Economics Consulting Services

Water and the Western Australian Minerals and Energy Industry: Certainty of Supply for Future Growth

Report prepared for:

The Chamber of Minerals and Energy of Western Australia

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Water and the Western Australian Minerals and Energy Industry: Certainty of Supply for Future Growth

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The Chamber of Minerals & Energy Western Australia

Western Australian Department of Industry and Resources

Government of Western Australia
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Study Undertaken by:

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Note:
Water use involves a volume and time dimension. This report generally uses gigalitres of water per annum as the standard measure. This represents a thousand million litres of water (10^9) and for convenience has been abbreviated to GL/a. For smaller volumes, mega litres (10^6) per annum is used, shortened to ML/a.

EXECUTIVE SUMMARY

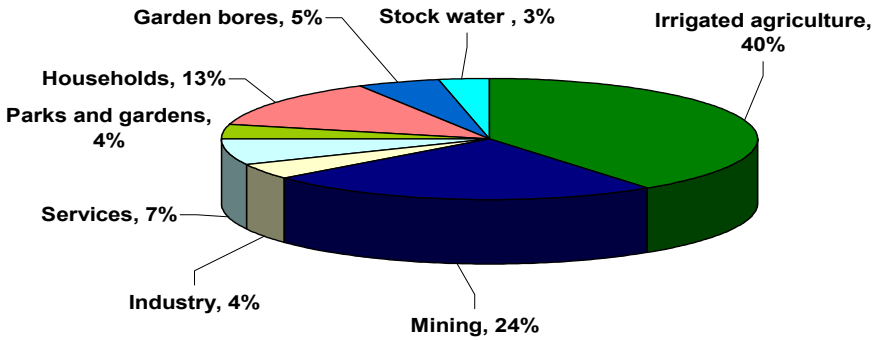
Mineral and petroleum extraction and processing activities are major water users in Western Australia. However, the total water use statistics overemphasise the importance of such use in the State as they do not take into account the ways in which water is used, the location of use or the quality of the water used.

This study was commissioned by the Western Australian Chamber of Minerals and Energy under the Australian Government *Regional Minerals Program* to describe water use in the resources sector and the role of the industry in the development of water sources and water use in Western Australia. The Program's aim is to achieve both a cooperative and coordinated approach by industry and government to facilitate regional mineral and petroleum development and thereby generate regional employment opportunities.

The resources sector underpins the economy of Western Australia. It is the largest single economic sector, provides a fifth of direct and indirect employment, and approximately three-quarters of total exports. It makes substantial payments to government and contributions to the communities in which it operates. The industry is highly diversified and geographically dispersed with almost 500 projects and some 50 different minerals.

Much of the State's economic development can be traced to the mining industry and the companies have made substantial investment in water infrastructure. A brief survey carried out for this study suggests an investment in water supply development by the companies in excess of $700 million. Annual operating and management costs almost certainly exceed $100 million.

While the industry is a large water user, it ranks well behind agricultural water in the State as a whole. The minerals industry is a more significant in remote areas of the State including the Pilbara, Goldfields, Murchison and the Mid West where there is limited demand from other water users in these regions.



Most mining operations in Western Australia are found in remote areas and are some distance from each other. Water supplies are generally obtained from groundwater sources with some from dewatering operations. The survey estimates that 75% of water used is from groundwater sources and 25% from surface water sources. This is consistent with the findings of the 1999 National Land and Water Audit.

Despite the arid climate, some mining projects have a water surplus problem with water pumped from working areas to allow mining to proceed. Much of this water is placed back in local watercourses and ends up back in the aquifer system from which it was pumped. In the Pilbara, that same water may be pumped out again by other projects downstream from the dewatering project.

Most mining operations, with some effort, have located acceptable groundwater supplies. Some water is obtained from other licensed water providers but it is estimated that the industry supplies nearly 95% of its own water needs. However, some has to be pumped from distant sources or obtained by desalination. Mines in the survey sample reported borefields up to 40 Kms distant from mine operations with significant piping and pumping costs.

The minerals industry provides the overwhelming proportion of its own water needs. It locates suitable sources, develops supply facilities (borefields, dams), and builds supply pipelines and holding tanks. The industry manages most water disposal on site minimizing any need for off – site drainage.

Water quality varies widely across the State. Brackish and saline groundwater is common in the Goldfields and Murchison regions. Indeed, it was the development of gold ore processing technology using saline water that enabled much of the gold sector to develop in the arid areas of Western Australia. Without the ability to utilise poor quality water that would not be used in other economic sectors, the mining industry would be much smaller than it is.

The limited survey conducted for this study suggested that around 60% of the water used in the industry is of poor quality and not well suited to other uses without expensive treatment.

Only a few areas of the State face potential water supply limitations that could restrict mining operations. The South West corner of the State with its rapidly rising population is facing longer term water supply challenges. However, the mining sector is not a large water user in this part of the State although the current companies are well aware of potential future access constraints.

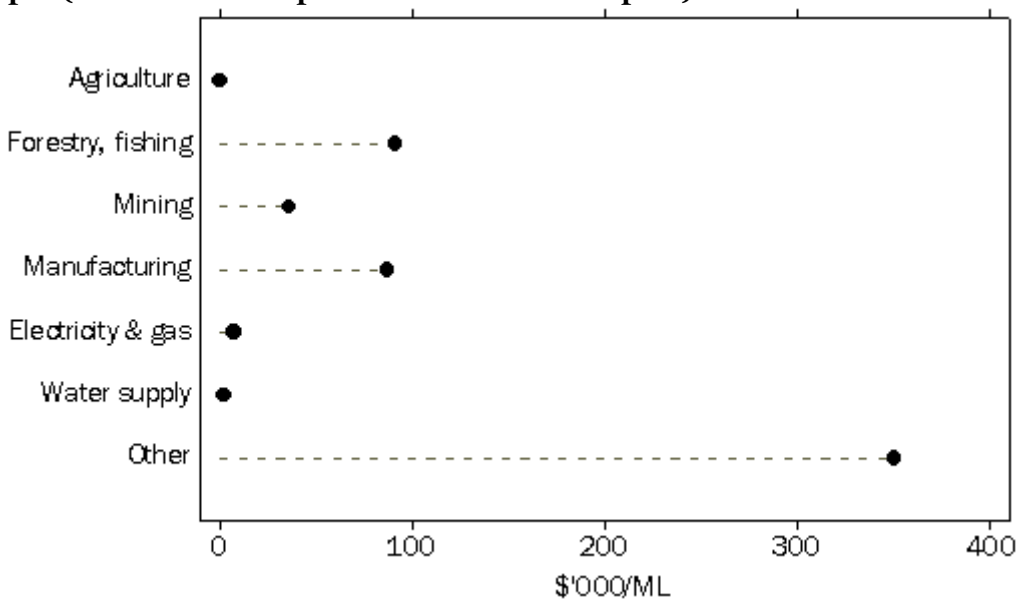
An important consideration in the minerals industry is that mines usually have limited lives, rarely exceeding 25 years and often less than 10 years. Groundwater resources are generally robust and can be managed to meet these fairly short term requirements. Nevertheless, mining operations are managed to limit groundwater contamination, and effects on wetlands and water dependent ecosystems. The industry is generally aware that it must be seen to value water resources and to use them in an efficient and effective manner if continued access to water is to be provided.

The minerals industry is conscious of conservation effort and the survey suggests that as much as 30% of water on mine sites is recycled at least once and sometimes many times before disposal. The industry has become a "best practice manager" in water use and management. Water balance tables have been developed by some companies and others are moving to improve such water accounting practices.

The industry supports policies for the *sustainable* use of natural resources including water and hence employs a triple bottom line assessment of sustainability in which economic, environmental and social impacts are all assessed. *Mining* of water in remote and arid areas is reasonable in such an approach. The abstraction of water in excess of the recharge amount is reasonable on the grounds that there is exceptionally little alternative water demand and that the regional development benefits outweigh any environmental impact.

The mining sector ranks fairly well in terms of the value of water use. A financial evaluation demonstrates that water for human survival and health will be placed first in any hierarchy of water use followed by the water needed for essential food production. The value of water in industry sectors will be a function of the output produced by that sector and the amount of water needed in the industry. Low water use sectors with high sales outputs such as the services sectors (legal, finance, insurance, advisory services) will be near the top of the ladder. Industries requiring large volumes of water for processing purposes will be deemed less efficient from a water-use perspective.

Gross output (Gross sector output less intermediate inputs)



Source: ABS Catalogue 4210

Metropolitan water sales are almost certainly the highest value use for water. Broadacre pasture production using flood irrigation methods represent the other end of the spectrum. Mining industries rank in between – well above irrigated agriculture applications but below many manufacturing industries.

The State Government manages water use by the industry through a comprehensive licensing and environmental management process. The industry is subject to more rigorous assessment than many other water users.

Under the Australian Constitution, the responsibility for water policy rests with the State governments. However, the Australian Government has influenced water policy through agreement with the State and Territory Governments. Major initiatives have included the Council of Australian Governments (COAG) Water Reform Framework Agreement and the National Water Quality Management Strategy

The COAG process commenced in 1994 introduced a package of reforms aimed at improving the management of water resources in Australia. The reforms recognise the multi-jurisdictional nature of water resources and the need for changes to pricing and water trading arrangements and the necessity to preserve water for environmental applications.

Work completed under the COAG process and through subsequent policy initiatives has developed important policy principles relevant to water use in mining. These principles have been further refined through intergovernmental processes the most recent being the National Water Initiative. This Initiative reinforces the sustainable use of water particularly in relation to an allocation to the environment.

The Western Australian and Tasmanian governments are not parties to the National Water Initiative but Western Australia has its own policies and processes for water allocation, management and use. The key requirements for the resources sector are covered by legislation and the State Water Strategy. Legislation requires all groundwater users to be licensed in areas prescribed by the government. All areas of the State where groundwater use is environmentally sensitive or where there is competition for water are prescribed. Use is intended to be governed by management plans but these have only been developed in limited areas to date.

Licences are issued for groundwater abstraction, surface collection, and dewatering and water disposal. Major resource projects are issued with an Operating Strategy requiring water use measurement, quantity and quality monitoring, environmental impact reporting and aquifer review processes.

KEY FINDINGS AND RECOMMENDATIONS

Competition for Water

1. The minerals and energy industry in Western Australia is a substantial water user. However, there is little competition for the water from other consumers in most areas due either to the remote location of the project or the poor quality of water used.
2. The majority of the water used in some regions is from dewatering of mine sites to allow mining to proceed. When it is replaced in local aquifers with negligible environmental impact, it is questionable whether it should be regarded as *used*.
3. Contrary to public perception, few companies have faced technical difficulties in developing suitable water supplies for mining projects despite the arid nature of most of the State.
4. There is competition for water in small areas of the State but over 75% of the water used is remote from agriculture and populated centres. The alumina/bauxite and heavy mineral sand sectors face more competition than other sectors due to their location in agricultural areas.

Discovery and Development

5. The minerals and energy industry plays a major role in the discovery, development and ongoing management of water resources.
6. The industry is almost totally dependent on groundwater which it sources from its own borefields or dewatering of mine operations.
7. The industry develops 95% of its own water supplies. A small survey carried out for this study suggests that the cost of water discovery and development may have been in excess of $700 million, while ongoing operating and management costs almost certainly exceed $100 million per annum.

Water Value

8. The minerals and energy industry ranks second to agriculture in the total volume of water used in the State but at least half of the water used is poor quality water and unsuited to other uses without treatment that would make it uneconomic. Were it not for the development of mineral processing technology capable of using such water, there would be no use for it.
9. The industry values water because of the investment needed to discover and develop and manage the resource.
10. The minerals and energy industry ranks fairly highly in terms of the value of industry output per volume of water use. It ranks behind water for human survival and health and domestic food production but well above export based irrigated agriculture, which is the largest water use sector.

Allocation

11. Mines usually have a limited life and in most locations adequate groundwater exists to meet the short-term requirements. Shortage of water is not an impediment for most mines.

12. The nature of mining operations means that the industry seeks groundwater licences that are fixed in volume and duration rather than open ended rights to variable volumes.

Management

13. The minerals and energy industry is aware of the value of water and the need to use it efficiently. In many situations, mining operations are able to recycle large amounts of water.

14. Mining companies are aware of water use efficiency objectives and the need to account for all water used but could do more to adopt best practice water accounting principles.

15. The industry publicly supports the sustainable use of all natural resources and a triple bottom line assessment for access to new resources. Some mining of water in remote and arid areas is justified under such an approach given the temporary nature of use, a lack of alternative demand and the regional development benefits that accrue.

16. The State Government administers water allocation through a comprehensive licensing and environmental assessment process. Water allocations to the minerals industry are subject to more rigorous assessment than most other industries.

17. Water abstraction by the minerals industry is closely monitored and comprehensively reported. Metering, water level and water quality monitoring programs are intensive compared to other large users.

Knowledge

18. While government regulation of the industry is rigorous, the hydrogeological support traditionally provided needs to be refocused to assist industry locate and develop water resources. Annual reports provided to the Department of Environment should be electronically captured and made available to the public through a comprehensive database.

19. The emphasis in hydrogeological work in the State Government has shifted away from regional assessment and industry support towards environmental assessment. The important role played by hydrogeology in the development of water resources needs greater recognition.

20. Management plans form the basis for water allocation and use in regional areas but only a limited number have been completed.

21. The State Government Mining and Water Liaison Committee set up to liaise on water management issues has identified priorities for hydrogeological work. Consideration needs to be given as to how this work should be developed.

Recommendations

1. Industry bodies and governments should communicate the key findings and recommendations of this study to the community and key stakeholders to promote a better understanding of water use in the minerals and energy industry.

2. Groundwater information submitted to the State Government as part of water licence reporting is a valuable information source and should be actively managed. The current Department of Environment proposal for electronic data management and dissemination should be supported.

3. The hydrogeological expertise in the government is a valuable public resource. This expertise needs to be used to promote industry development and sound environmental management. The structure of the State Government should support a balanced approach to triple bottom line assessment.

4. The State and Australian governments should develop a more sophisticated approach to groundwater management that more explicitly recognises the value of water as a social and economic good in remote areas and the location and quality of water used.

5. The State Government should increase the rate at which Groundwater Management Plans are completed with a focus on areas that have surface environmental impacts or where competition is greatest.

6. A review of the process for preparation of groundwater management plans is recommended to ensure that the interests of the State and all stakeholders are reflected in their development.

6. Mining companies should be urged by mining industry bodies and the State Government to develop water balance accounting at all projects.

Chapter 1

INTRODUCTION

Mineral and petroleum extraction and processing activities are major water users in Western Australia. With water supplies under pressure in some areas, it is important to better understand water use and water discharge. A regional focus is essential as the balance of supply and demand varies enormously as do community water needs.

This study was commissioned by the Western Australian Chamber of Minerals and Energy under the *Regional Minerals Program (*RMP*)*, which is administered by the Australian Government Department of Industry, Tourism and Resources, and also financially supported by the Western Australian government through the Department of Industry and Resources and Department of Environment (incorporating the former Water and Rivers Commission).

The RMP was established by the Australian Government in 1996 as a key element of its strategy to encourage both a cooperative and coordinated approach by industry and governments to facilitate regional development of mining and processing activities (including oil and gas) and to promote regional employment opportunities. Key aims of the program are to:

- Provide an overview of the mineral resources and the potential for mineral and processing development in selected regions;
- Asses the infrastructure and government services of a region and develop proposals to overcome impediments; and
- Facilitate a coordinated approach to regional minerals development.

Grants are provided on a competitive basis to fund collaborative studies with industry and governments. In addition to mineral resource and processing potential, and infrastructure and government services issues, the studies also identify wider policy issues which warrant further attention such as environmental impacts and water management.

To date, fourteen RMP studies covering regions across Australia have been completed. These studies have created a substantial information base and regional policy context development of mineral and petroleum industries and resultant employment over large parts of regional Australia[1].

The study terms of reference require the report to:

- Describe water use in the resources sector by quality, quantity, region and source;
- Describe the industry contribution to discovery and development of water supplies;
- Quantify the industry contribution to water development;
- Describe water treatment, disposal methods and environmental management; and
- Make recommendations to ensure any water resource management framework developed through the COAG is responsive to the needs of the minerals industry.

The study was coordinated by the Western Australian Chamber of Minerals and Energy on behalf of the Australian Government Department of Industry, Tourism and Resources and the State Government Department of Industry and Resources and the Department of the Environment. The study commenced in March 2004 and was concluded in July of that year. A Management Committee, comprising of the key financial contributors met regularly to oversee the project. The Management Committee and funding groups for the study are listed in Appendix 1.

This report has been prepared to describe the role of the mining industry in the development of water sources and water use in Western Australia. It begins with a brief review of the mining industry, covers water availability in the State, water use and management issues. The focus of the report is on the mining sector. Most oil and gas recovery is in offshore areas with substantial water use in processing activity rather than primary production. This report generally excludes the mineral and petroleum processing activities.

The study has been carried out with the assistance of the Western Australian mining companies and licensed water service providers. Their support is gratefully acknowledged.

[1] Information about these and current studies can be found at: www.industry.gov.au/rmp.

Chapter 2

THE RESOURCES SECTOR

The resources sector underpins the economy of Western Australia. It is the largest sector in terms of contribution to Gross State Product providing around a quarter of the total economy output in 2003. It also provided a fifth of direct and indirect employment, and approximately three-quarters of total exports.

Much of the State's economic development can be traced to the minerals and energy industry. It was the catalyst for the boom that followed the discovery of gold in the 1890's and again the driver in the 1960's for the modern resource driven expansion.

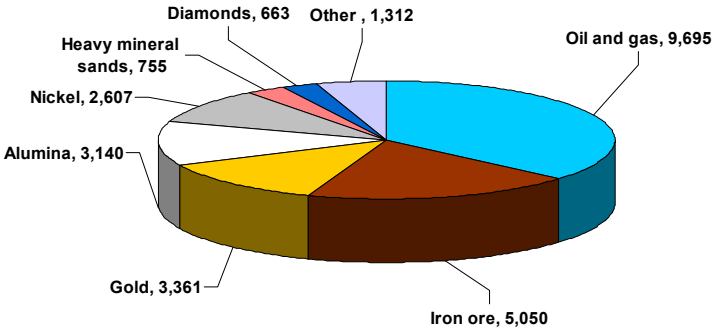
Western Australia has a highly diversified and geographically dispersed resource sector. There are almost 500 projects with some 50 different minerals. Major projects (over $10 million) in oil and gas, iron ore, diamonds and manganese are predominantly in the North West of the State covering the vast Pilbara and Kimberley regions (Figure 2). Gold and nickel production dominate in the Goldfields and Mid West regions while alumina, heavy mineral sands and coal mining are focused on the South West corner of the State.

The value of production in 2003 was $26.6 billion with additional value from mineral processing facilities adding further value to this primary production. The value of output is dominated by the petroleum sector, iron ore, gold, alumina and nickel (Figure 1). Over 20 commodities had a total value of production in 2003 in excess of $20 million.

Most production is exported to world markets and the State is a substantial world participant in diamonds, iron ore, gold, nickel, heavy mineral sands, tantalum, and silicon markets.

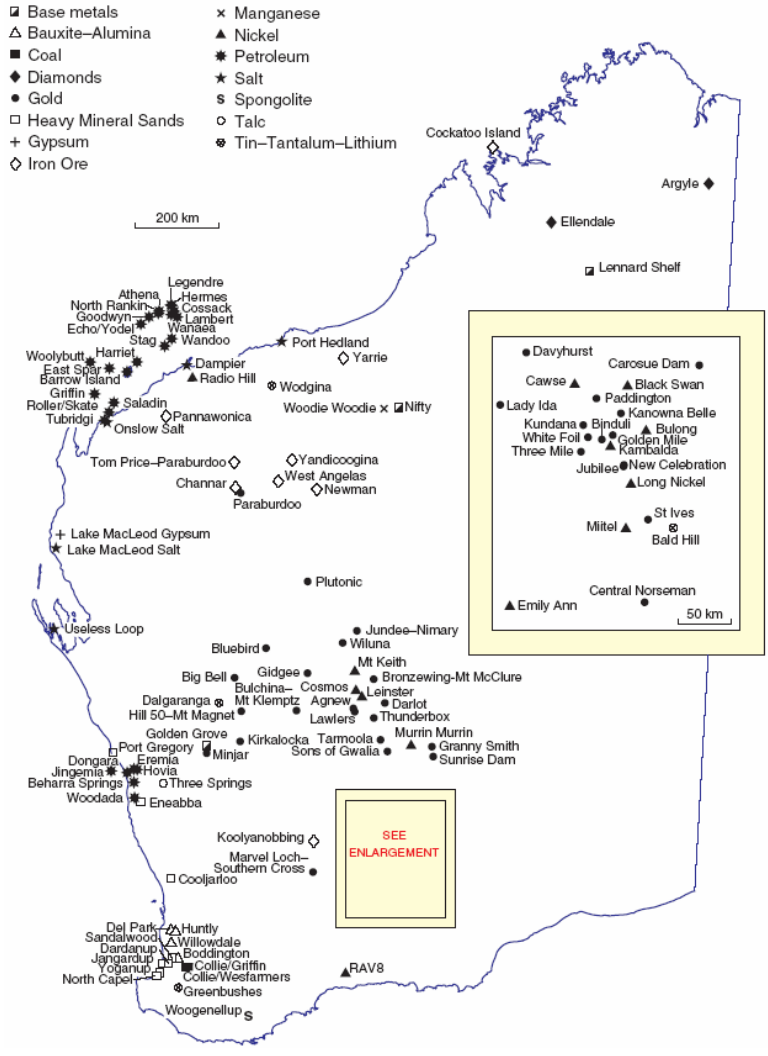
Given the low population, vast areas and limited water resources, mining companies have played a key role in the discovery and development of water resources. The next chapter looks at the water endowment in Western Australia as background for the discussion of the industry role.

Figure 1: Value of Output, Western Australia, ($million, 2003)



Source: Department of Industry and Resources

Figure 2: Major Project Locations



Source: Department of Industry and Resources

Chapter 3

WATER ENDOWMENT AND DEVELOPMENT

3.1 Introduction

Western Australia has an area of about 2,525,000 km^2 covering nearly one third of the Australian continent. The State extends from 14°S to 35°S latitude, a distance of about 2,500 km. The landform is best described as a variably dissected plateau mostly 200 to 600 m above sea level.

Rainfall incidence, uniformity and reliability vary widely. Reliable rainfall is received in the South West in winter while the remainder of the State is relatively dry. The reverse occurs in summer with widespread but less reliable rainfall in the north and dry conditions or sporadic rainfall over the rest of the State. Rainfall results from monsoonal activity in the north, and rain-bearing depressions in the south. Other sources of rainfall are occasional tropical cyclones during summer which may bring widespread rain; thunderstorm activity, and occasional mid-level rain systems originating in the tropics.

Average annual rainfall ranges from negligible amounts in large desert areas to more than 500 mm in the South West and Kimberley regions. Much of the inland area receives less than 350 mm in total and this is irregular and unreliable. The rainfall is notable for its temporal and geographic variability and for the variability of the intensity and duration of rainfall events. These factors affect runoff in drainage systems and recharge to groundwater systems. The availability of water is also affected by relatively high air temperatures which result in average annual evaporation ranging from 1,000 to 4,000 mm and rainfall exceeding evaporation only in small areas in the extreme north and South West.

Western Australia has been described as one of the driest States in the most arid of the earth's inhabited continents[2]. Water has been a fairly limited resource since the establishment of European settlers and has been collected from rivers and streams and piped to urban areas from early settlement.

[2] Western Australian Water Resources Council (WAWRC) 1986 "Water Resources through Good Design" WAWRC, Perth.

3.2 Surface Water

Large well developed seagoing drainage systems occur in the Kimberley and Pilbara regions and smaller, less well developed systems in the South Western and southern parts of the State. They extend from continent-scale drainage divides which separate the seagoing drainage system from mainly internal palaeodrainage or ancient drainage systems. The seagoing drainage systems occur over about 45% of the State; the palaeodrainage occur over the remainder and are part of a deeply eroded drainage system now filled with sediments. The palaeodrainage systems follow poorly defined drainage lines and include large salt-lake systems.

Flows in the seagoing rivers are intermittent given that regular runoff only occurs in the Kimberley and South West. Elsewhere runoff is dependent on rainfall conditions and only occurs after intense rainfall or when catchment conditions exceed certain thresholds.

In the inactive drainages and palaeodrainage, apart from some local flows, runoff only occurs after cyclonic events which may bring intense rainfall over large regions. These irregular, spatially variable events may be decade's apart but can cause substantial flows.

Runoff is generally fresh in the Kimberley and Pilbara region, but ranges from fresh to brackish in the South West and fresh to saline in palaeodrainage systems.

Sites for construction of large dams occur in the Kimberley and Pilbara regions and on various rivers in the South West where most of the major sites yielding fresh water have dams.

In the Kimberley region a major dam is located on the Ord River and a failed barrage on the Fitzroy River. Numerous other potential sites exist, but remoteness, native title claims and environmental concerns limit their development.

In the Pilbara the Ophthalmia dam near Newman was constructed by Mt Newman Mining as a source of water for artificial recharge of local alluvial aquifers. A dam on the Harding River was constructed by the Water Corporation to supplement groundwater from Millstream for the Karratha region. However, infrequent runoff and operational problems have affected the viability of the scheme. The construction of a major dam on the Gascoyne River in the Kennedy Range has also been investigated but a shallow reservoir site, infrequent runoff and potentially very large evaporation losses have inhibited construction.

In the South West from Geraldton to Esperance various numerous dams and pipe heads have been constructed. The large dams such as Canning, Serpentine and Wungong dams are used for Perth's water supply. Other dams at Harvey and Collie are used for irrigation. Numerous small dams are used as local sources for public water supplies, large industrial projects or agricultural irrigation.

The Goldfields are centred along the major regional drainage divide between the seagoing and palaeodrainage systems. In general, the rainfall is too erratic and the relief too flat for surface water dams. Some mining companies operate small dams on local drainage lines and have directed surface water runoff into abandoned open-pit mines for subsequent use.
In summary, Western Australia has 208 major rivers with 75% of the surface water flow occurring in the Kimberley region. The South West and Arid Zone receive 15% and 10% of

the mean annual flow of surface water respectively. The Arid zone in this case refers to the interior of the State outside the South West corner and Kimberley areas. The sustainable yields of these surface waters show a similar pattern, whereby the Kimberley Region has 61% of the sustainable yield and the South West and Arid Zone have 31% and 8% respectively. The total sustainable yield amounts to 520GL, which represents 12% of the mean annual flow[3].

The concentration of surface water resources in the Kimberley has not been a catalyst for economic development. Most of the population live in the South West corner of the State which has surface water sources but not the volume in the Kimberley. The mining sector is located throughout the State, with many large projects in areas of very limited surface water supply.

3.3 Groundwater

Groundwater originates from the infiltration of a small proportion of direct rainfall and from surface runoff which infiltrates through drainage lines into the fabric of rocks. The groundwater is stored and moves along underground flow systems.

Rock types which yield economic supplies of groundwater are referred to as aquifers with three types recognised:

- Fractured rock aquifers – usually rocks without primary porosity and permeability in which the groundwater is stored and moves in facture systems produced by various tectonic and erosion processes;
- Sedimentary aquifers – rocks in sedimentary deposits that have primary and secondary porosity and permeability; and
- Surficial aquifers – comprising alluvial, eolian, weathering, lake deposits, and infill of palaeodrainage systems which are superimposed on the fractured rock and sedimentary aquifers.

About 60% of Western Australia is underlain by fractured rocks with 40% sedimentary basins. Both the fractured rock provinces and sedimentary rocks are overlain by surficial aquifers which are estimated to cover about 15% of the land area.

Groundwater flows at slow rates from less than 5 metres per annum to possibly 100 metres. It may discharge into streams, riverine pools, springs and soaks or into the ocean underground. The groundwater may be unconfined and spread out to form a regional water table, or under pressure in confined aquifers usually located in the sedimentary basins.

The salinity (total dissolved solids content) of groundwater may vary from that of rainwater to ten times the salinity of seawater. Groundwater may also vary widely in the dissolved salts, temperature, pH, heavy metals, and radio-nuclides and dissolved gases which it contains. Large regional variations in salinity are recognisable. The highest salinity groundwater is centred over the Goldfields in the fractured rocks and palaeodrainage near the regional drainage divide separating seagoing and internal drainage systems.

[3] Water and Rivers Commission: "Western Australia Water Assessment 2000 - Water Availability and Use" WRC Policy and Planning Division, Perth.

Groundwater is usually pumped from aquifers via boreholes and yields vary widely depending on the nature of the aquifer and the bore construction. In general, the highest yields are obtained from the sedimentary and surficial aquifers and smaller yields are obtained from fractured rock aquifers.

Most mines are located in fractured rock aquifers. Safe operation may require some dewatering of the fractured rock aquifer. This water is available for minesite operations and can supplement other water sources. Where such sources are inadequate for mining operations, other supplies are usually sourced from surficial aquifers.

In general, in Western Australia, groundwater supplies are more readily available than surface water supplies. They are less affected by variations in rainfall and are not subject to large evapotranspiration losses. However, they can be more expensive and difficult to locate and quantify.

Western Australia and the Northern Territory differ from the other States in Australia in that both extract the majority of the water used from groundwater rather than surface water supplies. This reflects the low rainfall and population distribution.

3.4 Water Development and the Resources Sector

Mining has been instrumental in the development of the State economy and its water resources. The first real population boom began with the discovery of gold in the 1880's and 1890's which saw the population increase by a factor of more than five in a decade.

Water for the Goldfields was largely supplied by the State Government from a series of wells, bores and dams established for prospectors between 1902 and 1912, and for town water supplies and Government operated gold processing batteries. The largest contribution by the Government was through the construction of the Mundaring – Kalgoorlie pipeline which was commissioned in 1903. This pipeline overcame the reliance on condensers and small local water supplies, and provided reliable water supplies to the major mining centres at Southern Cross, Coolgardie and Kalgoorlie.

The major engineering work and risk associated with the Mundaring Weir to Kalgoorlie pipeline in 1903 was a huge undertaking for a small economy. It provided water along its length to farmers and encouraged agricultural enterprises when gold prospecting slowed.

Gold production peaked in 1903 and declined thereafter until the depression years of the 1930's when out of work and disillusioned workers again turned to gold prospecting to make a living.

The Western Australian economy grew slowly until the 1950's with supported by inward migration but counterbalanced by significant outward migration to the eastern states. The development of an oil refinery at a small holiday resort 40 Kms south of Perth (Kwinana) by the Anglo – Iranian Oil Company (later BP) in 1952 was one of the first major resource based projects in the State and was a catalyst for water development in the metropolitan region. The Kwinana area was to become the State large industry hub with large volumes of water sourced from dams and groundwater sources.

The resources sector boom of the 1960's was again a catalyst for investment and inward migration. This boom was more broadly based than the gold rushes with development of iron ore, mineral sands, bauxite-alumina and oil supporting economic expansion. These industries needed water supplies and again provided a demand for new supplies and water infrastructure.

In the early 1960's a range of major mining operations commenced in the State in what has been termed the second mining boom. Projects included bauxite mining in the Darling Ranges, iron-ore mining in the Pilbara and mineral sands mining in the Perth Basin. The companies involved developed water supplies for self-supply and in some cases, were guaranteed access to water supplies through State Agreement Acts. Upgrading of some State public water supplies such as Port Hedland was also assisted by funding from mining companies.

Hamersley Iron built desalination plants at Dampier and bores at the Maitland River. With contributions from most iron ore companies, the Government investigated and developed new sources from the Millstream underground aquifer. Pipelines were built by the companies to Dampier, Cape Lambert and Wickham. With Woodside contributions, the State and Australian governments developed the Harding Dam to supplement supplies in the Karratha area and Burrup Peninsula. With contributions from the Mt Newman Joint Venture, the State government developed borefields in the Yule, Turner and De Grey Rivers to supply Port Hedland.

The 'nickel boom' which occurred in the late 1960's saw further co-development with the Government in upgrading water supplies to nickel mines and processing plants in Kalgoorlie and Kambalda.

The introduction in the early 1980's of carbon-in-pulp gold extraction technology revolutionised the gold mining industry. This innovation enabled processing of low-grade deposits and, coupled with high gold prices, led to a gold mining boom which continued with some interruptions up until the mid 1990's. Many new mines were established. The extent of saline groundwater resources in the palaeodrainage systems was realised and large-scale development of these groundwater supplies was undertaken. The availability of poor quality saline groundwater made possible the rapid expansion of gold mining during this period. Many large groundwater investigations were undertaken by mining companies and consulting groups to upgrade and obtain additional water supplies for various mines established during this period.

The 1980's also saw diamond mining commence at Argyle, base-metals mining near Fitzroy Crossing and new base-metal mines in the eastern Pilbara and Goldfields.
Significant expansion of the mineral sands, bauxite, iron ore and coal mining industries also occurred and most of these developments were accompanied by increased demand and use of water supplies. There was a slowing of the mining industry during the late 1990's but a recovery in world commodity prices has seen a recent revival in the industry. In particular, a number of nickel mines have been developed based on new technology for processing laterite ores including the large Murrin Murrin mine near Leonora.

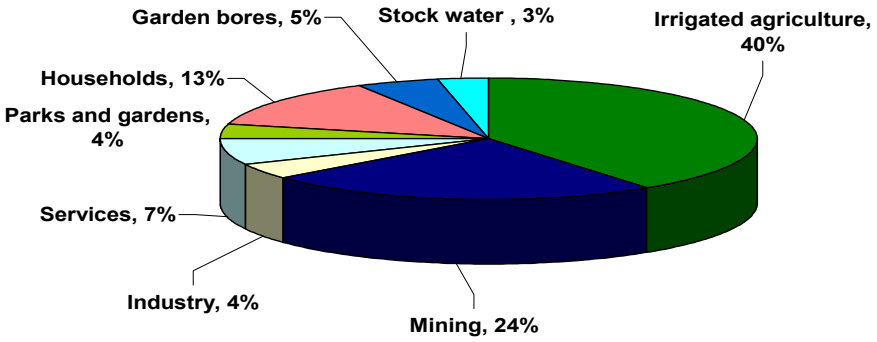
Chapter 4

WESTERN AUSTRALIA WATER USE

4.1 Total Water Use

The Water and Rivers Commission estimated water use in the State as part of a National Land and Water Audit process carried out in 1999-2000. Total water use was estimated at 1,795 GL per annum of water. The mining industry was ranked as the second largest water use sector behind irrigated agriculture (Figure 3). Mining use was put at 430GL per annum or 23% compared with irrigated agriculture at 40% and household use at 13%.

Figure 3: Total Water Use in Western Australia (1999-2000)



Source: Water and Rivers Commission, A State Water Strategy

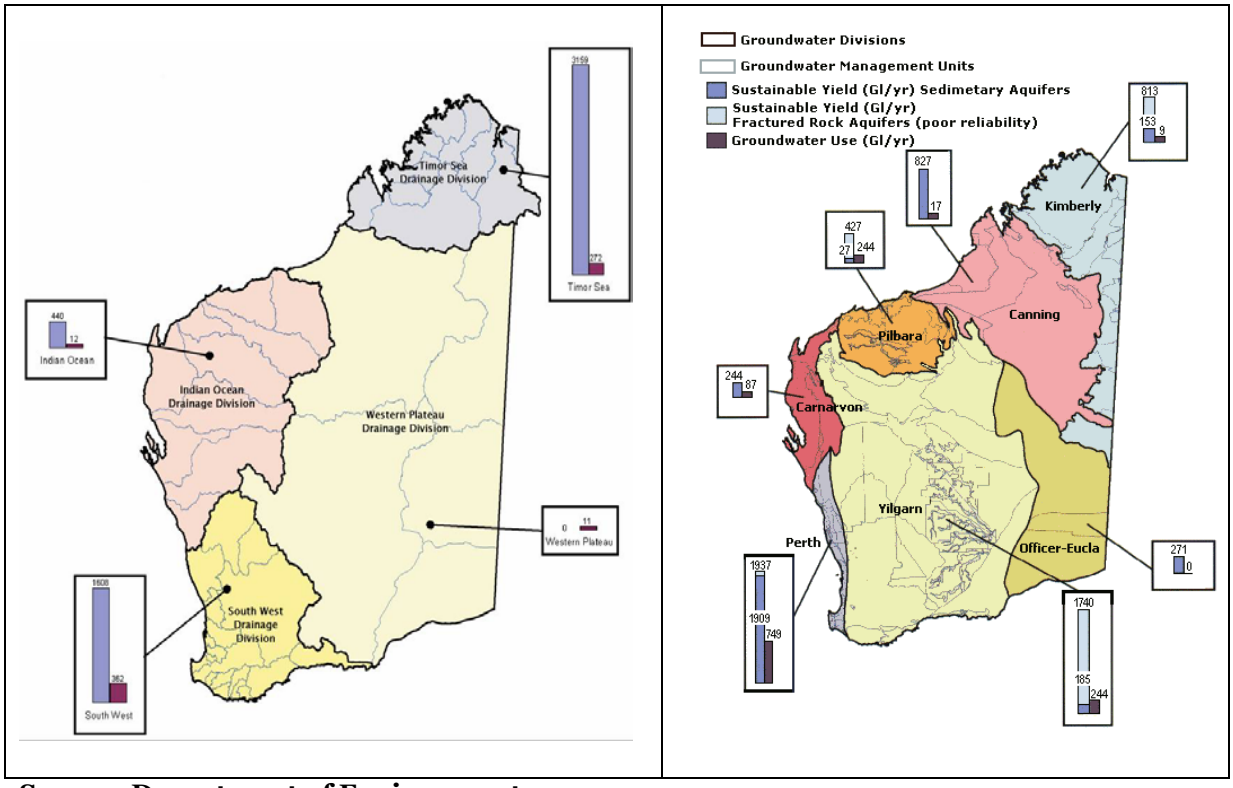
4.2 Surface and Groundwater Use

Water use in the State can be analysed on a regional basis using the distribution of sedimentary and rock formations. This creates four surface water areas and seven geographic groundwater divisions (Figure 4).

The Department of Environment has estimated that **surface** water resources in Western Australia have 44,390 GL of water flowing in them each year, of which only 5,207 GL can be abstracted without causing unacceptable environmental harm[4].

Over 60% of the sustainable surface yield was located in the Kimberley and associated with the Timor Sea Drainage Division and 30% in the South West leaving a very small volume in the remainder of the State (Table 1). Surface water use represented 13% of the sustainable yield. The range of use to yield varied from negligible volumes in the Indian Ocean division to 23% in the south west. In the inland area of the Western Plateau there was not considered to be any sustainable surface yield primarily due to the extremely low level of reliable surface flow. Local dams for livestock and mining purposes capture 11 GL of water per annum.

Figure 4: Surface and Groundwater Areas



Source: Department of Environment.

Groundwater use was estimated at 1,350 GL or 21% of the estimated sustainable yield. The utilisation varied from less than 1% in the Officer – Eucla Basin to a high of 52% in the Pilbara.

4 Water and Rivers Commission (WRC-1, 2002) "Groundwater"

Table 1: Sustainable Water Yield and Use, 2000

Resource	Sustainable Yield (GL)	Water Used (GL)	Proportion (%)
Surface Drainage Division			
Timor Sea	3,159	272	9
Indian Ocean	440	12	3
Western Plateau	0	11	na
South West	1,608	362	23
Total Surface Yield	*5,207*	*657*	*13*
Groundwater Division			
Kimberley	813	9	1
Canning	827	17	2
Pilbara	472	244	52
Carnarvon	244	87	36
Yilgarn	1,740	244	14
Perth	1,937	749	39
Officer – Eucla	271	0	<1
Total Groundwater	*6,304*	*1,350*	*21*
Total water	***11,511***	***2,007***	***17***

Source: Department of Environment, Groundwater, 2000.

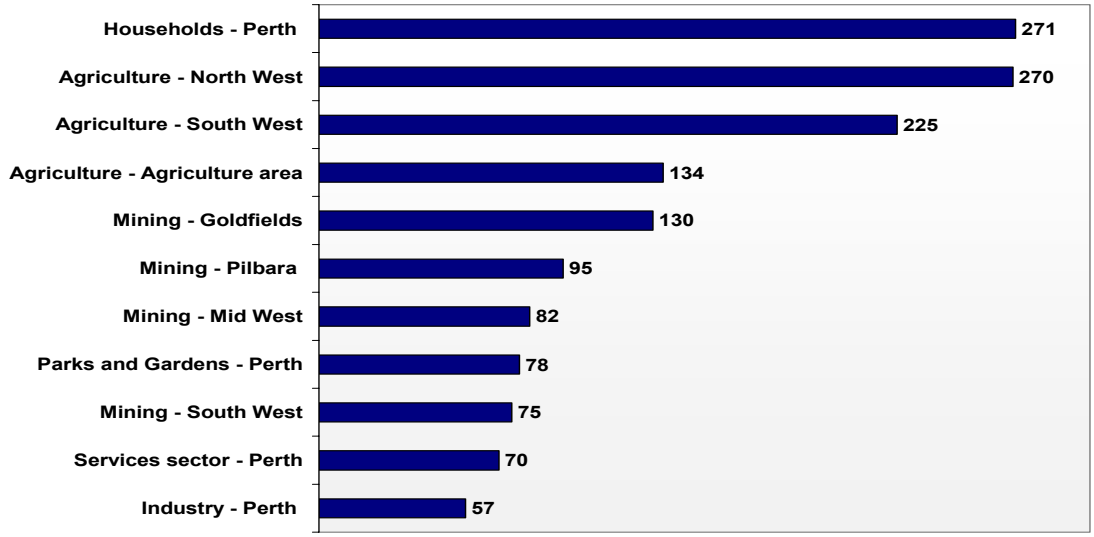
In all regions groundwater use is less than the estimated sustainable yield. In the Pilbara, use is around 58% of the estimated yield while in the Perth division, use is 38%. All other divisions have water use less than this level. The lowest proportion is in the Officer – Eucla division where there is an extremely small population and very little mining or pastoral industry activity.

This broad analysis suggests that groundwater resources are not being over-exploited and that there is scope for further abstraction in all regions. However, this aggregate approach in such a large land area tends to mask local water use pressures. It also overlooks the potential for sustainable yields to fall with any reduction in rainfall or pollution that could reduce the value of groundwater resources.

Another way of looking at use is to examine industry sector and location. The National Land and Water Audit classified seven key industry sectors and 19 regions. The top ten water use sectors accounted for close to 85% of total water use in the State (Figure 5). The top four categories account for 50% of total water use and are all related to agriculture or household use.

Mining in the Goldfields – Esperance region was the largest regional mining use followed by the Pilbara and Mid West areas. The mining sector provided four of the top eleven regional water use sectors and accounted for one quarter of the total use.

Figure 5: Top Ten Water Use Sectors

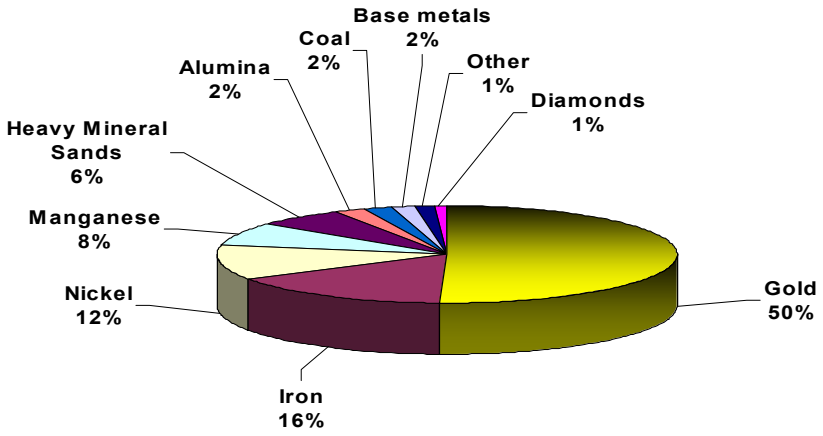


Source: Water and Rivers Commission, National Land and Water Audit

4.3 Mineral Commodity Use

The gold sector dominates water allocations with half of the licensed volume (Figure 6). Iron ore and manganese take up 24% followed by nickel projects at 12%. These three commodity groups account for 86% of the total water allocation.

Figure 6: Water Licence Allocations by Mineral



Source: Water and Rivers Commission, March 2004

Chapter 5

MINING WATER USE

5.1 Introduction

Mining companies require water for many *uses* including:

- human consumption;
- transport of ore (slurries, suspension);
- mineral separation (centrifuging);
- to physically break up materials (jetting);
- cooling (power generation);
- dust suppression (crushing and screening, conveyors and roads)
- washing equipment; and
- dewatering of mines to enable safe mining to proceed.

Water that is pumped from a pit or underground mine as part of a dewatering operation can be used around the minesite for different purposes depending on the water quality or put straight back into local watercourses away from mining operations. Water put back into local watercourses or dams may end up in the same groundwater aquifers from which it was extracted. In such cases, the impact on the groundwater aquifers and overall environment is minimal and it could be argued that while the water has been temporarily displaced, it has not been "used". In a similar way, some water used in dust suppression will be lost through evaporation but some will end up back in the same local groundwater.

A more stringent way of classifying *use* is to segregate *consumptive* use where water use is only included if it is used in a process that removes it from local use or renders it unfit for further use. The best approach is to use a Water Balance model that accounts for all water supplies, use and disposal. Companies are moving to such an approach.

The lack of a sophisticated classification of water use means that this study begins with a description of total use and then explores those elements which make this aggregate assessment misleading. A detailed examination of water use in mining is possible using the Department of Environment licence database and the results of a survey conducted as part of this study. Both have limitations but they provide more information than is otherwise available. This chapter looks at the role of water service providers in the mining sector, the patterns of water use obtained from the survey and the regional pattern of use reflected in the licence database.

5.2 Groundwater Licence Holders

The majority of water used by the industry is self supplied under a groundwater licence issued by the Department of Environment.

At March 30, 2004, there were 641 licences in the database involving a total allocation of 629 GL. Water uses were broadly defined and included such applications as mining operations, exploration, mining camp, process water, dewatering, dust suppression and combinations of all of these. The State Government has assessed total mining use at around 430 GL per annum or just over two thirds of this total allocation.

This study used the licence database to provide a more detailed picture of mineral and energy industry water use. Some caution is needed in the interpretation as the database was developed with local management issues in mind and does not cover all water supplies. For example, the Wheatbelt area is not included and some mining companies obtain their water supplies from other organisations such as the State Government Water Corporation. The large North West Shelf Joint Venture Burrup Peninsular gas processing plant obtains water from the Corporation and hence does not hold any substantial water supply licences. This means that water for the project will be supplied under the Water Corporation licences and will not be identified in the database as a mining application. Similarly, projects associated with mineral processing such as alumina, heavy mineral sands, silicon refining and nickel smelting and refining will not be included as they are not regarded as mining activities in the narrow sense of the term. The net effect is that water use estimates derived from the licence allocations will not be fully representative of the minerals and energy industry.

The allocation by groundwater management areas was concentrated in three areas with the Goldfields (40%) Pilbara (33 %) and East Murchison (10%) accounting for 85% of the total (Table 5). Licence allocations in the South West corner of the State are low with the two most significant areas south of Perth (Collie and Busselton-Capel) together accounting for only 5% of the total.

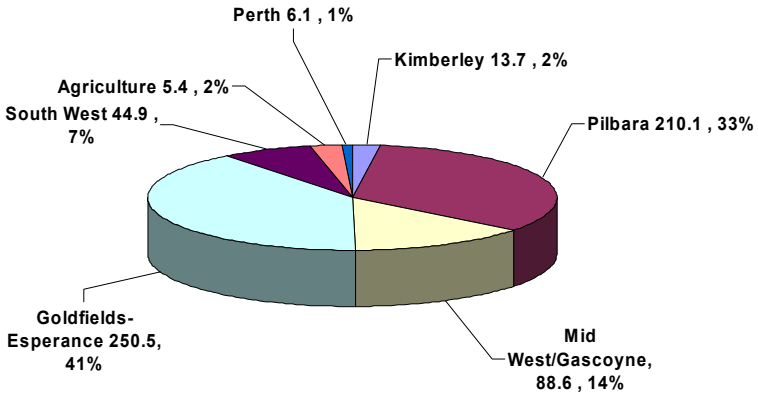
Table 2: Water Licence Allocations, GL per annum

Groundwater Management Area	Allocation (GL)	Proportion (%)
Goldfields	250.475	40
Pilbara	210.086	33
East Murchison	60.316	10
Arrowsmith	21.048	3
Collie	18.200	3
Kimberley	13.748	2
Murray	12.960	2
Busselton-Capel	11.521	2
Gingin	8.835	1
Gascoyne	7.181	1
Kondinin-Ravensthorpe	5.155	1
Other	9.672	2
Total	**629.199**	**100**

Source: Water and Rivers Commission, April 2004

To simplify a more detailed examination of water use, the Groundwater Management Areas can be grouped into seven larger areas corresponding to broadly - accepted administrative regions. Notes on each region follow.

Figure 7: Water Licence Allocations by Administrative Region



Source: Water and Rivers Commission, April 2004

5.3 Water Service Providers

Some water for mining and mineral processing and oil and gas processing is supplied to resource companies by other licensed water service providers. The Water Corporation of Western Australia and Harvey Water supply water to companies primarily for mineral processing activities. Specific details are confidential and hence only regional scale information can be provided. Total sales in 2003 were 27 GL (Table 3). This includes sales for oil and gas processing activities, nickel refining, titanium production, ship loading and port operations, hot briquette iron manufacture and alumina refining. While it is not possible to break up these sales, it is suggested that around 18 GL is an approximate use in "mining and mineral transport activities as distinct from mineral processing. Mining in this context includes primary production at the mine sites, mineral transport operations, alumina processing, and ship loading and port activities where they are conducted by the mining company.

Table 3: Resource Sector Water Sales by Service Providers, 2003, GL per annum

Region	Sales (GL)
Pilbara	13.5
Mid West-Gascoyne	1.5
Goldfields – Esperance	5.5
South West	3.4
Perth	3.5
Total	**27.4**

Source: Licensed Water Service Providers

5.4 Mine Site Water Use

For this study, mining companies provided water use details for 24 sites including a port and a titanium dioxide pigment plant. The latter projects obtain most water from the Water Corporation with minimal self supply and hence have been excluded from the analysis.

The 22 projects included 7 gold mines, 6 iron ore operations, 2 nickel, 2 heavy mineral sands, one base metals and one tantalite project. The total water licences held were 185 GL per annum of water of which 101 GL was used in 2003. Total use represented 51% of the allocation (Table 4). Surface water sources, including dewatering or recovery from open pits or underground operations accounted for 25% of water with 75% from bores.

Table 4: Company survey water use

Mine site	Allocation	Use	Source*		Quality	
	ML/a	ML/a	Bore	Surface	Fresh	Other
Lawlers	3,065	1,874	50%	50%		100%
Plutonic	9,806	3,763	72%	28%	100%	
Darlot	805	340	100%			100%
Area C	876	250	100%		100%	
Jimblebar	600	380	100%		3%	97%
Orebody 23/25	1,420	518	100%			100%
Whaleback/29/30/35	16,000	6,570	100%		95%	5%
Yandi	31,065	2,506	100%		100%	
Yarrie	3,810	1,095	50%	50%	100%	
Murrin Murrin	17,630	10,400	95%	5%		100%
Golden Grove	3,510	4,130	8%	92%	8%	92%
Jundee	5,800	3,060	100%		17%	83%
Mesa J	30,000	20,805	100%		100%	
West Angelas	3,102	840	100%		100%	
Wodgina	3,515	3,066	100%		100%	
Leonora	5,325	4,257	100%			100%
Southern Cross	8,785	4,010	97%	3%	3%	97%
Carosue Dam	8,867	3,610	100%			100%
Chandala	1,265	812	80%	20%	80%	20%
Cooljarloo	8,780	9,974	1%	99%	100%	
Leinster	5,250	4,090	92%	8%	20%	80%
Mt Keith	31,800	14,800	95%	5%	1%	99%
Total	**184,511**	**101,240**	**75%**	**25%**	**42%**	**60%**

Source: Mining companies * Surface includes water from dewatering.

The Mt Keith and Murrin Murrin nickel projects have large water licence allocations as do the iron ore operations at Mesa J, Yandi, and Whaleback. The average amount of water used when compared with the water licence allocation was 51% with sites ranging from 17% (Yandi) to over 100% for the Golden Grove and Cooljarloo sites. Mine site use can be misleading. The Mesa J iron ore mine operates below the watertable as does the Cooljarloo and Yandi mines. The Mesa J and Yandi mines have to be dewatered before mining can commence with continuous pumping as mining continues. Pumping volumes depend on rainfall, the pit intersection, the pit area and depth. Well over 50% of the Yandi and Mesa J water dewatered from the pit area is replaced into a local watercourse

downstream from the pit area. It quickly soaks into the surface aquifers and in time filters back into the aquifer system from which it was pumped. At Cooljarloo, mining involves a floating dredge on a pond. Water infiltrates the pond and is removed with the dredge operations. A substantial volume is recycled from the tailings dam and concentrates stockpiles with excess water discharged into dams and ponds on the site. A limited volume of borewater is used to supplement the pond operations.

The water use figures for the Mesa J, Yandi and Cooljarloo sites tend to overestimate water lost to the groundwater system as more than half the amount used is returned to the local aquifer system without any consumptive use.

The source of water included rivers (Boddington), dams (Boddington and Whaleback), open pits, underground mines, and borefields. On average, 75% of water was sourced from borefields and 25% from surface or open catchments (surface or underground). Borefields and other sources were located up to 40Kms from the mine site.

Water quality varied widely from fresh to hypersaline. On average, 40% of the water used was of potable or fresh quality (less than 1, 000 mg/L total dissolved solids) and 60% ranged from brackish to hypersaline.

The proportion of water recycled varied from no recycling to over 70%. The dredge pond at Cooljarloo is used to recycle most water extracted with the heavy mineral sands. Only a small volume of additional bore water is needed to supplement the pond water.

The amount of water recycled varies with the water availability and water needs (Table 5). The measure of recycling used here is the proportion of water sourced in daily operations from tailings dams or other storage facilities after having been used in part of the mining operation. The iron ore operations require some water for processing, some for dust suppression and some for townsite uses but they do not tend to use large water volumes for process applications. In the cases of Yandi and Mesa J and to a less extent at Whaleback the dewatering operations provide water for such purposes and recycling is not necessary to supplement other sources. Significant volumes of water are being discharged to the environment in the case of Yandi and Mesa J.

Table 5: Company survey water recycling

Mine site	Allocation	Recycled
	ML/a	ML/a
Lawlers	1,874	60%
Plutonic	3,763	70%
Darlot	339	63%
Area C	250	0%
Jimblebar	380	0%
Orebody 23/25	518	0%
Whaleback/29/30/35	6,570	10%
Yandi	2,506	0%
Yarrie	1,095	0%
Murrin Murrin	10,400	10%
Golden Grove	4,132	40%
Jundee	3,060	65%
Mesa J	20,805	12%
West Angelas	840	0%
Wodgina	3,066	15%
Leonora	4,257	40%
Southern Cross	4,010	27%
Carosue Dam	3,610	30%
Chandala	812	2%
Cooljarloo	9,974	99%
Leinster	4,090	18%
Mt Keith	14,890	22%
Total	**101,241**	**30%**

Source: Mining companies

5.5 Regional Use and Management Issues

5.4.1 Kimberley

This vast region includes only three local government areas and a very small population centred on Broome, Kununurra, Derby and Wyndham. The population is growing slowly but is less than 2% of the State total and the population density is very low by world standards.

The value of mineral and oil production in 2003 was $808 million. There were 22 mineral and oil extraction projects but production was dominated by two projects – the Argyle diamond mine and the Lennard Shelf base metals mine. Collectively, they had a value of output estimated at $772 million or 95% of the total for the region.

The Water Corporation supplies water to towns but not to mining companies and hence all mining water is self-supply under licence. All mining operations in the region have developed their own water sources. The Argyle diamond mine uses surface water and groundwater from near Lake Argyle while the Lennard shelf operations use groundwater. Total licence allocations at April 2004 for the Kimberley region were for 13.7 GL per annum of water supply (Table 6). Over 90% of this allocation was held by the four projects being the Argyle

and Ellendale diamond projects, the Western Metals base metals project and the Kimberley Nickel Mine.

Table 6: Water Licence Allocations, Kimberley

Mineral	Allocation (GL)
Diamonds	6.7
Base metals	5.4
Nickel	1.5
Other	0.1
Total	**13.75**

Source: Water and Rivers Commission Database, April 2004

The Kimberley region as a whole has huge water resources with a number of large river systems.

In general, the distance between mines and the low population density mean there is little pressure on water sources in this region. The limited number of mines and location of each mean that environmental issues are unique to each project. No significant water related issues are thought to exist at this stage.

5.4.2 Pilbara

The vast Pilbara region includes four local government areas with most town's dependant on the mining industry for their prosperity. Like the Kimberley, the region is huge in area but has a very small population (39,000 people) with less than 2% of the State total in an area of more than 500,000 km^2. The population density is very low as a consequence.

The region has been called the powerhouse of the Western Australian economy with a gross value of production in 2003 estimated at $14,900 million from more than 20 mining projects. The most valuable of the commodities are hydrocarbons with the world-class North West Shelf project at the Burrup Peninsula dominating output. Crude oil and natural gas are extracted from around 40 fields; all located in waters offshore from the Pilbara coast. Water is used in processing with plants located on the Burrup Peninsula, Barrow Island, Thevernard Island, Varanus Island and Tubridgi. There are also offshore platforms using desalinated water for processing purposes. The Water Corporation supplies the Woodside operated plant on the Burrup Peninsula while the offshore islands have their own water supplies – either groundwater or desalination.

Iron ore production ranks second in the region with a gross sale value of $5,100 million. Mining occurs in the East and West Pilbara areas with exports through three coastal ports. Water is used in mining and ore handling operations for dust suppression and in ore concentration processes. Substantial volumes are used in operations around the ports for dust suppression and at the Boodarie direct reduced iron plant. The Water Corporation supplies water to the iron ore operations at each port while the three companies hold licences for minesite and railway operations. The companies hold licences for mine dewatering operations with some operations requiring substantial volumes to be extracted before mining can proceed. Some water abstracted is put back into local watercourses downstream from mining operations.

Gold is important with the Telfer mine in the desert area a historically large producer. That mine is being reopened in 2004 and will again be a major contributor to the region economy.

Salt is recovered from seawater at three projects in the region with tantalite, manganese and copper the next ranked commodities in terms of production value.

Mining companies have established much of the infrastructure in the region including rail and road transport systems, electricity and gas networks, water supplies and towns with health, education and recreation services. Company-built towns include Karratha, Dampier, Tom Price, Newman, Paraburdoo, Pannawonica, and Wickham. Companies have established major port facilities at Onslow, Cape Lambert, Port Hedland, and Dampier. Airports have been established at Karratha, Newman, Paraburdoo, Pannawonica, Port Hedland, Wickham and Marillana Creek.

The Pilbara experiences intense summer rainfall with associated river flooding. Except for the eastern Sandy Desert area, the large volumes of water discharge to the ocean. Most groundwater aquifers show a rapid response to recharge following rainfall events demonstrating renewable groundwater resources. Some recharge reservoirs have been installed including the Ophthalmia Dam at Newman.

Total Water Corporation sales in 2003 to resource companies were 13.5 GL and there were nearly 40 water licences allocated for a total of 200GL per annum. Twelve companies held water licences.

Iron ore and manganese operations represented most (88%) of the volume of water allocated (Table 7). Consolidated Minerals (manganese) and Robe River Iron undertake substantial dewatering before mining and hold licences of 64.8 GL per annum and 33.9 GL per annum respectively.

Table 7: Water Licence Allocations, Pilbara

Mineral	Allocation (GL)
Iron ore	120.9
Manganese	64.8
Gold	17.8
Tantalite	3.5
Copper	3.0
Other	0.1
Total	**210.1**

Source: Department of Environment Database, April 2004

Actual water use in the Pilbara in 2000 by the iron ore sector was estimated at 55 GL per annum[5]. Assuming that this has increased in line with iron ore production (around 20%), the use in 2003 may have been around 66 GL. Subtracting the 13.5 GL supplied by the

[5] Johnson S and Commander, P, Groundwater Utilization by the Mining Industry in Arid Western Australia, October 2003.

Water Corporation suggests an abstraction from groundwater by the companies of 53GL or 25% of the total allocated licences.

The iron ore sector is growing rapidly and all companies are expanding their operations along with at least four new companies striving to establish projects in the region.

The Pilbara is an arid region with limited water supplies. Groundwater is recovered at Millstream and the surface water at Harding Dam are struggling to meet the growing demand in the West Pilbara. Desalination is being developed at the Burrup Peninsula to supplement industrial water needs. The Water Corporation manages the Harding Dam and Millstream water supplies as well as the Yule and DeGrey systems and will manage the desalination plant on the Burrup Peninsula. The companies manage their own borefields for mining purposes.

The Canning Basin which lies in the east of the region and to the south of the Kimberly has very large water supplies and includes large desert areas.

A few mines in the region such as Telfer (gold) and Nifty (copper) face challenges with water supplies.

In the East Pilbara, mining companies hold significant water abstraction licences. There is little competing water demand and much of the water allocated returns to regional supplies following dewatering. There are local water supply scarcities for mining purposes but no regional water supply tensions.

5.4.3 Mid West – Gascoyne

The Mid West region as defined for this report includes 23 local government areas encompassing the largely pastoral areas of the Meekatharra, Murchison and Carnarvon Shires and the agricultural areas around the Gascoyne River and south of Northampton to the Shire of Coorow.

The 606,000 square kilometres represents nearly one quarter of the State land mass but includes only 3.2% of the State population or 61,000 people. This represents a very low population density with only one town having a population in excess of 10,000 – Geraldton. The small towns of Yalgoo, Mt Magnet, Meekatharra and Wiluna are dependent on the mining sector for most employment whereas Carnarvon primarily services the pastoral industry and irrigated agriculture on the Gascoyne River. Geraldton is the regional service centre and centre of a popular tourism region.

The population has doubled in 40 years but remains very low although the density of settlement is above that of the Kimberley and Goldfields regions.

The Mid West and Gascoyne regions include a wide range of mining activities with more than 45 projects and a combined value of production of $2,215 million. The highest valued commodities are nickel (the WMC owned Mt Keith Mine), Heavy mineral sands, copper, salt, zinc and gypsum.

The Mid West region has hot dry summers and cooler wet winters. Conditions become dryer to the east and rainfall less reliable. Some rainfall occurs in summer from tropical rainfall depressions or isolated thunderstorm activity. Extended drought periods are common in the Murchison area. The western areas drain to the coast through intermittent river systems while the eastern areas tend to drain to salt lakes further east.

The Gascoyne region has a predominantly summer rainfall with occasional heavy showers from tropical depressions. The coastal rainfall is relatively low with rainfall decreasing quickly inland. With the exception of a coastal strip, the region is generally arid.

Surface water supplies in the Mid West – Gascoyne region are of limited use for water supplies and nearly all water is obtained from groundwater sources. The region can be differentiated into four groundwater categories. The Northern Perth Basin area overlies a large sedimentary basin with a significant aquifer system of potable and brackish water. Around Geraldton and into Northampton is a block with only small water supplies in fractured rock varying in quality over short distances. Closer to the coast from Geraldton is a sedimentary area with large supplies of fresh to brackish water. The vast Murchison province covering most of the region has variable groundwater sources. Estimates of availability have only been made on a broad scale and are not suitable for planning purposes. There are surficail, sedimentary and fractured rock aquifers with different salinity levels. Some areas have high salinity with salt in the groundwater palaeochannels believed to have accumulated over periods of hundreds of thousands of years.

The Water Corporation provides water to most towns in the region and 1.5 GL was sold to mining operations in 2003. There was over 40 water abstraction licences allocated to mining companies with a total of 88.6 GL per annum allowable abstraction. Gold licences dominated with 60% of the total volume followed by heavy mineral sands with 23% together accounting for 83% of the total volume allocated (Table 6).

The outlook for minerals and oil and gas development in the region is promising. High nickel prices are encouraging further development and gold exploration and development continues. Significant oil and gas discoveries offshore the Exmouth Gulf at Enfield–Vincent–Laverda and in the northern Perth Basin at Cliff Head has renewed interest in this region for hydrocarbons. Base metals offer medium - term potential and a range of other minerals such as lead, salt, gypsum, and vanadium, heavy mineral sands offer development opportunities.

Table 8: Water Licence Allocations, Mid West – Gascoyne

Mineral	Allocation (GL)
Gold	54.4
Heavy Mineral Sands	21.0
Base metals (with lead)	7.0
Vanadium	3.5
Other	2.7
Total	**88.6**

Source: Department of Environment Database, April 2004

Surface and groundwater supplies around Geraldton are generally plentiful while groundwater supplies in the dry Murchison area are specific to local situations. The limited population spread out mining activity and lack of demand from other water users means that water supplies in the region are not under great pressure.

With a number of mines, decommissioning of borefields has been possible as mining pits deepen and dewatering supplies enough water for project needs. A study completed in 1995 suggested that mining companies were only using about 40% of the licensed allocation. Use in the region was estimated at 23 GL per annum in 1997 and is unlikely to have increased substantially since then. This suggests that the proportion of water actually being used from that allocated is likely to be significantly less than 50%.

5.4.4 Goldfields – Esperance

This large area stretches from east of Wiluna in the north eastern Goldfields to the southern coast from Ravensthorpe to the South Australian border. It is the second largest of the regions defined for this study encompassing 30% of the State land mass. The population is small at 55,000 making the density of settlement very low.

This region was the effective origin of mining in Western Australia and the gold discoveries have continued for over 110 years. The region now produces gold ($2,336 million), nickel ($1,700 million), cobalt ($132 million), lime materials ($14 million), tantalite ($14 million), and a range of other minerals for a total value of $4,215 million in 2003. Mining activity is more concentrated in the northern area, around Kalgoorlie and more recently in the Johnson Lakes area.

Mining companies have been the driving force for the establishment of much of the infrastructure in the region. Kalgoorlie–Boulder, Coolgardie, Leonora, Laverton, Norsemen, and Ravensthorpe owe their establishment to mineral discoveries. Companies have also underwritten port development at Esperance, and construction of natural gas pipelines. With strong nickel prices, substantial expansion and new investment is planned or is being evaluated.

Mining continues to play a strong role in the regional economy far surpassing the agricultural sector.

Water availability varies widely across the region. Most of the area is arid with higher rainfall on the southern coast. There is little surface water flow and most supplies are from groundwater. The Mundaring to Kalgoorlie pipeline and extension to Norsemen provides water to towns and projects along the route. Away from the pipeline, groundwater is the only option.

In the northern Goldfields there is a combined rainfall pattern with lighter, winter rainfall from cold-fronts passing over the South West land division and more intense, summer rainfall moving from the tropics. Internal paleodrainages are a common groundwater source. Recharge appears slow

The Goldfields south of Leonora and Laverton experience light winter rainfall and infrequent, intense summer rainfall. Surface drainage is poorly-defined and marked by

chains of saline playas that interconnect infrequently and overlie an eastward-draining, buried palaeodrainage. The long period of low rainfall, high evaporation and internal drainage has created saline to hypersaline groundwater conditions. The hypersaline groundwater in palaeochannels is inferred to have accumulated over periods of hundreds of thousands of years to account for the high salinity.

Potable water supplies in the Southern Cross – Esperance region are only available on the south coast. The Water Corporation meets local town needs from groundwater sources while the remainder of the region relies on local surface catchments or groundwater sources.

Groundwater quality varies greatly. Some local sources are potable but much is saline or even hypersaline. The latter sources have provided substantial quantities for gold processing and more recently for nickel processing. The use of saline water was limited until the 1980's when the development of new technology for gold processing enabled their use. Ancient underground watercourses (palaeochannels) are an important source of water across the region.

The mining industry is the largest groundwater user and demand has increased rapidly over the last three decades with changes in gold processing technology and the development of new nickel projects. Demand at present appears to be static as mines opening are matched by closures.

Groundwater resources in the Goldfields can be segregated into four sub areas.

The *Northern Goldfields* groundwater resources are considered adequate for local development needs. Available supplies are estimated at 212 GL per annum after use in 2001 was taken into account[6]. Potable water supplies are limited but town demands are not large and supplies are considered adequate for future expansion. Non potable sources appear adequate for future growth.

The *Eastern and Southern Goldfields* also do not contain groundwater sources that would support a regional water supply scheme. The available water is poor in quality ranging from saline to hypersaline. The total resource for future use is estimated at 278 GL per annum.

The *Officer Basin* is a major sedimentary basin in the north east of the region. Fresh to brackish water exists at depth with a preliminary estimate of a 182 GL per annum sustainable draw. This entire yield is available for development by any industry that can use the quality available – effectively only mining.

The *Eucla Basin* at the eastern border of the State is a major sedimentary basin. The sustainable yield is estimated at 88 GL per annum and therefore readily capable of meeting the future projected needs of the Kalgoorlie – Boulder region. However, the quality is thought to be generally poor and the Basin has not been fully investigated.

The Water Corporation provides water to mining and mineral processing projects around Kalgoorlie from the Mundaring to Kalgoorlie pipeline but all other mines obtain their own

[6] Department of Mineral and Petroleum Resources: Goldfields Esperance Water Supply, January 2003

supplies from groundwater sources. The Water Corporation supplied 5.5 GL in 2003 and there were more than 100 projects licensed by the Department of Environment for a total of 250GL per annum of potential supply. The gold sector dominated the licence allocations with 75% of the total volume allocated and nickel was responsible for most of the remainder with 25% (Table 9).

Water use in the mining sector was estimated at 42 GL per annum in 2000[7]. Assuming an increase of 10% to allow for expansion of the nickel mines, the total appears to be less than 50 GL or 20% of that allocated under licence.

Table 9: Water Licence Allocations, Goldfields – Esperance

Mineral	Allocation (GL)
Gold	187.4
Nickel	60.9
Other	2.2
Total	**250.5**

Source: Department of Environment Database, April 2004

The long-term issue for the region is the longevity of the groundwater resources. Recent research suggests that that there has been no impact of the groundwater resource from 15 years of abstraction and that abstracting at current levels is sustainable in the long-term.

5.4.5 South West

The South West of the State includes all areas south of Mandurah to Walpole on the southern coast. It does not include the great southern areas around Albany as these are included in the Agricultural region for this study.

The region, encompassing the Peel and South West Development Commission areas, is Western Australia's most diverse region in terms of landform, vegetation, human settlement and land use. It covers agricultural land and forest and includes the most populated areas of the State but does not include the Perth metropolitan area or Mandurah.

The region is 29,470 square kilometres in area with a population of 211,000. It is the most populous of the regions outside the metropolitan area used in this regional evaluation and the smallest in area. Only one town has a population in excess of 10,000 (Bunbury) but there are many towns in the range from 1,000 to 10,000 reflecting the population concentration in this region.

While the economy has a strong agricultural component, the resources sector provides the largest single component with a value of production in 2003 estimated at $3,934

million from 64 mining operations. The key commodities were alumina ($3,140 million), coal ($266 million), heavy mineral sands ($260 million) and gold ($156 million). Mineral

[7] Johnson S and Commander, P, Groundwater Utilisation by the Mining Industry in Arid Western Australia, October 2003

processing adds to this primary extraction with the production of titanium dioxide pigments and silicon metal taking the total for the industry closer to $5,000 million.

Mining companies have established public and private infrastructure in the region and underwritten much investment in such facilities. The road and railway system carries coal, bauxite, alumina, quartz rock, mineral sands, tantalite, tin, and spodumene and silica sand. Port facilities at Bunbury export many of these commodities.

The region includes most of the States surface water reservoirs and a comprehensive pipeline distribution system. A number of water service providers operate in the region and groundwater is available over most of the area. This region has traditionally provided much of the water for the metropolitan area to the north. Water service providers supply most water users in the area and supplied water to alumina and heavy mineral sand producers with total sales in 2003 of 3.4 GL.

Mining projects also source their own water supplies from groundwater with limited volumes from surface water supplies. By April 2004, 22 licences had been issued to mining and petroleum companies involving 45 GL per annum of water. Coal, alumina and the heavy mineral sands sectors dominated allocations (Table 10). Most o f the coal allocation is for dewatering of the open cut pits and the water is used in the electricity power stations for cooling.

With a growing population in the region and demands from this area to supply the metropolitan area, the demand for water sources is high and growing. Groundwater sources in some locations are fully allocated and there is local resistance to the construction of new dams and reservoirs. The community expectations for verification of sustainable yield estimates are higher than in the past making it more difficult to develop new groundwater sources.

Table 10: Water Licence Allocations, South West

Mineral	Allocation (GL)
Coal	16.1
Alumina	14.26
Heavy mineral sands	14.1
Other Coal	0.4
Total	**44.86**

Source: Department of Environment Database, April 2004

Among existing sectors, power generation and alumina production are continuing to expand while heavy mineral sands production is relatively stable. The region is considered to be highly prospective for further mineral discoveries and energy resources. However, development may be constrained by access to land in the more densely settled areas, environmental restrictions and water availability.

5.4.6 Agricultural Areas

The agricultural zone in this report refers to the Wheatbelt and Great Southern Development Commission areas ranging from Coorow to north of Perth to Bremer Bay east of Albany. The region has an area of 194,000 square kilometres and covers most of the broadacre farming land in the State with some pastoral properties in the Mt Marshall and Yilgarn Shires.

There is one city in the region (Albany) and many smaller rural centres including Northam, York, Wongan Hills, Merredin, Moora, Wagin, Katanning, and Kojonup. These towns primarily provide services to the farming community with some of those in the Avon Arc area providing accommodation for people commuting from Perth.

The population is 126,000 and has been static or declining in most Shires over the last 40 years with the exception of areas closer to Perth and the coast. Agricultural production makes up over half of the economic output with crops and pastures the dominant activity. Mining and oil and gas production make up only about 10% of the gross regional output.

This region has the lowest level of mining activity of any regional area outside Perth partly for geological reasons but also because access to the farm areas for exploration is difficult. In 2003, the value of mineral and oil and gas production was $508 million with around 20 active mining projects. The heavy mineral sands sector dominated ($180 million) followed by iron ore ($118 million), gold ($111 million), petroleum ($84 million) and a range of other minerals.

Water Corporation pipelines service a lot of the area but the mining companies mostly operate outside this service area and a very small amount of water was provided to mining companies in 2003.

Water licences were on issue to 11 projects at April 2004 including a total allocation of 15GL per annum. Heavy mineral sands projects dominated with nearly 60% of the total followed by nickel and gold (Table 11).

Table 11: Water Licence Allocations, Agricultural Areas

Mineral	Allocation (GL)
Heavy mineral sands	8.8
Nickel	5.1
Gold	1.4
Total	**15.4**

Source: Department of Environment Database, April 2004

Water in the area comes from the pipeline system, local surface water catchments and groundwater sources. Water is not abundant in the pastoral areas of the region where gold and nickel mines operate but are more plentiful in the coastal areas around Gingin where the heavy mineral sand projects are found. Overall, the low level of human activity, where most of the mines are located reduces the demand to manageable levels.

5.4.7 Perth

The metropolitan area includes a number of mines and mineral processing activities. The largest operations are those associated with nickel refining, alumina production and the production of titanium dioxide pigment. Most of these operations are classified as manufacturing activities even though their existence is due to the local supply of minerals for processing. This classification means that the value of production is not known with certainty. Production recorded by the Department of Industry and Resources for the Perth area relating to on-site mining activity under the Mining Act was in excess of $20 million. This did not include most mineral processing activity or quarrying carried out for materials such as limestone, sand, gravel and rock much of which occurs on private land and is outside the jurisdiction of the Mining Act.

The Water Corporation supplies virtually all water in the metropolitan area and had sales classified as mining related of 3.5 GL in 2003. Licences totalled 6.1 GL per annum at April 2004. Licences were issued to quarries north and south of the city with an alumina producer also holding a substantial licence.

Chapter 6

WATER MANAGEMENT ISSUES

6.1 Water Development and Operating Costs

In large areas of the State, public water supplies are limited or non – existent. Mining companies have had to develop their own sources for human use and mining activities.

Some dams have been constructed to utilize surface water resources have been constructed the most significant being the Ophthalmia dam at Newman in the 1960's with several smaller dams in the South West for bauxite and gold projects. A few dams have been constructed in the Goldfields in areas where surface water exists but have generally been developed in conjunction with groundwater supplies.

The lack of surface water in most mining areas means that groundwater has been the major source of water. Mining companies have invested heavily in hydrogeological research and water studies, borefield development, piping systems and disposal facilities. Much of the early investigation work has been undertaken by expert consulting groups backed up by a specialist State Government hydrogeological group.

Groundwater is generally extracted from borefields located near minesites. Some mines need to dewater underground operations or open pits before mining can commence and this water can be a source for operational activities. Some mines have water from dewatering in excess of minesite needs and the residual is discharged to local water courses. However, most do not have enough water from dewatering activities and need to develop and operate borefields.

The cost to develop groundwater supplies varies widely depending on the quantity of water required the difficulty in locating suitable quality sources, the distance to the borefield and water treatment costs. There is no comprehensive estimate of the cost which the mining industry has incurred in locating and developing water sources. Assuming that the provision of water supplies was at least 5% of mine establishment costs, the total investment has almost certainly exceeded hundreds of millions of dollars.

Survey work conducted as part of this study provides some information on capital and operating costs. This data should be interpreted with caution. The survey did not attempt to the cost into a period of time and the results are biased towards more recent projects for which data is readily available rather than older projects where records are poor.

The total investment for 20 projects involving licensed allocations of 126 GL per annum of water was $114 million (Table 12). It is important to note that the sample does not include any mines near Kalgoorlie or the South West of the State. The expenditure was dominated by the large Mt Keith nickel project with water development costs in excess of $38 million. The costs for the Minara nickel project are likely to be at least this amount also but were not recorded in the survey and have been omitted. The implication from this very limited sample is that with total allocations more than six times the size of this sample, total capital development costs will have been at least $700 million in current dollar terms.

Table 12: Water Supply Costs

Company	Project	Allocation	Source	Capital cost	Operating cost	Management cost
		ML/a		$m	$,000/a	$,000/a
Barrick	Lawlers	3,065	Open pit, borefield	0.09	18	3
Barrick	Plutonic	9,806	Open pit, borefield	6.1	357	18
Barrick	Darlot	805	Borefield	1.2	240	4
Boddington	Boddington	9,400	Dam, borefield	32	50	5
BHP	Area C	876	Borefield			41.4
BHP	Jimblebar	600	Borefield			26
BHP	Orebody 23/25	1,420	Borefield			26
BHP	Orebody 29/30/35	16,000	Open pit, borefield			600
BHP	Yandi	6,867	Open pit			55
BHP	Yarrie	3,815	Open pit, borefield		1290	55
Newmont	Golden Grove	3,510	Open pit, borefield	12.2	1,630	250
Newmont	Jundee	5,800	Borefield		1,660	
SOG	Wodgina	3,515	Borefield	5	276	45
SOG	Leonora	5,325	Borefield	7	1,453	53
SOG	S. Cross	8,785	Open pit, borefield	1.43	5,600	750
SOG	Carosue Dam	8,867	Open pit, borefield		378	420
Tiwest	Chandala	1,265	Borefield	1.25	60	37
WMC	Leinster	5,250	Open pit, borefield	9.5	400	100
WMC	Mt Keith	31,800		38.5	1,500	320
Total		**126,771**		**114.27**	**14,912**	**2,808.4**

Operating cost data is similarly limited but data was provided for 14 projects with a total cost close to $15 million per annum. Management costs added nearly $3 million to this running cost. This suggests mining companies could be spending more than $100 million per annum on water supplies and water management issues.

Chapter 7

THE VALUE OF WATER

7.1 Introduction

Western Australia is a dry State and water is critical to the environment and to human settlement and endeavour. This chapter seeks to highlight the value created with water used by the minerals industry, and look at some of the equity issues associated with water use that influence the allocation of water resources in Western Australia.

7.2 The Economic Value of Water

A measure of the value of water to the economy is the value of production from an industry sector in terms of actual water use. Industries with a high value of output and low water use will clearly be the most efficient in terms of output per volume of water use. Industry segments with little water use include most of the services sector in the economy where water is largely needed for personal health and wellbeing. Office based sectors are likely to figure prominently including such sectors as legal, financial, insurance, banking, tourism services, public sector services, and justice.

An analysis by the Australian Bureau of Statistics (ABS) reveals that across Australia the agricultural sector is the most intensive water user of water with an output ratio of $588 per ML of water in 1996-97[8].

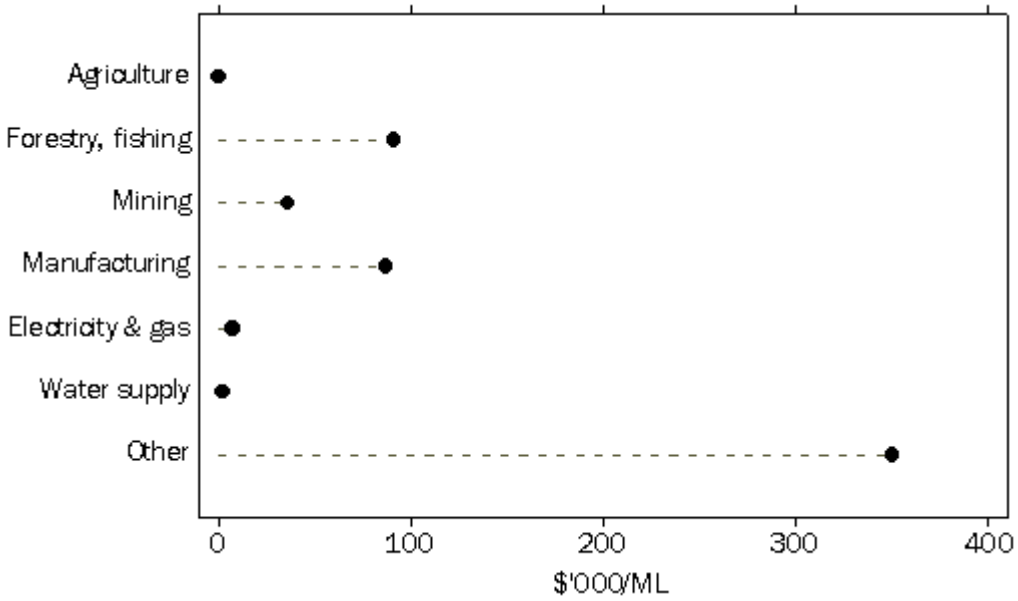
This contrasted with the services sector where low water use provided an economic output of $382,000 per ML of water used. All other sectors fell in between these extremes (Figure 8).

The mining sector ranked well above agriculture and higher than the water supply sector as an industry and above the utilities of electricity and gas.

This broad analysis suggests that an economy with limited water supplies would be better to use it for mineral production and sale than for uses such as export agriculture.

[8] ABS, Water Account for Australia, 1993-94 to 1996-97, Catalogue 4610.

Figure 8: Gross Industry Production (per ML of water use in 1996-97)*



Source: ABS Catalogue 4210. * Gross output is gross product less intermediate inputs.

Work completed for the Water and Rivers Commission as part of a water study in Western Australia in 2003 provided results[9] broadly similar to the ABS:

- Urban water use - $183 per KL of water used;
- Mining and oil and gas - $63 per KL;
- Milk manufacturing plant - $118 per KL used;
- Viticulture Farm - $4 per KL used;
- Dairy Farm - $0.47 per KL used; and
- Dairy Milk Powder Industry as a whole $4.45 per KL used.

7.3 Employment

Another way of looking at the value of water is the employment its use generates. Industry sectors with high employment but little water use will provide the most jobs in an economy where water is a limiting factor. The services sectors such as retail and wholesale use little water and averaged less than 1.5 ML per employee a year in 1996-97. The petroleum and coal tertiary service sectors had a ratio of around 6.7 ML per employee. By way of comparison, broadacre agriculture enterprises have limited employment but can use large volumes of water. A 500 cow dairy farm at Harvey using flood irrigation could use 2,200 ML of water per annum with a full time employment of four people giving an employment level of 550 ML per person employed.

More work is needed on the relative performance of different industry sectors, but in general terms, the mineral and energy industries appear to rate fairly well in employment terms.

[9] Economics Consulting Services: South West Yarragadee-Blackwood Groundwater Area Economic Study, 2003

7.4 Community Aspirations in Water Allocation

Most economic theory is concerned with the way in which competitive markets operate to ensure that transactions occur in a way that ensures *efficient* production processes with minimal waste, constant innovation and efficient distribution for both goods and services. Competition is the driver of innovation and cost reduction with personal gain the reward.

The economist model of self-interest as the key motivating force has well-established explanatory power. While motives other than self-interest are recognised, they tend to be regarded as peripheral to the main thrust of human endeavour.

To gain a better appreciation of the full range of human behaviour and aspiration, recent economic work has increasingly focused on the issues of equity or fairness. A key finding is the consistent influence of non-financial variables in self-reported measures of happiness and wellbeing. The diversity of views is also paramount, as is the finding that actual observed behaviour does not fully describe individual wellbeing.

Importantly, people evaluate their well-being taking into account the circumstances and comparisons with other persons, their past experience and their expectations of the future. It is not the absolute level that matters but the comparison with others. This introduces the important criterion of equity or fairness.

Community attitudes to "fairness' have a profound impact on water allocation decisions. Aspects of allocation that are seen as important in a *fair* allocation decision include the following process characteristics.

1. Process

The process is as important as the outcome. Procedural fairness does not require that every person has been consulted, but that people affected by a decision have been informed of the issue and given a reasonable time and level of information to enable them to respond if they choose. They will also want to be sure that their "voice" will be given due consideration and that all those affected have been given a similar right and weight in consultation.

2. Freedom from Corruption

Corruption is used in the widest sense to mean that the process was not biased by the undue influence of any stakeholders. This includes elements of democratic processes and freedom from inhibition on the part of participants.

3. Environmental Responsibility

A substantial proportion of the population will demand that unused resources are now allocated and used in a way that does not create further environmental degradation and that cultural and recreational needs are fully met.

4. Employment

Unemployment is now recognised as carrying a social cost far in excess of the cost of unemployment benefits. Surveys in European countries have shown that a move from the lowest income quartile to the highest income quartile would not be enough to offset the adverse effect of unemployment, suggesting that unemployed people suffer high non-pecuniary costs that income does not overcome. An allocation of resources that denied or

reduced employment is likely to be seen in a negative context. Perhaps a corollary of this is that human work is not seen as a "burden" but the opportunity to work is highly desirable.

5. Efficiency

In a similar way to the issue of environmental responsibility, the "efficient" use of scarce natural resources is now seen as important. Recycling has become socially desirable and continued attention to more efficient resource use is demanded.

6. Certainty

A core value for many people is a degree of certainty over the future. This is not the same as stability, although many aspire to this also, but more to do with predictability. Certainty provides a degree of assurance that current labour and effort will not be wasted and that the nurturing going into the future generations is worthwhile. The concept of sustainability is effectively about the desire to ensure that we hand on a worthwhile environment (natural, built and social) to future generations.

Efficient water use in a physical sense means minimising wastage. In an economic context it has a similar meaning being defined as maximising economic output per unit of water used. The aim is to use water to provide the greatest community benefit. This is generally achieved when water is allocated to the person/organisation(s) willing to pay the most on the assumption that they can still pay this level and undertake a productive process at a profit. The greater the absolute profit margin on the process, the more they can afford to pay for the water to use in the process. However, many social surveys have demonstrated that the community does not feel comfortable with a water allocation system based on ability to pay.

Economists favour the use of market mechanisms such as ability to pay on the grounds that the industry sectors or people prepared to pay the most will use the water most carefully and efficiently to produce the highest level of economic output. A tender or auction approach to the allocation of the water would reveal the industry sectors and companies most willing to pay the highest price. There is little doubt that those providing water to urban areas would be willing to pay more for water than say farmers wanting to irrigate pasture or winery owners wanting to create a lake for visual appeal.

Market mechanisms are desirable when there are numerous competing interests in similar enterprises and there is difficulty in developing "fair" systems of distribution. However, markets may not provide an acceptable outcome to the community in this situation for the reasons outlined in the following paragraphs.

In the absence of a market based process, some form of government administered allocation system is the more likely approach. The traditional *first come - first served* system of allocation is not supported by COAG agreements nor can it produce maximum community gains. A system of allocation that recognises the value of the use appears desirable to meet the economic efficiency objective.

Equity Considerations

The earlier discussion of equity and fairness issues raised key principles for "fair" outcomes. Zajac has outlined six propositions for fairness in government regulation and process[10].

These can be developed into a list of criteria relevant to water allocation as follows:

- A fair process;
- The right to be involved;
- Resources to be efficiently used;
- Resources to be soundly managed;
- Everyone has a right to a minimum entitlement;
- Equality of opportunity;
- Reward for effort – no free kicks;
- Sharing of pain and gain;
- Existing users have priority rights;
- Society compensates losers from market allocation; and
- Deregulation of government involvement is supported when it reduces inequality - while regulation is supported when it curbs abuses of power or monopoly behaviour.

Again an emphasis on efficiency continues but also process becomes important, recognition of existing rights and equality of treatment and opportunity. The concepts of sharing and compensation emerge as key issues.

These guidelines for equity considerations should be reflected in the social survey of the community conducted as part of the evaluation for the application for a water licence. The Australian Research Centre for Water in Society report does in fact reinforce many of these aspirations11. The study found that the survey respondents in the South West of the State ranked environmental needs highly along with a preference for allocation that provided local development and employment opportunities.

A brief survey of Perth residents generally supported the importance of environmental allocation and the right of local people to the use of the water before others outside the region.

A ranking of preferred water allocation demonstrated that water use in mining is not given a high priority by the community in the south west. Mining industry and household use outside the region both ranked poorly.

The community ranking of preferred water allocation clashes with the assessment of economic value from water use. Urban domestic water use ranked close to last in the

[10] Zajac, E. Political Economy of Fairness, MIT Press

[11] Australian Centre for Water in Society, CSIRO, Social Values and Impact Study, South West Yarragadee, Results of the South West and Perth Community Surveys. June 2003

community preferences but is almost certainly the highest value water use available in the State while mining use also ranked poorly in the community but highly in value added.

A focus on the efficient allocation of water does not appear to be seen as delivering regional development opportunities despite the value added by the minerals sector and the employment creation. This perception may be because regional communities either do not see mining as a long lasting enterprise or fail to recognise the employment generation and flow on impact. A desire by mining companies to adopt a low profile in the landscape for environmental reasons may be one reason for this perception.

7.5 Summary

In summary, the value of water in a financial context reflects common sense conclusions. Water for human drinking purposes will be placed first followed by the water needed to maintain sanitation and health. Essential food production will follow.

Water values in other industry sectors concerned with the overall economy rather than human survival will be a function of the output produced by that sector and the water needed for the industry. Low water use sectors with high sales outputs such as the services sectors concerned with business (legal, finance, insurance, advisory services) will be near the top of the ladder. Industries requiring large volumes of water will be deemed less efficient from a water-use perspective.

Metropolitan water sales are almost certainly the highest value use for water. Broadacre pasture production using flood irrigation methods represent the other end of the spectrum. Mining industries rank fairly highly – well above irrigated agriculture applications but below many manufacturing industries.

Chapter 8

WATER ALLOCATION AND USE POLICIES

8.1 National Policies

The Australian Constitution intended that natural resource policy, including that relating to water and water quality, would be a responsibility of the States. One section specifically restricts the role of the Commonwealth in relation to water. However, the Australian Government has the capacity to influence public policy in Australia and has done so with water by developing national policies through agreement with the State and Territory governments. Four major initiatives have been:

- The Council of Australian Governments (COAG) Water Reform Framework Agreement;
- National Competition Policy driven reform in the water industry at the national level; and
- The National Water Quality Management Strategy; and
- The National Water Initiative – not signed by Western Australia or Tasmania.

The key elements of the agreed COAG reform process can be summarised as:

- water pricing to be based on full cost recovery and transparency of cross-subsidies;
- new irrigation schemes only if economically viable and ecologically sustainable;
- comprehensive systems of water allocations or entitlements are to be adopted, backed by the separation of water property rights from land with clear specification of entitlements;
- Trading, including cross border sales, of water allocations and entitlements within the social or physical and ecological constraints of catchments; and greater responsibility at the local level for the management of water resources.

Under the COAG umbrella, the governments formed a *High Level Steering Group on Water*. This group further clarified some of the COAG objectives including*:*

- trade of groundwater entitlements should be within common aquifers and consistent with groundwater management plans and other relevant resource management policies;
- trade in volumetric allocations should be possible among hydraulically linked groundwater and surface water systems;

- unallocated resources should be allocated to promote the most efficient and beneficial uses;
- allocation methods should be equitable;
- methods such as "first-in first-served" should be phased out well before resources approach full allocation; and
- water trading zones and groundwater management units should be defined in terms of the ability to transfer the water physically from one area to another, environmental requirements and other third party issues.

The COAG Water Reforms make it clear that a water trading mechanism seeks to move water to the highest value use, which is not necessarily local. Allocation will, of course, take into account the economic and social ramifications, and any necessary adjustments to account for these, but there is no presumption of local ownership or local priority access rights.

The National Water Initiative firms up water users rights to a share of the consumptive pool of a water resource subject to meeting allocation conditions. Environmental outcomes have been stressed as a necessity and not an "optional extra". Water is to be allocated from a "consumptive pool". Any water system in which there is overallocation or use will be adjusted to reduce use with substantial progress expected by 2010.

In its submission to the National Water Inquiry, the Western Australian Government emphasised some differences in the approach adopted in the State. In particular, licences are issued for fixed volumes and durations, licences have not been reduced in size to date and there is little demand for water trading in the State at this time. Western Australia has decided against pursuing full cost recovery with management costs for water resources funded from general State revenue. Western Australia has also suggested that the "mining" of hypersaline groundwater may be acceptable for fixed periods where the environmental impacts are acceptable, the project is sustainable, and where demand usually ceases when mining finishes. Western Australia is also considering means to increase the level of work in resource investigation, planning and monitoring.

The parties to the Initiative specially agreed that:

> "there may be special circumstances facing the minerals and petroleum sectors that will need to be addressed by policies and measures beyond the scope of this Agreement. In this context, the Parties note that specific project proposals will be assessed according to environmental, economic and social considerations, and that factors specific to resource development projects, such as isolation, relatively short project duration, water quality issues, and obligations to remediate and offset impacts, may require specific management arrangements outside the scope of this Agreement."

This provision acknowledges the special circumstances that mining in remote areas faces.

8.2 Western Australian Government Policies

In Western Australia, the *Rights in Water and Irrigation Act 1914* vests control of water in watercourses and underground water in the State thus abolishing common law riparian rights in proclaimed groundwater and surface water areas. The Act aims to:

- encourage the responsible development of water resources and limit abstraction from a water source to a level which can be sustained over the long-term;
- allocate resources for beneficial private and public purposes and to meet environmental requirements of the area;
- enable the resources to be shared in an equitable manner; and
- protect present and future sources of water for public water supplies and for private use, where appropriate.

Guidelines for the allocation of water under the Act require the Commission to take into account whether the allocation:

- is in the public interest;
- is ecologically sustainable;
- is environmentally acceptable;
- may prejudice other current or future users;
- would have a detrimental effect on another person;
- could be provided by another source;
- is consistent with local practices, by-laws, any approved plan under the Act or previous Commission decision;
- is consistent with land use planning instruments;
- is consistent with the requirements and policies of other government agencies; or
- is consistent with any intergovernmental agreement.

These criteria may be categorised for convenience into four broad sections – environmental impact, social impact, economic impact and consistency with government policies.

The legislation has been amended a number of times and is considered to be generally consistent with the Australian Government and State agreements endorsed under the COAG, National Competition Principles Agreement and policies of the Higher Level Water Users group. The National Competition Council in 2003 judged Western Australia to be in substantial compliance with its commitments under the CPA with the exception of some concerns over water pricing, transparency of pricing and cross subsidies, management charges and the slow rate at which management plans are being developed. The State has considered the application of management charges for water resource licensing and compliance management but has deferred such charges at this stage. The NCC also expressed some concern with inhibitions on the trading of water entitlements.

Most of Western Australia, with the exception of the agricultural area known as the Wheatbelt, has been subdivided into declared areas which vest management of groundwater resources in the State. Groundwater management is generally achieved by reference to a management plan. However, management plans have only been prepared

for the Perth Basin, Goldfields and some minor areas. For about 80% of the State there are no management plans including the East Murchison, Pilbara and Canning-Kimberley of particular interest to the mining industry.

Licences to abstract groundwater are allocated on a ‘first come, first serve’ basis subject to meeting environmental water requirements and notification to the community. Licences are free and are issued for fixed periods up to 10 years or indefinitely and can encompass

dewatering as well as water for mineral processing, camp supplies and dust suppression. There is a presumption that licences will be renewed.

Licences are issued with conditions. Major operations will be issued with an Operating Strategy that will usually include:

- monthly measurements of water pumped;
- monthly measurement of water levels in operating bores and monitoring bores;
- monthly measurement of salinity from production bores;
- major ion analysis from each production bore annually;
- site specific requirements such as monitoring water levels and water quality in pastoral bores, water quality of camp water supplies; water levels in bores in and around wetlands, and monitoring environmental impacts on flora and fauna; and
- provision of production summaries, monitoring reports or aquifer reviews depending on the size and possible impact of pumping activities.

Large water users such as the mining sector face significant constraints in obtaining and managing licences. An environmental assessment is needed for applications in most areas and hydrogeological studies are essential. Other large water service providers face similar constraints but the largest water user in the State, agricultural irrigation, generally does not face the same requirements.

Smaller water users face less stringent licensing conditions with users licensed to take less than 500,000 kilolitres of water exempt from any measuring or monitoring requirements.

The Western Australian *State Water Strategy* was released in February 2003 with the aim of providing a guide for a sustainable water future for the State. The Strategy emphasised that a multi-faceted approach was vital combining new water sources, new efficiency measures and innovative ways of using wastewater.
The State Water Strategy requires *reasonable* regional needs to be met before any transfers occur from a region and for local involvement in water management. It also emphasises that water is to be used efficiently, the most valuable resources should be used for the highest value uses, water used should be "fit for purpose" and that consideration should be given to reservations for future beneficial use. These aspirations have the potential to clash if the highest and best uses lie outside the region.

The application of these principles assumes that water has value and be definition is therefore in demand. Much of the water used in the mining sector is either poor in quality or remote from other potential users. The application of these principles is thus doubtful.

Some differences in emphasis have emerged between the Western Australian government approach and the national process. Western Australia does not face over-allocation issues for surface water or the environmental degradation faced in the Murray – Darling Basin. With reasonable access to groundwater resources and less potential for water transfers between areas, water trading is less likely to "improve" allocation processes. The State also argues that water use in mining can be justified where allocation is in excess of short term recharge levels on the grounds that mining needs are short term, groundwater systems will recover, there is negligible environmental impact and the social and economic benefits are significant.

In short, groundwater *mining* **may** be justified under a triple bottom line sustainability assessment.

8.3 National Mining Industry Policies

The Minerals Council of Australia is committed to the sustainable development and management of water resources. The Council advocates[12] nationally consistent markets for the trade of water, full cost recovery in water pricing that accounts for the industry's considerable private investment in infrastructure; and water entitlements that are guaranteed for a specified time and volume.

8.4 Environmental Management

8.4.1 Sustainable use

Sustainable water yield is defined at the Australian Government level as "the amount of water that can be sustainably harvested each year from water resources after making provisions for environmental and social values". This is conceptually a sound approach but raises complex issues in identifying and assessing the environmental and social **values**.

The State Government has defined the concept as:
"meeting the current and future generations through integration of environmental protection, social advancement and economic prosperity"

Again this raises the complex issue of intergenerational equity and the extent to which the current generation might create capital assess from current resources that will be of benefit to future generations. Substantial challenges are emerging in interpretation of this issue where resource development projects necessitate some environmental trade-off.

By way of interpretation of how the government might apply this concept, the Water Corporation has recently been advised that an application for a large water licence will be assessed by taking into account economic, social and environmental impacts – a triple bottom line assessment. This approach implies a trade – off between the three impact

areas. The optimists suggest that it is possible to achieve gains in all areas. Others suggest that prioritisation and measurement when there are conflicting gains and losses make this a qualitative approach better left to political processes than quantitative assessment.

The Department of Environment definition is:

> "*The amount of water that can be taken from a water resource system without causing unacceptable impacts"*[13].

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[12] Minerals Council of Australia; Australian Minerals Industry Position Paper for Australia's Water Reform Agenda, March 2004

[13] Water and Rivers Commission, Policy Statement on Water Sharing, Policy No 3, May 2000

Such an approach appears to recognise the negative impact of water recovery but benchmarks this impact as "unacceptable". Applied to groundwater this definition appears to implicitly accept a negative storage depletion effect. The Commission approach implies that there will be some environmental impact (possibly only at a micro scale) and that this needs to be counterbalanced against the other potential water uses and community aspirations.

In most of the arid areas of the State, extremely low rainfall means that any substantial abstraction of groundwater will involve volumes in excess of the "sustainable" level if this level is defined to mean water recharge at the same rate as abstraction. Any groundwater abstraction involves some water removal and mining in a strict sense. The time frame thus becomes the determinant of water balance. In an arid area, mining may occur for some years before a prolonged rainfall recharges lost water. A mining company may even use water for a protracted period (ten or more years) but on cessation, the groundwater level will be gradually restored. The critical issue is thus the environmental impact during mining operations rather than the recovery of the system. The effective "mining" of the water resource is justified when there is no significant environmental impact, the water has little alternative use and use provides social and economic benefits.

The resources sector argues that the mining of water in such areas is reasonable on the grounds that there is a negligible local demand now or in the foreseeable future and that the economic benefits outweigh the environmental impacts. In other words, there is a net "sustainable" impact.

One of the challenging issues is the measurement of water recharge in arid areas and hence the assessment of sustainable levels. Recent work has shown that the paleochannel aquifers in the Goldfields recharge from large episodic rainfall events and that there is more water available than volumetric measurements might suggest

The minerals industry suggests that the continued taking and disposal of groundwater (particularly saline) is acceptable provided abstraction and disposal is carefully monitored and managed. The arid environment does not have a high value in most areas and the flora and fauna systems are widespread. Local impacts do need to be monitored.

Another area of potential concern with the concept of sustainable development is the appropriate level of community assessment. The State Water Strategy requires that "reasonable regional needs should be satisfied" before water is transferred out of a region.

Local communities are often antagonistic to water allocations for mining use despite the benefits to both the local and State economies. The intangible nature of the sustainable concept can thus be used to oppose water use by the minerals industry locally and any water transfer from a region.

The key policy issues is how to balance the desire for overall economic gain resulting from the allocation of water to the highest and best uses with the desire to maximise local community benefit.

8.4.2 Environmental Management

The variable topographical and geological conditions in which mining occurs and the varied water recovery, water use and tailings alternatives create a wide range of management issues. Detailed discussion of these issues is beyond the scope of this report. A list of some of the more well-known issues serves to illustrate the need for management and co-operation of the mining companies with the Department of Environment and the environmental management agencies (Table 13).

Table 13 – Water Related Management Issues in Western Australia

Issue	Comment
Groundwater dependent ecosystem	Detailed plans are now required in areas where ecosystems depend on a groundwater/surface interaction.
Groundwater contamination	Leakage from tailings ponds causing groundwater contamination
Mine voids	Effects of mine operations and mine closure options on groundwater systems.
Groundwater mining	Depletion of groundwater resources by over-pumping.
Closure of borefields	Need for plugging boreholes and dismantling infrastructure so that bores can be relocated or re-accessed in the future if necessary.

An area of constant attention in the industry is water use efficiency both for cost control reasons and environmental responsibility. It is known that significant water savings can be achieved on mine sites by preparing a reliable water balance which shows where all water is obtained, used, recycled and disposed on a mine site. The preparation of the balance often indicates areas where water savings or improvements in the operations can be achieved.

Mine site water balances are important for cost savings measures and if additional groundwater supplies should be required, provide evidence of efficient water use, and demonstrate water requirements to satisfy the Department of Environment.

8.4.3 Regional Environmental Issues

In general, the distance between mines and the low population density mean there is little pressure on water sources in the Kimberley region. In fact, the Ord River was dammed a long time ago to secure some of the large flow of that river for agricultural irrigation.

The limited number of mines and location of each mean that environmental issues are unique to each project. No significant water related issues are thought to exist at this stage.

Environmental issues in the Pilbara include groundwater abstraction impacts on local wetlands and springs, impact on underground Stygofaunal communities, salinisation of mine voids and the potential for acidification of surface water.

Acid rock drainage has emerged as an issue in the Pilbara only recently. Acidification is associated with the oxidation of some black shale rocks and subsequent runoff events.

Covering such rock types to prevent oxidation and careful placement of mined material appears likely to overcome problems.

Open cut mining in the Pilbara has created substantial voids that commonly extend below the water table. Once mining ceases, the voids are likely to become increasingly saline with high evaporation and low infill rates. Depending on local groundwater movements, some voids could become point sources of salinity for local groundwater or surface water. Mine voids that have the potential for groundwater through flow now have much more stringent environmental conditions imposed.

The impact of groundwater abstraction on Stygofaunal communities is hard to assess. Communities have been assessed in the vicinity of most mines but a general lack of data and understanding of the regional context has made assessing the environmental impact difficult.

Some specific local issues arise from the impact of abstraction on water flows to wetlands and springs. Seven key regional localities have been identified where attention is being focused on water management. Additional constraints on abstraction and monitoring are required in these localities. Some limits on potential abstraction have been developed as well as agreement on mine closure practices where necessary.

No general environmental issues have been identified in the Mid West or Gascoyne regions with most issues specific to sites. The heavy mineral sand mines at Eneabba operate in relatively sensitive flora areas and have stringent revegetation requirements. The gold and base metal and iron ore mines are in far more arid locations with less environmental demands.

The Goldfields have seen issues with saline water use and disposal and the management of tailings ponds in the arid environment.

8.5 Conclusions for Industry Policies

1. Water use in the minerals industry has been very difficult to estimate with data on water quality and source even more problematic. Much of this information is held in reports submitted to the Department of the Environment as part of water licence requirements. The information needs to be compiled into local and regional databases that can give a more comprehensive picture, facilitate future water discovery, development and management and be accessible to the public.

2. The monitoring reports submitted to the Department of the Environment contain comprehensive information on water resources. This information needs to be interpreted and compiled into local and regional databases to facilitate future water discovery, development and management. The information is a valuable community resource and needs to be accessible to reflect this value.

3. The hydrogeological work undertaken by the State government is the foundation of water knowledge in the State. The work on describing the State water inventory has shifted to environmental assessment. Water is essential for social development and a valuable economic resource. Social and economic aspects have been given less focus. Hydrogeological work needs to address all of the triple bottom line sustainability measures.

4. Groundwater Management Plans form the basis for water allocation and use. Only a limited number of plans have been completed and the Department of Environment needs to increase the rate at which these are completed. The devolution of responsibility to local committees has created some difficulties in the development of priorities for water use. A review of the process is recommended to ensure that the interests of the State and all stakeholders are reflected in their development.

5. The State government Mining and Water Industry Liaison Committee set up to work on water management issues has identified priorities for hydrogeological work. Work on these issues needs to be considered.

6. Mining companies invest substantial resources in water management. While water is not a scarce resource in most locations, it is important from a community perspective that it is conserved and managed as if it was is. Water balance accounting is a valuable tool for improved management and it is important that more emphasis be placed on such accounting by companies.

7. Industry Associations and Governments need to promote a better understanding of water use in mining both within industry and the broader community. The emphasis should be on the industry self supply role, the poor quality of water commonly used and the lack of alternative water uses that would justify the development costs in most areas of mining operation.

8. A more sophisticated approach to water allocation and use should be developed by the Australian and State governments that recognises the value of water as a social and economic good, the location and quality of water used.

APPENDIX 1: PROJECT MANAGEMENT AND SPONSORSHIP

Sponsoring Organisations

- Australian Government Regional Minerals Program – administered by the Department of Industry, Tourism and Resources.
- Western Australian Chamber of Minerals and Energy.
- Western Australian Department of Industry and Resources.
- Western Australian Department of Environment - Water and Rivers Commission.

Management Committee

Chair - Keith Berry, WMC Resources.
Project Manager – Shaheen Hughes, Chamber of Minerals and Energy.
Mike Balfe – Department of Industry and Resources.
Rick Rogerson - Department of Industry and Resources.
Seth Johnson - Department of Environment.
Ian Foster -Assistant Manager, Australian Government Department of Industry, Tourism and Resources.