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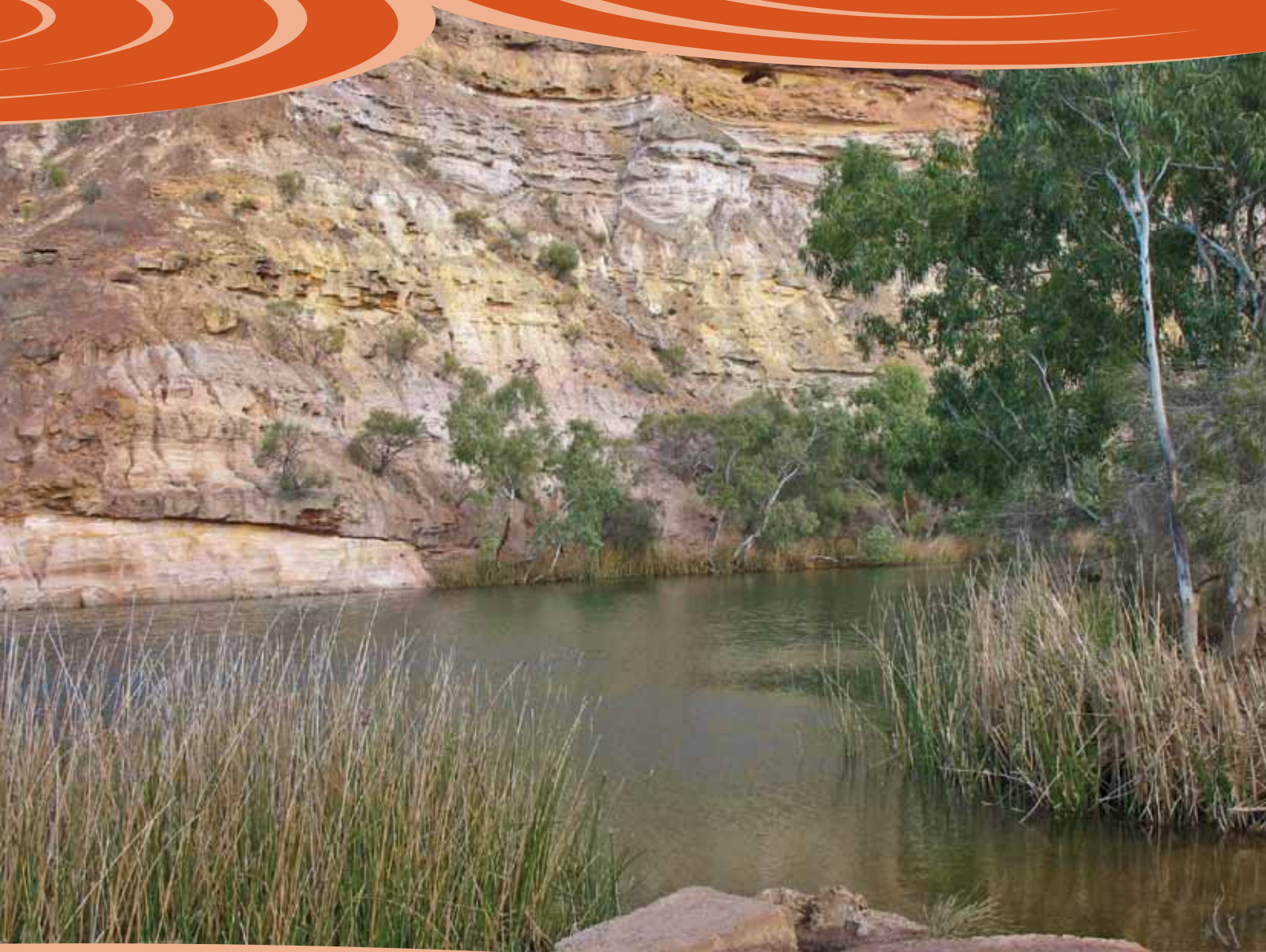
Department of **Water**



Looking after all our water needs

Capacity of water resources in the Mid West to meet mining and industrial growth

Hydrogeological record series

Report no. HG55
December 2011

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A status report –
Addendum to *Mid West Minerals Province – groundwater resource appraisal*

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Department of Water

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December 2011

ISSN 1329-542X (print)
ISSN 1834-9188 (online)

ISBN 978-1-921992-12-4 (print)
ISBN 978-1-921992-13-1 (online)

Acknowledgements

The Department of Water would like to thank the following for their contribution to this publication: Katherine Bozanich, Fleur Coaker, Craig Scott, Natalie Lauritsen, Seth Johnson, Lazarus Leonhard, Rebecca Palandri, Liz Western, Adam Maskew, Susan Worley and Patrick Sears.

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Cover photograph: Ellendale Pool, Ellendale WA (Department of Water)

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Summary

This report is an addendum to the hydrogeological record series report *Mid West Minerals Province – groundwater resource appraisal* (HG 17) published in 2006 as part of the Mid West regional minerals study. This addendum summarises current information on the availability of water resources in the Mid West, in the context of expected mining and industrial growth in the region. Specifically, at the time HG 17 was produced, gold mining was the major use of water in the area. The Mid West is now experiencing a shift towards mining other minerals including iron ore. Water requirements (volume and quality) vary depending on the target mineral and amount of processing required. This report updates HG 17 on the types of minerals mining in the area and their water requirements.

The Mid West groundwater resources within the East Murchison, Gascoyne and Arrowsmith groundwater areas (GWAs) will be the main source of water for future growth. These GWAs have complex and varied hydrogeological characteristics resulting in variable water quality and quantity. Potentially these water resources can meet the expected demands of mining and industrial projects proposed for the region, of those currently known to the Department of Water.

Growth within the mining and industrial sectors is estimated to increase current water demand by approximately 97 GL/yr within the next 10 years. Yet it is anticipated this volume will be greater, given that water requirements for many proposed projects remain unknown.

The most significant growth in water use from current levels is expected to be associated with the iron ore industry, attributed to an increase in the number of operational projects, iron ore production and the need for larger quantities of water for magnetite mining. This increase is expected to be 62 GL/yr. Four proposed uranium projects would require a combined total of approximately 10 GL/yr if approved, and water use by the coal mining industry is also anticipated to significantly increase from current levels if proposed projects proceed.

Water demand from industry is expected to increase by a minimum of 6 GL/yr – attributed to several proposed power projects and the Oakajee Port and Rail Project. Based on initial discussions with Landcorp about water demand for the Oakajee Industrial Estate, this figure is expected to rise significantly.

Mining and industry proponents need to recognise that accessing a suitable water resource is often complex and can involve a high level of investigation. A range of factors need to be considered including fit-for-purpose water use and low-water-use solutions for processing and transport options. This should be done in the early stages of planning. The department should be contacted early in the planning stage to help identify water planning options.

One of the biggest challenges facing the region is finding large yields of fresh groundwater in the Murchison Minerals Province. Current investigations in these and other areas will improve understanding and information available for water resource

management. In addition, further water supply and demand planning in the Mid West will enable the department to manage these resources effectively into the future.

Three mining projects are sourcing water outside their immediate lease areas as water yield and quality onsite are poor. Extension Hill Pty Ltd and Karara Mining Limited are within the northern agricultural area and the Crosslands Resources Limited is in the pastoral area. The Crosslands proposal is under assessment. All other projects are able to source water within their mining lease areas.

There are only two projects sourcing water within the Arrowsmith GWA for use outside the management area. Demand for water between competing water use sectors remains low. Groundwater is available for projects of any nature, including those related to mining, industry or agriculture, which are presented to the department and meet the licence assessment process. Applications for groundwater are currently managed under the department's first-in first-served policy. This policy (among others) is being reviewed as part of the state's water reform agenda.

1 Purpose of this report

This report is an addendum to the *Mid West Minerals Province – groundwater resource appraisal* (HG 17) completed in 1999 as part of the Mid West regional minerals study. HG17 provides an overview of groundwater occurrence, potential yield, quality and use of groundwater resources in the Mid West, with a particular emphasis on the mining industry. Specifically, at the time HG 17 was produced, gold mining was the major use of water in the area. The Mid West is now experiencing a shift towards mining other minerals including iron ore. Water requirements (volume and quality) vary depending on the target mineral and amount of processing required. This report updates HG 17 on the types of minerals mining in the area and their water requirements.

This addendum summarises current information on the availability of water resources in the Mid West, in the context of expected mining and industrial growth in the region. The report describes the various water resources and how the Department of Water currently manages them. Current and proposed demand for water by mining and industry is examined and a summary of existing and future studies into water resources in the region is also provided.

The department also recognises the potential growth in demand for water from the agricultural sector. The water availability figures provided are available for licensing to all prospective projects, whether mining, industry or agriculture. We are working with other state agencies, particularly the Department of Agriculture and Food, to examine water demand in relation to future agricultural development in the region.

This report only covers the mining and industrial projects within the Mid West Development Commission boundary. However, the *Mid West water supply plan*, currently in preparation, will expand on this information by including all water use industries potential future water requirements and include the Jurien groundwater area.

1.1 Study area

For consistency purposes in this report, the Mid West has been defined using the boundary set by the Mid West Development Commission. This boundary is shown in Figure 1.

The Department of Water's Geraldton office manages licensing in all shires within this boundary with the exception of the Shire of Wiluna and the Shire of Sandstone. These two shires are managed by our Swan Avon Region but have been included in this study.

The Jurien groundwater area (GWA) falls outside the Mid West's southern boundary, as described in this report. Therefore we have not referred to projects or water availability figures in this GWA.

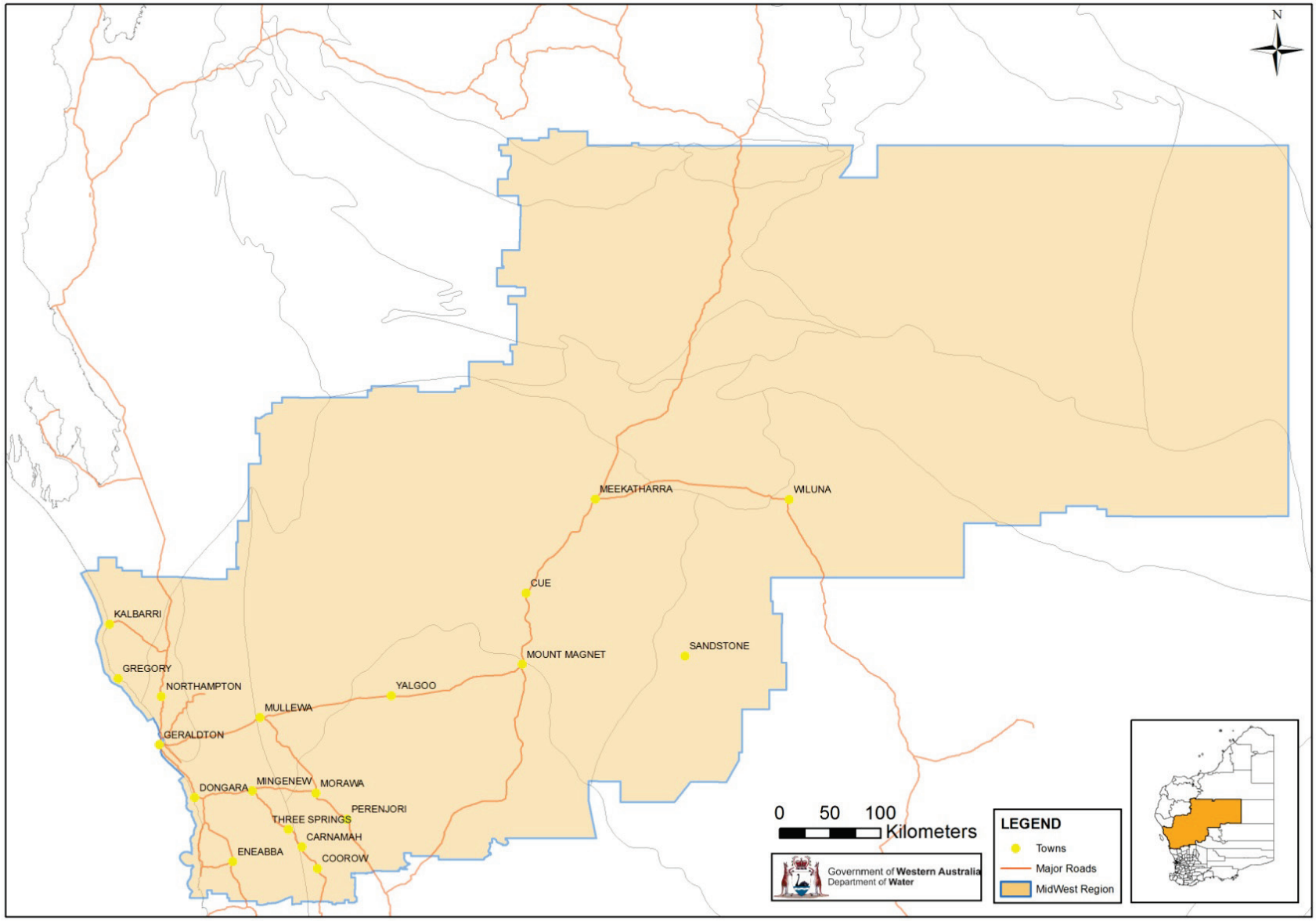

Figure 1 Location – Mid West boundary

2 Mining and industry overview

Mining is becoming an important water use sector in the Mid West for a variety of mineral resources. These include mineral sands, gold, copper, zinc, iron ore and gas, each with the potential for further industrial processing within the region.

The gross regional product (GRP) of the Mid West in 2008–2009 was $4100 million, which accounts for 2.4 per cent of the state's total. Mining is the biggest contributor to the Mid West's GRP, accounting for $2200 million or approximately 53 per cent of the total GRP. The second-biggest industry in the region is agriculture, accounting for about 11 per cent of total GRP (DSD 2010).

The value of minerals and petroleum in Western Australia in 2009 totalled $61 billion, with the Mid West accounting for four per cent of this. Gold is the biggest contributor in the Mid West (38 per cent), followed by copper, lead and zinc (16 per cent) and nickel, cobalt and talc (15 per cent) (DSD 2010).

The iron ore sector is an emerging industry in the region, with potential iron ore production expected to exceed 100 Mtpa by 2017. Iron ore operations rely on a water supply for mining and processing activities, which in the Mid West is currently sourced from groundwater.

To date, water demand from the mining industry has been largely confined to inland gold and base metal projects and coastal mineral sands operations. Water demand was comfortably met by local water resources. In recent years, widespread development of existing and proposed iron ore mines, in particular, has placed increasing pressure on and competition for groundwater resources.

This surge in water demand can be attributed to a proposed increase in the mining of magnetite ore bodies. Magnetite ore requires processing and refinement before export; haematite ore only requires crushing. The proposed iron ore operations involving magnetite ore have much larger water requirements. For example, a single project could require up to 37 GL/yr.

Large quantities of water may also be required for a range of industrial uses associated with the Oakajee Industrial Estate, north of Geraldton. With limited quantities of water available at the project location, water resources may need to be sourced further afield.

See Section 5 for an outline of existing and proposed projects in the Mid West expected to require access to water resources.

3 Water resources

Sporadic, inconsistent rainfall and the lack of divertible surface water resources means the Mid West largely depends on groundwater for its water requirements. Groundwater resources in the region fall into broad provinces: the Perth and Carnarvon sedimentary aquifer basins, and the inland fractured-rock areas such as the Yilgarn-Murchison and Yilgarn-Southwest provinces – as shown in Figure 2.

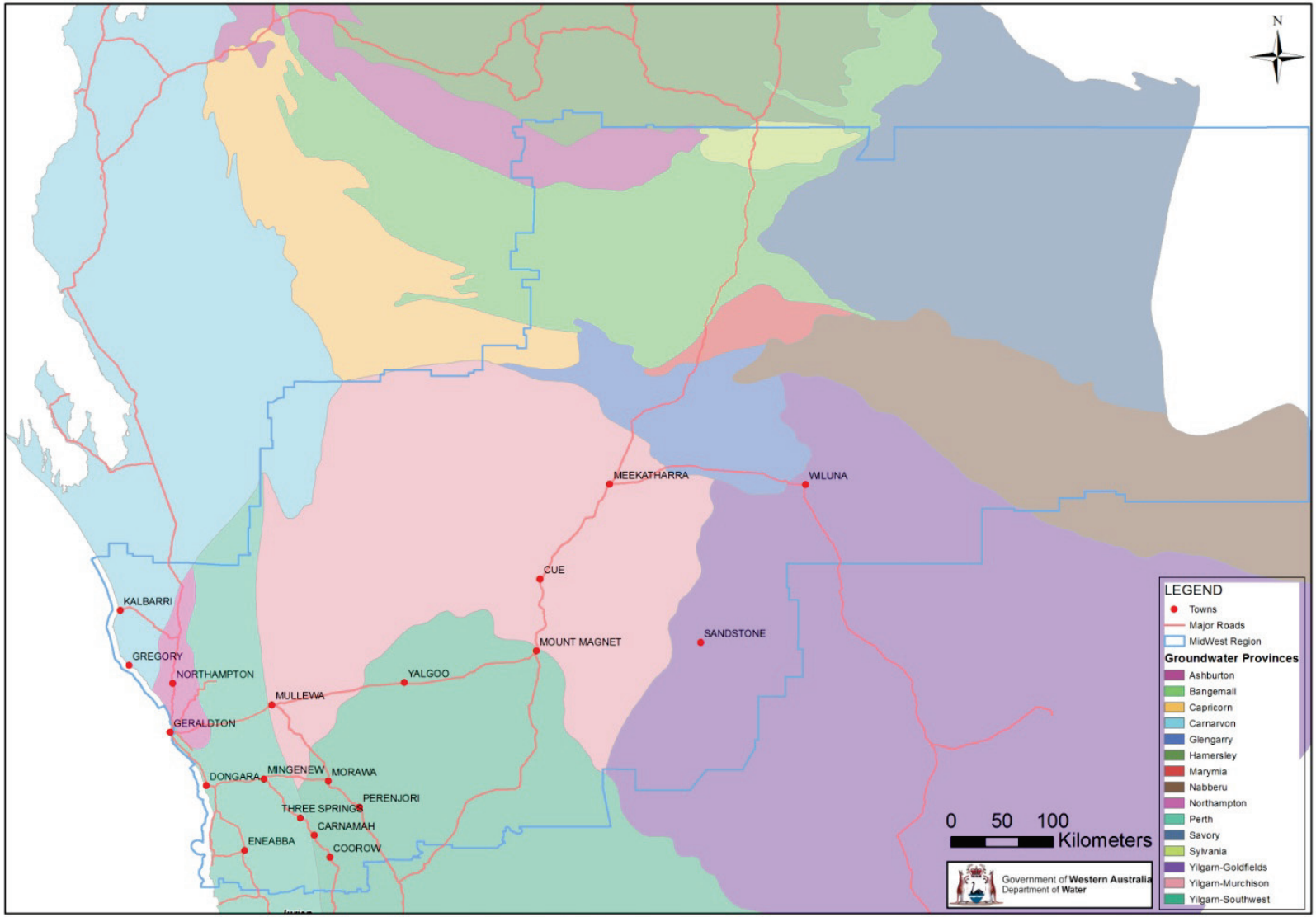

Figure 2 Groundwater provinces

3.1 Northern Perth Basin

The northern part of the Perth sedimentary basin is referred to as the Northern Perth Basin (NPB) and extends from Geraldton in the north to Muchea in the south and as far east as Watheroo and Moora. The Darling Fault (north of Gingin) and the Urella Fault (north-east of Eneabba) mark the basin's eastern boundaries.

The major unconfined aquifer system of the NPB is the superficial aquifer that occurs along the Swan Coastal Plain. The major confined aquifers of the NPB include the Leederville-Parmelia, Yarragadee and Lesueur aquifers.

The Yarragadee Formation forms an extensive aquifer of the NPB and contains large volumes of fresh to brackish groundwater. The formation is up to 3000 m thick and underlies most of the NPB.

The largest low-salinity groundwater resources in the Mid West are located in the NPB between Eneabba and Allanooka. As part of the State Groundwater Investigation Program, the Department of Water is researching the water quality, recharge and supply characteristics of the Yarragadee Aquifer in the Allanooka and Casuarinas subareas. Results of this investigation will indicate whether additional water can be made available for licensing in the future.

Groundwater-dependent ecosystems (GDEs) are located throughout the NBP. Based on our current understanding of the area's hydrogeology, the important GDEs requiring careful consideration and impact management provisions are:

- wetlands, native vegetation, river baseflow and cave systems on the Swan Coastal Plain, where the superficial aquifer occurs
- wetlands, native vegetation and river baseflow systems on parts of the Leederville-Parmelia Aquifer, particularly along the Dandaragan Scarp
- River baseflow systems, including the Irwin, Arrowsmith and Moore rivers, and some wetlands on parts of the Yarragadee Aquifer.

The department is undertaking further investigations to improve our understanding of the relationships between hydrogeological processes and GDEs (see Section 7). Information from this project will enable us to identify and manage potential impacts to GDEs from current and future groundwater abstraction.

3.2 Carnarvon Basin

Groundwater resources located north of Geraldton are principally sourced from the Birdrong and Tumblagooda Sandstone aquifers underlying most of the Carnarvon Basin. These are brackish to saline subartesian to artesian aquifers used primarily for stock water and to a lesser extent town water supply and mineral sands development. The mineral development industry in cooperation with the department has been evaluating the occurrence of groundwater resources within saturated Permian / Silurian sandstone units across the eastern and southern extent of the Carnarvon Basin.

3.3 Inland fractured rocks: Yilgarn

Most of the groundwater in the Yilgarn-Southwest and Yilgarn-Murchison groundwater provinces is drawn from fractured-rock aquifers. Groundwater quality and quantity can vary significantly from one location to another in these aquifers. Groundwater is also abstracted from borefields in alluvium and localised calcrete aquifers located within the fractured-rock provinces.

In contrast to the Northern Goldfields region, there are few borefields developed in the palaeochannel aquifers of the upper Murchison and Gascoyne river systems. The characteristics of these aquifer systems have not been evaluated in detail, however recent investigations by Geoscience Australia into the Murchison palaeochannels show these aquifer systems are very different to those of the Goldfields region. There is substantially less plasticine, lacustrine clay within the sedimentary sequence of the Murchison palaeovalleys and noticeably increased amounts of sand and gravel (English & Johnson 2010). The Murchison palaeovalleys are two to three times deeper than their counterparts in the southern Yilgarn (English & Johnson 2010).

Future water demand for projects will largely be met by groundwater within the most prospective palaeovalley sediments, which is contrary to previous and current groundwater development in the region that has focused on either shallow alluvial- colluvial or valley calcrete aquifers (English & Johnson 2010).

4 Water resource management

The use of groundwater is regulated under the *Rights in Water and Irrigation Act 1914* (WA). All the Mid West's groundwater resources are regulated under this Act and the Department of Water provides access to water by granting licence entitlements. The Mid West currently has more than 800 licensed groundwater users.

The department manages the groundwater resource, assesses licence applications and allocates licence entitlements consistent with legislation, state-wide strategic and operational licensing policies and applicable water allocation plans (see Table 1).

Proponents are encouraged to consider water issues in the early stages of project development and to contact the department to help with this. Some aspects that should be considered by proponents include:

- low-water-use solutions in processing and transport options (including dry tailings and carting magnetite via rail instead of slurry pipeline)
- fit-for-purpose water use options or the use of desalinated groundwater
- investigating the suitability of local water resources in the Gascoyne and East Murchison GWAs
- opportunities for recycling water within the operation
- improving water efficiency throughout the project.

Applications for groundwater may require a hydrogeological investigation, consistent with *Operational policy no. 5.12 – Hydrogeological reporting associated with a groundwater well licence* (DoW 2010), before the licence can be issued.

The department also provides a parallel processing approach in cases where proponents require approvals from other departments and agencies.

We undertake hydrogeological investigations and planning in areas where there is existing or predicted demand for water resources. Groundwater investigations are being undertaken in the Allanooka and Casuarinas subareas to determine the Yarragadee Aquifer's water quality, recharge and supply characteristics. Hydrogeological investigations are also being undertaken in the Northern Perth Basin and the Murchison region (see Section 7).

Table 1 Legislation, policy and plans to manage groundwater resources

Name	Type
Rights in Water and Irrigation Act 1914	Legislation
Rights in Water and Irrigation Regulations 2000	Legislation
Arrowsmith groundwater allocation plan, August 2010	Plan
Carnarvon Artesian Basin groundwater management plan, 2007	Plan
Operational policy no. 5.11 – Timely submission of required information, 2009	Policy
Operational policy no. 5.12 – Hydrogeological reporting associated with a groundwater well licence, 2009	Policy
Operational policy no. 5.13 – Water entitlement transactions, 2009	Policy
Operational policy no. 1.2 – Policy on water conservation and efficiency plans, 2009	Policy
Operational policy 5.08 – Use of operating strategies in the licensing process, 2011	Policy
Statewide policy 9 – Water licensing – Staged developments, 2003	Policy
Statewide policy 11 – Management of unused licensed water entitlements, 2003	Policy
Hydrogeological record series HG17: *Mid West Minerals Province – groundwater resource appraisal*	Guideline
Pilbara water in mining guideline, 2009	Guideline

4.1 Groundwater management areas

The department manages groundwater resources using defined groundwater management areas (GWAs). These GWAs are then divided into groundwater subareas primarily for licensing purposes. The Mid West contains the Arrowsmith, East Murchison and Gascoyne GWAs. Figure 3 illustrates the location of these areas, while their characteristics are summarised in Table 2.

The large sedimentary aquifers of the Northern Perth Basin, located in the Arrowsmith GWA, provide large quantities of often good quality water. The Arrowsmith GWA is dominated by the Leederville-Parmelia and Yarragadee aquifers. The department manages groundwater in this area through the *Arrowsmith groundwater allocation plan,* August 2010.

The East Murchison and Gascoyne GWAs are dominated by fractured-rock, alluvium, calcrete and palaeochannel deposits. These systems produce groundwater that is variable in quality and quantity. As such, these resources have only notional allocation limits (see Section 4.2).

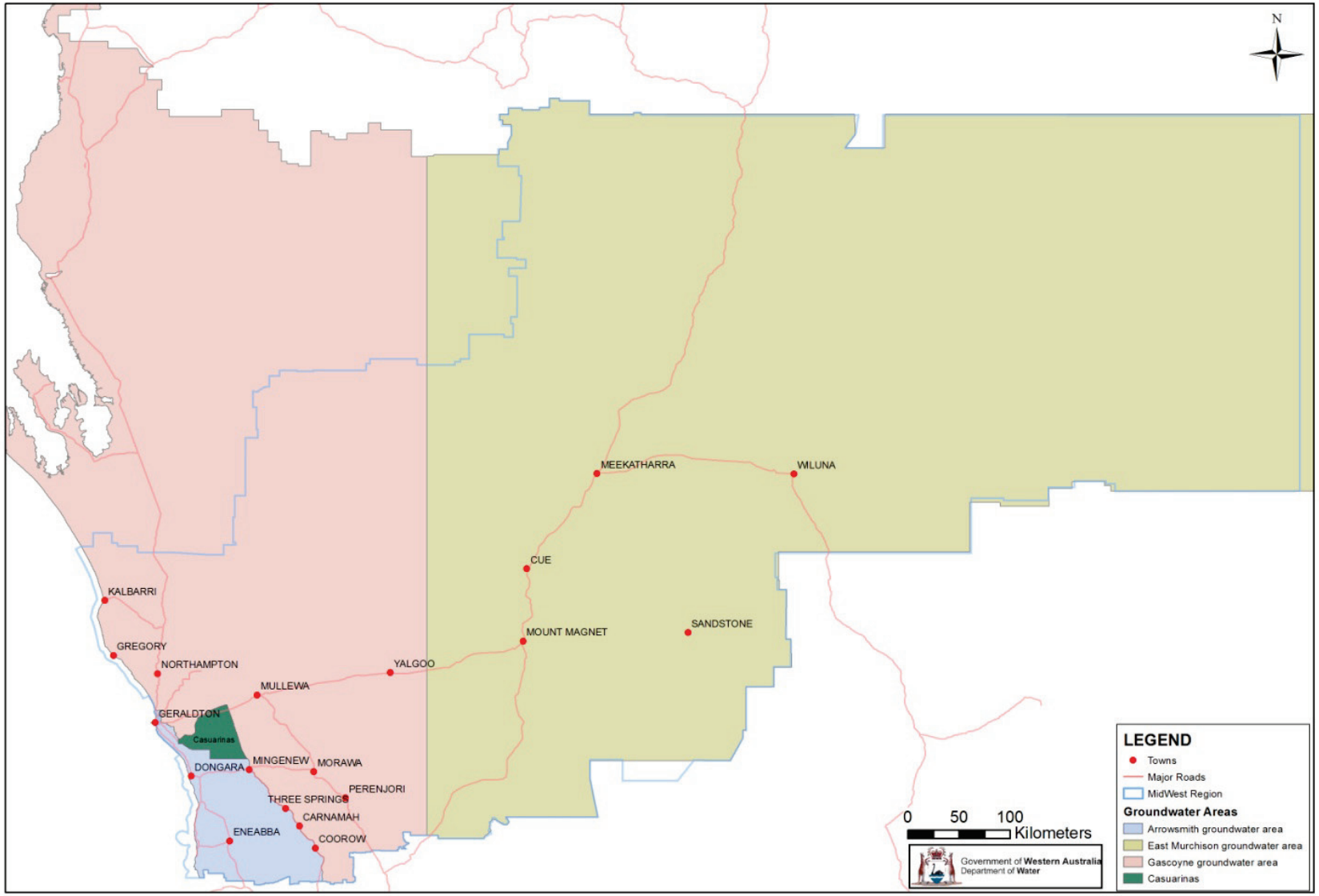

Figure 3 Groundwater management areas

Table 2 Groundwater management area summary

Groundwater area	Subareas	Allocation plan	Groundwater resources	Use
Arrowsmith	Dongara, Eneabba Plains, Allanooka, Twin Hills, Mingenew, Tathra, Morrison and Darling.	*Arrowsmith groundwater allocation plan,* 2010	Perth Basin: seven major sedimentary aquifer systems in combination with minor fractured-rock aquifer systems. They include the superficial, surficial, Cattamarra, Eneabba, Leederville-Parmelia, Lesueur and Yarragadee.	Public water supply, agriculture, horticulture and mining.
Gascoyne	Sixteen subareas, seven within the Mid West: Casuarinas, Kalbarri/Eurardy, Mullewa/Byro, Northampton/Gelena, Talisker/Mia Mia, Yuna/Eradu and Zuytdorp/Ningaloo.	*Carnarvon Artesian Basin groundwater management plan*, 2007	Fractured-rock and palaeochannel aquifers. Water drawn from fractured-rock aquifers can vary widely in terms of yield and quality. Casuarinas subarea being investigated as potentially part of the Perth Basin.	Mining, stock watering and Aboriginal community or town water supplies.
East Murchison	Egerton, Meekatharra and Officer.	No allocation plan for the East Murchison groundwater area.	Fractured-rock and palaeochannel aquifers, alluvium and localised calcrete aquifers. Water drawn from fractured-rock aquifers can vary widely in terms of yield and quality.	Mining, stock watering and Aboriginal community or town water supplies.

4.2 Groundwater availability

The allocation limit is the total amount of water the department sets aside to be used annually from a resource; that is, the consumptive use. In setting allocation limits, the aim is to provide water for consumptive use without causing unacceptable impacts on water quantity and quality, water-dependent ecosystems or existing water users.

The allocation limit includes water:

- that is available for licensing
- we account for that is exempt from licensing
- used under stock and domestic and riparian rights
- set aside for future public water supply.

Water needed for the 'environment' is not included in the allocation limit. This is because this water is left in the system and considered a non-consumptive use. For further information on the setting of allocation limits, refer to *Review of the Jurien and Arrowsmith groundwater allocation limits* (DoW 2009).

Table 3 outlines the allocation limit and the amount of groundwater available in each of the GWAs as of 22 November 2011. The volume of water available for licensing varies as licence entitlements are issued or amended. Water availability is therefore subject to change, so licence applicants are encouraged to contact the department's Mid West Gascoyne Region office in Geraldton for current information.

The allocation limit figure provided for the Gascoyne and East Murchison GWAs is only notional. This is because the aquifer systems in these areas are primarily fractured rock, meaning water yields can vary significantly from one location to another. The department is able to increase this allocation limit if an applicant can demonstrate that groundwater is available and that impacts from its abstraction are acceptable.

In the Arrowsmith GWA the presence of sedimentary aquifers enables more reliable allocation limits to be set, therefore the allocation limit in this case is the total amount of groundwater available for licensing. Once the allocation limit is reached, no more licences are issued.

At present, approximately 348 GL/yr of water is available for future licensing across all of the water resources (aquifers) of the Mid West GWAs. In the Arrowsmith GWA in particular, a total of 68.9 GL/yr of water is currently available to be licensed.

This groundwater is available for projects of any nature, including those related to mining, industry or agriculture, which are presented to the department and meet the licence assessment process. At present demand for water between competing water use sectors remains low. Applications for groundwater are currently managed under the department's first-in first-served policy. This policy (among others) is being reviewed as part of the state's water reform agenda.

Table 3 Allocation limits and available groundwater, GL/yr (22 November 2011)

GWA	Allocation limit	Licensed	Reserved public water	Committed for existing projects	Under assessment	Water available
Arrowsmith	184.8	78.0	18.5	0.03	19.4	68.87
Gascoyne	206.6*	44.0	5.0	19.1	31.9	106.6*
East Murchison	240*	55.5	0	0.6	11	172.9*
Total	**631.4***	**177.5**	**23.5**	**19.73**	**62.3**	**348.2***

** notional figure only*

5 Water demand

Table 4 outlines the existing and proposed mining and industrial projects in the Mid West of which the Department of Water is aware. These projects currently have, or may require access to, water resources in the short to medium term.

Licence applications have not been received for all the projects listed, however in most cases discussions about project water requirements have begun. The department cannot act without licence applications.

A number of additional projects not included in Table 4 have been identified through the Mid West Development Commission or the Department of Mines and Petroleum. These projects are at the very early stages of exploration and any water use demands would be expected in the longer term. These projects include:

- Ferrowest's Yalgoo and Western Hematite projects
- Weld Range Metal's nickel project
- Prairie Down's base metals project
- Encounter Resource's Hillview uranium project
- Impact Mineral's Quinns Lake and Yarrabubba uranium and nickel projects.

Proponents are encouraged to contact the department early in each project development phase to enable a collaborative approach to groundwater investigation. This will greatly assist all parties during the groundwater licence assessment process.

Figure 4 shows where resource projects are located in the Mid West. The majority of the mining projects are located within the pastoral areas and generally source water from the inland fractured rock areas of the Yilgarn province. Only two projects (Extension Hill and Karara) located in these areas are sourcing water in the sedimentary aquifers of the Arrowsmith groundwater area.

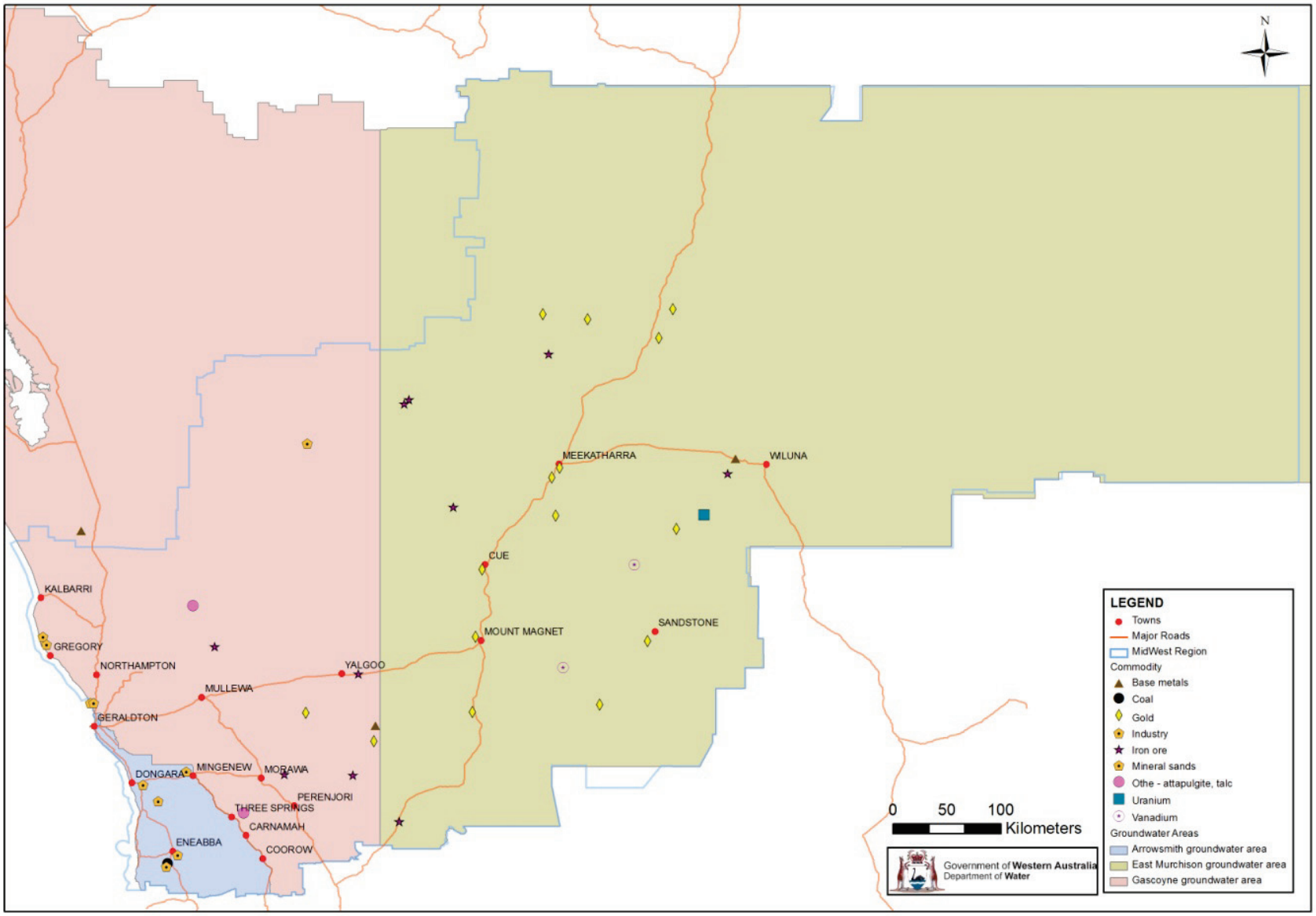

Figure 4 Resource projects in the Mid West

Table 4 Existing and proposed mining and industry projects as of July 2011 requiring water resources

Company	Project name	Commodity	Project status	Groundwater well licence status[1]	Licensed or estimated total annual water abstraction (GL/yr)
Mining					
Hudson Resources Ltd	Lake Nerramyne	Attapulgite	Operational	Licence held	0.01
MMG Golden Grove Pty Ltd	Golden Grove	Base metals	Operational	Licence held	3.66
Magellan Metals Pty Ltd	Wiluna Operations	Base metals – lead carbonate	Operational	Licence held	2.5
Aviva Corporation Ltd	Central West Coal Mine	Coal	Proposed	Under assessment	7.2
Sandfire Resources NL	DeGrussa Copper-Gold Project	Copper and gold	Proposed	Under assessment	1.6
Apex Minerals NL	Wiluna Operations	Gold	Operational	Licence held	5.14
Apex Minerals NL	Gidgee Gold Project	Gold	Care and maintenance	Licence held	2.29
			Proposed for redevelopment	No application received	Will remain at 2.29
Apex Minerals NL	Youanmi Gold Project	Gold	Care and maintenance	Licence held	1.48
ATW Gold Corporation Pty Ltd	Gullewa Gold Mining Project	Gold	Care and maintenance	Licence held	0.15
Jinka Minerals Limited	Burnakura Mine	Gold	Care and maintenance	Licence held	0.6
Big Bell Gold Operations Pty Ltd	Golden Crown Mine	Gold	Care and maintenance	Licence held	1.0
Barrick Gold of Australia Ltd	Plutonic Gold Mine	Gold	Operational	Licence held	9.8
Minjar Gold Pty Ltd	Minjar Gold Project	Gold	Care and maintenance	Licence held	0.8
			Proposed for redevelopment	No application received	Unknown
Murchison Copper Mines Pty Ltd (Horseshoe Metals Limited)	Horseshoe Lights Mine	Gold/Copper	Care and maintenance	Licence held	0.024

Company	Project name	Commodity	Project status	Groundwater well licence status[1]	Licensed or estimated total annual water abstraction (GL/yr)
Grosvenor Gold Pty Ltd	Fortnum Gold Project	Gold	Care and maintenance	Licence held	0.03
GMK Exploration Pty Ltd (Reed Resources Limited)	Bluebird Project	Gold	Care and maintenance	Licence held	3.5
GMK Exploration Pty Ltd (Reed Resources Limited)	Paddy's Flat Project	Gold	Care and maintenance	Licence held	0.5
GMK Exploration Pty Ltd (Reed Resources Limited)	Reedy's	Gold	Care and maintenance	No application received	Unknown
Montezuma Mining Company Ltd	Peak Hill	Gold	Care and maintenance	Licence held	0.03
Mount Magnet Gold NL (Ramelius Resources)	Mount Magnet Gold Project	Gold	Proposed for redevelopment	Licence held	3.7
Mount Magnet South NL	Kirkalocka Project Yalgoo	Gold	Care and maintenance	Licence held	0.165
Navigator Resources Ltd	Bronzewing Gold Project	Gold	Operational	Licence held	3.5
Newmont Australia Ltd	Jundee–Nimary Project	Gold	Operational	Licence held	6.2
Silver Lake Resources Limited	Murchison Goldfields Project	Gold	Proposed	No application received/ In discussions	Unknown
Troy Resources NL	Sandstone Operations	Gold	Care and maintenance	Licence held	5.38
Australian Manganese Pty Ltd (FerrAus Ltd)	Robertson Range	Iron ore – hematite	Proposed	Licence held	0.166
			Future expansion	No application received	2.0
Golden West Resources Ltd	Wiluna West Iron Project	Iron ore – hematite	Proposed	No application received	Unknown
Mount Gibson Mining Ltd	Extension Hill	Iron ore – hematite	Started construction	Licence held	0.5
Mount Gibson Mining Ltd	Tallering Peak	Iron ore – hematite	Operational	Licence held	0.41
Sinosteel Midwest Corporation	Koolanooka/ Blue Hills/	Iron ore – hematite	Operational	Licence held	0.165

Company	Project name	Commodity	Project status	Groundwater well licence status[1]	Licensed or estimated total annual water abstraction (GL/yr)
Ltd	Mungada				
Sinosteel Midwest Corporation Ltd	Weld Range	Iron ore – hematite	Proposed	No application received	6 to 12
Crosslands Resources Ltd	Jack Hills & Jack Hills Expansion Project	Iron ore – hematite and magnetite	Stage 1 – operational	Stage 1 – licence held	Stage 1 – 0.46
			Stage 2 – proposed	Stage 2 – under assessment	Stage 2 – 37
Karara Mining Ltd	Karara Iron Ore Project	Iron ore – hematite and magnetite	Started construction	Licence held	5.0
			Future expansion	No application received	11.2
Sinosteel Midwest Corporation Ltd	Jack Hills	Iron ore – hematite and magnetite	Proposed	No application received	Unknown
Sinosteel Midwest Corporation Ltd	Robinson Range/Peak Hill	Iron ore – hematite and manganese	Proposed	No application received	Unknown
Asia Iron Holdings Ltd (Extension Hill Pty Ltd)	Extension Hill	Iron ore – magnetite	Proposed	Licence held	5.5
			Future expansion	No application received	Unknown
Ferrowest Ltd	Yalgoo Iron Project	Iron ore – magnetite	Proposed	No application received	Unknown
Process Minerals International Pty Ltd	Peak Hill Manganese	Manganese	Operational	Licence held	0.05
Process Minerals International Pty Ltd	Elsa Mary Mine	Manganese	Proposed	Under assessment	1.05
Australian Garnet Pty Ltd (Altura Mining Ltd)	Balline Mineral Sands Project	Mineral sands	Operational	Licence held	1.05
GMA Garnet Pty Ltd	Port Gregory	Mineral sands	Operational	Licence held	0.6
Iluka Resources Ltd	Eneabba	Mineral sands	Existing	Licence held	16
Tiwest Pty Ltd	Dongara	Mineral sands	Proposed	Under assessment	5
BHP Nickel West Pty Ltd	Mt Keith Project	Nickel	Operational	Licence held	7.06

Company	Project name	Commodity	Project status	Groundwater well licence status[1]	Licensed or estimated total annual water abstraction (GL/yr)
Norilsk Nickel Australia (MPI Nickel Pty Ltd)	Honeymoon Well Project	Nickel	Proposed	Licence held	2.21
Luzenac Australia Pty Ltd	Three Springs Talc Mine	Talc	Operational	Licence held	1.5
BHP Billiton Ltd	Yeelirrie Project	Uranium	Proposed	No application received	Up to 5.4
Mega Lake Maitland Pty Ltd	Lake Maitland Uranium Project	Uranium	Proposed	No application received	Up to 2
Nova Energy Ltd	Lake Way/Toro	Uranium	Proposed	No application received	Unknown
Toro Energy Ltd	Wiluna Uranium Project	Uranium	Proposed	No application received	Up to 2.5
Atlantic Ltd	Windimurra Vanadium Project	Vanadium	Proposed	Licence held	3.5
Reed Resources Ltd	Barrambie Vanadium Project	Vanadium	Proposed	Under assessment	3.34
		Industry			
CSIRO	Square Kilometre Array	Radio astronomy	Proposed	No application received	Unknown
Oakajee Port and Rail Pty Ltd	Mid West Rail Infrastructure and Deep Water Port	Transport	Proposed	No application received	Construction – 1.16 for three years Operation – 0.13
Eneabba Gas Ltd	Centauri 1 Gas Fired Power Station and UCG Project	Power generation	Proposed	No application received	Unknown
ERM Power Limited	Three Springs Gas Fired Power Station	Power generation	Proposed	Under assessment	0.30
Aviva Corporation Ltd	Coolimba Power Project	Power generation	Proposed	Under assessment	2.3
Midwest Energy Pty Ltd	200MW Perenjori Solar Thermal Power	Power generation	Proposed	Under assessment	2.5
Landcorp (various proponents)	Oakajee Industrial Estate	Various	Proposed	No application/s received	Unknown

Notes: 1. Refers to groundwater well licences issued for production purposes. Many projects may have licences issued for uses associated with exploration or camp supply but these are not reflected in the table because uses are generally minimal.

5.1 Water demand summary

Water demand for many proposed projects is currently unknown. Even the known water requirements often change as a project evolves through its planning stages. Therefore, it is important to note that the information given in the following section is based on data available to the Department of Water in July 2011 and is subject to change at any time.

Figure 5 illustrates the spread of existing licensed water use across the mining and industrial sectors, current as of July 2011. At present, a total of 94.6 GL/yr is licensed with one hundred of this, licensed to the mining industry. All of the industrial projects listed in Table 4, all are proposed and no water licenses are currently held by this sector.

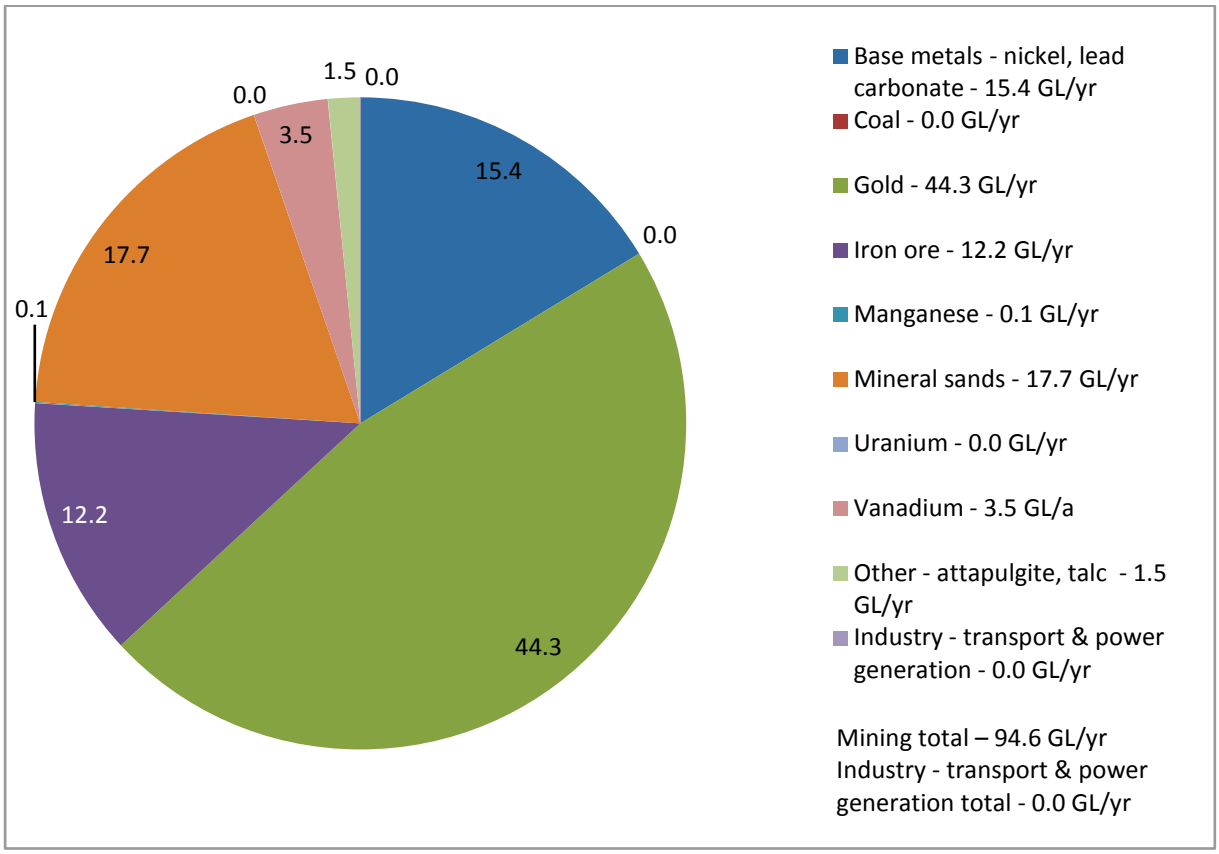

Figure 5 Existing licensed annual water use for mining and industry (GL/yr)

Gold and mineral sands operations have the largest water requirement and are licensed for a total of 44.3 and 17.7 GL/yr of groundwater respectively. The third-most significant user is made up of base metal mining operations, requiring a total of 15.4 GL/yr. The majority (10.5 GL/yr) of the water licensed to iron ore is not yet in use as the two magnetite projects that have not yet started processing magnetite. The remainder of 1.7 GL/yr is licensed to iron ore companies are currently mining direct-shipping hematite ore. Processing requirements for this ore are limited and large amounts of water are not needed.

Figure 6 represents the anticipated demand for water as currently known by the department in July 2011. This additional demand is estimated to be 97 GL/yr.

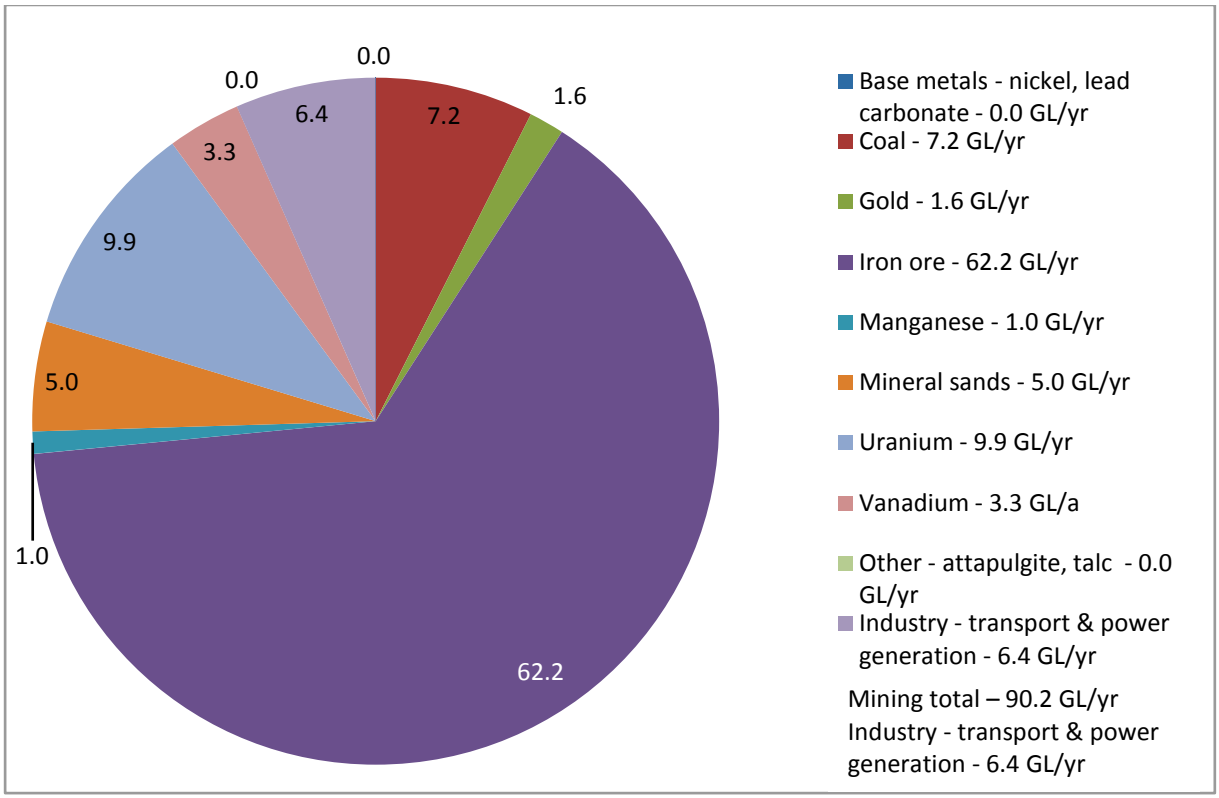

Figure 6 Anticipated water demand for mining and industry (GL/yr)

Figure 6 illustrates the proposed significant increase in water use by the iron ore industry – 62.2 GL/yr. This is attributed to an increase in the number of operational projects, iron ore production and the need for larger quantities of water for magnetite mining.

Four proposed uranium projects would require a combined total of approximately 10 GL/yr, and water use by the coal mining industry is also expected to significantly increase from current levels. This increase is primarily attributed to the proposal for the Central West coal mine near Eneabba. This project requires a total of 7.2 GL/yr.

Water demand from base metal and attapulgite and talc mining operations is not expected to change. However, water demand from industry is expected to increase by a minimum of 6 GL/yr – attributed to several proposed power projects and the Oakajee Port and Rail project. Based on initial discussions with Landcorp about water demand for the Oakajee Industrial Estate, this figure is expected to increase significantly.

This estimation of water demand is considered conservative because, at present, the department is not aware of the water needs of many proposed mining and industrial projects within the Mid West.

Based on this expected demand for water in the future, the anticipated total allocation of water is shown in Figure 7. The projected total amount of water that would be

allocated if all projects proceeded and all groundwater well licences were granted on top of existing use, would be 191.3 GL/yr. Iron ore, gold and mineral sands mining would be the largest water users, with base metal and uranium mining being the second largest users.

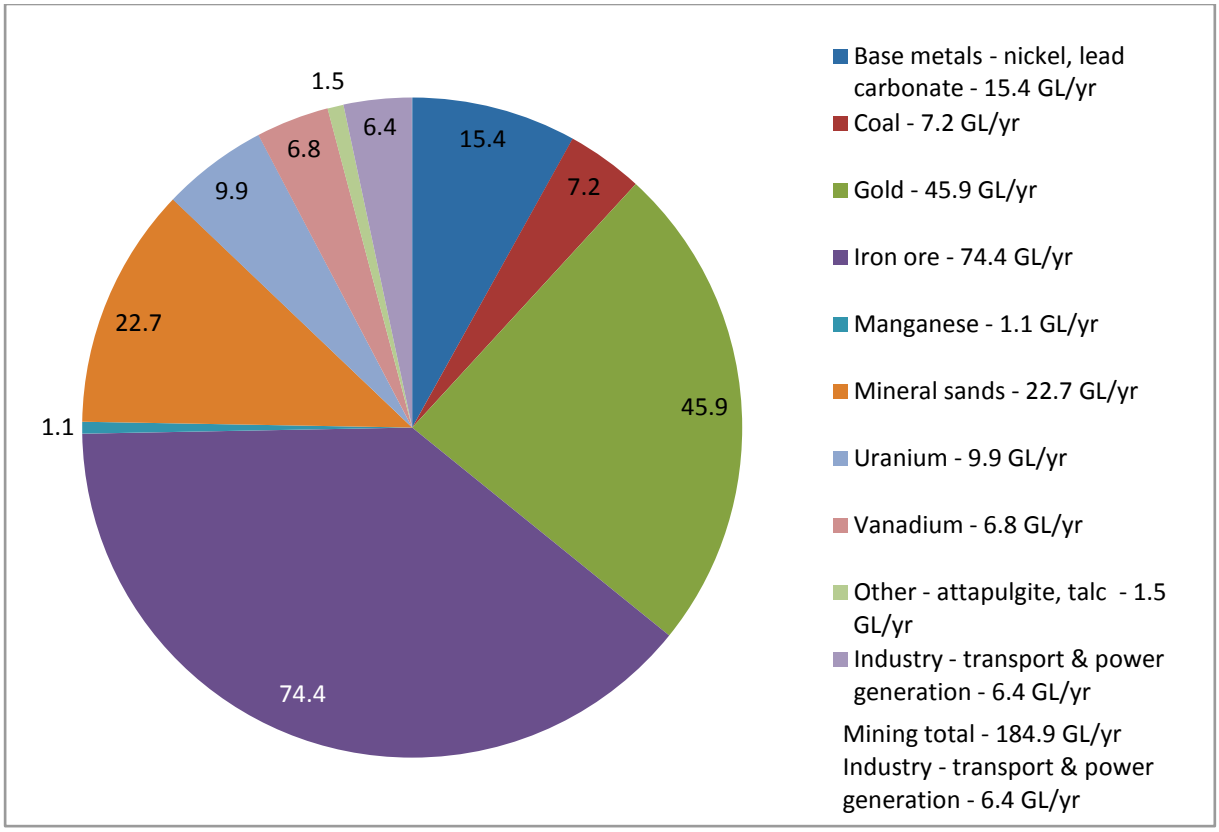

Figure 7 Projected total water use by mining and industry (GL/yr)

5.2 Mining projects

Mid West mining operations are diverse and include a range of commodities:

- gold
- base metals including zinc, copper, nickel and lead carbonate
- heavy mineral sands
- iron ore – hematite
- talc
- attapulgite.

There are new proposals to mine magnetite iron ore, uranium, vanadium and coal.

Gold

Eighteen gold mines in the Mid West are currently licensed for a combined total of approximately 44 GL/yr. At present the gold mining industry has the largest volume of

allocated water, but not all of this water is being used. Figure 8 illustrates that just over 14.8 GL/yr or 30 per cent of the total groundwater allocated to gold mines is being used by operational mines. The remainder is allocated to the 15 mines currently under care and maintenance.

Three projects anticipate re-starting gold mining operations in the short term. These are the Gidgee Gold project operated by Apex Minerals NL, the Minjar Gold project operated by Minjar Gold Pty Ltd and the Mt Magnet Gold project operated by Ramelius Resources. The department is not aware if these projects require increases in current licence allocations before they re-start. The department is also aware of other gold projects looking to restart mining in the short – medium term.

The only new project proposed is Sandfire Resources NL's DeGrussa copper and gold project, whereby development is expected to begin in the second quarter of 2011. This project requires a total of 1.6 GL/yr of groundwater.

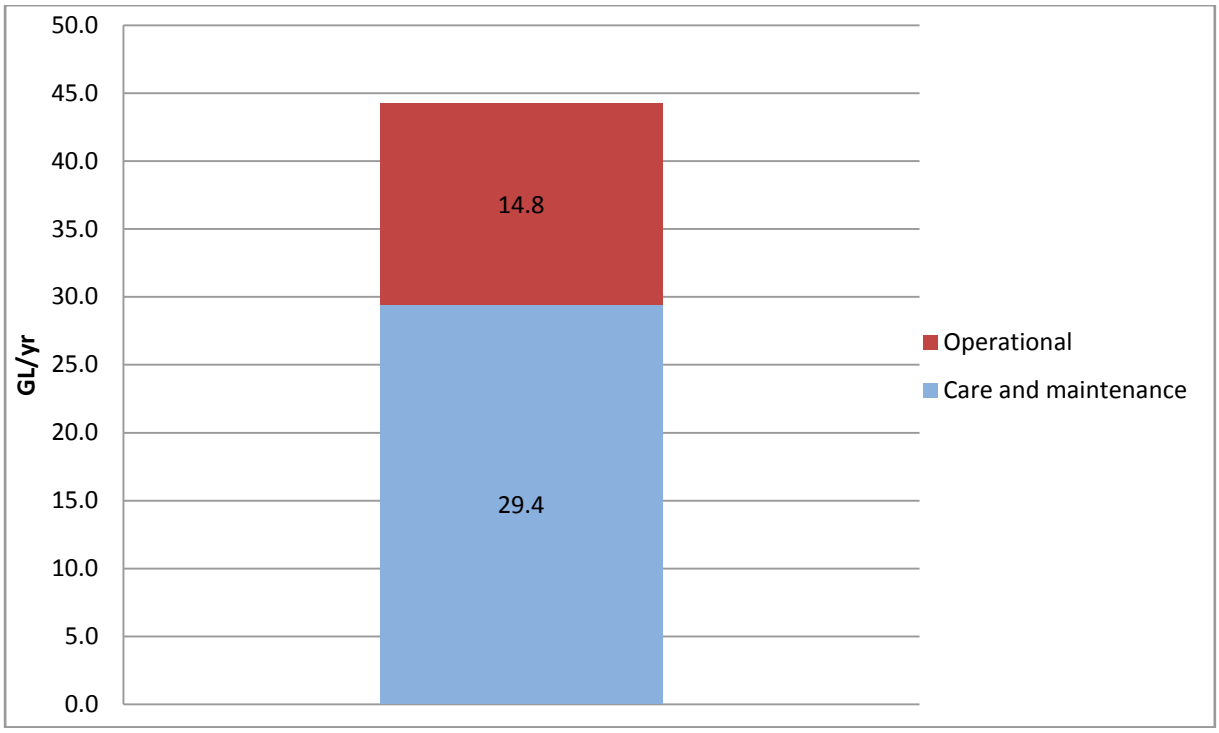

Figure 8 Current use of allocated groundwater by gold mining projects

Base metals

The two base metal projects in the Mid West – MMG Golden Grove and Magellan Metals' Wiluna Operations – are both operational. These projects are licensed to use a combined total of 6.16 GL/yr of groundwater. The department is not aware of any proposed expansion plans for these projects or of any new base metal projects requiring access to additional water resources. The department is aware that MMG has recently commenced an open pit operation, however this has not altered MMG's water requirement.

The nickel mining operations, BHP Nickel West's Mt Keith and Norilsk Nickel Australia's Honeymoon Well mine are also included in the base metal category. These operations hold current groundwater well licences for a total of 9.27 GL/yr.

Norilsk Nickel Australia is focusing on the potential redevelopment of the existing Honeymoon Well project. The project is not currently using its licensed entitlement of 2.21 GL/yr from the East Murchison GWA (licence is held under MPI Nickel Pty Ltd).

Mineral sands

Three mineral sands projects in Mid West are licensed for a total of 17.65 GL/yr of groundwater, as shown in Figure 9. The mineral sands deposits are found within the marine depositional portions of the Arrowsmith and Gascoyne GWAs along the coast.

At present the department is assessing one new licence application from Tiwest Pty Ltd for its proposed operation at Dongara. This project requires a total of 5.0 GL/yr of groundwater from the Arrowsmith GWA. The project has an expected mine life of seven years.

The Iluka Eneabba mineral sands project is managed under a State Agreement, the *Mineral Sands (Eneabba) Agreement Act 1975*. Under this Agreement the department is responsible for providing the required water for the project to Iluka in the form of a groundwater licence.

A recent hydrogeological investigation undertaken by Australian Garnet Pty Ltd, in support of its licence application for the Balline Mineral Sands Project, has found new information not previously recorded by any past study. The study, located in the Gascoyne GWA, found the presence of the Tumblagooda and superficial aquifers and identified that they were able to provide sufficient quantities of water for the project's operation.

This highlights the importance of proponents undertaking hydrogeological investigations in the relevant project locations – to determine the nature of the groundwater resources and to support their application for a groundwater well licence.

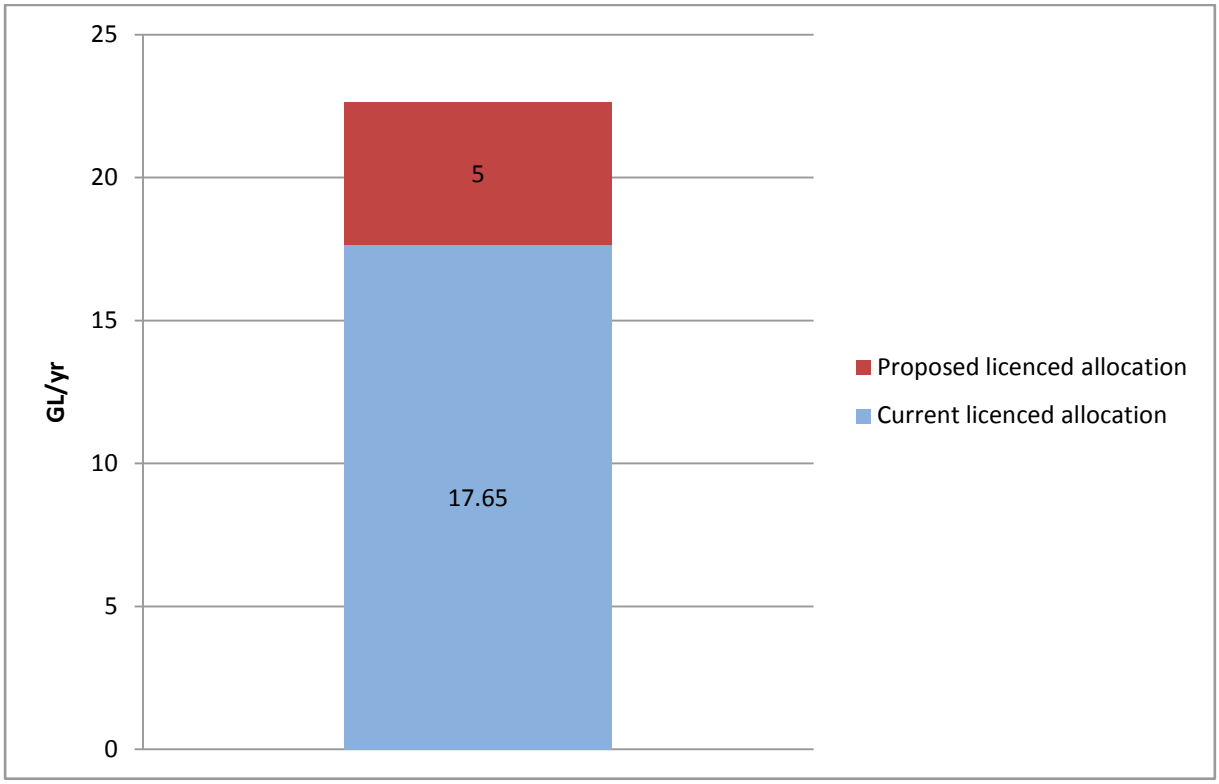

Figure 9 Current licensed use and proposed additional water use: mineral sands operations

Iron ore

Information published by Economics Consulting Services (ECS 2010), as shown in Figure 10, indicates that iron ore production is expected to increase from a current total of 10 Mtpa to more than 100 Mtpa in the next five to 10 years. By 2030, production is estimated to be at 202 Mtpa (ECS 2010).

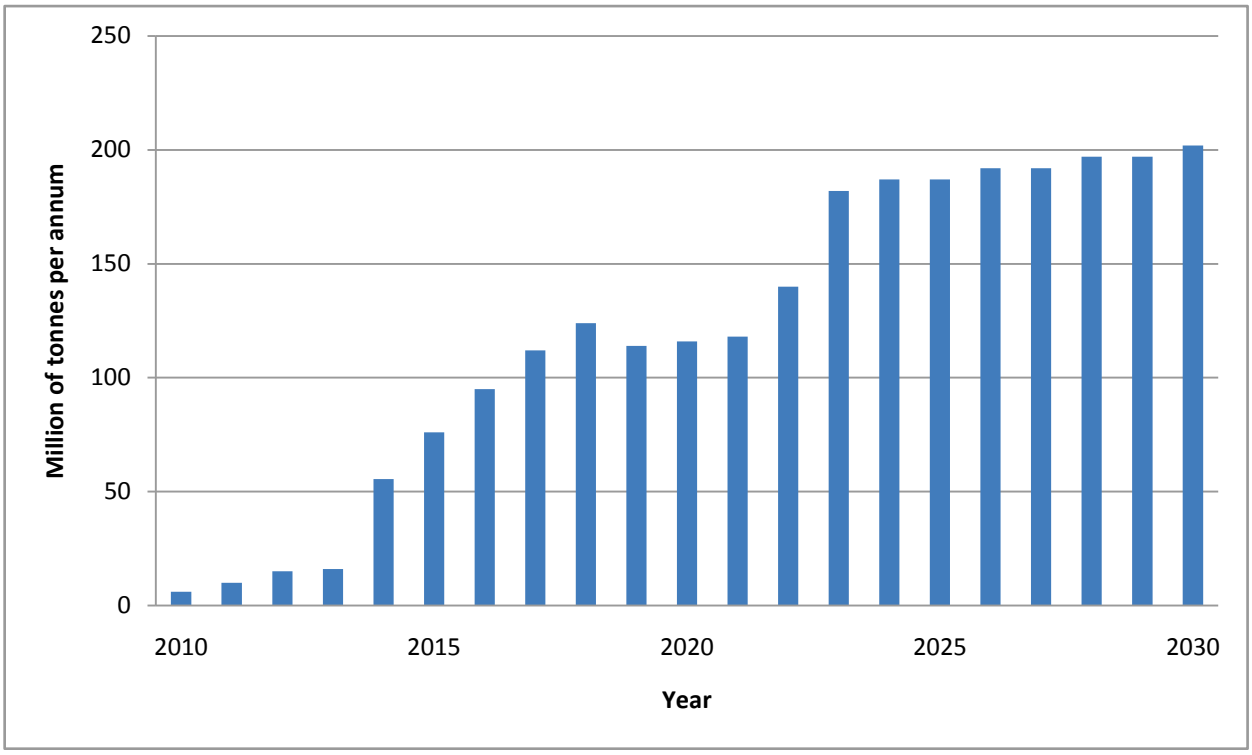

Figure 10 Projected iron ore production from the Mid West (ECS 2010)

Five iron ore projects in the Mid West are currently operational, with an additional eight projects proposed in the short to medium term. Two of the existing projects also have plans for future expansion.

The forecast increase in production is also expected to increase demand for water. This is due to the direct relationship with production increases, as well as the shift from the mining of hematite ore to the mining and exporting of magnetite ore. Based on current figures the iron ore industry will require an additional 72.7 GL/yr of water. But given the absence of water demand figures for many of the proposed projects, this figure is expected to rise. Figure 11 illustrates this anticipated demand on water resources.

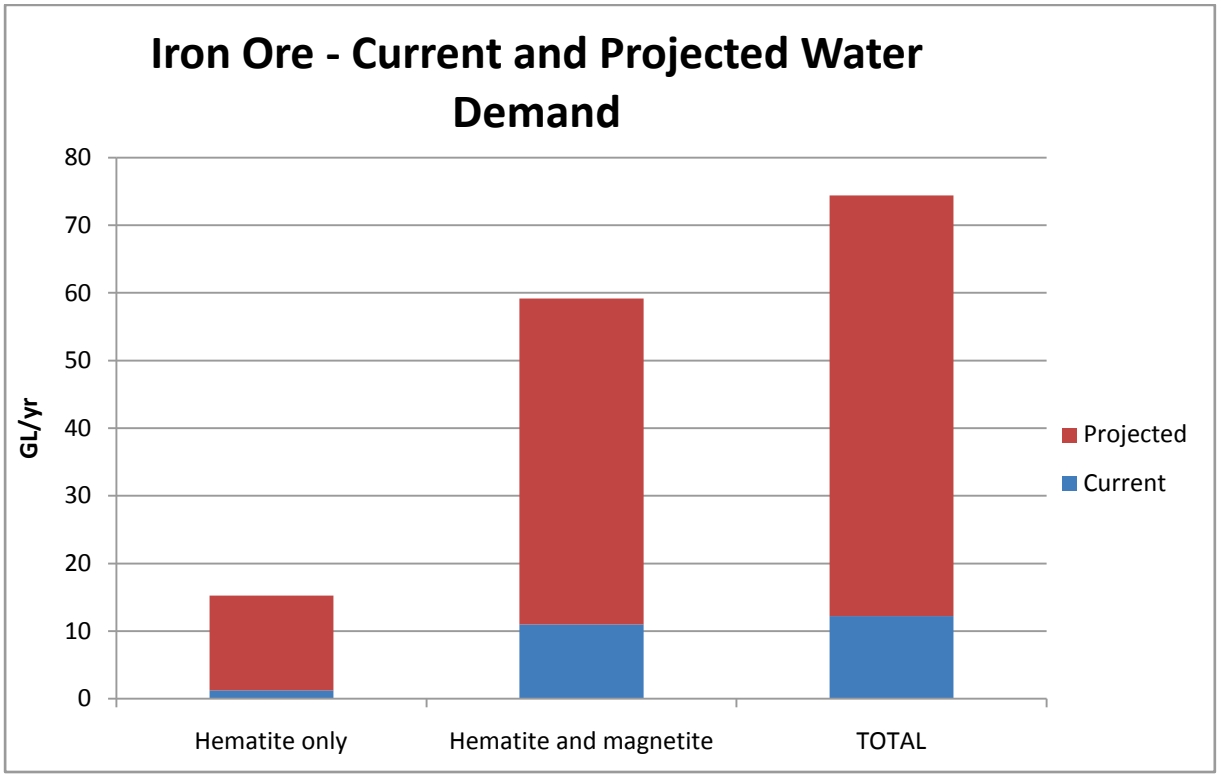

Figure 11 Iron ore – current and projected water demand (GL/yr)

At present hematite is the only type of iron ore mined in the region with mining occurring at Tallering Peak, Jack Hills Stage 1, Koolanooka, Extension Hill. In addition, Karara Mining Limited (KML) recently commenced shipping of hematite from the Karara Iron Ore project. A total of approximately 1.7 GL/yr of water is abstracted by hematite only mining operations. An additional 10.5 GL/yr is currently licensed to projects that will mine both hematite and magnetite however water abstraction is yet to commence.

Hematite ore only requires crushing and dry screening before export, hence these projects only require limited amounts of water for dust suppression and camp purposes. Typically, mining 1 Mtpa of hematite requires 0.1 GL/yr of water. However, this can increase if dewatering is required or if fibrous material is encountered during mining, when additional water for dust suppression will be required.

Magnetite mining projects require larger amounts of water for the process of grinding and magnetic separation and generally this water needs to have a low level of salinity. In some projects, water is also used to transport ore via a slurry pipeline (e.g. from mine to port). In these cases, much of the excess water is recycled into processing and transport streams.

Figure 11 does not accurately reflect the demand for water by the magnetite operations exclusively, because many of the projects are combined hematite magnetite operations. There is only two projects solely targeting magnetite ore and the water requirement for one of these is currently unknown.

Asia Iron's Extension Hill and Karara Mining's magnetite projects intend to extract water from the sedimentary basin in the Arrowsmith GWA and transfer (pipe) the water up to 160 km inland to the mine site. This is because the groundwater available in the fractured-rock aquifer at the mine's location does not provide the quantity or quality of water required for magnetite processing. Groundwater in the Arrowsmith GWA is more favourable in terms of water quantity and quality due to the presence of the sedimentary aquifers. However, these scenarios involving the transfer of water are raising considerable debate within the community, particularly where the availability of water in these areas is limited.

The department manages these instances on a case-by-case basis within the framework of legislation, policy and local groundwater management plans to guide decision making. We require proponents to engage in community consultation to systematically work through the issues raised during the licence assessment process.

Asia Iron's Extension Hill project intends to transport processed magnetite via a slurry pipeline to the Geraldton Port. The ore slurry will be dewatered and the excess water returned to the mine site for re-use. The project's has a licence to draw 5.5 GL/yr of water for stage 1. Stage 2 water requirements remain unknown.

Karara Mining Limited has a licence to draw 5 GL/yr from the Parmelia aquifer from stage 1 water requirements. It is expected this project will require an additional 11.2 GL/yr for future expansion and to meet its water needs for the 30 to 40 year project life.

Sinosteel Midwest Corporation's proposed Weld Range Hematite project requires extensive dewatering of approximately 12 GL/yr to produce 15 Mtpa of ore. It is expected that 3 GL/yr of water will be required for dust suppression and camp supplies, leaving an excess of approximately 8 GL/yr. The quality of this water varies from fresh to hypersaline. Opportunities to re-use this mine dewater need to be further explored and developed. Sinosteel Midwest Corporation has also proposed iron ore operations at Jack Hills and Robinson Range/Peak Hills. The expected water requirements for these operations are currently unknown to the department.

The Crosslands Resources Jack Hills expansion project, with a planned production rate of 35 Mtpa, requires approximately 36 GL/yr of water. For the first five to seven years a combination of hematite and magnetite will be mined. For the next 20 years of the project, only magnetite will be mined. Water will be used for the both magnetite and hematite ores. Initial testing has shown the required volume of groundwater may not be available at the mine site. Therefore Crosslands is exploring for water within a 200 km radius of the site. Although Crosslands plan to construct a water treatment facility to decrease the level of salinity for the final washing, the required tolerance levels for processing is not as low as other projects. This is expected to be the third project to in the region to source water outside the mine site area.

The water quality tolerances vary for the four main projects processing requirements.

The department is aware of three other proposed iron ore projects that have not indicated their expected water use during production. These include one hematite project – Golden West Resources Ltd's Wiluna West Iron project and two magnetite operations – Emergent Resources Ltd's Beyondie Iron project and Ferrowest Ltd's Yalgoo Iron project. However, the department is unaware of the potential requirements of water quality and quantity for these projects.

Coal

No coal mines are currently operating in the Mid West, however Aviva Corporation Ltd is proposing to develop the Central West coal mine near Eneabba. The project would mine and supply approximately 75 million tonnes of subbituminous-grade crushed coal to the proposed Coolimba power station at a rate of 2 to 2.5 Mtpaover 30 years.

The mine would require extensive dewatering to enable access to the coal reserves. On average this is estimated to be 8 GL/yr. It is proposed this volume be supplied directly to the Coolimba power project for cooling purposes. The power station requires additional water to supplement this supply (see Section 5.3). Aviva Corporation has submitted groundwater well licence applications for access to water from the Arrowsmith GWA, for both the coal mine and the power project. The department is currently assessing these licence applications.

Uranium

The Department of Mines and Petroleum (DMP) has identified 27 potential uranium projects in Western Australia, 15 of which are located in the Mid West. Of these, four are in development. These projects are classified as surficial or calcrete-hosted uranium deposits.

Uranium can be mined using traditional techniques such as open pit and underground methods. It can also be mined via a process termed *in situ leaching*, which involves a solution injection onto the ore body (usually an acid or alkaline) to leach the uranium. The leach uranium is then recovered through recovery wells.

The department has not received any groundwater well licence applications for water for the proposed uranium projects in the Mid West, although discussions with project proponents have begun. For the four projects listed in table 4, water use per project is expected to be between 2 and 5.4 GL/yr, which includes the requirement to undertake dewatering during the mining process.

Vanadium

In 2010, Atlantic Ltd consolidated 100 per cent ownership of the Windimurra Vanadium project. The company intends to recommission the project in 2011 with first production expected to begin mid-year. The project holds a groundwater well licence for 3.5 GL/yr in the East Murchison GWA. The licence enables water to be abstracted for dust suppression, mineral ore processing and mining camp purposes.

The other vanadium project in the Mid West is the proposed Reed Resources Ltd Barrambie Vanadium project. The department is currently assessing an application for a groundwater well licence of 3.34 GL/yr. This water is proposed to be abstracted from a fractured-rock and a calcrete resource in the East Murchison GWA.

Other

There is one attapulgite mining operation at Lake Nerramyne, 150 km north-east of Geraldton, and one talc mining operation at Three Springs – which completes the diversity of mining operations in the Mid West. Both of these projects are operational and hold a current groundwater well licence of less than 1.5 GL/yr.

5.3 Major industrial projects

A number of industrial projects are scheduled for the region that will require water resources. These include:

- Oakajee Port and Rail (OPR): Oakajee Deep Water Port and Rail Infrastructure
- Landcorp: Oakajee Industrial Estate
- Eneabba Gas: Centauri 1 gas fired power station and UCG project
- Aviva Corporation: Coolimba power project
- CSIRO: Square kilometre array (SKA)
- Midwest Energy: Solar thermal power project.
- ERM Power Limited: Three Springs gas fired power station

Oakajee Port and Rail: Oakajee Deep water port and rail infrastructure

Water requirements for the construction and operation of the OPR project will be met through a combination of groundwater and desalination water sources. Given the low quality and quantities of groundwater available at the site, OPR intends to construct and operate a 5 GL/yr desalination plant. This desalination plant will provide sufficient quantities of water for the port's operation. Water for construction will be required from groundwater sources, which are being investigated at present.

OPR will also require water for construction and operation of the railway. OPR is currently investigating groundwater availability along the proposed rail route. The rail has a construction-phase water requirement of 3.5 GL over 36 months and an operational water requirement of 0.14 GL/yr.

Feasibility studies for the project are expected to be completed in 2011. The consideration of water supply options should be undertaken at a strategic level in association with planning for the Oakajee Industrial Estate, to ensure a sustainable approach to water management is achieved.

Landcorp: Oakajee Industrial Estate

Landcorp is drafting a structure plan for the Oakajee Industrial Estate (OIE), and was released for public comment in early 2011. The structure plan will contain an 'industrial ecology strategy' to help plan for the different industry types and densities in the industrial estate. The strategy encourages the use of cleaner production technologies, renewable energy, smart technology and high levels of innovation. One of its aims is to identify how the industries can be linked to minimise water use and maximise water efficiency (Ferart Design et al. 2010).

The industrial estate will potentially require large amounts of water for a range of industrial users. Water resources at the Oakajee site are limited due to the fractured-rock nature of the local hydrogeology. Therefore water supply options need to be examined further afield. Options to access water from the Casuarinas subarea of the Arrowsmith GWA or undertaking desalination at the port are being investigated. An option to use treated wastewater from the wastewater treatment plant at Sunset Beach is being considered if this is relocated close to the Oakajee site.

The department is actively involved in the development of a district water management strategy (DWMS) for the industrial estate. The DWMS will be a high-level water planning document for the use and management of local groundwater and surface water resources in the industrial precinct. All proponents are encouraged to consult with Landcorp and the department when preparing any water management plans to ensure their integration with the DWMS.

Eneabba Gas: Centauri 1 gas fired power station and UCG project

Eneabba Gas Ltd is proposing to develop a 168 MW 'syngas' gas-fired power station 8 km east of Dongara. The project intends to use underground coal gasification (UCG) to convert coal into gas in situ, which eliminates the need to mine coal via traditional mining methods. The project's commercial feasibility has not been finalised, although the company is seeking preliminary approvals and conditional certifications (Eneabba Gas Ltd 2011).

The proponent has not lodged a groundwater well licence application nor has it entered discussions with the department about the power station's anticipated water needs.

Aviva Corporation: Coolimba Power Project

The Coolimba Power Project, located near Eneabba, proposes to develop up to 808 MW of electricity generation comprising 450 MW of coal-fired baseload generation and 358 MW of gas-fired peaking plant. Fuel for the power project will be provided by the adjacent Central West coal deposit.

The power station will require an estimated total of 11 GL/yr of water for its cooling process (Coolimba Power & URS 2009). The power station project intends to source, on average, 8 GL/yr of this requirement from the dewatering of the Central West Coal Mine, thus leaving the remaining 3 GL/yr to be obtained directly from groundwater

reserves. Aviva Corporation has submitted groundwater well licence applications for access to water from the Arrowsmith GWA, for both the coal mine and the power project. The department is currently assessing these licence applications.

CSIRO - Square kilometre array

Initial discussions between the department and CSIRO indicated groundwater would be required for construction and ongoing camp supplies for the SKA. Water may also be required for cooling the satellite dishes, however the required quantities and quality of water are still being determined with CSIRO.

A final decision on the location of the SKA will be made in 2012.

Midwest Energy - Solar thermal power project

Midwest Energy is proposing to develop a 200 MW solar thermal power plant north west of Perenjori. The project is to be deployed in two stages of 100 MW, with stage one scheduled for completion in late 2013 and stage two in late 2015 (Midwest Energy 2011).

The project proposes to extract 2.5 GL/yr of water from the Arrowsmith GWA because not enough water is available at the site. Water will be required for the construction and operation of the power plant. Water will be used to generate electricity when it is fed through a solar field, pressurised, then condensed. This project aims to recycle water.

ERM Power Limited – Three Springs gas fired power station

ERM Power Limited is proposing to develop a 330 MW gas fired power station near Three Springs. The ERM power limited pal to construct 2 X165 MW gas turbines and 50 Km gas pipeline connecting to the Dampier to Bunbury natural gas pipeline.

The project proposes to extract 0.3 GL/yr of water from the Arrowsmith GWA because not enough water is available at the site. Water will be required for the construction and operation of the power plant. Construction is planned to commence in 2012 with operations scheduled for late 2013/early 2014.

6 Previous studies

A number of studies relevant to the Mid West have been undertaken. These are listed in Table 5 with a review of each study provided in the sections below.

Table 5 Previous studies: mining and water resources

Title	Publisher	Date
Iron ore expansion in the Mid West: water issues	Economic Consulting Services	2009
Mining water use and demand projection study	Parsons Brinkerhoff	2008
Water futures for Western Australia 2008–2030	Department of Water	2008
Mid West Minerals Province – groundwater resource appraisal	Department of Water	2006
Groundwater investigation program in Western Australia (2005–2020)	Department of Water	2005

6.1 Iron ore expansion in the Mid West: water issues

In March 2009, Economic Consulting Services prepared a report for the Geraldton Iron Ore Alliance. It assessed water needs for the iron ore industry's development in the Mid West, recognising the industry's potentially significant growth during the next decade and a corresponding increase in water demand. The report also highlighted the need for a greater level of regional water planning to provide improved certainty about future water availability.

The report highlighted that although a large quantity of water was available, many of these resources were located in fractured-rock aquifers, and therefore might not be suitably located for individual projects. The report recognised the availability of water in the sedimentary aquifer systems in the Arrowsmith and Jurien GWAs. (However the department emphasises that this water may not be of suitable quality or available in the quantities needed in particular areas. It is vital these factors be considered when determining total water availability.)

The report concluded (given the estimates of water availability presented in it) that no difficulty should be encountered in meeting the iron ore industry's water needs of 31 GL/yr (as estimated by the report) in 10 years' time.

6.2 Mining water use and demand projection study

In 2008, Parsons Brinckerhoff (PB) Australia produced a report commissioned by the Department of Water examining current water use and demand predictions until 2027 for mining in the Northern Perth Basin. The area examined is different to the area covered in this report. The PB report covered the Arrowsmith, Jurien and Gingin GWAs and therefore only considered the limited number of mining operations located within this area.

The report identified the primary water users in this region to be mineral sands operations followed by oil and gas producers. It was identified that water use by the mining industry in these areas was expected to increase by 70 per cent from 2007 to 2012, then remain relatively static by 2017 and significantly decline by 2027.

The PB report identified the constant changes within the mining industry and the challenges this presents when assessing future water use and demand predictions.

6.3 Water futures for Western Australia 2008–2030

In December 2008, the Department of Water produced a report on the future demand for water in Western Australia. The report developed a 'water demand scenario modelling tool' for low, medium and high growth as well as a climate-dependent scenario for the period from 2008–2030.

The report split the Mid West into two study areas based on the Australian Bureau of Statistics boundaries: Greenough and Murchison.

The report assessed proposed water use for the mining industry including the Aviva, Gindalbie, Oakajee and Extension Hill projects. The report found that compared with the rest of the state, demand in relation to water availability in the Mid West was relatively low. However, the report does not acknowledge variable water quality and quantity given that large parts of both study areas include fractured-rock aquifers.

This document is being updated, with a particular focus on the Greenough and Murchison study areas (see Section 7.5).

6.4 Mid West Minerals Province – groundwater resource appraisal

The Department of Water published *Mid West Minerals Province – groundwater resource appraisal* (HG 17) in 2006. It covers the Arrowsmith GWA and part of the Gascoyne and East Murchison GWAs. HG17 is a rewrite of an unpublished report from 1999 and based on work from 1997. As a result, interpretations are largely based on gold mining operations in the Gascoyne and East Murchison GWAs. It does not take into account the volume and quality of water required by potential iron ore projects.

The report stated that significant groundwater resources were available for use by the region's mining industry. It also stated that due to the large distances between most mining operations and the variability in aquifer distribution, mining operations would have no problems locating long-term groundwater supplies and have minimal interference between neighbouring borefields. In the context of current demand, this information is misleading because it assumes sufficient good quality water is available. The report identified two main areas for further investigation: the Allanooka/Casuarinas subareas and the Murchison palaeodrainage system. These areas are currently being investigated (see Section 7).

6.5 State groundwater investigation program in Western Australia (2005–2020)

In June 2005, the department published *State groundwater investigation program in Western Australia (2005–2020)* (HG 10) under the hydrogeological record series. The report identifies priority areas throughout the state for investigation over a 15-year timeframe. Those areas located in the Mid West are listed in Table 6.

Table 6 Priority areas – groundwater investigation program – Mid West

Project name	Target area	Project detail	Cost ($)	Anticipated dated and timeframes
Priority C3/C4 investigation program (aquifer systems above 70% allocated)	Allanooka subarea	Because this area is of high use this project intends to further investigate the water resource through the drilling of 18 bores in the Yarragadee Aquifer and undertake data assessment.	2 246 100	2008–09 to 2009–10 (years 4 and 5 of project)
	Dinner Hill subarea	Because this area is of high use this project intends to further investigate the water resource through the drilling of 10 bores in the Leederville-Parmelia Aquifer and undertake data assessment.	892 800	2017–18 to 2018–19 (years 13 and 14 of project)
State-wide strategic investigation	Murchison palaeodrainage system	Investigate the possible presence of Tertiary palaeochannels in the Murchison River catchment, and the potential for water resource development. It is possible there are low-salinity groundwater resources in palaeochannels up-gradient of salt lakes, and this may have implications for understanding salinity of the Murchison River and associated alluvial aquifers.	1 000 000	2016–17 to 2017–18 (years 12 and 13 of project)
	Northern Perth Basin – Ajana	Investigation drilling of the Tumblagooda Sandstone, east of the Northampton Complex, to assess the groundwater resources' potential. The resources are poorly understood but it is likely they are brackish. The area, which is agricultural, has a potential demand for groundwater supply from the aquifer.	250 000	2016–17 (year 12 of project)
	Eastern Carnarvon Basin – Birdrong Sandstone Aquifer	Investigate low-salinity groundwater resources in the Birdrong Sandstone. It is possible there is low-salinity groundwater along the eastern margin, which may prove a useful resource in areas of very low rainfall.	200 000	2016–17 to 2017–18 (years 12 and 13 of project)

Project name	Target area	Project detail	Cost ($)	Anticipated dated and timeframes
Regional assessment and groundwater dataset provision	Perth Basin	Prepare reports on the northern and southern Perth Basin to complement GSWA Bulletin 142 (Davidson 1995), or complete a basin-wide publication that includes the metropolitan area.	500 000	2005–06 to 2006–07 (years 1 and 2 of project)
	Murchison	Prepare regional maps and description of the Murchison region to encompass mining areas from Yalgoo to Meekatharra. This regional mapping program must be linked to drilling of the palaeochannels in the Murchison area, as outlined in the strategic drilling program.	350 000	2018–19 to 2019–20 (years 14 and 15 of project)
TOTAL			**5 438 900**	

7 Current and future studies

A number of studies in relation to groundwater resources in the Mid West are underway and planned for completion. These are listed in Table 7 and outlined in the sections below.

Table 7 Current and future studies

Title	Responsible agency	Status
Northern Perth Basin groundwater investigations	Department of Water	Current
Water resource investigations in the Allanooka and Casuarinas subareas	Department of Water	Current
Murchison palaeochannels	Geoscience Australia and Department of Water	Current
Groundwater-dependent ecosystems vulnerability in the Mid West	Department of Water	Current
Update of water futures for Western Australia 2008–2030	Department of Water	Current
Mid West water supply plan	Department of Water	Current
Review of the Pilbara water in mining guidelines	Department of Water	Proposed

7.1 Northern Perth Basin groundwater investigations

Groundwater investigations in the Northern Perth Basin aim to consolidate previous hydrogeological investigations and existing knowledge to examine the water resources throughout the basin. This will enable the department to review the suitability of allocation limits for each resource and identify areas of potential for and limitations on resource development. It is expected the investigations will be completed in 2011 and a report will be published at this time.

7.2 Water resource investigations in the Allanooka and Casuarinas subareas

The Casuarinas subarea is located in the Gascoyne GWA immediately north-east of the Allanooka subarea of the Arrowsmith GWA. The Yarragadee Aquifer of the Allanooka subarea is the main water supply source for Geraldton and surrounding towns. At present the Water Corporation has a licence to take 12 GL/yr from this aquifer and wants to increase this by a further 2 GL/yr. A further 5 GL/yr is reserved for future public water supply in the Allanooka subarea.

Currently the Yarragadee Aquifer of the Casuarinas subarea has a notional allocation limit of 10 GL/yr, of which 5 GL/yr is reserved for future public water supply. As recommended by HG10 and HG17, a groundwater investigation is underway to determine the nature of this aquifer's groundwater resources. This information will enable the allocation limit of the Casuarinas subarea to be estimated more accurately.

Shallow seismic geophysical transects of the area were completed in 2009. Exploration drilling began in May 2010, with a total of 24 bores to be drilled at 12 sites over nine months.

Initially the bores were to be screened at different depths in the Yarragadee Formation – shallow (up to about 150 m below ground surface) and deep (up to 600 m deep). The two levels were to provide water-level information on the shallow and deep groundwater systems – to help understand the potentiometric head distribution throughout the aquifer and confirm the recharge area and groundwater flow processes. However, initial testing has found that fresh water only occurs at shallow depths. Therefore most bores will now be drilled in the shallow portion of the aquifer (i.e. less than 340m total depth).

Further resource assessment of this formation will include recharge estimation studies, groundwater flow modelling and geochemical modelling. The estimated time to complete the drilling investigations is one year, with a resource report due to be finished in 2011.

7.3 Murchison palaeochannels

The palaeodrainage aquifer systems of the Murchison region are currently used for stock, town water supplies and mining activity. Groundwater in upstream tributaries is commonly fresh to brackish, with salinity increasing both vertically and in a downstream direction, and saline to hypersaline groundwater underlying salt lakes. Palaeodrainage aquifers associated with the Murchison region are not well known.

The National Water Commission has invested approximately $4.9 million in the Raising National Water Standards project: *Water for Australia's arid zone – identifying and assessing Australia's palaeovalleys groundwater resources.* Geoscience Australia began work on this four-year project in April 2008 with the objective to improve existing knowledge on the distribution, quality and sustainability of groundwater resources in palaeodrainage systems across arid Australia. Study areas in Western Australia comprise palaeodrainage systems within the Paterson Province – Canning Basin and Murchison region.

Work by Geoscience Australia in the Murchison region will focus on palaeodrainage systems within the upper Murchison River catchment with four traverse lines across headwater valleys at Austin Downs, Belele, Mt Padbury and Beringarra. This work aims to provide baseline data on spatial and aquifer characteristics of the Murchison palaeovalley systems and determine how these differ from better-known systems elsewhere in the Yilgarn and Pilbara.

Preliminary results indicate these systems are very different from those documented elsewhere in the Yilgarn. There is substantially less plasticine, lacustrine clay within the sedimentary sequence of the Murchison palaeovalleys and noticeably increased amounts of sand and gravel (English & Johnson 2010). The depths of the Murchison palaeovalleys are two to three times deeper than their counterparts in the southern

Yilgarn (English & Johnson 2010). The study's final results are expected to be available by 2012.

The department is also scheduled to investigate the Murchison palaeochannels in 2016. This investigation may be brought forward depending on findings from Geoscience Australia's project and the pressure on water supplies in the region. Information from both studies will feed into updating *Mid West Minerals Province – groundwater resource appraisal* (HG 17).

7.4 Groundwater-dependent ecosystems vulnerability in the Mid West

The department has received $2.46 million funding from the National Water Commission to study the vulnerability of groundwater-dependent ecosystems (GDEs) in the Mid West. With an increased demand on water resources, the department initiated this study to understand the dynamic relationship between GDEs and groundwater and thus better inform management of the resource.

A number of high-conservation and representative GDEs have been selected throughout the Jurien and Arrowsmith GWAs. Drilling of monitoring bores in these areas has begun. Information gathered during the project will enable the department to identify and manage potential impacts to GDEs from current and future groundwater abstraction. The project will be completed by 2012.

7.5 Update of water futures for Western Australia 2008–2030

Work is underway on the *Update of water futures for Western Australia 2008–2030*, with a focus on the Greenough and Murchison water demand regions. This review will inform development of the *Mid West water supply plan*.

7.6 Mid West water supply plan

In May 2011 the department started to develop a water supply plan for the Mid West. The need for this plan was identified as part of the department's recently reviewed strategic direction – undertaken in consultation with government and industry stakeholders. One of the consistent priorities highlighted was for us to provide clearer and more definitive advice about water availability and demand, along with early advice on gaps in the demand/supply balance and potential solutions.

The water supply plan will complement work we have already completed, including this status report and the Arrowsmith and Jurien water allocation plans. The plan's scope and timing will be determined with the input of the Mid West Development Commission and are yet to be finalised. The Mid West water supply plan will be the first of its kind in the state.

This report only covers the mining and industrial projects within the Mid West Development Commission boundary. However, the Water supply plan will expand on

this information by including all water use industries potential future water requirements and include the Jurien groundwater area.

7.7 Review of the Pilbara water in mining guideline

In 2009 the department published the *Pilbara water in mining guideline* to improve the information available to proponents on our regulatory processes for allocating water licences. It was designed to help proponents consider water issues in the early stages of project development, as well as help us improve how water is managed across the mining industry.

This document was developed specifically for the Pilbara region, however the department recognises its applicability to the whole state. We are considering a review of this document to create a state-wide publication.

8 Conclusion

The Mid West is experiencing growth in mining and industrial projects. A key growth area is the iron ore industry. Associated with this growth is a projected increase in water demand of approximately 97 GL/yr within the next 10 years. However, this volume is expected to be greater, given that water requirements for many proposed projects remain unknown.

The regional groundwater resources within the East Murchison, Gascoyne and Arrowsmith GWAs will be the main source of water for future growth. These GWAs have complex and varied hydrogeological characteristics resulting in variable water quality and quantity. Potentially these water resources can meet the expected demands of the projects proposed for the region, of those currently known to the Department of Water.

One of the biggest challenges facing the region is finding large yields of fresh groundwater (primarily required by the iron ore industry) in the Murchison Minerals Province. Current investigations in these areas will improve understanding and information available for water resource management. This information will be used to update the report *Mid West Minerals Province – groundwater resource appraisal* (HG 17).

Mining and industry proponents need to recognise that accessing a suitable water resource is often complex and can involve a high level of investigation. A range of factors need to be considered including fit-for-purpose water use and low-water-use solutions for processing and transport options. This should be done in the early stages of planning. The department should be contacted early in the planning stage to help identify water planning options.

The department is well positioned to support proponents with advice to meet their water needs, given that:

- water resources and water availability in the Northern Perth Basin are well known
- the likely water needs of prospective projects are known via demand studies and proactive consultation with proponents
- water licensing processes and requirements are well documented and accessible to proponents
- work is underway to improve management of groundwater-dependent ecosystems through licences (where these are likely to be impacted by water abstraction).

The department is able to provide continual advice to mining and industrial proponents by way of ongoing water resource investigations and water supply and demand planning.

List of shortened forms

CSIRO	Commonwealth Scientific and Industrial Research Organisation
DMP	Department of Mines and Petroleum
DOW	Department of Water
DSD	Department of State Development
DWMS	district water management strategy
ECS	Economic Consulting Services
GDEs	groundwater dependant ecosystems
GL	gigalitre
GRP	gross regional product
GWA	groundwater area
kL	kilolitre
km	kilometre
MW	mega watts
Mtpa	million tonnes per annum
m	metre
NPB	Northern Perth Basin
OIE	Oakajee Industrial Estate
OPR	Oakajee Port and Rail Pty Ltd
PB	Parsons Brinkerhoff
SKA	Square Kilometre Array
yr	year

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