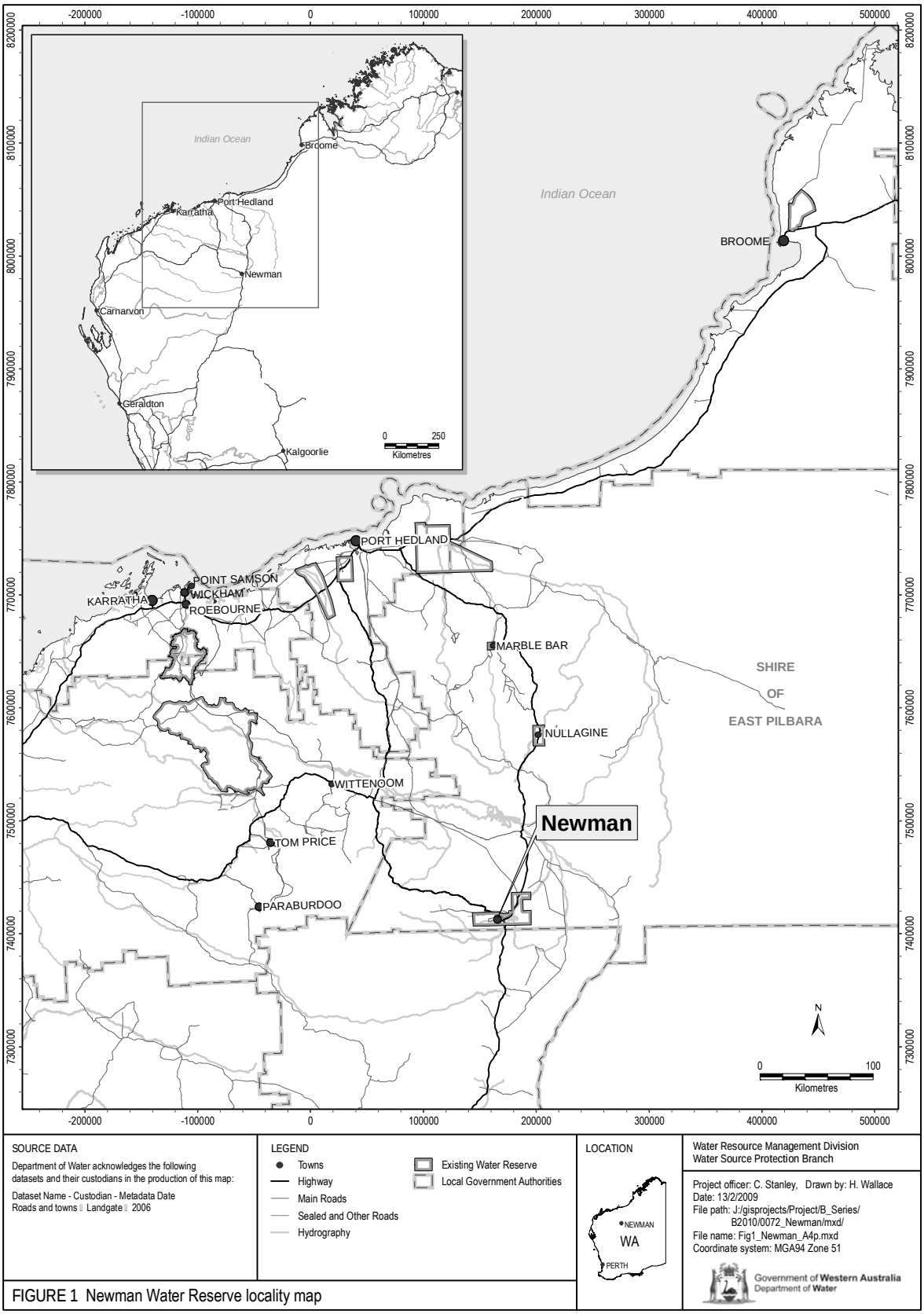

Figure 1 Newman Water Reserve locality map

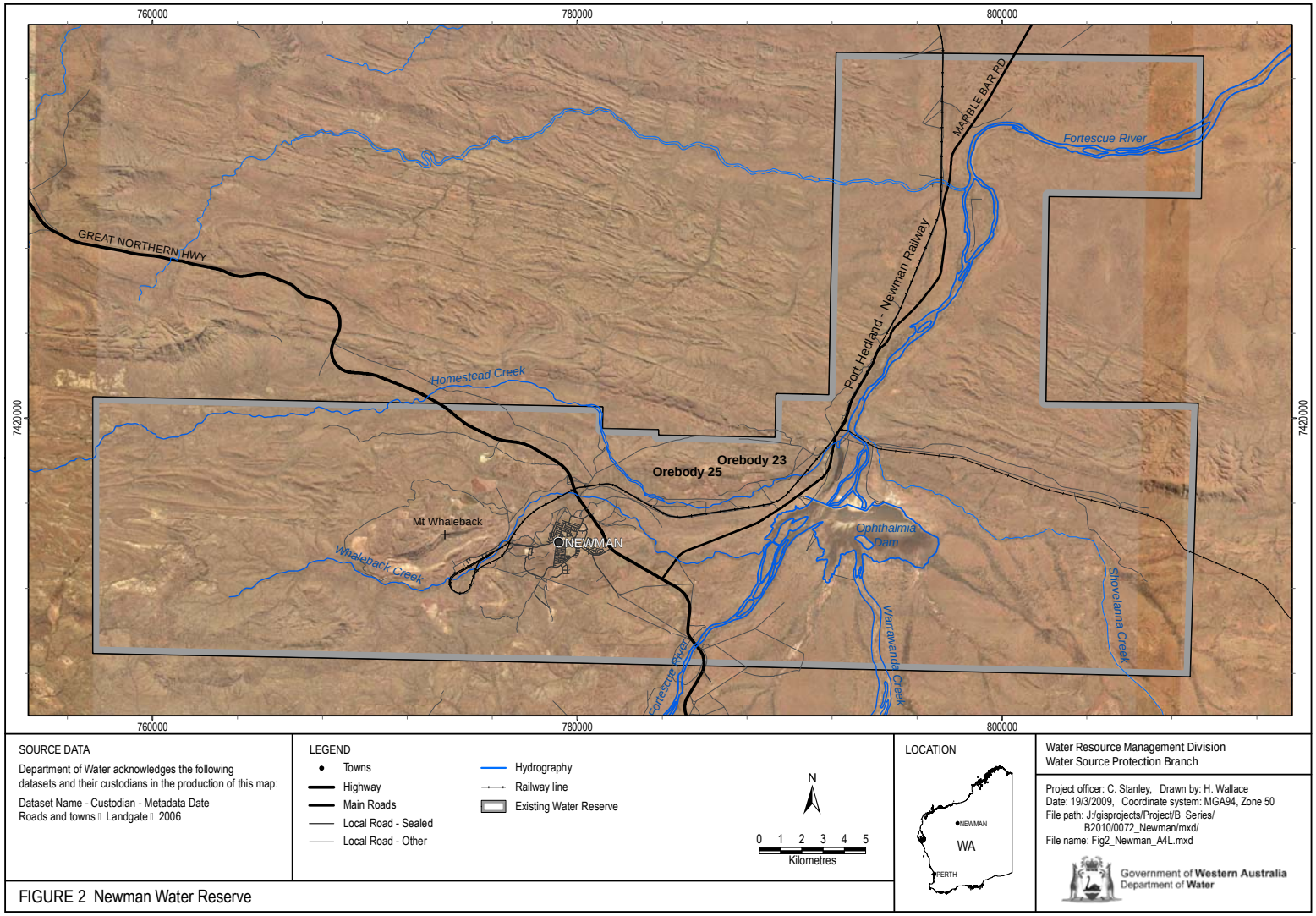

Figure 2 Newman Water Reserve

2 Water quality monitoring and contamination risks

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

BHP Billiton regularly monitors the quality of raw water from the Newman Water Reserve for microbiological, health-related and aesthetic (non-health-related) characteristics. This data shows the quality of water in the catchment. In addition, an assessment of the drinking water quality is made against the ADWG to ensure safe, good quality drinking water is available to consumers. An intergovernmental committee known as the Advisory Committee for the Purity of Water, which is chaired by the Department of Health, makes this assessment based on water quality data provided by the Water Corporation.

A water quality summary for the Newman Water Reserve from January 2004 to January 2009 is presented in Appendix A. For more information on water quality, see the Water Corporation's most recent drinking water quality annual report at <www.watercorporation.com.au> Publications > Water quality > Water quality annual report.

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

2.1 Microbiological

Pathogens are micro-organisms that are capable of causing diseases and include bacteria, protozoa and viruses. In water supplies, pathogens that can cause illness are mostly found in the faeces of humans and domestic animals (such as dogs and cattle).

A number of pathogens are commonly known to contaminate water supplies around the world. These include bacteria (e.g. salmonella, *Escherichia coli*, cholera), protozoa (e.g. cryptosporidium, giardia) and viruses. *E. coli* counts are a way of measuring these pathogens and are an indicator of faecal contamination.

Pathogen contamination of a drinking water source is influenced by many factors such as the existence of pathogen carriers (e.g. humans and domestic animals), the transfer to and movement of the pathogen in the water source and its ability to survive in the water. The percentage of humans in the world that carry 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).

When people (while fishing, marroning, swimming or the like) or domestic animals come into contact with a body of water, pathogens may enter that water source. This

primarily occurs through the direct transfer of faecal material (even a very small amount can cause contamination) or indirectly through runoff moving faecal material into the water.

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

When people consume drinking water contaminated with pathogens, the effects vary considerably: ranging from mild illness (such as stomach upset or diarrhoea) to hospitalisation and even death. In 2000 in Walkerton, Canada, seven people died due to contamination of the town water source and supply by a pathogenic strain of *E. coli* and campylobacter (NHMRC & NRMMC 2004b). Preventing the introduction of pathogens into the water source is the most effective barrier in avoiding this public health risk.

Raw water samples for Newman are routinely tested by BHP Billiton for faecal coliforms. Positive results have been recorded in 42 per cent of samples and of this, 2.3 per cent of samples exceeded a count of 20 MPN/100mL. The results of microbiological testing are shown in Appendix A and are for the period 1998 to 2004.

Possible sources of faecal coliforms are from cattle grazing in the water reserve or discharges of water from the town's wastewater treatment plant. These possible sources are discussed in more detail in Section 3.

E. coli is a more accurate indicator of microbiological contamination because it better represents the possible presence of microbes that are more dangerous to human health compared with testing for faecal coliforms. It is recommended that raw water at Newman be tested for *E. coli*.

2.2 Health related

Land- and water-based uses and activities within a catchment can directly affect water quality and treatment. For example, off-road driving contributes to erosion and the uprooting of vegetation, which can increase turbidity in water. This turbidity can subsequently reduce the effectiveness of treatment processes.

Chemicals attached to suspended material, such as soil particles, can pollute drinking water sources. This may occur as a result of natural leaching from mineral deposits or from different land uses (NHMRC & NRMMC 2004a). A number of these chemicals (organic and inorganic) are potentially toxic to humans.

Pesticides include agricultural chemicals such as insecticides, herbicides, nematicides (used to control worms), rodenticides and miticides (used to control mites). Contamination of a drinking water source by pesticides (and other chemicals)

may occur as a result of accidental spills, incorrect use or leakage from storage areas. In such cases, the relevant authorities should be notified promptly and the spill cleaned up.

Drinking water supplies can also be contaminated by nutrients (such as nitrate) as a result of fertiliser applications, faulty septic systems, leach drains and from domestic animal faecal matter that washes through or over soil and into a water source. Nitrate and nitrite (ions of nitrogen) can be toxic to humans at high levels, with infants younger than three months being most susceptible (NHMRC & NRMMC 2004a).

Hydrocarbons can occur in water supplies as a result of spills and leakages from vehicles (e.g. fuel, oil) and are potentially toxic to humans. Harmful chemical by-products may be formed when hydrocarbons are combined with chlorine, which is used in the water-treatment process.

Raw water from the Newman Water Reserve is analysed for health-related chemicals, such as heavy metals, industrial hydrocarbons and pesticides. Health-related chemicals that have been recorded at detectable levels are shown in Appendix A. Since 2004, health-related chemicals have not been detected at levels greater than the guideline values. The monitoring of health-related parameters will continue.

2.3 Aesthetic

Impurities in drinking water can affect its aesthetic qualities, including its appearance, taste, smell and feel. Such impurities are not necessarily hazardous to human health; for example, cloudy water with a distinctive odour or a strong taste is not necessarily harmful to health, while clear, pleasant-tasting water may still contain harmful micro-organisms (NHMRC & NRMMC 2004b).

Iron and dissolved organic matter can affect the colour and appearance of water and salinity can affect the taste. Some properties such as pH (a measure of acidity or alkalinity) can contribute to the corrosion and encrustation of pipes.

The ADWG sets aesthetic water quality criteria to meet the aesthetic requirements of consumers and to protect water supply infrastructure (such as pipes).

Aesthetic water quality analysis for raw water from the Newman Water Reserve is summarised in Appendix A. The results show that total dissolved solids and hardness exceeded the aesthetic guideline values. Although these are naturally occurring impurities, the raw water is nevertheless treated before it is supplied to consumers.

2.4 Groundwater bores

The Newman Water Reserve is located within the Pilbara Groundwater Area, which is proclaimed under the *Rights in Water and irrigation Act 1914* (WA). Under the provisions of sections 26D and 5C of the Act, a licence is required to construct a bore

or extract water within a proclaimed groundwater area (unless exempt under the *Rights in Water and Irrigation Act 1914* Exemption and Repeal (Section 26C) Order 2001).

BHP Billiton owns and operates the drinking water production bores in the Newman Water Reserve; however, the Water Corporation is the licensed water service provider for the Newman town water supply. If bores for other purposes (e.g. irrigation, dewatering) are drilled near a public drinking water supply bore, they can cause contamination of the drinking water source. For example, a poorly constructed private bore may introduce contaminants from surface leakage down the outside of the bore casing into an otherwise uncontaminated aquifer.

It is therefore important to ensure that any bores are appropriately located and constructed to prevent contamination impacts on the Newman drinking water source. Where necessary, this will be assessed through the Department of Water's water licensing process under the *Rights in Water and Irrigation Act 1914* (WA). All bores should be constructed in accordance with *Minimum construction requirements for water bores in Australia* (National Minimum Bore Specifications Committee 2003).

3 Land-use assessment

3.1 Existing land uses and activities

The Newman Water Reserve covers a large area and a wide variety of land uses occur within its boundaries. The town of Newman sits in the south of the water reserve and is surrounded by facilities and infrastructure necessary for a town of its size. These facilities include a wastewater treatment plant, cemetery and various recreational facilities. To the west of the town are the Mt Whaleback and Orebody 29 iron ore mines and to the north-east are the Orebody 23 and Orebody 25 mines (see Appendix B, Figure B2). A large amount of infrastructure and facilities serving these mines are located within the water reserve.

Pastoral leases are also held over parts of the water reserve, with the largest areas under lease in the south-western corner and eastern end of the water reserve. The water quality risks from these land uses and activities are described below.

A number of the land uses considered incompatible with source protection policies where legally established before proclamation of the water reserve or current water source protection policies where in place. These land uses need to be managed as existing non-conforming land uses, provided they continue to operate according to their relevant approvals. The adoption of best management practices will be encouraged as part of the implementation of this plan.

Figure 3 shows the major land uses in the water reserve. The water quality risks from these land uses are discussed in Table 1.

3.1.1 Crown land

Mining tenements

BHP Billiton is the major tenement holder within the water reserve and operates the existing mines there. The main tenement (ML244SA) is managed under a State Agreement Act, being the *Iron Ore (Mount Newman) Agreement Act 1964* (WA). A number of other exploration tenements are held throughout the water reserve by various parties.

The major risks to water quality from mining operations are from hydrocarbon and other chemical spills, particularly from bulk chemical storage or accidents on railway lines. Pathogens from office wastewater systems also pose a high risk to the water source, particularly in areas close to production bores. Other risks come from acid rock drainage discharge ponds, mechanical servicing and washdown areas and disused pits on mine closure (see Appendix B, figures B3 to B6). These different risks are further discussed in Table 1.

As mining of the individual ore bodies is completed, it is anticipated that the pits will be left open and form lakes. These have the potential to become saline and create plumes that may affect groundwater quality over time. These pits are not expected to create any acid mine drainage problems (Johnson and Wright 2001). Open pit lakes, however provide a hydraulic connection between surface water and groundwater and create a pathway for contaminants to enter the aquifer.

Railway

The Port Hedland–Newman railway line runs through the water reserve. This railway line is used to transport ore from BHP Billiton's mine sites to port facilities at Port Hedland. Fuel from locomotives that may be spilt as a result of an accident poses a contamination risk, as production bore H7 is located approximately 20 m from the railway line. Any spill of hydrocarbons in this area therefore has the potential to rapidly contaminate this bore (see Appendix B, Figure B6).

Wastewater treatment plant

The Shire of East Pilbara operates a wastewater treatment plant north of Newman on the Great Northern Highway. Treated water is discharged into a managed wetland east of the wastewater treatment plant (see Appendix B, Figure B7). The plant and wetland pose a water quality risk from pathogens, nutrients and other possible chemicals of concern in the raw and treated water. The plant is close to Whaleback Creek and any accidental or deliberate loss of inadequately treated water may enter the creek and possibly contaminate production bores. However, the considerable distance to the production bores reduces this risk, as it allows time for the wastewater to undergo naturally occurring filtering processes.

Power station

A gas-fired power station operated by a private company is located approximately 2 km north-west of the Newman town centre, near Whaleback Creek. This power station provides power to the town as well as to BHP Billiton's mine sites. The water quality risks from gas power stations are mainly from the storage and use of chemicals.

Pastoral leases

There are two pastoral leases that partially intersect the water reserve. The accumulation of faecal matter from the stock may lead to pathogens being leached into the water. This is of particular concern when the faeces are being deposited near the bores (see Appendix B, Figure B8). At times raw water from Newman has recorded high counts of faecal coliforms – with cattle faeces a possible source. An annual muster is held to remove cattle from the area surrounding Ophthalmia Dam.

BHP Billiton currently holds the two leases and is actively working to remove the cattle from around the mine sites and the town, which will have the flow-on effect of removing them from the immediate vicinity of the production bores.

Roads and tracks

The Great Northern Highway is the main transport thoroughfare through the water reserve. It runs in a north-westerly direction and bisects the water reserve. A roadtrain park-up area is situated south-east of the town alongside the highway, and trailers may be connected and disconnected there. Disconnected trailers may be left in this park-up area for some time. This poses a water quality risk if the trailers are being used to transport toxic or hazardous substances and an accident or spill results in the release of those substances.

Marble Bar Road is also a major road and runs through the catchment close to the H-line production bores. Fuel and other chemical spills constitute the major water quality risk along this road, particularly because it is used for heavy haulage of large quantities of these substances. Other roads throughout the water reserve also pose a risk by providing access to bores and waterways within the water reserve. This risk is partially reduced by restricted access to the mine sites.

Unauthorised recreation

There is evidence that off-road vehicles are being used at unauthorised areas throughout the water reserve. The main water quality risks being from spills of hydrocarbons and other chemicals and people toileting in non-approved facilities. This type of activity is difficult to control within the water reserve because the nature of the vegetation and landforms allows easy access for off-road vehicles. The availability of areas for off-road racing in the water reserve is partly limited because access to BHP Billiton mine sites is restricted.

Recreation on Crown reserves

A number of recreational facilities surround the town on Crown reserves vested in the Shire of East Pilbara (see Appendix B, Figure B9). These include motor racing facilities, a horse racing track, gun clubs and a shooting range, as well as a golf course. The major water quality risks from these activities are fuel and chemical spills from motor sport facilities, nutrients (fertilisers) and pesticides leaching into the groundwater from the golf course and horse racing track, and heavy metals accumulating in the soils and leaching out into the groundwater from the gun clubs and rifle range.

Other Crown reserves

The Parnpajinya Aboriginal community is situated on the northern outskirts of the town. The Western Australian Planning Commission has produced a community layout plan for Parnpajinya. This plan is designed to incorporate town planning

principles (including water source protection) and the community's social and cultural values. The water quality risks from this community are the same as those emanating from other residential areas (see Section 3.1.2).

Contaminated sites

A number of sites throughout the water reserve have been reported as known or suspected contaminated sites under the *Contaminated Sites Act 2003* (WA), which is administered by the Department of Environment and Conservation (DEC). Some of these sites have been classified and others are still awaiting classification. Hydrocarbons from pipeline leaks and old underground storage tanks are the main forms of contamination. Any sites that the DEC has classified as requiring remediation should be addressed as soon as possible to reduce the risk of groundwater contamination.

3.1.2 Private land

Residential

Residential lots in Newman are connected to deep sewerage, which presents a lower risk to the water supply than areas connected to septic systems. Residential areas can pose a water quality risk from the use of pesticides, fertilisers and other household chemicals.

Demand for new housing at Newman is high and as a result, a number of large subdivisions are being developed, mostly on the eastern edge of the town. BHP Billiton has built a number of Eco Villages in the town (see Appendix B, Figure B10), which have been designed to reduce the water and energy consumption of each house compared with traditional mine-camp accommodation.

Commercial and industrial premises

The town's main light industrial area is located on its southern edge. It contains a number of different businesses typical of a light industrial area (see Appendix B, Figure B11). The highest contamination risks to the water source are hydrocarbons and other chemicals from mechanical servicing workshops and a fuel storage and other depots, as well as pathogens and nutrients from a boarding kennel. The distance to the production bores reduces the water quality risk; however, it can be reduced further if the businesses adopt best-management practices appropriate to their industries, if these are not already in place.

Near the centre of town is a commercial area that includes a shopping centre. Individual commercial premises are also found throughout the town, including service stations with underground and above-ground fuel storage. The main water quality risks from commercial areas are hydrocarbon and chemical spills; for example, drainage containing hydrocarbons from car parks.

The town's drainage system directs water from the main commercial and light industrial areas into a large drainage channel, which eventually discharges into Whaleback Creek to the east of the town (see Appendix B, Figure B12). This creates the potential for hydrocarbons, chemicals and nutrients to be washed through the drainage system into the creek and towards the production bores.

Recreation and community facilities

Much of the town's public open space is irrigated using recycled water from the town's wastewater system (see Appendix B, Figure B13). The system is licensed by the Department of Health and the water is treated and chlorinated before being reused. The treated water is also tested monthly for bacteria levels to ensure the recycled water does not pose a public health risk.

The use of nutrients and pesticides on public open space poses a water quality risk; however, the distance to the production bores reduces this risk.

3.1.3 Aboriginal sites of significance

Aboriginal sites of significance are those areas that Aboriginal people value as important and significant to their cultural heritage. The sites are significant because they link Aboriginal culture and tradition to place, land and people over time. These areas form an integral part of Aboriginal identity and the heritage of Western Australia. The *Aboriginal Heritage Act 1972* (WA) protects all Aboriginal sites in the state.

More than 100 Aboriginal sites of significance exist within the water reserve. For further information about these sites, contact the Department of Indigenous Affairs, the Yamatji Marlpa Barna Baba Maaja Aboriginal Corporation or Central Desert Native Title Services Limited.

3.1.4 Native title

Native title is a form of land title that recognises the unique ties some Aboriginal groups have to land. Native title exists where Aboriginal people have maintained a traditional connection with their land and waters, since sovereignty, and where acts of government have not removed it.

There is one native title claim within the Newman Water Reserve. This claim is Nyiyaparli (WAD6280/98).

3.2 Proposed land uses and activities

Newman is a key component of BHP Billiton's expansion plans in the Pilbara. The main project focused on Newman is Rapid Growth Project 4. As part of this project, BHP Billiton plans to relocate some of its operations from Port Hedland to Newman, because the water resources currently available at Port Hedland are insufficient. The

project includes development of a new crushing and screening plant, as well as additional stockyards, car dumping and train loading facilities at Mt Whaleback.

It is anticipated that new ore bodies will be brought into production as existing pits become unviable to mine. Orebody 23 is currently estimated to have one year of useful life left, while Orebody 24 is due to be commissioned in the near future.

BHP Billiton is proposing to duplicate large parts of its rail network in Western Australia. This includes sections of the track within the water reserve. The subsequent increase in rail traffic will increase the associated risk (see Section 3.1.1).

The expansion of mining and associated operations around Newman will result in an increase in the town's population, which will pose a higher risk to water quality as land uses intensify in and around the town. To cater for the expected population growth, new residential areas are also required. These areas will raise the volume of wastewater created by the town, which may place excessive pressure on the managed wetland and therefore create an increased contamination risk.

Given the historic development of Newman as a mining town, the mining activities and the water supply system are intrinsically linked. Therefore, future planning decisions on proposed land uses relating to mining and its impact on Newman's drinking water supply system will need to be carefully considered to ensure the ADWG can be achieved and Newman can continue to prosper as a community.

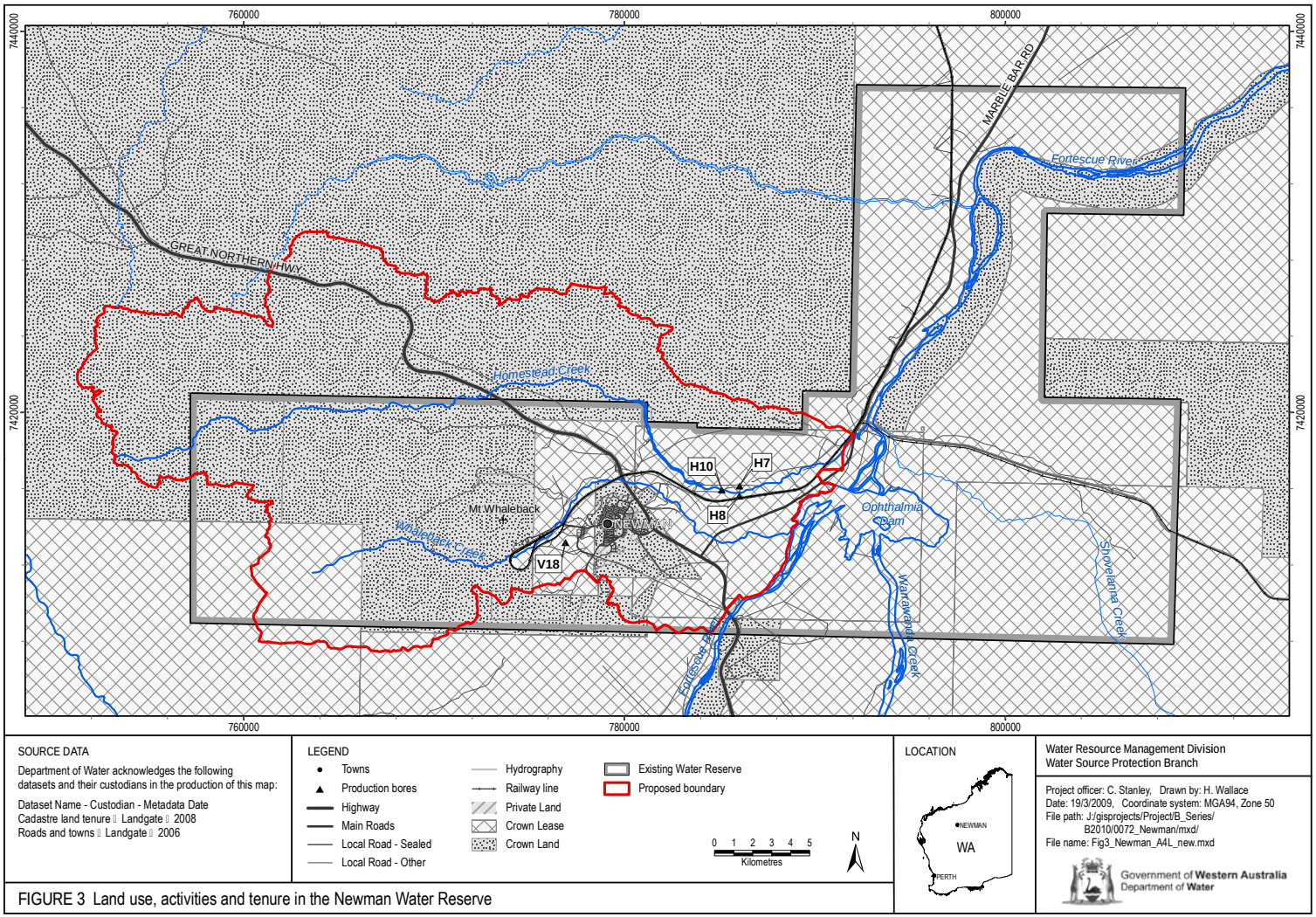

Figure 3 Land use, activities and tenure in the Newman Water Reserve

Table 1 Land use and potential water quality risks

Land use/activity	Hazard	Management priority	Compatibility of land use/activity*
Mining activities			
Ore extraction	Hydrocarbon and other chemical spills from machinery, equipment and vehicles.	High	Mining is compatible with conditions in priority 1 (P1) areas.
Chemical storage[#]	Hydrocarbon and other chemical spills from storage, use and transfer.	High	Above-ground fuel and chemical storage is incompatible in P1 areas.
Wastewater treatment plant[#]	Pathogens from discharges and leaks of wastewater. Hydrocarbons and other chemicals in the wastewater. Nutrients in the wastewater.	High Medium Low	Wastewater treatment plants are incompatible in P1 areas.
Offices and staff facilities (including ablutions)	Pathogens from aerobic treatment units and septic systems. Nutrients from aerobic treatment units and septic systems.	High Medium	Toilet blocks are compatible with conditions in P1 areas.

Land use/activity	Hazard	Management priority	Compatibility of land use/activity*
Mechanical workshops and washdown areas[#]	Hydrocarbon and other chemical spills from mechanical servicing and washdown facilities. Nutrients from detergents and other cleaning products.	Medium Low	Mechanical servicing and vehicle washdown areas are incompatible in P1 areas.
Railways[#]	Hydrocarbon and other chemical spills from accidents on the railway line.	High	Railways are incompatible in P1 areas.
Roads	Hydrocarbon and chemicals from accidents and spills.	Medium	Major transport routes are incompatible in P1 areas.
Tailings dam[#]	Chemicals leaching from the tailings.	Low	Tailings dams are incompatible in P1 areas.
Acid rock drainage evaporation ponds[#]	Acidic water leaching heavy metals into the water. Acidification of raw water from drainage through potentially acid forming material.	Low Low	Acid rock drainage ponds are incompatible in P1 areas.
Exploration	Hydrocarbon and other chemical spills from storage and use.	Low	Mineral exploration is compatible with conditions in P1 areas.

Land use/activity	Hazard	Management priority	Compatibility of land use/activity*
Crown land and reserves			
Pastoral leases	Pathogens from faecal matter (cattle). Nutrients	High Low	Pastoral activities are compatible with conditions in P1 areas.
Shire facilities and other town infrastructure	Pathogens from wastewater treatment plant spills and discharges. Hydrocarbons and other chemicals (including pesticides) from storage and use Nutrients from wastewater treatment plant spills and discharges.	Medium Low Low	Town infrastructure is generally considered compatible with conditions in P3 areas. Refer to *Water quality protection note: Land use compatibility in public drinking water source areas* for compatibility of individual land-use types.
Roads	Hydrocarbon and other chemicals from accidents and spills.	Low	Major transport routes are incompatible in P1 areas.
Power station[#]	Hydrocarbon and other chemical spills from storage and use.	Low	Power stations are incompatible in P1 areas.
Town site			
Residential areas	Nutrients from fertiliser use. Chemical contamination from household chemical and pesticide use. Hydrocarbon contamination from fuel and oil storage and use.	Low Low Low	Residential developments are compatible with conditions in P3 areas.

Land use/activity	Hazard	Management priority	Compatibility of land use/activity*
Light industrial areas	Hydrocarbon and chemical spills from storage and use.	Low	Light industrial areas are compatible with conditions in P3 areas.
Public open space and recreational parks	Nutrients from fertiliser application and wastewater reuse. Pathogens from wastewater reuse. Chemical contamination from chemical and pesticide use.	Low Low Low	Public open space and recreational parks are compatible with conditions in P3 areas.
Drainage	Hydrocarbons and chemicals washing into the drainage system. Nutrients from residential areas and public open spaces and recreational parks.	Low Low	Drainage systems are compatible with conditions in P3 areas.
Roads	Hydrocarbon and other chemicals from spills and accidents.	Low	Roads are compatible with conditions in P3 areas.
Commercial areas	Hydrocarbons and other chemicals from accidents and spills. Hydrocarbons from leaking storage tanks.	Low Medium	Commercial premises are generally considered compatible with conditions in P3 areas. Refer to *Water quality protection note: Land use compatibility in public drinking water source areas* for compatibility of individual land-use types.

Land use/activity	Hazard	Management priority	Compatibility of land use/activity*
Recreation			
Authorised recreational facilities	Hydrocarbon and other chemicals from accidents and spills. Pathogens from septic systems. Nutrients from septic tanks and fertiliser application on turf and other vegetated areas.	Low Medium Low	Refer to the Department of Water's *Statewide Policy No. 13: Recreation on Crown land in public drinking water source areas.*
Unauthorised recreation	Hydrocarbon and other chemicals from accidents and spills. Pathogens from toileting in non-approved facilities	Low Medium	Refer to the Department of Water's *Statewide Policy No. 13: Recreation on Crown land in public drinking water source areas.*

* Compatibility is based on the Department of Water's *Water quality protection note 25: Land use compatibility in public drinking water source areas*.

Non-conforming existing land use.

4 Catchment protection strategy

4.1 Protection objectives

The objective of this plan is to ensure that safe drinking water is available to consumers now and in the future. This objective needs to be achieved while recognising the rights of existing approved land uses to continue. The protection objectives for the Newman Water Reserve should be to:

- improve the quality of raw water abstracted from the production bores
- ensure drinking water source protection is sufficiently built into land-use planning (including mine planning) decisions
- identify land uses that pose a contamination risk and manage those land uses to reduce the risk level.

4.2 Proclaimed area

The Newman Water Reserve is already proclaimed under the *Country Areas Water Supply Act 1947* (WA). As part of this plan's preparation, the boundaries of the water reserve were reviewed to assess whether they reflected the water source's physical characteristics and allowed an appropriate level of protection.

The E-line bores that were historically part of the town's water supply system are no longer used due to poor water quality. They are still connected to the scheme and may be used in an emergency situation. A critical valve has been installed and BHP Billiton can only use the bores for potable supply with the agreement of the Water Corporation and with extra water quality monitoring in place.

Modelling shows that the H-line bores have no hydrogeological connectivity with Ophthalmia Dam. This means that Ophthalmia Dam does not provide water to the Newman town water supply (although it is still part of the mine dewatering system).

This plan proposes that the boundary be altered to reflect that:

- the E-line bores are no longer used for the town water supply
- the H-line bores have no hydrogeological connectivity with Ophthalmia Dam.

Relevant hydrogeological information was also reviewed and as a result, further changes to the water reserve's boundary are recommended to more accurately reflect the recharge area for the production bores.

The existing proclaimed area is shown in Figure 2 and the proposed proclaimed area is shown in Figure 4.

4.3 Priority areas

The protection of public drinking water source areas (PDWSAs) relies on statutory measures available in legislation for water resource management and land-use planning. The Department of Water's policy for the protection of PDWSAs includes three risk-based priority areas:

- Priority 1 (P1) areas have the fundamental water quality objective of risk avoidance.
- Priority 2 (P2) areas have the fundamental water quality objective of risk minimisation.
- Priority 3 (P3) areas have the fundamental water quality objective of risk mitigation.

The determination of priority areas is based on the strategic importance of the land or water source, the local planning-scheme zoning, the form of land tenure and existing approved land uses or activities. For further details, please refer to the Department of Water's *Water quality protection note: Land use compatibility in public drinking water source areas*.

The priority areas for the Newman Water Reserve have been determined in accordance with current Department of Water policy. These areas are described below and displayed in Figure 4. The department's *Water quality protection note: Land use compatibility in public drinking water source areas* outlines activities that are 'acceptable', 'compatible with conditions' or 'incompatible' within the different priority areas. For an explanation of the background and support for protection of PDWSAs, please refer to water quality protection note: *Protecting public drinking water source areas*.

All Crown land (except that within the gazetted town site) in Newman Water Reserve will be classified as P1 for the following reasons:

- Water from this source is the sole source for the Newman water supply, so it should be afforded the highest feasible level of protection.
- Most existing land uses on the Crown land are considered compatible with P1 source-protection objectives.
- The groundwater is vulnerable to contamination from inappropriate land uses because the aquifer is unconfined.

All land within the gazetted Newman town site will be classified as P3 for the following reasons:

- Land uses allowed in these areas under the *Shire of East Pilbara town planning scheme* are generally compatible with conditions in P3 areas.
- The light industrial area is zoned industrial so existing land-use rights are recognised.

- Existing land uses are considered compatible with P3 protection objectives.
- It will allow expansion and development of land uses within the Newman town site so that the town can grow as anticipated, but will prevent land uses intensifying in higher-risk areas closer to the production bores.

4.4 Protection zones

In addition to priority areas, specific protection zones are defined to protect drinking water sources from contamination in the immediate vicinity of water extraction facilities. By-laws of the *Country Areas Water Supply Act 1947* (WA) may prohibit, restrict or approve defined land uses and activities to prevent water source contamination or pollution. Specific conditions may apply within these zones such as restrictions on the storage of chemicals.

Wellhead protection zones (WHPZ) are used to protect groundwater sources. They are generally circular (unless information is available to determine a different shape or size) with a 500 m radius around each production bore in a P1 area and a 300 m radius around each production bore in P2 and P3 areas. WHPZ do not extend outside the boundary of a water reserve.

Four 500-m-radius WHPZ are proposed for the Newman Water Reserve (see Figure 4): three of them around H-line bores and one around bore V18. Fuel storage and a Biomax wastewater treatment unit for Orebody 25 are within the WHPZ for bore H7 and the Port Hedland–Newman railway passes through the WHPZ for bore H8. This is a high-risk arrangement and measures should be considered to remedy the situation. This could be achieved by moving the bores or the land uses that create the risk.

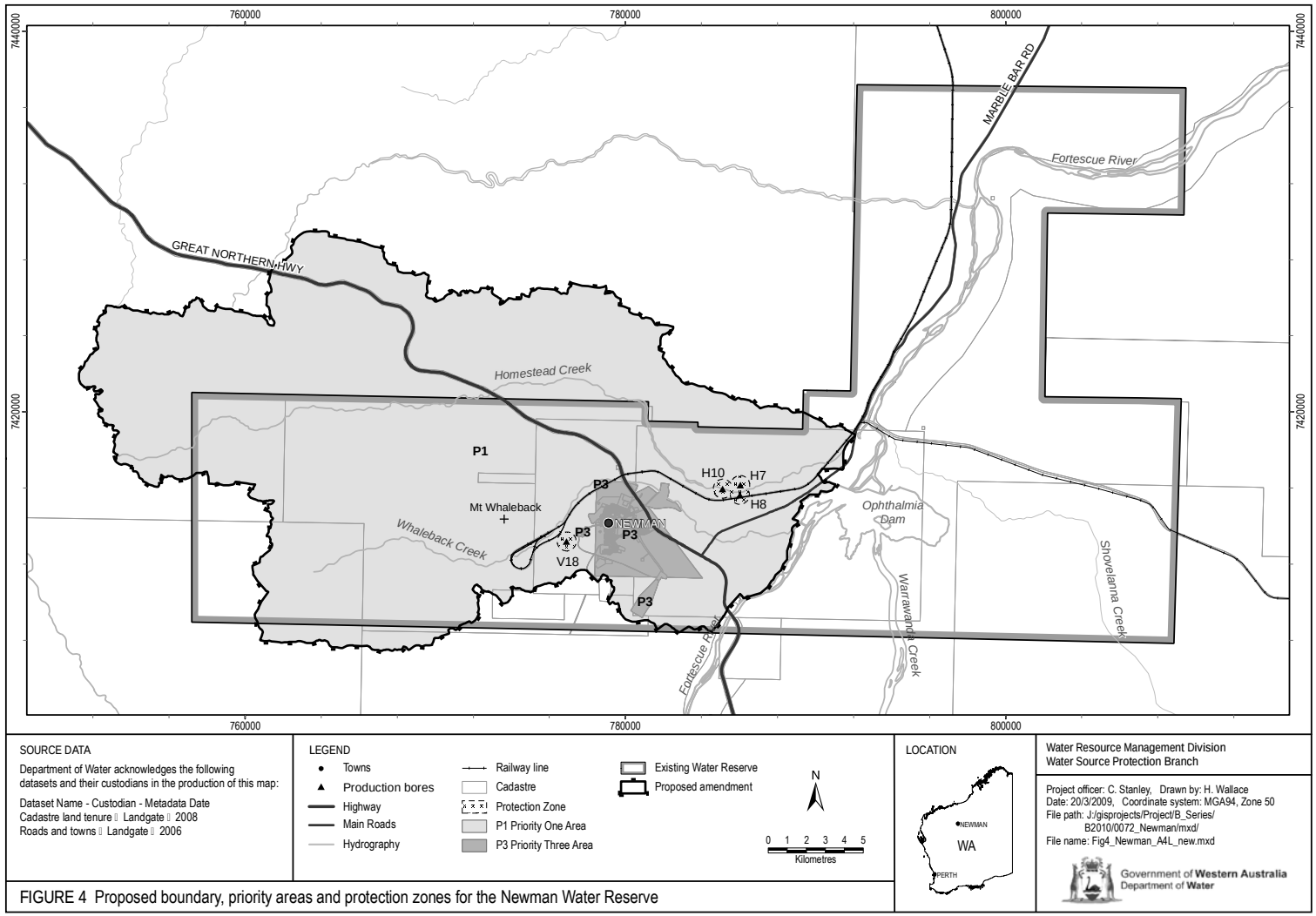

FIGURE 4 Proposed boundary, priority areas and protection zones for the Newman Water Reserve

Figure 4 Proposed boundary, priority areas and protection zones for Newman Water Reserve

4.5 Land-use planning

It is recognised under the *State planning strategy* (Western Australian Planning Commission 1997) that appropriate protection mechanisms in statutory land-use-planning processes are necessary to secure the long-term protection of drinking water sources. As outlined in the *Statement of planning policy 2.7: Public drinking water source policy* (Western Australian Planning Commission 2003), it is appropriate that the Newman Water Reserve, priority areas and protection zones be recognised in the *Shire of East Pilbara town planning scheme*. Any development proposals within the Newman Water Reserve that are inconsistent with advice in the Department of Water's *Water quality protection note: Land use compatibility in public drinking water source areas* or recommendations in this plan, should be referred to the Department of Water. For further information on land-use planning and water source protection, please refer to the Department of Water's *Water quality protection note: Protecting public drinking water source areas*.

The department's protection strategy for public drinking water source areas (PDWSAs) provides for lawfully established and operated developments to continue – despite their location or facilities posing a level of risk to water quality that would not be accepted for new developments. The department may negotiate with landowners/operators on measures to improve these facilities and reduce water quality contamination risks.

In strategically significant areas the department has developed a policy that allows it to approach landowners with a view to buying land or negotiating water-contamination-risk reduction measures.

4.6 Best-management practices

There are opportunities to significantly reduce water contamination risks by carefully considering design and management practices. The Department of Water will continue to encourage the adoption of best-management practices for various land uses. On freehold land, the department aims to work with landowners by providing advice on achieving sound management practices for the protection of water quality.

Guidelines on best-management practices for many land uses are available in the form of industry codes of practice, environmental guidelines and water quality protection notes. These have been developed in consultation with stakeholders such as industry groups, agricultural producers, state government agencies and technical advisers. Examples include *Mining and mineral processing guidelines* and *Light industry near sensitive waters*, both of which are listed in this report's Bibliography. The guidelines outline the recommended practices to ensure the protection of water quality and therefore help managers reduce any detrimental effects of their operations.

Education and creating awareness (e.g. signage and information) are also key mechanisms for protecting water quality, especially for those people visiting the area who are unfamiliar with the Newman Water Reserve. A brochure will be produced once this plan is endorsed, describing the Newman Water Reserve, its location and the main threats to water quality. This brochure will be available to the community and will inform people in simple terms of the drinking water source and the need to protect it.

4.7 Surveillance and by-law enforcement

The quality of public drinking water sources within country areas of the state is protected under the *Country Areas Water Supply Act 1947* (WA). Declaration of these areas allows existing by-laws to be applied to protect water quality.

The Department of Water considers by-law enforcement, through surveillance of land-use activities in PDWSAs, to be an important mechanism to protect water quality.

Signs are erected on the boundaries of PDWSAs to educate and advise the public about activities that are prohibited or regulated. This plan recommends that surveillance and by-law enforcement for the Newman Water Reserve be delegated to the Water Corporation.

4.8 Emergency response

The escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The Shire of East Pilbara local emergency management committee (LEMC), through the Pilbara emergency management district, should be familiar with the location and purpose of the Newman Water Reserve. A locality plan should be provided to the fire and rescue services headquarters for the hazardous materials (HAZMAT) emergency advisory team. The Department of Water's role should be to advise the HAZMAT team in relation to incidents in the Newman Water Reserve.

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

4.9 Implementation of this plan

Table 1 and Appendix C identifies the potential water quality risks associated with existing land uses in the Newman Water Reserve and recommends protection strategies to deal with these risks.

Following publication of the *Newman Water Reserve drinking water source protection plan*, an implementation strategy will be drawn up based on the recommendations in Table 1 and Appendix C.

5 Recommendations

The following recommendations apply to the entire Newman Water Reserve. The bracketed stakeholders are those expected to have an interest in implementing the relevant recommendation.

1 The boundary of the Newman Water Reserve should be amended under the *Country Areas Water Supply Act 1947* (WA). (Department of Water.)

2 Prepare an implementation plan including the recommended protection strategies as detailed in Appendix C of this plan, showing key stakeholders and planned timeframes. (Department of Water, applicable stakeholders.)

3 The *Shire of East Pilbara town planning scheme* should incorporate this plan and reflect the identified Newman Water Reserve boundary, priority 1, 2 and 3 areas and protection zones in accordance with *Statement of planning policy No. 2.7: Public drinking water source policy*. (Shire of East Pilbara.)

4 All development proposals within the Newman Water Reserve that are inconsistent with the Department of Water's *Water quality protection note: Land use compatibility in public drinking water source areas* or recommendations in this plan should be referred to the Department of Water for advice and recommendations. (Department for Planning and Infrastructure, Shire of East Pilbara, proponents of proposals.)

5 Incidents covered by WESTPLAN–HAZMAT in the Newman Water Reserve should be addressed by ensuring that:

- the Newman LEMC is aware of the location and purpose of the Newman Water Reserve
- the locality plan for the Newman Water Reserve is provided to the FESA headquarters for the HAZMAT emergency advisory team
- the Water Corporation and Department of Water act in an advisory role during incidents in the Newman Water Reserve
- personnel dealing with WESTPLAN–HAZMAT incidents in the area have ready access to a locality map of the Newman Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality.

(Department of Water and Water Corporation.)

6 Signs should be erected along the boundary of the Newman Water Reserve to define the location and promote awareness of the need to protect drinking water quality. Signs should include an emergency contact telephone number. (Department of Water.)

7 The Department of Water should consider delegating responsibility for enforcement measures and monitoring of the Newman Water Reserve to the Water Corporation. (Department of Water, Water Corporation.)

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

9 Investigate alternative locations for dedicated public drinking water supply bores that are remote from existing or future mining operations and are upstream of the town site. (BHP Billiton, Water Corporation, Department of Water.)

10 Ensure BHP Billiton's standard operating procedures recognise the water reserve, including an on-site induction that educates people about their presence in a water reserve and informs them of the need to protect water quality. (BHP Billiton.)

11 Discontinue the use of production bore H7 for potable water supply. (BHP Billiton.)

12 Conduct quality testing on water being discharged from the wastewater treatment plant into the managed wetland and investigate alternative options to dispose of this water. (Shire of East Pilbara.)

13 Continue to remove cattle from the water reserve, particularly in the vicinity of the production bores. (BHP Billiton.)

14 BHP should prepare a catchment management strategy for the Newman Water Reserve, in consultation with the Department of Water. This plan should address the source protection issues identified in this plan. (BHP Billiton, Department of Water.)

Appendices

Appendix A Water quality data

The information provided in this appendix has been prepared by BHP Billiton in consultation with the Department of Water.

BHP Billiton in consultation with the Water Corporation has monitored the raw (source) water quality from Newman Water Reserve in accordance with the *National water quality management strategy: Australian drinking water guidelines 6, 2004* (NHMRC & NRMMC 2004a) and interpretations agreed to with the Department of Health. The raw water is monitored regularly for:

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

The following data represents the quality of raw water from the Newman Water Reserve. In the absence of specific guidelines for raw-water quality, the results have been compared with the ADWG values set for drinking water, which defines the quality requirements at the customer's tap. Results that exceed the ADWG have been shaded to give an indication of potential raw-water quality issues associated with this source.

It is important to appreciate that the raw-water data presented does not represent the quality of drinking water distributed to the public. Barriers such as storage and water treatment exist downstream of the raw water to ensure it meets the requirements of the ADWG. The values are taken from ongoing monitoring for the period January 2004 to January 2009, except pH and conductivity (which are for a 10-year period until January 2009) and microbiological testing (which is for 1998 to 2004).

Any water quality parameters that have been detected are reported; those that on occasion have exceeded the ADWG are shaded.

For more information on the quality of drinking water supplied to the Newman town water supply, refer to the most recent Water Corporation drinking water quality annual report at <www.watercorporation.com.au> > Water > Water quality > Latest report > Drinking water quality annual report.

Aesthetic

The aesthetic quality analyses for raw water from Newman Water Reserve are summarised in the following table.

Aesthetic detections for Newman Water Reserve

Parameter	Units	ADWG aesthetic guideline value*	Newman Water Reserve	
			Range	Median
Aluminium (acid soluble)	mg/L	0.2	<0.01–<0.20	<0.05
Chloride	mg/L	250	80–150	110
Conductivity	mS/m	–	310–3050	1100
Hardness as $CaCO_3$	mg/L	200	461–523	490
Iron unfiltered	mg/L	0.3	<0.05–0.2	<0.05
Manganese unfiltered	mg/L	0.1	<0.005–<0.025	<0.01
Sodium	mg/L	180	42–83	66.5
Sulfate	mg/L	250	50–110	80
Total dissolved solids (TDS)#	mg/L	500	170–1677	550
pH measured in laboratory	no unit	6.5–8.5	6.5–8.0	7.28

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

\# *Total dissolved solids is not measured in routine sampling. Figures where calculated from the conductivity*.

Health related

Health-related chemicals

Raw water from Newman Water Reserve is analysed for chemicals that are harmful to human health, including categories of chemicals such as inorganics, heavy metals, industrial hydrocarbons and pesticides. Health-related parameters that affect water quality are summarised in the following table.

Health-related detections for Newman Water Reserve

Parameter	Units	ADWG health guideline value*	Newman Water Reserve	
			Range	Median
Barium	mg/L	0.7	<0.005–<0.25	<0.02
Boron	mg/L	4	0.026–0.03	0.03
Manganese unfiltered	mg/L	0.5	<0.005–<0.025	<0.01
Nitrate (as nitrate)	mg/L	50	0.529–14.00	3.3
Nitrite plus nitrate as N	mg/L	11.29	<0.05–0.17	<0.05
Sulfate	mg/L	500	50-110	80

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

Microbiological contaminants

Microbiological testing of raw-water samples from the Ophthalmia borefield is currently conducted monthly. Faecal coliform counts are used as an indicator of the degree of recent faecal contamination of the raw water. A count of less than 20 MPN (most probable number) per 100 mL sample is typically associated with low levels of faecal contamination and is used as a microbiological contamination benchmark of the raw water (WHO 1996). As such, counts less than 20 MPN are seen as indicating raw water that has not been recently contaminated with faecal material.

During the reviewed period, positive faecal coliform counts were recorded in 42 per cent of samples. Of these samples, 2.3 per cent had faecal coliform counts greater than 20 MPN/100mL.

Appendix B Photographs

Figure B1 Fencing around drinking water production bore V18

Figure B2 Mt Whaleback iron ore mine pit

Figure B3 Production bore H7 with facilities associated with Orebody 25 in the background

Figure B4 Mt Whaleback acid rock drainage evaporation ponds

Figure B5 From Mt Whaleback overlooking mechanical workshops, ore processing, administration and other facilities servicing the mine

Figure B6 Siding on the Port Hedland—Newman railway taken from bore H7

Figure B7 Managed wetland at discharge point for Shire of East Pilbara wastewater treatment plant

Figure B8 Evidence of cattle grazing near production bores

Figure B9 Newman Moto-X track — an example of authorised recreational facilities within the water reserve

Figure B10 Housing at one of the Eco Villages

Figure B11 An example of a premises found in the main light industrial area

Figure B12 Main town drainage channel where it flows under the Great Northern Highway towards Whaleback Creek

Figure B13 Newman from Radio Hill showing public open space that is irrigated using recycled wastewater

Appendix C Land use, potential water quality risks and recommended protection strategies.

This table was prepared from data in Section 3 of this plan.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Mining – ML244SA					
Ore extraction	Hydrocarbon and chemical spills from machinery, equipment and vehicles.	High	Spills of hydrocarbons during mining operations are a common problem due to the nature of the ore extraction process. The risk is higher for Orebody 25 due to its close proximity to the production bores. Any contaminated water is likely to be removed by the dewatering process – reducing the risk of it contaminating the potable water supply. Dewatering will also ensure that a buffer is maintained between the	• Water quality monitoring • State Agreement Act	• Ensure adherence to Department of Water mining and mineral processing guidelines. • Any spills of contaminants should be cleaned up and any contaminated soil or other waste disposed of at an approved facility. • Ensure that BHP Billiton's operational procedures recognise the water reserve and the need to protect it. • It is recommended that BHP Billiton carries out its own risk assessment for the water reserve and

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			floor of mining pits where spills may occur and the watertable. The Government of Western Australia manages BHP Billiton's mining activities through the *Iron Ore (Mt Newman) Agreement Act 1964*.		develops a catchment management strategy that outlines how the water source will be protected, including future planning to improve source protection.
Chemical storage	Hydrocarbon and chemical spills from storage, use and transfer.	High	Large quantities of chemicals are stored within the water reserve for use in mining operations. The major risk is from hydrocarbon storage at Orebody 25, which is within the wellhead protection zone for bore H7. An ammonium nitrate storage facility is situated north-west of Mt Whaleback. This is an existing land use that is accepted as a non-	• Water quality monitoring • Emergency response procedures	• Storage of chemicals is considered incompatible in wellhead protection zones. Existing chemical storage within WHPZs should be relocated. • Chemical storage in the water reserve should adhere to the Department of Water's mining and mineral processing guidelines and the WQPNs *Toxic and hazardous substances – storage and use* and *Contaminant spills – emergency response*.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			conforming activity. Best-management practices must be employed.		• Establish monitoring bores between the production bores and any chemical storage identified as a high contamination risk for the bores, as well as a monitoring program. • Sites should be assessed and undergo remediation (where necessary) under the *Contaminated Sites Act 2003* (WA).
Wastewater treatment plant	Pathogens from discharges and leaks of wastewater. Hydrocarbons and other chemicals in the wastewater. Nutrients in the wastewater.	High Medium Low	There is a wastewater treatment plant with a discharge pond that treats water from the Mt Whaleback operations. It is situated alongside Whaleback Creek within the riparian zone and any overflow will rapidly enter the creek. Discharge ponds should have enough capacity to contain a 100-year-average-recurrence-	• Water quality monitoring	• A water quality monitoring program should be developed for the discharge pond. • Establish and maintain a vegetation buffer between the discharge ponds and Whaleback Creek as per *WQPN 6: Vegetation buffers to sensitive water resources*. • Ponds should be lined to prevent leakage into the

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			interval rainfall event in addition to the operating capacity.		groundwater.
Offices and staff facilities (including ablution facilities)	Pathogens from aerobic treatment units and septic systems. Nutrients from aerobic treatment units and septic systems.	High Medium	The highest water quality risk is from an aerobic treatment unit servicing Orebody 25 that is within the wellhead protection zone of bore H7.	• Water quality monitoring • Maintenance of wastewater treatment units	• Relocate any wastewater treatment units outside WHPZs. • Establish water quality monitoring bores between wastewater treatment units and production bores, as well as a monitoring program. • Wastewater treatment units should be regularly serviced to ensure correct functioning. • Use signs and advertising material to ensure staff and contractors are aware they are in the water reserve and inform them of the need to protect water quality.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Mechanical workshops and washdown areas	Hydrocarbon and other chemical spills from mechanical servicing and washdown facilities. Nutrients from detergents and other cleaning products.	Low Low	This is an existing land use that is accepted as a non-conforming activity. Best-management practices must be employed. Existing workshops have spill containment and wastewater treatment facilities in place. Any expansion of the mechanical workshop facilities should only be approved if it can be demonstrated that the overall risk to water quality remains the same or is reduced.	• Containment facilities • Wastewater treatment • Regulatory approvals and licenses	• Ensure adherence to mineral and mining processing water quality protection guidelines and WQPNs on mechanical servicing and workshops and mechanical washdown.
Railways	Hydrocarbon and other chemical spills from accidents on the railway line.	High	A railway siding is located within 50 m of bore H7. This railway is used to transport ore. In the event of an accident, fuel spilt from the locomotives may infiltrate the ground and contaminate the bores.	• Water quality monitoring • Emergency response procedures	• BHP Billiton should develop an emergency response plan specifically for a spill near the production bores that details how the bores will be protected from contamination. • Drinking water production

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			The Port Hedland–Newman main line is within the WHPZ of bore H8.		bores should be relocated away from railway lines.
Roads	Hydrocarbon and chemicals from accidents and spills.	Low	Most of the roads within the water reserve that are within BHP Billiton's operational area are subject to access restrictions, which reduces the risk of contamination.	• Access restrictions • Emergency response procedures	• Use signs and advertising material to ensure staff and contractors are aware they are in the water reserve and inform them of the need to protect water quality. • BHP Billiton's on-site induction should educate people that they are in a water reserve and inform them of the need to protect water quality. • Ensure adherence to *WQPN 44: Roads near sensitive water resources* and *WQPN 10: Contaminant spills – emergency response*. • The road network should be reviewed and any roads not necessary for mining

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
					operations should be closed and rehabilitated.
Tailings dam	Chemicals leaching from tailings.	Low	Tailings dams are generally considered incompatible in P1 areas. However, this is an existing land use that is accepted as a non-conforming activity. Best-management practices must be employed. It should be noted that iron ore tailings are chemically inert.	• Water quality monitoring	• Ensure adherence to the Department of Water's mining and mineral processing guidelines.
Acid rock drainage (ARD) discharge ponds	Acidic water leaching heavy metals into the water. Acidification of raw water from drainage through potentially acid forming material.	Low Low	Located north of Mt Whaleback, this system is used to hold drainage from potentially acid forming areas. The water is pumped to a series of evaporation ponds. A minor drainage line runs past the ARD ponds and into Whaleback Creek, which could potentially	• Water quality monitoring	• Ensure adherence to mining and mineral processing guidelines. • Ensure ARD ponds are maintained to contain at a minimum a 100-year-average-recurrence-interval storm event. • Renewal of Department of Mines and Petroleum (DMP) licence for ARD

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			carry any overflow from the ponds into the creek and down to the bores. The considerable distance from the ARD ponds to the production bores reduces the risk.		dam should be forwarded to the Department of Water for advice and comment.
Exploration	Hydrocarbon and other chemical spills from storage and use.	Low	A number of tenements held by different companies exist throughout the water reserve. These tenements are subject to licensing by the DMP. The DMP and the Department of Water have an administrative agreement in place to manage mining activities to protect public drinking water source areas (and other water resources).	• DMP mining tenement licence conditions • Water quality monitoring	• Ensure adherence to mining and mineral processing guidelines. • Ensure compliance with tenement licence conditions.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Other Crown reserves and land					
Pastoral leases	Pathogens from faecal matter. Nutrients from faecal matter	High Low	BHP Billiton owns the two pastoral leases within the water reserve and is actively working to remove cattle from the area surrounding the bores. The cattle may be a potential source of the high bacterial counts recorded during raw-water sampling.	• Water quality monitoring • Annual muster	• Ensure adherence to the *WQPN 35: Pastoral activities within rangelands*. • Uncapped bores should be backfilled and capped. • Continue program to exclude cattle from the water reserve. • Stock watering points should be outside the water reserve.
Shire facilities and other town infrastructure	Pathogens from wastewater treatment plant spills and discharges. Hydrocarbons and other chemicals from storage and use. Nutrients from wastewater	High Medium Low	Shire facilities on the outskirts of the town include a wastewater treatment plant, cemetery, community halls and other facilities. The town waste disposal facility is within the existing water reserve boundary, but is outside the proposed boundary. Treated wastewater from the wastewater treatment	• Water quality monitoring • Land-use planning controls	• Conduct water quality monitoring at the discharge point for the managed wetland. • Investigate alternative uses or disposal methods for water that is currently being discharged into the managed wetland. • Follow best-management practices as recommended in the Department of

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
	treatment plant spills and discharges. Pesticides from storage and use.	Low	plant is discharged into a managed wetland near Homestead Creek. This wetland will attract stock looking for water into the water reserve, increasing the potential pathogen and nutrient loading of the wetland.		Water's water quality protection guidance documents. • Pesticide use should be in accordance with *Statewide policy No. 2: Pesticide use in public drinking water source areas* and DoH Public service circular No. 88 (PSC88): *Use of herbicides in water catchment areas*.
Roads	Hydrocarbon and other chemicals from accidents and spills.	Low	The Great Northern Hwy is a major transport route that passes through the water reserve upstream of the bores. Marble Bar Rd is also used for haulage and passes close to the production bores. The greatest risk occurs if an accident happens where a road crosses Homestead and Whaleback creeks at a	• Water quality monitoring • Emergency response procedures	• Ensure adherence to the *WQPN 44: Roads near sensitive water resources.* • Use signs and advertising material to inform people of their presence in the water reserve and the need to protect water quality. Signage should include an emergency contact number. • Containment of spills on the roads should be

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			time when there is flowing water in these creeks. The Local Emergency Management Committee responds to spills and accidents.		incorporated into emergency response planning for Newman. • Ensure sumps and road drainage have adequate capacity to contain any spills. • Construct containment sumps around the road train park-up bay on the Great Northern Hwy.
Power station	Hydrocarbon and other chemical spills from storage and use.	Low	This is an existing land use that is accepted as a non-conforming activity. Best-management practices must be employed. The considerable distance to the production bores reduces the risk.	• Water quality monitoring • Land-use planning controls • Contaminated sites legislation	Ensure adherence to relevant water quality protection notes, including *WQPN 10: Contaminant spills – emergency response*; *WQPN 20: General and heavy industry near sensitive waters; WQPN 65: Toxic and hazardous substances – storage and use;* and *WQPN 83: Infrastructure corridors near sensitive water resources*.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Town site					
Residential	Nutrients from fertiliser use. Chemical contamination from household chemical and pesticide use. Hydrocarbon contamination from fuel and oil storage and use.	Low Low Low	Large subdivisions have resulted in a significant increase in the number of residential lots. Drainage and wastewater systems need to be able to handle the increased demands on their capacity. The town is connected to a deep sewerage system. The town drainage systems directs potentially contaminated stormwater into Whaleback Creek upstream of the production bores.	• Water quality monitoring • Land-use planning controls	• Use signs and advertising material to inform people of their presence in the water reserve and the need to protect water quality. Signage should include an emergency contact number. • Drainage and nutrient management plans for new residential areas should be developed in accordance with the Department of Water's stormwater management manual. • Ensure adherence to the *WQPN 65: Toxic and hazardous substances storage and use.*
Light industrial area (LIA)	Hydrocarbon and chemical spills from storage and use.	Low	Current activities in the LIA are considered acceptable or compatible with conditions in Priority 3	• Water quality monitoring • *Environmental Protection*	• Use signs and advertising material to inform people of their presence in the water reserve and the need to protect water quality.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			source protection areas. There is a smaller LIA near Mt Whaleback on the south side of the main access road to the Whaleback mine site. The town drainage systems directs potentially contaminated stormwater into Whaleback Creek upstream of the production bores.	*(Unauthorised Discharges) Regulations 2004* and *Environmental Protection (Controlled Waste) Regulations 2001*. • Land-use planning controls	Signage should include an emergency contact number. • Ensure adherence to the *WQPN 93: Light industry near sensitive waters.* • Ensure drainage from the LIA is captured and treated before release according to the stormwater management manual. • Review the drainage system from the LIA to determine if it could be redesigned to reduce the water quality risk.
Public open space and recreational facilities.	Nutrients from fertiliser application and wastewater reuse. Pathogens from wastewater reuse.	Low Medium	Treated wastewater is used on the town's parks and ovals. The treated water is tested monthly for bacterial levels. As part of the National Water Quality Management Strategy (NWQMS), the *Australian*	• Water quality monitoring • Treatment of recycled water	• A nutrient and irrigation management plan should be developed for all public open spaces and recreational facilities with turf or vegetation. • Wastewater recycling should comply with the NWQMS guidelines for

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
	Chemical contamination from chemical and pesticide use.	Low	*guidelines for water recycling: Managing health and environmental risks (Phase 1*) cover the treatment of sewerage and greywater for non-potable use.		water recycling. • Turf and grassed areas should be managed according to the water quality *protection* guidelines: *Environmental guidelines for the establishment and maintenance of turf and grassed areas.* • Pesticides should be used in accordance with *Statewide policy No. 2: Pesticide use in public drinking water source areas* and DoH Public service circular No. 88 (PSC88): *Use of herbicides in water catchment areas*.
Drainage	Hydrocarbons and chemicals washing into the drainage system. Nutrients from	Low Low	The town drainage system directs potentially contaminated stormwater into Whaleback Creek upstream of the production bores.	• Water quality monitoring	• A review of the town's drainage system is recommended. • Any new or altered drainage system should be designed in accordance

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
	residential areas and public open spaces and recreational parks.		The nature of the rainfall experienced in Newman means that there is periodically a large flow of water through the drains, which will have a dilution effect on the concentration of any contaminants. However, the transport of these lower concentrations of pollutants towards the creek will still be relatively fast.		with the Department of Water's *Stormwater management manual*.
Roads	Hydrocarbons and other chemicals from accidents and spills.	Low	The Local Emergency Management Committee responds to spills and accidents. Being an urban area there are a large number of local roads within the water reserve.	• Water quality monitoring • Emergency management procedures	• Use signs and advertising material to inform people of their presence in the water reserve and the need to protect water quality. Signage should include an emergency contact number. • Follow best-management practices recommended in the *WQPN 44: Roads near sensitive water resources*

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
					including the use of sumps to contain and treat road drainage.
Commercial areas	Hydrocarbons and other chemicals from accidents and spills. Hydrocarbons from leaking storage tanks.	Low Low	The main commercial area is a shopping centre in the centre of the town. Other commercial uses throughout the town include hotel/motels and service stations. Leakage from hydrocarbon storage tanks from service stations poses the greatest risk to water quality, especially if tanks are underground.	• Spill containment facilities for storage tanks • Water quality monitoring	• Use signs and advertising material to inform people of their presence in the water reserve and the need to protect water quality. Signage should include an emergency contact number. • Follow best-management practices recommended in the *WQPN 49: Service stations*. • Current and previous service station sites should be assessed and undergo remediation (if required) under the *Contaminated Sites Act 2003* (WA).

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Recreation					
Authorised recreational facilities	Hydrocarbon and other chemicals from accidents and spills. Pathogens from septic systems. Nutrients from septic tanks and fertiliser application on turfed and other vegetated areas.	Low Medium Low	A number of recreational facilities are found throughout the water reserve including a horse racing track, golf club, gun club, motor sport facilities and other multiple-use recreation facilities. Pathogen risk is increased when special events are held and extra toilet facilities that are not connected to deep sewerage are required.	• Water quality monitoring • Land-use planning controls	• Ensure facilities adhere to the relevant WQPNs including *Motor sport facilities near sensitive water resources; Outdoor events in public drinking water source areas; Contaminant spills – emergency response; Toxic and hazardous substances – storage and use.* • Turf and grassed areas should be managed according to the water quality protection guidelines: *Environmental guidelines for the establishment and maintenance of turf and grassed areas.*
Unauthorised recreation	Hydrocarbon and other chemicals from accidents and	Medium	Sites for unauthorised recreation within the water reserve are limited	• Water quality monitoring	• Use signs and advertising material to ensure public awareness that recreation

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
	spills. Pathogens from toileting in non-approved facilities.	Low	because of controlled access to BHP Billiton mine sites. However, access may still be possible because access controls are not fail safe. Site inspection shows signs of unauthorised recreation in the water reserve including off-road vehicle racing. Recreation should comply with the Department of Water's *Statewide Policy No. 13: Policy and guidelines for recreation within public drinking water source areas*.	• Mine site access restrictions	at unauthorised sites is prohibited within the water reserve. • Undertake surveillance throughout the water reserve with by-law enforcement. • Close down and rehabilitate any illegally established recreational facilities.

List of shortened forms

ADWG	*Australian drinking water guidelines*
AHD	Australian height datum
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
CFU	colony forming units
DEC	Department of Environment and Conservation
EC	electrical conductivity
GL	gigalitre
HAZMAT	hazardous materials
kL	kilolitre
km	kilometre
km^2	square kilometre
LEMC	local emergency management committee
m	metres
mg/L	milligram per litre
mL	millilitre
ML	megalitre
mm	millimetre
MPN	most probable number
mSv	millisievert
mS/m	millisiemens per metre
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	nephelometric turbidity units

PSC 88	public sector circular number 88
PDWSA	public drinking water source area
TCU	true colour units
TDS	total dissolved solids
TFSS	total filterable solids by summation
WHPZ	wellhead protection zone
WESTPLAN–HAZMAT	Western Australian plan for hazardous materials

Glossary

Abstraction	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.
Australian drinking water guidelines	The *National water quality management strategy: Australian drinking water guidelines 6, 2004* (NHMRC & NRMMC 2004a) (ADWG) outlines acceptable criteria for the quality of drinking water in Australia (see this report's *Bibliography*).
Aesthetic guideline value	The concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer, e.g. appearance, taste and odour (NHMRC & NRMMC 2004a).
Australian height datum	Australian height datum is the height of land in metres above mean sea level. For example, the AHD is +0.026 m at Fremantle.
Allocation	The quantity of water permitted to be abstracted by a licensee is their allocation, usually specified in kilolitres per annum (kL/a).
Aquifer	An aquifer is a geological formation or group of formations able to receive, store and transmit significant quantities of water.
Augment	Augment means to increase the available water supply. For example, pumping back water from a secondary storage/reservoir dam.
Bore	A bore is a narrow, lined hole drilled into the ground to monitor or draw groundwater (also see *well*).
Borefield	A group of bores to monitor or withdraw groundwater is referred to as a borefield (also see *wellfield*).
Catchment	The physical area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Colony forming units	Colony forming units are 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.

Department of Environment and Conservation	The Department of Environment and Conservation was established on 1 July 2006, bringing together the Department of Environment and the Department of Conservation and Land Management.
Diffuse source	A diffuse source of pollution originates from a widespread non-specific area (e.g. urban stormwater runoff, agricultural infiltration) as opposed to a particular point source (see *point source pollution*).
Effluent	Effluent is treated or untreated liquid, solid or gaseous waste discharged by a process such as through a septic tank and leach drain system.
Electrical conductivity	This estimates the volume of TDS or the total volume of dissolved ions in a solution (water) corrected to 25ºC. Measurement units include millisiemens per metre and microsiemens per centimetre.
Fractured rock	An aquifer where groundwater is present in the fractures, joints, solution cavities, bedding planes and zones of weathering igneous, metamorphic and deformed sedimentary rocks. Fractured rock aquifers are highly susceptible to contamination from land-use activities when aquifers crop-out or sub-crop close to the land surface.
Gigalitre	A gigalitre is equivalent to 1 000 000 000 litres or one million kilolitres.
Health guideline value	The concentration or measure of a water quality characteristic that, based on current knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHMRC & NRMMC 2004a).
Hydrocarbons	A class of compounds containing only hydrogen and carbon, such as methane, ethylene, acetylene and benzene. Fossil fuels such as oil, petroleum and natural gas all contain hydrocarbons.
Hydrogeology	The study of groundwater, especially relating to the distribution of aquifers, groundwater flow and groundwater quality.
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.
mg/L	A milligram per litre (0.001 grams per litre) is a measurement of a total dissolved solid in a solution.

Most probable number	Most probable number is a measure of microbiological contamination.
Millisievert	A millisievert is a measure of annual radiological dose, with a natural dose equivalent to 2 mSv/yr.
Millisiemens per metre	Millisiemens per metre is a measure of electrical conductivity of a solution or soil and water mix that provides a measurement of salinity.
Nephelometric turbidity units	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, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.
Pathogen	A disease-producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as *Escherichia coli*), protozoa (such as cryptosporidium and giardia) and viruses.
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.
pH	A logarithmic scale for expressing the acidity or alkalinity of a solution. A pH below seven indicates an acidic solution and above seven indicates an alkaline solution.
Point source pollution	Pollution originating from a specific localised source, e.g. sewage or effluent discharge; industrial waste discharge.
Pollution	Water pollution occurs when waste products or other substances (effluent, litter, refuse, sewage or contaminated runoff) change the physical, chemical or biological properties of the water, adversely affecting water quality, living species and beneficial uses.
Production bore	A bore that is equipped to deliver water for an end use, such as potable water supply.

Public sector circular number 88	A state government circular produced by the Department of Health providing guidance on appropriate herbicide use within water catchment areas.
Public drinking water source area	Includes all underground water pollution control areas, catchment areas and water reserves constituted under the *Metropolitan Water Supply Sewerage and Drainage Act 1909* (WA) and the *Country Areas Water Supply Act 1947* (WA).
Recharge	Recharge is the action of water infiltrating through the soil/ground 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.
Reservoir protection zone	A buffer measured from the high water mark of a drinking water reservoir, and inclusive of the reservoir (usually two kilometres). This is referred to as a prohibited zone under the *Metropolitan Water Supply, Sewerage and Drainage Act By-laws 1981.*
Run-of-the-river scheme	A scheme that takes water from a flowing river. Water is taken directly from the source and there is no detention (storage) time.
Runoff	Water that flows over the surface from a catchment area, including streams.
Scheme supply	Water diverted from a source or sources by a water authority or private company and supplied through a distribution network to customers for urban and industrial use or for irrigation.
Semi-confined aquifer	A semi-confined or leaky aquifer is saturated and bounded above by a semi-permeable layer and below by a layer that is either impermeable or semi-permeable.
Storage reservoir	A major reservoir of water created in a river valley by building a dam.
Stormwater	Rainwater that has run off the ground surface, roads, paved areas etc., and is usually carried away by drains.
True colour units	True colour units are a measure of degree of colour in water.

Total dissolved solids	Total dissolved solids consist of inorganic salts and small amounts of organic matter that are dissolved in water. Clay particles, colloidal iron and manganese oxides, and silica fine enough to pass through a 0.45 micrometer filter membrane can also contribute to total dissolved solids. Total dissolved solids comprise sodium, potassium, calcium, magnesium, chloride, sulfate, bicarbonate, carbonate, silica, organic matter, fluoride, iron, manganese, nitrate (and nitrite) and phosphate (NHMRC & NRMMC 2004a).
Total filterable solids by summation	Total filterable solids by summation is a water quality test which is a total of the following ions: Na (sodium), K (potassium), Ca (calcium), Mg (magnesium), Cl equivalent (chloride), alkalinity equivalent, SO_4 equivalent (sulfate) or S (sulfur) in grams, Fe (iron), Mn (manganese), and SiO_2 (silicon oxide). It is used as a more accurate measure than total dissolved solids (TDS). The higher the value, the more solids that are present and generally the saltier the taste.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.
Unconfined aquifer	An aquifer in which the upper surface of water is lower than the top of the aquifer itself. The upper surface of the groundwater within the aquifer is called the watertable.
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	Water quality is the collective term for the physical, aesthetic, chemical and biological properties of water.
Water reserve	A water reserve is an area proclaimed under the *Country Areas Water Supply Act 1947* (WA) or the *Metropolitan Water Supply Sewerage and Drainage Act 1909* (WA) for the purposes of protecting a drinking water supply.
Watertable	The upper saturated level of the unconfined groundwater is referred to as the watertable.
Wellfield	A wellfield is a group of bores located in the same area used to monitor or withdraw groundwater.

Wellhead	The top of a well (or bore) used to draw groundwater is referred to as a wellhead.
Wellhead protection zone	A wellhead protection zone (WHPZ) is usually declared around wellheads in public drinking water source areas to protect the groundwater from immediate contamination threats in the nearby area.

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