DRAFT
ENVIRONMENTAL IMPACT STATEMENT

BATCHELOR MAGNESIUM PROJECT

Prepared for

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URS

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EXECUTIVE SUMMARY

INTRODUCTION

Mt Grace Resources Limited (Mt Grace) propose to mine and process magnesite in a staged development at a site 4 km east of Batchelor, 90 km south of Darwin in the Northern Territory. This is a summary of the Draft Environmental Impact Statement (EIS) for the mine and processing plant of the Batchelor Magnesium Project. The EIS has been prepared for submission to the Northern Territory Government and the public, with information necessary to enable an informed evaluation of the environmental acceptability of the proposed project.

THE PROPONENT

Mt Grace is a wholly owned Australian company listed on the Australian Stock Exchange (code MGD). Mt Grace was first listed in 1994 and has operated as a mineral exploration company, principally within Australia. Mt Grace is primarily focused on the development of the Batchelor Magnesium Project, to which this EIS pertains.

PROPOSED PROJECT

The Mt Grace mining lease covers an area of 357 ha, located 4 km from Batchelor town site. The Winchester Magnesite Deposit lies beneath this site and Mt Grace proposes to mine magnesite ore and process it into magnesium metal at this site. There is currently a small trial mine pit filled with water and some survey lines that act as access tracks on the site. The remainder of the site is mid-densely vegetated primarily with savannah woodland. Currently the pit lies beside the Coomalie Creek (Right Branch) and this creek will be diverted for the expansion of the mine pit providing access to the magnesite resource. The proposal is to expand the mine pit progressively over the life of the mine in approximately three major stages and mine the ore on a ‘campaign’ basis each year. Ore will be transported to a processing facility on the same site and converted into magnesium metal by a thermic reduction process.

Construction summary

Construction will take approximately nine months, requiring a workforce of about 100. It is expected that site preparation will commence in September 2002 and construction will be complete by July 2003. The trial pit that exists on site and this will be expanded with a series of benches, to begin bulk extraction of ore. Most of the internal components of the processing plant will be constructed offsite, tested, then moved to the site for installation. All infrastructure will be built on site will primarily comprise office facilities, ablutions block and maintenance areas. Access and haul roads, and flood bunds will be constructed from overburden waste rock.

Operation summary

Operation is expected to commence in late 2003 and will involve the mining of 200,000t/a of magnesite ore for Stage 1 of the project for the production of 12,500t/a of magnesium metal. Stage 2 will increase production to 25,000t/a of magnesium and 50,000t/a in Stage 3. Ore will be mined in campaigns for 2 to 3 months each year and processed on site. Processing involves: crushing and screening the ore; calcination of magnesium carbonate (contained in the ore); metallo-thermic reduction in a DC arc furnace using appropriate fluxes and reductants; condensation of magnesium vapour; refining into pure magnesium; and casting into magnesium metal.

PHYSICAL ENVIRONMENT

Climate

The project area is located within the monsoonal tropics. There are two distinctive seasons: a hot, Wet Season and a hot, Dry Season. April and November are considered transitional months between the two seasons. Maximum temperatures are hot all year round with an average of 30°C. The annual average rainfall for the area is 1372mm, the vast majority of which falls in the Wet Season. Humidity averages 30% in the Dry Season and 80% in the Wet Season. In the Dry Season prevailing winds are predominantly south-easterly and in the Wet Season mostly north-westerly. Tropical cyclones and tropical depressions occur on average once in every two years during the monsoonal Wet Season.

Geology, soils and hydrology

The Winchester Magnesite Deposit occurs within the Coomalie Dolomite, which is bound to the north by sandstones of the Crater Formation and to the south by black shales of the Whites Formation. The deposit occurs beneath the floodplain formed by the Coomalie Creek. Soils in the catchment area are shallow lithosols with rocky outcrops on the hills and steeper slopes and red and yellow earths in the low-lying areas near Coomalie Creek (Right Branch). The project area falls within the Adelaide River catchment, covering an area of about 82 km^2, and the mine site is located on the right branch of Coomalie Creek. Coomalie Creek (Right Branch) will be diverted for approximately 1.2 km of its length to enable expansion of the mine-pit for access to the ore resource.

BIOLOGICAL ENVIRONMENT

Flora

The flora of the project area was classified within 6 main vegetation communities. The majority of the site is vegetated with open mixed species Eucalypt woodland dominated by *Eucalyptus tetrodonta* and *E.miniata*. There is a defined riparian corridor flanking the Coomalie Creek, supporting diverse aquatic flora and grading into *Lophostemon* woodland. Isolated pockets of dry vine-forest occur on dolomite outcrops within the project area. There were no rare or endangered species found in the project area and no communities of conservation significance. The vegetation within the project area suggests frequent fire events and weeds are established in heavy infestations.

Fauna

A total of 122 native terrestrial vertebrate species were recorded during field survey work, comprising 6 amphibian, 21 reptile, 74 bird and 21 mammal species. Two of the mammal species, the Northern Quoll and Pale Field Rat are listed as 'lower risk – near threatened' (Territory Parks and Wildlife Act, 2001). Aquatic fauna in Coomalie Creek (Right Branch) includes freshwater fishes (16 species), freshwater crocodile, crustaceans (5 species), molluscs, prawns and insects.

Biting Insects

Biting midges were found in very low numbers and are not expected to be a significant pest problem and no specific control measures are required. Mosquitoes were found in greater abundance than biting midges, with a greater diversity of species present at and around the site. Management measures to minimise the impact of mosquitoes will focus on preventing the creation of suitable mosquito-breeding habitats.

SOCIAL ENVIRONMENT

Socio-economics

The Batchelor Magnesium Project will beneficially impact both local and regional economies. The Northern Territory economy will benefit primarily by increased employment opportunities and diversification of skill base within the existing workforce.

As well as enhanced employment opportunities Batchelor will experience an increased use of services, utilities, and local business. Local businesses and facilities will be utilised to service the construction workforce for a period of 9 to 12 months.

The long-term operation of the mine and processing plant will provide specialised employment and training for a local workforce. A localised growth in population will stimulate local business and industry with an expected long-term growth in the local economy. There will be a more sustained and feasible growth in local enterprise with the mine facilitating a major boost in local economy.

Archaeology and Anthropology

There are four Registered Sacred Sites and one Recorded Sacred Site existing in the project area, as identified by the Aboriginal Areas Protection Authority. Six archaeological sites have been identified within the project area, most relating to, and in proximity to the Sacred Sites. None of the archaeological artefacts have been attributed with a high level of significance but the *Northern Territory of Australia Heritage Conservation Act (1991)* will protect them from disturbance.

The project area is located within an area acknowledged as being the traditional country of the Kungarakany and Warai People who are thus considered the Aboriginal custodians of this area. There are areas of spiritual significance emanating from, and particularly associated with the recognised Sacred Sites. The Custodians consider all subsurface water and water courses to be of spiritual significance. The Custodians have an intimate understanding of the relationships between the regional subsurface hydrology (including Litchfield Park), and the surface drainage, and are particularly concerned about any activity that impedes or impacts these landscape features.

ENVIRONMENTAL IMPACTS

The potential environmental impacts of the proposed project are summarised in **Table 1,** which addresses environmental factors; the existing environment; potential impacts; environmental management; and predicted outcome.

TABLE ES-1
SUMMARY: POTENTIAL ENVIRONMENTAL EFFECTS & MANAGEMENT MEASURES

Environmental Factor	Existing Environment	Potential Impacts	Environmental Management	Predicted Outcome
SOIL				
Dust and noise *Refer Sections 4.9 and 5.2.9*	There is some dust generated during the Dry Season. The site is currently well vegetated with native and introduced species that act to stabilise soil and prevent excessive dust generation. There is currently no mining or industrial activity creating noise in the area.	Significant dust levels could be generated (especially from construction and mining activities in the Dry Season). Noise will result from construction, mining and blasting activity.	Dust will be monitored and water will be used for dust suppression. Areas will be progressively re-vegetated to minimise dust generation and erosion. Daytime blasting and construction will minimise noise nuisance value. The public will be notified of blasting schedules. Mining on a 'campaign' basis for a defined period of each year will ensure noise is limited. Noise will be monitored at the boundary of the project area.	Dust generated due to mining and processing activities will be kept at manageable levels. Noise levels will be maintained within appropriate guideline levels.
Soil erosion *Refer Sections 3.3.6, 4.8 and 5.2.8*	The site is currently subject to ongoing natural erosion and deposition processes.	Increased erosion from disturbed areas or stockpiles or as a result of concentrated surface water runoff. Increased turbidity of runoff water entering Coomalie Creek (Right Branch) within and downstream of the site. Siltation of Coomalie Creek downstream of the site.	Implement soil conservation measures, stabilise drainage outfall points, schedule construction work during the Dry Season where practical. Ensure flood waters are accommodated by the Coomalie Creek diversion channel and retain hydraulic characteristics of the original stream and floodplain.	Increased turbidity during construction however not likely to result in long term impact. Minimal risk of erosion/turbidity during operation.
WATER				
Lowering of groundwater table, recharge of water to aquifers, diversion of Coomalie Creek (Right Branch), runoff from plant and mine site, and water quality *Refer Sections 2.11.2, 3.3.7, 3.3.9, 4.6, 4.7, 5.2.6 and 5.2.7*	Water table is at a depth of less than 5m below the surface during the Dry Season. During the Wet Season the water table is at, or about, the ground surface. Natural recharge occurs during and after each Wet Season. No discharge waters are currently released into the environment at the site. Coomalie Creek (Right Branch) in the area of the proposed mine site flows intermittently during the Dry Season as a result of seepage from the local superficial aquifer. The existing creek line includes a small low-flow channel and a floodplain in the area of the proposed mine site. Runoff is currently seasonal; high runoff rates occur during the Wet Season; during the Dry Season flows are largely the result of seepage from the local superficial aquifer.	Dewatering of the pit will cause the water table outside the pit to lower, the effect diminishing with distance from the mine. Dewatering of pit will provide water that will be released to Coomalie Creek (Right Branch). Some of this water will recharge downstream aquifers. Course of Coomalie Creek (Right Branch) and associated floodplain changed; vegetation removed; stream cross-section and hydraulic characteristics changed. Erosion may occur until vegetation and final creek form is established. Runoff in Coomalie Creek (Right Branch) below the mine site increased, particularly during the Dry Season.	To minimise the need to treat dewater to remove suspended solids before release to the surface environment as much groundwater inflow as practical will be intercepted by pumping from shallow production bores (10m to 20m deep) outside the pit. Design of the diversion channel and floodplain aims to retain hydraulic characteristics of the original stream and floodplain. Implement soil conservation measures; dumps to be stabilised; sediment or pollutants in runoff water to be collected/intercepted in settlement ponds prior to discharge. Settling ponds will be used to limit the amount of suspended sediment in discharge water. Regular program of water quality monitoring of discharge water and water run-off from the waste dumps to ascertain effectiveness of settling ponds and alter treatment regime where required.	Based upon current data, groundwater drawdown within Coomalie Creek (Right Branch) beyond 2km of the pit should not exceed 1m. Water levels will return to pre-mining levels and pit will refill after first Wet Season following completion of mining. Local floodplain hydraulic characteristics will be irreversibly changed, however no noticeable effect is expected at the larger catchment scale. Increased flows not likely to adversely affect the environment as the stream already flows as a result of seepage. There will be negligible impact on the quality of groundwater resulting from dewatering the mine and minimal impact on water quality of Coomalie Creek (Right Branch).

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		Potential for erosion from dumps, disturbed areas or drainage outfalls causing increased turbidity and siltation of the downstream environment; potential transport of pollutants to the downstream environment. Decrease in water quality as a result of increased sediment loads. Sediment in water may cause increased turbidity and siltation of the downstream environment; poor water quality may damage the downstream environment.		Risk of impacts from increased turbidity is small. No likely adverse effects from run-off from plant and mine site.
FLORA				
Vegetation clearing *Refer Sections 3.4.1, 4.1 and 5.2.1*	Extensive Eucalypt woodlands dominate the upland vegetation with open woodlands fringing a narrow riparian corridor along Coomalie Creek (Right Branch). Small patches of floristically distinctive vine-forest occur on dolomite outcrops. Evergreen monsoon vine-forest occurs upstream of the project area. No endangered plant species or special vegetation communities have been recorded in the lease area.	Loss of vegetation during construction will result in clearing of ~ 30% of the project area during Stages 1-3, with approximately 92 ha of woodland vegetation and 14 ha of drainage line communities cleared. Waste areas will largely be located within mixed Eucalypt woodland with the crusher, plant and storage located further up-slope in *E. tetrodonta/E.miniata* open woodland. Clearing of vegetation may encourage the spread and proliferation of weeds and increases in the distribution of Gamba Grass and Mission Grass would dramatically increase the fire hazard.	Mine layout is designed to minimise loss of vegetation and conserve areas of restricted distribution and of importance to fauna, such as vine-forest on rocky outcrops. As far as possible vegetation will be retained to: • reduce erosion and sedimentation; • maintain a visual buffer from the Batchelor Road; • reduce sediment loads in run-off; and • minimise the spread of weeds. Construction adjacent to riparian areas will be minimised where possible to protect riverine areas from negative impacts, including increased siltation and changes in drainage. Construction activities will be restricted to specified areas. Movement of construction vehicles will be managed to ensure minimal loss of trees.	The communities to be cleared are well represented elsewhere within the surrounding region. No significant adverse ecological impacts are anticipated as long as environmental management guidelines are adhered to eg, monitoring and control of weeds, sediment loads and pollution. The implementation of weed and fire management plans designed for the project area will reduce weed distribution and abundance and will result in protection of native vegetation respectively.
Diversion of Coomalie Creek *Refer Sections 2.11.2, 4.1 and 4.7*	Coomalie Creek (Right Branch) is a narrow, intermittent stream with, in places, a distinct, incised channel. Vegetation clearing will be required such that a 1.2 km section of the creek will be diverted, via a flood diversion channel to the south of the current alignment. Vegetation within the current drainage way and alluvial flats associated with Coomalie Creek will be cleared for siting of the proposed pit. Tracts of similar riparian habitat occur outside the boundary of the lease area and are represented in reserves elsewhere in the region.	Approximately 1.2 km of riparian vegetation will be affected by the creek diversion. Some areas of riparian vegetation not cleared prior to mine construction may survive if water table levels remain sufficiently high. The new creek alignment and floodway may provide habitat suitable for colonisation by native aquatic plant species and wetland communities.	Clearing will be kept to the minimum necessary for construction of the diversion bund. Clearing within drainage lines will be selective and minimised to prevent erosion and habitat loss. Regular surveys of lowland areas and the creek channel will be undertaken to control the introduction and spread of aquatic and floodplain weeds (eg: *Mimosa pigra*).	Initially, a loss of riparian and lowland habitat will occur and unless water quality is maintained, aquatic ecosystems will be adversely affected. New habitats will be created in which colonisation of riparian vegetation will occur. If the new flood channel is well designed, the loss of habitat should be balanced in the long term by expansion of new riparian areas.

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Indirect vegetation changes *Refer Sections 4.1 and 5.2.1*	Native vegetation across the project area is in reasonably good condition. Disturbance from grazing and agriculture has resulted in high numbers of weeds and exploration for mining and extensive terrain disturbance around adjacent mines has led to major sources of weeds both within and around the project area. Upland vegetation is well drained and although drainage in lowland areas may be slow, with extensive waterlogging in the Wet Season.	Changes in patterns of drainage, seepage and sedimentation are expected to lead to loss of riparian vegetation immediately downstream of the diversion bund. Upstream monsoon vine forest vegetation may be affected if major changes in water retention or drainage occur. Gradual shifts in species composition will occur within the new flood channel and creek alignment with upland species diminishing and species requiring high soil moisture (eg: Paperbark and *Lophostemon* communities) increasing in these areas. Proliferation of weeds from increased disturbance may alter fire regimes – dramatic increases in fuel loads result from Gamba Grass infestations.	Development of the mine will be undertaken according to sound principles of environmental management and within the scope of an approved MMP. Ongoing monitoring during each stage of the development will be undertaken to detect and if occurring, monitor major indirect changes to flora within the project area and in upstream and downstream locations. Outcomes of monitoring will form an input to rehabilitation works completed.	Riparian vegetation and species characteristic of drainage ways are expected to colonise the new flood channel. Colonisation will be minor and regionally insignificant. No major indirect changes to vegetation are anticipated if environmental guidelines are followed and site monitoring is undertaken (particularly focussing on weeds and water quality).
Weeds *Refer Sections 4.3 and 5.2.3*	In the project area weed infestations are common in the major habitats but are particularly dense in disturbed areas. Sixteen introduced species were recorded, seven of which are declared noxious weeds (Class B), with the most important noxious weeds to control in the vicinity of the mine considered to be *Hyptis suaveolens, Sida acuta, Stachytarpheta* spp. and *Senna obtusifolia*. Although not a declared weed, Gamba Grass (*Andropogon gayanus*) represents the most serious environmental weed and fire hazard on the site.	Extensive clearing of native vegetation and terrain disturbance will create favourable conditions for the proliferation of weed species. Significant increases in weed species growth will increase the risk of high intensity fires. The new floodplain channel may provide suitable conditions for weed species such as *Mimosa pigra.*	Weed management and prevention measures will include preparation of a Weed Management Plan for the project area. Strategies will include: • earthmoving equipment washed-down prior to entering the lease area to prevent weed spread; • weed removal from selected areas; • control of class B weeds including select chemical control; • slashing of fire breaks; and • annual weed surveys/ monitoring.	Management of weed issues will reduce the risk of weed introduction and the extent of infestations, and will restrict the further spread of weeds.
FAUNA				
Terrestrial fauna *Refer Sections 4.2 and 5.2.2*	There are three broad habitat types in the project area, each supporting a different fauna assemblage. A total of 122 native and 4 introduced terrestrial vertebrate species were recorded during field survey works. The riparian corridor is an important habitat for animals. The Northern Quoll and the Pale Field-Rat are both listed as 'lower risk – near threatened' in the *Territory Parks and Wildlife Conservation Act, 2001*.	Vegetation clearing will reduce available terrestrial fauna habitats within the project area. Project development will also result in disturbance to terrestrial fauna habitat. Severance to the riparian corridor. Disturbance to significant species and their habitats.	Clearing of vegetation will be minimised where possible and consideration for significant habitats will be made. The riparian corridor will be re-established along the new creek diversion, to encourage use by fauna. The rocky outcrops and monsoon rainforest were the more significant habitats for the Northern Quoll and Pale Field Rat, and these areas will be avoided during development of the mine.	The Northern Quoll and the Pale Field Rat will not be significantly impacted by the proposed development. The design of the proposed site development footprint will minimise the requirement for clearing, disturbance and indirect impact to habitats that support a range of and diversity of fauna within the project area.

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Aquatic fauna *Refer Sections 3.4.3 and 5.2.2*	Coomalie Creek (Right Branch) is an intermittent stream with some permanent refuge pools. The creek supports a relatively diverse assemblage of aquatic fauna.	Loss or disturbance of habitat, particularly permanent refuge pools. Reduction of habitat diversity along the creek. Change in species colonisations from resident habitat to transient habitat. Increase in flow/volume rates from pit dewatering that could affect nutrient levels and water quality downstream of the mine.	The creek diversion will be designed with inclusion of an excised creek channel, modelled from the existing creek channel to ensure the retention of permanent refuge pools along the creek. Soil conservation measures will be implemented to limit the amount of suspended sediment in water discharged to Coomalie Creek.	The creek will be temporarily disrupted, until the re-establishment of a riparian corridor to support the existing aquatic fauna community. Refuge pools will be maintained to support aquatic communities and the creek channel will be re-established over time. Flow rates and volumes will be significantly increased downstream of the pit resulting in a possible shift in aquatic community composition (to species better adapted to such conditions).
Feral Animals *Refer Sections 4.3 and 5.2.3*	Feral animals are present in low numbers across the project area.	The presence of humans and increased activity may result in a decrease in the numbers of feral animals.	Feral animals will be managed on an 'as required' basis.	Feral animals will not increase in numbers and they may decrease due to increased eradication effort.
BITING INSECTS				
Breeding sites for mosquitoes, Coomalie Creek and associated creek lines *Refer Sections 4.4 and 5.2.4*	Mosquitoes have been surveyed and, although found in relatively low number, certain species will periodically be present in significant numbers due to seasonal fluctuations in population.	Mosquito-breeding habitats may be created by alteration of the existing environment (via earthworks and ground disturbance). The settlement ponds and septic tanks are likely to provide suitable breeding habitats for biting insects. The diversion of Coomalie Creek could lead to small excised sections creating pooling and thus mosquito-breeding habitats. Prolific reed growth along the riparian corridor may result in creation of mosquito-breeding sites.	Management of biting insect will include: • drainage designed to prevent ponding of water in low-lying areas; • native fish populations maintained in settlement ponds to assist in control of larval mosquito numbers; • buildings positioned away from low-lying areas; • regular clearing of vegetation in vicinity of buildings; • clothing, repellents and antiseptic creams will be available to all personnel on site; • screening of staff facilities; and • staff induction. The creek diversion will be designed to recreate the defined nature of the central channel. Creek margins will be revegetated with trees to discourage marginal grass and reed growth. Any cut off sections of an altered creek created by a diversion will be filled and levelled to prevent pooling. Silt traps will be constructed in the upper arms of the major creek or its tributaries that are likely to receive silt from construction or operation activities.	Mosquitoes will be present on-site and will be more prominent during the Wet Season but not in such abundance so as to result in a significant nuisance. Designing the creek diversion to be similar to that already there will minimise impacts on the existing environment. If management measures are employed (such as silt traps) then mosquitoes will not be a significant problem.
FIRE REGIME				
Refer Sections 4.5 and 5.2.5	Frequent, extensive burning of project area and surrounds currently occurs. The presence of Gamba Grass decreases the effectiveness of early season, cool burns.	Reduction in frequency, timing and spread of fires if strict fire management plan is implemented. Frequent, high intensity fires if the spread of Gamba Grass around the project area is unchecked.	Development of a comprehensive Fire Management Plan in coordination with Bushfires Council. The plan will include: • fire break construction; • reduction of flammable fuel loads by slashing/chemical control of tall grasses; • protection of fire-sensitive flora; and • promotion of habitat heterogeneity.	A reduction in the frequency and intensity of fires will result in a shift in vegetation species composition towards a denser mid-stratum layer, including fire-sensitive monsoon forest species. Frequency, timing and spread of fires should be reduced due to site access restrictions, construction of fire breaks and safety regulations. This will have a positive impact on the protection of fire-sensitive vine-forest and riparian vegetation.

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				Increased habitat heterogeneity through improved fire management practices may improve wildlife habitat quality.
ATMOSPHERIC EMISSIONS				
Air emissions *Refer Sections 4.10.1 and 5.2.10*	While there is no ambient air quality data available for the region, existing air quality is expected to be good given the rural nature of the area, and the lack of either urban population or industry. On occasion suspended and deposited particulate levels may be elevated due to windblown dust, agricultural activities or bush fires.	Some increase in airborne particulate matter is expected as a result of construction and operation activities. Maximum ground level concentrations of pollutants are anticipated to be well below ambient air quality guideline limits in most instances. The primary exception is in relation to short-term concentrations of particulates, as PM_{10}, where there may be the potential for elevated levels especially during intermittent mining activity such as drilling and blasting (to occur 17 days in the first year).	Water sprays would be used (as required) across work zones, stockpiles and unsealed areas to suppress dust. Areas of excavation or works would not exceed the capacity of the water spray units. Blasting or particularly dusty works will be scheduled under favourable meteorological conditions only. Earth moving activity will be suspended where wind speeds exceed 30 km/hr. All major access roads would be sealed and vehicle speeds on unsealed areas will be strictly controlled to minimise dust. Vehicles will not be loaded above the height of the side and tailboards. Dust controls will be provided on all exhaust points from transfer and handling of grain and other dry bulk product, and baghouses would be provided for drillers used in the pit. The conveyor belts will be covered to minimise dust emissions. Fines to be mixed with slag before disposal to minimise windborne emissions. Any long-term stockpiles will be stabilised using fast-seeding grass or synthetic cover spray. Windbreak for limestone stockpile in Stage 3. Exposed areas will be minimised through rehabilitation as soon as practicably possible.	Slight increases in background pollutant concentrations are expected, although levels are predicted to be well below health-based guideline limits at either of the two nearest residences or the Batchelor township. Potential elevation of downwind particulate concentrations, in particular during short-term intermittent drilling and blasting activities. These will be minimised through dust minimisation measures during construction and operation of the Batchelor Magnesium Project.
Greenhouse *Refer Sections 4.10.2 and 5.2.11*	No significant anthropogenic sources of greenhouse gas (GHG) emissions are currently present in the project area.	There will be no direct potential impact due to the emission of any GHG from the Batchelor Magnesium Project. The project will represent an extremely small contribution to global emissions of GHG.	Mt Grace will establish an inventory of emissions, develop an Action Plan to minimise GHG emissions, forecast expected reductions in GHG emissions, and monitor and report emissions on a regular basis as agreed with the Australian Greenhouse Office (AGO). The Action Plan will include capital projects that improve energy or chemical conversion efficiencies, such as: • operating procedures that improve energy or chemical conversion efficiencies; • management initiatives and improvement programs that make "small step" GHG benefits; • use of alternative or renewable energy technologies; and • research and development projects with the potential to reduce GHG emissions.	Insignificant local/regional impact as a result of construction and operation activities. The production of magnesium for use in other industries will contribute to weight reduction and hence to energy savings and consequent GHG emission reduction.
WASTE AND WASTE DISPOSAL				
Refer Sections 2.12, 4.11 and 5.2.13	No significant anthropogenic waste is presently generated at the site.	Potential impacts include: • reduced water quality of receiving waters from runoff from the waste dumps; • contaminated runoff from workshop/washdown areas;	Runoff from waste dumps will be collected in settlement ponds and periodically tested before release to Coomalie Creek. A triple interceptor trap will be installed to remove	There will be an increase of the quantity of waste disposed to local landfill. Minimal adverse effects on the receiving environment from on-site operations and waste disposal.

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Environmental Factor	Existing Environment	Potential Impacts	Environmental Management	Predicted Outcome
		• reduced air quality from waste gases produced during the operational phase; • increased volumes of waste deposited at the local landfill; and • waste removed offsite to inappropriate locations.	potentially oily discharge water from workshop/washdown area. The plant will be designed to adequately vent any dangerous gases during the operating phase. The plant design and management will be in accordance with Workhealth requirements. Waste tracking documentation will be kept and regularly reviewed.	
SOCIO –ECONOMICS				
Economic environment in Batchelor and the Northern Territory *Refer Section 4.12*	Batchelor is a small township of about 650 residents. The main industry is agriculture, horticulture, tourism and service industries. There are currently no operating mines in the area.	The mine will enhance the local economy primarily by creating employment opportunities and injecting a significant amount of money into the town through the purchase of goods and services. The mine will be the first magnesium mine and processing facility in the Northern Territory.	Local people will be employed where the appropriate skills and qualifications are available. Mt Grace will utilise local goods and services where possible.	There will be increased employment locally and an enhanced skill base regionally. The local goods and service industry will benefit from the proposed project and there will be opportunity for economic growth. The mine will add significant economic value to the Northern Territory economy, the effects of which will spread to a range of services, businesses and industries.
Employment *Refer Section 4.13*	There is currently a shortfall in employment opportunities in Batchelor and the wider Coomalie region.	The development of the mine will create 120-130 jobs during construction and about 73 permanent jobs during operation.	Workers will be sourced locally, from Darwin or from elsewhere according to availability of appropriate skills.	There will be a local and regional boost in employment and a diversification of skill base in the region.
Education *Refer Section 4.14*	Batchelor has one primary school and the main campus and administrative headquarters for Batchelor College.	The mine could be used as an educational resource with organised tours and educational activities focussed on the mining industry.	Mt Grace will help develop and facilitate the enhancement of education at the Batchelor Area Primary school and the Batchelor College related to the mining industry.	Educational opportunities of the local community will be broadened given the integral part the project will play in the area.
Tourism *Refer Section 4.12*	Batchelor township services the local tourist industry, incorporating Litchfield National Park.	There is potential for an adverse effect on the tourism industry due to a conflict with the natural value and aesthetics of the area.	Mt Grace will develop a community education program which will incorporate mine tours and public educational material providing tourism opportunities in the area.	The mine will be a significant development in the area but will not interfere with the natural value of areas such as Litchfield National Park. Benefit will be derived from the mine being used as an educational tool and a potential tourist attraction.
Housing and accommodation *Refer Section 4.14.3*	There is currently limited accommodation available in Batchelor for large, temporary workforces.	The construction workforce will total approximately 120 – 130 people, a significant proportion of which will require temporary accommodation. The ensuing permanent workforce may face housing shortages in Batchelor and with no current plans for expanding residential development areas.	A temporary accommodation facility will be established, possibly at a local caravan park. Some of the workforce may commute from Darwin and some new houses will be built in Batchelor.	A significant proportion of the workforce is likely to elect to reside in the Batchelor area and the township/environs is likely to experience consequent residential growth.
TRAFFIC				
Light vehicle and heavy vehicle traffic *Refer Section 4.15*	Currently Batchelor Road is well used by local residents of Batchelor and also by tourists accessing the Batchelor township and Litchfield National Park. Crater Lake Road is primarily used by local residents, for access to the Stuart Highway when travelling south, Crater Lake swimming hole and the privately operated concrete batching plant.	Batchelor Road will be utilised by the local workforce to access the site, with occasional transportation of heavy machinery anticipated. Crater Lake Road will be developed as the primary access road from the site to Stuart Highway for delivery and dispatch, resulting in an increased volume of passenger and heavy vehicle traffic.	There may be a requirement for minor roadworks (turning lane) or sign-posting on Batchelor Road to ensure safety with the increase in workforce traffic. It is anticipated that additional roadworks will be required at the Stuart Highway and Crater Lake Road intersection and on Crater lake Road at the site turn-off point to accommodate the increase in heavy vehicle movements.	There will be a significant increase in heavy vehicle movement on Crater Lake Road that will exert significant pressure on the existing road. Some roadworks will be required for its effective use. With the exception of a small amount of additional light vehicular movement, no significant impact to Batchelor Road is expected.

TABLE ES-1
SUMMARY: POTENTIAL ENVIRONMENTAL EFFECTS & MANAGEMENT MEASURES

Environmental Factor	Existing Environment	Potential Impacts	Environmental Management	Predicted Outcome
	Stuart Highway is the major arterial road linking Darwin and Batchelor and the Northern Territory with other national arterial roads. It is heavily trafficked by local, interstate and international travelers and by road trains.	Stuart Highway will not be significantly affected by workforce traffic.	Stuart Highway is subject to an ongoing program of upgrade between Darwin and Katherine to accommodate increasing traffic requirements.	Stuart Highway will support increased heavy vehicle movement on a daily basis. There are many double-lane sections of Stuart Highway and continued upgrade is scheduled minimising the potential for impact.
ARCHAEOLOGY AND ANTHROPOLOGY				
Aboriginal Custodianship, sacred sites and heritage sites *Refer Sections 3.5.12, 3.5.13, 4.18 and 5.2.14*	The Aboriginal custodians of the area encompassing the site are the Kungarakany and Warai People. There are four Registered Sacred Sites within the project area and one Recorded Sacred Site (refer to AAPA Certificate C2001/040). The local Custodians have indicated that surface water and groundwater hold a spiritual significance. There are six archaeological sites that have been identified at the site.	The banks of Coomalie Creek is a Sacred Site and will, in part, be disturbed as a result of the creek diversion. The diversion of Coomalie Creek (Right Branch) and pit dewatering will disrupt the natural hydraulic regime of the immediate area. One archaeological site (of low archaeological significance) is located 40m from the proposed open cut. It is not expected to be directly impacted but is considered "vulnerable". Construction/operation activities may result in the inadvertent disturbance of other archaeological sites. Isolated artefacts are likely to be destroyed in the area of the mine pit.	Permission from the Aboriginal Custodians will be sought in conjunction with the AAPA to access any Sacred Sites. The creek diversion will be designed to have minimal impact to the overall flow of water in Coomalie Creek (Right Branch). The sacred sites (where practical) and archaeological sites located within the lease area will be clearly marked and protected by Machinery Exclusion Zones. Alterations to surface water and groundwater regimes will, as much as practical, be minimised and pit dewatering undertaken at the minimum rate required to facilitate mining operations and worker safety.	Disturbance of a Sacred Site will result from the diversion of Coomalie Creek. No archaeological sites are expected to be disturbed as a result of site development.
VISUAL AMENITY				
Visual amenity *Refer Section 4.16*	The site is largely undeveloped with open *Eucalypt* woodland predominating. There is a rain-filled trial pit and survey tracks traversing the site.	Over the life of the mine the pit will reach a maximum size of approximately 24 ha. The pit will be in close proximity to Batchelor Road but should not be readily visible. The processing plant will be housed in a 20m high building. The upper section of this building will be visible from Batchelor Road, but not from Crater Lake Road. Stage 1 involves the installation of three emissions stacks, one 63 m high and two 15-20m high. These will be replicated to allow Stage 3 operations. The tops of the stacks will be visible from the Batchelor and Crater Lake Roads from up to 4km away. Visible emissions from the stacks is expected to be minimal, with colourless carbon dioxide and some water vapour (as steam) being the primary emissions.	A screen of trees will be maintained along Batchelor Road to obscure the mine pit and majority of the processing plant. This screen will be thickened over time to maintain good visual amenity. The building housing the processing plant will be constructed with khaki color-bond cladding.	The mine pit and plant will be prominently visible by air but not obvious from the major access roads (being Batchelor Road and Crater Lake Road). The emissions stack will be visible from the Batchelor and Crater Lake Roads from up to 4km away and will impact the visual amenity of the landscape.

ENVIRONMENTAL MANAGEMENT

The EIS includes a preliminary Environmental Management Plan (EMP), which will form part of a Mining Management Plan (MMP) to be developed after the commencement of mining. The EMP addresses the management of the environmental impacts based on the currently available project information.

The objectives of the EMP are to identify issues requiring management and proposing strategies and monitoring programs that will help minimise potentially adverse impacts from the development.

MONITORING PROGRAM

The monitoring programs are designed to test and validate the primary predictions of impact assessment. Monitoring allows for ongoing assessment in order that measures can be taken to reduce the potential for environmental impact. Monitoring also provides quantitative assessment of environmental impact and provides information and data upon which to make decisions regarding project activities. Major monitoring programs will include: flora and fauna; weeds and feral animals; biting insects; fire; groundwater; surface water; erosion; dust and noise; air quality; sacred sites and archaeological sites.

EMERGENCY RESPONSE

A preliminary Hazard and Risk analysis has been carried out and is presented in the EIS. All major risks have been identified and this will form the basis for developing emergency response plans before the construction and operation of the project commences. Identification of all risks and their arbitrary quantification allows response plans to be prepared that prioritise certain risk activities and events management.

DECOMMISSIONING

There is a predicted 25-year lifespan to the ore deposits at the Batchelor Magnesium Project site, if processing is in accordance with the predicted quantities and staged development. The processing facility will be disassembled and removed from site. The mine pit will be rehabilitated with vegetation and stocked with fish to emulate a natural environment. All infrastructure and facilities will be removed and the site will be revegetated to its natural condition, in consultation with relevant governing agencies.

MT GRACE RESOURCES LIMITED
BATCHELOR MAGNESIUM PROJECT
BATCHELOR, NORTHERN TERRITORY

1 INTRODUCTION

1.1 Scope, Purpose and Structure

Mt Grace Resources Limited (Mt Grace) proposes to develop a new magnesite mine and magnesium processing facility (Batchelor Magnesium Project) 4 km east of the township of Batchelor in the Northern Territory (**Figure 1.1**). The scope of the proposal is presented in detail in Section 2 of this document, 'Description of Proposed Development'.

This Draft Environmental Impact Statement (EIS) has been prepared to satisfy the requirements of the Northern Territory *Environmental Assessment Act (1982),* and is in accordance with the guidelines issued by the Northern Territory Minister for the Department of Lands, Planning and Environment (now Department of Infrastructure, Planning and Environment, DIPE) in July 2001 (**Appendix A**).

The EIS comprises the following main sections:

SECTION 1 Introduction

This section introduces the project and provides background information on the development.

SECTION 2 Description of Proposed Development

This section describes the proposed development and the specific elements of the project, including the design, construction and operation of the facility.

SECTION 3 Description of Environment

This section describes the existing environment at and in the vicinity of the site.

SECTION 4 Environmental Effects and Management

This section predicts the potential environmental impacts arising from construction and operation of the development and outlines proposed management strategies.

SECTION 5 Environmental Management Plan

This section outlines the framework for the establishment of a site-specific Environmental Management Plan.

SECTION 6 Acknowledgments

This section acknowledges all authors and co-authors of this EIS document along with all sub-consultants and other professional and non-professional information sources.

SECTION 7 References

This section lists the references consulted and researched during the preparation of the EIS.

1.2 The Proponent

Mt Grace is an Australian company listed on the Australian Stock Exchange (code MGD). Mt Grace was first listed in 1994 and operates as a mineral exploration company, principally within Australia. Mt Grace is primarily focused on the development of the Batchelor Magnesium Project, to which this EIS pertains. Further information regarding the company is available from the Mt Grace website at www.mtgrace.com

1.3 Mt Grace Tenement Interests

Mt Grace, through its wholly owned subsidiary Savanna Mineral Resources Pty Ltd, holds several mining tenements in the Batchelor district of the Northern Territory. There are two granted tenements and one tenement application of direct relevance to this EIS. The two granted tenements are Exploration Licenses 9501 and 9253. Within the area covered by these, Mt Grace has made application for Mineral Lease N1984 covering 357 ha (**Figure 1.2**). Mt Grace has further tenement holdings in the Northern Territory, Queensland and Western Australia which are prospective sites for gold, nickel, zinc and magnesite deposits.

1.4 Limitations of this report

This report has been prepared for use by Mt Grace and DIPE, in accordance with widely accepted consulting practices. No other warranty, expressed or implied, is made to the professional advice included in this report. This report has not been produced for use by parties other than the client, the owner, and respective consulting advisers. It may not contain sufficient information for the purposes of other parties or for other uses.

Whilst, to our best knowledge, information contained in this report is accurate at the date of issue, environmental conditions can change over time. This should be borne in mind if the report is used after a protracted delay.

It should be noted that the impact prediction, assessment and monitoring sections of the EIS have been prepared based on URS's understanding of the project description as provided by the proponent. These sections will require review and potentially alteration if details of the project description change.

2 DESCRIPTION OF PROPOSED DEVELOPMENT

2.1 Overview of Proposed Project

Mt Grace proposes the mining and processing of magnesium at the Winchester deposit, located 4 km east of Batchelor and approximately 85 km south of Darwin in the Northern Territory (**Figure 2.1**).

The mine is expected to produce high purity magnesium (Mg) metal from a magnesite deposit. A simplified process chemistry flowsheet is provided as **Figure 2.2** and is briefly outlined below.

Material from an open cut mine will be crushed and screened prior to calcination in a rotary kiln. The calcination process produces dead-burned magnesium oxide (MgO). This will be fed with a metallic reductant, typically ferrosilicon or aluminium, to a direct current (DC) arc furnace where the magnesium oxide (magnesia) will be reduced to magnesium vapour inside the furnace. The ratios of reagents are adjusted to produce a slag waste with suitable 'flowability' characteristics, whilst the furnace is operated at atmospheric pressure. Slag is tapped from the furnace periodically for cooling, treatment and disposal. The magnesium vapour is condensed to magnesium liquid in a purpose-designed condenser. Crude magnesium metal will be tapped periodically from the condenser and taken to the adjacent refinery section of the plant. Impurities will be removed by addition of fluxing agents, and the purified magnesium metal will then be cast into ingots. The ingots will be transported by truck to Darwin Port for export.

Mining will be undertaken on a "campaign basis", for two to three months each year, with ore being processed on-site on an on-going basis. It is expected that the Project will have an operational life of greater than 25 years.

2.2 Companies Assisting Mt Grace

Mt Grace has developed relationships with external consultants with appropriate expertise in different aspects of the project. A brief outline of each is provided below.

Mintek is the operating name for the Council of Mineral Technologies, a Statutory body set up by the South African Government. Mintek's business role is research and development in the field of mineral processing and they have been in operation for over 60 years. Mintek has devised and patented an improved method for recovering magnesium metal (Barcza & Schoukens 1987) and Mt Grace has secured a license to use the technology.

Golder Associates Pty Ltd (Golder) is an international consultancy company specialising in resource estimation, mining hydrology and geotechnical engineering. Golder has provided Mt Grace with advice on mining, resource estimation, hydrology, hydrogeology and geotechnical aspects of the Batchelor Magnesium Project.

The Bateman Multiplex Joint Venture (BMJV) is made up of two entities Bateman Engineering Pty Ltd (Bateman Engineering) and Multiplex Constructions Pty Ltd (Multiplex). Bateman Engineering is the Australian arm of an engineering consultancy specialising in the minerals field. Multiplex is a major Australian construction company active throughout the country.

Mt Grace engaged BMJV in February 2001, to prepare the first stage of a Feasibility Study for the Batchelor Magnesium Project. Mt Grace is currently working toward completing a Definitive Feasibility Study.

Frank & Schulte is a division of **Stinnes AG**, a major German company which specialises in trade and supply of metals and commodities worldwide. Mt Grace and Frank & Schulte have signed a Memorandum of Understanding under which it is proposed that Frank & Schulte will purchase a minimum of 10,000 ton of magnesium metal per annum from the Batchelor Magnesium Project. Further negotiations regarding the detail of the arrangement are continuing.

2.3 Project Location

The Batchelor Magnesium Project will be based on the Winchester magnesite deposit, located approximately 4 km east of the township of Batchelor, adjacent to Coomalie Creek (Figure 1.2). The deposit is located approximately 800m north-east of the abandoned “Sundance” pits, which were mined for gold by Giants Reef Mining NL and others in the period 1985 to 1994 (Simpson 1994). The proposed Project site is located about 85 km south of Darwin and about 50 km from the southern suburbs of Palmerston.

2.4 Mine Infrastructure

The Winchester deposit is located approximately 200m south of Batchelor Road, the sealed main road between the Stuart Highway and Batchelor. Currently access to the deposit can be gained via an exploration track from Batchelor Road, however it is intended to close this track when the mine is developed. An access road will be constructed from Crater Lake Road, which abuts the eastern boundary of the site (**Figure 2.3**). This will form the main access road to the Stuart Highway.

A haul road will run from the mine pit to the Run of Mine (ROM) pad, which is located adjacent to a processing plant. It is planned to build the processing plant and office buildings for the Batchelor Magnesium Project about 800m east south-east of the Winchester deposit on slightly elevated land. It is usual to place the processing plant closer to the pit but it is considered that the black soil plain near the pit is less suitable for a plant site.

The processing plant site, ROM pad, mine pit, haul road and waste disposal sites will all be securely fenced with entry and exit being through a main gate located near the processing plant and site office. The processing plant will be housed in a standard clad building about 20m high with base dimensions of approximately 50 x 25m. The Stage 1 plant will incorporate three emission stacks, one approximately 63m in height and the other two about 15 to 20m in height. Expansion to Stage 3 will require three additional stacks, one measuring approximately 63m and the remaining two 15 to 20m.

A slag dump (comprising slag, fines and residue from sludge processing) and waste rock dump (comprising waste magnesite rock) will be located to the south-west of the processing plant. Settling ponds will be constructed in the area of the waste rock dump and adjacent to the mine pit. A minimum of three settling ponds will be constructed through to Stage 3, with overflow directed to subsequent ponds as required.

The existing 132 kV power line extending from Darwin to Katherine, owned by the Power and Water Authority (PAWA), passes approximately 1 km to the east of the proposed plant site. Discussions are in progress with PAWA regarding electricity supply from the PAWA grid via a spur line from the main line. A 750 kw diesel generator and associated 5,000L above ground fuel storage tank (AST), will be installed and used in ‘emergency’ situations when a power outage occurs on the domestic grid.

A corridor for an existing gas pipeline that runs from the gas-fields in Central Australia to Darwin passes approximately 10 km to the north-east of the processing plant site. If a new pipeline is constructed (for example, as part of the proposed Timor Sea gas development) it is expected that it will utilise, or be in close proximity to, the same corridor. Mt Grace is currently discussing potential gas purchase from the relevant gas suppliers.

2.5 Land Clearance Requirements

The Batchelor Magnesium Project site is located entirely within freehold land, denominated as Section 2937, Hundred of Goyder. Stanley Corporation (WA) Pty Ltd currently owns the land. Mt Grace is negotiating with Stanley Corporation to reach mutually satisfactory terms regarding access to the area. It is expected that the arrangement will provide for the creation of an easement through Section 2937 and the adjoining Section 2936 (also owned by Stanley Corporation) for an access road from Crater Lake Road to the site.

It is understood that the freehold land title was first created prior to 1900. The project area is not subject to any land claim under the *Aboriginal Land Rights Act 1976*. The long history of various types of leases over the subject area makes it highly unlikely that an Application for Native Title under the *Native Title Act 1993* would be lodged.

The Aboriginal Areas Protection Authority (AAPA) has surveyed the area and identified sites of significance to aboriginal people. Five sacred sites have been identified and Authority Certificate C2001/040 has been issued. Mt Grace has met with representatives of the relevant aboriginal groups (Kunurakamu and Warai) on the site on two occasions to discuss issues of significance.

2.6 Timetable for Operations

Currently the worldwide magnesium metal market is relatively small, demanding about 450,000 t/a, compared to aluminium which is over 20 million t/a and steel, being over 700 million t/a. However, greater use of magnesium in the automotive industry is consistent with a worldwide increase in demand. Mt Grace proposes a three staged approach to development of the Batchelor Magnesium Project, as outlined below.

- Stage 1

  Stage 1 of the project is based on a production rate of 12,500 t of magnesium metal per annum. Agreement in principle has been reached with a German company, Frank & Schulte, for purchase of a minimum of 10,000 t/a of this initial production.

  The anticipated timetable for the development of the Stage 1 is presented in **Table 2.1**.

Table 2.1
Proposed Stage 1 Development Schedule

Operation	Proposed Timing
Definitive Feasibility Study	31 May 2002
Environmental Impact Statement Approval	May 2002
Funding – The project will be funded by debt and equity	Finalised by 30 June 2002
Equipment (long lead time)	July-August 2002
Engineering design	May-August 2002
Site works commenced	September 2002
Construction complete	July 2003
Commissioning	July-October 2003
Ramp-up to design capacity	By mid 2004

- Stage 2

  Once the project has been established and is operating satisfactorily, Mt Grace intends to seek additional customers with a view to contracting sufficient new off-take to support the second stage of production. Stage 2 of the project will involve expansion to an additional 12,500 t/a capacity, taking the total capacity to 25,000 t/a.

- Stage 3

  Similarly, once the Stage 2 expansion is operating satisfactorily additional customers will be sought to support an expansion to a Stage 3 total capacity of 50,000 t/a.

The processes involved are not expected to change between stages. Each expansion will require the installation of additional equipment, which is basically identical to the original in design and capacity. Outputs of all waste streams will increase in direct proportion to the production capacity, as will input volumes of reagents and ore. Staffing levels will increase at a slower rate with a doubling of output capacity expected to require about a 50% increase in people employed.

Timings of the expansions will be driven by market demand, so it is currently impractical to specify key dates, however it is expected that a period of at least two years will separate each stage.

The resource base as currently defined is sufficient for greater than 25 years operation assuming a relatively rapid expansion rate resulting in 50,000 t/a capacity in Year 6.

2.7 Construction Materials

It is expected that waste rock and overburden material will be used to construct site structures such as water containment bunds, flood protection bunds, haul roads and access roads. It is reported that the waste rock materials will be suitable for such purposes (Golder 2001). Topsoil from the mine area, plant site and waste dumps will be removed and stockpiled separately, for use in later rehabilitation works.

Other construction materials, for example concrete, will be sourced from local Northern Territory suppliers and transported to the site by truck. The building to house the furnace, condenser, refining and casting operations will be constructed with a steel frame and partially clad. The office building and change rooms are expected to be suitably founded transportable buildings.

It is not anticipated that any on-site or off-site borrow pits will be required to obtain construction material for the project.

2.8 Temporary Construction Requirements

It is expected that some facilities for the temporary accommodation of personnel will be established in Batchelor during construction. It may be possible to negotiate usage of some existing facilities, and any additional facilities will be established in consultation with the Coomalie Community Council.

The mine office building and amenities/change rooms for the construction phase will be of a permanent nature to service all phases of development and its workforce. If practical, a septic tank sewerage system will be installed as part of the construction of the amenities/change rooms. Should a septic tank system be unsuitable a package treatment plant will be established.

2.9 Mining and Development Operations

2.9.1 Open Cut Mine Pit

A total area of approximately 17 ha of vegetation will be cleared to enable the establishment of the open cut mine (to Stage 3). The Stage 1 open pit is anticipated to be approximately 200m wide by 600m long by 35m deep, with final pit dimensions to Stage 3 anticipated to be approximately 400m wide by 600m long by 90m deep (**Figure 2.4**). The cleared vegetation will be stacked and burnt under controlled conditions to prevent it becoming a fire hazard and cleared areas will have the topsoil removed and stockpiled separately for later use in rehabilitation.

Prior to the commencement of mining a 1.2 km section of Coomalie Creek will need to be diverted, and groundwater will be required to be removed from the pit. Based on data collected by Uren (2001) and Golder (2001a), a pit dewatering rate of approximately 5,300m^3 of water/day (60l/s) has been calculated. This will be achieved by installation of ten dewatering bores placed around the margins of the pit with pumps as required in sumps in the pit floor (**Figure 2.5**). At the predicted final pit depth (-15mRL, Stage 3) groundwater in the immediate area of the pit will have been lowered by approximately 90m.

2.9.2 Mining Methods

Following clearing, the removal of topsoil and dewatering, a front-end loader and trucks, or scraper, will remove overburden.

Mining of the magnesite ore and rock waste will require conventional drilling and blasting treatment. It is anticipated that 5m high rock benches will be created in the pit by excavation activities. Mining will be carried out using a hydraulic backhoe such as the Komatsu PC 1000, or a similar capacity front-end loader.

Mining will take place on a campaign basis during the Dry Season, lasting two to three months per year. A contractor operating only on day shift will carry out mining. Drilling will take place throughout each shift but blasting will take place only twice a week, usually at the end of a shift (Golder 2001a). The ore/waste will be hauled to the ROM pad using conventional rear dump trucks, probably of 85t capacity such as the Caterpillar 777 (Golder 2001a). The ore will be stored on the ROM pad, awaiting pick up for crushing and screening. A one to fifteen month supply of ore will be held in stockpile.

The Stage 1 development will require approximately 200,000 t/a of magnesite ore (67,000 bcm) to be extracted from the pit. The total amount of ore to be extracted from the open pit in Stage 3 is estimated at 800,000 t/a (268,000 bcm).

2.10 Metallurgical Processing and Products

2.10.1 Ore Mineralogy

All blastholes will be sampled in 2.5m lengths and assayed. Assay results will be used to develop a 'block model' to coordinate ore grade control and assist with scheduling of production.

The magnesite ore is typically composed of four minerals: about 86% magnesite, 4% calcite ($CaCO_3$), 7% talc, and 1% quartz (Uren 2000). The remaining 2% are variably composed of small amounts of iron and aluminium oxides. Sulphide is unlikely to be present and if so only in trace amounts (**Appendix B**).

All the main mineral components of the ore are stable in the atmosphere and have no deleterious components. Both ore and waste may contain minor traces of sulphide. The potential for generation of acid waters in the dumps is very low. Any acid generated will be neutralised by the carbonate minerals that comprise 80% of the waste rock.

2.10.2 Ore Processing

Crushing and Screening

Ore will be fed through a basic, two stage crushing circuit and screened to attain the desired 6 to 30mm feed required for the calcination kiln. A primary jaw crusher and secondary cone crusher followed by a double deck screen will achieve this (**Figure 2.6**). Oversize (+30mm) material will be recycled to the secondary crusher and fine grade magnesite (fines) material will be rejected. Approximately 30,000 to 40,000 t of fines are expected to produced per annum (BMJV, 2001). This material may be saleable to the agricultural industry. As such allowance has been made for its disposal with the slag or separately (see **Section 2.13.2**).

Should the magnesite ore contain an excessively high component of fines an alternative process option is under consideration: magnesite would be crushed and screened to 100 to 300mm product and fed to a kiln. The calcined product would then be blended with water and lime to form a paste which would be fed into a dryer/pellitizer. This would produce a hard feed product that will flow easily through the feed system.

Magnesite Calcining

Crushed and screened magnesite will be fed to a natural gas fired rotary kiln, operated in the counter current mode, whereby the reaction zone is maintained at 1,500°C or greater. Magnesium carbonate ($MgCO_3$) dissociates into magnesia (MgO) and carbon dioxide (CO_2), the latter leaving the kiln together with combustion gases. The gas stream will contain fine particulate magnesite/magnesia that may form by attrition processes inside the kiln. Gases containing dust pass through an electrostatic precipitator (ESP), or baghouse, where the solids are removed. The gases will then be cooled and released to the atmosphere from a 63m high stack (BMJV 2001).

In the calcining of the magnesite, there are four primary waste discharges. These are particulate matter, the gas stream, partially calcined magnesia and kiln lining scale.

Hot magnesia gravitates from the lower end of the kiln, at about 900°C, into refractory lined hoppers that are transported to the DC arc furnace. The magnesia is not cooled prior to entering the DC arc furnace. Maintaining high temperature prevents any re-absorption of moisture and carbon dioxide that could adversely affect magnesium extraction and its subsequent condensation. Furthermore, maintaining feed temperature conserves energy consumption of the furnace.

DC Arc Furnace Operation

A number of preliminary tests have been performed in a small pilot DC arc furnace (Abdel-Latif *et al.,* 2001). Using these results and thermodynamic modeling, mass and energy balances have been estimated, as have the various product streams. Further tests will be undertaken to verify and confirm preliminary estimates.

The furnace comprises a hermetically sealed, refractory lined vessel with an adjustable graphite electrode at the top and a fixed electrode at the base (Mintek, 2001). On application of a direct current, an arc is established and maintained between the electrodes providing energy for the reaction

(**Figure 2.7**). Magnesium is formed using either silicon or aluminium as a reductant, or a mixture of both, through the following process:

$$2\,MgO + Si \longrightarrow 2\,Mg\,(vapour) + SiO_2$$
$$3\,MgO + 2\,Al \longrightarrow 3\,Mg\,(vapour) + Al_2O_3$$

There are two liquid phases present in the furnace:

1. **Metal**: When silicon is used as a reductant it is fed as ferrosilicon (75% silicon, 25% iron). Only part of the silicon is consumed while the iron plays no part in the reactions. Thus, a low-grade ferrosilicon is present in the furnace. This phase may be tapped separately or, alternatively, removed from the furnace with the slag phase. While the alloy is inert and poses no human health or environmental hazard, metal phosphides are sometimes associated with ferrosilicon. Upon hydration of the metal, phosphine gas may evolve. The cooled metal will be wetted in a well-ventilated controlled open space to dissipate any phosphine gas produced. The residual ferrosilicon will then be bagged and stored pending sale.

   When aluminium is used as a reductant, all of the aluminium reacts during the process and forms an alumina component in the slag.

2. **Slag**: Slag consists of non-reacted magnesia with oxides of silicon, aluminium, iron and other metals occurring in the magnesite plus the reaction products. Due to the high temperature in the furnace (1,750°C or greater) this phase is likely to comprise mostly magnesium silicates and aluminates. The silica content is amorphous rather than crystalline. Detailed slag composition will be known only after further pilot plant tests, but the composition of typical slag material has been estimated and is presented in Appendix B.

   Slag will be tapped from the furnace at two to four hour intervals and collected in pots and left to solidify. Once cooled, it will be broken into manageable sizes, treated (**Section 2.13.4**) and disposed to the slag dump. Approximately 80,000 t/a of slag will be produced in Stage 1, and approximately 320,000 t/a in Stage 3.

The furnace operation will require the addition of modest amounts of lime to the furnace feed. It is planned to obtain this from existing commercial operations either as dead burned lime or as limestone to be calcined on site. It is expected that about 14,000 t/a of limestone or approximately 7,100 t/a of burned lime will be required during Stage 1.

Hot magnesia and reductants are fed at stoichiometric rates to the furnace, with care being taken to eliminate air ingress into the furnace. Air ingress will be avoided by flushing the feed system with argon. Magnesium vapour subsequently leaves the furnace and enters the magnesium condenser.

Magnesium Condenser

Gas entering the condenser will primarily comprise magnesium vapour that will then be condensed to liquid magnesium. All other gases that do not condense pass through a manifold to the kiln where they are incinerated. Solid particulate products are separated from the gases by inertial forces in the cyclone section of the chamber. The remaining gases (approximately 2,000 t/a for Stage 1) will be recycled to the gas stream in the kiln. The condenser is designed in such a way that most magnesium vapour from the furnace is condensed and maintained in liquid phase until it is tapped off periodically into a ladle. The ladle is then moved to the refinery and casting station.

Magnesium Refining and Casting

The liquid magnesium has levels of contaminants that must be removed for the metal product to be marketable.

In a conventional Magnetherm process, magnesium is produced in an alternating current (AC) furnace operating at about 30 Torr (0.05 atmospheres) pressure. Typically, the liquid metal requires considerable refining to remove inclusions of calcium and silicon as well as magnesia that forms by ingress of air into the system. Refining is carried out by agitating the molten metal with refining agents, anhydrous magnesium chloride, potassium chloride, calcium fluoride, ferric chloride or titanium tetra chloride. Fumes emanating from the furnace and casting stations will contain hydrochloric acid (HCl), magnesia and fine flux particulate. This material will be captured in a wet scrubber with the “blow down” used in the sludge processing circuit.

Preliminary thermodynamic simulations of the Mintek DC arc furnace indicate the production of purer crude magnesium. Pilot plant trials at Mintek have not yet confirmed metal quality. Early indications show theoretical simulations to be reliable but this is yet to be verified.

Stage 1 is expected to produce about 7,000 t/a of sludge, a mixture of chloride fluxes and oxides generated from the cleaning of condensed magnesium. Sludge disposal is outlined in **Section 2.13.6**. Clean magnesium is transferred by ladle to the casting unit. A ladle is an insulated wheeled transfer container unit designed to transport liquid magnesium.

The refined magnesium metal is cast into ingots. During the casting process, a blanketing gas covers the liquid magnesium to prevent reaction with the atmosphere. Sulphur dioxide (SO_2) will be used as a cover gas at an annual consumption of 25t in Stage 1 and 100t in Stage 3. Excess sulphur dioxide will be absorbed in the wet scrubber to which the refining furnace fume is also directed. Alternative gasses suitable for use as a cover gas are being developed in a CSIRO research program. These are expected to become publicly available within the next few years. Consideration will be given to utilising these gases instead of sulphur dioxide once they become available.

The magnesium ingots will be transported to East Arm Wharf, Darwin, and temporarily stored in a warehouse at the wharf for periodic shipping to international markets.

2.11 Water

2.11.1 Groundwater

The water table in the vicinity of the deposit is within 2m of the surface throughout the year (Uren, 2001). It has been established that the overburden is quite permeable and porous (Uren 2001) and it is expected that pumping can reduce water levels.

An estimated 5,300m^3 of water per day will need to be pumped from the pit to enable mining to occur. Ten dewatering bores will be installed around the margins of the pit and additional pumps located in the pit floor on an ‘as needs’ basis. The groundwater quality is considered acceptable for direct release to local watercourses, as discussed in **Section 3.3.7**. However, some suspended solids will be present in the water from the pit floor sumps and therefore all water collected from the pit sumps will be directed to settling ponds for removal of sediment and water quality testing prior to release to local surface watercourses.

2.11.2 Surface Water

The main surface water feature in the area is Coomalie Creek. This is an ephemeral/intermittent stream in the area of the deposit with permanent water further downstream. Coomalie Creek generally exists as a narrow channel, 1m to 3m wide and about 0.5m to 2m deep, which meanders across the black soil plain. Coomalie Creek ceases to flow during some Dry Seasons (intermittently), and in the Wet Season following heavy rain it expands across the plain and can be several hundred metres wide.

Part of the deposit extends under the existing Coomalie Creek channel and there is a necessity to divert a 1.2 km section of the creek. The creek diversion will enable access to the ore deposit, prevent flooding of the pit and to allow sufficient room for the peak flow to discharge downstream without resultant damming.

Bunds will be constructed around the mine pit area to prevent creek water entering the pit. An artificial channel will be constructed to carry diverted low flows in the Dry Season but in the Wet Season the water will spread across the entire channel area to prevent artificial damming of Coomalie Creek. Additionally, the haul road will have culverts constructed so as not to impede water flow.

Hydrological analysis of the site is discussed in **Section 3.3.8**.

2.11.3 Process Water

The process plant will require about 660 m^3/day of process water in Stage 1 (BMJV 2001) and 2,640 m^3/day in Stage 3. This relatively modest requirement is a result of the non-aqueous processing operation, with water required primarily for temperature control. Temperature control water is recycled through cooling towers. Process water will be sourced from bore water extracted as part of the mine pit dewatering process. Preliminary estimates of the groundwater available from this process (approximately 5,300 m^3/day) exceed the process water requirements. A flow diagram detailing water distribution from pit dewatering is included as **Figure 2.8**.

Some water will be required for dust suppression purposes, mainly on the haul roads, during the Dry Season in particular. Golder (2001a) has estimated the required amount of water for dust suppression purposes to be in the range of 500 to 1,000 m^3/day. Water from the sumps in the pit will be used for dust suppression as it will most likely have an elevated turbidity. Using it in this way will minimise the amount of "dirty" water with a requirement for pre-discharge settlement. Water not required for dust control or processing will be held in settling ponds to allow particulates above 20μm to settle out prior to discharge into Coomalie Creek. The discharge point will be located downstream of the mine pit.

Potable drinking water and water for amenities onsite will be obtained from the groundwater extraction bores located around the mine pit. Water quality testing has indicated that the groundwater is suitable for domestic consumption (Golder 2001a).

There is a possibility that the excess groundwater may be used to supplement the local residential water supply. Preliminary discussions have been held with PAWA in this regard.

2.12 Construction Waste

Anticipated waste categories generated during the construction of the Batchelor Magnesium Project have been classified as either hazardous or non-hazardous in accordance with DIPE requirements. The anticipated waste classifications are presented in **Table 2.2**.

Table 2.2
Anticipated Construction Waste Classifications

Waste Type	Classification
Construction debris contaminated by oil	Potentially hazardous depending on percentage contamination
Waste oils	Hazardous
Waste batteries	Hazardous
Domestic waste (waste paper, plastics, cardboard, food waste etc)	Non hazardous
Aerosol containers	Non hazardous if empty and depressurised
Wood and scrap metal	Non hazardous

Hazardous wastes will not be disposed of on-site and non hazardous waste will be disposed to suitable off-site facilities.

Domestic wastewater will require treatment before on-site disposal. Vegetative waste from land clearing will be suitable for on-site disposal, though such waste is a potential fire hazard if untreated.

2.13 Operating Waste

The anticipated quantity of waste generated during the operation of the Batchelor Magnesium Project is summarised in **Table 2.3**, and the composition of the waste streams is presented in Appendix B**.**

Table 2.3
Anticipated Operational Waste at the Batchelor Magnesium Project

Source	Type of Waste	Estimated Quantity Generated	Proposed Disposal
Mine site	Topsoil	Undetermined	Stockpiled for rehabilitation works.
	Overburden soil	Undetermined	Construction of flood protection bunds, or stockpiled at the waste dump.
	Waste magnesite rock	Stage 1: 200,000 t/a	Construction of flood protection bunds, haul roads or disposal to the waste rock dump.
Crushing/screening	Magnesite fines	Stage 1: 30-40,000 t/a	Sale to agricultural industry, road maintenance/construction, or disposal to the slag dump.
Calcination	Off-gas	350,000 t/a (gas)	Released through stack.
	Off gas fines	2,500 t/a	Establish a market or disposal to the slag dump.
	Excess magnesia production	Variable	Disposal to the waste magnesite dump.
	Reaction products formed within the kiln	Variable	Disposed to the slag waste dump.

Source	Type of Waste	Estimated Quantity Generated	Proposed Disposal
DC arc furnace	Slag	Stage 1: 80,000 t/a	Disposed to the slag waste dump.
	Ferrosilicon	Stage 1: 10,000 t/a	Sold offsite, temporary onsite stockpile only.
	Unreacted reductant	Variable	Disposal to the waste magnesite dump.
	Phosphine gas	Variable	Vented.
Magnesium condenser	Magnesium condenser fines	Stage 1: 1,500 t/a	Disposed to the slag waste dump.
Refining (acid scrubber)	Ammonia	160 t/a	Sold to the agriculture industry or disposed offsite.
Refining	Solid phase from sludge treatment	Stage 1: 4,900 t/a	Disposed to the slag waste dump.
Cast house	Sulphur dioxide	<250 kg/a	Vented.
Ablution blocks	Domestic wastewater	Undetermined	Treated and disposed onsite to septic trenches.
Waste dumps	Topsoil	Undetermined	Stockpiled for rehabilitation works.
	Waste dump drainage	Undetermined	Collected in settling tanks, tested and released to adjacent waterways.
Office	Domestic rubbish	Undetermined	Offsite disposal.
Workshop	Waste oil and spent solvents	Undetermined	Offsite disposal.

Note: bcm/a = bank cubic metres per annum

2.13.1 Waste Soil/Rock from Mining

The waste soil/rock from mining operations will consist of topsoil, overburden soil (clay/gravels) and waste magnesite rock.

The topsoil and overburden soil is visually recognisable and contains no deleterious components. The topsoil will be removed and stockpiled for rehabilitation works at the site. The overburden soils will be removed and used for construction purposes, including construction of flood protection bunds, or otherwise stockpiled at the waste dump.

The estimated quantity of waste magnesite rock is expected to be 2,800,000 bcm over the life of the mine. Waste rock generated in Stage 1 is estimated to be 67,000 bcm/a (or 200,000t/a) which is approximately equal to the amount of ore mined and processed over the same period. Over the life of the project the percentage of waste rock will progressively decrease and in later years will total about half of the mined ore.

The waste magnesite rock is material that contains high levels of talc and/or quartz making it unsuitable for processing (see Appendix B). Waste magnesite is identified by sampling and testing from blast holes. Magnesite with more than 8% silica (SiO_2) will not be accepted for processing and will be disposed as waste rock. Waste rock will be utilised for construction of flood protection bunds, to construct the haul road leading from the mine pit to the plant site, or will be disposed to the waste rock dump. The waste rock is inert material and will not generate contaminated leachate.

The flood protection bunds will be constructed around the pit and plant to prevent potential inundation during the Wet Season. The bunds will be partly composed of broken rock to give strength, with an outer layer of overburden to prevent seepage of water through the placed rock. The design configuration of the flood protection bunds is presented in **Figure 2.9**.

It is proposed that the waste rock dumps be located to the south of the pit as shown in Figure 2.3. The dumps will be a maximum 20m high and will have a maximum final slope of 20°. As sections of the dump reach their full extent they will be progressively rehabilitated, by covering with topsoil to facilitate re-vegetation.

2.13.2 Fines from Crushing and Screening

Waste from crushing comprises fines of average ROM composition. It is anticipated that 15 to 20% of mined material will be rejected as fines after crushing. It is expected that production of fines in the first year will be between 30,000 to 40,000t. The fines from crushing and screening consist of crushed magnesite and do not contain deleterious components.

The fines are inert and are suitable for long term stockpiling, sale to the agricultural industry or use for road maintenance/construction. Initially, attempts will be made to market the fines to the agricultural industry. Should a market be identified, a temporary on-site stockpile will be established for storage of the fines. It is not anticipated that all the fines will be sold to the agricultural industry and on-site disposal of any excess will consist of using the fines for road maintenance/construction, mixing with slag and disposal to the slag dump or disposal to the waste rock dumps.

2.13.3 Waste from Calcining

Waste from calcining comprises generation of off gas, particulate matter, partially calcined magnesia and reaction products (scale) formed within the kiln.

Off Gas

It is expected that about 350,000 t/a of off-gas will be generated from burning natural gas fuel in the kiln for the Stage 1 project and from carbon dioxide produced by decomposition of magnesite into magnesia and carbon dioxide. Details of anticipated off gas composition are presented in Appendix B. Particulate matter in the off gas will be removed in an ESP or baghouse. The gases will then be cooled and released to the atmosphere from a 63m high stack. The height of the stack has been determined by air dispersion modeling to minimise impact on air quality in the surrounding environment. Details of the air dispersion modeling and composition of the off gas is presented in **Appendix C**.

Particulate Matter

It is anticipated that approximately 2,500 t/a of particulate matter (fines) will be collected in the ESP/baghouse from the off-gas exiting the kiln. The particle size will generally be less than 2mm and some fine fractions could give rise to dust. The fines will consist of oxides, mainly of magnesium and silicon as well as excess magnesia and kiln scale. The material will be caustic in nature but does not contain deleterious components.

There is a market for magnesia fines in Australia for use in neutralising acid waters produced by some mineral processing plants. A market for the magnesium fines will be sought, however, should onsite disposal be required the fines will be mixed with the slag and disposed to the slag dump.

Partially Calcined Magnesia

In the event of a mismatch between furnace requirements and kiln output, excess material generated by the kiln will have to be discharged as waste or recycled back to the kiln. Start up and shut down of the kiln will generate partially calcined magnesium that is unusable as reduction furnace feed. This material will be recycled through the system or disposed to the waste magnesite dump.

Reaction Products formed within the Kiln

Scale can form on the internal surface of the kiln as a consequence of reaction between the material being calcined, contamination carried with the feed product, and the type of refractory lining of the kiln. This scale will occasionally break free and be discharged from the kiln in large pieces. This material typically has the same composition as slag and will be disposed to the slag waste dump.

A similar waste product may sometimes arise in the bed of material being calcined. Rather than forming a slab on the surface of the kiln this phenomena will appear as a large agglomerated mass of magnesite that will eventually exit the kiln as a large lump. It will be disposed to the slag waste dump.

2.13.4 Waste from the DC Arc Furnace

The main wastes generated from the DC arc furnace are slag, residual ferrosilicon, unreacted reductant and phosphine gas.

It is anticipated that approximately 6.45t of slag will be produced per tonne of magnesium. Therefore, during Stage 1 approximately 80,000 t/a of slag will be generated. All slag will be disposed to the slag waste dump, to be located to the south of the pit. It will be constructed to a maximum height of 20m with a final maximum slope of approximately 20°. Topsoil from the proposed slag waste dump will be removed from the slag dump area and stockpiled for later use in rehabilitation, which will take place progressively over the life of the project and after decommissioning.

It is anticipated that approximately 0.8t of reidual ferrosilicon (40% silicon, 60% iron) will be produced per tonne of magnesium. Therefore, approximately 10,000 t/a of residual ferrosilicon will be recovered during Stage 1 and 40,000 t/a during Stage 3. The anticipated chemical composition of the residual ferrosilicon is presented in Appendix B. The residual ferrosilicon is expected to be sold to local or interstate markets and will not be stockpiled for long periods onsite.

Occasional blockages in the feed circuit can result in unreacted reductant. The unreacted reductant will consist primarily of magnesite. This will be segregated and disposed to the magnesite waste dump.

A common characteristic of certain types of slag generated from thermic magnesium processes is that they can evolve phosphine gas when wet. Phosphine, also known as hydrogen phosphide, is colourless with a characteristic fishy odour and is a recognised health and safety issue that requires appropriate management.

Problematic generation of phosphine gas generally occurs when the slag is slow cooled, which allows the slag to decrepitate (crystallise and crack apart). The slag undergoes a change in crystal structure resulting in the solid mass breaking apart into a finely divided powder that has a large surface area. The current practice in thermic magnesium processing is to either return hot, molten slag to the original pit or dump, or to granulate the slag using water, for use as a commercial road building material and soil improver.

Slags produced at the Batchelor Magnesium Project will be wetted in a well-ventilated controlled open space adjacent to the furnace to dissipate any phosphine gas produced. Preliminary tests carried out on Batchelor magnesite show that the furnace slag produced does not decrepitate, resulting in larger sized slag particles with a reduced surface area to volume ratio available for reaction. This means that the Batchelor magnesium slag has a low tendency to evolve phosphine gas. In order to determine the amount of phosphine gas evolved, samples of test slags were crushed to <1mm and reacted in an aqueous medium. Phosphine, paraffinic and olefinic gases were generated with the maximum measured concentration of phosphine (closed environment) being 2.5ppm (Abdel-Latif et al 2001).

2.13.5 Wastes from Magnesium Condenser

Gas entering the condenser will be primarily magnesium vapour that will be condensed to liquid magnesium. All other gases that do not condense then pass through a manifold to the kiln where they are incinerated. Solid particulate products (magnesium condenser fines) are separated from the gases by inertial forces in the cyclone section of the chamber. These particles are oxides of magnesium, sodium and manganese that are inert in the atmosphere. In Stage 1 of the mine, generation of about 1,500 t/a of such particulate matter is expected and will be disposed to the waste slag dump.

Solids that coat the interior of the condenser will be removed on a regular basis. Approximately every three days the condenser will be dismantled and cleaned. This will result in a waste stream condenser residue of about 300 t/a comprised of magnesia, magnesium and magnesium nitride (Mg_3N_2) (Appendix B). Magnesium nitride will be reacted with water to produce ammonia (NH_3) and magnesia. The ammonia will be scrubbed using sulphuric acid, producing ammonium sulphate. The resulting ammonium sulphate is a marketable product that will be sold to the agriculture industry if markets are available. If markets are not available the ammonium sulphate will be dispatched to a Darwin-based waste management contractor. The magnesia produced from the hydration of the magnesium nitride is inert and will be disposed to the magnesite waste dump.

2.13.6 Waste from Refining

The process of cleaning the condensed magnesium generates a sludge that consists of a mixture of chloride fluxes and oxides. The Stage 1 refining process is expected to produce about 7,000 t/a of sludge. The sludge is treated on a daily basis to recover contained magnesium metal with the remainder treated through a water-based process circuit. The treatment reduces the sludge to a precipitated solid phase and ammonia.

The solid phase is mainly magnesia, iron and gypsum (Appendix B) which is inert and will be disposed of with the slag. The ammonia (160 t/a) will be scrubbed to extract the ammonia as ammonium sulphate and the ammonia liquor sold to commercial industry or dispatched to a Darwin-based waste management contractor.

2.13.7 Casthouse Waste

Sulphur dioxide (SO_2) will be used as a cover gas for the liquid magnesium during casting. Excess sulphur dioxide will be trapped by the same scrubbing unit that removes the hydrogen chloride and flux particulate from the refining furnace off-gas. This scrubber effluent will be used in the sludge processing plant. Less than 250 kg/a (1%) of the sulphur dioxide is expected to be lost to the atmosphere after scrubbing.

2.13.8 Other Solid and Semi-Liquid Wastes

Other sources of solid and semi-solid operational wastes include domestic wastewater (sanitary sludge), domestic/commercial rubbish (waste paper, plastics, cardboard, food waste etc), spent solvents and waste oils. The source and hazard classification of these wastes are presented in **Table 2.4**.

Table 2.4
Anticipated Other Solid and Semi-Liquid Waste Generated

Type of Waste	Source	Classification
Domestic wastewater	Office and minesite	Non-hazardous
Domestic/commercial rubbish	Office	Non-hazardous
Spent solvents	Workshop	Hazardous
Waste oil	Workshop	Hazardous

Treatment and disposal methods for domestic wastewater are discussed in **Section 2.13.9** and the remaining wastes in **Section 4.11**.

2.13.9 Effluent/Wastewater

Domestic Effluent/Wastewater

It is proposed that the domestic effluent and wastewater generated on site will be treated through use of a septic tank system. If required, a package treatment plant will be commissioned with associated effluent disposal, irrigation system.

Drainage from Waste Dump/Ore Stockpile

Waste materials contained in the slag dump are stable in the atmosphere and the granular composition of the dump will allow rainwater drainage. There are no sulphides present and no potential for acid generation.

The waste rock dump will contain waste magnesite rock. The dump is entirely inert in air and moisture and will not react or chemically decompose even over an extended period.

The magnesite ore stockpile located on the ROM pad is entirely inert in air and moisture, and will not react or chemically decompose even over an extended period. The broken rock material is porous and rainwater will naturally drain through it.

Run-off water from the ROM pad, the slag dump and the waste rock dump is expected to be “clean” and will be contained within bunds and collected in settling ponds before release. Collection into a small number of ponds prior to release will facilitate point source monitoring of water quality and subsequent release of water will be designed to minimise erosion.

Figure 2.8 is a schematic illustration of the bunding, collection, settling and release system. As the project extends into Stages 2 and 3, the size of the dump areas will be expanded and the bunding and collection systems will be re-engineered to accommodate the growth in run-off volume.

2.14 Potential Effects of Abnormal Operating Conditions

Consideration has been given to the possible implications of equipment failure or emergency events relating to the project. This assessment has been made in order to prepare for, and minimise, the adverse effects of any such failure. Potential scenarios are outlined below and associated impacts, corrective actions and preventative measures are detailed in **Appendix D**.

2.14.1 Mining Activity Failure

Currently it is intended that mining be carried out on a campaign basis for a period of two to three months per year. Immediately following a mining campaign there may be as much as fifteen months worth of ore stockpiled. It is expected that an ore stockpile sufficient for a minimum of one month's processing will be maintained on the ROM pad at all times. Temporary cessation of mining due to equipment failure or bad weather will have little to no effect on production.

2.14.2 Process Plant Failures

Crushing Plant

A small stockpile of crushed and screened material will be maintained at all times. This stockpile can be utilised to supply the kiln during any shutdown of crushing and screening activity. A stockpile of material sufficient for several days of operation is envisaged, therefore, temporary cessation of crushing due to power outage, scheduled maintenance or equipment breakdown will not have any impact.

Kiln

The most likely events to trigger a failure in the kiln are interruptions to the electricity or gas supply. Where such interruptions are scheduled, an orderly slow down and curtailment of the kiln operation will be implemented. In the event of unscheduled interruption to the electricity supply an auxiliary diesel power unit will be available on site to provide emergency rotation of the kiln. If the outage lasts for an extended period, feed to the kiln will cease and the kiln will shut down. Material in the kiln during an extended outage of electricity or gas may not be properly calcined and will need to be treated as waste or recycled back into the kiln. Cessation of kiln operation will cause subsequent progressive shutdown of all process steps.

Other risks and hazards associated with kiln operation are:

- an explosion in the kiln or off-gas system;
- mechanical failure of the rotation mechanism resulting in thermal distortion of the kiln; or
- a blockage of the product/discharge outlet resulting in thermal distortion of the kiln.

Furnace

The most likely events to cause failure of the reduction furnace is blockage of the feed system through an air leakage; freezing and a solid crust forming on the slag due to loss of power, improper arc control or excess feed of raw material. Other possible furnace failures include:

- sintering of the magnesia in the containers feeding the reduction furnace;
- hydrogen explosion;
- rupture of furnace side wall through burning of hole;
- furnace hearth explosion; and
- explosion from spillage of molten metal or slag.

Refining and Casting

The probability of an accident in the casting furnace is very low. Potential casting furnace hazards are:

- a fire in the casting furnace if the crucible containing molten magnesium developed a hole and spilled its contents into the furnace chamber; or
- an eruption of gas, flux and metal from a crucible of molten metal in the cast house if the addition of non-anhydrous flux occurred.

2.14.3 Spills on the Plant Site

Solids Spills

Onsite solids spills of ore, reagents or waste could occur during transportation to the ROM pad, plant or waste disposal sites. Any solids spilled will be picked up by front-end loader and taken to the appropriate waste dump. Clean-up procedures will be implemented as required.

Water Spills

Process water is clean water used primarily for temperature control. The water is pumped through the cooling circuits and on to the cooling towers. It is expected that the temperature of the water will rise to a maximum of 40°C and then be reduced back to 30°C in the cooling process. The plant site will be bunded appropriately so that any water that leaks from the cooling system will be contained.

Fuel Spills

Re-fuelling areas will be appropriately bunded in accordance with Australian Standard AS1940-1997 'The Storage and Handling of Flammable and Combustible Liquids'. Procedures will be adopted to minimise the incidence of spillage and appropriate materials such as spill containment kits will be on hand to clean up any spills quickly.

All used engine and other oils or solvents generated on site will be contained in appropriate drum storage and periodically removed to an approved disposal site.

2.15 Health and Safety

The mine and plant will be designed to adhere to appropriate Worksafe requirements for health and safety. A section of the Licence Agreement with Mintek provides that Mintek will make their 1.5 MW furnace available for training of key staff prior to start-up and commissioning. Mintek will also make trained and professional personnel available to assist in commissioning and development of detailed operating procedures, to ensure safe operation of the facility.

Development of a comprehensive safety plan and appropriate training for staff will be completed prior to any activities onsite. Mt Grace is seeking comprehensive advice from consultants with prior experience in thermic magnesium plants for all aspects of health, safety, training and operations protocol.

Inductions will be essential for all personnel involved on-site with the Batchelor Magnesium Project. An induction program will be designed to include the following: safe operating procedures; all health and safety issues; relevant operations training; education on all aspects of the mine and processing facility; emergency response procedures; personal protection from biting insects and work hazards;

and environmental and cultural awareness, specifically in relation to sensitive ecological communities and sacred site issues.

2.16 Support Services

2.16.1 Utilities

The proposed development will utilise electricity and gas. It is expected that the initial power will be supplied from the PAWA grid, via the existing 132 KV line that passes to the east of the plant site, through appropriate sub-stations. The firing gas will be piped in from the existing natural gas pipeline located approximately 10 km north-east of the plant site. The estimated electricity and gas usage of the proposed development is detailed in **Table 2.5**.

Table 2.5
Proposed Electricity and Gas Useage, Batchelor Magnesium Project

Stage	Electricity (MW)	Gas (t/a)
Stage 1	16	17,000
Stage 2	32	34,000
Stage 3	64	68,000

2.16.2 Staffing

The construction workforce will vary and is expected to peak at about 100 persons.

It is estimated that 73 staff will be required for operation of Stage 1 mine and plant. This is based upon five eight hour shifts for continuous year round operation. Wherever possible, activities undertaken periodically will be completed during day shift only. There will be seven permanent professional and administration staff. Some key staff will need to be resident in Batchelor. Local residents will be favourably considered for employment where they have the necessary skills and experience. **Table 2.6** outlines the expected staffing levels.

Table 2.6
Anticipated Staffing Levels, Stage 1 Development

Staff	Number
Management/Administration	
Operations/Manager	1
Stores Supervisor/Purchasing	1
Payclerk/Accounts Clerk	1
Human Resources/OH&S/Training Coordinator	1
Receptionist/Secretary	1
Metallurgist Laboratory Supervisor	1
Maintenance Manager	1
Contract Labour	
Foremen	5
Administration Assistants	2
Laboratory Technician	2
Operator	30
Tradespeople	7
Control Room Operator	10
Trades Assistants/Labourers	10
TOTAL	**73**

Staffing levels will increase with expansion through Stages 2 and 3, with a final staff requirement of approximately 150 personnel.

2.16.3 Communications

Mt Grace intends to utilise the existing telecommunications network for external communications. The plant and office will have telephone, facsimile and internet connections. It is understood that there are current proposals to develop a mobile phone service in the Batchelor area but the timing of this is not presently clear. Mt Grace may utilise this service if it becomes available.

An internal telephone network will be established so that there will be access to a telephone at all usual workplaces in offices and at various points around the plant.

A separate, dedicated computer network will be established for process control. This will be held separate from the main office communications network and will have restricted access.

2.16.4 Traffic

Construction Traffic

Wherever possible equipment will be manufactured, assembled and tested prior to delivery to site. This will not be possible with large equipment such as the calcining kiln, which will be delivered in sections and assembled on site. Approximately 6,000 to 8,000 m^3 of concrete will be required for foundations, footings and floors. Some or all of this could be supplied from a nearby concrete batching plant located on Crater Lake Road.

Over the construction period of nine to twelve months it is estimated that an average of five trucks per day will deliver material and goods to the site, with possibly twice that number on any particular day. The main access and haul road to the site will be via Crater Lake Road, which joins Batchelor Road and the Stuart Highway. Trucks will travel only along Crater Lake Road to Stuart Highway and will avoid the publicly frequented Batchelor Road.

The construction workforce of up to approximately 100 persons will need to enter and leave the site daily either by private car or in a bus from a temporary campsite in, or near, Batchelor.

Operation Traffic

Heavy traffic during the operating phase will be required to deliver reagents to the site and to transport the product to East Arm Wharf for export. There are two main reagents that will be delivered to site. These are ferrosilicon and aluminium (total approximately 14,000 t/a for Stage 1) and burned lime (about 7,100 t/a for Stage 1). If it is assumed that trucking can take place 300 days per year then it will be necessary to bring in a little less than 50 t/day of ferrosilicon/aluminium and about 25 t/day of lime. This would result in about three trucks per day entering and leaving the site. These volumes and vehicle movements will quadruple for Stage 3. Once operational the Darwin to Alice Springs railway will be considered as an alternate means of transport.

The truck that delivers ferrosilicon will probably be back-loaded with magnesium metal and residual ferrosilicon. The Stage 1 plant will produce 12,500 t/a of magnesium metal and about 10,000 t/a of residual ferrosilicon, to be stored in a bonded warehouse at East Arm Wharf for periodic shipment. On the same assumptions as above this equates to about three trucks per day. Back loading should keep truck movements down to about four round trips per day. Occasional deliveries of process gases will be required. Stage 3 of the project will produce approximately 50,000 t/a of magnesium metal, with an associated four-fold increase in truck movements.

At the commencement and completion of each annual mining campaign there will be a one-off delivery and removal of mining equipment to and from the site. While campaign mining is taking place there will be approximately two tanker deliveries of fuel to the site per week. Fuel deliveries at other times of the year will be relatively infrequent.

Employees will need to travel to and from the site for work each day. Of the 73 people employed no more than half will be on site at any one time. Employees will travel by private vehicle or small bus.

Discussions are being held with the relevant authorities at the Department of Business, Industry and Resource Development (DBIRD) and DIPE regarding any requirements for modifications or road works at the junction of Stuart Highway and Crater Lake Road to facilitate safe and efficient movement of the additional traffic.

3 DESCRIPTION OF ENVIRONMENT

3.1 Data Sources

This section describes the physical, biological and socioeconomic environment in which the proposed Batchelor Magnesium Project will be constructed and operated. Most of the information presented in this section has been obtained by field survey of the project site and research into existing information. Available information has been reviewed and persons having specific knowledge of the region have been consulted.

3.1.1 Field Surveys

The surface water of Coomalie Creek (Right Branch) has been the subject of an initial survey of physicochemical variables and ongoing quarterly monitoring of heavy metals and other ions, at six locations, for the past year. This has been conducted by URS in conjunction Mt Grace. The purpose of the monitoring is to characterise the waters of Coomalie Creek (Right Branch) over time, providing baseline data. The results of the four sampling rounds and historical water quality data for the Coomalie Creek are included as **Appendix E**.

The vegetation of the site was described during field surveys conducted by Kristin Metcalfe (botanical consultant) in May/June 2001. The purpose of the study was to map the vegetation associations on the project site, particularly in the areas to be impacted by the proposed plant and infrastructure. Attention was given to weeds and species of conservation significance. Survey results are included as **Appendix F**.

The terrestrial fauna and aquatic fauna of the site were documented through field surveys undertaken by URS in collaboration with Ecological Management Services Pty Ltd in July 2001. The purpose of the survey was to describe species composition and distribution and gain an understanding of the likely faunal population of the area. The terrestrial fauna study and aquatic fauna report are included as **Appendices G** and **H**, respectively.

Biting midges and mosquitoes were surveyed by the Medical Entomology Branch (MEB) of the Territory Health Services (THS) in July 2001. Knowledge of potential breeding areas of mosquitoes and biting midges will assist in developing management strategies to combat biting insect problems and reduce the risk of insect-borne disease. A report on the biting insects in the project area is included as **Appendix I**.

A field survey was undertaken by Heritage Surveys Pty Ltd to assess the significance of any pre-historical and historical archaeological materials that might occur in the project area. The survey was conducted by pedestrian transect. Results are included as **Appendix J**.

Anthropological investigations were undertaken and consultations with local Aboriginal people carried out by W. Murgatroyd (consultant anthropologist) in order to identify land use and its significance to Aboriginal people. The investigation supplemented a study of sites of significance to Aboriginal people conducted by the AAPA. **Appendix K** presents the results of the anthropological investigations and **Appendix L** presents the Authority Certificate and supporting documents issued by AAPA.

3.1.2 Consultations

Consultations were undertaken with experts in various specialties related to the project, as well as various representatives from government and industry-related agencies. Assistance provided by the persons consulted is acknowledged in **Section 6**.

3.1.3 Literature Review

A review of published literature and technical reports was carried out; details of references cited in the text are provided in **Section 7**. Literature reviewed included previous environmental reports, historical references, information databases and scientific publications.

3.2 The Proposed Mine-Site

3.2.1 Landuse History

In 1869, part of the site was originally surveyed as Section 2831, Hundred of Goyder. W.O. Glyde purchased 1,020 acres of Section 2831 in 1884, and part of this area may have been used to grow tobacco over the subsequent eight years. In the early 1900s, land was acquired for use as an experimental farm, and in 1912 the Batchelor Demonstration Farm commenced operation (**Plate 1**). The farm covered an area of approximately 2,500 to 3,000 ha and encompassed the project area. Most of the project area was cleared, cultivated and fenced. Trial crops that were planted included grasses, (Paspalum, Rhodes, Couch and Sudan), cereals (Maize and Rice), legumes (Cowpeas), cotton and tobacco. Stock run on the farm included cattle (**Plate 2**), horses, goats and sheep (Heart of Rum Jungle, D.R. Barrie, 1982; Greg Smith, 2001 pers. comm.).

The Batchelor Demonstration Farm was not successful, mostly due to harsh conditions for labourers, stock and crops (mostly sourced from southern states). The farm ceased operations in 1919. The land was subsequently used as a depot for Government horses and stock. The land was then used for cotton growing and mixed farming and the lease changed hands several times. In 1941 the Commonwealth Government reclaimed the area/land for defence purposes during the Second World War. Earthworks, anti-aircraft gun-posts, aircraft dispersal runways and the remains of camps and buildings are still evident in the surrounding area. No known relics of such a nature exist on the project area.

The land tenure changed from Crown Land to Freehold Title in the 1970s. Much of the site, namely the black soil area adjacent to Coomalie Creek was then cleared and sown to improved pasture to run cattle and horses. In 1986 to 1987 and again in 1994, an area abutting the western boundary of Mt Grace's current lease area was mined for gold by Giants Reef Mining, the mine being named Sundance (Simpson, 1994). Two open-cut mine pits associated with the Sundance mine remain today, adjacent to the western boundary of the site.

Evidence of Aboriginal occupancy exists in the presence of some scattered and clustered artefacts and the presence of registered sacred sites. Many sleeping stories and legends were bought forward by the Kungarakany and Warai Peoples to support the Finniss River Land Claim in the early 1980s. The sleeping and partly forgotten legends and stories were pieced together by remembered information, with Aboriginal elders of the area confirming what they considered to be the correct heritage. On the site there are some large outcrops of magnesite, locally known as Janie Rocks. A local Aboriginal elder of the Kungarakany clan has identified the rock formations as 'Tungu', meaning 'giant lizard-like dragon'. The outcrops are hereafter referred to as Tungu Rocks.

More recently Mt Grace has acquired mineral tenure and commenced exploration drilling and mining at the project site. The Winchester deposit is the ore-body containing the magnesite deposits to be mined for this project. In late September to early November 2000, Mt Grace mined a trial pit within the Winchester deposit in order to extract a bulk sample for metallurgical test work. Overburden was removed and approximately 2,000t of magnesite was mined from a maximum depth of 12m and stockpiled near the Sundance pits. The trial pit is now water-filled and approximately 20m wide by 60m long.

3.2.2 Site Description

The Batchelor Magnesium Project site is bordered by Batchelor Road to the north, Crater Lake Road to the east and freehold land to the south. The site is approximately 357 ha in area and irregular in shape, lying 4 km east of the town of Batchelor and 6.5 km west of the Stuart Highway. Land to the west of the project area is owned by Exotic Timbers of Australia Pty Ltd, and is used for tree crop cultivation. An access track to the site currently extends from Batchelor Road. Survey gridlines traverse a large section of the property on an east-west and north-south orientation, and access is gained to most of the site via these tracks.

Coomalie Creek (Right Branch), the southern tributary of Coomalie Creek, flows in a north-easterly direction across the northern extent of the project area (generally parallel with Batchelor Road). This section of the creek channel is 1m to 3m wide and 0.5m to 2m deep. The creek is seasonally intermittent, often ceasing to flow in the Dry Season and flooding in the Wet Season.

The trial pit over the Winchester deposit is located in the north-western section of the project area. Two relic pits, comprising the former Sundance mine, remain permanently inundated just outside the site boundary to the west.

The project area varies from being moderately to densely vegetated, with six distinct vegetation communities. To reduce fuel loads and thus the likelihood of severe Dry Season fires, the majority of the project area is burnt under controlled conditions by Mt Grace personnel.

3.3 Physical Environment

3.3.1 Climate

The climate of the area is classified as ‘tropical savanna’, according to Köppen’s classification system (Stern *et al.*, 2001). The area has a distinct hot, wet summer (Wet Season) from October to March and hot dry winters (Dry Season) from May to August. September and April are transitional months, with some rainfall. Average annual rainfall is 1,372 mm, with 93% falling in the Wet Season.

Rainfall is reasonably reliable from year to year. The average annual rainfall is between 1,045 mm and 1,745 mm in 80% of years. The coefficient of variation (mean divided by standard deviation) of annual rainfall is 20%, which is lower than many other parts of Australia. Rainfall at Batchelor can be intense, occurring in extreme rainfall events. Intensities regularly exceed 200 mm/h in short bursts and can exceed 320 mm/h (Pilgrim 2001).

Maximum temperatures exceed 30^{o}C year round, with November being the hottest month (**Table 3.1**). Minimum temperatures vary from 16 to 24^{o}C during the year, with July being the coldest month. Humidity averages 60 to 80% during the Wet Season and 25 to 35% during the Dry Season. The total evaporative demand (pan) is high, 2,206 mm, which exceeds rainfall from April to November.

Table 3.1
Summary of Average Rainfall, Evaporation and Temperature, Batchelor

Month	Rainfall (mm)	Pan evaporation (mm)	Daily maximum temperature (^{0}C)	Daily minimum temperature (^{0}C)	Average daily temperature (^{0}C)
Jan	315	162	33	24	28
Feb	291	137	32	24	28
Mar	253	153	32	23	28
Apr	68	168	33	22	28
May	10	176	32	19	26
Jun	3	171	31	17	24
Jul	1	188	31	16	23
Aug	2	209	32	17	25
Sep	14	222	35	20	28
Oct	55	235	35	23	29
Nov	130	205	35	24	29
Dec	231	181	34	24	29
Sum	**1372**	**2206**			
Average			**33**	**21**	**27**
Wet Season (%)	93	49			
Dry Season (%)	7	51			

In the Dry Season, the prevailing winds are predominantly east to south-easterly and are commonly up to 30 km/h and in the Wet Season the winds are predominantly west to north-westerly and commonly up to 20 km/h.

The monsoonal tropics also experience cyclonic activity. The cyclone season in northern Australia extends from October to April. Tropical cyclones cause most damage within a distance of 50 km from the coast; once a cyclone has passed over land it weakens rapidly. Batchelor lies over 50 km from the coast and has not been significantly affected by direct cyclonic activity.

3.3.2 Air Quality

While there is no ambient air quality data available for the region, existing air quality is expected to be good given the rural nature of the area, and the lack of either urban population or industry. On occasion, suspended and deposited particulate levels may be elevated due to windblown dust, agricultural activities or bush fires.

3.3.3 Regional Geology

The Winchester magnesite deposit is located within the central part of the Pine Creek Geosyncline (**Figure 3.1**), an Early Proterozoic intracratonic sedimentary basin forming part of the North Australia Orogenic Province (Ahmad et al., 1993). The geosynclinal sequence comprises metasedimentary rocks, mainly shale, siltstone, sandstone, conglomerate, carbonate rocks and iron formation resting unconformably on an Archaean granitic and metamorphic basement.

At the close of sedimentation a suite of continental tholeiites intruded the sediments mainly as sills. The Top End Orogeny (1870 to 1800 Ma) followed the sedimentation. Tightly folded lower greenschist facies strata in the centre grade into isoclinally to recumbent folded amphibolite to granulite facies strata to the west and east.

Granitoid intrusions and associated contact metamorphism followed the deformation and regional metamorphism. Following the granitoid intrusions, the geosynclinal strata were uplifted, eroded and overlain by Middle Proterozoic and younger successions. Largely undeformed platform covers of Middle Proterozoic, Late Proterozoic, Cambro-Ordovician and Mesozoic strata (mainly sandstone and minor volcanics and carbonate rocks) rest on the Early Proterozoic rocks in the geosyncline with marked unconformity. Drape folding and locally intense deformation adjacent to major faults are common in these sequences. Unconsolidated Cainozoic sediments cover a large part of the Pine Creek Geosyncline.

The Rum Jungle Region, the mineral province in which the Winchester deposit is located, also contains uranium, phosphate and large base metal deposits.

Early Proterozoic formations are outlined in **Table 3.2**.

Table 3.2
The Early Proterozoic Formations that occur in the Project Region.

Formation Group	Sub-group	Description
Finniss River Group	**Burrell Creek Formation**	Siltstone, generally red to purple in colour with interbedded medium grained arkosic units.
South Alligator Group	**Mount Bonnie Formation**	Siltstone, generally red to purple in colour, with interbedded feldspathic, arkosic units.
	Gerowie Tuff Unit	Light green grey to light grey, siliceous tuff, minor tuffaceous greywacke and arenite.
	Koolpin Formation	Ferruginous siltstone and shale with chert bands, lenses and nodules; siltstone and shale, commonly carbonaceous; silicified, dolomitic lenses; ironstone bands associated.
Mount Partridge Group	**Wildman Siltstone**	Ferruginous siltstone and shale with chert bands, lenses and nodules; siltstone and shale, commonly carbonaceous; silicified dolomitic lenses; ferruginous, strongly weathered tremolitic, mafic extrusive.
	Mount Deane Volcanic Member	Altered, ferruginous, partially vesicular basic volcanics.
	Whites Formation	Calcareous and carbonaceous, pyritic argillite; dololutite; dolarenite.
	Coomalie Dolomite	Stromatolitic dolomite, magnesite and marble, in places chloriticand tremolitic, commonly silicified or lateritised at the surface; metalutite, commonly graphitic.
	Crater Formation	Haematite boulder conglomerate; cross-bedded pebbly arkose; pebbly conglomerate; quartzite; sandstone; minor siltstone and shale.

3.3.4 Local Geology

The Winchester magnesite deposit occurs within the Coomalie Dolomite, which is bound to the north by sandstones of the Crater Formation and to the south by black shales of the Whites Formation. The deposit occurs beneath the valley formed by the Coomalie Creek (Right Branch). Drilling has confirmed the presence of up to 25m of alluvium within the valley. The alluvium comprises mostly clay and silts, with occasional lenticular sand and gravel lenses associated with prior stream channels.

At the prospect, the Coomalie Dolomite consists of both dolomite and magnesite. Where magnesite ore occurs there is commonly a thin veneer of weathered dolomite, immediately below the contact and overlying the massive crystalline magnesite. The Dolomite is generally massive and competent and of uniformly high to very high strength below the upper weathered material and overlying deposits. Whilst the Dolomite is veined on the macro-scale, there is no apparent preferred orientation to the vein patterns. There are no prominent joint, fault, shear or other dominant geological structures mappable in the trial pit (Uren, 2001).

3.3.5 Land Systems and Land Units

Land systems in the project area have been mapped at a scale of 1:25,000 with a land use assessment provided in a report entitled, *Report of the Land Units of the Batchelor Township Area* (Wood and Day, 1976).

The Batchelor Magnesium Project is located within the 'Bend' land system and is identified on the basis of topography (Wood and Day 1976). Drainage from within the mine site area is via Coomalie Creek and its tributaries with the characteristic topography comprising hills, ridges and undulating rises with gently inclined wash slopes and minor alluvial flats adjacent to the drainage lines.

The land units that occur in the mining lease area have been identified primarily from a review of existing reports and data pertaining to regional geology, topography, soils and vegetation.

A land unit comprises a discrete or recurring area of land that is considered to have a unique combination of physical attributes in terms of bedrock, surface slope and form, surface drainage characteristics and soil/substrate conditions. Accordingly, engineering and/or environmental characteristics determined at one location may be extrapolated to other occurrences of the terrain unit identified through the terrain classification process.

Land unit types were differentiated primarily on the basis of surface slope and form. As mapped, the land units that occur within the project area are depicted in **Figure 3.2** and described in **Table 3.3**.

Table 3.3
Land Units and Soils in the Project Area (Source: Wood and Day, 1976)

Land Unit	Landform	Soils	Vegetation	Limitations	Land Use Potential
1	Hills and ridges up to 133m; slopes > 10%; extensive surface stone cover and abundant outcrop of quartz, greywacke, siltstone, sandstone, dolomite and laterite.	Predominately outcrop with some shallow lithosols.	Low open forest to open forest.	Shallow stony soils, abundant outcrop and locally steep slopes.	Unsuitable for any agricultural or urban development.
2	Footslopes below Land Unit 1; slopes 5-10%; extensive surface gravel, stone and outcrop.	Lithosols.	Variable low woodland to forest.	Shallow gravelly soils; areas of outcrop; steep slopes.	Not suitable for urban development; suitable for limited rough grazing of native pastures.
3	Low ridges and erosional slopes locally to 5%; extensive surface gravel cover and areas of outcrop.	Lithosols.	Variable woodland.	Shallow gravelly soils; areas of outcrop; excessive slopes.	Suitable for gravel and stone extraction subject to appropriate reclamation measures; rough grazing of native pasture in Wet Season.
4	Low erosional rises and slopes 2-5%; areas of surface gravel and outcrop.	Shallow red and yellow earths with abundant stone and gravel.	Variable woodland.	Shallow stony soils; frequent areas of outcrop; occasional excessive slopes.	Small areas capable for gravel extraction; suitable for rough grazing of native pasture.
5	Erosional slopes 2%; extensive areas of surface gravel.	Gravelly red and yellow earths, generally deeper than Land Units 3 and 4.	Variable woodland.	Gravelly surface; some areas of outcrop.	Isolated areas suitable for gravel extraction; suitable for rough grazing of native pasture.
6	Heads of drainage floors.	Gleyed podzolics and yellow earths.	Variable grassland to low open forest.	Highly erodible areas receiving run-off from surrounding higher areas; waterlogged for extended periods.	Suitable for pasture improvement but limited to Dry Season grazing.
7	Drainage floors with some minor alluvial plains.	Yellow podzolics.	Variable low open woodland to low open forest.	Waterlogged for a major part of the year; highly erodible in areas.	Some areas suitable for pasture improvement with water tolerant species but limited to Dry Season grazing.

3.3.6 Local Soil

Soils in the catchment area are shallow lithosols and rocky outcrops on the hills and steeper slopes and red and yellow earths in the low-lying areas near Coomalie Creek (Wood and Day, 1976). The shallow soils (Land Units 1 and 2) are characterised by low infiltration potential, low water holding capacity and rapid drainage of surface water. The alluvial soils (Land Unit 5) have more favourable physical characteristics than the shallow soils, hence higher infiltration potential and water holding capacity, but tend to be waterlogged during the Wet Season and are highly erodible. The deeper earths (Land Units 6 and 7) have the most favourable characteristics of soils in the area. These land units tend to occur toward the top, western edge of the catchment, and have higher infiltration and water holding capacity.

Physical Properties of the Soils

Soil descriptions for each land unit within the proposed site are provided in **Table 3.4**. Wood and Day (1976) provide profile descriptions and classifications using the Great Soil Group Classification System. Conversion of these descriptions to the Australian Soil Classification System was achieved through use of the table 'Approximate Correlations between the Australian and other Soil Classifications' provided in Appendix 5 of *The Australian Soil Classification* (Isdell, 1996). It should be noted that the table used is intended only to give approximate translations between different classification systems.

Erodibility

The susceptibility of a soil to erosion (erodibility) is a function of texture, and physical and chemical properties and may be largely independent of factors such as rainfall intensity, plant cover, etc. Erosion (hazard) potential, on the other hand, depends on a combination of factors including soil erodibility, climatic factors, surface hydrology, surface slope, surface cover and condition, and existing land use.

Shallow lithosols and gravelly red and yellow earths found in Land Units 1, 2, 3 and 4 typically have restricted infiltration potential and low water holding capacity resulting in rapid run-off of surface water. The characteristics of the soils combined with slopes ranging between 2% and greater than 10% make soils in these land units highly erodible once disturbed.

Alluvial soils found in Land Units 6 and 7 tend to have higher infiltration potential and water holding capacity but tend to receive run-off from higher areas, consequently they may be waterlogged for much of the Wet Season and are considered highly erodible, particularly where adjacent to drainage ways.

Table 3.4
Soil Characterisation

Land Unit	Great Soil Group Classification	Australian Soil Classification	Typical Profile Description	Depth (m)	Colour / Colour Id		pH	Comments
1	Predominately outcrop with some shallow lithosols	Leptic Rudosols	Shallow stony soils with abundant outcrop.	Shallow	-	-	-	-
2	Lithosols	Leptic Rudosols	Gravelly sandy loam, 70-80% gravel (100% gravel veneer on surface)	0-0.2	Dark reddish brown.	5YR 3/4	-	Occasional sandy clay loam or clay loam.
			Rock and stone.	0.2	-	-	-	-
3	Lithosols	Leptic Rudosols	Shallow gravelly soil with areas of outcrop.	shallow	-	-	-	-
4	Shallow red and yellow earths with abundant stone and gravel	Red & Brown Kandosols	Gravelly/stony sandy to silt loam surface soils, grading to clay loam to light clay subsoils.	<0.5	Reddish and yellowish brown.	-	-	Frequent areas of outcrop.
5	Gravelly red and yellow earths	Red & Brown Kandosols	Stony sandy to silt loam surface soils, over gravelly clay loam to light clay subsoils.	0.5-0.8	Reddish and yellowish brown.	-	-	Generally deeper than 3 or 4.
6	Yellow earths	Redoxic Hydrosols	Silty light clay; massive, earthy; dry, slightly hard; 30% Fe gravels.	0-0.15	Dark brown.	10YR 3/3	5.5	Variation: Silty clay loam, loam or light clay.
			Gravelly light clay; massive, earthy; dry, slightly hard; 30% Fe gravels.	0.15-0.35	Dark greyish brown.	10YR 4/2	6.0	-
			Gravelly light clay; massive, earthy; dry, hard; 50% Fe gravels.	0.35-0.75	Yellowish brown with distinct yellow brown mottle.	10YR 5/4	6.0	No gravels evident in some soils.
			Gravelly light clay; massive, earthy; moist, friable. 70% Fe gravels.	0.75-1.60	Brown with yellow brown mottles.	10YR 5/3	5.8	-

Land Unit	Great Soil Group Classification	Australian Soil Classification	Typical Profile Description	Depth (m)	Colour / Colour Id		pH	Comments
6 (Extra detail obtained from Wood & Day 1976)	Gleyed Podzolic	Redoxic Hydrosols	Organic loam; massive, earthy; dry, slightly hard.	0.0-0.06	Dark brown.	7.5YR 3/2	5.5	Variation: Sandy loam with gravel; 5% Fe gravel.
			Loam; massive, earthy; dry, slightly hard.	0.06-0.2	Dark grey with faint yellow brown mottles.	5Y 4/1	6.0	Variation: A_2 can be bleached grey to light grey (10YR 6/1); fine sandy clay loam.
			Clay loam with fine sand; massive, earthy; dry, slightly hard.	0.2-0.4	Grey with distinct yellow brown mottles.	5Y 5/1	6.0	Variation: If A_3 evident mottled brownish yellow (10YR 6/6) gritty clay loam; moist, friable.
			Gravelly medium clay; massive, earthy; moist, friable. 40% Fe gravel	0.4-0.8	Grey with prominent yellow brown mottles.	5Y 5/1	6.0	-
7	Yellow Podzolic	Redoxic Hydrosols	Loam; massive, earthy; dry, extremely hard.	0-0.1	Very dark greyish brown.	10YR 3/2	5.5	Variation: Silty clay loam.
			Silty, heavy clay loam; massive, earthy; dry, hard.	0.1-0.3	Very dark grey.	10YR 3/2	6.0	Variation: Silty clay loam.
			Silty light clay; massive, earthy; dry, extremely hard	0.3-0.6	Dark yellowish brown.	10YR 4/4	6.0	Variation: Moist, friable.
			Medium clay; angular blocky; rough ped; moist, friable.	0.6-0.95	Dark yellow brown with distinct yellow and fine red mottling.	10YR 4/4	6.0	Variation: Massive, earthy; dry, extremely hard.

3.3.7 Hydrogeology

There have been no dedicated hydrogeological investigations at the Winchester deposit, however hydrogeological data have been collected during earlier drilling programs and during excavation of the trial pit. These data comprise:

- groundwater levels;
- groundwater chemistry;
- groundwater recovery times in drill holes after completion;
- dewatering pumping rates during excavation of the trial pit; and
- groundwater level draw-downs and recoveries associated with dewatering activities for the trial pit.

It has been reported that whilst there is no hydrogeological data from the nearby Sundance Mine, the pits were approximately 20m deepand caves intersected within the Coomalie Dolomite initially yielded high groundwater flows. However, the long-term groundwater flows were managed with small sump pumps (Golder, 2001).

Regional Hydrogeological System

The catchment to the Coomalie Creek (Right Branch) valley upstream of the Winchester deposit covers an area of approximately 22 km^2 (**Figure 3.3**). Regional groundwater flow is probably to the north-east, along the valley of Coomalie Creek (Right Branch) and towards Coomalie Waterhole, where the Right and Left Branches meet to form Coomalie Creek. The waterhole is formed by the convergence of groundwater flow into the narrow gap in the range formed from the Wildman Siltstone. Outflow from the system occurs as surface and groundwater flow within the creek, at the waterhole and through the alluvium within the valley.

The important hydrogeological units in the vicinity of the Winchester deposit are surface alluvium in the Coomalie Creek (Right Branch) valley and Coomalie Dolomite. The main regional aquifers in the project area are the sand and gravels within the alluvium of Coomalie Creek (Right Branch) and the weathered dolomite at the contact with the alluvium. Golder (2001) reports that the above aquifers occur in association with relatively low permeability materials. The sands and gravels occur with low permeability clays that comprise the remainder of the alluvium, and the Coomalie Dolomite has been found to comprise, for the most part, massive dolomite and magnesite.

Drillhole logs record the loss of circulation and/or sample return and possibly cavity formation for several metres at the interface of the alluvium and the upper weathered zone of the Coomalie Dolomite. Drilling has intersected caves of 12m drilled depth within the Coomalie Dolomite. These are commonly filled with clay and silt. Minor cavities and vughs have also been observed in diamond drill cores and samples of ore collected during development of the trial pit. The location of the proposed mine has been selected as an area where there is no or minimal development of caves.

The degree of hydraulic connection between individual cave systems and between cave systems and the near surface alluvium is not known and is expected to vary. Observations at the Sundance Mine suggest poor interconnection between individual caves in the Coomalie Dolomite at that location. It is likely that caves that extend to the top of the dolomite would receive groundwater recharge from the overlying alluvial deposits.

Observations made during the dewatering of the trial pit indicate that the minor cavities and vughs that occur within the fresh magnesite are not major producers of groundwater. This suggests that these smaller openings are not interconnected within the crystalline magnesite.

Recharge to the system following rainfall events occurs as direct rainfall recharge and infiltration from creek flows. Groundwater levels are approximately 1 to 2m below ground surface at the end of the Dry Season and above ground level during the Wet Season (Golder, 2001). Discharge from the groundwater system occurs as throughflow, creek flow during the Dry Season, evaporation from water holes within the creek and evapo-transpiration from vegetation within the valley.

Orebody Hydrogeology

Hydraulic testing during the trial pit dewatering program (27 September to 7 November, 2000) indicated the aquifer system is largely unconfined. However, it was noticed that a number of holes in the vicinity of the trial pit were artesian. The aquifers associated with these artesian flows are likely to comprise sand or gravel lenses within the alluvial deposits, confined by overlying low permeability clay. Results from drilling the orebody did not identify any groundwater intersections within the dolomite (Golder, 2001).

Sixty drill holes were used to monitor groundwater levels during dewatering operations. The hydrographs for these drill holes show the following:

- pre-dewatering groundwater levels were generally 1 m ± 0.2 m below ground surface;
- drawdown of groundwater levels around the trial pit was about 2 m after 3 weeks of mining (25 September to 13 October 2000). Groundwater levels stabilised at about 3 m below ground surface, from 13 October 2000 to end of dewatering on 7 November 2000, at a discharge rate of 1,300 to 1,730 m^3 /day (15 to 20 L/s); and
- at completion of the trial pit, the groundwater levels in the drillholes rose above pre-mining levels to ground surface as a consequence of the onset of the Wet Season.

The main inflows into the trial pit occurred from sand and gravel lenses within the alluvial deposits that were exposed in the pit wall during mining. It was presumed that the groundwater in the alluvium drained laterally into the pit through a seepage face at the wall, thus limiting the amount of drawdown. A general flow gradient to the north-east is indicated from groundwater levels recorded in bores before dewatering of the trial pit commenced. However there are insufficient data available to gain additional information about groundwater flow patterns.

Aquifer Parameters

Aquifer parameters have been calculated from monitoring bore data collected during and after the excavation and dewatering of the trial pit (Golder, 2001). The hydraulic conductivity of the alluvial aquifer system has been estimated by applying the Thiem equation for unconfined steady state radial flow. A dewatering rate of 1,380 m^3/day (16 L/s) was used. This was the rate observed after six weeks of trial pit mining. The estimated hydraulic conductivity was calculated to be 14 m/day. Analysis of monitoring bore data using the Jacob straight-line method yielded values of hydraulic conductivity within the range 21 to 29 m/day.

Hydrochemistry

Comprehensive chemical analyses have been completed on groundwater samples collected from two drillholes (MRC–177 and MRC–214) within the project area. They have been analysed for total dissolved solids (TDS), major ions apart from chloride and sulphate, and heavy metals. Results of analysis are presented as **Appendix M**.

In summary, concentrations of TDS, major ions and heavy metals are low and below guideline levels outlined for the protection of aquatic ecosystems (ANZECC, 1992).

3.3.8 Hydrology

The mine site is located on the right branch of Coomalie Creek. The right branch merges with the left branch about 5 km downstream and to the east of the mine site, near the Stuart Highway. The catchment for Coomalie Creek occupies an area of approximately 82 km^2. Coomalie Creek then flows eastward for approximately 14 km before entering the Adelaide River. The Adelaide River flows north, discharging into Clarence Straight, east of Darwin.

The area of catchment at the downstream edge of the proposed mine site is 2,768 ha (Figure 3.3). Topography along the right branch of Coomalie Creek is gently sloping from west to east. Immediately to the south of the proposed mine site are hills rising up to 120m above the elevation of the mine area. These hills are dissected by a large number of small streams; those in the catchment flow generally north and become indistinct on the flat areas near the streamline. To the west, the catchment is divided by a low rise near the Batchelor Air Field and Batchelor township. The catchment reaches to the eastern edge of the town. The catchment is bound by a series of low hills to the north of Batchelor Road. Water drains from these hills into a swampy, low lying area between the two hills and into the right branch of Coomalie Creek over Batchelor Road, via a stream near the proposed pit area.

There are two main flood prone areas in the catchment: between the hills to the north of Batchelor Road, and near the mine site itself. These areas tend to remain waterlogged during the Wet Season because of a rising water table in the superficial aquifer within the alluvial deposits and from run-off from upstream catchments.

The defined streamline near the proposed mine is small, being 1 to 3m wide and 0.5 to 2m deep. This creek flows during the Wet Season as a result of run-off and seepage from the local aquifer. During larger rainfall events the creek overtops and the low lying areas around the mine site flood. During the Dry Season, the Coomalie Creek (Right Branch) is intermittently dry near the proposed mine site, but downstream groundwater seepage is often sufficient to maintain a small flow.

The Coomalie Creek (Right Branch) flows through the proposed pit area and as part of the project development will be redirected to the south, rejoining the original streamline immediately below the pit.

Water balance within the catchment is dominated by evapo-transpiration and run-off processes, although groundwater interactions with surface flow have an important impact on catchment hydrology. About 26% of rainfall is predicted to be run-off for the catchment under undisturbed conditions. This is relatively high and is a function of high rainfall intensities typical in the area, low infiltration capacity of many soils, and a high water table in valley floors during the Wet Season. Most run-off is predicted to occur between December and April. Run-off is relatively consistent from year to year compared to other parts of Australia, with the coefficient of variation in annual run-off predicted to be 43%.

Run-off rates from the catchment are predicted to be high for the catchment area as a result of shallow soils with low infiltration capacity, a high degree of channelisation, the presence of waterlogged areas, and intense rainfall. There is severe sheet and channel erosion in the steeper parts of the catchment, an indication of high run-off rates. The floodplain near the proposed pit, however, attenuates the flood hydrograph to a degree, reducing and delaying the peak. Predicted peak discharge from the catchment outlet prior to mining was 191 m^3/s, for a design rainfall event with 10-year recurrence interval. Two hours is the predicted rainfall duration that would give the greatest peak discharge.

Peak discharge increases sharply as the average recurrence interval of the design rainfall event increased. The 50-year discharge was nearly 50% larger than the 10-year event.

Further detail regarding the existing hydrological regime of the project area is provided in **Appendix N**.

3.3.9 Water Quality

Information pertaining to surface water quality on or in the vicinity of the project area has been obtained from the following sources:

- Results of surface water samples collected by Normandy Woodcutters Pty Ltd (Normandy) from a sampling point (RSP3) located on Coomalie Creek (Right Branch), approximately 300m upstream from its confluence with Coomalie Creek (Left Branch) and approximately 7 km downstream from the project area.
- Results of surface water samples collected by Normandy from a sampling point (SP6) located on Coomalie Creek (Left Branch), approximately 6 km north-east of the project area.
- A surface water quality monitoring program completed by URS in conjunction with Mt Grace Resources on and immediately downstream from the project area.

The location of surface water sampling points is shown in **Figure 3.4**.

Historical Data

Normandy formerly operated a copper/lead/zinc mine (Woodcutters Mine) located approximately 7 km to the north-east of the Mt Grace lease area. In 1998, Woodcutters Mine ceased operation and the area is currently being rehabilitated. As part of a water quality monitoring program undertaken by Normandy, surface water sampling was conducted at locations considered to represent control points in the Woodcutters program. Although the sampling was not undertaken specifically in the Mt Grace project area, information obtained from these monitoring rounds provides an historical account of water quality in the area of the proposed mine.

Based on the historical data, the water in Coomalie Creek is of approximately neutral pH, with levels of calcium, magnesium, nitrate and bi-carbonate that are comparable with similar waterways in the Top End. Short term and occasional spikes of several heavy metals were apparent, however no clear increasing or decreasing trend in concentration was evident.

Results of historical surface water analysis indicate variation in water quality exists between the Wet and Dry Seasons. The variations evident would at least in part be accounted for by the differing flow regimes between the two seasons. Apparent variations include:

- increased turbidity during the Wet Season, with correspondingly higher turbidity levels as a result of rainfall events;

- a drop in alkalinity levels during the mid to late Wet Season; and
- a tendancy for lower electrical conductivity (EC), salinity levels and pH during the Wet Season.

Current Field Surveys

The surface water of Coomalie Creek (Right Branch) has been the subject of an initial baseline survey of physicochemical variables (URS December 2000), and on-going monitoring on an approximate quarterly basis at six sites (SW1 to SW6) within and downstream from the project area. The initial survey comprised analysis of a broad suite of parameters, including pH, EC, temperature, nitrogen, phosphate, metals, organochlorine (OC) and organophosphorous (OP) pesticides. Subsequent to the initial survey, analysis was restricted to selected physico-chemical parameters, nitrogen, phosphate and metals. The results of the initial survey and three subsequent sampling rounds are included in Appendix E and a summary of results obtained is provided below.

Where detected, the concentrations of individual parameters were variable throughout the year. Nitrogen was detected in six of the twenty-four samples tested, at concentrations ranging between 170 µg/L and 690 µg/L, and phosphate was detected on three occasions, at concentrations ranging between 80 µg/L and 100 µg/L. A summary of the concentrations of metals detected is provided in **Table 3.5**.

Table 3.5
Summary of Metal Analysis - Coomalie Creek (Right Branch)

Metals	SW1		SW2		SW3	
	No. Detected	**Range** (µg/L)	**No. Detected**	**Range** (µg/L)	**No. Detected**	**Range** (µg/L)
Barium	2 of 3	19 – 22	2 of 4	13 – 36	2 of 4	14 – 32
Cadmium	1 of 3	2	1 of 4	2	1 of 4	3
Chromium	1 of 3	0.001	ND	ND	2 of 4	0.001 – 2
Cobalt	ND	ND	ND	ND	1 of 4	1
Copper	2 of 3	0.008 – 6	2 of 4	0.004 – 7	3 of 4	0.004 – 8
Lead	1 of 3	50	1 of 4	50	1 of 4	67
Manganese	2 of 3	0.022 – 60	2 of 4	0.059 – 21	3 of 4	2.4 – 75
Molybdenum	ND	ND	ND	ND	1 of 4	2
Nickel	1 of 3	0.003	ND	ND	1 of 4	0.003
Tin	1 of 3	470	1 of 4	340	1 of 4	550
Zinc	3 of 3	0.057 – 250	4 of 4	0.058 – 200	4 of 4	0.12 – 310
Metals	**SW4**		**SW5**		**SW6**	
	No. Detected	**Range** (µg/L)	**No. Detected**	**Range** (µg/L)	**No. Detected**	**Range** (µg/L)
Barium	2 of 4	17 – 26	2 of 4	11 – 29	2 of 4	13 – 29
Cadmium	ND	ND	1 of 4	2	1 of 4	3
Chromium	1 of 4	0.001	2 of 4	0.001 – 3	1 of 4	0.001
Cobalt	ND	ND	ND	ND	ND	ND
Copper	1 of 4	0.005	3 of 4	0.003 – 5	2 of 4	0.003 – 8
Lead	1 of 4	22	1 of 4	43	1 of 4	65
Manganese	3 of 4	23 – 35	3 of 4	0.022 – 28	2 of 4	0.021 – 26
Molybdenum	ND	ND	ND	ND	ND	ND
Nickel	1 of 4	0.003	1 of 4	0.002	1 of 4	0.002
Tin	1 of 4	160	1 of 4	230	1 of 4	46
Zinc	4 of 4	0.032 – 150	4 of 4	0.033 – 200	4 of 4	0.033 – 290

Note: ND = Non-detect.

The URS 2001 water quality sampling results for Coomalie Creek (Right Branch) are generally consistent with the available historical data for surface waters in the vicinity of the project area.

3.3.10 Seismicity

The proposed magnesium mine site and processing plant are located in an area of low seismic activity. The nearest recorded earthquake epicentre to the mine site is located at Bathurst Island, 180 km north of the site. This earthquake zone is the southernmost of a line of three recorded seismic centres extending north of Melville Island. A cluster of four other seismic centres have been recorded approximately 270 km south of Darwin in the vicinity of Fitzmaurice River (McCue et al. 1993).

3.4 Biological Environment

3.4.1 Flora

Vegetation within the project area was mapped using aerial photograph interpretation and field survey methods between May and September 2001, by Kristin Metcalfe. The field survey recorded a total of 173 plant species from 55 families and 136 genera. Seven defined vegetation communities were identified: six on site and one upstream of the project area. These can be broadly categorised into three habitat types: upland communities, drainage areas and rainforest communities. Vegetation across the project area mainly comprises *Eucalyptus*-dominated woodland and open woodland, also known as 'savanna'. Savanna is common, widespread and characteristic of the region. A vegetation map of the site is presented as **Figure 3.5** and a full report on the vegetation survey is provided in Appendix F.

Information used to characterise the terrestrial flora included: species composition and dominance; vegetation structure; ground cover; canopy cover; introduced species; disturbance; and environmental features.

The vegetation in the project area reflects the interplay of topography, soils and influence of seasonal fluctuations in fresh water supply and drainage. Consequently the vegetation types correspond broadly with major topographic contours. The pattern of drainage is the major factor determining distribution of vegetation.

Disturbance to the site in the past has been significant in shaping existing vegetation communities including wide-scale clearing, pasture cultivation and livestock grazing. The area supports dense infestations of exotic grasses that exacerbate the effect of frequent, widespread fires which play a major role in determining vegetation patterns.

3.4.1.1 Upland Communities

Upland vegetation comprises approximately 270 ha (about 76%) of the project area on gentle lower slopes and foothills that support *Eucalyptus*-dominated communities. These communities comprise various formations ranging from open woodland (with sparse trees and a well-separated canopy: 0.3 to 20% canopy cover) to woodland (where upper stratum trees have a clearly separated canopy: 20 to 52% canopy cover). Two main upland communities were identified and are described as follows:

***Eucalyptus tetrodonta/ Eucalyptus miniata* open woodland (Map Unit 1)**

This community covers approximately 64 ha (18%) of the site area and comprises Eucalypt-dominated open woodlands with minor areas of denser woodland habitat. The dominant species is characteristically *Eucalyptus tetrodonta* (Darwin Stringybark) and *E. miniata* (Darwin Woollybutt), either singly or in co-dominant stands forming a sparse upper stratum.

A mixed species mid-stratum layer comprises common and widespread shrubs and low trees including *Cycas armstrongii, Brachychiton megaphyllus* and *Livistonia humilis*. The relatively open tree canopy promotes a dense ground layer of grass species and subshrubs. Ground layer species include *Flemingia lineata, Flueggia virosa, Buchnera* sp. and *Uraria lagopodiodes*. Grasses include *Sorghum* spp. (annual Sorghum) and *Heteropogon contortus* along with introduced grass species such as *Pennisetum polystachion* and *P. pedicellatum* (Mission Grass). *Andropogon gayanus* (Gamba Grass) is also abundant in disturbed areas, but unlike most other weeds, this species also extends through intact woodland habitats.

Mixed *Eucalypt* woodland (Map Unit 2)

This community comprises a mixed woodland with variable dominance covering approximately 207 ha (58%) of the site, supported by the undulating lowlands and lower side-slopes of the main east-west range bordering the site. Areas supporting this community are generally well drained with some areas of poorer drainage and heavier soils toward a valley floor. Upper stratum species commonly include *Eucalyptus miniata*, *E. foelscheana, E. polycarpa* and *E. tectifica* with canopy trees to 10 or 15m high. The dominant *Eucalypt* species varies locally with changing topographic conditions and associated variations in drainage and soil type.

The understorey existing in this community is typically mid to dense, comprising species such as: *Petalostigma pubescens, Cycas armstrongii, Pandanus spiralis, Livistonia humilis, Planchonia careya, Terminalia ferdinandiana, Brachychiton megaphyllus* and *Pandanus spiralis*. The ground stratum includes a variety of herbs and subshrubs such as *Hibbertia* spp., *Flemingia lineata* and *Pachynema complanatum*. A diverse range of grasses was recorded, particularly in lowland areas with *Eriachne stipacea, E. triseta, Bothriochloa bladhii, Pseudopogonatherum contortum* and *P. irritans* being common.

3.4.1.2 Drainage Areas

Drainage areas within the site include several distinct habitats associated with Coomalie Creek (Right Branch) that retain or carry water during the Wet Season. The main drainage channel of Coomalie Creek (Right Branch) lies within a narrow riparian corridor. This linear band is situated within a broad drainage way comprising alluvial flats with heavy soils supporting *Lophostemon* open woodlands. These flats surrounding the creek represent Wet Season floodplain areas and transitional habitats between upland woodlands and lowland drainage lines. They are characterised by seasonal inundation or waterlogging for up to several months of the year and include several swampy areas and/or a perched water table supporting a *Melaleuca* woodland.

Riparian Corridor (Map Unit 3)

This community occupies approximately 14 ha (4%) of the site vegetation along the banks of Coomalie Creek (Right Branch), which is a typically narrow stream channel. The root systems of the riverbank species frequently define the creek channel and species include *Pandanus spiralis, Nauclea orientalis, Acacia auriculiformis, Lophostemon grandiflorus, Timonius timon* and *Ficus racemosa*.

Creekbank vegetation is commonly several trees thick in width but is characteristically flanked by a corridor of grassland in which *Ischaemum* spp. and *Imperata cylindrica* (Bladey Grass) forms dense monospecific stands. Scattered trees amidst the grassland include *Eucalyptus papuana, E. polycarpa, Lophostemon grandiflora, Melaleuca dealbata* and *Acacia auriculiformis* (Darwin Black Wattle).

Seven weed species were recorded in this community and can form dense infestations where riverbanks are disturbed. Intensive previous landuse has encouraged proliferation of weeds such as *Stachytarpheta* spp., *Hyptis suaveolens, Andropogon gayanus* and *Sida acuta*.

***Lophostemon* open woodland (Map Unit 4)**

The broad drainage way flanking Coomalie Creek typically supports an open woodland formation, covering approximately 50 ha of the site (~14%) and characterised by *Lophostemon grandiflorus*. *L. grandiflorus* is ubiquitous of seasonally inundated and waterlogged soils and occurs in monospecific stands on the site, or in association with various Paperbark species (*Melaleuca dealbata, M. cajuputji, M. nervosa* and *M. leucadendra*) and *Pandanus spiralis*.

The mid-stratum is sparse and characterised by *Pandanus spiralis, Melaleuca viridiflora* and *Planchonia careya*. Grasses are dense and diverse in this habitat, the most common species including *Eriachne burkittii, Paspalum scrobiculatum, Themeda triandra, Bothriochloa* sp., *Ischaemum* sp., *Imperata cylindrica, Pseudopogonantherum contortum* and *Sorghum stipodeum*.

Sedges including *Fuirena ciliaris* and *Fimbristylis pacucifora*, and the floodplain herbs *Ludwigia perenis, L. octovalvis, Nelsonia campestris* and *Limnophila fragrans* were all found in this community and are species tolerant of seasonal waterlogging.

***Melaleuca* woodland (Map Unit 5)**

Woodland formations in which *Melaleuca* spp. is dominant occur occasionally along the main drainage way and as isolated pockets in lowland terrain, covering less than 14 ha (4%) of the site. Paperbarks are characteristic of areas with high soil moisture conditions, waterlogging and/or seasonal inundation. These areas may support tall open forest (52 to 81% canopy-cover) to low woodland formations (3 to 6m high), characterised by almost monospecific stands of *Melaleuca* spp. (Paperbark). This community is of relatively restricted distribution in the project area and typically intergrades with the riparian corridor and *Lophostemon* open woodland.

This community is relatively simple floristically, with the upper stratum comprising mainly *Melaleuca* species, particularly *Melaleuca viridiflora, M. nervosa, M. dealbata* or *M. leucadendra* (mostly 2 to 8 m high*)*. Occasionally *Lophostemon grandiflorus, Pandanus spiralis* and *Acacia* spp. may occur in this habitat

Dense grasses including *Themeda triandra, Ischaemum australe* and *Eriachne burkittii* typically comprise the ground layer. Sedges (*Fimbristylis* sp., *Fuirena ciliata, Rhyncospora* sp.) and wetland herbs (*Limnophila fragrans, Drosera indica)* are common ground layer species.

3.4.1.3 Rainforest Communities

Dry-vine forest occurs within the Batchelor Magnesium Project area, and evergreen monsoon vine-forest occurs upstream of the project area. These vegetation communities are described below.

Dry Vine-forest on Dolomite Outcrop (Map Unit 6)

Dolomite outcrops support a dry vine-forest community, covering less than 14 ha (4%) of the site. While this community represents only a minor proportional area of the site it is floristically rich and supports a suite of species not normally associated with the more widespread *Eucalypt* woodland communities. Vine-forest species are frequently fire-sensitive and may be largely restricted to habitats associated with permanent water or to fire-protected rocky outcrops. At the site there is one significant outcrop (near Tungu Rocks) supporting a dry vine-forest in an open forest formation with occasional palms and abundant vines. The other smaller narrow rocky ridge supports a more open canopy habitat with vine-forest elements.

Common upper stratum species in this community include the rainforest coloniser species *Acacia auriculiformis,* tall *Erythrophleum chlorostachys* and *Ficus* spp. Common canopy species include *Terminalia microcarpa, Timonius timon* and *Nauclea orientalis.* In areas where the canopy is closed, a mid-stratum layer may be relatively sparse with the ground layer characterised by vines, seedlings and saplings of upper stratum species. Common vines include *Tinospora smilacina, Parsonsia velutina, Smilax australis* and *Abrus precatorius*. Patches of *Hypoestes floribunda* and ferns including *Cheilanthes contigua* and *C. nitida* are particularly common ground level species.

Dense weed infestations are characteristic of the fringes of these areas with Class B noxious weeds *Hyptis suaveolens, Cassia obtusifolia* and *Pennisetum polystachion* recorded. The smothering vines *Passiflora foetida* and *Calopogonium mucunoides* were also extremely thick in this community.

Evergreen Monsoon Vine-forest (Map Unit 7)

Immediately upstream of the project area, Coomalie Creek (Right Branch) is bordered by a zone of evergreen monsoon vine-forest, probably associated with springs or permanent water at depth. This community is more extensive than vine-forest patches within the project area although during the Dry Season field survey, was not found to be more diverse floristically. Weed species were less common and were present in low numbers, restricted to the fringes.

The dominant upper stratum species, *Syzygium nervosum,* occurs in association with *Terminalia microcarpa* and *Acacia auriculiformis* forming a closed-canopy vine-forest formation. Other canopy species include *Carallia brachiata, Erythrophleum chlorostachys, Lophostemon grandiflorus* and *Sesbania formosa.* The orchid, *Dendrobium affine* was common on the upper limbs of riparian trees. Ground orchids are also expected to occur in this habitat during the Wet Season.

3.4.1.4 Weeds

The site currently contains dense weed infestations patchily distributed within all major habitat types. Of particular significance is the distribution and abundance of the tall, introduced grasses *Andropogon gayanus* (Gamba Grass) and *Pennisetum polystachion* (Mission Grass). Sixteen weed species were recorded on the site (**Table 3.6**), seven of which are declared noxious weeds Class B (*NT Weeds Management Act, 2001*). The most common noxious weeds observed were *Pennisetum polystachion* (Mission Grass), *Hyptis suaveolens* (Horehound) and *Sida cordifolia* (Flannel Weed).

Table 3.6
Weed species recorded at the proposed mine site

Weed Species	Common Name	Classification
Ageratum conyzoides		—
Andropogon gayanus	Gamba Grass	—
Calopogonium mucunoides	Calopo	—
Capsicum annuum	Bird’s Eye Chilli	—
Cassia fistula	Golden Shower Tree	—
Hibiscus sabdariffa	Rosella	—
Hyptis suaveolens	Horehound	Noxious, Class B
Lantana camara	Lantana	Noxious, Class B
Melia azedarach	Neem Tree	Native, introduced to area

Weed Species	Common Name	Classification
Passiflora foetida	Wild Passionfruit	—
Pennisetum pedicellatum	Mission Grass	—
Pennisetum polystachion	Mission Grass	Noxious, Class B
Senna obtusifolia	Sicklepod	Noxious, Class B
Sida acuta	Spinyhead Sida	Noxious, Class B
Sida cordifolia	Flannel Weed	Noxious, Class B
Stachytarpheta spp.	Snake Weed	Noxious, Class B

Note: The classification is based on the NT *Weeds Management Act*, 2001 and no classification (-) means it is not a declared 'noxious' weeds.

Of the 16 weed species observed, several species were recorded in very low densities including *Lantana camara*, *Melia azedarach*, *Hibiscus sabdariffa, Capsicum annuum*, *Ageratum conyzoides* and *Cassia fistula*. No aquatic weeds were recorded in the survey and wetland habitats were relatively intact overall.

Weed infestations are typically concentrated in disturbed areas, such as roadsides, along tracks and seismic lines and around mines and associated infrastructure. Riparian habitats and the fringes of monsoon vine-forest are also key habitats, where a wide variety of weed species were recorded. Further, riverine habitats are often subject to intermittent natural disturbance from flooding and are prone to impacts from feral animals. *Hyptis suaveolens*, *Stachytarpheta* spp. and the smothering vine *Calopogonium mucunoides* and *Passiflora foetida* were all found in such habitats.

3.4.2 Terrestrial Fauna

The vertebrate fauna of the project area was assessed through reference to existing studies and a field survey conducted in July 2001. Full methodology and results of the fauna survey is presented as Appendix G and fauna survey sites are depicted in **Figure 3.6**.

The field survey used a range of standard techniques, such as live trapping with Elliot and pitfall traps for small mammals and reptiles, mist netting, harp trapping and electronic detection for bats, standard census methods and recording of calls for birds, active searches, night spotlighting, hair funnels and scat analysis.

Fauna habitats within the study area were defined with reference to topography, vegetation communities and soils. The distribution of fauna may also depend on other factors, such as the availability of open water, fire history and availability of microhabitat and other resources. These factors were also considered when assessing the fauna habitats present.

Six vegetation communities have been identified within the project area and one just off site has also been described. The vegetation communities occur within three broad habitat types; upland, drainage and rainforest areas. Anthropogenic activities within the study area have created a number of artificial habitats, including a mine pit.

A total of 122 native and four introduced terrestrial vertebrate species were recorded during field surveys in the project area. Terrestrial vertebrates recorded include 6 amphibian, 21 reptile, 74 bird and 21 native mammal species. Four introduced mammal species occur within or adjacent to the project area. A complete list of fauna species recorded, along with habitat and site detail are provided in Appendix G.

Amphibians

Six native amphibian species were observed within the project area, including representatives of 2 families (Myobatrachidae and Hylidae). Amphibian species were generally associated with wetter microhabitats within the areas sampled, including riverine forests, creek margins and in the vicinity of other water-bodies and mine pits. Species most frequently observed during the survey included Bilingual Frog (*Crinia bilingua*), Javelin Frog (*Litoria microbelos*), Striped Rocket Frog (*Litoria nasuta*) and Wotjulum Frog (*Litoria wotjulumensis*). The majority of amphibians were identified by spotlight survey on creek and waterbody margins, with two species (*Crinia bilingua* and *Litoria nasuta*) captured in pitfall traps on the margin of Coomalie Creek (Right Branch). At the time of survey the amphibian species richness and abundance was highest at sites on the main Coomalie Creek (Right Branch) drainage line and within riverine habitat associated with this drainage line. It is likely that Wet Season surveys would record additional amphibian species within the project area.

Reptiles

Twenty-one reptile species were identified during the survey, including representatives of six families. These included 4 geckos (Gekkonidae), 3 agamid lizards (Agamidae), 3 monitor lizards (Varanidae), 3 skinks (Skinkidae), 1 python (Boidae) and 1 elapid snake (Elapidae). Pitfall traps captured 5 skink species and 1 agamid species (*Diporiphora bilineata*). One reptile species, Mitchell's Water Monitor (*Varanus mitchelli*), was captured in an Elliott trap set on the margins of Coomalie Creek (Right Branch). The majority of reptiles identified within the project area were encountered during active searches of habitats during the day, during spotlight survey and incidentally within bushland areas and rock outcrops.

Reptile species richness and abundance was highest in the Tungu Rocks area, which reflects the variety of microhabitat (riverine margins, rock outcrops, vine forest on rocks and open forest) and the presence of permanent water at this site. Survey sites that included riverine habitats and fringing vegetation on Coomalie Creek supported high reptile abundance and species richness when compared to sites situated in open forest and woodland sites. A number of reptile species, including *Gehyra nana*, *Diporiphora albilabris* and *Liasis olivaceus*, were associated with rock outcrops and scree areas.

Mertens Water Monitor (*Varanus mertensi*), Mitchell's Water Monitor (*Varanus mitchelli*), Swamplands Lashtail (*Lophognathus temporalis*) and Freshwater Crocodile (*Crocodylus johnstoni*) were recorded in riparian forest and instream habitat along Coomalie Creek and/or in and around water filled test and mine pits in the local area. Reptile species frequently observed in dry open forest and woodlands within the project area include *Heteronotia binoei*, *Oedura rhombifer*, *Diporiphora bilineata*, *Carlia munda* and *Menetia greyii.*

Birds

Seventy-four bird species were observed within the project area during the survey period. This figure represents approximately 36% of the bird species known from the region (Griffiths *et al.* 1997). Bird species richness was relatively high given the limited duration of the survey, the absence of seasonal sampling and the nature and extent of the habitats present. The majority of species (approximately 60) inhabit primarily dry open forest and woodland habitats and are widely distributed in northern Australia. The remaining species include birds associated with wetlands and freshwater habitats and a limited number of species that primarily occur in riverine forests and vine thickets.

Open *Eucalyptus tetrodonta, E. miniata* and mixed eucalypt forest and woodlands displayed a low richness and abundance of birds during the survey period when compared to riparian forests, vine forest remnants, *Melaleuca* forest and vegetation associated with permanent water.

The highest number of bird species at any survey site (36 species) was recorded in mixed eucalypt forest, vine thicket and riparian/wetland habitat, and two other sites on Coomalie Creek (Right Branch) registered similarly high numbers of bird species (29 and 26 species, respectively). These results are indicative of the importance of riparian habitat and forests adjacent to permanent water for birds in the Dry Season. While fewer species were recorded at sites some distance from the main drainage line these areas supported significant numbers of forest birds. A number of waterbirds were observed on the larger pools on Coomalie Creek (Right Branch) and at mining pits within the local area.

Three nocturnal bird species, Tawny Frogmouth (*Podargus strigoides*), Southern Boobook Owl (*Ninox boobook*) and Barking Owl (*Ninox connivens*) were recorded during spotlighting within the project area. While five diurnal raptor species were recorded across the project area, only 2 species (Black Kite *Milvus migrans* and the Brown Goshawk *Accipiter fasciatus*) were commonly observed.

Mammals

Twenty-five mammal species were identified during the survey, including representatives from fourteen families, including four introduced species. Microchiropteran bats (eight taxa) and rodents (five taxa) were the most species rich mammal groups within the study area. Mammals were identified using live capture/release, characteristic tracks and signs, scat and hair analysis, call identification, observations during spotlight surveys and from diurnal observations. Hair and scat analysis identified a number of species that were not recorded using other survey methods.

Two Dasyurid species, Northern Quoll (*Dasyurus hallucatus*) and Red-cheeked Dunnart *(Sminthopsis virginiae nitela*), were identified within the project area. The Northern Quoll was captured in Elliott traps and identified from scats at a number of sites in a range of habitats, including *Lophostemon* woodland, *E. tetrodonta/E. miniata* woodland and vine thicket on rock outcrops. The Red-cheeked Dunnart was present in grassland adjacent to magnesite/dolomite outcrops at Tungu Rocks.

The Northern Brown Bandicoot *(Isoodon macrourus)* was common in all habitats within the project area, and was frequently recorded during spotlight survey, from hair analysis, from Elliott trap captures and was occasionally flushed from dense grass during diurnal surveys. Diggings and tracks characteristic of this species were noted at a number of sites, and diggings were common in riparian areas and black soil floodplain areas.

Five native murid (rodent) species were recorded within the project area. Grassland Melomys (*Melomys burtoni*) was the most commonly captured rodent, and was observed or captured in the riparian corridor along Coomalie Creek, *Lophostemon* woodland in the vicinity of the existing pit and in vine forest south of Tungu Rocks. This species may migrate between nearby habitats (such as riparian areas and rainforests) in response to flooding or seasonal fluctuations in food supplies. The Common Rock-rat (*Zyzomys argurus*) was common in dry vine thicket on rocky outcrops in the vicinity of Tungu Rocks, and burrows, runs and caches of *Terminalia* sp. seeds attributed to this species were noted in the vicinity of the rocks. Pale Field Rat (*Rattus tunneyi*) was captured in Mixed Eucalypt woodland *E. tetrodonta/E .miniata* woodland, and characteristic burrows and runs were noted throughout these habitats. The Dusky Rat (*Rattus colletti)* was less common and appears to be restricted to floodplain areas dominated by grassy understorey and Melaleuca woodland.

Two species of macropod were recorded within the project area. The Agile Wallaby (*Macropus agilis*) was recorded in Mixed Eucalypt woodland, *E. tetrodonta/E. miniata* woodland and *Melaleuca* woodland. The Antilopine Wallaroo (*Macropus antilopinus*) was also recorded in Mixed Eucalypt woodland and riverine forest. These species are likely to be widespread in the local area and tracks and scats indicated frequent utilisation of riparian habitats.

The Dingo (*Canis lupus dingo*) was recorded in the project area from direct observations and indirect methods (tracks, scats) in woodland to open forest. The small number of dingo/dog scats obtained within the project area contained Northern Brown Bandicoot hairs, indicating that this species may be a locally important prey item.

Survey using bat echolocation call detection and analysis recorded eight species. Species recorded include Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*), Northern Freetail-bat (*Chaerephon jobensis*), Beccari's Freetail-bat (*Mormopterus baccarii*), Gould's Wattled Bat (*Chalinolobus gouldii*), Northern Bentwing Bat (*Miniopterus oceanensis*) and Pygmy Long-eared Bat (*Nyctophilus walkeri*). The most common call type within the project area has been assigned to either the Hoary Wattled Bat (*Chalinolobus nigrogriseus*) or the Little Broad-nosed Bat (*Scotorepens greyi*): calls from Top End populations of these two taxa cannot be confidently separated. A number of additional calls characteristic of long-eared bats (*Nyctophilus sp*.) could not be identified to species level and may represent one or more additional bat species within the study area. In addition to the Pygmy Long-eared Bat, three *Nyctophilus* species that cannot be identified by echolocation calls occur in similar habitats in the Top End (*Nyctophilus bifax, Nyctophilus geoffroyi* and *Nyctophilus arnhemensis*).

3.4.3 Aquatic Ecology

The aquatic ecology of the Batchelor Magnesium Project area was assessed through reference to existing studies, and through a field survey conducted in July 2001. The full methodology and results of the aquatic survey is presented in a report provided as Appendix H, and reference to aquatic flora is available in Appendix F.

Coomalie Creek (Right Branch) widens in several areas to form small waterholes or refuge pools for local fauna, providing habitats for a range of aquatic and semi-aquatic plant species. The field survey collected information on aquatic habitats, water quality, plants, fishes, aquatic insects, molluscs and crustaceans. Standard methods were used and included seine and dip netting, trapping, night spotlighting, and bank-side and diving observations.

Three aquatic habitats were identified in the project area: semi-permanent streamlines; permanent refuge pools; and man-made open water pits. Sampling was carried out at six sites covering every habitat. A summary of the habitat characteristics at sampling sites is provided in Table 2, Appendix H.

The Coomalie Creek (Right Branch) flows right through the project area. Within the project area, Coomalie Creek (Right Branch) is a small, ephemeral stream with a clearly defined channel. In the western (upstream) portion of the project area, the stream is intermittent, and flows through a series of braided channels. Further downstream, the banks are clearly defined, and water flows appear to be nearly permanent. Several small permanent waterholes are present in the eastern portion of the project area, and the stream flows through rocky country with scattered dolomite outcrops. The stream crosses Crater Lake Road about 500m downstream of the eastern boundary of the project area. At this point, there is a large permanent rock pool that is used by the public for recreational swimming, picnics and informal camping.

Two mine pits from the original Sundance Mine and the Winchester deposit trial pit, are located in the area. Each pit was inundated at the time of the field surveys. These pits are flooded by Coomalie Creek (Right Branch) during the Wet Season, and aquatic fauna is able to colonise them at that time.

Aquatic Plants

In total, eight species of aquatic plants were recorded during the survey. Aquatic plants were abundant along Coomalie Creek (Right Branch), especially in the permanent waterholes such as that near Tungu Rocks (Tungu Rocks waterhole), where the most species were found and growth was profuse. In other areas, such as along the streamline and in the open cut pits, aquatic vegetation was sparse or non-existent. A notable species was the aquatic fern, *Helminthostachys zeylanica,* that was common throughout the area in slow flowing reaches.

The aquatic vegetation shows distinct zonation across the creek bed and some seasonal variation also. The typically narrow steep-sided creek channel provides habitat for the fern *Ceratopteris thalictroides* and submerged herbs *Blyxa* sp. and *Najas* sp. are abundant in deeper pools and fast flowing creek sections. The upper banks support the delicate fern *Canscora diffusa* as well as the introduced Bladey Grass.

Common semi-aquatic and emergent species recorded in the main channel include *Cyperus aquatilis, Staurogyne leptocaulis* and *Pogostemon stellatus*. As the creek dries out in the Dry Season, the creek bed supports species such as *Eleocharis geniculata*, *Nelsonia campestris* and the fine grass *Pseudoraphis spinescens*. Some aquatic herbs have a robust emergent form that can withstand Dry Season conditions, including *Hygrophila angustifolia*, *Persicaria attenuata* and *P. barbata*.

Deeper pools support *Hydrilla verticallata*, *Najas* sp., *Blyxa* sp. and *Ceratopteris thalictroides* on the muddy sand margins. *Nymphaeae violaceae* (Water Lilies) are characteristic of the deeper pools.

Fishes

A total of 16 species of freshwater fishes were recorded during the survey with anecdotal evidence indicating the seasonal presence of a further 5 species. This represents a comparatively rich variety considering the total known fish fauna for nearby Litchfield National Park, representing a Finniss River drainage system, is 21 species (Griffiths et al 1997). The two refuge pool sites exhibited the highest variety of fish species, with 13 and 11 species respectively, while the two open water mine-pit sites had the lowest species variety, with only five and six species respectively. The most frequently observed fish species were Ox-eyed Herring (*Megalops cyprinoids*), Chequered Rainbowfish (*Melanotaenia splendida inornata*) and Spangled Grunter (*Leiopotherapon unicolour*), which were recorded at all sites. Hyrtl's Catfish (*Neosilurus hyrtlii*), Black-banded Rainbowfish (*Melanotaenia nigrans*) and Purple-spotted Gudgeon (*Mogurnda mogurnda*) were recorded at four or more of the sites. All fish species, except three, were recorded at Tungu Rocks waterhole, probably due to the permanent nature of this waterhole.

All fishes observed were adults or sub-adults, and there was no evidence that recent breeding had taken place. This is expected during a mid Dry Season survey, as freshwater fishes breed mainly during the Wet Season (Larson & Martin 1990).

The largest species observed in the survey were Mouth Almighty (*Glossamia aprion*) and Ox-eye Herring. Although Sooty Grunter (*Hephaestus fuliginosus*) and Sharp-nosed Grunter (*Syncomistes butleri*) can grow to a large size, only sub-adult individuals were recorded.

Anecdotal evidence from locals suggests that some species may have been introduced to the Sundance mine pit for angling purposes. However, results of the survey show that all but one of the species recorded there are locally common and native to the adjacent stream. Futhermore, none of the species recorded is highly regarded for angling.

A previous survey of the Coomalie Creek (Left Branch) in the vicinity of Woodcutter's Mine recorded thirteen fish species (Bywater et al 1991). Two of these species, Spotted Blue-eye (*Pseudomugil gertrudae*) and Sleepy Cod (*Oxyeleotris lineolata*) were not recorded in the current survey, but may well be present within the project area. Additionally, anecdotal evidence suggests that Barramundi (*Lates calcarifer*), Archer Fish (*Toxotes chatareus*) and Saratoga (*Scleropages jardini*) are seasonally present at the Batchelor Road crossing of Coomalie Creek (Left Branch) (Bywater et al 1991).

Other Aquatic Vertebrates

Freshwater crocodiles (*Crocodylus johnstoni*) were observed in the Sundance mine pit, and in the permanent Tungu Rocks waterhole. No freshwater turtles were recorded during the survey. Two species of aquatic monitor lizards (*Varanus mertensi* and *V. mitchelli*) were recorded in the area and evidence of the Water Rat (*Hydromys chrysogaster*) was observed at Tungu Rocks waterhole.

Crustaceans and Molluscs

The survey recorded five species of crustacean and two molluscs (Table 5; Appendix H). Sites along the semi-permanent stream line and in refuge pool habitats had the highest diversity. The two open pit habitats had a poor diversity of molluscs and crustaceans.

Giant Freshwater Prawns (*Macrobrachium rosenbergii*) were commonly observed at most riverine sites, and were observed to be particularly active at night. Macroinvertebrate netting commonly yielded this species as juvenile examples. Other crustaceans recorded included Red-claw Crayfish (*Cherax quadricarinatus*), Freshwater Crab (*Holthusiana transversa*) and 2 species of shrimp. The only molluscs recorded were the Freshwater Mussel (*Velesunio angasi*), and a species of small gastropod.

Aquatic Insects

A total of 28 taxa of aquatic insects representing six orders and 18 families were recorded during this survey. The most diverse orders were Ephemeroptera and Trichoptera, with six taxa each, and Coleoptera and Diptera, with five taxa each.

A total of 606 individual animals were collected at six sites. The numbers of individuals in each sample ranged from several catches of only one animal up to 55. The orders Ephemeroptera (mayflies) and Coleoptera (beetles) were the most numerous groups in terms of overall numbers collected. The mayfly *Leptophlebiidae* sp 3 was the most common, occurring at four sites in large numbers. Other common taxa were two species of Coleoptera found at four sites, and a Chironomid (midge) found at all sites.

The highest number of taxa and highest numbers of individuals were recorded at a semi-permanent flowing stream near Sundance mine pit, and a permanent refuge pool adjacent to Crater Lake Road. These sites also had the highest ranking diversity indices. The two open pit sites had very low diversity by comparison, with a total of only five individuals from two species at both sites.

3.4.4 Introduced Species

Three introduced vertebrate fauna species were recorded during field surveys within the study area; the feral horse (*Equus caballus*), feral cat (*Felis catus*) and feral pig (*Sus scofra*). An additional species, the feral European Cattle (*Bos taurus*), occurs in the local area. It is likely that feral or domestic dogs (*Canis lupus familiaris*) also occur within the local area.

Feral pigs appear to be relatively common, with marks and tracks indicating frequent use of riparian and riverine habitats within the project area. Signs of disturbance caused by feral pigs were noted at all sites associated with permanent water or major drainage lines, and this species is likely to be the most numerous and significant introduced species in terms of numbers and disturbance. Small numbers of feral horse are known to occur in the local area and signs of their presence were noted in riparian vegetation at one site. One feral cat was observed on the main access track during spotlight survey, and this species is expected to be moderately common in the local area.

Introduced weed species are discussed in **Section 3.4.1.4**.

3.4.5 Biting Midges and Mosquitoes

A brief survey of biting midges and mosquitoes at the proposed site and surrounding area was conducted by the MEB of THS in July 2001 (**Figure 3.6)**. The purpose of the survey was to assess potential biting insect problems, investigate breeding sites and assess potential impacts of the development on biting insect problems. A full report by the MEB is provided as Appendix I.

Trapping activity was conducted overnight on 25 July 2001, with eight sites on and adjacent to the proposed mine site surveyed. Mosquitoe and biting midge abundance are heavily influenced by seasonal trends and this survey does not cover all temporal variability in biting insect populations. Other surveys conducted by MEB have been used to supplement data and give a broader regional indication of biting insect presence and problems. Data from a survey of the nearby Woodcutters Mine and from a survey conducted near Palmerston, Darwin, were used to compare results and to provide additional temporal and regional information.

Biting Midges

Biting midges were surveyed and found not be present in significant abundance. A total of 395 biting midge specimens were collected, representing nine different species. There were eight *Culicoides* species and one *Forcipomyia* species collected. *Culicoides marksi* is the only species of the nine recorded on site that is a potential pest to humans.

Seasonal biting midge trends, extrapolated from regional sites, indicate that peak numbers of *C. marksi* occur in July. Minimal numbers of this pest species were found at the proposed mine site (surveyed in July) suggesting they will not reach numbers that would constitute a significant problem.

Mosquitoes

Mosquitoes trapped totaled 1,851 adults and represented 13 different species. Most (1,835) were female. *Culex annulirostris* (the common banded mosquito) was the most frequently trapped species and *Coquillettidia xanthogaster* (the golden mosquito) the next most abundant. All species were found in relatively low abundances in the July survey. In extensive seasonal surveys conducted at the nearby Woodcutters Mine, these two species were also found to be the most common. Based on seasonal baseline monitoring conducted at Woodcutters Mine these species are likely to pose a low to moderate pest problem between January and July.

Several other species were present in lower numbers, including *Ochlerotatus normanensis* (the floodwater mosquito) and *O. vigilax* (the salt marsh mosquito). These species are likely to pose a greater pest problem than indicated by their relative abundance due to their persistent biting habits and day biting activity. However they are likely to provide only brief but intense seasonal problems during December and January.

Murray Valley Encephalitis, Ross River virus and Barmah Forest disease are all diseases harmful to humans, transmitted by mosquitoes known to exist in the area. Amongst mosquito species detected at the site were some known vectors of these diseases and included the species *Culex annulirostris*, *Ochlerotatus normanensis* and *O. vigilax.* Even though malaria is absent from the Northern Territory, a secondary mosquito vector for malaria was found at the site (*Anopheles annulipes*). The risk of these mosquitoes harbouring the malaria virus is very low, but their presence should be noted.

3.4.6 Fire

Similar to tropical savannas throughout the world, fire is an annual event in the landscape of northern Australia, with up to 50% of the region burnt each year (Williams 1995). Field surveys of the proposed lease area indicate a pattern of frequent, extensive burning with roughly 80% of the site burnt during the 2001 Dry Season. Coppicing from lignotubers, the sparse mid-stratum layer, the species present and abundant grasses all suggest frequent, annual burning within the site.

3.4.7 Ecological and Conservation Significance

Natural habitats have intrinsic conservation significance that is difficult to quantify and not often recognised, but have value to factors such as clean air and water, biological diversity and environmental stability. The concept of ecological and conservation significance is both subjective and relative and requires consideration and discussion in a local and regional context.

3.4.7.1 Plants and Communities of Conservation Significance

The project area contains common and widespread vegetation types of low conservation value in the local and regional context. It is anticipated that the proposed development will have a negligible impact on the conservation values of the vegetation in the area.

The majority of the site is classified as savanna, which is characteristic of the monsoonal tropics where there is a distinct Dry Season and where fire is a major factor determining vegetation structure. Minor areas of *Lophostemon* and Paperbark communities exist at the site but are regionally common and widespread.

The development could impinge upon plant communities adjacent to the site, in particular the evergreen monsoon vine-forest located along Coomalie Creek upstream of the site. This is a relatively extensive vine-forest patch and is quite intact, with weed species restricted only to its fringes. The area has some aesthetic and ecological value and is consequently of local significance as a habitat to fauna and for maintaining habitat heterogeneity and water quality.

None of the 172 plant species recorded during the survey are classified as rare, endangered or valuable. Species were checked against local (Northern Territory Herbarium database), regional (Connors, Oliver and Woinarski, 1996) and national (Briggs and Leigh 1988; Leach *et al.*1992;) lists of plants of conservation significance.

Indeed, rarity is unlikely, given the extensive clearing involved with previous land uses and the current frequency of fire. Further, the absence of plant communities of restricted distribution or vegetation types known to contain a high proportion of rare species (sandstone escarpment habitats or spring-fed rainforest for example) significantly reduces the likelihood that rare and endangered flora would occur in the project area.

A number of species endemic to the Northern Territory were recorded in the project area, including *Flemingia trifoliastrum*, *Livistona humilus*, *Briedelia tomentosa*, and *Lophostemon lactifluus.* Eleven percent of the flora is endemic to the Northern Territory, however these species are locally common and do not have declared rare status (Leach *et al.*1992).

Some species present at the site are listed as "protected" by Northern Territory Environmental Legislation (Schedule 8, Regulation 15 of the *Territory Parks and Wildlife Conservation Act* 1994). This legislation protects species of the families Cycadaceae and Orchidaceae (cycads and orchids) from collection or removal from bushland unless it is part of the lawful use of the land. *Cycas armstrongii* (cycad), *Dendrobium affine* and *Cymbidium canaliculatum* (orchids) were recorded at the site. While these species are protected and hold some intrinsic ecological value, their presence does not preclude development in areas with appropriate zoning or development approval.

3.4.7.2 Fauna Species of Conservation Significance

The level of significance of species of conservation interest was assessed with reference to Territory and Commonwealth legislation, and a number of recent references. Relevant legislation includes the *Northern Territory Parks and Wildlife Act 2000* (Parks & Wildlife Commission of the Northern Territory 2000) and the Commonwealth *Environment Protection & Biodiversity Conservation Act 1999* (*EPBC Act 1999*). Action plans for particular fauna groups were also reviewed, including Cogger *et al.* (1993) for reptiles, Tyler (1997) for frogs, Maxwell *et al.* (1996) for marsupials and monotremes, Duncan *et al.* (1999) for bats and Garnett & Crowley (2000) for birds. The conservation status of freshwater fishes was assessed with reference to Wager & Jackson (1993).

Amphibians and Reptiles

The frog species recorded within the study area are predominantly species which have their known distribution centred on the sub-humid tropical and semi-arid tropical regions of northern Australia, including the Top End, the Kimberley region of Western Australia and the southern western Gulf of Carpentaria. Some have been recorded in conservation reserves in the region. Griffiths et al. (1997) noted the presence of one significant amphibian, the microhylid frog *Sphenophryne adlephe*, within Litchfield Park. This species was not recorded within the study area. None of the amphibian species recorded within the study area are listed as significant (*EPBC Act 1999*; *Northern Territory Parks & Wildlife Act 2000*; Tyler 1997).

Habitats within the study area support reptile species that are generally common in the region, and none of the taxa recorded are considered to be regionally significant (Griffiths *et al.* 1997) or threatened by relevant conservation authorities (*EPBC Act 1999*; *Northern Territory Parks & Wildlife Act 2000*; Cogger *et al.* 1993).

Birds

Bird species present during the survey period are generally common in the region, and none of the taxa recorded are considered to be regionally significant (Griffiths *et al.* 1997) or threatened by relevant conservation authorities (*EPBC Act 1999*; *Northern Territory Parks & Wildlife Act 2000*; Garnett & Crowley 2000). Existing regional records for birds listed as 'vulnerable' in the *Northern Territory Parks & Wildlife Act 2000* and/or the Action Plan for Australian Birds (Garnett & Crowley 2000) include the Gouldian Finch (*Erythrura gouldiae*), Partridge Pigeon (*Petrophassa smithii*) and

Painted Snipe (*Rostratula bengalensis*). The Gouldian Finch is known to occur in the south-west of Litchfield National Park (Griffiths *et al.* 1997) but habitat within the project area is unlikely to be suitable for this species. Although the Partridge Pigeon was not recorded in the field survey, this species is considered likely to make occasional use of woodland habitats within the project area, as it is locally common in Litchfield National Park and widespread in the region (Griffiths et al 1997).

Mammals

Mammal species present within the project area during the survey period are generally common and widespread in the region, and none of the taxa recorded are noted as critically endangered, endangered or vulnerable by relevant conservation legislation (*EPBC Act 1999*; *Northern Territory Parks & Wildlife Act 2000*).

Two species present within the project area, (the Northern Quoll and Pale Field-rat) are listed as 'lower risk - near threatened' in the *Northern Territory Parks and Wildlife Act (2000).* Local records for the Northern Quoll indicate that this species is widespread in the region, with records from Litchfield, Tipperary, Elizabeth Downs and Mt Bundey Stations and Petherick's Rainforest (Griffiths *et al.* 1997). Although the Northern Quoll is considered locally common and widespread in the Litchfield area its distribution in northern Australia has been substantially reduced and is becoming increasingly restricted and disjunct (Braithwaite & Griffiths 1994). Analysis of its distribution indicates a 75% range reduction in northern Australia and possible causes for decline/potential threats include impacts associated with grazing, the expansion in range of the cane toad and exotic disease (Braithwaite & Griffiths 1994). Research suggests that this substantial reduction in range is directly related to habitat disturbance, suggesting that this species cannot maintain populations in sub-optimal environments that have been disturbed (Griffiths *et al.* 1997).

Regional records for Pale Field-rat include Litchfield, Tipperary, Elizabeth Downs Station and Petherick's Rainforest (Griffiths *et al.* 1997). Although the Pale Field-rat is locally common and widespread in the Litchfield area, museum records indicate a contraction in its overall distribution in the last 100 years. A decline in distribution of 85% has reduced it from having a continental distribution to a fragmented distribution, with the north-western and central east coast of Australia/southern Queensland coast, remaining as the most significant habitat and/or refuge habitat (Braithwaite & Griffiths 1996). Impacts primarily relate to habitat modification, loss of local refuges, loss of vegetation cover, and impacts associated with the low level of groundwater reducing the availability of refuge riparian habitat and the additional impact of introduced mammals including grazing impacts and soil compaction (Braithwaite & Griffiths 1996; Watts & Aslin 1981).

The Pale Field-rat was recorded in one habitat within the project area, *E. tetrodonta/E. miniata* woodland to open forest. Hair tube records and observations of characteristic burrows and runs indicate that it is relatively common in this habitat across the project area.

Freshwater Fishes

None of the fish species recorded during the survey, or from other studies in the Adelaide River catchment near Coomalie Creek, are regarded as threatened (Wager & Jackson 1993). The species occurring in Coomalie Creek are all common and widespread species that are well adapted to harsh seasonal conditions (Martin & Larson 1990). None of the aquatic invertebrate fauna occurring in the area is known to be of conservation value.

3.4.7.3 Habitats of Conservation Significance

Vine Forest and Dry Vine Thicket (Rainforest) on Rocky Outcrops

Small areas of vine forest and dry vine thicket occur in association with rock and scree outcrops within the project area. At some sites, larger areas of this vegetation occur, while at other sites fire has reduced this vegetation to a number of remnant trees associated with larger rock outcrops. This habitat supports the highest species diversity for amphibians, reptiles, birds and mammals in the project area. A range of fauna species that are not present in other areas of the project area, including saxicoline taxa such as the Common Rock-rat, the gecko *Gehyra nana* and birds associated with vine forest vegetation were also recorded in this habitat. These areas are also likely to act as significant refuges for open forest and woodland species and may be seasonally significant to particular species.

Riverine and Melaleuca Swamp Forest Communities

Riverine forests represent a restricted habitat, distinct from the *Eucalypt* dominated communities that cover a large percentage of the study area. These communities, although limited in size, support unique microhabitats acting as refuge habitats and facilitating movement of fauna species in the local landscape. Surveys indicated that these areas support a high percentage of fauna species, a result highlighting the significance of this habitat to wildlife during the Dry Season. The Northern Quoll (near threatened) was recorded in *Lophostemon* woodland.

Eucalyptus Dominated Communities

Eucalyptus dominated communities are the most extensive communities in the project area. These communities support two significant (near threatened) fauna species and support a diverse range of forest birds and reptiles. These areas displayed a notable paucity of arboreal marsupials potentially related to past clearing and fire regimes. However these areas of forest represent significant habitat for a range of bird, bat, reptile and ground mammal fauna species and are likely to attract larger numbers of birds and bats during mass flowering of canopy trees.

Permanent Refuge Pools

Permanent waterholes along Coomalie Creek offer refuge habitats to the aquatic fauna of the area when the stream dries late in the Dry Season. These pools had the highest diversity of aquatic life recorded in the survey, and are therefore of conservation interest at a local level. The most significant of these pools is the Tungu Rocks waterhole, but there are several others in that area. The refuge pool at the Crater Lake Road crossing is not important to the aquatic biota, but is a local recreational site.

Terrestrial fauna, including crocodiles, water rats, and aquatic monitors use these pools. They are also locally important to waterbirds.

3.5 Socioeconomic Environment

3.5.1 The Coomalie Region

The project area lies within the Coomalie Region (Coomalie), which encompasses the townships of Batchelor, Adelaide River and Lake Bennett (*Coomalie Planning Concepts and Land Use Objectives*, 2000). The region begins 70 km south of Darwin, at Acacia, and extends to 5 km south of Adelaide River. Coomalie is bordered by the Adelaide River to the east and Litchfield National Park to the west. Batchelor township is the administrative centre of the Coomalie region.

3.5.2 Tenure and Zoning

The project area is located within the Coomalie Community Council, Hundred of Goyder, Land Portion 2831. Currently the land has freehold status with active Exploration Licenses 9501 and 9253. Within the area covered by these, Mt Grace has made application for Mineral Lease N1984 covering 357 ha.

The Darwin Regional Land Use Structure Plan, 1990, outlines planning and development objectives for the Northern Territory. The Coomalie sub-region (including the Mt Grace project area and surrounding areas) is considered important to the Darwin region mostly for its valuable mineral and water resources. Subsequently the *Coomalie Planning Concepts and Land Use Objectives*, 2000, has been developed and provides legislative framework for development within this region.

3.5.3 Horticulture and Agriculture

Horticulture is an expanding industry in the Coomalie region and is mainly concentrated on fertile soils along watercourses and areas with high groundwater potential. Various horticultural products are currently grown, including bananas, rambutans, squash, mangoes, rockmelons, tomatoes, cucumbers, pumpkin, zucchini, watermelon, capsicum, chilli, Chinese cabbage, lemons, grapefruit, avocados and other tropical fruit (*Coomalie Planning Concepts and Land Use Objectives*, 2000).

A significant forestry industry exists and is expanding in the Batchelor region. Oil and timber are the primary products from this industry and have an international market. Indian Sandalwood is grown for oil extraction and American Mahogany is used as a host plant for Sandalwood seedlings, which in turn is harvested for craft-quality timber. Neem, a fast-maturing tree harvested for medicinal purposes, is also grown. A large multi-species plantation lies directly east of the site.

Some cereal crops such as rice, maize and sorghum (for stockfeed) are cultivated in the region. Most farms support mixed cropping.

Cattle production is a major agricultural activity across some of the Coomalie region, primarily for slaughter and live-export purposes. Many cattle are transported to the region from such areas as the Kimberley region, Barkly Tablelands and Queensland to be held for short-term agistment prior to their transportation to Darwin for live export. The transport of hay and stockfeed to the Coomalie area is expensive, encouraging some local pastoralists to develop on-site feed supplies. There is an increasing trend for mixed farming operations combining agistment, hay and crop production and horticulture.

3.5.4 Mining and Extractive Industry

The Coomalie region is considered to have a moderate to high mineral potential, with regard intensity of mineral occurrence and presence of suitable host rock. Uranium is an abundant resource but is not currently being considered for extraction in the area. There are concentrations of ore around the Rum Jungle area, a decommissioned uranium mine just outside of Batchelor. Lead-zinc occurrences have been identified for their commercial significance, as has magnesite within the Coomalie Dolomite sequence.

Woodcutters Mine, approximately 14 km north-east of Batchelor was in operation for over 10 years, extracting lead, zinc and silver. It was recently decommissioned and is now undergoing rehabilitation. Compass Resources NL (Compass Resources) is well advanced in the completion of a feasibility study for the 'Browns' Polymetallic Project, located approximately 5 km north-west of Batchelor (NT

Minerals Council *Minerals and Petroleum Seminar*, 2001). Compass Resources propose to mine and process ores of copper, lead, cobalt and nickel.

3.5.5 Water Resources in the Coomalie Region

The Coomalie region encompasses four main catchment areas: Darwin River Dam catchment, Manton Dam catchment, Mount Bennett Dam catchment and Marrakai Dam catchment areas (*Coomalie Planning Concepts and Land Use Objectives*, 2000). The Coomalie region is the main source of potable water for Darwin and Coomalie. The Darwin River Dam is the primary source and all human activity and building/development is prohibited within its boundaries. Manton Dam is a back-up water supply but is not a closed water supply, being available for recreational purposes.

Significant supplies of groundwater are available in the central Coomalie region, where Batchelor is located, and supplies extend in two major arcs to the north and the south. The groundwater in these areas would be sufficient to support large-scale horticultural and agricultural production. The rest of the region has moderate groundwater supplies, enough to support a much smaller domestic or agricultural development.

3.5.6 Residential, Commercial and Industrial Land Use

Within Coomalie there is a mixture of urban and rural residents. Batchelor is a low to medium density development with detached-style housing being most common and caravans reasonably abundant (*Coomalie Planning Concepts and Land Use Objectives*, 2000). There is a surplus of housing and accommodation for the current workforce and some local workers commute to Coomalie. For prospective industrial development in the region, primarily from the mining industry, a new area has been zoned for housing development.

Commercial and retail businesses are located in Batchelor but are limited. Many people travel to Darwin for their commercial and business requirements and will often purchase other household commodities and consumables whilst there. There are three business zones to service the local industry within the Batchelor township. Batchelor, being in the geographic centre of Coomalie, services most of the outlying regions and is considered the business epicentre.

There is an industrial precinct in Batchelor catering for industrial, light industrial and service commercial land uses. There are a limited number of industrial businesses currently operating in Batchelor.

3.5.7 Infrastructure and Services

Transportation

Transportation infrastructure is provided mainly by the Stuart Highway, which traverses the Coomalie region. This is a major highway connecting Coomalie to Darwin and to other arterial transport routes of Australia. Darwin is approximately 85 km from the project area. Batchelor Road is a sub-arterial road connecting Batchelor and Litchfield National Park to the Stuart Highway and runs past the proposed mine-site. This is a wide, sealed road, maintained in good condition.

Most other connecting roads in the region are unsealed and used to service the rural community and agricultural and pastoral land activities. These roads are of variable quality and maintenance status, and access can be restricted in the Wet Season. Crater Lake Road is an unsealed road utilised by cement trucks from the Boral Concrete Batching Plant (located on Crater Lake Road) and local people. The development of another arterial road to Batchelor has been proposed, running from

Batchelor through Litchfield National Park and re-joining the Stuart Highway at the northern end of Coomalie (*Coomalie Planning Concepts and Land Use Objectives*, 2000).

The Darwin to Alice Springs Railway (AustralAsia Railway) is planned to run through the Coomalie region, just west of the Stuart Highway and is in the initial phases of construction. This may provide transportation infrastructure for industry in the region.

Batchelor Air Field services light aircraft traffic in and around the area. It is owned by the Northern Territory Government and is classified as an "Authorised Landing Area" (*Darwin Regional Land Use Structure Plan, 1990*). It could become a licensed aerodrome if the demand for tourist charter flights makes it an economically viable option. The Batchelor Air Field is a base for some local recreational activities and is used as headquarters for several recreational associations, including the Northern Gliding Club, the Top End Aerial Sports Academy and the Darwin Parachute Club.

Utilities

Utilities are well developed in Batchelor. A major electricity transmission line runs parallel to the Stuart Highway from the Channel Island Power Station in Darwin Harbour to Katherine, connecting Coomalie to the electricity grid. The south-western portion of Coomalie is not connected to the grid and thus poorly serviced (*Coomalie Planning Concepts and Land Use Objectives*, 2000).

Batchelor is serviced by a reticulated sewerage system and the outlying rural areas serviced by septic tanks and other on-site waste disposal systems. Batchelor is also serviced by reticulated water while most of the rural areas are serviced by bores and/or rain water tanks.

Coomalie is mostly well serviced by terrestrial and microwave telephone networks. Some of the more remote areas within Coomalie require satellite phone telecommunications. Despite its close proximity to Darwin, Coomalie does not have mobile phone coverage. The local community and council have been campaigning for such a service and hope to have mobile phone service in the near future.

3.5.8 Education

The Batchelor Area Primary School provides primary and secondary schooling until Year 10. The Northern Territory Open Education Centre in Batchelor offers a limited service for Years 11 and 12. Associated with the Batchelor Area School is the Batchelor Outdoor Education Unit, which is often used by schools in Darwin and its outlying regions.

Batchelor Institute of Indigenous Tertiary Education (Batchelor Institute) is located in Batchelor township and is the largest specialist indigenous educational facility in Australia. The main campus is located in Batchelor but there are remote study centres throughout communities in the Northern Territory and some in southern Australia. Approximately 2,000 students attend the Institute from across the Northern Territory, about a quarter of whom are located at the central campus.

The Coomalie Cultural Centre, located in Batchelor, has been initiated and progressively developed by the Batchelor Institute. The Centre is intended to contribute to the Batchelor Institute's education program and provide a focus for the development and practice of indigenous visual and performing arts. The Centre attracts international and local tourists visiting the region, adding cultural value to the township.

3.5.9 Health

The Northern Territory Government, through THS, provides health care throughout the Northern Territory at hospitals, health centres and community care centres. Territory Health Services run a health centre in Batchelor, providing a 24-hour emergency service, infant health clinic and palliative care. A doctor is accessible part-time and other services are available by appointment.
The closest hospitals to Batchelor are located 88 km to the north in Tiwi, Darwin, where there is a large (289 bed) public hospital (the Royal Darwin Hospital) and a 150 bed private hospital (Darwin Private Hospital). The hospitals cater for medical, surgical, obstetric, paediatric and other specialist services as well as providing emergency services. The facilities are further augmented by three community health centres and a range of medical practitioners, specialists and dentists.

3.5.10 Recreation and Tourism

Batchelor has good access to recreational facilities and significant natural resources. The Dry Season climate is conducive to outdoor activities with camping and water sports being popular. Batchelor is well serviced with sporting and leisure facilities, including playgrounds, ovals, tennis courts, basketball courts, a bowling green and swimming pool. The Batchelor Air Field supports a range of recreational activities including gliding and parachuting.

Water-related sports and leisure activities are popular, Manton Dam being a major recreational resource. Skiing, power boating, fishing, swimming and sailing are popular at Manton Dam. Rum Jungle Lake and Crater Lake, both located on the outskirts of Batchelor, are also used for recreation and water activities.

Tourism is a major industry in the Northern Territory, and the Coomalie region has important resources related to the industry. Litchfield National Park is the most well known tourist attraction in the region and Batchelor is at the gateway to the Park. It services the tourist population passing through with information, fuel, services and consumable items.

Covering an area of approximately 1,500 km^2 within the Finniss River Catchment, Litchfield National Park is a prime recreational and tourism resource for Batchelor, Darwin and the Northern Territory. An estimated 350,000 interstate and international tourists visit the Park each year. Litchfield is very popular with local Darwin residents, due to its close proximity, easy all-year access and good camping and swimming locations. The eastern boundary of Litchfield National Park is located 15 km west of the Batchelor Magnesium Project.

Litchfield National Park lies across parts of three different bio-regions (Parks and Wildlife Commission of the Northern Territory, 1996), resulting in a large array of habitat types being present. There is a high diversity of both plants and animals existing in the Park as a consequence of the range of habitats. Some species are of conservation significance, and the Park has been set aside as a reserve, to protect their habitats and populations. Litchfield is unique for its representativeness of a diversity of habitat types, plants and animals.

Due to increasing development and growing population in the Top End, Litchfield National Park is an increasingly important resource not only for tourism, but also for its biodiversity and scientific research potential.

World War II activities are well documented throughout the region and relics and historical sites are of value to the tourism industry. The Batchelor region is also an important archive for developments in agriculture (Batchelor Demonstration Farm), transport and communications. There are plans to develop a regional museum for WWII materials, alongside a history of mining, agriculture and transportation in the area.

3.5.11 Demographic Profile of Coomalie Region

Batchelor has a population of 645, Adelaide River 274, Lake Bennett approximately 120 and the entire Coomalie region 1,615 people. The population profile by age is provided in **Table 3.7.**

Table 3.7
Population by Age: Coomalie Region

Age	%
0 - 9 yrs	18.39
10-19 yrs	12.71
20-29 yrs	12.78
30-39 yrs	18.11
40-49 yrs	13.21
50-59 yrs	12.85
60+	11.95

Source: Coomalie Community Profile, April 2001

The Aboriginal population is an integral part of the Northern Territory's history and culture, with 27% of the Northern Territory population comprising indigenous people.

3.5.12 Archaeology and Heritage

A detailed archaeological survey of the project area was undertaken by Heritage Surveys in June 2001, and the complete report is included as Appendix J.

The proposed mine-site was surveyed by pedestrian transects at intervals of 30 to 40m (**Figure 3.7**). In addition to the examined transects, erosion gullies and disturbed areas were inspected closely because of increased ground surface visibility in these areas.

One historically significant site and six archaeologically significant sites were identified in the survey. An iron pole from the historic Overland Telegraph line and six archaeological artefact scatters (labelled Coomalie Creek 1-6) were documented as significant sites.

The significance of each identified site was assessed with respect to "representativeness" and "archaeological research potential". These criterion concern the extent to which the archaeological remains within the site are represented at other localities within the region and the potential for them to contribute to timely and specific research questions.

The Overland Telegraph was built in 1872 between Darwin and Adelaide, connecting Australia for the first time to the rest of the world (NT Government, 2000). The Overland Telegraph pole relic, called an "Oppenheimer Pole" holds some significance through its historical association with this important development in Australian history. However, the pole identified on the site has been removed from its original context, and there is no evidence to indicate its function. The pole is therefore regarded to possess a low level of historical significance.

The paucity of historical archaeological materials within the proposed site was noted as surprising, given the historical significance of the Batchelor Experimental Farm and the widespread and significant Second World War military activities in the Batchelor area.

There were five prehistoric artefact scatters associated with rock-shelters and one open artefact scatter identified in the project area (Figure 3.7). Three types of stone artefacts: flakes, cores and retouched flakes, were identified within the artefact scatters. Details of the artefacts surveyed are summarised in **Table 3.8**.

Table 3.8
Summary of Archaeological Sites

Site	Size	Type	Comments
Coomalie Creek 1	1.0m x 0.3m	Artefact scatters associated with a rockshelter.	Artefacts are visible where the ground surface has been eroded by water associated with driplines of rock shelter overhangs. It is thus possible that additional, subsurface deposits may be present at the proposed mine-site.
	0.2m x 0.2m		
Coomalie Creek 2	10m x 15m		
Coomalie Creek 3	0.2m x 0.2m		
	0.4m x 0.2m		
Coomalie Creek 4	15m x 2m		
Coomalie Creek 5	5m x 1.5m		Quartz scatters
Coomalie Creek 6	12m x 5m	Open artefact scatter	Artefacts have been excavated by animals, suggesting the possibility of additional, sub-surface artefacts.

The artefact scatters found on site are all of a similar nature. They consist of clusters of artefacts ranging from 0.2m x 0.2m to 15m x 10m in extent. Nearly all of them are associated with rock outcrops and rock shelters. Some artefacts have been exposed and disturbed by digging animals. This could suggest the presence of more subsurface artefacts that are not yet exposed. Some of the clusters were found directly beneath rock overhang driplines and have been exposed by consequent water erosion. This also implies that there may be additional, as yet uncovered, subsurface artefacts.

Under the *Northern Territory of Australia Heritage Conservation Act (1991)* a prescribed archaeological place is defined as "… a place pertaining to the past occupation by Aboriginal or Macassan people that has been modified by the activity of such people and in or on which the evidence of such people exists….". All the prehistoric archaeological artefacts found in the project area fall within this definition. Any disturbance or damage to these artefacts will be carried out only by Ministerial consent, under sections 29 and 30 of the Heritage Conservation Act. It should be noted that the artefacts existing here are all of low archaeological significance as they are commonly represented throughout the region and are of moderately low research potential.

3.5.13 Anthropology and Aboriginal Sites of Significance

The project area is located within an area acknowledged as being the traditional country of the Kungarakany and Warai People, who are thus considered the Aboriginal custodians of this area. There are areas of spiritual significance emanating from, and particularly associated with registered sacred sites within the project area and other sites of significance adjacent to the project area, with ancestral trails passing in close proximity.

On 6 February 2001, the AAPA issued an 'Authority Certificate' for the Batchelor Magnesium Project. The certificate includes the identification of four registered and one recorded sacred site (5171-87, 5171-108, 5171-109, 5171-112 and 5171-114) and conditions attached to its issue. The location and conditions of the sites is presented in **Table 3.9** and the Authority Certificate attached as Appendix L.

Table 3.9
Sacred Sites, Batchelor Magnesium Project

Sacred Site	Location
5171-87	Dolomite outcrop, Tungu Rocks, associated with a permanent waterhole.
5171-108	Associated with archaeological site, Coomalie Creek 4.
5171-109	Outcrop of dolomite immediately North of Sundance Mine, close to artifact scatter.
5171-112	Small outcrop of dolomite, approximately 200m from 5171-109.
5171-114	Banks and bed of Coomalie Creek.
Conditions	
No damage to sacred sites 5171-87, 108, 109 & 112.	
No exploration or mining personnel to sacred sites 5171-87, 108, 109 & 112.	
All personnel must be aware of the conditions of the AAPA Authority Certificate.	
All personnel must be aware of Section 40(1) of the *Northern Territory Aboriginal Sacred Sites Act* 1989 which provides that the AAPA certificate does not negate the need for consent, approval or permission for the subject works or use of the land.	
No direct run-off of contaminants including water with high sediment load into Coomalie Creek.	

Ref: AAPA Certificate, Batchelor Magnesium Project, 6 February 2001.

Consultations were carried out with relevant Custodians, all of whom were women associated with the project area (Appendix K). The discussions were aimed at investigating perceptions and values held by the Custodians of the project area, and their concerns about possible impacts on sites and areas of significance to them.

Land granted to the Kungarakany and Warai Custodians under the Finniss River Land Claim (1981) lies to the immediate north and to the south-east of the project area. The project area itself is freehold land and is not subject to any land claim under the *Aboriginal Land Rights Act 1976*. The long history of various types of leases over the subject area makes it highly unlikely that an Application for Native Title under the *Native Title Act 1993* would be lodged.

It is evident that the past century of European activities in the region has caused severe disruption to the regional Aboriginal people. The Kungarakany and Warai were removed from the land and displaced by European expansion. The Kungarakany were affected by movements of other Aboriginal groups that were under pressure from European expansion.

Aboriginal people in this area also felt impacts of WWII. After air attacks on Darwin in 1942, the Military established compounds at a number of locations. Aboriginal people were, as far as possible, moved from other areas, including traditional bush camps, and resettled into such compounds. Kungarakany and Warai people remained living in areas between Adelaide River, Humpty Doo and Darwin. Since the Finniss River Land Claim they have moved permanently onto parts of the claimed land (near the project area).

The Custodians consider all subsurface water and water courses to be of spiritual significance. The Custodians have an intimate understanding of the relationships between the regional subsurface hydrology (including Litchfield National Park), and the surface drainage, and are particularly concerned about any activity that impedes or impacts these landscape features.

The Custodians have retained traditional knowledge in relation to land in and around the project area, including the sacred sites. They respect the significance of the land and sacred sites through their ancestry to current custodianship. They feel a strong sense of attachment to the country and a responsibility to maintain the land and its viability.

4 ENVIRONMENTAL EFFECTS AND ASSESSMENT

This section identifies and, where appropriate, quantifies the primary biophysical and socio-economic effects expected to result from the development of the proposed mine and processing facility. It identifies specific project activities requiring environmental management and provides an outline of associated control measures. This section is structured according to the main issues and effects resulting from both construction and operation activities of the proposed mine, which are also presented in **Table 4.1**.

4.1 Flora

Vegetation in the project area comprises six vegetation communities within three zones: upland communities, drainage areas and rainforest communities. No endangered plant species or special vegetation communities are present in the lease area.

The major impact to flora of the proposed mine (to Stage 3) will be the clearing of approximately 30% of existing vegetation within the project area for construction of the pit, haul and access roads, ROM pad, waste dumps, processing plant and storage facilities. Also the diversion of a 1.2 km section of Coomalie Creek (Right Branch) will have a significant impact on flora. Other potential impacts include alteration to species composition and increased weed infestations due to changes in water flow and clearing activities.

Construction

A total of approximately 112 ha (about 30%) of existing vegetation will be cleared for construction of the mine and associated infrastructure. Detail of the required clearing works is provided in **Table 4.2**.

Table 4.1
Summary: Potential Environmental Effects and Management Measures

Environmental Factor	Existing Environment	Potential Impacts	Environmental Management	Predicted Outcome
SOIL				
Dust and noise *Refer Sections 4.9 and 5.2.9*	There is some dust generated during the Dry Season. The site is currently well vegetated with native and introduced species that act to stabilise soil and prevent excessive dust generation. There is currently no mining or industrial activity creating noise in the area.	Significant dust levels could be generated (especially from construction and mining activities in the Dry Season). Noise will result from construction, mining and blasting activity.	Dust will be monitored and water will be used for dust suppression. Areas will be progressively re-vegetated to minimise dust generation and erosion. Daytime blasting and construction will minimise noise nuisance value. The public will be notified of blasting schedules. Mining on a 'campaign' basis for a defined period of each year will ensure noise is limited. Noise will be monitored at the boundary of the project area.	Dust generated due to mining and processing activities will be kept at manageable levels. Noise levels will be maintained within appropriate guideline levels.
Soil erosion *Refer Sections 3.3.6, 4.8 and 5.2.8*	The site is currently subject to ongoing natural erosion and deposition processes.	Increased erosion from disturbed areas or stockpiles or as a result of concentrated surface water runoff. Increased turbidity of runoff water entering Coomalie Creek (Right Branch) within and downstream of the site. Siltation of Coomalie Creek downstream of the site.	Implement soil conservation measures, stabilise drainage outfall points, schedule construction work during the Dry Season where practical. Ensure flood waters are accommodated by the Coomalie Creek diversion channel and retain hydraulic characteristics of the original stream and floodplain.	Increased turbidity during construction however not likely to result in long term impact. Minimal risk of erosion/turbidity during operation.
WATER				
Lowering of groundwater table, recharge of water to aquifers, diversion of Coomalie Creek (Right Branch), runoff from plant and mine site, and water quality *Refer Sections 2.11.2, 3.3.7, 3.3.9, 4.6, 4.7, 5.2.6 and 5.2.7*	Water table is at a depth of less than 5m below the surface during the Dry Season. During the Wet Season the water table is at, or about, the ground surface. Natural recharge occurs during and after each Wet Season. No discharge waters are currently released into the environment at the site. Coomalie Creek (Right Branch) in the area of the proposed mine site flows intermittently during the Dry Season as a result of seepage from the local superficial aquifer. The existing creek line includes a small low-flow channel and a floodplain in the area of the proposed mine site. Runoff is currently seasonal; high runoff rates occur during the Wet Season; during the Dry Season flows are largely the result of seepage from the local superficial aquifer.	Dewatering of the pit will cause the water table outside the pit to lower, the effect diminishing with distance from the mine. Dewatering of pit will provide water that will be released to Coomalie Creek (Right Branch). Some of this water will recharge downstream aquifers. Course of Coomalie Creek (Right Branch) and associated floodplain changed; vegetation removed; stream cross-section and hydraulic characteristics changed. Erosion may occur until vegetation and final creek form is established. Runoff in Coomalie Creek (Right Branch) below the mine site increased, particularly during the Dry Season.	To minimise the need to treat dewater to remove suspended solids before release to the surface environment as much groundwater inflow as practical will be intercepted by pumping from shallow production bores (10m to 20m deep) outside the pit. Design of the diversion channel and floodplain aims to retain hydraulic characteristics of the original stream and floodplain. Implement soil conservation measures; dumps to be stabilised; sediment or pollutants in runoff water to be collected/intercepted in settlement ponds prior to discharge. Settling ponds will be used to limit the amount of suspended sediment in discharge water. Regular program of water quality monitoring of discharge water and water run-off from the waste dumps to ascertain effectiveness of settling ponds and alter treatment regime where required.	Based upon current data, groundwater drawdown within Coomalie Creek (Right Branch) beyond 2km of the pit should not exceed 1m. Water levels will return to pre-mining levels and pit will refill after first Wet Season following completion of mining. Local floodplain hydraulic characteristics will be irreversibly changed, however no noticeable effect is expected at the larger catchment scale. Increased flows not likely to adversely affect the environment as the stream already flows as a result of seepage. There will be negligible impact on the quality of groundwater resulting from dewatering the mine and minimal impact on water quality of Coomalie Creek (Right Branch).

Environmental Factor	Existing Environment	Potential Impacts	Environmental Management	Predicted Outcome
		Potential for erosion from dumps, disturbed areas or drainage outfalls causing increased turbidity and siltation of the downstream environment; potential transport of pollutants to the downstream environment. Decrease in water quality as a result of increased sediment loads. Sediment in water may cause increased turbidity and siltation of the downstream environment; poor water quality may damage the downstream environment.		Risk of impacts from increased turbidity is small. No likely adverse effects from run-off from plant and mine site.
FLORA				
Vegetation clearing *Refer Sections 3.4.1, 4.1 and 5.2.1*	Extensive Eucalypt woodlands dominate the upland vegetation with open woodlands fringing a narrow riparian corridor along Coomalie Creek (Right Branch). Small patches of floristically distinctive vine-forest occur on dolomite outcrops. Evergreen monsoon vine-forest occurs upstream of the project area. No endangered plant species or special vegetation communities have been recorded in the lease area.	Loss of vegetation during construction will result in clearing of ~ 30% of the project area during Stages 1-3, with approximately 92 ha of woodland vegetation and 14 ha of drainage line communities cleared. Waste areas will largely be located within mixed Eucalypt woodland with the crusher, plant and storage located further up-slope in *E. tetrodonta/E.miniata* open woodland. Clearing of vegetation may encourage the spread and proliferation of weeds and increases in the distribution of Gamba Grass and Mission Grass would dramatically increase the fire hazard.	Mine layout is designed to minimise loss of vegetation and conserve areas of restricted distribution and of importance to fauna, such as vine-forest on rocky outcrops. As far as possible vegetation will be retained to: • reduce erosion and sedimentation; • maintain a visual buffer from the Batchelor Road; • reduce sediment loads in run-off; and • minimise the spread of weeds. Construction adjacent to riparian areas will be minimised where possible to protect riverine areas from negative impacts, including increased siltation and changes in drainage. Construction activities will be restricted to specified areas. Movement of construction vehicles will be managed to ensure minimal loss of trees.	The communities to be cleared are well represented elsewhere within the surrounding region. No significant adverse ecological impacts are anticipated as long as environmental management guidelines are adhered to eg, monitoring and control of weeds, sediment loads and pollution. The implementation of weed and fire management plans designed for the project area will reduce weed distribution and abundance and will result in protection of native vegetation respectively.
Diversion of Coomalie Creek *Refer Sections 2.11.2, 4.1 and 4.7*	Coomalie Creek (Right Branch) is a narrow, intermittent stream with, in places, a distinct, incised channel. Vegetation clearing will be required such that a 1.2 km section of the creek will be diverted, via a flood diversion channel to the south of the current alignment. Vegetation within the current drainage way and alluvial flats associated with Coomalie Creek will be cleared for siting of the proposed pit. Tracts of similar riparian habitat occur outside the boundary of the lease area and are represented in reserves elsewhere in the region.	Approximately 1.2 km of riparian vegetation will be affected by the creek diversion. Some areas of riparian vegetation not cleared prior to mine construction may survive if water table levels remain sufficiently high. The new creek alignment and floodway may provide habitat suitable for colonisation by native aquatic plant species and wetland communities.	Clearing will be kept to the minimum necessary for construction of the diversion bund. Clearing within drainage lines will be selective and minimised to prevent erosion and habitat loss. Regular surveys of lowland areas and the creek channel will be undertaken to control the introduction and spread of aquatic and floodplain weeds (eg: *Mimosa pigra*).	Initially, a loss of riparian and lowland habitat will occur and unless water quality is maintained, aquatic ecosystems will be adversely affected. New habitats will be created in which colonisation of riparian vegetation will occur. If the new flood channel is well designed, the loss of habitat should be balanced in the long term by expansion of new riparian areas.

Environmental Factor	Existing Environment	Potential Impacts	Environmental Management	Predicted Outcome
Indirect vegetation changes *Refer Sections 4.1 and 5.2.1*	Native vegetation across the project area is in reasonably good condition. Disturbance from grazing and agriculture has resulted in high numbers of weeds and exploration for mining and extensive terrain disturbance around adjacent mines has led to major sources of weeds both within and around the project area. Upland vegetation is well drained and although drainage in lowland areas may be slow, with extensive waterlogging in the Wet Season.	Changes in patterns of drainage, seepage and sedimentation are expected to lead to loss of riparian vegetation immediately downstream of the diversion bund. Upstream monsoon vine forest vegetation may be affected if major changes in water retention or drainage occur. Gradual shifts in species composition will occur within the new flood channel and creek alignment with upland species diminishing and species requiring high soil moisture (eg: Paperbark and *Lophostemon* communities) increasing in these areas. Proliferation of weeds from increased disturbance may alter fire regimes – dramatic increases in fuel loads result from Gamba Grass infestations.	Development of the mine will be undertaken according to sound principles of environmental management and within the scope of an approved MMP. Ongoing monitoring during each stage of the development will be undertaken to detect and if occurring, monitor major indirect changes to flora within the project area and in upstream and downstream locations. Outcomes of monitoring will form an input to rehabilitation works completed.	Riparian vegetation and species characteristic of drainage ways are expected to colonise the new flood channel. Colonisation will be minor and regionally insignificant. No major indirect changes to vegetation are anticipated if environmental guidelines are followed and site monitoring is undertaken (particularly focussing on weeds and water quality).
Weeds *Refer Sections 4.3 and 5.2.3*	In the project area weed infestations are common in the major habitats but are particularly dense in disturbed areas. Sixteen introduced species were recorded, seven of which are declared noxious weeds (Class B), with the most important noxious weeds to control in the vicinity of the mine considered to be *Hyptis suaveolens, Sida acuta, Stachytarpheta* spp. and *Senna obtusifolia*. Although not a declared weed, Gamba Grass (*Andropogon gayanus*) represents the most serious environmental weed and fire hazard on the site.	Extensive clearing of native vegetation and terrain disturbance will create favourable conditions for the proliferation of weed species. Significant increases in weed species growth will increase the risk of high intensity fires. The new floodplain channel may provide suitable conditions for weed species such as *Mimosa pigra*.	Weed management and prevention measures will include preparation of a Weed Management Plan for the project area. Strategies will include: • earthmoving equipment washed-down prior to entering the lease area to prevent weed spread; • weed removal from selected areas; • control of class B weeds including select chemical control; • slashing of fire breaks; and • annual weed surveys/ monitoring.	Management of weed issues will reduce the risk of weed introduction and the extent of infestations, and will restrict the further spread of weeds.
FAUNA				
Terrestrial fauna *Refer Sections 4.2 and 5.2.2*	There are three broad habitat types in the project area, each supporting a different fauna assemblage. A total of 122 native and 4 introduced terrestrial vertebrate species were recorded during field survey works. The riparian corridor is an important habitat for animals. The Northern Quoll and the Pale Field-Rat are both listed as 'lower risk – near threatened' in the *Territory Parks and Wildlife Conservation Act, 2001*.	Vegetation clearing will reduce available terrestrial fauna habitats within the project area. Project development will also result in disturbance to terrestrial fauna habitat. Severance to the riparian corridor. Disturbance to significant species and their habitats.	Clearing of vegetation will be minimised where possible and consideration for significant habitats will be made. The riparian corridor will be re-established along the new creek diversion, to encourage use by fauna. The rocky outcrops and monsoon rainforest were the more significant habitats for the Northern Quoll and Pale Field Rat, and these areas will be avoided during development of the mine.	The Northern Quoll and the Pale Field Rat will not be significantly impacted by the proposed development. The design of the proposed site development footprint will minimise the requirement for clearing, disturbance and indirect impact to habitats that support a range of and diversity of fauna within the project area.

Environmental Factor	Existing Environment	Potential Impacts	Environmental Management	Predicted Outcome
Aquatic fauna *Refer Sections 3.4.3 and 5.2.2*	Coomalie Creek (Right Branch) is an intermittent stream with some permanent refuge pools. The creek supports a relatively diverse assemblage of aquatic fauna.	Loss or disturbance of habitat, particularly permanent refuge pools. Reduction of habitat diversity along the creek. Change in species colonisations from resident habitat to transient habitat. Increase in flow/volume rates from pit dewatering that could affect nutrient levels and water quality downstream of the mine.	The creek diversion will be designed with inclusion of an excised creek channel, modelled from the existing creek channel to ensure the retention of permanent refuge pools along the creek. Soil conservation measures will be implemented to limit the amount of suspended sediment in water discharged to Coomalie Creek.	The creek will be temporarily disrupted, until the re-establishment of a riparian corridor to support the existing aquatic fauna community. Refuge pools will be maintained to support aquatic communities and the creek channel will be re-established over time. Flow rates and volumes will be significantly increased downstream of the pit resulting in a possible shift in aquatic community composition (to species better adapted to such conditions).
Feral Animals *Refer Sections 4.3 and 5.2.3*	Feral animals are present in low numbers across the project area.	The presence of humans and increased activity may result in a decrease in the numbers of feral animals.	Feral animals will be managed on an 'as required' basis.	Feral animals will not increase in numbers and they may decrease due to increased eradication effort.
BITING INSECTS				
Breeding sites for mosquitoes, Coomalie Creek and associated creek lines *Refer Sections 4.4 and 5.2.4*	Mosquitoes have been surveyed and, although found in relatively low number, certain species will periodically be present in significant numbers due to seasonal fluctuations in population.	Mosquito-breeding habitats may be created by alteration of the existing environment (via earthworks and ground disturbance). The settlement ponds and septic tanks are likely to provide suitable breeding habitats for biting insects. The diversion of Coomalie Creek could lead to small excised sections creating pooling and thus mosquito-breeding habitats. Prolific reed growth along the riparian corridor may result in creation of mosquito-breeding sites.	Management of biting insect will include: • drainage designed to prevent ponding of water in low-lying areas; • native fish populations maintained in settlement ponds to assist in control of larval mosquito numbers; • buildings positioned away from low-lying areas; • regular clearing of vegetation in vicinity of buildings; • clothing, repellents and antiseptic creams will be available to all personnel on site; • screening of staff facilities; and • staff induction. The creek diversion will be designed to recreate the defined nature of the central channel. Creek margins will be revegetated with trees to discourage marginal grass and reed growth. Any cut off sections of an altered creek created by a diversion will be filled and levelled to prevent pooling. Silt traps will be constructed in the upper arms of the major creek or its tributaries that are likely to receive silt from construction or operation activities.	Mosquitoes will be present on-site and will be more prominent during the Wet Season but not in such abundance so as to result in a significant nuisance. Designing the creek diversion to be similar to that already there will minimise impacts on the existing environment. If management measures are employed (such as silt traps) then mosquitoes will not be a significant problem.
FIRE REGIME				
Refer Sections 4.5 and 5.2.5	Frequent, extensive burning of project area and surrounds currently occurs. The presence of Gamba Grass decreases the effectiveness of early season, cool burns.	Reduction in frequency, timing and spread of fires if strict fire management plan is implemented. Frequent, high intensity fires if the spread of Gamba Grass around the project area is unchecked.	Development of a comprehensive Fire Management Plan in coordination with Bushfires Council. The plan will include: • fire break construction; • reduction of flammable fuel loads by slashing/chemical control of tall grasses; • protection of fire-sensitive flora; and • promotion of habitat heterogeneity.	A reduction in the frequency and intensity of fires will result in a shift in vegetation species composition towards a denser mid-stratum layer, including fire-sensitive monsoon forest species. Frequency, timing and spread of fires should be reduced due to site access restrictions, construction of fire breaks and safety regulations. This will have a positive impact on the protection of fire-sensitive vine-forest and riparian vegetation. Increased habitat heterogeneity through improved fire management practices may improve wildlife habitat quality.

Environmental Factor	Existing Environment	Potential Impacts	Environmental Management	Predicted Outcome
ATMOSPHERIC EMISSIONS				
Air emissions *Refer Sections 4.10.1 and 5.2.10*	While there is no ambient air quality data available for the region, existing air quality is expected to be good given the rural nature of the area, and the lack of either urban population or industry. On occasion suspended and deposited particulate levels may be elevated due to windblown dust, agricultural activities or bush fires.	Some increase in airborne particulate matter is expected as a result of construction and operation activities. Maximum ground level concentrations of pollutants are anticipated to be well below ambient air quality guideline limits in most instances. The primary exception is in relation to short-term concentrations of particulates, as PM_{10}, where there may be the potential for elevated levels especially during intermittent mining activity such as drilling and blasting (to occur 17 days in the first year).	Water sprays would be used (as required) across work zones, stockpiles and unsealed areas to suppress dust. Areas of excavation or works would not exceed the capacity of the water spray units. Blasting or particularly dusty works will be scheduled under favourable meteorological conditions only. Earth moving activity will be suspended where wind speeds exceed 30 km/hr. All major access roads would be sealed and vehicle speeds on unsealed areas will be strictly controlled to minimise dust. Vehicles will not be loaded above the height of the side and tailboards. Dust controls will be provided on all exhaust points from transfer and handling of grain and other dry bulk product, and baghouses would be provided for drillers used in the pit. The conveyor belts will be covered to minimise dust emissions. Fines to be mixed with slag before disposal to minimise windborne emissions. Any long-term stockpiles will be stabilised using fast-seeding grass or synthetic cover spray. Windbreak for limestone stockpile in Stage 3. Exposed areas will be minimised through rehabilitation as soon as practicably possible.	Slight increases in background pollutant concentrations are expected, although levels are predicted to be well below health-based guideline limits at either of the two nearest residences or the Batchelor township. Potential elevation of downwind particulate concentrations, in particular during short-term intermittent drilling and blasting activities. These will be minimised through dust minimisation measures during construction and operation of the Batchelor Magnesium Project.
Greenhouse *Refer Sections 4.10.2 and 5.2.11*	No significant anthropogenic sources of greenhouse gas (GHG) emissions are currently present in the project area.	There will be no direct potential impact due to the emission of any GHG from the Batchelor Magnesium Project. The project will represent an extremely small contribution to global emissions of GHG.	Mt Grace will establish an inventory of emissions, develop an Action Plan to minimise GHG emissions, forecast expected reductions in GHG emissions, and monitor and report emissions on a regular basis as agreed with the Australian Greenhouse Office (AGO). The Action Plan will include capital projects that improve energy or chemical conversion efficiencies, such as: • operating procedures that improve energy or chemical conversion efficiencies; • management initiatives and improvement programs that make "small step" GHG benefits; • use of alternative or renewable energy technologies; and • research and development projects with the potential to reduce GHG emissions.	Insignificant local/regional impact as a result of construction and operation activities. The production of magnesium for use in other industries will contribute to weight reduction and hence to energy savings and consequent GHG emission reduction.
WASTE AND WASTE DISPOSAL				
Refer Sections 2.12, 4.11 and 5.2.13	No significant anthropogenic waste is presently generated at the site.	Potential impacts include: • reduced water quality of receiving waters from runoff from the waste dumps; • contaminated runoff from workshop/washdown areas; • reduced air quality from waste gases produced during the operational phase; • increased volumes of waste deposited at the local landfill; and • waste removed offsite to inappropriate locations.	Runoff from waste dumps will be collected in settlement ponds and periodically tested before release to Coomalie Creek. A triple interceptor trap will be installed to remove potentially oily discharge water from workshop/washdown area. The plant will be designed to adequately vent any dangerous gases during the operating phase. The	There will be an increase of the quantity of waste disposed to local landfill. Minimal adverse effects on the receiving environment from on-site operations and waste disposal.

Environmental Factor	Existing Environment	Potential Impacts	Environmental Management	Predicted Outcome
			plant design and management will be in accordance with Workhealth requirements. Waste tracking documentation will be kept and regularly reviewed.	
SOCIO –ECONOMICS				
Economic environment in Batchelor and the Northern Territory *Refer Section 4.12*	Batchelor is a small township of about 650 residents. The main industry is agriculture, horticulture, tourism and service industries. There are currently no operating mines in the area.	The mine will enhance the local economy primarily by creating employment opportunities and injecting a significant amount of money into the town through the purchase of goods and services. The mine will be the first magnesium mine and processing facility in the Northern Territory.	Local people will be employed where the appropriate skills and qualifications are available. Mt Grace will utilise local goods and services where possible.	There will be increased employment locally and an enhanced skill base regionally. The local goods and service industry will benefit from the proposed project and there will be opportunity for economic growth. The mine will add significant economic value to the Northern Territory economy, the effects of which will spread to a range of services, businesses and industries.
Employment *Refer Section 4.13*	There is currently a shortfall in employment opportunities in Batchelor and the wider Coomalie region.	The development of the mine will create 120-130 jobs during construction and about 73 permanent jobs during operation.	Workers will be sourced locally, from Darwin or from elsewhere according to availability of appropriate skills.	There will be a local and regional boost in employment and a diversification of skill base in the region.
Education *Refer Section 4.14*	Batchelor has one primary school and the main campus and administrative headquarters for Batchelor College.	The mine could be used as an educational resource with organised tours and educational activities focussed on the mining industry.	Mt Grace will help develop and facilitate the enhancement of education at the Batchelor Area Primary school and the Batchelor College related to the mining industry.	Educational opportunities of the local community will be broadened given the integral part the project will play in the area.
Tourism *Refer Section 4.12*	Batchelor township services the local tourist industry, incorporating Litchfield National Park.	There is potential for an adverse effect on the tourism industry due to a conflict with the natural value and aesthetics of the area.	Mt Grace will develop a community education program which will incorporate mine tours and public educational material providing tourism opportunities in the area.	The mine will be a significant development in the area but will not interfere with the natural value of areas such as Litchfield National Park. Benefit will be derived from the mine being used as an educational tool and a potential tourist attraction.
Housing and accommodation *Refer Section 4.14.3*	There is currently limited accommodation available in Batchelor for large, temporary workforces.	The construction workforce will total approximately 120 – 130 people, a significant proportion of which will require temporary accommodation. The ensuing permanent workforce may face housing shortages in Batchelor and with no current plans for expanding residential development areas.	A temporary accommodation facility will be established, possibly at a local caravan park. Some of the workforce may commute from Darwin and some new houses will be built in Batchelor.	A significant proportion of the workforce is likely to elect to reside in the Batchelor area and the township/environs is likely to experience consequent residential growth.
TRAFFIC				
Light vehicle and heavy vehicle traffic *Refer Section 4.15*	Currently Batchelor Road is well used by local residents of Batchelor and also by tourists accessing the Batchelor township and Litchfield National Park. Crater Lake Road is primarily used by local residents, for access to the Stuart Highway when travelling south, Crater Lake swimming hole and the privately operated concrete batching plant. Stuart Highway is the major arterial road linking Darwin and Batchelor and the Northern Territory with other national arterial roads. It is heavily trafficked by local, interstate and international travelers and by road trains.	Batchelor Road will be utilised by the local workforce to access the site, with occasional transportation of heavy machinery anticipated. Crater Lake Road will be developed as the primary access road from the site to Stuart Highway for delivery and dispatch, resulting in an increased volume of passenger and heavy vehicle traffic. Stuart Highway will not be significantly affected by workforce traffic.	There may be a requirement for minor roadworks (turning lane) or sign-posting on Batchelor Road to ensure safety with the increase in workforce traffic. It is anticipated that additional roadworks will be required at the Stuart Highway and Crater Lake Road intersection and on Crater lake Road at the site turn-off point to accommodate the increase in heavy vehicle movements. Stuart Highway is subject to an ongoing program of upgrade between Darwin and Katherine to accommodate increasing traffic requirements.	There will be a significant increase in heavy vehicle movement on Crater Lake Road that will exert significant pressure on the existing road. Some roadworks will be required for its effective use. With the exception of a small amount of additional light vehicular movement, no significant impact to Batchelor Road is expected. Stuart Highway will support increased heavy vehicle movement on a daily basis. There are many double-lane sections of Stuart Highway and continued upgrade is scheduled minimising the potential for impact.

Environmental Factor	Existing Environment	Potential Impacts	Environmental Management	Predicted Outcome
ARCHAEOLOGY AND ANTHROPOLOGY				
Aboriginal Custodianship, sacred sites and heritage sites *Refer Sections 3.5.12, 3.5.13, 4.18 and 5.2.14*	The Aboriginal custodians of the area encompassing the site are the Kungarakany and Warai People. There are four Registered Sacred Sites within the project area and one Recorded Sacred Site (refer to AAPA Certificate C2001/040). The local Custodians have indicated that surface water and groundwater hold a spiritual significance. There are six archaeological sites that have been identified at the site.	The banks of Coomalie Creek is a Sacred Site and will, in part, be disturbed as a result of the creek diversion. The diversion of Coomalie Creek (Right Branch) and pit dewatering will disrupt the natural hydraulic regime of the immediate area. One archaeological site (of low archaeological significance) is located 40m from the proposed open cut. It is not expected to be directly impacted but is considered "vulnerable". Construction/operation activities may result in the inadvertent disturbance of other archaeological sites. Isolated artefacts are likely to be destroyed in the area of the mine pit.	Permission from the Aboriginal Custodians will be sought in conjunction with the AAPA to access any Sacred Sites. The creek diversion will be designed to have minimal impact to the overall flow of water in Coomalie Creek (Right Branch). The sacred sites (where practical) and archaeological sites located within the lease area will be clearly marked and protected by Machinery Exclusion Zones. Alterations to surface water and groundwater regimes will, as much as practical, be minimised and pit dewatering undertaken at the minimum rate required to facilitate mining operations and worker safety.	Disturbance of a Sacred Site will result from the diversion of Coomalie Creek. No archaeological sites are expected to be disturbed as a result of site development.
VISUAL AMENITY				
Visual amenity *Refer Section 4.16*	The site is largely undeveloped with open *Eucalypt* woodland predominating. There is a rain-filled trial pit and survey tracks traversing the site.	Over the life of the mine the pit will reach a maximum size of approximately 24 ha. The pit will be in close proximity to Batchelor Road but should not be readily visible. The processing plant will be housed in a 20m high building. The upper section of this building will be visible from Batchelor Road, but not from Crater Lake Road. Stage 1 involves the installation of three emissions stacks, one 63 m high and two 15-20m high. These will be replicated to allow Stage 3 operations. The tops of the stacks will be visible from the Batchelor and Crater Lake Roads from up to 4km away. Visible emissions from the stacks is expected to be minimal, with colourless carbon dioxide and some water vapour (as steam) being the primary emissions.	A screen of trees will be maintained along Batchelor Road to obscure the mine pit and majority of the processing plant. This screen will be thickened over time to maintain good visual amenity. The building housing the processing plant will be constructed with khaki color-bond cladding.	The mine pit and plant will be prominently visible by air but not obvious from the major access roads (being Batchelor Road and Crater Lake Road). The emissions stack will be visible from the Batchelor and Crater Lake Roads from up to 4km away and will impact the visual amenity of the landscape.

Table 4.2
Area of Vegetation to be Cleared

Feature	Area cleared (ha)	
	Stage 1	**Stages 1-3**
Open pit mine	7	17
Access road	3	3
Haul road	1	1
Plant and crusher	8	8
ROM pad	2	8
Creek diversion bund	3	3
Waste dumps	8	35
Slag dump	8	27
Fines storage	4	10
TOTAL	**44**	**112**

The majority of clearing for Stage 1 will be in the lowland drainage area where the pit is located. About 3 ha will be cleared for the creek diversion bund, affecting primarily *Lophostemon* woodland with some loss of *Eucalypt* woodland. There will be a loss of 800m of the riparian corridor by pit excavation and a further 400m of riparian vegetation in the truncation of the existing creek from the main seasonal flow, upstream and downstream of the bund.

A gradual decrease of creek bank species such as *Nauclea orientalis* and other aquatic and semi-aquatic species is expected in the area of the existing creek alignment. Hardier trees, such as *Acacia auriculiformis* and *Lophostemon grandiflorus*, may persist along the old creek alignment and alluvial flats.

The construction of the creek diversion bund will redirect the flow of the creek further to the south, where it will traverse mainly *Lophostemon* woodland habitat, rejoining the creek just upstream of the first main waterhole. The new flood channel will direct flows away from the mine and through minor areas of existing paperbark forest, mixed *Eucalypt* woodland and *Lophostemon* woodland. Species not adapted to seasonal waterlogging from temporary flooding may diminish in these areas depending on the nature and duration of Wet Season flows. However, revegetation of riparian species will be undertaken along the new creek alignment, and consequent shifts in species composition will occur along the new flood channel. Species such as *Pandanus spiralis*, *Melaleuca* spp. and *Lophostemon* may proliferate along the new creek alignment. Floodplain grasses are also expected to expand into this area with a decrease in upland woodland grass species.

The proposed plant and crusher will be located on higher ground comprising mainly *Eucalypt* woodlands. Approximately 92 ha of upland communities will be cleared for mine infrastructure (to Stage 3). Secondary impacts on down-slope habitats will include increased sedimentation and changes to the natural pattern of drainage resulting from major earthworks.

Vegetation cleared will be pushed into windrows and progressively burnt under controlled conditions. If practical, seed stock will be harvested prior to burning.

Overall, the aquatic and riparian flora are probably the most vulnerable plant communities to negative impacts arising from the proposed mine, particularly given that the location of the main ore body is directly below the current creek channel. Increased turbidity in run-off (resulting in downstream sedimentation) from vegetation clearing and earthworks may change the existing pattern of zonation of aquatic species which is largely determined by water depth. Heavy sediment loads will decrease photosynthesis by aquatic plants and may smother sensitive species. Changes in the plant community will impact on the riparian habitat as a whole, temporarily degrading environmental quality and opportunities for fauna.

Operation

Over the life of the mine there will be impact to vegetation other than removal by clearing. Soil erosion and surface water run-off (from excavation and earthworks) may have an effect on the vegetation by altering soil structure, surface hydrology and microhabitat conditions, and so increase vulnerability to weed invasion. Altering physical parameters such as moisture, temperature and nutrient flows to microhabitats may alter vegetation community composition.

The operational phase will introduce substantial waste dump (including slag, fines and waste rock) and ore storage areas (ROM), to be located in upland woodland areas. Clearing native vegetation and terrain disturbance will create conditions favourable for the proliferation of weed species, particularly in locations where adjacent areas already support populations of exotic species (for example, near the abandoned Sundance Mine). The spread of weeds into adjacent habitats is likely if a weed management plan is not implemented. The two species identified as the most serious for weed management are the robust, tall grasses *Pennisetum polystachion* and *Andropogon gayanus.* If these species proliferate over the site, there will be a consequent increase in fuel loads, leading to high intensity fires which may seriously damage native vegetation and create a fire hazard for remnant native vegetation, mine infrastructure and neighbouring properties.

It has been noted however, that vegetation assemblages at the site are already heavily infested with weeds. Management of the site, including fire management and restricted access, could lead to a decline in weed dominance and re-establishment of certain fire or disturbance-sensitive species.

Management

Project layout is such that flora habitats of restricted distribution will be conserved and vegetation clearing will be confined to that necessary for the establishment of required infrastructure for the proposed development. Haul road layout and construction will minimise impact on sensitive vegetation communities and the movement of vehicles will be managed to ensure minimal loss of vegetation.

Management strategies will be implemented to protect native vegetation communities by controlling the occurrence and spread of weeds (**Section 4.3**), restricting the spread of fire (**Section 4.5**) and minimising the impact of erosion/sedimentation (**Section 4.8**). In the area of the Coomalie Creek (Right Branch) diversion, revegetation will be undertaken to re-establish the riparian corridor, and environments suitable for the colonisation of aquatic flora communities will be established in the creek diversion, with pools to mimic original creek characteristics. Revegetation of other areas (for example the waste dump) will be undertaken progressively throughout the mine's life. Species used in the revegetation program will be selected with consideration given to habitat creation and pre-existing communities.

4.2 Fauna

Of the 122 native terrestrial vertebrate species recorded during field survey work, two mammal species (the Northern Quoll, *Dasyurus hallucatus* and Pale Field Rat, *Rattus tunneyi*) are listed as 'lower risk – near threatened' (*Territory Parks and Wildlife Act*, 2001).

Survey works indicated the two habitats that support the highest fauna species diversity were the dry vine-forest and the riparian vegetation associated with Coomalie Creek (Right Branch).

Construction and Operation

Establishment of the mine and its associated infrastructure will result in the loss of habitat for terrestrial and aquatic fauna through the clearing of vegetation and the diversion of a section of Coomalie Creek (Right Branch). Dewatering of the mine-pit and the release of water into Coomalie Creek (Right Branch) will significantly alter flow regimes in the area, with associated impacts on fauna.

Approximately 112 ha of vegetation will be cleared through Stages 1 to 3 of the project. The clearing of approximately 62 ha of vegetation will be required to establish the waste and slag dumps, resulting in the loss of a large percentage of habitat in the southern section of the project area, primarily *Eucalypt* woodland communities. The proposed mine will significantly reduce the availability of this habitat type for fauna in the project area. When the mine is operational, the waste and slag dumps could also have an indirect impact on habitat condition in neighbouring areas. Increased run-off from waste dumps and fragmentation of vegetation communities may create a disturbance to fauna habitats, affecting species that are sensitive to such disturbance.

The inundation and redirection of a 1.2 km section of Coomalie Creek (Right Branch) will have a direct impact on the quality, condition and availability of significant riparian habitat for fauna. Fauna habitats that will be disturbed in the construction of the new channel include *Melaleuca* woodland and *Eucalyptus tetrodonta* / *E. miniata* woodland, mixed *Eucalypt* woodland and *Lophostemon* woodland. The creek diversion will impact aquatic fauna through the loss of habitat (particularly small permanent refuge pools), ground and vegetation disturbance, and a reduction of habitat diversity along the channel. If the diverted channel is an extended length of a single aquatic habitat type (for example, deep water, fast flows, firm substrates, lack of vegetation, lack of vegetated banks), it may not be suitable for many species and will result in a change of species colonisation from resident habitat to transitory habitat.

The mine pit, creek diversion, release of pit dewater into the creek, settling ponds, waste and slag dumps, plant and other infrastructure modify the existing vegetation and ground forms, resulting in changes to water flow regimes and disturbance of fauna refuge areas. Dewatering may reduce water flowing into Coomalie Creek (Right Branch) upstream of the pit during the Dry Season and thus reduce water available to replenish refuge pools. Release of water will significantly increase flows downstream of the pit, which could affect nutrient levels and water quality. This could have an impact on downstream vegetation and habitat type. Increased flow rates may result in a shift in aquatic community composition.

Clearing, modification or disturbance to specific habitats will affect the Northern Quoll and the Pale Field-rat. Significant habitats for the Northern Quoll include *Eucalyptus tetrodonta* / *Eucalyptus miniata* woodland, mixed eucalypt woodland and *Lophostemon* woodland. The Northern Quoll is known to be sensitive to disturbance and is not generally able to maintain populations in sub-optimal environments that have been disturbed. This means the proposed development and associated habitat disturbance to these woodland communities, is likely to have an impact on the habitat quality and thus population and distribution of the Northern Quoll within the project area. Impacts associated with the pit and creek diversion may also affect this population, as it has been suggested that the most successful breeding sites for this species occur near creek-lines.

Although the Pale Field Rat was only recorded in *Eucalypt* woodland, characteristic burrows and runs indicate that it is relatively common in this habitat across the project area. Impacts of the proposed development primarily relate to the loss of vegetation cover, refuge riparian habitat, habitat modification and soil compaction.

Fauna populations may also be effected by indirect impacts as a result of mining operations such as an increase in the generation of noise (in particular blasting activities) and changes to the fire regime of the area.

Management

The design of the proposed site development footprint will minimise the requirement for clearing, disturbance and indirect impact to habitats that support a range of and diversity of fauna within the study area, including *Melaleuca* woodland, *Eucalypt* woodland and *Lophostemon* woodland communities. The proposed layout of road networks, equipment dumps, associated works and operational areas will avoid disturbance to the most significant communities that support the Northern Quoll and Pale Field Rat and minimise the loss of vegetation cover and riparian habitats.

The Coomalie Creek (Right Branch) diversion will incorporate an excised channel similar to that of the original creek. To minimise the potential for impact on aquatic fauna in Coomalie Creek, permanent refuge pools will be established in the diversion channel.

Where possible, revegetation of cleared areas will be undertaken to re-establish fauna habitats. Waste dumps will be progressively revegetated. Habitat connectivity along the Creek will be maintained and enhanced where possible; canopy breaks and disturbance along this riparian corridor will be minimised and the area revegetated with the objective of re-establishing a continuous riparian corridor.

Impact on habitat value and condition will be minimised by preventing indirect impacts associated with drainage, waste contamination and the spread of weeds. The quality of water discharged from operational areas, including the waste rock dump, into Coomalie Creek (Right Branch) will be monitored and appropriate management/mitigation measures instigated as required.

Implementation of fire management procedures (in combination with appropriate weed management) should reduce the intensity and frequency of fire in the area and result in a positive effect on the maintenance of fauna populations.

4.3 Weeds and Feral Animals

Vegetation in the project area has been disturbed in the past and sixteen weed species were identified during field survey works, seven of which are declared noxious weeds (Class B). Of the feral animals identified in the area, pigs were the most numerous.

Clearing works undertaken during construction and increased vehicular movement through the project area during construction and operation may result in an increase in weed infestations, leading to an increased fire risk. The number of feral animals in the project area will remain unchanged or decline after the commencement of operations.

Management measures to control the introduction and spread of weeds will be implemented in a coordinated manner through the application of a Weed Management Plan. As part of this Plan cleared areas will be regularly maintained, vehicle movement will be controlled and wash down procedures employed to restrict the potential spread of weeds. Weed removal will be undertaken in selected areas and Class B weeds will be controlled by the targeted application of weedicides.

A management program for the control of feral pigs, especially in riparian habitats in the study area, will be implemented. The control of feral pigs may also assist in weed management.

4.4 Biting Insects

Biting midges are not present in significant numbers within the project area. Thirteen mosquito species were identified and, at current levels, are considered to represent a low to moderate pest problem. A number of the species identified are known to be vectors of Murray Valley encephalitis, Ross River virus and Barmah Forest disease.

Construction

An increase in the number of mosquitoes and biting midges will result if construction activities result in the creation of new breeding sites (pools).

Mine infrastructure includes construction of settling ponds. If the design of the settling ponds allows the establishment of reed species such as *Eleocharis* and *Typha*, the ponds may become a breeding site for mosquitoes such as *Culex annulirostris*, *Mansonia uniformis* and *Coquillettidia xanthogaster,* increasing their abundance in the medium to long term.

Earthworks and ground disturbance during construction has the potential to create new mosquito-breeding habitats through water retention and pooling. Blocking drainage lines from earthworks and subsequent erosion could also cause pooling. Such pools can produce breeding ponds for mosquito species such as *Anopheles amictus, A. annulipes, Ochleroteratus normanensis, Vigilax reesi* and *Culex annulirostris.*

Operation

Water from the mine pit will be pumped into settling ponds prior to its discharge to Coomalie Creek (Right Branch). Continual discharge of large amounts of pit water may alter the ecology of the creek, possibly encouraging the growth of *Eleocharis* and *Typha* reeds, and subsequently promoting breeding of the *Culex annulirostris, Mansonia uniformis* and *Coquillettidia xanthogaster*.

Septic tanks and wastewater from watering or wash down operations have the potential to harbour a number of mosquito species, including *C. quinquefasciatus* and *C. annulirostris.* Septic tanks in particular have a significant capacity to support mosquitoes due to a high organic content and the absence of biological control organisms (for example, fish). Stormwater drains with low flow in the Dry Season could also be potential breeding grounds for the above-mentioned species.

Artificial containers such as tyres, drums, disused machinery and rubbish items can collect rainwater and become potential mosquito-breeding sites.

Management

The requirement for biting insect control will be incorporated in the design of settling ponds and water impoundment structures.

Similarly, design and management procedures will minimise the creation of potential biting insect breeding sites during construction and operation. The Coomalie Creek (Right Branch) diversion channel will be constructed such that no pooling or significant downstream sedimentation occurs. The proposed diversion of the creek will recreate the defined nature of the central channel, and the margins will be revegetated with trees to discourage marginal grass and reed growth. The cut-off section to the altered creek will be filled and leveled to prevent pooling. Roads constructed on the mine site will have engineered culverts and drainage structures will be designed so as not to impound water.

Where installed, septic tanks will be completely sealed and absorption trenches positioned such that there is no surface run-off/pooling. Septic and rainwater tanks will be constructed to meet THS regulations. Administration facilities will either be mosquito proof (with insect screening) or sealed and air-conditioned. Mt Grace employees will be advised of dangers and appropriate personal protection measures.

Any pooling or unnecessary collection of stagnant water, such as within tyres, drums and wheel track depressions, will be drained or filled as appropriate. If necessary, biological control of mosquito larvae will be undertaken in consultation with THS, using a larvicide such as *Bacillus thuringiensis* var. *israelensis*.

4.5 Fire Regime

The current fire regime involves frequent Dry Season burning of the entire property to maintain fuel loads at minimum levels and prevent high intensity, uncontrolled burns. This fire practice is common and widespread throughout the region and burning is usually carried out in consultation with the NT Bushfires Council.

Construction of the mine will require approximately 30% of vegetation to be cleared. The cleared vegetation will be stacked and burnt under controlled conditions to prevent it becoming a fire hazard.

Clearing of vegetation and extensive disturbance of the ground surface may promote weed growth and increased weed growth will provide fuel loading for quick spreading Dry Season fires. However, for safety purposes and to ensure protection of all facilities and infrastructure, the fire regime on site is expected to be more controlled than in the past through the implementation of a Fire Management Plan. Firebreaks will be established and regularly maintained and a weed management program will also be implemented. As a result of the implementation of these measures it is expected that areas of the site will be afforded greater protection from fire, encouraging the growth of more fire sensitive species.

The administration facility, operations area and associated infrastructure will incorporate a dedicated reticulated water supply for fire fighting purposes. A dedicated fire-fighting unit will be part of the Mt Grace vehicle fleet and be operated by trained staff.

4.6 Groundwater

Construction and Operation

Groundwater in the project area occurs at a relatively shallow depth. Dewatering will be required to lower the depth of the groundwater table to below the working base of the pit. At the predicted final pit depth (-15mRL) the groundwater table in the immediate area of the pit will have been lowered by approximately 90m. The alluvial and upper weathered dolomite aquifers (occurring in the upper 5m to 25m of the pit) will be the major aquifers affected by pit dewatering.

Dewatering will be commenced prior to the start of mining. The steady state dewatering rate (the rate that would apply towards the end of the Dry Season after the alluvium and upper weathered Coomalie Dolomite aquifers have been fully penetrated by the mine) has been estimated as 5,300m^3/day (60 L/s).

Drawdown values have been derived based on various scenarios, with predicted values ranging from zero drawdown at 500m to no more than 1m drawdown at 2km. These values and related assumptions are outlined below:

- Using a value for hydraulic conductivity of 14 m/day, for a 15m aquifer-thickness and a mine size of 500m length and 300m width, a distance of 500m was estimated as the distance to zero drawdown from the centre of the pit.

- Through the application of 'constant head' numerical modeling, the estimated groundwater drawdown during the planned dewatering of the mine would be no more than 1m at a distance of approximately 1 to 1.2 km from the mine. Modeling assumed a hydraulic conductivity of 10m/day for the main aquifer (alluvium and weathered Coomalie Dolomite), after one year, without any recharge.

- Using 'constant head' numerical modeling with a value for hydraulic conductivity of 30 m/day, and assuming no recharge, the drawdown would be no more than 1 m at a distance of 2 km from the mine after 1 year.

Considering the expected large amount of recharge to the groundwater system during the Wet Season each year, it is reasonable to assume that drawdown effects will be far less than predicted by 'constant head' numerical modeling.

It is anticipated that the lowering of the water table by dewatering during the life of the mine will have negligible impact on vegetation beyond a distance of 500m from the mine. This estimation does not take into account the potential influence of surface water runoff and recharge. Currently no beneficial use of groundwater is made within a 1km radius of the mine, and therefore lowering of the groundwater table will not impact on neighbouring properties.

Management

To minimise the need to treat dewater to remove suspended solids before release to the surface environment as much groundwater inflow will be intercepted as practical by pumping from shallow production bores (10m to 20m deep) outside the pit. This water will be used within the plant and for dust suppression.

An increased volume of water will require removal from the pit during the Wet Season, due to run-off within the pit and greater rates of groundwater inflow. The water will be discharged after passing through settling ponds. During the Wet Season, natural surface flows tend to be turbid and the requirement for reducing the suspended solid concentrations may be less than in the Dry Season.

The above operations will minimise the potential for impact on the quality of regional groundwater resulting from dewatering the mine.

4.7 Surface Water

4.7.1 Hydrology

The main impact on the hydrology of the project area will be the modification to natural drainage lines. This will disrupt the surface water flow regime, which could lead to erosion and sedimentation.

Construction

The main impacts of construction activities on erosion, run-off and surface water quality will be related to the construction of plant and access roads, and the diversion of Coomalie Creek (Right Branch). The potential for impact will be greatest during the Wet Season. The probability of high intensity rainfall events and flooding will be considered when scheduling and undertaking construction work with the majority of works being completed in the Dry Season.

Construction work may lead to temporary increases in turbidity of run-off water entering the downstream environment. Little impact is anticipated as the turbidity of natural run-off water during the Wet Season is typically elevated.

Operation

Dewatering operations will increase the overall volume of discharge of water to Coomalie Creek (Right Branch) downstream of the mine site, particularly during the Dry Season. Coomalie Creek (Right Branch) intermittently flows during the Dry Season, chiefly from groundwater seepage, and increased flows resulting from dewatering are not likely to be large enough to cause significant erosion or deposition.

After Closure

The main hydrologic change after closure is likely to be as a result of the cessation of dewatering. This will reduce flows in Coomalie Creek (Right Branch), particularly during the Dry Season, but low flow from groundwater seepage will still occur to the same degree as before mining. The reduced flows are not likely to adversely impact on erosion or deposition potential. Coomalie Creek (Right Branch) will have been diverted early in the project’s life, so there are no additional environmental impacts likely after closure, provided any areas in the streamline/floodplain disturbed by mining activities are adequately rehabilitated.

Should the pit overtop, no substantial environmental impact is predicted, provided the water is equal in quality to run-off from the catchment north of the mine. The risk and effects of overtopping will be minimised by adequate design of an emergency by-wash, and by minimising surface water inflows.

Flows from the catchment after closure are not likely to be substantially different to the pre-mining discharge, as rehabilitation will restore the hydrologic condition of the mine area to pre-mine condition.

Management

The risk of adverse environmental impact during construction and operation of the plant will be minimised by adopting appropriate soil conservation measures, minimising the disturbed area and scheduling construction and subsequent mining activities to avoid the Wet Season.

4.7.2 Surface Water Quality

Construction

The greatest potential for impact on water quality throughout the construction period will result from erosion and resulting increased turbidity of surface water run-off. Earthworks, vegetation clearing, excavation and building works could result in erosion if soil conservation works and appropriate construction techniques are not employed. Erosion during construction could result in increased turbidity of surface water and consequent sedimentation of Coomalie Creek (Right Branch) down-stream from the mine site. The quality of dewater is expected to be good and any turbid water pumped from the pit floor will be passed through a settling pond, removing coarse sediments, prior to discharge to Coomalie Creek (Right Branch).

Operation

During operation erosion and increased turbidity of surface water may result from run-off from cleared areas, waste piles and slag dumps. There are no major contaminants within the slag or waste (Appendix B), which is comprised primarily of oxides of magnesium, silica and calcium.

Management

Sewage will be treated via a septic tank system or a package sewage treatment plant. Waste dumps will be adequately bunded to collect rainwater run-off and direct it to a settling pond. Settling ponds will be designed and constructed to enable a retention period of three days to ensure adequate reduction of total suspended solids (TSS). Point source discharge will allow constant monitoring to ensure a high quality of discharge water is maintained.

4.8 Erosion and Sedimentation

An Erosion and Sediment Control Management Plan will be developed and implemented throughout construction and operation phases of the Project.

Construction

Construction during the Dry Season will ensure that erosion by run-off will be minimised. Wind erosion will be of potential concern during this period as it is a means of dust generation, and accordingly will be minimised through a dust suppression program. Redirection of Coomalie Creek (Right Branch) during the Dry Season will minimise erosion and sedimentation, as the creek is intermittent within the project area during this time.

Operation

Dewater from the pit floor is expected to have a high sediment load, and if released untreated to Coomalie Creek (Right Branch) would result in sedimentation within the creek. Similarly, run-off from roads, waste dumps, stockpiles and other cleared areas within the project area will have elevated sediment levels. Bunds enclosing these features will be both important in containing the turbid water to be channelled to the settling ponds and silt-traps, and in diverting catchment run-off from draining through the project area. Vehicles (especially heavy plant equipment), through mechanical disturbance of the soil matrix, have the potential to exacerbate erosion problems, particularly where crossing drainage lines.

The Coomalie Creek (Right Branch) diversion has the potential to create sources of erosion and sedimentation. The first is the disturbed, relic creek channel, which may be scoured by channel erosion causing an input of sediment to Coomalie Creek (Right Branch). Secondly, the diversion channel itself may be subject to channel erosion and become a major source of turbid, sediment-laden water if the channel is not constructed to minimise erosion.

After Closure

If the project area is not rehabilitated and erosion protection measures are not maintained a significant source of sedimentation would result in Coomalie Creek (Right Branch). However, it is not anticipated that significant erosion will occur after mine closure as the scheduled recontouring and rehabilitation of the landscape will largely restore the natural drainage regime of the project area.

4.9 Dust and Noise

Construction

Dust generated during construction will result from earthworks, leveling and bund construction. As construction will be carried out in the Dry Season, when humidity levels are relatively low and there is little to no rainfall, the potential for dust generation is enhanced.

Noise will be generated by earthmoving equipment and general construction activities. The proposed mine-site is 2 km away from the closest residential dwelling and noise disturbance is not expected to be severe.

Operation

Dust and noise will be generated during mining due to drilling, blasting (twice weekly), excavation and general operational activities. Mining will be carried out on a campaign basis (in the Dry Season) and thus will only generate significant dust and noise during a defined period of each year.

Management

A buffer zone will be incorporated into the mine layout plan such that the generation of dust or noise during construction and operation will not significantly impact residential properties in the area or roads.

During construction and operation drilling and blasting will be restricted to daylight hours and mine operation will be undertaken on a campaign basis. The public will be notified of the mining and blasting schedule.

Dust generation will be monitored and controlled on an “as needs” basis through the application of water.

4.10 Atmospheric Emissions

4.10.1 Air Quality

An assessment of potential air quality impacts arising from the proposed Batchelor Magnesium Project was undertaken on behalf of Mt Grace by URS. The detailed assessment report is attached as Appendix C, with the key results and conclusions summarised below. Emissions of CO_2 and other substances from the project that may have greenhouse consequences are considered separately in **Section 4.10.2**.

An emissions inventory was developed, using National Pollutant Inventory (NPI) methodology guidelines, for each of the three production stages of the project. The atmospheric dispersion model AUSPLUME (v.5.3) was used to predict downwind concentrations of key pollutants from the proposed site anticipated during Stages 1 and 3 of the project, and then assessed against appropriate health-based ambient standards and guideline values applicable in Australia.

Emissions that were assessed for significance included:

- Particulates (PM_{10}, $PM_{2.5}$ and Total Suspended Particulates (TSP)): from drilling and blasting, process plant and equipment including the magnesite kiln and crusher, stockpiles, exposed areas and loading and unloading activities.
- Products of combustion (including Oxides of Nitrogen (NO_x) and Carbon Monoxide (CO)): from the magnesite kiln which burns natural gas.
- Sulphur dioxide (SO_2): from the acid scrubber.
- Magnesium oxide (MgO): from the magnesite kiln and fugitive sources such as exposed areas containing waste.
- Ammonia (NH_3): from the ammonia scrubber.

Assessment Conclusions

Stage 1

The first year of operation will see the largest potential impact from fugitive particulate emissions as topsoil and overburdens are removed to expose the ore. Tables 6.1 to 6.3 in Appendix C summarise the annual emissions of key pollutants estimated for Stage 1 production, from stack sources, vehicles and fugitive sources respectively.

On an annual basis, the greatest contributor to dust emissions is blasting (56 %, as shown in **Figure 4-1**). This only occurs however, on an intermittent basis, with blasting activities estimated to be carried out on only 17 days in the first year. Due to the short, intense nature of emissions from blasting it is not technically feasible to include them in the dispersion modelling study. It is likely that short-term levels of TSP and PM_{10} would be elevated downwind of the blast area beyond the site boundary during blasting activities. It is unlikely, however that significantly elevated levels would be experienced as far afield as the Batchelor township or at either of the two neighbouring residences (shown in Appendix C, Figure 4-1), as dust minimisation practices will be adopted during drilling and blasting.

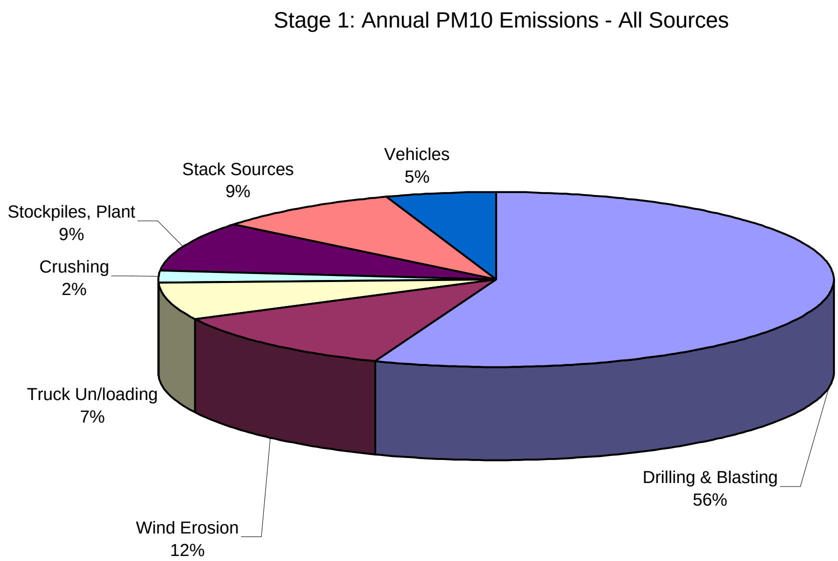

Figure 4-1: Stage 1 annual particulate emissions (as PM10) by source

Table 4.3 summarises the results of the AUSPLUME modeling to predict downwind concentrations of key pollutants at all offsite receptor locations, and the discrete receptor locations representing the nearest residential premises. Maximum predicted concentrations of MgO, NH_3, SO_2 and NO_x (as NO_2) were shown to be well below the applicable guideline limits.

Table 4.3
Stage 1 Dispersion Modeling Results

Pollutant		Maximum Predicted Concentration	Guideline	Units, Time Average
MgO	Off-site	12.6	330	µg/m^3, 3-minute
	Discrete 1	2.63		
	Discrete 2	6.45		
NH_3	Off-site	12.4	600	µg/m^3, 3-minute
	Discrete 1	2.41		
	Discrete 2	5.67		
SO_2	Off-site	1.6	712	µg/m^3, 10-minute
	Discrete 1	0.27		
	Discrete 2	0.34		

Pollutant		Maximum Predicted Concentration	Guideline	Units, Time Average
NO_x (as NO_2)				
	Off-site	5.5	246	µg/m^3, 1-hour
	Discrete 1	0.95		
	Discrete 2	1.12		
CO	Off-site	4.41	10,000	µg/m^3, 8-hour
	Discrete 1	0.7		
	Discrete 2	0.3		
TSP	Off-site	3.9	90	µg/m^3, annual
	Discrete 1	0.42		
	Discrete 2	0.61		
PM_{10} (24- hours)				
	Off-site	15	50	µg/m^3, 24-hours
	Discrete 1	4		
	Discrete 2	7.6		
PM_{10} (annual)				
	Off-site	1.9	30	µg/m^3, annual
	Discrete 1	0.2		
	Discrete 2	0.3		

Note: Discrete 1, 2 refers to nearest residences (west and north-east of project area respectively).

The resulting contour plots of maximum predicted concentrations anticipated during Stage 1 production are shown in Appendix C (Figures 6-2 to 6-9 inclusive). The discrete receptors, representing the nearest residential premises to the proposed Batchelor project, typically experienced concentrations in the range of 0.05 – 2.0 % of the guideline values for most pollutants (MgO, NH_3, SO_2, NO_X, and CO). Predicted TSP and PM10 ground level concentrations, although still well below acceptable limit values, were shown to be closest to their guidelines, reaching a maximum of 8 to 15 % of the 50 µg/m^3 limit for PM10 (24-hour average), at discrete receptors 1 and 2 respectively.

It was concluded that the main contributors of particulates are fugitive sources. Therefore, it was concluded that control measures should focus on these fugitive sources, especially during events such as blasting.

Stage 3

Emissions from Stage 3 of operation (that is, Year 6 and subsequent years) of the proposed Batchelor Magnesium Project were estimated using the conservative assumption of a maximum production rate of 50,000 tpa Mg, and 1.925 million tonnes of overburden, ore and waste removed from the pit.

The inventory took into account the increased capacity and plant configuration proposed for Stage 3 production, whereby three magnesite rotary kilns, two acid scrubbers, two ammonia scrubbers and two crushers will be in operation. Tables 6.6 to 6.8 in Appendix C summarises the annual emissions of key pollutants estimated for Stage 3 production, from stack sources, vehicles and fugitive sources respectively.

An expansion to Stage 3 production will result in an increase in both stack and fugitive emissions. This is as a result of an increase in point sources as the plant and crusher section is expanded to meet additional demand for magnesite processing, as well as an increase in exposed areas (and hence fugitive sources of particulate) as the mine pit, fines storage, ROM pad and waste dump are expanded.

The trends observed for the Stage 1 inventory are again apparent for Stage 3, in that drilling and blasting activity is the largest contributor to dust emissions on an annual basis (**Figure 4-2**). However, this contribution decreases (from 56% in Stage 1 to 33% in Stage 3) as wind erosion from increased exposed areas are anticipated to become a more important contributor to particulates from the project (from 12% in Stage 1 to 27% in Stage 3).

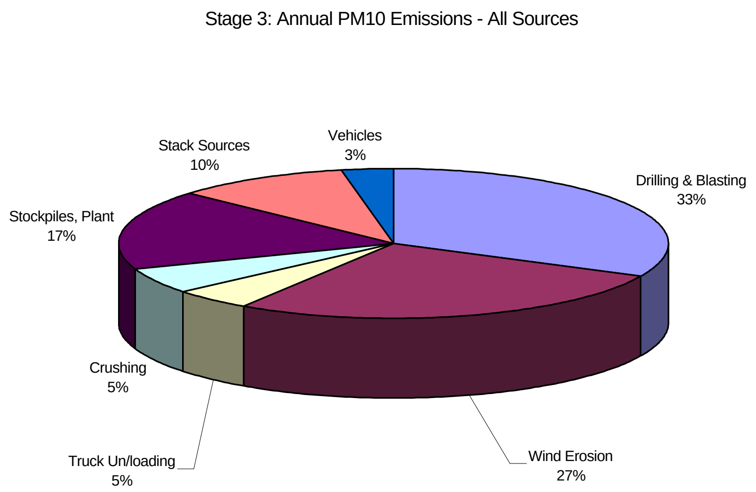

Figure 4-2: Stage 3 annual particulate emissions (as PM10) by source

Table 4.4 provides a summary of the predicted downwind concentrations of all pollutants anticipated from Stage 3 production of the Batchelor Magnesium Project, at all offsite receptor locations, and at each of the two discrete receptors. These results are shown pictorially in Appendix C, Figures 6-11 to 6-18 inclusive.

Table 4.4
Stage 3 Dispersion Modelling Results

Pollutant		Maximum Predicted Concentration	Guideline	Units, Time Average
MgO	Off-site	17.1	330	µg/m^3, 3-minute
	Discrete 1	4.2		
	Discrete 2	6.6		
NH_3	Off-site	49.8	600	µg/m^3, 3-minute
	Discrete 1	5.9		
	Discrete 2	9.3		
SO_2	Off-site	6.6	712	µg/m^3, 10-minute
	Discrete 1	0.78		
	Discrete 2	1.06		
NO_x (as NO_2)				
	Off-site	8.3	246	µg/m^3, 1-hour
	Discrete 1	1.9		
	Discrete 2	2.3		
CO	Off-site	7.4	10,000	µg/m^3, 8-hour
	Discrete 1	1.6		
	Discrete 2	1.0		
TSP	Off-site	6.5	90	µg/m^3, annual
	Discrete 1	1.01		
	Discrete 2	1.19		
PM_{10} (24- hours)				
	Off-site	30	50	µg/m^3, 24-hours
	Discrete 1	6.8		
	Discrete 2	12		
PM_{10} (annual)				
	Off-site	3.2	30	µg/m^3, annual
	Discrete 1	0.5		
	Discrete 2	0.6		

Note: Discrete 1, 2 refers to nearest residences (west and north-east of project area respectively)

The model results show maximum off-site concentrations of all pollutants to be higher than those anticipated during Stage 1, yet all are below their respective guideline limits. Of all the pollutants considered in the modelling study, predicted maximum TSP and PM10 ground level concentrations are closest to guideline limits during Stage 3. Short-term PM10 concentrations, calculated over a 24-hour average, are predicted to reach maximum ‘worst-case’ concentrations of 30 $\mu g/m^3$, or 60 % of the 24-hour PM10 standard of 50 $\mu g/m^3$. Indeed, the contour plot suggests there is the potential for the standard to be exceeded just beyond the southern boundary, which was not detected at the nearest gridded receptors within the model domain. However, it should be noted that PM10 levels at either of the nearest residences are still predicted to remain low (6.8 $\mu g/m^3$ and 12 $\mu g/m^3$, respectively). On an annual basis, particulate concentrations are expected to be less than 5 $\mu g/m^3$, or no more than 15 % of the annual guideline limit.

Management

The following best practice environmental safeguards that would be implemented during mining and processing are listed below.

- An EMP will be prepared which addresses air monitoring and management issues.
- Water sprays would also be used (as required) across work zones and unsealed areas to suppress dust. The water would be applied by water cart across ground surfaces whenever the surface has the potential to generate excessive levels of dust. Areas of excavation or works would not exceed the capacity of the water spray units.
- Exposed surfaces and stockpiles will be watered or sprayed where required.
- Blasting or particularly dusty works will be scheduled under favourable meteorological conditions only. Earth moving activity will be suspended where wind speeds exceed 30 km/h.
- Where necessary, long-term stockpiles will be stabilised using fast-seeding grass or synthetic cover spray and exposed areas will be minimised through rehabilitation.
- Unsealed access roads will be sprayed with water as required and vehicle speeds will be controlled to minimise dust. If necessary, consideration will be given to sealing major roads.
- Vehicles will not be loaded above the height of the side and tailboards.
- Dust controls will be provided on all exhaust points from transfer and handling of grain and other dry bulk product (that is, baghouses on all major plant and equipment generating significant point sources of dust).

4.10.2 Greenhouse Gases

An initial GHG emission inventory was developed for the project based on current process information provided by Mt Grace. Total GHG emissions were derived on the basis of emission per kg of refined magnesium metal. Both on-site and off-site sources of GHGs were considered. A discussion of greenhouse gas emissions is provided in **Appendix O**.

Table 4.5 below summarises the GHG inventory for the proposed Batchelor Magnesium Project, on a ‘CO_2 equivalent’ basis. Of the six GHGs specified in the Kyoto Protocol, emissions of carbon dioxide constitute the great majority of GHG contribution from the project. In addition, small quantities of nitrous oxide (N_2O) are anticipated as a component of oxides of nitrogen (NO_x) from combustion processes in the magnesite and lime kilns. Other GHGs, that is methane, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, are negligible.

Table 4.5
GHG Inventory for Batchelor Magnesium Project

	kg.CO_2eq/kg.Mg	k.tonnes CO_2-eq/year at Stage 3
On-site emissions		
Diesel use for mining operations	0.034	2
Magnesite calcining kiln	8.94	447
Limestone calcining kiln	0.72	36
N_2O from combustion in the kilns	0.08	4
Carbon electrode consumption	0.04	2
Off-site emissions		
Diesel for limestone mining	0.003	0.1
Electricity generation	3.68	184
Total	**13.5**	**675**

The total GHG inventory of 675,000 tpa $CO_{2\ eq}$ is dominated by the calcining processes and the electricity requirements. In contrast, the minor emissions identified above are probably smaller than the uncertainty in those principal sources of GHG. The total GHG emissions from Stage 3 of the Batchelor Magnesium Project would comprise 0.19% of the total 1998 Australian energy GHG emissions.

The greenhouse assessment also compared the GHG emissions anticipated from the Batchelor Magnesium Project with published data presented for other magnesium projects proposed to be constructed in Queensland (Australian Magnesium Project in Stanwell) and South Australia (SA Magnesium in Port Pirie; Appendix O). The assessment showed that, when considered on a common energy supply basis, the three technologies have very similar GHG emissions.

Magnesium components are increasingly being used in the automotive industry, where weight reduction is a cost effective means to further reduce fuel consumption, and consequently CO_2 emissions. In addition, reduction of vehicle weight results in energy savings in vehicle manufacture, with consequent CO_2 emission reductions. Considerable work has been undertaken by the automobile industry on life cycle analysis of light materials as a replacement for iron and steel. The replacement of steel components in motor vehicles by magnesium components is estimated to reduce life cycle GHG emissions by 50 kg CO_2 per kg of magnesium used. The foregoing assessment shows that the overall GHG emissions attributable to the Batchelor Magnesium Project would be 13.5 kg.CO_2/kg.Mg. Therefore, if more than 27% of the product is used to replace steel in motor vehicles, there will be an overall GHG benefit.

Management

Mt Grace intends to participate in the Commonwealth Greenhouse Challenge Program with the Batchelor Magnesium Project.

Through its commitment to the Greenhouse Challenge Program, Mt Grace will refine the initial inventory of GHG emissions, develop an Action Plan to minimise emissions, forecast expected reductions in GHG emissions, and monitor and report emissions on a regular basis as agreed with the Australian Greenhouse Office (AGO).

The types of policies and measures that could be included in an Action Plan for the Batchelor Magnesium Project include:

- capital projects that improve energy or chemical conversion efficiencies;
- operating procedures that improve energy or chemical conversion efficiencies;
- management initiatives and improvement programs that make “small step” GHG benefits;
- use of alternative or renewable energy technologies; and
- research and development projects with the potential to reduce GHG emissions.

4.11 Waste

Construction

Waste generated as a result of construction activities will be removed from site either by waste management contractors or by construction contractors/subcontractors. Accordingly, there is little potential for environmental impact as a result of inappropriate disposal of waste on site.

Operation

The operation of the mine will generate significant quantities of excess material/waste. The bulk of this waste is non-hazardous and suitable for on-site utilisation or disposal. Such wastes are topsoil, overburden, waste magnesite rock, magnesite fines, off-gas fines, kiln degradation fines, excess magnesia, kiln reaction products, slag, unreacted reductant, magnesium condenser fines, and solid phase from sludge treatment.

Gases will be vented to the atmosphere during operation and will include calcination off-gas during Stage 1 of 350,000 t/a (carbon dioxide, water vapour and nitrogen) and small amounts of phosphine and sulphur dioxide.

Domestic rubbish will require appropriate disposal while domestic wastewater will require treatment prior to discharge.

A few waste streams are not suitable for on-site disposal such as ammonium sulphate, ammonia, and ferrosilicon. If a buyer for these products cannot be identified they will need to be disposed to an appropriate off-site facility. Waste oil and spent solvents will also require off-site disposal.

Management

During operation a large range of materials are generated that may be recycled off-site if local markets are identified or the value of the material justifies transport to markets. This includes the magnesite fines, off-gas fines, kiln degradation fines, residual ferrosilicon, ammonium sulphate and ammonia. Mt Grace will, wherever practical, attempt to maximise the recycling of wastes. Where markets for these materials are unavailable, they will be disposed either to waste slag dump (magnesite fines, off gas fines and kiln degradation fines) or disposed to appropriate off-site disposal sites (ammonium sulphate and ammonia), including approved landfills either locally or interstate. It is anticipated that a market will be readily available for residual ferrosilicon.

A limited quantity of hazardous gases will be produced in the operational phase, including phosphine gas and sulphur dioxide. Mt Grace will adhere to all appropriate Health and Safety requirements regarding the appropriate handling and venting of these gases.

Inert wastes will be disposed to either the waste magnesite dump or the slag dump. Generally, fine inert material will be blended with the slag in order to improve the handling characteristics of the material. The dumps will be bunded such that sediment will settle out and so water quality will not be compromised.

Mt Grace will review waste tracking documentation supplied by the waste management contractors as well as the proposed disposal plans of construction contractors/subcontractors to ensure that waste generated is disposed to facilities approved by DIPE.

All runoff from the workshop areas and the washdown bays will be passed through a triple interceptor trap (TIT) in order to remove oily residue. The TIT will be regularly maintained.

Pending the suitability of the soil for sewage disposal, domestic wastewater generated onsite will be disposed to a septic tank system and associated absorption/evaporation trenches. Where unsuitable, a package treatment plant will be installed.

4.12 Economics

Construction

During construction of the proposed mine it is expected that the local and regional economy will be enhanced. The Northern Territory economy will benefit primarily by increased employment opportunities, the diversification of skill base within the existing workforce and revenue from company taxes/royalties. The proposed mine is in accordance with regional development plans developed by the Northern Territory and local governments which anticipates that mining and extractive industries are likely to be one of the Coomalie regions strongest growth areas, particularly for employment and the local economy.

As well as greater employment opportunities Batchelor will experience an increased use of services, utilities, and local business. Local businesses and facilities will be utilised to service the construction workforce for a period of 9 to 12 months.

The Batchelor Magnesium Project will add significant economic value to the Northern Territory, the effects of which will spread to a range of services, businesses and industries. The magnitude of the project could stimulate housing, retail, and business and construction industries in the local area and the Greater Darwin region.

Operation

The long-term operation of the mine and processing plant will provide specialised employment and training for a local workforce. A localised growth in population will stimulate local business and industry with an associated long-term growth in the local economy. There will be sustained growth in local enterprises servicing the mine, which will provide a major boost to the local economy.

4.13 Employment

Construction

There is expected to be a construction workforce of about 100 full-time personnel for a period of about nine to twelve months. Staff will be sourced locally if appropriate skills are available, from Batchelor and Darwin. Mt Grace has no preference for bringing to site its own construction team, except where specific technical skills and professional staff are unavailable locally. The residents of Batchelor will be well positioned to find employment on the temporary construction team as well as part of the ongoing, permanent operations workforce.

Batchelor, being township with a population of only 645, will be significantly affected by an increase in residential population (as much as 10% population growth) associated with the Project's construction works. There will be increased pressure on community infrastructure, with a potential short-term shortage of services and facilities anticipated.

Operation

Employment resulting from the operation of the mine will be smaller than that during construction. Approximately 73 full time staff will be employed for post-construction operational activities.

The longevity of the proposed project (possibly more than 25 years) is expected to encourage long-term growth and investment in the Batchelor community and a consequent boost to the local economy. An increased residential population will enhance the economic viability of some business and service industries.

Initially there is expected to be a strain on the local socio-economic environment with a sudden increase in the local population, but over time as local business and industry expand supply, demand is expected to stabilise. The local economy will benefit with more local business and services being patronised. The overall outcome is anticipated to be economic and social growth in the region, particularly for the township of Batchelor.

4.14 Community

4.14.1 Health and Education Services

An increase in the population of Batchelor will potentially result in expansion of existing health services. This will benefit the Batchelor community and promote its future growth.

It is expected that an increased population will increase school enrolments and thus promote the sustainability and expansion of the Batchelor Area School and annexes. Increased enrolments will benefit services and facilities provided to education in the region.

The mine will also provide a source of educational material for the Batchelor Area School and Batchelor Institute.

4.14.2 Recreation

An increase in the local population is likely to result in more funding becoming available for local recreational facilities. An increase in the population should also make some sports or recreation activities and facilities feasible, where previously a lower population number restricted certain development.

4.14.3 Housing and Accommodation

There is a surplus of housing/accommodation in the Batchelor area for the current workforce, however, in the past there has been a shortage of housing in Batchelor to accommodate large, especially temporary, workforces. The construction workforce is estimated at approximately 100 full-time staff, employed for a period of nine to twelve months. Temporary accommodation will be established for the additional workforce and Mt Grace is assessing options of establishing a temporary workers camp in Batchelor. There is a possibility that a local caravan park may be utilised for this purpose.

A new area has been zoned for housing development in Batchelor to service prospective industrial development, primarily from the mining industry.

4.15 Traffic

Construction

With the exception of large equipment, such as the calcining kiln, most equipment will be manufactured off-site and transported to the site. Large equipment will be transported in parts and constructed on site. For Stage 1 of the Project there will be an estimated five trucks per day entering and leaving the construction site, and possibly twice that number on any one day. Trucks will travel only along Crater Lake Road to Stuart Highway and will avoid the publically frequented Batchelor Road. The subsequent expansions for Stages 2 and 3 are expected to result in doubling and then quadrupling of the initial Stage 1 heavy traffic. This is a significant increase from current traffic trends and may impact traffic movement onto Stuart Highway.

The workforce number will vary over the nine to twelve month construction period, peaking at about 130 personnel. The workforce will need to be transported to and from site each day from either Batchelor or Darwin by private car or bus. There will be significant increase in light vehicular traffic along Batchelor and Crater Lake Roads each day during the construction phase. Batchelor Road can be busy in the Dry Season during the peak tourist period. Provision for the additional traffic may need to be made, with potentially an additional turn-off lane at Crater Lake Road, to prevent congestion.

Operation

There will be a requirement for 50 t/day of reagent and 25 t/day of limestone for operation of Stage 1 of the processing plant. Approximately 40 t/day of magnesium product will be transported away from the mine during Stage 1 and approximately 160 t/day during Stage 3. Fuel will have to be transported to site much less frequently. There will be an estimated three trucks per day entering and leaving the mine site along Crater Lake Road during Stage 1 and up to twelve trucks per day during Stage 3. Trucks transporting product will utilise the Stuart Highway between Darwin and the Crater Lake Road turn-off. There may be some requirement for extra roadwork to accommodate the increase in heavy traffic and Mt Grace will liaise with Coomalie Council and the DIPE.

There will be an increase in light vehicular movements along Crater Lake and Batchelor Roads, transporting mine staff and contract maintenance staff to site. Potentially a small bus, mobilised from Darwin/Palmerston, will be utilised for commuting shift workers. There will be 10-12 people per shift during Stage 1 with around twice that number on site during day shift on normal week days. This is not expected to have a major impact on existing traffic.

4.16 Visual Amenity

Over the life of the mine the mine pit will reach a maximum size of about 24 ha. It will be a substantial alteration to the natural environment but will not be obvious from any publicly accessible vantage point. The pit will be set back from Batchelor Road and from the access point at Crater Lake Road. There will be a screen of trees and bush between Batchelor Road and the mine pit. The existing bush screen will be thickened to enhance visual amenity.

The processing plant will be housed in a small, standard ‘color-bond’ clad building about 20m high with base dimensions of approximately 50 x 25m. The upper section of the plant is expected to be visible from Batchelor Road from a distance of over 1 km but will not be visible from Crater Lake

Road. In Stage 1 there will be three emission stacks, one of about 63m in height and the other two about 15 to 20m in height, the tops of which will be visible from the Batchelor and Crater Lake Roads and Batchelor environs. In Stage 3 another main emissions stack (63m) and two small stacks (15 to 20m) will be added, totalling six stacks when plant is operating at full capacity. Visible emissions from the processing facility are anticipated to be minimal with colourless carbon dioxide and some water vapour (condensed into a steam cloud) being the primary emissions.

4.17 Conservation Issues

Mt Grace recognises the environmental, social and cultural significance of Litchfield National Park. The proposed project is not expected to have a significant effect on Litchfield National Park. The proposed mine-site is 15 km away from Litchfield National Park's nearest boundaries. Coomalie Creek (Right Branch), which flows through the proposed mine site, is part of the Adelaide River system and flows in an easterly direction. Litchfield National Park is primarily located in the Finniss River Catchment to the west of the proposed mine-site, which is distinct from the Adelaide River system and physically separated.

4.18 Archaeology and Heritage

Construction and Operation

No archaeological sites or isolated artefacts are situated directly within areas proposed for mine infrastructure construction. Archaeological site Coomalie Creek 4 is situated approximately 40m north of the proposed open cut pit, while the overland telegraph pole is located approximately 100m south of the proposed plant and crusher. All other archaeological materials are located at least 200m from the closest proposed project facility.

Coomalie Creek 1-6 and isolated artefacts are situated within or close to recorded Aboriginal sacred sites. As a result, both the *Aboriginal Sacred Sites Act (1989)* as well as the *Heritage Conservation Act (1991)* will restrict the range of development activities possible in these areas, thus protecting these artefacts.

It is not expected that any archaeological sites will be directly impacted as a result of mine construction. Coomalie Creek 4 is however considered vulnerable, although not directly threatened, due to its close proximity to the proposed open cut pit. Particular efforts will be made to protect this site from any inadvertent damage.

Given that mine construction and operation is likely to be associated with increased levels of activity on the mine lease, there is a potential risk of other sites being impacted inadvertently by vehicles, heavy machinery or through casual site visitation.

The mine construction and operation will disrupt the natural surface-water course of Coomalie Creek and pit dewatering will disrupt groundwater flow. The Aboriginal Custodians consider all surface water and groundwater courses to be of spiritual significance (the banks and bed of Coomalie Creek comprise a Registered Sacred Site) and have voiced concerns about the impact of the mine on these features.

Management

The project area is located within an area of significance to the Kungarakany and Warai people, who are considered the Aboriginal custodians of the area. Four registered sacred sites, one recorded sacred sites, six artefact clusters and six archaeological sites are located within the lease area.

No archaeological sites are expected to be disturbed as a result of site development. Diversion of Coomalie Creek (Right Branch) will result in the disturbance of sacred site number 5171-114 (‘the banks and bed of Coomalie Creek’).

During construction and operation sacred sites will only be accessed following permission from the Aboriginal Custodians in conjunction with AAPA. The sacred sites and the archaeological sites located within the lease area will be clearly marked and protected by Machinery Exclusion Zones, prohibiting any construction, earthmoving, or vegetation clearing within the sacred/archaeological site boundaries. Access to these sites will also be restricted and their boundaries will be fenced and clearly marked.

Alterations to surface water and groundwater regimes in the lease area will, as much as practical, be minimised. The diversion of Coomalie Creek (Right Branch) will be constructed in a manner that minimises the impact on the flow regime of the creek, and pit dewatering will be undertaken at the minimum rate required to facilitate mining operations and worker safety.

An awareness program will be conducted for all employees, contractors and visitors to the site including the presence and significance of sacred and archaeological sites.

5 ENVIRONMENTAL MANAGEMENT PLAN

5.1 Introduction

5.1.1 Terms of Reference

This Draft Environmental Management Plan (EMP) is structured to address potential environmental impacts identified in the EIS as a result of the construction and operation of the Batchelor Magnesium Project. The EMP outlines Mt Grace's policy on environmental management, addressing in brief the main management issues and the proposed approach to be taken.

This EMP addresses environmental issues pertinent to the project, including:

- flora;
- fauna;
- biting insects;
- groundwater;
- surface water;
- erosion;
- air emissions;
- waste management; and
- cultural heritage.

The EMP also outlines the monitoring programs that will be conducted during site development/ operation, and decommissioning and rehabilitation procedures.

Under the requirements of relevant Northern Territory legislation, Mt Grace will prepare a Mining Management Plan (MMP) prior to and annually after the commencement of mining. The aim of the MMP is to provide company employees and relevant regulators with an understanding of the operations proposed, identify changes to environmental and safety considerations and principles for rehabilitation. The MMP will draw on information and commitments provided in the EMP.

5.1.2 Company Commitment

Mt Grace is committed to achieving and maintaining environmental standards, such that all Northern Territory and Commonwealth environmental regulations and guidelines are met and adverse environmental impacts resulting from the construction and operation of the mine and associated plant are removed or minimised. This will be achieved through:

- appropriate project planning and site selection;
- adoption of methods of construction/operation that are considered to be best practice; and
- the development and implementation of an ISO 14000 accredited Quality Management System.

Implementation of on-going environmental monitoring programs will enable the assessment and modification, if required, of the EMP. Mt Grace will carry out annual reviews of its EMP in response to monitoring outcomes, allowing iterative improvement of the management strategy over time. Progression of the project through each development stage will not occur unless monitoring of direct and indirect effects of on-site activities indicate management strategies employed are successful in the control of adverse environmental impact.

Mt Grace has instigated a community consultation program whereby members of the local community and relevant interest groups are able to participate in the decision-making process concerning various aspects of mine and plant operation.

5.1.3 Regulatory Requirements

The Batchelor Magnesium Project will be operated in accordance with relevant Northern Territory and Commonwealth legislation and regulations, including the:

- *Aboriginal Sacred Sites Act (1989);*
- *Environmental Offences and Penalties Act 1997*;
- *Heritage Conservation Act 1991*;
- *Coomalie Community Government By-laws 1998*;
- *Coomalie Community Government Scheme 1990*;
- *Dangerous Goods Act 1996;*
- *Mining Act 1980*;
- *Mine Management Act 1990* (soon to be replaced by the *Mining Management Act*);
- *Waste Management and Pollution Control Act 1998*;
- *Water Act 1992*;
- *Weeds Management Act 2001*; and
- *Work Health Act 1986.*

Summary of Overall Management Objectives

- Minimise any adverse environmental impacts resulting from the construction and operation of the Batchelor Magnesium Project.
- Carry out all mining and related procedures in accordance with Northern Territory and Commonwealth regulations and legislation.
- Develop and implement an ISO 14000 accredited Quality Management System.
- Implementation of on-going environmental monitoring programs.
- Annual reviews the MMP and EMP to allow for iterative improvement.
- Work with the government and community to ensure relevant concerns (where present) are addressed.

5.2 Environmental Management Measures and Commitments

5.2.1 Flora

Vegetation in the lease area comprises three broad habitat types: upland woodland, drainage areas and rainforest areas. No endangered plant species or regionally special vegetation communities are present in the project area.

MANAGEMENT COMMITMENT	
Through the design of the project and management strategies adopted during construction and operation, Mt Grace will conserve flora habitats of restricted distribution and minimise the loss of vegetation in other areas.	
Management Strategies	Clearing of vegetation will be confined to that necessary for the establishment of required infrastructure for the proposed development and the movement of vehicles will be managed to ensure minimal loss of vegetation. In the area of the Coomalie Creek diversion, re-vegetation will be undertaken to re-establish the riparian corridor. Management strategies will be implemented to control the occurrence and spread of fire, restrict the spread of weeds and to minimise the impact of erosion/sedimentation. These measures will serve to minimise the potential for adverse impact on vegetation communities in the area.
Monitoring	Annually.
Reporting	Annually, as part of MMP.

5.2.2 Fauna

A total of 122 native terrestrial vertebrate species were recorded during field survey work, comprising 6 amphibian, 21 reptile, 74 bird and 21 mammal species. Two of the mammal species, the Northern Quoll and Pale Field Rat, are listed as ‘lower risk – near threatened’ (*Territory Parks and Wildlife Act*, 2001). Aquatic fauna in Coomalie Creek includes freshwater fishes (16 species), freshwater crocodile, crustaceans (5 species), molluscs, prawns and insects.

A 1.2 km section of Coomalie Creek (Right Branch) will be diverted during construction, resulting in some clearing of riparian vegetation and removal of aquatic habitat.

MANAGEMENT COMMITMENT	
Clearing activities will be avoided in areas representing significant habitats for the two mammal species identified as ‘lower risk – near threatened’, and clearing of vegetation during construction and operation phases of the project will be minimised to protect other fauna habitats. Where possible, re-vegetation of cleared areas will be undertaken to re-establish fauna habitats.	
Management Strategies	The design of the proposed site development footprint will minimise the requirement for clearing, disturbance and indirect impact to habitats that support a range of and diversity of fauna within the study area, including *Melaleuca* woodland, *Eucalypt* woodland and *Lophostemon* woodland communities. The proposed layout of road networks, equipment dumps, associated works and operational areas will avoid disturbance to the most significant communities that support the Northern Quoll and Pale Field Rat and minimise the loss of vegetation cover and riparian habitats. During the construction and operational phases of the project, habitats that support the highest species diversity in the study area will be protected from disturbance. These habitats include dry vine-forest, and the riparian vegetation associated with Coomalie Creek (Right Branch). Impact on the habitat value and condition will be minimised by preventing indirect impacts associated with drainage, waste and the spread of weeds. The Coomalie Creek (Right Branch) diversion will incorporate an excised channel similar to that of the original creek. Habitat connectivity along the creek will be maintained and enhanced where possible - canopy breaks and disturbance along this riparian corridor will be minimised and the area re-vegetated with the objective of re-establishing a continuous riparian corridor.

	To minimise the potential for impact on aquatic fauna in Coomalie Creek (Right Branch), permanent refuge pools will be established in the diversion channel, and the quality of water discharged from operational areas, including the waste rock dump, will be monitored and appropriate management/mitigation measures instigated prior to release.
Monitoring	Biannual Wet and Dry Season survey of fauna.
Reporting	Annually, as part of MMP.

5.2.3 Weeds and Feral Animals

Weed infestations were evident in all major habitat types during survey works. Sixteen weed species were recorded, seven of which are declared noxious weeds (Class B). Feral horses, cats and pigs were recorded during survey works, with pigs being the most numerous and exacting the most damage. It is likely that feral dogs and cattle also occur in the study area.

MANAGEMENT COMMITMENT	
Mt Grace will undertake a program of weed and feral animal management such that the lease area does not represent a significant breeding area/habitat for these introduced species.	
Management Strategies	A Weed Management Plan will be prepared and implemented. The Plan will incorporate management requirements for cleared areas, vehicle/equipment washdown and an on-going control program to target weed species. Weed removal will be undertaken in selected areas and Class B weeds will be controlled by the targeted application of weedicides. A management program for the control of feral pigs, especially in riparian habitats in the study area will be implemented. Feral pigs are likely to have the highest impact as they are the most numerous and destructive species in the study area. The disturbance caused by feral pigs may also result in an increase in the spread of weeds and the control of feral pigs may also assist in weed management.
Monitoring	**Weeds –** Annual weed surveys will be undertaken to ensure that the activities of the proposed mine does not cause weeds to proliferate within or beyond the project area. Areas to be monitored include waterways, access roads and fire breaks. Survey works will involve data collection relating to species composition and spread. **Feral Animals -** Record sightings and signs of feral animals.
Reporting	Annually, as part of MMP

5.2.4 Biting Insects

Biting midges were not present in significant numbers within the lease area and are not expected to represent a significant pest problem. Mosquitoes were found in greater numbers and, at current levels, are considered to represent a low to moderate pest problem. A total of 13 mosquito species were identified, of which a number of species known to be vectors of Murray Valley encephalitis, Ross River virus and Barmah Forest disease.

MANAGEMENT COMMITMENT	
Mt Grace will actively work to minimise and ameliorate potential biting insect breeding sites and control emergent populations in an appropriate manner.	
Management Strategies	The creation of potential biting insect breeding sites during construction and operation will be minimised, for example, roads constructed on the mine site will have engineered culverts so as not to impound water. Any pooling or unnecessary collection of stagnant water, such as within tyres, drums and wheel track depressions, will be drained or filled as appropriate. The requirement for biting insect control will be employed in the design of settling ponds and water impoundment structures. The Coomalie Creek (Right Branch) diversion channel will be constructed such that no pooling or significant downstream sedimentation occurs. The proposed diversion of the creek will recreate the defined nature of the central channel, and the margins will be revegetated with trees to discourage marginal grass and reed growth. All cut-off sections to the altered creek will be filled and leveled to prevent pooling. Where installed, septic tanks will be completely sealed and absorption trenches positioned such that there is no surface run-off/pooling. Septic and rainwater tanks will be constructed to meet THS regulations. Roads constructed on the mine site will have engineered culverts and drainage structures will be designed so as not to impound water that could create new mosquito-breeding habitats. If required, biological control of mosquito larvae will be undertaken in consultation with THS, using a larvicide such as *Bacillus thuringiensis* var. *israelensis*. Administration facilities will either be mosquito proof (with insect screening) or sealed and air-conditioned. Mt Grace employees will be advised of appropriate personal protection measures.
Monitoring	Biannual survey (Wet Season and Dry Season) of biting insect number and type will be undertaken. Survey work will involve trapping and logging. In addition, sewage treatment facilities and any other wastewater storage/artificial ponds created by mining operation will be inspected for mosquito larvae twice yearly.
Reporting	Annually, as part of MMP.

5.2.5 Fire

Frequent extensive burning during the Dry Season typically occurs in the lease area each year. Flora survey work indicated approximately 80% of the lease area was burnt in 2001.

MANAGEMENT COMMITMENT	
Mt Grace will minimise the potential for uncontrolled fire within and extending across the lease boundary.	
Management Strategies	A Fire Management Plan will be developed, incorporating Northern Territory Bushfire Council and local Shire requirements for annual fuel reduction burning and the installation of firebreaks. Implementation of the Plan will minimise the potential for uncontrolled and inappropriate burning. The Plan will address the wildlife and habitat issues in remnant and refuge habitat and will include an appropriate fire regime and sequence for the protection and maintenance of the dry vine-forest, riparian forest and *Melaleuca* woodland communities. The Fire Management Plan will consider the requirements of fauna species that are favoured by early Dry Season low intensity fires, maintaining a mosaic of

	vegetation with varying fire seasons, intensities, between-fire intervals and structural development, and development of a spatial diversity of vegetation structures.
Monitoring	On-going visual assessment of fuel load, weed species and firebreak adequacy will be undertaken.
Reporting	Annual reporting, as part of MMP.

5.2.6 Groundwater

The main regional aquifers in the project area are the sand and gravels within the alluvium of Coomalie Creek (Right Branch) and the immediately underlying weathered Dolomite at the contact with the alluvium. These aquifers occur at a depth of greater than 1m below ground level and during the Wet Season rise to surface or near surface levels in the lower lying sections of the project area. While mining is being undertaken a requirement exists to lower the level of the groundwater table in the area of the pit. This will be undertaken through the installation of a series of groundwater abstraction bores located around the area of the pit. Groundwater abstracted will be of a high quality and suitable for use as process water and dust suppression, with the balance to be discharged to Coomalie Creek (Right Branch) within the project area.

MANAGEMENT COMMITMENT	
Mt Grace is committed to ensuring that mining operations have a negligible long-term impact on the regional groundwater regime.	
Management Strategies	The groundwater level will be lowered in a staged manner, such that the level will be maintained at a depth greater than the base of the open pit. Abstraction will occur on an on-going basis with a relatively constant flow rate. Measures to minimise the impact of erosion/sedimentation from the discharge of excess groundwater (dewater) to Coomalie Creek (Right Branch) will be employed. For example, settling ponds will be installed to reduce the level of suspended sediments in discharge water. Adjustments will be made to the physico chemical properties/quality of dewater prior to release to Coomalie Creek (Right Branch) where a potentially adverse environmental impact is anticipated, for example by cascading discharge water to elevate levels of oxygen.
Monitoring	A groundwater model for the Winchester deposit and surrounding area will be used to provide a temporal and three dimensional analysis of the effected aquifers. A groundwater monitoring program will be developed, with baseline data collected showing pre-development conditions. The program will include the on-going monitoring of: regional groundwater levels; groundwater quality; and pumping rates, pumping water levels and the operational status of production bores.
Reporting	Annually, as part of MMP.

5.2.7 Surface Water

Coomalie Creek (Right Branch) flows through the project area. To minimise the potential for flooding of the pit, a creek diversion will be constructed around the open cut pit. During operation, excess mine dewater will be discharged to Coomalie Creek (Right Branch). Run-off from the waste rock dump and plant and crusher area will also discharge into Coomalie Creek (Right Branch).

MANAGEMENT COMMITMENT	
Mt Grace is committed to: maintaining the existing high quality of surface water on site and immediately downstream; ameliorating any adverse effects that the Project has on water quality; and regularly monitoring water quality for the purpose of on-going management.	
Management Strategies	Plant areas will be designed and constructed to ensure that drainage is adequate and open unlined drains do not scour or overtop during intense rainfall events (> 50 year average recurrence interval). Mitigation measures will be employed to ensure sediment and contaminants do not come into contact with, or are transported off-site in surface water run-off. Sediment and pollutants in run-off water from the plant and mine site will be intercepted and collected in settling ponds prior to discharge. Sediment and TITs will be installed as required and bunding, and other measures will be designed to prevent fuel, oil or other contaminants being released to run-off water. The slopes and slope lengths of the waste dumps will be minimised and drains installed to intercept and divert run-off water from the dumps. Waste dumps will be bunded and incorporate sediment traps. Road crossings and other traffic areas will be located and constructed to minimise the concentration or diversion of water in the creek/floodplain area. Channel grade and flow width will be designed to allow some attenuation of the run-off hydrograph. Surface cover will be maintained in the channel and floodplain areas. The diversion of Coomalie Creek (Right Branch) has been designed such that hydraulic and floodplain characteristics of the original stream and floodplain are retained and to accommodate a 1 in 50-year flood without sustaining substantial erosion damage.
Monitoring	Monitoring of discharge water quality from the project area, including the waste dumps will be undertaken on a three-monthly basis, incorporating first flush monitoring at the commencement of the Wet Season.
Reporting	Annually, as part of MMP.

5.2.8 Erosion

As part of site development approximately 112 ha of vegetation across the lease area will be cleared. As a result of clearing and site leveling during construction, and changes to the current hydraulic regime of the area, there is a significant potential for erosion/sedimentation if appropriate control measures are not implemented.

MANAGEMENT COMMITMENT	
Mt Grace is committed to mitigating potential erosion resulting from land clearing and mine/plant activities during construction and operational phases.	
Management Strategies	An Erosion and Sediment Control Management Plan will be developed and implemented throughout construction and operation phases of the Project. The Plan will address the potential for short-term point sources of accelerated erosion/scour as well as potential long-term alterations to soil structure and the environment. The Coomalie Creek (Right Branch) diversion channel will be constructed with a wide flat bed to reduce stream velocity and will incorporate erosion prevention structures and silt traps to ensure no unplanned pooling occurs and to minimise sediment load to Coomalie Creek (Right Branch). The proposed diversion of the creek will incorporate a defined central channel similar in dimension to the existing Coomalie Creek (Right Branch) drainage line, and the margins will be revegetated with trees to discourage marginal grass and

	reed growth. The remnant drainage line will be filled and leveled to prevent pooling. To reduce the potential for erosion, construction activities will be carried out during the Dry Season and only the minimum area of land required will be cleared and/or disturbed. Slopes created as part of site development will be stabilised, where practical, with vegetation or appropriate erosion control matting. Stockpiles will not be located close to watercourses and silt traps will be installed where required. Run off water from access roads will be directed to open drains. All drains will be constructed at appropriate slopes and of suitable material to prevent erosion. Water will be discharged at engineered discharge points. Where possible disturbed or cleared areas will be protected from erosion through the retention of ground cover vegetation or revegetation. Protection against erosion will also be afforded through the use of strategically placed silt traps, filters (such as hay bales) or silt fences. During mine operation soil conservation techniques will be adopted to prevent erosion from waste dumps. The waste dumps will be progressively revegetated, slopes and slope lengths will be minimised and silt traps and drains installed to intercept and divert run-off water from the dumps. The waste dumps will be bunded and run-off will be discharged at non-erosive velocities. Bunds will be armoured, as required, to prevent erosion.
Monitoring	The condition and operability of site drains and erosion mitigation measures will be routinely assessed (weekly during the Wet Season and episodically after significant rainfall events). Stockpiles and areas of revegetation will be routinely inspected.
Reporting	Quarterly progress reports, and annually, as part of MMP.

5.2.9 Dust and Noise

The site is currently undeveloped, comprising predominantly open woodland with a moderate ground cover. The generation of dust is currently limited to isolated occurrences, as a result of wind disturbance during the Dry Season. There are no operations in the immediate area that result in the generation of noise.

Management Commitments	
Mt Grace is committed to maintaining a healthy environment for staff, residents and visitors to the area. To this end dust and noise will be carefully monitored and appropriately managed.	
Management Strategies	**Dust** – During construction and operation dust generated on unpaved roadways and plant areas will be controlled by the application of water on an “as needs” basis. Re-vegetation will be progressively undertaken, limiting the generation of dust. **Noise** – Activities that are likely to generate elevated noise levels at the lease boundary (for example, construction and blasting) will only be undertaken during daylight hours. Mining will be conducted on a campaign basis, limiting the periods of noise generation, and local residents will be notified with regard blasting schedules. Appropriate occupational health and safety measures will be employed for on-site personnel.
Monitoring	Dust and noise monitoring will be undertaken on site and, where required, in surrounding areas. Noise will be monitored by use of portable noise dose meters/sound level meters and dust monitoring will largely be completed by visual assessment of nuisance.

	On-site monitoring will be undertaken on a monthly basis at locations including in and around the open cut pit during mining and in the area of the Plant. Off-site locations, such as the nearest residential dwelling and Batchelor township, will be monitored on an "as required" basis where a specific issue has been identified.
Performance Indicators	AS 1055.1 – 1997 *Acoustics – Description and Measurement of Environmental Noise.*
Reporting	Initially monthly after commencement of operations, to annually (as part of MMP).

5.2.10 Air Quality

Existing air quality in the Batchelor region is expected to be good, with occasional elevated levels of suspended and deposited particulates due to windblown dust, agricultural activities or bush fires. The project will contribute minor emissions of pollutants, primarily fugitive dust emissions, however off-site impacts at Batchelor township or nearest residences are predicted to be minimal with appropriate dust mitigation measures.

MANAGEMENT COMMITMENT	
Mt Grace is committed to manage and minimise all atmospheric emissions from the project to ensure the protection of health, well-being and amenity for Mt Grace employees, contractors, visitors and residents in the Batchelor region.	
Management Strategies	Water sprays will be used (as required) across work zones and unsealed areas to suppress dust. The water would be applied by water cart across ground surfaces whenever the surface has the potential to generate excessive levels of dust. Areas of excavation or works would not exceed the capacity of the water spray units. Mt Grace will ensure that exposed surfaces and stockpiles are watered or sprayed where required. Blasting or particularly dusty works will be scheduled under favourable meteorological conditions only. Earth moving activity will be stopped where wind speeds exceed 30 km/hr. Unsealed access roads will be sprayed with water as required and vehicle speeds on unsealed areas will be strictly controlled to minimise dust. If necessary consideration will be given to sealing major roads. Vehicles will not be loaded above the height of the side and tailboards. Dust controls will be provided on all exhaust points from transfer and handling of grain and other dry bulk product. (i.e. baghouses on all major plant and equipment generating significant point sources of dust). Where required, long-term stockpiles will be stabilised using fast-seeding grass or synthetic cover spray. Exposed areas will be minimised through rehabilitation.
Monitoring	Monitoring requirements, to be focused on particulates, will be detailed in the MMP.
Reporting	Annually, as part of MMP.

5.2.11 Greenhouse

The Batchelor Magnesium Project is anticipated to emit approximately 675,000 tonnes per annum of GHG emissions ($CO_{2\ eq}$), primarily from calcining processes and electricity requirements. However if more than 27% of the product is used to replace steel in motor vehicles, there will be an overall GHG benefit.

MANAGEMENT COMMITMENT	
Mt Grace is committed to manage and minimise all atmospheric emissions from the project which have the potential to contribute to the enhanced greenhouse effect, and will strive for continuous improvement in greenhouse gas management.	
Management Strategies	Mt Grace intends to participate in the Commonwealth Greenhouse Challenge Program with the Batchelor Magnesium Project. Through this cooperative agreement, the following steps will be undertaken: • Establish an inventory of emissions. • Develop an Action Plan to minimise GHG emissions. • Forecast expected reductions in GHG emissions that would result from the implementation of the Action Plan. • Sign an agreement with the Commonwealth committing to the actions outlined in the Action Plan. • Monitor emissions against forecasts. • Provide annual reports on progress. Various 'no regrets' and 'beyond no regrets' measures will be evaluated for possible inclusion in an Action Plan. These include capital projects or operating procedures that improve energy or chemical conversion efficiencies, management initiatives and improvement programs that make "small step" GHG benefits, use of alternative or renewable energy technologies, and Research and Development projects with the potential to reduce GHG emissions.
Monitoring	Monitoring requirements for GHGs will be agreed with the DIPE and AGO during development of the MMP.
Reporting	Annually, as part of MMP and Greenhouse Challenge Cooperative Agreement with AGO.

5.2.12 Fuel, Chemical and Dangerous Goods Handling and Storage

All fuel and chemicals utilised on-site will be appropriately stored and handled, in compliance with legislation such as the Northern Territory *Dangerous Goods Act 1996* and relevant standards, such as AS/NZS 1940: 1993, The storage and handling of flammable and combustible liquids, AS/NZS 3833:1998, The storage and handling of mixed classes of dangerous goods in packages and intermediate bulk containers, and VID018-1997, Safe handling of hazardous substances**.**

MANAGEMENT COMMITMENT	
Mt Grace will ensure that fuel and any chemical or dangerous goods used on-site will be stored and handled in accordance with appropriate standards, guidelines and operating procedures such that they do not represent a risk to human health or the environment.	
Management Strategies	Fuel, chemical and dangerous goods storage and handling procedures will be designed and operated in accordance with relevant standards and any specific requirements of Workhealth. Employees working in areas with possible contact with fuel, chemical and dangerous goods will be appropriately trained. Occupational health and safety and emergency response procedures/plans for clean-up, etc will be developed and implemented as required.
Monitoring	An annual compliance audit will be conducted, in consultation with DBIRD.
Reporting	Annual reporting, as part of MMP.

5.2.13 Waste

Operational waste will be disposed in a number of ways including, disposal to the waste dumps, slag dumps, sold to recycling/agricultural markets, vented to the atmosphere or dispatched to a appropriately licensed waste management contractor/facility. Domestic wastewater and sewage effluent will be disposed to on-site septic tank and associated absorption trenches or a self-contained package sewage treatment plant.

MANAGEMENT COMMITMENT	
Mt Grace will appropriately remove and/or treat wastes generated on site and will regularly review waste disposal procedures.	
Management Strategies	All solid waste generated during the construction of the mine and plant will be removed from site by either waste management contractors or the construction contractors. Solid wastes generated during mine and plant operation will be directed to designated waste disposal sites. The waste dumps and the slag dumps will be bunded. Surface water run-off from these areas will be passed through a sediment pond and run-off will be periodically sampled and tested to confirm water quality prior to release. Waste water and runoff from the workshop areas and the washdown bays will be passed through a TIT in order to remove oily residue. Wastes that are unsuitable for disposal on-site, such as ammonium sulphate and ammonia, will be sold or dispatched to waste management contractors. Hazardous gases, produced in the operational phase, including phosphine and sulphur dioxide, will be adequately vented in accordance with all appropriate health and safety requirements pertaining to the use of these gases. Recycling of waste will be maximised. Waste tracking documentation will be utilised such that the disposal/recycling of all solid waste generated as part of site operations is open to audit.
Monitoring	Conduct testing on waste dump runoff in settlement ponds prior to release. Generation of hazardous gases will be monitored and vented in accordance with all appropriate Health and Safety requirements.
Reporting	Annual reporting, as part of MMP.

5.2.14 Archaeological and Anthropologically Significant Sites

The project area is located within an area of significance to the Kungarakany and Warai people, who are considered the Aboriginal custodians of the area. Four registered sacred sites, one recorded sacred site, six artefact clusters and six archaeological sites are located within the lease area. In addition, local custodians have indicated all surface water and groundwater water in the area holds spiritual significance.

No archaeological sites are expected to be disturbed as a result of site development. Diversion of Coomalie Creek (Right Branch) will result in the disturbance of sacred site number 5171-114 (‘the banks and bed of Coomalie Creek’).

MANAGEMENT COMMITMENT	
Mt Grace will comply with regulatory requirements of the AAPA and consult with the Aboriginal Custodians of the area regarding sacred and archaeological sites and artefacts located on the lease area.	
Management Strategies	Sites will only be accessed following permission from the Aboriginal Custodians in conjunction with AAPA. The sacred sites and the archaeological sites located within the project area will be clearly marked and protected by Machinery Exclusion Zones, prohibiting any construction, earthmoving, or vegetation clearing within the sacred/archaeological site boundaries. Access to these sites will also be restricted. Alterations to surface water and groundwater regimes in the project area will, as much as practical, be minimised. The diversion of Coomalie Creek (Right Branch) is designed to have minimal impact to the overall flow of water through the creek, and pit dewatering will be undertaken only at a rate necessary to facilitate mining operations and worker safety. One archaeological site (Coomalie Creek 4) associated with a sacred site is in close proximity to the proposed mine pit and particular efforts will be made to protect this site from any inadvertent damage due to increased traffic and activity. A Machinery Exclusion Zone will be created with a radius of 20m and its boundaries will be fenced and clearly marked. The precise location of this site has been delineated in the field by AAPA and is surveyed and marked on the ground. The workforce will be educated with regard the presence and significance of sacred and archaeological sites. This will protect the sites from casual vandalism, unauthorised collection of material and any other anthropogenic disturbance, throughout all phases of the mine. Mt Grace, upon request, will make access to sacred and archeological sites freely available for the Aboriginal Custodians, although safety of all people will be a priority and direct access to mining operations areas will be strictly prohibited.
Monitoring	Sacred and archaeological sites identified within the lease area will be visually assessed on a three-monthly basis to monitor their integrity.
Reporting	Annual reporting, as part of MMP.

5.3 Decommissioning and Rehabilitation

The life-span of the mine is likely to be greater than 25 years. The following discussion outlines the proposed approach to decommissioning the mine and rehabilitation of the mine-site after the cessation of mining activity. The long-term objectives of the rehabilitation process will be to achieve a stable post-mine terrain and landscape not drastically different to its surrounding and original environment, and to preserve water quality in the area. Implementation of the strategies suggested should enable relinquishment of the mining lease after cessation of mining. The rehabilitation and decommissioning procedure will be regularly reviewed and developed prior to implementation, as there is a long projected time frame before it will be activated.

At closure, the following safeguards will be undertaken:

- roads, stockpiles and other unstable areas will be rehabilitated by revegetation, landform shaping and drainage designed to prevent run-off converging to create erosion gullies;

- road crossings will be rehabilitated and the Coomalie Creek (Right Branch) channel and floodplain will be made stable under all flow conditions; and

- any discharge from the pit overtopping will be monitored and if required treated to ensure no adverse impact to downstream water quality.

After closure, up until relinquishment of the mining lease, a monitoring program will be implemented that demonstrates that rehabilitation work has successfully stabilised the mine area and water quality has returned to normal. Monitoring will consist of:

- visual assessment of the occurrence of erosion or siltation around and downstream of the mine site;

- sampling of run-off water at increasing intervals as the site stabilises; samples will be tested for high sediment or nutrient levels and the presence of other pollutants; and

- on-going surface water sampling during the Wet Season will be undertaken post closure to allow monitoring of water quality, particularly sediment loads, the presence of metals and ions. Opportunistic sampling will also be undertaken after run-off events.

The potential groundwater impacts after mining operation of the Winchester deposit area are associated with decommissioning the mining area. Based upon the trial pit dewatering results and the expected recharge to the shallow aquifers during the annual Wet Season, it is expected that the final pit void will fill with water by the end of the first Wet Season after de-commissioning. It is also expected that groundwater levels will recover to pre-mining levels during the same period.

Revegetation

The general resilience of the localised environment has been recognised by the high diversity of animals and plants on site, following significant historical disturbance. Although the site is somewhat degraded with an abundance of weeds, the diversity and abundance of animal species is high. There is a significant chance that the site may be rehabilitated to a better quality environment than currently exists.

Overall Rehabilitation Objectives

- Establish a stable post-mine terrain and landscape as close as practical to the original environment.
- Maintain air, surface water and groundwater quality in and downstream of the project area.

5.4 Compliance Audit and Reporting

In accordance with applicable regulatory requirements, Mt Grace will undertake regular audits and reviews of mine operations and the processing facility's environmental and health and safety management procedures. Significant environmental incidents will be immediately investigated and Site Management will regularly review operational performance.

There will be reports as required to:

- Department of Business, Industry and Resource Development;
- Department of Infrastructure, Planning & Environment; and
- Territory Health Services (Workhealth).

In addition to a program of annual reporting, Mt Grace propose to regularly conduct internal audits of health, safety and environmental procedures.

6 ACKNOWLEDGMENTS

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The study team and authors are as follows:

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- Scott Mitchell, Heritage Surveys
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8 ABBREVIATIONS AND GLOSSARY

Chemical Symbols and Formulae

Symbol/Formulae	**Chemical**
Al	Aluminum
Al_2O_3	Aluminum oxide
C	Carbon
$Ca\ CO_3$	Calcium carbonate
CaO	Calcium oxide; lime
CO_2	Carbon dioxide
Fe	Iron
Fe_2O_3	Ferris oxide
K_2O	Potassium oxide
KCl	Potassium chloride
Mg	Magnesium
$MgCl_2$	Magnesium chloride
$MgCO_3$	Magnesium carbonate; Magnesite
MgO	Magnesium oxide
$MgSO_4$	Magnesium sulphate
Mn	Manganese
MnO	Manganese oxide
Na	Sodium
NH_3	Ammonia
NH_4SO_4	Ammonium Sulphate
O_2	Oxygen
P_2O_5	Phosphorous pentoxide
PH_3	Phosphine
Si	Silicon
SiO_2	Silicon dioxide
SO_2	Sulphur dioxide
TiO_2	Titanium dioxide

Abbreviations

AAPA	Aboriginal Areas Protection Authority
ABS	Australian Bureau of Statistics
AC	Alternating Current
ANZECC	Australian and New Zealand Environment and Conservation Council
ASX	Australian Stock Exchange
bcm	Bank cubic metres
BMJV	Bateman Multiplex Joint Venture
CBD	Central Business District
CPI	Consumer Price Index
CSIRO	Commonwealth Scientific and Industrial Research Organisation
dB(A)	Decibel
DBIRD	Department of Business, Industry & Resource Development
DC	Direct current
DIPE	Department of Infrastructure, Planning & Environment (formerly DLPE):
DL	Detection limit
DLPE	Department of Land, Planning & Environment (now DIPE)
DME	Department of Mines and Energy
DO	Dissolved Oxygen
EC	Electrical Conductivity:
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPBC	Environment Protection & Biodiversity Conservation Act 1999
ESP	Electrostatic precipitator
ha	Hectare
Km/hr	Kilometres per hour
Kt/a	Kilotonnes per annum
Kv	Kilovolts
Kw	Kilowatts
Kw-h	Kilowatt-hour
L	litre
L/s	Litres per second
LOI	Lost on ignition

LR	Leach Residue
LRSF	Leach Residue Storage Facility
M/day	Metres per day
MEB	Medical Entomology Branch
µg/L	Micrograms per litre
µS/cm	Microsiemens per centimetre
mg/L	Milligrams per litre
ML	Mineral Lease
MLN	Mineral lease Northern
MMP	Mining Management Plan
MW	Megawatt
NATA	National Association of Testing Authorities of Australia
ND	Non-detect
NTU	Northern Territory University
OC	Organochlorine
OP	Organophosphorous
PAWA	Power and Water Authority
ppm	Parts per million
PWCNT	Former Parks & Wildlife Commission of the Northern Territory (now DIPE)
ROM	Run of Mine
t/a	Tonnes per annum
t/day	Tonnes per day
TDS	Total dissolved solids
THS	Territory Health Services
V	Volts
W	Watts
WWII	World War 2
µg/L	Micrograms per litre
µS/cm	Microsiemens per centimetre
µm	Micrometre

GLOSSARY

The meanings attributed to the words and phrases herein are those which are most relevant to this EIS.

Alloy	A mixture or solid solution of two or more metals.
Alluvial	Deposited from flowing water.
Amorphous	Material which has no regular visible structure or shape.
Amphibolite	A metamorphic rock composed basically of amphibole or hornblende.
Anhydrous	Material which contains no water.
Anthropogenic	Generated by or originating from personkind.
Aquatic	Of or pertaining to water; living, growing in or near water.
Aqueous	Consisting of, containing, formed in or deposited from water.
Aquifer	A layer of rock which holds water and allows water to percolate through it.
Arc furnace	A vessel used for heating, melting or chemical reaction, which is heated by means of a flow of electricity through a gas from one electrode to another (voltaic arc)
Archaeology	The science or special study of antiquities
Argillite	Any compact sedimentary rock composed mainly of clay minerals
Arkose	A coarse, hard sandstone composed of quartz and at least 10% feldspar
Artesian	Of, being, or concerning an aquifer in which water rises to the surface due to pressure from overlying water
Assay	The scientific determination of the quantity of metal in an ore
Baghouse	An air pollution control device used to remove particulate matter from waste gases. Filters are used to trap the particles which are then collected and bagged for disposal
Batching plant	A facility in which materials are stored temporarily and then loaded for transport to a customer
Biological control	The control of pests, etc. by using other organisms that destroy them
Biota	The combined flora and fauna of a region
Blanket gas	Inert gas utilised during the magnesium casting phase to prevent the combustion (reaction with air) of molten magnesium
Blasthole	A hole drilled in rock in a mine for the purpose of being charged with explosive and detonated to breakup the rock
Blow down	Periodic discharge of a fluid from a containment vessel performed to reduce the quantity of fluid or to lower the concentration of a constituent, which gradually accumulated
Borrow pit	A small pit from which construction material may be sourced

Brine	Water containing a high percentage of salts
Bund	An earth, rock or concrete wall constructed to prevent the inflow or outflow of liquids
Bywash	A channel that directs fluid around the usual processing system when abnormal conditions are encountered
Calcareous	Of, coated with, containing, or like calcium carbonate; chalky
Calcination	A process of heating mainly carbonate rock to drive off carbon dioxide and water
Casting	The act of pouring liquid into a mold to allow it to solidify in the shape of the mold
Catchment	An area, the rainfall in which feeds a river-system
Channel erosion	Erosion that forms channels and gullies
Channelisation	Action of creating an artificial watercourse
Chloride flux	A mixture of chloride salts added to liquid magnesium to help precipitate impurities
Chloritic	Of or pertaining to a group of minerals, hydrous silicates of aluminium, ferrous iron, and magnesium, occurring in green plate-like crystals or scales
Coefficient of variation	The ratio of change of a function of a variable, to the change in that variable
Condenser	An apparatus in which a vapour is condensed to a liquid
Cone crusher	A type of crusher used to break rock into smaller pieces
Conglomerate	A rock consisting of rounded and waterworn pebbles, etc. embedded in a finer cementing material
Cross-bedded	Having irregular laminations as, as strata of sandstone, inclining in various directions not coincident with the general stratification
Cyclone	An apparatus in which heavier materials can be separated from lighter material
Dead-burned	A metal oxide that has been heated to the point where it has low chemical reactivity
Dewater	The process of removing water from a mine area, usually by pumping
Diurnal	Of or pertaining to a day or the day-time
Draw-down	Of or pertaining to the region of the water table depressed by the extraction to the surface of water at a bore location
Dust suppression	Refers to actions taken to reduce or prevent the formation of dust
Ecosystem	An ecological community of living organisms together with the physical environment associated with it, considered as a single unit
Electrostatic precipitator	An air pollution control device used to remove fine particulate matter from waste gases. In the device a high voltage is imparted between two sets of electrodes. One set of electrodes induces a

	charge on the particles which are attracted to and collected on the other set of electrodes.
Endemic	Characteristic of or peculiar to a particular locality, region, or people
Ephemeral	Short-lived, transient
Epicentre	The point over the focus of an earthquake
Erodibility	The susceptibility of a soil to erosion
Evapotranspiration	The combined water vapour emitted by the biotic and abiotic components of an area
Evergreen	A plant which retains its foliage throughout the year
Exploration License	A mining title that permits the holder to undertake exploration activities and confers a deed of ownership of minerals that may be present
Fault	A break in the continuity of a body of rock or of a vein, with dislocation along the plane of fracture
Fauna	The animals of a given area or period, taken collectively
Feasibility Study	An engineering and economic study carried out to determine whether a proposed project is viable, often used to support an application for finance for the project
Feral	Having reverted to the wild state, as from domestication
Ferrosilicon	An alloy of iron and silicon metals
Ferruginous	Iron-bearing; containing iron
Fines	Fine grained material
Firing gas	Natural gas to be combusted in a kiln or similar apparatus
Flora	The plants of a particular region or period, listed by species
Flowability	Pertaining to molten material which has a relatively low viscosity allowing it to flow easily through a narrow tap-hole
Fume	The gas and particulate stream which emanates from a chemical reaction
Geosyncline	A portion of the earth's crust subjected to downward warping during a large fraction of geological time
Graphite	A very common mineral, soft native carbon, occurring in black or dark grey foliated masses with metallic lustre and greasy feel
Graphite electrode	An electrode made of graphite
Groundwater	Underground water contained within a saturated zone or rock
Haul road	A private road constructed for trucks which carry ore and/or waste from the open pit to the ROM pad or waste dump
Hermetically sealed	Sealed off to prevent contact with the external environment
Host rock	The rock which surrounds and/or is mixed with an ore deposit
Hydraulic	Pertaining to water or other liquid

Hydrosol	A colloidal suspension in water
Indigenous	Original inhabitant or species of a given area
Infiltration	The act of filtering into or through; permeate
Inflow	The material that flows in to a space or area
Ingot	A mass of molten metal, such as a bar or block, that is cast in a standard shape for convenient storage or transportation.
Inundation	Covered by water
Ion	An electrically charged atom, radical, or molecule, formed by the loss or gain of one or more electrons
Ironstone	Any ore of iron (commonly a carbonate of iron) with clayey or siliceous impurities
Isoclinal	Denoting or pertaining to a fold of strata which is of the nature of an isocline (a fold of strata so tightly compressed that the parts on each side dip in the same direction
Jaw crusher	A type of crusher used to break rocks into smaller pieces
Joint	A fracture plain in rocks, generally at right angles to the bedding of sedimentary rocks and variously oriented in igneous and metamorphic rocks
Kiln scale	Material that sticks to the kiln and builds up, eventually falling off in large flakes
Ladle	A refractory-lined container into which liquid magnesium is poured for transfer to another area of the plant.
Larvicide	An agent for killing of larvae
Lateritised	The state of underlying rock, having been decomposed to form a reddish ferruginous soil in tropical regions
Lenses	Minor, discontinuous occurrences of material within or between major, continuous layers
Lenticular	Of or pertaining to a lens
Lignotuber	A woody thickening or outgrowth of a subterranean stem or shoot, from which plants may arise
Lime	Calcium oxide
Limestone	Calcium carbonate rock
Lithosols	Shallow, skeletal soils, as often found on steep slopes and rock outcrops
Magnesite	Magnesium carbonate ore from which magnesium can be produced
Magnetherm	The name of a patented process which produces magnesium metal
Manifold	A pipe with several outlets
Metallic reductant	A metal that is used in a reduction reaction
Mineral Resource	An identified *in-situ* mineral occurrence from which valuable or

	useful minerals may be recovered.
Mining tenement	A generic name for a title that conveys some form of title to minerals to the holder
Mintek	The common name for the Council for Mineral Technology of South Africa
Monospecific	Composed of a singular species
Neutralised	Made inert or neutral usually through the addition of an alkaline or acid substance
Nocturnal	Of or pertaining to the night
Normandy Woodcutters Pty Ltd	The company that operated the former Woodcutters (zinc/copper/lead) Mine at its closure, and is now undertaking rehabilitation of the site
Noxious weed	A weed llisted as such under the *NT Weeds Management Act 2001*
Off-gases	Gases liberated during metallurgical treatment processes
Olefinic	Containing olefin compounds
Ore grade	Pertaining to a percentage of valuable commodity considered likely to be economic
Organochlorine	Of or pertaining to an organic compound in which one or more chlorine atoms are linked to a carbon atom
Organophosphorous	Of or pertaining to an organic compound in which one or more phosphorous atoms are linked to a carbon atom
Outcrop	A cropping out, as of a stratum or vein at the surface of the earth
Outflow	The act of flowing out
Overburden	Poorly consolidated weathered rock and soil overlying a mineral resouce
Oxide	A compound between any element and oxygen
Pan	Average annual evaporative demand
Paraffinic	Containing paraffin compounds
Parameter	One of several physical quantities whose values control the way in which a system will perform
Pedestrian transect	A simple transect survey that is conducted on foot
Per annum	Per year; annually
Perennial	Lasting or continuing throughout the year, as a stream. In plants, having a life cycle lasting more than two years
Permeability	The capacity for transmitting a fluid
Permeable	Pertaining to a material through which a fluid can flow
Phosphine	A compound of phosphorous and hydrogen occurring as a gas
Pit floor sump	A hole excavated in the base of a pit into which water is encouraged to drain and from where it can be pumped out

Plasma	A highly ionised gas which, because it contains an approximately equal of positive ions and electron, is electrically neutral and highly conducting
Polymetallic	Refers to a material containing two or more metals
Porous	A material having pores which may hold gas or liquid
Precipitate	A process in which a dissolved substance separates from solution as a fine suspension of solids which tend to settle to the base of the container
Processing plant	A set of equipment that processes material converting it from one form to another
Qualitative	Pertaining to or concerned with quality or qualities
Quantitative	Of or pertaining to the describing or measuring of quantity
Quartzite	A granular rock consisting essentially of in interlocking grains
Reagent	A chemical which takes part in a reaction
Redoxic	Of, pertaining to, relating to or causing oxidation-reduction
Reductant	A reagent which takes part in a reaction by combining with oxygen to convert an oxide into a metal
Refractory lining	Special materials which are stable under very high temperatures used to line the internal walls of a vessel to protect the outer walls of the vessel
Refuge habitat	A habitat providing aid, relief, or escape
Refuge pool	A pool providing aid, relief, or escape
Remnant	A part, quantity, or number (usually small) remaining
Richness	Of ecology, a measure of the number of species present in a discreet area
Riparian	Of, pertaining to, or situated or dwelling on the bank of a river or other body of water
Riverine	Of or pertaining to a river. Situated or dwelling beside a river
ROM pad	An area set aside for the temporary storage of run of mine ore prior to processing
Rotary kiln	An inclined refractory lined tube, which is rotated as a means of conveying material while exposing it to high temperature provided by means of a heat source, typically a burner, located in one end of the tube
Run-off	The water which runs off an area following rain
Sandstone	A rock formed by the consolidation of sand, the grains being held together by a cement of silica, lime, gypsum, or iron salts
Savanna	Grassland region with scattered trees, grading into either open plain or woodland

Saxicoline	Living or growing among rocks
Scat	A animal faeces sample collected for analysis
Scree	Unconsolidated rock pieces lying of the surface of the earth
Screening	The act of passing material across a surface which has gaps of a requisite size so that the finer material falls through thus separating the coarse and fine fractions
Sediment load	A measure of the amount of sediment mixed in a solution, watercourse, water-body, etc. usually in weight per constant volume (eg. grams per litre)
Seepage	That which seeps or leaks out
Seismic	Pertaining to, of the nature of, or caused by an earthquake
Septic tank	A tank in which solid organic sewage is decomposed and purified by anaerobic bacteria
Settling pond	An area in which water is allowed to stand while suspended sediment settles to the base of the area
Shear	The tendency produced by loads to deform or fracture a member by sliding one section against another
Sheet erosion	Erosion where no scouring of channels and gullies occurs
Silicified	Converted into silica
Silt trap	A device that slows flowing water causing silt to be deposited out of the water column, reducing sediment load, and hence turbidity
Siltstone	A consolidated silt; a fine sandstone
Slag	The rock material remaining in the base of the furnace after the reduction has taken place
Socio-economic	Of or relating to a combination of social and economic factors
Species	The basic category of biological classification, consisting of a group of individuals that resemble each other and can interbreed to produce fertile offspring
Stratum	One of a number of portions likened to layers or levels
Stromatolite	Calcareous rocky mass formed by blue-green algae
Sulphide	A compound of sulphur and another element
Sundance mine/pits	The two abandoned pits immediately south-west of the proposed project site
Superficial aquifer	A near surface layer of rock which holds water and also allows water to permeate through it
Temporal	Of or pertaining to time
Terrestrial	Living on the ground; not aquatic, arboreal or aerial
Thermic	Of or pertaining to heat
Thermodynamic	The science of relations between heat and all other forms of energy

Top End	The northern region of the Northern Territory
Topography	The relief features or surface configuration of an area
Torr	A unit of measure of pressure
Trial pit	A small pit dug in the magnesite deposit by Mt Grace in September – November 2000 to obtain a bulk sample
Tuff	A rock of volcanic origin, comprising compacted or cemented volcanic ash and dust
Turbidity	A unit of measurement that quantifies the amount of particles of extraneous matter in a liquid causing an opaque or muddy appearance
Vein	Any body or stratum of ore, coal, etc., clearly separated or defined; a body or mass of igneous rock, deposited mineral, or the like, occupying a crevice or fissure in rock; a lode
Vertebrate	Having a backbone or spinal column
Vesicular	Of or pertaining to a small, usually spherical cavity in a rock or a mineral, due to gas or vapour
Wet scrubber	An apparatus which removes some chemicals from a gas stream by dissolving them in water
Wind rose	A meteorological diagram which shows for a locality or area the frequency and strength of the wind from various directions
Zonation	Arrangement or distribution in zones