Nammuldi-Silvergrass Iron Ore Project

Consultative Environmental Review

February 2000

HAMERSLEY IRON

NAMMULDI-SILVERGRASS IRON ORE PROJECT

Consultative Environmental Review

HAMERSLEY IRON PTY. LIMITED
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PERTH WESTERN AUSTRALIA

February 2000
(Docs #11686)

INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

Hamersley proposes to develop the Nammuldi-Silvergrass Iron Ore Project, located about 55km north-west of Tom Price. In accordance with the *Environmental Protection Act, 1986*, a Consultative Environmental Review (CER) has been prepared which describes this proposal and its likely effects on the environment.

The CER is available for public review for a period of 4 weeks, from **Monday 27 March 2000** closing on **Wednesday 26 April 2000.**

Comments from Government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to Government.

Why write a submission?
A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the *Freedom of Information Act*, and may be quoted in full or in part in the EPA's report.

Why not join a group?
If you prefer not to write your own comments, it may be worthwhile joining with a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission
You may agree or disagree with, or comment on, the general issues discussed in the CER or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the CER:
- clearly state your point of view;
- indicate the source of your information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives

Points to keep in mind
By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the CER;
- if you discuss different sections of the CER, keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:
- your name
- address
- date
- whether you want your submission to be confidential

The closing date for submissions is: **Wednesday 26 April 2000.**

Submissions should be addressed to:

The Environmental Protection Authority
Westralia Square
141 St George's Terrace
PERTH WA 6000

Attention: Murray Hogarth

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SUMMARY

Hamersley Iron Pty. Limited (Hamersley) proposes to develop its Marra Mamba iron ore deposits at Nammuldi (includes some detritals) and Silvergrass. These deposits are near the Brockman No. 2 Mine, located 55km north-west of Tom Price (refer Figure 1). The Nammuldi deposit lies along an east-west alignment north of the Brockman No. 2 Mine. The Silvergrass deposit is across the valley from Brockman/Nammuldi, about 12km to the north (refer Figure 2).

This proposal forms part of a multi-staged approach to the development of Hamersley's Marra Mamba deposits. Stage I was for a trial mining operation in a small area of Nammuldi; this was assessed and approved by Government and is currently in operation (Figure 3). Stage II is the development of the Nammuldi and Silvergrass deposits (the current Project). Stage III is for the future development of Homestead deposits (to be assessed separately from this Project).

The Stage II Project was referred to the Environmental Protection Authority (EPA) in September 1998. The EPA determined that the Project was to be assessed as a Consultative Environmental Review (CER).

Project options

The Project is in the early development phase, with preliminary feasibility studies being undertaken in parallel with the environmental approval process. By subjecting some options to environmental assessment at this stage of the Project, Hamersley can identify whether any such options have undesirable environmental effects that require particular approaches to managing them. This information can then be fed into technical studies to resolve the key options.

The main areas where Project options exist are:

- Processing (wet or dry) – the environmental impacts of both wet and dry processes are described in the CER, but the wet process has potentially larger environmental impacts. This CER assumes wet processing. Dry processing results in less ground disturbance, less processing (wet processing requires a tailings storage facility) and less water demand, but a higher risk of dust emissions.
- Means of transporting ore from Silvergrass to Nammuldi – options include railway, road and conveyor (none preferred over the other at this stage).
- Tailings storage – a combination of in-pit disposal and central thickened discharge is preferred, but valley impoundment, waste rock dump, paddock impoundment and co-disposal were also considered (refer Figure 4).
- Disposal of mine dewatering – feasibility studies for recharge to aquifers at Nammuldi will continue. Initially, excess water will be discharged into the existing natural drainage system at Nammuldi. If recharge proves feasible, this will replace surface discharge. At Silvergrass, excess mine water will be discharged directly into Cave Creek.

The Project

At Nammuldi, five Marra Mamba pits (A, B, C/D, E and F), plus additional detritals pits will be developed, while at Silvergrass, three pits (Valley, Range and Flats) will be developed (Figure 6). Conventional open cut iron ore mining approaches and equipment will be used.

Production will commence at 2-3Mt/a and could increase to about 20Mt/a. Mine life will be 15-20 years, but may be longer.

As 80% of the Marra Mamba ore is below water table, dewatering will be required. About 30,000ML will be extracted from each of the aquifers at Nammuldi and Silvergrass. Maximum total dewatering rate will be about 18ML/d. Dewatering strategies (rates of dewatering and volumes of discharge) are dependent on the mining schedule/sequence, which will need to be flexible to meet market demand. In-pit dewatering bores will target the primary zone of permeability in each pit that is associated with fractures within the Marra Mamba mineralisation (the main aquifer). Pumping from in-pit sumps in addition to dewatering bores may be required to maintain dewatering rates in the later stages of mining.

Water obtained from dewatering will be utilised for the processing of ore, dust suppression and potable purposes. At Nammuldi, water will be discharged into existing natural drainage lines flowing away from the mining areas. Depending on the outcome of further feasibility studies, excess water will be recharged into aquifers, but only if practical and feasible. At Silvergrass, excess water will be discharged into Caves Creek.

Mining will move about 750Mt of waste material (overburden/waste rock) to extract about 280Mt of ore. Mine voids will be in-filled and/or backfilled with waste rock and overburden to 1m above the pre-mine mean water table. The various pit voids at Nammuldi will be filled to between 575 and 581mRL and between 548 and 550mRL at Silvergrass. Some waste dumps will remain at the end of the Project and will be approximately 40m high and battered down during rehabilitation. About 30% of the waste material will be returned to mine pits.

Crushed Silvergrass ore will be transported to the Nammuldi plant by a new rail, road or conveyor (Figure 6). Ore will be processed using wet or dry processing at Nammuldi. If wet processing is undertaken (the most likely scenario), tailings will be piped into available Brockman (Pits 1 and 3) and Nammuldi (Pit B) mine voids. A new tailings storage facility (central thickened discharge) will also be required as these pit voids are insufficient to accommodate all tailings from Nammuldi and Silvergrass (Figure 4 and Figure 6). The voids nominated for in-pit disposal of tailings will have sufficient capacity to contain about 50-60% of the tailings generated; the remainder will report to the new storage facility. At full production, wet processing will generate about 2Mt/a (dry) tailings, consisting of fine clays, limonite and goethite washed from the ore. Decant water will be collected and returned to the process water circuit.

A portion of the Brockman rail loop overlies the planned Pit C/D (Figure 6); this area will be mined. Brockman product may be loaded onto rail wagons through Nammuldi facilities (by a conveyor connection).

Product will be loaded into rail wagons at Nammuldi and transported to Dampier via the existing Brockman rail spur and the main Paraburdoo-Dampier railway. No additional facilities are required at Dampier for this new product.

Infrastructure requirements include:

- a wet processing plant at Nammuldi, dry crushing at Silvergrass and Pit E/F at Nammuldi
- extensions to the existing Nammuldi camp for the Project construction workforce
- a new Village east of the Nammuldi camp for the operations workforce
- anew rail loop near the Nammuldi plant
- upgrading the Brockman airstrip
- extensions to the existing Dampier-Tom Price power line and distribution network
- dewatering borefields and associated pipework and pumps (Figure 7 and Figure 8)
- off-take from the dewatering discharge lines and water storage facilities
- in-pit and new tailings storage and pipeline facilities
- offices, workshops, laboratories, service areas
- separate bulk fuel and ammonium nitrate and explosives storage facilities

A summary of the key characteristics of the Project is provided below.

Component	Project characteristic	Description
General	Area to be cleared	Around 2,000ha
Mine and mining	Pits and ore type	Nammuldi - Pits A, B, C/D, E and F (all Marra Mamba) and detritals near Pit F. Silvergrass - Range Pit, Valley Pit, Flats Pit - all Marra Mamba
	Area (mines and waste dumps)	About 1685ha: made up of mines 685ha, waste dumps 900ha (some waste will be returned to mine pits), haul roads 100ha
	Ore reserve	About 280Mt (230Mt of Marra Mamba and 50Mt of detritals)
	Mining rates	Initially 2-3Mt/a and could increase to 20Mt/a
	Estimated mine life	15-20 years
	Ore below water table	About 80%
	Stripping ratio	3:1 (waste:ore) overall
	Waste ore disposal	About 750Mt of waste rock to be generated. Some waste will be used to backfill voids to above pre-mine mean water table level, some used in construction works and the remainder left as out-of-pit waste dumps
	Pit voids	Voids to be backfilled to one metre above the mean pre-mine water table using waste ore and overburden. Backfilled pits will be 575-581mRL at Nammuldi and 548-550mRL at Silvergrass
	Waste dumps	Waste dumps will be 40m high. Maximum batter slope of 20° during rehabilitation.
	Proportion of waste to be backfilled	About 30%
Dewatering	General	Dewatering required to access below water table ore from most pits
	Arrangement	In-pit dewatering bores to achieve the bulk of dewatering, associated with in-pit sumps in the later stages of mining
	Combined rates	Maximum rate approximately 18ML/d
	Total volumes	Nammuldi about 31,000ML, Silvergrass about 30,000ML
	Discharge strategy	At Nammuldi, discharge will initially be into drainage lines, then to recharge via mined pit (if suitable pit available and it is feasible). At Silvergrass, discharge will be to Caves Creek
Processing and tailings	Plant	Wet or dry processing at Nammuldi, dry crushing plant at Silvergrass and a dry crushing plant around Pit E/F at Nammuldi.
	Tailings (if wet processing)	About 2Mt/a (dry), made up of clays and fine iron fraction – defined as high plasticity silt. Discharge into Brockman pits 1 & 3 and Nammuldi Pit B, plus a central thickened discharge facility
	Stockpiles	Product stockpiles at Nammuldi, crushed ore stockpile at Silvergrass
Infrastructure	Power	New extension off Dampier-Tom Price line
	Water	Dewatering will supply water for potable, processing and dust control purposes; decant water from tailings storage will supplement processing requirements
Transport	Ore from Silvergrass	Railway, haul road or conveyor
	Product transport	By rail to Dampier on existing rail network
Workforce	Workforce (approx.)	For construction about 400. Operations 150-190 on FIFO basis.
	Accommodation	Nammuldi Camp for construction, new Village for Nammuldi workforce

Existing environment and environmental impacts and management

Table S1 provides a summary of the environmental issues and management associated with the Project.

Commitments

Hamersley has made environmental commitments to manage the Project (Table 5.1). These are:

Commitment 1: Environmental Management Plan (EMP). Hamersley will prepare and implement an EMP for the Project that will outline the:

- environmental performance objectives for relevant environmental factors;
- management of environmental impacts from construction and operation;
- monitoring of key environmental aspects;
- reporting and auditing procedures

The EMP will be prepared in consultation with relevant Government agencies and will be subjected to a targeted public review.

Commitment 2: Environmental Management System. Hamersley will develop and subsequently implement an Environmental Management System for the Project that incorporates the following elements:

- environmental policy and associated corporate commitment
- mechanisms and processes to ensure
    - planning to meet environmental requirements
    - implementation and operation of actions to meet environmental requirements
    - measurement and evaluation of environmental performance
    - review and improvement of environmental outcomes.

Commitment 3: Annual Environmental Reporting. Hamersley will include the Project in its consolidated annual and triennial environmental reporting to Government once construction commences.

Commitment 4: Closure Plan. Hamersley will prepare a detailed closure plan for the Project. The plan will address closure actions to be taken toward:

- mine voids
- waste dumps
- tailings storage facilities
- transport linkage between Silvergrass and Nammuldi
- processing plants
- associated infrastructure

and will provide the basis for the development of an eventual 'walk-away' closure strategy for the Project. As part of this closure plan, final backfill levels in pit voids will be assessed, taking account of mean water table levels and capillary rise relationships.

Commitment 5: Additional surveys – biological. Hamersley will undertake additional biological (flora, vegetation and fauna) surveys of those areas not already surveyed where Project infrastructure is planned, such as the tailings storage facility (central thickened discharge area), the Village and the power line from the Dampier - Tom Price line.

Commitment 6: Riverine vegetation monitoring. Hamersley will develop and implement a riverine monitoring program to determine the extent of any impacts on vegetation that may occur as a result of dewatering the Silvergrass mine pits and from mine dewatering discharges into Caves Creek.

Commitment 7: Rare Fauna. Hamersley will prepare and implement a management plan for the Ghost Bat as part of the EMP, plus any fauna species that are present in the Project area which may be listed in future revisions of the Western Australian Rare and Endangered List or the Commonwealth Critically Endangered List.

Commitment 8: Stygofauna. Hamersley will prepare and implement a co-ordinated program of stygofauna sampling within and around the Project area to improve the current understanding of stygofauna that occur in the Pilbara.

Commitment 9: Caves Creek stream flow. Hamersley will monitor stream flows in Caves Creek and make the data available to the Water and Rivers Commission.

Commitment 10: Groundwater monitoring and modelling. Hamersley will prepare and implement a groundwater monitoring plan (including monitoring water levels in Palm Springs) and incorporate the outcomes to improve the groundwater modelling predictions.

Commitment 11: Recharge options. Hamersley will investigate the feasibility of groundwater recharge options at Nammuldi for handling water generated from mine dewatering that will otherwise be discharged via surface drainage.

Commitment 12: Additional surveys – Aboriginal sites. Hamersley will involve the Maliwartu Aboriginal Corporation in additional archaeological and ethnographic surveys to identify sites, and their significance, within the Project area that are likely to be disturbed.

Commitment 13: Mechanism for future Aboriginal site surveys. Additional Aboriginal site surveys will be undertaken in accordance with a heritage survey protocol that is to be agreed with the Maliwartu Aboriginal Corporation through the establishment of a Land Use Agreement.

Commitment 14: Consultation on Section 18 application. Hamersley will consult with the Maliwartu Aboriginal Corporation and Eastern Gurama Elders on Aboriginal sites in the Project area before any Section 18 application is developed in keeping with an agreed protocol.

Commitment 15: Submission of Section 18 application. Hamersley will make a written application to the Aboriginal Cultural Materials Committee (for subsequent consent by the Minister for Aboriginal Affairs) if any identified Aboriginal site in the Project area is required to be disturbed.

Commitment 16: Aboriginal social and cultural issues associated with the environment. Hamersley will consult with the Maliwartu Aboriginal Corporation (and the Native Title Claimants it represents) to identify and assess any social and cultural aspects of the physical and biological environment impacted. This will be addressed through the establishment of a Land Use Agreement.

Table S1. Summary of Issues and Management for the Project

	SCOPE OF WORK		EXISTING ENVIRONMENT		FUTURE ENVIRONMENT	
Factor	**EPA Objective**	**Work required for the CER**	**Existing Environment**	**Predicted impacts**	**Proposed management**	**Predicted outcome**
BIOPHYSICAL						
Terrestrial Flora						
Vegetation Communities	Maintain the abundance and diversity of species, and geographic distribution and productivity of vegetation communities.	Baseline studies to identify existing vegetation communities. Assessment of potential impacts (direct and indirect) on vegetation communities as a result of mining activities and infrastructure. If there exists the potential for impacts on Mulga communities, then reference should be made to the draft Central Pilbara Mulga Study. Proposed measures to manage impacts.	*Refer Section 3.2.1* • Vegetation and flora surveyed over most of Project area • 22 vegetation associations identified (Figures 15, 16, 17) belonging to three broad vegetation types. No vegetation association is restricted to surveyed area • Three vegetation associations have local significance B1-Tall woodland of *Eucalyptus camaldulensis/E. victrix* over *Acacia citrinoviridis* A3-*Eucalyptus leucophloia* and mixed shrubs over *Triodia wiseana/T. pungens* A8-*E. leucophloia/Eucalyptus socialis* over *Triodia angusta* • Some Mulga at Nammuldi and Silvergrass (48ha), none in transport corridor	*Refer Section 4.2.3* • 2,000ha will be cleared - most vegetation associations will be affected • Vegetation with local significance will not be greatly impacted (development will affect 9.5% of B1, 1.8% of A3 and <0.2% of A8) • Vegetation associations with the greatest percentage loss are locally widespread and well represented in the Brockman Valley or occur elsewhere in known locations • Impacts on habitats significant for fauna: Riverine habitat (B1 – 15ha or 9.5% affected), Mulga (B5 – 15ha or 31% affected), deep alluvium soils at Nammuldi (A6 – 239ha or 9.3% affected), clays (C1-C4 – 20ha or 1.8% affected) • Without supplementation (by rainfall and creek flow), dewatering at Silvergrass will cause drought stress on phreatophytic vegetation in Caves Creek. Some *E. camaldulensis* (5-10%) and *E. victrix* (>5%) will be affected over 2km of Caves Creek • Vegetation around pits at Nammuldi and some parts of Silvergrass are non-phreatophytic and will not be affected by dewatering. • Pooled water will change composition and relative abundance of vegetation around and downstream of discharge points – the understorey will contain more grasses, sedges and annuals, but will revert back once discharge ceases • Dust will impact health of vegetation adjacent to roads • Project will increase risk of spreading introduced species, but little potential for introduction or spread of water weeds in Caves Creek greater than that which already exists • Risk of erosion will increase with any riverine tree loss, but small relative to erosion from flood events • New vegetation communities based on phreatophytic vegetation likely to establish in backfilled mine pits	*Refer Section 4.2.4* • Site disturbance to be minimised - areas to be cleared only when required • Periodic spraying (or other means) to control weeds • Roads and mine pits to be watered to control dust • Weeds/introduced plants to be monitored as part of rehabilitation monitoring programs • Progressive rehabilitation to be undertaken (including mine pits) • Local provenance seed to be used if seeding required in rehabilitation • Dewatering discharge points located to prevent erosion or suitable structure installed • Riverine vegetation to be monitored to assess impacts from dewatering and discharge	*Refer Section 4.2.5* Loss of 2000ha of vegetation communities. Impact on vegetation will be minimal on local and regional level. No vegetation association of particularly high conservation value will be impacted. Temporary changes to vegetation structure below the discharge point in Caves Creek. Long term (over 6 years) dewatering will affect some phreatophytic Eucalypt species on Caves Creek if no significant flow event occurs. Revegetation of all areas disturbed by mining in the long term. Phreatophytic vegetation communities likely to become established in backfilled mine pits.
Declared Rare and Priority Flora	Protect Declared Rare and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act 1950.*	Baseline studies to identify any Declared Rare and/or Priority Flora. Assessment of potential impacts (direct and indirect) on vegetation communities as a result of mining activities and infrastructure. Proposed measures to manage impacts.	*Refer Section 3.2.1* • 373 species of vascular flora recorded - no Declared Rare Flora • Five currently listed Priority species recorded (all Priority 3 – *Tephrosia* sp. [Cathedral Gorge], *Goodenia stellata, Bulbine pendula* ms., *Gymnanthera cunninghamii, Triumfetta leptacantha* • Palm Springs on Caves Creek (30km from Silvergrass) contains large numbers of native Millstream Palms • Five introduced flora species (none designated noxious weeds)	*Refer Section 4.3.3* • No Declared Rare Flora will be impacted • Based on current infrastructure arrangements, no impact on *Tephrosia* sp. [Cathedral Gorge] (but one population within 100m of the conveyor), *Bulbine pendula* ms., *Gymnanthera cunninghamii*, or *Triumfetta leptacantha* (but one population is 150m from infrastructure), while *Goodenia stellata* will be impacted as it is present in a future mine pit	*Refer Section 4.3.4* • Areas that contain Priority flora to be considered in final design of infrastructure • Additional flora surveys to be undertaken in areas not already surveyed and where infrastructure to be sited • Additional flora surveys will target known Priority species to extent local geographic distribution • Appropriate Priority species to be encouraged to establish in rehabilitation areas • Refer also management for 'Vegetation Communities Factor'	*Refer Section 4.3.5* One Priority species (*Goodenia stellata*) will be impacted, rest will not be impacted. Impact on local and regional status of Priority species will be minor.

	SCOPE OF WORK		EXISTING ENVIRONMENT		FUTURE ENVIRONMENT	
Factor	**EPA Objective**	**Work required for the CER**	**Existing Environment**	**Predicted impacts**	**Proposed management**	**Predicted outcome**
Terrestrial fauna						
Terrestrial fauna	Maintain the abundance, species diversity and geographic distribution of terrestrial fauna.	Baseline studies to identify existing terrestrial fauna throughout the areas to be affected by the proposal. Assessment of potential impacts (direct and indirect) on terrestrial fauna as a result of mining and associated activities. Proposed measures to manage impacts.	*Refer Section 3.2.2* • Vertebrate fauna surveys conducted; recorded 66 reptiles, 21 mammals, 76 birds - level of species richness comparable with other intensive surveys in Pilbara • Vertebrate community has pattern of species abundance and distribution typical of semi-arid habitats and the Central Pilbara. Fauna assemblage typical of other comparable Pilbara areas • Species inventories and measures of species diversity and evenness for each taxon similar to other areas • Areas of local fauna significance (riverine areas, Mulga woodland and deep alluvial soils at Nammuldi, and riverine and cracking clays at Silvergrass)	*Refer Section 4.4.3* • Project will have no regional implications for fauna • Impacts to riverine habitats, Mulga woodlands and deep alluvial soils at Nammuldi addressed in 'Vegetation Communities Factor' • Roadkills and physical obstructions to fauna will occur • Additional and alternative habitats for fauna to be created by pools from dewatering discharges • Pooling from dewatering discharges will form artificial wetlands (with short term beneficial and negative impacts) • Infrastructure may fragment or isolate fauna populations, with little regional or local impacts • Risk of occasional physical entrapment of large fauna in tailings and the consumption of decant water by wildlife (not toxic)	*Refer Section 4.4.4* • Clearing of habitats to be minimised and undertaken progressively • Additional fauna surveys to be conducted where required • Habitats for fauna to be provided in rehabilitation areas • Workforce inductions to include fauna protection • Refer also management for 'Specially Protected (Threatened) Fauna Factor'	*Refer Section 4.4.5* Negligible regional impact, some impact on areas of locally significant fauna (not well represented locally) Restoration of some habitats for fauna in rehabilitation areas
Specially Protected (Threatened) Fauna	Protect Specially Protected (Threatened) Fauna, consistent with the provisions of the *Wildlife Conservation Act 1950*.	Baseline studies to identify Specially Protected (Threatened) Fauna that may be found within the areas to be affected by the proposal. Assessment of potential impacts (direct and indirect) on terrestrial fauna as a result of mining and associated activities. Proposed measures to manage impacts.	*Refer Section 3.2.2* Mammals of conservation significance: • *Macroderma giga* (Ghost Bat) – Priority 3 (WA), Vulnerable (C'wealth) • *Leggadina lakedownensis* (Lakeland Down Mouse) – Priority 4 (WA), Endangered (C'wealth) • *Pseudomys chapmani* (Pebble-mound Mouse) – Priority 4 (WA), Vulnerable (C'wealth) • *Sminthopsis longicaudata* (Long-tailed Dunnart) – Priority 4 (WA) Reptiles • *Notoscincus butleri* – Priority 4 • Morelia olivacea barroni (Pilbara Olive Python) – Schedule 1 Several *Ctenotus* species appear different to those recorded previously	*Refer Section 4.4.3* • No Declared Rare fauna will be impacted • Ghost Bat and Long-tailed Dunnart – no direct impacts as nearest recorded individuals over 1km from infrastructure • Lakeland Downs Mouse , Pebble-mound Mouse and *Ctenotus* species – habitats to be impacted • Pilbara Olive Python – not found, no direct impacts, but risk from workforce personnel • Refer also impacts for 'Terrestrial Fauna Factor'	*Refer Section 4.4.4* • Management plan for Ghost Bats to be prepared as part of the EMP and monitoring to assess impacts • Relevant management plans to be prepared for species present in the Project area that may be listed in future revisions of WA or Commonwealth Rare Lists • Refer also management for 'Terrestrial Fauna Factor'	*Refer Section 4.4.5* Negligible regional impact and a small local impact. Habitats that contain Lakeland Downs Mouse, Pebble mound Mouse and *Ctenotus* species will be partially impacted. Some habitats for fauna to be created in rehabilitation areas
Subterranean Fauna	Ensure that subterranean fauna are adequately protected in accordance with the *Wildlife Conservation Act 1950* Maintain the abundance, diversity and geographical distribution of subterranean fauna. Improve our understanding of subterranean fauna through appropriate research including sampling, identification and documentation.	Baseline studies to determine the likelihood of subterranean fauna living within the project area or areas which could be affected by proposed operations. This will require identification of potential subterranean fauna habitats in the areas to be affected by the proposal. Assessment of potential impacts (direct and indirect) on subterranean fauna as a result of mining and associated activities. Proposed measures to manage impacts.	*Refer Section 3.2.2* • Marra Mamba aquifers in Project area sampled on three occasions, with methodology developed after consultation with Government (WA Museum) and national (Australian Museum) specialists • Stygofauna found in Marra Mamba aquifer and expected in Caves Creek alluvium – amphipods, copepods, worms and collembola found • Samples being identified by specialists • Hamersley continues its stygofauna sampling program across all sites • No known mainland Pilbara stygofauna species on Schedule 1 list – until sample identification is completed, not known whether anything recorded in Project area is significant (on Schedule 1) • No underground caves in Project area so troglobitic fauna not sampled	*Refer Section 4.5.3* • Stygofauna in area affected by groundwater drawdown (refer 'Groundwater Factor') will be impacted • Capacity to re-establish in dewatered sections of the aquifer when dewatering ceases and water tables rise is also unknown • Pooling from mine dewatering discharges in Caves Creek will impact stygofauna inhabiting creek alluvium • Extent to which stygofauna can migrate downward with gradually declining water table is uncertain – if capacity is limited, then stygofauna in affected area will be impacted	*Refer Section 4.5.4* • Hamersley's stygofauna research program to continue to sample (Project area, other mine sites, development areas) and document the distribution and population dynamics • Next sampling in the Project area scheduled in mid 2000. • Information collected to be disseminated to general research community to improve understanding and clarify conservation status of recorded species	*Refer Section 4.5.5* Decline in stygofauna in sections of aquifers affected by draw down from dewatering (assumes no stygofauna re-colonisation and migration). Regional impact uncertain. Until stygofauna samples identified, not known whether any are on Schedule 1.

	SCOPE OF WORK		EXISTING ENVIRONMENT		FUTURE ENVIRONMENT	
Factor	**EPA Objective**	**Work required for the CER**	**Existing Environment**	**Predicted impacts**	**Proposed management**	**Predicted outcome**
Watercourses	Maintain the integrity, functions and environmental values of watercourses.	Baseline studies to identify watercourses and types of surface water flow throughout the areas to be affected by the proposal. Description of proposed dewatering operations. Assessment of the potential impacts on surface water flow rates, drainage patterns, sediment transport, riparian vegetation and pools, as a result of mining and associated activities. Assessment of the potential for increased erosion over the minesite as a result of earthworks and changes to surface water patterns. Proposed measures to manage impacts.	*Refer Section 3.1.3* • Caves Creek flows past Silvergrass, is minor tributary to Ashburton River, has 1100km^2 catchment above mine pits, flows westward (Figure 11) • No stream gauging station on Caves Creek, nor any continuous streamflow data • Creeks only flow after heavy rain in catchment, no permanent pools in Caves Creek near Silvergrass • A 50 year Annual Recurrence Interval is predicted to produce a likely flow of 2,000m^3/s and a depth of 5.8m in Caves Creek (Figure 12) • Drainage is not well defined at Nammuldi and flows through low points in Nammuldi hills into dendritic Duck Creek catchment that flows to north-west	*Refer Section 4.6.3* • Some draw down in creek alluvium of Caves Creek will occur during dewatering at Silvergrass, but will be recharged by streamflow from the catchment above Silvergrass • Saturation of alluvium may weaken root systems of large trees • Hydrological effects of dewatering discharges will not affect Palm Springs due to distance from Silvergrass • Minor constriction by flood control levee will delay passage of flood waters – expected for short duration only • Water flow constriction by the levees will be insufficient to cause tree kills by flooding • Rocks that enter Caves Creek from Range Pit may cause barriers to normal creek flow • Surface waters will extend 3km from the discharge point on Caves Creek and 3-4km from discharge at Nammuldi • Transport corridor contains defined drainage so the risk of drainage shadow from railway or haul road will be minor	*Refer Section 4.6.4* • Streamflow in Caves Creek and water levels in Palm Springs to be monitored • Large rocks that enter Caves Creek as result of construction or mining activities to be retrieved • Culverts and associated downslope drainage systems to be used for any rail or road infrastructure between Silvergrass and Nammuldi to maintain drainage patterns • Erosion protection to be installed at dewatering discharge points	*Refer Section 4.6.5* Some short term changes to Caves Creek. Permanent flow for a section of Caves Creek and drainage lines at Nammuldi for duration of dewatering discharge. Minor drainage lines at Nammuldi will be intersected by pits and infrastructure.
Groundwater	Maintain the quantity of groundwater so that existing and potential uses, including ecosystem maintenance, are protected.	Details of the hydrogeological systems of the project area, existing beneficial uses of groundwater (including ecosystem maintenance) and the proposed dewatering operations. Assessment of the potential short-term and long-term impacts on groundwater systems as a result of below water table mining. Proposed measures to manage impacts.	*Refer Section 3.1.4* • Principal aquifer is the mineralised Marra Mamba – is semi-confined by lower permeable West Angelas Shale and valley fill sediments overlying the aquifer • Transmissivity at Nammuldi is 40 to 400m^2/d, at Silvergrass is 200 to 500m^2/d. Through-flow 160-650m^3/d at Nammuldi and 260-680m^3/d at Silvergrass • Groundwater levels are 18 to 47m below ground level at Nammuldi, and 9 to 24m below ground level at Silvergrass (Figures 13 and 14) • Natural water table fluctuations greater than 7m recorded during hydrogeological fieldwork after heavy catchment rainfall • Groundwater flow is from east to west at Nammuldi and from north-east to south-west at Silvergrass	*Refer Section 4.7.3* • Modelling defines draw down as a 5m lowering of groundwater level (below recorded natural fluctuations) • Impacts on shallow unconfined system associated with Caves Creek will be less than the model predicts and will be more responsive to natural fluctuations as a result of creek flow at Silvergrass • Pit dewatering will result in cones of depression of between 300m (Pit B) and 1,000m (Pit C/D) at Nammuldi pits, extending 500m to 800m across strike (southwards). At Silvergrass, cones of depression will be 3km from Range and Valley pits (Figure 19) • Brockman and Nammuldi Camp borefields will be impacted, requiring substitution. Several Hamersley Station bores (operated by Hamersley) will be affected by water table changes • Return of waste material to above mean pre-mine groundwater levels will allow Nammuldi water table to rise rapidly (within 2 years given rainfall) to a level between 570mRL and 580mRL. Similarly at Silvergrass, the water table will recover to between 540mRL and 545mRL within 18 months after voids have been backfilled • Formation of phreatophytic vegetation/trees in pit floors will help keep groundwater depressed and may help reduce potential for capillary rise	*Refer Section 4.7.4* • Mine pit voids to be filled to above original (pre-mine) mean water table level • Appropriate scheduling of mining to match dewatering with demand for process make-up water to reduce additional groundwater draw • Potential for aquifer recharge (re-injection or infiltration) to be investigated and implemented (if feasible) at Nammuldi to replace discharge to surface drainage • Regional water levels to be monitored to verify predicted impacts on regional water levels from dewatering to allow remedial actions to be undertaken if required • Additional baseline data to be obtained to calibrate the model against longer term data to increase confidence in the predicted modelling and dewatering strategy • Station bores affected by dewatering to be replaced or supplemented with dewatering discharge water, if required • The relationship between mean pre-mine water level and capillary rise in backfilled pit voids to be evaluated as part of closure planning	*Refer Section 4.7.5* Based on initial modelling, dewatering will result in 300-1000m draw down at Nammuldi and a 3km draw down at Silvergrass. Water table will re-establish to near original levels within 2 years after mining ends, given expected recharge events. Some existing bores (owned by Hamersley) will be affected by dewatering.
Landform	Ensure that, as far as is practicable, the post-mining landform is stable and is integrated into the surrounding environment.	Assessment of potential impacts of the proposal on existing landforms. Evaluation of the landscape values of the project area and how these will be affected by the proposal. Details of measures proposed to rehabilitate the impacted areas to an acceptable standard and which will integrate the post mining landform with the surrounding environment.	*Refer Section 3.1.3* • The Marra Mamba Formation outcrops as low undulating hills, dipping toward south at Nammuldi and toward the north at Silvergrass • The undulating hills are separated from the steep Brockman Iron Formation escarpments by areas of valley fill • Area between Nammuldi and Silvergrass is characterised by low relief with numerous small blind creeks and flood-out sections	*Refer Section 4.8.3* • Temporary changes to landforms will occur from roads, ore stockpiles, processing plant, offices, workshops, Village, dewatering infrastructure, powerlines – upon mine closure, these will be removed and the areas rehabilitated • Permanent change to include pits, waste dumps, tailings storage area, cut and fills for transport infrastructure • Pit area will be 685ha, backfilled to 575-581mRL at Nammuldi and 548-550mRL at Silvergrass. Waste dumps will be about 40m high, battered down to 20° slope. Tailings in central thickened discharge area to be 8m high, covering around 290ha • Views of permanent landforms to be limited due to few public roads nearby	*Refer Section 4.8.4* • Temporary and permanent landforms to be rehabilitated to stable and vegetated surfaces as they become available (progressive rehabilitation) • Closure plan to be developed for final landforms	*Refer Section 4.8.5* Temporary landforms will be rehabilitated. Permanent changes to landform from mine voids, waste dumps, tailings storage and transport corridor cuts/fills will remain. Vegetated mine pit floors. In-pit disposal will have restrictions for several years until consolidated sufficiently for earthmoving

	SCOPE OF WORK		EXISTING ENVIRONMENT		FUTURE ENVIRONMENT	
Factor	**EPA Objective**	**Work required for the CER**	**Existing Environment**	**Predicted impacts**	**Proposed management**	**Predicted outcome**
						equipment
POLLUTION MANAGEMENT						
Particulates/dust	Ensure that particulate/dust emissions, both individually and cumulatively, meet appropriate criteria and do not cause an environmental or human health problem. Use all reasonable and practicable measures to minimise the discharge of particulates/dust.	Identification of sources of particulate/dust and estimates of emissions of project-wide emissions. Analysis of the significance of these emissions with regard to human health and environmental impacts, in particular, impacts on vegetation. Proposed measures to manage potential impacts.	*Refer Section 4.9.3* • Pilbara has a naturally high dust environment – levels can be near or higher than National Environment Protection Measure (NEPM) standard – the NEPM has not been applied to any part of the Project area or Dampier by the EPA through an Environmental Protection Policy	*Refer Section 4.9.3* • Marra Mamba ore sourced from below water table will be moist, reducing dust risks during mining and wet processing • Marra Mamba product with a moisture level below 6% can generate dust – product moisture for this Project will be higher than 6% • Product from dry processing will have highest risk of dust • Tailings will have a low risk of dust, but Marra Mamba waste dumps may be a source of dust • Asbestiform fibres not present in mineralised Marra Mamba, but does occur in waste material below the strata to be mined • Product handling in Dampier will be partial replacement of other Hamersley products • Marra Mamba from Marandoo (Lump and Fines) is not a major source of dust, nor is wet Paraburdoo fines at Dampier	*Refer Section 4.9.4* • Water sprays to be fitted to processing plant • Marra Mamba product stockpiles to be monitored and treated if they become dust source • Water to be sprayed onto roads and work areas • Regular housekeeping to remove accumulated material • Hamersley's standard asbestiform fibre management procedures to be adopted • Existing dust control systems at Dampier to be used • Dust monitoring at Dampier to incorporate that for product associated with the Project • Further testing and analytical work to be done on handling characteristics of Marra Mamba • Ore samples to be obtained from stockpiles to assess moisture levels to determine requirements for any special treatment with water sprays	*Refer Section 4.9.5* Some dust during construction. Mining of above watertable ore and product from dry processing to be highest dust risk. Little change to Dampier airshed expected.
Greenhouse Gases	Minimise greenhouse gas emissions for the project and reduce emissions per unit product to as low as reasonably practicable. Mitigate greenhouse gas emissions in accordance with the Framework Convention on Climate Change 1992, and in accordance with established Commonwealth and State policies.	Details of potential sources of greenhouse gases and estimates of the quantities of these gases produced annually. Proposed measures to minimise greenhouse gas emissions. (Refer to EPA *Interim Guidance for the Assessment of Environmental Factors* No. 12 "Minimising Greenhouse Gases").	*Refer Section 4.10.2* • The Kyoto Protocol was signed by Australian Government (but not yet ratified) committing Australia to limit greenhouse gas emissions in the period 2008-2012 to 108% of 1990 emissions	*Refer Section 4.10.3* • Vegetation clearing will produce about 60ktCO_2 • At maximum production and railing levels, total Project emissions will be 200ktCO_2/a, made up of power from Dampier (100ktCO_2/a), diesel and ANFO use (50ktCO_2/a) and railing/shipping (50ktCO_2/a) • Rehabilitation areas will offset a small amount of greenhouse emissions • Contextual greenhouse emission production provided for Australia, Western Australia and the WA resource sector	*Refer Section 4.10.4* • Through Rio Tinto, Hamersley is a signatory to the Greenhouse Challenge • The Project is to be incorporated into corporate reporting of annual emissions to the Australian Greenhouse Office as well as any practical abatement projects • Requirements of EPA Guidance on Greenhouse Gases being complied with	*Refer Section 4.10.5* Construction will contribute 60kCO_2. Operations will contribute 200ktCO_2/a. Relative to other sectors, greenhouse emissions will be low. Rehabilitated areas will help offset small part of greenhouse emissions.
Groundwater quality	Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA 1993) and the NHMRC/ARMCANZ Australian Drinking Water Guidelines – National Water Quality Management Strategy.	Details of the existing water quality of groundwater aquifers. Identification of potential sources of contamination associated with the proposal, details of the dewatering operation, and a description of the long term closure plans for the final pit voids. Assessment of the potential impacts on groundwater quality, including assessment of the potential short-term and long-term impacts on groundwater quality, particularly as a result of below water table mining. Proposed measures to manage impacts.	*Refer Section 3.1.4* • Based on groundwater samples, water quality is fresh, with Total Dissolved Solids (TDS) between 340 and 860mg/L • Hydrochemical typing of groundwater analyses indicates three main types of groundwater present at Nammuldi: -mineralised Marra Mamba aquifer is Type I (dominant in magnesium and bicarbonates and often lowest in TDS), typifying a relatively recent recharge signature -Silvergrass aquifer is Type II (mixed speciation and often slightly more saline than Type I), suggesting location outside influence of direct upland recharge -Low permeability detritals/valley fills at Pit F is Type III (dominant magnesium and bicarbonate, with ion exchange having occurred)	*Refer Section 4.11.3* • Dewatering will not affect groundwater quality as adjacent hydrogeological units have similar quality water • Capillary rise has potential to create surface salinity • Increases in salinity of water discharged to surface drainage will be expected prior to its infiltration • Return of waste material to mine voids to above water table levels will avoid formation of permanent pit lakes or groundwater sinks post-mining • No changes anticipated to the long term beneficial uses of groundwater resources • Seepage from tailings structures will not contain hazardous chemicals • No area to be mined contains pyritic shales	*Refer Section 4.11.4* • Mine pits to be filled to above pre-mine mean water table level • Final backfill levels in pit voids to take account of mean water table level and the risk of capillary rise to determine the optimum backfill height • Water quality of groundwater and surface flows from plant areas to be monitored • Hydrocarbons to be contained so as to prevent off-site release of pollutants	*Refer Section 4.11.5* No long term impact due to return of waste material into mine voids. Dewatering will not result in deterioration of groundwater quality as adjacent hydrogeological units have similar water quality

	SCOPE OF WORK		EXISTING ENVIRONMENT		FUTURE ENVIRONMENT	
Factor	**EPA Objective**	**Work required for the CER**	**Existing Environment**	**Predicted impacts**	**Proposed management**	**Predicted outcome**
Surface water quality	Maintain or improve the quality of surface water to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA 1993) and the NHMRC/ARMCANZ Australian Drinking Water Guidelines – National Water Quality Management Strategy.	Details of site drainage, hydrocarbon use, dewatering and fate of water used/pumped. Assessment of the implications this may have on local surface water quality. Proposed measures to manage impacts.	*Refer Section 4.12.3* • No permanent water bodies at Nammuldi or Silvergrass • Caves Creek is ephemeral, with occasional flows following heavy rains • Water quality of temporary pools in Caves Creek is variable and dependent on inputs from cattle and other wildlife, weather conditions and drying status of pools	*Refer Section 4.12.3* • Water discharged will be the same quality as groundwater • The target water quality from surface discharges is that of ANZECC (1992), but where receiving waters exceed criteria, alternative criteria will be required • Pools will be formed in Caves Creek and drainage lines at Nammuldi - water quality of these will be variable, with drying pools becoming more saline while *E. coli* and nutrient level may rise, as occurs in natural pools • Residual flocculants and coagulants in the tailings impoundments are expected to be low concentrations, not affecting surface water quality – cationic polymers pose a risk to fish if the pre-used product is directly spilled into waterways	*Refer Section 4.12.4* • Bulk fuel storage areas to be bunded and monitored • Washdown and oil spillages to drain into sumps and oil interceptor traps • Surface flows from plant to pass through holding dam and skimmers • Waste oil to be stored then removed from site • Runoff from ammonium nitrate shed and fuel areas to be contained and treated • Discharges of runoff from plant areas to be contained on-site, where feasible • Clean and dirty water streams to be separated so they can be handled differently • Central thickened discharge facility to have ponds to contain surface runoff, with diversion dams to divert natural runoff • Water quality of discharges to be monitored to verify acceptable water quality with DEP Licence specifications	*Refer Section 4.12.5* Negligible impact on surface water quality.
Solid waste	Ensure that wastes are contained and isolated from ground and surface water surrounds and treatment or collection does not result in long term impacts on the natural environment.	Details of the composition and storage of all solid wastes, in particular, details on the proposed disposal of tailings. Potential for waste rock to generate acid mine drainage. Assessment of the implications this may have on groundwater quality. Proposed measures to manage impacts.	*Refer Section 4.13* • Tailings (fine clay fraction) will be generated from wet processing • Solid wastes currently handled by landfills and re-use (collected by Contractors) at Brockman No. 2 Mine	*Refer Section 4.13.3* • Project solid waste will include plastic, paper, wood, scrap metal, tyres, rubber, batteries and domestic solids (including putrescibles) • Material to be placed in landfills will be inert - batteries will be taken off-site • Leachate generation will be minimal • Little risk of acid mine drainage from Marra Mamba waste rock as no material to be mined is pyritic	*Refer Section 4.13.4* • Landfills to be sited away from creeks and above water table - specific sites to be reported with DEP Works Approval application • Standard landfill management and rehabilitation practices to be adopted • Tailings areas to be managed in accordance with DME guidelines	*Refer Section 4.13.5* Some impact from ground disturbance
Noise	Protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring that noise levels meet statutory requirements and acceptable standards.	Estimate the potential increase in noise resulting from the construction and operation of the project. Comparison of estimates with relevant standards and limits.	*Refer Section 4.14.2* • Existing Nammuldi Camp is 5km from nominal Nammuldi plant site and 3km from Pit E • Village will be 3.5km further to east of Nammuldi Camp • Hamersley Station homestead is 40km from Project area (Hamersley owned and managed)	*Refer Section 4.14.3* • Noise will be generated from earthmoving operations, vehicles, blasting, ore handling and processing • Project-related noise will not impact on nearest noise sensitive premises (Hamersley Station homestead) 40 km away	*Refer Section 4.14.4* • Protective hearing equipment to be made available • Sound attenuation enclosures to be fitted to stand-by diesel generators	*Refer Section 4.14.5* No impact on Hamersley Station homestead.
SOCIAL SURROUNDS						
Culture & heritage						
Aboriginal culture and heritage	Ensure that the proposal complies with the requirements of the *Aboriginal Heritage Act 1972.* Ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area.	Identify Aboriginal cultural and heritage sites of significance through archaeological and ethnographic surveys of the project area and through consultation with local Aboriginal groups and the Aboriginal Affairs Department. Consult with the Aboriginal people of the area to determine potential impacts of the proposal on cultural associations with the project area. Proposed measures to manage impacts.	*Refer Section 3.3* • Hamersley currently negotiating an Indigenous Land Use Agreement with native title claimants • Archaeological surveys at Nammuldi cover some of Pit A (to be surveyed by mid 2000), all Pit B, most Pit C/D, all Pit E and Pit F, but not transport corridor or most infrastructure (eg tailings storage, Village) – refer Figure 18 • No archaeological sites recorded in surveyed areas of Pit A, B or C. 13 sites and 17 isolated artefacts recorded in Pit E/F area • Past archaeological surveys at Silvergrass found 4 sites (burial and engravings) • An ethnographic survey of Nammuldi found no sites - no ethnographic survey of Silvergrass conducted • Enviro-cultural areas significant to Eastern Gurama people examined, with all components of land being of equal importance, but specific information is confidential for cultural reasons	*Refer Section 4.15.3* • No ethnographic sites will be impacted at Nammuldi - Silvergrass ethnographic survey not yet completed. • Of the surveyed areas completed, 11 archaeological sites will be impacted (or are at risk of impact) around Pit E and Pit F at Nammuldi, while 4 sites will be similarly at risk at Silvergrass • The relative significance of these sites are to be determined in consultation with Eastern Gurama people • Some plants within the Project area that are used by Eastern Gurama people will be impacted - sufficient other local areas contain these targeted species to enable continued use of them • No Section 18 approvals under the *Aboriginal Heritage Act* have been sought	*Refer Section 4.15.4* • Ethnographic surveys of Silvergrass and other areas not covered to be done in co-operation with Maliwartu prior to ground disturbance and once an agreed protocol for conducting heritage surveys is in place • Findings of Aboriginal heritage surveys to be forwarded to Aboriginal Affairs Department • Where Aboriginal sites cannot otherwise be avoided, clearance to disturb those sites to be sought after consultation with Maliwartu • Workforce inductions to include Aboriginal cultural and heritage issues • Further opportunities for Aboriginal communities to be explored with Maliwartu • Increased understanding of enviro-cultural issues to be sought and to be addressed through a Land Use Agreement	*Refer Section 4.15.5* Based on completed surveys, minimal impacts on the Aboriginal cultural and heritage. Depending on the outcome of additional surveys to be undertaken, this assessment may change

1. INTRODUCTION

1.1 INTRODUCTION

1.1.1 Background

Hamersley Iron Pty. Limited (Hamersley) is seeking to develop Marra Mamba and small detrital deposits near its Brockman No. 2 Mine (55km north-west of Tom Price) located in the Pilbara region of Western Australia (Figure 1). Collectively, these mostly Marra Mamba deposits form the Homestead Project that covers deposits at Homestead, Nammuldi and Silvergrass (Figure 2).

Hamersley has commenced a multi-staged approach to the development of these Marra Mamba deposits, namely:

- Stage I - a Trial Operation at Nammuldi to obtain bulk ore samples
- Stage II - development of the Nammuldi-Silvergrass deposits
- Stage III - development of the Homestead deposits

Stage I was assessed at "Informal Review with Public Advice" level by the EPA, with advice provided to Hamersley in September 1998 (Section 1.1.2).

In September 1998, Hamersley referred the proposal for Stage II to the Environmental Protection Authority (EPA) for determination of the appropriate level of environmental assessment. The referred proposal covered the mining and processing of Marra Mamba deposits at Nammuldi and Silvergrass, plus small detrital deposits near Nammuldi.

The referred proposal is the Nammuldi-Silvergrass Project (hereafter 'the Project'). The Project does not include the development of the Homestead deposits. Subject to market demand and further resource assessments, approval for Homestead will be sought sometime in the future.

The EPA determined that the level of assessment for the Project was a Consultative Environmental Review (CER). The EPA guidelines for the Project are provided in Appendix A. The environmental assessment process for the CER is outlined in Section 1.5.2.

1.1.2 Nammuldi Trial Operation (Stage I)

Site works for the Trial Operation commenced in December 1998. The Trial Operation enables:

- Hamersley to obtain bulk ore samples from an area of Lens C (Figure 3)
- customers to assess the performance of the new Marra Mamba type ore as a separate product
- Hamersley to determine whether there is a viable, long-term market for the ore

and involves:

- extraction of up to 7Mt of ore from one pit over 3 years
- accessing a 150,000t bulk sample of below water table ore

- a small dewatering and discharge program for the below water table bulk sample
- an out-of-pit waste dump to contain 8-9Mt of waste rock
- a haul road to the Brockman processing plant
- crushing and screening ore through the Brockman dry plant

Environmental commitments for the Trial Operation are provided in Appendix B. These will be replaced by commitments and conditions for this Project, should it commence within the 3-year time limit for the Trial Operation.

1.2 THE PROPONENT

Hamersley, a wholly owned subsidiary of Rio Tinto Limited is the proponent for the Project. Contact details are as follows:

Hamersley Iron Pty. Limited
152-158 St Georges Terrace, Perth
GPO Box A42, Perth, WA 6837

Hamersley owns and manages infrastructure associated with the following (refer Figure 1):

- open cut mines and crushing, screening, blending, stockpiling and train loading facilities at Mt Tom Price, Paraburdoo, Brockman, Marandoo and Yandi and an open cut mine and crushing facilities at Channar (as part of the Channar Joint Venture)

- a processing plant for fines ore at Paraburdoo and a concentrator at Mt Tom Price

- 625km of mainline railway that links Paraburdoo, Mt Tom Price, Yandi, Marandoo and Brockman with Dampier, plus a 20km conveyor from Channar to Paraburdoo

- train unloading, ore stockpiling and ship loading facilities at Parker Point and East Intercourse Island at Dampier

- facilities within the towns of Dampier, Tom Price and Paraburdoo, residential facilities at Karratha, also camps or villages at Yandi and Brockman (the Nammuldi Camp) and offices in Perth and overseas

1.3 PROJECT SCOPE AND TIMING

The Project is in the early development phase, with preliminary feasibility studies being undertaken in parallel with the environmental approval process. Some aspects of the Project have alternative options that are not yet resolved (refer Section 1.4). Locations for infrastructure are indicative and may change as the Project becomes better defined. Project definition will be increased as feasibility studies are completed.

The main components of the Project include:

- open-cut mines at Nammuldi (Marra Mamba, detritals) and Silvergrass (Marra Mamba)
- dewatering to access ore below the water table
- an ore transport link from Silvergrass to Nammuldi
- a wet or dry processing (most likely to be wet) plant at Nammuldi
- crushing facilities at Silvergrass and at the eastern Nammuldi pits
- tailings disposal (assuming wet processing occurs) into available mine void/s, plus a new tailings storage facility
- associated support infrastructure

The rate of production of saleable ore will commence at 2-3Mt/a and could increase to about 20Mt/a. Project commencement will depend on market demand for this Marra Mamba ore, plus Board priorities based on the outcome of feasibility studies.

1.4 EVALUATION OF ALTERNATIVES

While the location of mine pits and waste dumps is essentially set by the location of the geological resource, some aspects of the Project are yet to be finalised. By subjecting these options to environmental assessment at this stage of the Project, Hamersley can identify whether any such options have undesirable environmental effects that require particular approaches to managing them. This information can then be used in technical studies to resolve options.

Project components with options include:

- transport of ore from Silvergrass to Nammuldi (rail, road or conveyor) – Section 1.4.1
- type of processing (wet or dry) – Section 1.4.2
- handling and storage of tailings at Nammuldi (if wet processing adopted) – Section 1.4.3

1.4.1 Ore transport options

A comparative assessment of options for transporting ore from Silvergrass is outlined in Table 1.1. Resolution of these options will be based on economics, long term planning requirements (the future Homestead Project) and environmental considerations.

Table 1.1 Ore transport from Silvergrass

Aspect	Railway option	Haul road option	Conveyor option
Technology	Proven	Not proven for this distance	Proven
Rolling stock	Available	New truck fleet	Not applicable
Reliability	High	Moderate	High
Maintenance	Moderate	High	Moderate
Environmental aspects • area of direct disturbance • interference with surface drainage • water requirements	 About 75ha Potentially High Minimal	 About 45ha Potentially Moderate High (dust control)	 About 30ha Potentially Low Minimal
Strategic/integration	High	Moderate/High	Moderate/High
Needs crushing plant	Yes	No	Yes
Capital cost	Moderate	Low	High
Operating cost	Low	Moderate	Moderate

Under technology for the haul road option, the statement "not proven for this distance" concerns tyres on trucks used by Hamersley that are not designed for long hauls. The long road distance between Silvergrass and Nammuldi will result in tyres overheating on loaded trucks, with associated safety and cost implications. Past enquiries to tyre manufacturers found that current tyre technology cannot yet rectify the problem. Replacing the truck type is likely to result in lower loads and higher costs.

1.4.2 Processing options

A comparative evaluation of wet and dry processing is summarised in Table 1.2.

Table 1.2 Processing options (wet versus dry)

Aspect	Wet processing option	Dry processing option
Technical capacity	Acceptable	Constrained
Product quality	Superior	Adequate
Wastes generated	Tailings	All remains product
Storage of wastes	Refer Table 1.3	All remains product
Environmental aspects • water demand • dust emissions • tailings generation • area of disturbance	 Higher Lower Yes Higher	 Lower Higher (slightly) No Lower (no tailings storage area)
Capital cost	Higher	Lower
Operating cost	Higher	Lower

A decision on wet or dry processing will be based on:

- practicality of processing ore sourced from below water table (wet ore) through a dry plant
- evaluation of the increased value of washed products
- relative cost of wet processing versus dry processing
- trade-off between capital, operating cost, selling price and the customer requirements

Based on the anticipated outcome of feasibility studies, the Project is likely to incorporate wet processing. Dry processing is still being evaluated. As Table 1.2 summarises, dry processing has:

- a lower water demand (other than for water sprays, dry processing requires little water as it does not involve slurries or tailings transport)
- a higher risk of dust emissions (the product would be drier/dustier but crushing/screening processes are similar for wet and dry processing)
- no tailings (negating the need for tailings storage facility)
- a smaller area of ground disturbance (no tailings storage required)

Therefore, from an environmental perspective, the overall environmental impact associated with dry processing will be lower than for wet processing. Dry processing also requires less processing facilities compared with wet processing.

This CER addresses the impacts of both options as the Project could include dry processing if it is technically feasible.

1.4.3 Tailings handling and storage options (assuming wet processing)

Tailings from iron ore processing are essentially comprised of fine clays, limonite and haematite washed from the ore, plus a relatively small amount of residual material from thickeners (flocculants and coagulants).

An evaluation of the options for tailings from Nammuldi wet processing is summarised in Table 1.3 and is based on the findings of a tailings disposal options study (MPA Williams and Associates 1999). Potential sites for tailings storage are shown in Figure 4. No sites were considered at Silvergrass because there is no requirement for tailings storage there.

Table 1.3 Tailings handling and storage options

	Options					
Aspect	**In-pit disposal**	**Central thickened discharge**	**Valley impoundment**	**Waste rock dump**	**Paddock impoundment**	**Co-disposal**
Area disturbed (ha)	0*	288	150	75	75	Not applicable
Tailings solids content (%)	22.5	40	22.5	22.5	22.5	8
Assumed insitu density (t/m^3)	1.5	2.3	1.6	1.6	1.6	0.8
Distance from plant (km)	1.5/2.5	7	4	3	3	Not applicable
Technology	Proven	Proven	Proven	Proven	Proven	Not proven
Capacity for expansion	Qualified (pits available)	Yes	Yes	Qualified	Yes	Qualified
Independent of mining operation	No	Yes	Yes	No	Yes	No
Return water flow (l/sec)	156	59	154	154	154	0
Rehabilitation	Progressive	At closure	Some years after closure	Some years after closure	Some years after closure	At closure
Capital cost	Lowest	Moderate	Moderate	Moderate	Highest	Not costed
Operating cost	Lowest	Moderate	High	High	Highest	Not costed

**Utilises already disturbed areas*

Siting of tailings storage areas is constrained by factors such as proximity to plant location, topography, hydrology, geology and groundwater. The relative importance of these factors varies according to the disposal method under consideration. Sites that have been identified and been the subject of desk-top evaluations may prove unsuitable when additional site information (such as geotechnical conditions) becomes available.

Further studies are being commissioned on the viability for central thickened discharge, in-pit disposal and waste rock dump disposal. The other tailings storage options (valley impoundment, paddock impoundment and co-disposal) appear less attractive due to combinations of cost, identified difficulties and questionable viability or technologies. The further studies will help decide the option, or combination of options, that will be adopted. In-pit disposal and central thickened discharge are the preferred options and are addressed in this CER.

A brief outline of each tailings disposal option at Nammuldi is provided below. These descriptions are based on MPA Williams and Associates (1999).

In-pit disposal (a preferred option potentially in combination with central thickened discharge)

In-pit disposal involves the placement of tailings in existing Brockman and future Nammuldi mine voids, with tailings discharged directly into the pit from one or more sides. Water is returned to the plant from a decant pond within the pit. Unless there is scope for rotational disposal of tailings between one or more pits, the rate of increase in the height of tailings is usually rapid, with limited opportunity for evaporative drying and consolidation of tailings. This can pose restrictions on getting earthmoving machinery onto the tailings for rehabilitation purposes once the void has been filled. Some benefits of in-pit disposal are the proximity of the pits to the plant, it uses existing void space (that will otherwise remain) and it requires no additional clearing.

Brockman Pit 1 (West) and Pit 3 will be the only voids available from the commencement of the Project that are sufficiently near the new Nammuldi plant. The capacity of these pits is relatively small; based on assumed production schedules, Pit 1 (West) has a capacity of 4 years, while Pit 3 has a capacity of 3.5 years. These will have to operate in tandem to allow adequate drying and consolidation.

Separate tailings pipelines and decant pumping systems will be required for each pit. Depending on the final water balance, decant waters may or may not be required by the Nammuldi plant. If not required, decant water may be used by Brockman/Nammuldi operations, or held until it is evaporated. When operated in conjunction with Pit 1 (West), Pit 3 will be filled within 7.5 years, with a rate of tailings rise varying from 8m/a (initially) to 3.5m/a in the later stages of disposal. Pit 1 (West) will be filled in the same time, with a rate rise of 10m/a (initially) to 3m/a.

Once these pits become filled, Pit B at Nammuldi may have been mined and tailings could then be directed there. About 5Mt of waste rock may be placed in Pit B initially to a level such that with the discharge of tailings into the pit, the rate of rise in the height of tailings is sufficiently gradual to ensure adequate consolidation. Placement of waste rock will reduce the capacity of Pit B from 8Mt to 3Mt and an effective disposal time of 2-3 years.

To accommodate tailings generated from processing Silvergrass ore, other mine voids at Nammuldi or an alternative tailings storage facility (eg central thickened discharge) will be required.

Central Thickened Discharge (a preferred option potentially in combination with in-pit disposal)

This option involves a 7km tailings line from the plant that discharges in the centre of a tailings stack site (shown in Figure 4). As the cone forms, the discharge point is raised on an access ramp. The decant water is collected in ponds to the south and north of the stack. As there may be little requirement to return water to the plant in the first few years, disposal of decant water will be required (re-used, evaporated or treated to remove suspended solids then disposed off-site). When required, water from the south pond will be pumped to the main decant pond to the north from where it will be pumped 7.5km to the plant through a return water pipeline. Some diversion drains will be constructed around the facility to divert runoff and reduce scour of the deposited tailings.

Tailings will beach at about a 0.75% slope which, at the end of processing all Nammuldi ore (without using Brockman pits and Nammuldi Pit B), will give a stack height of 7m at the centre and 0.9km x 3.2km in area (288ha). The Silvergrass ore will increase the height of the stack by a further 0.75m and increase the area to a total of 1km x 3.3km (330ha).

Waste Rock Dump (an option being evaluated, but not currently a preferred option)
This option involves forming a tailings impoundment or cells within a waste dump formed by mining at Nammuldi. The site considered (refer Figure 4) is constrained by the natural surface rising to the south and west, Pit B to the north and the fines stockpile to the east.

The impoundment would be about 1km x 0.75km (75ha), divided into two cells. The first stage would be approximately 10m high and constructed with pre-strip material. Additional compaction would be required to ensure the walls are reasonably impermeable and have sufficient strength. The impoundment would be progressively raised as waste material is placed in the waste dump.

At the end of mining at Nammuldi, the waste dumps would be 22m high. Processing of Silvergrass would increase this a further 3.75m. To increase the height, rehandling of the surrounding waste dump would be required, adding significant cost.

A 1.5km tailings line would discharge alternately to each cell through a series of spigots on a ring main. The development of the tailings beach would be managed to retain the decant pond in the centre of the cell. The decant water would be drawn off through a decant tower and pipe to a return water storage from whence it would be pumped back to the plant through a 1.8km return water line. Diversion drains would be required to divert natural runoff around the side of the waste rock dump.

Valley Impoundment (not being considered further)
Siting for valley impoundments is constrained by suitable topography, catchment areas, proximity to the processing plant, possible archaeological sites and geological conditions. Two possible sites were identified (Figure 4). For both shown sites, tailings would be pumped to the impoundment over the ridge along the northern edge of the range. Due to a more favourable (lower) height of the saddle on the ridge at the eastern site, that option is better suited.

A tailings pipeline would pass over the saddle to discharge tailings down the valley with the decant pond forming adjacent to the embankment. After Year 5, when decant water may be required, a 7km long return water pipeline would be constructed through the steep terrain back over the saddle to the plant.

The embankment would be built in stages by downstream raise to a height of 23m (including spillway and freeboard) for the Nammuldi tailings, and ultimately to 26m to accommodate Silvergrass tailings.

Paddock Impoundment (not being considered further)
Due to the limited flat terrain, the best site for paddock impoundment is about 3km from the plant (Figure 4).

This scheme involves a 1km x 0.75km (75ha) paddock divided into two cells that would be raised in stages by upstream raises. A 3.5km tailings line would discharge alternately to each cell through spigots on a ring main. Development of the tailings beach would be managed to retain the pond in the centre of the cell. Decant water would be drawn off through a decant tower and pipe to a return water storage from whence, it would be pumped to the plant via a 4km return water line.

The paddock starter dam would be constructed from compacted waste rock from the Nammuldi Trial Operation. Subsequent raises would be constructed from the Pit C waste rock. The embankment would be constructed in stages up to about 18m high to store Nammuldi tailings. An additional 2.5m would be required to accommodate Silvergrass tailings, or additional cells constructed adjacent to these.

The construction of the return water pump and pipeline would be deferred until required. Diversion drains would be required to divert natural runoff around the upslope side of the paddock.

Co-disposal (not being considered further)
This scheme involves combining coarse waste material with fine tailings for joint storage. The aim of co-disposal is to fill the voids in coarse waste (that would otherwise be empty) with tailings but without compromising the normal high strength and steep repose angles featured in active waste dumps. Co-disposal has been investigated in the coal mining industry, but not the iron ore industry due mainly to the difficulty in pumping hard waste rock. The uncertainty (whether it would work) and the amount of further studies required have ruled out its serious consideration.

1.5 LEGISLATIVE FRAMEWORK & ENVIRONMENTAL ASSESSMENT PROCESS

1.5.1 Legislative requirements

Relevant environmental legislation for the Project and the responsible Government agencies is listed in Table 1.4.

Table 1.4 Relevant environmental legislation and Government agencies

Legislation	Responsible Government agency
Western Australian:	
Aboriginal Heritage Act 1972	Aboriginal Affairs Department
Agricultural & Related Resources Protection Act 1976	Agriculture Western Australia
Bush Fires Act 1954	Bush Fires Board
Conservation & Land Management Act 1984	Department of Conservation and Land Management
Environmental Protection Act 1986	Department of Environmental Protection/EPA
Explosives & Dangerous Goods Act 1961	Department of Minerals and Energy
Health Act 1911	Health Department of Western Australia
Iron Ore (Hamersley Range) Agreement Act 1963	Department of Resources Development
Land Act 1933	Department of Land Administration
Local Government Act 1960	Department of Local Government/Shire of Ashburton
Mine Safety & Inspection Act 1995	Department of Minerals and Energy
Mining Act 1978	Department of Minerals and Energy
Rights in Water & Irrigation Act 1914	Water and Rivers Commission
Soil & Land Conservation Act 1945	Agriculture Western Australia
Wildlife Conservation Act 1950	Department of Conservation and Land Management

Legislation	Responsible Government agency
Commonwealth:	
Aboriginal & Torres Straight Islander Heritage Protection Act 1984	Aboriginal & Torres Straight Islander Commission
Australian Heritage Commission Act 1975	Australian Heritage Commission
Environmental Protection & Bio-diversity Conservation Act (gazetted, but not yet commenced)	Environment Australia
Native Title Act 1993	National Native Title Tribunal

1.5.2 Environmental assessment process

The environmental assessment process is shown in Figure 5.

The purpose of a CER is to:

- place the proposal in the context of the local and regional environment
- provide information to interested parties to elicit informed comment
- outline the approach to managing environmental issues
- allow the EPA to base its advice to the Minister for the Environment on valid information

Hamersley has prepared and released the CER for a four-week public review period. Issues raised in submissions during this period will be summarised by the DEP. The summary of issues will be provided to Hamersley to address.

The EPA will assess the Project taking into account public submissions and Hamersley's response to them and will then report its findings and recommendations to the Minister for the Environment. The EPA's report to the Minister will address the maintenance of EPA objectives for environmental factors of the Project and recommend applicable conditions.

The Minister will decide to either grant or deny approval for the Project in conjunction with other decision-making authorities. If approved, a Ministerial Statement will be issued setting conditions under which the Project may be implemented.

1.6 PUBLIC CONSULTATION

The organisations consulted on this Project and the issues raised by these organisations are summarised in Table 1.5.

Table 1.5 Program of consultation and issues raised

<table>
<tr><th>Organisation</th><th>Activity</th><th>Date</th><th>Issues</th></tr>
<tr><td>Government</td><td></td><td></td><td></td></tr>
<tr><td>DEP/EPA</td><td>Provided briefing to DEP officers as part of annual Government tour of Hamersley operations.</td><td>20 May 1999</td><td rowspan="5">• Rare and priority listed flora/fauna species identified from surveys
• Bio-diversity issues
• Methodology and monitoring of infiltration trial
• Location and siting of injection borefield
• Proximity of Silvergrass pit to Caves Creek
• Caves Creek flows</td></tr>
<tr><td>DME</td><td>Provided briefing to DME officers as part of Government tour. Date: 20 May 1999</td><td>20 May 1999</td></tr>
<tr><td>WRC</td><td>Provided briefing to WRC officers as part of Government tour.
Hosted WRC officer on tour of Nammuldi recharge trials and Silvergrass area.
Issued copy of hydrogeology report to Karratha and Perth offices.</td><td>20 May 1999
4 May 1999
20 August 1999</td></tr>
<tr><td>DRD</td><td>Provided briefing to DRD officers as part of Government tour.</td><td>20 May 1999</td></tr>
<tr><td>CALM</td><td>Provided briefing to CALM officers as part of above Government tour.</td><td>20 May 1999</td></tr>
</table>

Organisation	Activity	Date	Issues
Shire of Ashburton	Provided letter with summary of Project and offered opportunity to have a briefing.	28 July 1999	None.
NGOs			
Aboriginal groups	Hamersley's Aboriginal Training and Liaison group has been liaising with the Eastern Gurama people (and their representatives) on the Project and clearances for exploration and evaluation programs for well over a year. These Aboriginal people have been made aware of the Project and Hamersley's proposals through numerous meetings and discussions as part of continuing negotiations for an Indigenous Land Use Agreement. Conducted survey on Eastern Gurama people views toward environmental aspects of Project.	Various/ Ongoing July 1999	• Protection of resources that Aboriginal people utilise in the general area • Protection of Aboriginal sites • Native Title • Land Use Agreement
Conservation Council	Provided briefing of the Project to representatives.	2 August 1999	• Long term stability of tailings structure/s • Water management • Changes to Caves Creek ecosystems • Bio-diversity implications
Hamersley Station	Provided Station Manager copy of same information package sent to Shire.	28 July 1999	None.

2. PROJECT DESCRIPTION

2.1 PROJECT OVERVIEW

The key aspects of the Project are summarised in Table 2.1.

Table 2.1 Key characteristics of the Project

Component	Project characteristic	Description
General	Area to be cleared	Around 2,000ha
Mine and mining	Pits and ore type	Nammuldi - Pits A, B, C/D, E and F (all Marra Mamba) and detritals near Pit F. Silvergrass – Range Pit, Valley Pit, Flats Pit - all Marra Mamba
	Area (mines and waste dumps)	About 1685ha: made up of mines 685ha, waste dumps 900ha (some waste will be returned to mine pits), haul roads 100ha
	Ore reserve	About 280Mt (230Mt of Marra Mamba and 50Mt of detritals)
	Mining rates	Initially 2-3Mt/a and could increase to 20Mt/a
	Estimated mine life	15-20 years
	Ore below water table	About 80%
	Stripping ratio	3:1 (waste:ore) overall
	Waste ore disposal	About 750Mt of waste rock to be generated. Some waste will be used to backfill voids to above pre-mine mean water table level, some used in construction works and the remainder left as out-of-pit waste dumps
	Pit voids	Voids to be backfilled to one metre above the mean pre-mine water table using waste ore and overburden. Backfilled pits will be 575-581mRL at Nammuldi and 548-550mRL at Silvergrass
	Waste dumps	Waste dumps will be 40m high. Maximum batter slope of 20° during rehabilitation.
	Proportion of waste to be backfilled	About 30%
Dewatering	General	Dewatering required to access below water table ore from most pits
	Arrangement	In-pit dewatering bores to achieve the bulk of dewatering, associated with in-pit sumps in the later stages of mining
	Combined rates	Maximum rate approximately 18ML/d
	Total volumes	Nammuldi about 31,000ML, Silvergrass about 30,000ML
	Discharge strategy	At Nammuldi, discharge will initially be into drainage lines, then to recharge via mined pit (if suitable pit available and it is feasible). At Silvergrass, discharge will be to Caves Creek
Processing and tailings	Plant	Wet or dry processing at Nammuldi, dry crushing plant at Silvergrass and a dry crushing plant around Pit E/F at Nammuldi.
	Tailings (if wet processing)	About 2Mt/a (dry), made up of clays and fine iron fraction – defined as high plasticity silt. Discharge into Brockman pits 1 & 3 and Nammuldi Pit B, plus a central thickened discharge facility
	Stockpiles	Product stockpiles at Nammuldi, crushed ore stockpile at Silvergrass
Infrastructure	Power	New extension off Dampier-Tom Price line
	Water	Dewatering will supply water for potable, processing and dust control purposes; decant water from tailings storage will supplement processing requirements
Transport	Ore from Silvergrass	Railway, haul road or conveyor
	Product transport	By rail to Dampier on existing rail network
Workforce	Workforce (approx.)	For construction about 400. Operations 150-190 on FIFO basis.
	Accommodation	Nammuldi Camp for construction, new Village for Nammuldi workforce

2.2 MINE PLANNING

2.2.1 Mine areas

Five pits will be mined at Nammuldi (Pit A, Pit B, Pit C/D, Pit E and Pit F) and three at Silvergrass (Range, Valley and Flats). These pits will target Marra Mamba ore. Some detritals will also be mined from pits near Pit F. Mine pit boundaries are shown in Figure 6.

2.2.2 Provisional mining sequence

A provisional mining sequence for Nammuldi pits is provided in Table 2.2. The combined life of the Nammuldi pits would be about 10 years for a 20Mt/a production rate. Actual mine life is expected to be longer than 10 years and perhaps up to 20 years, depending on the actual production rate.

Table 2.2 Provisional mining sequence and pit life - Nammuldi

Year	A	B	C/D	E	F (plus Detritals)
1	■		■		
2	■		■		
3	■	■	■		
4			■		
5			■		
6			■		
7			■	■	■
8			■		■
9			■		■
10					■

Mining will commence at Pit C as that pit:

- has existing open mine faces (the Trial Operation) that are easily extendable
- provides the major source of ore supply and has the longest life
- is likely to be closest to the new Nammuldi plant

Pits have different ore qualities and dewatering requirements. Pit scheduling will optimise product grade control and best align dewatering to demand from the wet process. Dewatering is addressed in Section 2.3.1.

A provisional mining sequence for Silvergrass pits is provided in Table 2.3. Mining at Silvergrass will commence toward the end of Nammuldi mining. Silvergrass has a mine life of about 7 years, assuming a production rate of 8Mt/a.

Table 2.3 Provisional mining sequence and pit life - Silvergrass

Year	Valley	Range	Flats
1	■		
2	■		
3	■	■	
4	■	■	
5		■	
6		■	■
7			■

2.2.3 Pit profiles

Approximate pit profile characteristics and ore reserves are provided in Table 2.4.

Table 2.4 Conceptual pit profile characteristics and ore reserves

		Nammuldi Pits						Silvergrass Pits		
	Unit	**A**	**B**	**C/D**	**E**	**F**	**Detritals**	**Valley**	**Range**	**Flats**
Ground level	mRL	600	610-620	610-650	610	630-670	640-650	570-580	560-570	570
Water level*	mRL	574	574	574-576	579	579-580	581	545-547	548-549	548
Pit floor (lowest)	mRL	500	510	380	510	500-530	590	440	450	500
Backfilled pit level+	mRL	575	575	577	580	581	582	548	550	550
Mine area (surface)	ha	50	30	190	25	165	50	90	45	40
Ore reserve	Mt	22	9	94	4	91	13	27	12	9

** Water table monitoring has indicated local fluctuations of up to 7m following rainfall/flood events. Baseline monitoring continues to be undertaken to determine the mean pre-mine water table height*

+ Backfill levels are based on 1m above mean water table levels; further evaluation will determine whether this is sufficient to avoid capillary rise effects

2.3 SITE PREPARATION

2.3.1 Dewatering and discharging

Dewatering

About 80% of the Marra Mamba ore is below water table. To mine the below water table ore, dewatering will be required.

The dewatering approach is based on the hydrogeological investigation (PPK Environmental & Infrastructure 1999) and is summarised in Table 2.5. Schematic mine dewatering arrangements are shown Figure 7 (Nammuldi) and Figure 8 (Silvergrass). Modelling was based on 10 year mining at Nammuldi and 7 year mining at Silvergrass; however, mining is likely to extend beyond these timeframes. Modelling therefore assumes a maximum-case for dewatering rates.

Table 2.5 Summary of mine dewatering strategy

Pit*	Dewatering rate (approx) (ML/d)	Total volume (approx) (ML)	Bore arrangement and rates	Comments
A	10 to 12	12,000	4 bores at 4ML/d each (including a standby bore)	Duration - 3 years. Dewater at 12ML/d for first year, thereafter 10ML/d.
B	2	1,000	3 bores at 1ML/d each (including a standby bore)	Duration - 1 year. Dewater at 2ML/d for first 3 months, then 1ML/d thereafter.
C/D	4 to 6	13,000	4 bores at 2ML/d each (including a standby bore)	Duration– Pit C 8 years, Pit D 1 year. Dewater at 6ML/d for first 3 years, then 4ML/d by Year 6. Modelling indicates Pit D should be dewatered as part of Pit C dewatering.
E and F	3 to 6	5,000	Minimum 8 bores at rates between 0.5ML/d in the east to 1ML/d in the west	Duration - 3 years. Need to dewater Pit E and Pit F concurrently. Initial dewatering (first year) at 6ML/d, reducing to 3ML/d thereafter.
Range	6 to 10	12,000	4 bores at 3.5ML/d each (including a standby bore)	Duration - 3 years. Initial 3 months at 10ML/d, thereafter 8ML/d.
Valley	10 to 19	18,000	7 bores at 3.5ML/d (including a standby bore)	Duration - 3 years. Initial dewatering at 19ML/d for Year 1, 16.5ML/d for next 6 months, next 1.5 years 10.5ML/d.

** Nammuldi detritals will not require dewatering. Only a small portion of Flats Pits extends below water table and is not covered*

Dewatering to progressively draw down the groundwater level in the pits will be achieved by designated borefields that target specific zones of higher permeability. Local hydrogeological conditions and the required timing for dewatering in advance of mining will ultimately determine the final configuration (number and spacing) of the dewatering borefields.

Because the primary zone of permeability in each pit is associated with fractures within the Marra Mamba mineralisation, most dewatering bores will be sited within the pits. This approach targets dewatering of the Marra Mamba and promotes downward drainage from overlying valley fill and shale.

As the removal of the primary aquifer may affect dewatering efficiency as the transmissitivity is reduced, local in-pit sumping (in combination with borehole dewatering) may be required in the later stages of mining.

Dewatering simulations using numerical groundwater models (calibrated against pumping test data) indicate that to dewater the Nammuldi ore bodies, a total of about 31,000ML of groundwater needs to be removed over the mining life. This should be achieved with 19 bores. The maximum dewatering rate will be dependent on the mine schedule, but will be highest (18ML/d) if Pit A and Pit C are mined concurrently.

Further optimisation of the dewatering approach will be attained through verifying the groundwater model against the continued operation of the Brockman borefield and/or calibration against initial dewatering operations for Nammuldi pits (including the Nammuldi Trial Operation). New data may lead to revisions to the dewatering approach.

None of the detritals pits are below water table, so no dewatering is required for those pits.

At Silvergrass, a total of 30,000ML will be abstracted using 11 bores. The maximum dewatering rate will also be 18ML/d during initial mining of the Valley Pit.

Flats Pit at Silvergrass was not included in the numerical groundwater models. Because only a small portion of that pit will extend into water table, the pit has no significant dewatering implications. Some advance dewatering using bores may be required; however total draw from the pit will be relatively small.

Discharges

The volume of excess dewatering discharge will be dependent on the mining schedule adopted and the ultimate process water demand. Hamersley will attempt to align these volumes, but this may not always be possible. Wet processing might require more water than available from dewatering later in the mine life and not start until mid way through mine life, requiring an initial discharge of 10-15ML/d at Nammuldi.

The key element in the dewatering discharge from Nammuldi is the timing of mining at Pit A as it has the greatest dewatering requirement. The predicted dewatering discharge rates under various mining schedules are provided in Figure 9.

At Nammuldi, discharges will initially be directed to drainage channels that flow away from the mining area (refer Figure 7). Options for groundwater recharge (through re-injection and/or infiltration) will continue to be examined. One opportunity may be to use Pit A as a recharge site, if it is mined early in the mining sequence. Hamersley will continue to investigate groundwater recharge options and the feasibility of applying such approaches at Nammuldi.

If recharge to groundwater is not effective, dewatering will revert to surface discharge.

At Silvergrass, once water has been diverted for dust control and potable uses (about 1ML/d), excess dewatering water will be discharged into Caves Creek. The discharge point will be about 5km downstream of the Range Pit to prevent water recirculation in mining areas. Dewatering discharges will range between 5ML/d and 18ML/d, with an average of about 12ML/d.

The discharge pipeline outfall at Silvergrass will be sited over hard rock to reduce erosion. If no suitable rock is available, a structure to reduce the velocity of water (thereby preventing erosion) will be constructed. This also applies to the surface discharge outfall at Nammuldi.

2.3.2 Vegetation and topsoil removal

Clearing will be undertaken progressively in accordance with the final mining sequence. Areas to be cleared will be delineated, then cleared. Available topsoil and vegetation will be stripped and stockpiled. Preference will be given during rehabilitation toward direct utilisation of topsoil, rather than using stockpiled material.

2.3.3 Mine pre-development

Overburden material will be removed using conventional mining machinery (scrapers, dozers and haul trucks). Drilling and blasting will be required. Some overburden will be used as fill for ramps, haul roads and levees; the remainder will be hauled to waste dumps or taken to mine voids as infill/backfill.

Once working profiles in each mine are developed, routine mining operations will commence.

2.3.4 Surface water control structures

The Range Pit and Valley Pit at Silvergrass will require flood control structures (levees) to prevent pit inundation during major flood events in Caves Creek. Conceptual locations of these levees are shown in Figure 6. The levee structures will maintain the 100 year design flood level (refer Section 3.4.3, Figure 12).

Material sourced during mine pre-development will be used to construct the levees. To prevent scouring of the base of these levees, the lower and outer sections will have rock armouring.

Because the levees are important for continued mining in the Range and Valley pits, they will be designed so that they will be stable and floodwaters do not over-top the embankments.

One-way flow culverts will be incorporated to allow excess storm water run-off from the mine area to be released (after passing through a retention basin), but be designed to prevent floodwaters from entering the pits. The levees will be 3-4m high.

At Nammuldi, drainage structures will be required to intercept and re-direct surface waters away from pits.

2.4 MINING OPERATIONS

2.4.1 Mining

Mining will involve conventional drill and blast, load and haul. For ore blending purposes, several mine faces within the same pit will be worked simultaneously. Several pits will also be open at the same time.

2.4.2 Waste rock and overburden handling

About 750Mt of waste material (overburden plus waste rock) will be generated. The predicted stripping ratio for all pits is 3:1 (waste to ore).

A preliminary and conceptual approach toward waste material handling is provided in Table 2.6.

More definitive waste handling strategies will be available when more detailed mine planning and scheduling is undertaken. Mine voids will be in-filled and backfilled to above pre-mine mean water table levels using waste material. Wherever practicable, mine pits will be directly in-filled (placement of waste material as a single operation during mining) as this minimises double handling and reduces cost. Where direct infilling is not feasible, pits will be backfilled (picking up already stockpiled waste material and then dumping into a void, either during pit mining or soon after) to above the pre-mine water table level.

Table 2.6 Conceptual strategy for waste rock and overburden material handling

Pit	Waste (Mt)	Strip ratio (w:o)	Initial waste handling	Backfilling status for void	Comment
A	45	2.0	Surface waste dump.	Backfill to pre-mine ground contours with waste from maybe Pit C and Pit A at a later time.	Depending on further studies, this pit void may be used as a groundwater recharge area during dewatering; this will prevent backfilling until the pit void becomes available. Timing is dependent on mine sequencing.
B	24	2.7	Surface waste dump.	Backfill to pre-mine ground contours (or mounded above ground level) with waste from Pit C.	Pit will be fully backfilled with either waste or tailings, or both.
C/D	268	2.8	Mostly to surface waste dumps, Pit B and mined sections of same pit.	Backfill to above pre-mine water table level with waste from same pit and maybe Pit E and from out-of-pit waste.	Most backfilling scheduled toward end of Pit C mining.
E	16	4.0	Eastern portion of Pit C/D (maybe surface waste dump).	Backfill to above pre-mine water table level with waste from Pit F Central.	Any dumps will be located south of pit. Waste from Pit F may fill Pit E void.
F	215	2.4	Pit E, some surface waste dump and western part of same pit.	Backfill void to above pre-mine water table level with waste from same Pit.	Due to length of mine, backfilling may commence during mining operations.
Detritals	37	2.8	Pit F and surface waste dumps.	Pit floor will be above water table level.	Direct backfilling of Pit F and/or Pit E is dependent on favourable scheduling.

Pit	Waste (Mt)	Strip ratio (w:o)	Initial waste handling	Backfilling status for void	Comment
Valley	78	2.9	Surface waste dump.	Backfill void to above pre-mine water table level.	Waste used for Range Pit.
Range	33	2.8	Surface waste dump/infill Valley Pit.	Infill Valley Pit void to above pre-mine water table level.	Waste from waste dumps may be used as backfill.
Flats	30	3.3	Surface waste dump/infill Valley Pit.	Small portion of pit floor will be below water table. Backfill to above pre-mine water table level with waste.	Waste used as direct infill of Valley Pit and as waste dump near Flats Pit ready for backfilling.

Waste dumps will be formed until mine pits are wholly or partly available for backfill. The total waste dump area will be approximately 900ha (650ha for Pits A, B, C/D, 125ha for Pits E and F and 125ha for Silvergrass pits); however, about 30% of waste will be returned to mine voids. Waste dumps that remain at the end-of-mine life will be re-contoured and rehabilitated.

2.5 ORE PROCESSING

The proposed processing arrangement is:

- use of existing Brockman plant to crush ore from Pits A, B and C/D
- a wet processing plant at Nammuldi
- a dry crushing plant at Pit E/Pit F (initially trucks will haul ore to the Nammuldi plant)
- a dry crushing plant at Silvergrass

At full production, the combined processing will generate:

- about 9Mt/a of lump product (-31.5mm+6.3mm)
- about 11 Mt/a of fines product (-6.3+0.02mm)
- about 2Mt/a (dry) of tailings in slurry form (-0.02mm)

2.5.1 Nammuldi plant

A schematic process flow is provided in Figure 10. The principal components of the plant are crushing, screening and fines washing. Dry processing forms the necessary preliminary stages for wet processing. Wet processing improves the final product that would otherwise be generated from just dry processing.

Crushing and screening (the dry processing)

Ore from Pits A, B and C/D will either be crushed to –30mm in the existing Brockman plant or fed to a new primary crusher. Ore from Nammuldi Pits E/F and Silvergrass pits will be dry crushed via primary/secondary crushing units at those locations, then crushed material transported to and fed into the Nammuldi plant.

Crushed ore from the new Nammuldi primary crusher will pass over a scalping screen (80mm) with oversize being further crushed in secondary crushers. Secondary crusher product from Silvergrass and the second Nammuldi plant (at Pit E/F) will be combined with scalping screen undersize and conveyed to a 30mm screen operating in closed circuit with a tertiary crusher. Screen undersize will feed a new wet plant. Product from the existing Brockman plant will be conveyed directly to the wet plant.

Wet processing

Lump product screens (6.3mm) will be wet screens with sprays to remove fines from the lump product. The screen oversize (lump product) will be conveyed to the blending stockpile via a sample station. The screen undersize will be directed to the fines product wet screen that will have a nominal separation size of 1mm. Oversize will be conveyed to the fines blending stockpile via a sample station.

The fines product screen undersize will be processed through a two-stage hydrocyclone circuit to remove the fine portion (-0.02mm). Horizontal belt vacuum filters will dewater cyclone underflow before being combined with fines product screen material for conveying to the fines product stockpile.

Cyclone overflow (-0.02mm material) will form the tailings portion. The tailings will be flocculated and thickened prior to being pumped to a tailings storage facility. Some flocculants/coagulants will be required in this process.

The flocculants recommended for use by Rio Tinto Research & Technology Development (1999) are:

- Magnafloc 800HP (high molecular weight, nonionic polyacrylamide) – dosage 20g/t
- Magnafloc 336 (high molecular weight, anionic polyacrylamide) – dosage 20g/t

while the recommended coagulants are

- Magnafloc 368 (low molecular weight cationic polymer) – dosage 20g/t
- Magnafloc LT35 (low molecular weight cationic polymer) – dosage 20g/t

Tailings storage facilities

In-pit and central thickened disposal are being evaluated to assess their viability (MPA Williams and Associates 1999). Additional tailings storage in cells constructed in the waste rock dumps will be investigated further as a supplement to in-pit disposal.

The total quantity of tailings from Nammuldi will be 20Mt, plus 6Mt from Silvergrass ore.

The likely properties of tailings are 8% (process slurry) or 20-40% (thickened) solids content depending on the disposal option. The assumed in-situ density for in-pit disposal is 1.5t/m^3 and for central thickened discharge is 2.3t/m^3.

In-pit disposal will occur in Brockman Pit 3 and Brockman Pit 1 (West) and Nammuldi Pit B, the latter depending on mine sequencing. The location of the central thickened discharge and pits are shown in Figure 4. Details of the in-pit disposal and central thickened discharge options are provided in Section 1.4.3.

Product stockpiles
The product stockpile at Nammuldi will have underdrainage facilities installed. A layer of coarse pebble or rock will be placed over the base of the product stockpile area to allow seepage of some water from the product. Pipework beneath the coarse layer will feed the water to a holding pond. This retained water may be used for local dust control activities.

2.5.2 Additional Nammuldi crusher plant

The mining of Pit E and Pit F may initially involve hauling ore by truck to the processing plant. The long strike length at Nammuldi may warrant eventually installing a crushing plant at the eastern pits (Pit E and F) and convey the crushed product to the plant rather than hauling ROM ore by truck. This is being evaluated.

2.5.3 Silvergrass crusher plant

Processing at Silvergrass will be primary crushing/screening to produce up to 10Mt/a of crushed product for transport to Nammuldi for further processing.

2.6 ORE TRANSPORT FROM SILVERGRASS

Ore from Silvergrass will be transported to Nammuldi by railway, road or conveyor.

2.6.1 Railway (rail option)

A conceptual railway route between Nammuldi and Silvergrass is shown in Figure 6. The total length of the railway (including loops) will be 21km while the width of all railway infrastructure (including embankment and roads) will be about 25m, providing a total area of 52ha.

Detailed engineering and geotechnical evaluations will confirm the optimum alignment. The provisional route departs from the existing Brockman rail spur through a gap in the Nammuldi Ridge between Nammuldi Pit C/D and Pit E and continues in a north-westerly direction along the slopes of the ridge avoiding low ground associated with the Duck Creek and Caves Creek flood plains.

Construction and drainage
The railway will be designed and constructed in a manner similar to Hamersley's Central Pilbara Railway (CPR) Extension to Yandi. The railway will require new embankment formation and mainline standard track work. The earthwork standards, construction methodology, rock protection for the railway and associated infrastructure will be similar to that for the CPR Extension. Continuous improvement will ensure that the design and construction of the new railway will be a further improvement on earlier railways.

Drainage planning and drainage structures will be confirmed during engineering design work. The route traverses areas characterised by defined drainage lines with little sheet flow drainage. Rolled steel and concrete box culverts will be used. The use and positioning of these culverts will depend on embankment heights and predicted flood flows at each drainage line crossing.

Borrow requirements
Earthworks will be designed on the basis of optimised 'cut-to-fill' – ie material from cuts will be used in areas of fill to minimise demand for borrow materials. Any shortfall of material will be sourced from borrow pits. Borrow pit requirements will be determined following geotechnical review of prospective sites and test sampling.

Ore unloading
If a railway is constructed, ore could be unloaded by either bottom opening wagons or by a car dumper. Ore could discharge into a hopper and conveyor that feeds the Nammuldi plant. Alternatively, front-end loaders could feed ore from stockpiles into a hopper/conveyor system feeding into the plant.

2.6.2 Haul road option

The route and approach to construction for a haul road will be similar to that for the railway. The length of the haul road (without loops) will be about 18km and the width about 25m, providing an area of 45ha. Trucks will haul ore from the Silvergrass plant to feed it directly into the Nammuldi plant. Due to more flexible ruling grade requirements, borrow material needs will be less for a road than for a railway.

If a haul road is used, trucks will dump ore on the ROM Pad or into the hopper/conveyor system feeding the Nammuldi plant.

2.6.3 Conveyor option

The route for a conveyor from Silvergrass to Nammuldi is shown in Figure 6. The earthworks for a conveyor will be less than for the railway, although allowances for a parallel service road will be needed. Drainage considerations will be similar to those applied for the 20km Channar-Paraburdoo conveyor.

If a conveyor is used, ore would be stockpiled (then fed into the system by front-end loader) or fed directly into the plant.

2.7 PRODUCT TRANSPORT TO DAMPIER

Product will be loaded into rail wagons and transported to Dampier on the existing railway network. While production rates remain low during the initial stages, product loading will be undertaken by front-end loaders. As production increases, a train loader (bin) facility will be required. Dust control measures (eg water sprays, conveyor transfer containment) will be used to manage dust from the Marra Mamba during product handling.

Marra Mamba mineralisation extends under the Brockman rail loop (refer Figure 3, Figure 6). A section of the resource below the Brockman rail loop is to be mined, forming part of Pit C/D; the remainder of the rail loop will be retained. Areas of the Brockman rail loop that are decommissioned and not mined will be retained.

A new rail loop for the Project will be established east of Pit C/D near the Nammuldi plant (refer Figure 6). The new rail loop will utilise a section of the Brockman rail system. There is scope to handle Brockman ore through this loop by establishing a conveyor connection between the Brockman stockpiles and the Nammuldi plant load out system.

Marra Mamba product will be railed separately from Brockman product. At maximum capacity, two or three trains will depart daily; each train carrying between 22,000t and 24,000t of product.

The incremental ramp-up to 20Mt/a of product railed to Dampier will not necessarily represent an equivalent increase to Hamersley's annual production. Instead, Marra Mamba and detritals product from the Project is likely to represent a partial replacement of product from other mines.

Trains will be unloaded at Dampier at East Intercourse Island or Parker Point and the ore conveyed to stockpiles where it will be blended. When a shipment is scheduled, product will be reclaimed then conveyed to ship loading facilities for transportation to world markets. Existing dust control systems implemented at Dampier will be applied for handling of product from this Project.

No capital works at the Port are being considered as part of this CER.

2.8 INFRASTRUCTURE

2.8.1 Construction camp

The existing Nammuldi Camp at Brockman (capacity 100 personnel) will be extended using additional transportable units to accommodate the Project construction workforce of about 400 people. Additional recreational and essential facilities will also be established for this workforce.

2.8.2 Village

A new Village will be constructed east of the Nammuldi Camp for the Brockman and Nammuldi operational workforces. The Village will consist of pre-fabricated accommodation buildings and will include a kitchen, dry and wet messes, offices, recreational facilities and first-aid facilities.

2.8.3 Power

Power will be obtained by extending the Dampier-Tom Price 33kV transmission line that passes east of Nammuldi. Additional 33kV distribution lines will be provided to the borefields, Village and Silvergrass facilities.

Diesel generators will be provided for stand-by purposes at the Village/construction camp, train load-out, key transfer pumps and pit dewatering bores. Skid-mounted diesel generators will be used for the dewatering bores until power is supplied from the main grid.

2.8.4 Water

Daily water use will be around 1ML/day mostly for dust control in the mines and on haul roads. This demand will increase significantly (possibly by a factor of 5 or 6 times) if a haul road is used between Silvergrass and Nammuldi due to the amount of water needed for dust control purposes.

Water will be diverted from the mine dewatering discharge pipeline at Nammuldi to a large raw-water storage tank. Water from this tank will be used for potable, processing and fire fighting purposes. Water will be distributed by gravitation and pumping to the mine, plant, administration and Village areas.

Water for potable purposes will be UV sterilised to maintain drinking water standards. Process water will be supplemented by decant water from the tailings storage.

Water requirements at Silvergrass will be met from mine dewatering.

During construction, water for dust control will be sourced from the Brockman borefield or production bores established during hydrogeological investigations. During operations, water will be sourced from standpipes connected to the dewatering discharge system.

2.8.5 Road access

A 30km-gravel road provides access to Nammuldi from the Paraburdoo-Dampier Railway service road. This road will not be upgraded but will continue to be maintained.

2.8.6 Airstrip

The existing Nammuldi airstrip needs to be upgraded to allow Dash 8 aircraft (carrying 36 to 50 people) to be used for Brockman and the Project (construction and operation). If required by Brockman before the commencement of the Project, the upgrade will be notified separately to Government. The upgrade will include extending the cleared area at each end of the runway by 100m and widening the clearing adjacent to the runway by 10m on either side (total area 4.6ha). In addition, a vehicle parking area will be required.

2.8.7 Fuel

Provision of power from the Dampier Power Station grid system and the re-fuelling of locomotives at other sites will reduce diesel demand. Probably two 110,000L above ground diesel storage tanks will be required; these bulk tanks will be held inside a lined and bunded storage facility in accordance with Mine Regulations and AS1940. Fuel will be delivered by road train.

2.8.8 Sewage treatment

Sewage treatment systems will be constructed at the Nammuldi plant and the Village. Package aerobic treatment plants will be used where septic tank systems are not practical. Treated effluent will be chlorinated, then either spray irrigated over vegetated areas or piped to evaporation ponds. If spray irrigation is adopted, the treated effluent will be sprayed over native vegetation in rotation, as undertaken at Brockman and Yandi. The irrigation or ponds will be fenced. Other facilities (at Silvergrass and at the eastern Nammuldi pits) will have individual septic tank systems.

2.8.9 Ammonium nitrate and explosives

Ammonium nitrate will be stored in an open-ended shed with a concrete floor. ANFO will be delivered in bulker bags. Emulsion (for wet blasting) will be held in a bunded storage vessel near the ANFO store and be delivered by road-trains. The high explosives and detonators store will be fenced and will be a safe distance from other buildings.

2.8.10 Offices, workshops, laboratories and service areas

A pre-fabricated permanent office will accommodate site management and support personnel. A light vehicle/plant workshop to service and maintain light vehicles and plant and a separate workshop for servicing heavy vehicles will be provided. A wash-down pad for site vehicles and plant will be constructed, with runoff flowing to an appropriately sized oil separation pit. A laboratory, crib huts and a first-aid post will also be provided.

2.9 WORKFORCE

2.9.1 Construction

Assuming a wet plant is required, the construction workforce will peak at around 400 people. Construction is likely to be undertaken as a series of discrete packages, being spread over a number of years. This will result in periods of construction activity interspersed between periods when no construction activity occurs.

2.9.2 Operations

The operations workforce (150-190) may commute on a Fly-in- Fly-out basis, but some may commute by road from Tom Price (as does some of the Brockman workforce now).

3. EXISTING ENVIRONMENT

3.1 PHYSICAL ENVIRONMENT

3.1.1 Climate

Regional climate is described as arid tropical with two distinct seasons (Gentilli 1972). The summer months extend from November to April when temperatures can reach 47°C (mean daily maxima of 39°C in January), while winter temperatures are cool (mean daily maxima of 24°C in July). There is a high diurnal variability.

Annual rainfall is highly variable from year to year but is mostly between 300mm and 400mm. This variability is a consequence of periodic summer cyclones that pass along the Pilbara coast, but occasionally extending inland becoming rain-bearing depressions that cause widespread and intensive rainfall.

Annual evaporation rates are high (pan evaporation is about 3600mm: PPK Environment & Infrastructure 1999) and peak in summer. Evaporation exceeds rainfall every month of the year.

Winds tend from the east and southeast in summer and from the west in winter.

3.1.2 Geology and soils

The following outline of the regional and local geology is a summary of the description provided in PPK Environment & Infrastructure (1999). Nammuldi and Silvergrass lie on opposing limbs of a broad anticlinal structure. The stratigraphic sequence (from oldest to youngest) is the Jeerinah Formation, the Marra Mamba Formation (3 members), the Wittenoom Formation (3 members), the Mount Sylvia and Mount McRae Shales, the Brockman Iron Formation (BIF), the valley fill deposits and recent alluvial deposits.

Nammuldi

The Marra Mamba Formation dominates the geology. This outcrops as low undulating hills and dips towards the south. An area of variable valley fill separates the formation from the BIF escarpment. Variably weathered West Angelas Shale (non-pyritic) overlies the Marra Mamba in most intersected areas of the valley fill.

The primary mineralisation occurs as a series of elongate lenses of mostly hematite and goethite within the Marra Mamba Formation. Adjacent to where it outcrops, the formation is overlain by a variable thickness of detrital ore within the local valley fill.

At the western end of the deposit strike length, the orebody is almost flat, but towards the east, it dips increasingly steeply. The maximum depth of the base of mineralisation is 70m at Pit A and about 250m at Pit C. The thickness of mineralisation ranges from 10m to 50m. Within the area of Pit C there is a low angle thrust fault that has locally displaced the Marra Mamba mineralisation leading to repeats in the local stratigraphy and a generally thicker mineralisation.

The nature of the valley fill is highly variable, but tends to be dominated by clays and sandy clays that may increase in maturity from east to west. The valley fill can attain a thickness of 120m (Pit C and Pit F).

Local accumulations of alluvial sands and gravels make up the intermittent drainage lines. Extensive calcrete deposits occur above and at the current water table across much of the deposit.

Silvergrass

The Marra Mamba Formation at Silvergrass is similar to that at Nammuldi, except that it dips toward the north. An area of variable valley fill occupied by the current Caves Creek drainage line separates the Marra Mamba Formation from the BIF escarpment. The West Angelas Shale overlying the formation is less prevalent than at Nammuldi.

The Marra Mamba at Range Pit dips toward the north but is locally folded. At Valley Pit, the mineralised Marra Mamba occupies a valley feature surrounded on three sides by low undulating outcrops. In these pits, the predominant hematite and goethite mineralisation is about 25-30m thick and dips to 100m where it levels out and extends beneath the valley floor for several hundred metres. Flats Pit has a similar geology to the Range Pit area, but the depth of mineralisation appears shallower.

The valley fill is highly variable, but is generally dominated by clays and sandy clays. The valley fill is about 100m thick adjacent to the Range Pit.

Caves Creek has relatively shallow river sands and gravels with some local calcrete (sheet carbonate) development. Adjacent to the creek, sediments include shallow scree slope deposits (ironstone rubble, sands and clays) with some local chemical sediment development (calcretes and goethites). Calcrete deposits also occur above and at the water table across much of Silvergrass.

Soils

The dominant soils at Nammuldi and Silvergrass have been identified and mapped (Halpern Glick Maunsell 1999a). The soils along the transport corridor were not identified.

Soil types Um5.51 and Um5.52 account for over 90% of the area of Nammuldi and 75% of Silvergrass.

Soil type Um5.51 is a shallow, coherent and porous loamy soil occurring on hills; the 'A' horizon is very shallow (<30cm), with dark red to red sandy clay loam and a stony, hard-setting surface and a low to high coarse fraction. It has low salinity, a slightly acid pH and low nutrient levels. Vegetation associations that occur with this soil type include A1, A2 and A3 (refer Section 3.2.1, Table 3.3).

Soil type Um5.52 is similar to Um5.51, but occurs on lower slopes of hills and on stony undulating plains and has a deeper 'A' horizon (75-100cm). It also has low salinities, slightly acidic and low nutrient levels. Vegetation associations that occur with this soil type include A6, A5, A7 and B2, B3, B4, B5 and B7 in drainage areas (refer Section 3.2.1).

3.1.3 Topography and surface drainage

Both Nammuldi and Silvergrass have Marra Mamba mineralisation outcropping as low undulating hills separated from the steep BIF escarpments by an area of valley fill (refer Figures 7 and 8). At Nammuldi, elevations range between 630mRL at Pit F (in the east) and 600mRL at Pit A (in the west). At Silvergrass, elevations range between 570mRL at Flats Pit and 560mRL near Caves Creek.

Surface drainage at Silvergrass is dominated by Caves Creek. This creek is a minor tributary to the Ashburton River and has a catchment of about 1,100km^2 above Range Pit. The catchment extends 15km east of Tom Price where its main tributary (Barnett Creek) originates (Figure 11). Barnett Creek flows to near Hamersley Station homestead. At its confluence with Wackiliana Creek it becomes Caves Creek. Silvergrass is 32km from the confluence of the Barnett, Wackiliana and Caves creeks.

East of Hamersley Station homestead and Hamersley's Paraburdoo-Dampier railway, lies a large flat plain stretching 15km with little change in elevation (596-600m AHD). During floods, water on the plain can flow west down Caves Creek, but most runs north down Weelumurra Creek and eventually into the Fortescue River.

Hamersley's Central Pilbara Wetlands Study mapping (Figure 11) shows no wetland at Nammuldi, except an area 5km south-east of Pit F described as 'Area subject to inundation' (Ref: 164). No wetlands occur on Caves Creek at Silvergrass, except Caves Creek itself. Palm Springs (Ref: S2), a permanent groundwater-fed spring sourced from creek alluvium, is 30km downstream of Silvergrass. Other wetlands within a 10km radius of Silvergrass are Donkey Hole (165), South Mill Well (166), an un-named Waterhole (167) and a Semi-permanent Rockhole (S1).

There is no WRC stream gauging station on Caves Creek, nor is there any continuous streamflow data available. Five WRC stream gauges in the West Pilbara with various catchment sizes were analysed and interpolated to obtain peak flow (flood) estimates for Caves Creek at Silvergrass (Gilbert & Associates and Muirden 1999).

The likely peak flows and flood levels at Silvergrass are provided in Table 3.1.

Table 3.1. Likely peak flows and levels on Caves Creek at Silvergrass.

Average Recurrence Interval (Year)	Likely flow (m^3/s)	Creek depth (m)	Flood height (approx. m AHD)
2	91	2.5	559.4
5	380	3.9	561.0
10	710	4.5	561.6
20	1,180	5.0	562.1
50	2,000	5.8	562.9
100	2,900	6.4	563.5
200	3,900	7.0	564.1
1000	7,300	8.7	565.8

The more conservative peak flow estimates (Figure 12) were developed for detailed design purposes due to the lack of measured data available with the flow estimation. Hamersley will commence measuring stream flows in Caves Creek in advance of Project commencement at Silvergrass (refer Table 5.1).

Drainage at Nammuldi is much less defined with no permanent surface bodies or clearly identifiable creek channels. Drainage from the area flows north through several low points in the Nammuldi hills and eventually joins the dendritic Duck Creek catchment that flows toward the north-west.

3.1.4 Hydrogeology

Groundwater in the mineralised Marra Mamba is semi-confined. The confining influence is likely to be the lower permeability characteristics of the West Angelas Shale and valley fill sediments overlying the aquifer.

Aquifer hydraulics

A summary of aquifer hydraulics is provided in Table 3.2.

Table 3.2. Summary of aquifer hydraulics

	Aquifer parameters			Aquifer through-flow estimates			
Pit	**Transmissivity (m^2/d)**	**Storativity**	**Saturated thickness (m)**	**Hydraulic conductivity (m/day)**	**Hydraulic gradient**	**Marra Mamba cross-section (m^2)**	**Through-flow (m^3/d)**
Nammuldi							
A	300-400	0.0025	23	38	0.0028	6,000	650
B	150-250	0.0005	10	8	0.0067	3,000	160
C/D	30-70	0.00014	72	0.7	0.0025	100,000	175
E	40-80	0.0003	23	5	0.0017	30,000	250
F (1)	4-10	-	145 (valley fill)	-	-	-	-
F (2)	30-50	0.0007	13	5.1	0.001	40,000	200
Silvergrass							
Range	200-300	0.00026	35	7	0.005	7,500	260
Valley	350-500	0.0014	24	17	0.0033	12,000	680

Adapted from PPK Environment & Infrastructure (1999)

The transmissivity at Nammuldi ranges from 40 to 400m^2/d, while at Silvergrass it ranges between 200 and 500m^2/d. Storage values confirm the semi-confined nature of the aquifers. Estimates of local aquifer through-flow range from 160 to 650m^3/d at Nammuldi and between 260 and 680m^3/d at Silvergrass.

Groundwater levels and flow

Groundwater level contours at Nammuldi are shown in Figure 13 and those for Silvergrass are shown in Figure 14.

At Nammuldi, confined water levels range from 18 to 47mBGL (between 582mRL and 574mRL). Groundwater flow follows topographical gradient (and drainage) from east to west. Limited data on the local unconfined water levels suggest comparable levels to the deeper system, indicating some connection between the shallow and deep systems. Following significant rainfall events, water level in the shallow unconfined system rises rapidly and perches above the lower permeability valley fill clays for a short time.

Water levels in the Brockman borefield (Pit C at Nammuldi) have been lowered around 7m (adjacent to the bores) since abstraction commenced in 1992. The Brockman borefield intersects the upper sections of the mineralised Marra Mamba aquifer. The Brockman No. 2 Mine uses abstracted water.

At Silvergrass, confined water levels range from 9 to 24mBGL (between 545mRL and 549mRL). Groundwater flow follows the topographical gradient from north-east to south-west. Again, there appears to be some connection between the shallow and deep aquifers at Silvergrass.

Groundwater quality
A summary of water quality analyses of groundwater samples collected at Nammuldi and Silvergrass is provided in Appendix C. Groundwater is fresh with Total Dissolved Solids (TDS) ranging between 340 and 860mg/L.

Hydrochemical typing of the water analyses (adopting the Piper and Expanded Durov plots) has identified there to be four distinctive water types. This water typing exercise is specific to the water samples taken from within the Project area and demonstrates the different origins of groundwater.

Groundwater in the mineralised Marra Mamba aquifer at Nammuldi is Type I (dominant in magnesium and bicarbonate and often lowest in TDS) reflecting a relatively recent recharge signature. The aquifer at Silvergrass is Type II (mixed speciation and often slightly more saline than Type I) suggesting a location slightly outside the influence of direct upland recharge. Groundwater in the low permeability detritals/valley fill at Nammuldi Lens F is Type III (dominant magnesium and bicarbonate, with ion exchange having occurred). Type IV water is end point groundwater, where flow is locally closed.

This hydrochemical typing highlights the local variability within the groundwater systems due to the relative influence of local upland recharge and relative location with the flow regime. It also confirms that:

- Brockman (Dales Gorge Member) groundwater system is isolated from the Nammuldi groundwater system to the north by lower permeability strata
- valley fill and mineralised Marra Mamba aquifers have different hydrochemical signatures (at least in Pit F)
- a degree of interconnection of groundwater exists between Range and Valley pits at Silvergrass (as they have similar hydrochemical signatures)

3.2 BIOLOGICAL ENVIRONMENT

3.2.1 Flora and vegetation

The vegetation and flora of the Project area has been surveyed (Halpern Glick Maunsell 1998, 1999a, 1999b). Survey work was conducted in the Nammuldi Trial Operation in July 1998, the

Nammuldi and Silvergrass mine areas in August-September 1998 and along the transport corridor in March 1999. In addition, the findings of an earlier survey of the Brockman area (Mattiske 1990) were reviewed, then correlated and cross-referenced (Halpern Glick Maunsell 1999a). A detailed description of the methodology and analysis used to derive the defined vegetation associations is provided in Halpern Glick Maunsell (1999a, 1999b).

The Project area has been grazed for over 100 years, firstly by sheep then (since 1970) by cattle (refer Section 3.3.3). Grazing and periodic wild fires (from lightning strikes) represent recent historical threatening processes to flora and vegetation in the area. In more recent times, exploration programs have also been conducted.

Vegetation communities

Vegetation was recorded at 90 survey sites (Nammuldi/Trial Operation 52 sites, Silvergrass 23, transport corridor 15). These were sited to be representative of the major vegetation communities.

Twenty-two vegetation associations belonging to three main vegetation types were identified.

The three broad vegetation types were:

- vegetation of hills and stony plains
- drainage vegetation
- vegetation associated with clay soils

The vegetation associations for each vegetation type are provided in Table 3.3, with vegetation associations mapped for Nammuldi (Figure 15), Silvergrass (Figure 16) and the transport corridor between Nammuldi and Silvergrass (Figure 17).

Table 3.3. Vegetation associations for each vegetation type

Vegetation type	Code	Vegetation association
Hill/Stony Plains	A1	Tall shrubland dominated by *Acacia maitlandii* over *Triodia wiseana*
	A2	*Eucalyptus leucophloia* over *T. wiseana*
	A3	*E. leucophloia* and mixed shrubs over *T. wiseana/Triodia pungens*
	A4	*E. leucophloia* over *Triodia brizoides*
	A5	Open tall shrubs dominated by *Acacia exilis* over *Triodia wiseana*
	A6	*Senna/Acacia* shrubland over *T. pungens*
	A7	Open *Acacia xiphophylla/A. aneura* shrubland
	A8	*E. leucophloia/E. socialis* over *Triodia angusta*
	A9	*E. leucophloia/Acacia* species over *T. angusta*
	A10	*Acacia bivenosa* over *Triodia brizoides*
Drainage	B1	Tall woodland of *Eucalyptus camaldulensis/E. victrix* over *Acacia citrinoviridis*
	B2	Dense tall shrubland of *A. aneura* over *T. pungens*
	B3	*A. aneura/A. ayersiana* tall shrubland over *T. wiseana*
	B4	Open Eucalypts over mixed tall shrubland
	B5	*A. aneura/A. ayersiana* tall shrubland over *T. pungens*
	B6	Dense *Acacia maitlandii/A. atkinsiana/A. exilis* tall shrubland
	B7	Dense mixed tall shrubland
	B8	Dense *Acacia ancistrocarpa/A. atkinsiana/A. exilis* tall shrubland
Clay Soils	C1	Moderately dense herbland
	C2	Low shrubland of *Senna artemisioides* subsp. *oligophylla* (*sericea* form)
	C3	Tall shrubland of *Acacia xiphophylla*
	C4	Low shrubland of *Eremophila maculata* over herbs

No vegetation association is restricted to the surveyed area, but some are restricted locally because of relatively low occurrence of some landform features (eg creek lines or breakaways):

- *Association B1* – major creek lines represent refugia for various species during drought
- *Association A3* – when present in gorges or along breakaways, this may support Priority species (*Triumfetta leptacantha*) – also supports *Brachychiton acuminatus* (a Priority listed species when surveyed but has since been removed – refer below)
- *Association A8* – found at Nammuldi, but appears to be well represented to the north based on Mattiske (1990) mapping

Mulga woodland (Association B2) is present at Silvergrass and Nammuldi (total surveyed area is 80ha), but not the transport corridor.

Flora species
A total of 373 species of vascular flora (166 genera from 58 families) was recorded from the combined survey areas (Appendix D). The number of recorded species reflects the variety of landforms (and vegetation associations) within the surveyed area, the optimal timing of the surveys (after above average rainfall when ephemeral species present) and the presence of post-fire disturbance communities of different ages.

Most flora recorded were from the Poaceae (grasses), Malvaceae (hibiscus etc), Mimosaceae (wattles), Papilionaceae (pea flowers), Amaranthaceae (mulla-mulla) and Asteraceae (daisies) families. In terms of genera, most species came from *Acacia* (wattles), *Ptilotus* (mulla-mullas), *Sida*, *Senna*, *Corymbia* (bloodwoods) and *Eucalyptus*. The commonly recorded species were *Dysphania rhadinostachya* (59 sites), *Triodia wiseana* (57 sites), *Senna glutinosa* subsp *glutinosa* (54 sites) and *Eucalyptus leucophloia* (51 sites).

Species of conservation significance – Rare flora species
While all native flora are protected under the *Wildlife Conservation Act 1950*, some are assigned an additional level of protection based on their limited number of known populations and perceived threats to these areas. Species of the highest conservation significance are designated Declared Rare Flora.

No Declared Rare Flora were recorded.

Species of conservation significance – Priority flora species
Species that appear rare or threatened, or for which there is insufficient information to assess their conservation significance, are assigned one of four Priority flora categories.

Definitions for each Priority flora categories are provided below.

Priority One - Poorly known Taxa
Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, eg. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, eg. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

Priority Two - Poorly Known Taxa

Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

Priority Three - Poorly Known Taxa

Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.

Priority Four - Rare Taxa

Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

At the time of the flora surveys, six Priority species were recorded. Rare Flora Report Forms for these were issued to CALM and voucher specimens lodged with the Herbarium.

In January 2000, a revised Declared Rare and Priority Flora List was released by CALM. Of the original six Priority flora recorded in the Project area, the revisions to the Priority Flora List resulted in one species (*Brachychiton acuminatus* - a Priority 4 species) being removed. In addition, the priority classification of two others was amended; *Tephrosia* sp (Cathedral Gorge) changed from Priority 1 to Priority 3, while *Goodenia stellata* changed from Priority 2 to Priority 3. No flora species recorded in the surveyed Project area has been added to the Priority Flora List since the surveys were completed.

The five Priority species (all Priority 3) recorded in the surveyed area are:

- *Tephrosia* sp. (Cathedral Gorge) – Recorded at Silvergrass (30 individuals within 100m^2 at base of small rocky outcrop), two sites at Nammuldi (scattered individuals on ridges or stony undulating plains) and two burnt areas in the transport corridor (30 individuals, on stony hill and a calcareous plain). Specimens lodged with the Western Australian Herbarium are from Cathedral Gorge, Fortescue Valley and west of the West Angelas Camp, but likely to be more widely distributed in the Pilbara than current records suggest.

- *Goodenia stellata* – Recorded at two drainage areas at Nammuldi (scattered individuals at one site and over 100 plants within 25m^2 at other site) and in the transport corridor (200 individuals in one creek line and 35 elsewhere). Recorded locations include 102km north of Sandstone, 20km east of Juna Downs Homestead, Marillana Creek, Yampire Gorge, West Angelas, Erlistoun Station and Hamersley Range. Due to its small size, seasonal dieback to rootstock and the relative paucity of botanical collection in the Pilbara, this species may be more widely distributed than current records suggest.

- *Bulbine pendula* ms. – Recorded at Silvergrass (scattered individuals within herbland on heavy clay) in area subject to grazing. Specimen in WA Herbarium collected from cracking clay 8km east of Hamersley Station homestead, but other known locations include Rudall River, Mt Augustus Station, Minilya River and Juna Downs.

- *Gymnanthera cunninghamii* – Sterile specimen that may be *G. cunninghamii* found at Caves Creek (5 individuals). Also recorded at Woodstock, Boodarie and Mooka stations, Enderby Island, Minilya River and Eighty-Mile Beach, also in the Northern Territory and Queensland.

- *Triumfetta leptacantha* – Recorded at Nammuldi (10 mature shrubs and a seedling at base of rock face), two individuals observed in gorge north-west of Trial Operation and about 100 individuals at other gorge locations around Nammuldi. Also recorded in similar gully/gorge habitats near Mt Bruce and in Hancock Gorge in KNP and on the Paraburdoo Flats.

Individuals of these Priority flora species are not limited to single identified vegetation association.

A separate flora and fauna survey of the Homestead area (Hamersley 1995) found that Palm Springs (30km west of Silvergrass) contains large numbers of Millstream Palms (*Livistonia alfredii*). This palm population is significant as it is large and, unlike those that occur at Millstream, Date Palms are not present.

Flora species of interest were also recorded:

- *Haloragis* aff. *gossei* – some *Haloragis* specimens could not be identified to species level and may represent a variety of *H.gossei* or a new species: collected from Silvergrass

- *Sida* sp. (white leaf margins) – low shrub form of *Sida* with distinctive white margins does not match currently described species and appear to represent a new type: collected from burnt area at Nammuldi and opportunistically elsewhere

Introduced flora species (weeds)
Five introduced flora species were recorded (none designated noxious weeds), including:

- *Bidens bipinnata* (Beggar's Ticks) – mostly associated with drainage channels
- *Cenchrus ciliaris* (Buffel Grass) – introduced as source of fodder, now widespread, frequently dominant ground cover in creeks and floodplains of the Pilbara, but recorded from single creek site at Nammuldi
- *Malvastrum americanum* (Spiked Malvastrum) – recorded at 13 sites associated with drainage areas, only present at significant densities in three recently burnt creek sites
- *Sigesbeckia orientalis* (Indian weed) – recorded at a single site in breakaway/gorge area
- *Rumex vesicarius* (Ruby dock) – recorded opportunistically at Nammuldi, represented by small number of individuals

3.2.2 Fauna

Vertebrate
Vertebrate fauna surveys were conducted over two seven-night periods (Hamersley 1999a). Nammuldi and Silvergrass were surveyed in November 1998 and May 1999, while the transport corridor was surveyed in May 1999.

Terrestrial vertebrates were recorded at each vegetation type using trapping grids at 21 sites (Nammuldi 8, Silvergrass 10, transport corridor 3). The locations of fauna sites are shown in Figures 15, 16 and 17. Avian fauna was recorded in the November survey by the fixed time method of census.

The level of species richness recorded for each taxon is compatible with other intensive Pilbara surveys; Abydos-Woodstock (How *et al.* 1991), Tom Price (Anstee unpublished data) and Marandoo (Ninox 1992).

The survey recorded 66 reptile species, 21 mammals and 76 birds. The vertebrate fauna species list is provided in Appendix E.

On a regional scale, the vertebrate community exhibits a pattern of species abundance and distribution regarded as typical of the composition of semi-arid habitats and the Central Pilbara. The vertebrate assemblage utilising the Project area is typical of other areas in the Pilbara. Species inventories and measures of species diversity and evenness for each taxon were similar to those recorded at Abydos-Woodstock, Tom Price and Marandoo (How *et al.* 1991, Anstee unpublished data, Ninox 1992).

Of local fauna significance are the:

- riverine areas at Nammuldi and Silvergrass (vegetation association B1)
- Mulga woodland at Nammuldi (vegetation association B2)
- areas with deep alluvial soil at Nammuldi (vegetation association A6)
- cracking clay soils at Silvergrass (vegetation associations C1, C3, C4)

These areas are relatively small and poorly represented on a local scale.

Mammal species of conservation significance include:

- *Macroderma giga* (Ghost Bat) – status: Priority 3 (taxa with several, poorly known populations, some on conservation lands) under the *Wildlife Conservation Act 1950* and Vulnerable under the Australian and New Zealand Environmental Conservation Council (ANZECC) List of Threatened Australian Vertebrate Fauna 1995 (the ANZECC List). Several individuals (including reproductively active female) were recorded in deep caves in the Marra Mamba Formation east of Silvergrass. The maternity roost is an important resource for this species in the Nammuldi area.

- *Leggadina lakedownensis* (Lakeland Downs Mouse) – status: Priority 4 (taxa in need of monitoring) under the *Wildlife Conservation Act 1950* and Endangered under the ANZECC List. Recorded at four sites on or near cracking clay soils at Silvergrass and are known to have close affinity to cracking clays. Previously known from one or two offshore islands and at Millstream, but known distribution has increased rapidly with more surveys.

- *Pseudomys chapmani* (Pebble-mound Mouse) – status: Priority 4 under *Wildlife Conservation Act 1950* and Vulnerable under the ANZECC List. Well represented on Marra Mamba hills around Nammuldi and Silvergrass deposits and elsewhere in the region (Figure 2 shows the regional distribution of Marra Mamba Iron Formation).

- *Sminthopsis longicaudata* (Long-tailed Dunnart) – status: Priority 4 under the *Wildlife Conservation Act 1950*. Two specimens recorded, found throughout the Pilbara in rugged breakaways and rocky outcrops. Its rarity may be due to the large trapping efforts required to capture it.

Reptiles of conservation significance recorded or that may occur include:

- *Morelia olivacea barroni* (Pilbara Olive Python) – status: Schedule 1 under the *Wildlife Conservation Act 1950*. Not recorded, but likely to occur and has been located in most of the Pilbara.

- *Notoscincus butleri* – status: Priority 4 under the *Wildlife Conservation Act 1950*. One specimen recorded at Nammuldi, well represented in Homestead area (Hamersley 1995).

- *Ctenotus* aff. *helenae* – status: not listed under priority fauna list. Eleven specimens recorded at nine sites at Nammuldi and Silvergrass, these differ in appearance from Museum collection in colour and habitat preference. Taxonomic status unresolved.

- *Ctenotus* aff. *robustus* – status: not listed under priority fauna list. Considered endemic to Kimberley region; further surveys may extend its known range. Taxonomic status unresolved.

- *Ctenotus* aff. *rutilans* – status: not listed under priority fauna list. These differ in appearance from Museum collection. Taxonomic status unresolved.

No recorded bird species is listed under Schedule 1 or Schedule 3. Sightings of a Peregrine Falcon (*Falco peregrinus*) - a Schedule 4 species - were made at Silvergrass. This is a highly mobile species with no habitat specificity.

Stygofauna

The occurrence of stygofauna in the Pilbara was originally considered to be limited to calcrete and karst systems; stygofauna have since been recorded in calcrete and non-calcrete aquifers in the Central and East Pilbara. Other than calcrete aquifers, recent findings have been in aquifers associated with Marra Mamba, karstic dolomite and shear zones in Jeerinah dolerite. Stygofauna can also occur in the alluvium of ephemeral and permanent creeks.

As part of the stygofauna research program initiated by Hamersley in 1998, Nammuldi and Silvergrass (as well as Brockman and Homestead) was sampled for stygofauna in November 1998 (by Halpern Glick Maunsell on behalf of Hamersley) and again in May 1999 and October 1999 (by Hamersley). Another round of monitoring in the Project area is scheduled for mid 2000. This will make the Project area one of the most comprehensively monitored (for stygofauna) in the Pilbara.

The methodology for the 1999 and 2000 stygofauna sampling was discussed with state (Western Australian Museum: Bill Humphrey) and national (Australian Museum: Buz Wilson) specialists in this area. Input from these specialists was incorporated in the design and implementation of the stygofauna sampling program.

The November 1998 sampling was part of the Nammuldi-Silvergrass biological assessment and used airlift pumps at targeted drillholes; no stygofauna was recorded.

In May 1999 and October 1999, sampling of the same drillholes using dip nets identified some stygofauna. The stygofauna recorded at Nammuldi, Silvergrass and Brockman are provided in Appendix F.

Samples of stygofauna have been issued to national and international specialists for species identification; results will be available by late 2000 or early 2001.

Stygofauna sampling in the Marra Mamba aquifers at Nammuldi and Silvergrass found amphipods (provisionally identified as being from Melitidae and Bogidiellidae families), copepods, worms and collembola.

On the basis of the above work, stygofauna do occur in the Marra Mamba aquifer of the Project area, and are also hypothesised to occur in the alluvium of Caves Creek.

Sampling for troglobitic fauna was not undertaken as there are no underground caves in the Project area. This is based on the findings of drilling programs undertaken in the mineralised portions of the Project area.

Some species of stygofauna from elsewhere in Western Australia have been placed on Schedule 1 of the *Wildlife Conservation Act 1950*. No known mainland Pilbara species has been placed on the Schedule 1 list to date. Until final identification of the stygofauna samples has been completed, it is not known whether any species recorded in the Project area is significant (ie is on the Schedule 1 list).

3.3 HUMAN ENVIRONMENT

3.3.1 Regional setting

The Project is located in the Shire of Ashburton. The nearest towns are Tom Price and Paraburdoo. Tom Price was established in 1966 by Hamersley to support mining at Mt Tom Price and has a population of approximately 3,600. Paraburdoo was established in 1971 to support mining at Paraburdoo (and later Channar) and has a population of approximately 1,700. Most of the town residents work directly or indirectly for Hamersley.

At the request of Government, a process of town 'normalisation' commenced in the late 1980's. Under this arrangement, state and local government authorities are gradually assuming their normal role in providing services and utilities, with Hamersley continuing to contribute funds.

Relative to Nammuldi, the nearest boundary of Karijini National Park is 75km to the east, while the nearest boundary of the Millstream National Park is 95km to the north. These national parks are managed by CALM and are a major focus of the increasing Pilbara-based tourism industry.

3.3.2 Aboriginal setting

Aboriginal Communities
Aboriginal people with an interest in the Project area are the Eastern Gurama people and related family groups represented by the Maliwartu Aboriginal Corporation (Maliwartu). Due to historic factors, these people are today widely dispersed.

The main communities are located at:

- Karratha - Aboriginal population of about 300 people of mixed language groups
- Roebourne - about 900 Aboriginal people of mixed language groups
- Wakathuni (20 km south of Tom Price) - 100 Aboriginal people of mixed language groups

Wakathuni is the closest community; however, most Eastern Gurama people reside in the Roebourne - Karratha region.

Economic Opportunity
Aboriginal people are keen to participate in the regional economy and this is why most now reside in coastal towns that provide greater employment opportunities. Wakathuni has been strategically located to allow the community to access employment opportunities with Hamersley and the Karijini National Park. The local pastoral industry provides seasonal work.

Aboriginal communities and employment
Hamersley operates over the traditional lands of ten language groups and believes these people, as stakeholders in our business, should have opportunities to participate in the local economy that mining generates. Since 1992, Hamersley, through its Aboriginal Training and Liaison department, has implemented a number of programs to increase Aboriginal participation within the mining industry. These programs range from education and scholarships, skills and personal development, clerical and trade apprenticeships, to business development and alliances.

Hamersley's operator skills development program provides on the job training and skills enhancement over an 18-month period allowing graduates to compete for jobs at mine sites. Over 95% of Aboriginal people completing the program have gained full time employment, 60% with Hamersley.

3.3.3 Land use and ownership

The Project is located on the Mt Brockman Station that was incorporated into Hamersley Station in 1993. The Hamersley Pastoral Lease (including the Mt Brockman Pastoral Lease) covers 302,000ha and is used for pastoral purposes. The station has been active for over 100 years, with grazing by sheep until about 1970 and by cattle thereafter.

Hamersley holds the Hamersley Station Pastoral Lease (CL No. 742/1993). A Station Manager manages the Lease on Hamersley's behalf. The Station Manager and other station staff reside at the station homestead, located 40km north-east of the Brockman No. 2 Mine and Nammuldi.

Current land tenure includes mining leases and exploration licences - ML4SA (Secs 107, 108, 239), M47/369, E47/46, E47/43, E47/50, E47/904, E47/940, E47/994 and TR5587H. Both E47/940 and E47/994 are pending Exploration Licence applications.

Hamersley is in the process of negotiating an Indigenous Land Use Agreement with native title claimants from the Eastern Gurama people. This Agreement will include the current Project area (Stage II, refer Section 1.1) and Homestead (Stage III, refer Section 1.1) and will cover heritage protocols and economic benefits to Aboriginal people. The Agreement will be Hamersley's second such agreement, having signed the Yandi Land Use Agreement in 1997 for the Yandi Project.

3.3.4 Aboriginal heritage

Archaeological sites
Aboriginal archaeological surveys have been conducted within the Project area (Archae-Aus 1998, 1999a, 1999b, 1999c, 1999d) for site clearance ahead of drilling programs and site investigations.

The coverage of heritage (archaeological) surveys at Nammuldi is shown in Figure 18. The transport corridor, most infrastructure (plant, tailings storage, haul roads, powerlines, Village) and some areas to be mined have not yet been surveyed. Once agreement has been reached on the adoption of a heritage clearance protocol, these remaining areas will be surveyed (with involvement of the Maliwartu Aboriginal Corporation). These surveys will identify any archaeological (or ethnographic) sites that are within the Project area and the management approach to be taken toward each site.

The area of Pit A used during the hydrogeological investigation was surveyed and cleared; the remainder of Pit A will be surveyed by mid 2000. Pit B and Pit C has been mostly surveyed, with no archaeological sites recorded. Both Pit E and Pit F have been surveyed, with 13 archaeological sites identified, including 10 rock shelters, 3 artefact scatters, 2 quarries and 3 gnamma holes. In addition, 17 isolated artefacts (including grinding implements) were found. The significance of these sites will be finalised through consultations with the Eastern Gurama people.

The Aboriginal archaeological survey of Pit E and Pit F (Archae-Aus 1999d) was preliminary advice only; the survey was aimed at identifying any sites that were present rather than documenting their respective significance. Site importance becomes significant in the event that disturbance to recorded sites cannot be avoided. Should disturbance be unavoidable, consultations will be undertaken with the Eastern Gurama people (and the Maliwartu Aboriginal Corporation) to disturb the affected site. The significance of these sites has not been determined with the Eastern Gurama people because disturbance to such sites has not yet been required. The consultation process for disturbance to any recorded site (that cannot otherwise be avoided) will be undertaken when the Indigenous Land Use Agreement is finalised.

Past archaeological surveys at Silvergrass have recorded four sites; three of these (P077064, HSA12, HSA13) are burial sites and one (P00849) contains engravings. Another four sites (BRA04, BRA05, BRA06 and BRA07) are recorded east of Silvergrass; all these are artefact scatters.

All archaeological site locations and details will be forwarded to the Aboriginal Affairs Department (AAD) for registration.

No Section 18 approvals (under the *Aboriginal Heritage Act 1972*) to disturb Aboriginal sites have been sought as sites have been avoided during the various drilling and hydrogeological investigations. The appropriate approval to salvage or disturb any Aboriginal heritage site will be sought from the Minister for Aboriginal Affairs through the Department of Aboriginal Affairs before any disturbance occurs.

Ethnographic sites
An ethnographic survey of the Nammuldi area was conducted in October 1998 (McDonald Hales and Associates 1999). No ethnographic sites were recorded.

No ethnographic survey has been undertaken at Silvergrass or the transport corridor; however, Eastern Gurama elders have contributed to the archaeological surveys in these areas. Burial sites at Silvergrass are likely to have ethnographic significance.

Palm Springs (30km west of Silvergrass on Caves Creek) is significant to the Eastern Gurama Aboriginal language group.

3.3.5 Aboriginal enviro-cultural issues

A study of the environmental-cultural areas (defined as areas that consist of natural resources utilised by Aboriginal people, such as specific plants, rocks and animals) was undertaken (Hamersley 1999b). This study involved consultations and a site visit with Eastern Gurama representatives.

The key outcomes from that study were:

- information provided by Eastern Gurama people regarding the use of resources is considered confidential for cultural reasons
- Eastern Gurama people consider all components of the land to be of equal importance
- some resources have more uses than others (materials are used for making artefacts and tools, and for hunting, eating, ceremonial and medicinal purposes)
- resources within some areas of the Project area are gathered for use – these are determined by the distribution of those resources within the boundary of the Eastern Gurama people

The issues will be addressed as an integral part of negotiating a Land Use Agreement with the Eastern Gurama native title claimants.

3.3.6 European heritage

No place or object within the Project area is included on the Register or the Interim List of the Register of the National Estate.

4. IMPACTS AND MANAGEMENT

4.1 ENVIRONMENTAL MANAGEMENT

4.1.1 Environmental Management Plan

An Environmental Management Plan (EMP) will be the main operational tool through which effective and consistent environmental management will be achieved.

The EMP will include environmental management of the following:

- groundwater
- surface drainage
- flora and fauna
- waste management
- hydrocarbons
- Greenhouse emissions
- dust and noise
- environmental weeds
- workforce
- landform
- rehabilitation and decommissioning

The EMP will include provisions for monitoring to assess whether defined environmental objectives are being met. Specific monitoring will include:

- groundwater quality
- regional groundwater levels
- water levels in Palm Springs
- surface water quality
- stream flows on Caves Creek
- riverine vegetation along Caves Creek
- rehabilitation
- fauna (including Ghost bats and stygofauna)
- environmental weeds
- Greenhouse emissions

<u>Commitment 1: Environmental Management Plan</u> (refer Table 5.1)
Hamersley will prepare and implement an Environmental Management Plan for the Project that will outline the:

- ***environmental performance objectives for relevant environmental factors***
- ***management of environmental impacts from construction and operation***
- ***monitoring of key environmental aspects***
- ***reporting and auditing procedures***

The EMP will be prepared in consultation with relevant Government agencies and will be subjected to a targeted public review.

4.1.2 Environmental Management System

To meet established corporate targets, Hamersley will develop and implement the international ISO14001 (or equivalent) environmental management system across all its operations by Year 2001. Some areas of Hamersley have already implemented ISO14001 systems.

To manage the environmental impacts of this Project and to help meet the requirement of all Project commitments and conditions, Hamersley will extend the environmental management system being developed for the existing operations to this Project. This will ensure the Project is operated under the same environmental management system as other Hamersley mines.

<u>Commitment 2: Environmental Management System</u> (refer Table 5.1)
Hamersley will develop and subsequently implement an Environmental Management System for the Project that incorporates the following elements:

- ***environmental policy and associated corporate commitment***
- ***mechanisms and processes to ensure***
  - ***planning to meet environmental requirements***
  - ***implementation and operation of actions to meet environmental requirements***
  - ***measurement and evaluation of environmental performance***
  - ***review and improvement of environmental outcomes***

4.1.3 Reporting

Hamersley will prepare and submit reports to Government on the environmental performance of the Project and its compliance with environmental requirements through the existing mechanism of Annual Environmental Reports. Such reporting will commence once Project construction is underway.

<u>Commitment 3: Annual Environmental Reporting</u> (refer Table 5.1)
Hamersley will include the Project in its consolidated annual and triennial environmental reporting to Government once construction commences.

4.1.4 Closure planning

Hamersley will prepare a closure plan for the decommissioning and rehabilitation of the Project that will address the major components of land disturbance. The closure plan will be developed within two years of Project commissioning and will address closure actions for key facilities. It will also clarify the final backfill levels in relation to water table level and consider the risk of capillary rise.

<u>Commitment 4: Closure plan</u> (refer Table 5.1)
Hamersley will prepare a detailed closure plan for the Project. The plan will address closure actions to be taken toward:

- ***mine voids***
- ***waste dumps***

- *tailings storage facilities*
- *transport linkage between Silvergrass and Nammuldi*
- *processing plants*
- *associated infrastructure*

and will provide the basis for the development of an eventual 'walk-away' closure strategy for the Project. As part of this closure plan, final backfill levels in pit voids will be assessed, taking account of mean water table levels and capillary rise relationships.

4.2 VEGETATION COMMUNITIES

4.2.1 EPA Objective

Maintain the abundance and diversity of species, and geographic distribution and productivity of vegetation communities

4.2.2 Potential impacts

The main impact during construction will be clearing areas of vegetation that exist where mining and infrastructure are planned.

Indirect impacts on vegetation can include the:

- effects of dust generated by the Project on plants
- effects of dewatering on deep rooted vegetation
- effects of dewatering discharge on creekline/drainage line communities
- risk of introducing and spreading weeds

4.2.3 Predicted impacts

Impact of clearing (includes tailing storage facility)

As no recorded vegetation association is restricted to the surveyed Project area, the geographic distribution of vegetation will be maintained.

The Project will require clearing of about 2,000ha of vegetation. The estimated areas to be cleared are summarised in Table 4.1.

Table 4.1 Vegetation associations to be cleared for Project facilities

Project component	Facilities included	Area to be cleared	Vegetation association to be affected (refer Table 3.3)
Mining	Mine pits, waste dumps, haul roads	1560ha	A2, A5, A6, A8, B1, B3, B8, C3
Transport	Rail/road, borrow pits, load-outs, rail loop	100ha	A1, A2, A3, A5, A6, A9, B1, B4
Ore processing	Plants, stockpiles,	10ha	A5, A6, B2, C1, C3, C4
Tailings option	Central thickened discharge option, associated pipelines	290ha	Not in surveyed area
Infrastructure	Workshops, offices, powerlines, borefields, Village	40ha	A5, A6 (Village not surveyed)

The area of each vegetation association affected by clearing is stated in Table 4.2.

Table 4.2 Estimated area of each vegetation association to be cleared+

Vegetation association	Area covered in survey (ha)	Area to be cleared (ha)	% of surveyed area cleared
A1 - Tall shrubland dominated by *Acacia maitlandii* over *Triodia wiseana*	2211	348	15.7
A2 - *Eucalyptus leucophloia* over *T. wiseana*	1353	62	4.6
A3 - *E. leucophloia* and mixed shrubs over *T. wiseana/Triodia pungens*	497	9	1.8
A4 - *E. leucophloia* over *Triodia brizoides*	57	0	0
A5 - Open tall shrubs dominated by *Acacia exilis* over *Triodia wiseana*	2754	834	30.3
A6 - *Senna/Acacia* shrubland over *T. pungens*	2570	239	9.3
A7 - Open *Acacia xiphophylla/A. aneura* shrubland	72	<1	0.7
A8 - *E. leucophloia/E. socialis* over *Triodia angusta*	165	<1	0.2
A9 - *E. leucophloia/Acacia* species over *T. angusta*	1508	11	0.7
A10 - *Acacia bivenosa* over *Triodia brizoides*	96	0	0
B1 - Tall woodland of *Eucalyptus camaldulensis/E. victrix* over *Acacia citrinoviridis*	157	15	9.5
B2 - Dense tall shrubland of *A. aneura* over *T. pungens*	80	2	2.5
B3 - *A. aneura/A. ayersiana* tall shrubland over *T. wiseana*	133	22	16.5
B4 - Open Eucalypts over mixed tall shrubland	375	61	16.3
B5 - *A. aneura/A. ayersiana* tall shrubland over *T. pungens*	48	15	31.2
B6 - Dense *Acacia maitlandii/A. atkinsiana/A. exilis* tall shrubland	Not mapped or measured as area is too small		
B7 - Dense mixed tall shrubland	27	12	44.4
B8 - Dense *Acacia ancistrocarpa/A. atkinsiana/A. exilis* tall shrubland	112	44	39.3
C1 - Moderately dense herbland	454	0	0
C2 - Low shrubland of *Senna artemisioides* subsp. *oligophylla* (*sericea* form)	99	3	3.0
C3 - Tall shrubland of *Acacia xiphophylla*	296	17	5.7
C4 - Low shrubland of *Eremophila maculata* over herbs	263	0	0
TOTAL	13, 327	1,694*	12.7

+ Excludes area of the central thickened discharge, the Village and power line alignment
* *Includes Nammuldi, Silvergrass and transport corridor (shown in Figures 15, 16, 17)*

Based on other surveys undertaken by Hamersley and its consultants (Halpern Glick Maunsell), the landforms and dominant flora species recorded in the surveyed area are widespread and well represented in both the Tom Price area and surrounding Pilbara, with the exception of areas of cracking clays at Silvergrass. These cracking clays form part of the Brockman Land System that comprises $87km^2$ (0.09%) of the $93,520km^2$ of range lands in the Ashburton River catchment area (Payne *et al.* 1988). The principal land systems of the surrounding areas (Boolgeeda, Newman and Rocklea) cover $2,589km^2$, $6,529km^2$ and $8,096km^2$ respectively (Payne *et al.*, 1988).

The vegetation associations occurring on cracking clay soils, which while widespread, are localised and frequently subject to intensive grazing pressure, will not be greatly impacted (maximum of 5.7% affected for vegetation association C3, refer Table 4.2).

Although they occur elsewhere in the Pilbara, the vegetation associations identified by Halpern Glick Maunsell (1999a) to have some local significance were:

- B1 - Tall woodland of *E. camaldulensis/E. victrix* over *A. citrinoviridis*
- A3 - *E. leucophloia* and mixed shrubs over *T. wiseana/T. pungens*
- A8 - *E. leucophloia/E. socialis* over *T. angusta*)

None of these vegetation associations considered to be locally significant will be greatly impacted. Vegetation association B1 will experience a 9.5% loss (or 15ha of 157ha recorded in the surveyed area) from the Project area, vegetation association A3 will experience a 1.8% loss (or 9ha of 497ha) and vegetation association A8 will experience a 0.2% loss (<1ha of 165ha). These vegetation associations occur outside the Project area within the Brockman Valley. On a regional basis, the percentage loss of these vegetation associations will be even less.

The vegetation associations with the highest proportion of their recorded areal distribution within the surveyed Project areas that will be affected by clearing are:

- B7 - Dense mixed tall shrubland: 12ha of 27ha (44.4%) to be impacted
- B8 - Dense *Acacia ancistrocarpa/A. atkinsiana/A. exilis* tall shrubland: 44ha of 112ha (39.3%)
- B5 - *A. aneura/A. ayersiana* tall shrubland over *T. pungens*: 15ha of 48ha (31.2%)
- A5 - Open tall shrubs dominated by *Acacia exilis* over *Triodia wiseana*: 834ha of 2,754ha (30.3%)

None of the vegetation associations recorded are restricted to the Project area. Those subjected to the larger impact (>25% of their area affected) include:

- <u>Vegetation associations A5 and B7</u>: these are widespread and well represented in the Brockman Valley (based on HGM and Hamersley surveys and observations). Mattiske & Associates (1989) describe its association Ta-Am (that would encompass the B6 and B7 associations) as being "well represented on minor gullies which dissect the foothills and lower slopes of the extensive ranges in the Pilbara region."

- <u>Vegetation associations B5 and B8:</u> these are not specifically listed in other existing reports. The vegetation association B5 combination of *Acacia aneura/A. ayersiana* over *Triodia pungens* could be included in other surveys under the broader vegetation type of 'Mulga Woodland', which occurs at numerous locations around the Tom Price area (based on observations by HGM and Hamersley). Minor drainage associations such as B8 are frequently only described as variations of the more broadly occurring steppe vegetation, due to the difficulties associated with mapping numerous, narrow drainage features. Hence they may appear more geographically restricted than is actually the case. The flora characterising associations B5 and B8 are widespread in the Pilbara, as are the supporting drainage landforms. Both vegetation types will occur elsewhere in the Brockman Valley.

The scope of a recent report on Mulga in the Central Pilbara (Fortech 1999) commissioned by the DRD did not extend into the Project area. The report documented the perceived environmental pressures on Mulga in the Central Pilbara and indicated that careful consideration should be given to locating infrastructure corridors to ensure that sufficient contiguous areas of Mulga can be set aside for conservation management.

The extent of Mulga (*Acacia aneura*) woodlands in the Project area is limited (vegetation association B5 covers 48ha [0.36% of survey area], with 15ha maybe affected) and confined to small sections of Nammuldi and Silvergrass, but not the transport corridor. The distribution and nature of Mulga within the Project area is not sufficient to warrant being set aside for conservation management.

The tailings storage facility (central thickened discharge), the Village and power line have not been surveyed, but total disturbance will be of the order 300-310ha. Future surveys will determine what vegetation associations occur in these areas. If any locally significant communities are identified, they will be avoided where practicable in the siting of infrastructure. The EMP will address any management requirements that arise from the surveys.

Impacts from groundwater draw down
The potential impacts of mine dewatering on groundwater levels are outlined in Section 4.7.3 and shown in Figure 19.

In summary:

- At Nammuldi: the 5m contour of the cone of depression will extend 500m from Pit A, 300m from Pit B, 1,000m from Pit C/D and 800m from Pit E/F

- At Silvergrass: the 5m contour of the cone of depression will extend 3,000m from the Range Pit and the Valley Pit.

Dewatering of the Valley Pit (after 2 years) at Silvergrass will have little or no effect on phreatophytic species such as *E. camaldulensis* and *E. victrix* that occur along and around Caves Creek. Based on research on Hamersley Station by the University of Western Australia, these species (found in vegetation association B1 - Tall Woodland of *E. camaldulensis/E. victrix* over *Acacia citrinoviridis*) can access groundwater to at least 20m (Landman P.A, M. Adams and L.T. Bennett, 2000 – in preparation).

Following prolonged dewatering at Silvergrass (over 6 years until the Range Pit is mined), it is estimated that over a distance of about 2km along Caves Creek, some (5-10%) *E. camaldulensis* and some (>5%) *E. victrix* trees will be severely drought stressed and some may die.

The actual impacts on vegetation on Caves Creek will be dependent on rainfall experienced during the dewatering period; if significant rains occur, then this will assist the maintenance of the vegetation through recharging the shallow creek alluvium. If no significant rainfall occurs within the Caves Creek catchment upstream of Silvergrass over the dewatering period, then riparian vegetation will be severely stressed, with the more susceptible species unlikely to survive until the next rains or when the water table returns to its pre-mine levels. Although recent years have experienced above average rainfall, the unpredictable nature of rainfall in the Pilbara does not guarantee similar or continued favourable rainfall patterns.

If the final mining schedule requires Silvergrass to be mined (and dewatered) at a significantly higher rate than that provided in Table 2.3, then there is potential for greater impact on riverine vegetation. This higher mining/dewatering rate is not likely.

With any loss of trees, particularly in or adjacent to creek lines, the risk of erosion increases. In the event that mine dewatering at Silvergrass results in trees deaths, there will be some associated increased erosion risk. Any increased erosion from the loss of trees will be small relative to that which occurs naturally along creek lines during flood events.

The effects of draw down around mine pits at Nammuldi and Silvergrass will not affect vegetation, other than the riverine vegetation. Based on research on Hamersley Station, the vegetation of Hills/Stony Plains and Clay Soils are non-phreatophytic, surviving on soil water only (Landman P.A, M. Adams, L.T, Bennett, 2000 – in preparation). It is unlikely that vegetation in minor creeks, flowing down off the ranges to the south of Nammuldi have access to groundwater, so groundwater draw down will not impact on that vegetation either.

Impacts from dewatering discharges
Pooled water and streamflow around the discharge point on Caves Creek and at Nammuldi will lead to changes in the composition, abundance and overall nature of the vegetation community. The existing vegetation will be replaced/enhanced by those species that tolerate more long-term moisture (eg *E. camaldulensis*). This has been evident along Marillana Creek where several mine dewatering discharge outfalls have led to a significant increase in *E. camaldulensis*.

The understorey will also be altered; more grasses, sedges and annuals will become established. In the longer term and once discharge ends, this artificial understorey will collapse due to reduced water availability. The original vegetation structure should gradually become re-established in the long term once discharge ends.

There is little or no increased potential for introduced waterweeds to spread to Palm Springs from the discharge point on Caves Creek. The periodic flow events in Caves Creek are already likely to spread waterweeds, were they present. Increased water flow and ponding (as a result of discharges) will promote wetland species, including weeds, but will not introduce any more species than that already found at Palm Springs or along Caves Creek.

The saturation of the alluvium in Caves Creek may weaken the resistance of large trees (*E. camaldulensis* and *E. vitrix*) to major floods. This may result in some trees being uprooted during flood events.

At Nammuldi, the composition, abundance and overall nature of the existing vegetation communities at and down slope from the discharge point will be similarly changed. With surface water expected to saturate the drainage lines for 3-4km downstream from the discharge point, a 'permanent' wetland will develop, favouring plants that thrive on such conditions. Until discharge ceases, these species will become dominant over those favouring the existing drier conditions. As the ephemeral conditions return, the invading species that favour wetland conditions will decline in favour of the more arid/ephemeral species. Ultimately, the structure of the vegetation will return towards the original pre-discharge vegetation communities.

Impacts from dust
Although the Pilbara is a naturally dusty environment, excessive and concentrated dust fallout can impact on roadside vegetation. The main sources of dust will be from earthmoving activities, vehicle traffic on access roads and haul roads and from blasting and ore handling during mining the dry Marra Mamba ore from above the water table.

If a haul road is adopted for transporting ore from Silvergrass to Nammuldi, then dust lift-off from loaded haulage trucks will pose a risk to adjacent vegetation. The extent of this risk to vegetation depends on the frequency of vehicle trips. Similarly, dust from the haul roads at Nammuldi may cause some impact on adjacent vegetation. Water trucks will be used to maintain the surface of these roads for environmental and safety reasons.

Active tailings storage areas will not be a source of dust as the surface of the tailings will be kept wet by the application of tailings slurries. When tailings discharge ceases and the tailings are left to consolidate, the risk of dust will increase but will not pose a significant risk to vegetation. Dust lift-off from Hamersley's existing tailings storage areas at Tom Price and Paraburdoo is not significant and adjacent vegetation does not appear to have been adversely affected. With these storage facilities, the clay component in tailings effectively cements the stored material together.

Impacts from threatening processes
Although no declared noxious weeds occur in the Project area, some introduced flora species do (Section 3.2.1). Earthmoving activities and vehicles will increase the risk of spreading these species (particularly Ruby Dock). Although some weed management strategies will be developed, it is likely that some weeds will become established in disturbed areas as a consequence of Project activities. The presence of cattle in the area will pose a greater risk of introducing and spreading weeds in the Project area.

4.2.4 Management

The management and monitoring of vegetation in the Project area will be addressed in the EMP.

The measures to be implemented to manage vegetation communities will include:

- site disturbance will be minimised, with vegetation retained between facilities
- areas will be cleared only when required
- progressive rehabilitation will be implemented
- siting of dewatering discharge points on rock or concrete structure to prevent erosion
- watering of haul roads and work areas to reduce dust
- periodic spraying or other means will be undertaken to control weeds
- if seeding is required for rehabilitation, local provenance seed will be used
- monitoring for weeds/introduced plants as part of rehabilitation monitoring
- monitoring to determine any changes in riverine vegetation on Caves Creek

4.2.5 Predicted outcome

The Project will result in the loss of about 2,000ha. The loss of the affected vegetation associations or their current status will not be significant on a local and regional level. Areas disturbed during construction and mining will be rehabilitated so that vegetation is re-established. No vegetation association with particularly high conservation value will be impacted.

There will be a local impact on the unconfined water table adjacent to the Range Pit at Silvergrass as a result of dewatering from the underlying valley fill and Marra Mamba aquifers. Without supplementation from periodic significant creek flow or rainfall, 5-10% of *E. camaldulensis* and >5% of *E. victrix* will be severely drought stressed over about 2km of Caves Creek, and some may die.

Draw down impacts on vegetation around the pits (other than riverine vegetation) will be negligible, as it is non-phreatophytic.

At the Silvergrass and Nammuldi discharge points, the understorey of the existing vegetation association will change toward increased grasses, sedges and annuals in the short term, but this will revert back toward the original vegetation structure in the long term once discharge ends.

Although some weed management strategies will be developed, it is likely that some weeds will become established in disturbed areas as a consequence of Project activities.

Commitment 5: Additional surveys – biological ***(refer Table 5.1)***
Hamersley will undertake additional biological (flora, vegetation and fauna) surveys of those areas not already surveyed where Project infrastructure is planned, such as the tailings storage facility (central thickened discharge area), the Village and the power line from the Dampier - Tom Price line

Commitment 6: Riverine vegetation monitoring ***(refer Table 5.1)***
Hamersley will develop and implement a riverine monitoring program to determine the extent of any impacts on vegetation that may occur as a result of dewatering the Silvergrass mine pits and from mine dewatering discharges into Caves Creek.

4.3 DECLARED RARE AND PRIORITY FLORA

4.3.1 EPA Objective

Protect Declared Rare and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act 1950.*

4.3.2 Potential impacts

Declared Rare Flora can be directly or indirectly impacted by construction and operation activities. Priority flora species can be similarly impacted.

4.3.3 Predicted impacts

The Project will have no impact on Declared Rare Flora because none were recorded in the surveyed areas, despite the large survey effort.

The predicted impacts on Priority flora species populations are outlined in Table 4.3.

Table 4.3. Predicted impacts on Priority flora species

Species	Predicted impact
Tephrosia sp. (Cathedral Gorge) Priority 3	Recorded at Nammuldi (2 populations), Silvergrass (1) and the transport corridor (2). The Nammuldi populations are located well away from any mining or infrastructure and will not be impacted. The Silvergrass population is near the existing track to Silvergrass but is over 1km from the Flats Pit – it is unlikely to be impacted. Neither of the two populations in the transport corridor are on the route of the railway, haul road or conveyor (although one is within 100m of the conveyor route). None of these will be directly impacted.
Goodenia stellata Priority 3	Recorded at two drainage sites at Nammuldi and two similar sites in the transport corridor. Both Nammuldi populations are near mine pit boundaries and are likely to be directly impacted by mining. One population in the transport corridor is within about 100m of the conveyor route and will not be impacted on the current conveyor alignment. The other population is near the corridor boundary and will not be impacted. Occurs at a range of other locations in the Pilbara.
Bulbine pendula ms. Priority 3	One population recorded on the heavy clays at Silvergrass about 500m from the rail loop. Based on the current location of infrastructure, it will not be impacted. Occurs at other locations in the Pilbara.

Species	Predicted impact
Gymnanthera cunninghamii Priority 3	One suspected population (5 individuals – refer Section 3.2.1) recorded from Caves Creek near Range Pit. Mining will not impact this population, as it is about 200m from the Range Pit. Occurs at other locations in the Pilbara, the Northern Territory and Queensland; however new bio-diversity conservation legislation considers geographic isolates of widespread species.
Triumfetta leptacantha Priority 3	All four populations were recorded at Nammuldi. Waste dumps west of Pit C will approach to within 150m of one population; with the current mine plan, it will not be impacted. The other three populations are further away from mining and will not be impacted. The species is recorded in other locations in the Pilbara, mainly in the KNP.

4.3.4 Management

Measures to be implemented to manage Priority flora species will include:

- planning of infrastructure to avoid them where it is feasible to do so. Due to specific requirements for railways, such as ruling grades, bend limitations and the need to avoid areas subject to inundation or unsuitable geotechnical conditions, there are some constraints to the flexibility in siting such facilities – these can affect the ability to re-align infrastructure to avoid Priority flora species or other

- additional flora studies in the Project area (such as for the central thickened discharge and Village areas) will target the known Priority species to extend the known information on their local geographic distribution

- encourage appropriate Priority species to establish in rehabilitation areas

- those management measures listed in Section 4.2.4 for vegetation communities

4.3.5 Predicted outcome

Based on the current position of infrastructure, the only Priority species to be directly impacted by the Project is *Goodenia stellata* (a Priority 3 species) – two populations at Nammuldi are in areas to be mined (two populations in the transport corridor will be unaffected). The other four Priority listed species in the Project area will not be directly impacted. The impact of the Project on the local and regional status of these species will be minor.

***Commitment 5: Additional survey – biological** (refer Table 5.1)*
Hamersley will undertake additional flora and vegetation surveys of areas to be disturbed but have not already been surveyed – refer commitment provided in Section 4.2.5

4.4 TERRESTRIAL FAUNA

4.4.1 EPA Objectives

Maintain the abundance, species diversity and geographic distribution of terrestrial fauna.

Protect Specially Protected (Threatened) Fauna, consistent with the provisions of the *Wildlife Conservation Act 1950*.

4.4.2 Potential impacts

Direct impacts on terrestrial fauna can be:

- loss of fauna habitat
- death of individuals of a population (through physical trauma or stress)
- fragmentation and isolation of populations
- erection of barriers to fauna movement or access to resources
- changes in the hydrological cycle arising from changes to water course directions or flow
- changes in groundwater levels that affects vegetation and fauna habitats

Indirect impacts on fauna can include the effects of noise, dust, pollution and the workforce.

4.4.3 Predicted impacts

General
Regionally, the Project area contains a fauna community with a pattern of abundance and distribution and an assemblage (inventory, diversity, evenness) that are typical of other Pilbara areas (Section 3.2.2). Therefore, the impacts of the Project on the fauna community will not have regional implications.

Impacts to riverine habitats (vegetation association B1), Mulga woodland (vegetation association B5) and deep alluvial soils at Nammuldi (vegetation association A6) could be significant locally as these habitats are relatively small in area and are not well represented locally. The impacts on these areas of local fauna significance are described in Section 4.2.3.

Impacts on Priority fauna
No Declared Rare Fauna were recorded in the Project area.

Clearing will reduce the area of habitat available to terrestrial fauna (Section 4.2.3). Impacts on those fauna species with conservation significance is summarised in Table 4.4.

Table 4.4 Predicted impacts on terrestrial species of conservation significance

Species	Status	Impact
Ghost Bat	Priority 3 (WA) Vulnerable (C'wealth)	Maternity roost identified 2.5km from Valley Pit boundary at Silvergrass. No direct impacts. Mining and infrastructure may impact indirectly (light spill or noise). Regional and local distribution/abundance of species will not be affected.
Lakeland Downs Mouse	Priority 4 (WA) Endangered (C'wealth)	Confined to cracking clays at Silvergrass. Infrastructure at Silvergrass sited on edge of cracking clay area. Likely to be some direct impact on its habitat. Mining and infrastructure may indirectly impact species (light spill or noise). Regional distribution/abundance unlikely to be impacted. Some impact on local population expected.
Pebble-mound Mouse	Priority 4 (WA) Vulnerable (C'wealth)	Found throughout Marra Mamba hills. Those mice in areas to be mined or where infrastructure is planned will be directly impacted. Monitoring elsewhere (eg Marandoo) suggests that proximity to mine sites does not significantly affect its activities. Regional distribution/abundance will not be impacted. Local abundance will be reduced.
Long-tailed Dunnart	Priority 4 (WA)	Found on Caves Creek 3.5km from Range Pit and 1km from Pit A. No direct impacts. Regional distribution/abundance will not to be impacted.
Pilbara Olive Python	Schedule 1 (WA)	Not recorded, but expected to occur. Has a wide distribution throughout the Pilbara. No direct impacts. Regional and local distribution/abundance of species will not be affected.

Species	Status	Impact
		The greatest risk to this species will be from roadkills or mistaken identity by individuals leading to attempts to kill them.
Notoscincus butleri	Priority 4 (WA)	One individual recorded 1km from Pit A. No direct impact from the Project. Well represented locally. Regional and local distribution/abundance unlikely to be impacted.
Ctenotus aff. helenae	Not listed (WA or C'wealth)	This species recorded on all types of substrate including rocky scree slopes. Some of the habitats in which it has been recorded in the Project area are where mine pits/waste dumps are sited for Flats Pit at Silvergrass and for Pit E and Pit F at Nammuldi. These areas of its habitat will be impacted.
Ctenotus aff. robustus	Not listed	No site where this species was recorded is on any mine pit. The schematic discharge pipeline arrangement for Silvergrass passes through an area where this species has been recorded adjacent to the track leading to Homestead; part of its habitat will therefore be impacted. Regional and local distribution/abundance of the species is unlikely to be impacted.
Ctenotus aff. rutilans	Not listed	No site where this species was recorded is on the mine pits or where infrastructure to be sited.
Peregrine Falcon	Schedule 4	This is a very mobile species with no habitat specificity. Mining or infrastructure will have no impact on the regional or local abundance or distribution of this species.

Impacts from dewatering discharges

Pools created from discharges into Caves Creek and ill-defined drainage lines at Nammuldi will create wetland ecosystems during dewatering operations. This will provide an additional and alternative habitat for some terrestrial fauna. This will have some positive (eg water supply, increased resources) and some adverse impacts (loss of section of ephemeral habitat, facilitation of water-dependent species). Upon cessation of dewatering, the artificial wetland ecosystem will collapse and gradually return to the ephemeral habitat.

Impacts from tailings

Tailings generated for central thickened discharge, will have less water content that that for the in-pit disposal and will be less attractive to wildlife; however both will have available surface water. Occasionally, some animals (kangaroos, emus) seeking access to water may become trapped in the tailings impoundment facilities. The enhanced availability of local water is likely to increase the numbers of those animals that can access the water (eg birds).

As tailings will be comprised of inert and non-toxic material, with only minor residual material from thickeners (flocculants and coagulants), consumption of decant waters or other surface water associated with the tailings residues by wildlife will pose little environmental risk.

General impacts

Linear infrastructure (eg railway/haul road, pipelines, access roads, and drainage controls), mine pits and waste dumps will form barriers to some fauna and result in fragmentation or isolation of fauna populations and make access to resources more difficult. Increased traffic movements and the larger workforce will increase the risk of road kills, especially for kangaroos, monitor lizards and some birds.

4.4.4 Management

The measures to be implemented to manage terrestrial fauna will include:

- clearing of habitats will be minimised to that which is feasible
- clearing for new pits and associated areas will be undertaken progressively

- rehabilitation will aim to help fauna colonisation through microhabitats and plant cover
- workforce inductions will include fauna protection issues
- conducting fauna surveys in areas to be developed that have not been surveyed already
- management and monitoring of Ghost Bats to assess Project impacts as part of the EMP

Hamersley will develop relevant management plans for any fauna species present in the Project area that may be listed in future revisions of the Western Australian Rare and Endangered List or the Commonwealth Critically Endangered List.

4.4.5 Predicted outcome

The regional impact on fauna from the Project is expected to be negligible, while there will be some impact on areas of local fauna significance (as not well represented).

<u>Commitment 5: Additional surveys – biological</u> (refer Table 5.1)
Hamersley will undertake additional fauna surveys of areas to be disturbed but have not already been surveyed – refer commitment provided in Section 4.2.5

<u>Commitment 7: Rare fauna</u> (refer Table 5.1)
Hamersley will prepare and implement a management plan for the Ghost Bat as part of the EMP, plus any fauna species that are present in the Project area which may be listed in future revisions of the Western Australian Rare and Endangered List or the Commonwealth Critically Endangered List.

4.5 SUBTERRANEAN FAUNA

4.5.1 EPA Objectives

Ensure that subterranean fauna are adequately protected in accordance with the *Wildlife Conservation Act 1950*.

Maintain the abundance, diversity and geographical distribution of subterranean fauna.

Improve our understanding of subterranean fauna (stygofauna) through appropriate research including sampling, identification and documentation.

4.5.2 Potential impacts

Aquifers and creek alluvials can contain stygofauna. Some stygofauna species are listed in Schedule 1 under the *Wildlife and Conservation Act 1950*; to this time, none are from the Pilbara mainland. Groundwater abstraction and dewatering for mining lowers the water table and can impact on stygofauna present within the aquifer.

4.5.3 Predicted impacts

Dewatering

Hamersley has recorded small numbers of stygofauna in the Marra Mamba aquifer at Homestead and Brockman and they are also anticipated to occur in the alluvial material in Caves Creek. The dewatering program will lower the water table for a distance of 3km around the Silvergrass pits and for a distance between 1km and 300m around the Nammuldi pits (Section 4.7.3). A section of Caves Creek will experience pooling of water as a result of dewatering discharges.

Stygofauna within the Marra Mamba aquifer inside the cones of depression around each mine pit will be impacted. Due to the lack of understanding of the ecology of stygofauna, the extent to which they can migrate downward with a gradually declining water table is uncertain (no information is available to demonstrate unequivocally whether this is possible or not). If the capacity to migrate and survive with changes in water table is limited, then stygofauna in that portion of the groundwater that is being lowered will be directly impacted and some individuals may not survive. For the purpose of this CER, it is assumed that stygofauna in those areas that experience a water table draw down will be impacted.

Post-mining

There is also limited information on the capacity of stygofauna to recover with the eventual return of groundwater to the pre-mining water table levels. Constraints to re-colonisation may be the presence of physical barriers (eg the presence of any fine clays) that could prevent stygofauna movement from non-impacted areas into the dewatered and impacted areas.

As stated in Section 3.2.2, stygofauna can occur in the alluvium of ephemeral and permanent creeks. For this reason, the pooling of water in Caves Creek will have some impact on stygofauna that already occur in the creek alluvium. Little is known on the behavioural aspects of stygofauna in permanent and ephemeral water bodies.

4.5.4 Management

The measures to be implemented to manage stygofauna will include:

- the stygofauna research program initiated by Hamersley in 1998 will continue to sample for and document the distribution and population dynamics of stygofauna populations that occur around the Project area, existing mining operations and new development sites – the next sampling scheduled for the Project area is mid 2000

- the results from the above actions will be pooled with other studies of the distribution and ecology of Pilbara stygofauna underway by BHP Iron Ore and the Western Australian Government (including the WA Museum) to determine the conservation status of the species found

4.5.5 Predicted outcome

During mining and dewatering operations, stygofauna populations within the mine and dewatered areas will be adversely impacted. The local impact in those areas to be dewatered is assumed to be high (assumes no re-colonisation and migration). The regional impact is unknown due to the relative paucity of information on regional stygofauna distribution.

Until the species of the stygofauna recorded during sampling are identified by specialists, it is not known whether any stygofauna recorded in the Project area are on the current Schedule 1 of the *Wildlife and Conservation Act 1950*.

***Commitment 8: Stygofauna* (refer Table 5.1)**
Hamersley will prepare and implement a co-ordinated program of stygofauna sampling within and around the Project area to improve the current understanding of stygofauna that occur in the Pilbara

4. 6 WATERCOURSES

4.6.1 EPA Objective

Maintain the integrity, functions and environmental values of watercourses.

4.6.2 Potential impacts

Dewatering, mining and infrastructure can result in changes to the hydrological characteristics of watercourses. Release of dewatering discharge waters into watercourses can change the hydrological regime and subsequently the nature of the riverine ecosystem.

4.6.3 Predicted impacts

Impacts from mine dewatering
Dewatering of the Silvergrass pits will draw down the water table around the pits. The dewatering strategy will target the main aquifer (Marra Mamba mineralisation), but the creek alluvium in Caves Creek may also experience some associated draw down. The creek alluvium will continue to be recharged from streamflow from the catchment above Silvergrass.

The discharge into Caves Creek will result in pooling of water downstream of the discharge point. This will change a section of Caves Creek from a typical ephemeral creek habitat to a temporary (about 6 years) wetland environment. The distance pooling or streamflow extends downstream will vary according to discharge rate, the nature of the creek alluvium, rainfall in the catchment and the time of the year.

The hydrological effect of dewatering discharge pooling in Caves Creek will not extend to Palm Springs, as it is located too far (30km) downstream from Silvergrass. Based on the outcome of test pumping during the hydrogeological investigation, it is expected that surface water will extend about 3km from the point of discharge on Caves Creek before it infiltrates into the creek alluvium.

At Nammuldi, discharges of excess water to surface drainage will result in inundation of the affected drainage lines. The area of surface water will vary with the amount of process water usage and the particular drainage line used. Surface water may extend 3-4km before the water infiltrates into the soil or evaporates.

Erosion at and beneath the discharge point is a risk because the surface drainage lines at Nammuldi do not normally carry large volumes of flow. This erosion potential will be greatest around the discharge point where the flow rate will be highest.

Impacts from alterations to drainage

The proximity of the Range Pit and associated flood control structures to Caves Creek may result in rocks rolling into the braided creek bed. If not removed, these rocks could be transported downstream by floodwaters to form barriers to normal creek flow and causing flooding in areas not normally subject to inundation.

In addition, the Range Pit flood control levee may form a marginal constriction by narrowing the width between the pit and the ridge to the north through which floodwaters must pass. This will prolong the time it takes for flood waters to pass the Range Pit; the duration of this delay is anticipated to be measured in hours, rather than days.

The levee near Caves Creek will have minimal impact on riverine vegetation because local flooding should only last several days. Research has shown that *E. victrix* begins to lose leaves and progressively die after about 2-3 months of flooding (Landman P.A, M. Adams, M. Kemp, 2000 - in preparation).

The transport corridor will traverse defined drainage lines rather than areas subject to sheet-flow. The risk of drainage shadow down-gradient of the transport infrastructure will therefore be small.

Some of the minor drainage lines by mine pits or infrastructure at Nammuldi will be intersected by cut-off and diversion drainage structures. This will have localised drainage impacts in some areas.

4.6.4 Management

The measures to be implemented to manage watercourses will include:

- large rocks that enter Caves Creek as a result of construction or mining activities will be retrieved before they are transported downstream by floodwaters

- culverts and associated downslope water spreading systems will be used for any rail or road infrastructure between Silvergrass and Nammuldi to maintain drainage patterns where it is appropriate

- the dewatering discharge point on Caves Creek and at Nammuldi will have a hard substrate to break the velocity of water being discharged and prevent erosion – if no hard surfaces are present, an engineered structure will be constructed to serve the same purpose

- water levels at Palm Springs will be monitored as part of the regional groundwater monitoring program (Section 4.7.4)

4.6.5 Predicted outcome

The Project will have some short term changes (eg pooling of water in creeks resulting from dewatering discharge) to the main watercourse of Caves Creek. The flood control levees around Range Pit and Valley Pit will result in a marginally longer time for major flood waters to pass Silvergrass.

<u>Commitment 6: Riverine vegetation monitoring</u> (refer Table 5.1)
Hamersley will develop and implement a riverine monitoring program – refer commitment provided in Section 4.2.5

<u>Commitment 9: Caves Creek stream flow</u> (refer Table 5.1)
Hamersley will monitor stream flows in Caves Creek to quantify the actual flow regime and will make the data available to the Water and Rivers Commission

4.7 GROUNDWATER

4.7.1 EPA Objective

Maintain the quantity of groundwater so that existing and potential uses, including ecosystem maintenance, are protected

4.7.2 Potential impacts

The abstraction of groundwater can lead to short and long term changes in groundwater levels and groundwater flow during mining and post-mining.

4.7.3 Predicted impacts

Impacts from mine dewatering
Mine pit dewatering will lower the regional groundwater level; the cones of depressions will vary between each pit. Water table fluctuations in excess of 7m in response to heavy catchment rainfall were recorded around Pit A during the hydrogeological fieldwork. A groundwater decline of 5m or more in the valley fill aquifer (as a consequence of dewatering) is used as the definition of draw down as this is less than that measured by local natural water level fluctuations.

The predicted draw down from model simulations (PPK Environment & Infrastructure 1999) is summarised in Table 4.5 and shown in Figure 19.

The methodology for the modelling incorporates conservative aspects which tend to over-predict draw down. Pit draw down is based on the predicted water level at the maximum time the model simulated. The numerical model was noted to become unstable once the draw down reached the primary mineralised Marra Mamba aquifer at depth and pumping cells became effectively dry. This generally occurs towards the final stages of pit development and highlights a potential requirement for the utilisation of in-pit sumps during the later stages of mining.

Table 4.5 Predicted draw down around modelled pits

Pit	Extent of cone of depression (m)	Maximum draw down at pit margin (m)	Duration of dewatering (months)
A	500	40	19
B	300	15	12
C/D	1,000	55	39
E/F	800	55	15
Valley	3,000	50	24
Range	3,000	50	72

Note: Nammuldi detritals will not require dewatering. Only a small portion of the Flats Pit extends below water table and is not covered

Generally the predicted draw down within the valley fill sediments around the modelled pit are believed to be overestimates of the actual impact. The water level impact in the shallow unconfined system associated with the Caves Creek drainage is likely to be less than predicted and will also be made more responsive to natural fluctuations as a result of rainfall/creek flow.

The cone of depression from pit dewatering at Nammuldi pits will be between 300m (Pit B) and 1000m (Pit C/D) and will extend between 500m to 800m across strike (southwards into the valley). These distances are from the centre of the deepest area of draw down within each pit. At Silvergrass, the cone of depression will be 3km around the Valley Pit and Range Pit.

Impacts on other groundwater users

Localised groundwater flow toward pit or pits being dewatered will occur as a result of hydraulic gradients; this should have little short or long term impacts as the main aquifer being targeted for dewatering is the Marra Mamba within the mine.

The interaction of the dewatering cones of depression with the nearest actively used bores is summarised in Table 4.6.

Table 4.6 Other groundwater users

Bore	User	Nearest pit	Distance/direction from pit (m)	Extent of impact (m)
Brockman borefield	Brockman No. 2 Mine	C/D	Within Pit C/D	Mined as part of pit
Camp borefield	Nammuldi Camp	E	900 (north-west)	Some
One-Mile Well	Hamersley Station	Valley	2,000 (west)	5
Crossing Bore	Hamersley Station	Range	2,400 (east)	<5

The Brockman and Nammuldi Camp borefields will need to be replaced or supplemented as the Brockman borefield is located within Pit C/D, while the Camp borefield will be impacted by draw down from Pit E dewatering. One-Mile Well has the potential for current beneficial use, as a stock bore by Hamersley Station (the lease is held by Hamersley). An alternative water source will be developed (such as an outlet from the dewatering discharge) should falling water levels impose limitations to the continued use of the bore.

The Crossing Bore will not be impacted. The House Well (an unused bore 1km of Valley Pit) which formerly served the old Mt Brockman Station homestead (incorporated in the Hamersley Station lease held by Hamersley) will experience substantial drop in water level. As this well is no longer used, no replacement or supplementation of water supply is proposed.

Impact from tailings
The impact of tailings on groundwater is influenced by the disposal method, tailings characteristics and the level of the watertable, or whether there are conduits of suitably permeable rock between the tailings and the water table.

Tailings generated by iron ore processing do not contain hazardous chemicals, thereby reducing potential impacts if tailings did contact the water table. The ecological and environmental implications of the flocculants and coagulants used in wet processing are provided in Section 4.12.3 (Table 4.10).

Hydrogeological investigations have not been undertaken in the area of the central thickened discharge. Based on Hamersley's experience at Brockman, there are few direct connections to aquifers in the area. The watertable is about 40-45m below ground surface in the vicinity of the central thickened discharge area. There is no Marra Mamba mineralisation connection to aquifers. The central thickened tailings will have a high insitu density with solids content and will therefore be less mobile (refer Table 1.3).

The in-pit tailings will be closer to the water table, which is about 10-15m below the base of the Brockman pits. These tailings will have lower density and solids content than at the central thickened discharge facility. Initial deposition of tailings in the pits will form a physical barrier between the underlying watertable and the base of the tailings, limiting any seepage from the tailings to the aquifer.

Post-mining impacts
All mine pits will be filled to at least one metre above the level of the pre-mining mean water table. Ongoing monitoring will further establish the extent of local natural water table fluctuation and better determine what is the mean pre-mine water table.

The return of waste material in voids will mean no exposed permanent pit lakes and no groundwater sinks being formed. Given the imbalance of evaporation/rainfall ratio in the Pilbara, the long-term salinisation of pit lake water and down gradient aquifers could otherwise occur.

The final backfill level in the pits will be re-visited during closure planning once details on the extent of local natural water table fluctuations have been obtained. The closure plan will be submitted to the DEP for approval within two years of commissioning of the Project.

An evaluation will be undertaken to determine the potential level of unsaturated capillary rise from the unconfined water table in backfill areas. This evaluation will be undertaken during the early stages of mining for implementation during the later and post-mining stages of mining. A key factor will be determination of the mean pre-mining water table level to use as a benchmark. The characterisation of the waste material to be backfilled in relation to its ability to facilitate or limit capillary rise will be an important aspect as well. The purpose of ensuring backfilling is above the unsaturated layer is to reduce the potential for the development of any surface salinity.

With the cessation of dewatering and the return of waste material, the water table will gradually rise (via progressive recharge) toward its original level. The water table in the Nammuldi area is expected to rise rapidly (within two years, with the addition of rainfall) to recover to a level between 570mRL and 580m RL. At Silvergrass, the cessation of mining and dewatering is expected to result in a rapid rise (within 18 months, with the addition of rainfall) in the water table to levels between 540mRL and 545mRL.

This recovery process will be enhanced by rainfall/streamflow recharge events that occur following cyclonic recharge within the catchment.

Formation of phreatophytic vegetation/trees in pit floors will keep groundwater depressed and reduce the potential of capillary rise to the surface. The pit floors will be treated such that the establishment and continued growth and survival of vegetation occurs; this may involve spreading of available topsoil and ripping to establish a roughened and non-compacted surface profile.

4.7.4 Management

The measures to be implemented to manage groundwater will include:

- scheduling of mining to match dewatering with the demand for process make-up water so that additional groundwater draw from the borefield is minimised
- further investigating the potential for aquifer recharge (re-injection or infiltration) for implementation to replace discharging to surface drainage at Nammuldi
- filling mine pit voids to above the pre-mine mean water table levels

To increase the level of confidence in the predicted modelling and dewatering strategy, further calibration of the model against longer-term data will be undertaken. Improved confidence in the model output will be obtained by:

- monitoring regional water levels to calibrate the groundwater modelling and to verify draw down predictions in the PPK Environment & Infrastructure (1999)
- developing a separate model with greater resolution for Pit C (due to its relatively complex geometry)
- calibration against the long term pumping from the Brockman borefield (that draws from the overthrust aquifer)
- carrying out a longer-term (30 day) pumping test to better define storage parameters and re-calibrating the model against this data; alternatively, re-calibrating against the initial dewatering period to support or replace the extended pumping test

Hamersley will prepare and implement a groundwater monitoring and modelling plan that will incorporate the continuation of collecting data on the character and behaviour of the local aquifers to better understand the groundwater system and to calibrate the current numerical model. Monitoring of the regional water levels will enable verification of the predicted impacts on regional water levels from dewatering allowing remedial management options to be investigated and implemented.

4.7.5 Predicted outcome

Based on initial numerical modelling, dewatering will lower the water table a depth of 5m to a distance of 300-1,000m from the location of the in-pit borefields at Nammuldi and for a distance of 3km at Silvergrass. Existing bores affected by dewatering are used by Brockman and will be supplemented or replaced; others are station bores that will be supplemented with mine dewatering, while one is no longer used for station purposes. Tailings from wet processing are not hazardous, even if seepage reaches underlying aquifers.

The water table is predicted to re-establish to its near original levels within two years after mining.

<u>Commitment 10: Groundwater monitoring and modelling</u> (refer Table 5.1)
Hamersley will prepare and implement a groundwater monitoring plan (including monitoring water levels in Palm Springs) and incorporate the outcomes to improve the groundwater modelling predictions

<u>Commitment 11: Recharge options</u> (refer Table 5.1)
Hamersley will investigate the feasibility of groundwater recharge options at Nammuldi for handling water generated from mine dewatering that will otherwise be discharged via surface drainage

4.8 LANDFORM

4.8.1 EPA Objective

Ensure that, as far as is practicable, the post-mining landform is stable and is integrated into the surrounding environment.

4.8.2 Potential impacts

Temporary and permanent changes to the landform can result from mining operations. The stability and visual characteristics of the permanent new landforms can pose long term liabilities.

4.8.3 Predicted impacts

Short-term changes to the landform will include:

- access, haul and internal roads
- ore stockpiles
- processing plant, offices, workshops, Village, dewatering infrastructure, powerlines

Some components of the Project (eg transport corridor infrastructure) may be utilised by future Hamersley projects in this area, such as perhaps Homestead (Stage III). This will extend the period that these structures remain.

Project components that will remain at the end of mining (permanent landforms) are listed in Table 4.7.

Table 4.7 Permanent landform changes

Permanent landform	Area (approx)	Comment
Mine pits (filled to above water table)	510ha (Nammuldi) 175ha (Silvergrass)	Includes pit floor area. Final landforms will be pit voids to variable depths between 575mRL and 581mRL at Nammuldi and between 548mRL and 550mRL at Silvergrass, all of which will be above the water table. Benches will be visible on the mine pit sides. Mine voids will have protective safety bunds around the perimeter. Brockman Pit 1 and Pit 3 and Nammuldi Pit B may be infilled with tailings to ground level - some restrictions may be put in place for several years after each is no longer active until they can be consolidated and rehabilitated.
Waste dumps not returned to mine voids	600ha (Nammuldi) 0ha (Silvergrass)	Excludes those areas used as waste dumps from which backfilling sourced. Final waste dump landforms will be about 40m high, battered down to a 20° slope and be rehabilitated (ripped with topsoil or seeding).
Out-of-pit tailings storage area	290ha (Nammuldi)	With a central thickened discharge, the final landform will be a gently sloping feature that is about 8m high and is rehabilitated (probably capped and ripped) soon after decommissioning. In its current position, the central thickened discharge facility will be below the Nammuldi ridgeline.
Railway/haul road/conveyor cuttings and fill	15-20ha	No engineering design has been undertaken at this stage of the feasibility study. The final landform of the transport corridor infrastructure will be determined during closure planning.

The larger of these facilities (waste dumps, mine pits and the central thickened discharge facility) will be visible from the air and from several kilometres away. No frequently trafficked public road passes through or near the Project area.

4.8.4 Management

The measures to be implemented to manage landforms will include:

- rehabilitation of the temporary and permanent landforms to achieve stable and vegetated surfaces as they become available and no longer required for other purposes

- a closure (decommissioning and rehabilitation) plan will be developed within two years of commissioning to provide details of the approach for all final landforms

Hamersley and industry experience in the Pilbara now provide successful rehabilitation solutions for disturbed temporary and permanent landforms; for example, the Brockman No. 2 Mine is readily meeting its Government-endorsed completion criteria.

The decommissioning of the levees at Silvergrass (refer Section 2.3.4) will be addressed as part of mine closure planning, but it is likely that these structures will be removed and placed in the nearest pit void.

4.8.5 Predicted outcome

The permanent landforms that will remain after mining ends will include mine voids, waste dumps, tailings storage (central thickened discharge and in-pit) and transport corridor cuts and fills. Temporary landforms will be rehabilitated and infrastructure will be removed. The in-pit tailings will not be trafficable for perhaps several years after tailings discharge ends, whereas the central thickened discharge tailings will be trafficable very soon after discharge ends.

***Commitment 4 Closure plan** (refer Table 5.1)*
Hamersley will prepare a detailed closure plan within two years of Project commissioning that addresses actions for the rehabilitation and decommissioning of those facilities listed in Section 4.1.4 (and Table 5.1) and will provide the basis for the development of an eventual 'walk-away' closure strategy for the Project.

4.9 PARTICULATES/DUST

4.9.1 EPA Objectives

Ensure that particulate/dust emissions, both individually and cumulatively, meet appropriate criteria and do not cause an environmental or human health problem.

Use all reasonable and practicable measures to minimise the discharge of particulates/dust.

4.9.2 Potential impacts

General construction activities (bulk earthworks, blasting), mining (drilling, blasting, overburden/waste removal), ore handling (loading, unloading, conveyor transfers), ore transport (waste, ore, product) and ore processing can generate dust. Dust can affect vegetation health through reducing the photosynthetic capabilities of plants and their potential for growth or survival. Dust can also pose health risks.

4.9.3 Predicted impacts

General
The Pilbara region experiences dry and often windy conditions and has a naturally high dust environment. This is recognised in the discussion paper on a State-wide Air Quality Environmental Protection Policy (EPA 1999) that notes airborne dust in the Pilbara (and Goldfields) can be a problem as background levels can be close to or higher than the National Environmental Protection Measure (NEPM) standard.

The NEPM standard for dust (particles as PM_{10}) is provided in Table 4.8. It should be noted that this standard has not been applied to any of the Project area or Dampier by the EPA through an Environmental Protection Policy.

Table 4.8 Ambient air quality NEPM standard for particles

Pollutant	Averaging time	Maximum concentration	Allowed exceedences (10 year goal)
Particles as PM_{10}	1 day	50 $\mu g/m^3$	5 days a year

Much of the natural windblown dust consists of particles larger than those covered by the NEPM standard; this sized dust fraction poses a nuisance or may smother vegetation rather than a health risk. Some windblown dust (in the PM_{10} size range) may be derived from material handling activities and tailings storage facilities.

Mining and processing impacts
Construction works, pre-mine development, the mining and crushing of above water table ore (before below water table ore is accessed) and the use of gravel roads and haul roads will be the greatest potential sources of dust.

Most (80%) of the Marra Mamba ore will be mined from below water table and is expected to have a moisture of 12-13%. Ore from below water table is unlikely to be a source of dust during mining.

Wet processing of ore at Paraburdoo does not generate dust. Based on experiences with Marra Mamba ore at Hamersley's Marandoo mine, the greatest risk of dust is when it is in product form (post processing) and has moisture level less than 6%. With wet processing, the ex-plant Nammuldi product may have a moisture content higher than 6%. With dry processing, there will be a greater risk of dust generation from the Marra Mamba ore than for other Hamersley ore types. As with most ores, if left in stockpiles for extended periods, the outer portion can crust and limit wind-blown dust.

Impacts from tailings
Depending on the processing option adopted, tailings are likely to have a low risk of causing dust. Due to its slurry form, tailings will not dust in operational areas but edge areas that dry out may be a source of dust during periods of high winds. However, experience with existing Hamersley tailings facilities indicates that little dust is generated. Marra Mamba waste dumps may be a source of some dust emissions until they are rehabilitated.

The potential risk of dust from the central thickened discharge will be greater than that associated with the in-pit disposal. This results from the larger, more exposed open surface of the central thickened discharge storage compared with the tailings in the pits, plus the short term protection from winds afforded by the surrounding pit walls with in-pit disposal of tailings.

Asbestiform fibres
Recent drilling programs have encountered asbestiform material that occurs naturally throughout the Pilbara. This material poses an occupational health hazard if inhaled.

Asbestiform fibres have been encountered by drilling in waste material at the base of the Marra Mamba ore body; this material is below that which is targeted for mining. Fibrous material has been encountered in the mineralised Marra Mamba ore, but none contain asbestiform fibres (the principal hazard). Therefore, there is little risk that mining of the ore or handling of the overburden and waste rock will be a serious occupational health hazard.

Product handling at Dampier
The unloading, stockpiling, reclaiming and ship loading operations of the Marra Mamba product from this Project will be incorporated into Hamersley's Dampier operations.

Based on a recent assessment of the relative dustiness of Hamersley products at Dampier, the Marandoo Fines and Marandoo Lump (both Marra Mamba ore), together with wet Paraburdoo Fines, were found to have little potential for dust generation relative to other ore types (Sinclair Knight Merz 1999a). This was determined following sampling of the various ores at the 1-5E transfer station to quantify dust potential of the ores at the present railed moisture contents. On this basis, and with expected higher moisture content than for Marandoo ore, the incremental impact of this product on the Dampier airshed is anticipated to be minimal.

A review of Hamersley's existing dust monitoring program in Dampier between 1993 and late 1999 (Sinclair Knight Merz 1999b) concluded that:

- annual dust levels are typically in the range 40μg/m^3 to 55μg/m^3 at the two monitoring sites in Dampier, with Karratha experiencing similar levels
- exceedance of the 150μg/m^3 level (the Kwinana limit) are typically low with two exceedances estimated to occur each year
- since 1995 (when iron analysis commenced) the annual average contribution from Hamersley sources and the number of days with "high" contributions have shown a distinct downward trend
- dust levels vary between summer (higher dust levels) and winter (lower dust levels) and between wet and dry summers (eg 1997-98 was a very dry summer with more exceedances than with other years)

Analysis of the initial 18 months of the PM_{10} data collected by the DEP at Hamersley's Training Centre indicate only one exceedance of the 50μg/m^3 standard (Sinclair Knight Merz 1999b). This exceedance was attributed to a distant wildfire.

The handling of the Marra Mamba product at Dampier from the Project will fit into the above context.

4.9.4 Management

The measures to be implemented to manage dust will include:

- unsealed work areas and access roads will be regularly sprayed with water using a water truck to control dust, while haul roads will be similarly sprayed during mining and pre-mine development
- water sprays will be fitted to the dump hoppers and crushing and screening plants (especially for above water table ore and for the crushing and screening processes)
- regular housekeeping will be undertaken to collect and remove material that may represent a potential dust source from around conveyors and loading/unloading areas

- product stockpiles of Marra Mamba ore will be monitored to determine whether there is dusting and additional water will be applied if they become a source of dust

- personnel will be removed from mine pits in advance of blasting (high dust risk) for safety purposes

- Hamersley's standard asbestiform fibre management procedures that meet the requirements of the DME will be implemented if asbestiform mineralisation is encountered during construction or mining

- other measures - minimising site disturbance, clearing only when required, progressive rehabilitation, establishment of green areas, reducing vehicle speeds/access in some areas

At Dampier, dust control measures that are already in place will be used for handling the Project product when it arrives by rail. Existing water sprays fitted to ore handling equipment and conveyor transfers will be available for use during the train unloading and conveying operations. Water will be added to the product stream on stacking and out-loading operations, if required.

Ore samples will be taken from the face of stockpiles formed with each incoming train. Sampling will assess moisture levels and allow for the determination of the requirements for additional water to be applied; the decision on whether more water is applied will weight up customer requirements and environmental conditions. Upon ship loading operations, water can be added after the ore passes the screening plant and before it enters the primary sampling point.

Hamersley will be conducting further detailed test and analytical work to determine the handling characteristics of the Marra Mamba ore. This work will include a series of dust tests to determine the dust extinction moisture and associated characteristics.

Any dust emissions arising from the Project products handling and stockpiling operations at Dampier will be monitored as part of Hamersley's existing dust monitoring network. Air emission standards that may apply to Dampier will cover the ore handling of the Marra Mamba product derived from the Project.

4.9.5 Predicted outcome

Construction and operation will generate some environmental dust, but with dust control measures, the impacts on the local dust levels will be minor. Mining of the above water table ore and dry processing of ore (with dry product) will represent the highest risk of dust. Existing dust control measures at Dampier will be applied, although other Marra Mamba ore from Marandoo and Paraburdoo wet fines are not significant sources of dust.

4.10 GREENHOUSE GASES

4.10.1 EPA Objectives

Minimise greenhouse gas emissions for the project and reduce emissions per unit of product to as low as reasonably practicable.

Mitigate greenhouse gas emissions in accordance with the Framework Convention on Climate Change 1992, and in accordance with established Commonwealth and State policies.

4.10.2 Potential impacts

Greenhouse gases in the Earth's atmosphere play a role in maintaining global temperature by absorbing infra red radiation. The International Panel on Climate Change has determined that it is likely that increases in greenhouse gases are implicated in changes to the Earth's climate.

In 1998, the Australian Government signed the Kyoto Protocol committing Australia to limit greenhouse gas emissions in the period 2008 – 2012 to 108% of 1990 emissions. The Government is yet to ratify the Protocol.

For the current Project, the only relevant greenhouse gas is carbon dioxide (CO_2).

4.10.3 Predicted impacts

Carbon dioxide emissions from the Project will be generated from:

- emissions of CO_2 from decomposition of vegetation cleared and soil materials
- emissions of CO_2 from the additional burning natural gas in power generation at Dampier
- emissions from the combustion of diesel fuel in train journeys from the mine to Dampier (not all train movements will be incremental, refer Section 2.7)
- emissions of CO_2 in combustion products from diesel fuel and explosive used on site

To partially offset the above emissions, there will be some Greenhouse sink capacity derived from the absorption of CO_2 from vegetation that becomes established in rehabilitated areas, including the mine pits, waste dumps and tailings disposal areas.

The predicted levels of CO_2 emission from the Project calculated for the full production rate of 20Mt/a are provided in Table 4.9. This does not take account of offsets from Greenhouse sinks in rehabilitation areas.

Table: 4.9 CO_2 emissions from various sources (at 20Mt/a production)

Source	Emission	Comment
Vegetation clearing	60kt CO_2 (2,000 ha @ 8tC/ha)	Total emissions over project life, incurred mostly at Project start-up
Power from Dampier (electricity from gas)	100kt CO_2/a	Annual off-site emission
Local emissions – diesel combustion, ANFO	50kt CO_2/a	Annual on-site emission
Railing & Shipment of ore	50kt CO_2/a	Annual off-site emission

Project emissions at maximum production and railing levels will therefore be around 200ktCO_2/a.

Contextual greenhouse emission productions (CO_2 equivalents) are:

- Australia's total greenhouse gas emission in 1990 was 385Mt

- Western Australia's resource industry emission predicted for 2010 is 39.8Mt
- the increase in Western Australia's resource industry emission for 1990-2010 is estimated to be 27.6Mt

4.10.4 Management

The EPA's interim guidance note on Minimising Greenhouse Gas Emissions (Environmental Protection Authority 1998) requires proponents to:

- estimate greenhouse gas emissions for each year of project operation
- estimate the effects of enhancement or loss of sinks
- indicate measures and technologies to be used to minimise emissions
- compare emissions from the project with similar established projects
- indicate if the project will be entered into the Australian Government's Greenhouse Challenge

Meeting these criteria will also meet National and State Greenhouse Strategy requirements.

Hamersley's response to the above requirements is (in order):

- The annual greenhouse emissions of operating the project (estimated using techniques audited by the Australian Greenhouse Office (AGO) under Rio Tinto's participation in the Greenhouse Challenge) will rise from around 50 ktCO_2/a to 200 ktCO_2/a at full production.

- Clearing of vegetation for the Project will remove around 2,000ha of spinifex and shrubland over the life of the project, with most eventually revegetated. These ecosystems have a relatively low capacity for carbon sequestration. However, vegetation that does become established in rehabilitated areas (especially in the mine voids) will help offset some of the Greenhouse emissions over the life of the Project.

- The principal source of emissions is the conversion of fuel (gas and diesel) to energy. Reduction of emissions is thus most likely from either fuel switching or more efficient use of fuels/energy. In response to pressures for cost efficiencies and Hamersley's commitment to the Greenhouse Challenge, most of the operation has been optimised within a 'no regrets' framework. Significant technological opportunities investigated to date have been limited to using gas to replace diesel in the locomotive and truck fleet. Analysis suggests that this is not a practical option under present technology. Minimising greenhouse gas emissions will be considered further during project design and operation. Energy efficiency projects will be considered during project design.

- Project emissions have been estimated using comparable existing Hamersley operations which range between 9-12 kgCO_2/t ore railed; other iron ore operations report similar figures, namely BHP 12kgCO_2/t ore (BHP Iron Ore Pty Ltd 1997) and Robe River 10-13kgCO_2/t ore (Robe River Mining Co Pty Ltd 1998).

Through Rio Tinto Limited, Hamersley was a founding signatory of the Greenhouse Challenge and has taken an active role in Challenge programs since then. The Project will be incorporated into this background. Therefore annual emissions will be recorded and reported to the AGO as well as any practical abatement projects.

4.10.5 Predicted outcome

The construction and operation of the Project will result in a net increase in the rate of Hamersley's CO_2 production and will contribute to Australia's greenhouse gas emissions. However, the greenhouse gas emissions of iron ore mining are relatively small compared to more energy intensive industries.

4.11 GROUNDWATER QUALITY

4.11.1 EPA Objective

Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA 1993) and the NHMRC/ARMCANZ Australian Drinking Water Guidelines – National Water Quality Management Strategy.

4.11.2 Potential impacts

Potential impacts may include:

- final voids below the surrounding water table can lead to increased salinity in groundwater through evaporation
- seepage from tailings dams can enter groundwater
- pollutants from hydrocarbon storage or usage areas can enter the groundwater

4.11.3 Predicted impacts

Operational impacts
The geology of the Jeerinah and Brockman formations, situated adjacent to the Nammuldi and Silvergrass deposits, is dominated by low permeability shales. Water quality within these formations is believed to be essentially the same as that found at Nammuldi. Groundwater quality will therefore not be affected by any inflow of significant quantities of poorer quality groundwater from adjacent hydrogeological units under dewatering conditions.

The predicted impacts on surface water from the residual material from thickeners used during wet processing are addressed in Section 4.12.3.

Leaks from bulk fuel tanks and significant spillages of hydrocarbon and chemicals have potential to contaminate groundwater, given sufficient volumes, time and ground conditions. Hydrocarbon management procedures in place at Hamersley mines make such an event unlikely.

Although the stratigraphic sequence (Section 3.1.2) includes Mount Sylvia and Mount McRae Shales (consisting of predominantly shale with minor BIF marker horizons), these are present in areas that will not be mined or disturbed as part of the Project. The West Angelas Member of the Wittenoom Formation (the lowest member) comprises highly weathered shales and clays, but there is no pyritic shale component. No other components of the stratigraphic sequence are pyritic.

Impacts from discharges
The quality of the water to be discharged during dewatering operations will be the same as that of the underlying groundwater. Some increase in salinity of water discharged to surface drainage (through evaporation/concentration) will be expected prior to its infiltration into the creek alluvium.

Post mining impacts
The greatest potential risk to local and regional groundwater quality is upon mine closure. Because mine voids will be filled to above pre-mine mean water table levels (with the risk of capillary rise to be taken into account during initial closure planning to determine final backfill levels), no exposed permanent pit lakes or groundwater sinks will develop (Section 4.7.3). The establishment of vegetation in mine pit floors will assist keep the post-mining water table lowered. With no exposed pit lakes of groundwater sinks, the risk of impacts on groundwater quality after mining ends will be reduced.

There will be no significant changes to the long-term beneficial uses of groundwater resources in the area. Once groundwater levels have returned to their original levels, there will be no impediments to the use of the groundwater resource for whatever purpose it is intended.

Impacts from tailings
The tailings will not contain significant contaminants. The central thickened discharge option will have little available water, whereas the in-pit disposal option will have higher available water. Decant water will be contained in ponds at the central thickened discharge facility and will remain in the pits for the in-pit disposal; decant will be used when required by the process plant.

Given that the tailings will comprise fine clays, limonite and goethite washed from the ore and have only residual chemical materials from processing, the impact on groundwater quality will be minimal. Hamersley's existing conventional valley impoundment tailings storage facilities at Paraburdoo and Tom Price have not contaminated the groundwater in the area that can be attributed to the tailings facilities.

4.11.4 Management

The measures to be implemented to manage groundwater quality will include:

- filling pits to above the level of the pre-mine mean water table
- final backfill levels in pit voids will be assessed (as part of initial closure planning) and will take into account mean water table levels and capillary rise relationships to determine the optimum backfill height for each pit

- monitoring the water quality of groundwater and surface flows from plant areas to identify whether there are any detrimental impacts
- managing hydrocarbons to ensure containment and treatment and preventing the release of pollutants
- implementing surface flow measures to minimise pollution as outlined in Section 4.12.4

There is no potential for acid rock drainage, so the procedures for handling such material that are applied at some other Hamersley operations will not be required for this Project.

4.11.5 Predicted outcome

The impact on groundwater quality during mining will be minimal. The nature of the tailings to be stored will not contaminate the groundwater. The return of waste material into voids will prevent the formation of groundwater sinks or long term salinisation.

4.12 SURFACE WATER QUALITY

4.12.1 EPA Objective

Maintain or improve the quality of surface water to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA 1993) and the NHMRC/ARMCANZ Australian Drinking Water Guidelines – National Water Quality Management Strategy.

4.12.2 Potential impacts

Discharges or releases from mine sites may contain hydrocarbons, nutrients, heavy metals, detergents and other contaminants that can result in adverse impacts on surface water quality in the receiving environment. The tailings storage facilities (in-pit disposal and central thickened discharge) may also affect the quality of surface runoff and the receiving environment.

4.12.3 Predicted impacts

Discharges of water will be limited to:

- dewatering discharges
- surface runoff from operations area
- discharges from tailings storage facilities

The receiving environment at Nammuldi and Silvergrass contains no permanent water bodies into which surface run-off from the Project area will discharge.

Impacts from dewatering/discharges

The groundwater to be abstracted and discharged as surface water will be the same quality as that provided in Appendix C.

PPK Environment & Infrastructure (1999) note that towards the bottom of some pits, dewatering may be difficult and require in-pit sumps. Water from this source will be used for dust control in the mine pit and on haul roads. Excess water will be fed from the pit sump into out of pit containment basins to settle out any sediment load. Water from the basins will then be released into Caves Creek or other drainage lines.

There will be no additions to (eg in-pit sump water) or treatment of water in the dewatering discharge pipeline that could affect water quality of surface water bodies. There is a low risk of adjacent hydrogeological units contributing poorer quality groundwater to that which is to be dewatered and discharged as surface water (refer Section 4.11.3).

The target water quality criteria from surface discharges from the Project will be those stated in Table 2.1 of the Australian and New Zealand Environment and Conservation Council (1992) Australian Drinking Water Guidelines – National Water Quality Management Strategy. Where background levels in receiving waters exceeds the criteria in the guidelines, alternative criteria will have to be adopted. The DEP Licence normally specifies limits for key water quality criteria that are relevant to the prevailing site conditions.

At Silvergrass, Caves Creek contains no permanent water body in the vicinity of the provisional discharge point (5km downstream) or that is sufficiently close that it will be adversely affected by dewatering discharges. Dewatering discharges into Caves Creek (and the drainage channels at Nammuldi) will create pools of water. The water quality of the pools will depend on inputs from cattle and other wildlife, on weather conditions and on the status of drying of the pools. In drying pools, the water quality will deteriorate, as would be expected; the water quality guidelines will be exceeded toward the end of the pool life. As pools dry, the water quality will become more saline, while *E. coli* and nutrient levels may increase.

The drying of pools created by discharges occurs naturally after major rainfall events within the Caves Creek catchment. The changes in water quality will reflect that which occurs as naturally created pools of water dry up.

At Nammuldi, surface discharges from mine dewatering may cause some erosion (and increased turbidity) of areas immediately downstream during the initial discharge period. This will be alleviated through proper siting of the discharge outfall and the use of hard surfaces (existing rock or engineered structures such as rock-breaks). Ponds that form at and downslope of the discharge point will have water quality that varies over time, as described for Silvergrass.

Impacts from surface runoff

The main risk of nutrient enrichment or hydrocarbon contamination of surface water quality will arise from the ammonium nitrate shed and the bulk fuel storage (and dispensing facilities). These will be sited so that surface water from those areas is controlled. Surface water quality will be protected through minimising the release of contaminated run-off.

Surface runoff from the Project area is likely to contain suspended solids material due to the amount of cleared areas. In large concentrations and without suitable controls, this can impact on the water quality of any existing water body and cause sedimentation of watercourses. Runoff from plant areas will pass through sedimentation basins designed to settle out suspended material prior to discharge off-site.

Impacts from tailings storage facilities
As previously stated, tailings from wet processing will comprise fine clays, limonite and goethite washed from the ore, plus a relatively small amount of residual material from thickeners. Most of the environmental risk from tailings is physical, with little potential for chemical pollution of surrounding land or groundwater.

Tailings are not contaminated with toxic substances. Tailings water is normally relatively high in Total Dissolved Solids (TDS) at about 1120mg/L and is considered Class 3 water for agricultural use (ANZECC 1992). This is near the typical water quality for the Pilbara (local drinking water TDS is about 800mg/L, ranging to 1000mg/L).

The flocculants and coagulants to be used (refer Section 2.5.1) are used elsewhere; Magnafloc 800HP at Tom Price, Magnafloc 368 at Argyle and Magnafloc LT35 at portable water treatment plants in Sydney (pers. comm: Rio Tinto Research & Technology Development).

A summary of the ecological and environmental implications of these flocculants and coagulants (extracted from Material Safety Data Sheets or Chem Alert Reports) is provided in Table 4.10.

Table 4.10 Environmental implications of flocculants/coagulants to be used.

Product	Composition	Ecological/environmental information extracted from Material Safety Data Sheet or Chem Alert Report	Implications
Magnafloc 800HP	Nonionic polyacrylamide	Do not flush into surface water drains or sanitary sewer system. 96hr LC_{50} freshwater fish *Brachydanio reri* is expected to be 357mg/L. 48hr EC_{50} *Daphnia magna* is expected to be 212mg/L	Avoid spillages near waterways. Project tailings storage areas are located well away from major creek lines
Magnafloc 336	Anionic polyacrylamide	This product is not anticipated to cause adverse effects to animals or plant life if released to the environment in small quantities. Not expected to bio-accumulate.	Avoid spillages. Project tailings storage areas are located well away from major creek lines
Magnafloc 368	Cationic polymer	Benzalkonium chloride derivatives/quaternary ammonium compounds are commonly used as disinfectants, indicating toxicity to micro-organisms. Benzalkonium chloride is toxic to trout above 2ppm.	If a large quantity is spilt into a river system, it will be detrimental to fish present (pers comm: Research & Technology Development). Project tailings storage areas are located well away from major creek lines
Magnafloc LT35	Cationic polymer	Do not allow product to enter surface water or sanitary sewer system. Toxic to fish, LC_{50} 96hr <10ppm. Although toxic to fish, this product is not expected to cause long term harm to the aquatic environment as it is very quickly and irreversibly bound to naturally occurring dissolved organic carbon and particulate material.	If a large quantity is spilt into a river system, it will be detrimental to fish present (pers comm: Research & Technology Development). Project tailings storage areas are located well away from major creek lines

Wet processing will use low dosages (20g/t) of the listed flocculant and coagulant in the process. This will reduce the amount of such chemicals that will be contained in decant water or possibly surface run-off from tailings storage areas. Also, the siting of the tailings storage facilities (on the other side of the valley from Caves Creek and with little defined drainage connecting the Project area with Duck Creek) will help reduce the risk of contaminated runoff entering significant watercourses.

The greatest risk to surface water quality from the flocculants and coagulants is from a major spillage of the chemicals directly into a running creek; this scenario will result in the probable loss of freshwater fish inhabiting the affected creek. Other than during transportation, this is not likely due to the setting of the tailings storage facilities relative to water courses.

4.12.4 Management

The measures to be implemented to manage surface water quality will include:

Measures to minimise risks of contaminating water on-site-

- bulk fuel storage areas will be bunded and lined, with monitoring to determine any loss of containment
- washdown and oil spillage from the bulk fuel storage, workshop and service areas will drain into sumps and then an oil interceptor trap
- washdown and spillage from the crushing and screening building will pass through a holding dam from which hydrocarbons will be skimmed from the water surface
- waste oil will be collected and held in drums before collection by a contractor
- runoff from ammonium nitrate shed and bulk fuel and oil storage and dispensing facilities will be contained and treated on-site prior to release
- clean and dirty water streams will be separated so that they can be handled in a different manner

Measures to contain contaminated water-

- sedimentation basins will be established to settle out suspended material in surface runoff prior to being released
- surface runoff from areas with a low risk of contamination will be handled, treated and released separately from areas with a higher risk of contamination (eg mine, workshop, bulk fuel, plant areas), and off-site discharges from plant areas will be contained
- the water quality of surface water discharges from the plant/mine area at Silvergrass and Nammuldi will be monitored to verify that only water of an acceptable water quality is released

- the central thickened discharge facility will have a pond at each end to contain surface runoff and decant water, while diversion drains will be established to divert natural runoff from mixing with water generated from the stored tailings
- surface water runoff will be sampled and analysed for its water quality at established discharge points at Nammuldi and Silvergrass

4.12.5 Predicted outcome

The impact on surface water quality will be negligible.

4.13 SOLID WASTES

4.13.1 EPA Objective

Ensure that wastes are contained and isolated from ground and surface water surrounds and treatment or collection does not result in long term impacts on the natural environment.

4.13.2 Potential impacts

Construction and operation activities generate waste materials, such as plastic, paper, wood, scrap metal, tyres, rubber, batteries and domestic solid (including putrescible) wastes.

If not adequately handled, stored or disposed, this material can contaminate local soil, groundwater or surface waters. Contamination can arise from the escape of leachate containing elevated nutrients, Biological Oxygen Demand or heavy metals. Additional impacts from landfills can also include vermin, fire/smoke, pathogens, litter and greenhouse gas emissions.

4.13.3 Predicted impacts

Most material placed in the Project landfills will be inert. The low rainfall will help reduce leachate generation and subsequent movement toward the water table, as will the absence of nearby permanent surface water bodies. Landfills will be appropriately sited and managed, such that predicted impacts on groundwater or surface waters are anticipated to be minimal.

There is negligible potential for Marra Mamba waste rock or ore to produce acid rock drainage. Geological mapping and drilling has not identified any geological formations that is pyritic and that will be mined (refer Section 4.11.3).

4.13.4 Management

The measures to be implemented to manage solid waste will include:

Recycling-
- generation of waste material will be reduced, where it is practical to do so
- material that can be recycled or re-used will be separated from material that cannot
- recyclable material will be made available for Contractors to periodically collect

- separate storage bays will be installed for wood, steel, batteries, plastics, tyres and drums
- less than 100 tyres will be stored at any one time (1996 *Used Tyre Regulations*)
- non-recyclables will be placed in a landfill or a series of landfills

Landfill siting-
- landfills will be sited so that the base is at least 3m above groundwater level
- no landfill will be sited nearer than 150m from Caves Creek or other surface water

Landfill management and rehabilitation-
- deliberate burning of rubbish in the landfill will not be undertaken without DEP approval
- fencing will be installed around the landfill to exclude vermin and contain windblown litter
- exposed material (especially putrescibles) will be regularly covered with backfill
- landfills will be backfilled and rehabilitated when full
- backfilling will result in at least one metre of soil covering the top layer of waste
- replacement landfills will be made adjacent to the full one and within the fenced enclosure.

The siting and operation of landfills will be outlined in Hamersley's Works Approval Application to the DEP. The operation of landfills will be covered under conditions of the DEP Works Approval and Licence issued for the Project.

Management of the tailings area/s will be undertaken in accordance with the DME's Guidelines on the Safe Design and Operating Standards for Tailings Storage (Department of Minerals and Energy 1999).

4.13.5 Predicted outcome

The management of solid wastes will result in negligible environmental impacts.

4.14 NOISE

4.14.1 EPA Objective

Protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring that noise levels meet statutory requirements and acceptable standards.

4.14.2 Potential impacts

During construction, noise can be generated by earthmoving equipment, heavy haulage vehicles and by general assembly of infrastructure. During operations, noise can be generated by blasting, ore handling, ore processing, earthmoving machinery and from equipment such as motors, conveyors, compressors and workshops.

The Nammuldi Camp is 5km from the Nammuldi plant and 3km from Pit E. The Village will be 3.5km further east of the Nammuldi Camp. Hamersley Station homestead is the nearest noise sensitive premises and is about 40km from Nammuldi and mining at Silvergrass.

Criteria for assessing environmental noise in Western Australia are specified in the *Environmental Protection (Noise) Regulations 1997* that are being reviewed by the DEP. The Regulations prescribe "assigned noise levels" for noise-receiving locations. The assigned noise levels depend on the type of premises receiving the noise (eg residential, commercial, industrial) and, for residential premises, on the time of day.

The assigned noise levels are provided in Table 4.11. As there is no commercial or industrial zoning within 450m of noise-sensitive premises and there are no major roads or secondary roads, the Influencing Factor will not apply.

Table 4.11. Assigned noise levels

	Assigned noise level (dB)		
Premise type	$L_{A\ 10}$	$L_{A\ 1}$	$L_{A\ max}$
Noise sensitive eg residential (most sensitive time of day/night)	35 (plus Influencing Factor*)	45 (plus Influencing Factor*)	55 (plus Influencing Factor*)
Commercial	60	75	80
Industrial and Utility	65	80	90

$L_{A\ 10}$ is a noise level not to be exceeded for more than 10% of the time. $L_{A\ 1}$ is a noise level not to be exceeded for more than 1% of the time. $L_{A\ max}$ is a noise level that is not to be exceeded at any time

*Influencing Factor – considers the amount of industrial and commercial zoned land and the presence of major roads within a 450m radius around the noise receiver

The Regulations also consider blasting noise. For daytime blasting (7am to 6pm, Monday to Saturday, except public holidays), the air blast levels received at any other premises must be less than 125dB $L_{linear,\ peak}$ for any blast and 120dB $L_{linear,\ peak}$ for nine in any 10 consecutive blasts, regardless of the interval between blasts.

4.14.3 Predicted impacts

Due to distance, Project-related noise will not impact on the nearest noise sensitive premises at Hamersley Station homestead.

Construction and operations will cause periodic increases in noise levels, but this will be similar to that associated with Brockman. The main source of noise will be from blasting which will be conducted during daylight hours, mostly Monday to Saturday.

4.14.4 Management

The measures to be implemented to manage noise will include:

- all personnel in areas subject to elevated noise levels will be supplied appropriate protective hearing equipment
- stand-by diesel generators will have sound-attenuation enclosures and will be sited at an appropriate distance from where people are present
- installed equipment will be designed to meet the current occupational noise standard (maximum noise level of 85dB [A] at one metre from the source)

4.14.5 Predicted outcome

Project noise will have no impact at the Hamersley Station homestead.

4.15 ABORIGINAL CULTURE AND HERITAGE

4.15.1 EPA Objectives

Ensure that the proposal complies with the requirements of the *Aboriginal Heritage Act 1972*.

Ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area.

4.15.2 Potential impacts

Hamersley's Aboriginal Heritage Protocol states that sites or areas of particular significance to Aboriginal people are to be respected and protected. Preservation of such sites and their values is of considerable importance to Aboriginal people and for maintaining the richness and diversity of Australian culture.

The *Aboriginal Heritage Act 1972* stipulates that no Aboriginal site can be disturbed without consent from the Minister for Aboriginal Affairs. Aboriginal sites have been recorded in the Project area and some have the potential to be impacted by Project construction.

4.15.3 Predicted impacts

Impacts on ethnographic sites
Aboriginal heritage site surveys indicate there are no ethnographic sites within the Nammuldi area, therefore no ethnographic sites will be impacted at Nammuldi. No ethnographic surveys have been undertaken at Silvergrass, but it is understood that some sites in the general area may be significant to the Eastern Gurama people.

Impacts on archaeological sites
Several archaeological sites in the Nammuldi Pit F area will be impacted by mining or are sufficiently close to mine pits that they are at some risk of being directly or indirectly impacted. Similarly, there are sites at Silvergrass that are at risk of impact from mining or infrastructure.

The Pit F and Silvergrass sites that may be impacted are summarised in Table 4.12.

Table 4.12 Aboriginal sites that may be impacted

Reference	Site type	Size	General location
Pit F:			
NAM99-1	Artefact scatter	10m x 20m	150m north of Pit F
NAM99-2	Rock shelter	10m x 5m	50m north of Pit F
NAM99-3	Rock shelter Gnamma Hole	12m x 4m 5m x 5m	Within Pit F
NAM99-4	Rock shelter	60m x 35m	About 200m north of Pit F
NAM99-5	Artefact scatter/Gnamma Hole	110m x 70m	Within Pit F
NAM99-6	Rock shelter	10m x 10m	250m north of Pit E
NAM99-7	Rock shelter	4m x 6m	250m north of Pit E
NAM99-9	Artefact scatter	150m x 90m	250m north of Pit E

Reference	Site type	Size	General location
NAM99-10	Rock shelter	16m x 9m	About 250m north of Pit E
NAM99-11	Rock shelter	11m x 5m	About 225m north of Pit F
NAM99-12	Rock shelter	30m x 7m	About 450m north of Pit F
Silvergrass:			
P077064	Burial site	N/a	600m north-west of Valley Pit
HSA12	Burial site	N/a	850m north-west of Valley Pit
HSA13	Burial site	N/a	600m north-west of Valley Pit
P00849	Engraving	N/a	1.4km north-west of Valley Pit

No archaeological sites exist within the surveyed areas of Pit B or Pit C/D. Pit A is to be surveyed by mid 2000.

Enviro-cultural issues
Specific information on enviro-cultural areas and the use of resources is confidential (Section 3.3.4) so the predicted impact cannot be provided in the CER. It is understood that all components of the land are important to Eastern Gurama people and that no enviro-cultural areas are more significant than others. Also, the type and variety of uses that a resource has does not influence the level of significance Eastern Gurama people place on that resource.

Plants used by the Eastern Gurama people include *Acacia aneura*, *Acacia xiphophylla*, *Triodia pungens*, *Triodia wiseana*, *Brachychiton acuminatus* and some Eucalypt species. These plants occur within the Project area and some will be cleared; however, all are common locally and occur in the broader region.

Sufficient areas contain these targeted species within the local area to enable the continued use of them by Eastern Gurama people.

4.15.4 Management

The measures to be implemented to manage Aboriginal culture and heritage issues will include:

Aboriginal sites-

- ethnographic surveys at Silvergrass and the transport corridor and archaeological surveys over those areas not already covered (Pit A, eastern area of Pit C/D, Village, central thickened discharge facilities and the transport corridor) will be undertaken in co-operation with Maliwartu prior to ground disturbance and once an agreed protocol for conducting heritage surveys has been developed

- the findings of archaeological and ethnographic surveys completed and those of planned surveys in the Project area will be forwarded to the Aboriginal Affairs Department for the registration of identified sites

- consultation with Maliwartu will take place regarding all Aboriginal sites within or in proximity to the Project prior to any Section 18 application

- if any Aboriginal site is required to be disturbed for the Project, a written application (under Section 18 of the *Aboriginal Heritage Act 1972*) will be made to the Aboriginal Cultural Materials Committee for consent by the Minister for Aboriginal Affairs

- any new Aboriginal site identified during construction and operation will be reported to Hamersley's Aboriginal Training and Liaison department for assessment and notification to Maliwartu and the Aboriginal Affairs Department

- workforce induction programs will include Aboriginal cultural and heritage issues

Cultural and economic issues-

- the current economic, employment and training opportunities and cultural programs (refer Section 3.2) will continue to be made available to Eastern Gurama people

- in collaboration with Aboriginal communities, further efforts will be made to explore potential opportunities for programs to further address their education, training, employment, enterprise development and community development needs

- work with Maliwartu will continue to determine particular opportunities that may arise from the Project

Enviro-cultural issues-

- a greater understanding of enviro-cultural issues will be sought by Hamersley (with guidance by Aboriginal people) so as to better appreciate resource utilisation patterns and to improve future planning

4.15.5 Predicted outcome

Based on completed surveys, the Project is likely to have a minimal impact on Aboriginal culture and heritage; however, depending on the outcome of additional surveys to be undertaken this may change.

<u>Commitment 12: Additional surveys – Aboriginal sites</u> (refer Table 5.1)
Hamersley will involve the Maliwartu Aboriginal Corporation in additional archaeological and ethnographic surveys to identify sites, and their significance, within the Project area that are likely to be disturbed

<u>Commitment 13: Mechanism for future Aboriginal site surveys</u> (refer Table 5.1)
Additional Aboriginal site surveys will be undertaken in accordance with a heritage survey protocol that is to be agreed with the Maliwartu Aboriginal Corporation through the establishment of a Land Use Agreement

<u>Commitment 14: Consultation on Section 18 application</u> (refer Table 5.1)
Hamersley will consult with the Maliwartu Aboriginal Corporation and Eastern Gurama Elders on Aboriginal sites in the Project area before any Section 18 application is developed in keeping with an agreed protocol

<u>Commitment 15: Submission of Section 18 application</u> (refer Table 5.1)
Hamersley will make a written application to the Aboriginal Cultural Materials Committee (for subsequent consent by the Minister for Aboriginal Affairs) if any identified Aboriginal site in the Project area is required to be disturbed

<u>Commitment 16: Aboriginal social and cultural issues associated with the environment</u> (refer Table 5.1)
Hamersley will consult with the Maliwartu Aboriginal Corporation (and the Native Title Claimants it represents) to identify and assess any social and cultural aspects of the physical and biological environment impacted. This will be addressed through the establishment of a Land Use Agreement.

5. SUMMARY OF COMMITMENTS

The environmental commitments made by Hamersley for this Project are provided in Table 5.1.

Table 5.1 Summary of environmental commitments

Commitment	Objective	Action	Phase	Sign-off (advice from)	Compliance
Commitment 1: Environmental Management Plan (EMP)					
Hamersley will prepare and implement an EMP for the Project that will outline the: • environmental performance objectives for relevant environmental factors; • management of environmental impacts from construction and operation; • monitoring of key environmental aspects; • reporting and auditing procedures The EMP will be prepared in consultation with relevant Government agencies and will be subjected to a targeted public review.	Manage environmental impacts of the Project	Develop and implement EMP to manage the Project	Prior to construction	DEP (DME, WRC, CALM)	EMP developed
Commitment 2: Environmental Management System					
Hamersley will develop and subsequently implement an Environmental Management System for the Project that incorporates the following elements: • environmental policy and associated corporate commitment • mechanisms and processes to ensure - planning to meet environmental requirements - implementation and operation of actions to meet environmental requirements - measurement and evaluation of environmental performance - review and improvement of environmental outcomes	Manage environmental impacts of the Project and fulfil requirements of all Project commitments and conditions	Develop and implement the EMS	Prior to commissioning (the EMP will be used during construction)	DEP	EMS developed and implemented
Commitment 3: Annual Environmental Reporting					
Hamersley will include the Project in its consolidated annual and triennial environmental reporting to Government once construction commences	Report on the environmental performance of the Project and its compliance status with environmental requirements	Prepare and submit annual environmental report	By 30 March each year	DRD (DEP, DME, WRC, CALM)	Submission of AER each year
Commitment 4: Closure Plan					
Hamersley will prepare a detailed closure plan for the Project. The plan will address closure actions to be taken toward: • mine voids • waste dumps • tailings storage facilities	Prepare a detailed closure plan for the decommissioning and rehabilitation of the Project	Develop plan	Within two years of Project commissioning	DEP (DME, WRC)	Closure plan approved by the DEP

Commitment	Objective	Action	Phase	Sign-off (advice from)	Compliance
• transport linkage between Silvergrass and Nammuldi • processing plants • associated infrastructure and will provide the basis for the development of an eventual 'walk-away' closure strategy for the Project. As part of this closure plan, final backfill levels in pit voids will be assessed, taking account of mean water table levels and capillary rise relationships.					
Commitment 5: Additional surveys – biological					
Hamersley will undertake additional biological (flora, vegetation and fauna) surveys of those areas not already surveyed where Project infrastructure is planned, such as the tailings storage facility (central thickened discharge area), the Village and the power line from the Dampier - Tom Price line	Identify and assess the environmental impacts of development in areas not already surveyed	Undertake additional required biological surveys	Prior to construction	DEP (CALM)	Completion and reporting of additional biological surveys
Commitment 6: Riverine vegetation monitoring					
Hamersley will develop and implement a riverine monitoring program to determine the extent of any impacts on vegetation that may occur as a result of dewatering the Silvergrass mine pits and from mine dewatering discharges into Caves Creek	Assess and report on the extent of any impacts on vegetation along Caves Creek	Monitor status of riverine vegetation	All	DEP (CALM, WRC)	Completion of monitoring
Commitment 7: Rare Fauna					
Hamersley will prepare and implement a management plan for the Ghost Bat as part of the EMP, plus any fauna species that are present in the Project area which may be listed in future revisions of the Western Australian Rare and Endangered List or the Commonwealth Critically Endangered List.	Manage Ghost Bat and future listed Rare/Endangered fauna species	Prepare and implement management plans	Prior to construction/As required	DEP (CALM)	Plans approved and implemented
Commitment 8: Stygofauna					
Hamersley will prepare and implement a co-ordinated program of stygofauna sampling within and around the Project area to improve the current understanding of stygofauna that occur in the Pilbara	Understand the distribution and population dynamics of stygofauna population and share the findings with the general research community	Undertake sampling	All	DEP (WAM, CALM)	Completion of sampling

Commitment	Objective	Action	Phase	Sign-off (advice from)	Compliance
Commitment 9: Caves Creek stream flow					
Hamersley will monitor stream flows in Caves Creek and make the data available to the Water and Rivers Commission	Improve understanding of Caves Creek flow regime	Establish monitoring facilities	Pre-construction Ongoing	DEP (WRC)	Data obtained
Commitment 10: Groundwater monitoring and modelling					
Hamersley will prepare and implement a groundwater monitoring plan (including monitoring water levels in Palm Springs) and incorporate the outcomes to improve the groundwater modelling predictions	Improve confidence in the predictive modelling and dewatering strategy	Prepare plans, collect data and revisit model	Ongoing	DEP (WRC)	Refined numerical modelling
Commitment 11: Recharge options					
Hamersley will investigate the feasibility of groundwater recharge options at Nammuldi for handling water generated from mine dewatering that will otherwise be discharged via surface drainage	Optimise recharge to local and regional aquifers	Conduct recharge feasibility studies	Ongoing	DEP (WRC)	Completion of studies
Commitment 12: Additional surveys – Aboriginal sites					
Hamersley will involve the Maliwartu Aboriginal Corporation in additional archaeological and ethnographic surveys to identify sites, and their significance, within the Project area that are likely to be disturbed	Identify any heritage sites in those areas not already surveyed	Undertake additional surveys	Prior to construction	DAA	Additional surveys conducted
Commitment 13: Mechanism for future Aboriginal site surveys					
Additional Aboriginal site surveys will be undertaken in accordance with a heritage survey protocol that is to be agreed with the Maliwartu Aboriginal Corporation through the establishment of a Land Use Agreement	Agree on a survey protocol	Establish survey protocol	Prior to construction	Hamersley/ Maliwartu	Agreed protocol in place
Commitment 14: Consultation on Section 18 application					
Hamersley will consult with the Maliwartu Aboriginal Corporation and Eastern Gurama Elders on Aboriginal sites in the Project area before any Section 18 application is developed in keeping with an agreed protocol	Consult with the Maliwartu Aboriginal Corporation on sites	Conduct meaningful consultation	Prior to construction	Hamersley/ Maliwartu	Project design minimises impact on sites
Commitment 15: Submission of Section 18 application					
Hamersley will make a written application to the Aboriginal Cultural Materials Committee (for subsequent consent by the Minister for Aboriginal Affairs) if any identified Aboriginal site in the Project area is required to be disturbed	Obtain consent to disturb nominated Aboriginal sites	Submit written application	Prior to construction	DAA	Consent issued by Minister
Commitment 16: Aboriginal social and cultural issues associated with the environment					
Hamersley will consult with the Maliwartu Aboriginal Corporation (and the Native Title Claimants it represents) to identify and assess any social and cultural aspects of the physical and biological environment impacted. This will be addressed through the establishment of a Land Use Agreement.	Obtain agreement with the Native Title Claimants	Negotiate Land Use Agreement	Prior to construction	Hamersley/ Maliwartu	Registration with NNTT

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ABBREVIATIONS, UNITS AND GLOSSARY

Abbreviations

AAD	Aboriginal Affairs Department
AHD	Australian Height Datum (roughly relative to sea level)
ANFO	Ammonium Nitrate Fuel Oil
ANZECC	Australian and New Zealand Environment and Conservation Council
BIF	Brockman Iron Formation
CALM	Department of Conservation and Land Management
CER	Consultative Environmental Review
CPR	Central Pilbara Railway
DEP	Department of Environmental Protection
DME	Department of Minerals and Energy
DRD	Department of Resources Development
EPA	Environmental Protection Authority
MM	Marra Mamba
NEPM	National Environmental Protection Measure
TDS	Total Dissolved Solids
WRC	Water and Rivers Commission

Units

cm	centimetre
CO_2	carbon dioxide
CO_2/a	carbon dioxide per annum
dB	decibel
dB(A)	decibels A weighted
g/t	gram per tonne
ha	hectare
kgCO_2/t	kilogram of carbon dioxide per tonne
km	kilometre
km^2	square kilometre
kt	kilotonne
kV	kilo volt
L	litre
m	metre
m^2	square metre
m^3/s	cubic metre per second
m^3/d	cubic metre per day
m/a	metre per annum
$\mu g/m^3$	microgram per cubic metre
mAHD	metre above Australian Height Datum
mBGL	metre below ground level
m/d	metre per day
mg/L	milligram per litre
mg/m^3	milligram per cubic metre
mm	millimetre
mRL	metre reduced level
ML	megalitre
ML/d	megalitre per day
Mt	million tonne
Mt/a	million tonne per annum
t	tonne
t/m^3	tonne per cubic metre
w:o	waste to ore ratio
%	percent
^oC	degrees Celsius

Glossary

Abstraction/dewatering	Removal of groundwater from aquifer system
Alluvial	Materials transported and deposited by the action of rivers or streams, in recent geological times
Anticlinical structure	A ridge or fold of stratified rock in which the strata slope down from the crest
Aquifer	A permeable rock formation which stores and transmits groundwater
Asbestiform	Having a fibre-like crystal form similar to that of asbestos minerals eg chrysolite or crocidolite
Banded Iron Formation	Tabular rock body usually consisting of alternating bands of quartz and iron rich minerals
Borefield	Series of holes that are drilled into an aquifer for the purpose of withdrawing water
Bund	An earth, rock or concrete wall constructed to prevent the inflow or outflow of liquids
Catchment	Surface area from which runoff flows to a river or any other collecting reservoir
Confluence	Joining of two or more drainage systems

Copepod	Any small aquatic crustacean of the class Copepoda
Cut-to-fill	Where material from cuts is used in areas needing fill –resulting in flat terrain for infrastructure
Dendritic	Type of drainage pattern which has fanning-out appearance
Ephemeral	Water course that flows on only few occasions in a year
Detrital	Material derived from the weathering of pre-existing rocks
Fines	That portion of iron ore product that is sized less than 6mm
Goethite	An iron mineral consisting of oxides and hydroxides or iron
Hydrogeology	The geology of groundwater
Hydraulic gradient	Slope of the water table over distance Change I static head per unit of distance in a given direction
Impermeable	Material that does not allow a particular substance to pass through it
Lump	That portion of iron ore product that is sized greater than 6mm
Marra Mamba	Stratigraphic name of oldest banded iron formation of the Hamersley Group of sedimentary rocks
Mineralisation	The outcome of the introduction of valuable elements into rock material
Overburden	Soil and rock overlying a mineral deposit that must be removed before the deposit can be mined
Permeability	The extent to which fluids can pass through rock
Potable water	Fresh and marginal water generally considered suitable for human consumption
Putrescible	Waste material that has potential to rot, such as food matter
Recharge	The process where water penetrates soil to a temporary or permanently saturated zone
Riverine	Habitat around large drainage lines
Stratigraphic	Formation, composition and occurrence of stratified rocks
Storativity	Volume of water an aquifer can release from or takes into storage per unit surface area
Stripping ratio	The ratio of overburden to ore mined
Stygofauna	Mostly invertebrates that are adapted to inhabiting subterranean aquatic environments
Tailings	Material remaining after the processing of ground/crushed ore
Through-flow	Amount of water that passes through a given area
Thrust fault	A reverse fault of low angle, with older strata displaced horizontally over newer
Transmissivity	Rate of water can be transmitted through material
Void	An open structure or pit that remains after ore has been removed by mining
Water table	Top surface of the groundwater, whether above or below ground level

Figures

Figure 1 Regional setting and Hamersley operations

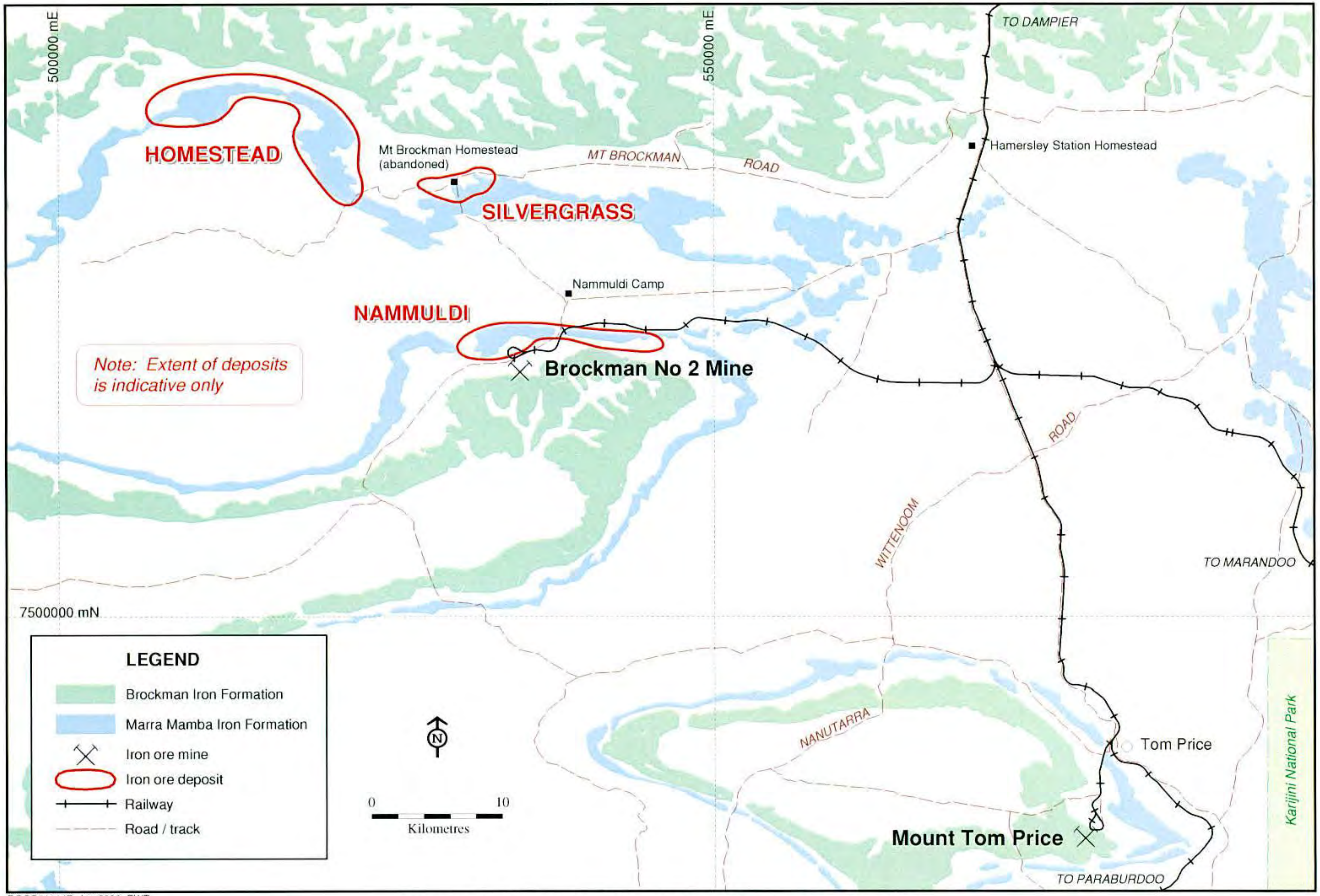

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Figure 2 Deposits included in Homestead Project

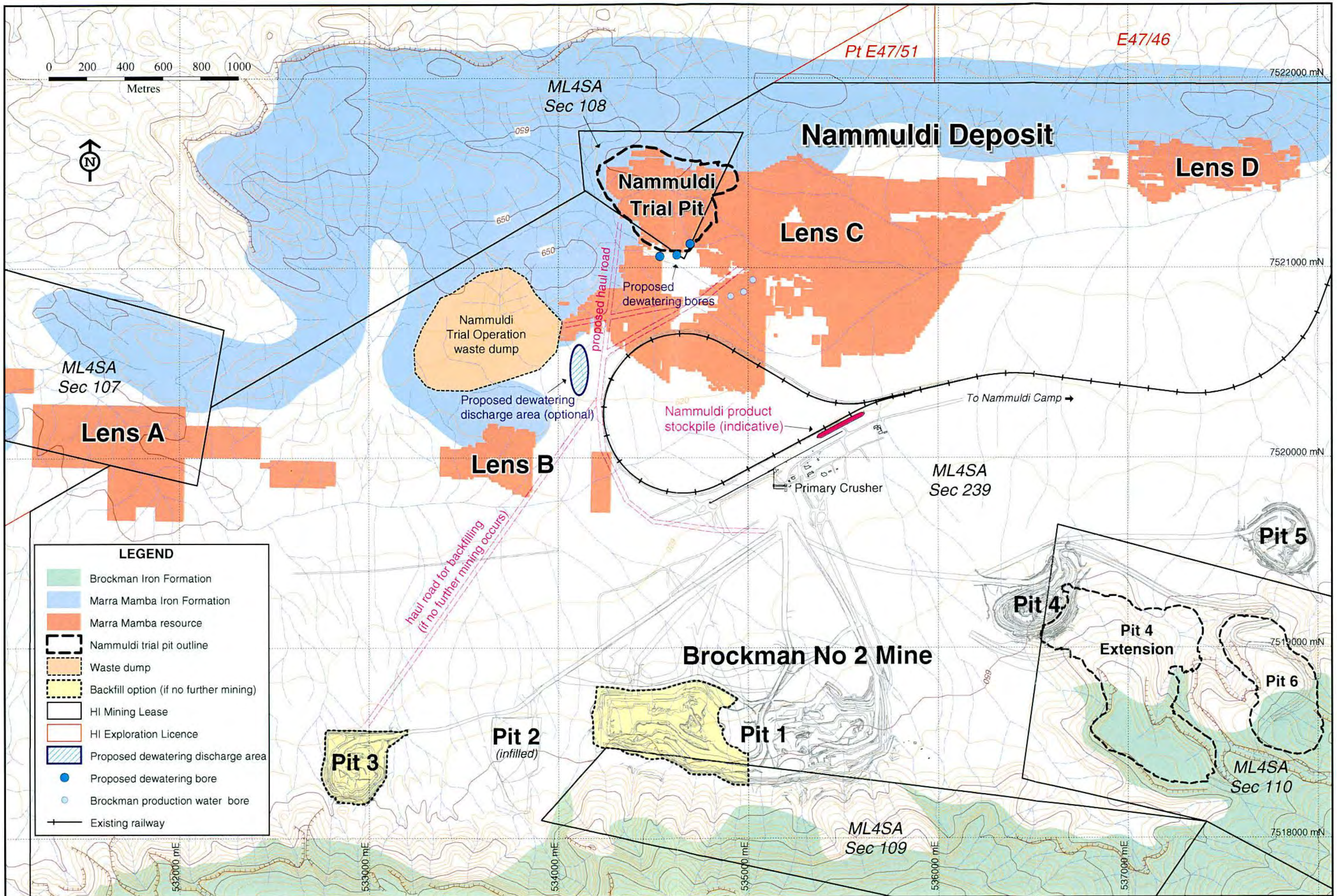

Figure 3 Components of the Nammuldi Trial Operation (Lens C)

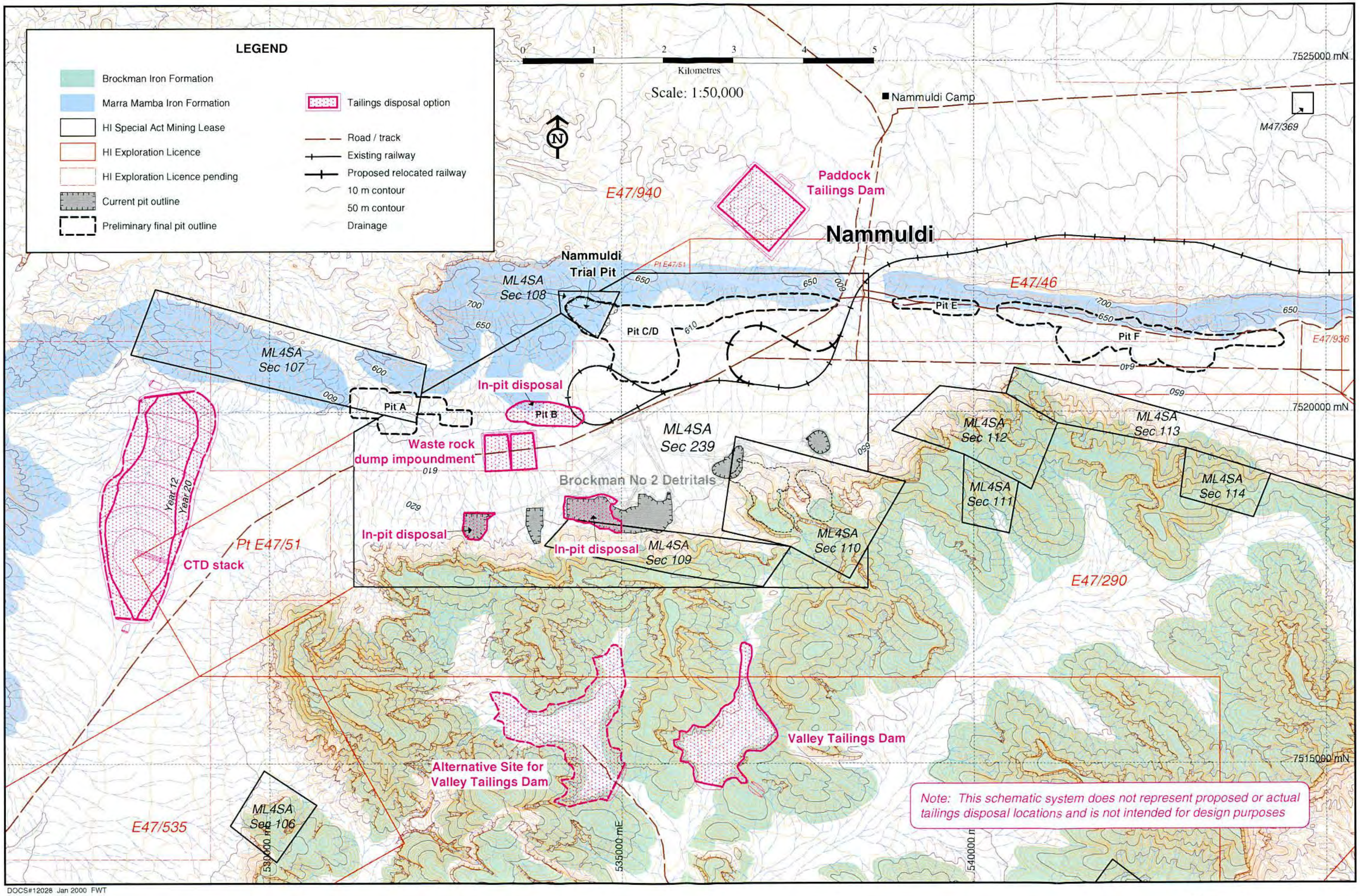

Figure 4
Tailings disposal options - Nammuldi

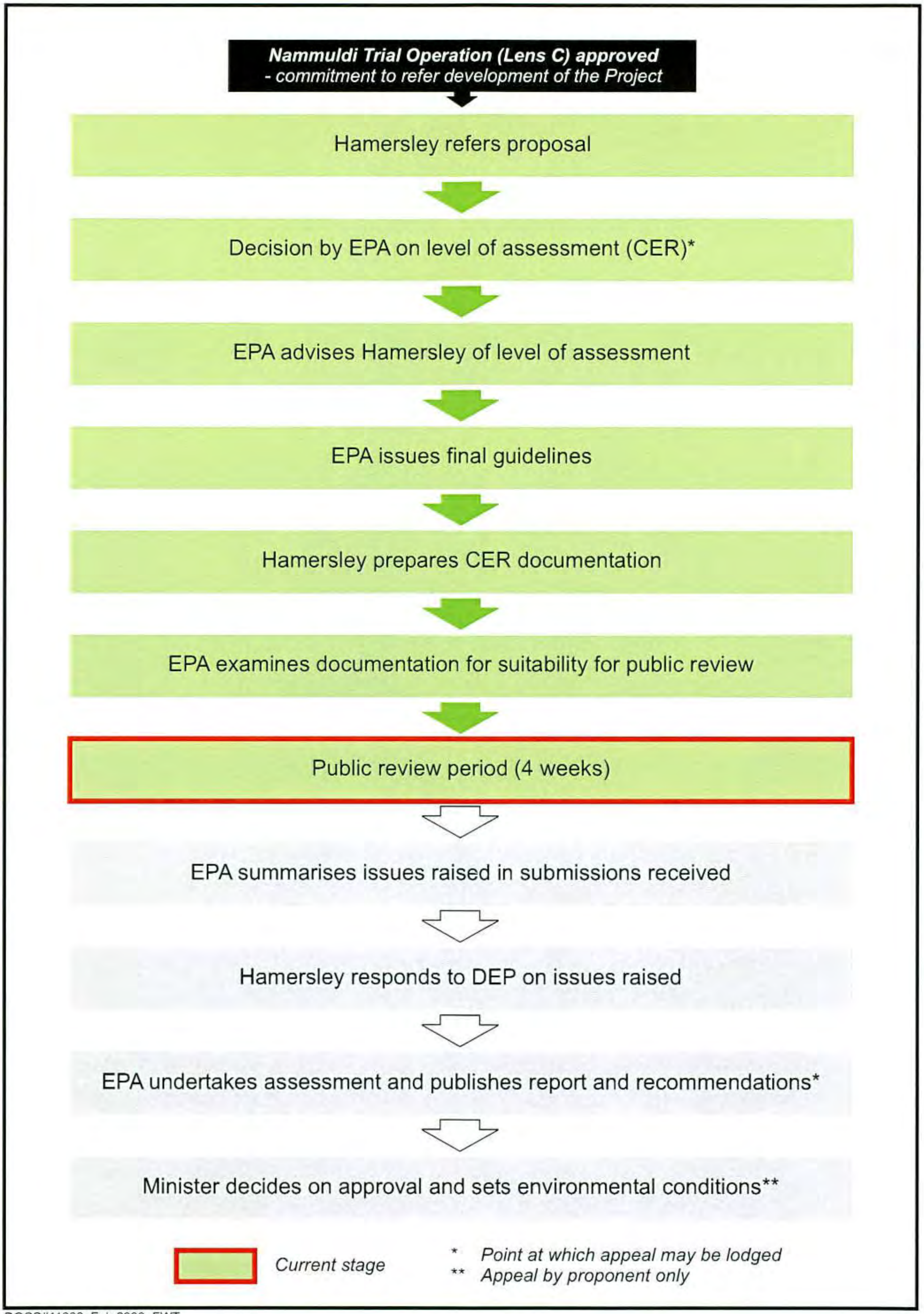

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Figure 5 Environmental assessment process

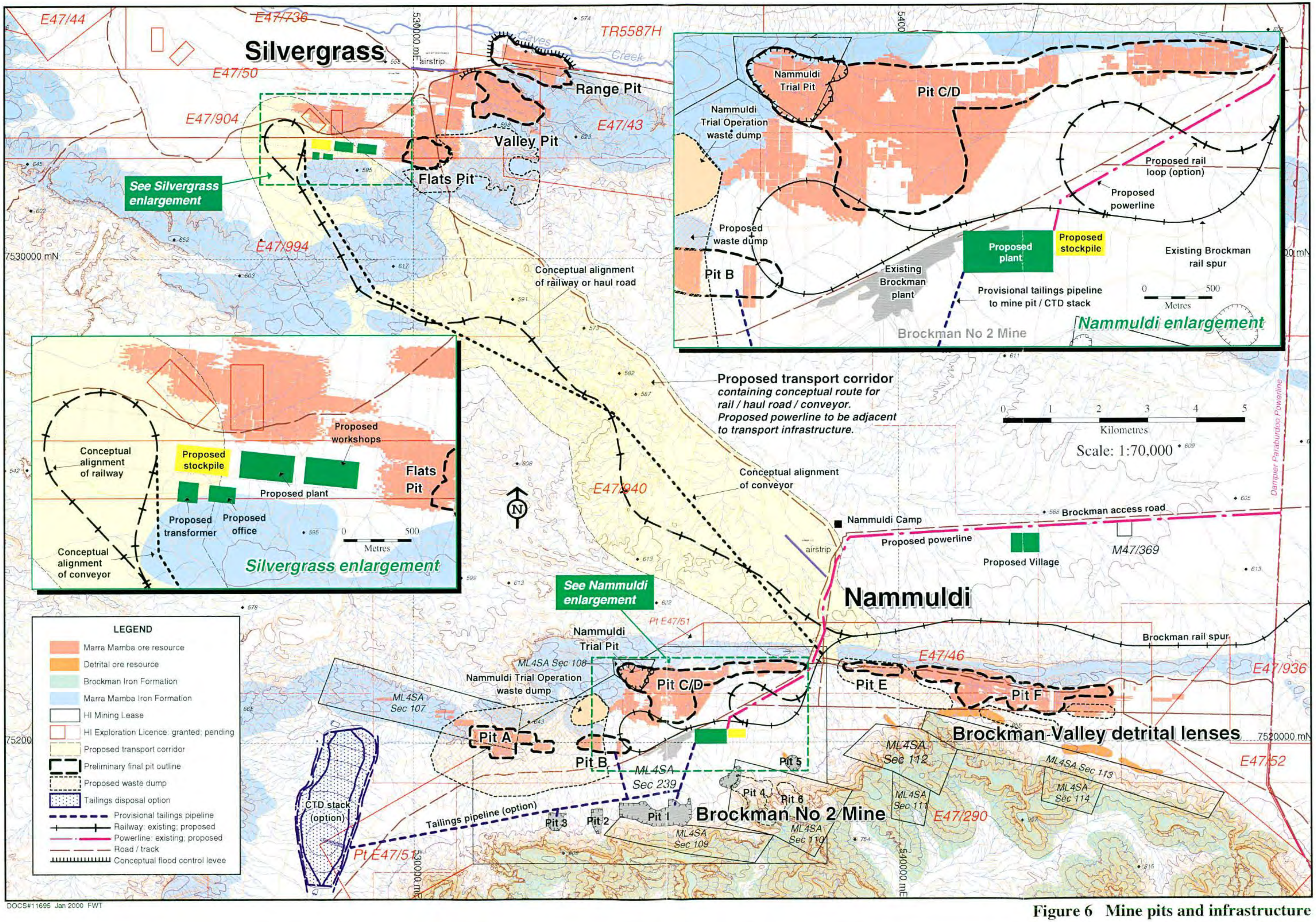


Figure 6 Mine pits and infrastructure

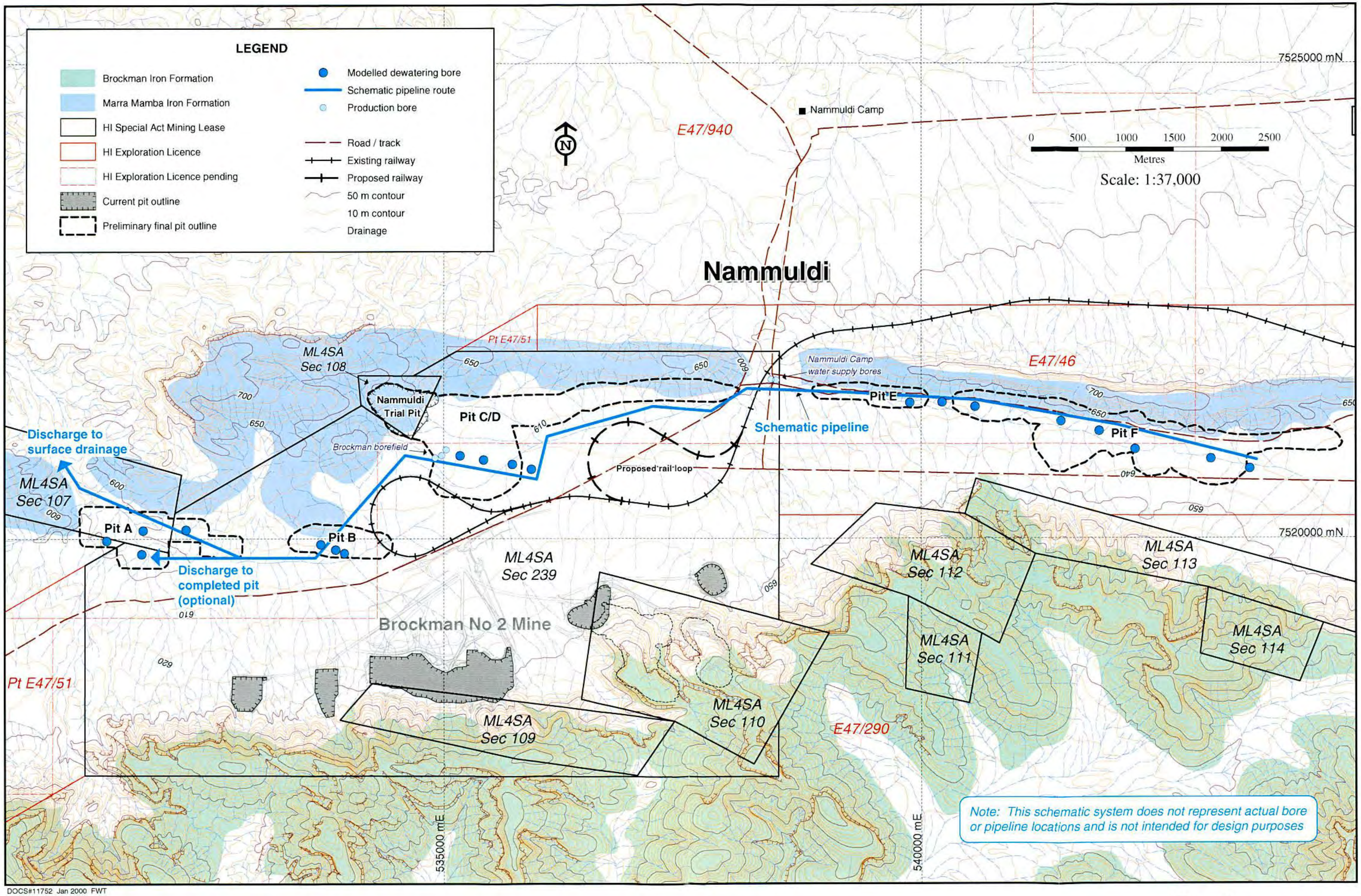


Figure 7
Schematic dewatering system - Nammuldi

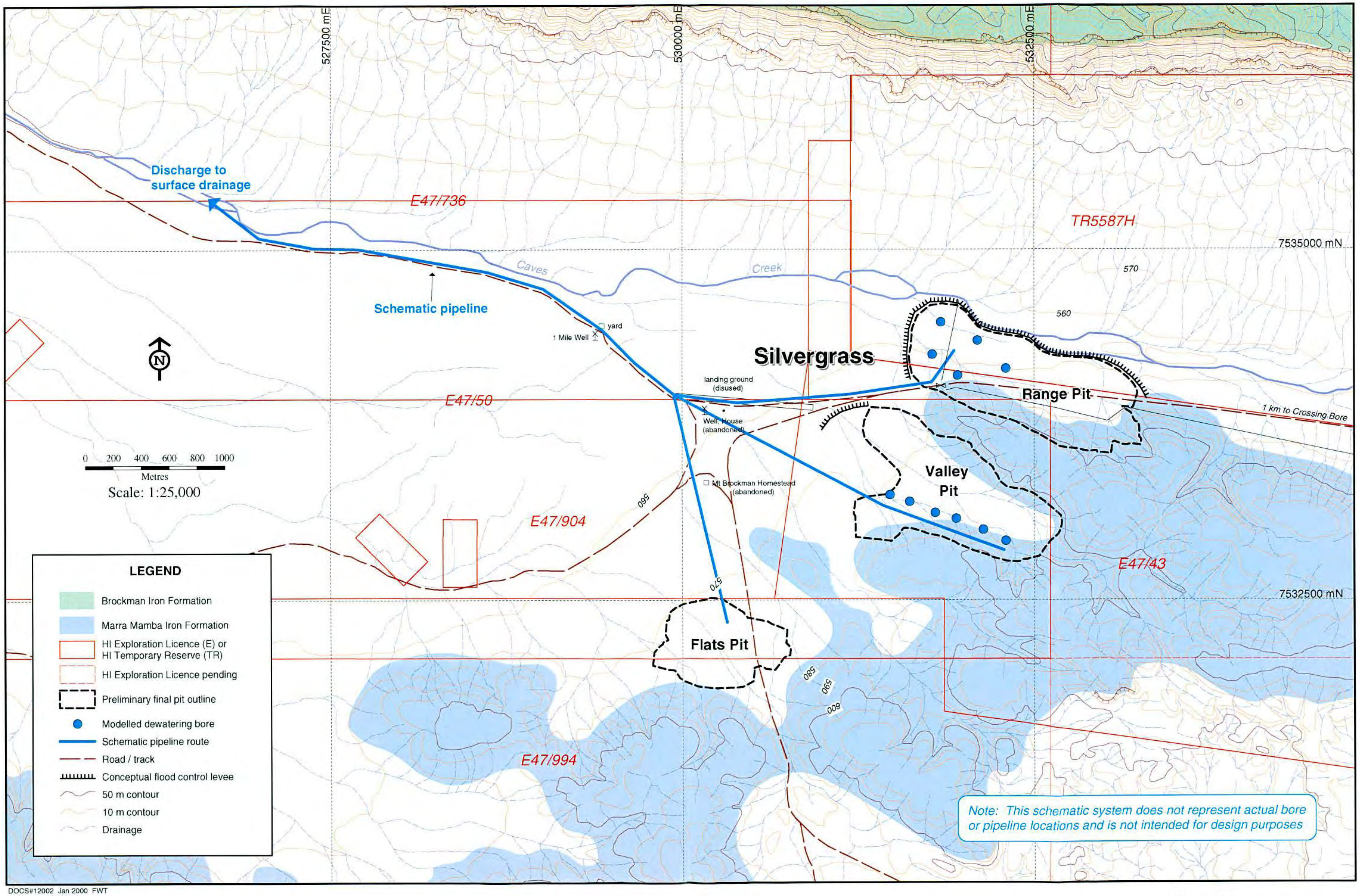
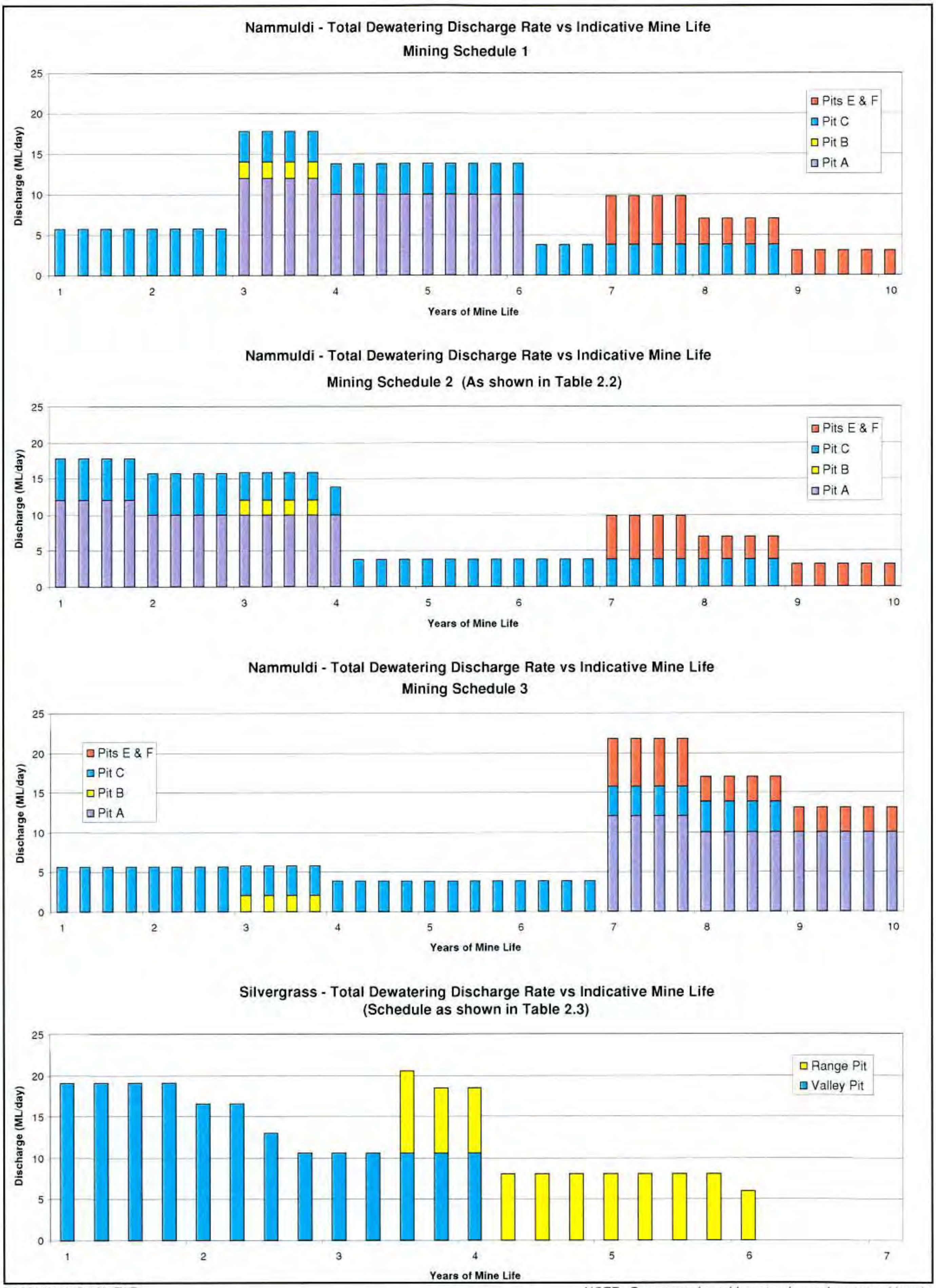


Figure 8
Schematic dewatering system - Silvergrass



DOCS#12040 Oct 99 FWT

NOTE: Process and potable water demands not considered

Figure 9 Annualised dewatering discharge rates for various mining schedules

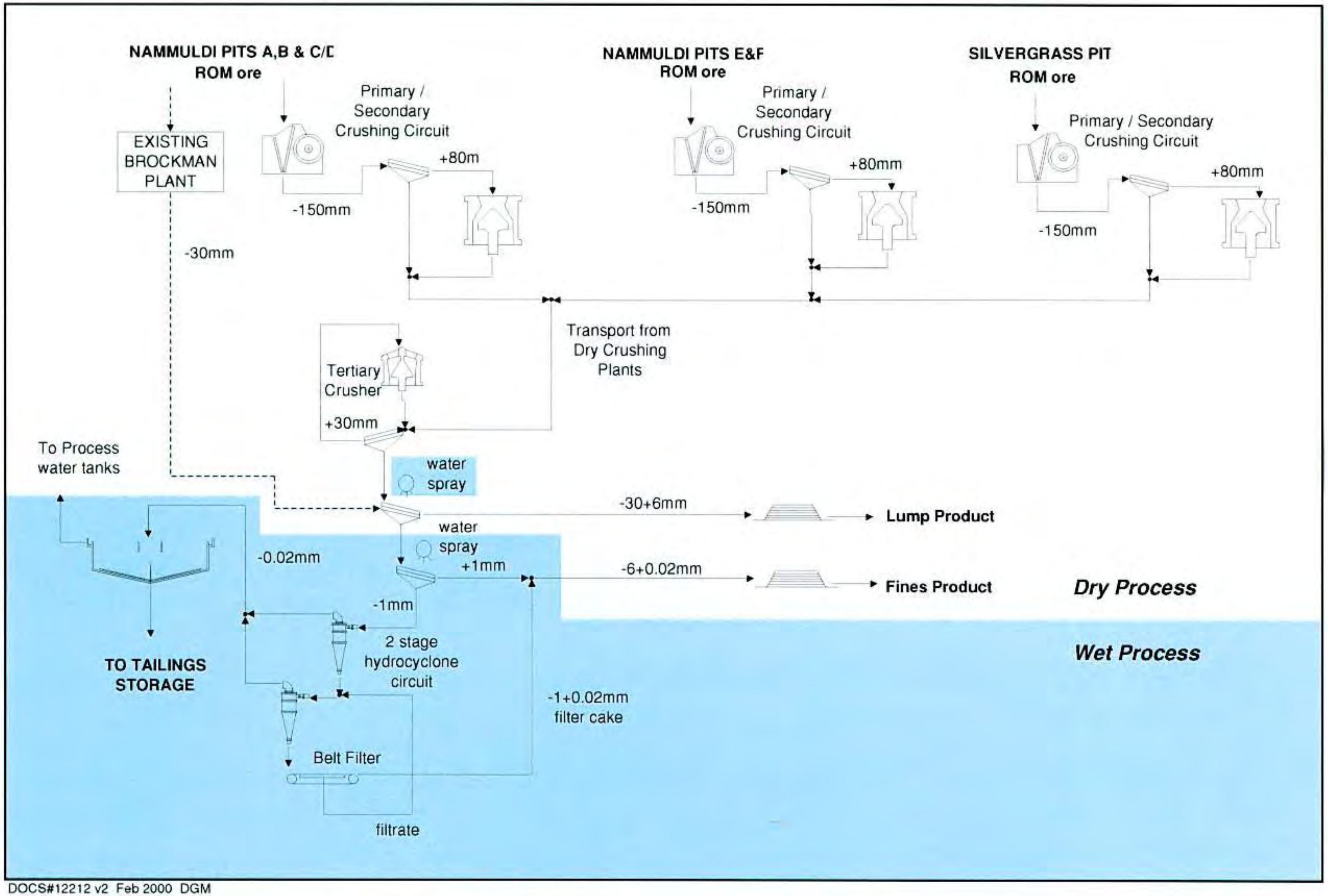


Figure 10 Schematic flowsheet for Nammuldi wet plant

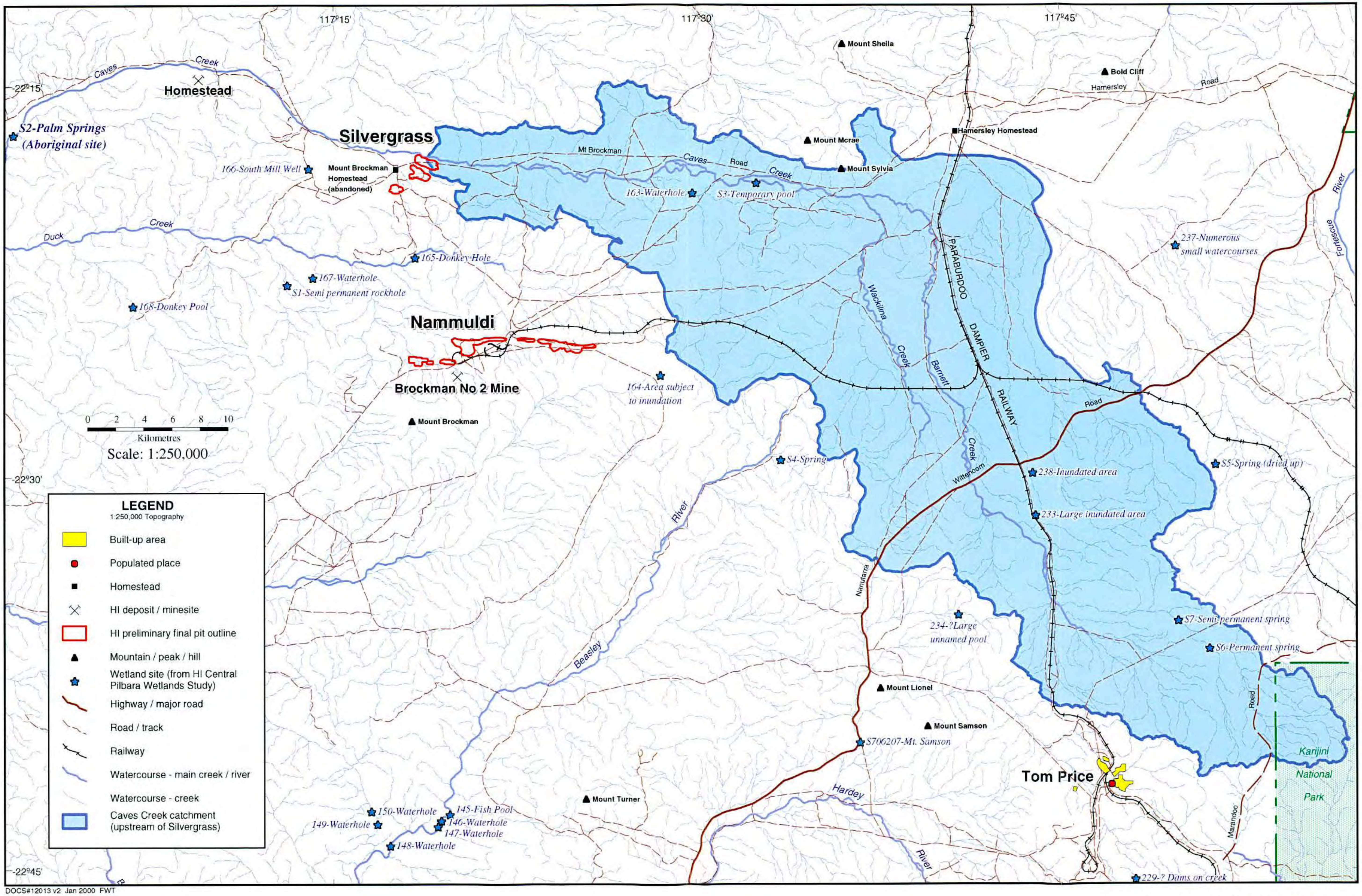


Figure 11 Caves Creek catchment and wetland areas

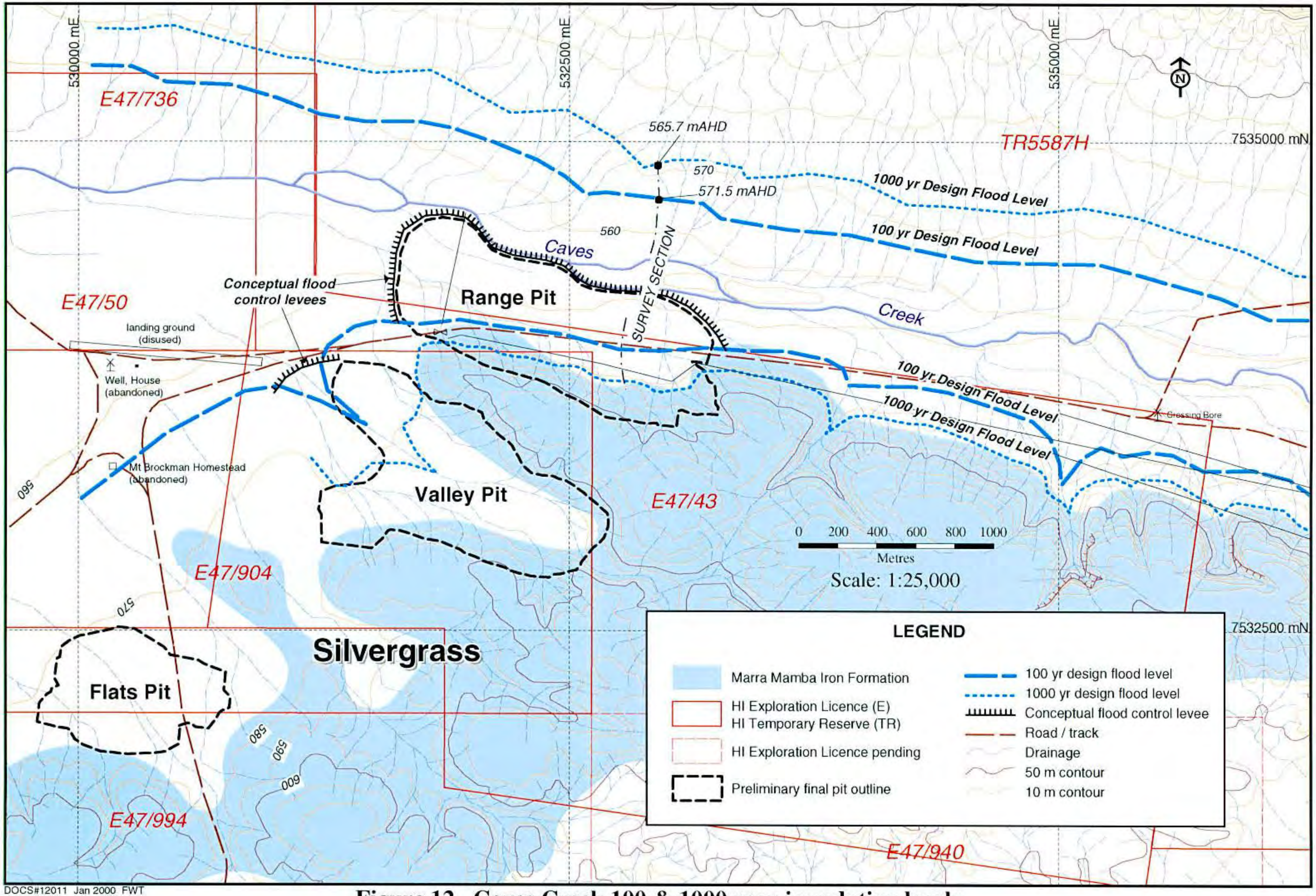


Figure 12 Caves Creek 100 & 1000 year inundation levels

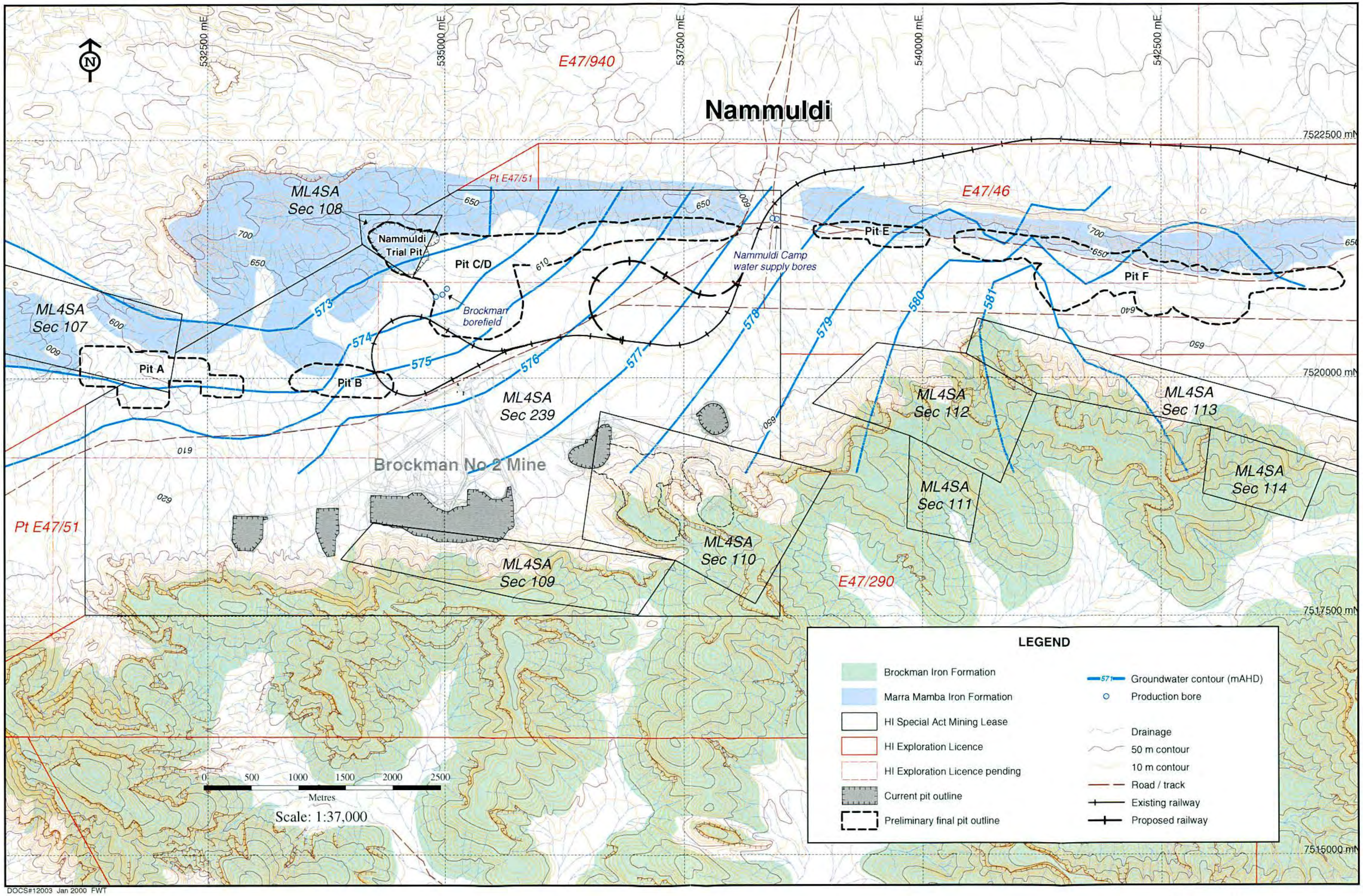


Figure 13
Groundwater level contours - Nammuldi

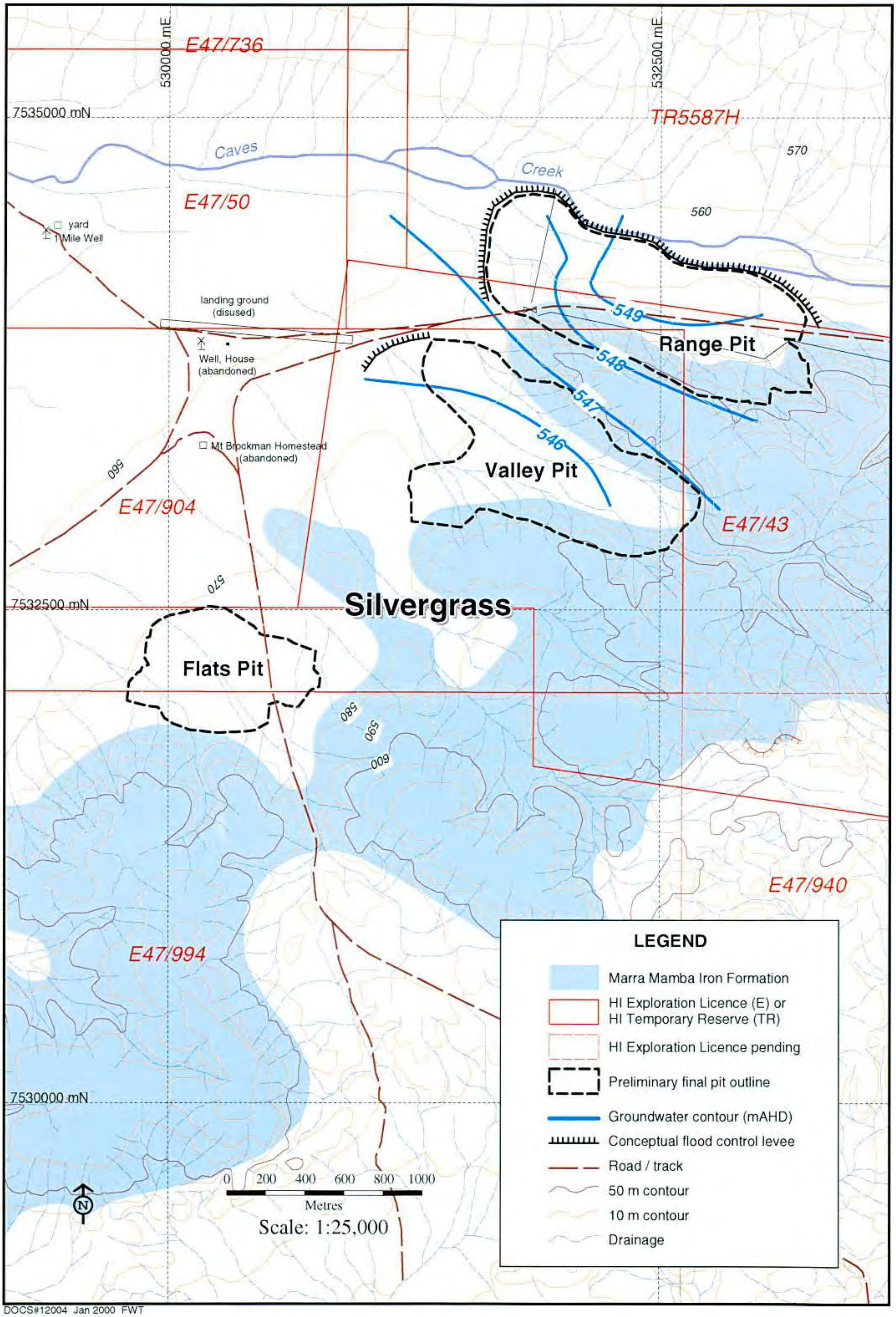


Figure 14 Groundwater level contours - Silvergrass

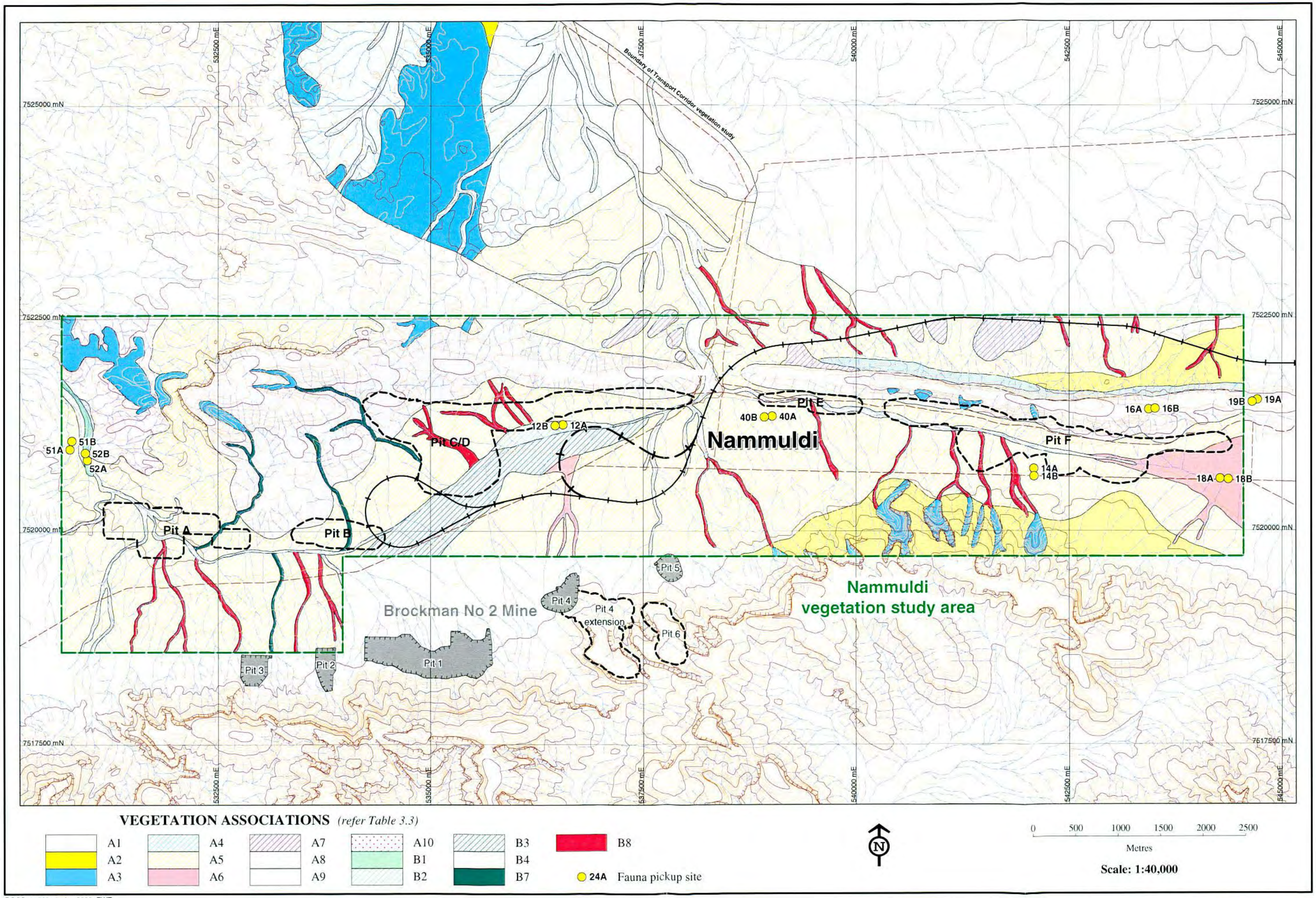
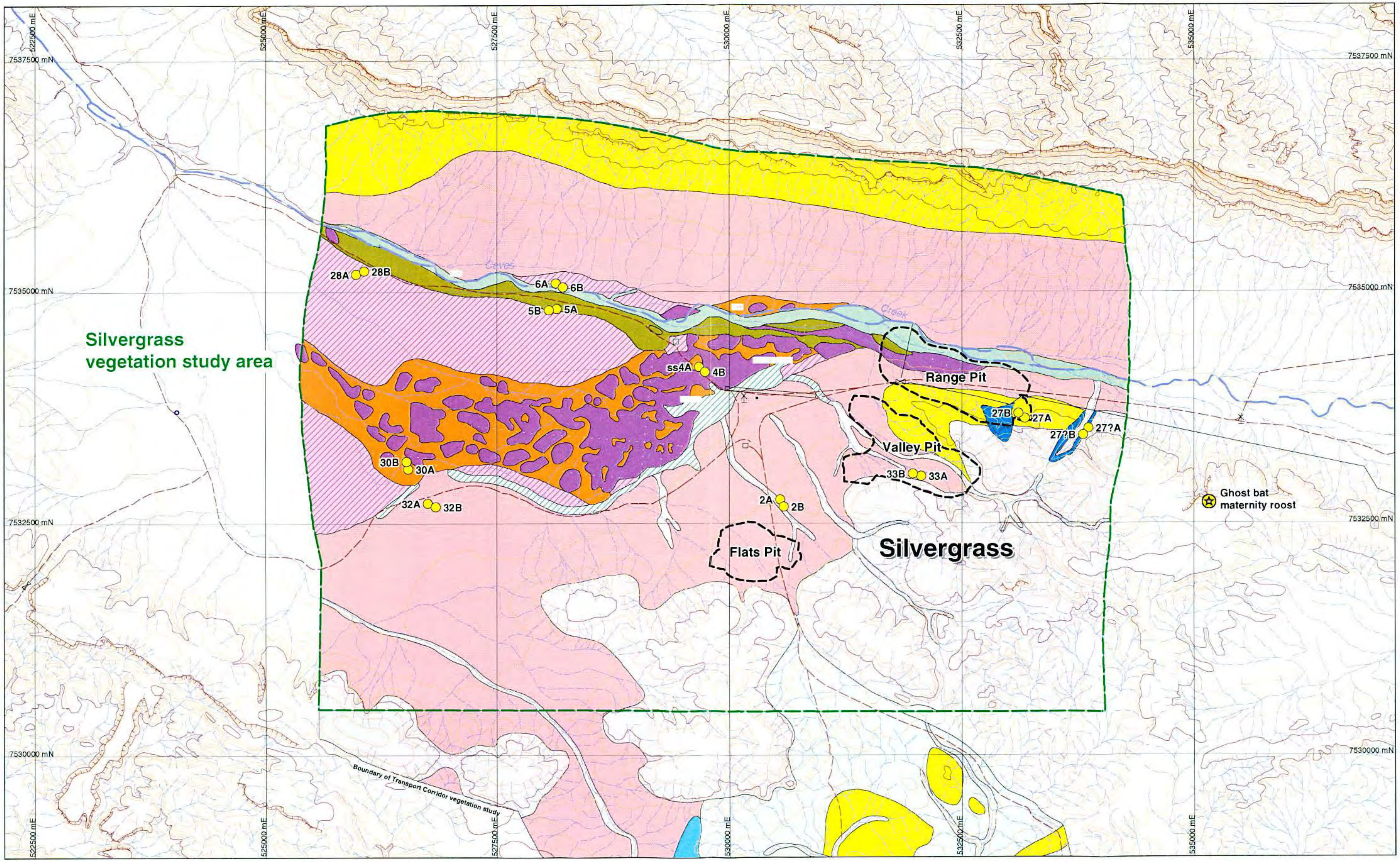


Figure 15 Vegetation (and fauna sites) - Nammuldi



VEGETATION ASSOCIATIONS *(refer Table 3.3)*

A1	A6	B2	C2
A2	A9	B4	C3
A3	B1	C1	C4

24A Fauna pickup site

N

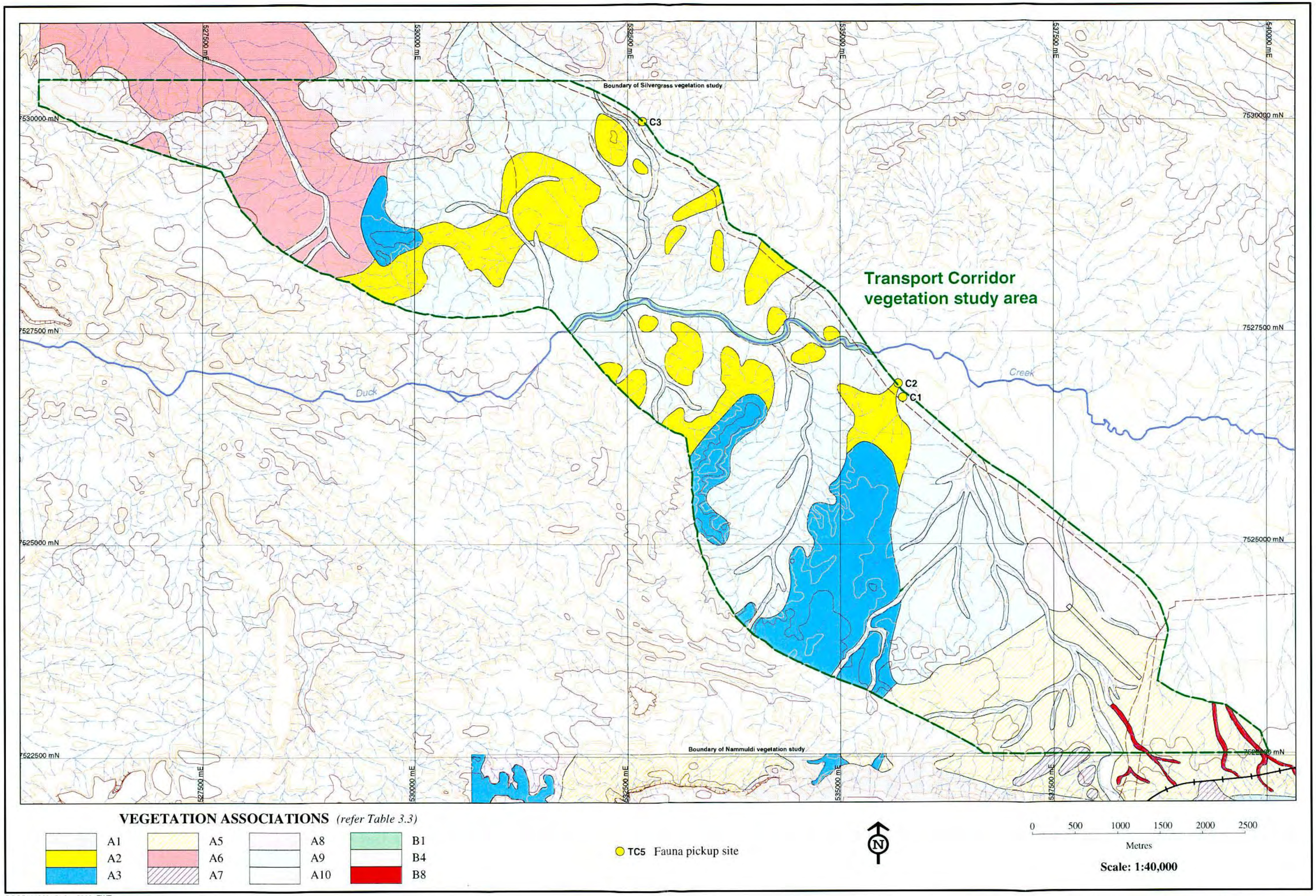
0 500 1000 1500 2000 2500

Metres

Scale: 1:40,000

DOCS#11660 v3 Jan 2000 FWT

Figure 16 Vegetation (and fauna sites) - Silvergrass



DOCS#11660 v3 Jan 2000 FWT

Figure 17 Vegetation (and fauna sites) - transport corridor

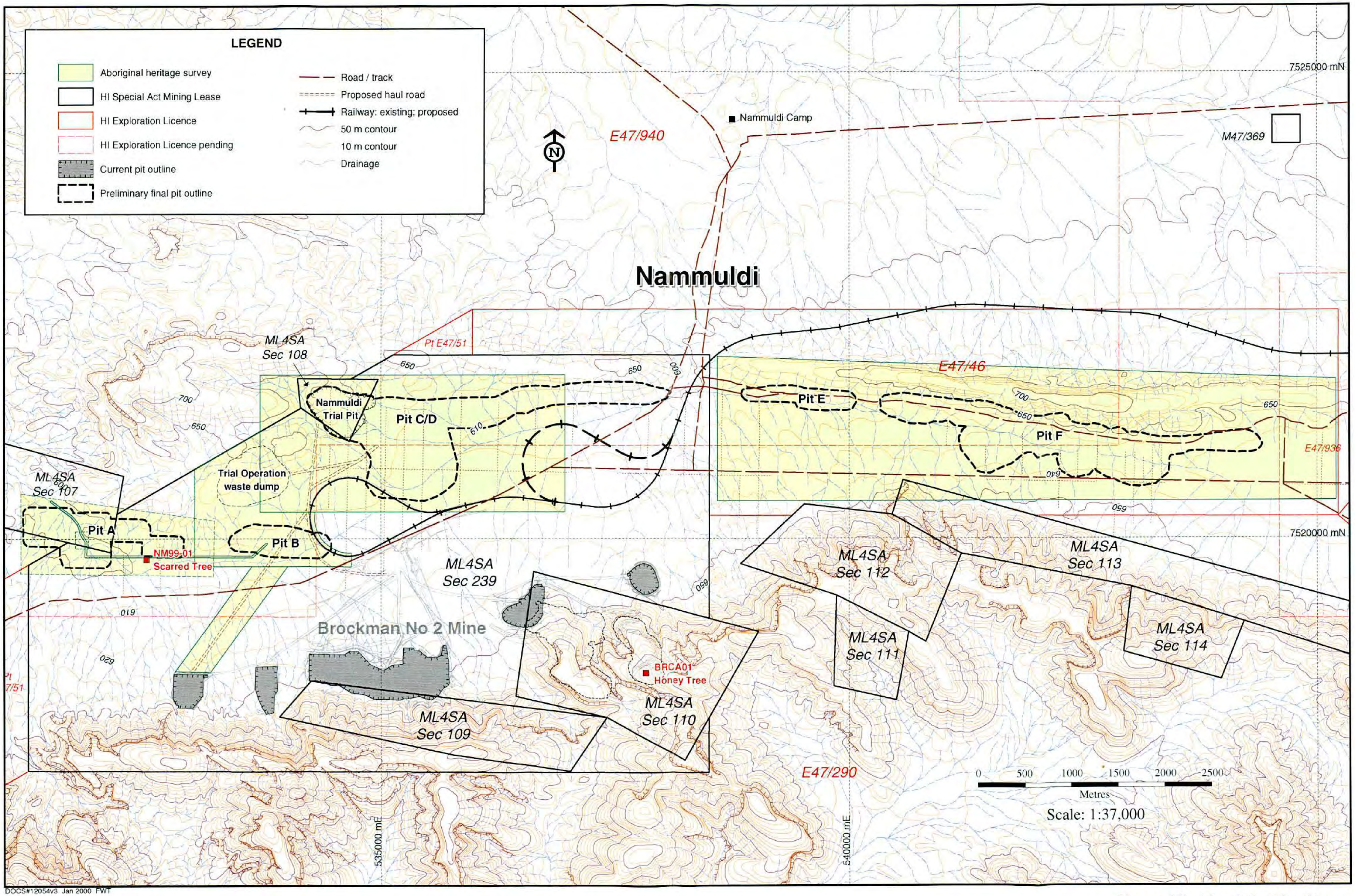
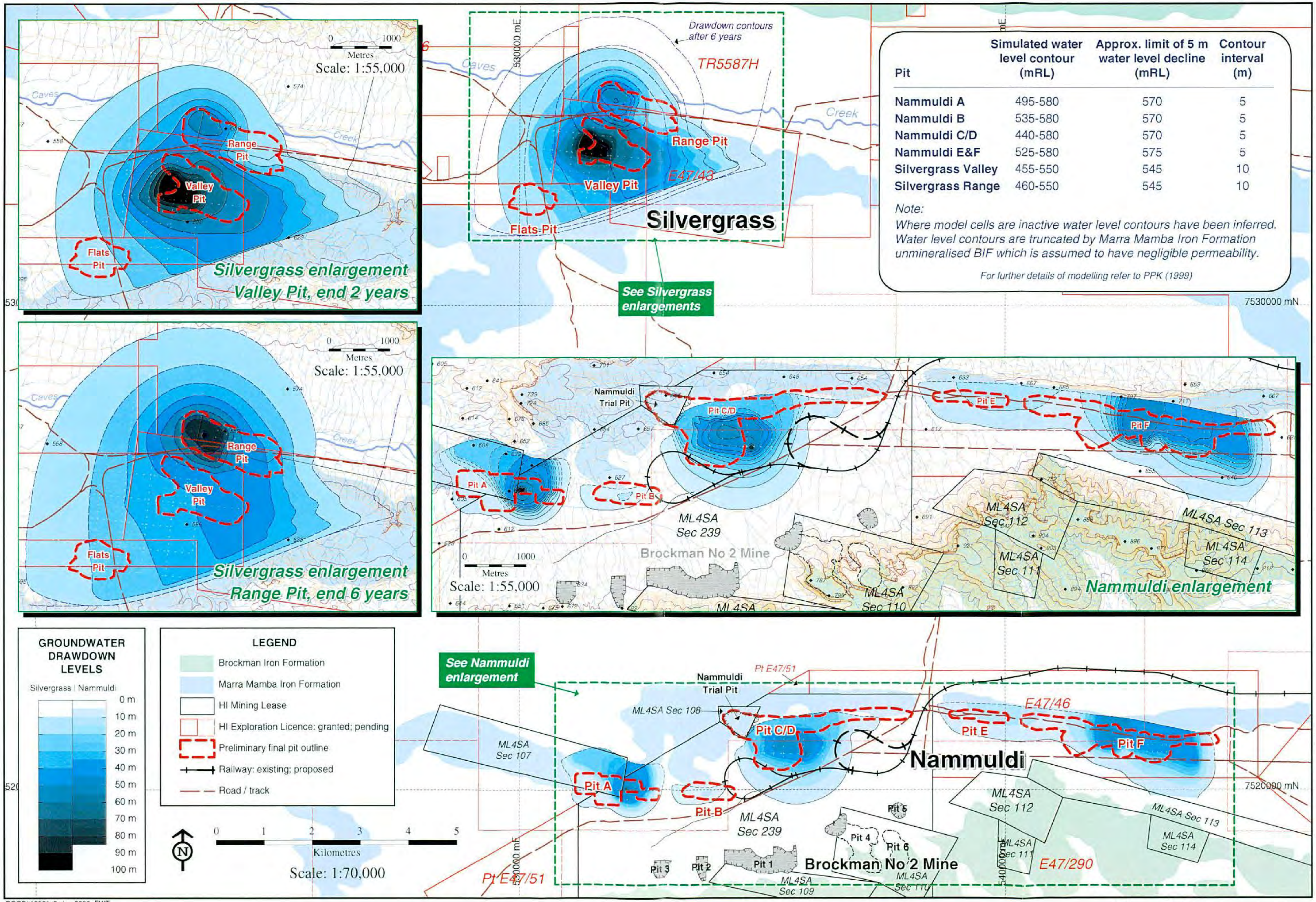


Figure 18 Aboriginal heritage (archaeological) survey coverage



Pit	Simulated water level contour (mRL)	Approx. limit of 5 m water level decline (mRL)	Contour interval (m)
Nammuldi A	495-580	570	5
Nammuldi B	535-580	570	5
Nammuldi C/D	440-580	570	5
Nammuldi E&F	525-580	575	5
Silvergrass Valley	455-550	545	10
Silvergrass Range	460-550	545	10

DOCS#12061v2 Jan 2000 FWT

Figure 19
Schematic predicted groundwater drawdown

Appendix A
EPA Guidelines for the Project

THE GOVERNMENT OF WESTERN AUSTRALIA

Environmental Protection Authority
Guidelines

NAMMULDI/SILVERGRASS IRON ORE PROJECT, 55 KM NORTH-WEST OF TOM PRICE

(Assessment Number 1247)

Part A	Specific Guidelines for the preparation of the Consultative Environmental Review
Part B	Generic Guidelines for the preparation of an environmental review document

Attachment 1	Example of the invitation to make a submission
Attachment 2	Advertising the environmental review
Attachment 3	Regional location map
Attachment 4	Nammuldi/Silvergrass deposits figure

These guidelines are provided for the preparation of the proponent's environmental review document. The specific environmental factors to be addressed are identified in Part A. The generic guidelines for the format of an environmental review document are provided in Part B.

The environmental review document must address all elements of Part 'A' and Part 'B' of these guidelines prior to approval being given to commence the public review.

Part A: Specific Guidelines for the preparation of the Consultative Environmental Review

1. The proposal

Hamersley Iron Pty Limited (the proponent) intends to develop two iron ore deposits near its current Brockman No. 2 iron ore mine, 65 km north-west of Tom Price. The proposed project areas are indicated on the attached plan (Attachment 3).

Hamersley proposes to mine the Nammuldi/Silvergrass deposits shown in Attachment 4. The deposits contain Marra Mamba ore, plus some separate detrital ore that is to be included as a secondary resource. The existing Brockman No. 2 loadout facilities and rail spur would be utilised where practicable to transport the ore from the mine. Some modifications to the rail loop and/or additional load-out facilities may be required.

Both deposits will involve mining below the water table, with approximately 80% of the mineable Marra Mamba ore being below the watertable. Therefore a substantial dewatering operation will be required during mining.

High stripping ratios will result in significant volumes of waste rock. Hamersley intends to backfill much of the waste rock into the mine voids to at least the height of the original water table in each pit.

Ore from the two mines will be hauled by road/rail to a processing plant at either Nammuldi or Brockman No. 2. Processing will involve crushing and screening and may include some form of beneficiation. Should a wet processing option be selected, tailings would report to either an existing Brockman No. 2 void, or alternatively, a constructed tailings storage facility.

Could you please supply the project officer with an electronic copy of the document for use on Macintosh, Microsoft Word Version 6, and any scanned figures. Where possible, figures should be reproducible in a black and white format.

2. Environmental factors relevant to this proposal

At this preliminary stage, the Environmental Protection Authority (EPA) believes the relevant environmental factors, objectives and work required is as detailed in the table below:

CONTENT		SCOPE OF WORK	
Factor	**Site specific factor**	**EPA objective**	**Work required for the environmental review**
BIOPHYSICAL			
Terrestrial Flora	Vegetation communities	Maintain the abundance and diversity of species, and geographic distribution and productivity of vegetation communities.	Baseline studies to identify existing vegetation communities. Assessment of potential impacts (direct and indirect) on vegetation communities as a result of mining activities and infrastructure. If there exists the potential for impacts on Mulga communities, then reference should be made to the draft Central Pilbara Mulga Study. Proposed measures to manage impacts. The following EPA *Guidance for the Assessment of Environmental Factors* may also be relevant to this proposal in regard to this factor: • No. 5 "Rangelands (State) Protection"
	Declared Rare and Priority Flora	Protect Declared Rare and Priority Flora, consistent with the provisions of the Wildlife Conservation Act 1950.	Baseline studies to identify any Declared Rare and/or Priority Flora. Assessment of potential impacts (direct and indirect) on vegetation communities as a result of mining activities and infrastructure. Proposed measures to manage impacts

Terrestrial Fauna		Maintain the abundance, species diversity and geographical distribution of terrestrial fauna.	Baseline studies to identify existing terrestrial fauna throughout the areas to be affected by the proposal. Assessment of potential impacts (direct and indirect) on terrestrial fauna as a result of mining and associated activities. Proposed measures to manage impacts. The following EPA *Guidance for the Assessment of Environmental Factors* may also be relevant to this proposal in regard to this factor: • No. 5 "Rangelands (State) Protection"
	Specially Protected (Threatened) Fauna	Protect Specially Protected (Threatened) Fauna, consistent with the provisions of the Wildlife Conservation Act 1950.	Baseline studies to identify Specially Protected (Threatened) Fauna which may be found within the areas to be affected by the proposal. Assessment of potential impacts (direct and indirect) on terrestrial fauna as a result of mining and associated activities. Proposed measures to manage impacts.
Subterranean Fauna		(i) Ensure that subterranean fauna are adequately protected, in accordance with the Wildlife Conservation Act 1950; (ii) Maintain the abundance, diversity and geographical distribution of subterranean fauna; and (iii)Improve our understanding of subterranean fauna through appropriate research including sampling, identification and documentation.	Baseline studies to determine the likelihood of subterranean fauna living within the project area or areas which could be affected by proposed operations. This will require identification of potential subterranean fauna habitats in the areas to be affected by the proposal. Assessment of potential impacts (direct and indirect) on subterranean fauna as a result of mining and associated activities. Proposed measures to manage impacts.

Watercourses		Maintain the integrity, functions and environmental values of watercourses.	Baseline studies to identify watercourses, and types of surface water flow throughout the areas to be affected by the proposal. Description of proposed dewatering operations. Assessment of the potential impacts on surface water flow rates, drainage patterns, sediment transport, riparian vegetation, and pools, as a result of mining and associated activities. Assessment of the potential for increased erosion over the minesite as a result of earthworks and changes to surface water patterns. Proposed measures to manage impacts.
Groundwater		Maintain the quantity of groundwater so that existing and potential uses, including ecosystem maintenance, are protected.	Details of the hydrogeological systems of the project area, existing beneficial uses of groundwater (including ecosystem maintenance), and the proposed dewatering operations. Assessment of the potential short-term and long-term impacts on groundwater systems as a result of below-the-watertable mining. Proposed measures to manage impacts. The following EPA *Guidance for the Assessment of Environmental Factors* may also be relevant to this proposal in regard to this factor: • No. 48 “"Groundwater Environmental Management Areas"
Landform		Ensure that, as far as is practicable, the post-mining landform is stable, and is integrated into the surrounding environment.	Assessment of potential impacts of the proposal on existing landforms. Evaluation of the landscape values of the project area and how these will be affected by the proposal. Details of measures proposed to rehabilitate the impacted areas to an acceptable standard and which will integrate the post mining landform with the surrounding environment.

POLLUTION MANAGEMENT

Particulates / Dust		(i) Ensure that particulate/dust emissions, both individually and cumulatively, meet appropriate criteria and do not cause an environmental or human health problem; and (ii) Use all reasonable and practicable measures to minimise the discharge of particulates/dust.	Identification of sources of particulates/dust and estimates of project-wide emissions. Analysis of the significance of these emissions with regard to human health and environmental impacts, in particular, impacts on vegetation. Proposed measures to manage potential impacts.
Greenhouse gases		(i) to minimise greenhouse gas emissions for the project and reduce emissions per unit product to as low as reasonably practicable; and (ii) to mitigate greenhouse gases emissions in accordance with the Framework Convention on Climate Change 1992, and in accordance with established Commonwealth and State policies.	Details of potential sources of greenhouse gases and estimates of the quantities of these gases produced annually. Proposed measures to minimise greenhouse gas emissions. (Refer to EPA Interim Guidance for the Assessment of Environmental Factors No. 12, *Minimising Greenhouse Gases*.)
Groundwater quality		Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993) and the NHMRC / ARMCANZ Australian Drinking Water Guidelines - National Water Quality Management Strategy.	Details of the existing water quality of groundwater aquifers. Identification of potential sources of contamination associated with the proposal, details of the dewatering operation, and a description of the long-term closure plans for the final pit voids. Assessment of the potential impacts on groundwater quality, including assessment of the potential short-term and long-term impacts on groundwater quality, particularly as a result of below-the-watertable mining. Proposed measures to manage impacts.
Surface water quality		Maintain or improve the quality of surface water to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993) and the NHMRC / ARMCANZ Australian Drinking Water Guidelines - National Water Quality Management Strategy.	Details of site drainage, hydrocarbon use, dewatering, and fate of water used/pumped. Assessment of the implications this may have on local surface water quality. Proposed measures to manage impacts.

Solid waste		Ensure that wastes are contained and isolated from ground and surface water surrounds and treatment or collection does not result in long term impacts on the natural environment.	Details of the composition and storage of all solid wastes, in particular, details on the proposed disposal of tailings. Potential for waste rock to generate acid mine drainage. Assessment of the implications this may have on groundwater quality. Proposed measures to manage impacts.
Noise		Protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring that noise levels meet statutory requirements and acceptable standards.	Estimate the potential increase in noise resulting from the construction and operation of the project. Comparison of estimates with relevant standards and limits.
SOCIAL SURROUNDINGS			
Culture and Heritage	Aboriginal culture and heritage	(i) Ensure that the proposal complies with the requirements of the Aboriginal Heritage Act 1972; and (ii) Ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area.	Identify Aboriginal cultural and heritage sites of significance through archaeological and ethnographic surveys of the project area and through consultation with local Aboriginal groups and the Aboriginal Affairs Department. Consult with the Aboriginal people of the area to determine potential impacts of the proposal on cultural associations with the project area. Proposed measures to manage impacts.

These factors should be addressed within the environmental review document for the public to consider and make comment to the EPA. The EPA expects to address these factors in its report to the Minister for the Environment.

The EPA expects the proponent to take due care in ensuring any other relevant environmental factors which may be of interest to the public are addressed.

3. Availability of the environmental review

3.1 Copies for distribution free of charge

Supplied to DEP:

- Library/Information Centre.................................9
- EPA members...6
- Officers of the DEP (Perth)...............................6

Distributed by the proponent to:

Government departments	• Department of Conservation and Land Management...2 • Department of Minerals and Energy.......................2 • Department of Resources Development...................1 • Pollution Prevention Division, Department of Environmental Protection..1 • Pilbara Regional Office, Department of Environmental Protection..................................2 • Aboriginal Affairs Department.............................1 • Water and Rivers Commission ....2 • Environment Australia......................................1 • Western Australian Museum...............................1 • Water Corporation..1 • Pilbara Development Commission........................1
Local government authorities	• Shire of Ashburton..2
Libraries	• J S Battye Library..3
Other	• Conservation Council of WA..............................1 • Innawonga Aboriginal Corporation.......................1 • Wakathuni Aboriginal Corporation........................1

3.2 Available for public viewing

- J S Battye Library;
- Department of Environmental Protection Library; and
- Pilbara Regional Office, Department of Environmental Protection

Part B: Generic Guidelines for the preparation of an environmental review document

1. Overview

All environmental reviews have the objective of protecting the environment. Environmental impact assessment is deliberately a public process in order to obtain broad ranging advice. The review requires the proponent to describe:

- the proposal;
- receiving environment;
- potential impacts of the proposal on factors of the environment; and
- proposed management strategies to ensure those environmental factors are appropriately protected.

Throughout the assessment process it is the objective of the Environmental Protection Authority (EPA) to help the proponent to improve the proposal so the environment is protected. The DEP will co-ordinate, on behalf of the EPA, relevant government agencies and the public in providing advice about environmental matters during the assessment of the environmental review for this proposal.

The primary purpose of the environmental review is to provide information on the proposal within the local and regional framework to the EPA, with the aim of emphasising how the proposal may impact the relevant environmental factors and how those impacts may be mitigated and managed.

The language used in the body of the environmental review should be kept simple and concise, considering the audience includes non-technical people, and any extensive, technical detail should either be referenced or appended to the environmental review. It should be noted that the environmental review will form the legal basis of the Minister for the Environment's approval of the proposal and therefore the environmental review should include a description of all the main and ancillary components of the proposal, including options where relevant.

Information used to reach conclusions should be properly referenced, including personal communications. Such information should not be misleading or presented in a way that could be construed to mislead readers. Assessments of the significance of an impact should be soundly based rather than unsubstantiated opinion, and each assessment should lead to a discussion of the management of the environmental factor.

2. Objectives of the environmental review

The objectives of the environmental review are to:

- place this proposal in the context of the local and regional environment;
- adequately describe all components of the proposal, so that the Minister for the Environment can consider approval of a well-defined project;
- provide the basis of the proponent's environmental management program, which shows that the environmental impacts resulting from the proposal, including cumulative impact, can be acceptably managed; and

- communicate clearly with the public (including government agencies), so that the EPA can obtain informed public comment to assist in providing advice to government.

3. Environmental management

The EPA expects the proponent to have in place an environmental management system appropriate to the scale and impacts of the proposal including provisions for performance review and a commitment to continuous improvement. The system may be integrated with quality and health and safety systems and should include the following elements:

- environmental policy and commitment;
- planning of environmental requirements;
- implementation and operation of environmental requirements;
- measurement and evaluation of environmental performance;
- review and improvement of environmental outcomes.

A description of the proposed environmental management system should be included in the environmental review documentation. If appropriate, the documentation can be incorporated into a formal environmental management system (such as AS/NZS ISO 14001). Public accountability should be incorporated into the approach on environmental management.

The environmental management program (EMP) is the key document of an environmental management system that should be adequately defined in an environmental review document. The EMP should provide plans to manage the relevant environmental factors, define the performance objectives, describe the resources to be used, outline the operational procedures and outline the monitoring and reporting procedures which would demonstrate the achievement of the objectives.

4. Format of the environmental review document

The environmental review should be provided to the DEP officer for comment. At this stage the document should have all figures produced in the final format and colours.

Following approval to release the review for public comment, the final document should also be provided to the DEP in an electronic format.

The proponent is requested to supply the project officer with an electronic copy of the environmental review document for use on Macintosh, Microsoft Word Version 6, and any scanned figures. Where possible, figures should be reproducible in a black and white format.

5. Contents of the environmental review document

The contents of the environmental review should include an executive summary, introduction and at least the following:

5.1 The proposal

A comprehensive description of the proposal including its location (address and certificate of title details where relevant) is required.

Justification and alternatives

- justification and objectives for the proposed development;
- the legal framework, including existing zoning and environmental approvals, and decision making authorities and involved agencies; and
- consideration of alternative options.

Key characteristics

The Minister's statement will bind the proponent to implementing the proposal in accordance with any technical specifications and key characteristics[1] in the environmental review document. It is important therefore, that the level of technical detail in the environmental review, while sufficient for environmental assessment, does not bind the proponent in areas where the project is likely to change in ways that have no environmental significance.

Include a description of the components of the proposal, including the nature and extent of works proposed. This information must be summarised in the form of a table as follows:

[1] Changes to the key characteristics of the proposal following final approval, would require assessment of the change and can be treated as non-substantial and approved by the Minister, if the environmental impacts are not significant. If the change is significant, it would require assessment under section 38 or section 46. Changes to other aspects of the proposal are generally inconsequential and can be implemented without further assessment. It is prudent to consult with the Department of Environmental Protection about changes to the proposal.

Table 1: Key characteristics (example only)

Element	Description
Life of project (mine production)	< 5yrs (continual operation)
Size of ore body	682 000 tonnes (upper limit)
Area of disturbance (including access)	100 hectares
List of major components • pit • waste dump • infrastructure (water supply, roads, etc)	refer plans, specifications, charts section immediately below for details of map requirements
Ore mining rate • maximum	 • 200 000 tonnes per year
Solid waste materials • maximum	 • 800,000 tonnes per year
Water supply • source • maximum hourly requirement • maximum annual requirement	 • XYZ borefield, ABC aquifer • 180 cubic metres • 1 000 000 cubic metres
Fuel storage capacity and quantity used	litres; litres per year
Heavy mineral concentrate transport • truck movements (maximum)	 • 75 return truck loads per week

Plans, Specifications, Charts

Adequately dimensioned plans showing clearly the location and elements of the proposal which are significant from the point of view of environmental protection, should be included. The location and dimensions (for progressive stages of development, if relevant) of plant, amenities buildings, accessways, stockpile areas, dredge areas, waste product disposal and treatment areas, all dams and water storage areas, mining areas, storage areas including fuel storage, landscaped areas etc.

Only those elements of plans, specifications and charts that are significant from the point of view of environmental protection are of relevance here.

Figures that should always be included are:

- a map showing the proposal in the local context - an overlay of the proposal on a base map of the main environmental constraints;
- a map showing the proposal in the regional context; and, if appropriate,
- a process chart / mass balance diagram showing inputs, outputs and waste streams.

The plan/s should include contours, a north arrow, a scale bar, a legend, grid co-ordinates, the source of the data, and a title. If the data is overlaid on an aerial photo then the date of the aerial photo should be shown.

Other logistics

- timing and staging of project; and
- ownership and liability for waste during transport, disposal operations and long-term disposal (where appropriate to the proposal).

5.2 Environmental factors

The environmental review should focus on the relevant environmental factors for the proposal, and these should be agreed in consultation with the EPA and DEP and relevant public and government agencies. Preliminary environmental factors identified for the proposal are shown in Part A of these guidelines.

Further environmental factors may be identified during the preparation of the environmental review, therefore on-going consultation with the EPA, DEP and other relevant agencies is recommended. The DEP can advise the proponent on the recommended EPA objective for any new environmental factors raised. Minor matters which can be readily managed as part of normal operations for the existing operations or similar projects may be briefly described.

Items that should be discussed under each environmental factor are:

- a clear definition of the area of assessment for this factor;
- the EPA objective for this factor;
- a description of what is being affected - why this factor is relevant to the proposal;
- a description of how this factor is being affected by the proposal - the predicted extent of impact;
- a description of where this factor fits into the broader environmental / ecological context (only if relevant - this may not be applicable to all factors);
- a straightforward description or explanation of any relevant standards / regulations / policy;
- environmental evaluation - does the proposal meet the EPA's objective as defined above;
- if not, environmental management proposed to ensure the EPA's objective is met;
- predicted outcome.

The proponent should provide a summary table of the above information for all environmental factors, under the three categories of biophysical, pollution management and social surroundings:

Table 2: Environmental factors and management (example only)

Environmental Factor	EPA Objective	Existing environment	Potential impact	Environmental management	Predicted outcome
BIOPHYSICAL					
vegetation community types 3b and 20b	Maintain the abundance, species diversity, geographic distribution and productivity of vegetation community types 3b and 20b	Reserve 34587 contains 45 ha of community type 20b and 34 ha of community type 3b	Proposal avoids all areas of community types 20b and 3b	Surrounding area will be fully rehabilitated following construction	Community types 20b and 3b will remain untouched Area surrounding will be revegetated with seed stock of 20b and 3b community types
POLLUTION MANAGEMENT					
Dust	Ensure that the dust levels generated by the proposal do not adversely impact upon welfare and amenity or cause health problems by meeting statutory requirements and acceptable standards	Light industrial area - three other dust producing industries in close vicinity Nearest residential area is 800 metres	Proposal may generate dust on two days of each working week.	Dust Control Plan will be implemented	Dust can be managed to meet EPA's objective
SOCIAL SURROUNDINGS					
Visual amenity	Visual amenity of the area adjacent to the project should not be unduly affected by the proposal	Area already built-up	This proposal will contribute negligibly to the overall visual amenity of the area	Main building will be in 'forest colours' and screening trees will be planted on road	Proposal will blend well with existing visual amenity and the EPA's objective can be met

5.3 Environmental management commitments

The implementation of the key characteristics of the proposal and the environmental management commitments made by the proponent become legally enforceable under the conditions of environmental approval issued in the statement by the Minister for the Environment. All the auditable environmental management commitments should be consolidated in the public review document in a list (usually in an Appendix). This list is attached to the Minister's statement and becomes part of the conditions of approval.

The proponent's compliance with the consolidated environmental management commitments will be audited by the DEP, so they must be expressed in a way which enables them to be audited.

A commitment needs to contain most (if not all) of the following elements to be auditable:

- who (eg. the proponent)

- will do <u>what</u> (eg. prepare a plan, take action)
- <u>why</u> (to meet an environmental objective)
- <u>where</u>/how (detail the action and where it applies)
- <u>when</u> (in which phase, eg. before construction starts)
- to <u>what standard</u> (recognised standard or agency to be satisfied)
- <u>on advice from</u> (agency to be consulted).

The proponent may make other 'commitments', which address less significant or non-environmental matters, to show an intention to good general management of the project. Such 'commitments' (or management strategies/policies) would not be included in the consolidated list of environmental management commitments appended to the statement.

Continuous improvement during the implementation of the consolidated commitments may necessitate changes whilst ensuring the environmental objective is still achieved; these can be made in updates to the environmental management plan. Modified and/or additional proponent commitments arising from the fulfilment of environmental conditions will be audited by the DEP and should follow the accepted format.

Once the proposal is approved under a statement of conditions, any proposed modifications or additional commitments should be referred to the EPA for consideration of the environmental impacts. Such changes to the consolidated list of commitments would normally be dealt with through the audit process; however, if significant impacts are involved, the proposed changes may constitute a change to the proposal which would require assessment.

Examples of the preferred format for typical commitments are shown in the following table:

Table 3: Summary of proponent's commitments (example only)

Who/What <u>**Commitment**</u>	**When plan prepared** <u>**Timing**</u>	**Why** <u>**Objective**</u>	**How/Where** <u>**Action**</u>	**Whose advice** <u>**expert consulted**</u>	**Evidence Standard** **Compliance criteria**
1. The Proponent will develop and implement a rehabilitation plan	before construction commences	to protect the abundance, species diversity, geographic distribution and productivity of the vegetation community types 3b and 20b (fig 3.1, EMP)	by limiting construction to 10 ha of Reserve 34587 and rehabilitating the area	on advice of CALM.	similarity rating of rehab'd area consistent with vegetation community types 3b and 20b.
2. The Proponent will prepare and implement a dust control plan	before the start of construction	to minimise dust generation and impact on nearby land owners	by measures such as watering roads and monitoring wind direction	preparation of the plan on advice of DEP.	1000mg/m3 (EPA Dust Control Criteria)

Commitments should preferably be written in tabular format, preferably with some specification of ways in which the commitment can be measured, or how compliance can be demonstrated.

Draft commitments, whether in textual or tabular format, which are not in a format that can be audited will not be accepted by DEP assessment officers for public review documentation. Proponents will be assisted to revise inadequate commitments.

5.4 Public consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the environmental review. It should describe the activities undertaken, the dates, the groups/individuals involved and the objectives of the activities. Cross reference should be made with the description of environmental management of the factors which should clearly indicate how community concerns have been addressed. Those concerns which are dealt with outside the EPA process can be noted and referenced.

5.5 Other information

Additional detail and description of the proposal, if provided, should go in a separate section.

Attachment 1

The first page of the proponent's environmental review document must be the following invitation to make a submission, with the parts in square brackets amended to apply to each specific proposal. Its purpose is to explain what submissions are used for and to detail why and how to make a submission.

Invitation to make a submission

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

[the proponent] proposes [the rezoning of land and the development of a Marina Complex in the City of Bunbury]. In accordance with the Environmental Protection Act, a [PER] has been prepared which describes this proposal and its likely effects on the environment. The [PER] is available for a public review period of [8] weeks from [**date**] closing on [**date**].

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the [PER] or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the [PER]:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the [PER];
- if you discuss different sections of the [PER], keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name;
- address;
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is: **[date]**

Submissions should be addressed to:

The Environmental Protection Authority
Westralia Square
141 St George's Terrace
PERTH WA 6000

Attention: **[Project Officer name]**

Attachment 2

Advertising the environmental review

The proponent is responsible for advertising the release and arranging the availability of the environmental review document in accordance with the following guidelines:

Format and content

The format and content of the advertisement should be approved by the DEP before appearing in the media. For joint State-Commonwealth assessments, the Commonwealth also has to approve the advertisement. The advertisement should be consistent with the attached example.

Note that the DEP officer's name should appear in the advertisement.

Size

The size of the advertisement should be two newspaper columns (about 10 cm) wide by about 14 cm long. Dimensions less than these would be difficult to read.

Location

The approved advertisement should, for CER's, appear in the news section of the main local newspaper and, for PER's and ERMP's, appear in the news section of the main daily paper's ("The West Australian") Saturday edition, and in the news section of the main local paper at the commencement of the public review period and again two weeks prior to the closure of the public review period.

Timing

Within the guidelines already given, it is the proponent's prerogative to set the time of release, although the DEP should be informed. The advertisement should not go out before the report is actually available, or the review period may need to be extended.

Example of the newspaper advertisement

SCM CHEMICALS LTD

Consultative Environmental Review

EXTENSION TO DALYELLUP RESIDUE DISPOSAL PROGRAM

(Public Review Period: **[date]** to **[date]**)

SCM Chemicals Ltd is planning to extend the company's existing residue disposal program at Dalyellup, south of Bunbury, from March 1992 to March 1993.

A Consultative Environmental Review (CER) has been prepared by the company to examine the environmental effects associated with the proposed development, in accordance with Western Australian Government procedures. The CER describes the proposal, examines the likely environmental effects and the proposed environmental management procedures.

SCM has prepared a project summary which is available free of charge from the company's office on Old Coast Road, Australind.

Copies of the CER may be purchased for $5 from:

SCM Chemicals Ltd
Old Coast Road
AUSTRALIND WA 6230
Telephone: (08) 9467 2356

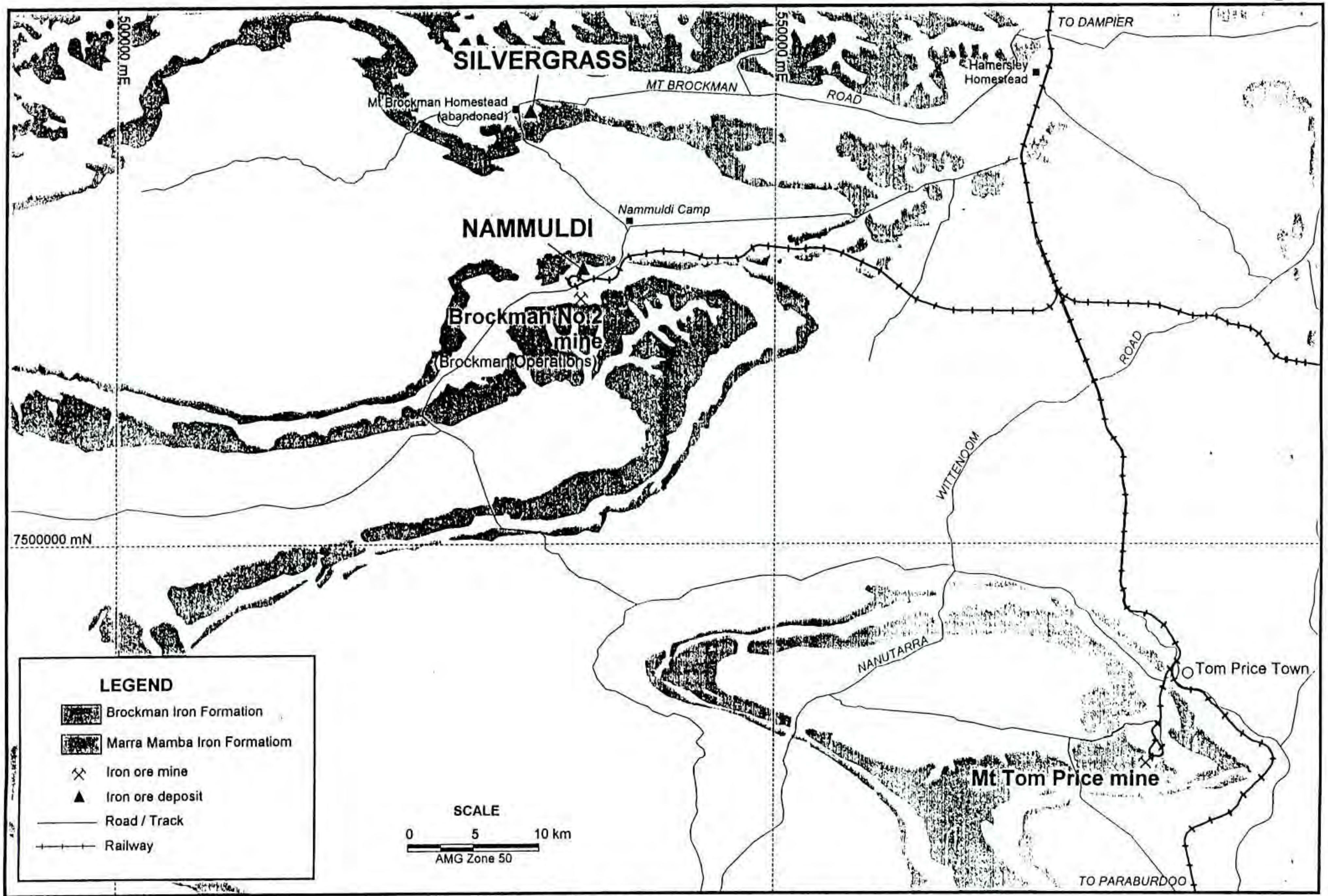
Copies of the complete Consultative Environmental Review will be available for examination at:

- Environmental Protection Authority
  Library Information Centre
  8th Floor, Westralia Square
  38 Mounts Bay Road
  PERTH WA 6000
- Environmental Protection Authority
  65 Wittenoom Street
  BUNBURY WA 6230
- City of Bunbury public libraries
- Shire of Capel libraries
- Shire of Harvey library (Australind)
- Shire of Dardanup (Eaton)

Submissions on this proposal are invited by [**closing date**]. Please address your submission to:

Chairman
Environmental Protection Authority
8th Floor, Westralia Square
38 Mounts Bay Road
PERTH WA 6000
Attention: **[Project Officer name]**

If you have any questions on how to make a submission, please ring the project officer, [**Project Officer name**], on (08) 9222 7xxx.

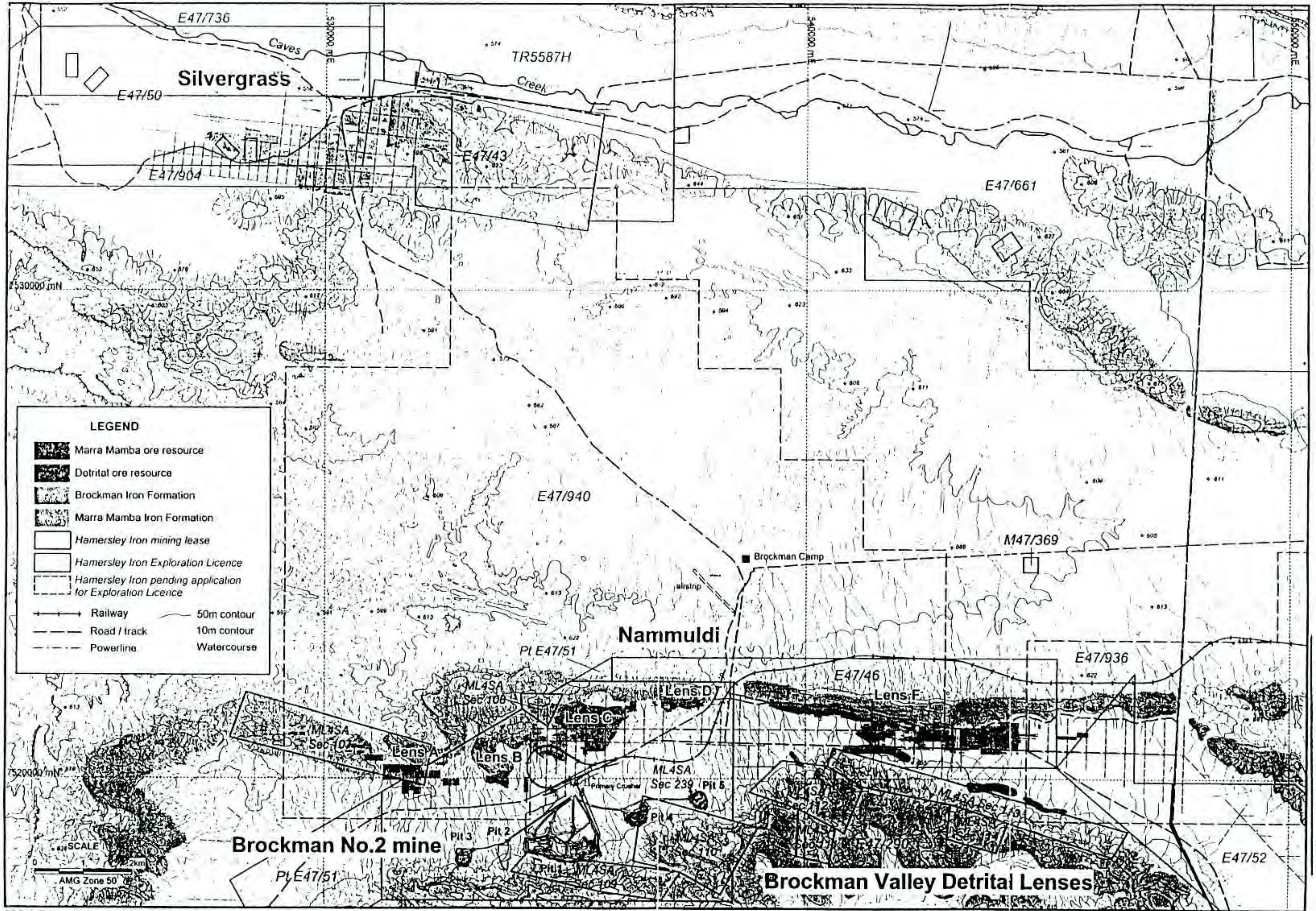


RDD5148V3 Sept 1998

Attachment 1. Regional location - Nammuldi / Silvergrass

ATTACHMENT 3

4



ATTACHMENT 4

RDD... Sept 199...

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Appendix B
Nammuldi Trial Operation environmental commitments

Department of Environmental Protection

Head Office:
Westralia Square
141 St Georges Terrace
Perth, Western Australia 6000
Tel (08) 9222 7000 Fax (08) 9322 1598
http://www.environ.wa.gov.au

Postal Address:
PO Box K822
Perth, Western Australia 6842

S M C Walsh
Managing Director, Operations
Hamersley Iron Pty Limited
Box A42 G.P.O.
PERTH WA 6837

Your Ref:
Our Ref: CRN 129688
Enquiries: M Hogarth (9222 7139)

Dear Mr Walsh

NAMMULDI TRIAL OPERATION, WITHIN ML4SA, SHIRE OF ASHBURTON - INFORMAL REVIEW WITH PUBLIC ADVICE

The above proposal was referred to the Environmental Protection Authority for assessment under Part IV of the Environmental Protection Act 1986 on 10 August 1998. Subsequently the level of assessment of this proposal was set at "Informal Review with Public Advice". The Department of Environmental Protection (DEP) provides the following advice on this project.

The DEP notes that Hamersley Iron Pty Limited has, in support of its referral document of 4 August 1998, given a number of environmental commitments in relation to the above proposal. These commitments are contained within Hamersley Iron Pty Limited's letter to the DEP of 4 August 1998 (Attachment 1).

The Department considers that the environmental impact of this proposal can be adequately managed, provided it is implemented in accordance with the descriptions given, and the environmental commitments are complied with.

This proposal may also require Works Approvals and Licences under Part V of the *Environmental Protection Act 1986*.

Yours sincerely

K J Taylor
DIRECTOR
EVALUATION DIVISION

21 September 1998

Enc

cc: Department of Resources Development, PO Box 7606, Cloisters Square, PERTH WA 6850. Attention: Beverley Bower

Department of Minerals and Energy, 100 Plain Street, EAST PERTH WA 6004. Attention: Bill Biggs

Department of Conservation and Land Management, 50 Hayman Road, COMO WA 6152. Attention: Frank Batini

Water and Rivers Commission, P.O. Box 6740, Hay Street East, EAST PERTH WA 6892. Attention: Greg Davis

Pollution Prevention Division, Department of Environmental Protection, 141 St Georges Terrace, PERTH WA 6000. Attention: Stephen Watson

HAMERSLEY IRON PTY. LIMITED

A.C.N. 004 558 276

Central Park, 152-158 St. Georges Terrace
Perth, Western Australia 6000
Box A42 G.P.O. Perth, 6837
Telex No. AA94765
Telephone (08) 9327 2327

Direct Line ....9 327 2458........
Facsimile No. ......9 327 2311........

Ref: 7.20.1 *doc#9351*

4 August 1998

Director, Evaluation Division
Department of Environmental Protection
PO Box K822
PERTH WA 6842

ATTENTION : Mr Kim Taylor

Dear Mr Taylor,

NAMMULDI TRIAL OPERATION
ENVIRONMENTAL COMMITMENT

I attach Hamersley Iron Pty Limited's (Hamersley's) referral of the above project to the Department of Environmental Protection (DEP) for assessment. In addition, I provide the following information to aid you in determining an appropriate level of assessment.

Hamersley and its parent, Rio Tinto, are strongly committed to a path of social and environmental accountability. I attach a copy of our environmental policy. In compliance with this policy and our standard practice for the environmental management of new projects, Hamersley routinely implements a number of environmental management actions. These actions are carried out under an overarching framework consistent with the environmental management systems standard, ISO14001.

Hamersley plans to develop a large Marra Mamba ore resource in the Nammuldi area (see figures in the referral) to meet a recently identified market opportunity. We see two key issues to the success of the project as:

- the acceptance of this new ore source by our customers which requires an assured supply of ore;
- development of a suitable overall project design to meet long term environmental objectives.

To allow us to address both issues simultaneously, we are proposing a two stage process.

129688

- Stage I would involve development of a trial operation over 3 years which would supply up to 7 Mt of product to customers and allow Hamersley to take a 150,000 t bulk sample of below water table ore to determine how best to process such wet material. This is essential for the successful design of the Stage II project. All processing will use existing Brockman facilities. Dewatering to obtain the wet bulk ore sample would be part of Hamersley's intensive hydrogeological studies undertaken to support the environmental assessment of Stage II. The timing for taking the bulk sample from below water table may be determined by market factors governing the rate of uptake of the above water table material.
- Stage II would involve the formal assessment of the long-term vision for Hamersley's Marra Mamba deposits in the Brockman valley - which may include multiple pits at Nammuldi, one or more at Homestead and the Silvergrass deposit, dewatering and closure aspects, as well as processing of wet ore and tailings structures.

To provide DEP and EPA a context for assessing the environmental aspects of the Stage I project, I provide the following list of commitments Hamersley makes toward managing the potential environmental impacts of the trial operation.

1. The life of the trial operation will not exceed 3 years from commencement of mining, without a subsequent environmental approval.

2. Hamersley will develop an environmental management plan to cover all environmental aspects of the project, including dust, water, flora and fauna, noise and aesthetics, to the satisfaction of the Department of Environmental Protection before construction commences.

3. Before mining commences, Hamersley will liaise with the Department of Conservation and Land Management on biodiversity conservation within the area and develop flora or fauna management plans where required on the basis of biological surveys to be carried out prior to mining.

4. Before commencing mining, Hamersley will develop a rehabilitation plan, that covers ongoing rehabilitation, to the satisfaction of the Department of Environmental Protection on advice from the Department of Minerals & Energy.

5. Before any dewatering occurs, Hamersley will develop a plan to cover dewatering, water disposal and decommissioning (see 6.3) to DEP's satisfaction on advice from the Waters & Rivers Commission.

6. Before mining ceases, Hamersley will develop a site closure plan to the satisfaction of the Department of Environmental Protection and the Department for Resources Development on advice from the Department of Minerals & Energy for implementation at closure. This plan will be built around the following commitments:

6.1 mining will cease after 3 years, unless a subsequent environmental approval is in place;

6.2 if within 12 months of ceasing mining, Hamersley has not determined that it wishes to proceed with mining of this pit and does not hold an environmental approval to do so, all out-of-pit dumps and stockpiles will be backfilled into an existing void or voids and disturbed areas will be rehabilitated;

6.3 the dewatered void will be backfilled to a level at least 1 m above the original water table;

6.4 all backfilling and rehabilitation will be completed within 12 months of commencement.

7. Hamersley will provide details of the site's environmental performance to the Department of Resources Development in an Annual Environmental Report in a format to be agreed by the Department of Resources Development and the Department of Environmental Protection.

With respect to the last point, preliminary advice from the Department of Resources Development is that the trial operation will be handled by them under the amendment to the *Iron Ore (Hamersley Range) Act* which covers the Brockman Project. On that basis, reporting for the trial operation would be appended to the Brockman Annual Environmental Report.

Hamersley will submit a referral for the full Stage II Nammuldi Project. My current intention is that the referral will be issued to the DEP by the end of September 1998. It is anticipated that an operation of that size would undergo a formal environmental approval process and that commitments/conditions of that assessment would supersede those given above.

Yours sincerely,

SMC Walsh
Managing Director, Operations

Attach.

cc. Ms Bev Bower - Department of Resources Development

Appendix C

Summary of water quality of groundwater in the Project area

Appendix C

Summary of water quality of groundwater in the Project area

		Nammuldi						Silvergrass	
Location		**Pit A**	**Pit B**	**Pit C**	**Pit E**	**Pit F(1)**	**Pit F(2)**	**Range Pit**	**Valley Pit**
Date of sample	Unit	5/3/1999	3/2/1999	18/2/1999	14/2/1999	16/2/1999	27/2/1999	15/12/1998	19/12/1998
pH		7.0	7.6	7.5	6.7	7.8	7.7	7.7	7.4
Electrical conductivity @25°C	mS/cm	900	940	1000	700	730	600	1100	1400
Total Dissolved Solids (grav.)	mg/L	510	530	600	410	460	340	720	860
Sodium (Na)	mg/L	56	56	63	42	110	31	130	140
Potassium (K)	mg/L	12	12	12	11	8.7	8.8	8.5	8.7
Calcium (Ca)	mg/L	60	60	65	47	25	39	62	63
Magnesium (Mg)	mg/L	38	44	49	36	21	35	53	54
Chloride (Cl)	mg/L	110	120	140	56	45	45	150	170
Bicarbonate (HCO_3)	mg/L	260	330	310	260	290	230	380	360
Sulphate (SO_4)	mg/L	61	75	55	37	46	42	83	100
Nitrate (NO_3)	mg/L	0.4	3.1	3.8	4.3	2.4	5.0	13	16
Hardness (equivalent $CaCO_3$)	mg/L	310	330	360	270	150	240	450	380
Copper (Cu)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron (Fe)	mg/L	<0.05	<0.05	<0.05	<0.05	1.4	<0.05	0.05	<0.05
Manganese (Mn)	mg/L	<0.05	<0.05	<0.05	<0.05	0.15	<0.05	<0.05	<0.05
Lead (Pb)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05	<0.005
Zinc (Zn)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05

Source: (PPK Environment & Infrastructure 1999)

Appendix D
Vascular flora recorded in the Project area

Appendix D
Vascular flora recorded in the Project area

FAMILY — **Species**

ADIANTACEAE:

Cheilanthes lasiophylla
Cheilanthes sieberi subsp. *sieberi*

MARSILEACEAE:

Marsilea hirsuta

POACEAE:

Amphipogon sp. 1
Aristida contorta
Aristida exserta
Aristida holathera
Aristida latifolia
Astrebla elymoides
Bothriochloa ewartiana
Brachyachne convergens
Brachyachne prostrata
**Cenchrus ciliaris*
Chloris pectinata
Chrysopogon fallax
Cymbopogon ambiguus
Cymbopogon obtecta
Dactyloctenium radulans
Dichanthium sericeum ssp. *humilius*
Dichanthium sericeum ssp. *sericeum*
Digitaria brownii
Enneapogon avenaceus
Enneapogon caerulescens
Enneapogon clelandii
Enneapogon polyphyllus
Enteropogon acicularis
Eragrostis aff. *desertorum*
Eragrostis eriopoda
Eragrostis pergracilis
Eragrostis setifolia
Eragrostis tenellula
Eragrostis tenuifolia
Eragrostis xerophila
Eriachne benthamii
Eriachne ciliata
Eriachne mucronata
Eriachne pulchella
Eulalia aurea
Iseilema dolichotrichum
Iseilema macratherum
Iseilema ?membranaceum
Paraneurachne muelleri
Paspalidium clementii
Paspalidium tabulatum
Setaria dielsii
Sporobolus australasicus
Themeda triandra
Tragus australianus
Triodia angusta
Triodia brizoides
Triodia pungens
Triodia wiseana
Tripogon loliiformis

FAMILY — **Species**

CYPERACEAE

Cyperus cunninghamii
Fimbristylis ?simulans
Fimbristylis sp. 1
Schoenoplectus dissachanthus

COMMELINACEAE:

Commelina ensifolia

ASPHODELACEAE:

Bulbine pendula ms.

MORACEAE:

Ficus platypoda

PROTEACEAE:

Grevillea ?pyramidalis
Grevillea wickhamii
Grevillea sp. 1 (*?eriostachya*)
Grevillea sp. 2
Hakea chordophylla
Hakea lorea subsp. *suberea*

SANTALACEAE:

Anthobolus leptomerioides
Exocarpos sp. 1
Santalum lanceolatum
Santalum spicatum

LORANTHACEAE:

Amyema ?fitzgeraldii
Amyema miquelii
Diplatia grandibractea
Lysiana casuarinae

POLYGONACEAE:

**Rumex vesicarius*

CHENOPODIACEAE:

Chenopodium melanocarpum
Dysphania glomulifera
Dysphania kalpari
Dysphania rhadinostachya
Enchylaena tomentosa
Halosarcia halocnemoides
Maireana ?eriosphaera
Maireana georgei
Maireana melanocoma
Maireana planifolia
Maireana triptera
Maireana ?villosa
Rhagodia eremaea
Salsola kali
Sclerolaena cornishiana
Sclerolaena densiflora
Sclerolaena eriacantha
Sclerolaena ?lanicuspis
Sclerolaena sp.

FAMILY **Species**

AMARANTHACEAE:

Alternanthera denticulata
Alternanthera nana
Alternanthera nodiflora
Amaranthus mitchellii
Amaranthus pallidiflorus
Gomphrena cunninghamii
Ptilotus aervoides
Ptilotus astrolasius
Ptilotus atriplicifolius
Ptilotus calostachyus
Ptilotus carinatus
Ptilotus clementii
Ptilotus exaltatus
Ptilotus fusiformis
Ptilotus gaudichaudii
Ptilotus gomphrenoides
Ptilotus helipteroides
Ptilotus incanus
Ptilotus macrocephalus
Ptilotus obovatus
Ptilotus polystachyus var. *polystachyus*
Ptilotus polystachyus var. *rubriflorus*
Ptilotus rotundifolius

NYCTAGINACEAE:

Boerhavia coccinea
Boerhavia repleta

GYROSTEMONACEAE:

Codonocarpus cotinifolius

MOLLUGINACEAE:

Mollugo molluginis

PORTULACACEAE:

Calandrinia ptychosperma
Portulaca oleracea
Portulaca sp. 1

CARYOPHYLLACEAE:

Polycarpaea holtzei

Polycarpaea longiflora

MENISPERMACEAE:

Tinospora smilacina

LAURACEAE:

Cassytha capillaris

CAPPARACEAE:

Capparis lasiantha
Capparis umbonata
Cleome viscosa

BRASSICACEAE:

Lepidium muelleri-ferdinandi
Lepidium phlebopetalum
Lepidium pholidogynum
Stenopetalum anfractum

SURIANACEAE:

Stylobasium spathulatum

FAMILY **Species**

MIMOSACEAE:

Acacia ancistrocarpa
Acacia aneura (form unspecified)
Acacia aneura (flattened form)
Acacia aneura (terete form)
Acacia atkinsiana
Acacia ayersiana
Acacia bivenosa
Acacia citrinoviridis
Acacia colei
Acacia coriacea
Acacia cowleana
Acacia dictyophleba
Acacia exilis
Acacia farnesiana
Acacia hamersleyana
Acacia inaequilatera
Acacia kempeana
Acacia maitlandii
Acacia monticola
Acacia pruinocarpa
Acacia pyrifolia
Acacia rhodophloia
Acacia sclerosperma
Acacia spondylophylla
Acacia stowardii
Acacia tenuissima
Acacia tetragonophylla
Acacia tumida
Acacia victoriae
Acacia xiphophylla
Neptunia dimorphantha

CAESALPINIACEAE:

Petalostylis labicheoides
Senna artemisioides subsp. *helmsii*
Senna artemisioides subsp. *oligophylla*
Senna artemisioides subsp. *oligophylla (sericea* form)
Senna artemisioides subsp. *oligophylla* x *helmsii*
Senna artemisioides subsp. *stricta*
Senna glutinosa subsp. *glutinosa*
Senna glutinosa subsp. *pruinosa*
Senna glutinosa subsp. x *luerssenii*
Senna hamersleyensis
Senna notabilis
Senna symonii

FAMILY	Species
PAPILIONACEAE:	
	Clianthus formosus
	Crotalaria ?benthamiana
	Crotalaria medicaginea
	Crotalaria novaehollandiae
	Cullen cinereum
	Cullen graveolens
	Cullen lachnostachys
	Cullen leucanthum
	Cullen pogonocarpum
	Gastrolobium grandiflorum
	Glycine canescens
	Gompholobium polyzygum
	Indigofera linifolia
	Indigofera monophylla
	Indigofera rugosa
	Isotropis atropurpurea
	Lotus cruentus
	Mirbelia viminalis
	Polygala isingii
	Rhynchosia minima
	Swainsona maccullochieana
	Swainsona sp. Hamersley Station
	Templetonia egena
	Tephrosia densa
	Tephrosia rosea
	Tephrosia aff. *stipuligera*
	Tephrosia sp. Cathedral Gorge
ZYGOPHYLLACEAE:	
	Tribulus astrocarpus
	Tribulus hirsutus
	Tribulus macrocarpus
	Tribulus platypterus
	Zygophyllum iodocarpum
POLYGALACEAE:	
	Polygala isingii
EUPHORBIACEAE:	
	Adriana tomentosa
	Euphorbia australis
	Euphorbia boophthona
	Euphorbia drummondii subsp. *drummondii*
	Phyllanthus lacunellus
	Phyllanthus maderaspatensis
STACKHOUSIACEAE:	
	Stackhousia intermedia
SAPINDACEAE:	
	Diplopeltis stuartii
	Dodonaea coriacea
	Dodonaea lanceolata subsp. *lanceolata*
	Dodonaea pachyneura
	Dodonaea petiolaris
TILIACEAE:	
	Corchorus crozophorifolius
	Corchorus lasiocarpus
	Triumfetta leptacantha
	Triumfetta maconochieana

FAMILY	Species
MALVACEAE:	
	Abutilon cunninghamii
	Abutilon lepidum
	Abutilon macrum
	Abutilon malvifolium
	Abutilon otocarpum
	Abutilon sp. 1
	Gossypium australe
	Gossypium robinsonii
	Hibiscus brachylaenus
	Hibiscus burtonii
	Hibiscus coatesii
	Hibiscus goldsworthii
	Hibiscus leptocladus
	Hibiscus sturtii var. 1
	Hibiscus sturtii var. 2
	**Malvastrum americanum*
	Sida arenicola
	Sida cardiophylla
	Sida echinocarpa
	Sida excedentifolia
	Sida fibulifera
	Sida filifolia
	Sida ?phaeotricha
	Sida rohlenae
	Sida ?spodochroma
	Sida trichopoda
	Sida sp. spiciform panicles
	Sida sp. ("white leaf margins")
	Sida sp. 1
	Sida sp. 2
STERCULIACEAE:	
	Brachychiton acuminatus
	Keraudrenia nephrosperma
	Rulingia kempeana
	Waltheria virgata
FRANKENIACEAE:	
	Frankenia hispidula
VIOLACEAE:	
	Hybanthus aurantiacus
THYMELAEACEAE:	
	Pimelea ammocharis
	Pimelea holroydii
MYRTACEAE:	
	Calytrix carinata
	Corymbia deserticola
	Corymbia hamersleyana
	Eucalyptus camaldulensis
	Eucalyptus ?ferriticola
	Eucalyptus gamophylla
	Eucalyptus leucophloia
	Eucalyptus socialis
	Eucalyptus trivalvis
	Eucalyptus victrix
	Eucalyptus xerothermica
	Melaleuca eleuterostachya

FAMILY	Species
HALORAGACEAE:	
	Haloragis gossei
	Haloragis aff. *gossei*
ARALIACEAE:	
	Astrotricha hamptonii
APIACEAE:	
	Daucus glochidiatus
	Trachymene oleracea
OLEACEAE:	
	Jasminum didymum var. *lineare*
ASCLEPIADACEAE:	
	Cynanchum floribundum
	?Gymnanthera cunninghamii
	Rhyncharrhena linearis
	Sarcostemma australe
CONVOLVULACEAE:	
	Bonamia rosea
	Convolvulus erubescens
	Evolvulus alsinoides
	Ipomoea ?lonchophylla
	Polymeria ambigua
	Polymeria longifolia
	Porana commixta
BORAGINACEAE:	
	Ehretia saligna
	Heliotropium chrysocarpum
	Heliotropium conocarpum
	Heliotropium heteranthum
	Heliotropium ovalifolium
	Trichodesma zeylanicum
VERBENACEAE:	
	Clerodendrum tomentosum var. *lanceolatum*
	Clerodendrum tomentosum var. *tomentosum*
LAMIACEAE:	
	Prostanthera albiflora
SOLANACEAE:	
	Datura leichhardtii
	Nicotiana benthamiana
	Nicotiana occidentalis
	Nicotiana rosulata
	Solanum diversiflorum
	Solanum ferocissimum
	Solanum horridum
	Solanum lasiophyllum
	Solanum ?phlomoides
	Solanum sturtianum
SCROPHULARIACEAE:	
	Mimulus gracilis
	Stemodia grossa
	Stemodia kingii
ACANTHACEAE:	
	Dicladanthera forrestii
	Dipteracanthus australasicus
	Rostellularia adscendens

FAMILY	Species
MYOPORACEAE:	
	Eremophila cuneifolia
	Eremophila forrestii
	Eremophila fraseri
	Eremophila lanceolata
	Eremophila ?latrobei ssp. *glabra*
	Eremophila longifolia
	Eremophila maculata
PLANTAGINACEAE:	
	Plantago ?drummondii
RUBIACEAE:	
	Oldenlandia crouchiana
	Psydrax latifolia
	Psydrax suaveolens
	Synaptantha tilaeacea
CUCURBITACEAE:	
	Cucumis melo
	Mukia maderaspatana
CAMPANULACEAE:	
	Wahlenbergia ?tumidifructa
	Wahlenbergia sp. 1
LOBELIACEAE:	
	Lobelia heterophylla
GOODENIACEAE:	
	Dampiera candicans
	Goodenia cusackiana
	Goodenia heterochila
	Goodenia microptera
	Goodenia muelleriana
	Goodenia pascua
	Goodenia stellata
	Goodenia stobbsiana
	Scaevola amblyanthera
	Scaevola parvifolia
	Scaevola spinescens
	Velleia connata
ASTERACEAE:	
	**Bidens bipinnata*
	Calocephalus ?knappii
	Calocephalus sp. Pilbara Desert
	Calocephalus sp. Wittenoom
	Calotis hispidula
	Calotis multicaulis
	Calotis porphyroglossa
	Centipeda minima
	Flaveria australasica
	Olearia xerophila
	Pterocaulon sphacelatum
	Rhodanthe floribunda
	Rhodanthe humboldtiana
	Rhodanthe margarethae
	**Sigesbeckia orientalis*
	Streptoglossa bubakii
	Streptoglossa decurrens
	Streptoglossa liatroides
	Vittadinia arida
	Vittadinia ?eremaea

Appendix E
Vertebrate fauna species recorded in the Project area

Appendix E
Vertebrate fauna species recorded in the Project area

Family	Genus	Species	Common name
MAMMALS:			
Dasyuridae	*Dasykaluta*	*rosamondae*	Little Red Kaluta
	Dasyurus	*hallucatus*	Northern Quoll
	Pseudantechinus	*woolleyae*	Woolley's Pseudantechinus
	Planigale	*maculata*	Common Planigale
	Ningaui	*timealeyi*	Pilbara Ningaui
	Sminthopsis	*longicaudata*	Long-tailed Dunnart
	Sminthopsis	*macroura*	Stripe-faced Dunnart
Macropodidae	*Macropus*	*robustus*	Common Wallaroo
	Macropus	*rufus*	Red kangaroo
	Petrogale	*rothschildi*	Rothschild's Rock-wallaby
Megadermatidae	*Macroderma*	*gigas*	Ghost Bat
Emballonuridae	*Taphozous*	*georgianus*	Common Sheathtail-bat
	Taphozous	*hilli*	Hills Sheathtail-bat
Molossidae	*Mormopterus*	*planiceps*	Southern Freetail-bat
Vespertilionidae	*Chalinolobus*	*gouldii*	Gould's Wattled Bat
	Vespadelus	*finlaysoni*	Finlayson's Cave Bat
Muridae	*Leggadina*	*lakedownensis*	Lakeland Downs Mouse
	Pseudomys	*chapmani*	Pebble Mound Mouse
	Pseudomys	*hermannsburgensis*	Sandy Inland Mouse
	Zyzomys	*argurus*	Common Rock Rat
Canidae	*Canis*	*Lupus dingo*	Dingo
REPTILES:			
Agamidae	*Ctenophorus*	*caudicinctus*	
	Ctenophorus	*isolepis isolepis*	
	Diporiphora	*valens*	
	Diporiphora	*winneckei*	
	Lophognathus	*longirostris*	
	Pogona	*minor minor*	
	Tympanocryptis	*cephalus*	
Boidae	*Antaresia*	*perthensis*	
	Antaresia	*stimsoni*	
Elapidae	*Acanthopis*	*pyrrhus*	
	Denisonia	*fasciata*	
	Furina	*ornata*	
	Pseudechis	*australis*	
	Pseudonaja	*nuchalis*	
	Rhinoplocephalus	*monachus*	
	Simoselaps	*approximans*	
Gekkonidae	*Diplodactylus*	*conspicillatus*	
	Diplodactylus	*elderi*	
	Diplodactylus	*savagei*	
	Diplodactylus	*stenodactylus*	
	Diplodactylus	*wellingtonae*	
	Gehyra	*pilbara*	
	Gehyra	*punctata*	
	Gehyra	*variegata*	
	Heteronotia	*binoei*	
	Heteronotia	*spelea*	
	Nephrurus	*wheeleri*	
	Oedura	*marmorata*	
	Rhynchoedura	*ornata*	
Hylidae	*Litoria*	*rubella*	
Myobatrachidae	*Uperoleia*	*russelli*	
Pygopodidae	*Delma*	*elegans*	
	Delma	*nasuta*	
	Delma	*tincta*	
Pygopodidae	*Lialis*	*burtonis*	
	Pygopus	*nigriceps*	
Scincidae	*Carlia*	*munda*	
	Cryptoblepharus	*carnabyi*	

Family	Genus	Species	Common name
	Cryptoblepharus	*plagiocephalus*	
	Ctenotus	*aff. helenae*	
	Ctenotus	*aff. robustus*	
	Ctenotus	*duricola*	
	Ctenotus	*grandis*	
	Ctenotus	*helenae*	
	Ctenotus	*pantherinus ocellifer*	
	Ctenotus	*piankai*	
	Ctenotus	*rubicundus*	
	Ctenotus	*rutilans*	
	Ctenotus	*saxatilis*	
	Ctenotus	*schomburgkii*	
	Cyclodomorphus	*melanops melanops*	
	Egernia	*formosa*	
	Eremiascincus	*richardsonii*	
	Lerista	*muelleri*	
	Menetia	*greyii*	
	Morethia	*ruficauda*	
	Notoscincus	*butleri*	
	Tiliqua	*multifasciata*	
Typhlopidae	*Ramphotyphlops*	*diversus ammodytes*	
Varanidae	*Varanus*	*acanthurus*	
	Varanus	*brevicauda*	
	Varanus	*eremius*	
	Varanus	*gilleni*	
	Varanus	*panoptes rubidus*	
	Varanus	*pilbarensis*	
	Varanus	*tristis tristis*	
BIRDS:			
Casuaridae	*Dromaius*	*novaehollandiae*	Emu
Anatidae	*Anas*	*superciliosa*	Pacific Black Duck
Ardeidae	*Ardea*	*pacifica*	White-necked Heron
Accipitridae	*Accipiter*	*cirrhocephalus*	Collared Sparrowhawk
	Accipiter	*fasciatus*	Brown Goshawk
	Haliastur	*sphenurus*	Whistling Kite
	Circus	*assimilis*	Spotted Harrier
	Elanus	*axillaris*	Black-shouldered Kite
Falconidae	*Falco*	*berigora*	Brown Falcon
	Falco	*Peregrinus*	Peregrine Falcon
	Falco	*longipennis*	Australian Hobby
	Falco	*cenchroides*	Nankeen Kestrel
Otididae	*Ardeotis*	*australis*	Australian Bustard
Turnicidae	*Turnix*	*velox*	Little Button Quail
Columbidae	*Geopelia*	*cuneata*	Diamond Dove
	Geophaps	*plumifera*	Spinifex Pigeon
	Ocyphaps	*lophotes*	Crested Pigeon
	Phaps	*chalcoptera*	Common Bronzewing
Cacatuidae	*Cacatua*	*sanguinea*	Little Corella
	Eolophus	*roseicapillus*	Galah
	Nymphicus	*hollandicus*	Cockatiel
Psittacidae	*Barnardius*	*zonarius*	Australian Ringneck
	Melopsittacus	*undulatus*	Budgerigar
Cuculidae	*Chalcites*	*basalis*	Horsfield's Bronze-Cuckoo
	Cuculus	*pallidus*	Pallid Cuckoo
Strigidae	*Ninox*	*boobook*	Southern Boobook
Aegothelidae	*Aegotheles*	*cristatus*	Australian Owlet-nightjar
Caprimulgidae	*Eurostopodus*	*argus*	Spotted Nightjar
Alcedinidae	*Todiramhus*	*pyrrhopygia*	Red-backed Kingfisher
	Todiramhus	*sanctus*	Sacred Kingfisher
	Daelo	*leachii*	Blue-winged Kookaburra
Meropidae	*Merops*	*ornatus*	Rainbow Bee-eater
Climacteridae	*Climacteris*	*melanura*	Black-tailed Treecreeper
Maluridae	*Amytornis*	*striatus*	Striated Grasswren
	Malurus	*lamberti*	Variegated Fairy-wren
	Malurus	*leucopterus*	White-winged Fairy-wren
	Stipiturus	*ruficeps*	Rufous-crowned Emu-wren
Pardalotidae	*Acanthiza*	*uropygialis*	Chestnut-rumped Thornbill
	Gerygone	*fusca*	Western Gerygone

Family	Genus	Species	Common name
	Pardalotus	*rubricatus*	Red-browed Pardalote
	Pardalotus	*striatus*	Striated Pardalote
	Smicrornis	*brevirostris*	Weebill
Meliphagidae	*Ephthianura*	*tricolor*	Crimson Chat
	Lichenostomus	*flavicollis*	Yellow-throated Miner
	Lichenostomus	*keartlandi*	Grey-headed Honeyeater
	Lichenostomus	*penicillatus*	White-plumed Honeyeater
	Lichenostomus	*virescens*	Singing Honeyeater
	Lichmera	*indistincta*	Brown Honeyeater
Petroicidae	*Melanodryas*	*cucullata*	Hooded Robin
Pomatostomidae	*Pomatostomus*	*temporalis*	Grey-crowned Babbler
Pachycephalidae	*Colluricincla*	*harmonica*	Grey Shrike-Thrush
	Oreoica	*gutturalis*	Crested Bellbird
	Pachycephala	*rufiventris*	Rufous Whistler
Dicruridae	*Grallina*	*cyanoleuca*	Australian Magpie-Lark
	Rhipidura	*leucophrys*	Willie Wagtail
Campephagidae	*Coracina*	*maxima*	Ground Cuckoo shrike
	Coracina	*novaehollandiae*	Black-faced Cuckoo-Shrike
	Lalage	*sueurii*	White-winged Triller
Artamidae	*Artamus*	*cinereus*	Black-faced Woodswallow
	Artamus	*minor*	Little Woodswallow
	Artamus	*personatus*	Masked Woodswallow
	Cracticus	*nigrogularis*	Pied Butcherbird
	Cracticus	*torquatus*	Grey Butcherbird
	Gymnorhina	*tibicen*	Australian Magpie
Corvidae	*Corvus*	*bennetti*	Little Crow
	Corvus	*orru*	Torresian Crow
Ptilonorhynchidae	*Chlamydera*	*guttata*	Western Bowerbird
	Chlamydera	*maculata*	Spotted Bowerbird
Alaudidae	*Mirafra*	*javanica*	Singing Bushlark
Motacillidae	*Anthus*	*novaeseelandiae*	Richard's Pipit
Passeridae	*Emblema*	*pictum*	Painted Firetail
	Taeniopygia	*guttata*	Zebra Finch
Dicaeidae	*Dicaeum*	*hirundinaceum*	Mistletoebird
Hirundinidae	*Hirundo*	*nigricans*	Tree Martin
Sylviidae	*Cincloramphus*	*cruralis*	Brown Songlark
	Eremiornis	*carteri*	Spinifexbird

Appendix F

Stygofauna recorded in the Project area

Appendix F
Stygofauna recorded in the Project area

Site location	Site name	AMGE	AMGN	Capture date	ID number	Taxa name	Family name	Comments
Brockman	BRPB1	536555	7521249	10 May 1999	BES 7347	Collembolan		Brockman Borefield, water bore
Brockman	BRPB1	536555	7521249	10 May 1999	BES 7346	Collembolan		Brockman Borefield, water bore
Brockman	BRPB1	536555	7521249	10 May 1999	BES 7345	Amphipod	Bogidiellidae	Brockman Borefield, water bore
Brockman	BRPB1	536555	7521249	10 May 1999	BES 7344	Copepod		Brockman Borefield, water bore
Brockman	BRPB1	536555	7521249	10 May 1999	BES 7342	Collembolan		Brockman Borefield, water bore
Brockman	BRPB1	536555	7521249	10 May 1999	BES 7336	Collembolan		Brockman Borefield, water bore
Brockman	BRPB1	536555	7521249	10 May 1999	BES 7335	Collembolan		Brockman Borefield, water bore
Brockman	BRPB1	536555	7521249	10 May 1999	BES 7334	Collembolan		Brockman Borefield, water bore
Brockman	BRPB1	536555	7521249	10 May 1999	BES 7326	Collembolan		Brockman Borefield, water bore
Brockman	BRPB1	536555	7521249	10 May 1999	BES 7325	Collembolan		Brockman Borefield, water bore
Brockman	BRPB1	536555	7521249	10 May 1999	BES 7324	Amphipod	Bogidiellidae	Brockman Borefield, water bore
Nammuldi	NAR3	531789	7519984	27 October 1999	HI130	Copepod		Round, large, good condition
Nammuldi	NB1M1	533840	7519849	31 October 1999	HI129	Worm		Thin, large, good condition
Silvergrass	SEG1M2	531794	7534314	28 October 1999	HI110	Copepod		Round, small, good condition
Silvergrass	SEG1M2	531794	7534314	28 October 1999	HI109	Amphipod		Long antennae, small uropod, good condition
Silvergrass	SEG1M2	531794	7534314	28 October 1999	HI108	Amphipod		Medium size, poor condition
Silvergrass	SGE1M1	531965	7534194	28 October 1999	HI105	Amphipod		Medium size, poor condition
Silvergrass	SGE1M1	531965	7534194	28 October 1999	HI104	Amphipod		Long legs, medium good condition
Silvergrass	SGE1M1	531965	7534194	28 October 1999	HI103	Amphipod		Long antennae, small uropod, good condition
Silvergrass	SGE1M1	531965	7534194	28 October 1999	HI102	Amphipod		Small, very poor condition
Silvergrass	SGE2M3	531672	7533211	31 October 1999	HI107	Worm		Small, good condition
Silvergrass	SGE2M3	531672	7533211	31 October 1999	HI106	Worm		Small, good condition