13.0 Biology

13.1 Flora – Existing Environment

13.1.1 Introduction

This section describes the vegetation of the project area with reference to a number of existing studies supplemented by field surveys undertaken specifically for the EIS. Details of the sampling locations are given in Appendix H.1. Field surveys (February 2003) focussed on assessing areas of the main project components including the McArthur River realignment channel, open pit area, tailings storage facility and overburden emplacement facility areas.

Surveys (April 2003) were also conducted in the Glyde River area to provide data for a previously proposed weir. Although the weir is no longer proposed, the data are still presented as they provide information on the broader project region.

The locations of the flora sampling sites for the mine site and the Glyde River are shown in Figures 13.1 and 13.2 respectively.

13.1.2 Floristics

Appendix H.2 lists all plant species recorded during the vegetation survey and indicates which species are annual or perennial, native or introduced, their lifeforms and conservation status. A total of 364 plant species from 84 families and 215 genera were recorded during two field trips. The most speciose plant families were Poaceae (53 species); Fabaceae (31 species); Myrtaceae (24 species) and Cyperaceae (20 species). Speciose genera included *Acacia* (14 species); *Eucalyptus* (8 species) and *Ficus* (7 species).

Prior to the EIS survey, 452 plant species had been recorded in the McArthur River mine project area. Smith (1996) recorded 234 species from Boomerang Creek on the Merlin Mining lease approximately 55 km to the south-east. The EIS study added 166 species records for the area.

13.1.3 Vegetation Communities and Mapping

A vegetation map of the project area was compiled for the 1992 EIS by interpretation of vegetation patterns from aerial photographs prior to ground truthing (Hollingsworth Dames & Moore, 1992). Duff and Orr (1992) further stratified the major plant communities surrounding the mine site by classification using multivariate analysis but did not produce a map indicating their distribution. A recent review of floristic information (URS, 2002) identified the need for a revised vegetation map of the project area and this has been compiled in the course of the current study.

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Drawn: VH | Approved: CMP | Date: 25-07-05

Job No: 42625552 | File No: 42625552-g-006c.wor

FLORA SAMPLING SITES MINE SITE

Figure: 13.1

Rev: C

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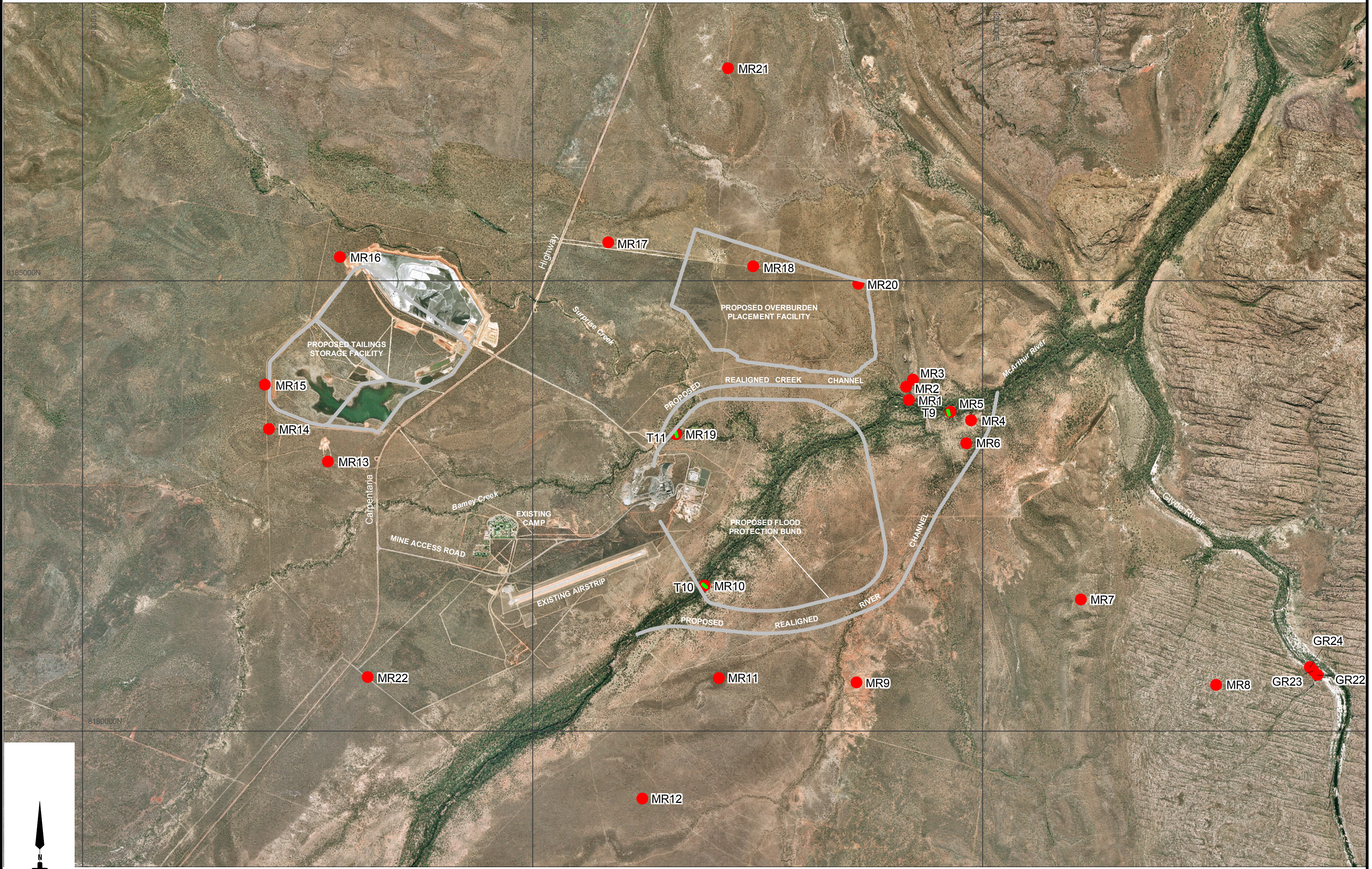


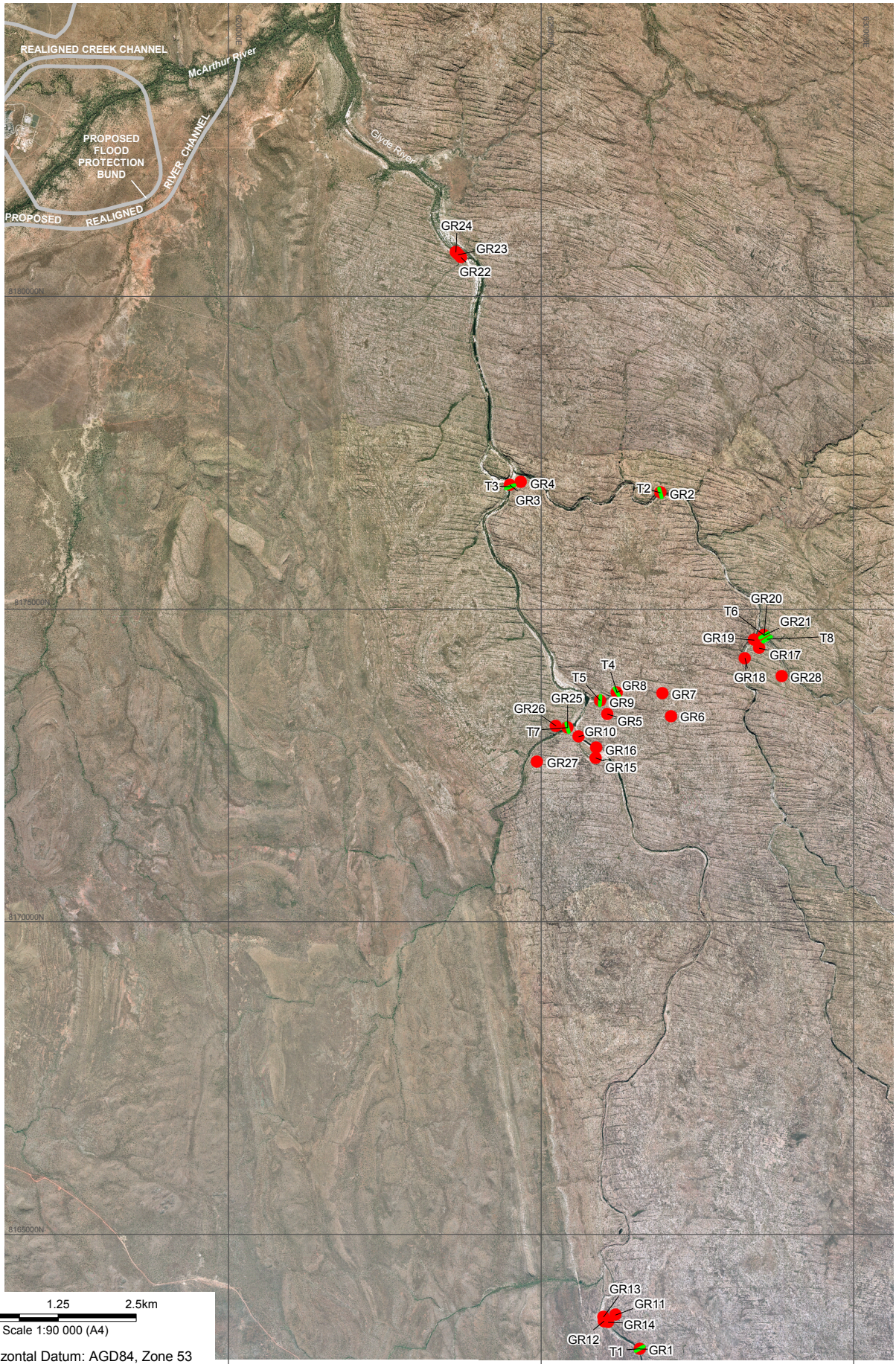
0 750 1500m

Scale 1:60 000 (A3)

Horizontal Datum: AGD84, Zone 53

Date of Aerial Photography, 2001

- Flora Sampling Site (sample site is a 20m x 20m quadrate)
- Transects (50m transect)



Horizontal Datum: AGD84, Zone 53
Date of Aerial Photography, 2001
Source: Kristin Metcalfe, Consultant Environmental Scientist

Flora Sampling Site (sample site is a 20m x 20m quadrate)
Transect (50m transect)

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FLORA SAMPLING SITES
GLYDE RIVER

Drawn: VH	Approved: CMP	Date: 25-07-05	Figure: **13.2**	Rev: B
Job No: **42625552**	File No: 42625552-g-007b.wor			**A4**

Based on the current and previous studies, nine distinct vegetation communities occur within the McArthur River mine project area. The distribution of these vegetation types is shown on Figure 13.3. Four of these are upland communities on sandstone or rocky hills, three are lowland woodland communities, and two are riparian or riverine communities.

In the east of the mapped area, the dominant vegetation is characteristic of the sandstone geological formations (Bukalara sandstone) bordered by a non-contiguous line of low hills including Mt Stubbs. West of these upland areas lies extensive woodland on flat to gently undulating plains with open woodlands on poorly drained floodplain soils.

Riparian vegetation bordering the braided channel of the McArthur River and its numerous tributaries transect the project area. These riverine areas experience erosion and depositional processes and the plant communities associated with broad drainage areas are subject to seasonal inundation. Cracking clays are common in the central and western section of the project area and mainly support open woodland and shrubland communities with minor grassland areas.

Each of the major vegetation communities mapped in Figure 13.3 is summarised in Table 13.1 and described in detail in Appendix H.3. Vegetation profile diagrams of these communities are given in Appendix H.4 and photographs of the major vegetation types are contained in Appendix H.5. A dendogram and ordination of vegetation sampling sites is provided in Appendix H.6.

UPLAND COMMUNITIES

1 **Sandstone Plateau:** *Eucalyptus phoenicea/Corymbia capricornia* - Open Woodland

2 **Hill Woodland:** *Erythrophleum chlorostachys/Terminalia canescens* - Low open Woodland

3 **Dry Vine-Thicket:** *Ficus spp./ Vitex glabrata/ Strychnos* - Shrubland

4 **Snappy Gum:** *Eucalyptus leucophloia* - Open Woodland

LOWLAND WOODLAND COMMUNITIES

5 **Inland Bloodwood:** *Corymbia terminalis/Eucalyptus chlorophylla* - Woodland to open woodland

6 **Coolibah:** *Bauhinia cunninghamii/Eucalyptus microtheca/Atalaya* - Low open woodland to shrubland

7 **Ghost Gum Woodland:** *Corymbia bella* - Woodland to Open Woodland

DRAINAGE AREAS

8 **Riverine woodland:** *Casuarina cunninghamii/Lophostemon grandiflorus* -Woodland

9 **Riparian corridor:** *Melaleuca argentea* - Woodland to open forest

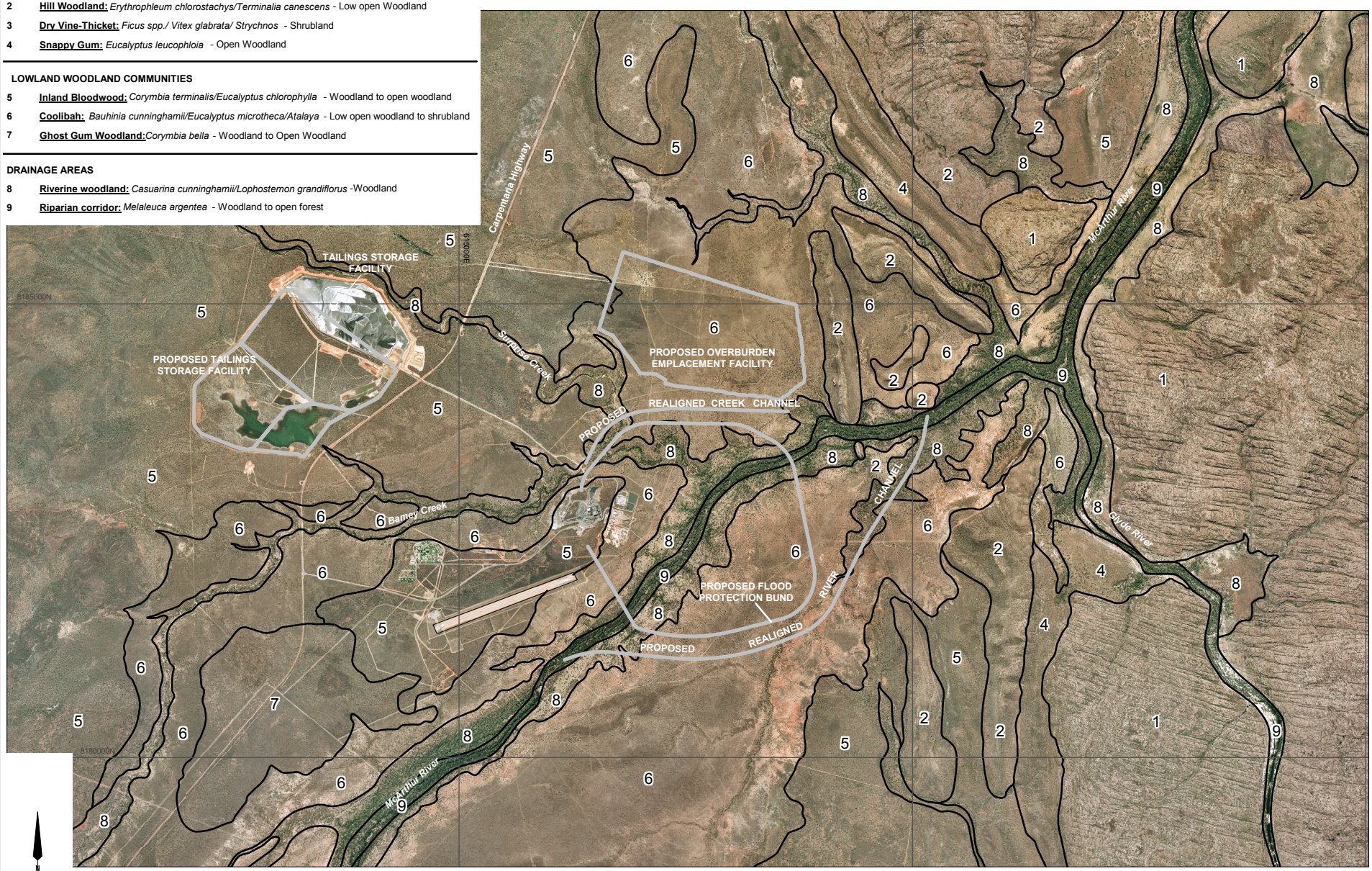

Table 13.1

Summary of Major Vegetation Communities within the McArthur River Mine Project Area

Map Unit	Profile Diagram (Appendix H.4)	Vegetation Community And Description	Mean Species Richness (n=No Sites)	Unit No from Duff and Orr (1992)	Unit No from Hollingsworth Dames & Moore (1992)
UPLAND COMMUNITIES					
1	Figure 16	Sandstone Plateau *Eucalyptus phoenicea/Corymbia capricornia* Open Woodland Eucalypt-dominated community in rugged sandstone plateaux areas bordering the eastern margin of the project area and the Glyde River.	14 (n=8)	Not sampled	H4 – Sandstone plateau *Eucalyptus phoenicea* OW
2	Figure 13	Hill Woodland *Erythrophleum chlorostachys/Terminalia canescens* Low open Woodland Mixed species community on rocky hills and slopes including Mt Stubbs and Emu Hill, with Ironwood (*Erythrophleum chlorostachys*), *Terminalia cansescens* and *Cochlospermumfraseri* and *C. gillivraei*. to an average height of 5 m.	20 (n=3)	Unit 9 – *Eucalyptus/ Erthrophleum/ Terminalia* LW/LOW	H2 – Low Hills *Erythrophleum chlorostachys, Eucalyptus grandifolia* OW
3		Dry Vine-Thicket *Ficus* spp../*Vitex glabrata/ Strychnos* Shrubland Comprises small pockets of monsoon vine-thicket occurring on boulder strewn scree slopes and fringing riparian areas in sandstone and hill woodland habitats. Characteristic species include *Ficus* spp., *Pouteria sericea, Vitex glabrata* and *Strychnos lucida* to an average height of 6 m. This community occurs mainly in the Glyde River gorge system while small patches are associated with rocky outcrops in the McArthur River floodplain. This community is too small to map separately in Figure 13.4.	25 (n=3)	Unit 1- Semi-deciduous monsoon vine thicket	H5 – Dry vine thicket *Ficus* spp. woodland

Map Unit	Profile Diagram (Appendix H.4)	Vegetation Community And Description	Mean Species Richness (n=No Sites)	Unit No from Duff and Orr (1992)	Unit No from Hollingsworth Dames & Moore (1992)
4	-	Snappy Gum Open Woodland *Eucalyptus leucophloia* low open woodland Distinctive community comprising almost monospecific stands on footslopes and low ridges of ranges in the east of the project area.	-	Unit 7 – *Eucalyptus leucophloia* LW	H3 – Snappy Gum *Eucalyptus leucophloia* open woodland
LOWLAND WOODLAND COMMUNITIES					
5	Figure 12	Bloodwood Inland *Corymbia terminalis/Eucalyptus chlorophylla* Woodland to open woodland Extensive woodlands occuring on lowland plains to the west of McArthur River. *Corymbia terminalis* (to 12 m) is dominant over much of the area but subtle changes in drainage favour local dominance of *E. chlorophylla,*and *E. tectifica* -either singly or as co-dominants. Patches of *Corymbia grandifolia* occur in the northern section of the project area.	15 (n=7)	Unit 3 – *Eucalyptus tectifica/ E.terminalis* Unit 5 – *Eucalyptus tectifica* W/O-W	L1 –Inland bloodwood *Eucalyptus terminalis* open woodland L5 –Mixed Eucalypt *Eucalyptus tectifica,E. terminalis, Erythrophleum chlorostachys* woodland L6 –Darwin Box *Eucalyptus tectifica* woodland
6	Figure 19 Figure 21	Coolibah *Bauhinia cunninghamii/Eucalyptus microtheca/Atalaya* Low open woodland to shrubland Low growing, open community on poorly drained floodplain areas with cracking clays. Extensive areas to east and west of McArthur River. Dominance varies locally between *Bauhinia* and Coolibah (*Eucalyptus microtheca)* with an average tree height of 6m. Characteristic mid-stratum species include *Acacia farnesiana* and *Carissa lanceolata*. Grassland (*Brachyachne convergens, Eulalia aurea*) occurs on black soil and Gutta Percha (*Excoecaria parvifolia)* in drainage areas.	14 (n=4)	Unit 6 – *Eucalyptus tectifica/E. terminalis/E. microtheca* W/OW Unit 10 – *Lysiphyllum/ Atalaya* LOW	L2 –Coolibah *Eucalyptus microtheca* mid-high open woodland L3 – Gutta Percha *Excoecaria parvifolia* mid-high open woodland L4 – Bauhinia *Lysiphyllum cunninghamii* woodland

Map Unit	Profile Diagram (Appendix H.4)	Vegetation Community And Description	Mean Species Richness (n=No Sites)	Unit No from Duff and Orr (1992)	Unit No from Hollingsworth Dames & Moore (1992)
7	Figure 14	Ghost Gum Woodland *Corymbia bella* Woodland to Open Woodland A distinctive community with sparse Ghost Gum (*Corymbia bella)* dominant in upper stratum to 10 m high. *Bauhinia cunninghamii, Carissa lanceolata* and *Terminalia volucris* in midstratum above grasses including*Sorghum timorenis, Eulalia aurea* and *Bothriochloa everticum.* Diverse range of seasonal herbs occur amongst dense (77%) ground layer.	17 (n=1)	Included in Unit 4 – Riparian Woodland	D2 – Ghost Gum *Eucalyptus papuana* tall woodland
DRAINAGE AREAS					
8	Figure 11 Figure 15 Figure 17 Figure 20	Riverine woodland *Casuarina cunninghamii/Lophostemon grandiflorus* Woodland Highly variable community including narrow linear bands of riverbank species on smaller tributary creeks and a broader vegetation community on diffuse drainage ways and overflow channels. Dominant upper stratum species may include *Casuarina cunninghamii* and *Eucalyptus microtheca* 8-10 m high. *Terminalia bursarina, Excoecaria parvifolia* and *Lophostemon grandifolia* common on banks of ephemeral creeks (e.g. Barney and Surprise Creeks)	14 (n=3)	Unit 4 – Riparian Woodland	D3 – Creek margins Mixed species woodland
9	Figures 9 and 10 Figure 18	Riparian corridor *Melaleuca argentea* Woodland to open forest Larger drainage lines with dense tree layer (8 to 23 m). Mid-stratum of riparian species (2 to 6 m), with terraced banks & sandy levees. The species characteristic of this unit is *Melaleuca argentea* Sub-dominants include *Casuarina cunninghamii* and *Nauclea orientalis* with *Barringtonia acutangula* in the mid-stratum. In sandstone areas *Eucalyptus camaldulensis* and *Lophostemon grandifolia* are more common with *Pandanus aquaticus* and *Syzygium eucalyptoides* around 2 to 4 m high.	4 (n=21)	Unit 2 – Riparian Open Forest	D1 – Riverine *Melaleuca* spp. tall closed woodland

13.1.4 Aquatic Plants

Very few aquatic plants were observed within the main channel and the tributary creeks of either the McArthur or the Glyde River systems. Table 13.2 lists the eight species of aquatic plants recorded during the surveys.

Table 13.2

Aquatic Plant Species Recorded Within the Project Area

Family	Species
Aponogetonaceae	*Aponogeton vanbruggenii*
Characeae	*Chara* sp.
Eriocaulaceae	*Eriocaulon patericola*
Haloragaceae	*Myriophyllum callitichoides* subsp. *callitrichoides*
Hydrocharitaceae	*Blyxa* sp.
Menyanthaceae	*Nymphoides crenata*
Nymphaeaceae	*Nymphaea* sp.
Scrophulariaceae	*Peplidium* sp. nov

The sparsity of aquatic plants in the main channels of both the McArthur and Glyde River systems suggests that the combined effects of extreme seasonal scouring by floods, extensive and rapid drying of channels, and unfavourable steep banks around permanent water holes presents a largely inhospitable environment for this class of flora.

The most diverse aquatic flora was observed in tributaries (four species) and overflow channels of the Glyde River (three species). Water lilies (*Nymphaea* spp.) and submerged aquatic species (*Aponogeton vanbruggenii, Chara* spp. and *Blyxa* spp.) were found in larger pools along the east branch of the Glyde River and in a tributary creek on the western side. These drainage lines have smaller catchment areas, are not exposed to such high velocity scouring during the wet season, and typically include substrates more conducive to aquatic plant growth.

Aquatic species were also found at several locations quite distant from the major rivers. An isolated pond on a minor drainage way, located within the area of the proposed overburden emplacement facility, provided suitable habitat for a population of the yellow flowering fringe lily *Nymphoides crenata*.

Ephemeral pools perched within the sandstone plateau above the Glyde River supported a specialised aquatic flora comprising four species. A specimen of *Peplidium* collected from pools on the plateau surface appears to be undescribed and previously uncollected. A voucher specimen was submitted to the Northern Territory Herbarium.

13.1.5 Weeds

A total of 18 weed species were recorded within the project area during surveys, including 3 which are declared noxious weeds Class B (NT *Weeds Management Act, 2001*) (Table 13.3). Given the long history of land disturbance from grazing in the area, combined with periodic, often severe, disturbance from flood events, the diversity and abundance of exotic species was lower than expected. This finding concurs with Smith (1996) who recorded eight introduced species from an area of 50 km^2 within the nearby Merlin Mining Lease.

Table 13.3

Weed Species Recorded Within the McArthur River Mine Project Area

Weed species	Common Name	Classification[1]
Bidens bipinnata	Cobbler's Peg	—
Chionachne hubbardiana		—
Clitorea ternatea	Butterfly Pea	—
Corchorus olitorius		—
Digitaria bicornis		—
Echinochloa colona	Barnyard Grass	—
Eragrostis amabilis		—
Heliotropium indicum		—
Hyptis suaveolens	Horehound	Noxious Class B
Mitracarpus hirtus	Berrimah Weed, White Eye	—
Parkinsonia aculeata	Parkinsonia, Jerusalem Thorn	Noxious Class B
Passiflora foetida	Wild Passionfruit	—
Physalis minima	Wild Gooseberry	—
Portulaca pilosa		—
Scoparia dulcis		—
Stylosanthes hamata	Verano	—
Trianthema portulacastrum	Giant Pig Weed	—
Xanthium strumarium [=Xanthium occidentale]	Noogoora Burr	Noxious Class B

Source: MRM Weed Management Plan, 2003
[1]*Weeds Management Act*, 2001

The areas of highest weed infestation were the riparian areas along the McArthur River and its tributary creeks. The dominant species in these situations was Noogoora Burr, *Xanthium strumarium*, which occurs in dense stands to over 2 m in height. It is quite possible that the dense thickets of Noogoora Burr along the McArthur River suppress infestations of other weed species that might otherwise flourish in this environment (e.g. *Hyptis suaveolens, Passiflora foetida, Malvastrum*

americanum, *Stachytarpheta* spp., *Senna occidentalis*) and that populations of some these species, recorded in previous surveys, were diminished during wet season floods.

Riverine areas are highly dynamic systems and the distribution of weeds in this habitat is also heavily influenced by grazing intensity and the impacts of feral animals. Furthermore, weed introductions, particularly of pastoral weeds from upstream sources, is a continual threat to the MRM project area (MRM, 2003) and the concentration of weeds along riverine habitats clearly reflects this. Other situations where weeds were concentrated included disturbed areas such as road sides, tracks and cleared land.

Upland sandstone environments were typically weed-free. However, weed species such as *Bidens bipinnata*, *Heliotropum indicum*, the grass *Chionachne hubbardiana* and the vines *Clitoria ternatea* and *Passiflora foetida* were distributed patchily within grazed woodlands, lowland plains and hill woodland habitats. In general, fewer weed species were recorded at lower densities on the typically sandy substrates of riverine habitats in the Glyde River system. However, *Hyptis suavelolens* was recorded on the upper sections of river banks and extremely dense entwining vines including *Passiflora foetida* smothered vegetation and hampered access along the river prior to the 2002-2003 wet season (P. Barden pers. comm., 2003). Weed distribution and abundance in riverine areas varies in response to the scouring effect of wet season flooding.

13.1.6 Significant Flora Species

Threatened Species

Current threat status of the 364 species recorded during this survey according to the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2004) and *Territory Parks and Wildlife Conservation Act 2000* is listed in the plant species list provided in Appendix H.2. The majority of species are not threatened or listed as least concern (lc). No plants with declared endangered or threatened IUCN threat status were found during the surveys. One species was listed as near threatened (nt), while four others were listed as data deficient (dd), a category usually indicative of a species' rarity in the NT. Eleven species lacked formal threat status codes while two species collected during the survey could prove to be new to science.

Appendix H.2 also identifies nine species accepted as endemic to the NT. These species are important for the reason that they cannot be conserved anywhere else but in the NT. This level of endemism is quite low compared to many other regions in the NT but it is understandable because the region is close to Queensland and many of the local environments are represented extensively across the border.

The significance of the near threatened (nt), data deficient (dd), and potentially new species is discussed in Table 13.4.

Table 13.4

Threatened Species

Species	Threat Status	Description
Astrebla lappacea	Data Deficient	A perennial species of Mitchell grass found at a single site on a black soil plain on the eastern side of the McArthur River. It is predominantly known from scattered records throughout the extensive, more southerly Mitchell grass plains of the NT and Qld. This species is a valuable, highly palatable pasture grass (Milson, 2000) which could contribute to its apparent rarity.
Ophioglossum gramineum	Near Threatened	A tiny fern recorded once on the sandstone plateau during this survey. It is widely, though sparsely distributed throughout the NT and is also known from WA and Queensland.
Portulaca oligosperma	Data Deficient	This plant is a very small annual ground cover species and was collected from one site on the sandstone plateau. It is known from just 13 records in the NT.
Nephrolepis arida	Data Deficient	This fern was recorded from damp crevices along the gorge of the Glyde River. It appears that this may be the first record of the species from the eastern side of the Top End (ABRS, 1998). All other, albeit sparse, records have been from the Victoria River district or from the Kimberley in WA. The distribution of the species elsewhere in the region is unknown.
Rothia indica subsp. *australis*	Data Deficient	An endemic, annual, herbaceous plant which was collected from a single site on an unconsolidated sandy bank along the Glyde River. There is no evidence that this species is particularly confined to the local region. Although it has been infrequently sampled in the NT, other records of it indicate that it occurs across a wide area of the NT.
Peplidium sp.	Potentially New	A small aquatic herb found in seasonal rock pools on the sandstone plateau above the Glyde River. This species appears to be undescribed and previously uncollected. A voucher specimen was submitted to the Northern Territory Herbarium.
Triodia affin. *bynoei*	Potentially New	This species is a spinifex grass that occurs on the sandstone plateau along Glyde River. Using current identification resources it keys to *Triodia bynoei* but does not convincingly match other collections under this name. It could therefore represent a currently undescribed taxon.

Endemic Plant Species

The nine endemic species recorded from the project area were *Gomphrena floribunda*, *Cleome microasustralica*, *Euphorbia armstrongiana*, *E. mitchelliana*, *Sauropus rigidulus*, *Leptosema villosum*, *Rothia indica* subsp. *australis*, *Mitrasacme glaucescens* and *Pityrodia angustisepala*. A description of *Rothia indica* is given in Table 13.4. All the remaining endemic species, except *Euphorbia mitchelliana*, were only found in elevated sandstone plateau environments.

Other Plant Species of Conservation Interest

Hollingsworth Dames & Moore (1992) indicated that two potentially rare species, *Calytrix mimiana* and *Sesbania erubescens* might occur within the mine site leases.

Calytrix mimiana is a specialist sandstone species and is currently listed as data deficient. It was not recorded during the surveys for this EIS and the environment in which it grows will not be affected by the open cut operation. The nearest known populations are some 20 km from the mine.

Sesbania erubescens is also listed as data deficient and is a rarely collected upright annual shrub with a wide geographical distribution (Briggs and Leigh, 1984). It has bright purple flowers but was not observed in the project area. The mauve-flowering *Sesbania brachycarpa*, which has a patchy distribution in black soil areas within the survey area, was the only *Sesbania* species observed during this survey.

A high proportion of Northern Territory orchid and cycad species (families Orchidaceae and Cycadaceae) have rare status due to their relatively restricted distribution patterns (Ian Cowie pers. comm., 2003). The presence of cycads and orchids is of some botanical importance. *Cycas angulata* is a distinctive localised cycad species from the Borroloola region but has not been recorded from the McArthur River area. No orchid species have been recorded from within the project area.

Cultural Significance

Three members of the local Aboriginal community (two Traditional Owners and one Senior Custodian) were asked if any of the flora at the mine site had cultural significance. While one person reported that a local plant (root vegetable similar to a carrot) has historically been used as food, it is not present on the mine site nor is it currently being used. There are no local plants that have been used for medicinal, cultural or spiritual purposes nor are there any that have been used for making materials or artefacts.

13.2 Flora – Impact Assessment and Management

13.2.1 Clearing Schedule

The main project elements that will result in vegetation clearing are shown on Figure 4.1. They include the following:

- The realigned channels of the McArthur River and Surprise and Barney Creeks;
- The flood protection bund around the open cut and the industrial area;
- The open cut area; and
- The area within the overburden emplacement facility.

The channel realignments will be cleared during the two years of the construction phase. They will be revegetated immediately after construction.

The flood protection bund and the industrial area will be cleared during the two year construction phase.

The open cut area will be cleared in accordance with the staged mining schedule.

Construction of the overburden emplacement facility will be undertaken in stages as described in Section 7.2. The clearing program will match this staged development.

The area proposed for the storage of tailings from the open cut project is already used as water runoff and storage areas from the existing tailings storage facility. No further clearing is required in this area.

The proposed clearing schedule is shown on Figure 13.4.

13.2.2 Realignment of the McArthur River

Impacts

Realignment of the McArthur River around the new open cut mine will result in loss of approximately 3.6 km of riparian habitat. Profile diagrams of the vegetation communities associated with the riverbanks and overflow channels in this section of the McArthur River are given in Figure 13.5 with further details provided in Appendix H.4. The vegetation comprises an open forest formation to 20 m high with only a few constituent species. The mean species richness for the 21 riparian sites examined during this survey was 4 species.

Melaleuca argentea is the characteristic riparian species in the river length to be disturbed by mining with subdominants including *Casuarina cunninghamii* and *Nauclea orientalis.* Upper banks support Ghost Gum (*Eucalyptus bella)* and Coolibah *(E. microtheca).* The understorey layer is similarly species poor, mainly comprising *Barringtonia acutangula, Pandanus spiralis* and the noxious weed *Xanthium strumarium.*

The riparian vegetation within the area of the proposed open cut (2.5 km) will be cleared to allow the open cut to be developed. Realignment of the river will also cause a gradual decline and eventual loss, in response to a lack of water, of the riparian vegetation along the sections of the old river channel between the realignment take off point and the open cut (0.5 km) and from the open cut to the point where the realigned channel of Surprise and Barney Creeks joins the river channel (0.6 km). The riparian vegetation downstream of where the creek realignment joins the river (1.2 km) will continue to be supplied with water from the creeks. While this supply of water will be less than is currently the case (there will be no river flow), complete loss of riparian vegetation in this area is not expected although a change in the vegetation structure is likely.

During construction, material excavated from the new channel will be used to construct the bund wall around the open pit. The movement of trucks between the channel and the bund will be limited to designated haul routes so that the extent of clearing of the existing floodplain vegetation is limited. Vehicle movement outside of the designated haul routes will be prohibited without permission.

Erosion of the new channel, particularly during major flood events, may increase the amount of sedimentation causing smothering of downstream vegetation. While this is an existing characteristic

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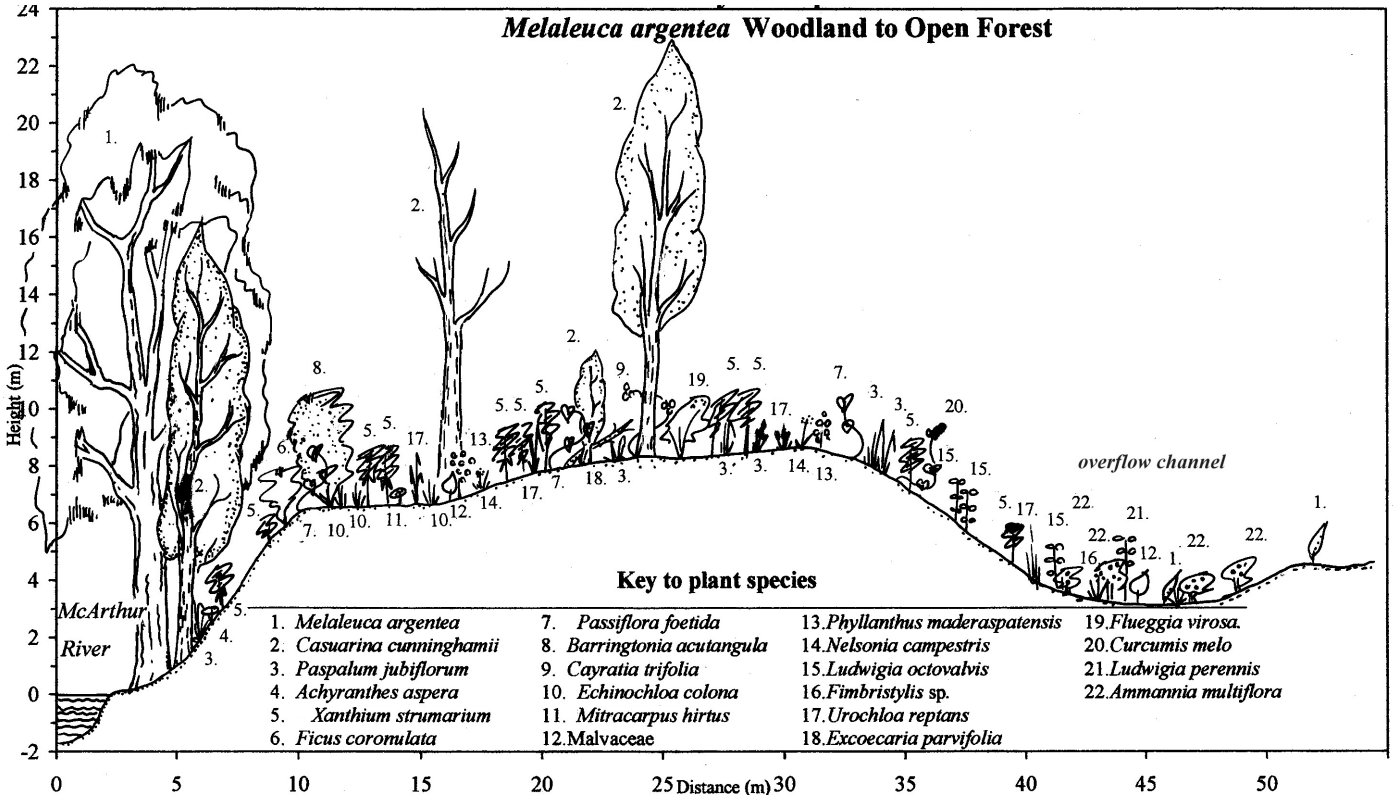
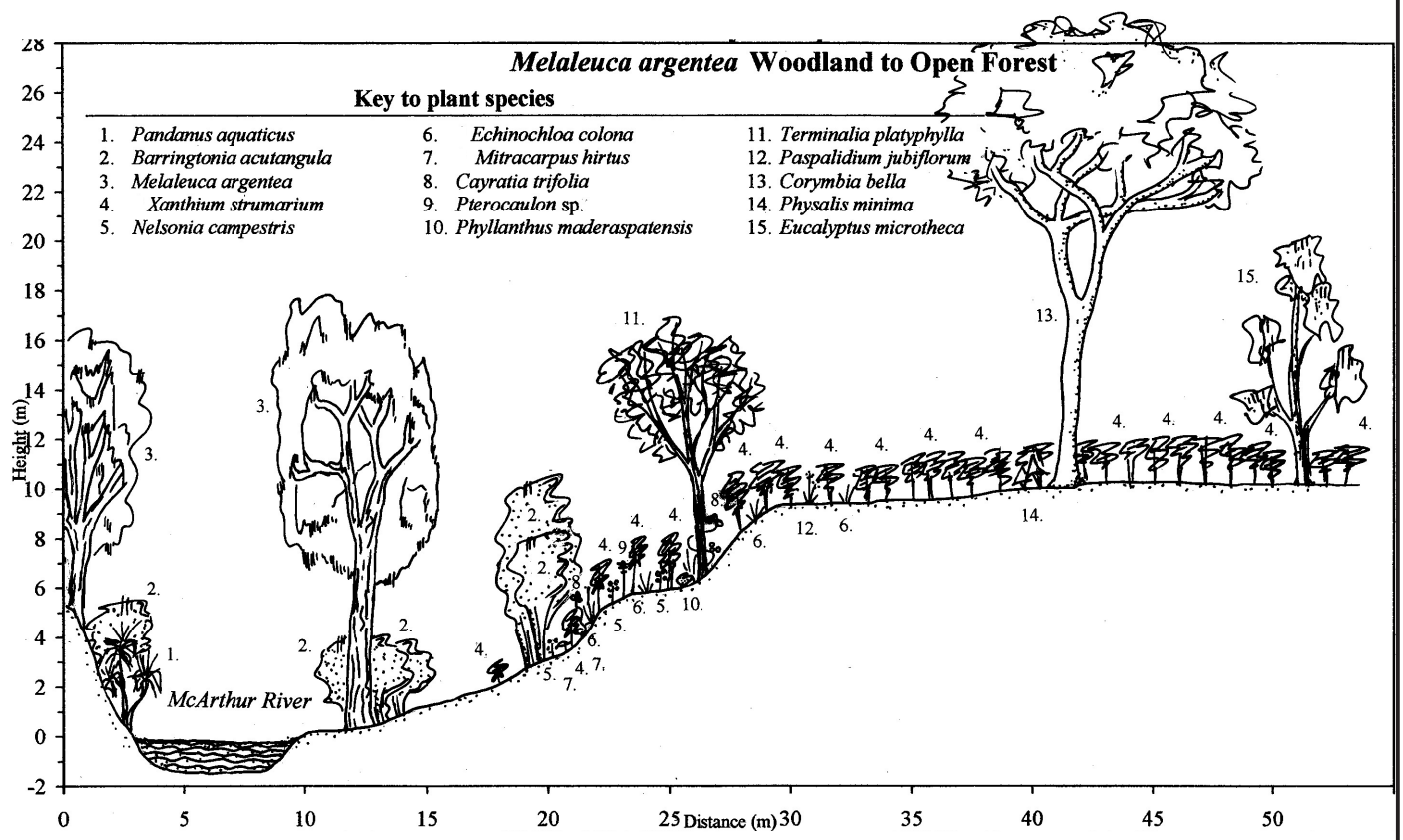
CLEARING SCHEDULE

Drawn: VH	Approved: CMP	Date: 25-07-05	Figure: **13.4**
Job No: **42625552**	File No: 42625552-g-151.wor		Rev: A **A4**



TRANSECT T9



TRANSECT T10

See Figure 13.1 for location of transects.

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RIPARIAN TRANSECTS ON THE McARTHUR RIVER

Drawn: VH	Approved: CMP	Date: 13-01-2005	Figure: 13.5	Rev. A
Job No.: 42625552	File No. 42625552-g-042.cdr			A4

of the river, the sediment load can be expected to increase for the initial flood events following construction of the realigned channel.

Successful revegetation of the river realignment is likely to significantly reduce negative downstream impacts on flora. Erosion potential will be highest during the first wet season flows while the substrate is still consolidating. Furthermore, weeds could spread at this stage and lead to problems with weed infestations. Once established, native vegetation cover on the banks of the new channel will assist in reducing the introduction and spread of weed species, decrease river velocities and reduce erosion and downstream turbidity/sedimentation.

Altered habitat conditions for aquatic and/or riverine species are anticipated along the realignment. However the proposed management strategies discussed below have been designed to minimise these effects.

Further management strategies to be introduced to minimise the effects of the realignment of the river are discussed in Sections 13.4.1 and 13.5.7.

Channel Revegetation

Revegetation Strategy

The cross section of the realigned river channel will be designed to have a bed approximately 15-28 m wide and up to 18 m deep with batter slopes between 2:1 and 3:1. Where the depth is greater than 12 m, a berm 4 to 6 m wide will be placed 9 m above the bed level. The batters and berm will be revegetated with native species to reduce the potential for erosion. Micro habitats will be established in the channel bed for aquatic fauna.

The foundation conditions along the banks of the channel will be a driving factor for the success of, and need for, revegetation. As discussed in Section 12.10, approximately one third of the channel will be in alluvium (silty sands and clays) and the balance in rock (breccia and mudstone). It is proposed that sections of the channel in the alluvium will be more fully vegetated. In the rocky sections, it will be more difficult to establish vegetation, though not impossible. Many natural watercourses with channels through bedrock material support vegetation growth in rock fractures and crevices, and such features will be incorporated into the new channel to encourage opportunities for vegetation establishment. However, in the rocky sections it is not necessary to establish riparian vegetation to slow flow velocities and enhance resistance to erosion. In these sections the main requirement for bank revegetation will be to enhance ecological aspects of the channel.

The target rehabilitation strategy for rocky reaches of the realignment will therefore be the revegetation of the high parts of the realigned banks (alluvial soils), and the strategic revegetation of the lower rock banks where necessary for ecological reasons, targeted to areas where rock fractures and crevices can be enhanced to maximise the success of revegetating the rock banks.

Revegetation Species

The species to be affected by the McArthur River realignment include *Melaleuca argentea* with subdominants including *Eucalyptus camaldulensis, Corymbia bella, Lophostemon grandiflorus and Casuarina cunninghamii*. Common grasses in the area include *Urochloa reptans, Chrysopogon elongatus, Chrysopogon fallax, Echinochloa colona*, *Paspalidium jubiflorum* and *Paspalum scrobiculatum*. Herb species typical of riverine woodland inclue *Ammannia multiflora, Hybanthus enneaspermus*, *Melochia corchorifolia, Boerhavia schomburgkiana, Alternanthera nodiflora* and *Phyllanthus maderaspatensis*. Woody species include *Hibiscus panduriformis* and *Sida spinosa*.

These species are naturally occurring along the riverine system and are important to the sustainability of the ecosystem. The woody species are generally hardy and well suited to a variety of well drained soils. Because of this hardiness, these species are likely to survive in undisturbed areas adjacent to construction activities. For the areas disturbed by construction, these woody species are generally well suited to cultivation from seed.

These will be the prime species selected for use in the channel revegetation program. Using them will maintain the species diversity within the revegetated area and will allow natural succession to occur until the area has reached ecological stability.

Seed Collection

The species mentioned above all occur upstream and downstream of the proposed realignment. Seeds will be collected from the surrounding riverine habitats to ensure that the genetic diversity of the area is not changed. Seed collect will occur in these naturally occurring habitats preferably free of the noxious weed species, *Xanthium strumarium* (Noogoora burr) and other introduced species. Seed collection will include the key woody species as well as the grasses and herbs. Seed collection will be an ongoing process and will continue until the revegetated area is ecologically sustainable.

Seed collection will occur at the time of seeding for each of the species to ensure fresh seed is collected that will have a higher chance of germination. For example, *Casuarina cunninghamii* fruits during the late dry season and *Melaleuca* spp. often produce fruit during the wet season (M. King pers. comm., 2003). Seed storage will be in an area free of moisture and protected from fire and other factors that may allow for accidental germination.

Revegetation

Apart from natural generation, the revegetation of the realigned channel will use three techniques; direct seeding, hand seeding and seedling planting.

Direct seeding will be used in areas not subject to high erosion and in areas where seed will not be lost by being either washed or blown away. The seed mix will include woody, herbaceous and grassy species in a ratio of approximately 3:4:5 that reflects the existing natural species density. This method is suited to large areas, is quick and easy, and requires minimal staff, time and labour. This process however does require a considerable more amount of seed than the other techniques. Subject to seed availability, a seeding rate of approximately 2-5 kg/ha is anticipated.

Where areas are not suitable for direct seeding, where species selection is required, or where it is observed over time that direct seeding is not effective, hand seeding will be used. Hand seeding is expected to be used mainly for the woody species where site selection may be an issue. Hand and direct seeding will take place after the first rains of the wet season. This will ensure the seeds have maximum moisture for germination.

Direct planting of seedlings will be utilised in areas where initial establishment from direct seeding and hand seeding is not effective, in areas where specific species are required, and in areas more susceptible to erosion. Seedlings will be grown in a nursery on site from the locally collected seed. Seedling planting has a higher success rate than the other two methods, however it is a more costly process due to the time and labour required to germinate the seed to a seedling and then to plant the seedling. Direct planting will first be undertaken before the onset of the 2006 wet season. Subject to seed availability, a seedling planting rate of approximately 300-400 (woody species) seedlings/ha is anticipated. This planting density is representative of a woodland to open forest community.

As water begins to flow down the realigned channel, natural regeneration of the area will begin. Seed will be transported downstream where it will settle and germinate. This is likely to occur initially for the herbaceous and grassy species as they will be more abundant in the surrounding areas.

Weed and Animal Control

Weed management prior to the start of revegetation is essential to the control and prevention of weed establishment. In a riverine system, the management of weeds is more difficult as seed is transported downstream in water flows, as is evidenced by *Xanthium strumarium* which forms dense infestations along the McArthur River. For this reason a weed management plan and weed monitoring program will be developed and maintained within the revegetated area.

Regular monitoring of the realigned channel will be undertaken to allow early detection and eradication of weeds before establishment. The area will be fenced from cattle and other large feral animals to further reduce the likelihood of seed transportation in particular *Xanthium strumarium* (a spiny seed that sticks to the fur of animals) and other weedy species into the revegetation area.

Excluding cattle and other herbivores from the area will reduce the likelihood of plant mortality from destruction of the newly generated shoots. The exclusion of cattle and other hard-hoofed animals will also eliminate the trampling of young seedlings. Although feral pigs are not a major concern in the area, their elimination from the area will prevent the pugging of soil.

Successful revegetation of the river realignment is likely to significantly reduce negative downstream impacts on flora. Erosion potential will be highest during the first wet season flows while the substrate is still consolidating. Furthermore, weeds could spread at this stage and lead to problems with weed infestations. Once established, native vegetation cover on the banks of the new channel will assist in reducing the introduction and spread of weed species, decrease river velocities and reduce erosion and downstream turbidity/sedimentation.

Revegetation Monitoring

Monitoring of the newly regenerated vegetation will be on a regular basis until the area is considered ecologically sustainable. Monitoring will allow identification of areas that are not regenerating and may require different establishment techniques. It will also allow for the identification of species that are failing or succeeding in the regeneration process. A site vegetation monitoring program will allow for the successful implementation of the weed management and weed monitoring plan.

13.2.3 Realignment of Barney Creek

Impacts

Barney Creek is a small, non-perennial streams flowing though relatively level country with a narrow fringing vegetation of riverine woodland (Vegetation Unit 8). Since the vegetation of these systems is sparse compared to the McArthur river channel (Vegetation Unit 9), effects will consequently be less pronounced.

The riparian vegetation community to be affected by the realignment of these creeks is highly variable and includes narrow linear bands of riverbank species and a broader vegetation community on diffuse drainage ways and overflow channels. Dominant upper stratum species may include *Casuarina cunninghamii* and *Eucalyptus microtheca*, at 8-10 m high. *Terminalia bursarina, Excoecaria parvifolia* and *Lophostemon grandifolia* are common on the creek banks.

Construction of the open cut and the mine infrastructure facilities will result in 2.1 km of the riparian vegetation along Barney Creek being removed.

Erosion from the new channel of Barney Creek may result in sedimentation causing smothering of downstream vegetation, particularly during major flood events. Altered habitat conditions for aquatic species are also anticipated along the realignment.

Management Strategies

As for the McArthur River, the realignment of Barney Creek will be designed with a cross sectional profile based on that of the existing creek. The channel bed will have a width of 15 m, side slopes of 2:1, and a typical excavation depth of 5-6 m (maximum 11 m). The new channel banks will be revegetated with native species in a manner similar to that proposed for the McArthur River to reduce the potential for erosion.

Erosion potential will be highest during the first wet season flows while the substrate is still consolidating. Once established, native vegetation cover on the banks of the new channel will assist in reducing the introduction and spread of weed species, decreasing flow velocities, and reducing erosion and downstream turbidity/sedimentation.

Revegetation of the channel banks will be accomplished by a combination of direct seeding and planting of tube stock. Rehabilitation species to dominate will include the tree species *Lophostemon grandifolius* and *Casuarina cunninghamii.*

Every effort will be made to reduce the area of suitable habitat for weed proliferation. Regular monitoring of the new channel will be incorporated into the MRM Weed Management Plan.

13.2.4 Drawdown from Water Extraction

As discussed in Section 11.10, drawdown caused by dewatering has the potential to lower groundwater levels in the superficial sediments around the pit and in the alluvium associated with both the current McArthur River channel and the palaeochannel sediments. Groundwater levels in the superficial sediments over most of the area (away from the major drainages) are already reasonably deep (10 to 15 m below ground surface) and in some areas, these sediments are largely unsaturated. Lowering of groundwater levels in these sediments, therefore, will not have a significant environmental impact as most flora in the area are likely to rely on soil moisture (rather than the water table) for survival.

13.2.5 Tailings Storage Facility

The open cut project will not require any expansion of the tailings storage facility (TSF) beyond the footprint area that is currently occupied for underground operations. Therefore, no additional clearing will be necessary and no impacts on flora will result.

13.2.6 Overburden Emplacement Facility

The main flora considerations in relation to construction of the new overburden emplacement facility is the loss of vegetation during the construction phases of the project and associated impacts on the surrounding vegetation. Changes in drainage and the potential for erosion resulting from earthworks and the potential introduction/spread of weeds could result from the construction of the emplacement facility. These impacts are localised in nature.

There will be 300 ha of vegetation removed as part of the facility's construction which will occur in stages over 15 years (Figure 13.4). The vegetation community to be most affected is Vegetation Unit 6, with small areas of Vegetation Units 5 and 8. In Unit 6, dominance varies locally between *Bauhinia* and Coolibah (*Eucalyptus microtheca)* with an average tree height of 6 m. Characteristic mid-stratum species include *Acacia farnesiana* and *Carissa lanceolata*. Grassland (*Brachyachne convergens, Eulalia aurea*) occurs on black soil and Gutta Percha (*Excoecaria parvifolia)* occurs in drainage areas. Unit 5 a Bloodwood woodland dominated by *Corymbia terminalis*. Unit 8 is Riverine woodland dominated by *Casuarina cunninghamii/Lophostemon grandiflorus.*

None of these species has significant conservation status.

13.2.7 Effects on Significant Species

No Endangered, Vulnerable or Near Threatened plant species have been recorded from sites affected by the proposed open cut mine.

All but one threatened plant species recorded in the surveys occur in sandstone habitats, which are outside of the project area. The one species within the project area is a perennial species of Mitchell grass (*Astrebla lappacea)* (status data deficient) which was found at a single site on the black soil plain on the eastern side of the McArthur River. It is possible that some of the local population of this species could be lost during construction of the new channel for the McArthur River. However there is no evidence to suggest that this species is confined to the local region.

All but one of the endemic species identified will not be affected by the open cut operation as they are confined to sandstone habitats and are widely distributed. The one species that could be affected is *Euphorbia mitchelliana* which is a small diffuse annual herb, recorded from the inland bloodwood community. While some local populations could be affected by the open cut operation, this species is widespread elsewhere in the Top End of the NT.

Twenty-four of threatened plant species are listed for the Gulf Coastal bioregion, which encompasses the McArthur River Mine project area, representing 2.6% of the total bioregional species (Connors, Woirnarski and Oliver, 1996). This figure is relatively low, especially in comparison with the same data for the Top End Coastal bioregion with 163 threatened species (representing 8.6% of species tally). Thus, on a regional basis, it is unlikely that species of high conservation significance are present although some may remained undetected by flora surveys within the project area.

13.2.8 Effects on Regional Vegetation Communities

Woodland

The McArthur River region is comprised mainly of *Eucalyptus* and *Corymbia* dominated vegetation communities, either as woodland or open woodland formations. This vegetation type, where trees co-occur with a more or less continuous grass cover, is commonly known as savanna and occurs across vast areas of northern Australia. The Inland Bloodwood community which equates with Unit 16 (*Eucalyptus tectifica/E. terminalis* woodland) in the Northern Territory vegetation map (Wilson *et. al.,* 1990) occurs extensively on flat to undulating plains in the Gulf region covering an area of 30,000 km^2.

The terrestrial vegetation communities within the area proposed for development are typical of *Eucalypt* woodland and open woodland in the Gulf of Carpentaria and comprise part of the extensive Gulf Coastal bioregion, covering 28,000 km^2. Thus, in the regional context, the conservation value of terrestrial habitats found on the site is not significant. However, it is noted that only <1% of this bioregion is currently reserved for conservation purposes (Woinarski, 2003).

Riparian

The project site contains areas of riparian and floodplain communities associated with the McArthur River, and Barney and Surprise Creeks. These communities are common and widespread in the region generally. As the riparian corridors are too fine to map at a large scale, there are no figures available on their regional extent.

Sandstone Plateau

Dissected, low ranges (Bukalara Range) occur to the east of the project area (Figure 13.3, Vegetation Unit 1) comprising distinctive vegetation communities largely restricted to rocky (*Eucalyptus. leucophloia* open woodland) and sandstone areas (*E. phoenicia/Corymbia capricornia* open woodland). Intervening low hills, scree slopes and rocky buttes may also support small, dry vine-forest or vine-thicket communities. Vine forest communities are often floristically diverse and the sandstone habitats contain plant species of botanical importance. The two vegetation types have no declared conservation status but they do have some local ecological value. This area will not be affected by the project.

The Bukalara Range, is heavily dissected sandstone within the Carpentarian Land System and encompasses the Glyde River catchment. It is regarded as significant at both the national and Territory level, and has in the past been proposed for a conservation reserve (NT Department of. Lands and Housing, 1991). The sandstone vegetation is in largely undisturbed, intact condition with relatively few introduced weed species and little evidence of impacts from feral animals. Sandstone habitats in the Kakadu region of the Top End are habitats of high conservation value, typically supporting a relict flora containing numerous species of conservation significance. However, the sandstone vegetation in the McArthur River area is relatively species poor, being largely an attenuated version of the more highly speciose sandstone flora of the Arnhem plateau in the northern Top End.

Recent fires on the western side of the Glyde River have had an impact on the sandstone vegetation, with scant regeneration observed at the time of the survey. The eastern side of the gorge however, supports areas of dense ‘old growth’ spinifex grassland interspersed with areas that have not burnt for several years. Strategies used by MRM to control bushfires in the vicinity of the mine site are discussed in Section 8.1.3.

13.2.9 Weed Management

McArthur River Mining has a comprehensive weed management plan for the mine site and surrounding area, which is implemented with the assistance of the district weeds officer from the Department of Infrastructure, Planning and Environment (DIPE). Officers from DIPE have inspected the MRM site for the presence of noxious weeds. Signs indicating weed infestations have been placed on access tracks, instructing personnel to check their vehicles and clothing for seeds.

A weed management plan is used to strategically manage site weeds. This plan sets long term (three year) and annual strategies. The weed management plan is required to remain dynamic to manage new issues that may arise, whilst maintaining long-term strategies to facilitate programs which need to be undertaken over successive years. The plan is reviewed annually. Programs are in place at both the mine site and Bing Bong and employ integrated weed management strategies where possible. The primary weeds of concern and the relevant management strategies employed are shown in Table 13.5.

Table 13.5

Weed Management Strategies

Weed	Common Name	Declaration (*Weed Management Act 2001*)	Management Strategies		
			Burn	Spray	Biological Control
Martynia annua	Devils Claw	A	✓	✓	
Hyptis suaveolens	Hyptis	B		✓	
Jatropha gossypifolia	Bellyache Bush	B	✓	✓	
Parkinsonia aculeata	Parkinsonia	B		✓	✓
Xanthium occidentale	Noogoora Burr	B	✓		
Ziziphus mauritania	Chinese Apple	A	✓	✓	

13.2.10 Vegetation Monitoring

Riparian vegetation communities in the vicinity of the mine have been monitored in 1995, 1996, 1999 and 2002. The objectives of this program are to monitor the mine-related effects of groundwater drawdown, water and air quality, erosion or weed infestation and provide data that will allow for development of appropriate management programs. The results have indicated very few changes in species richness or cover of trees and shrubs, grasses and herbs, with the variation being consistent between upstream and downstream sites.

A comprehensive riparian flora monitoring program will be developed as part of the environmental management program for the open cut project. The impacts of grazing and fire play a major role in shaping the vegetation of the local region and it is necessary for monitoring programs to distinguish fire and grazing impacts from possible impacts of mining.

The existing monitoring program will be reviewed and updated with regards to monitoring parameters, site selection and monitoring frequency, and will be expanded to include new sites along the river realignments and in upstream and downstream areas. The proposed open cut mine will necessitate the relocation of a number of the existing riverine monitoring sites.

A draft environmental management plan for biology is given in Section 22.4.

13.3 Fauna – Existing Environment

13.3.1 Introduction

The terrestrial fauna of the project area is described with reference to a number of existing studies, and has been supplemented by additional field surveys conducted as part of the EIS investigations. Previous fauna surveys include:

- A series of wide-ranging surveys for terrestrial fauna in the Lower McArthur River Region (CSIRO, 1976);
- Surveys of terrestrial fauna in the mine project area for the Draft Environmental Impact Statement (Hollingsworth Dames & Moore, 1992a); and
- Terrestrial fauna studies undertaken in 1992 (Ecostudy, 1992).

Further terrestrial fauna surveys were undertaken in December 2002 and April 2003 as part of this EIS. These surveys focussed on assessing areas not well covered by the previous fauna studies, especially the McArthur River proposed realignment, the open pit area and the overburden emplacement facility area.

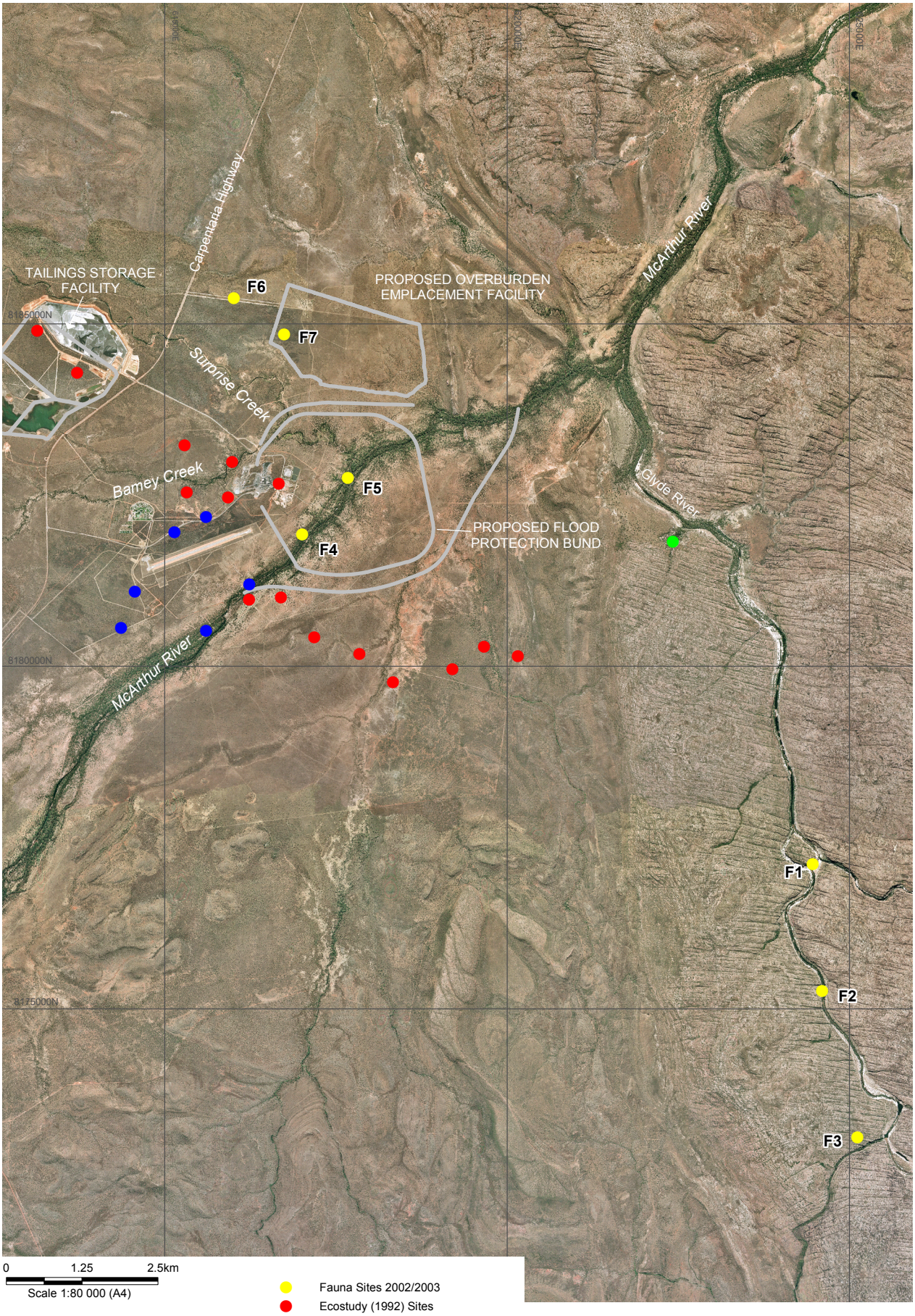
Surveys were also conducted in the Glyde River area to provide data for a previously proposed weir. Although the weir is no longer proposed, the data are still presented as they provide information on the broader project region

Sampling for the terrestrial fauna survey was carried out at seven sites in December 2002 and April 2003 (Figure 13.6).

Standard biological survey techniques were used during field surveys, including a number of live capture/release trapping techniques, standard and general observational and habitat searches, as well as methods to indirectly detect the presence of terrestrial fauna. The surveys focussed on rare and threatened/significant terrestrial vertebrate taxa, with incidental observations aimed at identification of any significant terrestrial invertebrate species. Full details of the survey sampling methods are presented in Appendix I.1.

13.3.2 Terrestrial Fauna Habitats

Habitats for terrestrial fauna were classified according to vegetation type, substrate and landform. Fauna habitat classifications are generally at a broader scale than vegetation or land units. The following general habitat classifications have been used by previous authors and are retained here.



Horizontal Datum: AGD84, Zone 53
Date of Aerial Photography, 2001

xstrata

URS

McARTHUR RIVER MINE
OPEN CUT PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TERRESTRIAL FAUNA SAMPLING SITES

Drawn: VH	Approved: CMP	Date: 25-07-05	Figure: **13.6**	Rev: C
Job No: **42625552**	File No: 42625552-g-009c.wor			**A4**

Riverine

Habitats along the main McArthur River channel within the mine project area are characterised by a relatively narrow dense fringing riverine *Melaleuca argentea* tall closed forest, surrounded by open floodplain forest types (generally *Eucalyptus camaldulensis* tall woodland). The canopy of the riverine forest is relatively dense and common plant species include *Melaleuca argentea, Eucalyptus camaldulensis*, *Casuarina cunninghamiana* and sparse *Pandanus aquaticus*. During the late wet season survey, large areas of the ground layer in this habitat supported dense stands of Noogoora Burr (*Xanthium strumarium*). This habitat has a very sandy substrate and semi-permanent water. A view of the McArthur River in the vicinity of the proposed open cut is shown on Figure 13.7.

Woodland/Grassland

Floodplains associated with the McArthur River support a number soil and vegetation types ranging from low-lying open woodland with blacksoil grassland understorey to dry eucalypt or mixed woodland. Ground cover consists mainly of small shrubs and seasonal grasses.

Stony Rises

A number of stony rises and low hills occur within floodplain areas of the McArthur River. These habitats support mid-high open woodland often dominated by *Erythrophleum chlorostachys* (Ironwood), with *Eucalyptus grandifolia*, *E. tectifica* and *E. terminalis* also present.

Sandstone Plateau and Gorges

Habitat in the Bukalara Range consists of rugged dissected sandstone plateau with vegetation occurring on shallow sandy soils and lithosols. Vegetation is generally sparse *Eucalyptus phoenicea* and *E. aspera* open woodland with some *E. leucophloia* and *E. grandifolia* (Hollingsworth Dames & Moore, 1992). A relatively sparse mid-layer may contain *Grevillea parallela, Acacia latifolia* and *Calytrix acheata* with *Plectrachne pungens* (spinifex) common in the ground layer (Hollingsworth Dames & Moore, 1992).

Depauperate monsoon vine-thickets occur in some deeply dissected outcrops and gorge margins on the plateau. At these sites protection from fire and the presence of higher seasonal soil moisture levels within the sheltered gorge environment allow the survival of vine-thicket species. These areas are relatively minor habitats and the vegetation is rarely dense enough to form a canopy, often restricted to a few individual trees and shrubs.

The Glyde River flows through a rugged series of sandstone gorges of the Bukalara Range. The river has a highly seasonal character, with massive flow rates observed in the wet season, reducing to a series of refuge pools in the dry season. The river channel ranges from steep, narrow-sided rock ravines (10 m wide, 10 m deep) in the upper reaches, to gorges about 90 m wide with some 30 m deep.

McArthur River in Area of Proposed Open Cut

McArthur River - Djirrinmini Waterhole

xstrata

URS

McARTHUR RIVER MINE
OPEN CUT PROJECT
ENVIRONMENTAL IMPACT STATEMENT

McARTHUR RIVER PHOTOS

Drawn: VH	Approved: CMP	Date: 14-01-2005	Figure: **13.7**	Rev. A
Job No.: **42625552**	File No. 42625552-g-043.cdr			A4

Mine Site Habitats

A number of anthropogenically influenced habitats were identified within the project area. These include modified landscaped areas associated with the accommodation camp, cleared areas associated with the airstrip and other infrastructure, and tailings areas/artificial waterbodies. The latter habitats are of some significance to wildlife, as they offer permanent large waterbodies that attract waterbirds that would otherwise not occur within the project area, including migratory wading birds.

13.3.3 Terrestrial Fauna Species

Trapping Results

Results of the fauna trapping program are detailed in Appendix I.2. In general, results for small mammal trapping were poor, with only one species (common rock-rat) trapped. These results were in line with other surveys previously undertaken in the area which have also demonstrated a generally low population of small mammals in the area. Five species of frogs were caught by pit and Elliot trapping, including the introduced cane toad. This species was the most frequently trapped animal, and was especially abundant at sites F5 along the McArthur River, and F7 within the proposed overburden emplacement facility. Five species of a small skink were trapped in the program.

Amphibians

Thirteen amphibian species were identified in the project area during the current survey (Appendix I.3) and a total of 17 species are known to occur within the project area (Appendix I.4). One introduced species, the cane toad (*Bufo marinus*), was common across a range of habitats, including the riverine forest, floodplain woodland, grassland and sandstone gorge habitats.

The most commonly encountered native amphibians in the riverine forests on the McArthur River were *Limnodynastes ornatus, Litoria rothi* and *Cyclorana australis*. During surveys of floodplain woodlands and grasslands in the late wet season, the most common species were *Cyclorana australis, Crinia deserticola, Litoria caerulea, Limnodynastes ornatus, Litoria inermis, Litoria pallida* and *Cyclorana cultripes*. In the floodplain areas of the McArthur River, highest amphibian abundances and species richness were associated with artificial watering points (dams) and ephemeral drainage lines. It was noted that *Cyclorana australis* appeared to be more abundant than the introduced cane toad in woodland/grassland habitats during the 2003 late wet season.

The most common native species in the Glyde River gorge were *Cyclorana australis, Litoria meiriana, Litoria rothii* and *Litoria caerulea*. A single species (*Litoria meiriana*) was observed in the sandstone escarpment habitats of the Bukalara Range. Habitats with the highest amphibian species richness included the Glyde River gorge (10 species) and woodland grassland habitats on the McArthur River floodplain (9 species).

Reptiles

Twenty-seven reptile species were recorded within the project area during the 2002-2003 surveys (Appendix I.3). A number of these species, including the sandstone heteronotia (*Heteronotia planiceps*), sharp-snouted delma (*Delma nasuta*), stripe-headed finesnout ctenotus (*Ctenotus striaticeps*), northern bluetongue (*Tiliqua scincoides*), olive python (*Liasis olivaceus*), freshwater snake (*Tropidonophus mairii*) and the Arafura filesnake (*Acrochordus arafurae*), have not been previously recorded within the McArthur River Mine project area. A total of 53 reptile taxa have now been identified within the local area from various studies (Appendix I.4).

The riparian and in-stream habitats associated with the McArthur and Glyde Rivers supported a number of reptiles that were strongly associated with these habitats, including the Arafura filesnake, freshwater snake, freshwater crocodile (*Crocodylus johnstoni*) and Worrell's turtle (*Emydura worrelli*). The freshwater crocodile was present on both the McArthur and Glyde Rivers, but was most abundant on the Glyde River. Along the Glyde River, many juvenile crocodiles and crocodile nesting sites were observed in association with permanent waterholes and large sand banks, which are also likely to be important breeding sites for the Worrell's turtle. Reptiles such as the Gilberts lashtail (*Lophoganthus gilberti*) were not restricted to riparian habitats but were most abundant there.

Commonly encountered species in sandstone escarpment/gorge habitats included the ring-tailed dragon (*Ctenophorus caudicinctus*), blotched shinning-skink (*Cryptoblepharus megastictus*), bauxite rainbow-skink (*Carlia amax*), stripe-headed finesnout ctenotus, bar-shouldered ctenotus (*Ctenotus inornatus*), Borroloola gecko (*Gehyra borroloola*) and children's python (*Antaresia childreni)*. Reptiles recorded in grasslands and open woodlands of the McArthur River floodplain include the Binoe's gecko (*Heteronotia binoei*), Burton's legless lizard (*Lialis burtonis*), shaded-litter rainbow-skink (*Carlia munda*), Main's skink (*Menetia maini*), northern bluetongue (*Tiliqua scincoides*), black-headed python (*Aspidites melanocephalus*) and children's python.

Reptile species richness was highest in the Glyde River gorge habitat (12 species) and open woodland/grassland on the McArthur River floodplain (10 species). During the late wet season surveys there was a notable absence of small skinks and other terrestrial reptiles in close association with the major rivers, perhaps due to the catastrophic effects of recent wet season flood events.

Birds

There were 114 species of birds recorded within the project area during the current assessment (Appendix I.3). A combined list of 163 species has been reported to occur within the project area from various studies (Appendix I.4). This represents approximately 70% of the bird taxa known to occur in the lower McArthur region (Hollingsworth Dames & Moore, 1992a). Seventeen bird species observed during current survey had not been previously reported within the project area. These include the great-billed heron (*Ardea sumatrana*), black bittern (*Ixobrychus flavicollis*), osprey (*Pandion haliaetus*), grey falcon (*Falco hypoleucos*), oriental plover (*Charadrius veredus*), oriental pratincole (*Glareola maldivarum*), black-eared cuckoo (*Chrysococcyx osculans*) and barking owl (*Ninox connivens*).

Habitats with the highest bird species richness included Glyde River gorge habitat (55 species), McArthur River riverine habitat (44 species) and open woodland/grassland on McArthur River floodplain (42 species).

The existing tailings dam was a unique habitat in the wider project area in that it supported a number of wetland birds that would otherwise be unlikely to utilise natural habitats that occur in the project area on a long-term basis. Common waterbirds on the tailings dam included the hoary-headed grebe (*Poliocephalus poliocephalus*), grey teal (*Anas gracilis*), pink-eared duck (*Malacorhynchus membranaceus*), hardhead (*Aythya australis*), magpie goose (*Anseranas semipalmate*) and black swan (*Cygnus atratua*).

Gorge habitats in the Glyde River contained a range of waterbird species at refuge pools in the late dry season (December 2002), including the great-billed heron, black-necked stork (*Ephippiorhynchus asiaticus*), magpie goose, little black cormorant (*Phalacrocorax sulcirostris*), Australian pelican (*Pelicanus conspicillatus*), black bittern (*Ixobrychus flavicollis*), black-winged stilt (*Himantopus himantopus*) and black-fronted dotterel (*Elseyornis melanops*).

Mammals

There were 22 mammal species recorded during the 2002-2003 surveys, including 10 bat species (Appendix I.3). Thirty-two mammal species are known from lowland and riverine habitats in the mainland McArthur River region (Hollingsworth Dames & Moore, 1992a) and previous studies within the project area have identified 18 species (Appendix I.4).

Two macropods were observed in the project area. These were the agile wallaby (*Macropus agilis*), which was common along the McArthur River and in floodplain woodland/grassland habitats, and the common wallaroo (*Macropus robustus*). The latter species was observed in the Glyde River escarpment and gorge habitat, and in rocky hill habitat on Barney Hill. The spectacled hare-wallaby (*Lagorchestes conspicillatus*) has previously been reported from floodplain grassland and woodland habitat within the project area (Hollingsworth Dames & Moore, 1992a) but was not observed during the current survey.

Trapping and other survey methods in the sandstone/gorge habitats recorded a number of mammal species associated with saxicoline habitats, including the common rock rat (*Zyzomys argurus*) and the rock ringtail possum (*Petropseudes dahli*). However, trap returns were poor across the project area, particularly for small mammal species. This reflects the results of previous trapping programs, which also returned few captures (Ecostudy, 1992; Hollingsworth Dames & Moore, 1992a).

Mist netting and hand-net captures at natural and artificial roost sites recorded four microchiropteran species, including the dusky leaf-nosed bat (*Hipposideros ater*), common sheathtail-bat (*Taphozous georgianus*), northern cave bat (*Vespadelus caurinus*) and little broad-nosed bat (*Scotorepens greyi*). Microchiropteran roost sites identified in the project area included natural shallow caves and fissures in the sandstone escarpment of the Bukalara Range, where a number of small colonies of common sheathtail bat and northern cave bat were located. Other bat roost sites included fissures in culverts

and road bridges in the mine area and on major roads in the McArthur River area, and martin nests under rock overhangs and in culverts.

Survey using bat echolocation call detection and analysis recorded eight species within the study area. The northern freetail bat (*Chaerephon jobensis*) was the most frequently detected bat species (44% of all call sequences with identifiable calls) and was present across all habitat types. The northern freetail-bat is a high flying species with a call that is readily detected using the AnaBat system, potentially maximising the number of detected calls for this species. The northern cave bat was common in sandstone escarpment and gorge habitat (70% of all call sequences with identifiable calls in sandstone escarpment/gorge habitat), but was rarely recorded in floodplain woodlands and grassland habitats.

Tree roosting bat species, including the yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*), Gould's wattled bat (*Chalinolobus gouldii*) and long-eared bat (*Nyctophilus* sp.), were the most common species detected in woodland/grassland habitats on the McArthur River floodplain. All northern myotis (*Myotis moluccarum*) records were associated with the main Glyde River and McArthur River channels.

13.3.4 Feral Animals

Feral animals, particularly the donkey (*Equus asinus*), are numerous in the project area. Signs of the presence of feral pigs (*Sus scrofa*) were observed across the project area, generally in association with stream lines, major riparian corridors and lower gorge habitats. Feral cats (*Felis catus*) were seen during spotlight surveys in the vicinity of the mine camp.

Donkeys are common and widespread and were present in habitats ranging from riparian forests to the edges of the sandstone escarpment. Cattle (*Bos taurus/indicus*) are also present and have caused considerable damage to the riverine and floodplain habitats, particularly in the McArthur River area. As McArthur River Station is an operational cattle station, these animals are not feral, but are station stock. Management of cattle and feral donkeys on McArthur River Station is an issue which is the responsibility of the pastoral property owners, who operate the station under practices conforming to existing NT Government requirements.

Cane toads (*Bufo marinus*) are abundant in the McArthur river area, occurring in large numbers particularly around human habitation (i.e. the camp area), artificial water bodies such as bores, and in riverine habitat along the McArthur and Glyde Rivers. The only areas where this species was not abundant were in the drier woodland habitats, and on the sandstone plateau and stony rises.

Cane toads spread through the southern Gulf region in the 1980's and are now well established in the McArthur River district. Cane toads are thought to cause significant ecological effects, especially on predatory native species which may ingest them. Cane toads have been directly implicated in the decline of native animals such as monitor lizards (*Varanus* spp.), larger elapid snakes such as the death adder (*Acanthurus* spp.) and king brown snake (*Pseudechis australis*), and carnivorous marsupials, especially the northern quoll (*Dasyurus hallucatus*) (Braithwaite and Griffiths, 1994).

Results of the current survey indicates that most of these species still occur in the McArthur River district, but are uncommon and confined to habitats where cane toads are absent, such as the sandstone plateau. There are currently no known management options for successfully controlling cane toads.

No species of introduced bird or reptile was observed in the area.

13.3.5 Significant Fauna Species

Threatened Fauna Species

Fauna species occurring within the project area are assigned threatened status according to Northern Territory, Commonwealth and International criteria as described in the:

- *Territory Parks and Wildlife Conservation Act 2000*;
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act); and
- IUCN Red List of Threatened Species (IUCN, 2004) respectively.

Threatened species known to occur within or near the McArthur River Mine project area are listed in Table 13.5. Generally, only species which fell within the three highest threat categories (Critically Endangered, Endangered or Vulnerable) have been considered in detail, and the threat level of most species is not consistent between NT, Commonwealth and International listings.

Table 13.5

Status of Threatened Fauna Species

Common Name	Scientific Name	IUCN	EPBC	NT
Worrell's Turtle	*Emydura worrelli*			NT[3]
Red Goshawk	*Erythrotriorchis radiatus*	VU[1]	VU	VU
Grey Falcon	*Falco hypoleucos*	NT		NT
Australian Bustard	*Ardeotis australis*	NT		VU
Purple-crowned Fairy-Wren	*Malurus coronatus mcgillavrayi*			NT
White-browed Robin	*Poecilodryas superciliosa cerviniventris*			NT
Spectacled Hare-wallaby	*Lagorchestes conspicillatus*	LR/NT[2]		NT
Northern Quoll	*Dasyurus hallucatus*	LR/NY		VU

[1] VU=Vulnerable

[2] LR/NT=Low Risk/Near Threatened

[3] NT=near threatened

Red Goshawk *(Erythrotriorchis radiatus)*

This species is listed as Vulnerable by IUCN, the *Territory Parks and Wildlife Conservation Act 2000* and the EPBC Act. The red goshawk occurs sparsely across northern Australia and the total population is estimated to be about 1,000 breeding birds (Garnett and Crowley, 2000). The species generally favours watercourses and builds a conspicuous stick nest usually close to riverine locations (Woinarski, 2002).

This species was tentatively recorded from the mine project area once in 1992 (Ecostudy, 1992). This sighting has not been confirmed and subsequent searches for this bird in the area have been unsuccessful. These searches have included regular bird surveys conducted by MRM environmental staff between 1998 and 2002. During April 2003, the proposed open pit area along the McArthur River was searched intensively and no individuals or nests were found.

This species has been reported elsewhere in the McArthur River region (Ecostudy, 1992), so its presence in the area cannot be discounted.

Australian bustard (*Ardeotis australis)*

This large bird is widely but sparsely distributed in open habitats across Australia. Its status under the *Territory Parks and Wildlife Conservation Act 2000* has recently been upgraded to Vulnerable. This species is increasingly threatened in southern Australia and is thought to have declined in parts of northern Australia through a combination of altered fire regimes, invasion of woody weeds, predation by introduced predators and possibly hunting pressure (Garnett and Crowley, 2000; Ziembicki, 2003).

The species is present in low numbers in open woodland and grassland habitat on the McArthur River floodplain.

Northern quoll *(Dasyurus hallucatus)*

This species was commonly recorded in previous surveys of the McArthur River region, but was last observed in the area of sandstone plateau habitat of the Glyde River in December 2002. Quolls appear to have been generally declining over the past few decades, but this has accelerated in recent years, due almost entirely to the spread of the introduced cane toad, as quolls appear particularly susceptible to cane toad poisoning (Braithwaite and Griffiths, 1994; Woinarski, 2003a). Due to this dramatic recent decline, this species is now listed as Vulnerable under the *Territory Parks and Wildlife Conservation Act 2000.*

Northern quolls generally prefer rocky habitats, but are also found in *Eucalyptus* woodlands. It is likely that this species is now locally extinct in the project area, but populations may still exist in the sandstone ranges, where cane toads are less abundant.

Other Threatened or Near-threatened Species

Several species found, or suspected of occurring, within or near the proposed project area are classified in threatened categories, including one Endangered species. Additionally, seven species are classified as Near Threatened. The status of these species in the McArthur River area is described below.

- **Carpentarian Grasswren** is listed as Endangered under the *Territory Parks and Wildlife Conservation Act 2000*, but is unlisted by IUCN or the *EPBC Act*. This species inhabits the rugged, spinifex-covered sandstone hills and plateaux of the southern Gulf of Carpentaria. It has been recorded in the region from Nathan River Station (NT) to Westmoreland (Qld), with an unusual isolated population in the Mt. Isa/Gunpowder area (Lewis, 2001; Garnett and Crowley, 2000). This species is well known from the Glyde River area in the vicinity of the original pumping station, as this site is the type locality where specimens were first collected in 1914. The species was observed many times at this site up until the mid 1980's (Martin and McKean, 1986). Since then, Carpentarian grasswrens have been discovered at more accessible locations, and bird observers no longer visit the Glyde River to see this bird. Searches for the species in December 2002 failed to locate the species in this area, but a large wildfire that swept through the area in late November 2002 caused severe habitat destruction. The bird has most recently been seen in the district at Caranbirini Conservation Reserve (Lewis, 2001). This species does not occur in the vicinity of the proposed open cut project.

- **Spectacled hare wallaby** is known from a single record in the mine project area in 1992, but has not been recorded since. Potential threats to this species that have been cited include introduced predators, fire regime and pastoral activities (Langford and Pavey, 2002).

- **Purple-crowned fairy-wren and white-browed robin** (both listed as near threatened under the *Territory Parks and Wildlife Conservation Act 2000)* are common species found in suitable riverine habitat along both the McArthur River and Glyde River, where they are more patchily distributed. They are largely restricted to dense riverine forest habitat, although the wren is also seen in adjacent grasslands. The local race of the purple-crowned fairy-wren (*mcgillavrayi*) is considered more secure than the western race (*coronatus*), which is classified as Vulnerable under the EPBC Act. White-browed robin is common on the Glyde River and was present in almost all areas of dense riparian vegetation investigated along the river in the vicinity of survey sites. In contrast, the purple-crowned fairy-wren was only recorded at one site in the Glyde River catchment (dense vegetation on Amelia Creek). In the McArthur River riverine forests the white-browed robin and purple-crowned fairy-wren were both common, being recorded during a large percentage of the timed-area bird counts conducted in this habitat.

- **Grey falcon** was observed on a single occasion on the upper Glyde River in gorge habitat. It is described as rare in the region by CSIRO (1976) and has not been previously reported in the project area (Hollingsworth Dames & Moore, 1992a; Ecostudy, 1992).

- **Worrell's turtle** is listed as near threatened under the *Territory Parks and Wildlife Conservation Act 2000*. The species is poorly known and there are no indicators of threat. It is a very common inhabitant of the McArthur River system, and also occurs in other Gulf region streams in the NT and Queensland (Cann, 1998).

Two other Endangered species occur in the region, but have not yet been recorded in the vicinity of the mine project area. The Gouldian finch (*Erythrura gouldiae*) has been previously recorded from Caranbirini Conservation Reserve (Parks & Wildlife Commission of the NT, 2003) although even surveys of the region in the 1960s and 1970s reported the species in decline then (CSIRO, 1976). The Carpentarian Rock-rat (*Zyzomys palatalis*) is known from three locations on Wollogorang Station, to the east of McArthur River. It has not been found elsewhere in the region even though surveys of suitable habitat in the Abner Range (near Cape Crawford) were undertaken in 1990 (Ecostudy, 1992). Trapping and searches for this species at potential sites along the Glyde River gorge were unsuccessful.

Significant Terrestrial Invertebrates

A number of terrestrial invertebrate taxa are listed as rare and threatened or in lower risk/data deficient schedules under the *Territory Parks and Wildlife Conservation Act 2000* (Parks & Wildlife Commission of the NT, 2000). Based on available information and ecological data, and consultation with NT Parks & Wildlife, it is considered that none of the species currently listed in this Act are likely to occur within the McArthur River project area. However is should be noted that the distribution and ecology of many of these invertebrates is likely to be poorly known, and some threatened invertebrate species (such as the invertebrates associated with sandstone habitats of the Top End) may extend into the lower Gulf Region, or new threatened invertebrate taxa may be discovered in the region.

Migratory Fauna

Species listed as migratory under the EPBC Act are recognised as significant. This list covers species which are included in three international agreements to which Australia is a signatory nation as follows:

- Japan-Australia Migratory Bird Agreement (JAMBA);
- China-Australia Migratory Bird Agreement (CAMBA); and
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

Nine species of migratory birds listed under the EPBC Act occur on the McArthur River mine project area. These species are detailed below:

- **Common Greenshank** (*Tringa nebularia*) is a northern hemisphere breeding species that arrives in northern Australia in August. It disperses throughout much of Australia and large numbers occur in coastal areas of northern Australia. It mainly inhabits near-coastal saline

wetlands, but is also found on inland swamps (Lane, 1987). This species has been observed foraging on the artificial water bodies within the project area.

- **White-bellied sea-eagle and osprey** have both been recorded in the vicinity of riverine habitats on the Glyde and McArthur Rivers. The white-bellied sea-eagle was also observed soaring over mine site areas, possibly in the vicinity of water storage areas. While listed in international migratory treaties and hence the migratory species schedule of the EPBC Act, Australian populations of these species are mostly sedentary (Marchant and Higgins, 1993). Marchant and Higgins (1993) indicate that while osprey forage over a wide area, adults return to nesting territory in the breeding season, and that established pairs of white-bellied sea-eagle are mostly sedentary, although adults often move long distances.

- **Rainbow bee-eater** is an extra-limital migrant (north to New Guinea and associated islands) although some are present year-round (Schodde and Tidemann, 1988). The rainbow bee-eater is a generally common and widespread species that does not have any specific habitat requirements.

- **White-browed robin** is sedentary, with pairs or groups of three to four holding the same territory year-round (Schodde and Tidemann, 1988). This species is described in greater detail in the previous section.

- **Cattle egret** has been reported from the mine project area by MRM environmental staff. This species was probably introduced from Asia as it was not known to occur in Australia prior to the 1930's-1940's (Schodde and Tidemann, 1988). While there are some internal north-south seasonal movements, the Australian population is not considered to be an extra-limital migratory species. It is generally common and widespread and within the study area it is most likely associated with modified and open areas, such as tailings dam edges and open grasslands.

- **Glossy ibis** wanders nomadically in search of feeding grounds and do not use regular breeding sites (Schodde and Tidemann, 1988). Core breeding areas are in southern Australia around the Murray-Darling basin (Schodde and Tidemann, 1988). This species is common and widespread in the wetlands of northern Australia, and the main habitats for this species within the project area are associated with the tailings dam.

- **Oriental plover** (*Charadrius veredus*) is a northern hemisphere breeding species that arrives in northern Australia in October. It generally disperses throughout northern Australia where it inhabits bare plains, road edges, the flat edges of lakes and lagoons, shore flats and claypans, and rarely remains at a particular site for more than a few days (Schodde and Tidemann, 1988). CSIRO (1976) reported the presence of this species in small numbers on open grassland on coastal floodplains in the lower McArthur River area. Within the project area this species was observed on sealed tarmac and adjacent open grassy areas at the McArthur River airstrip in December 2002. It was not observed in naturally occurring habitat within the project area which are largely unsuitable for this species.

- ***Oriental pratincole*** (*Glareola maldivarum*) breeds in the northern hemisphere and arrives in Australia during October/November when it moves into northern Australia in flocks of varying sizes. The birds rarely remain in an area for more than a week (Schodde and Tidemann, 1988). As with the oriental plover, the oriental pratincole was most commonly observed in managed areas around McArthur River airstrip (tarmac and adjacent low grassland) or on roads. A large flock of some hundreds of individuals was seen hawking insects around the mining camp during December 2002 and some individuals were present on the airstrip and surrounding roads at this time.

Cultural Significance

Three members of the local Aboriginal community (two Traditional Owner and one Senior Custodian) were asked if any of the animals, fish or reptiles at the mine site had cultural significance. They reported that there are no animals at the mine site currently used by the local community. Furthermore, there are no animals with any cultural or spiritual significance nor are there any that are used for making materials or artefacts.

13.4 Fauna Impacts and Management

13.4.1 Open Cut and River Realignment

The proposed realignment of the McArthur River will remove approximately 3.6 km of existing riverine habitat. Surveys along this section of the river indicate that mammal and reptile diversity is low, possibly due to the severity of the annual flooding and the abundance of weed species in this habitat. For birds however, this habitat is particularly rich, and it contains several specialist species.

The break in the riverine corridor that will occur as a result of the realignment will affect bird species which are specialised to this habitat, such as white-browed robin and purple-crowned fairy-wren. It will also affect movements of other species that travel up and down the riverine corridor or utilise this habitat as a feeding or dry season refuge area. This may include riparian reptiles and mammals such as the agile wallaby. However, the break in corridor habitat is not expected to be a major barrier to the dispersal of riverine forest specialist birds which are more mobile. During the course of surveys in the Glyde River area, the white-browed robin and purple-crowned fairy-wren were encountered at several small pockets of riverine forest which were separated from other suitable sites by several kilometres (e.g. Amelia Springs). These observations indicate that these species are not dependant on a continuous riverine habitat corridor for dispersal.

Increased disturbance during the construction phase may cause some species to vacate the area due to the increase in human activity, noise, dust and habitat disturbance. These effects are likely to be localised and temporary.

Initially, construction of the flood protection bund and the early stages of mining will not remove all of the riverine forest along the length of the McArthur River to be affected by the project, as

disturbance will be gradual over several years. Therefore, fauna presently using the existing riverine forest occurring along this reach will have time to relocate to adjacent habitats as the existing channel becomes less attractive to them.

Concurrent with this happening, riverine forest trees will be establishing along the new river channel creating a new habitat so that terrestrial fauna will eventually have a have new riverine corridor to use. As discussed in Section 13.2.2, the new channel will be revegetated to limit erosion and to recreate the riverine habitat. Plant species to be used in the revegetation program will be the same as those already existing along the river in the vicinity of the mine site and will include a variety of eucalypts and melaleucas. Melaleucas are relatively quick growing and 3-5 m high trees will grow within a few years from seedlings. Furthermore, the existing low open woodland and shrubland alongside the realigned channel will be retained as much as possible. Therefore, the loss of riverine habitat from the open cut mine will have no long-term effects.

The realignment of parts of Barney and Surprise Creeks is likely to have minimal impacts on terrestrial fauna, as these areas are generally occupied by woodland species or generalists, and do not offer the same type of corridor habitat as the McArthur River.

The channel depth of the realigned McArthur River will be up to 18 m below the existing surface, with a bank slopes varying from 2:1 to 3:1. Where the depth is greater than 12 m, a berm 4 to 6 m wide will be placed 9 m above the bed level. The varying slope angles and the presence of an intermediate berm will reduce the potential obstruction to animals, such as wallabies, that may require access to the water or to cross the river. It should be noted however that banks steeper than 2:1 are common along much of the existing channel. To further improve access to the river channel, existing creek and drainage lines entering the river will be modified to allow easier fauna access to the river. Some drainage lines may be modified as they enter the McArthur River to serve as refuge stopovers for aquatic fauna, and these will also allow terrestrial fauna easier access to the river. Over time, the natural shaping of the realigned channel will also improve fauna access.

13.4.2 Overburden Emplacement Area

The proposed overburden emplacement facility will occupy an area of approximately 300 ha. The site of this project component is chiefly dominated by a low open coolibah woodland (Vegetation Unit 6) which is severely degraded by cattle and introduced weeds. Small, semi-permanent waterholes and artificial dams are present in the area, but none are significant for fauna. No fauna species are specialised to this woodland habitat and the conservation value of the site for fauna is low. This habitat is widespread in the region.

13.4.3 Tailings Storage Facility

There is no change to the existing TSF proposed by the open cut project. The existing tailings storage facility is already used by many species of waterbirds, including listed migratory species and will continue to provide this habitat. Water quality resulting of the open cut operation will be similar to

the existing underground operation and the current water quality monitoring program will be continued. The current bird monitoring program has not recorded any bird deaths or other deleterious effects to birds using the site. The fringes of the existing dam offer habitat to several frog species.

13.4.4 Effects on Significant Species

No Endangered fauna species have been confirmed as occurring within the proposed project area in recent years. The red goshawk (Vulnerable) has been noted on the basis of a possible sighting in 1992, but recent searches and call trapping have not yielded additional sightings. Searches of the riverine corridor within the river realignment zone have also failed to locate any evidence (e.g. nest sites) of this species. However, the possibility that the species may be present, even if as a visitor to the area, cannot be discounted. The loss of riverine forest along the McArthur River due to the realignment would cause a temporary reduction in habitat for this species if it was present.

Australian bustard (Vulnerable) occurs in woodlands and grassland habitats within the project area, and currently uses habitats that will be disturbed or removed for construction of the overburden emplacement facility area. This is a very wide ranging species and based on the amount of available habitat in the region, the project is expected to have only a minor local impact on this species.

The spectacled hare-wallaby (Low Risk/Near Threatened) potentially occurs in woodland habitats within the project area and would thus suffer a loss of habitat due to the open cut project. However, as with the previous species, there is no recent evidence that spectacled hare-wallabies occur in the area and, in any event, the loss of woodland habitat from the project compared to that available in the surrounding area is insignificant.

Effects on the white-browed robin and purple-crowned fairy-wren (Near Threatened in NT) are discussed in Section 13.4.1.

None of the migratory species are likely to be significantly affected by the project. By their nature, migratory species are wide ranging, and in the absence of important habitats in the project area, they will be largely unaffected. Their non-breeding status, preference for open and modified habitats, and high mobility would indicate a low potential impact on species such as oriental pratincole and oriental plover. The retention of the existing tailings storage facility will continue to provide available wetland habitat for some migratory species.

13.4.5 Regional Ecosystems

EPBC Act

None of the habitats or ecosystems within or affected by the proposed project are listed as threatened ecological communities under the EPBC Act. There are no World Heritage properties in close proximity to the project site.

Conservation Reserves

The only conservation reserve in the region is the Caranbirini Conservation Reserve. This is a small reserve, located about 20 km north of the project area, which protects a waterhole on Caranbirini Creek (a tributary of the McArthur River) as well as an area of sandstone habitat typical of the Bukalara Range. The proposed project will have no impacts on this reserve.

13.4.6 Monitoring and Management

To monitor effects of the changed conditions, regular bird counts will be undertaken at points upstream and downstream of the mine site and at points along the realigned channel. Particular attention will be focussed on the occurrence of riverine forest specialists such as white-browed robin and purple-crowned fairy-wren along the realigned channel. Regular bird monitoring will also be undertaken in the overburden areas to indicate changes in bird populations.

Protection of the sandstone habitats to the east of the project area against fire and human disturbance is recognised as a priority, due to the high conservation value of this area, including the presence of an Endangered species (Carpentarian grasswren). While this area will not be directly affected by the open cut project, a management plan specifically aimed at reducing fire risk in this area will be implemented.

13.5 Aquatic Ecology

13.5.1 Introduction

The aquatic ecology of the McArthur River system is described with reference to a number of previous studies and supplemented by additional field surveys conducted as part of the EIS investigations. Previous surveys have included:

- A series of wide-ranging surveys for fishes, crustaceans and molluscs conducted throughout the McArthur River and other Gulf catchments, including a survey for Mount Isa Mines of the McArthur River (Midgley, 1975, 1982, 1994);
- Surveys of fish and macroinvertebrates of the McArthur River and tributaries near the mine project area (Hollingsworth Dames & Moore, 1992a); and
- Surveys of ephemeral stream habitats for fishes, molluscs, crustaceans and aquatic insects at sites along Surprise and Barney Creeks (Hanley, 1993).

Aquatic surveys were undertaken as part of this EIS in 2002 and 2003. They focussed on the McArthur River main channel in the area of the proposed realignment and a large refuge pool (Djirrinmini) in the McArthur River upstream of the proposed open pit.

Surveys (April 2003) were also conducted in the Glyde River area to provide data for a previously proposed weir. Although the weir is no longer proposed, the data are still presented as they provide information on the broader project region.

13.5.2 Aquatic Surveys

Surveys for this EIS were undertaken at 10 sites in the McArthur and Glyde Rivers in December 2002 and April 2003 (Figure 13.8). Detailed habitat descriptions were recorded at all sites where sampling was carried out. Parameters noted were site location, turbidity, depth (maximum and average in sampled area), width and length of sampled habitat, habitat class, substrate type, stream flow, aquatic vegetation, bankside vegetation, weather and the current level of disturbance and land use.

Survey methodologies are detailed in Appendix J.1 while details of the habitat characteristics at each site are given in Appendix J.2.

13.5.3 Aquatic Habitats

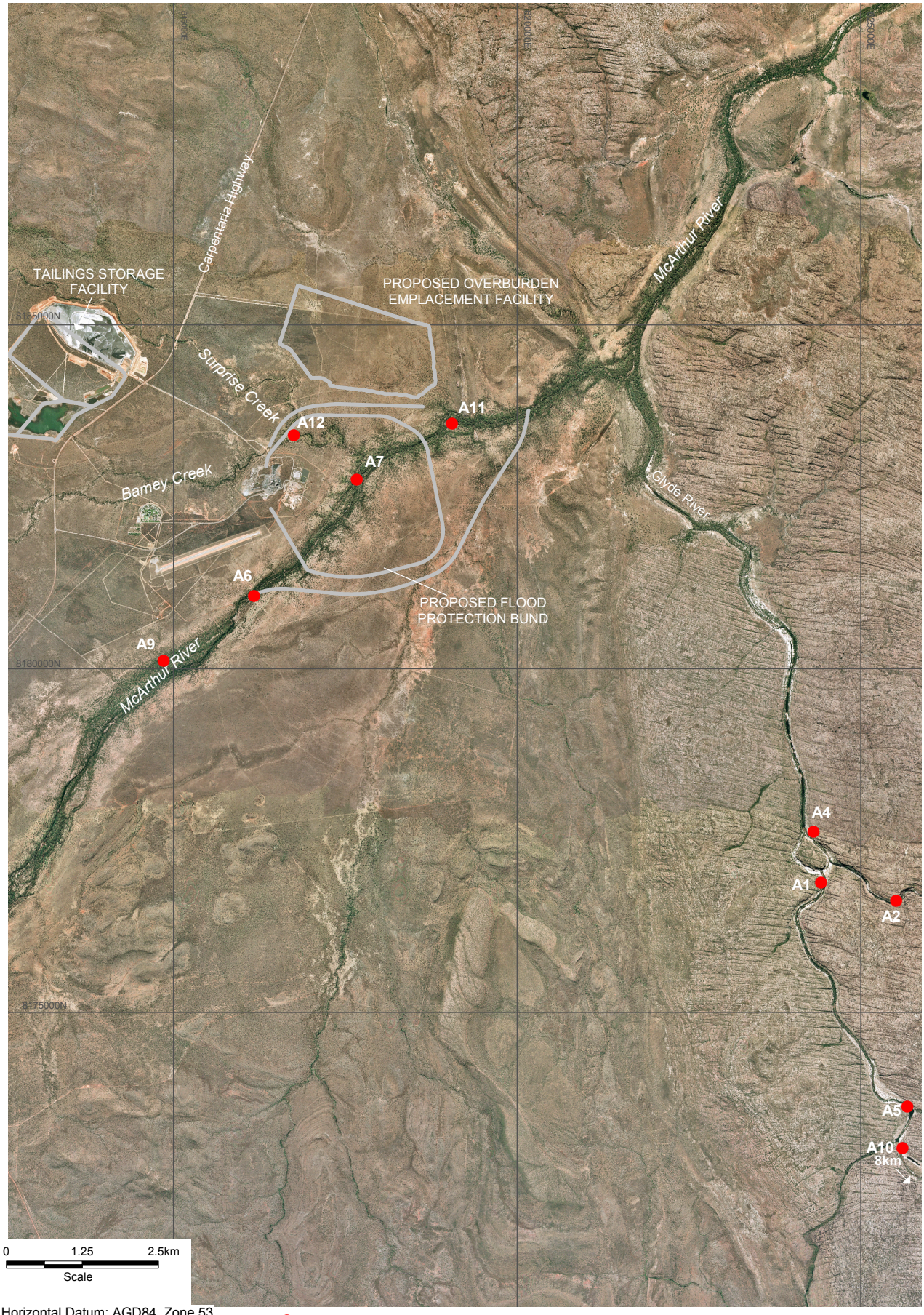
The McArthur River system is a relatively minor component of the Gulf drainage division. It has an overall catchment area of some 20,000 km^2 including three major tributaries, Glyde River, Kilgour River and Batten Creek. With the exception of some spring-fed tributaries, particularly in the sandstone ranges, most of the flow in the McArthur drainage comes from wet season rains. The river ceases to flow during most dry seasons and most stretches, particularly in reaches near the mine project area, dry to a series of large isolated pools. During the wet season, the river can be extremely turbid when in flood and carries a high silt load. Apart from the sandstone ranges in the headwaters of the Glyde and Kilgour Rivers, much of the course of the McArthur River traverses open woodland plains country which is heavily grazed by cattle.

Downstream of the mine project area, the river flows through open woodland country in the Narwinbi Aboriginal Land. The tidal limit is reached a few kilometres upstream of Borroloola. Downstream of Borroloola, the river forms an extensive estuary complex which enters the sea opposite the Sir Edward Pellew Islands.

McArthur River Main Channel

Habitats along the McArthur River in the region of the mine site include deep, permanent refuge pools with dense fringing vegetation, relatively shallow sandy bottomed runs, and rock bars.

The major permanent refuge pools in the area are Eight Mile Waterhole, about 8 km upstream of the mine project area, and Djirrinmini (Jirinmini) Waterhole, which is about 1 km upstream of the proposed river realignment (Figure 13.7). There are no permanent waterholes within the section of river to be realigned.



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URS

McARTHUR RIVER MINE
OPEN CUT PROJECT
ENVIRONMENTAL IMPACT STATEMENT

AQUATIC BIOTA SAMPLING AITES

Drawn: VH	Approved: CMP	Date: 22-07-05	Figure: **13.8**	Rev: C
Job No: **42625552**	File No: 42625552-g-017c.wor			**A4**

Eight Mile Waterhole is by far the largest permanent waterhole in the area, being some 5 km in length, about 200 m wide in some areas. It is of indeterminate depth, but probably exceeds 5 m in many areas. Fringing vegetation is generally fairly sparse and narrow, consisting typically of *Melaleuca argentea*, *Eucalyptus camaldulensis*, *Casuarina cunninghamiana* and sparse *Pandanus aquaticus*. These permanent waterholes are the most important aquatic habitats in the region as they act as dry season refuge habitat for aquatic species.

Downstream of Djirrinmini Waterhole, and through the mine project area (including the proposed river realignment zone), the river flows through a deeply incised channel. The channel has a benched profile, with an inner width of about 15 m. The river flows through this narrow channel for most of the year, although dries completely late in most dry seasons. The total width of the greater channel is about 40 m, and in many areas there are one or more braided overflow channels running parallel to the main river. Along the main channel, the river flows swiftly over sandy substrate and is relatively shallow (about 1-2 m base flow following the wet season). Aquatic vegetation is either sparse or not present. The channel is fringed by tall riverine forest. This habitat is used as a transit zone for migrating aquatic fauna. A section of the McArthur River in the area of the proposed open cut is shown on Figure 13.7.

Numerous rock bars and shallow riffle habitats occur along the river, especially at either ends of the larger waterholes. These shallow habitats are important as resting and feeding sites for migrating fauna, and are also an important habitat for aquatic macroinvertebrates. Some fish species, such as small gudgeons and gobies have a preference for these habitats.

Surprise/Barney Creeks

These small creeks flow only during and immediately following the wet season and dry to a series of small pools after cessation of rains. The pools dry completely as the dry season progresses. These creeks traverse dry, open woodland and have a generally stony or muddy substrate with a sparse fringing vegetation community dominated by *Casuarina cunninghamiana*. These streams offer temporary aquatic habitat, and some species have a preference for this habitat over the main river habitats. Detailed habitat descriptions of many sites in this system are presented in Hanley (1993).

Glyde River

The Glyde River is a tributary of the McArthur River, joining it at a point about 5 km downstream of the mine project area. For much of its length, the Glyde River flows through a rugged series of sandstone gorges of the Bukalara Range. The river has a highly seasonal character, with massive flow rates observed in the wet season, when the river may flood up to 25 m above base flow within the gorge. Even in the upper gorges, flood levels 10-15 m above base flows have been observed.

The river channel ranges from steep, narrow-sided rock ravines (10 m wide, 10 m deep) in the upper reaches, to gorges about 90 m wide and some 50 m deep in the lower areas where the river bed is extremely sandy and in the dry season, contracts to a series of permanent waterholes, some of which are very deep.

The permanent waterholes are fringed with a narrow band of riverine forest dominated by *Melaleuca argentea*, *Acacia* spp. and some rainforest species to a height of 15 m. The understorey is covered by a dense matting of creepers and non-perennial weeds, especially wild passionfruit (*Passiflora foetida*). Aquatic vegetation is generally sparse, although *Blyxa* sp. and *Chara* sp. are common in some isolated pools, and patches of the lily *Nymphoides* sp. are present in some areas. Aquatic plants occurring in the area are described in Section 13.1.4.

13.5.4 Aquatic Fauna Species

Fishes

Based on results of the current surveys combined with previous studies, the known freshwater fish fauna of the McArthur River system consists of about 27 species. All species are naturally occurring and there are no introduced or translocated species recorded from the catchment. A summary of the distribution of these species within the McArthur River system is shown in Appendix J.3. The middle reaches of the McArthur River (including the mine project area) have the highest number of recorded species (23). There are 21 species known from the upper McArthur River catchment and the major tributaries (e.g. Kilgour River, Toonganginie Creek), while 17 species occur in the Glyde River. A total of 11 species has been recorded from Surprise and Barney Creeks.

During surveys in December 2002 and April 2003 there were 20 species of fish recorded at 12 sites within the mine project area and Glyde River (Appendix J.4).

Many of the species recorded are abundant throughout the system. Seven-spot archerfish (*Toxotes chatareus*), chequered rainbowfish (*Melanotaenia splendida inornata*) and barred grunter (*Amniataba percoides*) were recorded at 11 of the 12 aquatic sample sites. Other common species which were recorded at more than half the sites were bony bream (*Nematolosa erebi*), long tom (*Strongylura kreffti*), Macleay's glassfish (*Ambassis macleayi*), sooty grunter (*Hephaestus fuliginosus*), spangled perch (*Leiopotherapon unicolor*), flathead goby (*Glossogobius giurus*) and sleepy cod (*Oxyeleotris lineolatus*). Refuge pools in both the McArthur River and Glyde Rivers contained the largest species, including barramundi (*Lates calcarifer*), sooty grunter (*Hephaestus fuliginosus*), Berney's catfish (*Arius berneyi*) and Gulf shovel-nosed catfish (*Arius paucus*). These species were commonly caught by line fishing methods.

In the shallow main channel of the McArthur River, a total of 11 species have been recorded. Most of these are smaller species. In Barney and Surprise creeks, fewer species are present compared to the main McArthur River channel. However, notable differences include the common presence of the northwest glassfish (*Ambassis* sp.) which has not been recorded elsewhere in the area, and the abundance of Hyrtl's catfish (*Neosilurus hyrtlii*), which is uncommon elsewhere in the system. Both of these species are generally common in northern Australia, and their presence in these systems is a reflection on their preference for ephemeral habitats.

The fish fauna of the Glyde River is of similar composition to that recorded in the McArthur River although to date, fewer species have been recorded in the Glyde River. Large permanent waterholes

along the Glyde River are isolated for much of the dry season, and at these locations, large species such as barramundi, sooty grunter and seven-spot archerfish are abundant.

Four species recorded in the McArthur River catchment by Midgley (1975) have not been recorded in more recent surveys. These are freshwater sawfish (*Pristis microdon*), mullet (Mugilidae), purple-spotted gudgeon (*Mogurnda mogurnda*) and gulf grunter (*Scortum ogilvyi*). Although the current status of these species is unconfirmed, there is no reason why they should not still be present.

None of the fish species recorded from the McArthur River system are restricted in range or specialised to a particular habitat. Most species are common and widespread across northern Australia.

Fish populations in tropical Australian rivers such as the McArthur are greatly influenced by seasonal changes. Some of the species found in the McArthur River are diadromous, meaning that they migrate between freshwater and estuarine areas, mainly for breeding purposes. Fishes in this category include barramundi, mullet, freshwater sawfish and spotted scat. Some species, such as seven-spot archerfish and freshwater sawfish can also breed in pure freshwater, and in December 2002, many juvenile archerfish were observed in isolated pools in the Glyde river, indicating that they had recently bred.

Following the wet season, many freshwater fish attempt to populate available temporary habitat, such as that found in Surprise and Barney Creeks. For some species this habitat is preferred because even though it is temporary, food resources are rich and predators are few. In April 2003, three fish species (chequered rainbowfish, Hyrtl's catfish and spangled grunter) were observed to have travelled upstream as far as the existing tailings storage facility area via a small tributary of Barney Creek, and it was reported that spangled grunter occasionally occur in the dam itself.

Aquatic Reptiles

Freshwater crocodiles (*Crocodylus johnsoni*) are common in the McArthur and Glyde river systems. They occur in all habitats, including the ephemeral streams of Surprise and Barney Creeks, but are most abundant in sandy refuge pools along the Glyde River. The steep sandy banks which are common along the Glyde River gorge offers suitable nesting habitat for this species and during the December 2002 field survey, several recent nests were found, along with "crèches" of newly hatched crocodiles.

Estuarine crocodiles (*Crocodylus porosus*) occur in the lower reaches of the McArthur River, but there are no documented records from near the mine project area. Anecdotal reports indicate that individuals of this species have been occasionally sighted at Eight Mile Waterhole.

The only turtle species recorded in the area is Worrell's turtle (*Emydura worrelli*), and this species is abundant along the McArthur River and especially along the Glyde River. Like the freshwater crocodile, this species nests in sandy river banks.

The April 2003 surveys (Appendix J.4) yielded two records of the Arafura file snake (*Acrochordus arafurae*). This species was found at two locations along the McArthur River in shallow sandy

habitats within the proposed realignment zone. This is a common aquatic snake in northern Australia but was not previously recorded in the mine project area.

Molluscs and Crustaceans

Six mollusc species were identified in macroinvertebrate samples, with families present including the Lymnaeidae, Hydriidae, Planorbidae, Ancylidae and Corbiculidae (Appendix J.5). Most types were uncommon in samples, with the exception of the Planorbidae species 1 (*Gyraulus* sp.) which was very common at some sites on the Glyde River. The mussel *Velesunio angasi* was poorly represented in samples but shells of this species were observed at many of the sites.

A number of species of crustacea were encountered during the survey. The freshwater crab (*Holthuisiana transvera*) was commonly observed at sites on the McArthur River floodplain and associated minor tributaries (Barney and Surprise Creeks), however it was not observed at the main McArthur and Glyde Rivers survey sites and was very infrequently encountered (a single specimen) in macroinvertebrate samples. This is likely to reflect the nature of the sampling method and activity patterns of the crab rather than the abundance of this species. Larger specimens of the long-armed prawn (*Macrobrachium rosenbergii*) and freshwater crayfish (*Cherax quadricarinatus*) were observed during bankside spotlighting and captured in bait traps on the McArthur and Glyde Rivers and associated tributaries. The atyid shrimp (*Caridinides wilkinsi*) was present at five sites in low numbers.

Microcrustacea (Cyclopida, Ostracoda, Caldocera and Conchostraca) were most frequently recorded at sites with slow or no flow, and the Cladocera and Ostracoda were particularly abundant in some refuge pools on the Glyde River during the late dry season.

Aquatic Insects

A total of 72 taxa of aquatic/semi-aquatic insect were recorded during the survey (Appendix J.5). The most species-rich groups were the true flies (Diptera, 19 spp./types), aquatic/semi-aquatic beetles (Coleoptera, 17 spp./types) and aquatic/semi-aquatic bugs (Hemiptera, 15 spp./types). An additional number of pupae and larvae were identified in samples but not included in data analysis, including six species/types of Coleoptera larvae, four chironomid pupae types and one Trichoptera pupae type.

A total of 1,869 individual aquatic insects were counted in samples. The numbers of individuals at each sample site ranged from 48 insect specimens (sandbed habitat, Glyde River late dry season) to 455 insect specimens (riffle habitat, Surprise Creek early dry season). The Ephemeroptera (mayflies, 561 individuals), Diptera (true flies, 499 individuals) and Trichoptera (caddis flies, 422 individuals) were the most numerous groups in terms of overall numbers collected. The Coleoptera and Odonata displayed relatively high diversity of species but occurred in relatively low numbers in samples. The common species included the Baetidae species 1 (Ephemeroptera, 357 individuals) and Cheumatosyche species. (Trichoptera, 321 specimens).

Freshwater Macroinvertebrate Community Structure

In general the aquatic/semi-aquatic insect fauna of the project area is highly mobile and adapted to drying out events and poor water quality associated with ephemeral habitats (Hanley, 1993). Macroinvertebrate communities of the larger permanent refuge pools and other habitats on the main river channels are also likely to be greatly influenced by the massive flooding events that occur in the wet season and the general deterioration of in-stream conditions in the late dry season. Details of the macroinvertebrate diversity are given in Appendix J.5.

13.5.5 Significant Aquatic Fauna

Freshwater Sawfish

The freshwater sawfish (*Pristis microdon*) is currently listed as Endangered by IUCN (the Southeast Asian population classed as Critically Endangered) and Vulnerable under the EPBC Act and *Territory Parks and Wildlife Conservation Act 2000*. Additionally, the status of this species has been recommended as "Critically Endangered" by the Australian Society for Fish Biology (Hammer, 2004)

The freshwater sawfish is known from several rivers across northern Australia including the Fitzroy, Durack and Ord Rivers (Western Australia), the Adelaide, Victoria, Daly and McArthur Rivers (Northern Territory), and the Gilbert, Mitchell, Norman and Leichhardt Rivers (Queensland). Outside Australia, it is known from New Guinea, Indonesia and possibly India (Last and Stevens, 1994; Pogonoski *et. al.*, 2002; Stirrat and Larson, 2002). Recent surveys of freshwater elasmobranchs in northern Australia recorded the species from the Robinson, Wearyan, McArthur, Roper, Adelaide, Daly and Victoria Rivers in the NT, and in the Fitzroy and Robinson Rivers in WA. The survey also recorded the species in northern Queensland. The species was caught several hundred kilometres upstream from the coast in the Roper and Fitzroy Rivers, and the Fitzroy River (WA) was found to be a stronghold for this species in Australia (Thorburn *et. al*., 2004).

In Australia, freshwater sawfish appear to be confined to freshwater drainages and the upper reaches of estuaries in northern Australian waters. They prefer slightly alkaline waters, and are known to breed in pure freshwater. Freshwater sawfishes prefer sandy or muddy substrates away from riparian vegetation and feed on slow-moving shoaling fish, molluscs and small crustaceans which are swept out of the sand and mud by the saw (Pogonoski *et. al*., 2002).

The main threat to this species has been identified as gill net fishing to which it is particularly susceptible. The McArthur River was closed to commercial fishing in 2002 and thus gill netting in this area is no longer considered a threat. The species is also occasionally taken by recreational line anglers.

This species was recorded from five localities in the McArthur River catchment during a fish survey conducted in 1975 (Midgley, 1975). The recorded locations were: Toonganginie Creek; Glyde River; Eight Mile Waterhole (McArthur River); Kilgour River; and Frog Lagoon (McArthur River). Surveys

of the McArthur and Glyde Rivers freshwater reaches in 1993 and 2002/3 did not record any specimens.

Thorburn *et. al*., (2004) recorded freshwater sawfish in estuarine reaches of the McArthur River near Borroloola. Local anecdotal evidence suggests the species may have recently been caught by line fishermen at Borroloola and at the "Top Crossing" (on the Tablelands Highway) of the McArthur River (D. Thorburn, pers. comm.), which is upstream of the mine project area.

Based on these data, it may be assumed that this species is still present through the McArthur River system.

Other Species

No fish known to occur in the area, other than the Freshwater Sawfish, have any conservation significance.

Worrell's Turtle is listed as Near Threatened under the *Territory Parks and Wildlife Conservation Act 2000*. This species is common in the McArthur River within the project area, and widespread in streams of the southern Gulf region.

13.5.6 Project Effects and Management

River and Creek Realignments

The length of the McArthur River to be realigned is approximately 3.6 km. The river has a fairly consistent character throughout this length. There are no permanent refuge pools and the river generally ceases to flow late in the dry season, and dries completely in most areas. The closest permanent refuge pool is located about 1 km upstream of the start of the proposed realignment.

The newly created channel will initially contain habitat not typical of the existing system. This will include formed channels with altered microhabitats and exposed sunlit reaches. Initially, the changed substrate conditions may deter some migrating aquatic species or limit the ability of migrating aquatic fauna to colonise upstream areas. This might result in a temporary change to fish communities in upstream refuge pools, however these effects will reduce over time, as natural sediments settle in the channel and the riparian vegetation becomes established. Increased sedimentation or turbidity is not expected to be a significant issue, as high levels of sedimentation already exist in the river system.

The initial absence of vegetated banks along the realignment will have the effect of a reduction in riparian habitat diversity, a reduction of shade possibly causing increased water temperatures, and an increased vulnerability to predators such as birds. As no permanent refuge pools will be lost because of the river's realignment, these effects will be largely confined to wet season and post-wet season movements of aquatic fauna.

To minimise these effects, the new channel will be designed to emulate the existing physical characteristics of the river, so that flow regimes, including depths, widths and currents- will be similar to the existing situation. Table 13.6 lists the main habitat characteristics of sites A7 and A11 (Figure 13.8) which are the aquatic sampling sites in the section of the McArthur River that will be removed as part of the open cut project. These characteristics will be used to guide the design of the realignment.

As discussed in Section 12.10.1, the cross section of the realigned channel will be designed to a bed width of between 15 to 25 m, with depths between 5 and 18 m below the surrounding ground level. Bank slopes will be approximately 2:1. Upper banks and batters of the channel will be revegetated with native species to reduce the potential for erosion. This will also provide shade and cover for the river channel. Once established, native vegetation cover on the banks of the new channel will assist in reducing the introduction and spread of weed species, decrease river velocities, reducing erosion and reducing downstream turbidity/sedimentation.

Table 13.6

McArthur River Habitat Characteristics

Characteristic	Sampling Site A7	Sampling Site A11
Total habitat % - sand/silt bed	80-100	60-80
Total habitat % - gravel/rock bed	0	0
Total habitat % - riffle	0	0
Total habitat % - macrophytes	0	0
Total habitat % - snags	0	1-20
Sediment coverage	Moderate	Limited
Sediment type	Sand	Sand
Vegetation cover of river (%)	60-80	60-80
Aquatic vegetation	None	None
Bank-side erosion	None	None
Permanent pools	None	None

Source: Appendix J.2

Within the realigned channel, a variety of microhabitats will be provided in the form of logs, rocks, sandy substrate etc. This will provide some protection and resting areas for fish until other habitats establish naturally. No permanent pools will be provided as none exist at present along the stretch of river to be realigned. However, where existing drainage lines enter the channel, off-river embayments will be established to provide calm water refuge points for aquatic species.

The realignment of Surprise and Barney Creeks will have little impact on aquatic fauna. These are small ephemeral streams which are populated by a small group of opportunistic species, including some species that are somewhat specialised to this temporary habitat. The presence of these species in existing channels around the tailings storage facility is an indication that they will persist in the area following the changes. Similar management strategies to those to be used for the McArthur River (i.e. low flow channel, microhabitats, overflow channel, revegetation etc.) will be provided to minimise erosion effects and to provide for those aquatic fauna which use the creek system.

Water Quality

Some project components have the potential to degrade downstream aquatic habitats through release of contaminated runoff or increased sedimentation. These components include the mine and associated infrastructure area as well as the tailings storage and overburden emplacement facilities.

As discussed in Section 12.9, surface water at the mine will be managed to ensure minimal spill risk from these containment structures, thereby achieving acceptable containment capacity for the majority of moderate and larger rainfall events, while ensuring sequences of smaller rainfall events do not unnecessarily contribute to the excessive accumulation of mine waters. The probability of overflow from the containment storage structures is low, with the TSF designed to retain the 1 in 500-year ARI event and the OEF Potential Acid Forming retention pond to retain the 1in 100-year ARI event.

To ensure that there will be no impact from any containment overflow on the receiving waters, the management and mitigation strategies detailed in Section 12.9.1 will be implemented. These include a strategic peak wet season release procedure that will be implemented opportunistically to discharge excessive accumulation of the cleaner waters in the mine water management system to the McArthur River when it is carrying greater than a pre-determined high flow rate. This strategy will increase the total available water storage capacity on-site during above average wet seasons (e.g. Nov to Feb rainfall greater than 1 in 5-year ARI rainfall for this period) and minimise the risk of an uncontrolled release of contaminated water at a time when river flow is low.

The implementation of these strategies means that no deterioration of downstream aquatic habitats due to poor water quality is expected. Modelling of an emergency release from the site (Section 12.9.1) has shown that no deleterious water quality impacts are expected downstream.

Because of these controls, no project impacts are expected on the Port McArthur Tidal Wetlands at the mouth of the McArthur River which are 60-100 km downstream of the mine.

Drawdown Effects on Permanent Pools

As discussed in Section 13.5.3, there are two permanent pools in the McArthur River upstream of the mine. The major pool is Eight Mile Waterhole, about 8 km upstream of the mine site. It is some 5 km in length, up to about 200 m wide, and has a depth likely to be in excess of 5 m. The second and smaller pool is Djirrinmini (Jirinmini) Waterhole which is about 1 km upstream of the proposed river realignment.

Section 11.10.4 discusses the drawdown effects from the mine dewatering on these river pools. At a distance of 8 km, the Eight Mile Waterhole will not be affected by mine induced drawdown of the water table and hence there will be no impact on its aquatic biology.

At Djirrinmini Waterhole the modelling results have predicted the drawdown will be approximately 0.5 m in both the weathered bedrock and the alluvial aquifers after 25 years of mining. This is likely to result in a reduced lateral flow into the waterhole. This may result in a decrease in the depth and extent of the waterhole at the end of the dry season prior to it being replenished in the following wet season. The depth and extent of the waterhole varies naturally from year to year depending on climatic conditions and the aquatic biology is already adapted to these varying conditions.

The predicted drawdown of 0.5 m is a maximum will not occur until after 25 years of mining. Prior to that, the drawdown will be less. During the initial years of mining, a program for monitoring the aquatic biology in the waterhole will be implemented to identify if there are any noticeable changes caused by the drawdown induced change in depth and extent. In the event that the monitoring program indicates that noticeable changes are occurring, mitigation measures such as sustaining upstream river flows from suitable existing bores will be considered.

At mine closure, the dewatering will cease and the groundwater levels will rise to their pre-mine levels. It is expected that at the waterhole pre-mining groundwater levels would be obtained within less than 5 years.

Environmental Flows

Flow Volumes

In the alluvial sections, the realigned river channel is likely to be in hydraulic connection with groundwater. In this area the annual stream flow could potentially reduce if groundwater levels under channel are significantly lowered. Obviously during peak flooding periods in the wet season, this is not an issue. However at low-flow times during the dry season, significant loss to groundwater recharge could alter flow amounts or extend the duration of no-flow periods.

As discussed in Section 11.10, groundwater modelling shows that the increase in leakage to aquifers underlying the river (170 kL/day) is insignificant during the wet season when flows in the McArthur River at the mine site average 4,750,000 kL/day. Even at the end of the dry season (September) when average flows have declined to about 23,000 kL/day, the increase in vertical leakage is still less than 1 % of river flows. During dry years when river flows cease, the predicted vertical leakage will not significantly extend the no-flow period. Thus the mining operation will not cause any significant change to the volume of flow in the river.

Hydraulic Barriers

Consideration has also been given to the potential for the changed conditions in the realigned river channel to create an hydraulic barrier to fish movement.

As discussed in Section 12.10, the realigned river channel has been designed to ensure that its maximum and average flow velocities will be comparable to those in the pre-mining river channel for flow conditions when fish are likely to be migrating. Hence a hydraulic barrier to fish movement resulting from high flow velocities that exceed the burst speed and sustained speed swimming ability of fish is considered unlikely.

One difference between the flow velocity profiles for the existing and realigned channels is the variation of flow velocity along the channel. The velocity profiles for the existing river show that low velocity zones (less than 0.3 m/s) occur at regular intervals along the river (typically around 1 to 2 km intervals). Velocity profiles for the realigned channel show that constant velocities in excess of 0.3 m/s could occur along its entire 5 km length.

To address this issue, off-stream pools will be provided along the realigned channel to act as fish resting areas. Large pools will be available at the upstream and downstream ends of the realigned channel in the isolated sections of the original McArthur River channel that are retained immediately upstream and downstream of the mine pit. Three additional off-stream pools along the realigned channel will be created at the locations where it intersects tributary streams. Additional ecological mitigation strategies will be included around these constructed resting pools such as enhancing substrate/habitat diversity (e.g. placement of snags, creation of deep zones, and silt bars), and ensuring adequate riparian vegetation coverage around the perimeter of the pool.

13.5.7 Monitoring and Management

An aquatic monitoring program will be designed to assess populations of species in permanent pools above the river realignment and to assess movements of species through the realigned channel.

Due to the current lack of data on the Endangered freshwater sawfish in the region of the mine, a specific survey for this species will be undertaken and, based on the survey findings, a management and monitoring plan for this species will be developed.

Hanley (1993) suggests that the macroinvertebrate communities present in the ephemeral creeks of the study area are unsuitable for monitoring due to the high mobility of many species and adaptations to ephemeral waterbodies. However, the development of bio-assessment models for the assessment of river health for the Northern Territory (Dostine, 2002) may enable the establishment of a macroinvertebrate monitoring program where suitable habitats are available in association with the main McArthur River channel. Habitat models being developed for the Northern Territory include sand bed and edge habitats (Dostine, 2002). Details of the preferred monitoring method will be developed in consultation with the Northern Territory Government.

As part of the continuing management of the river realignment, results from the aquatic monitoring program will be regularly assessed and if necessary, changes to the management of the realigned channels may be made to alleviate adverse effects.

A draft environmental management plan for biology is given in Section 22.4.

13.6 Biting Insects

13.6.1 Introduction

Biting midges are not present in significant numbers within the project area and do not represent a significant pest problem.

In April 1994, MRM undertook a study to determine the baseline mosquito numbers for a minimum period of 12 months, in cooperation with the Medical Entomology Branch (MEB) of Territory Health Services (now Department of Health and Community Services, DHCS). Five adult mosquito monitoring sites were established, two sites were located near the mine, two at Bing Bong, and the fifth at Borroloola.

A report was produced that summarised the results of the first 12 months of baseline monitoring and discussed the implications of the mosquito species, their relative numbers, and the spatial and temporal distribution of the mosquito species in the area (Whelan, 1995). An overview of the outcomes of the study is given below.

13.6.2 Mosquito Species

A total of 27 species of mosquito were collected during the baseline monitoring program. This included 4 *Anopheles* species, 16 *Aedes* species and 6 *Culex* species.

A total of 7,553 female mosquitoes were trapped over a 12 month period. The most predominant species trapped was *Anopheles amictus*, followed by *An. annulipes, Aedes normanensis, Ae. vigilax, Culex annulirostris, Cx. sitiens* and *An. hilli*. The major differences in habitat between the coastal sites at Bing Bong and the inland sites at the mine result in a different mosquito species profile for each area.

During baseline monitoring, five potential vectors for arbovirus diseases were identified. *An. amictus* and *An. annulipes* are potential vectors of malaria, *Ae. normanensis* and *Cx. annulirostris* are potential vectors of Australian encephalitis, endemic polyarthritis and Barmah Forest Disease, and *Ae. vigilax* is a potential vector of endemic polyarthritis and Barmah Forest Disease. The most important vector of malaria in the NT (*An. farauti*) was not detected.

McArthur River Mine

A total of 4,652 mosquitoes were trapped, with the two monitoring sites at the mine trapping 17 species each. *An. amictus* was the most frequently trapped species, followed by *An. annulipes* (the common Australian *Anopheline*). The highest numbers of mosquitoes were collected in March 1995. The greatest numbers of mosquitoes at the mine occur on a seasonal basis following the wet season rainfall in the flooded creeks and McArthur River.

Bing Bong

A total of 2,307 mosquitoes were trapped, with the two monitoring sites at Bing Bong trapping 10 and 13 species respectively. *Ae. vigilax* (the salt marsh mosquito) was the most frequently trapped species, followed by *Cx. sittens* (the salt water Culex mosquito). *Ae. vigilax* peaked in numbers in March 1995, although *Cx. sittens* peaked much earlier, indicating the presence of a stable breeding site(s) nearby. The three most abundant species occurring in the area breed in brackish to salt water habitats.

Borroloola

A total of 594 mosquitoes were trapped at Borroloola, recording 13 different species. *Ae. normanensis* (a floodwater Aedes mosquito) was the most common species trapped, followed by *An. amictus. Ae. normanensis* peaked in numbers in both January and March 1995, and *An. amictus* peaked in March 1995. Unsealed septic tanks and the McArthur River were the main breeding sites for mosquitoes in the township.

13.6.3 Mosquito Habits

The times of year when the most common mosquito species are present are given in Table 13.7.

Table 13.7

Mosquito Seasonality

Mosquito Species	Time of Year when most Prevalent				
	MRM[1] Site 1	MRM Site 2	BB[2] Site 1	BB Site 2	Borroloola
Aedes spp.	March	March	March	March	January
Anopheles spp.	March	March	March	March	March
Culex spp.	March/May	April	April	March	April
Tripteroides spp.	March	-	-	-	-

[1] MRM = McArthur River Mine
[2] BB = Bing Bong

The habits of the mosquitos found in the project area are summarised in Table 13.8.

Table 13.8

Mosquito Habits

Mosquito Species	Habits
Anopheles amictus	This species breeds in freshwater ground pools and swamp margins, either sunlit or shaded. Often water is muddy and larvae are sometimes found in running water. The larvae often occur in shallow muddy pools formed by the drying out of larger temporary waterbodies at the end of the wet season. The highest number of *An. amictus* was trapped at MRM site 1 (the intersection of Barney Creek and McArthur River) in March.
Anopheles annulipes (The common Australian Anopheline)	This species breeds in sunlit ephemeral and perennial freshwater ground pools, often in association with emergent vegetation or algae that offers some protection from aquatic predators. It is highly responsive to newly created waterbodies in earth without vegetation. The numbers of this species reached high numbers at MRM site 2 (500 m west of the intersection of McArthur River and Barney Creek) in late wet season and mid-dry season. *Anopheles* species do not bite until after dusk.
Aedes normanensis (A floodwater Aedes mosquito)	This species breed in newly flooded ephemeral ground pools during the wet season. The highest numbers of this species were trapped in March at MRM site 2. It can bite in significant numbers during the day in shaded areas and can be a major pest around sundown.
Aedes vigilax (Salt marsh mosquito)	This species commonly breeds in salt water swamps and temporary pools that are filled by the highest spring tides and after episodes of significant rain. This species bites during the day in shaded areas and can be a significant pest. *Aedes vigilax* was recorded in high numbers at both Bing Bong sites in March.
Culex annulistri (Common banded mosquito)	*Culex annulirostris* breeds in open sunlit ground pools, often in association with vegetation such as grasses and semi-aquatic sedges and reeds. The highest number trapped was at Bing Bong site 1 (behind the coastal access track, east of the barge loading facility) in April.
Culex sitiens (Salt water Culex mosquito)	This species breeds in brackish to salt water pools influenced by high tides. It is often found with *Ae. vigilax* and *Ae. hilli* in salt marshes or in pools that have some salt water influence. Numbers may be highest in December-January after spring tides at Bing Bong-
Culex quinquefasciatus (Brown house mosquito)	This is a species associated with human settlement. Larvae are often found in septic tanks, polluted ground water and artificial containers. Breeding sites may only be productive during and for the few months following the wet season. They are found in low numbers at MRM and Bing Bong.

13.6.4 Breeding Sites

Potential breeding sites in the McArthur River mine site include:

- Septic tanks and waste water from watering or wash down operations have the potential to breed a number of mosquito species including *Cx. quinquefasciatus*, due to the high organic content and the lack of any biological control organisms.
- The ephemeral creek lines leading to Barney Creek and the McArthur River that have areas of poorly draining flood-ways during the wet season.
- The McArthur River and associated creek lines. The McArthur River near the mine site retains water into the dry season in defined and deeper channels in the lower reaches of its tributaries.

The lower reaches of these tributaries will continue to breed mosquitoes after the wet season at specific sites of thick marginal vegetation or isolated pools.

- Retention dams. Large retention dams and water storage sites have the potential to become mosquito breeding sites.
- Pooling due to impeded stormwater runoff. Various artificial structures and earth disturbances could have the potential to increase breeding habitats.
- Artificial containers such as tyres, drums, disused machinery and any rubbish items that can collect rain water are potential mosquito breeding sites.

13.6.5 Project Effects and Management Strategies

Tailings Storage Facility

Under the proposed open cut operation there will be no change to the existing TSF. To minimise the risk of the existing TSF becoming a breeding site, any encroaching emergent and semi-aquatic vegetation will be eradicated if it establishes. Vegetation will be controlled by mechanical removal or chemical (herbicide) control. Larval monitoring and adult trapping will be implemented during the wet season if problematic and, where necessary, appropriate control measures will be implemented in consultation with DHCS.

Stormwater

Existing stormwater management procedures at the mine site have not resulted in the development of significant mosquito breeding sites.

The additional stormwater facilities to be established as part of the open cut mine will be designed to minimise the potential for mosquito breeding. They will be designed to be free flowing and to avoid pooling of runoff water. Drainage channels will be steep-sided and any emergent vegetation or sediment build-up will be removed so that mosquito habitat cannot form.

Any new stormwater retention or water quality control ponds to be developed will be deep and steep-sided and no fringing aquatic vegetation will be allowed to become established.

Construction

Consideration of mosquito management has been based on Whelan (1988).

During construction, care will be taken to ensure that earthworks will not result in areas for water to pond. If any such areas do occur, they will be filled as soon as they are identified and contoured to prevent further ponding. Similarly, management plans will ensure that all rubbish that could become a breeding site following rain will be removed from the site.

All borrow pits developed during the construction phase will be graded regularly to prevent ponding of water for significant periods following rain. Care will be taken to ensure that borrow pits are not developed in areas where there is a risk of intersecting the groundwater table. All stockpiles will be deposited in an area that will not impede natural drainage and will be shaped to prevent ponding.

Stormwater runoff from the construction camp and laydown areas will be managed by diverting it into natural drainage lines to ensure that additional breeding sites are not created. Additional control measures to be incorporated include:

- Where sub-surface drainage is not used, all drainage channels/spoon drains will be kept as shallow as possible to prevent ponding.
- Rock bars will be placed in the channels to trap sediment to prevent the development of downstream, off-site impediments to streamflow and sites where emergent plants could establish.
- The drainage lines will be developed to facilitate easy access and will be monitored and maintained regularly to remove silt and prevent water ponding.
- Natural drainage lines will not be impeded by fill unless piping is installed.
- Regular inspection and cleanup of potential breeding receptacles (rubbish, tyres, drums etc.).

Worker Education and Personal Protection

A cosmopolitan, temporary construction workforce has the potential to not only be unaware of potential health risks associated with mosquito borne arbovirus transmission, but to be vectors for arboviruses themselves, either bringing disease to the site or transporting it to their own or other communities. Therefore, education of all construction contractors working on the project will be a priority.

Workers will be instructed to be especially vigilant during periods of peak mosquito activity during and after the wet season through the use of long-sleaved shirts and trousers, minimising going outside at sundown, and the regular use of insect repellent with a high DEET concentration. Insect repellent will be provided at work sites. All construction accommodation facilities will be screened and air conditioned and external street lighting will be fitted with yellow bulbs to discourage mosquitos. Insectocution devices may also be installed in areas where large numbers of mosquitos may congregate.

Environmental Management Plans

Environmental management plans for mosquito management for both the construction and operational phases are given in Sections 22.3 and 22.4.

13.7 Marine Biology

13.7.1 McArthur River Estuary

The estuarine complex at the mouth of the McArthur River, some 60-100 km downstream of the project site, is of conservation interest. This area is listed as the "Port McArthur Tidal Wetlands System" in the Directory of Important Wetlands (Jaensch, 1993a). This wetland system site is described as a "major migration stop-over area and possibly a major over-wintering area for shorebirds. The seagrass beds are a major breeding area for prawns and an important feeding area for Dugong (*Dugong dugon*). It is an important seabird (tern) breeding area". A total of 55 species of wetland birds have been recorded in the area, including 26 species which are listed under international treaties (Jaensch 1993a). An inventory of the flora and marine fauna of this area is provided in Arnol *et. al.*(1983).

13.7.2 Bing Bong

Monitoring Program

The Environmental Analytical Chemistry Unit of Charles Darwin University has been conducting the annual environmental monitoring program at Bing Bong since 1995. Sampling is carried out November/December each year of seawater, surface sediment, molluscs (oysters, telescopium and terebralia), and seagrass (*Syringodium isoetifolium).* All samples are analysed for cadmium, copper, lead and zinc.

The objective of the monitoring program is to assess whether the Bing Bong loading facility is having an impact on biota within the western parts of the Sir Edward Pellew Islands. Analysis of heavy metal concentrations in three species of mollusc (an oyster (*Sacostrea* sp.), and two species of marine gastropod (*Telescopium telescopium* and *Terebralia semistriata*), has been incorporated into the program. A local seagrass species (*Syringodium isoetifolium*) is also collected and analysed for heavy metal concentrations as it is a primary food source for several marine species in the area.

In 2002 and 2003, the monitoring had been extended to the McArthur River mouth, Sir Edward Pellew Islands and the offshore transfer zones. These reports are distributed to the Northern Territory Government as a component of the annual monitoring report. Regionally, there have been no impacts identified as a result of the Bing Bong operations.

Seagrass

The western coastline of the Gulf of Carpentaria contains areas of extensive seagrass beds. They exist in the coastal waters west of Bing Bong to the Limmen Bight River and east to the Sir Edward Pellew Islands.

The seagrass beds of the Gulf region are ecologically significant and those present in and around the Bing Bong mining lease have been subject to significant disturbance due to cyclonic activity in the last three years. Storm surges and siltation associated with cyclones has removed and altered previously dense seagrass to the extent that surveys conducted between 1994 and 1996 are no longer representative of the current seagrass density or species composition found at Bing Bong. To quantify the extent of these changes, a follow-up survey of the remaining seagrass in and around the lease was conducted in 2003. Seagrass was found to be establishing in sparse quantities by recolonising species.

Three cyclones in 2001 resulted in extensive damage to the seagrass beds along the Bing Bong coast. The MRM annual monitoring program in December 2001 found there was virtually no seagrass along the coast from east of the mouth of Mule Creek and west to the mouth of Home Creek. This area was previously dominated by dense stands of *Syringodium isoetifolium,* interspersed with areas of *Enhalus acoroides* and *Thalassia hemprichii* (MRM, 2005). Dead roots of *E. acoroides* were observed protruding above the sediment surface and covered in algal growth. A measure of the degree of disturbance could be obtained from the observation that a substantial amount of *E. acoroides* root material was washed up on the beach. *Enhalus acoroides* is deeply rooted with a very thick, long tap root, extending down to 0.5 m in the sediment.

There was still no observable regrowth of *S. isoetifolium* in November 2002, but there was some regrowth of *Halodule uninervis* and *Halophila ovalis.* The November 2003 monitoring program recorded limited recovery of *Halodule* and *Halophila* species. These observations are consistent with a survey in July/August 2003 which identified *Halodule uninervis* and *Halophila ovalis* as the species showing signs of recovery.

An assessment of the uptake of heavy metals by the seagrass at Bing Bong was undertaken by Moir (2002) to identify the extent of any impacts on the seagrass from the existing port operations. Spatial, seasonal and temporal effects on tissue heavy metal concentrations in three seagrass species, *Syringodium isoetifolium, Thalassia hemprichii* and *Enhalus acoroides,* were determined over the period 1996 to 1999. The study area extended approximately 3 km east and up to 7 km west of the Bing Bong loadout facility. Metal concentrations (iron, manganese, cobalt, nickel, copper, zinc, cadmium, and lead) did not show any anthropogenic inputs during the period of the study.

While the lead concentration data did not show any impact, lead isotope ratios, which are far more sensitive, did indicate that there has been transport of low concentrations of MRM lead in seawater exchanged from the swing basin during tidal flow. Despite this, metal concentrations in seagrass have not shown any changes since the commencement of the monitoring program with no indication of any impact from the Bing Bong operations.

Sediments

The coastline in the vicinity of Bing Bong is comprised of a series of low sandy beach ridges overlying mud flats in typical chenier formation. These beach ridges are fringed by mangroves in places and contain a high shell content. Wide intertidal flats extend seawards from the toe of the frontal beach ridge.

Sediments from sampling sites 60-100 m offshore contain a mixture of sand silt and shell with an average grain size of 0.25 mm. Sediments from further offshore contain a greater percentage of silts and muds.

Marine sediment is sampled on a monthly basis. Within the swing basin, sediment samples are collected from three transects parallel with the wharf, 50 m apart. Sampling of the sediment in the offshore concentrate transfer zone occurs on a biennial schedule. Intertidal sediment is also sampled in conjunction with the annual marine biota monitoring program. Evaluation of results is undertaken by comparing trends to those historically and geographically relevant.

The concentration of lead and zinc in surface sediments from the beach immediately west of the channel have shown elevated levels since 1996, compared to the sites east of the channel. This is consistent with the elevated levels of lead and zinc recorded in the dust collectors at the western end of the wharf. Potentially contaminated sediments have been identified in the immediate area of the swing basin where the Aburri is loaded.

Toterdell (PhD thesis in progress) has examined the remobilisation of metals and leaching behaviour of the sediments in the swing basin. This work to date has shown that the rate of metal dissolution from the sediments is very low and in most cases does not exceed the rate of metal uptake in the sediments. The controlling mechanisms are the rapid adsorption onto external sediment particles and organic complexation. In an extreme laboratory experiment of continual resuspension of contaminated sediment in a fixed volume of seawater, metal concentrations did not exceed the ANZECC (2000a) water quality guideline values.

As discuss in Section 3.6.7, a maintenance dredging program is currently being undertaken at Bing Bong. As part of that program, the contaminated sediments in the swing basin will be removed. Alternative disposal options for this material, including land disposal, will be considered. Prior to these sediments being dredged, an evaluation will be made and a full assessment will be provided to DBIRD.

Water Quality

A network of water quality monitoring sites has been established in the Bing Bong navigation channel and swing basin with a control site located outside the lease, 4 km to the north-east of the port. Samples are collected monthly and analysed for salinity, pH, cadmium, copper, iron, lead and zinc. Seawater is also sampled in the wider area in conjunction with the annual marine biota monitoring program.

In addition to evaluating results and comparing relative trends to those historically and geographically relevant, the 2000 ANZECC Guidelines for 95% marine protection are utilised as a trigger. Total lead and zinc seawater concentration of 4.25 and 15 mg/L respectively are the seawater standards.

The results of the annual monitoring program undertaken by Charles Darwin University since 1995 has indicated that metal concentrations in seawater have not shown any changes since

commencement of the monitoring program, with no indication of any impact from the MRM ore concentrate.

Batterham (1999) examined the dissolution of mixed zinc/lead sulfide ore concentrate in seawater and the subsequent trace metal cycling in the vicinity at Bing Bong. The study found that the metabolism of organic matter and the formation of a highly reactive iron sulfide pool dominated the sediment chemistry in the Bing Bong swingbasin. The iron sulfide pool efficiently scavanged metals entering the sediment and there was no significant effect on the quality of the seawater. Even the porewater in the sediment had low concentrations of trace metals. The physicochemical characteristics of the Bing Bong swingbasin are conducive to preventing heavy metal contamination of seawater in the event of either an accidental concentrate spillage or through resuspension of concentrate-contaminated sediment.

The two studies on sediments and seawater metal concentrations at Bing Bong (Munksgaard and Parry, 2002, 2001) concluded that the metal concentrations in seawater and sediment in the Bing Bong coastal area are at “near-pristine” levels. These studies covered a number of estuaries and near coastal areas from Darwin Harbour to the south-east Gulf of Carpentaria, including the Bing Bong coast and McArthur River.

The results of the monitoring and research projects discussed above show that the Bing Bong operation has a low level of localised impact, largely within the lease area. There are no data which would indicate that there is lead and/or zinc contamination in seawater along the Bing Bong coast.

13.7.3 Impact Assessment and Management

The nature of the existing operations at Bing Bong will not change as a result of the open cut proposal.

To minimise the risk of spills to the marine environment, strict operational procedures are followed. These procedures are described in Section 19.5.1. In the nine years since operations commenced at Bing Bong, there has been no major spill of concentrate into the sea. This demonstrates the effectiveness of the procedures to manage the concentrate loading operations. As discussed in Section 13.7.2, the minor amount of spillage that has occurred has not resulted in any significant impacts on water quality, sediment or marine biota. The existing concentrate handling procedures will continue to be implemented and a similar spill record is expected.