McArthur River Mine

Overburden Management Project

9

Biodiversity

Draft Environmental Impact Statement

9 Biodiversity

9.1 Introduction

The Terms of Reference (TOR) (refer **Appendix A – Final Terms of Reference**) for the preparation of this environmental impact statement (EIS) requires an assessment of risks to biodiversity from the Overburden Management Project (the Project). The purpose of this chapter is to fulfil the TOR relating to the assessment of impacts on biodiversity. Specifically, this chapter fulfils the following requirements as they appear in the TOR:

- Details of listed threatened species likely to be present in the Project area and in areas that may be impacted by the proposal, including detail of the scope, timing and methodology of studies or surveys used to provide information on the listed threatened species and their habitat potentially impacted by Project activities.
- The results of surveys for species listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Territory Parks and Wildlife Conservation Act* (TPWC Act) in the area of the proposed action and potentially impacted areas.
- Details of the area and location/s of any proposed land disturbance required for the Project within the context of habitat for listed species that may be impacted.

Some of the biodiversity values potentially affected by the Project are matters of national environmental significance (MNES), protected under the EPBC Act. These are discussed in detail within **Chapter 10 – Matters of National Environmental Significance**. For the purpose of completeness, assessment of MNES is included in this chapter, but is afforded only cursory treatment in light of the detail provided elsewhere. The present chapter prioritises the description of overall biodiversity values, with special focus on listed species protected under legislative frameworks outside the EPBC Act.

9.1.1 Project Background

The Project represents a variation on a previously approved project, the McArthur River Mine (MRM) Phase 3 Development Project (Phase 3). The redesign was required to adequately accommodate increased volumes of non-benign overburden to be excavated during mining operations following improved and revised overburden characterisation and assessment. The proposed changes constitute the actions that require assessment under this EIS. A comprehensive description of the proposed actions is provided in **Chapter 3 – Project Description and Justification**. The principal actions that may affect biodiversity values are:

- The design, cover and management of the North Overburden Emplacement Facility (NOEF) have been adjusted to account for changes to the characterisation of materials on-site.
- The footprint of the NOEF is reduced by 177 hectares (ha), compared to Phase 3, by increasing its height and employing in-pit dumping during late stages of mining.
- There are additional disturbances associated with the extraction of benign material and clay used for cover and rehabilitation purposes. This will increase the footprint of the NOEF domain by 16.9% (775 ha versus 663 ha proposed for Phase 3).
- The former South and East Overburden Emplacement Facilities (SOEF and EOEF) between the mine levee wall and the McArthur River have been removed, reducing the footprint of the open cut domain by 45% (421 ha versus 765 ha proposed for Phase 3).

- The scale of the Tailings Storage Facility (TSF) will be reduced, but new clay and topsoil borrow areas will be required. Consequently, the disturbance footprint of the TSF domain is 43.6% larger (550 ha versus 383 ha proposed for Phase 3).
- By utilising in-pit dumping during the final stages of mining, there will be earlier rehabilitation and closure of the NOEF.
- Tailings will be reprocessed and deposited within the final void left by the open cut, instead of being capped in situ. This reduces the risks associated with the long-term storage of potentially reactive material.
- The final void will contain a mine pit lake that at closure will be intermittently recharged by the McArthur River. This is achieved by removing the mine levee wall in two locations creating a permanent through flow system, instead of remaining isolated.
- There are changes to water treatment, handling and storage.
- The Project duration has been extended; there will be one extra year of mining and ten additional years of reprocessing tailings.
- The Project has a much-expanded commitment to long-term (100-1,000 years) monitoring and maintenance.

9.1.2 Regulatory Framework

9.1.2.1 Commonwealth Legislation and Policy Requirements

9.1.2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act is the principal piece of Commonwealth legislation that protects biodiversity values of national significance. Significant impacts on MNES require approval under the EPBC Act. A referral and assessment process (referral 2014/7210) determined that the Project was a controlled action, with potential impacts on listed threatened species and communities. The Referral Decision also identified that the Project would be assessed via accredited assessment under the Northern Territory's (NT's) *Environmental Assessment Act*. This means the NT's assessment framework and EIS process will be utilised to assess the Project's impacts on MNES. The NT Government will provide assessment advice to the Department of the Environment and Energy (DEE) for consideration and approval under the EPBC Act.

Significant impacts to MNES are only approved if they can be adequately offset under the *EPBC Act 1999 Environmental Offsets Policy*.

9.1.2.2 Northern Territory Legislation and Policy Requirements

9.1.2.2.1 Mining Management Act

The *Mining Management Act* (MM Act) is administered by the NT Department of Mines and Energy. It is the principal legislation for the regulation of mining proposals in the NT. Under the MM Act, it is an offence for a person to engage in conduct that results in "serious environmental harm". Under this act, "environmental harm" includes harm to organisms and ecosystems, and "serious environmental harm" is defined as harm that:

- is irreversible or otherwise of a high impact or on a wide scale; or
- damages an aspect of the environment that is a high conservation value, high cultural value, or high community value, or is of special significance; or
- results, or is likely to result, in more than $50,000 or the prescribed amount (whichever is greater) being spent in taking appropriate action to prevent or minimise the environmental harm or rehabilitate the environment; or

- results in actual or potential loss or damage to the value of more than $50,000 or the prescribed amount (whichever is greater).

Species and ecological communities that are listed as threatened constitute an aspect of the environment with high conservation value and are therefore protected under the MM Act.

9.1.2.2.2 Environmental Assessment Act

The *Environmental Assessment Act* and the Environmental Assessment Administrative Procedures establish the framework for the assessment of potential or anticipated environmental impacts of development within the NT. Under this act, the Minister determines the appropriate level of assessment for new developments, which dictates the detail required when assessing impacts of the Project on biodiversity matters.

9.1.2.2.3 Territory Parks and Wildlife Conservation Act

The TPWC Act is the principal legislation protecting biodiversity values in the NT. This act provides for the declaration of threatened species, reserves, sanctuaries, wilderness areas and areas of essential habitat. Under the TPWC Act, it is prohibited to take, interfere with, or kill protected wildlife.

9.1.2.2.4 Territory Parks and Wildlife Conservation Regulations

This legislation prescribes the classification of wildlife protected under the TPWC Act.

9.1.2.2.5 Weeds Management Act

Under the *Weeds Management Act*, the Minister can declare a plant to be a declared weed. The classification of declared weeds determines whether the weed must be eradicated, prevented from being grown or spread, or prevented from being introduced into the NT. Owners and occupiers of land must take all reasonable measures to prevent the land being infested with a declared weed and prevent a declared weed on the land spreading to other land.

9.1.2.2.6 Weeds Management Regulations

This legislation prescribes the disciplinary actions to be taken in the event of infringements of the *Weeds Management Act*.

9.1.2.2.7 Animal Welfare Act

The *Animal Welfare Act* provides for the humane treatment of animals, including those caught and handled during biodiversity surveys.

9.1.2.2.8 Fisheries Act

The *Fisheries Act* was created to manage fisheries and fishery resources in a sustainable manner. It is administered by the Department of Primary Industry and Resources (DPIR).

9.1.3 Environmental Objectives

The environmental objectives presented in the TOR, are:

- to maintain the conservation status, diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance and management of adverse impacts; and
- to minimise the risk of significant impacts to EPBC Act listed species and communities during construction, operation and closure of the Project.

This is directly related to closure objectives for successful rehabilitation being:

- metal levels in fauna comparable to background levels; and
- appropriate habitat for fauna utilisation.

To address these objectives, this chapter will:

- describe the methodology used to survey biodiversity values of the Project area;
- identify the biodiversity values of the Project area and in areas that may be impacted by the Project;
- assess the potential impacts to biodiversity values resulting from the Project;
- describe the management measures that will be implemented to mitigate impacts to biodiversity matters; and
- propose a survey program to monitor the effectiveness of mitigation measures proposed.

9.2 Survey Methodology

9.2.1 Terrestrial Flora

The terrestrial flora of the Project area is well characterised, based on numerous general and targeted ecological surveys spanning multiple decades. The following surveys have studied the flora of the Project area:

1. Early land system surveys undertaken by the CSIRO (Scott and Speight 1966) provided a generalised overview of the plant communities of the region, listing dominant species.
2. In 1976, an extensive set of plant specimens was collected by B.L. Rice and L.A. Craven across the MRM area, and these specimens are held at the NT Herbarium and the Australian National Herbarium.
3. Surveys undertaken in the late 1980s by the Conservation Commission of the Northern Territory (Wilson *et al.* 1990; Wood *et al.* 1981) mapped and described the plant communities present at scales ranging from 1:1,000,000 to 1:85,000. These were used to produce the vegetation map of the NT, and provide a coarse description of the vegetation present on-site.
4. Duff and Orr (1992) re-classified the vegetation communities present within the original MRM project area based on 31 sites sampled using standard NT Government methodology (full floristics and cover data measured within 20 metres (m) by 20 m quadrats).
5. Nine flora transects were assessed by Hollingsworth Dames and Moore (1992) as part of the original MRM project. These were used to generate profile diagrams of vegetation structure and composition. An additional 14 quadrats (10 m by 10 m) were surveyed.
6. Permanent 10 m by 10 m vegetation monitoring plots in riparian vegetation along the McArthur River and Barney Creek have been monitored regularly since 1992 (ERA 1994, 1995; URS 2003; Bellairs 2009).
7. In February and April 2003, extensive terrestrial flora surveys were undertaken for the MRM Open Cut Project (URS 2005). These involved the collection of detailed information about vegetation communities growing at 54 study locations sampled using standard 20 m by 20 m quadrats, as well as eleven 50 m transects.
8. Cuff *et al.* (2009) produced a vegetation map for the entire McArthur River catchment at the scale of 1:100,000. This was based on 799 sites sampled between 1981 and 2008, combined with remote sensing imagery.

9. In May 2011, the flora in 16 standard full characterisation sites was assessed as part of the MRM Phase 3 EIS (EcoScience NT 2012). These survey sites were located within the footprint of Phase 3, which overlap extensively with the footprint of the current Project. These surveys were used to produce a detailed vegetation map at the scale of 1:40,000.
10. In July-August 2012, vegetation communities west of the TSF were surveyed at 51 check sites (using a basal sweep to assess dominant species) and two full characterisation sites (20 m by 20 m quadrats) (MET Serve 2012).
11. Between December 2015 and September 2016, 345 flora check sites were surveyed across the mineral leases (**Appendix X – Terrestrial Ecology Report**). Check sites were based on methodology described by Brocklehurst *et al. (*2007), and involved a basal sweep to infer species dominance and an estimate of cover and height for dominant species. This survey was designed to check whether the previous vegetation mapping was current. The data was used to produce a current vegetation map of the mineral leases.

The *Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping* (Brocklehurst *et al.* 2007) specify that one site per square kilometre is required to adequately sample vegetation in order to produce a vegetation map at a scale of 1:50,000 (the approximate scale of the MRM). Many of the older studies listed above don't provide precise details about the number of survey sites sampled within the mineral leases. However, when only those surveys that adopted methodology specified in the NT guidelines are considered, the total of 103 full characterisation sites and 395 check sites far surpasses the 117 survey sites recommended by the guidelines for an area the size of the MRM mineral leases. The intensity of survey effort undertaken to date is therefore considered adequate for assessing potential impacts to flora of the Project. The locations of flora surveys undertaken at the MRM are shown on **Figure 9-1**.

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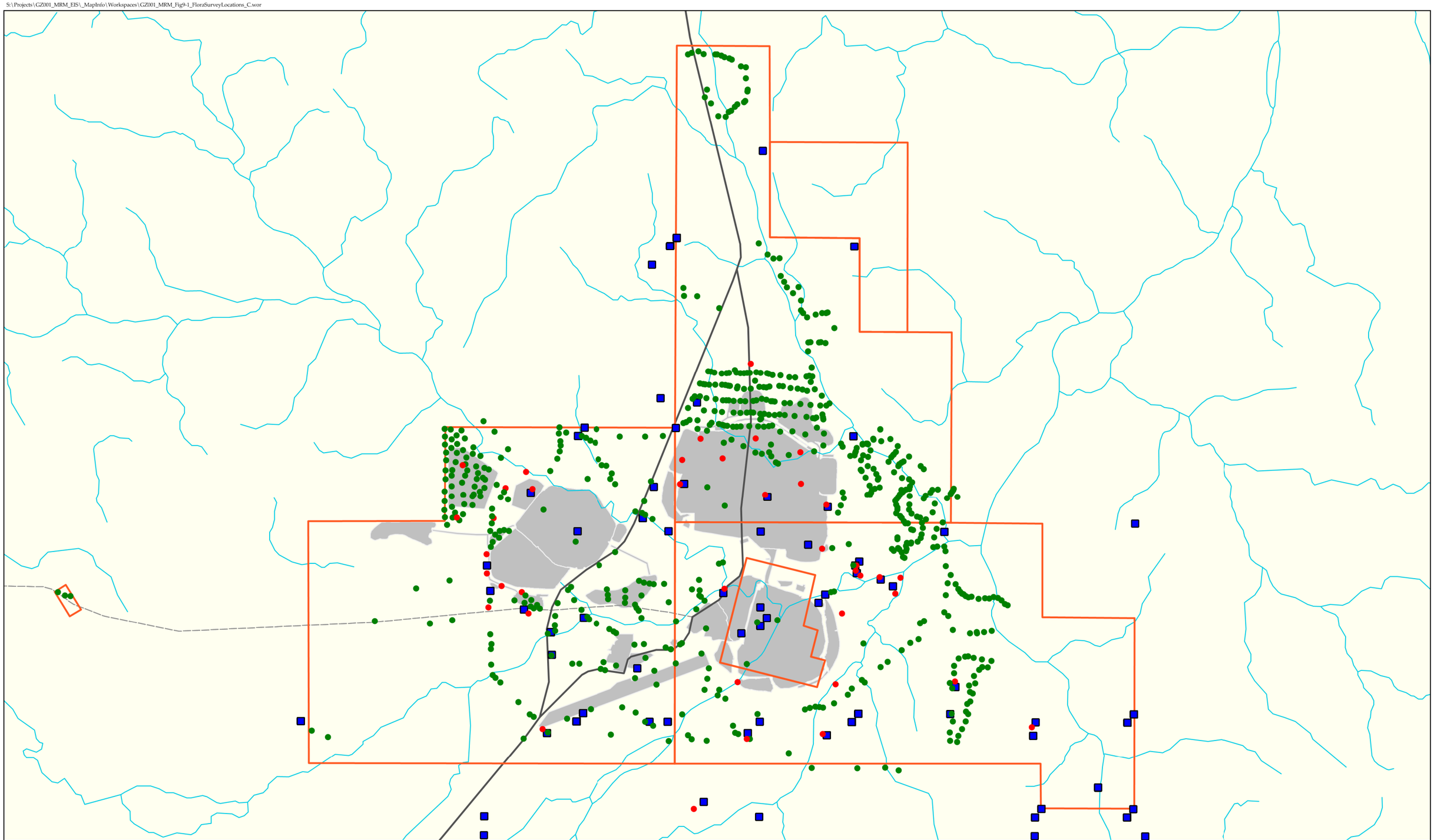

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Mining & Energy Technical Services Pty Ltd

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LEGEND

- Check Sites
- Full Characterisation Sites
- Specimen Collection Locations
- Sealed Road
- Unsealed Track
- Watercourse
- MRM Lease Boundary
- Maximum Project Footprint

Data Source: Tenements, Roads - NT Gov. (2012); Watercourse - Geoscience Australia (2006); Project Footprint - McArthur River Mining Pty Ltd (Jul 2015); Flora points - EMS/MetServe (2003-2017)

McArthur River Mine
Overburden Management Project EIS

Flora Survey Locations

1 0 1 2
Kilometres

Scale: 1:70,000 (A3)

31/01/2017

Datum: GDA94
Projection: MGA53

FIGURE 9-1

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9.2.2 Terrestrial Fauna

The terrestrial fauna of the Project area is well characterised, based on numerous general and targeted ecological surveys spanning multiple decades. These surveys meet the *Guidelines for Assessment of Impacts on Terrestrial Biodiversity* (NT EPA 2013). The following surveys have studied the terrestrial fauna of the Project area:

1. Early bird collections were undertaken in the McArthur River region by the Barclay Expedition 1911-1912 (Hill 1913) and Barnard (1914). Several of these collections were made in what are now the MRM leases.
2. A large-scale inventory of the ecology of the McArthur River region (from the MRM mineral leases to the Sir Edward Pellew Islands) was undertaken by the Commonwealth Scientific and Industrial Research Organisation during the 1970s (CSIRO 1976). Unfortunately, site-specific records are not listed in this report, and it is often difficult to infer which species were detected in the vicinity of the Project versus elsewhere in the McArthur River catchment. Nevertheless, this study provides a comprehensive assessment of the faunal communities within the broad region.
3. Surveys of the Glyde River area (adjacent to the MRM) in 1986 targeted the endangered Carpentarian Grasswren (Martin and McKean 1986).
4. Fauna surveys were undertaken across the MRM mineral leases as part of the draft EIS for the original MRM project (Hollingsworth Dames and Moore 1992).
5. Supplementary surveys, undertaken for the original EIS in 1992, targeted frogs (Tyler 1992) and surveyed for general fauna (Ecostudy 1992).
6. Fauna surveys were undertaken in 2002 and 2003 for the Phase 2 Expansion Project EIS (URS 2005).
7. Sites in the MRM region were surveyed for Carpentarian Grasswrens in 2005 as part of a Masters study (Perry 2005; Perry *et al.* 2011).
8. Additional targeted surveys for Carpentarian Grasswrens were undertaken in 2007 (URS 2007) and in 2008-2009 (Harrington *et al.* 2009).
9. Since 2006, monitoring of riparian birds within the MRM leases has been undertaken twice-yearly at 28 permanent monitoring locations along the McArthur River and Barney Creek (EMS 2016). This equates to 1,080 hours of search effort for birds in riparian habitats.
10. Fauna surveys were conducted as part of Phase 3 Development Project EIS, within parts of the MRM leases to be impacted by the expansion (URS 2012).
11. Bird surveys were undertaken in July-August 2012 at 53 sites in *Corymbia terminalis* and *Eucalyptus chlorophylla* open woodland west of the TSF as part of planning for a terminated irrigation scheme (MET Serve 2012).
12. Since the discovery of Gouldian Finches within the MRM mineral leases in 2013, extensive surveys of woodland birds have been conducted across the leases. These have included an annual assessment of potential Gouldian Finch foraging and drinking habitats, general surveys of bird communities within potential Gouldian Finch habitat, and targeted surveys (including camera trapping) at potential drinking locations (EMS 2013, 2014, 2015). Between 2013 and 2015, 100 sites were surveyed in the early to late dry seasons for woodland birds, using 10 minute long, 1 ha searches. In 2015 and 2016, 220 additional sites were surveyed during habitat mapping using ten minute long timed searches (**Appendix X – Terrestrial Ecology Report**). This equates to a total of 78 hours of search effort for woodland birds.

13. In November 2015, targeted surveys for Masked Owls using call playback were undertaken at 40 locations in and near the MRM mineral leases (**Appendix X – Terrestrial Ecology Report**). These surveys followed methodology recommended by the *Survey Guidelines for Australia's Threatened Birds* (DEWHA 2010) and the *Survey Protocol for Masked Owls in the NT* (DLRM 2010). They involved five minutes of broadcast calls, followed by five minutes of listening and spotlighting, at each site.
14. In November 2015 and August 2016, targeted surveys for Northern Quolls were undertaken in the closest potential habitat to the Project. This involved 80 trap-nights using baited wire cage traps, 80 trap-nights using baited Type B Elliott traps and 378 trap-nights using remote-sensory cameras angled at bait stations.
15. Between 2011 and 2015, bats have been surveyed through 100 trap-nights of harp trapping along Emu Creek, Barney Creek, Surprise Creek and in the NOEF area (**Appendix X – Terrestrial Ecology Report**). In open habitats (Emu Creek and the NOEF), echolocation lures were deployed to increase trap rates (Hill *et al.* 2015). In addition to trapping, full-spectrum bat calls were recorded at 28 sites using Petterson D500x bat detectors. Also, large, hollow trees potentially suitable for Bare-rumped Sheathtail Bats were searched for throughout the Project area.

The combined knowledge derived from the above surveys is likely to represent a thorough understanding of the local region's faunal community. One way of testing whether these surveys have been adequate is by fitting species accumulation curves to the data gathered. These curves (**Figure 9-2**) depict the rate at which new species are detected by additional survey effort. Sampling methodology was not consistent across all studies, which complicates the standardisation of survey effort across studies. Nevertheless, a crude method for testing adequacy of survey effort is to see how many additional species were detected in each five-year period since 1975 (excluding 1995-2000, when no surveys were undertaken). The software EstimateS version 2 was used to apply the methodology described by Chao (1984, 1987).

The total number of species that would be detected with infinite sampling can be estimated using Chao2 Richness Estimator. These can be used as an indication of the likely proportion of species missed by the survey effort to date. The species richness (i.e., number of species) of mammals (37.3), birds (225) and herpetofauna (amphibians and reptiles) (105.8) estimated by the curves closely matched the actual number of mammals (37), birds (210) and herpetofauna (100) detected by the surveys incorporated into the curve. These totals do not include historical records or records in nearby areas contained in public databases. When these additional records are considered, the numbers of species of mammals (40), birds (216) and herpetofauna (105) known to occur in the local region are 100%, 96% and 99% of the estimated richness of mammals, birds and herpetofauna present. This suggests that knowledge of local faunal communities is comprehensive, and few species would have been missed by past surveys.

Not only does the survey effort capture the vast majority of the faunal diversity present on-site, but all habitats have been sampled (**Figure 9-3**), sampling has covered all seasons and multiple years, and all species of conservation significance have been targeted to maximise their detection. The risk of the Project affecting species not known to occur in the region is therefore low. The confidence with which the absence of any one threatened species can be judged depends on the detectability of the species, which is discussed on a case-by-case basis in **Sections 9.3.1.3** to **9.3.1.5.**

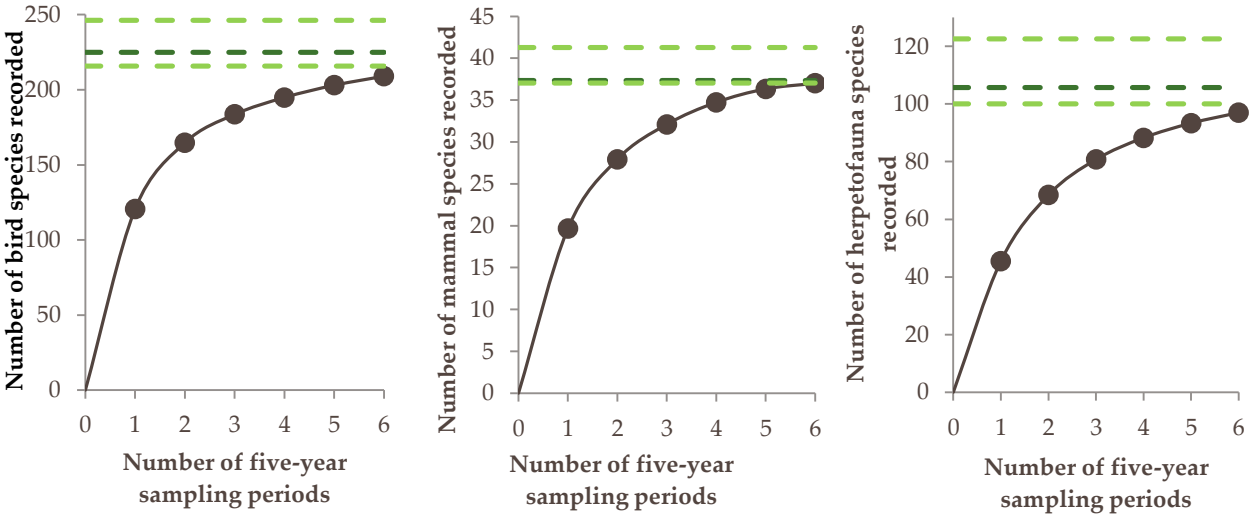

Figure 9-2 Species Accumulation Curves for Birds, Mammals and Herpetofauna.

Curves were fitted using the methodology of Chao (1984, 1987), as applied by the software EstimateS Version 9. The dashed lines represent the mean (dark green) and 95% confidence intervals (pale green) around the estimate of total richness calculated using the Chao2 richness estimator.

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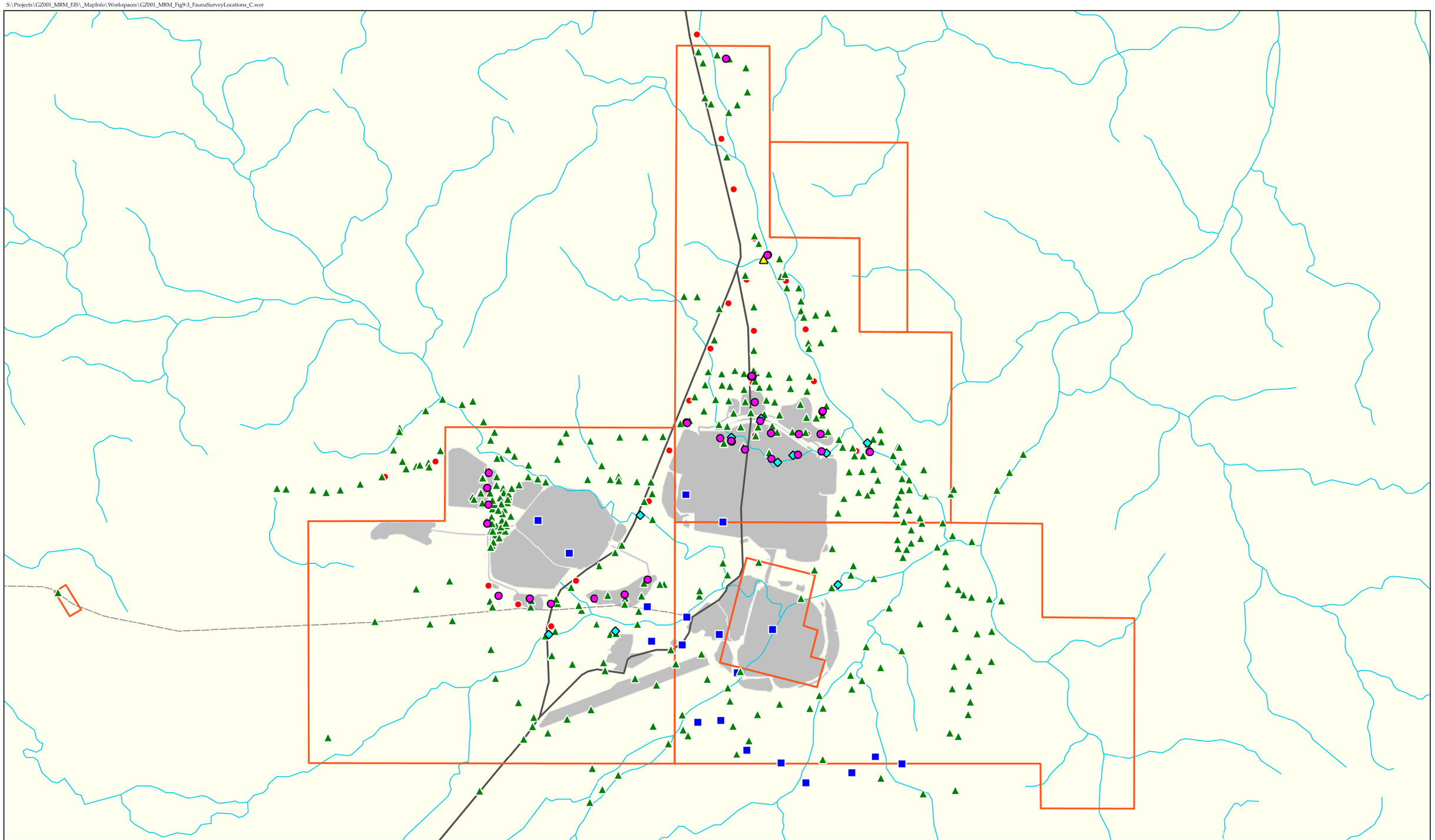

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- Bird Survey Locations
- Northern Masked Owl Broadcast Sites
- Bat Survey Sites
- Northern Quoll Trapping Sites
- Camera Traps
- Complete Fauna Trap Sites
- Watercourse
- Sealed Road
- Unsealed Track
- MRM Lease Boundary
- Maximum Project Footprint

Data Source: Tenements, Roads - NT Gov. (2012); Watercourse - Geoscience Australia (2006); Project Footprint - McArthur River Mining Pty Ltd (Jul 2015); Fauna points - EMS/MetServe (2006-2017)

McArthur River Mine
Overburden Management Project EIS

Fauna Survey Locations

1 0 1 2
Kilometres

Scale: 1:70,000 (A3)

31/01/2017

Datum: GDA94
Projection: MGA53

FIGURE 9-3

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9.2.3 Aquatic Biodiversity Values

The aquatic fauna of the freshwater reaches of the McArthur River catchment has been the subject of intense study over the past ten years. The studies undertaken to date are described in **Appendix W – Aquatic Ecology Report.** These can be summarised as follows:

1. The fish present in the vicinity of the MRM were first surveyed in 1975 (Midgley 1975).
2. Further surveys of fish occurring within the McArthur River and adjacent streams were undertaken in 1982 (Midgley 1982).
3. Surveys by the Northern Territory Museum of the fish and macroinvertebrates of Barney Creek and Surprise Creek were undertaken as part of the draft EIS for the original MRM project (Hollingsworth Dames and Moore 1992; Hanley 1993).
4. As part of the EIS for the Phase 2 Expansion Project, targeted surveys of the Largetooth Sawfish, *Pristis pristis*, were undertaken within the McArthur River, with focus on ascertaining the importance of waters upstream of the MRM for this threatened species.
5. A condition of the approval of the Phase 2 Expansion Project was the initiation of several aquatic monitoring programs. These commenced in 2006, and a total of over 300 hours of aquatic fauna sampling have been undertaken between 2006 and 2016:
   - The abundance and diversity of fish and other aquatic vertebrates in permanent and semi-permanent pools of the McArthur River, Surprise Creek and Barney Creek are monitored biannually. This is undertaken at 26 monitoring sites, from as far upstream as Top Crossing (50 kilometres (km) upstream of the Project), and as far downstream as the Burketown Crossing in the town of Borroloola. Survey techniques include fyke nets, seine nets, gill nets, electrofishing transects, line fishing and visual surveys.
   - The response of fish communities to the placement of large woody debris within rehabilitated stretches of the channel within the McArthur River has been studied by gathering fish density data from the vicinity of wood piles and comparing this with data gathered from bare bank channel habitats and natural sections of the river directly up and downstream of the channel.
   - The tissues of fish living within the McArthur River, Barney Creek and Surprise Creek are tested biannually to determine concentrations of metals. This is undertaken to ensure the safety for local people consuming fish from the area, investigate the early introduction of metals into the aquatic food chain, and monitor potential sources of contamination.
   - In 2015, a citizen science program was initiated to encourage interested members of the public to submit samples of fish caught recreationally for metals testing.
   - The movements of Barramundi (*Lates calcarifer*) and Largetooth Sawfish (*Pristis pristis)* within the McArthur River are monitored using conventional tagging techniques and, more recently, through acoustic tagging.
   - Annual monitoring of macroinvertebrate communities, a bio-indicator of water quality, is undertaken at 29 sites, including sites on the MRM leases with reference sites off the lease. Macroinvertebrate sample collection and laboratory processing closely follow established NT protocols (Lamche 2007), with reference to Lloyd and Cook (2002) and Environment Australia (2001) for sampling riffle habitats.
6. A baseline survey of the aquatic fauna of Emu Creek was undertaken in April 2015 to provide data against which a predictive impact assessment and post-construction monitoring could be compared. Tissue samples for metal, metalloid and lead isotope ratio (PbIR) analyses were also collected from the fish to establish baseline metal levels for this creek.

9.3 Existing Environmental Conditions

9.3.1 Terrestrial Biodiversity Values

9.3.1.1 Habitats Present

Most of the MRM mineral leases comprise low plains supporting open, grassy woodlands. These are dissected by the McArthur River and smaller tributaries (Barney Creek, Emu Creek and Surprise Creek), which provide a source of semi-permanent water for wildlife and support corridors of denser riparian vegetation. The plains are composed of a mosaic of red/yellow/brown earths and grey/brown cracking clays. Occasional low rises and stony hills occur within the plains. These tend to support woodlands with a similar structure but different species composition from the surrounding plains. Apart from the McArthur River, the most prominent habitat feature within the MRM leases is the large sandstone plateau, the Bukalara Range, located along the eastern boundary. The Bukalara Range stands 30 m to 100 m above the surrounding plains, contains extensive areas of exposed rock and is dissected by gorges. This sandstone plateau, at least historically, supported a distinctive flora and fauna, many species of which are of conservation significance.

Approximately 86% of the MRM mineral leases comprise remnant vegetation. The remainder contains existing mining infrastructure, the air strip and rehabilitated areas. Ten distinct vegetation types (vegetation mapping units: VMUs) occur within the MRM mineral leases (**Table 9-1**). The vegetation within the plain is primarily a low to mid-high open woodland. Where the soils comprise sandy earths, the dominant tree species are *Corymbia terminalis*, *Eucalyptus chlorophylla* and *Eucalyptus tectifera* (VMU 5). Where the soils comprise cracking clays, the woodlands are dominated by *Bauhinia cunninghamii*, *Eucalyptus microtheca* and *Corymbia bella* (VMU 6). The eight other VMUs are confined to the plateau, rocky slopes, alluvial terraces or stream banks. A vegetation map of the MRM mineral leases is presented in **Figure 9-4**.

Table 9-1 Vegetation Mapping Units within the MRM Mineral Leases

VMU	VMU subunit	Description	Area: MRM leases (ha)
1	**Low open woodland to mid high woodland on sandstone escarpments associated with the Bukalara Land System**		**2,249.3**
	1a	*Eucalyptus phoenicea* + *Corymbia dichromophloia* +/- *Eucalyptus miniata* +/- *Eucalyptus herbertiana* +/- *Corymbia setosa* low open woodland to mid-high woodland on sandy soils on sandstone escarpment.	2,227.3
	1b	Mixed species low woodland on remnant sandstone terraces	22.0
2	**Mixed species low open woodland to mid-high open woodland on stony hills and rises**		**537.1**
	2a	*Terminalia canescens* + *Erythrophleum chlorostachys* low open woodland to mid-high woodland on stony hills and rises	206.3
	2b	*Corymbia dichromophloia* + *Eucalyptus phoenicea* +/- *Corymbia setosa* +/- *Erythrophleum chlorostachys* low to mid-high open woodland on rocky hills and rises	89.4
	2c	*Erythrophleum chlorostachys* + *Corymbia grandiflora* low to mid-high open woodland with mixed tussock grass ground cover on stony rises and hillslopes	228.2
	2d	Low tussock grassland on low hills and rises	13.3
3	***Melaleuca* spp. low woodland on depositional and poorly drained plains and footslopes**		**31.9**
	3a	*Melaleuca viridiflora* low woodland	1.6
	3b	*Melaleuca citrolens* low woodland	24.8
	3c	*Melaleuca bracteata* low open woodland and closed shrubland	5.5
4	***Eucalyptus leucophloia* low open woodland and mid-high woodland on hillslopes, scarp-foot slopes and low rises**		**445.3**
	4a	*Eucalyptus leucophloia* low to mid-high open woodland on hillslopes, scarp-foot slopes and plateau	427.0
	4b	*Eucalyptus leucophloia* low to mid-high open woodland on low rises	18.4
5	**Mixed *Corymbia terminalis* +/- *Eucalyptus chlorophylla* +/- *Eucalyptus tectifica* low to mid-high open woodland on plains and hillslopes**		**4,224.9**
	5a	*Eucalyptus tectifica* + *Eucalyptus chlorophylla* mid-high to low woodland with mixed tussock grass ground cover	1,460.7
	5b	*Corymbia terminalis* mid-high to low open woodland with mixed tussock grass ground cover	2,727.5
	5c	*Eucalyptus pruinosa* low open woodland	36.7
6	**Mixed *Bauhinia cunninghamii* +/- *Eucalyptus microtheca* +/- *Corymbia bella* low open woodland to mid-high woodland to open forest on alluvial back plains**		**1,881.6**
	6a	*Bauhinia cunninghamii* + *Excoecaria parvifolia* + *Atalaya hemiglauca* low open woodland on alluvial back plains	831.4
	6b	*Eucalyptus microtheca* mid-high open woodland to open forest on alluvial back plains	501.6

VMU	VMU subunit	Description	Area: MRM leases (ha)
	6c	Mixed species low to mid-high open woodland on alluvial back plains	548.6
7	**Mixed species low open woodland to mid-high woodland to open forest on alluvial plains and low order stream terraces**		**384.0**
	7a	*Eucalyptus camaldulensis* + *Lophostemon grandiflorus* + *Casuarina cunninghamiana* + *Terminalia platyphylla* riparian mid-high open woodland to open forest on low order streams	265.1
	7b	*Corymbia bella* mid-high open woodland to open forest on alluvial plains and creek terraces in the Surprise land System	118.9
8	***Melaleuca* spp. seasonally inundated riparian woodlands to open forest on major drainage lines**		**177.4**
	8a	*Melaleuca leucadendra* +/- *Eucalyptus camaldulensis* +/- *Casuarina cunninghamiana* +/- *Nauclea orientalis* riparian forest	81.6
	8b	*Melaleuca argentea* riparian forest to mid-high woodland on the Bukalara Land System	95.8
9	**Mixed species woodland and open forest on seasonally inundated river terraces and levees**		**511.3**
	9a	*Corymbia bella* + *Eucalyptus camaldulensis* + *Casuarina cunninghamiana* + *Eucalyptus microtheca* mid-high woodland and open forest on floodplain levees	210.3
	9b	*Eucalyptus microtheca* mid-high woodland and open forest on floodplain levees	120.3
	9c	*Eucalyptus camaldulensis* open forest on floodplain levees	153.0
	9d	*Erythrophleum chlorostachys* mid-high open woodland on alluvial river terraces	27.7
10	**Deciduous microphyll vine thicket on dolomitic and sandstone outcrops**		**3.7**
11	**Modified habitats and existing infrastructure**		**1,706.9**
	11a	Existing mining infrastructure	1,569.6
	11b	Restoration areas along re-channelled waterways	137.2
		Total (ha)	**12,153.5**

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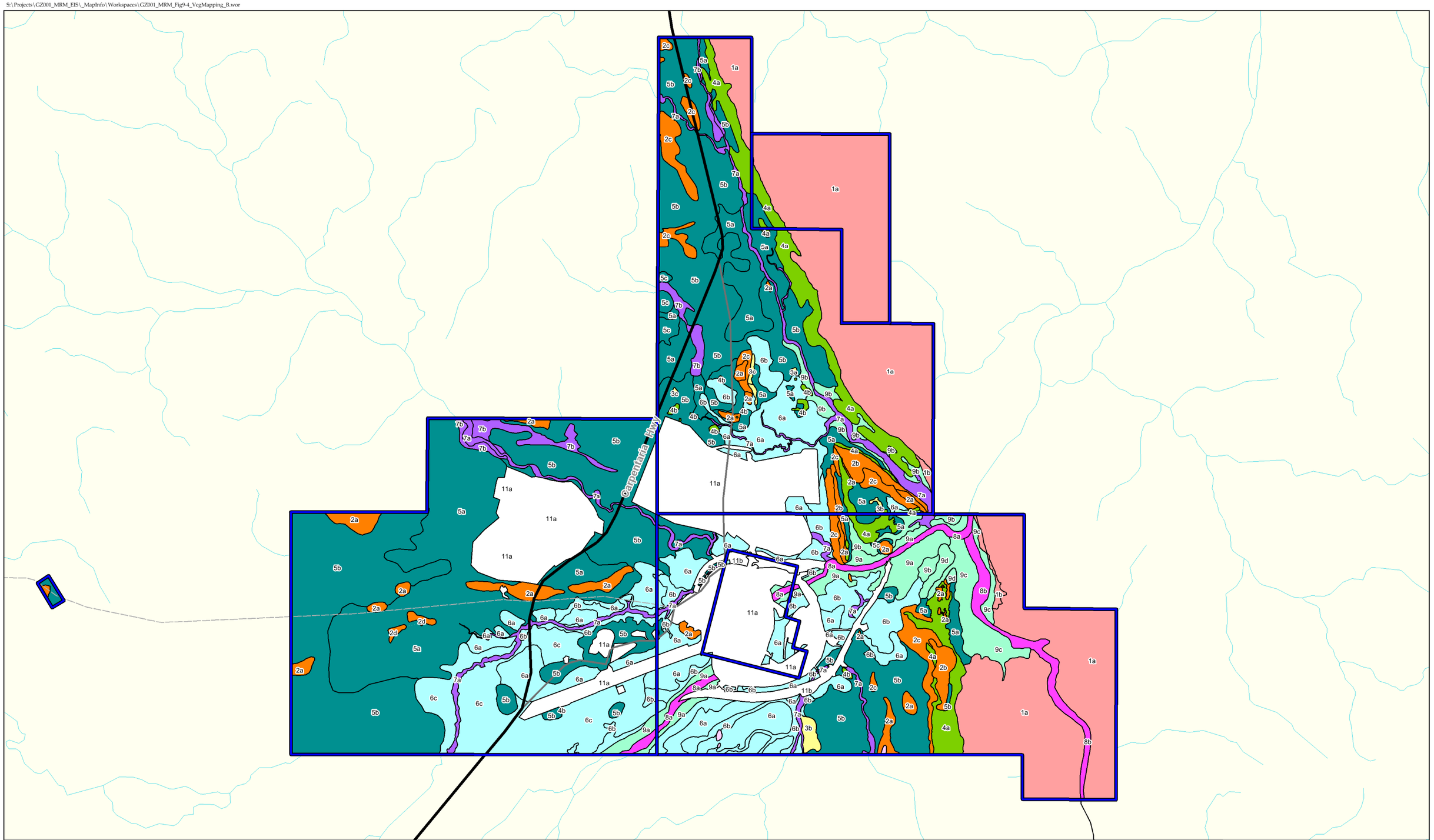

METSERVE
Mining & Energy Technical Services Pty Ltd

McArthur River Mining
A GLENCORE COMPANY

LEGEND

- Watercourse
- Highway
- Road
- Track
- McArthur River Mining Leases

Vegetation Mapping Units

1 - Escarpment Woodland/Terraces
2 - Mixed Species Low/Mid-High Woodland
3 - Melaleuca Low Woodland
4 - Snappy Gum Woodland (Hills/Low Rises)
5 - Inland Box/Bloodwood Woodland
6 - Mixed Species Woodland (Cracking Clays)
7 - Mixed Species Woodland (Drainage Lines/ Terraces)
8 - Melaleuca Riparian Forest
9 - Mixed Species (Alluvial Terraces)
10 - Deciduous Microphyll Vine Thicket
11 - Existing Infrastructure

Data Source: Vegetation Mapping Units - Glencore (Jan 2017); Tenements, Roads - NT Gov. (2012); Watercourse - Aust. Gov. (Jun 2006)

McArthur River Mine
Overburden Management Project EIS

Vegetation Mapping

1 0 1 2 3
Kilometres
Scale: 1:70,000 (A3)

31/01/2017

Datum: GDA94
Projection: MGA53

FIGURE 9-4

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9.3.1.2 Overall Terrestrial Biodiversity

Surveys of the MRM mineral leases and nearby regions have detected 445 species of vascular plant, with a further 727 species known from the broader region (20 km from the Project). Surveys of the MRM leases have also detected 26 species of amphibian, 79 species of reptile, 216 species of bird and 39 species of mammal (**Appendix X – Terrestrial Ecology Report**). This high diversity is testament to the intensity and duration of survey effort at the site.

The flora and fauna of the MRM leases are typical of the Gulf Fall and Uplands bioregion, within which it is located. There are no remarkable features of the local biodiversity that differentiate the MRM leases from the broader region. One exception is the McArthur River itself, being one of the major drainage systems entering into the Gulf of Carpentaria. The McArthur River provides a source of fresh water for terrestrial wildlife in an otherwise semi-arid landscape, contains numerous freshwater and estuarine aquatic species (discussed further in **Section 9.3.2**), and supports ribbons of riparian forest that act as important habitat corridors for wildlife. The McArthur River estuary, located approximately 100 km downstream of the Project, is an important foraging habitat for internationally significant populations of migratory shorebirds (discussed further in **Chapter 10 – Matters of National Environmental Significance**).

9.3.1.3 Species at or Near the Edge of their Geographic Distribution

The TOR for the preparation of this EIS specifies that any impacts of the Project on the geographic distributions of native flora and fauna species are to be assessed. For nine species of terrestrial animals and 15 species of plants, the Project lies at or near the edge of their geographic distribution. Any impacts to local populations of these 24 species may therefore potentially reduce their geographic distribution. Each of these species is discussed below.

9.3.1.3.1 Rockhole Frog

The Project area constitutes the eastern limit of the Rockhole Frog (*Litoria meiriana*). Local populations are genetically distinct from those further west, and may represent a new taxon. This species inhabits permanent creeks and waterholes of rocky hills and gorges within the Bukalara Range.

9.3.1.3.2 Clawless Gecko

The Project area is near the eastern limit of the Clawless Gecko (*Crenadactylus ocellatus*). This gecko lives within clumps of spinifex (*Triodia* spp.). It has never been recorded within the MRM leases, but is known to occur on the Bukalara Range closer to Borroloola (25 km north of the Project), as well as in the Glyde River Gorge (18 km south of the Project). It likely inhabits *Triodia* growing on the Bukalara Range along the eastern edge of the MRM leases.

9.3.1.3.3 Western Hooded Scaly-foot

The Project area lies near the northeastern limit of the Western Hooded Scaly-foot (*Pygopus nigriceps*). This legless lizard inhabits a broad range of arid habitats across inland Australia. A single specimen was collected by CSIRO in 1975 in the vicinity of the mine camp, but the species has not been recorded on the MRM leases since.

9.3.1.3.4 Hosmer's Skink

The Project area lies near the western limit of Hosmer's Skink (*Egernia hosmeri*). This large lizard lives on rock outcrops and stony hills, where it shelters in crevices and under piles of rock. This cryptic species is not often recorded in the Project area. It was recorded just south of the MRM leases in the 1970s (CSIRO 1976) and in 1992 the species was recorded in what later became the MRM open cut (Ecostudy 1992). It likely occurs in boulder-strewn scree slopes elsewhere in the MRM leases and surrounding areas.

9.3.1.3.5 Olive Whipsnake

The Olive Whipsnake (*Demansia olivacea*) inhabits woodlands of the northern NT and Kimberley region. The species has been recorded from the vicinity of Cape Crawford, 40 km southwest of the Project, which appears to be the easternmost extent of its distribution. It was recorded once on the MRM leases (Hollingsworth Dames and Moore 1992). Inferring the local status of the species is complicated by the uncertain taxonomy of local records. In 2007, what was then considered to be two species of tropical whipsnakes (*Demansia olivacea* and *Demansia torquata*) were split into ten species (Shea and Scanlon 2007). Three of these species potentially occur within the MRM region (*D. olivacea sensu stricto*, *D. quaesitor* and *D. shinei*). Because the local records occurred prior to this taxonomic revision, it is unknown to which taxon they refer. None of these three species of whipsnake have been recorded on the MRM leases in the 24 years since the 1992 record. The Olive Whipsnake is therefore best considered an unlikely but possible resident of the MRM leases in very low densities.

9.3.1.3.6 Stubble Quail and King Quail

Two species of quail were recorded by CSIRO during surveys undertaken in 1975, but have not been recorded since. The Project area constitutes a northern record for Stubble Quail (*Coturnix pectoralis*) and a unique Gulf of Carpentaria record for King Quail (*Synoicus chinensis*). Both species are highly nomadic and occasionally appear outside their normal range. Both species have distinctive calls and are therefore normally highly detectable when present. The lack of recent records therefore suggests their absence. 1974 and 1975 were wetter than average years, which may explain the presence of these two species at the time.

9.3.1.3.7 Pale-vented Bush-hen

The Pale-vented Bush-hen (*Amaurornia moluccana*) is a bird of rank creekside vegetation in the Top End and the east coast of Australia. A sighting of the species at Caranbirini Conservation Reserve (12 km north of the MRM leases) in 2012 represents a unique Gulf of Carpentaria record. It is possible that small numbers of this species utilise riparian vegetation along the McArthur River at least transiently. The species is highly vocal and therefore readily detected when present. The lack of records over ten years of riparian bird monitoring at MRM suggests that the species is only a transient visitor.

9.3.1.3.8 Chestnut-backed Buttonquail

The Project area lies at the eastern limit of the Chestnut-backed Buttonquail (*Turnix castanotus*). A specimen of this species was collected at Borroloola in 1913. A handful of additional records have occurred in the region since, but all have consisted of unverified sight records. The species is usually glimpsed briefly when flushed from long grass and distinguishing the species from the two other species of buttonquail present on-site is difficult unless good views are obtained. If it is present on-site, the Chestnut-backed Buttonquail would inhabit open, grassy woodlands.

9.3.1.3.9 *Melhania ovata*

Melhania ovata is a small shrub that grows in grassy eucalypt woodland across northern Queensland. It was reported on-site by Hollingsworth Dames and Moore (1992), but has not been reported since. It is likely that this early record represents a misidentification of *Melhania oblongifolia*, which is regularly recorded on the MRM leases in other surveys, but was absent from the inventory made by Hollingsworth Dames and Moore (1992). In the unlikely event that *M. ovata* is present on-site, the MRM leases would constitute the northwestern-most known location of the species.

9.3.1.3.10 *Acacia latescens*

Acacia latescens is a common large shrub in eucalypt woodlands across most of the Top End, but reaches the southeastern edge of its distribution in the vicinity of the Project. Within the MRM leases, *A. latescens* is most abundant on the sandstone plateau (VMU1), but also occurs less frequently in hill woodland (VMU4) and bloodwood/box woodland (VMU5).

9.3.1.3.11 *Goodenia leiosperma*

Goodenia leiosperma is a sprawling herb that grows in the grassy understorey of eucalypt forests, usually in wetter sites. This species occurs widely across coastal and sub-coastal parts of the NT but reaches the southeastern edge of its distribution in the vicinity of the Project. Within the MRM leases, this species is uncommon in bloodwood/box woodland (VMU5). There are records of the species from areas surrounding the MRM leases, suggesting that the species is locally common.

9.3.1.3.12 *Polygala barbata*

Polygala barbata is a small herb that grows in a wide variety of habitats, including dense vine thickets and riparian forests, *Acacia* scrubs and open grassy woodlands. Sandy loam soils are preferred. This species occurs widely across coastal and sub-coastal parts of the NT but reaches the southeastern edge of its distribution in the vicinity of the Project. Within the MRM leases, *P. barbata* has been recorded in bloodwood/box woodland (VMU5), where it is common, and hill woodland (VMU4). There are additional records of the species from the local region outside the MRM leases.

9.3.1.3.13 *Grevillea decurrens*

Grevillea decurrens is a tall shrub that grows in open woodlands, usually on skeletal soils, across northern parts of the NT. It reaches the southeastern edge of its distribution in the vicinity of the Project, where it is uncommon in hill woodland (VMU4) and bloodwood/box woodland (VMU5). None were recorded within the footprint of the Project.

9.3.1.3.14 Sandstone Plant Species

Ten additional species of plant inhabit sandstone escarpments and reach the edge of their known distribution in the vicinity of the Project. All of these species are widespread across the escarpments of the Arnhem Plateau and many extend into the Kimberley Ranges (Western Australia). These species are:

- *Gomphrena floribunda*, an annual herb that grows on ledges beside the Glyde River gorge;
- *Cleome microaustralica*, a herb that grows on the sandstone plateau beside the Glyde River, and which is likely to be distinct from the typical form in Arnhem Land (Northern Territory Herbarium 2013);
- *Eriocaulon patericola*, a herb that grows in small, ephemeral, rocky pools within sandstone escarpments;
- *Euphorbia armstrongiana,* an annual herb that grows in sandy soil among rocks;
- *Leptosema villosum*, a sprawling shrub that scrambles amongst sandstone boulders;
- *Myriophyllum callitrichoides*, an aquatic herb growing in ephemeral, rocky pools in the upper Glyde River gorge;
- *Mitrasacme glaucescens*, an annual herb that grows on sandstone escarpments, among scree slopes or beneath overhangs;
- *Calytrix achaeta*, a woody shrub that forms small thickets on bare, rocky rises;
- *Eriachne avenacea*, a small grass that grows on skeletal, gravelly soils over sandstone or laterite; and
- *Polygala obversa*, an annual herb growing on sandy or gravelly soils over sandstone.

For all of these species, the Bukalara Range, immediately east of the Project, supports the easternmost known populations. Due to the similar habitat preferences of these sandstone species, they are exposed to a similar set of risks and will therefore be assessed together.

9.3.1.4 Matters of National Environmental Significance

Thirty-four terrestrial species that are protected under the EPBC Act as threatened species or migratory species potentially occur within, or visit, the MRM leases (**Table 9-2**). An additional three species are primarily aquatic and are discussed in **Section 9.3.2.4**. Twenty of these species have been recorded within the MRM leases, although several of these have not been recorded for 20 years or more and are likely to be locally extinct. Each of these nationally protected species is discussed in detail within **Chapter 10 – Matters of National Significance**.

Table 9-2 Terrestrial MNES Potentially Inhabiting the MRM Mineral Leases

Common Name	Scientific Name	Status, EPBC Act	Local Status
Curlew Sandpiper	*Calidris ferruginea*	Critically Endangered, Migratory	Unlikely nonbreeding visitor
Eastern Curlew	*Numenius madagascariensis*	Critically Endangered, Migratory	No habitat present on-site.
Carpentarian Grasswren	*Amytornis dorotheae*	Endangered	Formerly resident but locally extinct.
Northern Quoll	*Dasyurus hallucatus*	Endangered	Formerly resident but probably locally extinct.
Gouldian Finch	*Erythrura gouldiae*	Endangered	Confirmed visitor in small numbers to feeding habitats within the MRM leases.
Australian Painted Snipe	*Rostratula australis*	Endangered	Possible visitor, but the region is not important for the species.
Plains Death Adder	*Acanthophis hawkei*	Vulnerable	Formerly present but possibly locally extinct.
Red Goshawk	*Erythrotriorchis radiatus*	Vulnerable	A possible nonbreeding transient visitor in very small numbers.
Crested Shrike-tit (northern)	*Falcunculus frontatus whitei*	Vulnerable	Unlikely to be present on-site, but there are historical records from Borroloola.
Partridge Pigeon (eastern)	*Geophaps smithii smithii*	Vulnerable	Locally extinct.
Painted Honeyeater	*Grantiella picta*	Vulnerable	Confirmed as a rare vagrant from southeast Australia.
Ghost Bat	*Macroderma gigas*	Vulnerable	Unlikely to be present on-site.
Carpentarian Antechinus	*Pseudantechinus mimulus*	Vulnerable	Probably absent from the MRM leases and the wider region.
Bare-rumped Sheath-tailed Bat	*Saccolaimus saccolaimus*	Vulnerable	Unlikely to be present on-site.

Common Name	Scientific Name	Status, EPBC Act	Local Status
Masked Owl (northern)	*Tyto novaehollandiae kimberli*	Vulnerable	Unlikely to be present on-site.
Common Sandpiper	*Actitis hypoleucos*	Migratory	Confirmed nonbreeding visitor in small numbers.
Fork-tailed Swift	*Apus pacificus*	Migratory	Confirmed nonbreeding visitor in small numbers.
Sharp-tailed Sandpiper	*Calidris acuminata*	Migratory	Confirmed nonbreeding visitor in small numbers.
Long-toed Stint	*Calidris subminuta*	Migratory	Confirmed as a rare visitor.
Red-rumped Swallow	*Cecropis daurica*	Migratory	Possible, but unlikely, vagrant.
Oriental Plover	*Charadrius veredus*	Migratory	Confirmed nonbreeding visitor in small numbers.
Oriental Cuckoo	*Cuculus optatus*	Migratory	Possible nonbreeding visitor in small numbers.
Snipe species	*Gallinago* spp.	Migratory	Confirmed as a rare visitor.
Oriental Pratincole	*Glareola maldivarum*	Migratory	Confirmed nonbreeding visitor in small numbers.
Barn Swallow	*Hirundo rustica*	Migratory	Possible, but unlikely, vagrant.
Caspian Tern	*Hydroprogne caspia*	Migratory	Confirmed nonbreeding visitor in small numbers.
Grey Wagtail	*Motacilla cinerea*	Migratory	Possible, but unlikely, vagrant.
Eastern Yellow Wagtail	*Motacilla tshutschensis*	Migratory	Confirmed as a vagrant.
Little Curlew	*Numenius minutus*	Migratory	Confirmed nonbreeding visitor in small numbers.
Eastern Osprey	*Pandion cristatus*	Migratory	Confirmed nonbreeding visitor in small numbers.
Glossy Ibis	*Plegadis falcinellus*	Migratory	Confirmed occasional visitor in small numbers.
Arafura Fantail	*Rhipidura dryas*	Migratory	Confirmed on-site as a scarce resident.
Common Greenshank	*Tringa nebularia*	Migratory	Confirmed as a rare visitor.
Marsh Sandpiper	*Tringa stagnatilis*	Migratory	Confirmed nonbreeding visitor in small numbers.

Apart from nationally protected threatened and migratory species, no other MNES are contained within the MRM leases. Matters of national environmental significance include:

- world heritage properties;
- national heritage properties;
- wetlands of international importance (listed under the Ramsar Convention);
- listed threatened species and ecological communities;
- migratory species protected under international agreements;
- Commonwealth marine areas;
- the Great Barrier Reef Marine Park;
- nuclear actions, including uranium mines; and
- a water resource, in relation to coal seam gas development and large coal mining development.

9.3.1.5 Matters of Northern Territory Environmental Significance

Fifty-six terrestrial species that are known to, or possibly, occur within the MRM leases have a status under the TPWC Act other than 'Least Concern' or 'Introduced' (**Table 9-3**). Of these, 22 are MNES and are discussed in detail in **Chapter 10 – Matters of National Significance**. Fifteen terrestrial species are classed as 'threatened' (Critically Endangered, Endangered or Vulnerable) in the NT. Five of these threatened species are not MNES protected under the EPBC Act.

Each species of environmental significance within the NT that is not addressed in **Chapter 10 – Matters of National Significance** is discussed in the following subsections.

Table 9-3 Species Present or Potentially Present at MRM with TPWC Act Status other than 'Least Concern' or 'Introduced'

Species	Common Name	Status, TPWC Act	MNES*
Dasyurus hallucatus	Northern Quoll	Critically Endangered	yes
Amytornis dorotheae	Carpentarian Grasswren	Endangered	yes
Acanthophis hawkei	Plains Death Adder	Vulnerable	yes
Calidris ferruginea	Curlew Sandpiper	Vulnerable	yes
Erythrotriorchis radiatus	Red Goshawk	Vulnerable	yes
Erythrura gouldiae	Gouldian Finch	Vulnerable	yes
Falco hypoleucos	Grey Falcon	Vulnerable	
Grantiella picta	Painted Honeyeater	Vulnerable	yes
Hipposideros stenotis	Northern Leaf-nosed Bat	Vulnerable	
Numenius madagascariensis	Eastern Curlew	Vulnerable	yes
Rostratula australis	Australian Painted Snipe	Vulnerable	yes
Tyto novaehollandiae kimberli	Masked Owl (mainland Top End)	Vulnerable	yes
Varanus mertensi	Mertens' Water Monitor	Vulnerable	
Varanus mitchelli	Mitchell's Water Monitor	Vulnerable	
Varanus panoptes	Floodplain Monitor	Vulnerable	
Acrocephalus australis	Australian Reed-warbler	Near Threatened	

Species	Common Name	Status, TPWC Act	MNES*
Amaurornis moluccana	Pale-vented Bush-hen	Near Threatened	
Ardeotis australis	Australian Bustard	Near Threatened	
Burhinus grallarius	Bush Stone-curlew	Near Threatened	
Dromaius novaehollandiae	Emu	Near Threatened	
Elanus scriptus	Letter-winged Kite	Near Threatened	
Falcunculus frontatus	Crested Shrike-tit	Near Threatened	yes
Heteromunia pectoralis	Pictorella Mannikin	Near Threatened	
Isoodon macrourus	Northern Brown Bandicoot	Near Threatened	
Lagorchestes conspicillatus	Spectacled Hare-wallaby	Near Threatened	
Lophoictinia isura	Square-tailed Kite	Near Threatened	
Macroderma gigas	Ghost Bat	Near Threatened	yes
Malurus coronatus macgillivrayi	Purple-crowned Fairy-wren (Gulf)	Near Threatened	
Neochmia ruficauda	Star Finch	Near Threatened	
Onychogalea unguifera	Northern Nailtail Wallaby	Near Threatened	
Phaps histrionica	Flock Bronzewing	Near Threatened	
Poecilodryas cerviniventris	Buff-sided Robin	Near Threatened	
Pseudantechinus mimulus	Carpentarian Antechinus	Near Threatened	yes
Pseudechis australis	King Brown Snake	Near Threatened	
Pseudomys nanus	Western Chestnut Mouse	Near Threatened	
Rattus villosissimus	Long-haired Rat	Near Threatened	
Rhinonicteris aurantia	Orange Leaf-nosed Bat	Near Threatened	
Saccolaimus saccolaimus	Bare-rumped Sheath-tailed Bat	Near Threatened	yes
Tyto longimembris	Eastern Grass Owl	Near Threatened	
Astrebla lappacea	Curly Mitchell Grass	Data Deficient	
Demansia olivacea	Olive Whip Snake	Data Deficient	
Dendrelaphis punctulata	Green Tree Snake	Data Deficient	
Gallinago hardwickii	Latham's Snipe	Data Deficient	yes
Gallinago megala	Swinhoe's Snipe	Data Deficient	yes
Gallinago stenura	Pin-tailed Snipe	Data Deficient	yes
Hibiscus setulosus	Native Hibiscus	Data Deficient	
Sesbania erubescens	Sesbania	Data Deficient	
Tiliqua scincoides	Common Blue-tongued Lizard	Data Deficient	
Turnix castanotus	Chestnut-backed Button-quail	Data Deficient	
Varanus scalaris	Spotted Tree Monitor	Data Deficient	

Species	Common Name	Status, TPWC Act	MNES*
Anas rhynchotis	Australasian Shoveler	Not Evaluated	
Calidris subminuta	Long-toed Stint	Not Evaluated	yes
Cecropis daurica	Red-rumped Swallow	Not Evaluated	yes
Hirundo rustica	Barn Swallow	Not Evaluated	yes
Motacilla cinerea	Grey Wagtail	Not Evaluated	yes
Motacilla tschutschensis	Eastern Yellow Wagtail	Not Evaluated	yes

9.3.1.5.1 Grey Falcon

The Grey Falcon (*Falco hypoleucos*) is an inhabitant of the Australian arid zone. Small numbers, especially immature birds, move towards coastal northern Australia during drought (Garnett *et al.* 2011). Barnard (1914) and CSIRO (1976) described the Grey Falcon as rare in the region. There are few records of the species north of Cape Crawford, 40 km southwest of the Project. A large amount of bird survey effort within the MRM leases has failed to detect the species. However, one individual has been recorded in the Glyde River catchment, approximately 15 km southeast of the Project (URS 2005). Grey Falcons are probably occasional visitors to the Project area but are unlikely to be resident in the region. Habitats within the region are probably marginal for the species.

9.3.1.5.2 Northern Leaf-nosed Bat

The Northern Leaf-nosed Bat (*Hipposideros stenotis*) inhabits rugged sandstone escarpment areas of the Top End and Gulf of Carpentaria (Milne 2012). Most records of the species come from the escarpments of western Arnhem Land, with relatively few observations in the southeastern parts of its distribution. The species has never been recorded within 100 km of the MRM leases, even though potential habitat is present. Bat trapping (100 harp trap-nights) and full-spectrum call recordings (31 nights) taken between 2011 and 2016 have failed to detect the species within the MRM leases, despite echolocation calls of the Northern Leaf-nosed Bat being diagnostic and the species is readily detected in areas where it occurs (Milne 2012). Potential roost sites (sandstone caves) do not occur near the Project.

9.3.1.5.3 Mertens' Water Monitor

The Mertens' Water Monitor (*Varanus mertensi*) is a semi-aquatic lizard that inhabits the edges of freshwater marshes, creeks and rivers. The principal threat to the species is lethality after the ingestion of Cane Toads (*Rhinella marina*). Mertens' Water Monitors experience marked population declines following colonisation of a region by Cane Toads (Ward *et al.* 2012). Prior to arrival of Cane Toads within the Project area, Mertens' Water Monitors were described as abundant along the McArthur River (CSIRO 1976). Since the arrival of Cane Toads, the Mertens' Water Monitor continues to persist locally, but in very low densities. The species has been recorded three times along the McArthur River since 1990 (Hollingsworth Dames and Moore 1992; **Appendix X – Terrestrial Ecology Report**), during more than 1,000 hours of surveys within riparian habitats. There have been additional sightings of the species at an artificial water body adjacent to the TSF (URS 2012).

9.3.1.5.4 Mitchell's Water Monitor

The Mitchell's Water Monitor (*Varanus mitchelli*) resembles the Merten's Water Monitor in its requirement for freshwater streams. It particularly prefers streams fringed with dense riparian vegetation. Like Merten's Water Monitors, Mitchell's Water Monitors are threatened by eating poisonous Cane Toads. Surveys that pre-date the arrival of Cane Toads suggest that Mitchell's Water Monitors were always relatively scarce in the McArthur River region. CSIRO (1976) collected several specimens of the species along Batten Creek, approximately 23 km north of the Project. The habitat was described as rocky streams fringed with dense *Pandanus*. Despite records in nearby creeks, Mitchell's Water Monitors have never been recorded along the McArthur River south of Borroloola. Furthermore, the species has not been recorded from the entire region since the arrival of Cane Toads. This is despite extensive survey effort in potential habitat. It is highly unlikely that the species occurs within the MRM leases, and it possibly never occurred there, even prior to the arrival of Cane Toads.

9.3.1.5.5 Floodplain Monitor

The Floodplain Monitor (*Varanus panoptes*) is the third species of monitor lizard found in the region that is threatened by lethality after the ingestion of Cane Toads. This large species occurs in small numbers within the MRM leases. It continues to be recorded, decades after the arrival of Cane Toads to the site, although sightings are irregular (**Appendix X – Terrestrial Ecology Report**). The vast majority of sightings have occurred in riparian and floodplain habitats along the McArthur River, although Floodplain Monitors are less tied to the immediate vicinity of water than the previous two varanid species. They may potentially occur in grassy woodlands anywhere within the lowlands of the MRM leases.

9.3.1.5.6 Australian Reed-warbler

The Australian Reed-warbler (*Acrocephalus australis*) is a small songbird that inhabits dense, low waterside vegetation, especially *Typha, Phragmites* and other tall reeds and sedges. Singing males are highly detectable, and resident populations are highly unlikely to go unnoticed. There are very few records of the species from the McArthur River catchment, with most records being downstream from Borroloola. The species has recently been recorded for the first time in the MRM leases, when it briefly colonised modified habitats along the re-channelled section of the McArthur River (**Appendix X – Terrestrial Ecology Report**). The species is highly mobile, colonising isolated lakes and dams. It is likely that the MRM leases support occasional transient individuals en route to more favourable habitats. None of the habitats present within the MRM leases are considered important to Australian Reed-warblers, and no local breeding is expected to occur.

9.3.1.5.7 Pale-vented Bush-hen

The Pale-vented Bush-hen (*Amaurornis moluccana*) is a small rail that inhabits dense, low vegetation near water. It has never been recorded in the MRM leases, despite 1,080 hours of bird survey effort in riparian habitats. It is highly detectable when breeding, due to its loud and characteristic calls. Transient individuals may easily go unnoticed due to their cryptic behaviour when not calling. A sighting of the species at Caranbirini Conservation Reserve (12 km north of the MRM leases) in 2012 represents a unique Gulf of Carpentaria record. The species is otherwise found in the Top End and along the east coast of Australia. It is possible that small numbers of this species utilise riparian vegetation along the McArthur River in a transient capacity.

9.3.1.5.8 Australian Bustard

The Australian Bustard (*Ardeotis australis*) is a large ground-dwelling bird that has declined in several regions of the NT. These declines are geographically patchy, driven by intense hunting pressure or fires in certain regions. Northern populations are considered to be large and stable, with no evidence of decline (Garnett *et al.* 2011). The Australian Bustard is common within the MRM leases. It is observed in grassy woodlands and is abundant in modified habitats, such as the MRM Aerodrome and at restoration sites along the re-channelled sections of McArthur River and Barney Creek. These modified environments closely resemble the open grasslands that the species favours. It is highly likely that the species has benefited from the exclusion of cattle and protection from hunting within the MRM leases. The species is known to inhabit the Project footprint.

9.3.1.5.9 Bush Stone-curlew

The Bush Stone-curlew (*Burhinus grallarius*) is a medium-sized, nocturnal, ground-dwelling bird that inhabits open woodlands across much of Australia. Populations in northern Australia are considered to be large and stable with no indication of decline (Garnett *et al.* 2011). The Bush Stone-curlew is an uncommon resident of the MRM leases. It has been recorded in grassy open woodland and grassland north of the NOEF and in restoration sites along the re-channelled section of the McArthur River. Bush Stone-curlews possibly occur widely, at low densities, within the MRM mineral leases. The species is known to inhabit the Project footprint.

9.3.1.5.10 Emu

Emus (*Dromaius novaehollandiae*) are generally scarce within the Borroloola region. They inhabit the MRM leases in very low densities. Despite the species being highly detectable and widely recognised, Emus are only recorded on-site an average of once every three years. Emus are probably absent from the sandstone escarpment areas in the east of the MRM leases and dense riparian forests, but may occur transiently in any of the wooded, grassy plains that constitute more than 60% of the MRM leases. The factors that limit local Emu populations are unknown, but excessively frequent fires are a possible threat.

9.3.1.5.11 Letter-winged Kite

Letter-winged Kites (*Elanus scriptus*) are nocturnal birds of prey that are normally confined to arid habitats within the Lake Eyre Basin. Occasionally, vagrants turn up elsewhere within Australia, usually in response to drought-driven collapse of rodent populations within their normal distribution (Marchant and Higgins 1993). There is a single record in 1967 of a Letter-winged Kite at the mouth of the McArthur River, and a second record (a dead specimen) was obtained in 2013 within the MRM leases in the vicinity of the TSF. The MRM leases do not constitute important habitat for the species, with any records representing non-breeding vagrants.

9.3.1.5.12 Pictorella Mannikin

Pictorella Mannikins (*Heteromunia pectoralis*) are finches inhabiting much of northern Australia. They have a patchy distribution and population sizes fluctuate markedly depending on rainfall. The species occasionally visits in large numbers at Borroloola, with the most recent irruption occurring in 2013 (numerous records exist for this period in the eBird database), a dry year following two years of exceptionally high rainfall in which populations are expected to have expanded. The species has only been recorded on the MRM leases on one occasion, in March 1992 (Hollingsworth Dames and Moore 1992). Small numbers were also recorded at Caranbirini Waterhole, 15 km north of the Project, nine months earlier. These records don't appear to be associated with any unusual rain events. No Pictorella Mannikins have been observed on the MRM leases since 1991, despite over 1,225 hours of avian survey effort, spread across multiple years. This suggests that the 1991 record probably represents a temporary influx rather than being evidence for a small local population. It is unlikely that the MRM leases contain important habitat for the species, although any lowland woodland and forest types (especially vegetation units 5, 6, 7 and 9) may be used in a transient capacity.

9.3.1.5.13 Northern Brown Bandicoot

The Northern Brown Bandicoot (*Isoodon macrourus*) is a scarce resident of the Gulf of Carpentaria, with relatively few recent records from the region, and most of those coming from coastal habitats and offshore islands. There is a single record of the species on the MRM leases, based on a skull found beneath a Wedge-tailed Eagle's (*Aquila audax*) nest in 2013. Wedge-tailed Eagles have large foraging territories, and it is possible that this bandicoot was captured by an eagle further than 50 km from the MRM leases (Brooker and Ridpath 1980). A large amount of trapping effort (1,016 Elliott B trap-nights, 116 cage trap-nights, 538 camera trap-nights and 560 hair funnel nights) within the leases has failed to detect the species there. The species is readily caught using traps and normally triggers remote-sensory cameras. The lack of detection is therefore likely to reflect a genuine absence of the species. If the species were to occur on-site, it could inhabit a wide range of forest, woodland and grassland habitats in lowland areas (vegetation mapping units 3, 5, 6, 7, 8 and 9).

9.3.1.5.14 Spectacled Hare-wallaby

The Spectacled Hare-wallaby (*Lagorchestes conspicillatus*) has a wide distribution across northern Australia, but is scarce in the Borroloola region. It was not recorded by CSIRO (1976) during extensive surveys in the 1970s. It has been recorded on the MRM leases on a few occasions (1992, 2010 and 2016), with all records coming from open woodlands with a dense grassy understorey. One record was of a road-killed specimen along the Carpentaria Highway. Vegetation mapping units 3, 5 and 6 constitute potential habitat for the species on-site.

9.3.1.5.15 Square-tailed Kite

The Square-tailed Kite (*Lophoictinia isura*) has historically been scarce within the McArthur River catchment (Barnard 1914; CSIRO 1976). This bird of prey inhabits a variety of forest and woodland habitats and has large home ranges (exceeding 100 km^2: Marchant and Higgins 1993). The species has been observed within the MRM leases on a small number of occasions, foraging over vegetation mapping units 1 (escarpment woodland) and 8a/9a (riparian forest), as well as modified habitats. All habitats present within the leases are expected to be utilised in a transient capacity. No nest sites have ever been found within the MRM leases, despite extensive surveys in riparian forests, where nests are most likely. Many observations of this species in northern Australia are thought to represent nonbreeding winter migrants from southern states (Marchant and Higgins 1993).

9.3.1.5.16 Purple-crowned Fairy-wren (Gulf)

The subspecies of Purple-crowned Fairy-wren (*Malurus coronatus macgillivrayi*) that inhabits the Gulf of Carpentaria inhabits dense, low riparian vegetation, especially cane grass (*Chionachne cyathopoda*). The subspecies is threatened by loss of habitat due to cattle grazing along rivers and tributaries. Purple-crowned Fairy-wrens are resident within the MRM leases and have benefited from the exclusion of cattle within the MRM cattle fence and mine levee wall (**Appendix X – Terrestrial Ecology Report**). The species has been recorded in 90% of the sites where cattle have been excluded, but there are no recent sightings on downstream sites where cattle continue to graze. A total of 10.6 ha of habitat for Purple-crowned Fairy-wrens exist along the old McArthur River channel within the mine levee wall. Studies of colour-banded individuals indicated that approximately 20 individuals inhabit this area, representing 20% of the fairy-wren population occurring within the MRM leases (**Appendix X – Terrestrial Ecology Report**). These studies also indicated that the population within the mine levee wall is geographically isolated from fairy-wrens inhabiting the remainder of the MRM leases.

9.3.1.5.17 Star Finch

The Star Finch (*Neochmia ruficauda*) inhabits grassy, waterside vegetation in scattered locations across northern Australia (Higgins *et al.* 2006). It has been severely impacted by habitat loss as a result of cattle grazing. Barnard (1914) recorded the species in cane grass habitat along the McArthur River, but the last record of the species from the region was in 1985. Outside of fenced areas in the MRM leases, grazing has led to the large-scale loss of cane grass from the McArthur River catchment. A total of 1,080 hours of bird surveys undertaken in riparian habitats of the MRM leases over the past ten years has failed to detect the species. Given the large-scale loss of habitat and lack of recent sightings, Star Finches are almost certainly locally extinct.

9.3.1.5.18 Northern Nailtail Wallaby

The Northern Nailtail Wallaby (*Onychogalea unguifera*) is an uncommon inhabitant of open eucalypt forest and woodland across northern Australia. It has been recorded three times within the MRM leases, in and near modified habitats (rehabilitation) along the re-channelled section of the McArthur River. The species potentially occurs in other habitats within the leases, such as low and mid-high open woodlands of vegetation mapping units 5 and 6.

9.3.1.5.19 Flock Bronzewing

The Flock Bronzewing (*Phaps histrionica*) inhabits treeless Mitchell Grass (*Astrebla* spp.) plains. It is a relatively common bird on the Barkly Tableland, 170 km south of the Project, but occasionally non-breeding individuals visit outside their usual distribution. A vagrant individual observed close to the MRM accommodation village in the 1970s (CSIRO 1976) is the only record of the species on the MRM lease. The MRM leases do not contain any important habitat for the species.

9.3.1.5.20 Buff-sided Robin

Buff-sided Robins (*Poecilodryas cerviventris*) inhabit dense stream-side vegetation across northern Australia between the Kimberley region and Mount Isa. They are resident in riparian forests within the MRM leases. Within the leases, they are confined to the McArthur River channel, especially where there is tall, dense forest of *Melaleuca leucadendra, Nauclea orientalis, Ficus racemosa, Terminalia platyphylla, Pandanus aquaticus* and *Barringtonia acutangula* (vegetation mapping units 8a, 8b and 9a). On-site, they occur in equal densities in areas within and outside the cattle exclusion area. Two pairs of Buff-sided Robins inhabit 10.6 ha of habitat contained within the mine levee wall. This represents approximately 10% of the total population inhabiting the MRM leases. The MRM population is connected to populations upstream and downstream along the McArthur River.

9.3.1.5.21 King Brown Snake

The King Brown Snake (*Pseudechis australis*) inhabits a broad range of woodland and grassland habitats across northern Australia. It has only been recorded on a single occasion within the MRM leases (CSIRO 1976), prior to the arrival of Cane Toads. King Brown Snakes are vulnerable to lethal effects of Cane Toad toxins (Shine 2010) and it is possible they have become locally extinct since the arrival of toads. The lack of recent records, despite the fact that the species is likely to be reported if observed near mine or accommodation infrastructure, suggests that the local area supports few, if any, of the species.

9.3.1.5.22 Western Chestnut Mouse

Western Chestnut Mice (*Pseudomys nanus*) have a broad distribution across central-northern Australia, where they inhabit the grassy understorey of woodlands and forests. Dense tussock grass growing on lateritic or sandy soils is the preferred habitat (Robinson and Cooper 2013). The species was recorded on the MRM leases in the 1970s (CSIRO 1976), but has not been recorded since. It also appears to have become extinct on the nearby Sir Edward Pellew Islands in the late 1980s (Woinarski *et al.* 2011). A total of 1,980 trap-nights of Elliott A trapping have been undertaken on MRM leases since 1980, which would have been expected detect the species if it remained present on-site.

9.3.1.5.23 Long-haired Rat

Long-haired Rats (*Rattus villosissimus*) inhabit arid plains across much of Australia, favouring isolated pockets of wet habitat around inland lakes and along rivers. Their core distribution is the Barkly Tableland of the NT and the Channel Country of southwestern Queensland and northeastern South Australia. After a series of wet years, populations may expand rapidly and the species may be found at locations in which they are not usually recorded (Robinson and Cooper 2013; CSIRO 1976). Within the MRM leases, Long-haired Rats were collected by CSIRO (1976) in the vicinity of the TSF and the accommodation village. The wet seasons of 1973-74 and 1975-76 brought exceptionally high rainfall to the MRM leases. Additional individuals were captured during surveys in 1992 (Hollingsworth Dames and Moore 1992), which were preceded by average rainfall periods. No further sightings have occurred since 1992, despite the fact that two periods equally as wet as the 1973-1976 event (1999-2004 and 2010-2012) have occurred during this time. Both instances corresponded to fauna trapping on the MRM leases; surveys for the Phase 2 Expansion were undertaken in 2002-2003 and surveys for Phase 3 were undertaken in 2011. It is possible that the MRM mineral leases may support small numbers of the species following successive wet years on the nearby Barkly Tablelands, but it is equally possible that local populations are extinct. The MRM area probably always constituted marginal habitat for the species.

9.3.1.5.24 Orange Leaf-nosed Bat

Orange Leaf-nosed Bats (*Rhinonicteris aurantia*) primarily roost in hot, humid caves and forage in a range of habitats that include monsoon vine forest, open savanna woodland and grassland (Churchill *et al.* 2013). During the wet season, they may temporarily roost in hollow trees or among dense foliage (Churchill *et al.* 2013). The species is infrequently captured in harp traps on the MRM leases, only representing 1.3% of all bat captures. All captures have taken place along minor drainage lines (Barney Creek and Surprise Creek). No caves suitable for roosting are found within the Project area, but may occur in remote areas of the Bukalara Range, immediately east of the MRM leases. Orange Leaf-nosed Bats potentially forage over and within most habitats within the MRM leases.

9.3.1.5.25 Eastern Grass Owl

Eastern Grass Owls inhabit open tussock grasslands in treeless areas across northern and eastern Australia (Higgins 1999). CSIRO (1976) recorded the species at Mallapunyah Springs Station, 75 km southwest of the Project. Mallapunyah Springs Station supports large expansive grasslands like those found on the adjacent Barkly Tableland, and unlike any habitats present on the MRM leases. The species has never been recorded in or near the MRM leases, and it is highly unlikely that any of the habitats present are suitable for the species.

9.3.1.5.26 Astrebla lappacea

Astrebla lappacea (Curly Mitchell Grass) is a common and widespread species across inland eastern Australia. Its distribution extends into eastern NT. It grows in open woodlands and grasslands on heavy clay soils, and its main habitat on-site is VMU 6 (mixed woodland on alluvial back plains).

9.3.1.5.27 Olive Whip Snake

The Olive Whipsnake (*Demansia olivacea*) is listed as Data Deficient under the TPWC Act, primarily because recent taxonomic revisions have resulted in uncertainty over the species' geographic distribution. A single record of the species on the MRM leases in 1992 is of unresolved taxonomy (see **Section 9.3.1.3.5** for a discussion of this species).

9.3.1.5.28 Green Tree Snake

The Green Tree Snake (*Dendrelaphis punctulata*) is a common and widespread reptile inhabiting denser forests across northern and eastern Australia. It is regularly recorded on the MRM leases, especially in riparian forest (vegetation mapping units 7, 8 and 9) along the McArthur River.

9.3.1.5.29 Native Hibiscus

The Native Hibiscus (*Hibiscus setulosus*) is small shrub that is widespread across sub-coastal northern Australia, but has a patchy distribution within the NT. In the vicinity of the Project, it is a widespread but uncommon species along the edge of sandstone escarpments (vegetation mapping unit 1).

9.3.1.5.30 *Sesbania erubescens*

Sesbania erubescens is an annual shrub that grows on seasonally flooded clay soils. It has been recorded from several locations across the northern Australia, and there are several records of the species from the MRM leases and around Borroloola. *Sesbania erubescens* has not been recorded on the MRM leases since 1992, but may have been overlooked by more recent surveys, as it only grows after flooding. Habitat for the species on MRM leases is contained within vegetation mapping unit 6.

9.3.1.5.31 Common Blue-tongued Lizard

The Common Blue-tongued Lizard (*Tiliqua scincoides*) is a widespread skink found across northern and eastern Australia. It is recorded infrequently within the MRM leases (CSIRO 1976; URS 2003), with no records over the past 13 years, despite intense survey effort. It is probably a resident species in very low densities, and may occur in most habitats within the MRM leases.

9.3.1.5.32 Chestnut-backed Button-quail

Confirmed sightings of the Chestnut-backed Buttonquail (*Turnix castanotus*) have never been recorded within the MRM leases, but a specimen was collected from Borroloola in 1913. See **Section 9.3.1.3.8** for further discussion about the species.

9.3.1.5.33 Spotted Tree Monitor

The Spotted Tree Monitor (*Varanus scalaris*) is a widespread species inhabiting open forests across northern Australia. It has never been recorded on the MRM leases, but several individuals were collected in 1976 immediately east of the MRM. It appears to have been a scarce resident of the McArthur River catchment. There were many records across the region in the 1970s, but no Spotted Tree Monitors have been recorded anywhere in the region in the past 30 years. The cause of their disappearance is unknown. Regardless, the MRM leases no longer constitute important habitat for the species.

9.3.1.5.34 Australasian Shoveler

The Australasian Shoveler (*Spatula rhynchotis*) is a nomadic duck found across most of eastern and southwestern Australia. It is a vagrant to the NT. The NT Fauna Atlas lists two records of the species from a point within the MRM leases; however, the precision of these records was only one decimal place of longitude/latitude degrees. This is equivalent to an error of ~11 km, suggesting that the sightings may have occurred outside the leases. The species has never been recorded on the MRM leases over several decades of fauna surveys. Suitable habitat for the species (large, shallow wetlands) is mostly absent.

9.3.2 Aquatic Biodiversity Values

9.3.2.1 Habitats Present

The McArthur River contains freshwater above Borroloola. Between Borroloola and Top Crossing (50 km upstream from the Project), the McArthur River has a well-defined channel with few major tributaries. In the dry season, the river rapidly contracts into a series of pools, separated by stretches of dry, sandy river bed. Some of the pools are maintained year-round by groundwater inflows. However, the vast majority of flow within the McArthur River originates from surface water runoff during the wet season.

Surprise Creek, Emu Creek and Barney Creek flow into the McArthur River within the MRM leases. These creeks are mostly ephemeral, although small spring-fed pools are usually maintained year-round in the upper reaches of Emu Creek and Surprise Creek.

Depending on the location and the time of year, the aquatic habitats present within the McArthur River and its tributaries include riffle zones, waterholes and extensive areas of submerged woody debris. The water can be up to 6 m deep in some of the larger waterholes (**Appendix W – Aquatic Ecology Report**).

9.3.2.2 Overall Aquatic Biodiversity

A total of 47 species of fish have been recorded from freshwaters of the McArthur River above the Burketown Crossing (in Borroloola). Twenty-eight of these are considered to be freshwater species (capable of breeding in freshwater), while the remaining 19 species are estuarine vagrants.

Of the estuarine vagrants recorded within the non-tidal waters of the McArthur River, three belong to the subclass Elasmobranchii (cartilaginous fishes). The Freshwater Whipray (*Himantura dalyensis*) has been recorded close to the Burketown Crossing, near the edge of the tidal influence. Bull Sharks (*Carcharhinus leucas*) and Largetooth Sawfish (*Pristis pristis*) are regularly captured as far upstream as Eight Mile Waterhole. All other species of fish present within the freshwater reaches of the McArthur River belong to the infraclass Teleostei (bony fishes).

The most abundant species of fish within the McArthur River in the vicinity of the Project is the Chequered Rainbowfish (*Melanotaenia splendida inornata*), with Spangled Perch (*Leiopotherapon unicolor*), Macleay's Glassfish (*Ambassis macleayi*), Northwest Glassfish (*Ambassis mulleri*), Barred Grunter (*Amniataba percoides*), Black-banded Gudgeon (*Oxyeleotris selheimi*), Bony Bream (*Nematalosa erebi*) and Tank Goby (*Glossogobius giurus*) also being common.

Fish diversity is generally lower in smaller creeks than in the main river channel, with 16 species recorded in Surprise Creek, 14 species in Barney Creek and 12 species in Emu Creek (**Appendix W – Aquatic Ecology Report**). The species present within the smaller tributaries are regularly recorded throughout the main channel of the McArthur River, with the exception of the Northern Purple-spotted Gudgeon (*Mogurna mogurnda*), which prefers headwaters. Most of the pools within these three creeks are ephemeral, and annual recruitment of these species occurs from the McArthur River.

Surveys of the aquatic macroinvertebrate communities within the MRM leases, undertaken between 2012 and 2016 have detected 64,151 individuals from 81 families. Sludgeworms (Naididae), Small Square-gilled Mayflies (Caenidae), Mayflies (Baetidae), Nonbiting Midges (Chironomidae), Finger-net Caddisflies (Philopotamidae) and Net-spinning Caddisflies (Hydropsychidae) were the most abundant taxa collected (**Appendix W – Aquatic Ecology Report**). The macroinvertebrate communities vary widely depending on the habitat (riffle zone versus edges of pools) and concentrations of metals and sulphates within the water.

Five species of aquatic reptiles have been recorded within freshwater sections of the McArthur River. Three of these, the Arafura File Snake (*Acrochordus arafurae*), Worrells' Short-necked Turtle (*Emydura subglobosa worrelli*) and Freshwater Crocodile (*Crocodylus johnstoni*) are regularly recorded in the McArthur River in the vicinity of the Project. The Estuarine Crocodile (*Crocodylus porosus*) is an occasional visitor to the MRM leases, but is more abundant further downstream. The Northern Snake-necked Turtle (*Chelodina oblonga*) is a scarce resident of the McArthur River catchment, including smaller tributaries such as Barney Creek.

9.3.2.3 Species at or Near the Edge of their Geographic Distribution

The TOR for the preparation of this EIS requires that any impacts of the Project on the geographic distributions of native flora and fauna species are to be assessed. For one aquatic species, the Fly River Garfish (*Zenarchopterus novaeguineae*), the Project lies at or near the western edge of its known geographic distribution. Any impacts to local populations of this species may therefore potentially reduce its geographic distribution. Within the McArthur River, the Fly River Garfish has been recorded immediately upstream of tidal influence (in Borroloola), but at no other survey locations (**Appendix W – Aquatic Ecology Report**). It is likely to be more widespread in estuarine environments within the McArthur River, and is highly unlikely to utilise habitats within the MRM leases.

9.3.2.4 Matters of National Environmental Significance

Three aquatic species that potentially occur within freshwater stretches of the McArthur River are MNES (**Table 9-4**). Two of these are known to occur within the MRM leases, and the third species is unlikely to be present within the McArthur River. Each of these nationally protected species is discussed in detail within **Chapter 10 – Matters of National Significance**.

Table 9-4 Aquatic MNES Potentially Inhabiting the MRM lease

Common Name	Scientific Name	Status, EPBC Act	Local Status
Gulf Snapping Turtle	*Elseya lavarackorum*	Endangered	No habitat present on-site.
Largetooth Sawfish	*Pristis pristis*	Vulnerable, Migratory	Confirmed on-site.
Estuarine Crocodile	*Crocodylus porosus*	Migratory	Confirmed nonbreeding visitor in small numbers.

9.3.2.5 Matters of Northern Territory Environmental Significance

One aquatic species that is known to occur within the McArthur River, the Largetooth Sawfish (*Pristis pristis*), is protected under the Fisheries Act and is listed as Vulnerable under the TPWC Act. It is also a matter of national environmental significance and is discussed in detail within **Chapter 10 – Matters of National Significance**.

No other aquatic species that constitute a matter of NT environmental significance is known to occur, or potentially occurs, within freshwater reaches of the McArthur River.

9.4 Impact Assessment

9.4.1 General Impacts of the Project

The following potential hazards of the Project were assessed with the respect to their potential impact on biodiversity values:

- habitat clearance;
- habitat fragmentation;
- contaminated runoff;
- contaminated ground water;
- draw-down of water tables;
- erosion and sedimentation;
- weeds and pests;
- altered fire regimes;
- collisions with vehicles;
- light and noise; and
- dust.

Each hazard is described in **Sections 9.4.1.1** to **9.4.1.11**. The risks posed to each matter of environmental significance from each hazard are discussed in **Section 9.4.2.**

9.4.1.1 Habitat Clearance

The removal of habitat can reduce the size of local populations of flora and fauna dependent on that habitat. These impacts are immediate and significant in the short term. Impacts may persist in the long term if habitat created during mine rehabilitation does not closely resemble pre-mining ecosystems. In addition, if sufficient habitat refuges are not maintained locally prior to the maturation of rehabilitated land, local extinction of certain species could occur. Given the small percentage of habitat contained within the mineral leases that will be cleared, the latter scenario is highly unlikely.

To accommodate the continued development of the TSF and NOEF, including sites where clay and benign material are sourced, 500.1 ha of remnant vegetation will be cleared. This is almost identical to the amount of vegetation clearing (499.5 ha) approved for Phase 3, implying negligible change to the overall risk posed by this hazard.

The VMUs affected by clearing are listed in **Table 9-5**. Disturbance largely avoids riparian vegetation and escarpment areas that constitute important habitat for several species of conservation significance. The two VMUs that will be most affected by the Project are 5 and 6 (**Table 9-5**). These are the same VMUs that would have been most affected by Phase 3.

Some of the impacts of habitat clearance are likely to persist in the long term. Rehabilitation of the TSF, borrow areas and the NOEF after operations cease will aim to return native flora to these areas. However, these rehabilitation efforts will not commence until 2031-2047, and may have a low likelihood of restoring vegetation communities and habitats to pre-mining conditions (Gould 2011; Cristescu *et al*. 2012).

9.4.1.2 Habitat Fragmentation

In general, highly fragmented habitats support fewer species than connected blocks of habitat of the same total size. Smaller habitat fragments support smaller populations of wildlife, and small, isolated populations are more vulnerable to extinction through stochastic events (Lande 1988; Shaffer 1981). The impacts of habitat fragmentation depend on the degree to which dispersal is inhibited by habitat gaps, the size of the remaining habitat fragments, and ecological attributes of the species.

Habitat fragmentation is a minor hazard of the Project. The proposed disturbance footprint exists within a largely intact matrix of remnant vegetation, allowing ample connectivity between remaining habitats (**Figure 9-5**). The potential for habitat fragmentation of aquatic habitats to arise as a result of local draw-down of the water table is assessed in **Section 9.4.1.5**. The overall risk of this arising as a result of the Project is low.

Table 9-5 Habitats to be Cleared to Accommodate the Project Infrastructure

VMU	VMU subunit	Description	Area: MRM leases (ha)	Area: Phase 3 EIS (ha)	Area: Project Footprint (ha)
1	**Low open woodland to mid high woodland on sandstone escarpments associated with the Bukalara Land System**		**2,249.3**	**0**	**0**
	1a	*Eucalyptus phoenicea* + *Corymbia dichromophloia* +/- *Eucalyptus miniata* +/- *Eucalyptus herbertiana* +/- *Corymbia setosa* low open woodland to mid-high woodland on sandy soils on sandstone escarpment.	2,227.3	0	0
	1b	Mixed species low woodland on remnant sandstone terraces	22.0	0	0
2	**Mixed species low open woodland to mid-high open woodland on stony hills and rises**		**537.1**	**16.2**	**54.5**
	2a	*Terminalia canescens* + *Erythrophleum chlorostachys* low open woodland to mid-high woodland on stony hills and rises	206.3	16.2	53.2
	2b	*Corymbia dichromophloia* + *Eucalyptus phoenicea* +/- *Corymbia setosa* +/- *Erythrophleum chlorostachys* low to mid-high open woodland on rocky hills and rises	89.4	0	0
	2c	*Erythrophleum chlorostachys* + *Corymbia grandiflora* low to mid-high open woodland with mixed tussock grass ground cover on stony rises and hillslopes	228.2	0	1.3
	2d	Low tussock grassland on low hills and rises	13.3	0	0
3	***Melaleuca* spp. low woodland on depositional and poorly drained plains and foot slopes**		**31.9**	**0.4**	**0**
	3a	*Melaleuca viridiflora* low woodland	1.6	0	0
	3b	*Melaleuca citrolens* low woodland	24.8	0.4	0
	3c	*Melaleuca bracteata* low open woodland and closed shrubland	5.5	0	0
4	***Eucalyptus leucophloia* low open woodland and mid-high woodland on hillslopes, scarp-foot slopes and low rises**		**445.3**	**2.9**	**4.1**
	4a	*Eucalyptus leucophloia* low to mid-high open woodland on hillslopes, scarp-foot slopes and plateau	427.0	0	0
	4b	*Eucalyptus leucophloia* low to mid-high open woodland on low rises	18.4	2.9	4.1
5	**Mixed *Corymbia terminalis* +/- *Eucalyptus chlorophylla* +/- *Eucalyptus tectifica* low to mid-high open woodland on plains and hillslopes**		**4,224.9**	**104.6**	**222.0**
	5a	*Eucalyptus tectifica* + *Eucalyptus chlorophylla* mid-high to low woodland with mixed tussock grass ground cover	1,460.7	62.9	152.2
	5b	*Corymbia terminalis* mid-high to low open woodland with mixed tussock grass ground cover	2,727.5	41.7	69.8
	5c	*Eucalyptus pruinosa* low open woodland	36.7	0	0
6	**Mixed *Bauhinia cunninghamii* +/- *Eucalyptus microtheca* +/- *Corymbia bella* low open woodland to mid-high woodland to open forest on alluvial back plains**		**1,881.6**	**290.8**	**199.5**
	6a	*Bauhinia cunninghamii* + *Excoecaria parvifolia* + *Atalaya hemiglauca* low open woodland on alluvial back plains	831.4	184.0	169.6

VMU	VMU subunit	Description	Area: MRM leases (ha)	Area: Phase 3 EIS (ha)	Area: Project Footprint (ha)
	6b	*Eucalyptus microtheca* mid-high open woodland to open forest on alluvial back plains	501.6	106.8	29.9
	6c	Mixed species low to mid-high open woodland on alluvial back plains	548.6	0	
7	**Mixed species low open woodland to mid-high woodland to open forest on alluvial plains and low order stream terraces**		**384.0**	**18.9**	**9.3**
	7a	*Eucalyptus camaldulensis* + *Lophostemon grandiflorus* + *Casuarina cunninghamiana* + *Terminalia platyphylla* riparian mid-high open woodland to open forest on low order streams	265.1	18.9	9.3
	7b	*Corymbia bella* mid-high open woodland to open forest on alluvial plains and creek terraces in the Surprise land System	118.9	0	0
8	***Melaleuca* spp. seasonally inundated riparian woodlands to open forest on major drainage lines**		**177.4**	**17.0**	**4.5**
	8a	*Melaleuca leucadendra* +/- *Eucalyptus camaldulensis* +/- *Casuarina cunninghamiana* +/- *Nauclea orientalis* riparian forest	81.6	17.0	4.5
	8b	*Melaleuca argentea* riparian forest to mid-high woodland on the Bukalara Land System	95.8	0	0
9	**Mixed species woodland and open forest on seasonally inundated river terraces and levees**		**511.3**	**48.7**	**6.2**
	9a	*Corymbia bella* + *Eucalyptus camaldulensis* + *Casuarina cunninghamiana* + *Eucalyptus microtheca* mid-high woodland and open forest on floodplain levees	210.3	48.7	6.2
	9b	*Eucalyptus microtheca* mid-high woodland and open forest on floodplain levees	120.3	0	0
	9c	*Eucalyptus camaldulensis* open forest on floodplain levees	153.0	0	0
	9d	*Erythrophleum chlorostachys* mid-high open woodland on alluvial river terraces	27.7	0	0
10	**Deciduous microphyll vine thicket on dolomitic and sandstone outcrops**		**3.7**	0	0
11	**Modified habitats and existing infrastructure**		**1,706.9**		
	11a	Existing mining infrastructure	1,569.6		
	11b	Restoration areas along re-channelled waterways	137.2		
		Total (ha)	**12,153.5**	**499.5**	**500.1**

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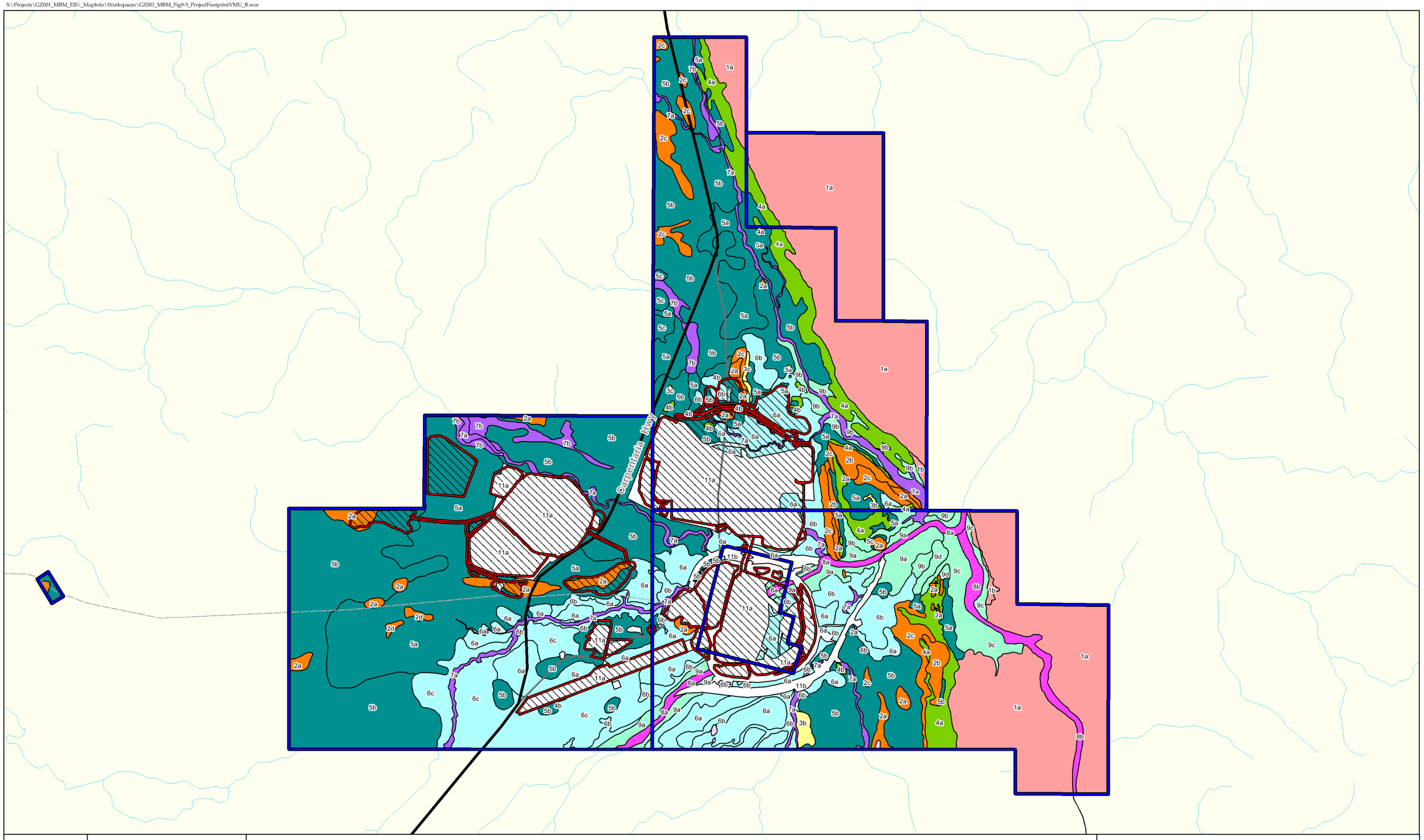

METSERVE
Mining & Energy Technical Services Pty Ltd

McArthur River Mining
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LEGEND

- Watercourse
- Highway
- Road
- Track
- Maximum Project Footprint
- McArthur River Mining Leases

Vegetation Mapping Units

- 1 - Escarpment Woodland/Terraces
- 2 - Mixed Species Low/Mid-High Woodland
- 3 - Melaleuca Low Woodland
- 4 - Snappy Gum Woodland (Hills/Low Rises)
- 5 - Inland Box/Bloodwood Woodland
- 6 - Mixed Species Woodland (Cracking Clays)
- 7 - Mixed Species Woodland (Drainage Lines/ Terraces)
- 8 - Melaleuca Riparian Forest
- 9 - Mixed Species (Alluvial Terraces)
- 10 - Deciduous Microphyll Vine Thicket
- 11 - Existing Infrastructure

Data Source: Vegetation Mapping Units - Glencore (Jan 2017); Tenements, Roads - NT Gov. (2012); Project Footprint - MetServe (Sept 2015); Watercourse - Aust. Gov. (Jun 2006)

McArthur River Mine
Overburden Management Project EIS

The Project Footprint in Relation to Vegetation Mapping Units

1 0 1 2 3
Kilometres
Scale: 1:70,000 (A3)

31/01/2017

Datum: GDA94
Projection: MGA53

FIGURE 9-5

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9.4.1.3 Contaminated Groundwater

Significant McArthur River Mining resources have been allocated to geochemical studies and overburden characterisation since the Phase 3 EIS (**Chapter 6 – Materials Characterisation**). There is a strong understanding of the potential effects of drainage water that comes into contact with reactive overburden as well as an understanding of what is needed to mitigate those effects. The extensive studies have not only facilitated the re-design of overburden storage facilities, but allowed for detailed groundwater models to assess the potential effects of acid and metalliferous drainage, as well as seepage from the TSF, on the quality of groundwater entering local creeks and the McArthur River (**Chapter 8 – Water Resources**). These models predicted that:

- the pH within local waterways is expected to remain neutral due to the extensive buffering qualities (large quantity of carbonates present) of local rock;
- the impacts of seepage are largely confined to lower reaches of Surprise Creek and Barney Creek;
- the principal contaminants expected to be elevated in groundwater entering Barney Creek and Surprise Creek are sulphates and zinc, with slight increases in lead and arsenic also possible;
- the main sources of seepage are the TSF and NOEF;
- the minor and localised seepage impacts associated with the TSF during closure are expected to reduce over the time as the groundwater quality of the area is gradually improved by groundwater recharge;
- the minor and localised NOEF seepage impacts are predicted to persist over the longer term; and
- with appropriate control measures in place, the impact of the Project on surface flows and water quality in receiving waters downstream is expected to be insignificant.

Based on the predictions of these models, the seepage of contaminated groundwater into the McArthur River and its tributaries is unlikely to have a significant impact on biodiversity values. Macroinvertebrate communities within Barney Creek and Surprise Creek are likely to be affected by elevated sulphates and metals (**Appendix W – Aquatic Ecology Report**); however, water quality within the McArthur River downstream of the Project is predicted to be maintained at levels appropriate for maintaining current biodiversity values. The potential impacts of reduced water quality within Barney Creek and Surprise Creek on each biodiversity value are discussed in **Section 9.4.2**.

9.4.1.4 Contaminated Runoff

Careful characterisation of materials and implementation of mitigation measures, including design and operation of runoff dams to capture contaminated surface waters, are required to prevent excessive contaminants from entering local surface waterways.

Runoff, as a source of contamination, was addressed as part of the surface water assessment. With appropriate controls in place (see **Section 9.7**), the impact of the Project on surface flows and water quality in receiving waters downstream is predicted to result in no adverse effects. Potential localised impacts on zinc and sulphate levels in the lower reaches of Barney Creek and Surprise Creek are anticipated.

9.4.1.5 Draw-down of Water Tables

Mining below the water table requires de-watering of the open cut to prevent flooding of the mining operations. Removal of this water from the open cut ultimately lowers the level of the water table, which can affect surface pools that are fed by groundwater. Bores and drains will also be used to extract contaminated groundwater adjacent to the TSF and NOEF, to prevent this water entering local creeks and the McArthur River. This could also act to lower the water table.

Loss of surface pools removes potential drinking sites for terrestrial fauna and could also result in loss of habitat or connectivity of habitat for aquatic fauna.

Detailed models of how the local aquifers are likely to respond to the various changes to groundwater inputs and outputs resulting from the Project (**Appendix T – Groundwater Report**) reveal that the water levels within the re-channelled sections of the McArthur River and Barney Creek closest to the open cut will be reduced. Water levels within Djirrinmini Waterhole, a major pool within the McArthur River adjacent to the open cut, are predicted to drop by 0.7 m. Water levels within the upper reaches of Surprise Creek and Emu Creek (important drinking sites for fauna) are not expected to be affected by the Project (**Appendix T – Groundwater Report**).

The extent of modelled draw-down predicted to result from the Project is very similar to that for the approved Phase 3. This is expected as the open cut geometries are similar. The model predictions imply that impacts on biodiversity values of draw-down are expected to be minor.

9.4.1.6 Erosion and Sedimentation

A lack of vegetation on exposed surfaces such as Overburden Emplacement Facilities (OEFs), dam walls, roads, levees and borrow areas prior to these being rehabilitated could increase the amount of sediment washing into local waterways following heavy rain. Sedimentation of waterways may decrease the size or connectivity of dry season pools, reducing potential drinking sites for terrestrial fauna and extent of habitat, or connectivity of habitat, for aquatic fauna.

Models of surface water quality throughout the duration of the Project reveal that, with various mitigations measures in place, no increase in the amount of total suspended solids is expected to occur within the McArthur River. On the contrary, a slight decrease in the amount of sediment within the McArthur River downstream of the Project is expected after 2060, when the mine pit lake is connected to the McArthur River and acts as a sediment sink.

Overall, with adequate mitigation measures, such as sediment traps, runoff dams and bund walls, erosion of sediment into waterways is considered a low risk to biodiversity values.

9.4.1.7 Weeds and Pests

The Project area has a long history of land disturbance associated with four main factors: grazing of cattle on the McArthur River Station; feral animals including pigs, donkeys and horses; periodic, often severe, disturbance from flood events; and major terrain disturbance from mining.

A total of 31 species of weeds (non-native plants) have been recorded from the MRM leases. Ongoing and integrated weed management is necessary as weeds are continually introduced from upstream, where they are prevalent. McArthur River Mining has a comprehensive weed management plan for the mine site and surrounding area, which is reviewed every three years. The plan identifies high-priority species for control, which include Devil's Claw (*Martynia annua*), Horehound (*Hyptis suaveolens*), Bellyache bush (*Jatropha gossypifolia*), Parkinsonia (*Parkinsonia aculeata*), Noogoora Burr (*Xanthium strumarium*) and Annual Mission Grass (*Cenchrus pedicellatum*).

The weeds that pose the greatest general risk to biodiversity values in northern Australia are exotic grasses that out-compete the native understorey and lead to more frequent and intense fires (TSSC 2009). Introduced grasses are currently scarce within the MRM leases, with Annual Mission Grass being the principal species present that threatens local biodiversity values. Annual Mission Grass is currently confined to the vicinity of mining infrastructure and is one of the priority species targeted by the weed management plan.

The overall potential impact to biodiversity posed by weeds, as a result of the Project, is relatively low. The weed species currently present are confined to areas of regular disturbance (flood-prone river banks and the vicinity of mining infrastructure) and infestations are unlikely to penetrate quickly into undisturbed habitats. This allows ample opportunity to control infestations before these threaten biodiversity values.

There are nine species of feral animals that have been recorded on the MRM leases. Five of these (horse, donkey, cattle, water buffalo and pig) are herbivores that pose a hazard to fauna dependent on dense, grassy understoreys. McArthur River Mining currently manages a 3,391 ha livestock-free fenced area (containing 1,698 ha of remnant vegetation) surrounding active operations in accordance with a Cattle Management Plan. Fences are checked every two weeks and intruding cattle are surveyed via helicopter at least quarterly. This cattle-free area will be enlarged to 4,314 ha (containing 2,607 ha of remnant vegetation) to accommodate the Project. This will result in an additional 909 ha of cattle-free habitat. As a result, the Project is expected to reduce the potential impacts posed by grazing feral animals on biodiversity values.

Predation by Feral Cats (*Felis catus*) represents a hazard to many species of fauna. No actions proposed as part of the Project are expected to result in the proliferation of this species.

The Cane Toad (*Rhinella marina*) is a threat to certain fauna that are poisoned after attempting to consume them. The Project will create new surface water, in the form of sediment traps and runoff dams, which provide potential new breeding sites for Cane Toads. However, due to elevated sulphate concentrations in runoff and seepage, the electrical conductivity of the waters collected in runoff dams is probably unfavourable for Cane Toads. Adult Cane Toads can tolerate water that is up to 40% seawater (Liggins and Grigg 1985), equivalent to an electrical conductivity of approximately 21,200 microSiemens per centimetre (μS/cm). Cane Toad eggs, however, do not develop in water that is more than 15% seawater (Ely 1944), equivalent to an electrical conductivity of 8,200 μS/cm. The electrical conductivity of water stored within runoff dams at the MRM varies between 4,000-16,000 μS/cm, with a median of approximately 8,500 μS/cm. This is likely to be slightly too saline for Cane Toads to utilise for breeding. Furthermore, while sediment basins may provide new breeding sites for Cane Toads, the Project proposes a reduction in the number from nineteen to six, compared to the approved Phase 3. Overall, the hazard posed by the Project to native fauna through its effect on Cane Toads is negligible.

The ninth feral species present on-site, the Asian House Gecko (*Hemidactylus frenatus*), is not considered a threat to any biodiversity values.

9.4.1.8 Altered Fire Regimes

Most Australian vegetation types experience regular fires, and fire is important for maintaining structural attributes of vegetation, as well as facilitating seed germination of certain species (Catling *et al.* 2001; Masters 1993). Effects of fire have been the focus of a substantial amount of research in northern Australia in recent years (Woinarski *et al.* 2004a; Woinarski *et al.* 2004b; Andersen and Hoffman 2011). This research has focused specifically on the effect of fire-frequency, timing and severity on wildlife and habitat within savannas and eucalypt woodlands. Fires of inappropriate intensity or timing can have detrimental impacts on native flora and fauna by:

- removing fallen timber and low vegetation used as shelter;
- reducing the density or extent of fire-sensitive flora;
- temporarily removing seeds, insects and other foods used by fauna;
- leading to vegetation 'thickening', the unnatural increase in mid-storey vegetation cover in response to infrequent fires, resulting in a decrease in understorey density and diversity; and
- causing direct mortality to slow-moving fauna.

Inappropriate fire regimes are a likely contributor to the local extinction of several local fauna (Carpentarian Grasswren [*Amytornis dorotheae*], Western Chestnut Mouse [*Pseudomys nanus*], Northern Brown Bandicoot [*Isoodon macrourus*], Partridge Pigeon [*Geophaps smithii smithii*], Northern Quoll [*Dasyurus hallucatus*] and Masked Owl [*Tyto novaehollandiae kimberli*]). Other species still present in the local area—for example, the Gouldian Finch (*Erythrura gouldiae*)—are also susceptible to frequent or intense fires, as this reduces the density of key food grasses (AWC 2009).

The Project is not expected to cause substantial changes to local fire regimes. New roads may act as fire breaks that reduce the scale of fires, preserving biodiversity values. McArthur River Mining manages fire on-site through a Fire Management Plan. The objectives of this plan do not currently include improving habitat value for wildlife. Revising this plan offers scope for providing benefits to biodiversity values via the Project.

9.4.1.9 Collisions with Vehicles

Slow-moving or easily startled fauna (e.g., mammals, reptiles, amphibians and ground-dwelling birds) are at increased risk of collision with vehicles when the amount of traffic increases. The three infrastructure domains, between which most traffic occurs, are clustered in close proximity (<2 km) to each other. This reduces the overall risk to wildlife of colliding with vehicles. No fauna of NT environmental significance that are susceptible to collisions with vehicles have important populations in habitats located along the proposed road corridors. The amount of overall traffic associated with the Project is not higher than that approved for Phase 3.

9.4.1.10 Light and Noise

The effects of noise on fauna are variable, depending on its regularity and duration. Ecological effects vary between species, although many species are able to adapt to increased levels of noise and vibration. While animals are likely to be disturbed and potentially have panicked reactions to loud, novel sounds (Fletcher and Busnel 1978), repeated exposure to loud sounds (such as mine blasting or 'bird scare guns') can be tolerated by most species (Welch and Welch 1970). Nevertheless, many species avoid feeding and reproducing close to ongoing disturbances such as roads (Arevalo and Newhard 2011; McClure *et al.* 2013), and others may have reduced reproductive success close (e.g., within 40 m) to disturbances (Holm and Laursen 2011; Kight *et al.* 2012; Dietz *et al.* 2013).

Artificial lighting can impact fauna through interfering with the navigation of nocturnal species (Howell *et al.* 1954; Salmon *et al.* 1995; Poot *et al.* 2008; Longcore *et al.* 2012), interrupting natural patterns of sleep and cell repair (Ben-Shlomo and Kyriacou 2010), exposing nocturnal prey to elevated predation risks (Baker and Richardson 2006; Rotics *et al.* 2011; Davies *et al.* 2012), disturbing the timing of daily activities (Miller 2006; Kempenaers *et al.* 2010), and leading to long-term declines in insect populations (Conrad *et al.* 2006). Artificial lighting may also interfere with photosynthesis (Roman *et al.* 2000) and flower development in plants (Wang *et al.* 2003).

The ecological impacts of light and noise are typically restricted to the close proximity (<100 m) of operational areas. The risk posed to matters of environmental significance from lighting and noise will not increase above that approved for Phase 3.

9.4.1.11 Dust

Earthworks and vehicular traffic associated with mining can generate substantial amounts of dust during dry weather. Dust settling on leaves of nearby plants reduces the amount of light reaching photosynthetic pigments within the leaf, and increases leaf temperature due to changed surface optical properties (Eller 1977; Thompson *et al.* 1984; Farmer 1993).

The significance of dust as an impact on the health and reproduction of native flora is poorly studied. Most research into the impacts of dust on vegetation has been undertaken in the temperate regions of the Northern Hemisphere. The pronounced wet and dry seasons in northern Australia may make vegetation in these areas less susceptible to the impacts of dust. This is because most or all annual growth occurs during a period of the year when rainfall is highest. This coincides with the time of year when dust is least problematic, as rain inhibits the dispersal of dust in the air, and washes deposited particles from leaves. The impacts of dust on vegetation vary according to distance from the source, as vegetation acts as a barrier to dust movement. The effectiveness of this barrier varies with wind speed, topography, vegetation density and leaf shape (Tiwary *et al.* 2005). Studies suggest that most dust settles within vegetation in the first 25m from the source (Cowherd *et al.* 2006; Zhu *et al.* 2010). Dust decreases exponentially away from the source (Zhu *et al.* 2010).

Dust can also affect fauna when it contains high concentrations of metals such as lead, which is toxic in moderate doses. Lead-rich dust is a hazard in the vicinity of the processing area, open cut and NOEF, as well as haul roads between these areas (**Chapter 13 – Air Quality**). These highly disturbed sites are unlikely to support species of conservation significance. Lead-rich dust from trucks using the main haul road contaminated Barney Creek in the past (**Appendix W – Aquatic Ecology Report**). This contamination was detected via regular water quality testing and successful remediation was undertaken. Such localised incidents could potentially reoccur in the future. Regular monitoring is required to allow any contamination to be remediated before it enters the McArthur River, where lead, for example, could accumulate in the tissues of aquatic fauna and sediment. Ongoing monitoring of lead concentrations in fish tissues suggests that early remediation of localised contamination is highly effective at preventing widespread contamination (**Appendix W – Aquatic Ecology Report**).

9.4.2 Potential Impacts to Biodiversity Values

9.4.2.1 Matters of National Environmental Significance

The potential impacts of the Project on MNES are assessed in detail within **Chapter 10 – Matters of National Environmental Significance**. Any species listed as threatened under the TPWC Act that do not constitute MNES are assessed in the following sections.

9.4.2.2 Grey Falcon

The MRM is unlikely to constitute important habitat for the Grey Falcon, and the species is best considered an occasional, transient visitor from arid habitats further south. The principal hazard posed by the Project for the Grey Falcon is the loss of 500.1 ha of remnant vegetation, which is marginal habitat for the species, contained within the NOEF and the borrow areas. The scale of this habitat loss is almost identical to that proposed for Phase 3 (499.5 ha of disturbance). The Project is not expected to have any effect on the conservation status of the Grey Falcon or the viability of the local population.

9.4.2.3 Northern Leaf-nosed Bat

It is unlikely that the Northern Leaf-nosed Bat occurs within the MRM leases given the absence of local records despite extensive survey effort and relatively high detectability (see **Section 9.3.1.5.2**). The risk of the Project impacting the species is therefore low. In the event that the species does occur in the local region, impacts to the species are expected to be negligible as no sandstone escarpment areas (the favoured habitat and the location of roost sites) will be disturbed.

9.4.2.4 Mertens' Water Monitor

The principal threat to the Mertens' Water Monitor is lethality after ingestion of Cane Toads. Therefore, any action that increases the prevalence of Cane Toads on-site could impact the Mertens' Water Monitor. The Project will create new surface water, in the form of sediment basins and runoff dams, which may provide potential new breeding sites for Cane Toads. However, runoff dams are likely to be too saline for Cane Toads to utilise for breeding (**Section 9.4.1.7**), and the number of sediment basins will be reduced from nineteen to six, compared with Phase 3.

Another potential impact posed by the Project to the Mertens' Water Monitor is a reduction in the monitor's riparian habitat (vegetation mapping units 7 and 8) to accommodate mine infrastructure. The mine footprint was largely designed to avoid riparian areas, with only 13.8 ha (2.3% of that contained within the MRM leases) of habitat to be cleared. The approved Phase 3 would have disturbed 2.6 times more riparian habitat (35.9 ha), suggesting that there has been a net reduction in risk to the Mertens' Water Monitor of habitat loss due to the Project. The loss of 13.8 ha of habitat is negligible in the context of habitat availability in the broader region.

Any loss of surface water due to sedimentation or water table draw-down could reduce foraging habitat for this semi-aquatic species. Surface water models suggest that a slight decrease in the amount of sediment within the McArthur River downstream of the Project is expected after 2060, when the mine pit lake is connected to the McArthur River and acts as a sediment sink. This implies that existing pools are unlikely to be lost through sedimentation. In contrast, pools within the McArthur River channel immediately adjacent to the open cut are predicted to be lowered by approximately 0.7 m due to draw-down of the water table. This will slightly reduce the area of these pools, but not affect the overall number. Significant impacts to the Mertens' Water Monitor are not anticipated as a result of draw-down.

Another potential impact posed by the Project to the Mertens' Water Monitor is the potential for contaminated groundwater or runoff to enter the McArthur River system and deteriorate the water quality of this system to the point that it is uninhabitable by the Mertens' Water Monitor or its prey, or causes adverse effects to the monitor or its prey. Mertens' Water Monitors feed on fish, frogs, turtles' eggs, insects and carrion. Groundwater and surface water models predict that levels of sulphates and zinc will be elevated during certain times of the year in the lower reaches of Barney Creek and Surprise Creek (**Chapter 8 – Water Resources**). The maximum concentrations predicted are likely to lower the abundance and diversity of aquatic insects and frogs (**Appendix W – Aquatic Ecology Report**). In contrast, many fish species are known to tolerate the concentrations of sulphates and metals predicted, and continue to occur at sites already affected by mine drainage (**Appendix W – Aquatic Ecology Report**). It is likely that prey populations will be locally reduced within the lower reaches of Barney Creek and Surprise Creek as a result of the Project. However, water quality within the McArthur River downstream from the Project is predicted by surface water models to be favourable for the Mertens' Water Monitor and its prey. Furthermore, it is doubtful that prey abundance currently limits populations of the Mertens' Water Monitor in areas where Cane Toads lead to widespread mortality.

Overall, it is considered that the Project will have a minor impact on the local population of the Mertens' Water Monitor.

9.4.2.5 Mitchell's Water Monitor

Mitchell's Water Monitors inhabit similar habitats to the Mertens' Water Monitor, and are exposed to a similar set of potential impacts as a result of the Project. The potential consequences of the Project on the Mitchell's Water Monitor are identical to those of the Mertens' Water Monitor, but the likelihood of these impacts are lower, in light of the absence of the species in the MRM leases. Mitchell's Water Monitors are, however, known to inhabit nearby drainage systems that flow into the lower McArthur River. The principal hazard posed to the species is, therefore, contamination of downstream waters by mine-affected groundwater or surface runoff. Surface water models predict that this is unlikely to occur.

9.4.2.6 Floodplain Monitor

Although the Floodplain Monitor is exposed to a similar suite of hazards to the Mertens' Water Monitor and Mitchell's Water Monitor, its diet consists predominately of terrestrial vertebrates and insects. The principal hazard posed by the Project to the Floodplain Monitor is proliferation of Cane Toads. As discussed in **Section 9.4.2.4**, the Project will reduce the amount of new sediment basins (potential breeding sites for toads), compared to that approved under the previous Phase 3.

A total of 441.5 ha of potential habitat for the Floodplain Monitor will be removed for the Project, which constitutes 6.1% of the habitat within the MRM leases. The extent of clearing is less than the amount approved to be cleared for Phase 3 (480.4 ha).

9.4.2.7 Near Threatened Species

Of the 20 species listed as Near Threatened under the TPWC Act that are not also MNES, the following five species are considered locally extinct within the MRM leases, and will not be impacted by the Project:

- Northern Brown Bandicoot;
- Star Finch;
- King Brown Snake;
- Western Chestnut Mouse; and
- Eastern Grass Owl.

An additional six Near Threatened species are considered occasional vagrants to the MRM leases, and are not normally present on-site. Any habitats of the following species that are impacted by the Project are unimportant for the viability of populations, and will not be considered further:

- Australian Reed-warbler;
- Pale-vented Bush-hen;
- Letter-winged Kite;
- Pictorella Mannikin;
- Flock Bronzewing; and
- Long-haired Rat.

The remaining nine species that constitute Near Threatened species under the TPWC Act maintain permanent populations within, or are regular visitors to, the MRM leases. While these are not threatened species, and therefore lack the level of protection afforded to species discussed in **Sections 9.4.2.1** to **9.4.2.6**, the TOR for the preparation of the EIS state that an environmental objective of the EIS process is "to maintain the conservation status…of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts". This is also in line with MRM's closure objectives. Because these species have the potential to be elevated to a threatened conservation status if populations decline further, potential impacts to each species are discussed below.

9.4.2.7.1 Australian Bustard

The principal impact to Australian Bustards predicted to arise as a result of the Project is the loss of 425.6 ha of open grasslands and woodland (vegetation mapping units 3, 4, 5 and 6). This represents 6.5% of the habitat present within the MRM, and is slightly more habitat loss than would have occurred as part of Phase 3 (398.7 ha).

Other effects of the Project will generally have a positive outcome for Australian Bustards:

- The expansion of the cattle exclusion zone to include 909 ha of additional remnant vegetation will improve the condition of local grasslands used as foraging and nesting habitat by the species.
- The species currently favours open, disturbed sites such as the aerodrome and restoration sites along the re-channelled sections of McArthur River and Barney Creek. Australian Bustards are expected to rapidly colonise newly rehabilitated sites following decommissioning of the TSF and borrow areas.

Local populations of the Australian Bustard are large and stable and any short-term loss of habitat is likely to be offset in the long term by cattle removal and creation of open, grassy rehabilitated sites. The Project is not expected to increase the likelihood that the Australian Bustard qualifies for a 'threatened' conservation status in the future.

9.4.2.7.2 Bush Stone-curlew

The Bush Stone-curlew overlaps extensively with the Australian Bustard in its habitat preferences and predicted risks of impact. Like the bustard, Bush Stone-curlews will lose 425.6 ha of habitat as a result of the Project, but will benefit from the creation of open, grassy rehabilitated sites that are favoured for foraging, as well as the exclusion of cattle from 909 ha of additional woodlands. Like the Australian Bustard, northern populations of the Bush Stone-curlew are relatively large and stable, and the Project is not expected to increase the likelihood that the Bush Stone-curlew qualifies for a 'threatened' conservation status in the future.

9.4.2.7.3 Emu

On the MRM leases, Emus are less common than Australian Bustards and Bush Stone-curlews, and less often utilise modified landscapes. Nevertheless, the impacts to the species are similar. A total of 427.7 ha of potential habitat (vegetation mapping units 2d, 5, 6, 7b and 9) will be cleared, which represents 6.3% of the habitat present within the MRM leases. This is less habitat loss than would have occurred as part of Phase 3 (444.1 ha).

Emus are expected to benefit from the extension of the cattle exclusion area by 909 ha, as most recent observations of the species have come from within the existing cattle exclusion zone (**Appendix X – Terrestrial Ecology Report**).

The broad distribution of Emus across the NT and the low relative importance of local populations or habitats suggest that the Project is not expected to increase the likelihood that the Emu qualifies for a 'threatened' conservation status in the future.

9.4.2.7.4 Spectacled Hare-wallaby

Spectacled Hare-wallabies will experience a loss of 421.5 ha of open grassy woodland (vegetation mapping units 3, 5 and 6) habitat, comprising 6.9% of the total habitat present within the MRM leases. This is a slight increase in habitat loss, compared with Phase 3 (395.8 ha).

Spectacled Hare-wallabies are highly vulnerable to predation from predators, and are therefore dependent on dense understorey vegetation for protection. The exclusion of cattle from 909 ha of additional woodlands will lead to extensive increases in the amount of grass cover important for the species.

Spectacled Hare-wallabies are vulnerable to collisions with vehicles, and increased traffic through important habitat may elevate the risk of this hazard. The main increase in traffic expected to occur as a result of the Project is between the open cut domain and the NOEF domain. These are located adjacent to each other, and no habitat for Spectacled Hare-wallabies is contained along the connecting haul road. The Project requires more borrow areas than Phase 3, and increased traffic is therefore expected between the borrow areas and the destinations for the benign capping material being extracted. These borrow areas are to be constructed adjacent to these destinations (the TSF and NOEF have separate borrow areas associated with these), reducing the amount of total traffic, and therefore risk to the Spectacled Hare-wallaby. Traffic elsewhere within the MRM leases is not expected to be substantially increased above what would have occurred as part of Phase 3.

The net impact to the Spectacled Hare-wallaby from loss of habitat quantity, but gain in quality through cattle exclusion, is negligible. The Project is not expected to increase the likelihood that the Spectacled Hare-wallaby qualifies for a 'threatened' conservation status in the future.

9.4.2.7.5 Square-tailed Kite

Square-tailed Kites are scarce visitors to the MRM leases, where they occupy a broad range of habitats (vegetation mapping units 1, 2, 4, 5, 6, 7, 8 and 9). A total of 500.1 ha of potential habitat will be cleared for the Project, which is 4.8% of the habitat within the leases and almost identical to that which would have been lost through Phase 3 (499.1 ha).

Square-tailed Kites occupy large home ranges (approximately 100 km^2: Marchant and Higgins 1993), and the habitat loss due to the Project constitutes 5% of an average home range. This is unlikely to compromise the habitat quality within such a home range, given the largely intact (uncleared) state of vegetation across the region.

Other hazards posed by the Project (see **Section 9.4.1**) are expected to have a negligible impact on the Square-tailed Kite.

9.4.2.7.6 Purple-crowned Fairy-wren

The Purple-crowned Fairy-wren will experience a loss of 10.6 ha of riparian habitat (vegetation mapping unit 8a, 8b and 9a) that occurs along the old McArthur River channel within the designated open cut. This is the same extent of impact that would have occurred for Phase 3. This site currently supports an estimated 20 individual fairy-wrens, which comprises 20% of the local Purple-crowned Fairy-wren population (**Appendix X – Terrestrial Ecology Report**). The habitat patch to be removed is currently isolated from other suitable habitat by the mine levee wall, which banding studies have confirmed is a barrier to the movements of Purple-crowned Fairy-wrens (**Appendix X – Terrestrial Ecology Report**).

In addition to the direct impact of habitat clearing, the small area of habitat that will remain within the mine levee wall (5.5 ha), isolated from other habitat, will likely become inviable. For this reason, the total loss of habitat is more accurately estimated to be 16.1 ha.

Large-scale reductions in Purple-crowned Fairy-wren populations have occurred across the local region outside the cattle exclusion areas on the MRM leases. The species is dependent on the dense growth of Cane Grass (*Chionachne cyathopoda*) and other riparian vegetation, which is removed by cattle and other livestock. Cattle grazing is the main threat to the species globally and locally. The Project will involve the expansion of the existing cattle exclusion area by 909 ha of remnant vegetation, including 22 ha of newly protected habitat for Purple-crowned Fairy-wrens.

9.4.2.7.7 Northern Nailtail Wallaby

The Northern Nailtail Wallaby will lose 474.7 ha of habitat (vegetation mapping units 2a, 3, 5, 6 and rehabilitated sites), which constitutes 7.4% of the habitat present within the MRM leases. This is slightly more than the loss that would have been incurred as a result of Phase 3 (412 ha).

Northern Nailtail Wallabies are dependent on dense understorey vegetation for protection from predators. The exclusion of cattle from 909 ha of additional woodlands will lead to extensive increases in the amount of grass cover important for the species.

Northern Nailtail Wallabies are vulnerable to collisions with vehicles, and increased traffic through important habitat may elevate the risk of this hazard. The main increase in traffic expected to occur as a result of the Project is between the open cut domain and the NOEF domain. These are located adjacent to each other, minimising exposure of wallabies to traffic. The Project requires more borrow areas than Phase 3, and increased traffic is therefore expected between the borrow areas and the destinations for the benign capping material being extracted. These borrow areas are to be constructed adjacent to these destinations (the TSF and NOEF have separate borrow areas associated with these), reducing the amount of total traffic, and therefore risk to the Northern Nailtail Wallaby. Traffic elsewhere within the MRM leases is not expected to be substantially increased above what would have occurred as part of Phase 3.

The net impact to the Northern Nailtail Wallaby from loss of habitat quantity, but gain in quality through cattle exclusion, is negligible. The Project is not expected to increase the likelihood that the Northern Nailtail Wallaby qualifies for a 'threatened' conservation status in the future.

9.4.2.7.8 Buff-sided Robin

Buff-sided Robins will lose 10.7 ha of riparian habitat, which currently supports two pairs. Unlike Purple-crowned Fairy-wrens, Buff-sided Robins appear unaffected by grazing (**Appendix X – Terrestrial Ecology Report**) and are therefore more widely distributed beyond the boundaries of the cattle exclusion area. The habitat loss to be experienced by the species constitutes 2.7% of the available habitat within the MRM leases. This is unlikely to affect the viability of the local population or the likelihood that the Buff-sided Robin qualifies for a 'threatened' conservation status in the future. The habitat loss that will result from the Project is substantially less than would have occurred for Phase 3 (65.7 ha).

Buff-sided Robins do not occur along Barney Creek or Surprise Creek, where localised impacts of mine seepage are predicted to occur. Surface water models predict that water quality within the McArthur River will not deteriorate substantially as a result of the Project, suggesting that key habitats for the Buff-sided Robin are unlikely to be affected by contaminated groundwater or surface runoff.

9.4.2.7.9 Orange Leaf-nosed Bat

The distribution of Orange Leaf-nosed Bats is thought to be limited by the availability of suitable large, humid caves as roost sites (Armstrong 2001). It is unlikely that any roosts exist within the voids created by previous underground operations on-site for two reasons. First, the species is highly sensitive to disturbance, and the regular blasting activity and heavy traffic experienced at the open cut (where old shafts are located) is likely to deter Orange Leaf-nosed Bats (Department of the Environment 2017). Secondly, most records of the species on the MRM leases occur in the humid summer months. The species travels further from its cave roost sites in humid weather (Churchill 1991), and a paucity of records in the drier months implies that important cave roosts are unlikely to be near the mining operations. It is likely that roost sites for this species occur in caves within the Glyde River Gorge or elsewhere within the Bukalara Range. No disturbance of these sites is anticipated to occur as a result of the Project.

A total of 445.6 ha of potential foraging habitat (vegetation mapping units 4, 5, 6, 7a, 8 and 9) will be cleared for the Project, constituting 5.9% of the total habitat present within the MRM leases. This amount of habitat clearing is slightly less than would have occurred as a result of Phase 3 (482.9 ha). It is unlikely that the extent of foraging habitat limits local populations of Orange Leaf-nosed Bats, given their broad habitat preferences and abundance of intact (uncleared) vegetation across the local region.

The species has been captured along Barney Creek and Surprise Creek, although it is unlikely to be dependent on water sources in these tributaries for drinking. In fact, the species is not known to drink (Department of the Environment 2017).

9.4.2.8 Data Deficient Species

Of the eight species listed as Data Deficient under the TPWC Act that are not also MNES, four species are rarely reported within the MRM leases and local habitats are considered marginal. The Project is therefore unlikely to remove important habitats for these species:

- Olive Whip Snake;
- Common Blue-tongued Lizard;
- Chestnut-backed Buttonquail; and
- Spotted Tree Monitor.

A fifth Data Deficient species, the Native Hibiscus (*Hibiscus setulosus*), is confined to sandstone escarpments within the Bukalara Range, far removed from potential impacts of the Project.

The remaining three species that constitute Data Deficient species under the TPWC Act maintain permanent populations within, or are regular visitors to, the MRM leases. While these are not threatened species, and therefore lack the level of protection afforded to species discussed in **Sections 9.4.2.1** to **9.4.2.6**, the TOR for the preparation of the EIS states that an environmental objective of the EIS process is "to maintain the conservation status…of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts." Because these species have the potential to be classed in a threatened conservation status if additional data suggest populations have declined, potential impacts to each species are discussed below.

9.4.2.8.1 *Astrebla lappacea*

A total of 199.5 ha of habitat for *Astrebla lappacea* (Curly Mitchell Grass) (vegetation mapping unit 6) will be removed for the Project. This is 10.6% of the total habitat contained within the MRM leases, and significantly less disturbance than would have occurred as a result of Phase 3 (290.8 ha). The species is widespread locally, and populations are unlikely to experience loss of viability as a result of the Project.

9.4.2.8.2 Green Tree Snake

Only 20 ha of riparian forests, inhabited by the Green Tree Snake, will be removed for the Project. This is less than 1.9% of the total habitat contained within the MRM leases and is less than one quarter of the amount of habitat that would have been removed for Phase 3 (84.6 ha).

The threat posed to Green Tree Snakes by the proliferation of Cane Toads is unknown but is probably small. On the one hand, Green Tree Snakes are considered to be a high-risk taxon, given that their natural diet is predominantly frogs and they are susceptible to Cane Toad toxin (Phillips *et al.* 2003). However, Green Tree Snakes remain common within the MRM leases, as they are throughout coastal Queensland where they have coexisted with Cane Toads for many decades.

The risk posed to the Green Tree Snake by other hazards assessed in **Section 9.4.1** is negligible.

9.4.2.8.3 *Sesbania erubescens*

A total of 199.5 ha of habitat for *Sesbania erubescens* (vegetation mapping unit 6) will be removed for the Project. This is 10.6% of the total habitat contained within the MRM leases, and significantly less disturbance than would have occurred as a result of Phase 3 (290.8 ha). There are numerous records from the broader Borroloola region, and the conservation status of the species is unlikely to be affected by the Project.

9.4.2.9 Species at or Near the Edge of their Geographic Distribution

The vast majority of species for which the MRM mineral leases lay at or near the edge of their geographic distribution are confined to, or favour, sandstone escarpments that lie outside the disturbance footprint of the Project. The following 14 species are therefore unlikely to experience any impacts as a result of the Project:

- Rockhole Frog;
- Clawless Gecko;
- Hosmer's Skink;
- *Acacia latescens*;
- *Gomphrena floribunda*;
- *Cleome microaustralica*;
- *Eriocaulon patericola*;
- *Euphorbia armstrongiana*;
- *Leptosema villosum*;
- *Myriophyllum callitrichoides*;
- *Mitrasacme glaucescens*;
- *Calytrix achaeta*;
- *Eriachne avenacea*; and
- *Polygala obversa*.

An additional seven species are best considered occasional vagrants to the Project area, or represent likely erroneous records, and will not be affected by the Project:

- Western Hooded Scaly-foot;
- Olive Whipsnake;
- Stubble Quail;
- King Quail;
- Pale-vented Bush-hen;
- Chestnut-backed Buttonquail; and
- *Melhania ovata*.

Three remaining species occupy habitats that will be affected by the Project and occur at the eastern limits of their geographical distribution. The TOR for the preparation of the EIS state that an environmental objective of the EIS process is "to maintain the…geographic distribution…of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts." Because the geographic distributions of these species have the potential to be reduced if the extinction of local populations occurs as a result of the Project, potential impacts to each species are discussed below.

9.4.2.9.1 *Goodenia leiosperma*

A total of 222 ha of potential habitat for *Goodenia leiosperma* (vegetation mapping unit 5) will be removed as a result of the Project. This represents 5.3% of the habitat present within the MRM leases. This minor scale of habitat reduction, coupled with the apparent abundance of the species in the local region (based on numerous specimens collected just outside the MRM leases), suggests that local extinction of this species is an extremely unlikely outcome of the Project.

9.4.2.9.2 *Polygala barbata*

A total of 226.1 ha of potential habitat for *Polygala barbata* (vegetation mapping units 4 and 5) will be removed as a result of the Project. This represents 4.8% of the habitat present within the MRM leases. This minor scale of habitat reduction, coupled with the apparent abundance of the species in the local region (based on numerous specimens collected just outside the MRM leases), suggests that local extinction of this species is an extremely unlikely outcome of the Project.

9.4.2.9.3 *Grevillea decurrens*

A total of 226.1 ha of potential habitat for *Grevillea decurrens* (vegetation mapping units 4 and 5) will be removed as a result of the Project. This represents 4.8% of the habitat present within the MRM leases. No individuals were observed within the designated Project footprint, suggesting that the impacts may be negligible. Local extinction of this species is a highly unlikely outcome of the Project.

9.5 Risk Assessment

The Glencore Corporate Risk Framework was applied to assess the overall risk of the Project to each matter of environmental significance that is not protected under the EPBC Act. This risk framework is summarised in **Table 9-6**. The risk posed by the Project for each matter of environmental significance is listed in **Table 9-7**.

Table 9-6 Glencore Corporate Risk Framework, Adapted for Assessing Risks to MNES

Consequence* of impact	Likelihood of impact				
	Rare	**Unlikely**	**Possible**	**Likely**	**Almost Certain**
	Unlikely to occur during lifetime OR Very unlikely to occur OR No known occurrences	Could occur about once during a lifetime OR More likely NOT to occur than to occur OR Has occurred at least once	Could occur more than once during a lifetime OR As likely to occur as not to occur	May occur about once per year OR More likely to occur than not occur	May occur several times per year OR Expected to occur
Catastrophic Will result in a significant impact as defined by the EPBC Act and will compromise the viability of the global population	**15(M)**	**19(H)**	**22(H)**	**24(H)**	**25(h)**
Major Will result in a significant impact as defined by the EPBC Act and will compromise the viability of the local population	**10(M)**	**14(M)**	**18(H)**	**21(H)**	**23(H)**
Moderate Will result in an impact that may be considered significant under the EPBC Act but will not compromise the viability of the local population	**6(L)**	**9(M)**	**13(M)**	**17(H)**	**20(H)**
Minor Will not result in a significant impact as defined by the EPBC Act and will require minor remediation to prevent long-term damage.	**3(L)**	**5(L)**	**8(M)**	**12(M)**	**16(M)**
Negligible Will not result in a significant impact as defined by the EPBC Act and any impacts will require no remediation to prevent ongoing damage.	**1(L)**	**2(L)**	**4(L)**	**7(M)**	**11(M)**

*The definitions of Consequence classes, as they relate to matters of environmental significance, have been adapted to align the assessment of risks with significant impact guidelines under the EPBC Act. This is in accordance with the request in the TOR that the significance of impacts to matters protected under other legislation such as the TPWC Act is assessed as for matters protected under the EPBC Act.

Table 9-7 Inherent Risks Biodiversity

Species	Scientific Name	Likelihood	Consequence	Overall Risk
THREATENED SPECIES				
Grey Falcon	*Falco hypoleucos*	Unlikely	Negligible	**Low**
Northern Leaf-nosed Bat	*Hipposideros stenotis*	Rare	Negligible	**Low**
Mertens' Water Monitor	*Varanus mertensi*	Likely	Minor	**Medium**
Mitchell's Water Monitor	*Varanus mitchelli*	Unlikely	Minor	**Low**
Floodplain Monitor	*Varanus panoptes*	Possible	Negligible	**Low**
NEAR THREATENED SPECIES				
Australian Reed-warbler	*Acrocephalus australis*	Rare	Negligible	**Low**
Pale-vented Bush-hen	*Amaurornis moluccana*	Rare	Negligible	**Low**
Australian Bustard	*Ardeotis australis*	Almost certain	Minor	**Medium**
Bush Stone-curlew	*Burhinus grallarius*	Almost certain	Minor	**Medium**
Emu	*Dromaius movaehollandiae*	Almost certain	Minor	**Medium**
Letter-winged Kite	*Elanus scriptus*	Unlikely	Negligible	**Low**
Pictorella Mannikin	*Heteromunia pectoralis*	Unlikely	Minor	**Low**
Northern Brown Bandicoot	*Isoodon macrourus*	Unlikely	Minor	**Low**
Spectacled Hare-wallaby	*Lagorchetes conspicillatus*	Almost certain	Minor	**Medium**
Square-tailed Kite	*Lophoictinia isura*	Possible	Negligible	**Low**
Purple-crowned Fairy-wren (Gulf)	*Malurus coronatus macgillivrayi*	Almost certain	Major	**High**
Star Finch	*Noechima ruficauda*	Rare	Minor	**Low**
Northern Nailtail Wallaby	*Onychogalea unguifera*	Almost certain	Minor	**Medium**
Flock Bronzewing	*Phaps histrionica*	Unlikely	Negligible	**Low**
Buff-sided Robin	*Poecilodryas cerviventris*	Almost certain	Minor	**Medium**

Species	Scientific Name	Likelihood	Consequence	Overall Risk
King Brown Snake	*Pseudechis australis*	Unlikely	Minor	Low
Western Chestnut Mouse	*Pseudomys nanus*	Unlikely	Minor	Low
Long-haired Rat	*Rattus villosissimus*	Unlikely	Minor	Low
Orange Leaf-nosed Bat	*Rhinonicteris aurantia*	Likely	Minor	Medium
Eastern Grass Owl	*Tyto longimembris*	Rare	Negligible	Low
DATA DEFICIENT SPECIES				
Curly Mitchell Grass	*Astrebla lappacea*	Likely	Minor	Medium
Olive Whip Snake	*Demansia olivacea*	Unlikely	Minor	Low
Green Tree Snake	*Dendrelaphis punctualata*	Possible	Negligible	Low
Native Hibiscus	*Hibiscus setulosus*	Rare	Negligible	Low
Sesbania	*Sesbania erubescens*	Likely	Minor	Medium
Common Blue-tongued Lizard	*Tiliqua scincoides*	Unlikely	Minor	Low
Chestnut-backed Buttonquail	*Turnix castanotus*	Rare	Minor	Low
Spotted Tree Monitor	*Varanus scalaris*	Unlikely	Minor	Low
SPECIES AT THE EDGE OF THEIR GEOGRAPHIC DISTRIBUTION				
Rockhole Frog	*Litoria meiriana*	Rare	Negligible	Low
Clawless Gecko	*Crenadactylus ocellatus*	Rare	Negligible	Low
Western Hooded Scaly-foot	*Pygopus nigriceps*	Unlikely	Minor	Low
Hosmer's Skink	*Egernia hosmeri*	Rare	Negligible	Low
Olive Whipsnake	*Demansia olivacea*	Unlikely	Minor	Low
Stubble Quail	*Coturnix pectoralis*	Unlikely	Negligible	Low
King Quail	*Synoicus chinensis*	Unlikely	Negligible	Low
	Melhania ovata	Rare	Negligible	Low

Species	Scientific Name	Likelihood	Consequence	Overall Risk
Ball Wattle	*Acacia latescens*	Possible	Negligible	**Low**
	Goodenia leiosperma	Likely	Minor	**Medium**
	Polygala barbata	Likely	Minor	**Medium**
Clothes-peg tree	*Grevillea decurrens*	Unlikely	Minor	**Low**
	Gomphrena floribunda	Rare	Negligible	**Low**
	Cleome microaustralica	Rare	Negligible	**Low**
	Eriocaulon patericola	Rare	Negligible	**Low**
	Euphorbia armstrongiana	Rare	Negligible	**Low**
	Leptosema villosum	Rare	Negligible	**Low**
	Myriophyllum callitrichoides	Rare	Negligible	**Low**
	Mitrasacme glaucescens	Rare	Negligible	**Low**
	Calytrix achaeta	Rare	Negligible	**Low**
	Eriachne avenacea	Rare	Negligible	**Low**
	Polygala obversa	Rare	Negligible	**Low**

9.6 Project Alternatives

A range of alternatives were considered for each of the domains that comprise the Project and these are described in detail in **Chapter 5—Project Alternatives**. How these alternatives compare with respect to their potential impacts on biodiversity values is discussed in the following sections.

9.6.1 Reduced Scale of Project

Reducing the scale of the Project (removing less ore over a shorter time frame) is unlikely to substantially reduce impacts on biodiversity values. Due to the nature of the ore body, large volumes of overburden material need to be removed over the first 10-11 years of the Project life in order to access the economic ore. The safe storage of this overburden material, necessitating the quarrying of benign material from borrow areas, will result in a similar project footprint, regardless of how much ore is removed afterwards.

9.6.2 Alternatives for the Open Cut Domain

Underground mining is not a viable option for accessing several ore bodies to be extracted, and is therefore not considered further. Alternative approaches for the open cut domain relate to the extent to which the open cut is used to store material after processing, and the extent to which water in the mine pit lake interacts with the McArthur River.

At the cessation of mining, the Project plans to dispose of tailings within the open cut. Another alternative proposed previously in the MRM Phase 3 EIS, is to cap the tailings within the existing TSF. The current alternative offers improved outcomes for biodiversity values, especially species dependent on water quality within the McArthur River, as it reduces the risk of contaminants seeping into neighbouring waterways. By returning tailings to the open cut, the areas containing the TSF can be ultimately rehabilitated back to local vegetation communities that support matters of environmental significance. This will reduce the long-term footprint of the project. Maximising the extent of in-pit dumping of material limits the need for external OEFs, reducing the overall footprint of the Project. The geometry of the open cut and the geotechnical properties of the rock preclude large-scale in-pit dumping. The extent of in-pit dumping undertaken in the later stages of the Project is designed to minimise, as far as is practicable, the footprint of external OEFs and the containment of the most reactive material within the void.

A variety of alternatives were considered relating to how much the final mine pit lake should be isolated versus connected to the McArthur River. Water quality within an isolated lake deteriorates over time, such that there is a risk that failure of flood protection levees could cause unacceptable levels of contamination to be released. In contrast, a lake with frequent interaction with the McArthur River via seasonal channels will result in a diffuse release of contaminants and preservation of water quality within the mine pit lake. However, this would expose the lake to extreme flooding events and certain aquatic species may become trapped within the mine pit lake during the dry season. The alternative to be adopted by the Project is an intermediate degree of interaction between the mine pit lake and the McArthur River. This is expected to offer the lowest risks to biodiversity values dependent on water quality downstream from the mine.

9.6.3 Alternatives for the NOEF Domain

Eight footprint and design alternatives were considered when planning the NOEF (see **Chapter 5—Project Alternatives**). Lower heights of the NOEF were considered, but these would have had a larger footprint and required more capping material, both of which would have led to larger impacts on biodiversity values. The optimal slope design of the NOEF was a compromise between ensuring adequate stability and minimising the footprint of the NOEF. Consequently, the overall design of the NOEF adopted by the Project minimises the overall footprint of the Project and therefore the loss of habitat for flora and fauna.

Five cover designs for the NOEF and five cover materials were considered (see **Chapter 5—Project Alternatives**). The alternative adopted by the Project provides the greatest potential for establishing native plant communities and minimising seepage from contaminated water into surface water systems.

9.6.4 Alternatives for the TSF Domain

A range of alternatives were considered for the treatment and disposal of tailings within the TSF domain. Four of the chief considerations when deciding on the alternative were:

- limiting seepage from the reservoirs;
- minimising overall risk of adverse environmental impacts;
- minimising interactions with ground water; and
- minimising the amount of construction material required from external borrow pits.

By reducing the disturbance footprint of the Project and the likelihood of contamination of the McArthur River downstream from the mine, impacts to biodiversity values are minimised by the proposed TSF design.

9.7 Mitigation Measures

For each matter of environmental significance that was deemed to have anything other than a low inherent risk of impact in the risk assessment (**Section 9.5**), management measures are proposed to limit the likelihood or consequences of potential impacts. These mitigation measures are discussed in the following subsections. Groups of species with similar habitat requirements and similar susceptibility to potential impact arising from the Project are assessed together.

The risk matrix presented in **Section 9.5** has been utilised to estimate the residual risk (risks after control measures are implemented), and compare this to the inherent risk (risks without control measures). For each potential impact being mitigated, a likelihood and consequence score is generated, which combine to determine the category of risk (high, medium or low).

9.7.1 Australian Bustard, Bush Stone-curlew, Emu, Spectacled Hare-wallaby and Northern Nailtail Wallaby

The Australian Bustard, Bush Stone-curlew, Emu, Spectacled Hare-wallaby and Northern Nailtail Wallaby are exposed to a similar suite of hazards related to the Project. All inhabit open, grassy woodlands, all benefit from the exclusion of cattle and management of fire to encourage a dense understorey of native grass, and most are at risk of collisions with vehicles. Management measures proposed to mitigate each risk to these species are listed in **Table 9-8**.

9.7.2 Mertens' Water Monitor

The principal threat leading to a decline in the global population of Mertens' Water Monitors is the proliferation of Cane Toads. This and other potential impacts arising as a result of the Project are listed in **Table 9-9**, along with management measures proposed to mitigate each risk.

9.7.3 Purple-crowned Fairy-wren

Loss of habitat through clearing is the principal impact of the Project on the Purple-crowned Fairy-wren. This and other proposed impacts posed by the Project are listed in **Table 9-10**, along with management measures proposed to mitigate each risk

9.7.4 Buff-sided Robin

A small amount of habitat for the Buff-sided Robin (2.7% of that contained within the MRM leases) will be cleared as a result of the Project. Mitigation measures will be in place to ensure that no further losses of habitat are incurred through deterioration of riverside vegetation as a result of declining water quality. These management measures and the expected residual risks for the Buff-sided Robin are listed in **Table 9-11**.

9.7.5 Orange Leaf-nosed Bat

The principal potential impact to the Orange Leaf-nosed Bat posed by the Project is the clearing of potential foraging habitat (**Table 9-12**). This impact is not considered likely to affect the viability of local populations of orange leaf-nosed bats.

9.7.6 *Astrebla lappacea, Sesbania erubescens, Goodenia leiosperma* and *Polygala barbata*

Astrebla lappacea, Sesbania erubescens, Goodenia leiosperma and *Polygala barbata* are all understorey plants exposed to a similar set of potential impacts as part of the Project. They also have a similar level of protection under NT legislation (TPWC Act); they are not threatened species, but either occur at the edge of their geographical distribution or are considered data deficient. They are therefore treated together for the purposes of describing mitigation measures and assessing residual risks.

Table 9-8 Mitigation and Risk Assessment for the Australian Bustard, Bush Stone-curlew, Emu, Spectacled Hare-wallaby and Northern Nailtail Wallaby

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments / Justification
Potential habitat is cleared to accommodate the Project.	- 425.6 ha of potential habitat for the Australian bustard and Bush Stone-curlew will be removed. - 427.7 ha of potential habitat for the Emu will be removed. - 421.5 ha of potential habitat for the Spectacled Hare-wallaby will be removed. - 472.5 ha of the Northern Nailtail Wallaby will be removed.	N/A	Medium	- The cattle exclusion area will be extended by 909 ha, which will result in the creation of new high-quality habitat, with a dense grassy understorey. This extension contains: • 423 ha of additional habitat for the Australian Bustard and Bush Stone-curlew; • 358.3 ha of additional habitat for the Emu; • 416.8 ha of additional habitat for the Spectacled Hare-wallaby; and • 404 ha of additional habitat for the Northern Nailtail Wallaby. - The size of the NOEF, and therefore the extent of habitat removed to accommodate it, was reduced by building it taller than the original design in the Phase 3 EIS. - Rehabilitation of the TSF and NOEF after decommissioning will reintroduce native grasses important as food and/or cover for these five species. Successful establishment of these grasses will be incorporated into rehabilitation completion criteria.	Low	Almost all records of these species within the MRM leases come from in or near the existing cattle exclusion zone, highlighting the importance of removing livestock for enhancing habitat quality. Impacts of grazing can generally be reversed by destocking, provided the level of degradation is not too severe and feral herbivores are managed appropriately (Cheal 2009; Price 2010; Legge *et al.* 2011; Kutt *et al.* 2012).
Rehabilitation of disturbed areas post-operation fails to establish natural understorey communities	- The physical environment in disturbed areas may be unfavourable for native plant establishment. - Weeds can prevent successful re-establishment of native grasses in rehabilitated sites. - The loss of potential habitat persists for longer than expected.	N/A	Medium	- Seed germination rates of local grass species will be considered when designing seed mixes to be applied to rehabilitation sites. - Small-scale trials will be undertaken to determine optimal site preparation and seed mixes for favouring establishment. - Monitoring will investigate the establishment success of these grasses and determine if early intervention is required (weed control, supplementary planting, fertilising).	Medium	Some grasses such as *Triodia* spp. and *Sorghum* spp. can have low seed viability or extended dormancy when used in mine rehabilitation (Farley 2007). This needs to be taken into account during the planning phase of rehabilitation. Invasion of exotic pasture grasses is known to be a major impediment to the establishment of a diverse native plant community on rehabilitated mine sites (Bayliss *et al.* 2006). Prevention of infestation and early control is fundamental to successful rehabilitation. The Australian Bustard, Bush Stone-curlew and Northern Nailtail Wallaby have previously been recorded recolonising rehabilitated sites within the MRM leases.
Increased vehicular traffic leading to increased dust generation.	- Increased levels of dust may settle on the leaves of plants growing along roads and near earthworks. - The growth of plants, important as food or cover, may be impaired. - Increased concentrations of metals such as lead may be deposited on plants eaten by these species.	- The Dust Management Plan is adhered to, which includes ongoing dust monitoring, soil quality testing and contingency for increased management.	Low	- The Dust Management Plan has been revised. - Dust management measures that will be in place to protect human health (**Chapter 13 – Air Quality**) will also reduce the risk to fauna of contact with lead dust.	Low	The annual average lead concentration within the air is predicted to exceed the 0.5 micrograms per cubic metre ($\mu g/m^3$) Australian air quality standard in the vicinity of the processing area (**Appendix Z – Air Quality Report**). However, the vast majority of the MRM leases, including most habitat for the Australian Bustard, Bush Stone-curlew, Emu, Spectacled Hare-wallaby and Northern Nailtail Wallaby, will experience concentrations of lead that are below the Australian standard.
Dewatering of the open cut and contaminated groundwater recovery, leading to loss of drinking sites.	- Pools fed by groundwater are reduced in extent by drawdown of the water table.	- The extent of expected drawdown assessed as part of Phase 3 did not warrant specific mitigation measures. - Ongoing monitoring of the water levels in the McArthur River investigates whether drawdown exceeds predicted levels and whether remedial action is required.	Low	- As the risks of drawdown as a result of the Project are no higher than that assessed under the Phase 3 EIS, no further mitigation measures are warranted. - If monitoring reveals that drawdown threatens the persistence of pools used by fauna, remedial action (enlargement of pools or supplementary watering) will be considered.	Low	The risks of drawdown as a result of the Project are the same as those approved for Phase 3. In the long term, recovery of water levels is predicted to be complete ten years following the flooding of the mine pit lake. Minor loss of water is unlikely to affect these species. The Spectacled Hare-wallaby doesn't drink (Burbidge and Johnson 2008), and the other species are highly mobile and can travel far in search of water.

Table 9-9 Mitigation and Risk Assessment for the Mertens' Water Monitor

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments / Justification
New Cane Toad breeding locations are created.	- Cane Toads may increase in abundance locally, increasing the threat to Mertens' Water Monitors from lethal ingestion.	N/A	Low	- As the Project will create fewer Cane Toad breeding sites than Phase 3, no additional mitigation measures are warranted.	Low	The number of sediment basins to be constructed for the Project is less than that proposed for the Phase 3 EIS.
Potential habitat is cleared to accommodate the Project.	- 13.8 ha of riparian vegetation will be cleared for the Project.	N/A	Medium	- As the negligible amount of habitat loss is substantially less than would have occurred for Phase 3, no additional mitigation measures are considered necessary.	Medium	Phase 3 would have resulted in the removal of 36.3 ha of habitat. The habitat to be removed for the Project is currently geographically isolated from other habitat by the bund wall, and is therefore of little habitat value to the Mertens' Water Monitor.
Increased vehicular traffic leading to increased dust generation	- Increased dust may be deposited into Barney Creek and Surprise Creek. - Increased concentrations of metals such as lead could occur in sediments within the local waterways. - Bioaccumulation of lead could occur within the food chain, having the greatest impact on predatory species such as the Mertens' Water Monitor.	- The Dust Management Plan is adhered to, which includes ongoing dust monitoring and contingency for increased management. - Dust is suppressed using of watercarts. - Water quality and fluvial sediment are monitored monthly at points across the Project to determine metal loads and whether additional management is warranted. - Fish tissues are monitored biannually at numerous sites across the Project to determine whether metals are entering the food chain and whether additional management is warranted. - The McArthur River water quality is monitored downstream at SW11 and site-specific trigger values adhered to. - A previous instance of lead deposition due to dust at the Barney Creek bridge triggered a suite of successful management measures that were targeted towards remediating the specific impacts: • a new sediment trap was installed; • new batters were installed between the haul road and creek; and • mechanical excavation removed contaminated sediment from the creek bed.	Low	- All existing mitigation measures will be maintained. - A new bund and sump will be installed in the lower reaches of Barney Creek (downstream from the Barney Creek bridge) to capture water in low- to moderate-flow seasons prior to this water reaching the McArthur River.	Low	Dust is the most likely means that lead may be introduced to local waterways as a result of the Project. Past studies have demonstrated that existing mitigation measures employed to suppress dust and capture runoff have effectively reduced lead concentrations in fluvial sediments and subsequently fauna (**Appendix W – Aquatic Ecology Report**). The monitoring programs in place have been effective at detecting previous localised incidents of elevated metals, and these programs have also revealed that the remediation efforts employed were highly successful (**Appendix W – Aquatic Ecology Report**). The degree to which the Project will increase risks to the Mertens' Water Monitor over the existing risks inherent in current operations is only slight. Therefore, existing measures are deemed adequate for mitigating risks to Mertens' Water Monitors from contamination of waterways with lead-rich dust.

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments / Justification
Acid mine drainage, arising from reactive material stored within the NOEF, TSF and mine pit lake, entering the McArthur River	- Oxidation of sulphides, when non-benign rock is exposed to air and water, releases metals (principally zinc) and sulphuric acid. Sulphuric acid reacts with the high levels of carbonates in local rock to produce sulphates. - If the metals and sulphates produced by this process leach into groundwater, they may eventually enter the McArthur River and water quality downstream may be affected. - Aquatic insects, fish and frog populations may be affected by reduced water quality, reducing the prey available to Mertens' Water Monitors.	- In-pit grade control of all overburden at the blast block level is undertaken to validate classification prior to load and haul operations. - Potentially reactive material is built in planned lifts at either 2 metres or 7.5 metres with advection barriers and stored without oxygen by encapsulation it within OEFs covered with benign material. - A thin cover of water is used at the TSF, to reduce the mounding of groundwater tables and degree of seepage into local creeks. - Sumps are installed around the TSF and NOEF to collect seepage and pump this to storage dams. - Ongoing monitoring of groundwater and surface water quality investigates whether modelled conditions are accurate and whether further measures are warranted. - The geochemistry of benign rock used as covers on OEFs is monitored monthly to maintain correct overburden placement.	Medium	Measures related to managing the risks of storing non-benign material are discussed in detail within **Chapter 3 – Project Description and Justification** and **Chapter 7 – Project Risk Assessment.** The general approach is similar to existing measures but also includes the following: - Tailings will be removed from the TSF and permanently stored within the open cut, to limit long-term risk. - While the TSF is in operation, ponding of water will be minimised to reduce seepage. Furthermore, tailings densities will be maximised to reduce permeability of the tailings. - The TSF will have improved barrier systems and groundwater recovery - The TSF will be subjected to ongoing bi-annual monitoring of stability, structure, operation and management. - A monitoring program will be implemented to detect concentrations of metals, acids and sulphates in groundwater and surface water that exceed acceptable levels. - There will be some in-pit dumping of non-benign rock. - The final open cut will be filled with a deep cover of water to inhibit oxygen contacting reactive material. - The open cut will be filled rapidly by pumping water from the McArthur River, to reduce the exposure of potentially reactive rock to oxygen. - Connection of the mine pit lake to the McArthur River will deliver an annual inflow of sediment, creating an increasing deep benign layer on the mine pit lake floor above reactive material. - The mine pit lake will be isolated from the McArthur River during the initial period after mining. Acceptable water quality within the mine pit lake will be demonstrated prior to connecting the lake with the McArthur River via levees. - Routine monitoring will determine the mine pit lake water quality and determine whether contingency measures are required, such as water treatment prior to release. - The NOEF design takes into consideration the classes of material being stored, with the most reactive rock being stored at the greatest depths. The entire NOEF will be encapsulated within a compacted clay liner and covered with benign material that acts as a store and release cover. - The NOEF has been carefully designed to manage physical and chemical stability. - Seepage recovery system will include interceptor drains and recovery bores. - There will be ongoing and indefinite monitoring of groundwater bores surrounding the NOEF to detect seepage before it enters the surface water systems. - Sumps will be installed on Barney Creek to intercept contaminated groundwater entering the creek and river systems. - There will be ongoing frequent monitoring of temperature and gases at the NOEF, as well as groundwater and surface water adjacent to the NOEF, TSF and mine pit lake, to detect the signs of unexpected reactivity. - Adaptive management allows for contingency planning and remediation, if high risk material pathways are identified during the life of the NOEF. - There will be a contingency to isolate the mine pit lake from the McArthur River in the event that water quality is compromised by unanticipated chemical reactions within material contained within it.	Low	The materials to be stored within the NOEF and final mine pit lake have been characterised (**Chapter 6 – Materials Characterisation**) and their geochemistry was a principal consideration when designing these storage facilities. The potential for tailings and stored rock to leach metals, acids and sulphates into the McArthur River and smaller tributaries has been the subject of detailed water models (**Chapter 8 – Water Resources**). These indicate that, with the mitigation measures proposed, sulphates and zinc are the only contaminants expected to be elevated above background levels, and even these are not predicted to reach levels damaging to aquatic ecosystems within the McArthur River. Local reductions in the populations of some prey (insects, fish) are predicted to occur within lower Barney Creek and Surprise Creek, but these ephemeral waterways are rarely utilised by Mertens' Water Monitors. Provided the site-specific trigger levels at the water monitoring point SW11 are not exceeded (as models predict), there are negligible anticipated impacts to Mertens' Water Monitor from acid mine drainage.

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments / Justification
Uncontrolled discharge of contaminated surface water into the McArthur River	- Runoff leaving the mine may contain elevated levels of metals and reactive sediments. - Non-benign material that washes into the McArthur River and its tributaries may cause acidification of the waters and the release of metals. - Extreme flood events could cause the uncontrolled release of contaminants within the TSF, runoff dams, sediment traps or the final mine pit lake. - Metals entering the food chain within the McArthur River could affect the health of Mertens' Water Monitors downstream.	Existing controls are described in **Appendix U – Surface Water Report**. These are reviewed in annual Site Water Balances and continuously improved. The existing controls can be summarised as follows: - McArthur River Mining has a waste discharge licence that specifies maximum concentrations of contaminants permitted at the downstream water monitoring point, SW11. - The waste discharge licence conditions are strictly adhered to. This outlines specific discharge locations, various waters that can be discharged and environmental objectives. - Diversions, drains, bunds and levees are used to limit uncontaminated surface water from interacting with the NOEF, open cut, TSF and haul roads. - Dust-containing runoff is collected through numerous silt/sediment traps, and contaminated sediments are periodically removed and transferred to the TSF. - Construction of the TSF, OEFs and the open cut conforms to Australian standards regarding the construction of large dams and storm storage.	Medium	The proposed measures to reduce the risk of contaminated surface waters discharging into the McArthur River are discussed in detail in **Appendix U – Surface Water Report** and **Chapter 8 – Water Resources**. These resemble existing controls, with the following additions: - The updated Water Management Plan will be adhered to. - Prior to any discharge of water, a water quality assessment will take place, which will determine the discharge frequency and rate. - Runoff storage dams and extensions to the TSF will be constructed in accordance with relevant Australian National Committee on Large Dams (ANCOLD) Guidelines including ANCOLD's Guidelines on Tailings Dam Planning, Design, Construction, Operation and Closure (ANCOLD, 2012). - The TSF will adhere to ANCOLD (2012) Extreme Storm Storage and Wet Season Storage Allowance criteria. - A Process Water Dam will be associated with the TSF to capture overflow during storms. The TSF spillway is designed to cope with floods to 1:100,000 Annual Exceedance Probability (AEP) (critical storm duration). - The TSF and runoff dams will be built to conform to the 1:1,000 AEP Max Design Earthquake (MDE) and 1:500 AEP Operating Basis Earthquake (OBE) criteria. - The crests of the spillways of the runoff dams are above the 100 year McArthur River flood level. Spillways are designed to safely pass a 1:2,000 AEP flood event with a 1:10 AEP wind event wave allowance. - There will be ongoing bi-annual monitoring of the stability, structure, operation and management of the TSF. - The Dam Safety Emergency Plan will be adhered to. - During NOEF construction, exposed areas of reactive rock will generate contaminated surface runoff. Numerous drainage channels, sumps and lined (clay or geopolymer) dams will be installed on and surrounding the NOEF to capture runoff. Run off dams capacities set to have a less than 5% probability of exceedance (spill) over the operating life of the dam. - There will be ongoing compliance with the site-specific trigger levels at SW11.	Low	Management of surface water to reduce impacts to the water quality of the McArthur River as a result of the Project has been the central focus of numerous studies and models. These are discussed in **Appendix U – Surface Water Report** and **Chapter 8 – Water Resources**. Detailed surface water models indicate that, with the mitigation measures proposed, sulphates and zinc are the primary contaminants expected to be elevated above background levels within the McArthur River, and even these are not predicted to reach levels damaging to the Mertens' Water Monitor. Provided the site-specific trigger levels at the water monitoring point SW11 are not exceeded (as models predict), there are no anticipated impacts to the Mertens' Water Monitor from uncontrolled discharge.
Mining below groundwater levels leads to drawdown in the adjacent McArthur River	- The size of pools near the open cut, such as Djirrinmini Waterhole and pools within the re-channelled section of the McArthur River, will be reduced in the dry season. - The extent of habitat available to the Mertens' Water Monitor may be reduced.	- The extent of expected drawdown assessed as part of the Phase 3 EIS did not warrant specific mitigation measures. - Ongoing monitoring of the water levels in the McArthur River investigates whether drawdown exceeds predicted levels and whether remedial action is required.	Low	- As the risks of drawdown as a result of the Project are no higher than that assessed under the Phase 3 EIS, no further mitigation measures are warranted. - If monitoring reveals that drawdown threatens the ability of pools to sustain Mertens' Water Monitors, remedial action (enlargement of pools or supplementary watering) will be considered.	Low	The risks of drawdown as a result of the Project are the same as those approved under the Phase 3 EIS. Models predict that the water level within Djirrinmini Waterhole will drop by 0.7 m during the operation phase of the Project (**Appendix T – Groundwater Report**). In the long term, recovery of water levels is predicted to be complete ten years following the flooding of the mine pit lake. Mertens' Water Monitors are highly mobile and can move across dry creek beds to colonise new pools.

Table 9-10 Mitigation and Risk Assessment for the Purple-crowned Fairy-wren

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments / Justification
Potential habitat is cleared to accommodate the Project	- 10.6 ha of habitat will be cleared for the Project. - An additional 5.5 ha of habitat will be rendered inviable due to isolation from other habitat fragments. - The viability of the Purple-crowned Fairy-wren population within the MRM leases may be compromised through the loss of 20% of the already small population.	- 173.4 ha of habitat are contained within a cattle exclusion area, which protects the quality of existing habitat. - Biannual monitoring of fairy-wren populations is undertaken to track long-term changes and determine whether additional measures are required to preserve the long-term viability of local populations.	High	- The cattle exclusion zone will be extended to include an additional 22 ha of habitat for the Purple-crowned Fairy-wren. - Once the newly fenced habitat has been demonstrated to be suitably recovered from grazing, fairy-wrens living within the disturbance footprint will be relocated to the newly fenced areas.	Medium	The potential impacts of the Project are very well characterised, as the exact numbers of individuals present within the disturbance footprint are known from banding studies. The impacts of grazing are also well characterised, through long-term studies of local populations inside and outside the fenced area. There are currently only two pairs of Purple-crowned Fairy-wrens living within the future exclusion zone, due to the heavy grazing pressure in this area. Based on population growth observed previously when areas were fenced from cattle, extending the cattle exclusion area is expected to provide habitat for 20-30 additional individual Purple-crowned Fairy-wrens.
Mining below groundwater levels leads to drawdown in the adjacent McArthur River	- The size of pools near the open cut, such as Djirrinmini Waterhole and pools within the re-channelled section of the McArthur River, will be reduced in the dry season. - Riparian vegetation used by the Purple-crowned Fairy-wren may become water-stressed.	- The extent of expected drawdown assessed as part of the Phase 3 EIS did not warrant specific mitigation measures. - Ongoing monitoring of the water levels in the McArthur River investigates whether drawdown exceeds predicted levels and whether remedial action is required.	Low	- As the risks of drawdown as a result of the Project are no higher than that assessed under the Phase 3 EIS, no further mitigation measures are warranted. - If monitoring reveals that drawdown threatens the health of riparian vegetation, remedial action (enlargement of pools or supplementary watering) will be considered.	Low	The risks of drawdown as a result of the Project are the same as those approved under the Phase 3 EIS. Models predict that the water level within Djirrinmini Waterhole will drop by 0.7 m during the operation phase of the Project (**Appendix T – Groundwater Report**). This is unlikely to significantly affect riparian vegetation adapted to large seasonal variation in water level. In the long term, recovery of water levels is predicted to be complete ten years following the flooding of the mine pit lake.

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments / Justification
Acid mine drainage, arising from reactive material stored within the NOEF, TSF and mine pit lake, entering the McArthur River	- Oxidation of sulphides, when non-benign rock is exposed to air and water, releases metals (principally zinc) and sulphuric acid. Sulphuric acid reacts with the high levels of carbonates in local rock to produce sulphates. - If the metals and sulphates produced by this process leach into groundwater, they may eventually enter the McArthur River and water quality downstream may be affected. - High concentrations of sulphates may affect the growth of riverside vegetation important to the Purple-crowned Fairy-wren.	- In-pit grade control of all overburden at the blast block level is undertaken to validate classification prior to load and haul operations. - Potentially reactive material is built in planned lifts at either 2 m or 7.5 m with advection barriers and stored without oxygen by encapsulation it within OEFs covered with benign material. - A thin cover of water is used at the TSF, to reduce the mounding of groundwater tables and degree of seepage into local creeks. - Sumps are installed around the TSF and NOEF to collect seepage and pump this to storage dams. - Ongoing monitoring of groundwater and surface water quality investigates whether modelled conditions are accurate and whether further measures are warranted. - The geochemistry of benign rock used as covers on OEFs is monitored monthly to maintain correct overburden placement.	Medium	Measures related to managing the risks of storing non-benign material are discussed in detail within **Chapter 3 – Project Description and Justification** and **Chapter 7 – Project Risk Assessment.** The general approach is similar to existing measures but also includes the following: - Tailings will be removed from the TSF and permanently stored within the open cut, to limit long-term risk. - While the TSF is in operation, ponding of water will be minimised to reduce seepage. Furthermore, tailings densities will be maximised to reduce permeability of the tailings. - The TSF will have improved barrier systems and groundwater recovery - The TSF will be subjected to ongoing bi-annual monitoring of stability, structure, operation and management. - A monitoring program will be implemented to detect concentrations of metals, acids and sulphates in groundwater and surface water that exceed acceptable levels. - There will be some in-pit dumping of non-benign rock. - The final open cut will be filled with a deep cover of water to inhibit oxygen contacting reactive material. - The mine pit lake will be filled rapidly by pumping water from the McArthur River, to reduce the exposure of potentially reactive rock to oxygen. - Connection of the mine pit lake to the McArthur River will deliver an annual inflow of sediment, creating an increasing deep benign layer on the mine pit lake floor above reactive material. - The mine pit lake will be isolated from the McArthur River during the initial period after mining. Acceptable water quality within the mine pit lake will be demonstrated prior to connecting the mine pit lake with the McArthur River via levees. - Routine monitoring will determine the mine pit lake water quality and determine whether contingency measures are required, such as water treatment prior to release. - The NOEF design takes into consideration the classes of material being stored, with the most reactive rock being stored at the greatest depths. The entire NOEF will be encapsulated within a compacted clay liner and covered with benign material that acts as a store and release cover. - The NOEF has been carefully designed to maintain physical and chemical stability. - Seepage recovery system will include interceptor drains and recovery bores. - There will be ongoing and indefinite monitoring of groundwater bores surrounding the NOEF to detect seepage before it enters the surface water systems. - Sumps will be installed on Barney Creek to intercept contaminated groundwater entering the creek and river systems. - There will be ongoing frequent monitoring of temperature and gases at the NOEF, as well as groundwater and surface water adjacent to the NOEF, TSF and mine pit lake, to detect the signs of unexpected reactivity. - Adaptive management allows for contingency planning and remediation, if high risk material pathways are identified during the life of the NOEF. - There will be a contingency to isolate the mine pit lake from the McArthur River in the event that water quality is compromised by unanticipated chemical reactions within material contained within it.	Low	The materials to be stored within the NOEF and final mine pit lake have been characterised (**Chapter 6 – Materials Characterisation**) and their geochemistry was a principal consideration when designing these storage facilities. The potential for tailings and stored rock to leach metals, acids and sulphates into the McArthur River has been the subject of detailed water models (**Chapter 8 – Water Resources**). These indicate that, with the mitigation measures proposed, sulphates within the McArthur River immediately downstream of the project are predicted to be elevated above background levels but not to the degree that aquatic fauna and flora are affected. Provided the site-specific trigger levels at the water monitoring point SW11 are not exceeded (as models predict), there are negligible anticipated impacts to Purple-crowned Fairy-wren from acid mine drainage.

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments / Justification
Uncontrolled discharge of contaminated surface water into the McArthur River	- Runoff leaving the mine may contain elevated levels of metals and reactive sediments. - Non-benign material that washes into the McArthur River and its tributaries may cause acidification or salinisation of the waters and the release of metals. - Extreme flood events could cause the uncontrolled release of contaminants within the TSF, runoff dams, sediment traps or the mine pit lake. - Sulphates entering the McArthur River could affect the growth of riverside vegetation important to the Purple-crowned Fairy-wren.	Existing controls are described in **Appendix U – Surface Water Report**. These are reviewed in annual Site Water Balances and continuously improved. The existing controls can be summarised as follows: - McArthur River Mining has a waste discharge licence that specifies maximum concentrations of contaminants permitted at the downstream water monitoring point, SW11. - The Waste Discharge Licence conditions are strictly adhered to. This outlines specific discharge locations, various waters that can be discharged and environmental objectives. - Diversions, drains, bunds and levees are used to limit uncontaminated surface water from interacting with the NOEF, open cut, TSF and haul roads. - Dust-containing runoff is collected through numerous silt/sediment traps, and contaminated sediments are periodically removed and transferred to the TSF. - Construction of the TSF, OEFs and the open cut conforms to Australian standards regarding the construction of large dams and storm storage.	Medium	The proposed measures to reduce the risk of contaminated surface waters discharging into the McArthur River are discussed in detail in **Appendix U – Surface Water Report** and **Chapter 8 – Water Resources**. These resemble existing controls, with the following additions: - The updated Water Management Plan will be adhered to. - Prior to any discharge of water, a water quality assessment will take place, which will determine the discharge frequency and rate. - Runoff storage dams and extensions to the TSF will be constructed in accordance with relevant Australian National Committee on Large Dams (ANCOLD) Guidelines including ANCOLD's Guidelines on Tailings Dam Planning, Design, Construction, Operation and Closure (ANCOLD, 2012). - The TSF will adhere to ANCOLD (2012) Extreme Storm Storage and Wet Season Storage Allowance criteria. - A Process Water Dam will be associated with the TSF to capture overflow during storms. The TSF spillway is designed to cope with floods to 1:100,000 AEP (critical storm duration). - The TSF and runoff dams will be built to conform to the 1:1,000 AEP Max Design Earthquake (MDE) and 1:500 AEP Operating Basis Earthquake (OBE) criteria. - The crests of the spillways of the runoff dams are above the 100 year McArthur River flood level. Spillways are designed to safely pass a 1:2,000 AEP flood event with a 1:10 AEP wind event wave allowance. - There will be ongoing bi-annual monitoring of the stability, structure, operation and management of the TSF. - The Dam Safety Emergency Plan will be adhered to. - During NOEF construction, exposed areas of reactive rock will generate contaminated surface runoff. Numerous drainage channels, sumps and lined (clay or geopolymer) dams (referred to as PRODS) will be installed on and surrounding the NOEF to capture runoff. Run off dams capacities set to have a less than 5% probability of exceedance (spill) over the operating life of the dam. - There will be ongoing compliance with the site-specific trigger levels at SW11.	Low	Management of surface water to reduce impacts to the water quality of the McArthur River as a result of the Project has been the central focus of numerous studies and models. These are discussed in **Appendix U – Surface Water Report** and **Chapter 8 – Water Resources**. Detailed surface water models indicate that, with the mitigation measures proposed, sulphate concentrations downstream from the Project will not be high enough to affect the growth of riparian vegetation. Uncontrolled releases are only likely during extreme flood events, when all contaminants will be substantially diluted. Provided the site-specific trigger levels at the water monitoring point SW11 are not exceeded (as models predict), there are no anticipated impacts to the Purple-crowned Fairy-wren from uncontrolled discharge.

Table 9-11 Mitigation and Risk Assessment for the Buff-sided Robin

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments / Justification
Habitat is cleared to accommodate the Project	- 10.7 ha of habitat will be cleared for the Project, representing 2.7% of the total habitat present within the MRM lease. - This will result in the loss of two pairs of Buff-sided Robins.	N/A	Medium	- As the extent of habitat loss is far less than would have occurred for Phase 3 (65.7 ha), no additional mitigation measures are warranted.	Medium	The potential impacts of the Project are very well characterised, as the exact numbers of individuals present within the disturbance footprint are known from banding studies.
Uncontrolled discharge of contaminated surface water into the McArthur River	- Runoff leaving the mine may contain elevated levels of metals and reactive sediments. - Non-benign material that washes into the McArthur River and its tributaries may cause acidification or salinisation of the waters and the release of metals. - Extreme flood events could cause the uncontrolled release of contaminants within the TSF, runoff dams, sediment traps or the mine pit lake. - Sulphates entering the McArthur River could affect the growth of riverside vegetation important to the Buff-sided Robin.	Existing controls are described in **Appendix U – Surface Water Report**. These are reviewed in annual Site Water Balances and continuously improved. The existing controls can be summarised as follows: - McArthur River Mining has a waste discharge licence that specifies maximum concentrations of contaminants permitted at the downstream water monitoring point, SW11. - The waste discharge licence conditions are strictly adhered to. This outlines specific discharge locations, various waters that can be discharged and environmental objectives. - Diversions, drains, bunds and levees are used to limit uncontaminated surface water from interacting with the NOEF, open cut, TSF and haul roads. - Dust-containing runoff is collected through numerous silt/sediment traps, and contaminated sediments are periodically removed and transferred to the TSF. - Construction of the TSF, OEFs and the open cut conforms to Australian standards regarding the construction of large dams and storm storage.	Medium	The proposed measures to reduce the risk of contaminated surface waters discharging into the McArthur River are discussed in detail in **Appendix U – Surface Water Report** and **Chapter 8 – Water Resources**. These resemble existing controls, with the following additions: - The updated Water Management Plan will be adhered to. - Prior to any discharge of water, a water quality assessment will take place, which will determine the discharge frequency and rate. - Runoff storage dams and extensions to the TSF will be constructed in accordance with relevant Australian National Committee on Large Dams (ANCOLD) Guidelines including ANCOLD's Guidelines on Tailings Dam Planning, Design, Construction, Operation and Closure (ANCOLD, 2012). - The TSF will adhere to ANCOLD (2012) Extreme Storm Storage and Wet Season Storage Allowance criteria. - A Process Water Dam will be associated with the TSF to capture overflow during storms. The TSF spillway is designed to cope with floods to 1:100,000 AEP (critical storm duration). - The TSF and runoff dams will be built to conform to the 1:1,000 AEP Max Design Earthquake (MDE) and 1:500 AEP Operating Basis Earthquake (OBE) criteria. - The crests of the spillways of the runoff dams are above the 100 year McArthur River flood level. Spillways are designed to safely pass a 1:2,000 AEP flood event with a 1:10 AEP wind event wave allowance. - There will be ongoing bi-annual monitoring of the stability, structure, operation and management of the TSF. - The Dam Safety Emergency Plan will be adhered to. - During NOEF construction, exposed areas of reactive rock will generate contaminated surface runoff. Numerous drainage channels, sumps and lined (clay or geopolymer) dams (referred to as PRODS) will be installed on and surrounding the NOEF to capture runoff. Run off dams capacities set to have a less than 5% probability of exceedance (spill) over the operating life of the dam. - There will be ongoing compliance with the site-specific trigger levels at SW11.	Low	Management of surface water to reduce impacts to the water quality of the McArthur River as a result of the Project has been the central focus of numerous studies and models. These are discussed in **Appendix U – Surface Water Report** and **Chapter 8 – Water Resources**. Detailed surface water models indicate that, with the mitigation measures proposed, sulphate concentrations downstream from the Project will not be high enough to affect the growth of riparian vegetation. Uncontrolled releases are only likely during extreme flood events, when all contaminants will be substantially diluted. Provided the site-specific trigger levels at the water monitoring point SW11 are not exceeded (as models predict), there are no anticipated impacts to the Buff-sided Robin from uncontrolled discharge.

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments / Justification
Acid mine drainage, arising from reactive material stored within the NOEF, TSF and mine pit lake, entering the McArthur River	- Oxidation of sulphides, when non-benign rock is exposed to air and water, releases metals (principally zinc) and sulphuric acid. Sulphuric acid reacts with the high levels of carbonates in local rock to produce sulphates. - If the metals and sulphates produced by this process leach into groundwater, they may eventually enter the McArthur River and water quality downstream may be affected. - High concentrations of sulphates may affect the growth of riverside vegetation important to the Buff-sided Robin.	- In-pit grade control of all overburden at the blast block level is undertaken to validate classification prior to load and haul operations. - Potentially reactive material is built in planned lifts at either 2 metres or 7.5 metres with advection barriers and stored without oxygen by encapsulation it within OEFs covered with benign material. - A thin cover of water is used at the TSF, to reduce the mounding of groundwater tables and degree of seepage into local creeks. - Sumps are installed around the TSF and NOEF to collect seepage and pump this to storage dams. - Ongoing monitoring of groundwater and surface water quality investigates whether modelled conditions are accurate and whether further measures are warranted. - The geochemistry of benign rock used as covers on OEFs is monitored monthly to manage correct overburden placement.	Medium	Measures related to managing the risks of storing non-benign material are discussed in detail within **Chapter 3 – Project Description and Justification** and **Chapter 7 – Project Risk Assessment.** The general approach is similar to existing measures but also includes the following: - Tailings will be removed from the TSF and permanently stored within the open cut, to limit long-term risk. - While the TSF is in operation, ponding of water will be minimised to reduce seepage. Furthermore, tailings densities will be maximised to reduce permeability of the tailings. - The TSF will have improved barrier systems and groundwater recovery - The TSF will be subjected to ongoing bi-annual monitoring of stability, structure, operation and management. - A monitoring program will be implemented to test concentrations of metals, acids and sulphates in groundwater and surface water that exceed acceptable levels. - There will be some in-pit dumping of non-benign rock. - The final open cut will be filled with a deep cover of water to inhibit oxygen contacting reactive material. - The mine pit lake will be filled rapidly by pumping water from the McArthur River, to reduce the exposure of potentially reactive rock to oxygen. - Connection of the mine pit lake to the McArthur River will deliver an annual inflow of sediment, creating an increasing deep benign layer on the mine pit lake floor above reactive material. - The mine pit lake will be isolated from the McArthur River during the initial period after mining. Acceptable water quality within the mine pit lake will be demonstrated prior to connecting the lake with the McArthur River via levees. - Routine monitoring will determine the mine pit water quality and determine whether contingency measures are required, such as water treatment prior to release. - The NOEF design takes into consideration the classes of material being stored, with the most reactive rock being stored at the greatest depths. The entire NOEF will be encapsulated within a compacted clay liner and covered with benign material that acts as a store and release cover. - The NOEF has been carefully designed to manage physical and chemical stability. - Seepage recovery system will include interceptor drains and recovery bores. - There will be ongoing and indefinite monitoring of groundwater bores surrounding the NOEF to detect seepage before it enters the surface water systems. - Sumps will be installed on Barney Creek to intercept contaminated groundwater entering the creek and river systems. - There will be ongoing frequent monitoring of temperature and gases at the NOEF, as well as groundwater and surface water adjacent to the NOEF, TSF and mine pit lake, to detect the signs of unexpected reactivity. - Adaptive management allows for contingency planning and remediation, if high risk material pathways are identified during the life of the NOEF. - There will be a contingency to isolate the mine pit lake from the McArthur River in the event that water quality is compromised by unanticipated chemical reactions within material contained within it.	Low	The materials to be stored within the NOEF and final mine pit lake have been characterised (**Chapter 6 – Materials Characterisation**) and their geochemistry was a principal consideration when designing these storage facilities. The potential for tailings and stored rock to leach metals, acids and sulphates into the McArthur River has been the subject of detailed water models (**Chapter 8 – Water Resources**). These indicate that, with the mitigation measures proposed, sulphates within the McArthur River immediately downstream of the project are predicted to be elevated above background levels but not to the degree that aquatic fauna and flora are affected. Provided the site-specific trigger levels at the water monitoring point SW11 are not exceeded (as models predict), there are negligible anticipated impacts to Buff-sided Robins from acid mine drainage.

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments / Justification
Mining below groundwater levels leads to drawdown in the adjacent McArthur River	- The size of pools near the open cut, such as Djirrinmini Waterhole and pools within the re-channelled section of the McArthur River, will be reduced in the dry season. - Riparian vegetation used by the Buff-sided Robin may become water-stressed.	- The extent of expected drawdown assessed as part of the Phase 3 EIS did not warrant specific mitigation measures. - Ongoing monitoring of the water levels in the McArthur River investigates whether drawdown exceeds predicted levels and whether remedial action is required.	Low	- As the risks of drawdown as a result of the Project are no higher than that assessed under the Phase 3 EIS, no further mitigation measures are warranted. - If monitoring reveals that drawdown threatens the health of riparian vegetation, remedial action (enlargement of pools or supplementary watering) will be considered.	Low	The risks of drawdown as a result of the Project are the same as those approved under the Phase 3 EIS. Models predict that the water level within Djirrinmini Waterhole will drop by 0.7 m during the operation phase of the Project (**Appendix T – Groundwater Report**). This is unlikely to significantly affect riparian vegetation adapted to large seasonal variation in water level. In the long term, recovery of water levels is predicted to be complete ten years following the flooding of the mine pit lake.

Table 9-12 Mitigation and Risk Assessment for the Orange Leaf-nosed Bat

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments / Justification
Habitat is cleared to accommodate the Project	- 445.6 ha of potential foraging habitat will be cleared for the Project.	N/A	Medium	- As the extent of habitat loss is the same as would have occurred for Phase 3, no additional mitigation measures are warranted.	Medium	Extent of foraging habitat is highly unlikely to be limiting the numbers of Orange Leaf-nosed Bats (Department of the Environment 2017). The removal of this small amount, relative to availability of foraging habitat across the local landscape, is unlikely to compromise local populations of the Orange Leaf-nosed Bat.

Table 9-13 Mitigation and Risk Assessment for *Astrebla lappacea, Sesbania erubescens, Goodenia leiosperma* and *Polygala barbata*

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments / Justification
Potential habitat is cleared to accommodate the Project.	- 199.5 ha of potential habitat for *Astrebla lappacea* will be removed. - 199.5 ha of habitat for *Sesbania erubescens* will be removed. - 222 ha of potential habitat for *Goodenia leiosperma* will be removed. - 226.1 ha of potential habitat for *Polygala barbata* will be removed.	N/A	Medium	- The cattle exclusion area will be extended by 909 ha, which will protect understorey plants from the impacts of grazing. - The size of the NOEF, and therefore the extent of habitat removed to accommodate it, was reduced by building it taller than the original design in the Phase 3 EIS.	Low	All four species are widespread in the local region and are not listed as threatened under NT (TWPC Act) or Commonwealth legislation (EPBC Act). The scale of the residual impacts to these species is not expected to compromise local populations or lead to an elevation in conservation status.

9.8 Risk Monitoring

An extensive suite of monitoring programs exists at MRM for investigating the effects of the operations on environmental values, including those pertaining to biodiversity. Monitoring programs are designed to test the adequacy of the mitigation measures employed. They are also designed to enable the timely detection of unanticipated impacts (those that deviate from model predictions) of the Project, allowing for early remediation and the initiation of additional mitigation measures.

Table 9-14 summarises the existing monitoring programs operating at MRM, and how these will monitor the risks posed by the Project to biodiversity values.

Table 9-14 Monitoring Programs Relevant to Biodiversity Values

Program	Timing	Hazards Assessed	Species Potentially Affected
Riparian bird monitoring	Biannual	• Habitat fragmentation; and • Draw-down of water tables.	Red Goshawk, Common Sandpiper, Sharp-tailed Sandpiper, Long-toed Stint, Oriental Cuckoo, Snipe spp., Caspian Tern, Grey Wagtail, Eastern Yellow Wagtail, Eastern Osprey, Glossy Ibis, Arafura Fantail, Common Greenshank, Marsh Sandpiper, Australian Reed-warbler, Pale-vented Bush-hen, Square-tailed Kite, Purple-crowned Fairy-wren, Star Finch, Buff-sided Robin.
Gouldian Finch monitoring	Annual	• Habitat clearance; and • Altered fire regime.	Gouldian Finch, Star Finch, Pictorella Mannikin, Partridge Pigeon, Chestnut-backed Buttonquail.
Aquatic macroinvertebrate monitoring	Annual	• Contaminated groundwater; • Contaminated runoff; and • Dust.	Largetooth Sawfish.
Fish monitoring throughout the McArthur River catchment, including within the mine pit lake when this is formed.	Biannual	• Draw-down of water tables; • Contaminated groundwater; • Contaminated runoff; • Dust; and • Habitat fragmentation.	Largetooth Sawfish, Mertens' Water Monitor, Mitchell's Water Monitor, Estuarine Crocodile.
Tag and release program for sawfish	Biannual	• Habitat fragmentation	Largetooth Sawfish
Monitoring metals in fish	Biannual	• Contaminated groundwater; • Contaminated runoff; and • Dust.	Largetooth Sawfish, Estuarine Crocodile, Eastern Osprey, Caspian Tern.

Program	Timing	Hazards Assessed	Species Potentially Affected
Shorebird monitoring in coastal estuaries	Biannual	• Contaminated groundwater; • Contaminated runoff; and • Dust.	Curlew Sandpiper, Eastern Curlew, Common Sandpiper, Sharp-tailed Sandpiper, Long-toed Stint, Caspian Tern, Common Greenshank, Marsh Sandpiper.
Monitoring metals in seawater and marine sediment	Annual	• Contaminated groundwater; • Contaminated runoff; and • Dust.	Curlew Sandpiper, Eastern Curlew, Common Sandpiper, Sharp-tailed Sandpiper, Long-toed Stint, Caspian Tern, Common Greenshank, Marsh Sandpiper.
Weed surveys	Annual	• Weeds	Gouldian Finch, and most other threatened species.
Surveys for cattle within the exclusion zone	Quarterly	• Pests	Gouldian Finch, Star Finch, Pictorella Mannikin, Purple-crowned Fairy-wren, Pale-vented Bush-hen, Australian Reed-warbler, Australian Bustard, Bush Stone-curlew, Spectacled hare-wallaby, Northern Brown Bandicoot, Western Chestnut Mouse, Long-haired Rat, *Astrebla lappacea.*
Register of roadkill	Ongoing	• Collisions with vehicles	Northern Quoll, Floodplain Monitor, Australian Bustard, Emu, Northern Brown Bandicoot, Spectacled Hare-wallaby, Northern Nailtail Wallaby.
Depositional dust sampling	Monthly	• Dust	All species
Groundwater monitoring across an array of bores	Every two months	• Contaminated groundwater; and • Draw-down of water table.	Largetooth Sawfish, Gouldian Finch, Eastern Curlew, Curlew Sandpiper, Mertens' Water Monitor, Mitchell's Water Monitor, Floodplain Monitor, Australian Reed-warbler, Pale-vented Bush-hen, Emu, Pictorella Mannikin, Purple-crowned Fairy-wren, Star Finch, Buff-sided Robin, Orange Leaf-nosed Bat, Bare-rumped Sheathtail Bat, Green Tree Snake, Snipe spp., Long-toed Stint, Common Sandpiper, Sharp-tailed Sandpiper, Oriental Cuckoo, Caspian Tern, Eastern Osprey, Glossy Ibis, Arafura Fantail, Common Greenshank, Marsh Sandpiper.
Surface water monitoring in artificial and natural waterways	Weekly for natural waterways; monthly for artificial waterways.	• Contaminated groundwater; • Contaminated runoff; • Dust; • Draw-down of water tables; and • Erosion and sedimentation.	Largetooth Sawfish, Gouldian Finch, Eastern Curlew, Curlew Sandpiper, Mertens' Water Monitor, Mitchell's Water Monitor, Floodplain Monitor, Australian Reed-warbler, Pale-vented Bush-hen, Emu, Pictorella Mannikin, Purple-crowned Fairy-wren, Star Finch, Buff-sided Robin, Orange Leaf-nosed Bat, Bare-rumped Sheathtail Bat, Green Tree Snake, Snipe spp., Long-toed Stint, Common Sandpiper, Sharp-tailed Sandpiper, Oriental Cuckoo, Caspian Tern, Eastern Osprey, Glossy Ibis, Arafura Fantail, Common Greenshank, Marsh Sandpiper.

Program	Timing	Hazards Assessed	Species Potentially Affected
Inspection of sediment traps, bund walls and other embankments	Weekly during wet season	• Erosion and sedimentation; and • Contaminated runoff.	Large-tooth Sawfish, Gouldian Finch, Eastern Curlew, Curlew Sandpiper, Mertens' Water Monitor, Mitchell's Water Monitor, Floodplain Monitor, Australian Reed-warbler, Pale-vented Bush-hen, Emu, Pictorella Mannikin, Purple-crowned Fairy-wren, Star Finch, Buff-sided Robin, Orange Leaf-nosed Bat, Bare-rumped Sheathtail Bat, Green Tree Snake, Snipe spp., Long-toed Stint, Common Sandpiper, Sharp-tailed Sandpiper, Oriental Cuckoo, Caspian Tern, Eastern Osprey, Glossy Ibis, Arafura Fantail, Common Greenshank, Marsh Sandpiper.
Monitoring of the stability, structure and operation of the TSF.	Biannual	• Contaminated groundwater; and • Contaminated runoff.	Gouldian Finch, Eastern Curlew, Curlew Sandpiper, Mertens' Water Monitor, Mitchell's Water Monitor, Floodplain Monitor, Australian Reed-warbler, Pale-vented Bush-hen, Emu, Pictorella Mannikin, Purple-crowned Fairy-wren, Star Finch, Buff-sided Robin, Orange Leaf-nosed Bat, Bare-rumped Sheathtail Bat, Green Tree Snake, Snipe spp., Long-toed Stint, Common Sandpiper, Sharp-tailed Sandpiper, Oriental Cuckoo, Caspian Tern, Eastern Osprey, Glossy Ibis, Arafura Fantail, Common Greenshank, Marsh Sandpiper.
Grade assessments of overburden prior to storage	Ongoing	• Contaminated groundwater; and • Contaminated runoff.	Gouldian Finch, Eastern Curlew, Curlew Sandpiper, Mertens' Water Monitor, Mitchell's Water Monitor, Floodplain Monitor, Australian Reed-warbler, Pale-vented Bush-hen, Emu, Pictorella Mannikin, Purple-crowned Fairy-wren, Star Finch, Buff-sided Robin, Orange Leaf-nosed Bat, Bare-rumped Sheathtail Bat, Green Tree Snake, Snipe spp., Long-toed Stint, Common Sandpiper, Sharp-tailed Sandpiper, Oriental Cuckoo, Caspian Tern, Eastern Osprey, Glossy Ibis, Arafura Fantail, Common Greenshank, Marsh Sandpiper.
Geochemical monitoring of overburden stored at OEFs	Monthly	• Contaminated groundwater; and • Contaminated runoff.	Gouldian Finch, Eastern Curlew, Curlew Sandpiper, Mertens' Water Monitor, Mitchell's Water Monitor, Floodplain Monitor, Australian Reed-warbler, Pale-vented Bush-hen, Emu, Pictorella Mannikin, Purple-crowned Fairy-wren, Star Finch, Buff-sided Robin, Orange Leaf-nosed Bat, Bare-rumped Sheathtail Bat, Green Tree Snake, Snipe spp., Long-toed Stint, Common Sandpiper, Sharp-tailed Sandpiper, Oriental Cuckoo, Caspian Tern, Eastern Osprey, Glossy Ibis, Arafura Fantail, Common Greenshank, Marsh Sandpiper.

Program	Timing	Hazards Assessed	Species Potentially Affected
Monitoring of spontaneous combustion using thermal monitoring, sulphur dioxide monitoring and visual checks	Daily	• Altered fire regime; • Contaminated groundwater; and • Contaminated runoff.	Gouldian Finch, Eastern Curlew, Curlew Sandpiper, Mertens' Water Monitor, Mitchell's Water Monitor, Floodplain Monitor, Australian Reed-warbler, Pale-vented Bush-hen, Emu, Pictorella Mannikin, Purple-crowned Fairy-wren, Star Finch, Buff-sided Robin, Orange Leaf-nosed Bat, Bare-rumped Sheathtail Bat, Green Tree Snake, Snipe spp., Long-toed Stint, Common Sandpiper, Sharp-tailed Sandpiper, Oriental Cuckoo, Caspian Tern, Eastern Osprey, Glossy Ibis, Arafura Fantail, Common Greenshank, Marsh Sandpiper.
Rehabilitation monitoring	Annual	• Habitat clearance; and • Habitat fragmentation.	All species.