14. Fauna

This Chapter describes the terrestrial fauna and aquatic biodiversity of the Mineral Leases and assesses the potential impacts of the Project on the area's fauna biodiversity. Mitigation measures that will be implemented in order to minimise the impact of mine construction and operations are discussed.

A detailed terrestrial fauna assessment is provided in Appendix N, a detailed aquatic fauna assessment is provided in Appendix O and Appendix P contains a baseline biting insect assessment.

The potential impacts and associated mitigation measures identified in this chapter form the basis of the fauna component of the project risk assessment undertaken in Chapter 5. The project risk assessment includes consequence, likelihood and residual risk ratings for fauna impact after management measures are implemented.

14.1 Background

The Mt Todd Gold Project is located in the Pine Creek Bioregion. It is a region of mostly foothills located west of the western Arnhem Land sandstone massif. It is dominated by Darwin stringy bark (*Eucalyptus tetrodonta*) and Darwin woollybutt (*E. miniata*) open forest and eucalypt woodlands, riparian vegetation and an occasion patch of monsoon thicket. An annual rainfall of about 1,000mm inland to 1,600mm on the coast supports a relatively species rich flora and fauna. There are 17 known threatened fauna species. There is one known threatened ecological community that occurs in the Pine Creek Bioregion: Arnhem Plateau Sandstone Shrubland Complex Ecological Community. This community is listed under the EPBC Act as endangered.

Vegetation in the Pine Creek Bioregion is well conserved with at least 12,124km^2 or 42.6% of the region under conservation management in parks and reserves (NRETA 2005). This includes large areas in Kakadu, Nitmiluk, Litchfield and Mary Rivers National Parks.

DLRM (formerly the NRETAS) determined that the Mineral Leases were part of the Yinberrie Hills SOCS. The area is particularly noted for having the largest known breeding population of the Gouldian finch (listed as endangered under the EPBC Act and vulnerable under the TPWC Act). Records of this species and some other threatened species seem likely to have been major contributors to determining the area to be a SOCS.

Terrestrial and aquatic vertebrates were surveyed as part of a Draft EIS for the previous mining (Lane *et al.* 1990). Extensive research on the area's Gouldian finch population began in the 1980s with active monitoring of the population occurring from 1993 to the present. Aquatic invertebrates have been regularly sampled and monitored since gold mining ceased.

The extensive historical information base and additional data collected for this Draft EIS provide a solid base for assessing the local and regional significance of fauna of the Mineral Leases and the risks posed to it by proposed mining. Previous information on, and recent investigations of, terrestrial fauna are detailed in Appendix N. Details on aquatic biodiversity and biting insects are documented in Appendix O and Appendix P respectively. These contain a detailed assessment of risk and mitigation of potential impacts on biodiversity.

14.2 Methodology

14.2.1 Desktop Review

Existing information on the fauna of the Mineral Leases and adjacent areas was reviewed prior to initiating investigations. Searches of government databases sought documentation of fauna previously recorded or predicted to occur within 10km of the project area. The review included previous mapping of vegetation, topographic maps, the scientific literature, technical reports, government publications, investigations conducted for the original Mt Todd EIS (Lane *et al.* 1990), and environmental monitoring associated with the previous mining operation.

Results of macroinvertebrate monitoring (2003 - 2010), water monitoring (2003 - 2008) and previous studies of fish were reviewed (Midgley 1980; Martin and Goodfellow 1988; Allen 1989).

14.2.2 Terrestrial Vertebrates

The fauna of the Mineral Leases was surveyed during the Dry and Wet Seasons (2 to 7 November 2012, and 24 to 28 February 2012 respectively). The DLRM (formerly NRETAS) *Environmental Assessment Guidelines: Terrestrial Fauna Survey* were followed.

Sampling was conducted in and around two quadrats in each vegetation type. Vegetation mapping and the descriptions of vegetation types are taken from Appendix M. Sampling involved small mammal trapping, capture of animals in pit fall traps and funnel traps, spotlighting on foot and from vehicles, day and night quadrat searches (in trees, on the ground, under rocks etc.), bird observation, recording of ultrasonic bat calls, setting of motion sensitive cameras and incidental observations made while moving around the leases (Figure 14-1).

A survey was specifically focused on locating species listed as threatened under the EPBC Act and TPWC Act between 3 and 7 May 2011 and between 18 and 19 September 2012. Investigations focused on species known to occur or to potentially occur in the Mineral Leases. Methods were tailored to suit the species being sought. Techniques are listed in the *Survey guidelines for Australia's threatened mammals* (SEWPaC 2011a), Ward and Voulkolos (2009), and the *Survey guidelines for Australia's threatened birds* (SEWPaC 2010) and described in Appendix N.

Adequacy of the sampling methods and overall sampling were assessed using graphs of species accumulation with increasing levels of effort. The fauna was well sampled (Appendix N).

Results of quadrat sampling were analysed to determine the similarity of faunas in each vegetation type (Canonical Discriminant Function Analysis), and the habitat features that may be important in determining faunal species richness (Multiple Linear Regression).

A list of fauna for the Mineral Leases was compiled from previous records and these investigations.

Summaries of the biology of the area's threatened species were developed from the scientific literature. Results of the focused threatened species investigation were supplemented with previous records from the area. These assisted in determining the likely importance of the Mineral Leases to those species.

The potential for impacts on the assessed threatened species was determined for the Yinberrie Hills SOCS. Mineral Lease boundaries are determined for the administration of Mineral Leases and do not have any biological or conservation significance. It is the Yinberrie Hills Gouldian finch population that is monitored, not that fragment of it that is found in the Mineral Leases.

14.2.1 Biting Insects

A previous baseline biting insect assessment was conducted from March 1993 to June 1994 (Whelan 1994). This involved monthly adult mosquito trapping and a field survey to identify actual or potential mosquito breeding sites during the early period of mine development.

The purpose of the current biting insect investigation is to identify current levels of pest and disease carrying mosquitoes, determine if past mining activities have created new mosquito breeding sites, and provide advice on preventing the creation of new mosquito breeding sites (Appendix P). A field survey to identify actual or potential mosquito breeding sites was conducted on 8 and 9 February 2012. Potential mosquito breeding sites were examined for larvae with potential sites either identified in advance by examining aerial photography, or identified by navigating the mine site on 4WD quad bikes.

Adult biting insect traps (carbon dioxide baited encephalitis virus surveillance traps) were set at five locations around the mine site on the afternoon of 8 February 2012, and collected after sunrise on the morning of 9 February 2012 (Appendix P). Larvae and adults were returned to the laboratory for identification.

14.2.2 Aquatic Fauna

Field sampling was undertaken in accordance with the Northern Territory AUSRIVAS sampling methods. Components of the sampling methodology include habitat, sediment, macroinvertebrate and fish sampling and assessment following prescribed methods.

Sampling of macroinvertebrates was conducted in the recessional flow period so as to capture the integrated effects of mine site runoff over the preceding Wet Season. This coincides with the optimal sampling time and is approximately four to six weeks after the last flushing (storm event) from Wet Season rains. The timing allows macroinvertebrates to recolonise stream habitats after disturbances from Wet Season flooding.

Macroinvertebrates are often used as indicators of water quality because of their limited mobility, relatively long residence times, and varying degrees of sensitivity to pollutants. Unaffected streams generally have a variety of species with representatives of all insect orders, including a high diversity of insects classed in the taxonomic orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT taxa).

Fish are often used as indicators of pollution. They are not as useful as macroinvertebrates because of their greater mobility. Fish may temporarily swim through a non-lethal impacted area or away from a discharge of intermittent duration.

Sites for the macroinvertebrate study were chosen to provide an assessment of the state of the aquatic environment in, and adjacent to, the existing mine site. All sites were positioned to quantify existing conditions and detect impacts from future potential pollutant sources from the mine site.

Samples were collected at sites selected to allow potential inputs from Horseshoe Creek, Batman Creek, Stow Creek and the site of controlled discharge to be distinguished (Figure 14-1). These were:

- three sites upstream of the mine and the confluence of Stow Creek and Horseshoe Creek (SC1, SC2, SC3) to act as an upstream reference for the two sites further downstream;
- one site downstream of the confluence of Stow Creek and Horseshoe Creek (SC4) to indicate whether the macroinvertebrate health of the creek is affected by water input from Horseshoe Creek;

- one site downstream of the confluence of Stow Creek with Batman Creek (SC5) to indicate whether the macroinvertebrate health of the creek is affected by water input from Batman Creek and to be used to differentiate between the input effects of Horseshoe and Batman creeks;
- one Edith River site upstream site (ERUS) of its confluence with Stow Creek to represent upstream reference conditions in Edith River for comparison with downstream sites;
- one site downstream of the Stow Creek confluence on the Edith River (ERDS) to detect change as a result of discharge from Stow Creek;
- one site downstream of the RP1 discharge location and West Creek confluence (ERSW4) to detect change to the Edith River macroinvertebrate community following both controlled and uncontrolled discharge from these two point sources; and
- two reference sites on the nearby Fergusson River that were sampled previously to be used for reference comparisons to similar sites from the Edith River and provide temporal change comparisons between the waterways.

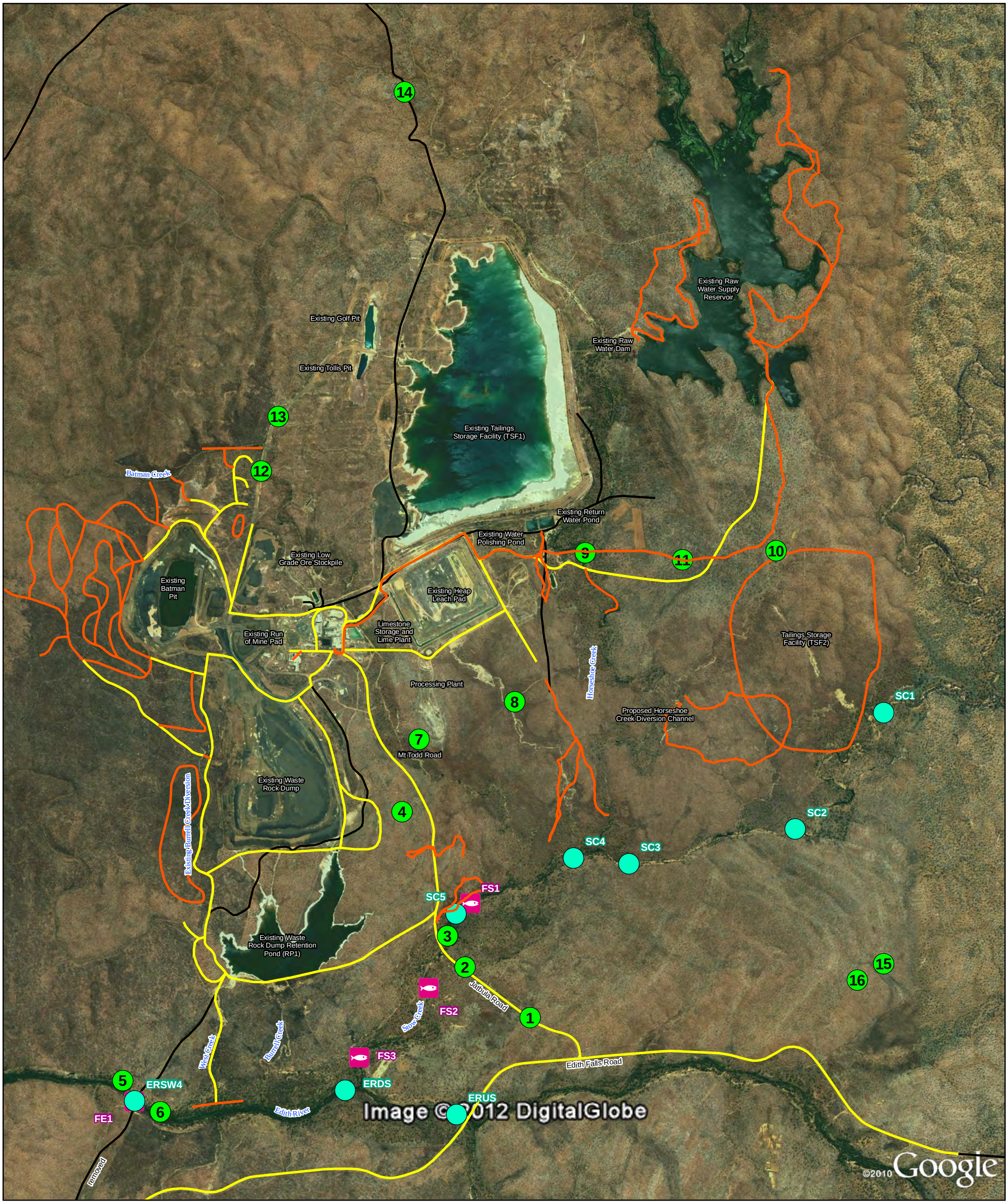
At each location:

- sediments and associated pore waters were investigated to assess levels of heavy metal contamination;
- particle size distribution was analysed to demonstrate the binding potential of sediments and to highlight any correlations between contaminant level and particle size;
- sediment total organic carbon and pH were analysed; and
- field measurements were taken of water temperature, pH, electrical conductivity, dissolved oxygen and turbidity.

Four sites were surveyed for fish during this assessment (Figure 14-1):

- three sites on Stow Creek (FS1, FS2 & FS3); and
- one site on the Edith River (FE1).

Full details of the methods, including maps showing the locations of sampling sites, can be found in Appendix O. Detailed water quality data and analyses can be found in Appendix J.



LEGEND

- Fauna Survey Sites
- Macro Invertebrate Sample Sites
- Fish Survey Sites
- Routes Driven and Surveyed from Vehicle
- Routes Walked
- Access Roads

1:25,000 @ A3

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 53

N

Vista Gold Australia Pty Ltd
Mt Todd Gold Project

Terrestrial and Aquatic Fauna Monitoring Locations

Job Number 43-21801
Revision 1
Date 27 May 2013

Figure 14-1

G:\43\21801\GIS\Maps 30000 TPA\EIS\Fauna\4321801_915E.mxd

66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com.au

Data source: Google Earth Pro - Imagery (Date Extracted = 30/01/2012). GHD - Fauna Survey Sites, Fauna Transects, Macro Invertebrate Sample Sites, Fish Survey Sites (2012). Created by: CM

14.3 Results

14.3.1 Terrestrial Vertebrates

Species of Fauna

The desktop assessment revealed records of 300 indigenous terrestrial vertebrate species from within 10km of the study area (reported in Lane *et al*. (1990) and / or the DLRM Fauna Atlas). These include 36 species of mammal, 183 species of bird, 67 species of reptile and 14 species of amphibian. Eight introduced fauna species are recorded, including seven mammals and one amphibian.

A total of 245 species were detected in the current surveys, including 32 mammal, 145 bird, 48 reptile and 20 amphibian species.

Additional species were found during these studies. The Mineral Leases, including an adjacent 10km buffer zone, are now know to maintain, or to have maintained at some time, 346 species of terrestrial vertebrate: 50 mammal, 197 bird, 77 reptile and 22 amphibian species. Eight of these are exotic in origin and all but one is a mammal. The remaining introduced animal is the cane toad, an amphibian. Complete lists of the results of Lane *et al.* (1990), the Northern Territory Fauna Atlas records and these studies can be found in Appendix N.

Faunas of Different Habitats

Analysis of the vertebrate species recorded in each vegetation type indicated there were no significant differences between the faunas in terms of presence or absence of vertebrate species. The same was true for mammals.

Birds demonstrated segregation among the vegetation types with bird species in the melaleuca forest differing from all other faunas, as did birds in the Darwin box (*E. tectifica*) woodland. The melaleuca forest had nine species of raptor, more than any other vegetation type, while the Darwin box woodland had none.

The reptile faunas showed significant variation among vegetation types with the melaleuca forest and riparian forest communities differing from the other vegetation types. This difference seems mostly related to there being no monitor (goanna) species recorded in melaleuca or riparian forests, and at least one in each of the other vegetation types.

The amphibian fauna at the melaleuca forest had higher numbers of ground frog species (eight). At the other end of the scale, the salmon gum (*E. tintinnans*), variable barked bloodwood (*C. dichromophloia*) woodland had the lowest number of ground frogs (two species).

Species Richness and Habitat Characteristics

Fauna species richness (all species) at sites was most strongly influenced by fire. Recently burnt sites tended to have lower species richness. Species richness of birds and amphibians (separate tests) showed the same pattern i.e. decreasing species richness with more recent fire. No habitat variable had an appreciable influence of the species richness of mammals or reptiles.

Changes in the Fauna since 1990

The number of species of terrestrial vertebrate (mammal, bird, reptile and frog) recorded during the survey for this draft EIS (in 2011-12) was very similar to those recorded by Lane *et al.* (1990). These surveys recorded 226 species including six feral species while Lane *et al.* (1990) documented 219 species including three feral species (Appendix N). While the species richness of the Mineral Leases has

not been changed by mining in the 1990s or some other factor, there were some changes in the fauna over the 22 year period.

Some of the differences are likely to be due to chance associated with failure to record species that are relatively uncommon and / or cryptic e.g. chameleon dragon, northern death adder, northern bandy bandy, and grey falcon. Some have resulted from Lane *et al.* (1990) surveying habitats not found in the Mineral Leases e.g. the rock rat was captured in rocky habitat occurring outside the leases. The two studies used slightly differing methods and intensities of sampling. These differences explain some of the differences in species detected, especially species of bat (Appendix N).

Other differences may be more significant. These include the apparent decline and absence of the northern quoll, the seeming absence / rarity of the yellow-spotted monitor and Mitchell's water monitor, the apparent decline in Mertens' water monitor, and the possible absence of two species of small mammal (Appendix N).

Northern Quoll

Trapping, night-time spotlighting and motion-sensitive cameras failed to locate the northern quoll in 2011-2012 (Appendix N).

The northern quoll is the only mammal demonstrated to be impacted by the cane toad invasion (Woinarski *et al.* 2008). Rapid contractions and local extinctions of populations have been reported following the toad's invasion of Cape York Peninsula (Burnett 1997) and parts of Kakadu National Park (Watson and Woinarski 2003). It is known to survive in its primary habitat of rugged rocky areas such as sandstone escarpments (Woinarski *et al.* 2008). The Mineral Leases have no such habitat and the species seems unlikely to now occur in the area.

Yellow-spotted Monitor, Mitchell's Water Monitor and Mertens' Water Monitor

These species of monitor (goanna) are known to exhibit population decline following cane toad invasion and both species are known to persist and recover (Burnett 1997; Freeland 2004; Griffith and McKay 2007; Doody *et al.* 2009). Mertens' water monitors and Mitchell's water monitors are susceptible to the cane toad's toxin (Doody *et al.* 2009). Individual yellow-spotted monitors that attempt to ingest cane toads mostly die within 15 minutes (Freeland 2004). They do not seem to learn to avoid toads. Surviving yellow-spotted monitors begin the population recovery within two years of the cane toad's invasion (Freeland 2004). Large-bodied goannas from areas invaded by the cane toad do not attempt to eat cane toads.

Mertens' water monitor was once relatively abundant in wetland habitat of the Mineral Leases (Lane *et al.* 1990). It now persists at what may be a lower density. The yellow-spotted monitor may persist in the Mineral Leases. The fact that it was not recorded could reflect of its secretive nature.

Small Mammals

Two small mammal species were recorded from habitat not present in the Mineral Leases i.e. granite outcropping (Appendix N). Two other small mammal species, the northern short-tailed mouse (*Leggadina lakedownensis*) and red-cheeked dunnart (*Sminthopsis virginiae*), recorded by Lane *et al.* (1990) were not recorded by GHD (Appendix N). Lane *et al.* (1990) recoded a single capture of both of these species. The absence of records during the recent surveys may reflect low probability of capture rather than the animals necessarily being absent. Alternatively, their apparent absence may contribute to reports of declines in the Northern Territory's Top End small mammal fauna (Woinarski *et al.* 2001).

Threatened Species

The Northern Territory Fauna Atlas and Commonwealth's Protected Matters Search Tool (PMST) predicted that the following threatened species occur or may occur in or adjacent to, the Mineral Leases:

- Gouldian finch (*Erythrura gouldiae*);
- northern quoll (*Dasyurus hallucatus*);
- crested shrike-tit (northern) (*Falcunculus frontatus whitei*);
- partridge pigeon (*Geophaps smithii smithii*);
- bare-rumped sheathtail bat (*Saccolaimus saccolaimus nudicluniatus*);
- masked owl (*Tyto novaehollandiae kimberli*);
- northern brush-tailed phascogale (*Phascogale pirata*);
- black-footed tree-rat (*Mesembriomys gouldii*);
- pale field-rat (*Rattus tunneyi*);
- freshwater sawfish (*Pristis microdon*);
- brush-tailed rabbit-rat (*Conilurus penicillatus*);
- red goshawk (*Erythrotriorchis radiatus*);
- painted honeyeater (*Grantiella picta*);
- grey falcon (*Falco hypoleucos*);
- Australian bustard (*Ardeotis australis*) (formely listed as threatened, now listed as near threatened);
- Mitchell's water monitor (*Varanus mitchelli*);
- Mertens' water monitor (*Varanus mertensi*); and
- yellow-spotted monitor (*Varanus panoptes*).

Not all of these have been recorded from the Mt Todd area, and some are unlikely to occur, including:

- bare-rumped sheathtail bat - critically endangered (EPBC Act):
  - only found on, or adjacent to, coastal floodplains (Milne and Pavey 2011), which are not present near the study area; and
  - previous survey has not located the species in the study area (Lane *et al.* 1990).
- northern brush-tailed phascogale - vulnerable (EPBC and TPWC Acts):
  - usually located in tall open forests which are absent from the study area;
  - uncommon with little known of their ecology or behaviour in the Top End (Woinarski *et al*. 2007);
  - existing populations are restricted to locations closer to the coast (Woinarski *et al*. 2007); and
  - previous survey has not located the species in the study area (Lane *et al.* 1990).
- brush-tailed rabbit-rat - vulnerable (EPBC and TPWC Acts):
  - recent records are restricted to the Tiwi islands, Cobourg Peninsula, Kakadu, the Inglis Islands and Groote Eylandt (Woinarski *et al*. 2007);
  - not recorded from locations as far inland as the project area, and there are no known records for the Yinberrie Hills; and
  - it was not recorded during previous surveys of the study area (Lane *et al.* 1990).

- masked owl - vulnerable (EPBC and TPWC Acts):
  - there is no record of this species from the Mt Todd - Yinberrie Hills area;
  - the species was not found during previous surveys of the Mt Todd area (Lane *et al.* 1990); and
  - this species was targeted using nocturnal call back methods during the general fauna surveys.
- red goshawk - vulnerable (EPBC and TPWC Acts):
  - no record within 10km of the Mineral Leases.

None of these species was recorded during the general fauna surveys or the survey focusing on threatened species.

Records of the remaining species are as follows:

- northern quoll - critically endangered (TPWC Act), endangered (EPBC Act):
  - one record four kilometres approximately northwest of the Mineral Leases.
- Gouldian finch - endangered (EPBC and TPWC Acts):
  - the Yinberrie Hills is the location of the largest known breeding population; and
  - individuals and nests have been recorded in the Mineral Leases.
- crested shrike-tit (northern) - vulnerable (EPBC and TPWC Acts):
  - one record from the Mineral Leases, immediately north of the Batman Pit;
  - one record of calling to the west of the Batman Pit; and
  - three other records within five kilometres of the Mineral Leases.
- partridge pigeon -vulnerable (EPBC and TPWC Acts):
  - eight records within approximately four kilometres of the Mineral Leases; and
  - one record adjacent to the railway line on the Edith Falls Road.
- Australian bustard - formerly listed as vulnerable now listed as near threatened:
  - six records from the Mineral Leases plus a 10km wide buffer.
- painted honeyeater – vulnerable (TPWC Act):
  - one record in the Mineral Leases; and
  - there is a recent Bird Atlas record of this species from the adjacent Nitmiluk National Park.
- grey falcon – vulnerable (TPWC Act):
  - one record at the northern end of the proposed mine site in October 1988;
  - two were seen near the end of old Edith Falls Road in April 1990; and
  - Lane *et al.* (1990) also reports that this species was seen regularly between Katherine and Victoria River Crossing.
- pale field-rat – vulnerable (TPWC Act):
  - one record at the north-east of the proposed mine in 1988; and
  - six records during Dry and Wet Season surveys.
- Mertens' water monitor - vulnerable (TPWC Act):
  - three records from the Mineral Leases; and
  - reported as "most common" along the Edith River (Lane *et al.* 1990).

- Mitchell's water monitor - vulnerable (TPWC Act):
  - no record in the Fauna Atlas within 10km of the Mineral Leases; and
  - reported as abundant along Horseshoe Creek and Yinberrie Creek (Lane *et al.* 1990).
- yellow-spotted monitor - vulnerable (TPWC Act):
  - one record from the Mineral Leases. That observation was made more than 20 years ago by Lane *et al.* (1990) at Horseshoe Creek.

The survey targeting threatened species and the two general fauna surveys failed to locate the northern quoll, the partridge pigeon, grey falcon, Mitchell's water monitor and the yellow-spotted monitor (Appendix N). The Gouldian finch was observed on six occasions to the west of Batman Pit and the crested shrike-tit heard, but not visually confirmed, on two occasions. Australian bustards were seen on the mine site in disturbed areas on 11 occasions. The pale field-rat was recorded on six occasions. One painted honeyeater was observed and three Mertens' water monitors were seen during baseline and targeted surveys.

Gouldian Finch

The Gouldian finch is well known to have a major breeding area in the Yinberrie Hills. Nesting occurs in areas in the west of the Mineral Leases. The population has been annually monitored since 1993. From 1993 to 1996 the monitoring involved surveying active nests near and further from the mine (Price 1992; Collins *et al.* 1993; Smith *et al.* 1995; Bamford and Bamford 1996). No impact was detected and nesting frequency was similar in both locations. Not all likely nest hollows were occupied. The Parks and Wildlife Commission of the Northern Territory initiated waterhole counts during the late 1996 Dry Season. This has continued to the present day and has not detected any trend in the population (Woinarski *et al.* 2007).

The monitoring was established to determine the potential effects of the gold mine on the population. The sources of impact included loss of 155ha of the Gouldian finch nesting habitat (Appendix N). Monitoring continued following closure of the mine.

Plate 14-1 Adult male Gouldian finch (red-faced form)

The threatened status of the Gouldian finch seems associated with poor survival during the early Wet Season (Woinarski and Tidemann 1992). A range of threatening processes may impact the species including high levels of infestation with the endoparasitic air-sac mite *Sternostoma tracheacolum* and its associated significant pathology among wild birds (Tidemann *et al.* 1992; Bell 1996). Pastoralism, trapping for the aviary trade and inappropriate fire regimes have been suggested as possible threats (Franklin 1999; Woinarski *et al.* 2007), although no direct evidence is available to link these to the decline in the species.

The Gouldian finch nests in hollows in salmon gum (*E. tintinnans*) during the Dry Season. The nests are found on rocky hillsides. The birds feed predominantly on the seed of a native sorghum (*Sarga timorense*) during the nesting period (Dostine and Franklin 2002; Woinarski *et al.* 2007). This food source declines as the late Dry Season approaches and the finches turn to a series of late Dry Season to late Wet Season seeding grasses for food (Dostine *et al.* 2001; Lewis 2007). These, in approximately the order of seeding, are cockatoo grass (*Alloteropsis semialata*), golden beard grass (*Chrysopogon falax*),

curly spinifex (*Triodia bitextura*) and giant speargrass (*Heteropogon triticeus*). Cockatoo grass and golden beard grass are relatively common in the western areas of the leases while sorghum is more abundant in the east (Appendix M).

Fire management in the Yinberrie hills is undertaken by the Jawoyn Rangers who use relatively cool burns during the early Dry Season. Sorghum, the major Gouldian finch food, is tolerant of hot fires (Watkinson *et al*. 1989). Giant speargrass, golden bread grass, cockatoo grass, and curley spinifex increase in fire sensitivity in that order (Dostine *et al.* 2001; Lewis 2007). Giant speargrass is fire tolerant, increasing when there are annual fires (Fensham 1990) and disappearing after 14 years without fire (Scott *et al.* 2010). Retention of the fire-requiring and fire-intolerant grass species and the absence of significant change in the Gouldian finch population over 17 years are suggestive of the fire management having been appropriate for the Gouldian finch.

Crested Shrike-tit

In the Katherine region this species is believed to prefer open mixed woodland with grassy understorey, on heavy soils shallowly inundated for much of the Wet Season (Ward 2008). This habitat type is patchily distributed in the area proposed for TSF2 closer to the Edith River. The shrike-tit has been recorded from a range of habitats and potentially could occur at very low density across the region.

The area around the mineral leases has been subject to extensive ornithological research and monitoring since the mid-1980s. The very few records of the crested shrike-tit, and the presence of a relatively small area of potentially suitable habitat in the lower lying areas and elsewhere in the Yinberrie Hills suggest that this species may visit occasionally or be a rare resident of the mineral lease area.

The absence of response to playing of recorded crested shrike-tit songs during the Wet Season suggests that the mineral leases may not provide breeding habitat for the species.

Australian Bustard

The Australian bustard typically occurs in open habitats, preferring grasslands, low shrublands, grassy woodlands and other structurally similar but artificial habitats such as croplands and airfields (Downes and Speedie 1982 in Woinarski *et al.* 2007). This species responds favourably to fire and is often located in recently burnt habitats, including woodlands. In the mineral leases it was only recorded from habitats that were created during previous mining e.g. the waste rock dump. These are open habitats with little vegetation. The species may benefit from the fire regimen limiting the density of understory vegetation during the Dry Season.

Plate 14-2 Adult male Australian bustard

Partridge Pigeon

Partridge pigeon benefit from patchily distributed relatively cool early Dry Season fires. The partridge pigeon prefers to feed in recently burnt areas but shelter, roost and nest in vegetated areas (Fraser *et al*. 2003). It occurs in open forest and woodland dominated by Darwin stringybark (*E. tetradonta*) and Darwin woollybutt (*E. miniata*) with a structurally diverse understorey (Higgins and Davies 1996; Garnet and Crowley 2000). There are no data that can be used to determine whether the local, unchanged absence of the partridge pigeon from the mineral leases, and local rarity is related to the long standing fire regimen that may benefit the Gouldian finch.

Painted Honeyeater

Painted honeyeaters are the most specialised honeyeaters, being almost wholly dependent on mistletoe fruits, but may also feed on nectar and insects. They inhabit woodlands and open forest and prefer habitats with more mature trees since these host more mistletoe (Garnett *et al.* 2011).

The painted honeyeater has a broad distribution in eastern Australia, but is nowhere very numerous. Most breeding occurs in the inland slopes of south-eastern Australia, and non-breeding birds move widely out into semi-arid and northern regions. There is no evidence of a breeding population in the Northern Territory and the records are thought to be of irregular visitors from the south-east (though it is possibly a regular visitor in small numbers).

This species was recorded once during the Dry Season survey. This is just the second record for this species in the Katherine area, with the majority of the very few known records coming from the eastern parts of the Top End.

Mertens' Water Monitor, Mitchell's Water Monitor and the Yellow-spotted Monitor

The apparently reduced presence of Mertens' water monitor and the possible absence of the yellow-spotted monitor and Mitchell's water monitor can be attributed to the impacts of the cane toad. The status of these three species in the Mineral Leases reflects a region wide situation, rather than any localised response to a threat. The details of the changes described above are detailed in Appendix N.

Plate 14-3 Mertens' water monitor

Pale Field-rat

The pale field-rat is found in high rainfall areas of the northern Australia ranging from the Kimberley to south-eastern Queensland. The pale field rat is nocturnal, sheltering in extensive shallow burrows during the day and form loose colonies.

The pale field-rat is has undergone considerable decline across the Top End of the Northern Territory over the past ten years, with no clear explanation. The current Territory-wide decline is probably due to ongoing inappropriate fire regimes (too frequent) affecting habitat suitability, and predation by feral cats (Woinarski *et al.* 2010).

The pale field-rat was trapped on six occasions during the wet and Dry Season surveys.

14.3.2 Biting Insects

Results of larvae searches and adult trapping are provided in Table 14-1 and Table 14-2 respectively. Complete details on the locations and characteristics of the sites can be found in Appendix P. Twelve of the larval sites visited were regarded as potential larval mosquito habitats and one as possible. Only two sites had larvae or pupae at the time of the survey (Table 14-1). The mosquito breeding sites were thought likely to produce levels of mosquitoes that could cause periodic pest and potential disease problems at Mt Todd, mainly during the wet and early Dry Season.

A total of 39 species of mosquitoes were collected during the trapping program (February 2012 to January 2013), accounting for a total of 6966 adult female mosquitoes. The most common mosquito was the floodwater *Aedes* mosquito *Aedes normanensis,* which accounted for 44.23% of all mosquitoes.

A maximum of 27 species were caught at any one site (Table 14-2). The most productive month for mosquitoes at Mt Todd mine was April, which recorded 3844 adult female mosquitoes, accounting for 55.18% of all mosquitoes collected during the trapping at an average of 768 mosquitoes per trap

Mosquito populations were regarded as relatively low, possibly influenced by a relatively long dry spell in January before the trapping in early February. The presence of low numbers of the floodwater mosquito *Aedes normanensis* suggested that populations of this mosquito would have been a lot higher in the previous weeks, starting 9 to 10 days after the heavy flooding in late December. *A. normanensis* numbers were high enough at Trap Sites 1 and 3 to cause a low pest problem.

Trapping in 1993 - 94 revealed that species such as *A. normanensis* and *Culex annulirostris* reached seasonal levels that could cause low to relatively high pest problems, while the potential malaria mosquito *Anopheles annulipes s.l.* reached seasonal levels that could cause potential low to moderate pest problems. It is possible that there are now more mosquito breeding sites at the mine site than in 1993 - 94.

Table 14-1 Larval Mosquito Habitats on the Mineral Leases

Date	Location	Mosquito species
8-2-12	L1 Borrow pits adjacent to Horseshoe Creek	Nil
	L2 Grassy depression adjacent to Horseshoe Creek	Nil
	L3 Morris Dam, south west edge	Nil
	L4 Raw Water Dam, southeast edge	Nil
	L5 Grassy floodway east of Horseshoe Creek	Nil
	L6 Seepage from Tailings Storage Facility, south margin	Nil
	L7 Tailings Storage Facility, disturbed area near south west edge	Nil
9-2-12	L8 Borrow pit and disturbed area both sides of road past Heap Leach Pad	Nil
	L9 Septic tank and adjacent disturbed area	Nil
	L10 Grassy floodway adjacent to ephemeral stream, south of mine site	*Verrallina reesi*
	L11 Small plastic lined water holding pond at mine site	*Culex annulirostris*
	L12 Roadside depression east of waste rock stockpile	Nil
	L13 Stow Creek, depressions near road	Nil

Table 14-2 Adult Mosquitos Trapped on the Mineral Leases

Location	No. of Species	No. of females
Morris Dam	24	1386
Tailings dam east	27	1675
Tailings dam west	25	2061
Stow Creek	24	1552
Mine site	22	292

14.3.3 Aquatic Fauna

Aquatic Macroinvertebrates

A total of 6,520 macroinvertebrate specimens from 39 taxa were identified from the three waterways during the 2011 investigation. Edith River and Stow Creek returned 33 taxa, while the Fergusson River returned 30 taxa.

Community composition varied across the three waterways. The Fergusson River and Edith River communities were relatively similar with Triochoptera and Coleoptera taxa dominating the community assemblage. Trichoptera taxa are generally regarded as pollution sensitive and the high representation of these taxa in these rivers indicates that the water quality and habitat are of good quality.

Trichoptera and Coleoptera taxa were present in Stow Creek although Dipteran taxa dominated the community. Dipterans are known to have a wide tolerance to pollution. The high representation of these taxa in Stow Creek indicates a possibly higher level of impact to this waterway.

The macroinvertebrate results demonstrate that despite the long history of mine discharges to Stow Creek and the Edith River, there appears to be minimal long term impact on the macroinvertebrate communities of these waterways.

The descriptive analysis of taxa diversity demonstrates that although there was a degree of variability in replicates for each site, the total number of families sampled at the site level was relatively consistent across the three waterways.

Analysis of the invertebrate community composition data indicated a significant difference between the macroinvertebrate communities at Stow Creek and those at the Edith and Fergusson Rivers. Dipteran taxa were most dominant in Stow Creek. The Chironomid sub family Chironominae was the most abundant Dipteran taxa. Although present in the Edith and Fergusson Rivers, they comprised less than 10% of the fauna at each location. Some Chironomids are known to be tolerant of metal pollution (e.g. see Norris *et al.* 1982). The consistency of community structure of sites upstream of the mine' influence with these sites downstream of the mine indicates that differences observed between Stow Creek and the Edith and Fergusson Rivers are most likely habitat related (i.e. it is driven by catchment wide influences rather than the point source input from the mine).

Trichopteran taxa dominated the community composition in the Edith and Fergusson Rivers. The abundance of Trichoptera was almost exclusively attributed to members of the family Leptoceridae, which is known to be tolerant of metal contamination (Norris *et al.* 1982). The similarity of the community at the upstream and downstream sites on the Edith and Fergusson Rivers suggests that catchment scale factors maybe determining the observed community structure.

No index demonstrated a pattern of increasing or decreasing values from upstream to downstream from the mine.

The AUSRIVAS results show no discernible difference between upstream and downstream of the mine. All sites returned an AUSRIVAS ranking of either band A or X, indicating that the macroinvertebrate faunas are equal to (A), or above reference populations (X) sampled for the Daly-Darwin model.

Fish

Eight species were identified from Stow Creek and nine species from the Edith River. Overall a total of 14 fish species was sampled from the Edith River and Stow Creek combined.

The data allow little inference about the potential impact of the mine on the fish fauna. Fish would have been capable of moving between the sample sites at the time of the study. The results were limited by the presence of large crocodile slides at the Mt Todd Mine Site. This largely restricted sampling to shallow areas. This has an influence on the species encountered during the survey. The deeper reaches of waterways are likely to contain a higher number of species than was recorded during the survey.

The only species sampled during the current survey that had not been recorded as part of previous surveys on the Edith River was the Indian Shortfin Eel (*Anguilla bicolor*). In Australia, this species is known only from the coastal drainages of the Kimberly region (WA) where it is not common (Allen *et al.* 2003). The presence of this species in the greater Daly River catchment is an anomaly.

The PMST search results identified the study area as potential habitat for the freshwater crocodile (*Crocodylus johnstoni*) and freshwater sawfish (*Pristis microdon*).

Freshwater crocodiles were observed during the course of the surveys at the Mt Todd mine site. The freshwater crocodiles observed were small (<50cm) and likely young of previous years juveniles. This indicates that suitable breeding habitats exist in the project area. This species is a listed marine species under the EPBC Act. Potential breeding habitat should be protected where in-stream works are required.

Freshwater sawfish are known to occur in the greater Daly River catchment, mostly in larger middle and lower Daly River reaches. None are recorded from the Edith or Fergusson Rivers.

14.4 Potential Impacts on Fauna

14.4.1 Terrestrial Vertebrates

Potential sources of impact on terrestrial fauna are assessed relative to the potential for impact on the fauna of the Yinberrie Hills area of conservation significance. The boundaries of the Mineral Leases hold no biological or conservation significance, being lines on a map drawn for regulating mining. The Yinberrie Hills in contrast is an area recognised by DLRM as an area of conservation significance. Potential sources of impact include:

- clearing of breeding and / or foraging habitat to allow expansion of the mine;
- dust generated by mining and processing activities impacting on animals or their habitats;
- noise generated by mining and processing activities impacting on animals;
- wildfire damaging breeding and feeding habitat;
- predation by, poisoning by and / or competition from exotic animals, or habitat degradation caused by exotic plants;
- poisoning from drinking tailings dam water;
- loss of habitat caused by lowering or contamination of the water table; and
- artificial light.

More detailed descriptions of the potential sources of impact are provided in Appendix N.

Land Clearing

The footprint of the Mt Todd Gold Project will cover 1267.13ha. Of this:

- 608.72ha is non-disturbed vegetation;

- 28.83ha is degraded (or modified) vegetation; and
- 629.58ha is cleared land.

The boundaries of the Mineral Leases hold no biological or conservation significance, being relatively arbitrary lines on a map drawn for regulating mining. The Yinberrie Hills in contrast is an area recognised by DLRM as having conservation significance.

Areas of vegetation to be cleared were calculated for each of the Mineral Leases' vegetation types using 1:250,000 mapping that covers all of the Mineral Leases, and 88.1% of the Yinberrie Hills SOCS. GHD (Appendix M) used these figures to calculate cumulative losses of each vegetation type (Table 14-3). These were converted into losses of breeding and feeding habitats likely to be experienced by each of the area's threatened species, and the fauna as a whole and were expressed as percentages of those available in the mapped component of the Yinberrie Hills SOCS.

Table 14-3 Area of Yinberrie Hills Habitat (1:250,000 scale) Previously and Proposed (1:50,000) to be Cleared (ha with % of Original Area) in the Study Area

Vegetation Type	Area in the Yinberrie Hills (ha)	Loss Due to Activity 1990-Current	Proposed Loss due to the Project (ha)	Cumulative Area to be Cleared (ha)	Cumulative Percentage Cleared
E. tintinnans	34,652	155.40	140.28	295.68	0.85
Other Mt Todd Woodlands	37,055	733.13	468.44	1201.57	3.24
All Mt Todd Vegetation Types	71,707	888.54	608.72	1497.26	2.09

Values overestimate the percentages likely to be lost as only 88.1% of the Yinberrie Hills SOCS is considered, and consideration is only given to vegetation types present in the leases, rather than to all vegetation types in the SOCS i.e. both factors are likely to cause the reported losses to be larger than those likely to occur. All estimates are for cumulative losses experienced during previous mining and proposed by the Project. The levels of diminution in the habitats of each of the threatened species and the fauna as a whole are:

- Gouldian finch:
  - A total cumulative loss (previously and proposed) of 295.68ha or 0.75% of the original undisturbed *E. tintinnans* woodland in the Yinberrie Hills SOCS;
  - A cumulative loss of 1201.57ha or 3.24% of the original undisturbed lowland woodland in the Yinberrie Hills SOCS. This estimate is for woodland types found in the Mineral Leases and does not include large areas of other woodland types. The lowland woodlands are mostly on the eastern side of the mine and do not have significant areas of grass species providing seed in the Wet Season (*Alloteropsis semialata, Chrysopogon fallax* and *Triodia bitextura*).
- crested shrike-tit:
  - A cumulative loss of 1497.26ha or 2.09% of potentially rarely used, possible foraging habitat (*E. tintinnans,* lowland woodland habitats), in the Yinberrie Hills SOCS. The absence of calls in the Wet Season suggests the area may not be used for breeding

- partridge pigeon:
  - A cumulative loss of 1497.26ha of potentially rarely used foraging / breeding habitat (*E. tintinnans* and lowland woodland habitats) or 2.09%of this habitat in the Yinberrie Hills SOCS.
- Australian bustard:
  - A cumulative loss of 1497.26ha or 2.09% of potentially rarely used, possible foraging habitat (*E. tintinnans,* lowland woodland habitats), in the Yinberrie Hills SOCS.
- pale field-rat:
  - A cumulative loss of 1497.26ha or 2.09% of foraging / breeding habitat used in the Yinberrie Hills SOCS.
- painted honeyeater:
  - A cumulative loss of 1497.26ha or 2.09% of potentially rarely used, possible foraging habitat (*E. tintinnans,* lowland woodland habitats), in the Yinberrie Hills SOCS. This species has been documented as an occasional visitor to the Northern Territory from the south-eastern states and is unlikely to breed in the project area.
- Mertens' water monitor, Mitchells' water monitor and yellow-spotted monitor:
  - No loss of foraging / breeding habitat (riparian vegetation) resulting in a no loss of the original riparian area in the Mineral Leases and in the Yinberrie Hills SOCS; and the
- entire fauna of the study area:
  - A cumulative loss of 1497.26ha of foraging / breeding habitat (all habitats) or 2.09% of these habitats in the Yinberrie Hills SOCS.

Clearing at the above levels is considered unlikely to have any significant direct impact on any of the threatened species and populations. The fauna as a whole is similarly unlikely to experience major effects. Any impact would likely be negligible and not amenable to detection at the population level.

Dust

The Gouldian finch population and the fauna as a whole seem to have been unaffected by previous mining and its dust levels. There was no reduction in the frequency of Gouldian finch nesting in hollows close to, as opposed to further from the pit during previous mining (Collins *et al*. 1993; Smith *et al.* 1995). The population remained relatively stable during previous mining. There has been no apparent loss of species or noticeable population decline attributable the previous mining activity.

There has been no report of damage to vegetation arising from dust during mining. The sclerophyllous nature of the more dominant plant species and the long vertically hanging petioles of the dominant eucalypts and *Corymbia* tend to minimise dust accumulation in the Dry Season, minimising potential impacts. The open leaf structure of eucalypt woodlands would aid in minimising impacts on the plants.

Levels of dust deposition would need to exceed $7g/m^2$ for impact on plants to be expected (Farmer 1993). The area covered by this contour is restricted to the near vicinity of the mine with possible impact on a relative small area of Gouldian finch breeding habitat (Appendix N and Appendix M).

The New South Wales Department of Environment and Conservation (DEC) (DEC 2005) sets a dust criterion for human exposure of $50\mu g/m^3$ for total suspended particulates (TSP). There is no applicable criterion for fauna. It would be anticipated that small birds like the Gouldian finch would require a lower dust criterion (Newman and Schreiber 1988) i.e. they have higher rates of inhalation per unit body mass

than do humans (approximately 13 times). Effects on individuals are critically influenced by inhalation rates.

Levels of predicted ground-level dust concentration greater than 50µgm^{-3} are predicted to encompass all of the Mineral Leases, extending well to the south and well outside the Mineral Leases to the west and northwest. Dust is expected to cover 7,162ha of Gouldian finch breeding habitat in the Yinberrie Hills, or a minimum of 10.0% of the breeding habitat in the Yinberrie Hills SOCS (the area of breeding habitat affected will actually be greater than 10.0% as this is only representative of the breeding habitat present within the 1:50,000 vegetation mapping extent. Additional Gouldian finch breeding habitat exists outside of this mapping extent but still within the Yinberrie Hills).

The air quality assessment also found that the Gouldian finch habitat in the Yinberrie Hills (to the west of the Batman Pit) has the potential to be exposed to predicted maximum 24-hour ground level concentrations of PM_{10} of greater than 200µg/m³, including background of 20.8µg/m³ (Appendix T).

Noise

Noise predictions for the original EIS predicted that the 50dB(A) contour would pass slightly to the west of the Batman Pit and through the developed mine areas to the north, south and east (NSR Environmental Consultants1992). Overpressure from blasting was estimated to meet the compliance limit of 115dB$_{linear}$ at 1,200m. Vibration was expected to be 5mm/s at 221m.

Levels of mining activity and anticipated noise levels are similar to those described in the original EIS for the Mt Todd Gold Mine (Appendix U). The 50dB(A) contour will pass near the western edge of the proposed pit and the blast overpressure dissipates to 115dB$_{linear}$ within 420m. Vibration is expected to be approximately 5mm/s at 221m.

Bird response to intense noise levels varies greatly. Approximately 60% of 43 species studied exhibited population declines adjacent to roads, with the declines directly related to level of traffic (Kaseloo 2005). Kaseloo (2005) and FHA (2004) reported that susceptible species exhibited declining populations in areas with greater than 50dB(A). Declines varied between years with interaction with, and between, habitat quality and population density playing significant roles in determining the nature of any decline.

Many bird species remain unaffected by, or maintain high population densities in areas with high noise levels e.g. near roads, mines, military testing / training grounds and airports (FHA 2004; Kaseloo 2005).

There was no reduction in the frequency of Gouldian finch nesting in hollows close to, as opposed to further from the pit during previous mining (Collins *et al*. 1993; Smith *et al.* 1995). The population as a whole remained relatively stable during the previous mining.

The fauna as a whole and the threatened species and populations are unlikely to suffer significant impacts from noise generated by mining activities. Any impact would likely be negligible, and not amenable to detection at the population level.

Wildfire

There are no available analyses of which habitats in the study area or Yinberrie Hills as a whole experience and / or have experienced impacts from fire. Early Dry Season control fires have been used to manage fire in the area of the mine since the initiation of mining at Mt Todd. This continues today and is planned to continue during the proposed mining.

The existing fire regime has had no observable impact on the population of Gouldian finch in recent times. Possible declines in populations of Mertens' water monitor, Mitchell's water monitor and the yellow-spotted monitor cannot be attributed to fire impacts. The Australian bustard may benefit from fire

opening up the understory of woodland in the Mt Todd area. There are no data that can be used to determine whether the local, unchanged rarity of the crested shrike-tit and partridge pigeon is related to the long standing fire regimen.

There are no data that can be used to determine whether the local, unchanged rarity of the crested shrike-tit, painted honeyeater and partridge pigeon is related to the long standing fire regime, although it is acknowledged that partridge pigeon requires a patchy mosaic of burnt and unburnt vegetation (Fraser *et al*. 2003; SEWPaC 2010).

The pale field-rat is thought to have declined over the past 10 years in the Top End due to a combination of ongoing inappropriate fire regimes (too frequent) affecting habitat suitability and predation by feral cats (DLRM 2013). It is possible that the existing fire regime is not advantageous to this species (six individuals captured over the entire survey), however, the proposed operation of the Mt Todd mine is unlikely to alter the current regime. With some planning, the existence of personnel and machinery in the area may lead to a reduction in the frequency of burning due to safety concerns, which may be beneficial to this species.

The fauna and the threatened species and populations are unlikely to suffer significant impacts from wildfire associated with the proposed mine. Any impact would likely be negligible, and not amenable to detection at the population level.

Exotic Animals

The study area has relatively minor feral animal problems other than the potential for significant impacts from pigs in lowland and riparian areas. The proposed mining activity is unlikely to result in enhanced feral animal populations or increases in the number of feral animal species.

Virtually all the species of feral animal are present in, or have ready access to, the mine site without intervention from the proposed mining. Exotic animal incursions e.g. black rats will be exterminated.

An exotic disease harmful to the fauna would most likely be brought to the site via introduction of a new species of exotic animal to Australia, or via transmission of a new disease by mosquito or arthropod vector. This mining proposal has no intention or capability of introducing either a new exotic animal or exotic disease. Mosquitos will be subject to ongoing management throughout the life of the mine.

With the proposed mitigation (section 14.6) the fauna and the threatened species and populations are unlikely to suffer significant impact from additional or existing exotic animals. Any impact would likely be negligible, and not amenable to detection at the population level.

Poisoning from Drinking Tailings Dam Water

Bird mortalities from drinking tailings water may become significant once the concentration of WAD cyanide is over 100mg/L. WAD cyanide disassociates in the acidic stomach environment when ingested by vertebrates, resulting in release of free cyanide and causing potential poisoning. Mortalities are usually non-existent when concentrations of WAD cyanide are less than 50mg/L (NICNAS 2010). This level of WAD cyanide is in keeping with the international guideline on the release of cyanide containing tailings water (ICMI 2006).

Vista Gold will treat the majority of WAD cyanide in tailings water prior to release. This will be undertaken using the air-sulfur dioxide process. Trial treatments have yielded WAD cyanide concentrations of 39.8mg/L (Tetra Tech 2013).

Concentration of some metals e.g. arsenic, copper and lead in trial tailings dam water are higher than the ANZECC & ARMCANZ (2000) levels recommended for release into the environment (Tetra Tech 2013). The Guidelines are conservative, and together with the Gouldian finch being less likely to drink at the tailings dam than at smaller available sources, it seems unlikely that metal poisoning will be an issue.

Tailings dam operation during previous mining, and recent retention of large volumes of metal (especially copper) containing water in the Batman Pit and other water bodies has not resulted in a decline in the Gouldian finch population.

The vast majority of the birds described by Donato (1998) as experiencing mortality from tailings dam water were not passerines. There are anecdotal reports of granivorous bird species drinking from tailings dams and suffering mortalities (Donato 1998). The general absence of passerines and granivors from mortality lists is likely to be due to them not coming into contact with tailings water. For example, Gouldian finches typically drink from small water bodies (Dostine *et al.* 2001). The tailing dam is a large expanse and not typical Gouldian finch drinking habitat.

Previous release and storage of tailings water does not seem to be associated with a significant decline of fauna in the area, including decline of threatened species.

The fauna and the threatened species and populations are unlikely to suffer significant impacts from consumption of tailings water. Any impact would likely be negligible, and not amenable to detection at the population level.

Lowering or Contamination of the Water Table

The impermeable nature of the hornfels in the western portion of the mine sites, and the hornfels basement rock to the south and east are expected to cause a localised drawdown of the water table (Appendix K). The basement rock to the east is overlain by the less metamorphosed Burrell Creek Formation and is more permeable. This is likely to result in a reversal in groundwater towards the pit. Groundwater in the vicinity of water storages (to the east and south of the pit) at the mine site are causing water mounding and contamination of groundwater with metals (Appendix K). Areas to the immediate north and west of the mine (hornfels) are unlikely to suffer significant lowering of the water table or contamination (Appendix K). Mounding and contamination are proposed for rehabilitation during the course of the mine life.

Areas of Gouldian finch breeding habitat are in areas of hornfels to the west of the pit. These are likely to be largely unaffected by draw down from mine operation. Areas to the east and south of the mine are largely cleared and this will expand during mine development. These areas may provide some Wet Season food sources although these are not as abundant as reported areas in the western side of, or outside, the Mineral Leases (Appendix N).

Impacts on the Gouldian finch from groundwater drawdown and possible groundwater contamination are expected to be unlikely and of very limited extent should it occur. Impacts on populations of other species are likely to be reflected in the size of the areas of lowland habitat cleared rather than groundwater changes (i.e. low likelihood of impacts).

The fauna and threatened species and populations are unlikely to suffer significant impacts from groundwater changes. Any impact would likely be negligible, and not amenable to detection at the population level.

Artificial Light

Artificial light is known to cause numerous forms of negative impacts on a wide range of fauna species. These include disorientation of marine turtles, bats and migrating birds, attraction and disorientation of amphibians, attraction and enhanced mortality of insects, and alteration of bird calling behaviour, breeding behaviour of amphibians, small mammal activity rhythms and daily migratory patterns of fish.

The study of the effects of artificial light on fauna is in its infancy and viewed as a new focus for research in ecology, and a pressing conservation challenge (Longcore and Rich 2004). Other than relatively superficial observations (e.g. cane toads are attracted to light) there are few if any generalities that can be applied to a fauna, or even a particular species, that has not been well studied.

The proposed 24-hours a day, seven days a week operation of the mine has potential to impact fauna, and specific species of fauna. The level of ignorance as to what the precise impacts may be precludes valid impact assessment. The valid approach under this circumstance is not to assess the potential impacts, but to implement measures to mitigate the types of impacts that have been recorded for other faunas and species of relevance.

14.4.2 Biting Insects

The factor with the greatest potential to cause a rise in the abundance of biting insects and a significant increase in the disease threat is an increase in the abundance of suitable breeding sites for mosquitos. This will inevitably occur if existing sites are not rectified where possible and active steps taken to limit the potential for inadvertent creation of new sites during mine development and operation.

Due to the seasonally high numbers expected at the mine site of *Aedes normanensis*, this species will pose a potential virus risk in the months of January to April. The risk of Ross River virus and Barmah Forest virus transmission will be moderate to high in these months, while this species will also pose a potential risk of Murray Valley encephalitis virus transmission.

14.4.3 Aquatic Fauna

Diversion Channel Impacts

The potential impacts anticipated from the proposed diversion channel on Horseshoe Creek are:

- changes in the overall character of the watercourse;
- fish passage restrictions; and
- loss of habitat.

Horseshoe Creek

A surface water diversion channel is proposed to be constructed to the southwest of TSF2 to divert Horseshoe Creek away from the toe of the embankment to prevent erosion of the facility. This will change the geomorphic and flow characteristics of the waterway.

Rip-rap will be used to line the diversion channel to prevent erosion (Tetra Tech 2012). The channel has been designed to accommodate a peak flow of approximately 182m^3/s comprising 100m^3/s of runoff from a 100 year, 24-hour storm event in the Horseshoe Creek catchment and 82m^3/s of overflow from the existing raw water supply dam.

This results in an average stream velocity of 2.0m/s with an average shear stress of 68.10N/m^2. This is likely to present a barrier to upstream fish movement and scour benthic communities; however given that

this is associated with a 100 year storm event, the low frequency of occurrence is unlikely to result in any significant ecological impact.

Modelling shows that natural channel sections in the mine area already experience high velocity during extreme flood events. Diversions will involve the protection of the channel against existing flow velocities in excess of 2m/s to prevent erosion. Protection is not intended to increase the existing velocity of the channel.

Stow Creek

A surface water diversion along the south-eastern edge of TSF2 will direct Stow Creek away from the TSF2 footprint. The channel will have a width and length of approximately 60 and 850m respectively and a nominal depth of 4.2m. Rip-rap will be used to line the channel. The channel has been designed to accommodate a peak flow of approximately 656m^3/sec from a 100 year, 24-hour storm event in the Stow Creek catchment.

Flow characteristics are controlled by the amount of flow entering a reach, its cross section area, channel bed gradient and roughness. The diversion may change the rate of flow entering the downstream reach for flows in excess of existing bank-full discharge (higher flows will now be contained rather than dissipating over the floodplain). However, this change in flow is likely small given the opportunity for higher flows to break-out of the channel over remaining reaches upstream.

The diversion channel within Stow Creek could have a significant impact on the greater Stow Creek catchment if fish passage is not considered in the design. The diversion reach is located at the bottom end of the catchment and as such there is approximately 20km of river upstream that may be inaccessible to migrating fish if sufficient depth, velocity and resting habitat are not provided in the diversion design for regular flow events. This is even more important considering that the Stow Creek catchment is located largely within Nitmiluk National Park and that restricted fish passage coupled with Dry Season drying events could significantly alter the composition of the aquatic ecosystem within the greater Stow Creek catchment.

The hydraulic modelling that has been undertaken for the diversion channel only addresses the 100 year, 24-hour storm event. There has been no modelling undertaken to investigate ‘normal’ flow periods through the diversion channel. Flow modelling will be completed under a number of higher frequency flow scenarios to determine if the diversion channel provides conditions sufficient to meet guidelines for providing fish passage in fishways, channel and regulators. The cross section area may need to change but this could involve a composite cross section shape leaving the natural cross section of the channel unchanged whilst increasing the channel area at higher flow depths. The roughness of the channel will change, however appropriate materials will be incorporated into the design to achieve the requirements for fish passage and habitat creation.

Loss of Habitat

Construction of the diversion channel will result in a loss of complex, in-stream habitat. Riparian vegetation plays an integral role in creating and maintaining the stability of newly constructed channels and providing habitat. There is always a risk that a large flow event, in excess of the design storm event could occur in the channel before riparian vegetation has become established to the point where it resists large flows. Contingency will need to be considered for maintenance following a large flow event early in the life of the channel.

A revegetation plan will be developed to suit the physical characteristics and requisite environmental values of the waterway. Further analysis during detailed design will determine the necessity, degree and

timing for establishment of vegetation along the channel. Ground cover should be established as a minimum using existing topsoil material containing seed stock.

Large woody debris will be placed or fixed into the diversion channel to provide habitat and channel 'roughness' that will assist with breaking up the flow profile. This would allow fish and other aquatic species to find and navigate low flow paths.

Large woody debris provides important habitat use by a number of aquatic and terrestrial organisms. Uses include shelter from high current velocities, shade, feeding sites, spawning sites, nursery areas for larvae and juvenile fish, territory markers and refuge from predation.

In general, the types of snags that provide habitat for fish also provide habitat for other aquatic and terrestrial organisms. Submerged wood, with a complex surface structure of grooves, splits and hollows, provides space for colonisation by a range of invertebrates, microbes and algae. Some invertebrates feed directly on the wood while others graze the biofilm.

Large woody debris contributes to development of other habitat types by their impact on channel structure. The main types of habitat formed depend on orientation and stream power (Table 14-4). Scour pools formed by large woody debris spanning the channel are particularly important for wildlife, especially in streams that regularly dry out. These pools provide the only habitat available for aquatic species when flow ceases and are a source of recruitment for re-colonisation when normal flow returns.

Table 14-4 Potential Habitat Development as a result of Large Woody Debris Orientation

Orientation to Flow	Habitat Form	
	Upstream	Downstream
Parallel	Scour pool	Bar/island
Angled	Combination pool/bar	Combination pool/bar
Perpendicular – on bed	Depositional zone	Scour pool
Perpendicular – above bed	Scour pool	Scour pool

Acid and Metalliferous Drainage

AMD at the Mt Todd site has the potential to impact the aquatic environment through two main pathways. These are point source and diffuse source. The management of point source inputs typically occurs through engineering design and treatment. A number of these types of controls have been built into the system (Chapter 12).

The control of diffuse sources of AMD (i.e. groundwater seepage) is more difficult to predict and manage. There is a large amount of acid producing rock in the Mineral Leases and the flow of groundwater is towards the Edith River. Diffuse sources of AMD created during mine operation and closure have the greatest potential to impact the aquatic environment, especially during low flow conditions.

Toxicity of AMD is dependent on discharge volume, pH, total acidity and concentrations of dissolved metals. pH is the most critical component: the lower the pH, the more severe the potential effects of AMD on aquatic life. The overall effect of AMD is influenced by the flow (dilution rate), pH, and alkalinity or buffering capacity of the receiving stream. The higher the concentration of bicarbonate and carbonate

ions in the receiving stream increases buffering capacity. This acts to protect aquatic life from the effects of AMD (Kimmel 1983).

AMD with elevated metal concentrations can have a devastating effect on aquatic life. Secondary effects can occur, increasing the toxic effects. These include increased carbon dioxide tensions, oxygen reduction by the oxidation of metals, increased osmotic pressure from high concentrations of mineral salts, and synergistic effects of metal ions (Parsons 1957). Physical effects may occur such as increased turbidity from soil erosion and smothering of the stream substrate with precipitated metal compounds (Parsons 1968; Warner 1971).

Macroinvertebrates and Fish

AMD can reduce diversity and total number, or abundance, of macroinvertebrates and alter community structure by favouring metal tolerant groups of animals, such as the EPT taxa. Impacts on fish can be equally severe.

Moderate levels of AMD pollution eliminate more sensitive species (e.g. mayflies) (Weed and Rutschky 1971). Severely degraded conditions are characterised by dominance of pollution-tolerant organisms such as earthworms (Tubificidae), midge larvae (Chironomidae), cranefly larvae (Tipulidae), caddisfly larvae (Trichoptera), and non-benthic insects like predaceous diving beetles (Dytiscidae) and water boatmen (Corixidae) (Nichols and Bulow 1973; Roback and Richardson 1969; Parsons 1968). Pollution tolerant animals often occur in unpolluted streams, but only dominate in polluted stream sections.

The primary causes of fish death in acidic waters are loss of sodium ions from the blood and loss of oxygen from other tissues (Brown and Sadler 1989). Acidic water increases the permeability of fish gills, adversely affecting gill function. Ionic imbalance in fish may begin at a pH of 5.5 or higher, depending on the tolerance of the species. Severe anoxia will occur below pH 4.2 (Potts and McWilliams 1989). Low pH that is not directly lethal may adversely affect fish growth rates and reproduction (Kimmel 1983).

Trace metals such as zinc, cadmium and copper present in AMD are toxic at extremely low concentrations and may act together to suppress algal growth and affect fish and benthos (Hoehn and Sizemore 1977). The tolerance of some fish to low pH is decreased by the presence of dissolved metals.

14.5 Risks to Fauna

Risk Assessment

The level of risk posed to fauna by each source of impact was assessed using standard semi-qualitative risk assessment procedures. The adopted process is consistent with AS/NZS ISO 31000:2009 ‘Risk Management – Principles and guidelines’ with a matrix form (Table 14-5). The likelihood of a particular consequence to fauna from a source of potential impact was determined (five levels, “Rare” to “Almost Certain”), as was the severity of that consequence (five levels, “Minor” to “Critical”). These together determine the level of risk on a scale of five levels, “Very Low” to “Extreme”. Risk assessments assume standard mitigation of potential impacts has been implemented. Level of likelihood and severity of consequences is defined in Table 14-6 and Table 14-7 respectively.

Table 14-5 Qualitative Risk Analysis Matrix

Likelihood of Consequence	Severity of Consequence				
	Critical (5)	Major (4)	Significant (3)	Moderate (2)	Minor (1)
Almost Certain (5)	Extreme	Extreme	High	High	Medium
Likely (4)	Extreme	High	High	Medium	Medium
Possible (3)	Extreme	High	Medium	Medium	Low
Unlikely (2)	High	Medium	Medium	Low	Very Low
Rare (1)	Medium	Medium	Low	Low	Very Low

Table 14-6 Definition of Likelihood

Level of Likelihood	Definitions
Almost certain	The event is expected to occur in most circumstances (The event is likely to occur once per year).
Likely	The event will probably occur in most circumstances (The event is likely to occur once every 1 – 2 years).
Possible	The event might occur at some time (The event is likely to occur once every 2 – 5 years).
Unlikely	The event could occur at some time (The event is likely to occur once every 5 – 10 years).
Rare	The event may occur only in exceptional circumstances (The event is unlikely to occur in any to year period).

Table 14-7 Definitions of Consequence

Levels of Consequence	Definitions*
Critical	Extensive long term environmental harm and / or harm that is extremely widespread. Impacts unlikely to be reversible within 10 years.
Major	Major or widespread, unplanned environmental impact on or off the site. Significant resources required to respond and rehabilitate.
Significant	Significant, unplanned environmental impact contained within the site or minor impact that is off the site.
Moderate	Moderate, unplanned localised environmental impact (maybe of a temporary nature) or discharge contained on-site or with negligible off-site impact.
Minor	Minor environmental impact. Any impacts are contained on-site and short term in nature. No detrimental effect on the environment.

Terrestrial Fauna

Risks are evaluated for threatened species populations and the entire fauna resident in the Yinberrie Hills area of conservation significance.

Evaluations of the significance of potential impacts on threatened species are based on the Commonwealth's *Significant Impacts Guidelines: Matters of National Environmental Significance* (the guidelines) as applied to critically endangered and endangered species.

In the absence of a generally recognised set of criteria for assessing potential impacts on a local fauna as a whole, potential impacts on the community of fauna in the Yinberrie Hills were assessed according to the guidelines on significance of impacts on natural values of National Heritage places.

An action having a significant consequence for a critically endangered or endangered species is defined as one that will:

- "lead to a long-term decrease in the size of a population;
- reduce the area of occupancy of the species;
- fragment an existing population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of a population;
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;
- introduce disease that may cause the species to decline; or
- interfere with the recovery of the species."

An action having a significant consequence for natural values is defined as one that will:

- "modify or inhibit ecological processes;
- reduce the diversity or modify the composition of plant and animal species;
- fragment or damage habitat important for the conservation of biological diversity;
- cause a long-term reduction in rare, endemic or unique plant or animal populations or species; or
- fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species".

An impact is regarded as significant if the risk analysis indicates that the consequence has a risk rating of "Extreme" or "High". It is customary for additional mitigation / management to be put in place should there be an "Extreme" or "High" risk. The effectiveness of proposed additional management is determined by repeating the analysis, and determining the level of residual risk i.e. risk after additional management has been applied.

Assessments of the cumulative risks of all sources of impact on each threatened species and the entire fauna are provided. In no case is it thought that the sources of impact are additive or synergistic. In some cases a "Very Low" level of risk stemming from one source of impact is rendered irrelevant by its spatial overlap with a higher risk posed by a different source of impact.

Complete documentation of the risk assessment and the multiple results can be found in Appendix N.

Gouldian Finch

The maximum risk to the Yinberrie Hills population of the Gouldian finch is "High" (Table 14-8). A risk of "High" was assessed for the potential for dust to cause population decline and interfere with the recovery of the species. The predicted level of ground level dust is high and based on a conservative scenario of possibly a higher generation of dust than may occur. This uncertainty, together with uncertainties about the potential effects of high dust levels on individual finches, the varying effects of various levels of dust concentration, the possible pattern of dust distribution through the breeding habitats, and the limited knowledge of other potential breeding areas in the Yinberrie Hills indicate that a precautionary approach be taken. This is described is section 14.6.

Table 14-8 Cumulative Risks to the Gouldian Finch Population of the Yinberrie Hills

Consequence according to the Significant Impact Guidelines	Severity of consequence	Likelihood of consequence	Risk
Long-term decrease in the size of a population	Major	Possible	High
Reduce the area of occupancy of the species	Major	Possible	High
Adversely affect habitat critical to the survival of a species	Major	Possible	High
Fragment an existing population into two or more populations	Minor	Unlikely	Very Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Moderate	Possible	Medium
Result in invasive species that are harmful to the Gouldian finch	Moderate	Unlikely	Low
Introduce disease that may cause the species to decline	Minor	Rare	Very Low
Interfere with the recovery of the species	Major	Possible	High

Crested Shrike-tit (Northern)

All but two of the risk levels to the crested shrike-tit are "Very Low" (Table 14-9). The two instances of "Low" are attributed to the potential impacts of wildfire on the habitat and the possible introduction of *Rattus rattus* to the area. This possibly reflects the existing situation where fire may favour food resources for the Gouldian finch (e.g. native sorghum and Wet Season seeding grasses), and impact on the crested shrike-tit's habitat. The shrike-tit is rarely recorded from the area and seems unlikely to be significantly impacted by the proposed mine.

Table 14-9 Cumulative Risks to the Crested Shrike-tit Population of the Yinberrie Hills

Consequence according to the Significant Impact Guidelines	Severity of consequence	Likelihood of consequence	Risk
Long-term decrease in the size of a population	Minor	Unlikely	Very Low
Reduce the area of occupancy of the species	Minor	Rare	Very Low
Adversely affect habitat critical to the survival of a species	Minor	Unlikely	Very Low
Fragment an existing population into two or more populations	Minor	Rare	Very Low

Consequence according to the Significant Impact Guidelines	Severity of consequence	Likelihood of consequence	Risk
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Minor	Rare	Very Low
Result in invasive species that are harmful to the crested shrike-tit	Moderate	Unlikely	Low
Introduce disease that may cause the species to decline	Minor	Rare	Very Low
Interfere with the recovery of the species	Moderate	Unlikely	Low

Partridge Pigeon

All but two of the risk levels to the partridge pigeon are “Very Low” (Table 14-10). The two instances of “Low” are attributed to the potential impacts of wildfire on the habitat and the possible introduction of black rats (*Rattus rattus)* to the area. This is largely due to this species not having been recorded in the study area i.e. consequences cannot be severe and likelihoods of impacts are low.

Table 14-10 Cumulative Risks to the Partridge Pigeon Population of the Yinberrie Hills

Consequence according to the Significant Impact Guidelines	Severity of consequence	Likelihood of consequence	Risk
Long-term decrease in the size of a population	Minor	Unlikely	Very Low
Reduce the area of occupancy of the species	Minor	Rare	Very Low
Adversely affect habitat critical to the survival of a species	Minor	Unlikely	Very Low
Fragment an existing population into two or more populations	Minor	Rare	Very Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Minor	Rare	Very Low
Result in invasive species that are harmful to the partridge pigeon	Moderate	Unlikely	Low
Introduce disease that may cause the species to decline	Minor	Rare	Very Low
Interfere with the recovery of the species	Moderate	Unlikely	Low

Australian Bustard

All risks to the Yinberrie Hills population of the Australian bustard are uniformly "Very Low" (Table 14-11). This reflects the species' preference for the cleared, mine modified areas of the project site.

Table 14-11 Cumulative Risks to the Australian Bustard Population of the Yinberrie Hills

Consequence	Severity of consequence	Likelihood of consequence	Risk
Long-term decrease in the size of a population	Minor	Rare	Very Low
Reduce the area of occupancy of the species	Minor	Unlikely	Very Low
Adversely affect habitat critical to the survival of a species	Minor	Unlikely	Very Low
Fragment an existing population into two or more populations	Minor	Rare	Very Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Minor	Rare	Very Low
Result in invasive species that are harmful to the Australian bustard	Minor	Unlikely	Very Low
Introduce disease that may cause the species to decline	Minor	Rare	Very Low

Painted Honeyeater

All risks to the Yinberrie Hills population of the painted honeyeater are uniformly "Very Low" (Table 14-12). This reflects the species' widespread distribution and lack of reliance on the Yinberrie Hills for suitable habitat.

Table 14-12 Cumulative Risks to the Painted Honeyeater Population of the Yinberrie Hills

Consequence	Severity of consequence	Likelihood of consequence	Risk
Long-term decrease in the size of a population	Minor	Unlikely	Very Low
Reduce the area of occupancy of the species	Minor	Unlikely	Very Low
Adversely affect habitat critical to the survival of a species	Minor	Unlikely	Very Low
Fragment an existing population into two or more populations	Minor	Rare	Very Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Minor	Rare	Very Low
Result in invasive species that are harmful to the painted honeyeater	Minor	Unlikely	Very Low
Introduce disease that may cause the species to decline	Minor	Rare	Very Low

Pale Field-rat

All risks to the Yinberrie Hills population of the pale field-rat are uniformly "Very Low" (Table 14-13). The primary impacts to this species appear to be a combination of inappropriate fire regimes and predation by feral cats. The re-opening of the mine is unlikely to exacerbate these impacts.

Table 14-13 Cumulative Risks to the Pale Field-rat Population of the Yinberrie Hills

Consequence	Severity of consequence	Likelihood of consequence	Risk
Long-term decrease in the size of a population	Minor	Rare	Very Low
Reduce the area of occupancy of the species	Minor	Unlikely	Very Low
Adversely affect habitat critical to the survival of a species	Minor	Unlikely	Very Low
Fragment an existing population into two or more populations	Minor	Rare	Very Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Minor	Rare	Very Low
Result in invasive species that are harmful to the pale field-rat	Minor	Unlikely	Very Low
Introduce disease that may cause the species to decline	Minor	Rare	Very Low

Mertens' Water Monitor, Mitchell's Water Monitor and Yellow-spotted Monitor

The three monitor species populations are likely to be subject to "Very Low" levels of risk from the mine (Table 14-14).

Table 14-14 Cumulative Risks to the Mertens' Water Monitor, Mitchell's Water Monitor and Yellow-spotted Monitor Populations of the Yinberrie Hills

Consequence	Severity of consequence	Likelihood of consequence	Risk
Long-term decrease in the size of a population	Minor	Rare	Very Low
Reduce the area of occupancy of the species	Minor	Rare	Very Low
Adversely affect habitat critical to the survival of a species	Minor	Rare	Very Low
Fragment an existing population into two or more populations	Minor	Rare	Very Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Minor	Rare	Very Low
Result in invasive species that are harmful to the species	Minor	Unlikely	Very Low
Introduce disease that may cause the species to decline	Minor	Rare	Very Low

The Yinberrie Hills Terrestrial Fauna

The risk levels associated with the mine's re-development have two consequences with "High" risk values (Table 14-15). The "High" risks are associated with the potential impacts of dust on the Gouldian finch, and possibly other fauna.

Table 14-15 Cumulative Risks to the Fauna of the Yinberrie Hills

Source of risk	Severity of consequence	Likelihood of consequence	Risk
Modify or inhibit ecological processes in a National Heritage place	Significant	Possible	Medium
Reduce the diversity or modify the composition of plant and animal species in a National Heritage place	Major	Possible	High
Fragment or damage habitat important for the conservation of biological diversity in a National Heritage place	Minor	Rare	Very Low
Cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a National Heritage place	Major	Possible	High
Fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a National Heritage place	Minor	Rare	Very Low

Biting Insects

The source of impact evaluated was the provision of breeding sites for mosquitoes. The consequences examined are:

- a long-term increase in the nuisance levels caused by mosquitoes; and
- a long-term increase in transmission of virus by mosquitoes.

The population of humans at risk is assumed to be that working / living on the Mineral Leases. Risk was assessed to be “Medium” (Table 14-16).

Table 14-16 Risks of Mosquito Nuisance and Disease Transmission on the Mineral Leases

Consequence	Severity of consequence	Likelihood of consequence	Risk
Long-term increase in nuisance levels of mosquitoes	Moderate	Possible	Medium
Long-term increase in transmission of disease by mosquitoes	Moderate	Possible	Medium

Aquatic Fauna

The aquatic fauna is a component of the fauna of the Yinberrie Hills area of conservation significance. Like terrestrial fauna, these are assessed according to the guidelines on significance of impacts on natural values of National Heritage places. Potential sources of impact are hazardous substances including AMD and sediment entering the streams in and adjacent to the Mineral Leases. Aquatic macroinvertebrate and fish fauna have not been impacted by previous mining and sources of potentially damaging contaminants are subject to effective control (Chapter 10). The level of risk has been assessed as low (Table 14-17).

Table 14-17 Risks to the Aquatic Fauna of the Yinberrie Hills

Source of risk	Severity of consequence	Likelihood of consequence	Risk
Modify or inhibit ecological processes in a National Heritage place	Moderate	Possible	Medium
Reduce the diversity or modify the composition of plant and animal species in a National Heritage place	Major	Possible	High
Fragment or damage habitat important for the conservation of biological diversity in a National Heritage place	Minor	Rare	Very Low
Cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a National Heritage place	Major	Possible	High
Fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a National Heritage place	Minor	Rare	Very Low

14.6 Management Measures and Proposed Monitoring

The Draft EIS Guidelines for the Project call for the establishment of "mechanisms to determine the long term impact of environmental impacts associated with key environmental issues (monitoring and reporting)".

14.6.1 Terrestrial Vertebrates

Mitigation

Land Clearing

Areas of land to be cleared will be clearly marked to ensure no intrusion into lands intended to remain intact. Activities will be monitored to ensure compliance with areas marked for clearing and no intrusion of any kind will be made on areas outside the clearing zone.

The Gouldian finch habitat, *E. tintinnans* woodlands adjacent to the pit, will only be cleared during the non-breeding season i.e. the Wet Season.

Dust

Standard dust mitigation will include:

- chemical treatment of roads to reduce dust generation;
- use of water sprays;
- wetting of ore prior to crushing;
- use of hooded crushers; and
- use of enclosed HPGR.

Additional mitigation measures will be implemented should dust levels prove excessive.

Noise

Standard mitigation will be applied to minimise noise levels (Appendix U and Chapter 17).

Wildfire

The existing system of early Dry Season controlled burns will be maintained. Subsequent fires late in the Dry Season (following early Dry Season burns) should be avoided as should multiple instances of fires in the same habitats within the same calendar year (i.e. only one burn per year should occur in Mt Todd area during the early Dry Season). Additionally, the introduction of a 'patchy' mosaic approach to burning will be investigated whereby patches of habitat could be left unburnt for subsequent years and not burnt at all. This approach may be beneficial for a range of species including partridge pigeon, pale field-rat and Gouldian finch.

Invading Foreign Organisms

Standard mitigation using sound waste management will limit the potential for colonisation by black rats (*Rattus rattus).*

Incursion by additional exotic species will be regularly monitored, and any incursions eradicated.

Artificial Light

The impacts of artificial light will be mitigated by:

- limiting artificial light to areas actively required at any given time, and turning off lights not required;
- insuring that artificial lighting does not point upwards or laterally, i.e. should point towards the ground;
- use of lower rather than higher lighting installations;
- avoiding the flood of light into natural habitats;
- use of lower wavelengths of light wherever possible i.e. red / yellow lights;
- use of light intensities that are as low as possible without reducing safety or efficiency; and
- avoiding painting large structures bright colours.

Monitoring

Monitoring will focus on dealing with uncertainties surrounding the highest recorded risk to the Yinberrie Hills fauna. There is the potential impact of dust on the Yinberrie Hills Gouldian finch population. This is also the highest risk to the fauna as a whole. The uncertainties are:

- the levels of near ground dust concentration and dust deposition in the breeding habitat adjacent to the Mt Todd mine before and during mine operation;
- the effects of dust levels on the intensity of Gouldian finch nesting and nesting success;
- the future population levels of the Gouldian finch in the Yinberrie Hills;
- the status of other potential breeding areas in the Yinberrie Hills and the Mt Todd to Pine Creek region; and
- fire management in the whole of the Yinberrie Hills.

Dust

Dust monitoring is will be undertaken (Appendix T and Chapter 16). Monitoring of potential dust impacts on fauna will be an expansion of that program. It will require a carefully constructed and appropriate statistical design to allow assessment of the effects of distance from the mine and habitat features on dust levels.

Nesting Intensity and Success

The only practical way of conducting monitoring is the establishment of large numbers of artificial nest boxes throughout the area potentially subject to levels of dust >50µg/m^3. It is critical that the plan of establishment be soundly statistically designed prior to establishment. This should be done in conjunction with the design of the dust monitoring and allow analysis of the effects of habitat, dust levels and distance from the mine on nesting frequency and success. Nest boxes would simplify the task of assessing frequency of nesting and nesting success. The feasibility of using artificial nest boxes needs to be investigated prior to commitment to the monitoring. The nest boxes should be established prior to the 2013 breeding season. Field work could be coordinated with volunteer groups and the Jawoyn Rangers.

Monitoring Gouldian Finch Populations

The long term population monitoring conducted by DLRM (formerly NRETAS) is a critical baseline database. It should be continued, possibly with assistance from the mine. This program is based on counting Gouldian finches around waterholes late in the Dry Season. It should be expanded and used as a tool for determining presence and size of populations adjacent to large areas of suitable breeding habitat in the Yinberrie Hills and / or Mt Todd to Pine Creek region, and so reduce uncertainty about other breeding areas. This should be preceded by a critical desktop examination of the attributes of these other possible breeding areas in comparison with the known area adjacent to the mine. This may allow subsequent field work to focus on areas most likely to support breeding Gouldian finches.

14.6.2 Biting Insects

Mitigation

A potential for increases in nuisance levels and disease transmission by mosquitos will be mitigated by:

- rectification of artificially created mosquito breeding sites including:
  - ground depressions around the mine site and alongside tracks;
  - shallow borrow pits;
  - disused septic tanks; and
  - the small plastic lined pond (Site L11) should be cleared of silt and vegetation. Access tracks crossing floodways, such as at Site L5, should have appropriate culvert or floodway provisions to minimise upstream flooding.
- improving drainage of grassy floodways and poorly draining areas associated with the creeklines around the mine site, or burning dead vegetation in the floodways before the start of the Wet Season to remove mosquito harbourage and nutrient loads;
- prevent potential mosquito breeding in artificial receptacles such as used tyres, drums, rubbish items, rainwater tanks and other items that can pond water by storing them under cover, burying or removing rubbish items, or in the case of used tyres, providing them with drainage holes or filling the tyres with soil;
- ensuring rainwater tanks are appropriately screened at the inlet and outlet;
- ensuring construction avoids establishment of areas of temporary water;
- treating artificial ponding with an undiluted bleach solution or a residual larvacide if breeding is detected ;
- ensuring personnel wear long sleeved shirts, long trousers and mosquito repellent;

- monthly inspections being carried out during the Wet Season, to identify areas of potential mosquito breeding associated with constructed or disturbed areas;
- the “Guidelines for preventing mosquito breeding sites associated with mining sites” (Medical Entomology Centre for Disease Control 2005) being followed; and
- developing a biting insect management plan, which summarises the potential mosquito risks, and outlines mitigation measures and commitments to managing and reducing mosquito populations.

14.6.3 Aquatic Fauna

Mitigation

Discharge of Acid Mine Drainage and Sediment

Mitigation of the potential for release of these is discussed in Chapter 10 and the Aquatic Fauna Study (Appendix O) in detail. Mitigation measures to prevent AMD entering waterways include:

- proactive management of water levels to ensure adequate storage capacity;
- increasing the rate of treatment and discharge if uncontrolled release is likely;
- ongoing monitoring and evaluation of water quality and macroinvertebrate and fish community structures;
- targeting sampling of refugia pools during the Dry Season to investigate to potential of groundwater seepage impacting the aquatic fauna;
- effective implementation of site water management plan; and
- compliance with the WDL.

Horseshoe Creek and Stow Creek Diversion Channel Design

The channels have been designed to (Appendix O):

- operate as part of a self-sustaining stream system promoting nutrient processing, ecological connectivity and sediment storage and transport;
- avoid the use of artificial grade control structures or other structures that likely to require maintenance beyond life of mine;
- include natural, locally and regionally occurring geomorphic and habitat features; and
- establish a state of dynamic equilibrium (equal rates of sediment erosion and deposition) with adjoining sections of the creek.

Construction of Diversion Channel

Measures to mitigate potential impacts on aquatic fauna are outlined in Table 14-18 to Table 14-23.

Table 14-18 Measures to Minimise Impact of Channel Construction

Specific Requirement	Responsibility
Implement spill and sediment control measures (such as silt curtains within the river channel) to minimise the potential for sediments to deposit on downstream foraging areas	Contractor
Stabilise banks, including appropriate native plantings, to consolidate banks post-construction and restore habitat to current, or improved, condition	Contractor
Post-construction monitoring to assess creek bank remediation measures	Contractor
Develop contingency measures to prevent flooding of the worksite by a rapid rise in the creek	Contractor

Table 14-19 Measures to be Implemented Regarding Site Management

Specific Requirement	Responsibility
A site induction program will be developed and provided to all construction site workers. This program will include the aspects of the following sections that all staff must be made aware of	Contractor
A clearly definable site boundary will be delineated (where practicable), with construction and vegetation clearance not occurring outside of this area	Contractor
Define site entry and exit points. All traffic accessing the site is to use these points	Contractor

Table 14-20 Measures to be Implemented Regarding Timing of Works

Specific Requirement	Responsibility
Works will be scheduled so that construction coincides with periods of low flow and low rainfall	Proponent
If heavy rain is falling, forecasted to fall or has recently fallen during the previous 24-hour, construction works will be postponed until water levels have returned to 'normal'	Foreman

Table 14-21 Measures to be Implemented Regarding Erosion Prevention and Management

Specific Requirement	Responsibility
Prior to Commencement of Construction	
Identify existing and proposed site drainage patterns	Contractor
Locate sediment ponds to prevent debris escaping into the natural drainage system	Contractor
During Construction	
Monitor the effectiveness of erosion mitigation measures during construction	Contractor
Avoid the stockpiling of soil along existing and proposed drainage lines	Foreman
Cover stockpiles with weighted plastic or tarpaulins, when not being actively used, to minimise the mobilisation of soil during storm events (heavy rain and / or strong wind)	Foreman
Keep vehicles to well-defined tracks and roads	Foreman
Divert storm water away from disturbed areas to minimise soil loss	Foreman

Specific Requirement	Responsibility
Minimise the area of exposed ground to minimise the amount of ground subject to erosion	Foreman
Conduct excavation in stages to minimise ground exposed to erosion	Foreman
Install temporary erosion control measures such as sedimentation fences, diversion drains sediment traps and hardstand covers	Foreman
Post Construction	
Develop and implement a revegetation program	Contractor
Maintain sediment control measures (including cleaning where necessary) until the site is completely stabilised (at least 4 weeks)	Foreman
Waterway Crossing	
Generally all machinery should be kept out of the waterway and operated on dry and stable areas within the works site	Contractor
Existing crossings should be used to move equipment across the waterway. If there is no crossing, machinery should be carefully 'walked' across the waterway	Contractor
If frequent crossings are required, a pad of clean rock will be laid at a shallow point of the waterway to make a temporary crossing	Contractor
Temporary crossings will be entirely removed when works have finished	Contractor
In-stream Works	
When excavating the channel, the flow should be diverted and the works site isolated	Contractor
Any diversion will be constructed using clean non-erodible material	Contractor
Line temporary diversion channels with non-erodible materials to the high water mark	Contractor
Install silt curtains downstream of excavation works	Contractor

Table 14-22 Measures to be Implemented Regarding Contamination

Specific Requirement	Responsibility
All workers will be trained and equipped to contain equipment spills and leaks	Contractor
If a spill occurs, immediate steps will be taken to stop it polluting the water	Contractor
The spill will be reported to the appropriate authorities as soon as possible	Foreman
Petroleum products and other hazardous substances will be kept out of the waterway	Contractor
Petroleum products and other hazardous substances will be kept in a bunded storage facility	Contractor
Refuelling, top-ups and oil checks will be done well away from the waterway	Contractor
Non-toxic hydraulic fluids, such as vegetable-based fluids will be used if possible	Contractor

Specific Requirement	Responsibility
All equipment will be inspected and repaired regularly to prevent oil and other fluids leaking	Contractor
If equipment is to be immersed in the waterway, it will be cleaned beforehand to remove any external grease, oil and other fluids	Contractor
Dirt and mud will be removed from all equipment before entering the works site and waterway to avoid transferring weeds and disease	Contractor
Wash-down water will not be allowed to enter waterways	Contractor
Any cast-in-place concrete will be isolated from the waterway for at least 48-hours to allow pH to neutralise	Contractor
Paints will not be allowed to enter the waterway when constructing, repairing and maintaining in-stream structures	Contractor
If using wood treated with preservatives, the chemicals will be given enough time to fix before immersing the wood in the water	Contractor

Table 14-23 Measures to be Implemented for Site Rehabilitation

Specific Requirement	Responsibility
The site will be rehabilitated when the works have finished. If practical, native vegetation will be established on all exposed soil surfaces, including the head-slopes of bridges and culverts	Contractor
Temporary control measures, such as geo-textile silt fences, diversion ditches, sediment traps and temporary seeding with fast growing annuals, will be used to control erosion	Contractor
Temporary controls will remain in place until long-term erosion control methods are established	Contractor
Long-term measures will be used to control erosion at the works site. Suitable measures include slope stabilisation, revegetation, soil coverings, rip-rap and armouring, check dams, sediment traps, brush barriers and vegetation filters	Contractor
The measures used will be inspected and regularly maintained to make sure they are effective	Foreman

Revegetation

A revegetation plan will be developed during the detailed design phase of the Stow Creek and Horseshow Creek diversions to suit the physical characteristics and requisite environmental values of the waterways. Further analysis and risk assessment during detailed design will determine the necessity, degree and timing for establishment of vegetation along the diversion. Ground cover will be established as a minimum through using existing topsoil material that may contain seed stock. It is recognised that limited quantities of quality topsoil is available on site.

Revegetation will include:

- large woody debris placed or fixed into the diversion channel to provide habitat and channel 'roughness' for fish and other aquatic species to find a low flow path to navigate; and
- placement of wood debris to secondarily provide habitat for a range of aquatic species e.g. scour pools formed by large woody debris spanning the channel.

Monitoring program

Section M4.1 of the WDL 178-1 requires a macroinvertebrate monitoring plan for future assessment of surface water mine impacts on the biological communities of the Edith River. The mine site's 2010 / 2011 Water Management Plan highlights the principal potential contaminants to Mt Todd surface waters as nitrate, sulfate, phosphorus, aluminium, cadmium, copper and zinc.

The monitoring plan takes into account the location of potential sources of impact, the large inputs of rain during the Wet Season and the necessary level of statistical power to detect change in macroinvertebrate communities. Site selection is discussed in the aquatic fauna report (Appendix O).

Several improvements to the integrity of some of the mine's water storage and retention facilities have been achieved. The main risk of future uncontrolled mine water inputs is a large rainfall event leading to overflow from several facilities into surrounding waterways and eventually discharging to Edith River. Controlled discharge currently occurs from the waste rock retention pond (RP1) during periods of heavy rainfall in the Wet Season and during the Dry Season to create capacity for the upcoming Wet Season.

Methods from previous surveys, including the multivariate analysis technique, will be retained with the addition of several macroinvertebrate data analysis tools (SIGNAL, AUSRIVAS, ANOVA). Additional sites will increase the statistical power of the analyses.

In light of the findings from the current assessment, sampling will focus on targeting refugia pools during the Dry Season to investigate the potential for groundwater seepage to impact aquatic fauna. To date there has been no Dry Season investigation undertaken at this site. Sites will be located upstream and downstream of known discharge locations.

Water quality will continue to be monitored at the time of sampling to provide data for interpretation of macroinvertebrate results (Chapter 10).