Government of Western Australia
Department of Water and Environmental Regulation

De Grey River Water Reserve

drinking water source protection review

Port Hedland Regional water supply

Water resource protection series
Report WRP 140
June 2018

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Cover photograph: Aerial photo of De Grey Water Reserve

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Summary

This report was prepared by the former Department of Water. On 1 July 2017, the Government of Western Australia established the Department of Water and Environmental Regulation, resulting from the amalgamation of the Department of Water, the Department of Environment Regulation and the Office of the Environmental Protection Authority. As such, this publication may contain references to previous government departments and programs. Please email drinkingwater@dwer.wa.gov.au to clarify any specific information.

This drinking water source protection review considers changes that have occurred in and around the De Grey River Water Reserve since completion of the *De Grey River Water Reserve water source protection plan* (Water and Rivers Commission 2000). This review should be read in conjunction with the 2000 plan.

The Port Hedland region is the coastal gateway and service hub to some of the world's richest resource deposits of iron ore. It is targeted as an area for growth within the state and is an important component of Government's *Pilbara Cities* initiative (Water Corporation, 2012b).

Commitments to residential and industrial growth in Port Hedland require an increasing water supply. The *Pilbara planning and infrastructure framework* (Western Australian Planning Commission 2012) listed the upgrade of the De Grey and Yule bore fields to service Port Hedland as a priority action.

Water Corporation supplies water to the region via the Port Hedland Regional Water Supply (alternatively referred to as the East Pilbara Water Supply Scheme), using the De Grey River Water Reserve and the Yule River Water Reserve. Water is abstracted from a shallow, unconfined, alluvial aquifer beneath the De Grey River, which is vulnerable to contamination from land uses. The entire water reserve has been assigned a priority 1 (P1) area to protect water quality.

The most significant changes since the 2000 water source protection plan are a proposed reduction in the size of the water reserve, and the development of a new bore field. Several investigation and review reports have become available since 2000. The most relevant reports deal with the review and redefinition of the boundaries of the Lower De Grey and Yule aquifers, to better reflect the local hydrogeology. Also, the De Grey water supply infrastructure has been upgraded, the water yield has increased and Water Corporation has a higher licensed water allocation (now 10 000 000 kL per year).

The water reserve is located on Crown land. The Department of Water and Environmental Regulation has prepared this document after consultation with key stakeholders, including pastoral lease and mining tenement holders, Native Title applicants/holders, the Water Corporation and the Town of Port Hedland.

This review is consistent with the *Australian drinking water guidelines* (ADWG) (NHMRC & NRMMC 2011) and State planning policy no. 2.7: *Public drinking water source policy.*

Key information about the De Grey River Water Reserve	
Status of this report	This report has been prepared based on information for the 2015/16 financial year
Local government authority	Town of Port Hedland
Locations supplied	Port Hedland Regional Water Supply (Port Hedland, South Hedland, Finucane Island, Nelson Point and Wedgefield)
Water service provider	Water Corporation
Aquifer type	Unconfined (therefore vulnerable to land use contamination)
Licensed abstraction	10 000 000 kL per year (Department of Water 2012a)
Number of bores	15 production bores
Bore name and GPS coordinates (Bore data from Water Corporation, 2012a)	Namagoorie bore field production bores: 7/03 (1/76) (E 736 950, N 7 754 050, zone 50) 2/76 (E 738 124, N 7 754 984, zone 50) 3/76 (E 739 302, N 7 755 944, zone 50) 5/76 (E 742 110, N 7 752 507, zone 50) 8/76 (E 740 727, N 7 752 650, zone 50) 7/76 (E 739 334, N 7 752 789, zone 50) 13/03 (8/76) (E 737 916, N 7 752 918, zone 50) 14/03 (10/76) (E 737 140, N 7 756 183, zone 50) 12/76 (E 735 295, N 7 758 517, zone 50) 15/03 (13/76) (E 736 208, N 7 757 314, zone 50) 9/03 (1/79) (E 736 208, N 7 757 314, zone 50)
	Bulgarene bore field production bores (not in use yet): 18/96 (E 728 952, N 7 761 461, zone 50) 19/96 (E 728 994, N 7 763 075, zone 50) 20/96 (E 727 574, N 7 761 913, zone 50) 21/96 (E 0727435, 7 N 762 827, zone 50)

Key information about the De Grey River Water Reserve	
Date/s of drinking water source protection reports	2000 – *De Grey River Water Reserve water source protection plan* 2018 – *De Grey River Water Reserve drinking water source protection review* (this document)
Consultation	2013 – Consultation with key stakeholders including the pastoral lease and mining tenement holders, Native Title applicants/holders, the Water Corporation and the Town of Port Hedland
Proclamation status	Proclaimed in 2001 under the *Country Areas Water Supply Act 1947*. Proclamation of the smaller water reserve will need to be progressed when this review is finalised

1 Review of De Grey River Water Reserve's drinking water source protection plan

1.1 Boundary, priority areas and protection zones

The most significant changes since publication of the *De Grey River Water Reserve water source protection plan* (Water and Rivers Commission 2000) are a proposed reduction in the size of the water reserve (shown in Figure A1) and the development of a new bore field.

Since 2000, several investigations and publications about the De Grey River Water Reserve have become available. The proposed changes to the water reserve boundary are based on numerous reviews and investigation reports (see the work of Department of Water 2011 and 2012b; FUGRO 2009; Haig 2009; Koomberi and Muller 2010; Loomes & Braimbridge 2010; Muller 2012; Sinclair Knight Merz 2003; and WorleyParsons 2003 and 2005).

However, the most relevant work underpinning this water source protection report was the recent review of the Lower De Grey and Yule aquifers and redefinition of the boundaries to better reflect the local hydrogeology (see *Lower De Grey and Yule groundwater allocation limits report: background information and method used to set an allocation limit for the De Grey and Yule alluvial aquifers* (Department of Water 2012a) and *Pilbara groundwater allocation plan* (Department of Water 2013a). This work found that the De Grey aquifer consists of both an infilled paleochannel and overlying Quaternary alluvium within the river valley. The alluvium comprises interbedded sequences of sands and gravels. Confining layers are discontinuous across the aquifer.

The aquifer is therefore largely unconfined within the water reserve, with good vertical connectivity between layers. The source is vulnerable to contamination from inappropriate land uses and is therefore assigned a priority 1 (P1) area. Most of the production bores target the more productive basal gravel/sand layer within the palaeochannel.

The greatest source of the De Grey aquifer's recharge is the flooding and streamflow of the De Grey River and other tributaries that flow ephemerally in the area, such as the Shaw, Ridley and Strelley (Figure A1). Recharge occurs directly by infiltration from the river. Rainfall associated with summer cyclones and autumn thunderstorms is highly episodic and variable between years.

The proposed water reserve is over Crown land (leases and reserves) used for government purposes such as roads and rest stops (Figure A2). The Department of Water and Environmental Regulation will arrange proclamation of the amended De Grey River Water Reserve boundary under the *Country Areas Water Supply Act 1947* as recommended in section 2.2. The whole water reserve remains a P1 area with a 500 m radius wellhead protection zone around each of the 15 production bores within the Namagoorie and Bulgarene bore fields (Figure A3).

The proposed water reserve boundary, priority area and protection zones above have been determined in accordance with current departmental policy. If you require more information about how we protect drinking water sources, please read Appendix E.

This 2015 review should be read in conjunction with the 2000 *De Grey River Water Reserve water source protection plan*, published by the former Water and Rivers Commission. Both of these documents are available on our website or by contacting us (see details on the inside cover of this report).

1.2 Update on water supply planning

The Port Hedland region is the coastal gateway and service hub to some of the world's richest resource deposits of iron ore. It is targeted as an area for growth within the state and is an important component of Government's *Pilbara Cities* initiative. Commitments to residential, resources and industrial growth in Port Hedland require an increasing water supply (Department of Regional Development and Lands 2012, Economic Consulting Services 2007; Water Corporation 2012b). The Western Australian Planning Commission's *Pilbara planning and infrastructure framework* (2012) lists the upgrade of the De Grey and Yule bore fields supplying Port Hedland as an infrastructure priority.

The *Lower De Grey and Yule groundwater allocation limits report* and associated *Pilbara groundwater allocation plan* (Department of Water 2012a and 2013a) discuss the methods used to set allocation limits for the De Grey and Yule coastal alluvial aquifers. The Water Corporation's groundwater allocation licence has been increased to allow the Water Corporation to annually draw 10 000 000 kL from the lower De Grey alluvial aquifer to supply the Port Hedland area's drinking water (Water Corporation 2012a). The *Pilbara groundwater allocation plan* (Department of Water 2013a) identifies the aquifer as being fully allocated with a high level of risk management needed.

The De Grey River flows intermittently, after rainfall from summer cyclones and autumn thunderstorms. Nonetheless, the De Grey River is by far the largest river by volume in the region (based on mean annual flow). The size of the catchment and the number of major tributaries result in a relatively reliable flow compared with other Pilbara rivers – with flow recorded in all but one of the past 36 years. Recharge events are therefore relatively frequent. This reliable source of drinking water is important to protect for the Port Hedland area.

Water use in the region is high due to the large volumes used by the mining industry. Groundwater abstracted for mine dewatering is often of 'non-consumptive' use as it is released into downstream riverine drainages (Department of Water 2012b, 2012c and 2013b; Loomes & Braimbridge 2010; Water and Rivers Commission 2001; Western Australian Planning Commission 2011).

The Pilbara Cities initiative is building on mining sector growth to diversify the economy, grow the population and provide liveable towns and cities in the Pilbara.

The Department of Water and Environmental Regulation is working on the basis that will be needed during the next 30 years and beyond.

The department's modelling and assessment has clarified the reliable supply of the water resources needed for short-term water demands for the West Pilbara area.

The *Pilbara regional water supply strategy: a long-term outlook of water demand and supply* (Department of Water 2013c) supports state government's *Pilbara Cities* vision by investigating and planning for the water supply options to provide early assessment and support further planning for new water supplies in the medium and long-term.

1.3 Update on water supply scheme

The *Pilbara regional water supply strategy* (Department of Water 2013c) discusses upgrades being made to the Port Hedland Regional Water Supply Scheme. This scheme, operated by the Water Corporation, supplies customers in Port Hedland, South Hedland, Wedgefield, Finucane Island and Nelson Point. The scheme is supplied with groundwater from two independent sources; the lower De Grey River and Yule River bore fields (Water Corporation 2012a and 2012; Department of Water 2012a and 2013a).

Projected increases in water demand led to the Water Corporation upgrading infrastructure and yield, and to a groundwater investigation along the De Grey River. A drilling program defined a new bore field, the Bulgarene bore field, in the north-west of the gazetted water reserve, downstream of the existing Namagoorie bore field (Figure A3). Four production bores were installed to supply drinking water (Department of Water 2010, Water Corporation 2012a & 2000b*).*

Abstracted water is stored by Water Corporation in tanks in South Hedland and then transferred to other bulk storage tanks in the port area and on Finucane Island. The water supply and storage network is shown in the Western Australian Planning Commission's *Port Hedland regional hotspots* (2011).

It should be recognised that although treatment and disinfection are essential barriers against contamination, public drinking water source area (PDWSA) 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* (ADWG; NHMRC & NRMMC 2011) and reflects an approach based on preventing risks and multiple barriers for providing safe drinking water to consumers. This 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.

1.4 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* protects all Aboriginal sites in the state.

There are 16 Aboriginal sites of significance registered within the De Grey River Water Reserve (Figure A5). The *Lower De Grey River: Ecological values and issues* (Loomes and Braimbridge 2010) discusses the indigenous groups for whom the De Grey River's pools hold significance, and their use for activities such as fishing and swimming.

The Department of Planning, Lands and Heritage is the custodian of the Aboriginal sites of significance dataset, and their website should be consulted for the most up-to-date information.

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. The National Native Title Tribunal is the custodian of native title information, and their website should be consulted for the most up-to-date information.

A native title determination (WCD2007/003) was registered within the De Grey River Water Reserve, named *Ngarla and Ngarla 2 Determination Area A* (WAD6185/1998, WAD6003/2000 and WAD77/2005). An Indigenous land use agreement named *Ngarla Pastoral ILUA* (WI2006/002) was registered and overlaps a large part of the water reserve (Figure A5).

The Department of Water and Environmental Regulation is committed to working with Aboriginal people in its planning and management activities. The department recognises that native title is an important framework for water management.

1.5 Enforcing by-laws, surveying the area and maintenance

This review recommends that the Water Corporation continue by-law enforcement under the existing delegation arrangement. This includes:

- erecting and maintaining signs in accordance with *S111 Source protection signage* (Water Corporation 2013)
- maintaining security and fencing surrounding the bores
- ongoing regular surveillance and inspections.

1.6 Other work of the Department of Water and Environmental Regulation and the Water Corporation

Since the publication of the *De Grey River Water Reserve water source protection plan* (Water and Rivers Commission 2000a), several investigations and publications about the water resources in the area have become available. Some of the Pilbara studies produced during this prolific period have already been referred to previously, others are listed in Table 1.

Table 1 Summary of publications and investigations relating to local water resources

Author, date	Report	Details
Ruprecht & Ivanescu (for the Water and Rivers Commission) 2000	*Surface hydrology of the Pilbara region*	Provided a regional review of the groundwater and surface water resources
Johnson & Wright (for the Water and Rivers Commission) 2001	*Central Pilbara groundwater study*	
Sinclair Knight Merz 2010	*Lower De Grey Groundwater Model*	Investigations co-funded by the former Department for Water, Government of Western Australia, Perth; and the Australian Government's *Water for the Future* program. Groundwater model development to predict groundwater conditions, the future effect of bore pumping rate.
Koomberi & Muller 2010	*Cyclone-reliant GDEs in the Pilbara – Lower De Grey River Groundwater Model*	
Economic Consulting Services 2007	*Prospective demand for water in the west Pilbara of WA*	Commissioned by former Department of Water, to develop estimates of current and future water usage in the Pilbara, for use in regional water planning processes and the various uses of water by the mining industry.
Fugro 2009	*De Grey and Yule: Falcon airborne gravity gradiometer and magnetic geophysical survey*	Geophysical studies contracted by the former Department of Water.
Department of Water 2011	*Hydrogeological investigations of Pilbara groundwater resources*	Discussed the parameters measured and used for assessing the hydrogeology of the Yule aquifer.

Author, date	Report	Details
Haig 2009	*The Pilbara coast water study*	Prepared for the former Department of Water. Discussed the need to set sustainable yields for the Yule and De Grey rivers' bore fields. Reviewed pre-2009 investigations, includes discussion of Sinclair Knight Merz's 2011 study of hydraulic conductivity from pumping tests; and investigations by WorleyParsons (2003 and 2005) for the Water Corporation. Discusses risk management.
Antao (for the Department of Water) 2013	*Monitoring program to support the Pilbara groundwater allocation plan*	Discusses the various users of the aquifer and the responsibility of the department and licensees to ensure that the resources are managed so that groundwater productivity, water quality and dependent values are maintained into the future.
Department of Water 2010b	*Pilbara regional water plan 2010–2030*	Sets the strategic direction for the management and sustainable development of the region's water resources. Commitments to residential and industrial growth in Port Hedland require an increasing water supply through developing new water sources and expanding existing water sources.
Department of Water 2013c	*Western Australian water in mining guideline*	Potential effects of mining on water resources and best practice guidance were discussed in these reports prepared for the former Department of Water. Mining projects in the Pilbara can have a significant effect on groundwater and surface water, particularly where mining occurs below the watertable or there is a risk of salinisation.

1.7 Update on water quality risks

As part of this review, we have conducted a new assessment of water quality contamination risks to the De Grey River Water Reserve drinking water source, in accordance with the ADWG. Table 2 shows a summary of the risks to water quality, and Appendix D provides more detailed information.

The main contamination risks to the De Grey River Water Reserve, would be from activities in close proximity to the bore field: recreation, infrastructure, mining activities and stock grazing.

1.7.1 Land tenure

The proposed water reserve is over Crown and Government of Western Australia land (Figure A2). The Namagoorie bore field is on Crown Reserve 37898, vested with the Department of Water and Environmental Regulation for the purpose of water supply. De Grey Station is a pastoral Crown lease (3114–1142) that overlaps much of the water reserve. A stock route (Crown reserve 9701) crosses the north-west of the water reserve. The present non-intensive pastoral land use (Figure A1) is considered to be compatible with conditions in P1 areas.

Main Roads manages the Great Northern Highway and owns Lot 243 on the north-eastern bank of the De Grey River, with tracks leading from the Great Northern Highway to riverine picnic spots.

The Pananykarra Aboriginal Corporation is the interim holder of a small Department of Planning, Lands and Heritage Crown lease (AB H-879753) in the south-western corner of the water reserve.

1.7.2 Flooding

There is active interaction between surface water and groundwater in the Pilbara region, especially on the coastal plain, where there is significant recharge from rivers into the groundwater systems. This interaction occurs as recharge to the alluvial groundwater systems underlying most of the coastal plain (Water and Rivers Commission 2000). The area is prone to cyclones and flood inundation which necessitate infrastructure repairs (figures C3 and C6). Flooding could lead to more rapid and further distribution of contaminants in the water reserve, via surface runoff and alluvial groundwater flow, as illustrated in Figure C2.

1.7.3 Infrastructure

The De Grey River alluvial aquifer has the potential to be contaminated with hydrocarbons and chemicals via several sources including spillage of contaminants along the Great Northern Highway, railway, gas lines and powerlines that traverse the water reserve close to the production bores (figures A3, C1, C3 and C5). Other infrastructure within the water reserve includes roads and tracks and water supply infrastructure (figures C4, C8 and C9).

1.7.4 Recreation

Recreation activities within the water reserve are well publicised, including picnicking, fishing and camping. Cooking on open fires increases the risk of fire within the water reserve (figures C10 and C11).

Recreation websites promote the De Grey River location as being free and dog-friendly, with many camp sites suitable for overnight stays, including drop toilets. A

Main Roads picnicking area (Figure C12) includes drum rubbish bins and dump site facilities for the disposal of sewage. The De Grey River flows through many semi-permanent pools of water on the way to the coast – some are popular swimming spots. During the dry season, camping occurs in the dry river bed as well.

Water quality risks from recreation include pathogens from body contact with the water, toilets and pet faeces; nutrients from onsite wastewater treatment systems and rubbish, and hydrocarbons from vehicles.

All recreational activities within the catchment area should be guided by the *Operational policy 13: Recreation within public drinking water source areas on Crown land* (Department of Water 2012).

1.7.5 Feral and domesticated animals

There have been reports of feral pigs in the water reserve and entering the river. Animals pose a water quality risk by introducing pathogens and nutrients, causing turbidity and damaging riverine vegetation buffers.

1.7.6 Mining

The proposed reduced water reserve overlies more than 20 mining tenements and active mines (see Figure A6). The area is a significant source of iron ore. Gold, construction material (gravel and clay), gems and semi-precious stones have also been mined. The Department of Mines, Industry Regulation and Safety is the custodian of mining information and up-to-date information can be found on their website.

Mining operations abstract groundwater for mine dewatering, dust suppression, wash-down of equipment and mineral processing. The dewatering discharge is often used in mineral processing or released at controlled points into downstream riverine drainages (Western Australian Planning Commission 2011 & Water and Rivers Commission 2001). An overview of the open-cut mining process in the Pilbara and the resultant impacts on water resources is outlined in the *Central Pilbara groundwater study* (Johnson and Wright 2001).

Key areas for water management in the mining industry include preventing potential contamination of local water resources, and addressing concerns about potential long-term impacts of mine voids, which may include the development of hyper-saline lakes. Contamination risks at mine sites include:

- pathogens associated with human waste, spills during sewage disposal and at mine campsites
- chemical contamination such as hydrocarbons and chemicals associated with:
    - vehicle and mobile plant refuelling
    - mining equipment and infrastructure leaks or repairs
    - mine void acidification
    - herbicides from weed spraying along edges of infrastructure such as roads and train lines
    - chemical storage

- wash down of mine equipment
- landfill
- exploration activities.

All mining activities within the water reserve should be guided by best practice documentation.

1.7.7 Bores

The Water Corporation production bores are in secure bore compounds with signs (figures C7–C9). Bores drilled near a public drinking water supply bore (e.g. for irrigation or private purposes) can cause drawdown and contamination of the drinking water source (Sinclair Knight Merz 2010 and 2012). For example, a poorly constructed 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, constructed and managed to prevent contamination of the public drinking water source. This will be assessed through Department of Water and Environmental Regulation's water licensing process where applicable under the *Rights in Water and Irrigation Act 1914.* All bores in the water reserve should be constructed in accordance with *Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee 2012).

The De Grey and Yule alluvial aquifers are close to the coast (Figure A2) and hence could be influenced by seawater intrusion. The position of the seawater interfaces remain relatively stable but can move inland into the aquifers if groundwater flow declines due to over-abstraction or failed recharge. Ongoing monitoring of water quality is required to manage potential movement of the seawater interface. The effects on water quality along the sides of the aquifer are considered a short- to medium-term issue that will need monitoring and management (see Koomberi and Muller; Muller and Nyquest 2012 and Sinclair Knight Merz 2010).

Table 2 Summary of potential water quality risks, land use compatibility and best management practices

Land use/activity	Hazard[2]	Management priority	Comments	Best management practice guidance[1]
Recreation (camping, picnicking, fishing and swimming in river and pools)	Pathogens, nutrients, hydrocarbons herbicides and pesticides Increased risk of fires Other risks to riverine vegetation buffer	Medium	May attract feral animals such as pigs. Main Roads clears rubbish bins at picnicking area. Fenced bore compounds. Signs and locked gates to Namagoorie bore field.	Operational policy no. 13: *Recreation within public drinking water source areas on Crown land*
Mining	Hydrocarbons chemicals and pathogens	Medium	Mining occurs mostly in the west of the water reserve. HAZMAT emergency response in place. Discoloured liquids flowing from heaps of deposited material have been reported. Ongoing Water Corporation surveillance and water quality	*Western Australian water in mining guideline* Water quality protection guidelines 1–11: *Water quality management in mining and mineral processing* Water quality protection notes (WQPNs): WQPN 5: *Toxic and hazardous substances: storage and use* WQPN 10: *Contaminant spills – emergency response* WQPN 15: *Extractive industries near sensitive water resources*

Land use/activity	Hazard[2]	Management priority	Comments	Best management practice guidance[1]
			monitoring as discussed in Appendix B.	WQPN 26: *Liners for containing pollutants using synthetic membranes* WQPN 28: *Mechanical servicing and workshops* WQPN 68: *Mechanical equipment wash down* WQPN 84: *Rehabilitation of disturbed land in PDWSA* Several WQPNs supply guidance for chemical storage, see WQPN 56, 58, 60, 61, 62 or 64, depending on the storage type. Statewide policy no. 1: *Policy and guidelines for construction and silica sand mining in PDWSA*
Pastoral station and stock route	Pathogens, nutrients, hydrocarbons and chemicals	Medium	Non-intensive pastoral activities are compatible with conditions in a P1 area. Cattle have access to the river.	WQPN 35: *Pastoral activities within rangelands* WQPN 96: *Pest animal management in PDWSA* Statewide policy no. 2: *Pesticide use in PDWSA* Public sector circular (PSC) no. 88: *Use of herbicides in water catchment areas (*see Department of Health 2007) *A guide to the use of pesticides in Western Australia – Providing information on legislation, policies and best practice* (see Department of Health 2013)

[1]Water quality protection notes (WQPNs) are available www.dwer.wa.gov.au. Full details of guidelines provided in the References section.

[2]Information on the hazards associated with each land use activity is detailed further within Appendix D.

1.8 Water quality information

The Water Corporation has provided updated water quality information for the De Grey River Water Reserve source. This is shown in Appendix B.

Some of the bores yielded samples exceeding ADWG aesthetic guideline values for chloride, filterable solids and hardness. However, Water Corporation treats the raw water to meet acceptable drinking water quality before supply to consumers.

2 Implementation of De Grey River Water Reserve's water source protection plan

2.1 Status of previous recommendations

Table 3 outlines recommendations from the 2000 *De Grey River Water Reserve water source protection plan* and their current status.

Table 3 Implementation status for De Grey River Water Reserve

No.	Recommendation (2000 plan)	Comments
1	The proposed De Grey River Water Reserve should be gazetted under the *Country Areas Water Supply Act 1947*.	Gazetted in 2001 under the *Country Areas Water Supply Act 1947.* This recommendation will be carried forward to ensure the amended boundary is proclaimed.
2	Planning strategies should incorporate the management principles outlined in *Land use compatibility in public drinking water source areas* and reflect the Priority 1 area assigned to the Water Reserve.	The water reserve was not incorporated in the Port Hedland local planning scheme as a special control area. This recommendation will be carried forward.
3	All development proposals in the water reserve that are likely to impact on water quality should be referred to the Water and Rivers Commission (now the Department of Water and Environmental Regulation).	Development proposals within the De Grey River Water Reserve are referred to the North West regional office of the Department of Water and Environmental Regulation. This recommendation will be carried forward and modified so that only those proposals that do not meet our recommended guidelines or conditions are referred to us.
4	Signs should be erected along the boundaries of the water reserve and at the De Grey River bridge picnic area to define the reserve and promote public awareness of the need to protect water quality.	Water Corporation signs are displayed on De Grey Water Reserve bore compounds and tracks. Signs to be installed and maintained in accordance with the Water Corporation's *S111 Source protection signage* (2013).

No.	Recommendation (2000 plan)	Comments
5	Emergency response: • develop response plan • inform WAHMEMS personnel of special requirements for the De Grey Water Reserve.	Emergency response protocols have changed to the jurisdiction of HAZMAT and the local emergency management committee (LEMC). This recommendation will be carried forward and updated.
6	A surveillance program should be established to identify potential contaminant threats within the water reserve.	Water Corporation undertakes surveillance within the water reserve. This recommendation will be carried forward.
7	Fuel and chemical storage should be bunded at the Strelley Pump Station to meet the Water and Rivers Commission's requirements. Disused diesel storage tanks should be removed.	Water Corporation has removed fuel from the bore compounds.
8	Production bores should be fenced off to prevent the intrusion of cattle.	Bore compounds are now fenced.
9	The use of non-chemical weed control measures within the bore compounds should be investigated.	Water Corporation has reviewed.
10	Implementation of these recommendations should be reviewed annually after this plan is endorsed. A full review of this protection plan should be undertaken after five years.	Undertaken through the preparation of this review document. A recommendation for the next review will be carried forward and updated.

2.2 Consolidated recommendations

Based on the findings of this review, the following recommendations will now be applied to the De Grey River Water Reserve. The bracketed stakeholders are those expected to have a responsibility for, or an interest in, the implementation of that recommendation.

1. Proclaim the amended boundary of the De Grey River Water Reserve under the *Country Areas Water Supply Act 1947*. (Department of Water and Environmental Regulation)
2. Incorporate the findings of this plan and location of the De Grey River Water Reserve (including its priority area and protection zones) in the local planning schemes of the Town of Port Hedland, in accordance with the Western Australian Planning Commission's State planning policy no. 2.7: *Public drinking water source policy*. (Town of Port Hedland)
3. Refer development proposals within the De Grey River Water Reserve that are inconsistent with our WQPN no. 25: *Land use compatibility in public drinking water source areas* or recommendations in this plan to the Department of Water and Environmental Regulation's regional office for advice. (Department of Planning, Lands and Heritage, Town of Port Hedland, proponents of proposals)
4. Ensure incidents covered by Westplan–HAZMAT in the De Grey River Water Reserve are addressed by ensuring that:
    - the Port Hedland LEMC is aware of the location and purpose of the De Grey River Water Reserve
    - the locality plan for the De Grey River Water Reserve is provided to the Department of Fire and Emergency Services headquarters for the HAZMAT emergency advisory team
    - the Water Corporation/Department of Water and Environmental Regulation acts in an advisory role during incidents in the De Grey River Water Reserve
    - personnel dealing with Westplan–HAZMAT incidents in the area have ready access to a locality map of the De Grey River Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality. (Department of Water and Environmental Regulation, Water Corporation)
5. Erect and maintain signs in the De Grey River Water Reserve including an emergency contact telephone number, in accordance with the Water Corporation's *S111 Source protection signage* (2013). (Water Corporation, Main Roads)
6. Water Corporation should continue the current regime of water quality monitoring, maintenance of fencing, inspections and by-law enforcement. (Water Corporation)
7. Update this report within seven years. (Department of Water and Environmental Regulation)

Appendices

Appendix A — Figures

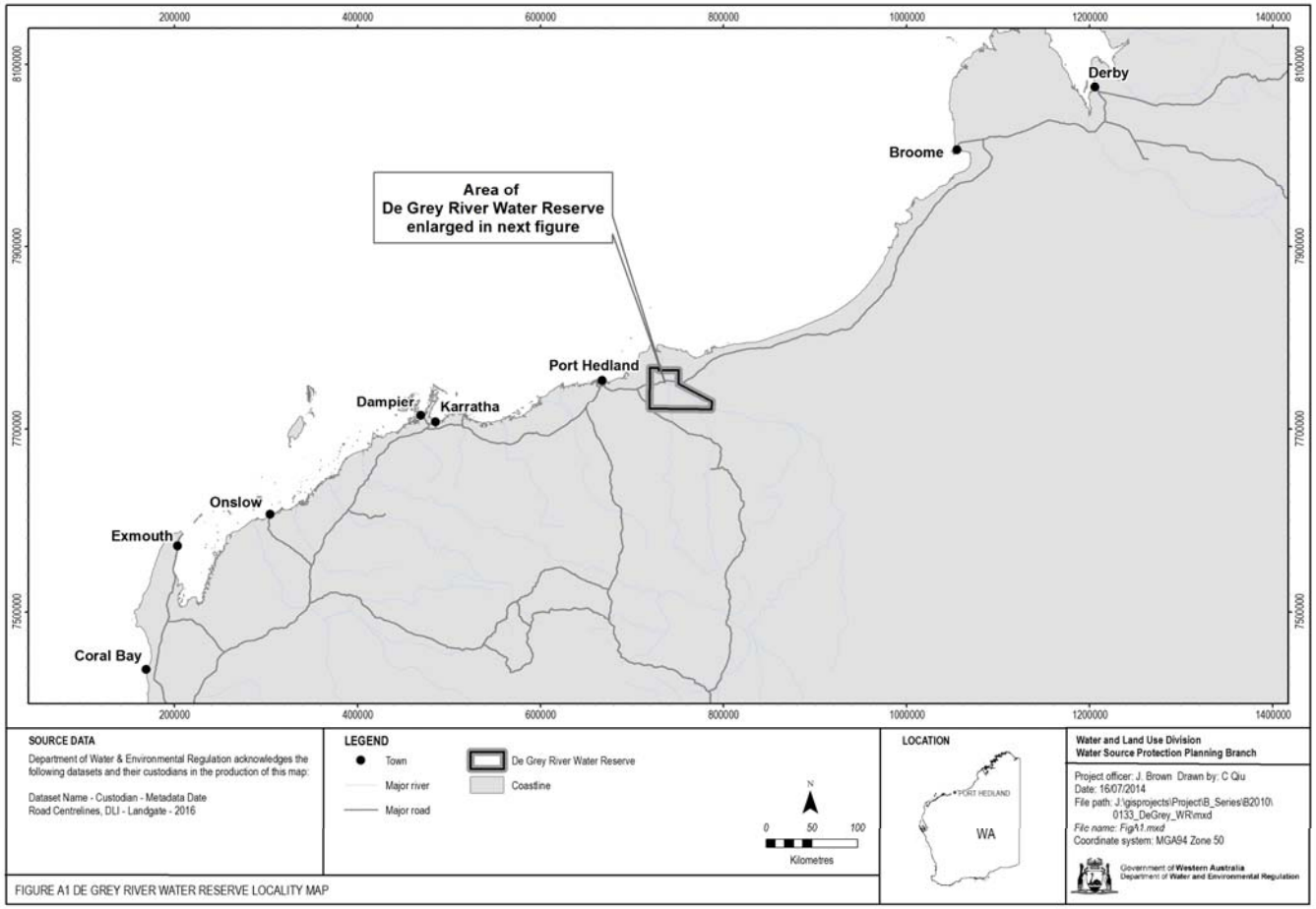

Figure A1 De Grey Water Reserve locality map

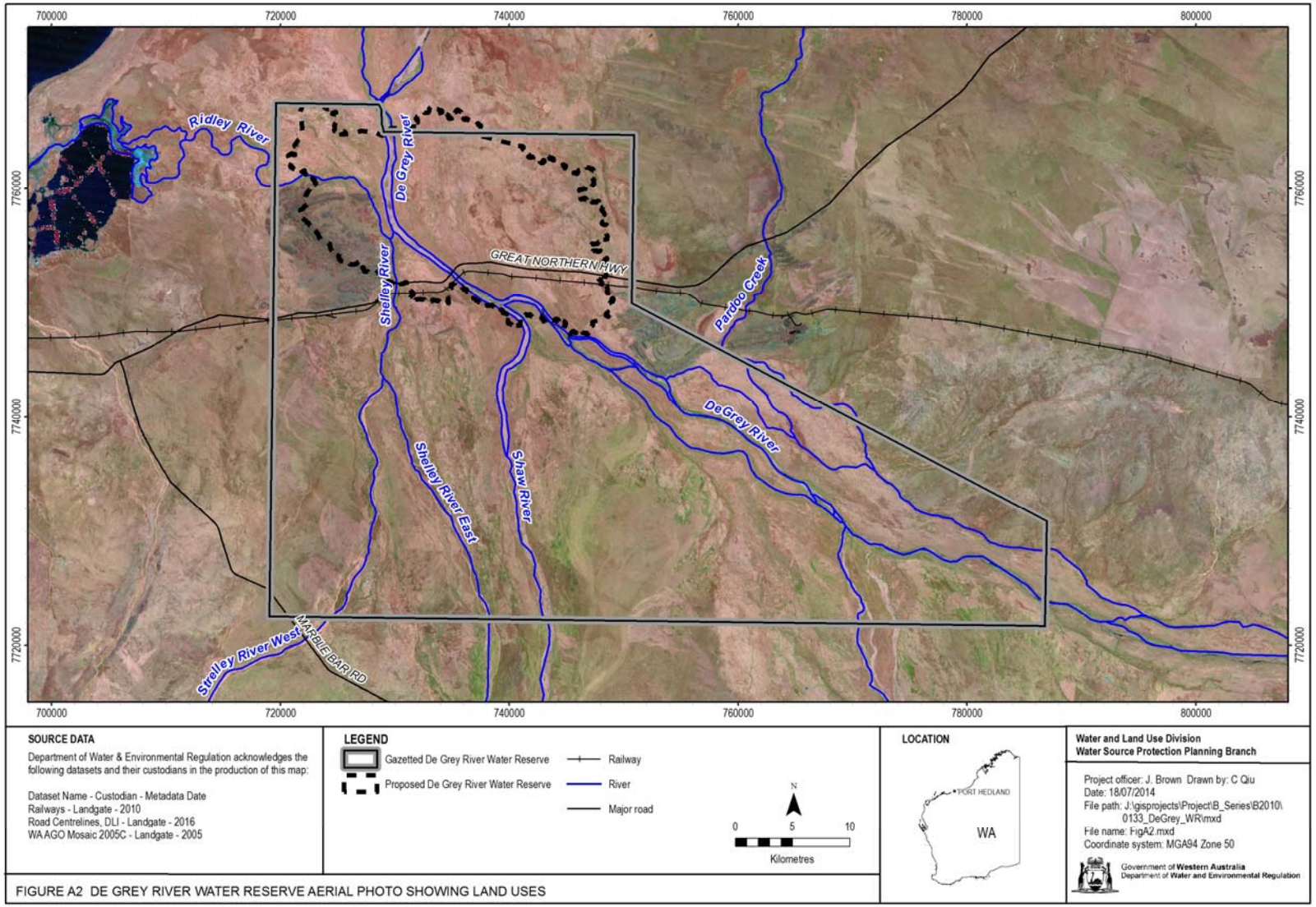

Figure A2 De Grey Water Reserve aerial photo showing land uses

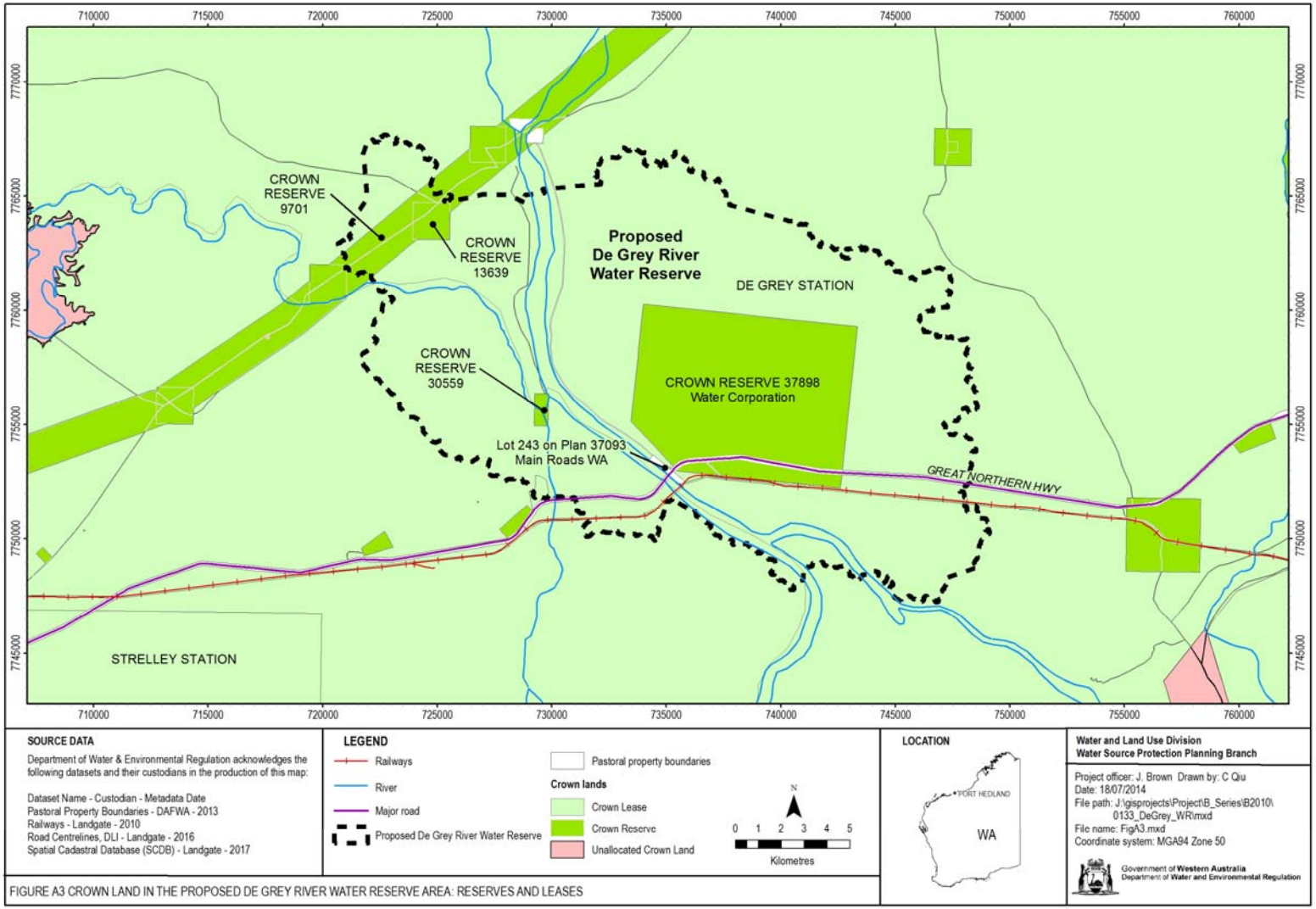

Figure A3 Crown land in the proposed De Grey Water Reserve, reserves and leases

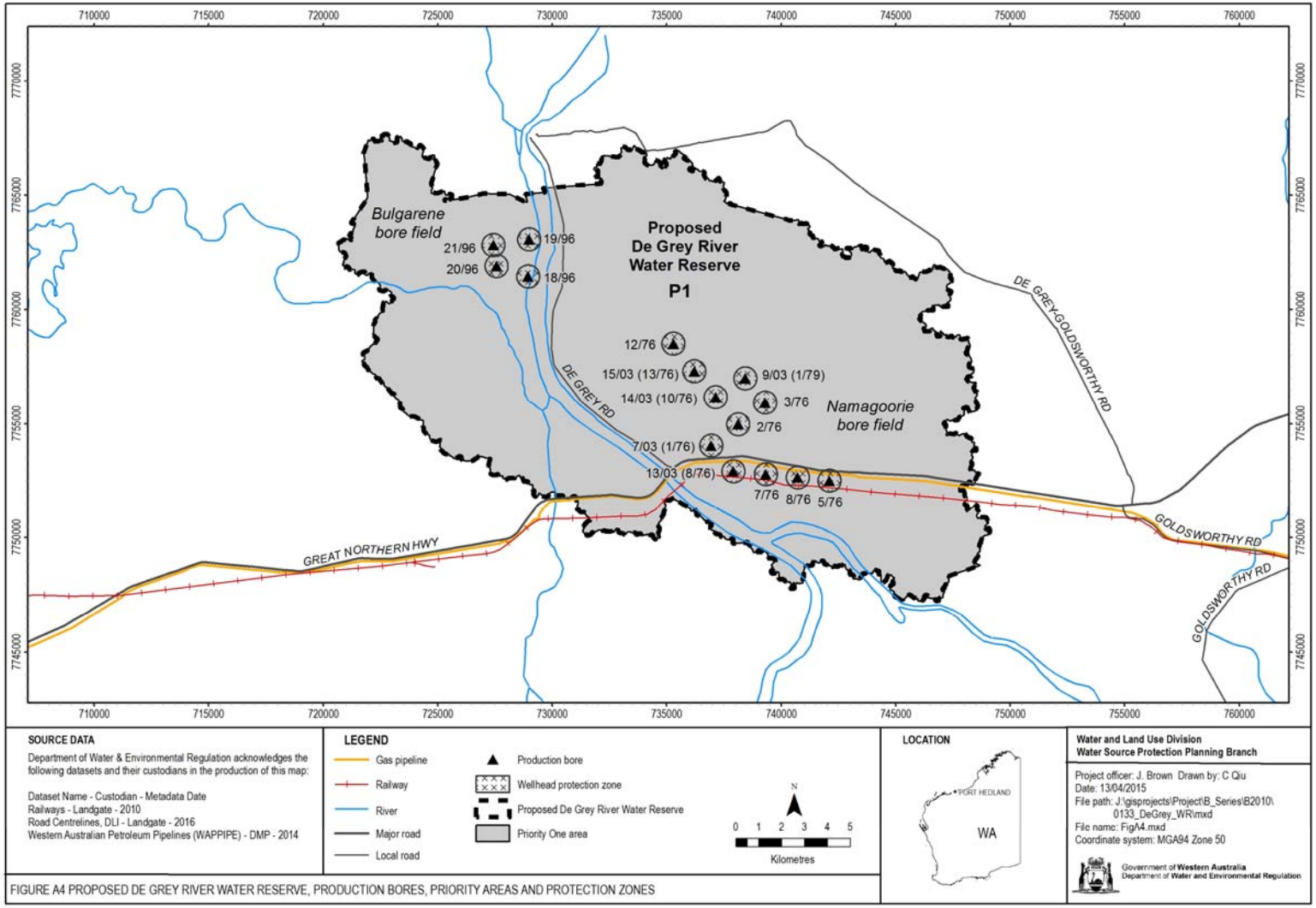

Figure A4 Proposed De Grey Water Reserve production bores, priority areas and protection zones

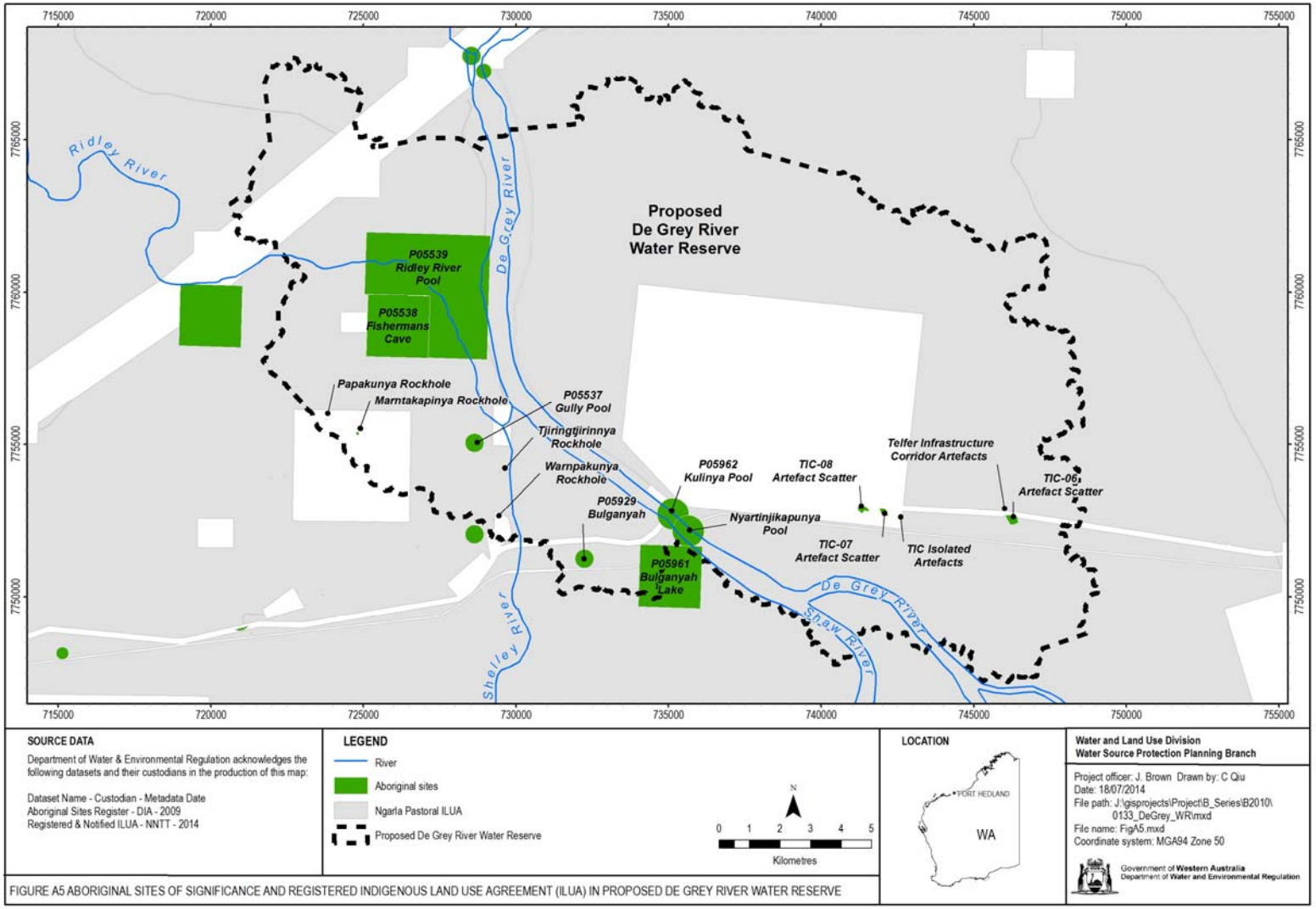

Figure A5 Aboriginal sites of significance and registered Indigenous land use agreement in proposed De Grey Water Reserve

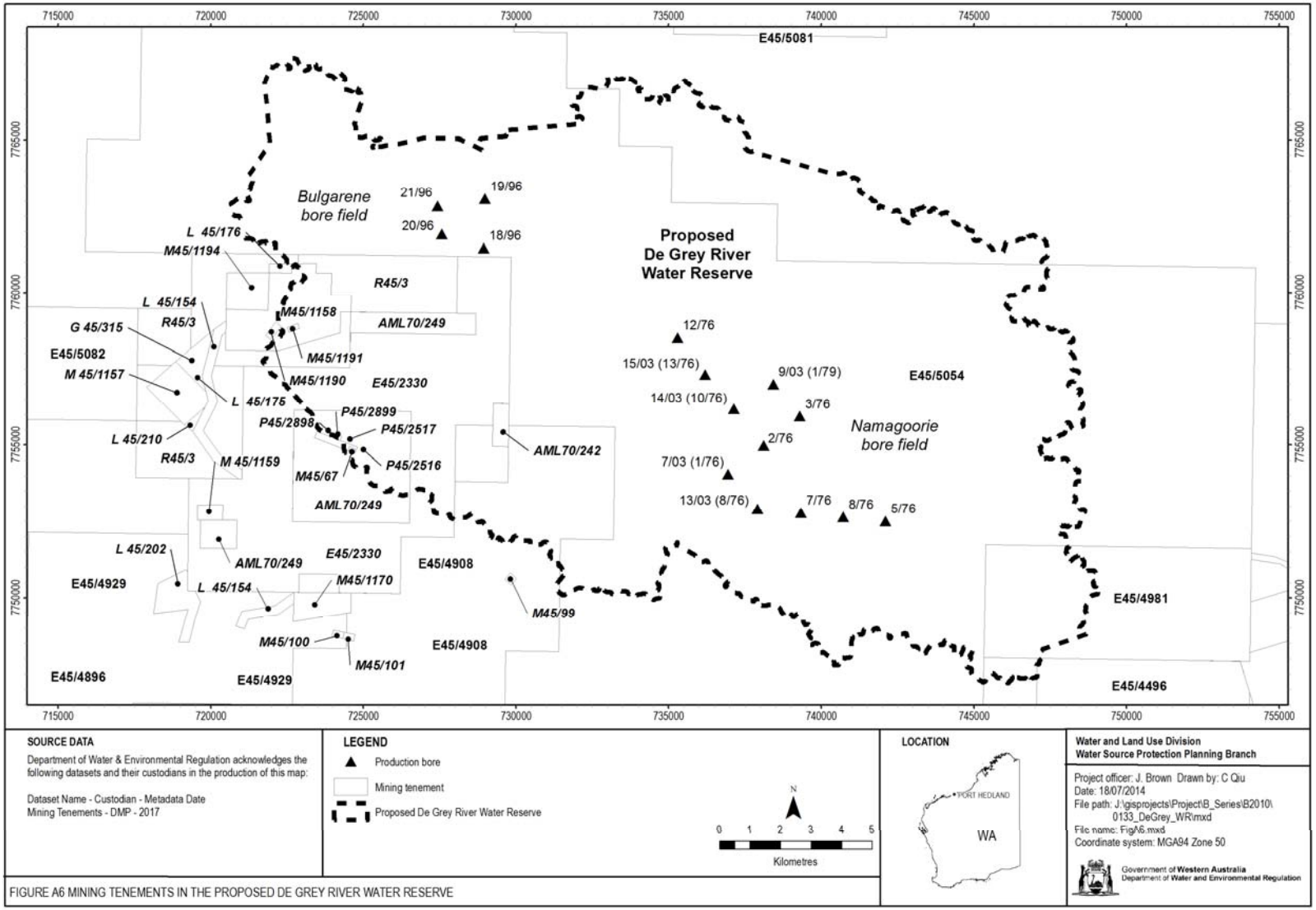

Figure A6 Mining tenements in the proposed De Grey Water Reserve

Appendix B — Water quality data

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

The Water Corporation has monitored the raw (source) water quality from De Grey in accordance with the requirements of the *Australian drinking water guidelines*, (ADWG; NHMRC & NRMMC 2011) and interpretations agreed to with the Department of Health. This data shows the quality of water in the water reserve. The raw water is regularly monitored for:

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

The following data represents the quality of raw water from De Grey River bore field. 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. Any water quality parameters that have been detected are reported; those that on occasion have exceeded the ADWG are in ***bold and italics*** to give an indication of potential raw water quality issues associated with this source. The values are taken from ongoing monitoring for the period December 2008 to November 2013.

It is important to appreciate that the raw water data presented does not represent the quality of drinking water distributed to the public. Barriers such as storage and water treatment exist downstream of the raw water to ensure it meets the requirements of the ADWG.

For more information on the quality of drinking water supplied to the North West Region refer to the most recent Water Corporation drinking water quality annual report at www.watercorporation.com.au.

Aesthetic characteristics

The aesthetic water quality analyses for raw water from De Grey River bore field are summarised in the following table.

Aesthetic detections for De Grey River bore field

Parameter	**Units**	**ADWG aesthetic guideline value***	**De Grey River raw water**	
			Range	**Median**
Chloride	mg/L	250	220–***275***	235
Hardness as $CaCO_3$	mg/L	200	***250–340***	***260***
Iron unfiltered	mg/L	0.3	<0.003–0.06	0.008
Silicon as SiO_2	mg/L	80	47–48	47.5
Sodium	mg/L	180	115–145	122.5
Sulfate	mg/L	250	40–55	44
Total filterable solids	mg/L	600	***711–869***	***747***
Turbidity	NTU	5	<0.1–0.3	<0.1
pH	pH units	6.5–8.5	7.51–7.95	7.63
Copper	mg/L	1	0.01–0.014	0.012

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

Health-related chemicals

Raw water from De Grey is analysed for chemicals that are harmful to human health including inorganics, heavy metals, industrial hydrocarbons and pesticides. Health-related parameters that have been detected in the source are summarised in the following table.

Health related detections for De Grey River bore field

Parameter	**Units**	**ADWG health guideline value***	**De Grey River raw water**	
			Range	**Median**
Nitrite plus nitrate as N	mg/L	11.29†	0.74–0.93	0.795
Sulfate	mg/L	500	40–55	44
Arsenic	mg/L	0.007	<0.002–0.003	0.002
Barium	mg/L	0.7	0.23–0.32	0.26
Boron	mg/L	4	0.16–0.3	0.22
Molybdenum	mg/L	0.05	<0.0005–0.0025	<0.0005
Selenium	mg/L	0.01	<0.003–0.005	<0.003
Uranium	mg/L	0.02	0.004–0.006	0.005
Chromium	mg/L	0.05	0.003–0.0035	0.0033
Copper	mg/L	2	0.01–0.014	0.012
Fluoride (lab)	mg/L	1.5	0.35–0.55	0.45
Iodide	mg/L	0.1	<0.02–0.06	<0.02

** 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 & NRMMC, 2011).*

† The guideline value of 11.29 mg/L (as nitrogen) has been set to protect bottle fed infants less than three months of age. Up to 22.58 mg/L (as nitrogen) can be safely consumed by adults and children over three months of age.

Microbiological contaminants

Microbiological testing of raw water samples from De Grey River bore field is currently conducted on a monthly basis. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw water from warm-blooded animals.

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

During the review period, positive *E. coli* counts were recorded in 15.5 per cent of samples.

Appendix C — Photographs

Figure C1 Great Northern Highway crossing De Grey River (note cattle in foreground)

Figure C2 Flooding of the De Grey River after cyclone Rusty, photograph by S Avery

Figure C3 Repairs to rail bridge crossing De Grey River, after cyclone Rusty

Figure C4 Powerline infrastructure (note vegetation in the water reserve)

Figure C5 Gas pipeline infrastructure in water reserve

Figure C6 Repair and maintenance of transport infrastructure

Figure C7 De Grey River bore field sign (note vegetation in the bore field area)

Figure C8 Fenced bore compound with sign

Figure C9 Access control to track

Figure C10 Picnicking occurs along the De Grey River and pools (note vegetation in water reserve)

Figure C11 Sign at picnicking spot near the Great Northern Highway

Figure C12 Toilet and wastewater facilities at picnicking site, near the bridge

Appendix D — Typical contamination risks in surface water and groundwater sources

Land development and land- or water-based activities within a water reserve can directly affect the quality of drinking water and its treatment. Contaminants can reach drinking water sources through runoff 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, resulting in illness, hospitalisation or even death. 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 2011). Contaminants can also interfere with water treatment processes, and damage water supply infrastructure (such as iron corroding pipes).

The ADWG (NHMRC & NRMMC 2011) outlines criteria for acceptable drinking water quality to protect human health, manage aesthetics and maintain water supply infrastructure.

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

Microbiological risks

Pathogens are types of microorganisms that are capable of causing illness. These include bacteria, protozoa and viruses. In drinking water supplies, pathogens 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 (for example *Salmonella*, *Escherichia coli* and cholera), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses. Monitoring for the presence of *E. coli* in water supplies provides an indication of the level of recent faecal contamination.

Pathogen contamination of a drinking water source is influenced by many factors including the existence of pathogen carriers (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 and 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, some 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).

Unlike chemicals, which dissipate and dilute when they enter a water source, pathogens can multiply under the right conditions, increasing the likelihood of contamination. Therefore it is important to understand both the surface water and groundwater systems to be able to protect the drinking water source from pathogens.

When people consume drinking water contaminated with pathogens the consequences 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 2011).

Given the wide variety of pathogens, the differences in how they act in the environment and the potential consequences of consuming contaminated water, the most effective way to protect public health and reduce water treatment costs is to avoid the introduction of pathogens into a water source.

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 aesthetically 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.

Chemical risks

Chemicals can occur in drinking water as a result of natural leaching from mineral deposits or from different land uses (NHMRC & NRMMC 2011). 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 (such as fuels and 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, septic systems, and faecal matter from domestic or feral animals 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 & NRMMC 2011).

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

Appendix E — How do we protect public drinking water source areas?

The *Australian drinking water guidelines* (ADWG) (NHMRC & NRMMC 2011) outline how we should protect drinking water in Australia. The ADWG recommends a 'catchment to consumer' framework that uses an approach based on preventing risks and multiple barriers. 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 the taps in your home. It ensures a holistic assessment of water quality risks and solutions to ensure the delivery of a reliable and safe drinking water to supply your home.

An approach based on preventing risks means that we look at all the different risks to water quality. We determine what risks can reasonably be avoided and what risks need to be minimised or managed to protect public health. 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 public drinking water source area (PDWSA) (the area from which water is captured to supply drinking water). 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, disinfecting the water (for example chlorination to inactivate pathogens), maintenance of pipes and testing of water quality. Another community benefit from PDWSA protection is that it complements the state's 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 by protecting water quality now and for the future.

In Western Australia, the Department of Water and Environmental Regulation protects PDWSAs by implementing the ADWG, writing reports, policies and guidelines, and providing input into land-use planning.

This drinking water protection report achieves elements 2 and 3 of the 12 elements in the ADWG recommended for protecting drinking water. It shows the PDWSA's location, its characteristics, existing and potential water quality contamination risks, and makes recommendations to deal with those risks.

The *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* and the *Country Areas Water Supply Act 1947* 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. The department works

cooperatively with other agencies and the community to implement this legislation and develop drinking water source protection reports. For example, the Western Australian Planning Commission has developed a number of state planning policies to help guide development in public drinking water source areas.

An important step in maximising the protection of water quality in PDWSAs is to define their boundaries, priority areas and protection zones to help guide land-use planning and to identify where legislation applies. There are three different priority areas. The objective of priority 1 (P1) areas is risk avoidance – ensuring there is no degradation of the water quality (for example over Crown land). The objective of priority 2 (P2) areas is risk minimisation – maintaining or improving water quality (for example over rural-zoned land). The objective of priority 3 (P3) areas is risk management – maintaining the water quality for as long as possible (for example, urban- or commercial-zoned land). Protection zones surround drinking water abstraction bores and surface water reservoirs so that the most vulnerable areas are protected from contamination.

With 129 proclaimed PDWSAs across Western Australia, the department prioritises the update of drinking water source protection reports (such as this document). Our aim is to update each report every seven years. In some locations, more frequent updates may be required to address changing water quality risks and land uses. These updates allow us to make changes to the PDWSA boundary, priority areas and protection zones if required. They also allow solutions to new water quality risks to be considered.

There are three different types of drinking water source protection report – each providing for different needs. The following table shows the differences between the types of reports.

There is a fourth type of report – land use and water management strategy – that performs the same functions as a drinking water source protection report. However, these strategies are prepared by the Western Australian Planning Commission (with input from the Department of Water and Environmental Regulation) and are strategic documents that integrate land use planning with water management. There are currently land use and water management strategies for Gnangara, Jandakot and Middle Helena.

If you would like more information about the ADWG and how we protect drinking water in Western Australia, visit http://drinkingwater.water.wa.gov.au or refer to our Water quality protection note (WQPN) no. 36: *Protecting public drinking water source areas*. You can also contact our Water source protection planning branch on +61 8 6364 7600 or email drinkingwater@dwer.wa.gov.au.

Drinking water source protection reports produced by Department of Water and Environmental Regulation

Drinking water source protection report	Scope and outcome	Consultation	Time to prepare	Implementation table	Proclamation
Drinking water source protection assessment (DWSPA)	Desktop assessment of readily available information.	Targeted	Up to 3 months	No	Proclamation to protect water quality and guide land use planning can occur as a result of any type of drinking water source protection report.
Drinking water source protection plan (DWSPP)	Full investigation of risks to water quality building on information in the DWSPA.	Public	6–12 months	Prepared from recommendations in the DWSPA and/or information from public consultation.	
Drinking water source protection review (DWSPR)	Review change in land and water factors and implementation of previous recommendations. Sometimes prepared to consider specific issues in a PDWSA.	Key stakeholders	Up to 3 months	Prepared from recommendations in the DWSPA or DWSPP.	

Appendix F — Understanding risks to drinking water quality

The existing integrated land use planning and public drinking water source protection program is based on the findings of three separate parliamentary committee reports in 1994, 2000 and 2010 (see Further reading). These findings resulted in the development of the *Jandakot land use and water management strategy* in 1995 and the *Gnangara land use and water management strategy* in 2001. Since 1995, this integrated program has resulted in the development of four Western Australian Planning Commission state planning policies. These state planning policies recognise the importance of public drinking water source areas (PDWSAs) for the protection of water quality and public health.

This integrated program relies upon an approach based on preventing risks in each PDWSA through the development of drinking water source protection reports. It is important to understand how risks are assessed to appreciate the impact of development within PDWSAs.

An assessment based on preventive risks is different to a typical risk assessment because it is based on a combination of the *likelihood* that contamination will occur and the *consequence* of a hazardous event occurring (see table below). The type and quantity of contaminants increases with land use intensification as does the likelihood that contamination will occur and the frequency at which contamination occurs. An understanding of this relationship will prevent the common misunderstanding that probability equals risk.

Risk matrix: Level of risk (from the Australian drinking water guidelines *2011)*

Likelihood	**Consequences**				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Moderate	High	Very high	Very high	Very high
Likely	Moderate	High	High	Very high	Very high
Possible	Low	Moderate	High	Very high	Very high
Unlikely	Low	Low	Moderate	High	Very high
Rare	Low	Low	Moderate	High	High

For example, just because a drinking water contamination incident has not occurred for many years (low likelihood) does not mean that the risk of land use intensification is low, because you also need to consider the consequence when determining risk. Further, no detection of contamination is not proof that development is acceptable.

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
GDE	groundwater-dependent ecosystem
HAZMAT	hazardous materials
kL	kilolitre
LEMC	local emergency management committee
mg/L	milligram per litre
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	nephelometric turbidity units
P1, P2, P3	priority 1, priority 2, priority 3
PDWSA	public drinking water source area
PSC 88	Public sector circular number 88
WAHMEMS	Western Australian hazardous materials emergency management scheme (old name for Westplan–HAZMAT)
Westplan–HAZMAT	Western Australian plan for hazardous materials
WHPZ	wellhead protection zone
WQPN	water quality protection note

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, for example appearance, taste and odour (NHMRC & NRMMC 2011).
Allocation	Is the volume of water that a licensee is permitted to abstract, usually specified in kilolitres per annum (kL/a).
Anisotropic	Having different properties in different directions. For example, an aquifer with variations in hydraulic conductivity horizontally and vertically, or different grain sizes in all directions.
Aquifer	An aquifer is a geological formation or group or formations able to receive, store and transmit significant quantities of water.
Australian drinking water guidelines	The *National water quality management strategy: Australian drinking water guidelines 6*, 2011 (NHMRC & NRMMC 2011) (ADWG) outlines acceptable criteria for the quality of drinking water in Australia (see this plan's References).
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 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.
Drinking water source protection report	A report on water quality hazards and risk levels within a public drinking water source area; includes recommendations to avoid, minimise, or manage those risks for the protection of the water supply in the provision of safe drinking water supply.
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.

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 2011).
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.
Hydrology	The science dealing with water on the land, including such things as its properties, laws and geographical distribution.
Interbedded	Layers between, or alternating with, other layers of differing geological character.
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 something (such as salinity) in a solution.
Nutrients	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.
Pathogen	A disease-producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as *Escherichia coli*), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses.
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	The area from which water is captured to supply drinking water. It includes all underground water pollution control areas, catchment areas and water reserves constituted under the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* or the *Country Areas Water Supply Act 1947*.
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.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.
Unconfined aquifer	An aquifer in which the upper surface of water is lower than the top of the aquifer itself. The upper surface of the groundwater within the aquifer is called the watertable. This is also known as a superficial aquifer.
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* or the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* for the purposes of protecting a drinking water supply.
Watertable	The upper saturated level of the unconfined groundwater 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 is usually declared around wellheads in public drinking water source areas to protect the groundwater from immediate contamination threats in the nearby area.
Western Australian hazardous materials emergency management scheme (WAHMENS)	This is now known as Westplan–HAZMAT.

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