Government of Western Australia
Department of Water and Environmental Regulation

Important information

The *Millstream Water Reserve drinking water source protection plan* (2010, WRP no.116) was reviewed during the 2017–18 financial year.

Please ensure you read the *Millstream Water Reserve drinking water source protection review* (2018, WRP no.178) alongside the 2010 plan to obtain all of the information about this drinking water source.

The 2018 review considers changes that have occurred in and around the Millstream Water Reserve since 2010. An assessment of previous recommendations has been done and additional recommendations have been prepared to ensure the ongoing protection of this source, including:

- reducing the water reserve boundary under the *Country Areas Water Supply Act 1947*
- updating the protection zones to reflect the existing production bores.

You can find the 2018 *Millstream Water Reserve drinking water source protection review* at www.dwer.wa.gov.au or by contacting the Department of Water and Environmental Regulation on +61 8 6364 7000 or drinkingwater@dwer.wa.gov.au.

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

Millstream Water Reserve

Drinking water source protection plan

West Pilbara water supply

Looking after all our water needs

Water resource protection series
Report WRP 116
June 2010

Millstream Water Reserve drinking water source protection plan

West Pilbara integrated water supply scheme

Looking after all our water needs

Department of Water

Water resource protection series

Report No. 116

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For more information about this report, contact the Water Source Protection Branch on +61 6364 7600 or drinkingwater@water.wa.gov.au.

Cover photograph: Crossing Pool (Photo: C. Stanley)

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Preface

How do we protect public drinking water source areas?

The Australian drinking water guidelines (ADWG) (NHMRC & NRMMC 2004a) outlines how we should protect drinking water in Australia. The ADWG recommends a 'catchment to consumer' framework that uses a risk-based, multiple-barrier approach. A similar approach is recommended by the World Health Organization in other countries worldwide.

The 'catchment to consumer' framework applies across the entire drinking water supply system. It ensures a holistic assessment of risks to drinking water to maximise the delivery of safe drinking water to consumers.

A risk-based approach means that we look at all the different risks to water quality, and how to address them. A multiple-barrier approach means that we use different barriers against contamination at different stages of a drinking water supply system. The first barrier is the catchment (the whole area from which water flows into the drinking water source). Other barriers against contamination include:

- storage of water to help settle out contaminants
- treating the water (e.g. chlorination) to remove contamination
- maintenance of pipes
- monitoring of water quality.

As water treatment practices evolve, it is understandable to think that we can 'engineer out the risks'. Nothing could be further from the truth (Krogh et. al 2008). Recent research and experience shows that a combination of catchment protection and water treatment is safer than relying on either barrier on its own. That's why this drinking water source protection plan (DWSPP) is important. It's about protecting the catchment's water quality now and in the future.

In Western Australia, the Department of Water protects public drinking water source areas (PDWSAs) by using the law; putting the ADWG into practice; writing plans, policies and guidelines; and providing input into land-use planning.

The ADWG outlines 12 elements to protect drinking water. The Department of Water implements element two (assessment of the drinking water supply system) and element three (preventative measures for drinking water quality management) by writing DWSPPs. Protection plans have been, or are being written for all PDWSAs around the state. They identify the location and describe the characteristics of each drinking water source and outline the risks to water quality and how to address them. Our regional offices work with the community, other government agencies and landowners to put the recommendations in each DWSPP into practice.

To maximise the protection of water quality in each PDWSA 'priority areas' and 'protection zones' are used to guide land use planning and the apply the *Metropolitan Water Supply Sewerage and Drainage Act 1909* (WA) and the *Country Areas Water Supply Act 1947* (WA).

There are three different priority areas, Priority 1 (P1) areas have a risk avoidance objective and P2 and P3 areas have a risk minimisation and risk management objective respectively. The protection zones surround drinking water extraction points, so that the most vulnerable areas may be protected from contamination.

If you would like more information about how we protect drinking water in Western Australia, go to <http://drinkingwater.water.wa.gov.au>.

The following table outlines the stages involved in the preparation of this drinking water source protection plan:

Stages in development of a plan		**Comment**
1	Prepare drinking water source protection assessment document. 1999	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. October 2009	Advice sought from key stakeholders using the assessment document as a tool for information and discussion.
3	Prepare draft drinking water source protection plan. March 2010	Draft protection plan developed taking into account input from stakeholders and any additional advice.
4	Release draft drinking water source protection plan. 17 May 2010	Draft protection plan released for a four-week public consultation period.
5	**Publish approved drinking water source protection plan.** **June 2010**	**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

The Millstream wellfield is located approximately 100 km south of Karratha. It is used as a source of water, along with Harding Dam, for the West Pilbara water supply scheme. This scheme supplies water to Karratha, Dampier, Roebourne, Wickham, Point Samson, Cape Lambert and the Burrup Peninsula.

The Millstream area is a complex system of permanent pools and wetlands which is predominantly fed by groundwater discharge from the Millstream Dolomite, along with seasonal flows in the Fortescue River. The area has significant ecological, cultural and social importance. This is recognised by its inclusion in the Millstream-Chichester National Park and in a proposal to have the Millstream Pools recognised as a Wetland of International Importance under the Ramsar Convention.

The bores at Millstream are drilled into the Millstream Dolomite, which is an unconfined and highly transmissive aquifer, making the wellfield vulnerable to contamination from inappropriate land uses. At present the main land uses in the water reserve are a national park, water supply infrastructure, pastoral stations and mining activities. The main risks to water quality are pathogens from wastewater treatment systems and hydrocarbons and other chemicals used in managing the national park and the water supply system.

A drinking water source protection plan was first prepared for the Millstream Water Reserve in 1999. This plan is a review and update of the original plan. As part of the review the Department of Water engaged a consultant to carry out particle track modelling of the water reserve boundary. The modelling results indicated that the existing water reserve boundary is valid.

The 2010 plan was prepared in consultation with the Water Corporation, the Department of Environment and Conservation and other key stakeholders with an interest in the Millstream Water Reserve.

As a result of the modelling, no significant changes to the existing water reserve and management arrangements are proposed. Minor changes to the water reserve boundary are however proposed to reflect improved catchment boundary information, while the existing priority areas are proposed to remain in place. The Priority 1 areas will protect the most vulnerable parts of the aquifer over and around the Millstream Dolomite and the Priority 2 areas will protect the outer catchment.

1 Drinking water source overview

1.1 Existing water supply system

The Millstream wellfield is located approximately 100 km south of Karratha in Western Australia's Pilbara region. The wellfield sits within the proclaimed Millstream Water Reserve and supplies water to the West Pilbara water supply scheme (WPWSS). The Water Corporation operates the Millstream wellfield in conjunction with Harding Dam to supply water to the towns of Karratha, Wickham, Roebourne, Point Samson and Cape Lambert as part of the WPWSS. Rio Tinto also sources water from the WPWSS to supply the town of Dampier. The existing Millstream Water Reserve is shown in Figure A1 and Figure A2 in Appendix A.

Groundwater has been abstracted from the Millstream aquifer for public water supply since 1968–69 (Water Authority of Western Australia 1992). The borefield originally consisted of six production bores (PB1–PB6) with an additional six bores commissioned in 1971 (PB7–PB12). Production from PB11 and PB12 ceased in 1988 due to high salinity levels and they were subsequently decommissioned in 2000. It is proposed that PB10 also be decommissioned in the near future. This means that nine bores in the wellfield can be used for production at present.

In addition to the production bores, two supplementation schemes – each consisting of three bores – are located near Chinderwarriner Pool and Deep Reach Pool. These bores abstract water from the aquifer and allow pumping directly into each of the pools during periods of low spring flow.

Use of the Millstream water supply has dropped significantly since Harding Dam was constructed in 1985 (Water Authority of Western Australia 1992). Currently the Millstream supply is primarily used as a secondary source when the water quality in Harding Dam deteriorates at low dam levels. Millstream is also used concurrently with Harding Dam to meet peak water supply demands on the scheme.

1.2 Water treatment

Raw water from the Millstream borefield is chlorinated to disinfect the water and then treated with Calgon to soften the water and prevent scaling of pipe work.

It should be recognised that although treatment and disinfection are essential barriers against contamination, catchment management of the wellfield is the first step in protecting water quality and 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, multiple-barrier approach for providing safe drinking water to consumers. This combination of catchment protection and water treatment will deliver more reliable, safer and lower-cost drinking water to consumers than either approach could achieve individually.

1.3 Catchment details

1.3.1 Physiography

The Millstream Water Reserve overlies a section of the western Fortescue River valley. The valley lies between the Chichester Range to the north and the Hamersley Range to the south. These major features lie along an east-west axis and rise up in a series of steps from the coastal plains.

The Fortescue River flows in a westerly direction through the water reserve. A number of permanent pools have been formed along the river and within the water reserve. Some pools and wetlands occur off the main channel of the Fortescue, including Chinderwarriner Pool and Woodley Pool. The Department of Environment and Conservation (DEC) has proposed that the Millstream Pools be listed as a Wetland of International Importance under the Ramsar Convention.

A number of creeks flow out of the Chichester and Hamersley ranges through the water reserve and into the Fortescue River. The major creeks flowing through the water reserve into the Fortescue are the Weelumurra, Kanjenjie and Caliwingina creeks.

1.3.2 Climate

The Pilbara coast climate is arid-tropical with low and variable annual rainfall. The long-term average annual rainfall at Millstream is 366 mm (110-year average) with totals ranging from 129 mm in 2003 to 899 mm in 1900.

This large variability is due to the episodic nature of the tropical cyclones, or cyclone-related events, which cross the area in the summer months between December and April and provide most (80%) of the total rainfall. Winter rainfall may also occur in May or June due to the influence of larger cold fronts that dominate winter weather patterns in the southern half of the state. The driest months are September to November and the wettest January to March.

Since 1970 the average annual rainfall at Millstream has increased to 402 mm, a 10 per cent increase from the long-term average of 366 mm/year.

Temperature data for Pannawonica, the nearest representative site with data from 1972 to 2005, indicates January has generally been the hottest month with a mean maximum of 41.0^{o}C and a mean minimum of 27.7^{o}C. July is the coldest month with a mean maximum of 26.7^{o}C and a mean minimum of 24.6^{o}C.

Evaporation at Millstream greatly exceeds rainfall due to high temperatures and the low rainfall. The average annual potential evaporation at Millstream is 3172 mm.

The Bureau of Meteorology has recently closed the recording station at Millstream, therefore future climate data will need to be sourced from a nearby weather station.

1.3.3 Hydrology/hydrogeology

The Millstream aquifer is an interconnected single complex flow system that consists mainly of Millstream Dolomite (dolomite, calcrete, silcrete and clay), Kumina Conglomerate (poorly sorted gravels with interbedded clay), Robe Pisolite (vuggy pisolitic ironstone interbedded with clay) and a weathered portion of the Wittenoom Dolomite (Haig 2009).

The aquifer has well-developed secondary porosity and solution cavities resulting in a highly transmissive aquifer. The Millstream aquifer has a saturated thickness of up to 33 m (Barnett & Commander 1986).

The aquifer is generally unconfined except in the east where it is confined by Kanjenjie Clay to a thickness of 47 m. Kanjenjie Clay consists of silty clay with interbeds of poorly sorted sand and pebbly gravel.

The watertable is approximately 5 to 15 m below ground level. Groundwater flows from the valley walls towards the centre and along the valley axis in an approximately west to north-westerly direction through the wellfield area.

Production bore depths range from 23.2 to 36.2 m below the top of casing and screened lengths vary from 8.3 to 13.9 m over the most productive horizons of the aquifer (Haig 2009).

The main source of aquifer recharge is direct infiltration of river water into the calcrete during flow events. Minor recharge also comes from streams draining into the Fortescue River valley from the Hamersley and Chichester ranges and directly from rainfall (Haig 2009).

The Millstream aquifer is highly vulnerable to contamination in the areas of Millstream Dolomite where the wellfield is located. This is due to the unconfined nature of the aquifer as well as the shallow depth to groundwater over the dolomite.

The Millstream Pools are formed by discharge from the aquifer, with Deep Reach Pool being the largest discharge point. These discharges support a number of groundwater-dependant ecosystems (Haig 2009).

1.4 Future water supply requirements

Demand for water from the WPWSS is predicted to exceed the existing supply capacity in the near future, principally due to an increase in industrial and mining demand. The Department of Water, in consultation with the Water Corporation and other stakeholders, is currently determining how best to meet future demand for the scheme. A pre-feasibility study has been completed that considered different supply options for the WPWSS (and the Port Hedland and Onslow supply schemes). Preferred options were a desalination plant and the use of mine dewatering, rather than the expansion of existing sources.

The Department of Water has recently completed work, including development of a groundwater modelling program (under funding from Water Smart Australia), to improve the accuracy of sustainable yield determinations for the Millstream aquifer. The work has confirmed the long term reliable allocation of the aquifer at 6 GL/year. Annual allocations above this amount will be possible if aquifer levels are high and conversely during some years when aquifer levels are very low restrictions would be required. The work confirmed the need for an additional source for the West Pilbara Supply Scheme due to the increasing demand and reliability of the current sources. Millstream however will remain a strategic source for the Water Corporation in supplying the WPWSS.

1.5 Existing drinking water source protection

The Millstream Water Reserve was proclaimed in 1969 under the *Country Areas Water Supply Act 1947* (WA) for the purpose of public drinking water source protection. By-laws created under this Act enable the Department of Water to consider potentially contaminating activities and land uses, and to inspect premises.

In 1999 the Water and Rivers Commission prepared the *Millstream Water Reserve drinking water source protection plan*. This document outlined risks to water quality from land uses and activities in the reserve. This drinking water source protection plan (DWSPP) builds on and replaces the old plan. That plan made a number of recommendations on what should be done to protect the water source. Most of those recommendations have already been implemented.

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 this Act, the right to use and control surface water and groundwater is vested with the Crown. The Act requires licensing of groundwater abstraction (pumping water from a bore, spring or soak) within groundwater areas proclaimed under the Act and all artesian wells throughout the state.

The Water Corporation operates the WPWSS under two licences: a groundwater licence for Millstream and a surface water licence for Harding Dam. It is currently licensed to extract a combined 15 GL/year from the two sources. While a nominal licensed allocation has been set at 15 GL/year, the actual amount of water available will depend on which water source is being used and on recent recharge.

When water is taken from the Millstream groundwater aquifer, it is in accordance with extraction rules set by the Department of Water. The extraction rules for Millstream are designed to limit extraction impacts on high-value groundwater-dependent

ecosystems and involve managing rates of groundwater-level decline and minimum groundwater levels.

1.6.2 Pilbara regional water plan

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

The Marble Bar DWSPP is also due for completion this financial year. Once the Marble Bar plan is complete, DWSPPs will have been done for all Water Corporation licensed sources currently harnessed in the Pilbara region. Existing DWSPPs are due for review five years after completion. DWSPPs for future and existing but unharnessed sources will be completed when use of those sources begins.

1.6.3 Pilbara Coast water study

The Department of Water carried out this study to review all groundwater, surface water and supplementary supply options for the region's coastal supply schemes, principally giving consideration to the port facilities of Onslow, Dampier and Port Hedland. The Millstream aquifer was included in this review. The study highlights the groundwater supply options with the most potential for development in the near future.

1.6.4 Pilbara water in mining guidelines

The Department of Water has developed a guide to facilitate good water management practices in mining operations across the Pilbara, aiming to achieve the best-possible water resource, environmental and economic management outcomes.

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

Part of the guidelines is 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, including mine site drinking water supply. The document also recommends that mining operations within public drinking water source areas (PDWSAs) recognise the potential impacts of their operations on drinking water sources and develop strategies to protect the water quality.

1.6.5 Pilbara integrated water supply: pre-feasibility study

The Department of Water commissioned a consultant to complete a pre-feasibility study to identify different water supply integration options for the Pilbara region (consistent with the objectives of the *Pilbara regional water plan*).

The study identified water supply options including the use of water extracted by mine dewatering operations, supplemental groundwater for water supply schemes, development of aquifers near the coast, construction of transfer pipelines from source to demand locations and desalination.

The supply options discussed in this study may have an indirect impact on the Millstream aquifer by influencing the amount of water required from Millstream to meet WPWSS demand.

1.6.6 Millstream status report

This 2009 report reviewed Millstream aquifer's existing management arrangements and consolidated the current understanding of the aquifer and the environment it supports. The document also aimed to review how management of the aquifer has evolved and identify assumptions and information gaps that exist in the current management arrangements.

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.

The Water Corporation regularly monitors the quality of raw water from the Millstream borefield for microbiological, health-related and aesthetic (non-health-related) characteristics. This data shows the quality of water in the water reserve. An assessment of the drinking water quality once treated is also made against the ADWG. The assessment of the treated water is made by an intergovernmental committee called the Advisory Committee for the Purity of Water that is chaired by the Department of Health. The drinking water supplied to the West Pilbara supply scheme complies with ADWG for microbiological and health parameters. Aesthetic parameters for hardness and total dissolved solids are exceeded when Millstream is used as the sole supply for the WPWSS, due to the natural characteristics of water from the borefield.

A water quality summary for the Millstream borefield from July 2004 to June 2009 is presented in Appendix B. For more information on water quality, see the Water Corporation's most recent drinking water quality annual report at <www.watercorporation.com.au> What we do > Water quality > Water quality publications > Water quality annual report 2008–09.

Some contamination risks relevant to drinking water sources are described below.

2.1 Microbiological

Pathogens are types of microorganisms that are capable of causing disease. These include bacteria, protozoa and viruses. In water supplies, pathogens that can cause illness are commonly 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 worldwide. These include bacteria (e.g. salmonella, *Escherichia coli* and cholera), protozoa (e.g. *Cryptosporidium*, *Giardia*) and viruses. *E. coli* counts are a way to measure these pathogens and provide an indication of faecal contamination.

Pathogen contamination of a drinking water source is influenced by many factors including 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 surface 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 fresh water (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 sometimes even death. During 2000, seven people died in Walkerton, Canada, because the town water source and supply was contaminated by a pathogenic strain of *E. coli* and campylobacter (NHMRC & NRMMC 2004b). Where possible, avoiding the introduction of pathogens into a water source is the most effective way to protect public health.

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 increased turbidity can subsequently reduce the effectiveness of treatment processes (such as disinfection).

Chemicals attached to suspended material, such as soil particles, can occur in 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 sources can also be contaminated by nutrients (such as nitrogen) from 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 can be toxic to humans at high levels, with infants younger than three months being most susceptible (NHMRC & NRMMC 2004a).

Hydrocarbons (e.g. fuels, oils) are potentially toxic to humans, and harmful chemical by-products may be formed when they are combined with chlorine during the water-treatment process. Hydrocarbons can occur in water supplies as a result of spills and leakage from vehicles.

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 strong taste is not necessarily harmful to health, while clear, pleasant-tasting water may still contain harmful microorganisms (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).

2.4 Groundwater bores

The Millstream 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 abstract water within a proclaimed groundwater area (unless exempt under the Rights in Water and Irrigation Exemption and Repeal [Section 26C] Order 2001).

The Water Corporation operates drinking water bores in the Millstream Water Reserve. If bores for other purposes (e.g. irrigation, private use) 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 of the public drinking water source. This will be assessed through the Department of Water's water licensing process where applicable under the *Rights in Water and Irrigation Act 1914* (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 Millstream Water Reserve consists of Crown land under various forms of reserves or leases. The main uses are land reserved for national park or water supply, pastoral leases and mining tenements. Current land uses and activities are outlined below, along with the water quality risks arising from those land uses. This information has been summarised in Table 1 at the end of this section. This table also identifies the recommended management priorities for different hazards. Appendix C of this plan uses data in Table 1 and this section to recommend protection strategies for key stakeholders to consider. The different land uses are shown in Figure A3 and Figure A4 in Appendix A.

3.1.1 National park

The Millstream Water Reserve sits within a portion of the Millstream-Chichester National Park. The Millstream area was initially gazetted as a wildlife sanctuary in 1956 to protect a cadjeput forest near Crossing Pool. It was then declared a national park in 1967 and has now been expanded to include three 'Class A' reserves covering around 199 736 ha (DEC 2007). A small portion of the national park overlies the Millstream Water Reserve in the national park's south-west corner. DEC has proposed that the Millstream Pools (within the national park) be classified as Ramsar wetlands. DEC believe that the Millstream Pools meet six of the nine criteria required for listing as a Ramsar wetland (DEC 2007). Wetlands are not required to meet all nine criteria to be considered for listing as a Ramsar wetland. Adoption under this international convention would see the pools given special protection (see Appendix D, figures D1 to D3).

The Millstream Park Council has been established to facilitate the joint management of the national park between DEC and the Yindjibarndi and Ngarluma people. The park council was established to ensure that the Traditional Owners have input into the management of the national park (DEC 2007).

The national park provides a number of facilities for visitors within the water reserve including:

- camping and picnicking areas (see Appendix D, Figure D4),
- toilets (see Appendix D, Figure D5),
- interpretation facilities for indigenous and non-indigenous heritage (Appendix D, Figure D6),
- walk trails (see Appendix D, Figure D7)

- access points for water-based activities such swimming and canoeing in the pools (see Appendix D, Figure D8).

The major water quality risks posed by these facilities are pathogens being shed into the water during body contact, or pathogens leaching out of the wastewater treatment systems for the toilets.

The Department of Environment and Conservation (DEC) manages the recreational facilities under *Policy statement no.18 – Recreation, tourism and visitor services* (DEC 2006). The number of visitors to the national park each year is estimated at 20 000 (DEC 2006) and this is expected to increase with the bituminisation of the Karratha-Tom Price Road <www.millstreamlink.com.au>. There is signage on the main road into the national park (see Appendix D, Figure D9) advising visitors that a public drinking water supply borefield is present.

The Department of Water's Policy No.13 *Recreation on Crown land in public drinking water source areas* also applies to guide recreation in the Millstream Water Reserve. This policy (and DEC policy No.18) is subject to review in 2010/11 pending the outcome of a parliamentary committee inquiry into recreation in PDWSA.

DEC has established a depot and rangers' quarters near the old Millstream homestead to service the national park and carry out essential maintenance programs for the park's facilities, as well as provide accommodation for park council meetings (see Appendix D, Figure D10). There are a number of wastewater treatment systems in place for the quarters and park council accommodation (see Appendix D, Figure D11) as well as chemical use and storage in the depot (see Appendix D, figures D12 and D13).

A Department of Corrective Services work camp is also located next to the DEC depot. The camp provides accommodation for workers who are involved in cultural, heritage, environmental and recreational projects associated with managing the national park. The work camp has a wastewater treatment system.

3.1.2 Water supply reserve (reserve 38991)

The *Land Administration Act* (WA) reserve 38991 is jointly vested with the Department of Water and the Water Corporation for the purpose of water supply. Reserve 38991 covers much of the Priority 1 (P1) area of the Millstream Water Reserve and extends outside it to the water reserve's west.

The Water Corporation also has a depot in the water reserve, located just north of the production bores and to Chinderwarriner Pool's west. The depot is used to maintain power generation and pumping facilities for the bores (see Appendix D, figures D14 and D15). Adjacent to the depot are living quarters for permanent and visiting maintenance personnel. With the reduced travelling time from Karratha to Millstream due to bituminisation of the Karratha-Tom Price Road, the Water Corporation has decided that permanent staff will not be housed at the depot any

longer. Maintenance work will now be carried out by staff from the Water Corporation's Karratha office. The main water quality risks associated with the depot are from bulk fuel storage and pathogens from wastewater treatment systems for staff accommodation. The Water Corporation depot was included in the particle tracking carried out for Millstream, and particles from this area of the aquifer showed the quickest travel time to the production bores.

A rubbish tip is sited approximately 500 m to the west of the Water Corporation depot. This is used for refuse from the DEC and Water Corporation depots (see Appendix D, Figure D16). Waste from the national park is not disposed of at this landfill because bins are not provided for the national park. Visitors are encouraged to take their waste with them so that DEC resources can be better used in other areas of national park management. The water quality risks from the rubbish tip are primarily from pathogens and chemicals from waste leaching into the groundwater.

A disused rubbish tip lies just to the south of the DEC depot. This was used for waste from the Millstream Station when it was still operational (see Appendix D, Figure D17). Use of this site continued when DEC took control of the homestead until the current rubbish tip was built. There is no record of what was disposed of at this site over the years. The site may have been used for the disposal of chemicals no longer required by the station and the main water quality risk is that this may have included chemicals that are persistent in the soil, particularly pesticides. However, water quality monitoring in the production bores has yet to show any evidence of such chemicals being present in the groundwater.

3.1.3 Crown leases

Pastoral leases

There are two pastoral leases covering parts of the water reserve. They are Coolawanyah Station in the east and Hamersley Station in the south. Hamersley Station is owned by Rio Tinto and is managed as an operational pastoral property.

The main water quality risk from cattle grazing is pathogens leaching into the water from faeces deposited close to the production bores. The risk is significantly reduced at Millstream because the two pastoral stations are a large distance from the production bores. Provided cattle are not allowed to stray from the area covered by the pastoral leases, then the risk is considered low.

Feral cattle can be found in the water reserve and are recognised as the main pest animal problem in the national park. As their movements are not controlled, they pose a higher risk to water quality. However, DEC is responsible for the control or eradication of pest animals in the national park and has an aerial shooting program to control the cattle (DEC 2007). Fewer cattle numbers will reduce the water quality risk, provided carcasses from any deceased cattle are removed from areas close to the production bores.

Mining tenements

There are a number of mining tenements held across the Millstream Water Reserve. While there are no active mines within the water reserve at present, significant exploration activity is being undertaken, particularly for iron ore. Most of this mineral exploration is being carried out in the water reserve's southern section away from the Millstream Dolomite, although some exploration work is occurring on tenements that overlie the Millstream Dolomite, which is the area of the aquifer most vulnerable to contamination from overlying land uses.

The environmental approvals' process in Western Australia will need to consider whether mining proposals will have any negative impacts on the Millstream aquifer should the projects be progressed further, particularly in areas where the highly vulnerable Millstream Dolomite occurs. The Department of Water will support mining projects and associated activities (such as mining camps, landfills, wastewater treatment facilities and tailings storage facilities for benign materials) sited away from the Millstream Dolomite in P1 and P2 areas, where the proponent can demonstrate that there are no unacceptable risks to water quality.

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 camp wastewater systems also pose a water quality contamination risk. Other risks come from mechanical servicing and washdown areas, changes in aquifer chemistry from dewatering, and disused pits on mine closure. The existing mining camps in the Millstream Water Reserve are a long distance from the production bores, which substantially reduces the water quality contamination risk to the bores.

Exploration drilling poses a risk to aquifers – they can be cross-contaminated through poor drilling techniques. Uncapped drill holes can also provide a pathway for surface contaminants to reach an aquifer.

Rio Tinto's Dampier-Paraburdoo railway runs in a north-south direction through the water reserve and is the dominant mining-related-infrastructure land use in the water reserve. Two camps servicing the railway are located within the water reserve: Ti-Tree camp in the east and Weelumurra Creek camp in the south.

3.1.4 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 from impingement and actions likely to damage or degrade these places.

The Millstream area is one of the most significant cultural and mythological sites of importance for Aboriginal people in northern Western Australia (DEC 2008). Consequently there are a large number of sites of significance within the Millstream Water Reserve. The Yindjibarndi Aboriginal Corporation is the prescribed body corporate with responsibility for decision-making regarding cultural heritage sites in the Millstream Water Reserve.

3.1.5 Native title

The Department of Water is committed to working with Aboriginal people in its planning and management activities. The department recognises that Native Title provides an important framework for water management. Native Title is the recognition in Australian law that some Aboriginal people continue to hold Native Title rights to lands and water arising from their traditional laws and customs. A significant proportion of the Pilbara is subject to Native Title or Native Title claims.

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 are two native title claims and two native title determinations within the water reserve. Those claims are Yindjibarndi 1(WAD 6005/03) and Kuruma Marthudunera (WAD 6090/98).

The Daniel v State of Western Australia native title determination in the Federal Court of Australia found that the Ngarluma/Yindjibarndi people had native title over an area of the Pilbara region, including parts of the Millstream Water Reserve. The court ruled that native title existed in parts of the determination area and that the Ngarluma/Yindjibarndi people had rights that related to access to some areas; the right to conduct rituals and ceremonies; and the right to hunt, fish, forage, collect bush tucker, bush medicine, ochre, flora, fauna and water. The native title holders also have the right to protect and care for sites and objects. The relevant native title claim number is WAD 6017/96.

The Eastern Guruma native title determination (WI2001/001) covers the southern part of the water reserve. The court found that native title existed over the entire determination area. The Eastern Guruma people have non-exclusive native title rights over mostly pastoral land, including rights to enter and remain on the land, camp, hunt, fish and gather and use resources of the land and waters (excluding minerals); engage in ritual and ceremonies; and protect areas of cultural significance.

3.2 Proposed land uses and activities

The expansion of accommodation facilities in the national park has been proposed in the draft national park management plan. The plan discusses the development of

built accommodation as well as new and expanded camping facilities, but to date no detailed proposals have been developed. Tourism WA, through its Naturebank project, has identified the Millstream area as a possible location for commercial eco and nature-based tourism operations that would include accommodation. Any proposals will need to ensure consistency with the state's water source protection policies and procedures. Where practicable they should be located downstream of the Millstream borefield.

The other potential large-scale change in land use in the water reserve is the development of new mining operations. Existing exploration work indicates that viable mining projects may be established in the water reserve, particularly in the southern section. These are potentially large mining projects that have reached fairly advanced stages of planning. Each project will be assessed through the state's environmental approvals' process, which will include consideration of the potential impacts on the Millstream Water Reserve and whether the project in question poses an unacceptable water quality risk.

In 2009 the state government released the *Review of the process to permit diversification on pastoral leasehold land in Western Australia*. The report has recommended that future diversification of activities on pastoral leases be allowed. Changes in activities carried out on pastoral leases may mean that pastoral leases pose new and different water quality contamination risks in the future.

Table 1 Land use and potential water quality risks

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance
National park				
Swimming	Pathogens from body contact with water	Medium	Refer to the Department of Water's *Statewide policy no. 13: Recreation on Crown land in public drinking water source areas* (This policy is subject to review in 2010/11).	*Managing tourism: guidelines for managing tourism in the Fortescue River – Millstream Water Reserve catchment area*
Camping and picnicking	Pathogens from ablutions servicing, camping and picnic sites Nutrients from ablutions servicing camping and picnic sites	High Low	Refer to the Department of Water's *Statewide policy no. 13: Recreation on Crown land in public drinking water source areas* (This policy is subject to review in 2010/11).	*Camping and tourism: guidelines for visitors to the Fortescue River – Millstream Water Reserve catchment area*
Fishing	Pathogens from body contact with water	Medium	Refer to the Department of Water's *Statewide policy no. 13: Recreation on Crown land in public drinking water source areas* (This policy is subject to review in 2010/11).	*Managing tourism: guidelines for managing tourism in the Fortescue River – Millstream Water Reserve catchment area*

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance
Canoeing	Pathogens from body contact with water	Medium	Refer to the Department of Water's *Statewide policy no. 13: Recreation on Crown land in public drinking water source areas* (This policy is subject to review in 2010/11).	*Managing tourism: guidelines for managing tourism in the Fortescue River – Millstream Water Reserve catchment area*
Department of Environment and Conservation depot[#]	Pesticides from storage and use Hydrocarbon and other chemical spills from storage and use	Medium Medium	Fuel depots are incompatible with Priority 1 (P1) areas.	Water quality protection note (WQPN) no. 65: *Toxic and hazardous substances – storage and use*; WQPN no. 10: *Contaminant spills – emergency response;* Public service circular 88: *Use of herbicides in water catchment areas*
Department of Environment and Conservation staff quarters	Pathogens from wastewater treatment systems Nutrients from wastewater treatment systems	High Low	Caretakers' dwellings are compatible with conditions in P1 areas.	WQPN no. 70: *Wastewater treatment – onsite domestic systems*

Land use/activity	**Hazard**	**Management priority**	**Compatibility of land use/activity**	**Best management practice guidance**
Department of Corrective Services work camp[#]	Pathogens from wastewater treatment systems Nutrients from wastewater treatment systems	High Low	Toilet blocks are compatible with conditions in P1 areas; corrective institutions are incompatible in P1 areas.	WQPN no. 70: *Wastewater treatment – onsite domestic systems*
Millstream Park Council accommodation	Pathogens from wastewater treatment systems Nutrients from wastewater treatment systems	High Low	Caretakers' dwellings are compatible with conditions in P1 areas.	WQPN no. 70: *Wastewater treatment – onsite domestic systems*

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance
Reserve 38991 (water supply)				
Water Corporation depot	Pathogens from wastewater treatment systems Nutrients from wastewater treatment systems Hydrocarbon and other chemical spills from storage and use	High Low High	Caretakers' dwellings are compatible with conditions in P1 areas.	WQPN no. 65: *Toxic and hazardous substances – storage and use;* WQPN no. 70 *Wastewater treatment – onsite domestic systems*
Fuel storage at production bores[#]	Hydrocarbon and other chemical spills from storage and use	High	Generally fuel storage in wellhead protection zones is incompatible but it is necessary for the water supply system in this situation.	WQPN no. 65: *Toxic and hazardous substances – storage and use*
Current Millstream rubbish tip[#]	Leaching of hydrocarbons and other chemicals into groundwater	Low	Landfills are incompatible in P1 areas.	WQPN no. 111: *Landfills for disposal of putrescible material*
Old Millstream rubbish tip[#]	Leaching of hydrocarbons and other chemicals into groundwater	Low	Landfills are incompatible in P1 areas.	WQPN no. 111: *Landfills for disposal of putrescible material*
Millstream airstrip	Hydrocarbons and other chemicals from storage and use	Low	Landing strips are compatible with conditions in P1 areas.	WQPN no. 65: *Toxic and hazardous substances – storage and use*

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance
Roads[#]	Hydrocarbon and chemicals from accidents and spills	Medium	Major transport routes are incompatible in P1 areas.	WQPN no. 44: *Roads near sensitive water resources*
Crown leases				
Mineral exploration	Hydrocarbon and other chemical spills or discharges from storage and use	Low	Mineral exploration is compatible with conditions in P1 and Priority 2 (P2) areas.	Water quality protection guideline series: *Mining and mineral processing*
Mining	Hydrocarbon and other chemical spills or discharges from storage and use	Low	Mining is compatible with conditions in P1 and P2 areas.	Water quality protection guideline series: *Mining and mineral processing*
Mining camps	Pathogens from wastewater treatment systems Hydrocarbon and other chemical spills or discharges from storage and use	Low Low	Mining and construction camps are compatible with conditions in P1 areas.	Water quality protection guideline series: *Mining and mineral processing*

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance
Railways[#]	Hydrocarbon and other chemical spills from accidents on the railway line	Low	Railways (major transport routes) are incompatible in P1 areas and compatible with conditions in P2 areas.	WQPN no. 10: *Contaminant spills – emergency response*
Roads[#]	Hydrocarbon and chemicals from accidents and spills	Medium	Major transport routes are incompatible in P1 areas.	WQPN no.44: *Roads near sensitive water resources*
Pastoral leases	Pathogens from faecal matter Nutrients from faecal matter	Medium Low	Pastoral activities are compatible with conditions in P1 areas and acceptable in P2 areas.	WQPN no. 35: *Pastoral activities within rangelands*; *Guidelines for pastoral properties and leases adjoining a water reserve*

[#] Non-conforming existing land use.

4 Catchment protection strategy

4.1 Protection objectives

This plan's objective is to ensure safe drinking water is available to consumers now and in the future. The Millstream Water Reserve's protection objectives are to maintain the source's water quality and ensure new inappropriate land uses are not developed that pose an unacceptable contamination risk to the source, while recognising the rights of existing approved land uses to continue.

4.2 Proclaimed area

As discussed in Section 1.5.1, the Millstream Water Reserve is already proclaimed under the *Country Areas Water Supply Act 1947* (WA). As part of the review of the 1999 DWSPP, the water reserve's existing boundary was assessed to see if its area was still appropriate to protect the water source. The assessment used new information about the Millstream aquifer gathered from the recent hydrogeological modelling work carried out by the Department of Water.

Particle tracking was included in the model using MODPATH, a semi-analytical particle tracking package. Reverse particle tracking was carried out to determine the location of individual particles in the model domain. The reverse particle tracking shows that groundwater flow is generally in a north-west direction throughout the aquifer. However, the production bores are in two groups and the groundwater flow to the northern group of bores shifts to an easterly direction as the water approaches these bores. The particle tracking chapter of the complete modelling report is shown in Appendix E.

This modelled flow direction is supported by the potentiometric head mapping that shows a higher head in the western portion of the Millstream Dolomite outcrop, which in turn creates a hydraulic gradient with groundwater flows to the east (from the western portion of the outcrop to the production bores).

The 1999 DWSPP recommended the proclamation of the western portion of the Millstream Dolomite outcrop up to a groundwater divide, to ensure areas that contributed recharge to the aquifer were adequately protected. Recent work carried out by the Department of Water confirms the need to continue protecting the western portion of the dolomite outcrop. This DWSPP therefore recommends that the existing western boundary of the Millstream water reserve remains unchanged.

In 1999, the southern and eastern boundaries of the water reserve were chosen to include the catchment of Weelumurra Creek, because surface water draining through this area was contributing recharge to the Millstream aquifer. More recently, the *Pilbara coast water study* (Haig 2009) confirmed that this area contributed recharge to the aquifer. Hence this DWSPP recommends that the Weelumurra Creek surface

water catchment be retained as part of the water reserve, with minor adjustments to the water reserve boundary to reflect improved topographical modelling of the area's surface water catchments.

The existing and proposed new boundaries are shown in Figure A2 and Figure A5.

4.3 Priority areas

The protection of 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 management.

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. This method is shown diagrammatically in Figure A6. For further detail, please refer to the Department of Water's Water quality protection note no. 25 (WQPN no. 25): *Land use compatibility in public drinking water source areas*.

The proposed priority areas for the Millstream Water Reserve have been determined in accordance with current Department of Water policy. These areas are described below and displayed in Figure A5. The department's WQPN no. 25: *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 WQPN no. 36: *Protecting public drinking water source areas*.

The existing P1 area of the Millstream Water Reserve is proposed to be retained for the following reasons:

- Water from Millstream is a strategic supply for the West Pilbara water supply scheme. The land over the Millstream Dolomite is the area most vulnerable to contamination so it should be afforded the highest feasible level of protection.
- A large portion of the Millstream Water Reserve is under a Land Administration Act reserve, which is jointly vested in the Department of Water and the Water Corporation for purpose of water supply. This vesting recognises the importance of the area as a water supply.
- The remainder of the proposed P1 area is Crown land vested for the national park, which is a land use compatible with P1 source protection objectives.

- The area overlying the Millstream Dolomite is covered by national park and Land Administration Act reserve. As the part of the aquifer most vulnerable to contamination, its classification as P1 will ensure protection of the area most at risk from contamination.

The outer part of the water reserve encompasses the surface water catchments that drain the Hamersley and Chichester ranges and contribute recharge to the aquifer. It is proposed that this area be retained as a P2 area because it is away from the Millstream Dolomite and, with the implementation of best management practices, the current land uses (pastoral lease and mineral exploration) are compatible with P2 water source protection objectives.

4.4 Protection zones

In addition to priority areas, protection zones are defined to protect drinking water sources from contamination in the immediate vicinity of water extraction facilities. Specific conditions may apply within these zones such as restrictions on the storage of chemicals.

Wellhead protection zones (WHPZs) 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. WHPZs do not extend outside the boundary of the water reserve.

As discussed in Section 1.1: Existing water supply system, of the 12 production bores used at Millstream over time, only nine are intended for water supply use, with the other three not considered suitable due to salinity issues. Therefore WHPZs are proposed for these nine bores, being PB1 to PB9. The proposed WHPZs are shown in Figure A5.

4.5 Land-use planning

It is recognised under the Western Australian Planning Commission's (WAPC) *State planning strategy* (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 WAPC's Statement of planning policy no. 2.7: *Public drinking water source policy* (2003) it is appropriate that the Millstream Water Reserve, its priority areas and protection zones be recognised in the *Shire of Ashburton local planning scheme*. Any development proposals within the Millstream Water Reserve that are inconsistent with advice in the Department of Water's WQPN no. 25: *Land use compatibility in public drinking water source areas* or recommendations in this plan, should be referred to the Department of Water for advice.

For further information on the integration of land-use planning and water source protection, please refer to the Department of Water's WQPN no. 36: *Protecting public*

drinking water source areas and WQPN no. 76: *Land use planning in public drinking water source areas*.

The department's protection strategy for PDWSAs provides for lawfully established and operated developments to continue despite those facilities posing a potential level of risk to water quality that would not be accepted for new developments. The department will provide advice to landowners/operators on best practice measures to improve these facilities and reduce water quality contamination risks.

The main existing land use established in the Millstream Water Reserve to which this strategy applies is the Dampier-Paraburdoo Railway. Whilst this is noted in Table 1 as a "non-conforming use, the Department of Water will work with the railway operator to ensure that the railway can continue to be utilised, whilst ensuring water quality is adequately protected.

4.6 Best management practices

There are opportunities to significantly reduce water contamination risks by carefully considering design and management practices. To help protect water sources, the Department of Water will continue to encourage the adoption of best management practices for various land uses.

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. They outline the recommended practices to ensure the protection of water quality and can thus help managers reduce any detrimental effects of their operations. Such guidelines have been developed in consultation with stakeholders such as industry groups, agricultural producers, state government agencies and technical advisers. Examples include the Water quality protection guideline series: *Mining and mineral processing* and WQPN no. 70: *Wastewater treatment – onsite domestic systems*, which are listed in this plan's References.

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

4.7 Surveillance and by-law enforcement

The quality of water in public drinking water source areas within country areas of the state is protected under the *Country Areas Water Supply Act 1947* (WA). Proclamation of PDWSAs 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 borefield's boundaries to educate and advise the public about activities that are prohibited or regulated. Additional signage should be erected on the water reserve's boundary. This plan recommends that surveillance and by-law enforcement for the Millstream 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 Pilbara local emergency management committee (LEMC), through the Pilbara emergency management district, should be familiar with the location and purpose of the Millstream Water Reserve. A locality plan should be provided to the fire and rescue services headquarters for the hazardous materials (HAZMAT) emergency advisory team. DEC is the lead agency for wildfire control management for the parts of the water reserve within national park. The Department of Water should have an advisory role to the HAZMAT team for incidents in the Millstream 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 Millstream 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 identifies the potential water quality risks associated with existing land uses in the proposed Millstream Water Reserve. Further information and the recommended protection strategies to deal with those risks are outlined in Appendix C.

When the final *Millstream Water Reserve drinking water source protection plan* is complete, an implementation strategy will be drawn up based on the recommendations in this plan.

5 Recommendations

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

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

2 Develop an implementation strategy for this plan's recommendations (including the recommended protection strategies as detailed in Appendix C) showing responsible stakeholders and planned timeframes. (Department of Water, applicable stakeholders)

3 The *Shire of Ashburton local planning scheme* should incorporate this plan and reflect the identified Millstream Water Reserve boundary, priority 1 and 2 areas and protection zones in accordance with the WAPC's Statement of planning policy no. 2.7: *Public drinking water source policy*. (Shire of Ashburton)

4 All development proposals within the Millstream Water Reserve that are inconsistent with the Department of Water's Water quality protection note no. 25: *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 of Planning, Shire of Ashburton, proponents of proposals)

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

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

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

7 Additional signs should be erected along the boundary of the Millstream 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, Water Corporation)

Existing signs located along the boundary of the Millstream Water Reserve should also be maintained for the reasons outlined above. (Department of Water, Water Corporation)

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

9 The *Millstream-Chichester National Park and Mungaroona Range Nature Reserve management plan* should ensure that source protection objectives are adequately addressed. (Department of Environment and Conservation, Department of Water)

10 New ablution facilities within the water reserve should be sited away from the Millstream Dolomite. (Proponents of proposal to install ablutions)

11 The Department of Water continue to work with the Yindjibarndi Aboriginal Corporation on planning and management activities related to the management of water at Millstream. (Department of Water, Yindjibarndi Aboriginal Corporation)

Appendices

Appendix A Figures

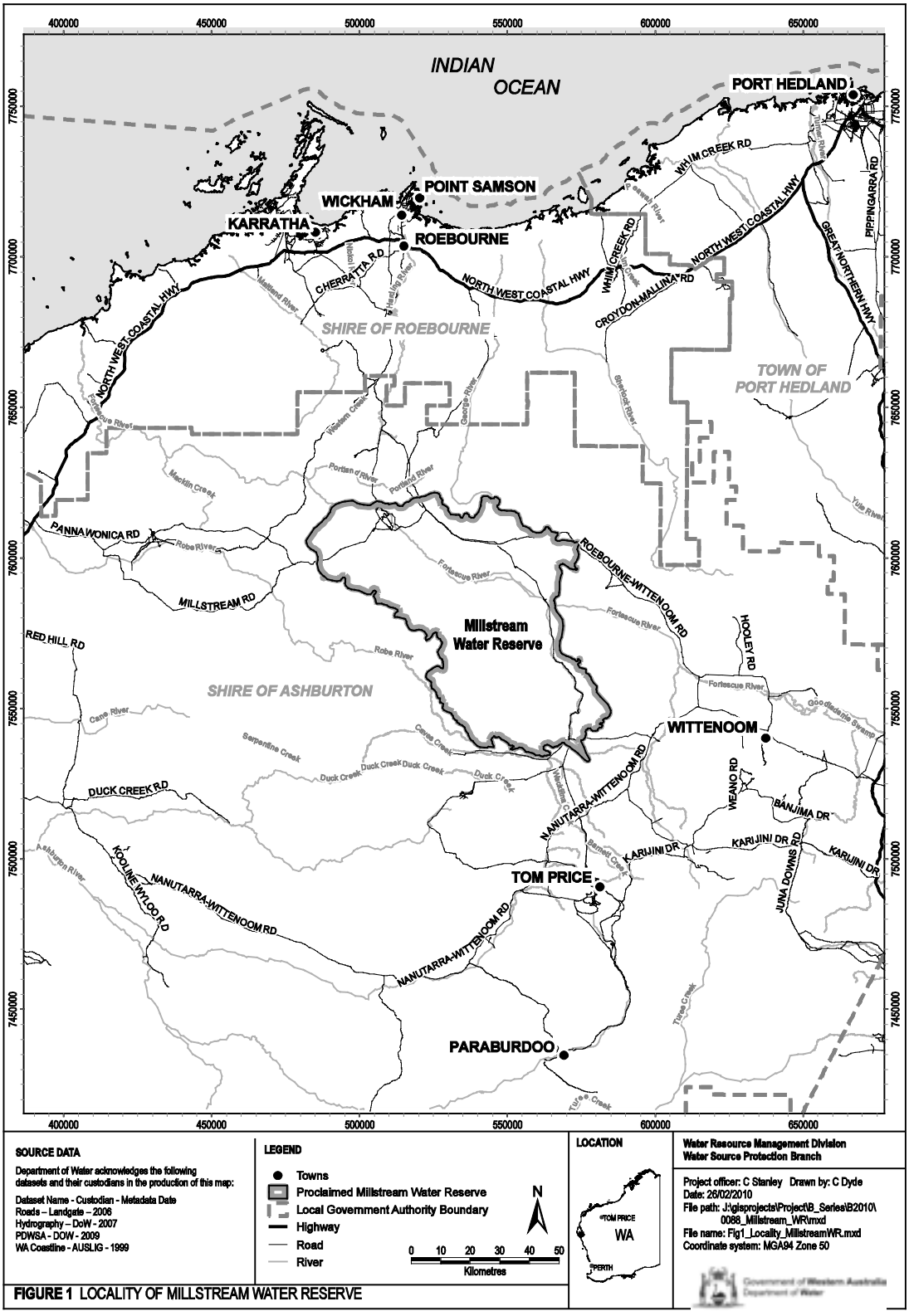


FIGURE 1 LOCALITY OF MILLSTREAM WATER RESERVE

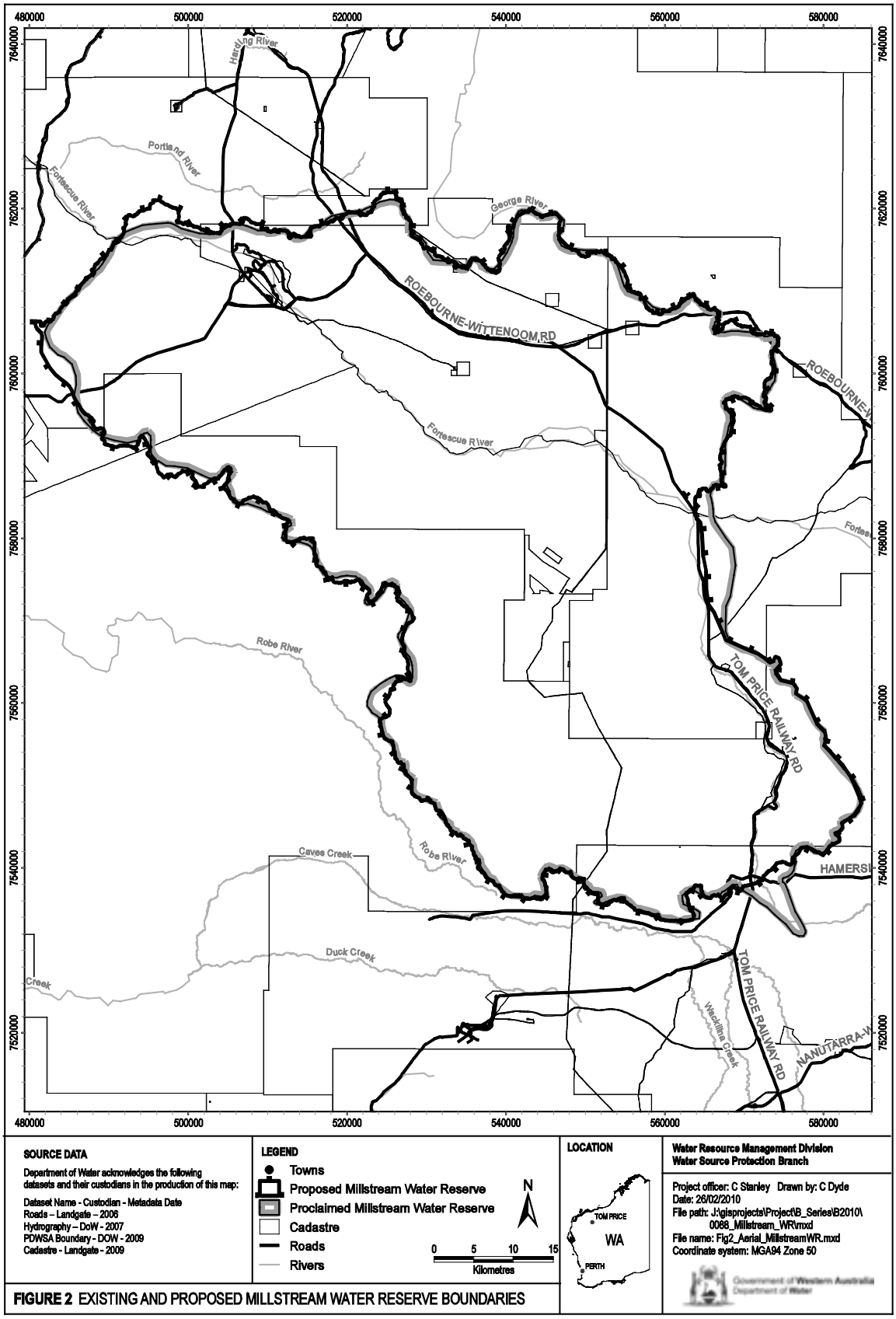


FIGURE 2 EXISTING AND PROPOSED MILLSTREAM WATER RESERVE BOUNDARIES

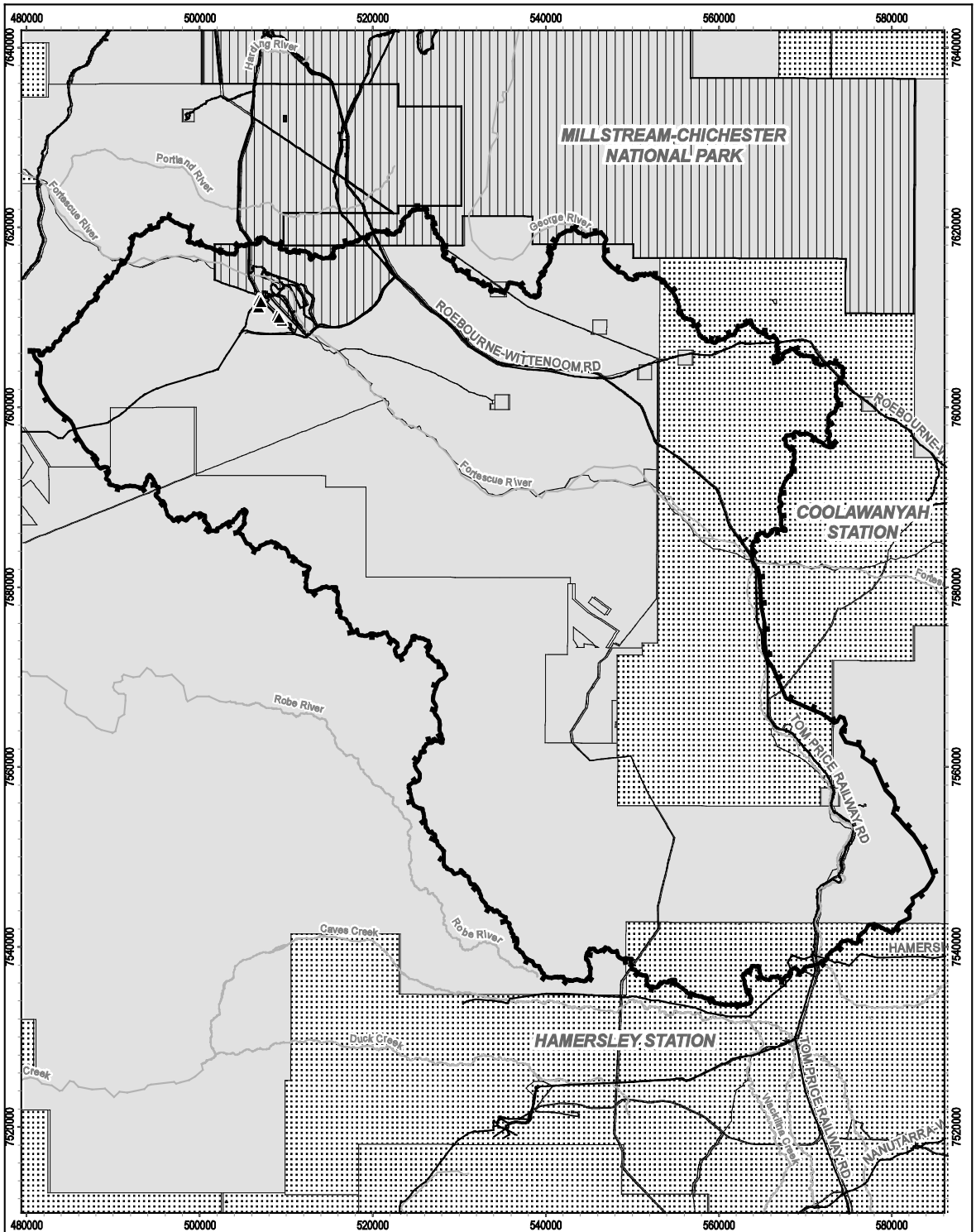
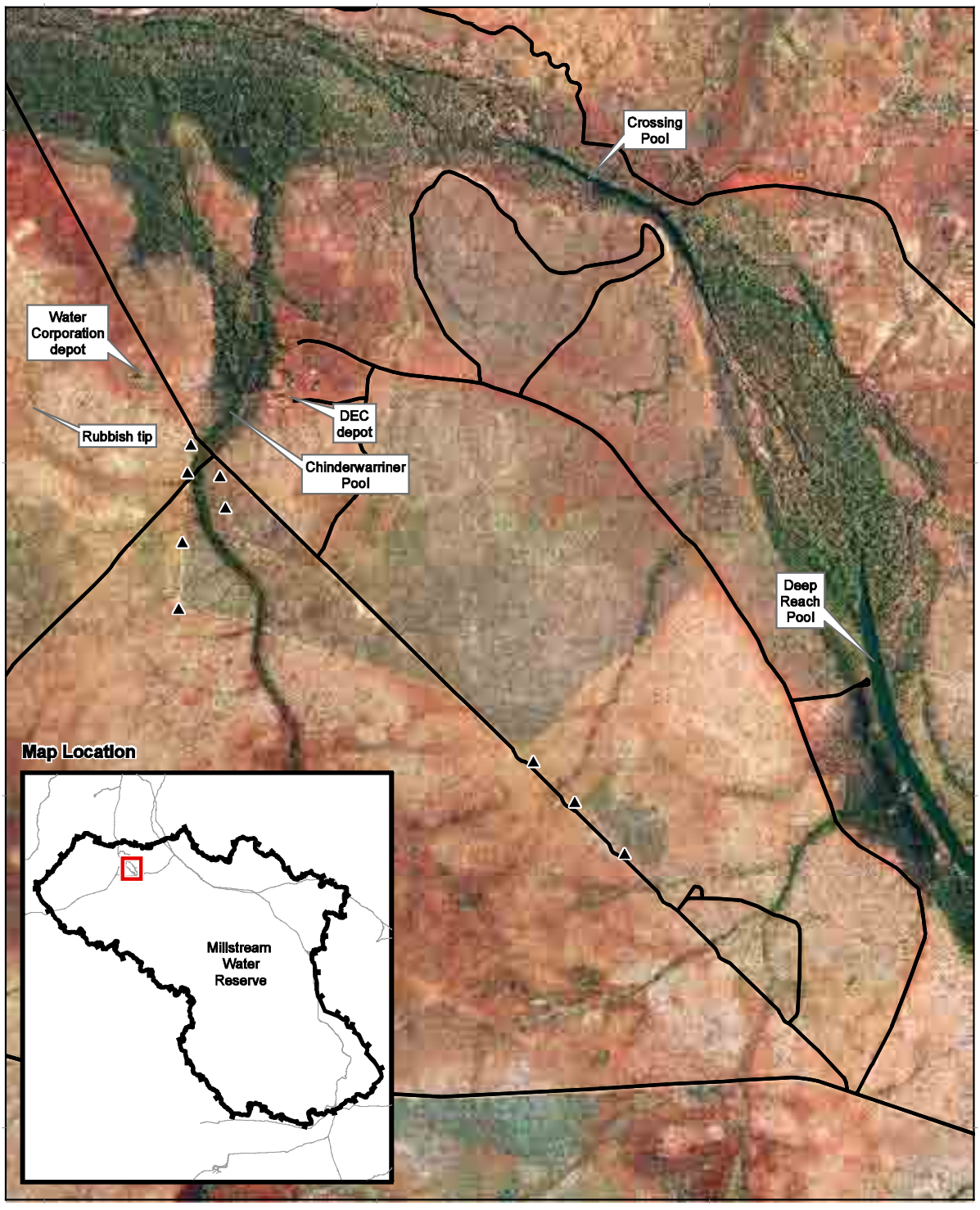


FIGURE 3 LAND USE, ACTIVITIES AND TENURE IN THE MILLSTREAM WATER RESERVE



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2006
Aerial Photography - Landgate - Millstream 2008
WIN Groundwater Sites - DoW - 2006

LEGEND

Production Bores
Proposed Millstream Water Reserve
Roads

N

500 250 0 500
Metres

LOCATION

TOM PRICE
WA
PERTH

Water Resource Management Division
Water Source Protection Branch

Project officer: C Stanley Drawn by: C Dyde
Date: 08/03/2010
File path: J:\gisprojects\Project\B_Series\B2010\0088_Millstream_WR\mxd
File name: Fig4_Aerial_MillstreamWR.mxd
Coordinate system: MGA94 Zone 50

Government of Western Australia
Department of Water

FIGURE 4 AERIAL PHOTOGRAPHY AND LAND USES IN THE MILLSTREAM WATER RESERVE

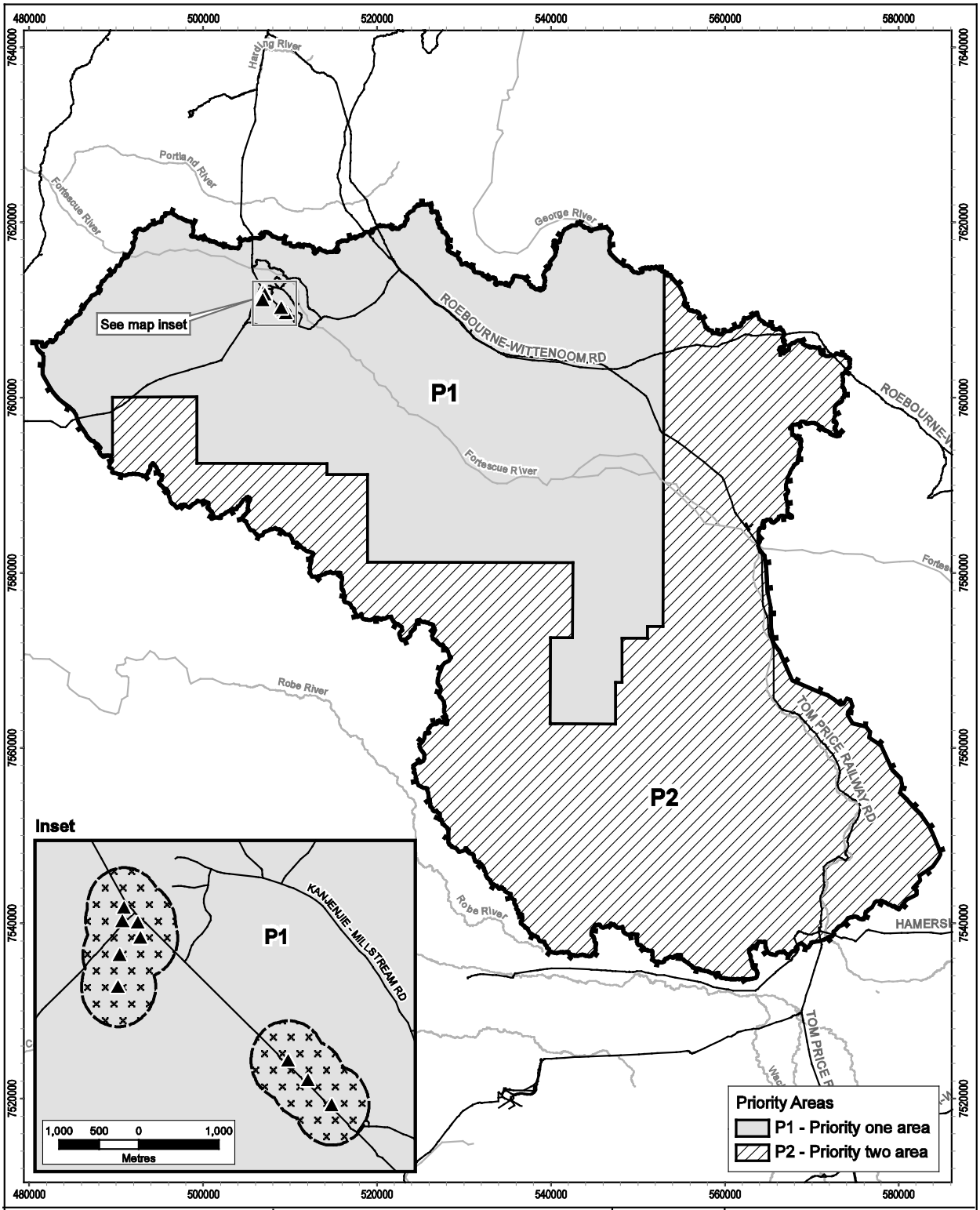
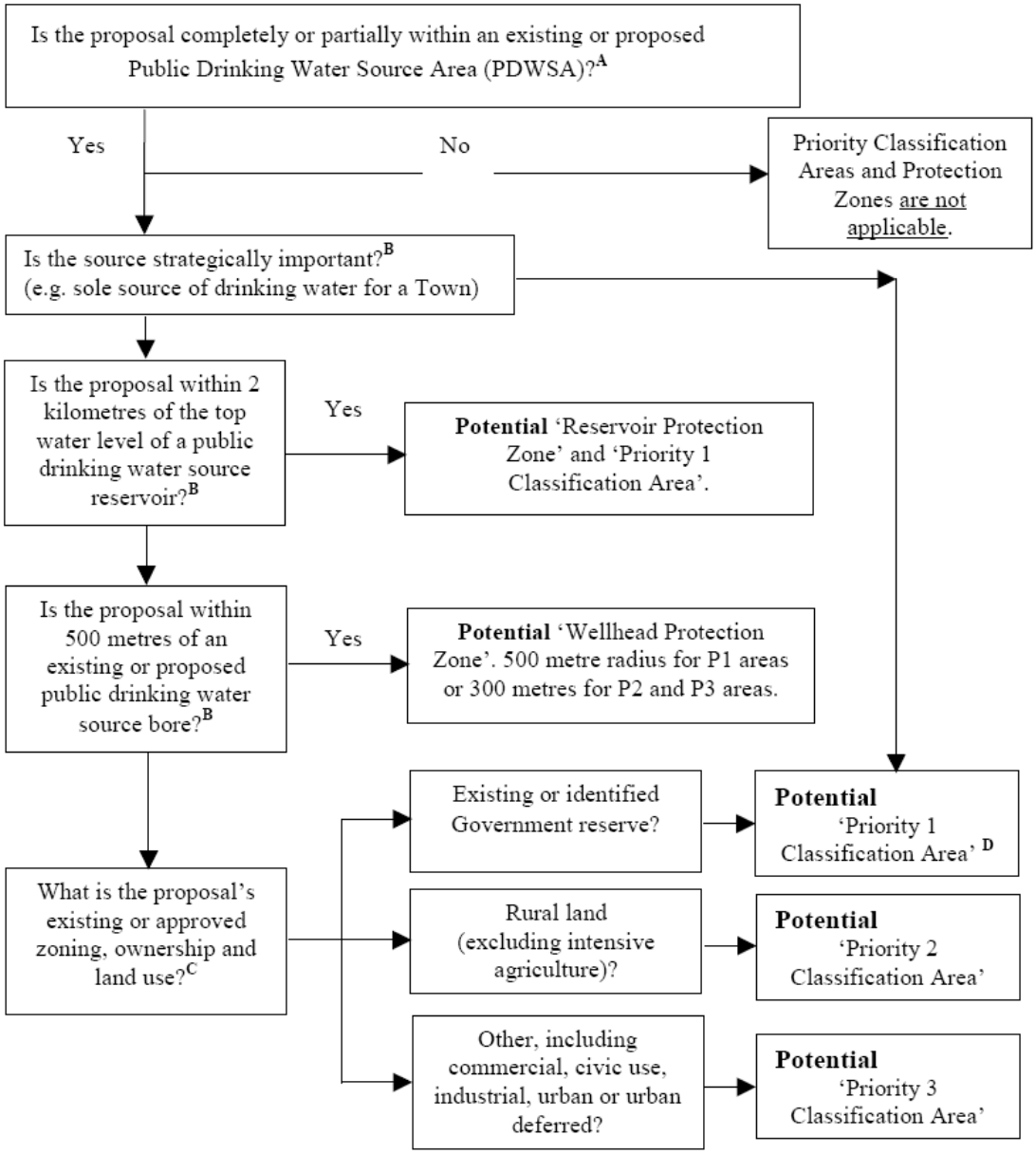


FIGURE 5 PROPOSED BOUNDARY, PRIORITY AREAS AND PROTECTION ZONES FOR MILLSTREAM WATER RESERVE



Legend

A. The location of PDWSAs can be found in DoE's Drinking Water Source Protection Assessments and Plans or through your regional DoE office, Local Government office, Water Corporation or from the Department for Planning and Infrastructure.

B. Strategically significant sources and potential contamination from land uses close to drinking water reservoirs or abstraction bores are considered first, due to these involving the highest risk of contamination reaching consumers.

C. Current zoning or land use information is available from your Local Government office.

D. Government land is protected to achieve the highest level of safety for drinking water in all parts of a catchment through a Priority 1 classification, wherever this is reasonable and practicable.

Figure A6 Flowchart that shows how priority areas and protection zones are determined

Appendix B Water quality data

The information provided in this appendix has been prepared by the Water Corporation.

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

a. **Aesthetic related characteristics**– (Non-Health Related)

b. **Health related characteristics**

- Health Related Chemicals
- Microbiological Contaminants

Following is data representative of the quality of raw water in Millstream borefield. In the absence of specific guidelines for raw water quality, the results have been compared with the ADWG values set for drinking water, which defines the quality requirements at the customers tap. Results that exceed the ADWG have been shaded to give an indication of potential raw water quality issues associated with this source.

It is important to appreciate that the raw water data presented does not represent the quality of drinking water distributed to the public. Barriers such as storage and water treatment, to name a few, exist downstream of the raw water to ensure it meets the requirements of the ADWG. For more information on the quality of drinking water supplied to the West Pilbara refer to the most recent Water Corporation Drinking Water Quality Annual Report at www.watercorporation.com.au/W/waterquality_annualreport.cfm

Aesthetic Related Characteristics

Aesthetic water quality analyses for raw water from Millstream borefield are summarised in Table 1.

The values are taken from ongoing monitoring for the period July 2004 to June 2009. All values are in milligrams per litre (mg/L) unless stated otherwise. Any water quality parameters that have been detected are reported, those that have on occasion exceeded the ADWG are shaded.

Data presented is a summary of all bores (Millstream Bores 1 to 12). Due to the preferred use of Harding Dam to supply the West Pilbara rather than the Millstream borefield, sampling is less frequent.

Table 2 Aesthetic related detections for Millstream Borefield

Parameter	Units	ADWG Aesthetic Guideline Value*	SP Millstream Borefield Raw	
			Range	Median
Chloride	mg/L	0 - 250	105 - 355	145
Colour - True	TCU	0 – 15	<1 - 11	<1
Hardness as $CaCO_3$	mg/L	0 – 200	322 - 593	403
Iron unfiltered	mg/L	0 - 0.3	0.004 - 0.65	0.035
Manganese unfiltered	mg/L	0 - 0.1	<0.002 - 0.01	<0.002
pH	N/A	6.5 - 8.5	6.89 - 8.09	7.23
Sodium	mg/L	0 – 180	63 - 200	83
Sulphate	mg/L	0 – 250	57 - 185	72
TFSS	mg/L	0 – 500	710 - 1400	867
Turbidity	NTU	0 - 5	<0.1 - 2.6	0.3

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

Health Related Characteristics

Health Parameters

Raw water from Millstream Borefield is analysed for health related chemicals including inorganics, heavy metals, industrial hydrocarbons and pesticides. Health related water quality parameters that have been measured at detectable levels in the source between July 2004 and June 2009 are summarised in Table 2. Any parameters that have on occasion exceeded the ADWG are shaded.

Table 3 Health related detections for Millstream Borefield

Parameter	Units	ADWG Health Guideline Value*	SP Millstream Borefield Raw	
			Range	Median
Fluoride†	mg/L	1.5	0.6 - 0.65	0.65
Manganese unfiltered	mg/L	0.5	<0.002 - 0.01	<0.002
Nitrite plus nitrate as N	mg/L	11.29	1.1 - 1.8	1.4
Sulphate	mg/L	500	57 - 185	72

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

† Denotes results based on 3 or less sampling events

Microbiological Contaminants

Microbiological testing of raw water samples from Millstream Borefield is currently conducted on a monthly basis. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw water.

A detection of *Escherichia coli* in raw water abstracted from any bore may indicate contamination of faecal material through ingress in the bore, or recharge through to the aquifer (depending on aquifer type).

During the reviewed period of July 2004 to June 2009, no positive *Escherichia coli* counts were recorded.

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**			
National park					
Swimming	Shedding of pathogens from body contact with water	Medium	Body contact with water allows the shedding of pathogens into the water. Ablutions managed by the Department of Environment and Conservation (DEC) at Deep Reach and Crossing pools provide a pathogen risk to the pools if wastewater leaches out of the system. Water that is used for recreation, such as the Millstream Pools, should meet the standards laid out in the *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC &	National park management plan Water quality monitoring Defined recreational areas	• Ensure compliance with the *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC & ARMCANZ 2000). • Ensure the *Millstream-Chichester National Park and Mungaroona Range Nature Reserve management plan* recognises water quality protection objectives. • Tourism activities should be managed in accordance with the Department of Water publications *Managing tourism: guidelines for managing tourism in the Fortescue River – Millstream Water Reserve*

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
			ARMCANZ 2000). Chapter 5 of the guidelines deals specifically with recreational water quality and aesthetics. Swimming is prohibited in Chinderwarriner Pool, which reduces the water quality risk as this is the closest pool to the production bores.		*catchment area* and *Camping and tourism: guidelines for visitors to the Fortescue River – Millstream Water Reserve catchment area*. • 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.
Camping and picnicking	Pathogens from ablutions servicing camping and picnic sites Nutrients from ablutions servicing camping and picnic sites	High Low	The *Millstream-Chichester National Park and Mungaroona Range Nature Reserve draft management plan* has identified the possibility of an expansion of camping and picnicking facilities in the water reserve. The establishment of commercially owned and operated 'built' accommodation was one option proposed. Any prospective commercial ventures will need to be made aware of the Millstream Water Reserve as well as the	National park management plan Water quality monitoring Defined recreational areas	• Development of new picnicking and camping sites should be downstream of production bores and outside the water reserve. • Ensure that the *Millstream-Chichester National Park and Mungaroona Range Nature Reserve management plan* recognises water quality protection objectives. • The Department of Water should consult with DEC on the development or expansion of camping and picnicking facilities.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			need to ensure their operations do not pose an unacceptable risk to water quality. DEC-managed ablutions are provided to service the campsites. Particle tracking shows that the travel times for particles originating at the ablutions are likely to be quicker than those from body contact with water in the Millstream Pools. This makes the ablution facilities a higher water quality risk than recreation in the pools.		• Tourism activities should be managed in accordance with the Department of Water publications *Managing tourism: guidelines for managing tourism in the Fortescue River – Millstream Water Reserve catchment area* and *Camping and tourism: guidelines for visitors to the Fortescue River – Millstream Water Reserve catchment area*. • 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.
Fishing	Pathogens from body contact with water	Medium	DEC-managed ablutions at Deep Reach and Crossing pools service people who wish to fish at the pools. The draft national park management plan proposes a	National park management plan Water quality monitoring	• Ensure that the *Millstream-Chichester National Park and Mungaroona Range Nature Reserve management plan* recognises water quality protection objectives. • Tourism activities should be

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			ban on fishing at parts of Deep Reach Pool, which will reduce the contamination risk from this activity. Only non-powered boats are currently allowed in the Millstream Pools. The draft national park management plan proposes the closure of Deep Reach Pool to all watercraft due to the cultural significance of the area.	Defined recreational areas	managed in accordance with the Department of Water publications *Managing tourism: guidelines for managing tourism in the Fortescue River – Millstream Water Reserve catchment area* and *Camping and tourism: guidelines for visitors to the Fortescue River – Millstream Water Reserve catchment area*. • 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.
Canoeing	Pathogens from body contact with water	Medium	DEC-managed ablutions at Deep Reach and Crossing pools service people who wish to canoe at the pools. Only non-powered boats are currently allowed in the Millstream Pools. The draft national park	National park management plan Water quality monitoring Defined	• Ensure that the *Millstream-Chichester National Park and Mungaroona Range Nature Reserve management plan* recognises water quality protection objectives. • Tourism activities should be managed in accordance with the

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
			management plan proposes the closure of Deep Reach Pool to all watercraft due to the cultural significance of the area.	recreational areas	Department of Water publications *Managing tourism: guidelines for managing tourism in the Fortescue River – Millstream Water Reserve catchment area* and *Camping and tourism: guidelines for visitors to the Fortescue River – Millstream Water Reserve catchment area*. • 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.
Department of Environment and Conservation depot	Pesticides from storage and use Hydrocarbons and other chemical spills from	Medium Medium	Bulk fuel storage at the depot is within a bunded compound. A small fuel pipe runs underground from the storage tank to the generator DEC uses as its power supply. As this pipe is underground, it is possible that leaks in it could go undetected.	Spill containment facilities Water quality monitoring	• Ensure that the *Millstream-Chichester National Park and Mungaroona Range Nature Reserve management plan* recognises water quality protection objectives. • Investigate alternatives to underground piping for

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
	storage and use		Pesticides and other small quantities of chemicals for use in managing the national park are stored within a bunded area at the depot.		generator fuel supply. • Ensure wastewater treatment systems are managed according to the WQPN no. 70: *Wastewater treatment – onsite domestic systems*. • Ensure adherence to WQPN no. 10: *Contaminant spills – emergency response* and WQPN no. 65: *Toxic and hazardous substances – storage and use*.
Department of Environment and Conservation staff quarters	Pathogens from wastewater treatment systems Nutrients from wastewater treatment systems	High Low	These are the living quarters for DEC staff based in the Millstream-Chichester National Park.	Water quality monitoring	• Ensure wastewater treatment systems are managed according to the WQPN no. 70: *Wastewater treatment – onsite domestic systems*. • Ensure that the *Millstream-Chichester National Park and Mungaroona Range Nature Reserve management plan* recognises water quality protection objectives.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Department of Corrective Services work camp	Pathogens from wastewater treatment systems Nutrients from wastewater treatment systems	High Low	The work camp is sponsored by DEC. Workers at the camp are involved in cultural, heritage, recreational and environmental projects within the national park. The main water quality risk is the leaking of wastewater containing pathogens into the groundwater as a result of a fault in the wastewater treatment system.	Water quality monitoring Wastewater treatment	• Ensure wastewater treatment systems are managed according to WQPN no. 70: *Wastewater treatment – onsite domestic systems*.
Park council accommodation	Pathogens from wastewater treatment systems Nutrients from wastewater treatment systems	High Low	Permanent eco-tents have been built next to the DEC depot to provide accommodation for park council members when council meetings are held. Council meetings are a forum to discuss management issues regarding the national park and associated water resources. The accommodation is only used intermittently (i.e. when park council meetings are held) which may affect how the wastewater	Water quality monitoring Wastewater treatment	• Ensure that the *Millstream-Chichester National Park and Mungaroona Range Nature Reserve management plan* recognises water quality protection objectives. • Ensure the maintenance program and type of wastewater treatment facilities are appropriate for their usage pattern.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
			treatment systems operate, as some systems work more efficiently when in constant use.		
Reserve 38991 (water supply)					
Water Corporation depot	Pathogens from wastewater treatment systems Nutrients from wastewater treatment systems Hydrocarbons and chemical spills from storage and use	High Low High	The Water Corporation is planning to relocate the permanent staff currently sited at Millstream to Karratha. The Water Corporation depot will remain in place but will only be used when staff are onsite to carry out work. This will reduce the load on the wastewater treatment system and the amount of waste disposed of at the rubbish tip. There is also an onsite generator used to power the depot and this is a potential source of hydrocarbon spills and leaks. Particle tracking has predicted that particle travel time from the Water Corporation depot to the production bores is the quickest	Water quality monitoring Spill containment measures	• Ensure adherence to the WQPN no. 10: *Contaminant spills – emergency response* and WQPN no. 65: *Toxic and hazardous substances – storage and use*. • Ensure wastewater treatment systems are managed according to the WQPN no. 70: *Wastewater treatment – onsite domestic systems*.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			compared with surrounding land uses. Therefore the depot is considered one of the highest contamination risks to the bores. This is expected given the proximity of the depot to the bores.		
Fuel storage at production bores	Hydrocarbons from spills and leaks	High	Each production bore has a day tank to store fuel for the generators at the production bore. Since the 1999 DWSPP was prepared, all bunding around the day tanks has been upgraded, including the installation of above-ground piping, reducing the water quality contamination risk from the fuel storage. There is also a bulk fuel storage tank between PB8 and PB9, which is within a spill containment bund.		• Investigate alternative power sources for the production bores that pose a lower risk to water quality. • Maintenance of spill containment measures should be carried out so that they operate according to their design. • Ensure adherence to WQPN no. 10: *Contaminant spills – emergency response* and WQPN no. 65: *Toxic and hazardous substances – storage and use*.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Existing Millstream rubbish tip	Leaching of pathogens from domestic waste Leaching of nutrients from domestic waste	Medium Low	The tip is used to dispose of the domestic waste from the Water Corporation and DEC staff quarters. To better use its resources, DEC has removed bins from the campsites throughout the national park. This has reduced the amount of waste being disposed of at the rubbish tip. The rubbish tip is not lined but situated within clay soils. Particle tracking shows that particle travel time between the tip area and the production bores to be relatively short.	Water quality monitoring	• Any new cells of the tip should have a synthetic or engineered soil liner to prevent contaminants leaching into the groundwater. • Rubbish tip should only be used for the disposal of domestic waste. • Manage the rubbish tip according to the recommendations in WQPN no. 111: *Landfills for disposal of putrescible material*.
Old Millstream rubbish tip	Leaching of chemicals into groundwater	Low	This is the old rubbish tip that was used when the homestead was still operating as part of the Millstream pastoral station. Use of this site continued when DEC took control of the homestead up	Water quality monitoring	• Install monitoring bores around the old tip and initiate a water quality sampling program. If the monitoring indicates that contaminants of concern are present, then management

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
			until the current rubbish tip was built. Monitoring bores should be installed between the old tip and the production bores and a water quality monitoring program initiated to determine if any hazardous substances are leaching out of the old tip site towards the bores. WQPN no. 30: *Groundwater monitoring bores* provides best practice guidance on establishing monitoring bores. The old tip was not included in the particle tracking modelling but sits relatively close to the DEC depot, which would provide an approximation of the time taken for water particles to move from the tip to the production bores.		measures should be undertaken that mitigate the risk. The appropriate management measures will depend on the type of contaminants of concern, if any are detected.
Millstream	Hydrocarbons	Low	Airstrip is rarely used, but		• Ensure fuel storage is in

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
airstrip	and chemical spills from storage and use		maintained for access by the Royal Flying Doctor Service as well as for occasional use during stock musters and for 'stop and go' training by pilots. The Department of Defence uses the Water Corporation's bunded compound to store fuel when necessary. Anyone who uses the airstrip should ensure they have plans in place to manage any fuel storage at Millstream. Storage in the Water Corporation or DEC bunding facilities is recommended.		accordance with the WQPN no. 65: *Toxic and hazardous substances – storage and use*. • A spill response plan should be developed in accordance with WQPN no. 10: *Contaminant spills – emergency response.* • Store fuel in the existing bunded compounds at either of the depots.
Roads	Hydrocarbons and other chemicals from accidents and spills	Low	The Millstream Link Stage 2 project has recently been completed, providing a sealed road from Karratha to the Millstream National Park. This is expected to lead to increased visitor numbers to the national		• Ensure adherence to WQPN no. 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

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
			park as a result of the easier access. Stages 3 and 4 of the road will cut through the water reserve and provide a sealed road from Karratha to Tom Price. The remainder of the public roads in the water reserve are unsealed.		quality. Signage should include an emergency contact number. • Road drainage should be designed to prevent the spread of contaminants from spills of chemicals. The use of sumps and drains is recommended.
Crown leases					
Mineral exploration	Hydrocarbon and other chemical spills or discharges from storage and use.	Low	There are a number of active exploration programs within the water reserve. These are generally confined to the outer catchment near the base of the Hamersley Range.	Water quality monitoring Department of Mines and Petroleum (DMP) tenement conditions	• Ensure adherence to the water quality protection guidelines: *Mining and mineral processing*. • Ensure compliance with mineral tenement licence conditions and endorsements.
Mining	Hydrocarbon and other chemical spills or	Low	There are currently no active mines within the water reserve, although a number of companies are looking to develop projects in	Water quality monitoring DMP	• Ensure adherence to the water quality protection guidelines: *Mining and mineral processing*. • Ensure compliance with DMP

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
	discharges from storage and use.		the water reserve, mostly in the P2 area. The Department of Water and DMP have a memorandum of understanding in place to facilitate the management of mining activities that may affect the state's water resources.	tenement conditions	mining tenement conditions and endorsements. • New mining projects should be sited away from the Millstream Dolomite.
Mining camps	Pathogens from wastewater treatment systems Hydrocarbon and other chemical spills or discharges from storage and use	Low Low	Particle tracking shows that the existing camps servicing the mining industry are a low water quality risk due to their distance to the bores. The existing mining camp wastewater treatment systems meet the state's licensing requirements for such systems.	Water quality monitoring DMP tenement conditions Regulatory approvals and licences	• Ensure adherence to the water quality protection guidelines: *Mining and mineral processing*. • Ensure compliance with DMP mining tenement conditions and endorsements. • New camps should be located away from areas overlying the Millstream Dolomite.
Railways	Hydrocarbon spills from	Low	The predominant use of the Dampier-Paraburdoo Railway is	Emergency response	• Ensure that the *Millstream-Chichester National Park and*

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
	accidents Use and spills of pesticides during weed control programs	Low	the transport of ore, however bulk quantities of fuel are transported regularly for use at mine sites south of the water reserve. Computer modelling predicts the existing railway poses a minimal risk to water quality because it is situated over the lower-permeability section of the aquifer. New mining projects may look to use existing rail infrastructure. Any increase in rail traffic, including the quantity of fuel transported, will increase the water quality risk. Herbicides are occasionally used to control weeds along the railway.	procedures Water quality monitoring	*Mungaroona Range Nature Reserve management plan* recognises water quality protection objectives. • Emergency response procedures should be reviewed to ensure they adequately address water quality protection issues. • Any new rail infrastructure should be within the P2 area of the water reserve. • Ensure adherence to the Department of Water's Statewide policy no. 2: *Pesticide use in public drinking water source areas* and WQPN no. 10: *Contaminant spills – emergency response*.
Roads	Hydrocarbons and other chemicals	Low	There are a number of access roads throughout the water reserve associated with mining		• Ensure adherence to WQPN no. 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**			
	from accidents and spills		operations		• Roads no longer required should be closed and rehabilitated
Pastoral leases	Pathogens from faecal matter from stock Nutrients from faecal matter from stock	Low	There are currently two active pastoral stations within the water reserve. Both stations are a considerable distance from the production bores, which reduces the water quality risk. Feral cattle can be found throughout the Pilbara region, including the Millstream Water Reserve.	Water quality monitoring Feral animal control	• Ensure adherence to WQPN no. 35: *Pastoral activities within rangelands*. • Feral animal control should be carried out in accordance with WQPN no. 96: *Pest animal management in public drinking water source areas*. • Where practical locate stock watering points outside the water reserve. • Follow best management practices as outlined in the Department of Water publication, *Guidelines for pastoral properties and leases adjoining a water reserve,* and the Department of Agriculture and Food's Farmnote series of publications.

Appendix D Photographs

Figure D1 Chinderwarriner Pool

Figure D2 Deep Reach Pool

Figure D3 Crossing Pool

Figure D4 Picnic facilities on the edge of Crossing Pool

Figure D5 Typical toilet provided at a national park campsite

Figure D6 Old Millstream homestead kitchen

Figure D7 One of the walk trails through the national park

Figure D8 Recreation at one of the Millstream pools

Figure D9 Water Corporation sign at the national park's main entry

Figure D10 Park council accommodation

Figure D11 Wastewater treatment system for park council accommodation. The DEC depot is in the background

Figure D12 Bulk fuel storage for the DEC depot

Figure D13 Storage facility for chemicals at the DEC depot

Figure D14 Water Corporation depot bulk fuel storage facility

Figure D15 Water Corporation staff quarters and depot

Figure D16 Millstream rubbish tip

Figure D17 Site of the old Millstream rubbish tip

Appendix E Extract on particle tracking from Millstream Model Recalibration report (prepared by Sinclair Knight Mertz).

Particle Tracking

A series of particle tracking scenarios were run using the MODPATH code. MODPATH uses a semi-analytical particle-tracking scheme. The method is based on the assumption that each directional velocity component varies linearly within a grid cell in its own co-ordinate direction. This assumption allows an analytical expression to be obtained describing the flow path within a grid cell. Given the initial position of a particle anywhere in a cell, the co-ordinates of any other point along its path line within the cell, and the time of travel between them, can be computed.

A series of forward and reverse tracking models were run using the outputs from the Scenario 2 and Scenario 4 models (i.e. extraction at 7 and 15 GL/year). Because of model file sizes it was only possible to run the models for a maximum of twelve years. Longer model runs produce particle trace files too large to open and results cannot be viewed and exported.

Forward Tracking

The forward tracking option allows an assessment of the particle flow paths assuming that they are released from the source location at the start of a model run. Particles are traced through the model domain as they flow through the aquifer during the course of the model run. This type of model is of interest in the case where there are specified potential sources of interest. In this case SKM was provided with a number of potential sources, some of which were inside the model domain and others just outside the model domain. For those potential sources located outside the model domain alternative sources were defined as points within the model domain nearest to the specified source location. All such sources are shown in Figure 75 to Figure 77.

The results are shown in the Figure 78 to Figure 82.

Figure 75 Particle Tracking Sources

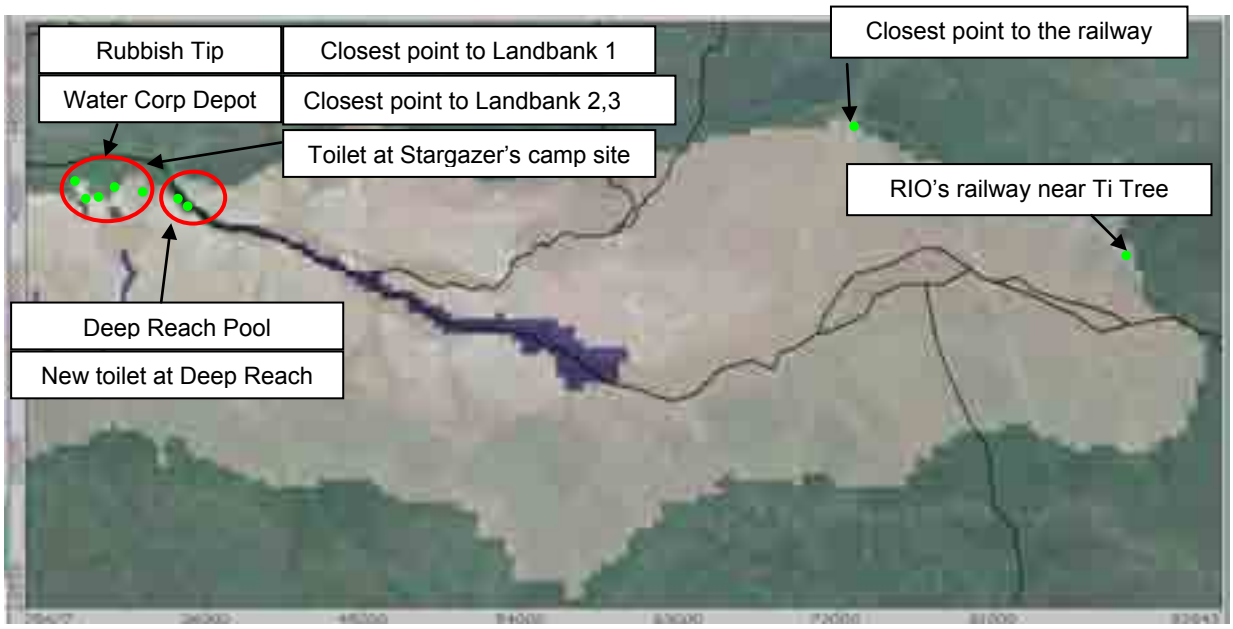


Figure 76 Locations of Particle Tracking Sources near Chinderwarriner

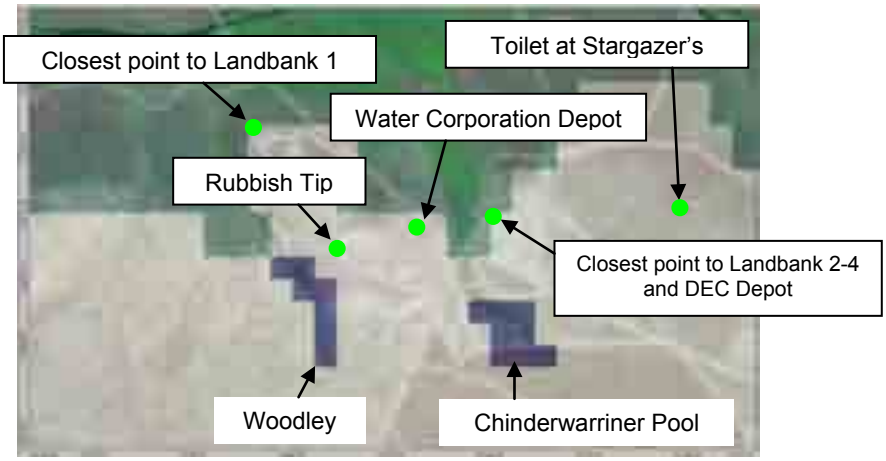


Figure 77 Locations of Particle Tracking Sources near Deep Reach Pool

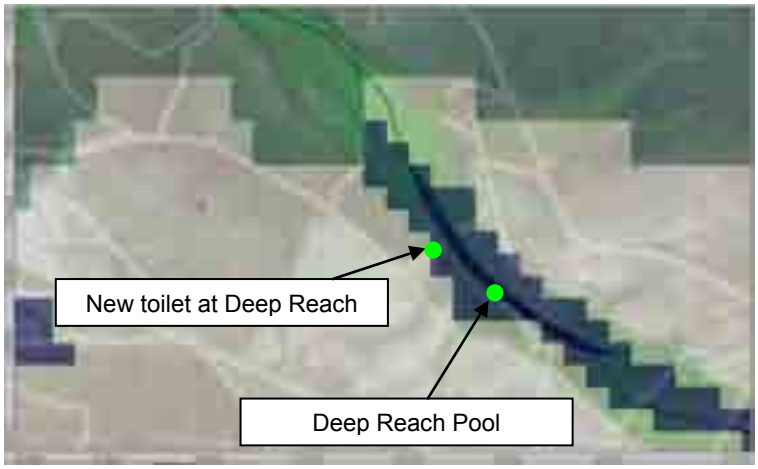
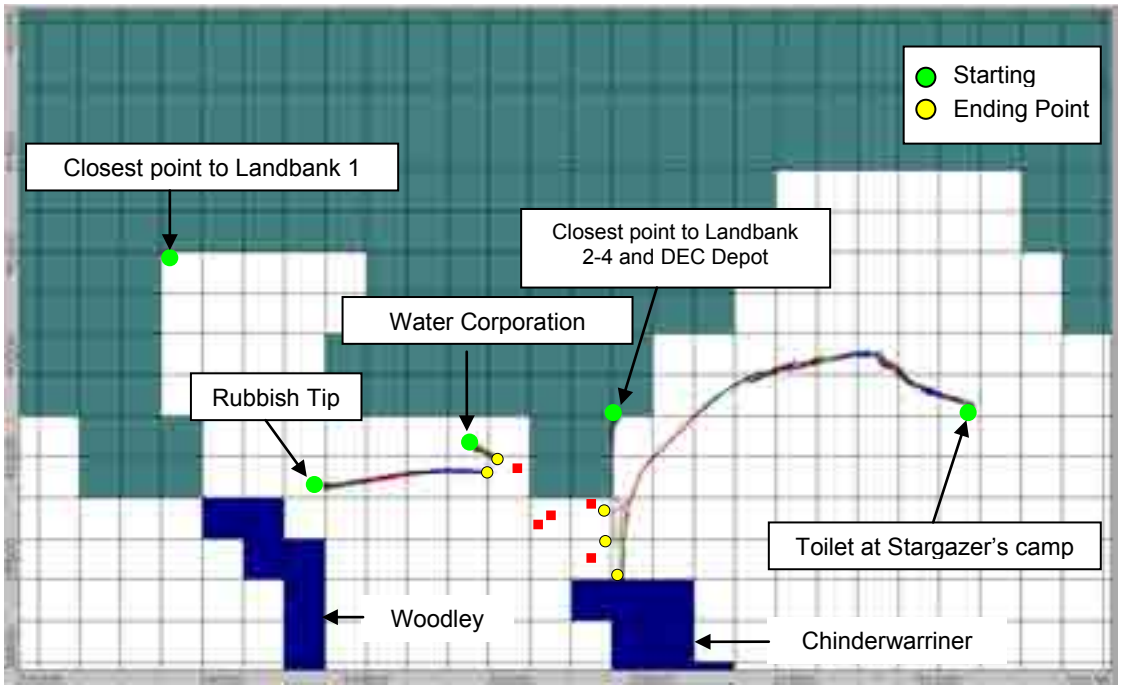


Figure 78 Results for Sources Near Chinderwarriner



Results for the Rubbish Tip and the Water Corporation Depot sites are shown in Figure 79. The result shows that particles originating from the Water Corporation Depot site are expected to reach the nearest production well after about 120 days. Note that the particles terminate once they enter a cell containing a pumping well. Particles originating from the Rubbish Tip take about 220 days before they reach a production well.

Results for the Stargazer toilet and the Landbank 2-4 and DEC Depot (closest point) are presented in Figure 80. Particles from the Stargazer site take between 1800 and 1900 days before they terminate at a production well and at Chinderwarriner. Similarly particles originating from the Landbank 2-4 and DEC Depot terminate in the production well and in Chinderwarriner after about 540 days of travel.

Particles released from Deep Reach Pool and the new toilet near the pool terminate immediately as they are either located in a river boundary cell (Deep Reach) or are immediately adjacent to a boundary cell where groundwater is discharging. The model grid cells are too coarse to be able to adequately model particle tracks originating from these sites. However it can be assumed that the flow from these sites to the pool is almost immediate.

Finally the particle traces for sources on the eastern margins of the model (i.e. sites near the railway and Rio Tinto's railway near Ti Tree Camp do not appear to travel at all during the course of the model run. This is because they are located in poorly permeable areas outside the main calcrete aquifer. The locations are sufficiently remote from any groundwater discharge sites and the permeability so low that there is effectively no movement of water from these sources during the twelve years of model run time.

Figure 79 Results for Rubbish Tip and Water Corporation Depot

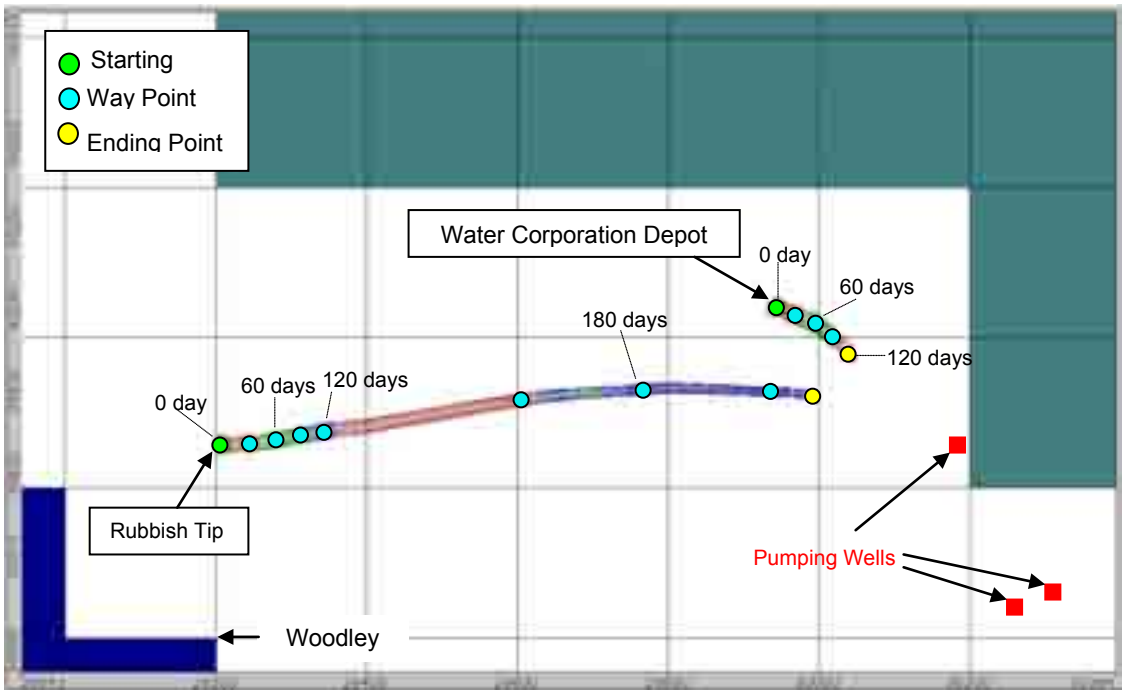


Figure 80 Results for DEC Depot and Stargazer's Camp

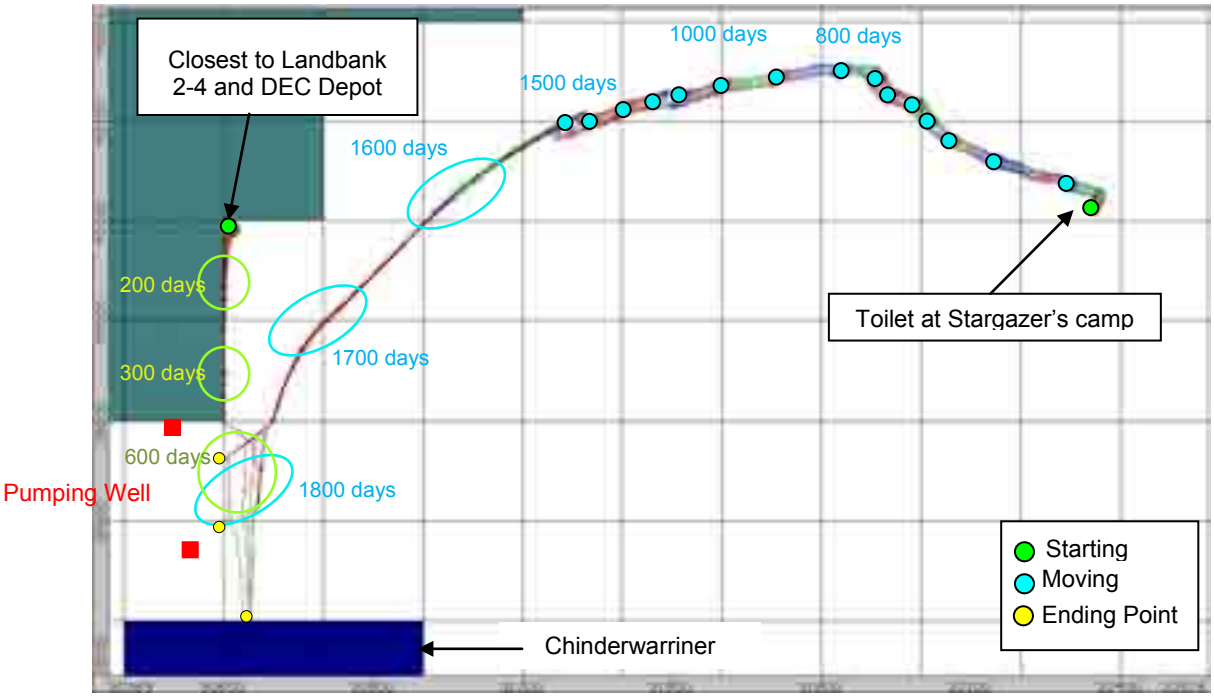


Figure 81 Results for Sources Near Deep Reach Pool

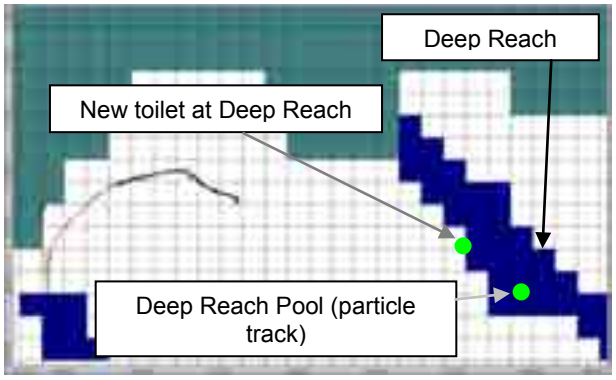
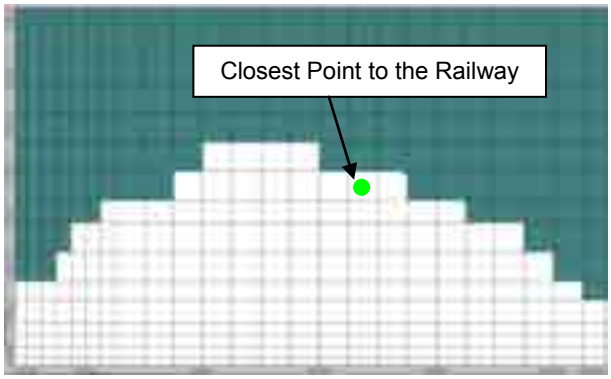


Figure 82 Results for Eastern Sources



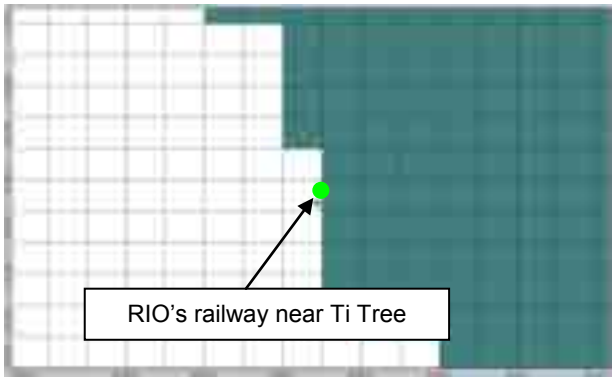


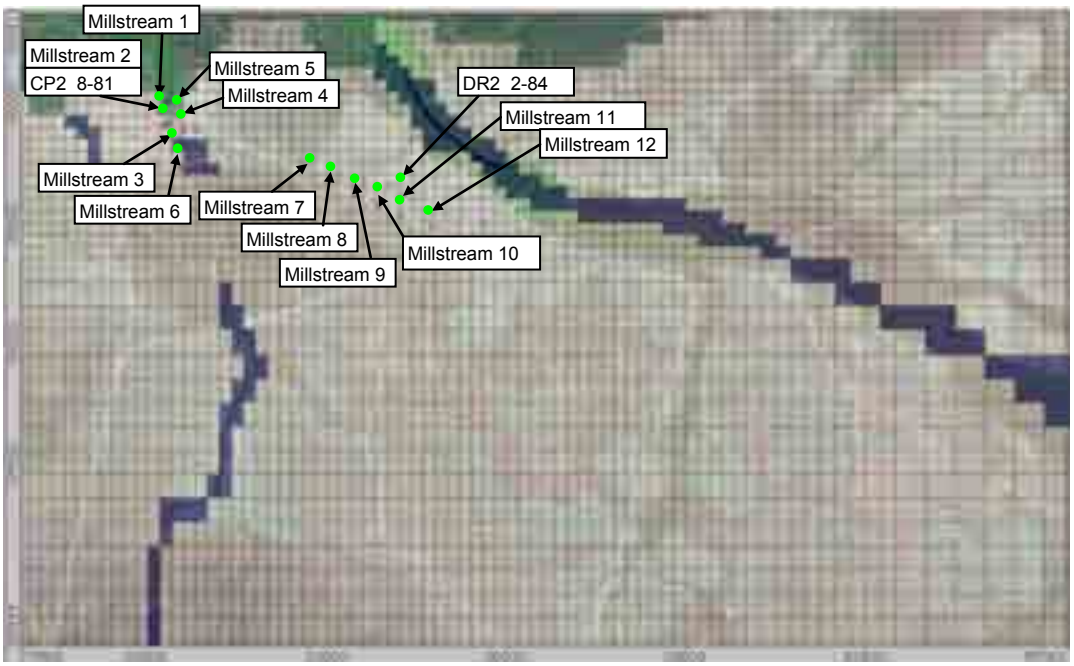
Table 9 Travel Times and Destinations for Forward Tracking from Potential Point Sources

Particle Track Starting Point			Travel Time	Destination
Name	X	Y	days	
Closest to Landbank 1	505607	7613761	-	-
Current rubbish tip	507381	7612264	230	Pumping well (Millstream 1)
RIO's railway near Ti Tree Camp	560999	7587381	-	-
Closest between the railway and the bores	524536	7612947	-	-
New toilet at Deep Reach	510829	7610615	-	-
Toilet at Stargazer's Camp	509030	7611717	1850	Pumping Well(Millstream 4 and 5) and Spring
Closest to Landbank 2-4 and DEC depot	506709	7612352	540	Pumping Well(Millstream 4 and 5) and Spring
Water Corporation depot	505953	7612429	120	Pumping well (Millstream 1)
Deep Reach Pool	511193	7610011	-	-

Reverse Particle Tracking

Reverse particle tracking is used to assess the locations of particles in the model, the location of which are defined at the completion of the model run. In other words the particle traces track the movement of particles towards their final location. This type of model is useful to determine the travel distances to sensitive receptors such as extraction wells. For the Millstream Aquifer Model reverse tracking was used to assess the distance that particles might travel to individual extraction wells in the Water Corporation borefield. The locations of the particle destinations (production wells) specified for reverse tracking are shown in Figure 82.

Figure 83 Locations of Particle Destinations



Results are presented in Figure 84 and Figure 85. Figure 84 shows all particle traces. In this figure the traces are marked every year so that back dating is possible. For the southern borefield it appears that most particles originated approximately ten kilometres south east of the borefield and travelled in a north westerly direction (parallel to the river) to terminate at the production wells.

Figure 85 is a close up view of the particle tracks predicted in the northern part of the model. Here we can see water moving to the south and east towards the bores in an upstream direction with reference to the natural state potentiometric surface. Particles cannot cross cells that contain wells or other boundary conditions where water is extracted from the model. This condition results in some of the particles being terminated prematurely at Woodley Spring and in nearby production wells.

Figure 84 Reverse Tracking Results

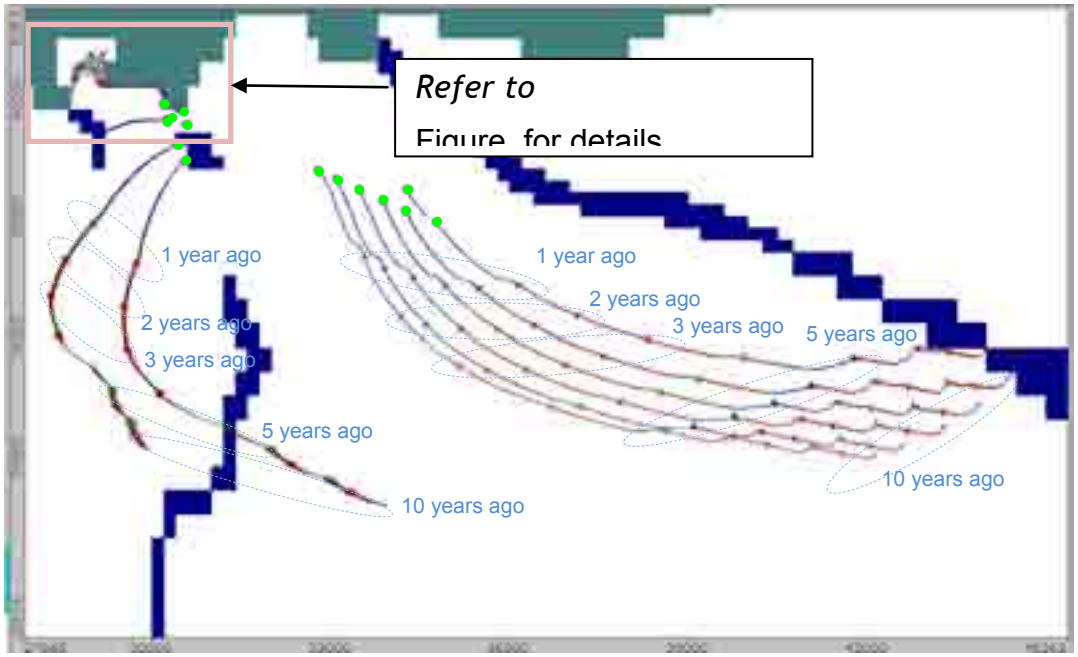
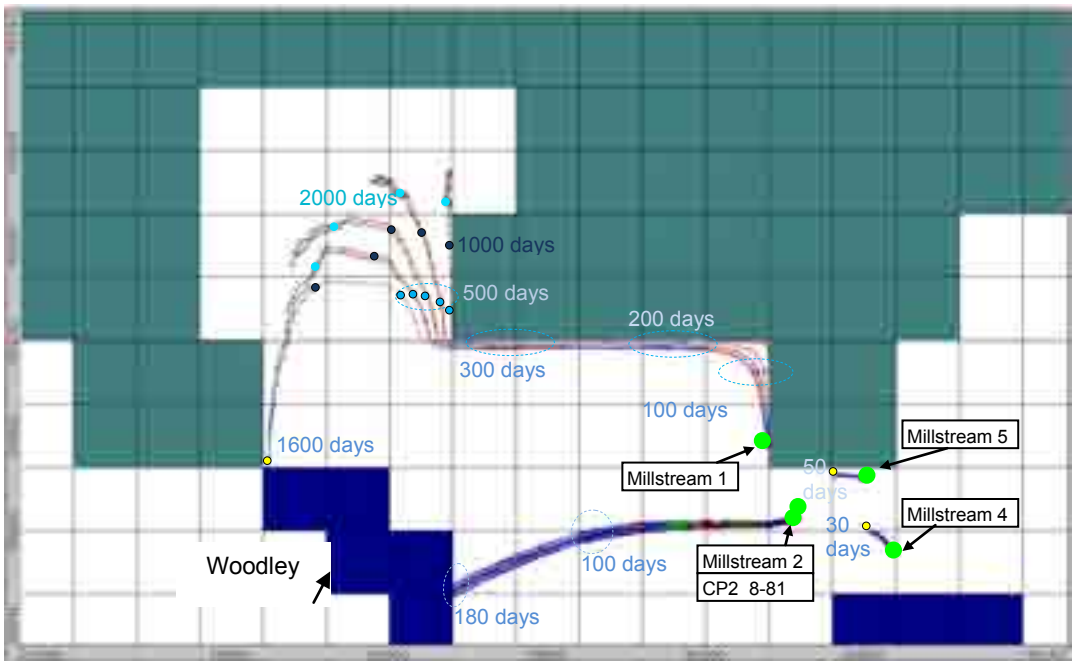


Figure 85 Results for northern bores



List of shortened forms

ADWG	*Australian drinking water guidelines*
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
DEC	Department of Environment and Conservation
GL	gigalitre
ha	hectare
HAZMAT	hazardous materials
kL	kilolitre
km	kilometre
km^2	square kilometre
LEMC	local emergency management committee
m	metres
mg/L	milligram per litre
ML	megalitre
mm	millimetre
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
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.

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).

Allocation The quantity of water that a licensee is permitted to abstract 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.

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 plan's Bibliography).

Bore A bore is a narrow, lined hole drilled into the ground to monitor or draw groundwater (also called a well).

Bore field A group of bores to monitor or withdraw groundwater is referred to as a bore field (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.

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.

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.

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).
Hectare	A measurement of area, equivalent to 10 000 square metres.
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.
Nephelometric turbidity units	Nephelometric turbidity units are a measure of turbidity in water.
Nutrients	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.
Nutrient load	The amount of nutrient reaching the waterway over a given timeframe (usually per year) from its catchment area.
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.

Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.
pH	A logarithmic scale for expressing the acidity or alkalinity of a solution. A pH below seven indicates an acidic solution and above seven indicates an alkaline solution.
Pollution	Water pollution occurs when waste products or other substances (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.
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).
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.
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.
Runoff	Water that flows over the surface from a catchment area, including streams.
Scheme supply	Water diverted from a source or sources by a water authority or private company and supplied via a distribution network to customers for urban 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.
Stormwater	Rainwater that has run off the ground surface, roads, paved areas etc., and is usually carried away by drains.

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.
True colour units	True colour units are a measure of degree of colour in water.
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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