



Government of Western Australia
Department of Water

Southern Fortescue and Marandoo Water Reserves

Drinking water source protection plan

Tom Price town water supply



Looking after all our water needs

Water resource protection series
Report WRP 125
June 2011

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Cover photograph: Mining within the water reserve (photo by Chris Stanley).

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Preface

How do we protect public drinking water source areas?

The *Australian drinking water guidelines* (ADWG) (NHMRC & NRMCC 2004a) outline how we should protect drinking water in Australia. The ADWG recommends a 'catchment to consumer' framework that uses a preventive risk-based and multiple-barrier approach. A similar approach is recommended by the World Health Organization.

The 'catchment to consumer' framework applies across the entire drinking water supply system – from the water source to your tap. It ensures a holistic assessment of water quality risks and solutions to ensure the delivery of a reliable and safe drinking water to your home.

A preventive risk-based approach means that we look at all the different risks to water quality, in order to determine what risks can reasonably be avoided and what risks need to be minimised or managed. This approach means that the inherent risks to water quality are as low as possible. A multiple-barrier approach means that we use different barriers against contamination at different stages of a drinking water supply system.

The first and most important barrier is protecting the catchment. If we get this barrier right, it has a flow-on effect that can result in a lower cost, safer drinking water supply. Other barriers against contamination include storage of water to help reduce contaminant levels, treating the water (e.g. chlorination to remove pathogens), maintenance of pipes and testing of water quality. It is also recognised that catchment protection supports environment conservation initiatives.

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 is important. We should not forget that ultimately it's about protecting your health, and about protecting the catchment's water quality now and for the future.

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

The *Metropolitan Water Supply, Sewerage and Drainage Act 1909* (WA) and the *Country Areas Water Supply Act 1947* (WA) provide us with important tools to protect water quality in proclaimed PDWSAs. These Acts allow us to assess and manage the water quality contamination risks from different land uses and activities. We work cooperatively with other agencies in the implementation of this legislation.

This drinking water protection plan has been developed to achieve elements two and three of the 12 elements recommended for the protection of drinking water in the ADWG. It shows where the PDWSA is located, its characteristics, existing and potential water quality contamination risks, and includes recommendations to deal with these contamination risks. Our regional offices then work with the community,

other government agencies and landowners to put these recommendations into practice.

An important step in maximising the protection of water quality in PDWSAs is to define priority areas and protection zones to guide land use planning and to identify where legislation applies. There are three different priority areas. Priority 1 (P1) areas are defined and managed to ensure there is no degradation of the quality of the drinking water source using the principle of risk avoidance. Priority 2 (P2) areas are defined and managed to maintain or improve the quality of the drinking water source using the principle of risk minimisation. Priority 3 (P3) areas are defined and managed to maintain the quality of the drinking water source for as long as possible using the principle of risk management. 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 the ADWG and 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	Background investigations. (July 2010 – Sept 2010)	Prepared after initial catchment survey and preliminary information gathering. Based on alternative documents to provide suitable information.
2	Conduct stakeholder consultation. (Sept 2010 – Feb 2011)	Advice sought from key stakeholders using the assessment document as a tool for information and discussion. Draft protection plan is prepared.
3	Consult draft drinking water source protection plan. (May 2011)	Draft protection plan released for a public consultation period.
4	Publish approved drinking water source protection plan. (June 2011)	Final protection plan published after considering submissions. Includes recommendations on how to protect water quality. Proclamation of this public drinking water source area can now be progressed.

Summary

Tom Price is situated in the Pilbara region of WA approximately 1470 km north of Perth and 570 km south-east of Karratha. The town was established to service the mining industry, with a number of iron ore mines close by. Rio Tinto iron ore operates the mines closest to the town and most of the population of Tom Price are employees of the company. Rio Tinto iron ore (through its subsidiary Hamersley Iron) is the licensed water service provider for the town. The town lies within the Shire of Ashburton and is the administrative base for the shire.

The water supply for Tom Price is currently sourced from the proposed Southern Fortescue borefield, 30 km north-east of town. As Rio Tinto iron ore commences below water table mining operations at its Marandoo mine, 37 km east of Tom Price, mine dewatering will become the primary source of supply for the town. When this happens, Southern Fortescue will become a back-up source for Tom Price.

Dewatering from Marandoo will also be reinjected into the Southern Fortescue aquifer to replenish the aquifer, as part of the water management plan for Marandoo.

Water from Marandoo will be drawn from an aquifer that is regionally confined, but is locally unconfined where the production bores will be located due to mining activity breaking the confining layer. The Southern Fortescue borefield draws water from a semi-confined aquifer, which is overlain by a layer of clay that is variable in its occurrence.

This plan proposes the establishment of water reserves to protect the Marandoo and Southern Fortescue borefields. The Marandoo Water Reserve is proposed to cover the footprint of the mine which reflects the unconfined part of the aquifer. The proposed Southern Fortescue Water Reserve is proposed to consist of a 500 m radius area surrounding the production bores to reflect the semi-confined nature of the source. The water reserves should be managed for Priority 1 source protection, with 500 m wellhead protection zones established around all production bores, to help protect the sources from contamination.

The major water quality risks to these water reserves are in-pit mining activities and pastoral activities close to the bores. This plan recommends careful management of mining operations and relocation of stock watering points to reduce the water quality contamination risk these activities pose to the Tom Price water supply.

This plan is consistent with the Australian drinking water guidelines (ADWG) (NHMRC & NRMCC 2004a) and State planning policy no. 2.7: *Public drinking water source policy* and was prepared in consultation with key stakeholders, including Rio Tinto iron ore.

The following table shows statistical and important information about the proposed Marandoo and Southern Fortescue Water Reserves.

Table 1 Key information

Local government authority	Shire of Ashburton
Locations supplied	Tom Price
Aquifer type	Semi confined (Southern Fortescue) and unconfined (Marandoo)
Volume of water abstracted	4.8 GL/year from Southern Fortescue and 36.6 GL/year from Marandoo ¹
Number of bores	10 (Southern Fortescue) To be confirmed (Marandoo)
Depth to bores	87 to 198 m below ground level (Southern Fortescue) 72 to 244 m below ground level (Marandoo) ²
Groundwater flow direction	North (Southern Fortescue) and west (Marandoo)
Proclamation status	Proclamation will need to be progressed under the <i>Country Areas Water Supply Act 1947</i> (WA) when this plan is finalised. These water sources are proposed to be called the Southern Fortescue Water Reserve and the Marandoo Water Reserve.

¹ Abstraction from Southern Fortescue will fall to zero whilst water is being abstracted from Marandoo.

² This is based on the current proposal for the Marandoo Phase II expansion. This data may change as development of the project takes place.

1 Overview of Tom Price's drinking water source

1.1 The drinking water supply system

Rio Tinto iron ore (through its subsidiary Hamersley Iron) is the licensed water service provider for Tom Price. Water for Tom Price is currently sourced from the Southern Fortescue borefield. However with Rio Tinto iron ore about to commence mining below the water table at Marandoo near Tom Price, the town water supply is going to be integrated with the overall water management strategy for dewatering at Marandoo. This means that dewatering bores at Marandoo will become the main supply of Tom Price's drinking water, with the Southern Fortescue borefield becoming a back-up supply. Excess water from Marandoo will also be reinjected into the Southern Fortescue borefield as part of the water management plan for the mine, and as a means of replenishing the aquifer that has been supplying Tom Price town and mine for more than 40 years.

The Southern Fortescue borefield is located approximately 30 km north-east of Tom Price, whilst the Marandoo mine is located approximately 37 km east of Tom Price as shown in Figures 1 and 2 in Appendix A.

Under the current system, raw water from Southern Fortescue is taken from the bores into the borefield collector tank where the water undergoes chlorination to disinfect the water before being transferred into the town. A backup chlorination unit is located at the Tom Price town storage tanks. The Marandoo mine has its own dedicated potable water supply source.

It should be recognised that although treatment and disinfection are essential barriers against contamination, catchment management is the first step in protecting water quality and ensuring a safe drinking water supply. This approach is endorsed by the *Australian drinking water guidelines, 2004 (ADWG)* (NHMRC & NRMCC 2004a) and reflects a preventive, risk-based, multiple-barrier approach for providing safe drinking water to consumers. The combination of catchment protection and water treatment will deliver a more reliable, safer and lower-cost drinking water to consumers than either approach could achieve individually.

For more information on why it is so important to protect our water reserves, please read the preface at the front of this plan.

1.2 Water management

1.2.1 Licence to take water

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 water is vested with the crown. This means that a licence is required for drilling bores and abstracting groundwater

(pumping water from a bore, spring or soak) within proclaimed groundwater areas throughout the state. An exception may apply such as abstracting water for domestic purposes only.

The proposed Southern Fortescue and Marandoo Water Reserves are located within the Pilbara Groundwater Area and the Ashburton subarea which are proclaimed under the *Rights in Water and Irrigation Act 1914* (WA).

Separate allocation licences under the act are held by Rio Tinto iron ore for the two water reserves. The Southern Fortescue borefield operates under a licence which covers a number of Rio Tinto iron ore's operations around Tom Price. This licence allows for Rio Tinto iron ore to abstract up to 11 GL per year for a variety of purposes including potable supply, mineral processing and dust suppression.

The existing Marandoo mine operates under groundwater licence GWL 107420(7), which has an annual allocation limit of 2 GL. Current abstraction under this licence is approximately 800 ML per year. Prior to the commencement of dewatering for the below water table project (Marandoo Phase 2), the groundwater licence will be amended to increase the allocation accordingly. The application for a licence for Phase 2 is in the process of being finalised for submission to the Department of Water.

1.2.2 Water planning

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 drinking water source protection plans (DWSPPs) are prepared for all sources across the Pilbara.

DWSPPs have been prepared 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 these sources begins.

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.

These guidelines are needed because the amount of mining below the watertable has significantly increased in the Pilbara, and are likely to continue to do so. 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.

1.2.3 Future water needs

Demand for water for Tom Price is predicted to rise associated with an increase in mining activity in the area. However the Southern Fortescue borefield and Marandoo mine dewatering are thought to be sufficient supplies to meet this increased demand.

1.3 Characteristics of the catchment

1.3.1 Physical environment

The Southern Fortescue borefield and Marandoo mine lie within the Hamersley Plateau. The northern edge of the Hamersley Plateau is bounded by a scarp and dissected by a series of northward flowing streams and gorges. The central portion of the plateau comprises elevated plains, valley floors and a series of hills, including Mount Bruce, which at 1 235 m above sea level is Western Australia's second largest mountain (Rio Tinto 2008).

The Mount Bruce Flats sub-catchment constitutes a major, flat-lying, internally draining basin and forms the upper reaches of the Turee Creek regional catchment. The western and northern boundaries of the Mount Bruce Flats sub-catchment form the drainage divide between the Turee Creek regional catchment and the Fortescue River regional catchment.

1.3.2 Climate

The area has an arid tropical climate, typical of the Pilbara region, with distinct wet and dry seasons. The Pilbara region is characterised by low rainfall, high temperatures and high evaporation.

The wet season occurs over the summer months with rainfall episodes due to tropical cyclones, or cyclone related systems.

Summer months extend from October to April, when maximum daily temperatures can exceed 47°C. The winter months extend from May to September, with temperatures ranging from approximately 12°C to 26°C.

Average annual rainfall near Marandoo is approximately 415 mm and is characterised by frequent, low-intensity events related to localised thunderstorms and tropical upper air disturbances, as well as annual high-intensity events associated with tropical cyclones. These high-intensity events can result in over 100 to 200 mm of rain falling within a 24 hour period, often leading to large-scale sheet flooding and considerable erosion (Rio Tinto 2008).

Average annual evaporation in the vicinity of Marandoo is approximately 1 840 mm, which greatly exceeds average annual rainfall and contributes to the arid environment in the area.

1.3.3 Hydrogeology

The Southern Fortescue aquifer system has developed in a broad drainage channel incised in the Proterozoic rocks of the Hamersley Group and subsequently in-filled by alluvial, colluvial and chemical sediments.

The Paraburdoo Member of the Wittenoom Formation or Wittenoom Dolomite underlying the detrital sequence forms the primary aquifer in the area, especially where it has been previously exposed and subject to weathering resulting in it being cavernous and unstable in places.

The primary aquifer is confined to semi-confined by clays of the valley fill sequence that are variable in their occurrence both vertically and horizontally.

Groundwater flow is generally towards the north following the slope of the surface topography with a component of the flow discharging to Hamersley gorge in addition to a component following the general direction of surface flow towards the north-west.

At Marandoo, groundwater occurs within a fractured basement and overlying Tertiary detritus sediments within the Mount Bruce area. The lower basement aquifer comprises the mineralised portion of the Marra Mamba Iron Formation, the Wittenoom Formation and lower Tertiary clastic and chemical sediments; comprising a predominantly clayey matrix, all in hydraulic connection. Across Mount Bruce, the lower basement aquifer is separated from the watertable by a thick sequence (30 – 40 m) of confining lacustrine, or 'lake' clay.

At the southern margin of the flats, adjacent to the Marandoo ridge the lake clay is discontinuous and so the aquifers become connected along the very margin of the ridge, and most likely around the edge of the entire Mount Bruce Flats.

Recharge to the deeper, confined aquifer is via direct infiltration and sheet flow infiltration over outcrop and sub-crop of basement rocks around the northern and eastern margins of the Mount Bruce Flats and at the base of Mount Bruce.

The upper watertable aquifer comprises Tertiary calcrete and clay above the lacustrine clays, alluvium, colluvium, canga and scree associated with the Marandoo ridge.

Monitoring indicates that groundwater flow direction is to the west and towards the Southern Fortescue borefield region.

1.4 How is the drinking water protected?

Water reserves for the Southern Fortescue and Marandoo borefields have not yet been proclaimed under the *Country Areas Water Supply Act 1947* (WA). We propose to proclaim these water reserves for the purpose of protecting the public drinking water sources from potential contamination, after this plan is published.

1.5 Other useful information

1.5.1 Other groundwater bores in the area

Rio Tinto iron ore operates production bores in the proposed Southern Fortescue and Marandoo Water Reserves. If bores for other purposes (e.g. irrigation, private household 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).

All exploration drilling holes should be rehabilitated in accordance with the Department of Mines and Petroleum's Mineral Exploration / Rehabilitation Activities Guidelines (2007).

1.5.2 Marandoo mine phase 2 public environmental review

Rio Tinto iron ore's proposed below water table expansion at Marandoo underwent a full public environmental review (PER) according to the requirements of the Environmental Protection Authority. The PER document that Rio Tinto iron ore produced as part of this process contains a significant amount of information about the Marandoo area, including about the existing environment and hydrogeology of the area. This document is available on the Rio Tinto iron ore website at www.riotintoironore.com.

2 Common contamination risks

Land uses and activities within a water reserve can directly affect the quality of the drinking water and its treatment. Contaminants can reach drinking-water sources through run-off over the ground and infiltration through soil. A wide range of microbiological, chemical and physical contamination risks can impact on water quality and therefore affect the provision of safe, good quality drinking water to consumers.

Some contaminants in drinking water can affect human health. Other impurities can affect the water's aesthetic qualities, including its appearance, taste, smell and 'feel' but are not necessarily hazardous to human health. For example, cloudy water with a distinctive odour or strong taste may not be harmful to health, but clear, pleasant-tasting water may contain harmful, undetectable microorganisms (NHMRC & NRMMC 2004b). Contaminants can also interfere with water treatment processes, and impact water supply infrastructure (such as pipes).

The ADWG outline criteria for acceptable levels of contamination in drinking water to protect human health, aesthetics and water supply infrastructure.

For more information about water quality in this drinking water source, see section 3.

Some commonly-seen contamination risks relevant to groundwater drinking water sources are described below.

2.1 Microbiological risks

Pathogens are types of microorganisms that are capable of causing disease. These include bacteria, protozoa and viruses. In drinking-water supplies, pathogens that can cause illness are commonly found in the faeces of humans and domestic animals (such as dogs and cattle).

Pathogens can enter drinking water supplies from faecal contamination in the water reserve. In groundwater sources, this occurs indirectly – faecal material can infiltrate through the soil and into the groundwater. For example, contamination can occur from septic tanks or grazing animals.

A number of pathogens are commonly known to contaminate water supplies worldwide. These include bacteria (e.g. salmonella, *Escherichia coli* (*E.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).

The survival and movement of pathogens in groundwater is influenced by the characteristics of the pathogen (such as its size and the length of time it normally takes to decay) and the groundwater properties (including flow rate, porosity, amount of carbon in the soil, temperature, pH). Inactivation rate (the time it normally takes a pathogen to decay) is one of the most important factors governing how far pathogens may migrate. Typical half-lives of pathogens range from a few hours to a few weeks. For example, maximum reported migration distances of bacteria in groundwater are:

- 600 m in a sandy aquifer
- 1000 – 1600 m in channelled limestone
- 250 – 408 m in glacial silt-sand aquifers (Robertson & Edbery 1997).

Therefore it is important to understand the groundwater system to be able to protect the drinking water source from pathogens.

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's water 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 Physical risks

Turbidity is the result of soil or organic particles becoming suspended in water (cloudiness). Increased turbidity can result in cloudy or muddy-looking water, which is not very appealing to consumers. Turbidity can also reduce the effectiveness of treatment processes (such as disinfection). This is because pathogens can adsorb onto soil particles and may be shielded from the effects of disinfection. Chemicals can also attach to suspended soil particles.

Some physical properties of water such as pH (a measure of acidity or alkalinity) can contribute to the corrosion and encrustation of pipes. Other properties such as iron and dissolved organic matter can affect the colour and smell of water. Although not necessarily harmful to human health, coloured or 'hard' water will not be as appealing to consumers. Salinity can affect the taste of drinking water.

2.3 Chemical risks

Chemicals can occur in drinking water 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 these cases, the relevant authorities should be notified promptly and the spill cleaned up to prevent contamination of the drinking water source.

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.

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

Other chemicals and heavy metals can be associated with land uses such as industry and landfill. These may enter drinking water sources and could potentially be harmful to human health.

3 Contamination risks in this drinking water source

3.1 Water quality

Rio Tinto iron ore regularly monitors the quality of raw water from the Southern Fortescue and Marandoo borefields for microbiological, health-related and aesthetic (non-health-related) characteristics. This data shows the quality of water in these water reserves. An assessment of the drinking water quality once treated is also made against the ADWG. This assessment is made by an intergovernmental committee called the Advisory Committee for the Purity of Water that is chaired by the Department of Health.

A water quality summary for the Southern Fortescue and Marandoo borefields from January 2004 to November 2010 is presented in Appendix B.

3.2 Land uses and activities

The proposed Southern Fortescue and Marandoo Water Reserves are located over a mixture of crown leases, being mining and pastoral leases as shown. The location of these land uses is shown in Figures 3 and 4. Current land uses and activities and their risks to the drinking water source are described below. Table 1, at the end of this section, summarises this information in an easy-to-read format. Appendix C displays the results of a more detailed risk assessment.

3.2.1 Mining tenements

Rio Tinto iron ore is the main tenement holder in the proposed Marandoo Water Reserve, with most of the mining activity being on State Agreement Lease AML 70/272, which is subject to the *Iron Ore (Hamersley Range) Agreement Act 1963* (WA).

Most of the infrastructure (and therefore water quality contamination risks) associated with the Marandoo mine is located outside and downstream of the proposed water reserve. The main water quality contamination risks from the Marandoo mine are in-pit use of hydrocarbons and other chemicals and the release of nutrients into the sub-surface during blasting operations (see appendix D, photo D1 to D3).

As the aquifer below the pit is being dewatered this creates a buffer between any hydrocarbon spills at the surface and the water source, which reduces the water quality contamination risk. However because the water supply and mining activities are intrinsically related there are still risks to water quality from the mining operations that will need to be managed.

Rio Tinto iron ore also hold crown leases over the proposed Southern Fortescue Water Reserve. These leases cover the area of infrastructure for the existing Tom Price water supply system.

Fortescue Metals Group holds two granted Exploration Licences and one Exploration Licence application. There are two granted Exploration Licences held by Iron Dwyfken Pty Ltd and Mulga Minerals Pty Ltd. Dynasty Metals Australia Ltd and AMCI (IO) Pty Ltd have Exploration Licence applications over the Southern Fortescue Water reserve. To date exploration activity in the proposed water reserve has been minimal.

3.2.2 Pastoral leases

In addition to mining tenements, the proposed Southern Fortescue Water Reserve also lies within the Hamersley Station pastoral lease. The lease is held by Rio Tinto iron ore and is operated as a fully functional pastoral property. There are stock watering points and a stockyard in close proximity to the Southern Fortescue borefield which means pastoral activity around the borefield is significant, which poses the risk of pathogens from faecal matter getting into the water source (see appendix D, photo D4 to D6). However as the Southern Fortescue borefield is drawing from a deep, semi-confined aquifer, the water quality risks are minimal, due to the bore headworks being sealed and the bore properly constructed. The results from microbiological testing of the raw water can provide some indication of whether the integrity of the bore headworks has been compromised.

The proposed Marandoo Water Reserve is not part of any pastoral lease, however, cattle occasionally stray in around the Marandoo mine and consequently close to the production bores. The amount of human activity associated with the mine limits the number of cattle straying into the area and therefore the water quality contamination risks, which are reflected in the lower level of risk shown in Table 1.

3.2.3 Dewatering reinjection into Southern Fortescue borefield

As some of the water being abstracted from Marandoo is being reinjected into the Southern Fortescue borefield before any form of treatment, the land uses (described in section 3.2.1 above) that pose a water quality contamination risk to the Marandoo Water Reserve also pose a risk to the Southern Fortescue borefield (see appendix D, photo D7).

3.2.4 Department of Environment and Conservation managed land

A small section of the proposed Marandoo Water Reserve intersects an area of land vested with the Conservation Commission and managed on their behalf by the Department of Environment and Conservation (DEC). This land sits adjacent to the Karijini National Park. It is vested for the purpose of allowing infrastructure corridors and has a different vesting to Karijini to allow the creation of an infrastructure corridor through the national park, principally the existing railway line.

As mentioned above, Rio Tinto iron ore hold crown leases across the proposed Southern Fortescue Water Reserve. There is currently a proposal by Rio Tinto iron ore and the DEC, for Rio Tinto iron ore to hand part of the Hamersley Station pastoral lease over for inclusion into conservation estate in 2015. This area includes

parts of the pastoral lease surrounding the borefield. Consequently the DEC will take on the responsibility of managing this land when it is handed over.

3.2.5 Contaminated sites

One site in the Marandoo Water Reserve has been reported as a known or suspected contaminated site under the *Contaminated Sites Act 2003 (WA)*, which is administered by the DEC. This site is still awaiting classification. Hydrocarbons from pipeline leaks and old underground storage tanks are the main forms of contamination. Any contaminated sites in PDWSAs that the DEC have classified as requiring remediation should be addressed as soon as possible to reduce the risk of groundwater contamination.

In accordance with the PER for Marandoo, the site shall be rehabilitated to a stable and non-polluting standard. An inventory of all contaminated sites must be produced along with their proposed management.

3.2.6 Aboriginal sites of significance and Native title claims

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.

There are more than 60 Aboriginal sites of significance in and around the proposed Marandoo Water Reserve. These sites were identified by Rio Tinto iron ore during the PER process for the Marandoo mine phase 2 expansion (Rio Tinto 2008). There are no registered Aboriginal sites of significance in the proposed Southern Fortescue Water Reserve.

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.

There is one native title determination within the proposed Southern Fortescue Water Reserve. This is the Eastern Guruma peoples claim (WAD 6208/98). It was determined that the Native title exists for the Eastern Guruma people across the entire determination area. Rio Tinto iron ore and the Eastern Guruma people have a Indigenous land use agreement in place, in which the state of Western Australia is also a party to (Rio Tinto 2008).

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.

3.3 Possible future contamination risks

The main future contamination risk to the proposed Marandoo Water Reserve is the expansion of mining activities and associated infrastructure at the Marandoo mine. The main risks to the proposed Southern Fortescue Water Reserve are problems introduced into the aquifer by failure of the reinjection scheme to operate as planned, including the introduction of contaminants and changes to the way the aquifer operates.

Table 1 Land use and potential water quality risks

Land use/activity	Hazard	Level of risk	Compatibility of land use/activity	Best management practice guidance
Marandoo				
In-pit chemical use including refuelling	Spills of hydrocarbons and other chemicals	High	Mining is compatible with conditions in Priority 1 (P1) areas	Water quality protection guidelines (WQPG): <i>Mining and mineral processing.</i>
Blasting	Nutrients	Moderate	Mining is compatible with conditions in P1 areas	WQPG: <i>Mining and mineral processing.</i>
Pastoral activity	Pathogens from faecal matter	Moderate	Pastoral leases compatible with conditions in P1 areas	Water quality protection note (WQPN) no. 35: <i>Pastoral activities within rangelands.</i>
Southern Fortescue				
Pastoral activity	Pathogens from faecal matter	High	Pastoral leases compatible with conditions in P1 areas	WQPN no. 35: <i>Pastoral activities within rangelands.</i>
Reinjection of Marandoo dewatering	Same as Marandoo Water Reserve above	High	Same as Marandoo Water Reserve above	Operational strategy 1.01: <i>Managed aquifer recharge in Western Australia</i>

4 Protecting your drinking water source

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

- Ensure drinking water source protection is sufficiently built into mine planning and other land use development decisions.
- Identify land uses that pose a contamination risk and manage those land uses to avoid or reduce the risk level.

4.1 Proclaiming the public drinking water source area

The proclamation process begins with public consultation as part of the development of the drinking water source protection plan. This plan recommends proclamation of the proposed Southern Fortescue and Marandoo Water Reserves under the *Country Areas Water Supply Act 1947 (WA)*. The proposed water reserves are shown in Figures 2 and Figure 3 in Appendix A.

Once the water reserves are proclaimed, the local government authority is expected to incorporate these PDWSAs into their planning schemes consistent with State planning policy no. 2.7: *Public drinking water source policy*. PDWSAs are commonly shown in planning schemes as special control areas. This provides guidance for state and local government planning decision makers and developers.

A special control area already exists for the proposed Southern Fortescue borefield in the Shire of Ashburton's town planning scheme. It is recommended that this boundary be amended to reflect the proposed boundary of the proposed Southern Fortescue Water Reserve.

Proclamation of a PDWSA will not change the zoning of the land. There is no requirement to obtain any licences to operate any differently within a proclaimed PDWSA.

All existing and approved land uses and activities in a proclaimed area can continue. However, we recommend that best management practices are employed in PDWSAs to protect the quality of the drinking water source. New developments or expansion of existing land uses or activities need to consider the recommendations in this plan.

For more guidance on appropriate land uses and activities in PDWSAs please refer to our WQPN no. 25: *Land use compatibility in public drinking water source areas*.

4.2 Defining priority areas

The protection of PDWSAs relies on statutory and non-statutory measures for water resource management and land-use planning. The Department of Water's policy for the protection of PDWSAs includes a system that defines three specific priority areas:

- Priority 1 (P1) areas have the fundamental water quality objective of risk avoidance (e.g. state forest and other crown land).
- Priority 2 (P2) areas have the fundamental water quality objective of risk minimisation (e.g. land that is zoned rural).
- Priority 3 (P3) areas have the fundamental water quality objective of risk management (e.g. areas zoned urban or light/general industrial).

The determination of priority areas is based on the strategic importance of the land or water source including risks to water quality and quantity, the local planning-scheme zoning, the form of land tenure and existing approved land uses or activities. For further detail, please refer to our WQPN no. 25: *Land use compatibility in public drinking water source areas*.

The proposed priority areas for the proposed Southern Fortescue and Marandoo Water Reserves have been determined in accordance with current Department of Water policy. These areas are described below and displayed in Figure 5. Our 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 proposed Southern Fortescue Water Reserve is proposed as a P1 area because the water reserve is entirely under crown lease and covers a 500 m radius for the bores due to the semi-confined and deep (greater than 50 m below the below the ground surface) nature of the aquifer.

In situations where the aquifer is semi-confined and deep, contamination threats are significantly reduced. It is considered that there is sufficient protection provided through a proclaimed wellhead protection zone (WHPZ) with priority areas assigned as this protects the area (closest to the abstraction bore) most vulnerable to contamination.

The Marandoo Water Reserve is proposed as a P1 area to reflect that the area is under crown lease and to encourage high water quality risk activities associated with the Marandoo mine expansion to be located outside of the water reserve, whilst allowing the lower risk activities associated with ore extraction to continue.

4.3 Defining 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 or public access.

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.

The WHPZs in the proposed Southern Fortescue Water Reserve extend for to a 500 m radius around the bores to reflect that the aquifer is semi-confined and that the most vulnerable area for contamination is around the bore headworks.

The Marandoo Water Reserve is proposed as P1 area, so WHPZs will have a radius of 500 m. The exact locations for WHPZs in the proposed Marandoo Water Reserve are yet to be determined as the location of the bores to be used for dewatering of the mine are still subject to hydrogeological work to select the optimal location. Over the life of the below water table operations at Marandoo, the locations of the dewatering bores will also change, meaning that the location of the WHPZs will also change. It should be noted that the variable location of the bores within the proposed Marandoo Water Reserve will not affect the boundary of the water reserve. The mobile nature of WHPZs of in the proposed Marandoo Water Reserve will need to be built into Rio Tinto iron ore's mine planning and environmental management plans for Marandoo.

4.4 Planning for future land uses

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 proposed Southern Fortescue and Marandoo Water Reserves, their priority areas and protection zones be recognised in the Shire of Ashburton local planning scheme. Any development proposals within the proposed Southern Fortescue and Marandoo Water Reserves that are inconsistent with advice in our WQPN no.25: *Land use compatibility in public drinking water source areas* or recommendations in this plan, need to 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 our WQPN no.36: *Protecting public drinking water source areas*. This protection note describes the findings of Parliamentary Committee reviews instrumental in the integration of water quality protection and land use planning in WA.

The department's protection strategy for PDWSAs provides for approved developments to continue even if those facilities would not be supported under current water quality protection criteria. In these instances, the department can provide advice to landowners or operators on measures they can use to improve their facilities and reduce water quality contamination risks (see section 4.5: *Using best management practices*).

4.5 Using best management practices

There are opportunities to 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.

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 help managers reduce any detrimental effects of their operations. These guidelines have been developed in consultation with stakeholders such as industry groups, agricultural producers, state government agencies and technical advisers. Examples include WQPG: *Mining and mineral processing* and WQPN no. 35: *Pastoral activities in rangelands*, which are listed in this plan's *References* section.

Education and awareness-raising (such as through providing information on signs and publications) are key mechanisms for protecting water quality, especially for people visiting the area. We will produce a brochure once this plan is finalised, describing the proposed Southern Fortescue and Marandoo Water Reserves, their location and the main threats to their water quality. The brochure will inform people in simple terms about the drinking water sources and why it is important to protect them. We will make it available to the community and other stakeholders.

4.6 Enforcing by-laws and surveying the area

The quality of water in PDWSAs within country areas of the state is protected under the *Country Areas Water Supply Act 1947 (WA)*. Proclamation of PDWSAs allows by-laws to be applied to protect water quality.

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

Signs will be erected on the boundaries of the water reserves to educate and advise the public about activities that are prohibited or regulated and the importance of the area to the Tom Price public water supply.

4.7 Responding to emergencies

The escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The Shire of Ashburton local emergency management committee (LEMC), through the Pilbara emergency management district, should be familiar with the location and purpose of the proposed Southern Fortescue and Marandoo Water Reserves. A locality plan will be provided to the fire and rescue services headquarters for the hazardous materials (HAZMAT) emergency advisory team. The Department of Water should have an advisory role to the HAZMAT team for incidents in the proposed Southern Fortescue and Marandoo Water Reserves.

Personnel who deal with WESTPLAN–HAZMAT (Western Australian plan for hazardous materials) incidents within the area should have access to a map of the proposed Southern Fortescue and Marandoo Water Reserves. These personnel

should have an adequate understanding of the potential impacts of spills on this drinking water source.

4.8 Putting this plan into action

Table 1 (found at the end of Section 3) identifies the potential water quality risks associated with existing land uses in the proposed Southern Fortescue and Marandoo Water Reserves. Further information and the recommended protection strategies to deal with those risks are outlined in Appendix C.

When the final *Southern Fortescue and Marandoo Water Reserves drinking water source protection plan* is complete, an implementation strategy will be drawn up based on the recommendations in this plan and Appendix C.

5 Recommendations

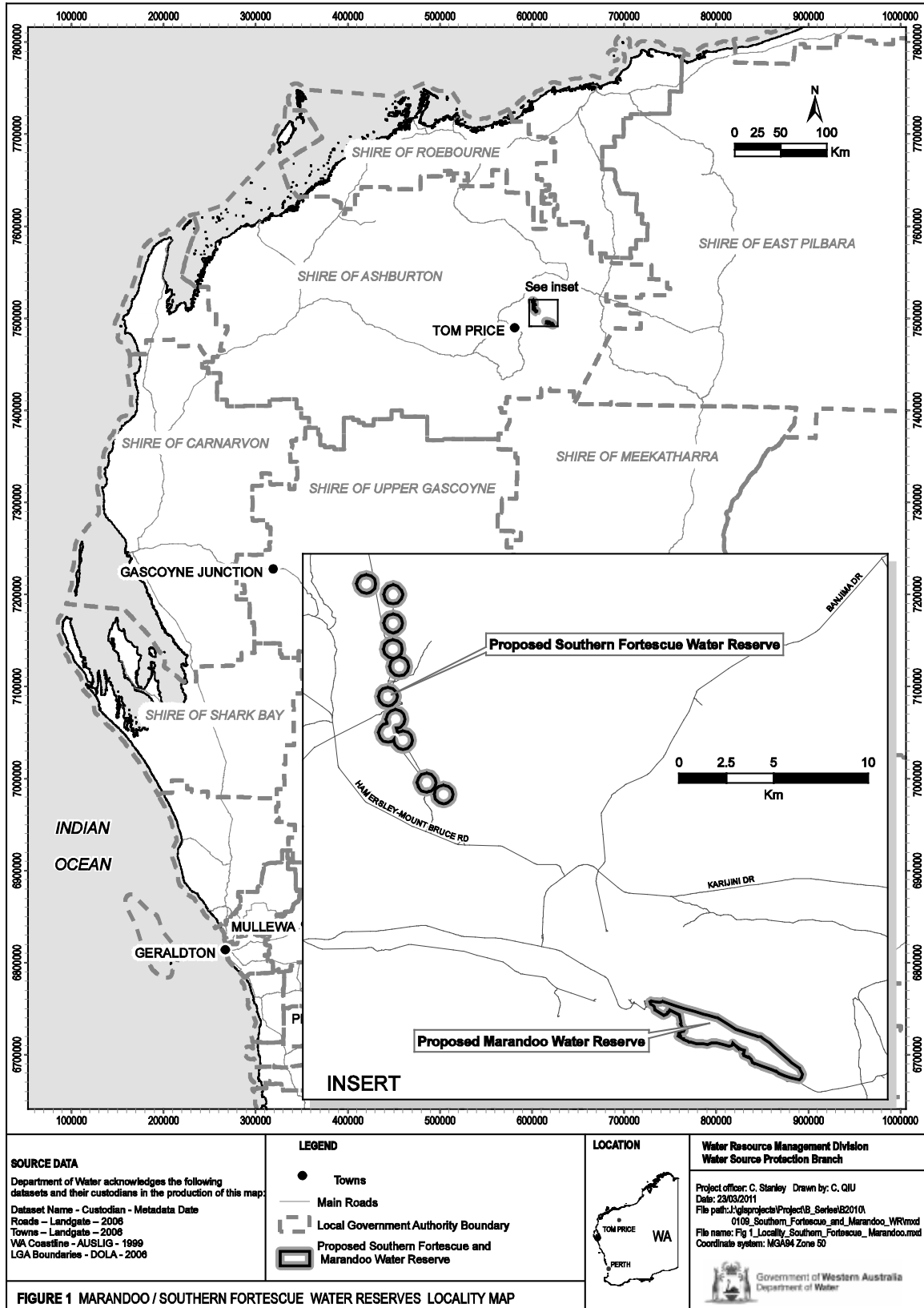
The following recommendations apply to the entire Southern Fortescue and Marandoo Water Reserves. The bracketed stakeholders are those expected to have a responsibility for, or an interest in, the relevant recommendation being implemented.

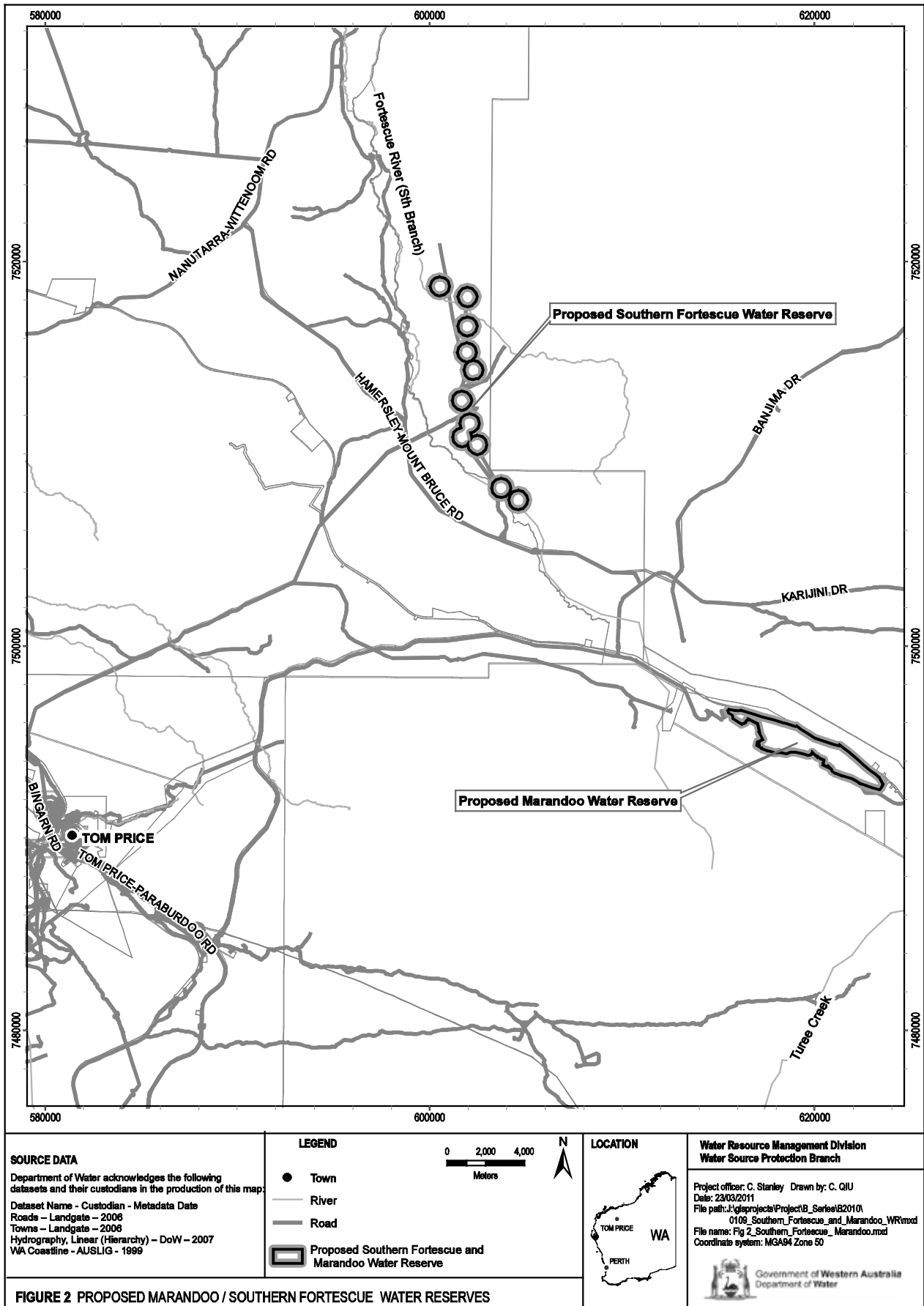
1. Proclaim the Southern Fortescue and Marandoo Water Reserves under the *Country Areas Water Supply Act 1947 (WA)*. (Department of Water)
2. Develop an implementation strategy for this plan's recommendations (including the recommended protection strategies as detailed in Appendix C) showing responsible stakeholders and planned timeframes. (Department of Water, applicable stakeholders)
3. Incorporate this plan and reflect the identified Southern Fortescue and Marandoo Water Reserves boundary, priority 1 areas and protection zones in the Shire of Ashburton local planning scheme 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 Southern Fortescue and Marandoo Water Reserves that are inconsistent with 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 and recommendations. (Department of Planning, Shire of Ashburton, proponents of proposals)
5. Incidents covered by WESTPLAN–HAZMAT in the Southern Fortescue and Marandoo Water Reserves should be addressed by ensuring that:
 - the Shire of Ashburton LEMC is aware of the location and purpose of the Southern Fortescue and Marandoo Water Reserves
 - the locality plan for the Southern Fortescue and Marandoo Water Reserves is provided to the fire and emergency services headquarters for the HAZMAT emergency advisory team
 - the Department of Water acts in an advisory role during incidents in the Southern Fortescue and Marandoo Water Reserves
 - personnel dealing with WESTPLAN–HAZMAT incidents in the area have ready access to a locality map of the Southern Fortescue and Marandoo Water Reserves and information to help them recognise the potential impacts of spills on drinking water quality. (Department of Water)
6. Erect signs along the boundaries of the Southern Fortescue and Marandoo Water Reserves including an emergency contact telephone number. (Rio Tinto iron ore, Department of Water)
7. Rio Tinto iron ore should prepare a catchment strategy for the water reserves including how the mining plan for Marandoo will incorporate water source protection measures. (Rio Tinto iron ore, Department of Water)

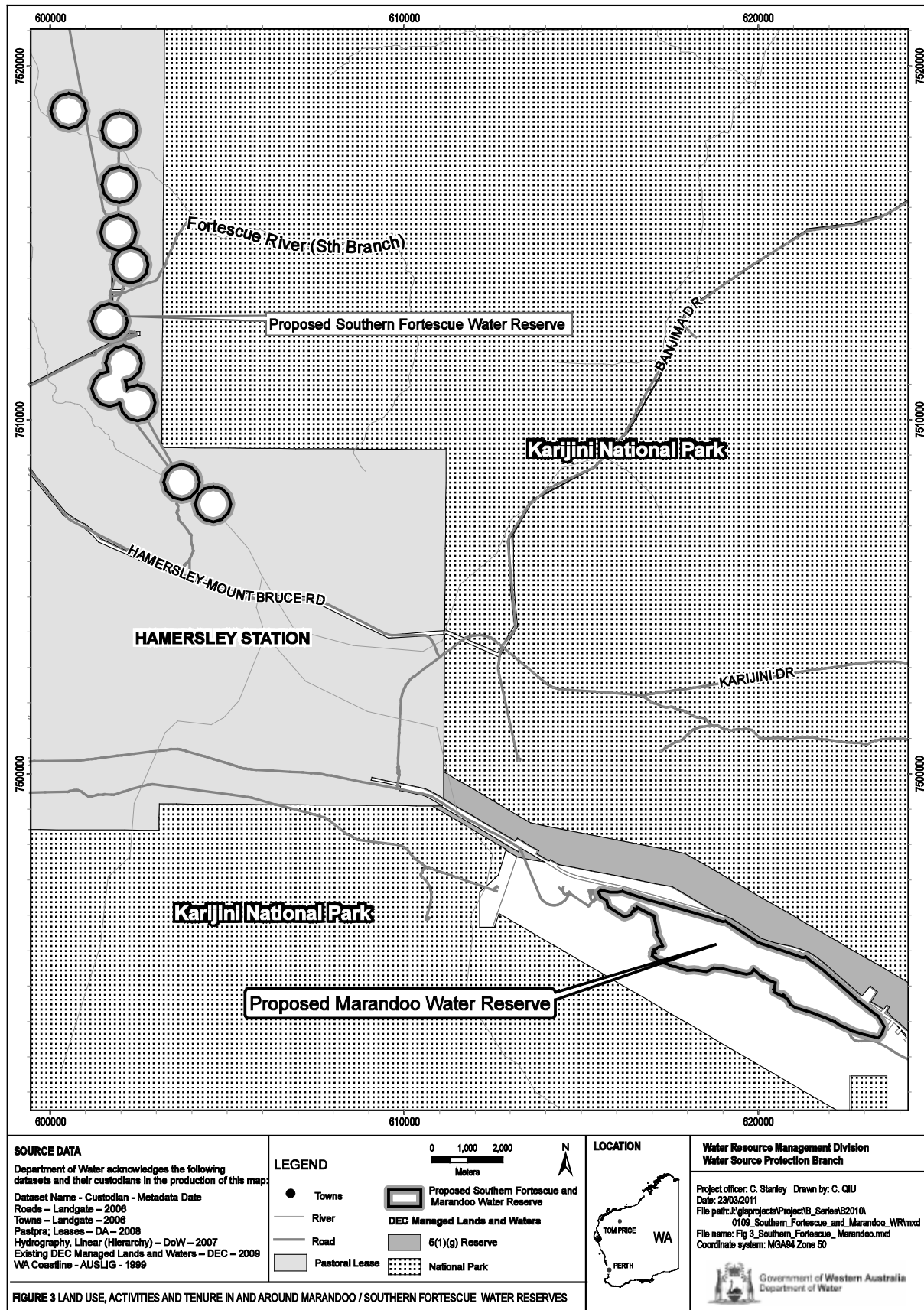
8. Stock watering points should be relocated outside of the Southern Fortescue Water Reserve. (Rio Tinto iron ore)
9. Review this plan after five years. (Department of Water)

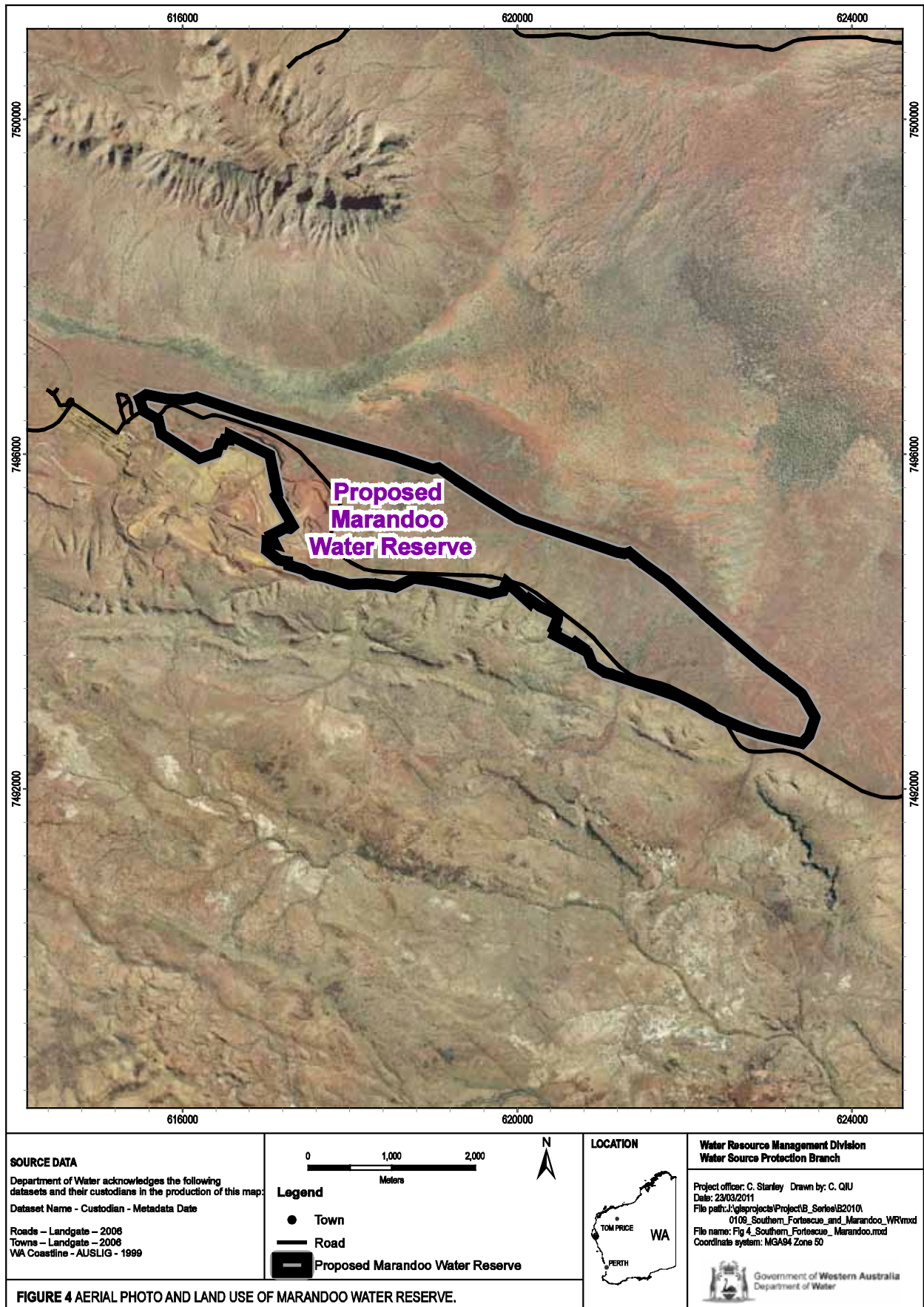
Appendices

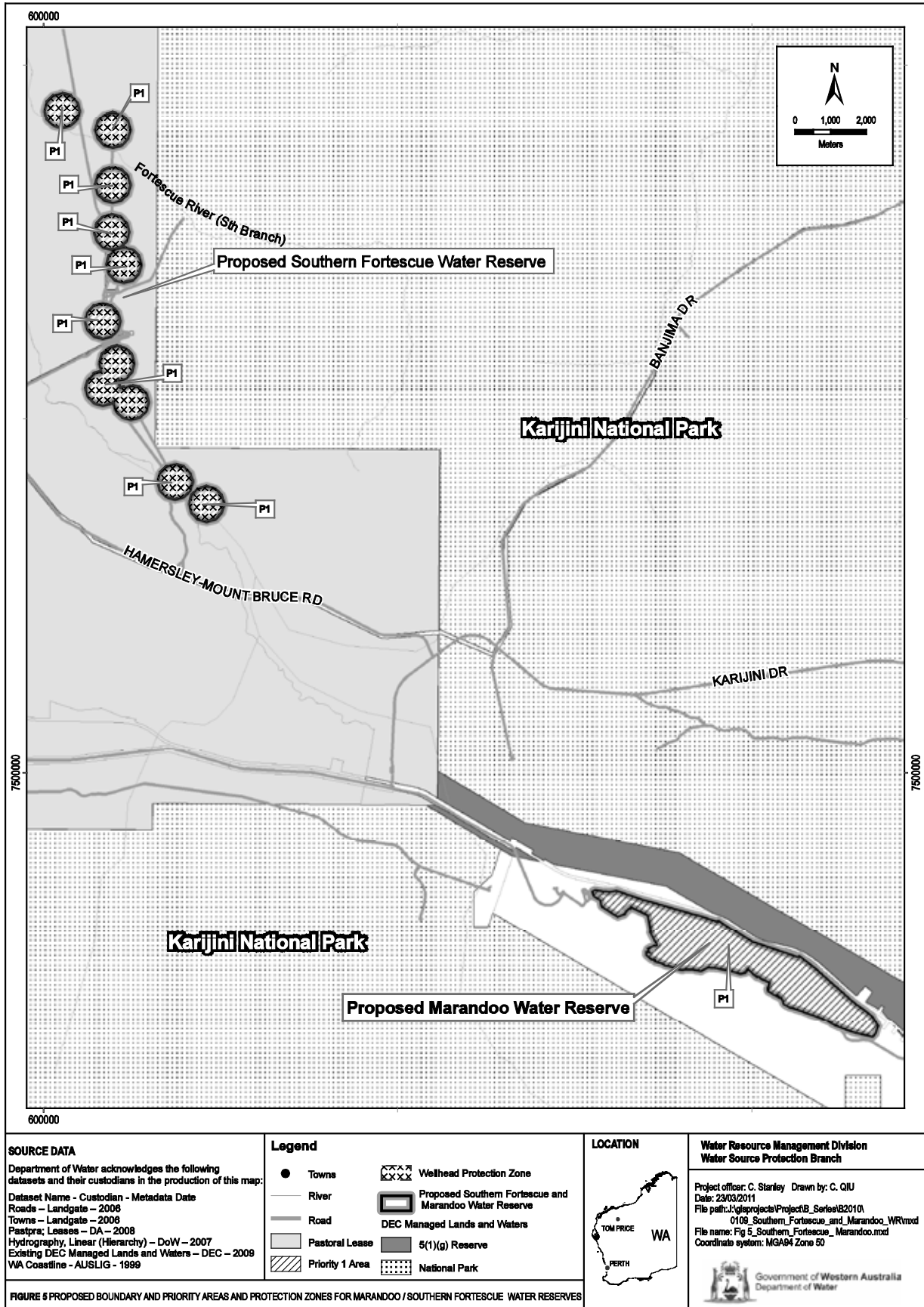
Appendix A – Figures











Appendix B – Water quality data

The information provided in this appendix has been prepared by Rio Tinto iron ore.

Rio Tinto iron ore has monitored the raw (source) water quality from the Marandoo and Southern Fortescue borefields. This data shows the quality of water in the water reserves. An assessment of the drinking water quality is also made in accordance with the *National water quality management strategy: Australian drinking water guidelines 6, 2004 (ADWG)* (NHMRC & NRMCC 2004a) and interpretations agreed to with the Department of Health. The raw water is monitored regularly for:

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

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

It is important to appreciate that the raw-water data presented does not represent the quality of drinking water distributed to consumers. Barriers such as storage and water treatment exist downstream of the raw water to ensure it meets the requirements of the ADWG. The values are taken from ongoing monitoring for the period January 2004 to November 2010.

Aesthetic

The aesthetic quality analyses for raw water from Marandoo and Southern Fortescue borefields are summarised in the following table.

Aesthetic detections for Marandoo and Southern Fortescue borefields

Parameter	Units	ADWG aesthetic guideline value*	Marandoo borefield		Southern Fortescue borefield	
			Range	Median	Range	Median
Aluminium unfiltered	mg/L	NA	< 0.02 – 0.1	< 0.02	< 0.02 – 0.34	0.01
Chloride	mg/L	250	78 - 160	100	63 - 110	94
Conductivity at 25°C	µS/m	na	592 – 1202	863.26	605 - 1431	839.45
Copper	mg/L	1	< 0.005	< 0.005	< 0.005 – 0.01	< 0.005
Hardness as CaCO₃	mg/L	200	330 – 440	361.2	280 – 380	332.5
Iron unfiltered	mg/L	0.3	< 0.02 – 0.05	< 0.05	< 0.02 – 0.57	0.01
Manganese unfiltered	mg/L	0.1	< 0.005 – < 0.05	< 0.005	< 0.005 – 0.34	0.03
pH	NOUNIT	6.5 - 8.5	6.19 – 7.92	7.15	6.2 – 9.94	7.19
Sodium	mg/L	180	32 – 51	40	0.5 – 58	44
Sulphate	mg/L	250	38 – 89	68.5	1 – 120	70
Zinc	mg/L	3	< 0.01 – 0.05	< 0.05	< 0.01 – 0.061	0.02

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

Health related

Health-related chemicals

Raw water from Marandoo and Southern Fortescue borefields is analysed for chemicals that are harmful to human health, including categories of chemicals such as inorganics, heavy metals, industrial hydrocarbons and pesticides. Health-related parameters that impact on water quality are summarised in the following table.

Health-related detections for Marandoo and Southern Fortescue borefields

Parameter	Units	ADWG health guideline value*	Marandoo borefield		Southern Fortescue borefield	
			Range	Median	Range	Median
Arsenic	mg/L	0.007	< 0.001 – 0.001	< 0.001	< 0.001 – 0.009	0.001
Barium	mg/L	0.7	< 0.048 – 0.2	0.04	< 0.005 – 0.2	0.001
Boron	mg/L	4	0.2 – 0.8	0.39	0.1 – 0.3	0.2
Cadmium	mg/L	0.002	< 0.001	< 0.001	< 0.001	< 0.001
Chromium	mg/L	0.05	< 0.005 – 0.01	< 0.005	< 0.005 – 0.005	0.001
Lead	mg/L	0.01	< 0.005	< 0.005	< 0.005 – 0.005	< 0.005
Molybdenum	mg/L	0.05	< 0.01	< 0.01	< 0.01 – 0.02	< 0.01
Nitrate	mg/L	50	5.8 – 18	10.4	< 0.005 - 33	16

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

Microbiological contaminants

Microbiological testing of raw-water samples from Marandoo and Southern Fortescue borefields has historically not been conducted. Microbiological testing has typically focussed on treated water with weekly testing occurring in the supply system. Recently Rio Tinto iron ore has carried a small number of microbiological tests of raw water quality with the results shown below. It is anticipated that microbiological testing will become a standard part of the testing regime of raw water quality at Marandoo and Southern Fortescue Borefields. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw water from warm-blooded animals. A count of less than 20 MPN (most probable number) per 100 mL sample is typically associated with low levels of faecal contamination and is used as a microbiological contamination benchmark of the raw water (WHO 2004). As such, counts less than 20 MPN are seen as indicating raw water that has not been recently contaminated with faecal material.

In 2010, three microbiological samples (two in Marandoo and one in Southern Fortescue) were taken, with positive faecal (thermotolerant) coliforms counts recorded in one of the samples from Marandoo and the Southern Fortescue sample. None of these samples had faecal coliform counts greater than 20 MPN/100mL.

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

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	Management priority			
Marandoo					
In-pit use of hydrocarbons and other chemicals	Hydrocarbons and chemicals from spills and accidents	High	<p>The majority of infrastructure associated with the mine, including bulk fuel storage, is located downstream of the proposed Marandoo Water Reserve.</p> <p>The Marandoo mine phase 2 below water table expansion has been approved through the Environmental Protection Authority's (EPA) Environmental impact assessment process.</p> <p>Ministerial approval statements (MAS) no. 286 and no. 833, specify the environmental conditions under which mining at Marandoo can take place.</p> <p>The Marandoo mine is also subject to the <i>Iron Ore (Hamersley Range)</i></p>	<ul style="list-style-type: none"> · water quality monitoring · Department of Mines and Petroleum (DMP) and EPA approvals. 	<ul style="list-style-type: none"> · Ensure adherence to the WQPG: <i>Mining and mineral processing</i>. · Ensure compliance with DMP mining tenement conditions and endorsements. · Ensure any contaminated sites have a proposed management plan to rehabilitate them back to stable conditions. · Ensure compliance with MAS no. 286 and no. 833 for Marandoo mine. · Prepare a catchment management strategy for the water reserves that

			<i>Agreement Act 1963 (WA).</i>		includes plans for how source protection will be built into mine planning.
Blasting	Nutrients	Medium	The drawdown in the water table created by dewatering limits the risk to water quality by creating a buffer between where contamination incidents will take place and the water.	<ul style="list-style-type: none"> · water quality monitoring · DMP and EPA approvals. 	<ul style="list-style-type: none"> · Ensure adherence to the WQPG: <i>Mining and mineral processing</i>. · Ensure compliance with DMP mining tenement conditions and endorsements. · Ensure compliance with MAS no. 286 and no. 833 for Marandoo mine. · Prepare a catchment management strategy for the water reserves that includes plans for how source protection will be built into mine planning.
Pastoral activity	Pathogens from faecal matter	Medium	<p>Marandoo is not part of any of the surrounding pastoral leases however a small number of cattle do stray throughout the area proposed for the water reserve.</p> <p>The amount of human activity and mine site safety measures limits the amount of cattle straying into the area.</p>	<ul style="list-style-type: none"> · water quality monitoring · mustering within Hamersley Station pastoral lease and Karijini National Park. 	<ul style="list-style-type: none"> · Ensure adherence to WQPN no. 35: <i>Pastoral activities within rangelands</i>. · Pest animal control carried out in accordance with WQPN no. 96: <i>Pest animal management in PDWSAs</i>.

Southern Fortescue					
Pastoral activity	Pathogens from faecal matter	High	<p>A number of stock watering points are located within the water reserve. This encourages cattle to congregate around the bores, which increases the risk of contamination of the bores.</p> <p>Much of the land where the cattle have been grazing is badly degraded, which reduces the natural buffering capacity of the ecosystem.</p> <p>Rio Tinto iron ore holds the pastoral lease that covers the proposed Southern Fortescue Water Reserve.</p>	<ul style="list-style-type: none"> water quality monitoring mustering within Hamersley Station pastoral lease and Karijini National Park. 	<ul style="list-style-type: none"> Ensure adherence to WQPN no. 35: <i>Pastoral activities within rangelands</i>. Pest animal control carried out in accordance with WQPN no. 96: <i>Pest animal management in PDWSAs</i>. Relocate stock watering points outside the water reserve. Investigate potential for fencing and revegetation of WHPZs.
Reinjection of water from Marandoo Water Reserve into Southern Fortescue Borefield	Hydrocarbons from spills and accidents Nutrients from blasting	High Low	<p>There is no treatment or water quality monitoring before water is reinjected into the proposed Southern Fortescue borefield.</p> <p>Risk is reduced as Southern Fortescue borefield is not the primary source whilst Marandoo dewatering scheme is in operation.</p>		<ul style="list-style-type: none"> Discontinue use of reinjection scheme if water quality monitoring at Marandoo indicates raw water has become contaminated. Operational strategy 1.01: <i>Managed aquifer recharge in Western Australia</i>

Appendix D – Photographs



Figure D1 Marandoo mine with Mount Bruce on the right



Figure D2 Marandoo mine with Mount Bruce Flats in the background



Figure D3 Drilling dewatering bores at Marandoo



Figure D4 Production bore at Southern Fortescue with stock in background



Figure D5 Stock watering point in the Southern Fortescue Water Reserve



Figure D6 Typical landscape of Southern Fortescue borefield with Karijini National Park in the background



Figure D7 Southern Fortescue reinjection bore

List of shortened forms

ADWG	<i>Australian drinking water guidelines</i>
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
CFU	colony forming units
DEC	Department of Environment and Conservation
GL	gigalitre
ha	hectare
HAZMAT	hazardous materials
kL	kilolitre
km	kilometre
km²	square kilometre
LEMC	local emergency management committee
m	metres
mg/L	milligram per litre
mL	millilitre
ML	megalitre
mm	millimetre
MPN	most probable number
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
PDWSA	public drinking water source area
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.
Adsorb	Adsorb means to accumulate on the surface of something.
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).
Australian drinking water guidelines	The <i>National water quality management strategy: Australian drinking water guidelines 6, 2004</i> (NHMRC & NRMMC 2004a) (ADWG) outlines acceptable criteria for the quality of drinking water in Australia (see this plan's Bibliography).
Catchment	The physical area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Colony forming units	Colony forming units are a measure of pathogen contamination in water.
Department of Environment and Conservation	The Department of Environment and Conservation was established on 1 July 2006, bringing together the Department of Environment and the Department of Conservation and Land Management.
Diffuse source	A diffuse source of pollution originates from a widespread non-specific area (e.g. urban stormwater runoff, agricultural infiltration) as opposed to a particular point source (see <i>point source pollution</i>).
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.
Gigalitre	A gigalitre is equivalent to 1 000 000 000 litres or one million kilolitres.
Half-life	The time required for one half of a sample of material to disintegrate.
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.
Most probable number	Most probable number is a measure of microbiological contamination.
Nutrient load	The amount of nutrient reaching the waterway over a given timeframe (usually per year) from its catchment area.
Nutrients	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.
Pathogen	A disease-producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as <i>Escherichia coli</i>), protozoa (such as <i>Cryptosporidium</i> and <i>Giardia</i>) 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.
Point source pollution	Pollution originating from a specific localised source, e.g. sewage or effluent discharge; industrial waste discharge.
Pollution	Water pollution occurs when waste products or other substances (effluent, litter, refuse, sewage or contaminated runoff) change the physical, chemical or biological properties of the water, adversely affecting water quality, living species and beneficial uses.

Public drinking water source area	Includes all underground water pollution control areas, catchment areas and water reserves constituted under the <i>Metropolitan Water Supply Sewerage and Drainage Act 1909 (WA)</i> and the <i>Country Areas Water Supply Act 1947 (WA)</i> .
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.
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.
Stormwater	Rainwater that has run off the ground surface, roads, paved areas etc., and is usually carried away by drains.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.
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.

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