08 The minerals industry and land and water development in northern Australia

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Aerial View of Century Mine, Queensland

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1. KEY POINTS

- Mining has been an important driver in the socio-economic development of the north and is likely to remain so into the future.
- Relations between mining companies and Indigenous peoples have improved substantially since the passage of the Native Title Act 1993. As part of this, there has been an increased focus by companies on providing Indigenous people with employment and business development opportunities.
- Greater collaboration between companies and cooperation with Indigenous communities and all levels of government is needed to deliver better development outcomes for Indigenous communities from mining. A key challenge is to address underlying socio-economic impediments to economic engagement in the sector.
- Closer alignment with regional planning processes and greater co-ordination of development in mining intensive regions, such as the Western Cape and North West Queensland, could facilitate synergies in key inputs (e.g. energy and water) and reduce the cumulative environmental impacts of resource developments.
- Several mines in the north are located in or near important groundwater resources. Rigorous ongoing monitoring of groundwater use and impacts is needed to manage this, as are stronger processes for assessing cumulative impacts on groundwater needs.
- The risk of discharge from mines can increase because of a range of factors, including the implementation of water saving initiatives. Enforcing the concept of zero discharge could potentially force mines to design their water system with the sole aim of containing extreme rainfall events, at the expense of designing mine water systems that are resilient and can also deal with scarcity of supply.
- In designing and managing mining operations and planning for closure, a key focus should be on ensuring that operations make a positive long term contribution to the regional asset base. These assets potentially include not only physical infrastructure (e.g. buildings, power, airstrips) but also human capital, in the form of a skilled and mobile workforce, and a more diversified economic base.

2. INTRODUCTION

The minerals industry has a significant role to play in the future development of Northern Australia. The region includes several areas of intense mineral activity, as well as significant offshore oil and gas deposits, and has known prospects for future exploration of key minerals including copper, aluminium and uranium. In recent years the markets for these commodities have featured strong growth linked to developing economies in Asia.

Mining in the region is characterised by isolated operations, with the majority located well away from major population centres. However, there are several towns such as Mt Isa, Weipa and Cloncurry in Queensland; Jabiru, Alyangula and Nhulunbuy in the Northern Territory and Kununurra in the Kimberley whose economies are wholly or partly dependent on nearby mineral operations. Most non-gold operations are confined to extraction and primary concentration, in order to produce a product which can be economically transported for further processing elsewhere in Australia or offshore. The notable exceptions to this are the copper and lead/zinc smelters at Mount Isa, and the alumina refinery at Gove.

Many industry operations in Northern Australia are located on or near land of significance to Indigenous communities. The history of early mining developments was often marked by Indigenous opposition. More recently, the passing of Native Title and Land Rights legislation and changes in the approaches of mining companies, governments and community stakeholders has been manifested in improvements in relationships and better outcomes for some Indigenous people. However, differences remain in the approaches of mining companies and the willingness of Traditional Owners to actively engage with mining developments.

In this chapter we review the history of mining development in the region, its current extent and future potential. The discussion is based on existing public domain sources, including relevant literature, government and industry reports. We consider possible development trajectories for the industry, and review the implications for land and water resources. We also review the history of and potential for further mineral developments in the three case study areas of Mitchell, Daly and Fitzroy. Finally, we offer some recommendations for strategies to both minimise the negative consequences and maximise the positive outcomes associated with mineral developments in the region.

3. THE MINERALS INDUSTRY IN NORTHERN AUSTRALIA

3.1 HISTORY AND THE EMERGENCE OF KEY ISSUES

3.1.1 Early developments

The history and pattern of mining development in northern Australia is intrinsically linked with the region's early exploration and pastoral settlement. Miners followed in the footsteps of early explorers and pastoralists, moving across in a westerly direction from the east coast of Queensland. During Queensland's pastoral boom of the 1860s, expeditions to determine the North's grazing potential reported indications of gold across the Northern Territory and into the Kimberley. However, during the pastoral boom, "little concern was shown with any possible mineral deposits" [1]. "Remoteness from the established goldfields of Victoria and New South Wales effectively discouraged early prospectors until positive news of payable gold was received" [1].

The first full-scale gold rush in the region commenced in 1867 at the Cape River diggings (south of Townsville), and was the forerunner to the Gilbert River and Etheridge River fields. A spate of other discoveries followed during the 1870s, the most significant of which was the Palmer River field North-East of Cairns which was discovered in 1872 [2]. The late 1870s saw a gold rush at Coen, on the remote Cape York Peninsula and at Bowerbird, north of Cloncurry. 1887 witnessed Queensland's last significant rush at Croydon, with gold yields diminishing by 1904, spelling the end of Queensland's golden era [3].

As well as pastoral settlement, another important contributor to the development of the mining industry in the Northern Territory was the construction of the Overland Telegraph Line. Its completion in 1872 attracted thousands of prospectors from the southern colonies and China [4], spurred on by the earlier reported indications of gold. By the mid 1870s the Pine Creek gold rush was well under way. However, in a trend not dissimilar to Queensland, gold production began to decline in the 1890s and was replaced by tin and wolfram by 1907.

Pastoralists reached and set up cattle stations in the Kimberley region in the mid-1880s after several years droving from the eastern colonies. Gold was discovered at Halls Creek in 1885, the first gold discovery in Western Australia. However, the gold rush was short-lived and certainly not on the scale of the subsequently discovered Kalgoorlie fields. The Kimberley's geographic isolation and inaccessibility restricted development to a greater extent than the rest of the Northern Australian region, a factor still of relevance today.

Although interest in gold mining had diminished across northern Australia by the first decade of the twentieth century, expertise gained during the gold rush enabled prospectors to diversify their interests and explore for other metals. The legacy of this period is also reflected in the existence of several towns which developed to support the gold boom and survived the subsequent 'bust', and a large number of abandoned mines and workings in certain areas.

3.1.2 The emergence of mining towns and regions

During the gold rush era, news of the discovery of a prospective deposit was accompanied by an influx of prospectors eager to vie for their share of the fortune. The prospectors would set up camp in the vicinity of the dig, often in very rudimentary conditions, forming over time, make-shift mining settlements. If the discovery was particularly prospective or sizable, these settlements commonly gained a degree of permanence, becoming predecessors of several modern day towns in Northern Australia. For example, Cooktown was established at the mouth of the Endeavour River to service the goldfield and quickly became one of Queensland's busiest ports.

Early mining developments often attracted not only a wide array of workers directly engaged in mining and processing the ore (such as geologists, engineers and operators), but also a myriad of support and service industries, both industrial (e.g. machinery suppliers and transport facilities) and social (e.g. health, education and recreation). "Many towns in existence today owe their foundation to mines found before the mid-20th century" [5].

In Queensland's North West Minerals Province, Mt Isa grew out of very humble beginnings to become North Australia's "premier interior centre", on the back of the discovery of copper and silver-led-zinc ore minerals in the 1920s. Its transformation was also assisted by the sheer size and value of the deposit, which held a strategic importance during the Second World War.

The establishment of Weipa on Cape York Peninsula, Nhulunbuy on the Gove Peninsula in the Northern Territory, were both a direct result of the discovery and subsequent development of bauxite mining, while Alyangula on Groote Eylandt grew out of the discovery of manganese. Jabiru in Northern Territory's Kakadu National Park was a mining township originally designated to service the Alligator River uranium mining province.

There are also numerous examples of towns that sprang up and prospered while mines operated but were deserted when operations ceased. Mary Kathleen in Queensland's North West, whose existence depended on the fate of the adjoining uranium mine, is one of the most famous of these 'ghost towns'.

3.1.3 Indigenous relations

Until very late in the 20th century, mining companies generally did not recognise and acknowledge Indigenous interests in the land, or the adverse impacts prospecting and mining activities often had on Indigenous communities and traditional way of life. Mining development historically functioned as an instrument of colonisation penetrating deep into the North Australian interior, with Indigenous communities often forcibly removed to make way for potential mining sites and operations [6]. For example, the settlement of Mapoon on Queensland's Western Cape was relocated in the 1960s to enable bauxite mining. Indigenous interests were also subordinated in the Northern Territory in the set-up of the Jabiluka uranium mine, and in the Kimberley when drilling took place at Noonkanbah in 1979 over the protests of traditional owners [7]. A significant cultural site was destroyed at the Argyle mine in 1980.

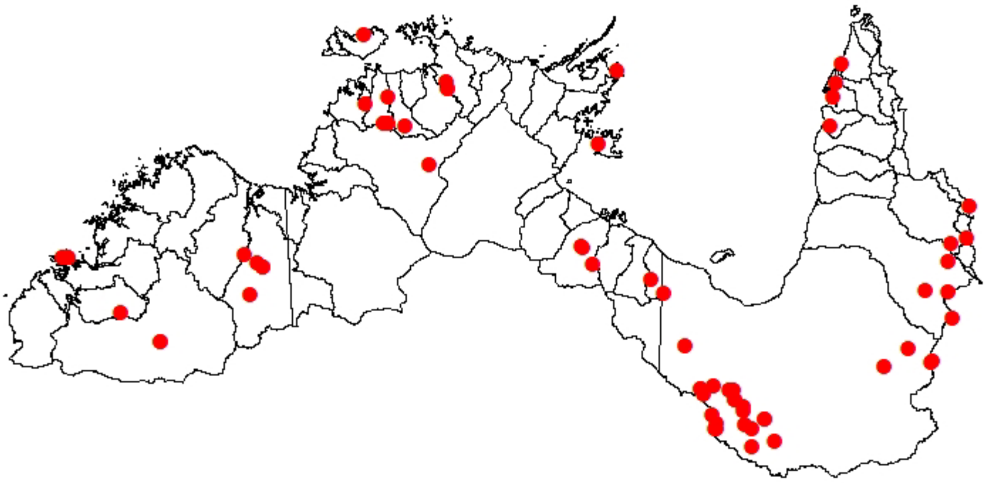
Mining industry approaches to Indigenous relations have, however, changed significantly in the last decades. The main catalyst for this transformation has been legislative recognition of Indigenous rights. Northern Territory's *Aboriginal Land Rights Act* of 1976, the first in a series of statutory land rights and cultural heritage protection schemes, enabled claims based on traditional connection to land, preceding the watershed High Court decision in Mabo by 16 years. The *Native Title Act 1993 (Cth)* bestowed rights upon Indigenous groups and obligations upon mining companies 'to come to the table'. It furnished two avenues for resolving mining project applications – the 'right to negotiate' future act process and the Indigenous Land Use Agreement (ILUA) process. The industry's response to these provisions is discussed further in subsequent sections.

3.2 CURRENT EXTENT OF MINERAL DEVELOPMENTS

3.2.1 Overview

There is an uneven distribution of existing mineral developments across the region under study, with concentrations of activity in certain areas. These include a globally significant minerals province centred around Mt Isa; significant deposits of bauxite, manganese and uranium distributed across the weathered, sedimentary environments of Cape York, the top end of the NT and the Kimberley; and isolated clusters of gold and base metal mines in several locations.

Figure 1 - Current mineral operations



Source: Geoscience Australia, National Mines Atlas

3.2.2 Queensland

The greatest concentration of mineral developments in the region is in Queensland's North West Mineral Province, which is known as one of the most significant metalliferous mining provinces in the world. In 2004-05 the region accounted for 3% percent of the world's copper production, 16% percent of the world's lead production, 9% percent of the world's silver production and 8% percent of the world's zinc production [8].

The Far North is also a well known resource region. Rio Tinto's operation at Weipa is the world's largest bauxite mine and 42% percent of the Far North's value of mineral production comes from bauxite. To the South-East, the Cape Flattery Silica Mines operation is the highest global producer and largest global exporter of silica sand.

At August 2009 of the 35 "significant mineral mines" in Queensland, as defined by the Department of Employment, Economic Development and Innovation, 16 were located in the north.

Table 1 - Significant operating mineral mines in Queensland

Region	Operation	Mineral	Company	Opened
Far North (Weipa)	Weipa/ Andoom	Bauxite	Rio Tinto Aluminium	1961
Far North (Cairns)	Balcooma/ Mungana/ Mount Garnet	Copper, Zinc, Lead, Silver, Gold	Kagara Ltd	2003
Far North (Cairns)	Wolfram Camp	Tungsten, Molybdenum	Queensland Ores Ltd	1894
Far North (Cooktown)	Cape Flattery	Silica sand	Cape Flattery Silica Mines Pty Ltd	1967
Far North (Cooktown)	Collingwood	Tin	Metals X Ltd	2005
NW (Cloncurry)	Eloise	Cooper, Gold	FMR Investments Pty Ltd	2005
NW	Ernest Henry	Copper, Gold	Ernest Henry Mining Pty Ltd	1997

(Cloncurry)				
NW (Mt Isa)	Mount Isa	Copper	Xstrata Copper	1924
NW (Mt Isa)	George Fisher/ Black Star	Zinc	Xstrata Zinc	1924
NW (Mt Isa)	Lady Annie	Copper (cathode)	Cape Lambert Iron Ore Ltd	2007
NW (Mt Isa)	Leichhardt	Copper (cathode)	(c/- Deloitte Touche Tohmatsu, Receivers and Managers)	Information not available
NW (Mt Isa)	Mount Gordon	Copper	Biria Mt. Gordon Pty Ltd	1927
NW (Karumba)	Century	Zinc, Lead, Silver	MMG Century	2000
NW (Duchess)	Osborne/ Trekelano*	Copper, Gold	Barrick Osborne Pty Ltd	1995
NW (Duchess)	Phosphate Hill*	Phosphate rock	Incitec Pivot Ltd	1960
NW	Cannington*	Silver, Lead, Zinc	BHP Billiton Ltd - Cannington	1996

* Located just outside the boundary of the study area
Source: Department of Employment, Economic Development and Innovation (Qld)

The number of advanced projects at feasibility stage reflects Queensland's high mineral prospectivity, particularly in the North West Minerals Province. Although the dramatic fall in prices at the height of the Global Financial Crisis at the end and start of 2008 and 2009 resulted in some projects being put on hold, market recovery has translated into a renewed spurt of activity. The market is highly determinative of the speed and extent of project development, as well as the existence of proponent companies, particularly junior and medium operators[1]. Larger companies are also not immune. The fortunes of Century, the world's largest zinc mine, have been affected by price volatility. Century's operator, Ozminerals, existed barely 12 months as a corporate entity before being bought out by the Chinese conglomerate MMG. Development of Dugald River, recognised as one of the world's largest undeveloped zinc deposits, and now part of MM Group's Australian portfolio, has been deferred pending a more favourable commercial environment [9].

Table 2 - Advanced mineral development projects in Queensland

Region	Operation	Mineral	Company	Status
Far North (Cairns)	Baal Gammon	Copper, Tin, Silver, Indium	North Queensland Metals Ltd	Construction
NW (Cloncurry)	Cloncurry Copper Project	Copper, Gold	Exco Resources Ltd	EIS submitted September 2009, production scheduled for 2011
NW (Cloncurry)	Cloncurry Project	Copper, Gold, Molybdenum, Rhenium	Ivanhoe Australia Ltd	Feasibility from 3Q 2009
NW (Mt Isa)	Dugald River	Zinc, Lead, Silver	MM Group Ltd	Development deferred until prices increase
Far North (Georgetown)	Einasleigh	Copper, Lead, Zinc	Copper Strike Ltd	Production scheduled for late 2009
NW (Cloncurry)	Kalman	Copper, Gold, Molybdenum, Rhenium	Kings Minerals	Pre-Feasibility studies
NW (Cloncurry)	Lady Loretta	Zinc, Lead, Silver	Xstrata Zinc	Feasibility
NW (Mt Isa)	Rocklands	Copper	CuDeco Ltd	Native Title Agreement finalised September 2009
NW (Mt Isa)	Roseby	Copper, Gold	Universal Resources Ltd	Development re-commencing in October 2009 due to increase in copper prices
NW (Mt Isa)	White Range	Copper	Deloitte Touche Tohmatsu, Receivers	On hold after Matrix Metals went into voluntary

[1] Matrix Metals and CopperCo are two examples of companies that went into receivership.

			and Managers	administration
Far North	Aurukun	Bauxite	Chalco Australia Pty Ltd	Feasibility
NW (Camooweal)	Di-Tree DSO	Phosphate rock	Legend International Holdings Inc	Production scheduled for 4Q 2009
NW (Cairns)	Mount Carbine	Tungsten	Icon Resources Ltd	Scoping Study
Far North (Western Cape)	Pisolite Hills	Bauxite	Cape Alumina Ltd	Construction scheduled for 2011/12, production in 2012/13
Far North (Western Cape)	South of the Embley Project	Bauxite	Rio Tinto Alcan	Feasibility, construction possibly starting in 2010
Far North (Cairns)	Watershed	Tungsten	Vital Metals Ltd	Feasibility

Source: Department of Employment, Economic Development and Innovation (Qld)

3.2.3 Northern Territory

In a 2008 list compiled by the NT Department of Regional Development, Primary Industry, Fisheries and Resources, five of the seven "major producing mines" were located in the north.

Table 3 - Significant operating mineral mines in the Northern Territory

Region	Operation	Mineral	Company	Opened
Gove Peninsula	Alcan Gove	Bauxite	Rio Tinto Alcan	1970
Groote Eylandt	Gemco	Manganese	Groote Eylandt Mining Company Pty Ltd (BHP Billiton/Anglo American Corporation)	1966
Borroloola	McArthur River	Lead, Zinc, Silver	McArthur River Pty Ltd (Xstrata)	2005
Jabiru	Ranger	Uranium	ERA (Rio Tinto)	1979
Melville Island	Tiwi Islands Mineral Sand Project	Mineral sands	Matilda Minerals Ltd	2006

Source: Department of Regional Development, Primary Industry, Fisheries and Resources (NT)

The Ranger Mine accounts for 10% of the world's supply of uranium and Gemco 10% of the world's supply of manganese. Alcan Gove is the third largest bauxite mine in Australia and accounts for 32% of the Territory's mineral production. There are also a number of small gold operations not included on this list.

The Department of Regional Development, Primary Industry, Fishery and Resources 2009 list of pending and potential projects within the next 12-36 months mainly comprises redevelopment of historic gold deposits and the reopening of old mines. The preponderance of gold is a function of the significant increase in gold prices since 2001, relative price stability during the Global Financial Crisis and technological advances which have enabled companies to develop remnant deposits previously deemed technically difficult and/or uneconomic to extract.

Table 4 - Advanced mineral development projects in Northern Territory

Region	Operation	Mineral	Company	Status
Batchelor	Browns Sulphide	Copper, Cobalt, nickel, Zinc, Lead	Compass Resources NL	Feasibility
Pine Creek	Mottrams & Chinese South	Gold	Crocodile Gold Australia	Development, production planned for 4Q 2009
Mt Bundy	Toms Gully	Gold	Crocodile Gold Australia	Development proposal
Katherine	Maud Creek	Gold	Crocodile Gold Australia	Development postponed
Pine Creek	Cosmo Deeps	Gold	Crocodile Gold Australia	Development proposal
Gulf	Merlin	Diamonds	North Australian Diamonds	Feasibility, reopening of old mine
Gulf	Redbank	Copper	Redbank Mines	EIS preparation, construction expected in mid 2010, production late 2010
Arunta	Napperby	Uranium	Toro Energy Ltd	Scoping study
Pine Creek	Spring Hill	Gold	Western Desert Resources	Reopening of old mine
Katherine	Mount Todd	Gold	Vista Gold Corporation	Pre-feasibility, construction planned for

				early 2011

Source: Department of Regional Development, Primary Industry, Fisheries and Resources (NT)

3.2.4 Western Australia

There are only five major operations in the areas under consideration in WA. Diamonds are the main commodity – Argyle Mine is the world's largest producer of pink diamonds, whilst Ellendale accounts for 50% percent of global yellow diamond production.

Table 5 - Significant operating mines in Western Australia

Region	Operation	Mineral	Company	Opened
East	Argyle	Diamonds	Rio Tinto Ltd	1983
East	Savannah	Nickel, Cobalt	Panoramic Resources Ltd	2004
East	Ellendale	Diamonds	Gem Diamonds	2002
West	Cockatoo Island	Iron ore	Henry Walker Eltin Cockatoo Pty Ltd	1948
West	Koolan Island	Iron ore	Mount Gibson Iron	1959

Source: Department of Mines and Petroleum (WA)

Relative to the other two jurisdictions, the Kimberley region is also characterised by a dearth of advanced projects, although as discussed later there is a considerable amount of exploration activity in the area. It should also be noted that the WA State Government has nominated James Price Point, 60km North of Broome, as the preferred site for onshore processing of gas from several offshore basins. This development is discussed in more detail later in the chapter.

Table 6 - Advanced mineral development projects in Western Australia

Region	Operation	Mineral	Company	Status
Wyndham	Sorby Hills	Lead, Zinc, Silver	Kimberley Metals Ltd	Development Plan by 4Q 2009
Halls Creek	Koongie Park	Copper, Zinc	Anglo Australian Resources NL	Feasibility studies

Source: Department of Mines and Petroleum (WA)

3.3 MINING AND SOCIO-ECONOMIC DEVELOPMENT

3.3.1 Economic Contribution

According to an analysis undertaken by Acil Tasman, the North West Minerals Province in Queensland in 2004-05 contributed $5,775 million to Gross State Product (GSP) of which $3,975 million was generated within the region. This represented around 3% of total GSP [8].

Table 7 - At a glance – economic impact of mining and mineral processing in North West Queensland (extracted from the Acil Tasman Report)

	2007 Report (2004-05 Data)	2002 Report (1999-00 Data)	% change
Direct output (A$m)	5,259	3,161	+66%
Direct value added at market prices (A$m)	3,196	1,517	+111%
Total contribution to wages & salaries income (A$m)	1,758	884	+99%
% Gross State Product	3.6%	1.76%	+100%
Total Qld employment (direct plus indirect)	32,620	14,020	+133%

During the same period, the Northern region, encompassing the Cape York Peninsula, contributed a further 1.5% [8].

In the Northern Territory, the industry contributed 23.6% of the GSP in 2007-08 [10] [11]. Production is dominated by a small number of large projects [10]. Four mining operations (Gove, Groote Eylandt, McArthur River and Ranger), all located in the northern part of the Territory, accounted for seventy-six (76) percent of the industry's GSP contribution in 2003 [11]. For example, the McArthur River operation generated direct economic value of $296.8 million in 2008, $138.4 million of which was generated within the Northern Territory [12]. Extrapolating further, local supply contracts accounted for $106.5 million of that local direct economic value, a 23% increase upon the value in 2007 [12].

In 2008 the Kimberley region contributed only 2% of the State's total mineral production by value, the second lowest of all WA's regions. However, at 63% share of the Gross Regional Product, mining represents the Kimberley's largest industry [13].

Royalties

Mining also makes a considerable economic contribution through annual royalty payments to State and Territory Governments, as well as through tax payments to the States and Federal Government. For example, in the 2008-09 financial year North Queensland generated $180M in minerals royalties [2]. Examples of the royalties paid by individual mines are provided in Table 8.

Table 8 – Annual royalty payments made by selected operations in 2008

State	Operation	Mineral	Company	Royalty payment
QLD	Weipa	Bauxite	Rio Tinto Alcan	$60M* ($46M* in 2007)
QLD	Lady Loretta, Mount Isa	Zinc, Lead, Silver	Xstrata Zinc North Australia	$17.2M
NT	Ranger	Uranium	ERA	$24.9M
WA	Argyle	Diamonds	Rio Tinto	$17.8M ($23.9M in 2007)

* Figure includes tax as well as royalty payments
Source: Company Sustainable Development Reports for 2008

While it is beyond the scope of this study, it should be noted that there is a growing debate about whether mining regions, including those in the north, are receiving back their 'fair share' of these royalties to support physical and social infrastructure. Under the historic Royalties for Regions Agreement the Western Australian Government committed in 2008 to return to the State's regional areas the equivalent of 25% of the State's mining and onshore petroleum royalties each year as an additional investment in projects infrastructure and community services [14]. There is a push within Queensland by regional politicians for a similar policy to be adopted in that State, although this does not seem likely to occur in the short term.

3.3.2 Employment

The most obvious way in which mining contributes to regional economies is through the creation of jobs: both direct (in mining related work) and indirect (in support and service industries).

[2] Data provided by Queensland Resources Council.

As a capital intensive industry, mining directly employs relatively small numbers in the north, accounting for only 3.1 % of the total employed workforce in the study area, according to the 2006 ABS Census (Table 8). However, in the areas where mines are located, the industry plays a much more prominent role as a source of employment. This contribution is further magnified when indirect effects are factored in. For example:

- in 2004-05 in the North West Minerals province, the industry directly employed 6,860 people [8] and an estimated 6,130 indirectly, accounting for 60% of the regional workforce [15].
- Rio Tinto's Weipa bauxite operation generated 734 jobs in 2006, out of a total of 2,837 jobs across all industries in the local economy, or just over 25%. Taking into account the estimated 1,711 indirectly generated jobs, in 2006 it provided for employment equivalent to 86% percent of all jobs in Weipa [3].
- Of Groote Eylandt's estimated labour force of 1014, 50% worked in the mining industry in 2006. Government, which employed 13% of the workforce, came a considerably distant second. GEMCO also contracts 50% of the businesses registered on Groote Eylandt [16] [4].
- A Social Impact Assessment study conducted in 2007 estimated that Ernest Henry Mine was responsible for creating 196 additional employment opportunities in 2007, the local economic benefit of these jobs amounting to approximately $10 million based on wages alone. The study estimated that half the money earned by local employees is spent locally in Cloncurry [17]

.Table 9 - Employment in mining: ABS 2006 Census

Jurisdictional boundaries within Northern Australia	Number of residents currently in employment	Number of residents employed in Mining	Proportion of residents employed in Mining (%)
Queensland*	61,624	3,363	**5.5**
Northern Territory**	74,092	1,605	**2.2**
Kimberley, Western Australia	12,828	546	**4.3**
Northern Australia composite	**148,544**	**4,671**	**3.1**

* aggregate of the North West and Far North (minus Cairns) statistical divisions
** Northern Territory (including Darwin) minus the Alice Springs statistical division

Table 9 provides a breakdown of employment by operation, where these data are available. Key points to note are that:

- The bulk of employment is generated by a few large mines, Xstrata's Mount Isa operations in particular
- The number of people employed in the northern Australian mining industry exceeds the number of residents who are employed by a considerable amount. This reflectsthe trend towards increased reliance on Fly-in Fly-out (FIFO) operations from capital cities and major regional centres such as Townsville (see below).

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[3] Weipa Community Baseline Study 2006; the study was commissioned by Rio Tinto Alcan as part of its Sustainable Mining Towns Project.

[4] In a personal communication, a representative of GEMCO has indicated that approximately 22 of GEMCO's contracting partners are Indigenous.

Table 10 - Employment numbers available for selected operating mines

State/Region	Operation	Company	Type	Employment numbers
Western Cape, QLD	Weipa	Rio Tinto Alcan	Residential	758
Cape York, QLD	Cape Flattery	Cape Flattery Silica Mines Pty Ltd	Residential	100
Cape York, QLD	Collingwood	Metals X Ltd	FIFO	87
NW, QLD	Mount Isa Mines	Xstrata Copper	Residential	4,500
NW, QLD	George Fisher/Black Star	Xstrata Zinc	Residential	1160
NW, QLD	Century	MM Group	FIFO	970
NW, QLD	Ernest Henry	Xstrata Copper	Mixed	500
Jabiru, NT	Ranger	ERA	Mixed	519
Groote Eylandt, NT	Gemco	BHP Billiton/Anglo American Corporation	Residential	449
Borroloola, NT	McArthur River	Xstrata	FIFO	515 (but fell to 279 due to impact of Global Financial Crisis)
East Kimberley, WA	Argyle	Rio Tinto Ltd	Mixed	758 (2007) 776 (2008)
East Kimberley, WA	Savannah	Panoramic Resources Ltd	FIFO	236 (2007) 294 (2008)
East Kimberley, WA	Ellendale	Gem Diamonds Ltd [15]	FIFO	374 (2007) 528 (2008)
West Kimberley, WA	Cockatoo Island	Henry Walker Eltin Portman Ltd	FIFO	139 (2007) 169 (2008)
West Kimberley, WA	Koolan Island	Mount Gibson Iron	FIFO	391 (2007) 503 (2008)

Source: Company websites and publically available annual Sustainability Reports.

Local employment vs. Fly-In/Fly-Out (FIFO)

FIFO arrangements began to be developed in the mid 1980s [18], dictated by market conditions but also in response to economic reform that opened the industry to global competitive pressures. Simply put, the cost of mining town construction would have rendered many mine projects financially unviable. The move to FIFO has opened the industry to criticism that companies' contribution to the economic and social base of communities within the footprint of their operations is on the decline and that the shift had ushered in an era of dual economies; that is, the benefit derived is no longer anchored in host communities, but is increasingly being channelled to the main urban centres along FIFO routes. In the Kimberley, while the mining industry is the largest contributor to the area's gross regional product, it was eleventh (11th) on the list of industry employers [13] in 2006; an anomaly that is likely to be partly a function of FIFO.

A 2005 study commissioned by the Western Australian Chamber of Minerals and Energy argued that the major reason for adopting long distance commuting is the geographic isolation of operations [19], a factor that is of particular relevance for the northern Australian region. FIFO has also enabled companies to draw upon a much larger pool of potential employees, a particularly relevant consideration in view of the current and projected skills.

The industry's overall preference for FIFO is unlikely to change, but some operations have taken steps to ameliorate its impacts. For example, Rio Tinto's Argyle Mine has implemented a policy of employing staff locally. Reversal of its original FIFO operating philosophy to a regionalisation strategy has led to an increase in the proportion of workforce resident in East Kimberley from 11 to 67% between 2000 and 2008 [20]. The stated intent is to aim towards an 80% total and 40% Indigenous

East Kimberley based workforce, in line with the region's demographics. Century Mine's response has been to expand its FIFO arrangements, incorporating regional routes that have enabled residents, particularly Indigenous community residents, living outside the immediate radius of the operation, to join the workforce. Xstrata's Mount Isa Mines operation, in Queensland's North West has maintained a 'no FIFO' policy, making it conditional to future employment that applicants relocate to the town.

3.3.3 Infrastructure development

Up until the early 1980s, when new projects were customarily planned in advance as large-scale operations, governments made it conditional to the grant of a mining lease that companies provide, or make significant contributions to, the necessary infrastructure [5]. This meant that companies were called upon to procure industrial development such as freight and port facilities, as well as social infrastructure to house and service their workforce and families.

For example, under the terms of the *Commonwealth Aluminium Corporation Pty Ltd Agreement Act 1957 (Qld)* for the setup of the bauxite operation in Weipa, establishment and management of the township vested in the company, a situation that remains largely unchanged to this day. Management includes road maintenance, water supply, town planning, maintenance of the public swimming pool, parks and ovals, and garbage collection, services customarily provided by local governments and councils. Although an independent Weipa Township Authority has been established, the now 3,500 strong community remains under Rio Tinto's domain.

In the case of the Northern Territory, the terms of the 1963 access agreement required GEMCO to provide municipal services to the township of Alyangula. Nhulunbuy owes its existence to the bauxite mine operated by Alcan Gove since the 1960s. The refinery steam power station, for example, generates electricity for use by the mine as well as the local communities at Nhulunbuy, Yirrkala and surrounding areas. In addition, the $8 Million new airport at Nhulunbuy in the Northern Territory opened in 2005 was funded by Rio Tinto Alcan. Similarly, the majority of houses, the supermarket, specialty shops, and the sports and social clubs in Jabiru are ERA-owned buildings. The Ranger Uranium Mine operator also supplies power to the town and maintains the airport infrastructure [21].

As discussed above, the mid-1980s saw companies shift from constructing fully-fledged residential facilities to fly-in/fly-out arrangements as part of new project development. No new mining towns - once synonymous with mining development - have been constructed in Australia since Roxby Downs was completed in the late 1980s to service Olympic Dam mine in South Australia [5].

While operations tend to have a much lighter infrastructure footprint than the residential-based operations, there are some cases of nearby communities benefiting from aspects of this infrastructure. For example, Century Mine in far North West Queensland has a large jet airstrip and a network of regional flights which are used on occasions to transport local people (e.g. those requiring medical attention). The mine has also been the stimulus for improving road access in the area. Across the border, McArthur Mine is co-funding the construction of a swimming pool in Borroloola and has refurbished the town's renal dialysis unit. The Kidston Dam originally built to service the Kidston Gold Mine continues to operate even though mining operations ceased in 2001.

There may be further opportunities for communities to utilise and adapt mine infrastructure post-closure, depending on factors such as the response of regulators and the outcomes of negotiations between mining companies and traditional owners. In the case of Century Mine and Argyle Mine, for example, there is some potential for the accommodation villages to be adapted for use as tourist or training facilities post-closure, although in both cases substantial refurbishment would be required. Both of these mines have the advantage of being located relatively close to high quality natural areas (Boodjamulla (Lawn Hill) National Park in the case of Century and Purnululu National Park and associated areas in the case of Argyle).

3.3.4 Indigenous engagement

Mining companies now generally prefer to utilise the Indigenous Land Use Agreement (ILUA) provisions under the *Native Title Act* 1993. An overview of negotiated agreements reveals a trend away from direct monetary/royalty payments towards diversified compensation packages. As well as containing commitments to provide employment and business development opportunities, the focus of some agreements has shifted to addressing underlying causes of socio-economic disadvantage (such as poor education and health) [22]. Argyle Diamonds in the East Kimberley is an example of a leading practice ILUA:

The original decision to proceed with the establishment of the Argyle operation was controversial, impacting on a site of significance to local Indigenous communities at Barramundi Gap. The first Glen Hill (Argyle) agreement and 'Good Neighbour Program' involving local Traditional Owner groups were limited in both scope and effectiveness.

As attitudes to Indigenous land rights shifted during the 1990's, both within the community as a whole and the mining industry in particular, the focus on the relationship between Argyle and local Traditional Owner groups increased. In 2001 Argyle established a Memorandum of Understanding with the Kimberley Land Council which set out the steps towards a new, comprehensive ILUA, in preparation for a possible move to an underground operation.

As Argyle developed its vision for the future, including both closure and underground expansion options, it pursued in parallel the goal of renegotiating an agreement with Traditional Owners. This was an extended and at times challenging process, as documented in Argyle's publication 'Breaking New Ground' (Argyle Diamonds, 2005). The agreement included ambitious targets for Indigenous employment, commitments for local business development and many other, diverse aspects. The end result was described by the Federal Minister for Indigenous Affairs as *"one of the most significant ILUA's negotiated under the native title system …… this is the jewel in the crown".*

The Century Mine Gulf Communities Agreement (GCA) between the Queensland Government, Traditional Owner groups and the operator of the mine at the time, Pasminco, signed in 1997, is another example of a relatively comprehensive agreement. During a period of highly contested negotiations the company's offer to the local Indigenous communities increased from $70,000 to an eventual $60 million package over the life of the mine to be spent on payments to native title parties, community development and employment and training [23]. Commitment to Indigenous employment in particular, earned Century 'star performer' status of the Australian mining industry [23]. The site has consistently maintained an Indigenous workforce in the vicinity of 20 percent or more.

The move towards collaboration and building relationships with Indigenous people, evidenced in the above examples, has also been reflective of a shift in attitude on the industry's part. For example, at a 1996 Canberra conference to celebrate twenty years of the Aboriginal Land Rights (Northern Territory) Act, a senior Rio Tinto executive *'commenced his speech with a public apology on the company's behalf, for (amongst other examples) the processes involved in negotiating the Argyle Agreement (1980)*" [24]. At the signing of the Western Cape Communities Co-Existence Agreement in 2001, Comalco Chief Executive noted how far the company had progressed since the former Chief Executive of Rio Tinto made a speech that surprised many people in and outside the industry [25]. Leon Davis had said in 1995 "*Let me say this bluntly. CRA is satisfied with the central tenet of the*

Native Title Act. …The next decade will see a series of CRA operations develop in active partnership with Aboriginal people."

Cultural concerns featured prominently in rejection of the Coronation Hill proposal in the Northern Territory in 1991, and more recently Rio Tinto has publicly committed not to proceed with the Jabiluka development without the support of local Traditional Owner groups [23].
The McArthur River Mine expansion, on the other hand, is an example of a recent development where there was contestation over cultural concerns, resulting in legal action by the Traditional Owners against the proposed open cut conversion. The redevelopment, initially approved in 2006, involved diversion of McArthur River, an area of significant cultural as well as environmental significance. Although the project was ultimately approved in February 2009, in handing down his decision, the Federal Environment Minister, Peter Garret, "strongly encouraged MRM to pursue a more active engagement with local stakeholders including traditional owners"[26].

Indigenous Employment

Indigenous employment in the mining industry can be traced to at least the early 1900s [27], an era when the treatment and conditions of Aboriginal workers were often substandard [6]. Recently as 1969 Aboriginal workers at the Weipa mining operation were not eligible for all the employment benefits provided to their non-Aboriginal counterparts [6]. However, as noted, with the legal recognition of native title rights, mining companies have become more proactive in seeking to increase Indigenous participation in the mining workforce. More recently, the climate of labour and skill shortages has also cemented the business case for Indigenous employment.

According to the 2006 census, there were just under 500 Indigenous residents of the region employed in mining (Table 14). However, the State aggregates conceal substantial regional variation. In Queensland's North West Minerals Province, for example, Indigenous employment consisted of 8.2% of the total mining employment (up from 7.3% in 2001) and in Cape York the figure was 7.5%. Furthermore, total Indigenous employment in the sector is almost certainly under-counted by this measure, as it does not include Indigenous employees who live outside the region and commute to work under FIFO arrangements.

Table 11 - Indigenous employment in mining: ABS Census 2006

Jurisdictional boundaries within Northern Australia	**Number of Indigenous people residing in the area**	**Number of Indigenous people employed in Mining**	**Proportion of Indigenous residents employed in Mining (%)**
Queensland*	33,660	287	**0.9**
Northern Territory**	38,740	90	**0.2**
Kimberley, Western Australia	12,324	102	**0.8**
Northern Australia composite	**84,724**	**479**	**0.6**

* aggregate of the North West and Far North (minus Cairns) statistical divisions
** Northern Territory (including Darwin) minus the Alice Springs statistical division

The table below provides an indication of what has been achieved by the better performing operations. Central to the effort has been an acknowledgement of the obstacles to Indigenous employment (e.g. poor literacy and numeracy), which have seen some companies adopt and implement culturally sensitive policies [22].

Table 12 - Indigenous employment at selected operations

State/Region	Operation	Company	Employment numbers
Cape York, QLD	Cape Flattery	Cape Flattery Silica Mines Pty Ltd	50 (or approximately 50 percent)
NW, QLD	Century	MM Group	20 percent of total workforce
Borroloola , NT	McArthur River	Xstrata	20 percent of total workforce target reached in 2008
Gove Peninsula, NT	Alcan Gove	Rio Tinto Alcan	18 percent (2008); seeking to reach a target of 21 percent
Groote Eylandt, NT	Gemco	BHP Billiton/ Anglo American	Of a total of 270 permanent employees 49 are Indigenous, 31 of who are local. Gemco aims to increase the proportion to 30 percent across site. It should be noted that Indigenous people make up 49 percent of the island's population [28].
NT	Ranger	ERA	In September 2009 the mine celebrated the appointment of its 100th Indigenous employee, lifting the proportion of Ranger's total workforce to 20 percent [29].
East Kimberley, WA	Argyle	Rio Tinto	In 2000 5 percent of Argyle's workforce was Indigenous. By 2008 that figure had risen to 25 percent. Rio Tinto ultimately aims to ensure that half of its workforce is Indigenous to reflect the East Kimberley's demographics [20].

While there are some good performers, overall the industry's performance is patchy and that there is still much to be achieved [27]. When consideration is given to the concentration of Indigenous people resident in remote and very remote regions that dominate the northern Australian landscape together with the projected rate of Indigenous population growth, the importance of maintaining the momentum towards increased Indigenous employment in the sector becomes apparent.

Long term development/contribution

Despite a recent period of unprecedented growth for the mining sector, many would argue that Indigenous people still do not share an equitable portion of the wealth generated by industry from their lands [30]. The 10 year review of the Century Mine operation revealed that despite record Indigenous employment, the GCA has not succeeded in engendering community development on the scale originally contemplated [31]. This is not an uncommon 'disappointment' [32]. At the Century Mine, for instance, a paucity of governance and implementation mechanisms undermined formation of a secure capital base. The industry's capacity to deliver sustainable development in the long term is also limited by the finite nature of mining operations, although this is being addressed by such means as the establishment of 'future generation trusts'. The Aurukun Bauxite Project in Western Cape is a recent example of government influence in the application of principles of sustainable development to resource developments. Applicants were required to bid for tenure through an internationally competitive process, addressing various social and economic criteria imposed by the State. These included the development and implementation of a sustainable development policy and management plan for the Aurukun community.

The mining industry, by itself, does not provide a panacea for addressing Indigenous disadvantage, but the industry's potential to be 'part of the solution' is considerable. For example, collaboration between the Western Cape College and Rio Tinto won the Prime Minister's Queensland Community – Business Partnership in 2007. Rio Tinto's entry into the arrangement was motivated by the need to address retention issues and future skill shortages, whilst the College was motivated by the need to support school retention and transition of senior students from study into work. The partnership has been credited with making a significant contribution towards lifting rates of Indigenous school attendance and performance. Since the program's inception in 2000 "the Indigenous numbers went from 160 to 450" [33].

Support for Indigenous ecotourism is another example of the industry's potential to contribute to post-mining regional economies. This is of particular relevance in Northern Australia where mines such as Weipa, Century and Argyle are located in or near areas of substantial Indigenous populations and are proximate to national parks, World Heritage Areas or scenic areas with considerable tourism potential [34]. The above mentioned operations also share in common mine management formally committed to supporting Indigenous enterprise development [34]. However, the success of Indigenous tourism ventures in remote and regional Australia is dependent upon the availability of a certain level of hard (transport corridors, accommodation) and soft (access to education, training and work experience) infrastructure [34].

Industry/Government partnerships

More recently, companies have also shown a greater willingness to collaborate with each other and with governments on initiatives to address Indigenous disadvantage and increase the participation of Indigenous people in the industry. Two notable examples are described below.

Minerals Council of Australia (MCA) Regional Partnership Agreement Initiative

The MCA and the Commonwealth Government signed a Memorandum of Understanding in 2005 to "work together with Indigenous people to build sustainable, prosperous communities in which individuals can create and take up social, employment and business opportunities in mining regions" [35]. Of the eight pilot sites located across Australia, two are within Northern Australia – Queensland's Western Cape York (Rio Tinto Alcan) and Western Australia's East Kimberley (Rio Tinto's Argyle Diamond Mine and Roche).

NWQ Indigenous Resources Industry Initiative

This initiative stems from a Memorandum of Understanding signed by the Queensland Resources Council (QRC) and the Queensland Government in 2007 to increase Indigenous employment and business development in the state's resources sector. Similar to the MCA initiative, it is a multi-stakeholder partnership, which seeks to leverage the economies of scale to deliver upon a vision of prosperous sustainable Indigenous livelihoods. The first pilot site selected (with implementation commencing in 2009) was the North West Minerals province [36].

Summary

- Mining operations in Northern Australia have generated considerable wealth, as reflected in annual revenue, tax and royalty payments, as well as contribution to Gross State Product. The economic contribution to regional economies is an impact more difficult to quantify variable, however. Some companies have adopted local employment and contracting policies and moved towards supporting non-mine related enterprises and industries. However, ensuring that a greater proportion of benefits generated by regions is retained within the regions remains a challenge.

- Development of resource projects has been synonymous with large-scale infrastructure development, giving rise to a number of modern-day regional centres. However, Fly-in/Fly-out operations, established in the 1990s onwards, have generally been characterised by considerably smaller infrastructure footprints than their residential-based predecessors.
- There is growing recognition in the mining industry of the importance of early closure planning, including assessment of the potential to utilise mine-associated infrastructure post closure for

the benefit of communities. Greater alignment between mine development and regional planning processes would allow these opportunities to be maximised.

- In recent years, the mining industry has made concerted efforts to redress past wrongs of Indigenous engagement. There has been growth in the complexity and diversity of benefits offered under Indigenous Land Use Agreements, with a particular emphasis on employment and business development opportunities. While this has been beneficial for some Indigenous people, greater collaboration between companies, and cooperation with Indigenous communities and all levels of government is needed to address the underlying causes of chronic disadvantage.

4. MINERAL DEVELOPMENTS AND WATER RESOURCES

Conflict between mining companies and local communities over water is a strong theme in the region, as mining is often perceived to impact on the quantity of available water and to degrade the surrounding environment. These perceptions are largely due to environmental legacies, which have arisen as a result of poor process designs and environmental practices less advanced than those that are currently used. Many of these legacies are associated with tailings, seepage of poor quality water and acid rock drainage. To properly assess the biophysical impacts of mining in general, and on water resources in particular, it is critical to understand the relationship between water and mining.

4.1 WATER SYSTEM MAP

Water is not only involved in all mining operations but it is a part of almost every stage of production. The minerals industry has adopted a water system map to represent its relationship with water [37], as presented in Figure 2.

Every operation is set within a surrounding environment and community and holds regulatory licence operating conditions which must be met, as outlined in Appendix A (water resources planning). Many operations go beyond these compliance requirements in response to community concerns and/or corporate policies. Community relationships and environmental management can often go hand-in-hand. Managing these well can provide an operation with significant business advantages, particularly where the community is in a remote or regional location. The site (lease) boundary is well-defined and provides the site interface to the surrounding community and environment. Regulatory compliance and production requirements determine the site water quantity and quality requirements around which the site water system is designed. The concept model for the site water system includes four elements:

1. Input, representing the receipt of water to the site for operational use;
2. Divert, moving water around or through the site so that it does not become part of the operation;
3. Task-treat-store cycle, representing the operational cycle of the site and including the majority of operational tasks associated with minimising losses, managing climate variability and implementing efficient technologies and processes; and
4. Output, representing the removal of water from the operational facility.

The intersection of the site with the surrounding landscape describes how minerals operations interact with the surrounding environment, community and other stakeholders. This is concerned with the reporting of inputs by source and quality (where does the water come from and how much water comes from where?) and outputs (where does the water go, what quality of water leaves the site?). Accounting for diversion occurs within this area.

Internal activities and uses of water describe the typical actions that water is subjected to whilst in control of the operational facility. This includes activities such as:

- Operational tasks – the most common ones for the mines in the region are processing the ore, which almost represents the major water tasks, dust suppression and potable uses.
- Storing of water from surface water, groundwater production bores, pit dewatering, runoff harvesting to supply the tasks
- water quality treatment (e.g. removing metals, cyanide destruction, physical settling)

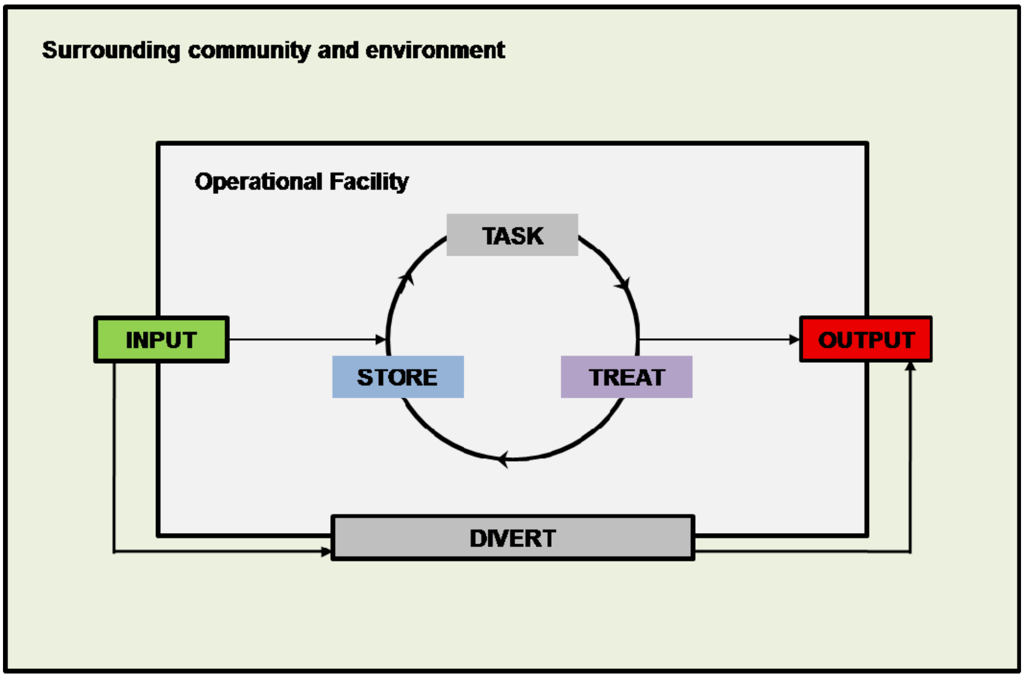

Figure 2: Minerals Industry Water System Map [37]

Inputs are characterised by their source, which qualifies the water resource body from which water is extracted. For the purpose of this report, we will be defining two sources of water: surface water and groundwater.

Mine water systems are characterised by a high level of water reuse, as is demonstrated by several of the case studies provided in this chapter. Most mines recover water from tailings storage facilities and have thickeners in place to recover water from the processing plant. To consistently deal with and report water reuse, the industry has adopted the concept of water status, which describes whether or not water has been tasked and / or treated after it has entered the operational facility as an input:

- Raw water is received as an input and has not been previously handled for any purpose by the operational facility.
- Worked water has been tasked and is returned for the same or another future task and/or is discharged.
- Treated water has been treated onsite to provide water of a suitable quality for a particular purpose.

It should be noted here that there are two types of stores: the stores that receive worked water flows (“worked water store”) and those that do not (“raw water store”). A raw water store only receives raw water and all water in this type of store is raw. A worked water store receives worked water but also raw water, in the form of precipitation and runoff inputs. The water in this type of store is a mixture of raw and worked water. The proportion of raw and worked water in a worked water store can only be obtained with specific calculations. In many regulatory frameworks, the water contained in those worked water stores is deemed "contaminated" and should be contained. This is discussed further in the section dealing with Stores.

The industry has adopted a risk-based approach towards managing the risks associated with each element of the water system map. Key risks and leading management practices to deal with those risks are clearly outlined in the Leading Practice Handbook [37]. The following sections highlight some of the water management issues that are specifically related to mine water management in the region.

4.2 INPUTS

Using the data from earlier sections outlining which mines are present in the region, a very broad estimate of water use by existing mining operations was derived. This estimate is based on:

- Reporting of water use in an operation's Sustainable Development report (where these data are available); or
- Calculation of water use based on production figures and water use per ton of product sources from a similar operation or published information [38]. Note that the publicly available information provided in Norgate and Lovel (2006) is derived from a small sample which did not necessarily contain operations from the region

For some operations neither water use figure or production data could be used and they are excluded from the assessment. They are the Cape Flattery silica mines, Collingwood tin mine, Wolfram tungsten and molybdenum mine, Savannah nickel mine, Tiwi Islands mineral sand project and ERA Ranger.

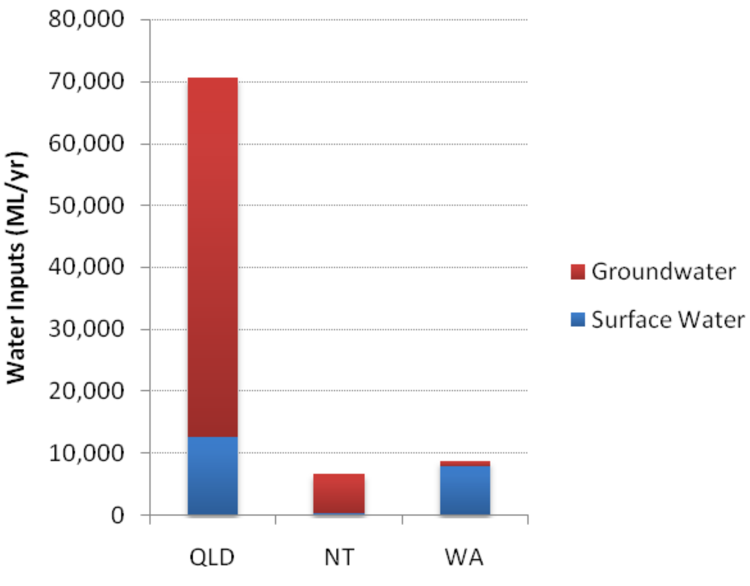

Figure 3 - Water inputs for mining operations in the region

Generally, the water inputs that are considered in Sustainable Development reports do not include the input of surface water from rainfall and runoff. This means that the figures provided here under-estimate the input of surface water. This will change as water accounting evolves, with the Minerals Council of Australia and the Sustainable Minerals Institute playing an active role towards improving the consistency and completeness of water reports. Despite this limitation, we can still conclude that: (a) operations in Queensland account for most of the water inputs; and (b) mining in the region relies heavily on groundwater. Assessing the impact of mining on groundwater, particularly in Queensland, is thus essential.

4.2.1 Groundwater

The nature and extent of mine and groundwater interactions depend on a number of factors: type and size of mine, geology of the deposit, geomorphology, topography, surface water interactions, climate and recharge characteristics. The complex nature of each of these factors and any relationships between them make characterisation of specific contexts difficult for each mining project. One approach is to construct a mine groundwater context using broader categories that enable the grouping of mines that are deemed to have comparable, but not equal, groundwater contexts. We have attempted to broadly describe the groundwater context of the Queensland mines that are present in the region and for which sufficient information could be sourced:

Table 13: Groundwater context for mines in the Queensland part of the Northern Region

Groundwater context	**Description**
Metalliferous Mines Underlying Great Artesian Basin Ernest Henry	Mineral deposits that are located in Proterozoic host rock on the western fringes of the Great Artesian Basin. Proterozoic layers are overlain by the Mesozoic sedimentary layers of the Great Artesian Basin. In addition to receiving recharge from the Great Artesian Basin to the east, aquifers overlying these mines are potentially recharged from basement outcrops on the western edge of the Great Artesian Basin.
Limestone Aquifer Century Zinc	Limestone aquifers constitute the primary source of groundwater in the mine area. Limestone aquifers have the potential to be really extensive, transmissive, and capable of storing large quantities of reasonable quality water.
Bauxite Mines Queensland's bauxite deposits	Extensive, flat, shallow deposits overlain by soil layers. The groundwater context of these deposits and associated mining operations may be generalised as follows: • Shallow coastal sediment aquifers that are fairly responsive to seasonal variations and may yield amounts of fresh water. • Tertiary sedimentary aquifers consisting of ironstone and partially consolidated sands that underlie the bauxite deposit. These aquifers are extensive in some areas yet absent in others. • Minor aquifers in the sandstone lenses of the Rolling Downs Group. These aquifers tend to have poor quality water and low permeability. • Deep sandstone aquifers of the Gilbert River Formation and Garraway Beds of the Great Artesian Basin. These aquifers contain large quantities of water but exploitation has been limited due to salinity and fluoride levels and the depth of the

	aquifer (>500m below surface level).
Duchess Embayment Aquifer Phosphate Hill	The groundwater context of the Phosphate Hill deposit, located around 130km south of Mt Isa, is different from those previously outlined. The context is notable due to the presence of the Duchess Embayment Aquifer, which is located in the same formation as the orebody. The aquifer is confined, with fresh quality water and high transmissivity. Significant dewatering is required to access lower sections of the orebody, which sit below the water level

For other mines, no information could be sourced to describe the groundwater context with any certainty but we can infer the following:

- Cape Flattery silica mine may sit within a coastal dune aquifer system;
- Cannington, Osborne (and potentially Eloise) mines underlie portions of the GAB or have water supply borefields that draw from the GAB.

There is bound to be some variation within settings as described. The settings outlined are designed to provide an "at a glance" description of the groundwater context of a given mine to enable a rough estimation of the types of impacts and the likelihood of them arising from mining operations. Forecasting impacts and apportioning probabilities to those impacts will require a more detailed assessment of the groundwater characteristics of any systems interacting with the mine. Further to this, there are a number of issues associated with identifying impact of mining on groundwater resources. These issues have been identified for Queensland [39] but they will also apply to the other two jurisdictions.

- There is no central repository of approvals or subsequent documents relating to groundwater and mining in Queensland. There is no central repository or database of groundwater monitoring data or reports associated with mining. The process of monitoring and managing groundwater impacts after the approvals process is not clear. Most mines improve the knowledge of their groundwater systems during the life of mine but there is no consistent process for capturing this information and ensuring that it is of a necessary standard to ensure ongoing effective management of impacts. The cumulative impacts of mining on groundwater systems are not being assessed.
- Irrespective of the total volumes involved, a number of mines are located in or near important groundwater resources and/or in association with sensitive ecosystems and other users of the groundwater. Therefore, it is essential that the processes for approval of new mines and expansions and the ongoing monitoring of groundwater use and impacts are dealt with in a rigorous manner.

This area is the focus of research sponsored by the National Water Commission, including a project on "Potential Local and Cumulative Impacts of Mining on Groundwater Resources and the Development of Tools to Aid the Prediction and Minimisation of Cumulative Impacts"

Osborne Mine [40]

The Osborne Mine currently operates an underground and open-cut mine to produce copper and gold in concentrate. They are currently considering producing magnetite as a secondary product, which will require access to additional water. The water used at the mine is sourced from the Great Artesian Basin and the current water permit allows access to 947 ML. Future water use was first estimated as 2,500 ML per year if standard water management practices were implemented. Investigation of leading practice technologies (such as new generation thickeners) showed that future water use could be lowered to 1800 ML/yr. This would still require an increase of the current water allocation.

The State of Queensland has set aside 10,000 ML of water from the Great Artesian Basin for projects of state or regional significance (*Great Artesian Basin Resources Operations Plan*). The Osborne project has applied for an increase in their water allocation under that scheme, demonstrating that (1) the water will be used responsibly and that all reasonable water conservation and reuse measures will be implemented and (2) demonstrating that the capacity of the existing bore field is sufficient to sustain the supply of the required water.

Clearly, the most significant issue for this project was to demonstrate that its additional water use would not threaten the Great Artesian Basin.

4.2.2 Surface Water

The only mines that rely on surface water are those which can draw water from the three main surface water supply schemes: in Queensland the Julius Dam Water Supply Scheme, operated by SunWater, and the Moondarra Dam Water Supply Scheme, operated by Mount Isa Mines Limited and in Western Australia, the Lake Argyle Water Supply Scheme.

Because of extreme rainfall variability, reliance on surface water is associated with access to large and reliable water supply schemes. Many mines harvest surface runoff generated on their sites but cannot provide the large storage capacities that would be required to ensure reliability of supply. The issue of rainfall variability and storage capacity is discussed in more detail in the next section.

Mount Isa Water Supply [41]

Surface water in the region of Mount Isa Mines flow into the Leichhardt river and then into Lake Moondarra approximately 20 kilometres downstream of the major site operations. This dam is the freshwater supply for the mine operation and the city of Mount Isa.

Freshwater consumed at Xstrata Mount Isa Mines is sourced from Lake Moondarra and Lake Julius. These two dams are used in combination to ensure the reliable supply of freshwater to Xstrata Mount Isa Mines and the Mount Isa community.

In 2008, a total of 8,074 megalitres of freshwater was consumed by Mount Isa Mines' mining, processing and smelting operations. 66% (5,329 ML) of freshwater consumed by Xstrata was from Lake Julius, and 34% (2,745 ML) from Lake Moondarra.

4.3 STORES

Unplanned discharge from mine worked water stores can compromise surrounding ecosystems. Discharges from raw water store do not pose any environmental threat as they generally contain water of high quality, close to potable water standards (although in some cases lack of matching of some constituents to water in external systems constrains their release). For mine sites, poor management of worked water excess also represents an operational risk as it can result in breaches of regulatory frameworks and associated license conditions, often leading to the payment of fines and loss of community support for the operation.

The risk of discharge during flood events is first minimised by designing mine water storages with dimensions that are appropriate for the climatic environment. Design is based on detailed hydrological modelling of relevant catchments. Extreme rainfall events are simulated and their impact on the storage capacity of key mine water bodies assessed. Statistical analysis is used to establish a relationship between frequency, duration and intensity of high-rainfall events in a particular area. Simulation results are then used to design site structures that take into account maximum probable rainfall event conditions. Most mine sites would be doing this at the moment to ensure their discharge risk is managed appropriately. Any future development would obviously adopt the same methods. However, in the northern region, containing runoff volumes generated during the large rainfall events of the wet season can present serious challenges to the selection of the most appropriate storage capacity. Local conditions and regulatory frameworks, particularly those dealing with dam safety, impose the design events that on-site storage must contain. These can range from high probability events (e.g. with a 1 in 10 years recurrence interval) to very low probability events, up to the maximum probable flood. With the northern region climatic conditions, the storage capacity that would be required to contain rainfall events of low to medium probability is often too large to be built within a site boundary.

Another issue that is often overlooked when assessing discharge risk is that the probability of discharge is not linked to rainfall events only. Mine water systems are dynamic and are likely to change from year to year. This can impact on the probability of discharge, as demonstrated in Cote and Moran, 2008 [42]. In the current context of dwindling water resources, and given general difficulties in securing water supply, mining operations are implementing significant changes to on-site water management. In fact, the probability that in a given year, a site will modify aspects of its water system is close to one.

Changes to mine site water systems are more likely to occur than any of the extreme hydrological events upon which traditional discharge analysis places so much emphasis. A perturbation in the water system leads to changes in the worked water balance status and the probability of discharge, as illustrated in the example below. For a mine located close to the southern Queensland border of the northern region, water balance simulations were undertaken for 50 years of daily rainfall records for different level of reduction in evaporation losses (evaporation losses as per current situation, 25% reduction in evaporation losses etc). Details about the modelling process are provided in Cote and Moran, 2008 [42].

Results (Figure 4) are reported as an exceedance curves for the worked water store, which provides the probability (on the vertical axis) that the volume stored in the reservoir will exceed a certain proportion of the available storage (on the horizontal axis). We also define the wet indicator as a measure of the relative frequency that the water level of the worked water store exceeded 90% of its storage capacity. The higher the wet indicator, the higher the risk that uncontrolled discharge will occur [43].

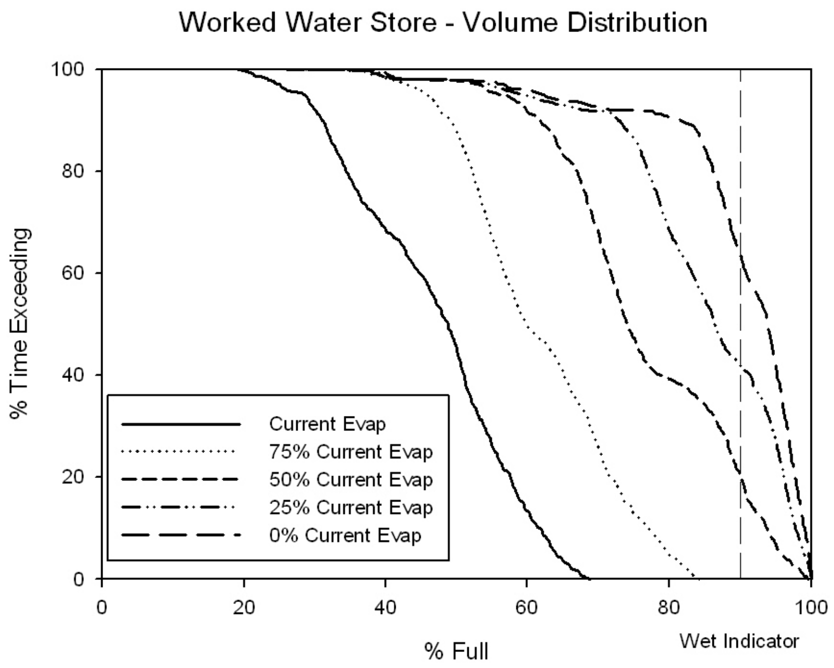

Figure 4: Example of impact of water management strategy (in this case, evaporation control) on discharge risk.

Table 14: Example of impact of of water management strategy (in this case, evaporation control) on the wet indicator which is closely associated with discharge risk.

Level of Evaporation Control	Wet Indicator
None	0
25% Reduction	0
50% Reduction	0.20
75% Reduction	0.42
100% Reduction	0.64

Decreasing the evaporation loss would lead to an increase in the stock of worked water and the wet indicator could potentially increase from 0 to 0.62. Up to an evaporation loss less than 50% of its current value, no discharges are predicted. For an evaporation loss equal to 50% of its current value, frequent discharges are predicted.

These results clearly illustrate that the risk of discharge from mine sites does not solely arise from hydrological events. Implementation of water management strategies, such as reducing losses, can also increase the probability of discharge. The relationships between the magnitude of a water system change and the associated predicted discharge risks are clearly non-linear and specific modelling is required for analysing the impact of water management strategies on discharge risk as the interactions between the various elements of the water system can lead to counter-intuitive results that cannot be easily deduced. When implementing initiatives to reduce water losses, it is imperative to plan for the use of that saved water (eg. by sending the water to another task) or for its storage (eg. through modification of storage capacity). It is also imperative that the emphasis that is placed on containing the runoff that is generated during extreme rainfall events does not create barriers towards implementing water saving initiatives. In other words, there is a risk that enforcing the concept of zero discharge for extreme rainfall events will prevent mining operations from implementing water saving initiatives.

4.4 WATER QUALITY AND TREATMENT

Water may need treatment if its quality prevents its use in the site's tasks (it is not fit-for-purpose) or its release to the environment. With a greater focus on water efficiency, increasing volumes of water are being treated for further use. Water quality issues can be categorised into six key contaminant groups: (1) inorganic, (2) organic, (3) suspended solids, (4) biological, (5) nutrients and (6) gases/odour. Water treatment technologies to deal with those issues are available and they include both passive and active approaches. They are described in detail in DRET 2008 [37]. We provide here two examples of water treatment technologies that have been implemented in the region.

ERA Ranger Mine [44]

ERA is one of the largest uranium producers in the world. ERA's Ranger mine, located 260 kilometres east of Darwin in Australia's Northern Territory, produces 11 per cent of the world's supply of uranium.

As with any other mines, water is used for a range of operational activities, such as processing. All water is managed by quality. Water is tested before release from site. Water treatment takes a range of forms, including both active treatment in specially designed water treatment plants and passive treatment practices such as biological filters, settling and polishing systems. ERA maintains a comprehensive water management system to direct, treat and release water.

4.5 OUTPUTS

Water outputs from mine sites include discharge, evaporation, seepage, entrainment (in the product and in the tailings), losses occurring in the underground mine (if relevant) and other task-associated losses. It should be noted that discharges are not always directed to rivers or creeks; they can also occur in marine environments, as is the case at Gove.

Gove [45]

The main discharge from Alcan Gove's operations to the marine environment is from the seawater outfall. Approximately 80% of the discharge is made up of cooling water from the evaporation circuit. The remaining 20% includes discharges of treated effluent from the Residue Disposal Area, recovered groundwater, treated sewage effluent, treated oily water, overflows from the Steam Power Station cooling tower, condensate and periodic discharges from the Western Pond. The Western Pond is a containment pond used to capture spills or overflows from the process. There is a procedure in place for testing the quality of the water in the pond before returning it to the process, discharging it to the Residue Disposal Area, or, if the water quality meets established criteria, releasing it to the seawater outfall.

As part of the 2006 work on the Marine Health Monitoring Program, Alcan Gove commissioned Charles Darwin University to review 2003-2005 monitoring data and develop protocols for establishing receiving environment water quality trigger levels and end of pipe discharge guidelines.

Evaporation rates in the region are high and any mine exposing large surface areas of water will lose a significant proportion of its site inputs to evaporation. New development should review and consider leading practice evaporation controls, as described in DRET 2008 [37].

On most sites, tailings storage facilities perform the dual roles of tailings storage and water recovery systems, and on some sites they store both tailings and tailings water, particularly where the tailings water is unsuitable for reuse in the processing plant and is required to be evaporated from the facility. Alternatively, excess unusable tailings water may be removed to separate evaporation ponds.

A significant proportion of the water in circulation within a mining operation is associated with the tailings storage facilities and large water outputs (entrainment, evaporation and seepage) occur in the course of tailings storage. One major issue is that seepage may go directly to the foundation and/or emerge from low points along the toe of the containment walls.

There are many environmental legacies that have arisen as a result of the poorer process designs and less advanced environmental practices that were used in the past. Many of these legacies are associated with tailings and waste. One of these legacies is acid rock drainage (ARD) or acid mine drainage (AMD) which naturally occurs when the surface of a rock is in contact with air and water. Sulphides in the rock oxidise in the presence of air and when water runs over the rocks, the oxides cause the water to become acidic. The acidic water then leaches out other metals in the rocks which then causes contamination of waterways.

ARD is a significant problem for mine waste rock dump heaps because the rock is in the form of fragments. Small rock fragments have a higher specific surface area than large rocks and so much of the rock surface is exposed. Acid rock drainage has proven a significant environmental legacy at the Rum Jungle mine near Batchelor and the Mt Todd mine. Most of these legacies can now be avoided by applying leading practices, as described in the Leading Practice Handbook for Tailings Management [46].

Rum Jungle

Rum Jungle is 75km south of Darwin. It was a uranium-copper open cut mine operated by CRA between 1954 and 1971. The east branch of the Finniss River runs through the mine lease.

From 1954 to 1961, the acidic mill effluent containing metals and radionuclides was deposited directly into the river. The pollution killed off the aquatic life in the Finniss River. The tailings were deposited directly onto the ground [47] [48]. From 1961 to 1971, the tailings were directed to open cuts. Tailings dams of that era were usually made from the tailings themselves. This was not the best strategy because if the material was not physically stable, the dam walls failed. Of course, acid rock drainage could still occur [49]. Nowadays there is better knowledge in creating material blends with better stability.

The waste rock piles suffered erosion [48]. This can be controlled now through grading the piles so that the slope of the pile minimises erosion [49].

The main source of acid rock drainage was three waste rock dumps. The pollutants were copper, manganese, zinc and sulphate. Other waste generated included three water filled open cuts, a tailings disposal area, and a copper heap leach pile [47].

The mine closed in 1971 and rehabilitation was carried out from 1982 to 1986. The polluted water within the flooded open cuts was treated with lime to raise the pH, precipitate the metals and then remove the metal-laden sludge. Waste rock dumps were covered, the tails and heap leach materials were relocated, surface flows on the site redirected, mill tailings from the copper heap leach pile were placed in the open cut and covered [48].

The covers on the waste rock dumps work to reduce the oxidation rate and the contact of water with the rock surfaces. They performed to specifications for at least a decade but over twenty years, the covers have deteriorated. They are made of natural soil, water infiltration has occurred due to root penetration of grasses, voids due to termites and ants and most significantly, desiccation cracking in the clay layer of the covers. The root penetration and termites are unavoidable but the desiccation cracking in the covers can be avoided in the future by making covers with better blends of materials [48].

Whilst the rehabilitation was somewhat successful in returning biodiversity to the Finniss River, there are still elevated levels of heavy metals in the river downstream of the mine. The groundwater is contaminated. As previously mentioned cracks in the waste rock dump covers will cause water infiltration to increase. Hence, Rum Jungle is meeting rehabilitation targets but is still a source of pollution [48].

4.6 DIVERSION

Diversion can occur by reinjecting or re-infiltrating groundwater produced during dewatering activities, changing the course of rivers and by redirecting clean surface runoff. Leading practice water diversion [37] manages not only the quality of diverted water but also the other values of the water, such as organism habitat and passage and human and operational safety for all stakeholders. An example of river diversion in the region due to mining is that operated by the Mc Arthur mine.

Mc Arthur River Mining [12]

In 2006, the Northern Territory Government approved the $110 million project to convert MRM from an underground to open-pit operation, which should extend the life of the mine by an estimated 21 years to 2027. The development was necessary because the zinc, lead and silver ore body to be mined lies under the McArthur River. While alternatives were considered, the viable option required rechannelling 5.5 kilometres of the McArthur River and 3 kilometres of Barney Creek. The development project includes design features in the river rechannels to mimic the form and function of the existing river and creek, additional safeguards for waste management and water quality, an expanded environmental monitoring program and a delivery model to improve social and economic benefits to the community.

4.7 MINE WATER USE - CONCLUSIONS

There are only three large supply schemes of surface water in the region: Lake Julius, Lake Moondarra and Lake Argyle. Mines that do have access to these supply schemes draw water from them.

Most mines do harvest some runoff flows but no data are publicly available to quantify these volumes. Because of rainfall variability, runoff is sporadic and often in large quantities over short periods of time. Storing harvested runoff requires selecting a site storage capacity large enough to provide water during dry periods without enhancing the probability of unregulated discharge. In addition, the risk of uncontrolled discharge does not solely arise from hydrological events but from a range of factors, such as the implementation of a water saving initiative. The threat of unregulated discharge is a particular concern if the site water inventory carries a contaminant load, which is unacceptably high.

Mines that do not have access to the surface water supply schemes rely on groundwater. The information base on groundwater use is increasing but there is no central repository for collating the impacts of mining on groundwater resourced. Cumulative impacts of mining are also poorly understood. Any new development will have to be rigorously assessed for its impact on groundwater.

Leading practice handbooks are available to guide development. Applying leading practice methods should ensure that past environmental legacies such as acid rock drainage, acid mine drainage, seepage of contaminated water, are avoided in the future.

5. THE FUTURE DEVELOPMENT OF MINING IN THE REGION

5.1 LONGER TERM MINERAL POTENTIAL

5.1.1 Known mineral resources

There are many known but undeveloped mineral resources across the region, some of which are the subject of active exploration programs, while others remain longer term prospects. In addition to the advanced projects mentioned in earlier sections, the following are worthy of mention.

- The Inkerman Project, a prospective mineral sand development on the western coastline of the Cape York Peninsula is in the early stages. Native Title negotiations commenced in 2007. The fourteen (14) Exploration Licence applications currently held by Mineral Sands Ltd cover in excess of 3,700 sq kilometres [50] of land, covering a large stretch of the South East coastline of the Gulf of Carpentaria.
- Queensland also has a number of known significant uranium deposits such as Valhalla in the North West, and the Maureen deposit near Georgetown. However, further development cannot proceed under the current State ban on uranium treatment and processing, which has remained unchanged since June 1998 [51].
- The bauxite deposits of the Mitchell Plateau in the Kimberley, discovered in the 1960s, are considered to be of national significance. UMC signed a Joint Venture with Norsk Hydro in 2007 to develop the Kimberley Bauxite/Alumina Project. Development at this stage is limited to a drilling program [52]. Other major mining companies hold extensive exploration licences which cover large areas of the plateau.
- Small-scale oil production is already occurring[5] in the Canning Basin East of Broome, but according to one operator the Basin remains the most under-explored sedimentary basin in the world. In a move to encourage 'greenfield' exploration in the region, the WA Department of Mines and Petroleum announced a petroleum acreage release in the basin in June 2009 [53]. In a statement accompanying the announcement, the Mines Minister, Norman Moore, highlighted the advantages of developing on-shore gas discoveries if the proposed LNG hub goes ahead [54].

The potential James Price Point LNG on-shore processing hub is to be located 60 km north of Broome, and will be a processing facility for gas piped from the Browse Basin by Woodside Petroleum, Chevron, Shell, BP and BHP Billiton. Feasibility studies are currently under way with State and Federal government approvals timeline extending to 2010. As part of the process, a Heads of Agreement has been signed by the Kimberley Land Council on behalf of Traditional Owners. If the development goes ahead, proximity to the resulting infrastructure hub may prove to be a key factor in the development of other prospects in the W Kimberley region, which as noted previously has remained relatively undeveloped due in part to its isolation.

5.1.2 Exploration activity

Exploration is the lifeblood of the resources industry [55]. It is seen as essential to replenishing the industry "pipeline of resources" [56], the discovery of greenfield sites in particular. Exploration is financially a highly risky endeavour, and is particularly susceptible to market fluctuations. For example, the Global Financial Crisis 'credit crunch' had a profound effect on the sector. The trend

[5] There are a number of known deposits – Yulleroo, Point Torment, Strokes Bay and Boundary.

estimate for total mineral exploration expenditure fell by 10.7 percent in the June quarter of 2009 [57], the highest falls registering in Queensland and Western Australia.

The sector is also highly influenced by government policies. The correlation between government investment in the exploration sector, the extent of activity undertaken by explorers and the number of operating mines, is evidenced by the following example. Between 1996-2001, a period during which government investment in exploration in the Northern Territory was at an historical low, the number of operating mines in the Territory shrank from eighteen (18) to nine (9) [11]. A change of policy in 2003 however, has been associated with a substantial increase in the number of potential and advanced projects.

The business case for government investment in exploration is that it creates jobs and company royalty payments are a return on investment in the long-term once projects materialise into operating mines. Mineral exploration activity in the Northern Territory had increased to "near historically high levels" in 2008. The increase in private investment is partly a function of the Government's introduction of two initiatives – Exploration Investment Attraction Initiative (2003-2007) worth $15.2 million over 4 years, and Bringing Forward Discovery (2007-2011) worth $14.4 million. The latest initiative is designed to "assist explorers to make the next major mineral and petroleum discoveries in the Territory" (see the Ore-Struck campaign). More favourable market conditions were obviously also a factor.

The importance of exploration was likewise emphasised in the 2007 Economic Impact Analysis "Expanding Queensland's Mining Exploration Capacity" commissioned by the Queensland Resources Council. To support a promise of making Queensland the greenfield capital of Australia, the State Government is funding two exploration initiatives – 'Smart Exploration (2005-2009)' worth $20 million over four years and 'Smart Mining – Future Prosperity (2006-2010)' worth $27.48 million over four years [56].

A recent survey of mining companies [58] placed WA, NT and QLD 4th, 7th and 9th respectively out of 71 national and sub-national mining jurisdictions in terms of mineral potential. This suggests that the underlying view of further development potential is still positive.

5.2 POSSIBLE DEVELOPMENT TRAJECTORIES

Despite some slowdown in activity during the economic downturn of 2008/9, the mining industry has significant potential to continue to expand the scope of its activities across Northern Australia. The rate of growth will demand both on global demand and commodity markets, and also a range of domestic influencing factors. Possible scenarios which describe the nature of future development are shown in the table below.

Table 15 - Possible development trajectories

	Low market demand for key minerals	High market demand for key minerals

Enabling regulatory and stakeholder environment	• Slower rates of growth. • Limited infrastructure development • Slowdown in exploration • New mines limited to existing, advanced projects	• Significant expansion of current activity • Co-ordinated infrastructure development for key regions • Focus on regional planning and synergy development • Expansion of exploration activity
Restrictive regulatory and stakeholder environment	• Slowdown in currently expanding regions • Little mining infrastructure investment • Few new mines • Closure of marginal operations	• Constrained growth • Conflict over high profile projects • Pressure on infrastructure bottlenecks •

Some of the significant non-market factors that will influence future minerals development include:

- Water availability and costs - at present, access to water supplies is not a major constraint for most existing mining operations, but there is potential for this to become more significant in some locations, particularly where mines access groundwater resources.
- Energy supply – while the development of gas pipelines through the Northern Territory and to North West Queensland has reduced the dependence on using diesel for many mining operations, energy supply remains a constraint in key areas. The recent SIMS review [59] identified power as one of the two critical issues for the development of the North West Minerals Province. Projections to 2026 indicate that the cumulative energy demand of existing and new mines will surpass current supply.
- Transport infrastructure development – rail and port facilities in several locations in the region are coming under pressure from existing operations, and will need upgrades if the current level of activity does expand. Transport was identified as the second critical issue for development of the North West Minerals Province.
- Skills shortage - in recent years, the mining industry has experienced a shortage of qualified personnel in skilled trades and professional roles to support the major expansions of activity in iron ore and coal sectors. The Federal Government recently announced that a national resources sector jobs taskforce will be set up to help secure up to 70,000 skilled workers needed to build and operate major Australian resources projects over the next decade.
- Relationships with Indigenous communities – Land Rights and Native Title legislation have provided Indigenous communities with a greater voice on mineral developments, and therefore the relationship between mineral developers and Traditional Owner groups is increasingly a factor in the progress of development proposals.
- Access to land – in recent decades increasing recognition of the environmental values of the region has resulted in growth of protected areas, including the declaration of Kakadu World Heritage Area and the designation of Wild Rivers in North Queensland.

- Government policy and incentives – all three state governments have been keen to encourage further mineral development in the region, albeit with some restrictions such as the current Queensland Government ban on uranium mining developments in the state. Facilitation has included several exploration initiatives as previously described.

The combination of these factors and market conditions will have a significant impact on the future development of mineral resources across the region. The following sections will consider the potential impacts of the high growth scenario in more detail.

5.3 POTENTIAL FUTURE SOCIO-ECONOMIC IMPACTS

5.3.1 Employment

The industry's current contribution in terms of regional employment was outlined earlier. The table below provides an indication of potential future contribution in the near to medium term, based on projected employment numbers available for select advanced projects in Northern Australia.

Table 16 - Projected employment numbers for advanced projects

State/Region	Project	Company	Projected workforce numbers
NW, QLD	Cloncurry Copper Project		200
Western Cape, QLD	Aurukun	Chalco Australia Pty Ltd	3800 during the 3 years of construction; 585 operational workforce
Western Cape, QLD	South of the Embley Project	Rio Tinto Alcan	350 during construction
Groote Eylandt, NT	Gemco refurbishment	BHP Billiton/Anglo American	150 during construction; addition of 40 staff to the permanent workforce
Broome, WA	James Price Point LNG onshore processing hub	Woodside Petroleum, Shell, Chevron, BP, BHP Billiton	400 permanent
East Kimberley, WA	Argyle underground expansion	Rio Tinto Ltd	250 construction and 500 operational workforce

A substantial proportion of these jobs will be short-term positions associated with mine construction or expansions, and that many are likely to be FIFO rather than locally based. This has obvious implications in an assessment of the industry's impact on and contribution to communities at the epicentre of existing and future mining operations.

5.3.2 Mining communities

Substantial increases in population that precede and follow the establishment of a new mining operation can put pressure on the area's existing social infrastructure, such as housing, health care provision and education facilities. A 2005 assessment of the West Kimberly's development potential indicated that whilst the social infrastructure was generally adequate to service the current population and expected business-as-usual growth, it would be inadequate in the event of the "most likely" 'medium growth and possible high growth scenarios [60]. The more recent MCA Vision 2020 Project [61] analysis of the Kimberley and Mount Isa regions paints a similar picture. The impact on housing availability is particularly acute. The Real Estate Institute of Queensland (REIQ) released figures in 2007 showing that the state's mining boom had led to a property boom in resource-rich areas such as Mount Isa [62], where median house prices recorded an increase in excess of sixty-five (65) percent over a 12-month period.

Commencement of a new mining operation is often accompanied by an increase in mine-related business opportunities and economic activity. This can lead to a distortion of the local economy and loss of skilled workers to the mining industry [63]; consequences particularly manifest during the boom stage of a mining industry cycle. For example, anecdotal evidence of construction workers and even teachers attracted to the industry in Mount Isa by comparably higher salaries during the latest boom.

Recent industry body initiatives, such as the MCA Vision 2020 project and the Sustainable Resource Communities Policy and Partnership Agreement launched by the Queensland Government, Queensland Resources Council (QRC) and the Local Government Association of Queensland in August 2008, evidence industry's recognition of the need to align with regional planning processes and adoption of a sustainable development framework. Planning for the future is crucial to alleviating and preventing negative community impacts associated with the industry's cycles of boom and bust.

5.4 POTENTIAL BIOPHYSICAL IMPACTS OF MINING

Apart from water, the most common biophysical impacts of mining that are regularly included in environmental impact statements are impacts on biodiversity, and air quality, through emissions of pollutants. With the increased focus on climate change and its impacts, mining operations have also been more active in compiling and reporting their greenhouse gas emissions. This section provides an overview of the impacts of mining on biodiversity, air quality and summarises some potential implication of climate change and associated mitigation strategies.

5.4.3 Biodiversity

The greatest threats that mining poses to biodiversity are habitat loss, habitat degradation, and habitat fragmentation. Mining has the potential to affect biodiversity throughout the life cycle of a project, both directly and indirectly. Direct or primary impacts from mining can result from any activity that involves land clearance (such as access road construction, exploration drilling, overburden stripping or tailings impoundment construction) or direct discharges to water bodies or the air (such as dusts or smelter emissions). Direct impacts are usually readily identifiable. Indirect or secondary impacts can result from social or environmental changes induced by mining operations and are often harder to identify immediately. Cumulative impacts occur where mining projects are developed in environments that are influenced by other projects, both mining and non-mining.

The potential for significant impacts is greater when mining occurs in remote, environmentally or socially sensitive areas. Mining in the northern region almost always occurs in remote locations. The northern part of Western Australia has also been identified as containing biodiversity-rich ecosystems that have so far been unexplored but might become developed for mining.

Despite the significant potential for negative impacts on biodiversity from mining operations, there is a great deal that companies can do to minimise or prevent such impacts in areas identified as being appropriate for mining.

There are many opportunities for companies to enhance biodiversity conservation within their areas of operations. Being proactive in the assessment and management of biodiversity is important not only for new operations but also for those that have been operating for many years, usually under regulatory requirements that were less focused on the protection and enhancement of biodiversity. Biodiversity management strategies are well described in publicly available guidelines [64]

Leading mining companies have adopted an increasingly sophisticated approach to managing biodiversity as part of their commitments to establishing and maintaining a social or functional 'licence to operate'.

Biodiversity at ERA Ranger Uranium Mine [44]

The Ranger Project Area and the Jabiluka Mineral Lease cover 15,200 hectares of land surrounded by Kakadu National Park. The park is listed twice on the World Heritage register for natural values and is internationally acclaimed as a biodiversity "hot spot". The park also contains protected areas covered by the Ramsar Convention on Wetlands of International Importance.

During 2008 ERA began biodiversity action planning, building on extensive biodiversity research carried out in previous years. In the first phase of this work, Rio Tinto and conservation partners Earthwatch Institute helped ERA to analyse its performance against a standard assessment criteria and begin identifying key regional biodiversity values. They then implemented key management initiative, which included weed management and traditional burning. A unique collaborative project called Jabiru Weedy Timebombs aims to completely eradicate targeted exotic weed species from the Jabiru township before they can spread to Kakadu National Park. ERA started a traditional burning programme to improve fire management on landscapes of significant biodiversity value through application of traditional ecological knowledge. In 2008 the number of Mirarr people taking part in the traditional burning programme doubled, and involved men's and women's burning groups.

5.4.2 Air Quality and Emissions

In the region being considered, the most significant impacts on air quality from mining and processing operations originate from the copper and lead smelters at Mount Isa Mines. The sulphur contained in the sulphide minerals being mined forms sulphur dioxide during the smelting process, released through stacks into the atmosphere. An Air Quality Control (AQC) System has been operated by Mount Isa Mines Ltd (MIM) to maintain ambient air quality, with the smelters shut down when unexpected atmospheric conditions cause the smelter plumes to impact on the town. More recently MIM constructed an acid plant, which traps and converts approximately 65% of the gaseous sulfur dioxide emissions into liquid sulfuric acid so that it is not discharged to the air. Emissions monitoring, control and impact reduction strategies are a major component of environmental management at MIM.

A related issue is that of lead in the environment. Recent investigations have identified elevated lead levels in some young children resident in Mt Isa, and studies are underway to understand the pathways involved through land, air and water [65].

6. CASE STUDIES

6.1 MITCHELL

There is a long history of mining in the Eastern highland areas of the Mitchell catchment, based initially on many small operations associated with gold rush activity over 120 years ago. These featured many common aspects of mining at the time, including conflict with local Indigenous populations and the development of boom/bust towns in the area such as Chillagoe. There are still a number of small scale alluvial and hardrock gold and tin operations in the region. There have also been several large scale metalliferous mines which included the Red Dome open pit gold mine and the Mt Carbine tungsten operation (both now closed).

This part of the catchment forms part of Queensland's North East Minerals Province (NEMP), and remains prospective for both base metals and gold. However, in scale of production the area does not compare with the Mt Isa region, and is instead characterised by small to medium-sized operations, which have gone through several closure/reopening cycles due to fluctuations in metal prices. The Queensland Government's Northern Economic Triangle taskforce included a study which identified options to double the transport capacity of this region to facilitate the movement of mineral products. More recently, exploration leases have been granted over the coastal areas on the Western side of the catchment to assess the potential for mineral sand development.

There are over 3000 historic mining sites located in the catchment, including some which have been registered as contaminated sites.

> *"There are many issues to include in management planning for historic mining and mineral processing sites. Many of these sites are contaminated with pollutants, the result of an era in which development was paramount and the environment not an issue. Whilst such an approach would never be acceptable today, communities are proud of their historic mining works and may not wish to have areas changed or rehabilitated. Similarly, any shaft-capping program needs to consider that many of these sites are now the home of bat colonies that would be displaced if the old workings were sealed completely. Indeed, a recent DME, DNR, Landcare and MRWMG risk assessment of derelict mine sites indicates an array of social and environmental issues that need to be considered in the management of these sites."*[66]

The dominant land-use in the catchment is grazing, occurring mainly in the western and Central Uplands areas. The catchment also includes five national parks.

While the area is still prospective for base metals and gold, it appears unlikely that it will experience significant growth in medium/large scale mining operations. Any developments of mineral sand deposits along the coastline will be closely assessed for impacts on rivers and groundwater resources.

6.2 DALY

The mining history of the Daly catchment commenced with the completion of the Overland Telegraph Line and establishment of a Telegraph Station in 1872, which opened the region to gold prospectors from the South and China. There is a strong cross-over in the nature and pattern of development of the Mitchell and Daly catchments. Both were characterised by small scale alluvial operations, conflict with Indigenous populations, and the rise of boom/bust mining townships. During the early era the township of Pine Creek, located 90 kilometres north of Katherine, was set up and functioned as a gold mining town until 1995.

A recent recovery in prices has seen a resurgence of interest in gold mining. The extent of current and pending tenure applications, however, is not on par with the scale of development anticipated in the southern region of the Territory around Alice Springs. Proposed development of the historic Maud Creek and Mount Todd deposits are in the 'advanced projects' category. Mount Todd in particular carries a legacy of environmental and water mismanagement. However, Vista Gold's proposal to reopen the mine includes several aspects to both address that legacy and reduce future biophysical impacts. These include the use of dewatering and 'dry-stacking' the process tailings, and using alternative crushing and grinding technology that will significantly reduce energy requirements compared with conventional approaches.

Mount Todd is located 40km north of Katherine. It was a gold and copper mine operated by Pegasus Gold. It opened in 1997 but closed later that year due to high production costs. It was in the hands of administrators, then the Northern Territory government. In June 2006 Vista Gold bought the mine.

The mine had a water management system of retention ponds, waste rock dump, open pit, and tailings storage facility but when the operation folded in 1997, the mine was decommissioned but the area was not rehabilitated. Current environmental problems are acid rock drainage from the waste rock dump and low grade ore dump, seepage from the tailings dam, heap leach ponds and retention ponds.

Controlled discharge of acidic water during times of major flows is an accepted practice. Research has been conducted to calculate the dilution factor to ensure the majority of species are unaffected (63). The problem was that during wet seasons, the acidic water - high in copper and zinc amongst other metals - overflowed into the Edith River in an uncontrolled fashion (63). This was due to an inadequate pumping system for the heap leach ponds and retention ponds. In 2006, the Northern Territory government installed a new pumping system (64). The preliminary economic assessment report for Vista Gold makes recommendations that utilise best practices such as thickening the tailings which makes them more stable and reduces the amount that has to be treated; separating the sulphide tailings from the non-sulphide tailings and subjecting them to different treatment; and installing covers on the tailings, waste rock dump, and heap leach pad.

The tailings storage facility for the sulphide tailings would be subject to more stringent conditions. It is recommended by the consulting company that prepared the report for Vista Gold that the facility should be lined so that the groundwater does not get contaminated. On closure, if the tailings are not chemically stabilised, the covers should be made of synthetic material to limit exposure to air, rather than soil covers, which can degrade. In contrast, the non sulphide bearing tailings impoundment need not be lined and on closure, they can be covered with soil and directly vegetated.

The Maud Creek deposit has a history dating back to 1887, when it was first discovered, and was last mined in 2000 by AngloGold. It is but one of a number of interests in the greater area recently acquired by Crocodile Gold Australia, a Canadian-based company. Previous proprietors have identified rick management issues such as proximity to a nearby pastoral property and the Nitmiluk National Park [67].

6.3 FITZROY AND CAPE LEVEQUE

As previously mentioned, the Kimberley area has been relatively undeveloped compared with other parts of Northern Australia, due to its isolation and a lack of infrastructure. The Fitzroy River and Cape Leveque catchments currently only include one mining project at Lennard Shelf, although this is not producing at present. The four older lead/zinc mines which make up this cluster (Kapok, Cadjebut, Goongewa and Pillara) have been operated by a number of different companies in the past decade and are currently undergoing rehabilitation for closure. However, Meridian Minerals is continuing to explore the same geological structure with a view to reopening an operation there if mineral prices permit. Kagara Zinc have an advanced prospect at Admiral Bay 200km South of Broome. Although this falls just outside the area under study, its development would have implications for various types of infrastructure in the Cape Leveque catchment.

Despite the previous and current lack of widespread mining activity, the area does feature a large number of known deposits and prospects. The extent of current and pending mineral exploration leases indicates continued interest in the area, possibly also reflecting the recent prioritisation of the Kimberley region by the Geological Survey of Western Australia (ref 2005 report). The Canning Basin is being actively explored for both coal and onshore oil and gas resources, with Rey Resources having identified a 500M tonne thermal coal resource at its Duchess/Paradise project located approximately 150 km SE of Derby. It is currently assessing the potential for a mine and export port, and also evaluating the concurrent potential for coal seam gas and methane developments across the leases. Buru Energy have a small oil operation just to the North of the catchment at Blina, and have described the Canning Basin area as underexplored and extremely prospective for significant oil and gas resources.

The DIR 2005 report on the mineral potential of the Kimberley highlighted both its significant potential and the need for infrastructure development. In the context of this case study area, recent public debate has focussed on the implications of an onshore gas processing facility located at James Price Point, with several suggestions that this development could unlock the potential for additional development in the region including within the Fitzroy and Cape Leveque catchments. A 2009 report from the MCA also highlighted the infrastructure requirements for the Kimberley region as a whole.

None of the projects referred to above are advanced enough to have developed detailed water supply plans. It is worth noting, however, that any development of onshore oil and gas resources is likely to generate water as a result of extraction processes.

7. WHAT IS REQUIRED TO MANAGE IMPACTS (POSITIVE AND NEGATIVE)?

The Leading Practice Sustainable Development Program for the Mining Industry, co-ordinated through the Federal Department of Resources, Energy and Tourism (DRET, formerly through DITR) represents a multi-stakeholder approach to summarising best practice management strategies to address many of the issues discussed in this chapter. Of particular relevance are the publications on Water Management, Working with Indigenous Communities, Tailings Management, and Managing Acid and Metalliferous Drainage, but every booklet in the series has information relevant to the region under consideration in this report. Each was developed by a panel which included representatives from government, industry, community stakeholder groups and technical consultants. It is beyond the scope of this chapter to reproduce all of the guidelines involved in that series, but the following issues are suggested as key focus areas.

- In designing and managing mining operations and planning for closure, a key focus should be on ensuring that operations make a positive long term contribution to the regional asset base. This should include not only physical infrastructure (e.g. buildings, power, airstrips) but also human capital, in the form of a skilled and mobile workforce; and, where practical, enterprises that are not mine-dependent. The current industry focus on early closure planning could be supplemented by legislation which require these considerations to be addressed in project approval processes (e.g. the requirement for Chalco to include a Sustainable Development Management Plan in their proposal to develop the Aurukun project).
- If mining projects are to be an effective mechanism for delivering improved employment outcomes for Indigenous people in the northern regions, a concerted effort is required by companies and state and federal governments to address underlying impediments to employment and grow the labour pool. This will require collaboration rather than competition between companies working in close proximity to each other. In addition, there needs to be a continued focus on creating effective agreement structures to leverage greater benefits from mining developments for remote Indigenous communities.
- Closer alignment and involvement of the minerals industry with regional planning processes and greater co-ordination in mining intensive regions, such as the Western Cape and North West Queensland, could facilitate synergies in key inputs (e.g. energy and water) and reduce the cumulative environmental impacts of resource developments. The recent SIMS review of energy infrastructure for the North West Mineral Province involved the use of confidential planning information sourced from individual companies which was then used to produce an aggregated estimate of future demand, allowing realistic scenarios to be considered. The availability of accurate and timely information will be critical for infrastructure planning.
- There is no single model of workforce location which will suit all locations. While the industry continues to favour FIFO arrangements for most operations, there is a need to ensure that local involvement is allowed for in the design of workforce arrangements so that regional communities are not isolated from the benefits that mineral developments could bring. Similarly, strategies which aim to base large workforces within or close to existing communities in Northern Australia must plan for the social infrastructure required to support the associated increases in population.
- Many mines across the region rely on groundwater sources. The information base on groundwater use is increasing but there is no central repository for collating the impacts of mining on groundwater resources. Cumulative impacts of mining are poorly known. Any new development will have to be rigorously assessed for its impact on groundwater.

- Discharges from a mine water store do not solely arise from hydrological events - a range of factors, such as the implementation of a water saving initiative, can combine to increase the discharge risk. Enforcing the concept of zero discharge in a region which features a monsoonal climate can potentially force mines to design their water system around containing extreme rainfall events, at the expense of designing a system that can deal with scarcity of supply. Operations need to follow best practice guidelines in designing and monitoring their water systems, and regulation should be designed to encourage appropriate treatment and discharge regimes for the context.

8. SUMMARY

Mineral developments have played an important role in the socio-economic development of Northern Australia, and have significant potential to further contribute to sustainable outcomes across the region. The industry is likely to continue to expand in existing areas of high activity, such as the North-West Mineral Province and Western Cape, where deposits of base metals and bauxite will continue to attract strong interest. There is also likely to be an increased focus on the development of mineral resources in the Kimberley region, in parallel with the development of offshore gas fields and associated onshore infrastructure.

Availability of water is not a major constraint to operations in the region, but management of groundwater impacts will be a key focus in several areas, particularly in the case of cumulative impacts arising from a number of operations. Best practice guidelines for water management have been developed, and can mitigate against some of the issues seen in legacy sites in the region.

Mining should be considered as part of an integrated development approach, in conjunction with other industries and regional priorities. There has been some progress in using the presence of mining operations to improve conditions for Indigenous communities in the region, through Indigenous employment initiatives and local business development. However, mining in itself is not a panacea. Careful design of operations from exploration through to closure should include a focus on their evolving contributions to the regional asset base, both through physical infrastructure and also the creation of human and social capital.

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APPENDIX A - WATER RESOURCES PLANNING

The process of water resources planning largely governs the volumes of water that can be accessed by mining operations. This process varies from State to State. This section aims at summarising the key points that will help determine whether any additional water can be acquired.

Queensland

The water resource planning process in Queensland is governed by the Water Act (water act 2000) and it utilises two key mechanisms. Firstly, water resources plans aim to achieve a sustainable balance between meeting human needs and those of the environment. Secondly, resource operations plans are concerned with the day-to-day management of water resources, in a way that meets the water resource plan objectives. The Department of Environment and Resource Management (formerly Natural Resources and Water) monitors the implementation of water resource plans.

Water resources plans are developed through detailed technical and scientific assessments as well as extensive community consultation to determine the right balance between the many interests that rely on the state’s water resources. Generally, a water resource plan will apply to a plan area’s rivers, lakes, dams and springs and, if necessary, underground water and overland flow.

Resource operations plans, in implementing the outcomes of water resources plans, aim to maintain the sustainable management of water by:

(1) allowing for the allocation of water and contributing to the fair, orderly and efficient allocation of water to meet community needs by stating a process for dealing with unallocated water; granting authorisations for the management of, taking of and interfering with water; and establishing water allocations that are tradable and separate from land.

(2) protecting the biological diversity and health of natural ecosystems and contributing to the protection and, where possible, reversal of degradation of water, watercourses, lakes, springs, aquifers, natural ecosystems and other resources.

(3) contributing to improving the confidence of water users regarding the availability and security of water entitlements.

(4) Contributing to increasing community understanding and participation in the sustainable management of water.

In those plans, unallocated water refers to water that it is technically possible to make available for future use without compromising the environment or the supply to existing water users. Understanding the extent of unallocated water in each part of the region is essential to assess any potential for further development.

The areas of Queensland that are within the region and for which water resources and/or resource operations plans are available are:

- Mitchell River Catchment: Water Resources (Mitchell) Plan (November 2007) and Mitchell draft Resource Operations Plan (October 2008) have been released;
- Gulf Catchment: Water Resource (Gulf) Plan (2007) and the Gulf draft Resource Operations Plan (October 2008) have been released. The resource operations plan is applicable to all water that is not water from the Great Artesian Basin;

- Great Artesian Basin: Water Resources (GAB) Plan (March 2006) and the Great Artesian Basin Resource Operations Plan (December 2006) have been finalised.

The Gulf Catchment resource operation plan is of particular interest as it provides the rules for releasing surface water from the two main surface water supply schemes of the region, namely the Julius Dam Water Supply, operated by SunWater, and the Moondarra Dam Water Supply Scheme, operated by Mount Isa Mines Limited. In those plans, significant volumes of unallocated water are identified and have been placed in reserves. A process has been put in place for granting unallocated water through applying for licences to take surface or groundwater.

Access to water from the Great Artesian Basin is outlined in the associated plans. Given that many mining operations in the region rely on groundwater, it is worth outlining the process for regulating groundwater use. It covers two aspects: (1) how to obtain an entitlement to take or interfere with groundwater (licence) and (2) how to assess and manage groundwater impacts (environmental authorities).

The entitlement to take or interfere with groundwater in Queensland is regulated under the Water Act (Water Act 2000). A water licence is required to take or interfere with artesian water throughout Queensland. A water licence is required to take or interfere with subartesian water in an area of Queensland, which is declared to be a subartesian area in the water resource plan. The decision on whether or not to declare a particular area to be a subartesian area depends on the significance of the water resource, the demand on the resource and the risk to the resource from overuse.

A water licence issued to a mining company is likely to include conditions requiring a detailed monitoring program, modelling to predict impact of mining, comprehensive reporting on the impacts, and conditions requiring the licensee to "make good" the impacts on individual landholders who have their access to groundwater impacted by mining. While the full extent of the impacts may not be well understood at the time of granting a water licence, licence conditions such as those above provide a framework for adaptive management of the impacts.

It should be noted that groundwater taken in the process of exploring for or producing petroleum is not subject to the water licence regime at any time. The petroleum legislation provides the right for petroleum tenure holders to take groundwater without holding a water licence. However, the petroleum legislation requires that petroleum tenure holders carry out monitoring, make good impacts on other water users, and produce reports. The regime is similar in structure to that provided under water licences issued for major mines, as described above.

Different arrangements for assessing and managing groundwater impacts apply depending on whether a water licence is required to take or interfere with groundwater at the location of a proposed mine.

In those parts of the state where a water licence is required, a two-stage approval process applies. The first stage concerns the environmental authority. Impacts on groundwater and possible mitigation measures are identified through the environmental impact assessment process. The environmental authority for the mining activity may include general conditions to deal with issues such as the need for a monitoring program and the need to obtain water licences. If it were not possible for the mine to proceed because of unmanageable groundwater impacts the environmental authority would not be issued. The second stage is the granting of a water licence. The water licence provides the right to take the water and sets specific conditions that manage the impacts of the extraction on other water users and the environment.

In those parts of the state where a water licence is not required an environmental impact assessment process is the only means of addressing impacts on groundwater. Under those circumstances the environmental authority for the mining activity needs to contain more rigour in its approach to the impacts of the mine on subartesian water resources.

Western Australia

Western Australia has embarked on the development of a water planning framework, which constitutes a core element of the State water resource management and reform program and will provide the basis for the ongoing development of strategic and statutory water plans, administered by the Department of Water. The framework will provide a comprehensive, integrated approach comprising:

- Regional water plans to address the water issues, challenges and opportunities of each region in Western Australia. In all, nine regional plans are being developed over the five years to 2012.
- Strategic water issue plans, which are flexible tools that address specific issues not covered by the regional plans. This enables government agencies to work together with the community.
- Detailed management plans to protect and share water resources and manage land-use changes. They will include specific strategies to allocate water sustainably, protect drinking water sources, preserve our waterways and manage drainage and floodplains.

Regional water plans and detailed management plans for the northern region are not complete yet. The part of Western Australia that belongs to the Northern Region is the Kimberley region, stretching from the Northern Territory border, west across the northern coastal areas down the coast south of Broome into the Lagrange area and back across to the Northern Territory border through the Sandy Desert. The region has about 30 major rivers and many more tributaries and tidal creeks. Many Kimberley rivers are unique and represent important examples of some of Australia's, and the world's, last remaining natural river systems. They are, however, under increasing pressure from threats such as weeds, overgrazing, new roads, tourism, feral animals, increased mining and exploration activity and inappropriate use and development.

The region has one of the largest rivers in Australia, the Fitzroy and the largest man made inland Lake, Lake Argyle situated on the Ord, which supplies water to some mining operations (e.g. Argyle Diamonds). There are also significant groundwater resources in the region which supply key mining operations, pastoral activities, town water supplies and a large number of irrigation and industrial operations.

Northern Territory

To manage the Northern Territory's water resources sustainably, the Department of Natural Resources, Environment, the Arts and Sport is responsible for its assessment, monitoring, management, planning, protection and sustainable utilization. It is working towards developing Water Allocation Plans for each region, based on Water Management Plans that will be developed by Water Advisory Committees, statutory bodies formed under the Water Act (2000) with members drawn from the community and selected for their particular expertise. There are five Water Advisory Committees:

- Rapid Creek Catchment Water Advisory Committee (RCCAC)
- Daly River Management Advisory Committee (DRMAC)

- Katherine Water Advisory Committee (KWAC)
- Mataranka Water Advisory Committee (MWAC)
- The NT Artesian Water Advisory Committee

The only complete Water Allocation Plan for the region is that developed for the Tindall Limestone Aquifer (around Katherine). This plan outlines:

- The allocation of 73 licenses with defined level of security;
- Water Trading in the Plan Area;
- The introduction of standards and procedures to protect water quality;
- Sustainable management of discharge from the Tindall Aquifer to the Katherine River;
- Consideration for Indigenous uses and values;
- Protection for groundwater dependent ecosystems, such as the Katherine Hot Springs.

An Implementation Strategy will be developed for the monitoring, investigation, and compliance of the Plan. This will be an ongoing process and the information gained will be used to improve the Plan at the 5 and 10 year review.

Beyond the areas that have been identified for the development of water allocation plans, the Northern Territory has defined water control districts, which can be proclaimed in areas where there is a need for close management of water resources. This is to avoid stressing groundwater reserves, river flows or wetlands. Legislation in Water Control Districts covers all aspects of sustainable water resource management including the investigation, use, control, protection and allocation of water. For example, a permit must be obtained before a bore can be drilled in a Water Control District. Water Control Districts are currently defined within the Darwin Rural Area, Gove peninsula, Daly Roper, Tennant Creek, Ti Tree and Alice Springs regions. Relevant to the region are the Darwin Rural Area, the Gove peninsula and Daly Roper water control districts.

One important water issue in the Northern Territory concerns the interactions between groundwater and surface water. Groundwater usually discharges at low-lying points in the landscape. It can take the form of individual springs or as diffuse seepage into stream beds. Recharge to groundwater is greatest in the higher rainfall zone in the north, so discharge is correspondingly greater. Many streams in the north maintain a flow for at least part of the long dry season because of groundwater discharge. Some streams, particularly those with major karstic or porous rock aquifers in their catchments, flow throughout the dry season. Springs with significant discharges (more than 100 L/s) only occur in karstic aquifers. There are many major and minor springs in the Daly catchment and any development would need to ensure they are not affected.