McArthur River Mine

Overburden Management Project

10

Matters of National Environmental Significance

Draft Environmental Impact Statement

10 Matters of National Environmental Significance

10.1 Introduction

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), actions that will have, or are likely to have, a significant impact on matters of national environmental significance (MNES) are considered 'controlled actions' and require approval by the Australian Government Minister for the Department of Environment and Energy. The nine MNES protected under the EPBC Act are:

- 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.

McArthur River Mining Pty. Ltd. (McArthur River Mining) referred the McArthur River Mine (MRM) Overburden Management Project (the Project) to the Commonwealth Government on 13 May 2014. On 15 June 2014, a delegate for the Minister determined that the Project was a controlled action and would require assessment and approval under the EPBC Act at an Environmental Impact Statement (EIS) assessment level. The controlling provision of the Project was that it was deemed to have a potential significant impact on listed threatened species and ecological communities.

The potential impacts of the Project on MNES, and proposed mitigation measures to limit these impacts, are discussed within this chapter. In accordance with Chapter 4, Part 8, Division 6 of the EPBC Act, this assessment follows the EIS guidelines contained within the Terms of Reference (TOR) provided by the Northern Territory Environment Protection Authority (NT EPA) in September 2014 (Refer to **Appendix A – Final Terms of Reference**).

10.1.1 Project Background

The Project represents a variation on a previously approved project, the McArthur River Mine Phase 3 Development Project (Phase 3). Phase 3 was referred to the Commonwealth Government by McArthur River Mining, and was determined not to be a controlled action and therefore did not require assessment or approval under the EPBC Act. This Project 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 from Phase 3 constitute the actions that require assessment under the EPBC Act. A comprehensive description of the proposed actions is provided in **Chapter 3 – Project Description and Justification**. The principal actions that may affect MNES 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 proposed disturbances associated with the extraction of benign material and clay used as a cover needed to manage the NOEF in an environmentally protective manner. 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 covered in situ and remaining permanently in the TSF. This reduces the risks associated with the long-term storage of potentially reactive material.
- The final void will contain a mine pit lake that is intermittently connected to the McArthur River, 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 known as the adaptive management period.

10.2 Relevant Matters of National Environmental Significance

The controlling provision of the Project was 'listed threatened species and ecological communities'. The EPBC Act Protected Matters Search Tool was consulted to determine whether any other MNES may have become relevant to the Project since the EPBC referral decision in June 2014. This search also provided an initial guide as to which threatened species and/or ecological communities are most likely to be affected by the Project. A search of an area within a 20 kilometre (km) radius around the co-ordinates -16.4408°, 136.0769° (latitude, longitude) undertaken on 4 November 2016 identified 16 listed threatened species and 13 listed migratory species, but no other MNES, relevant to the area. Three of the listed species are both threatened and migratory.

In addition to the 26 listed species identified by the EPBC Act Protected Matters Search Tool, 11 further species constituting MNES under the EPBC Act were considered to potentially utilise the McArthur River Mine region, based on field surveys and desktop-based reviews of published data (refer to **Chapter 9 – Biodiversity**, for a description of these studies). These species are listed in **Table 10-1** and the potential impacts to these species from the Project are assessed in detail in **Section 10.5**. No flora listed as threatened under the EPBC Act are known to occur in the vicinity of the Project.

Table 10-1 Threatened or Migratory Species (EPBC) Relevant to the Project

Common name	Scientific Name	Taxon	Status under the EPBC Act
Curlew Sandpiper	*Calidris ferruginea*	Bird	Critically Endangered, Migratory
Eastern Curlew	*Numenius madagascariensis*	Bird	Critically Endangered, Migratory
Carpentarian Grasswren	*Amytornis dorotheae*	Bird	Endangered
Northern Quoll	*Dasyurus hallucatus*	Mammal	Endangered
Gulf Snapping Turtle	*Elseya lavarackorum*	Reptile	Endangered
Gouldian Finch	*Erythrura gouldiae*	Bird	Endangered
Australian Painted Snipe	*Rostratula australis*	Bird	Endangered
Plains Death Adder	*Acanthophis hawkei*	Reptile	Vulnerable
Red Goshawk	*Erythrotriorchis radiatus*	Bird	Vulnerable
Crested Shrike-tit (northern)	*Falcunculus frontatus whitei*	Bird	Vulnerable
Partridge Pigeon (eastern)	*Geophaps smithii smithii*	Bird	Vulnerable
Painted Honeyeater	*Grantiella picta*	Bird	Vulnerable
Ghost Bat	*Macroderma gigas*	Mammal	Vulnerable
Largetooth Sawfish	*Pristis pristis*	Fish	Vulnerable, Migratory
Carpentarian Antechinus	*Pseudantechinus mimulus*	Mammal	Vulnerable
Bare-rumped Sheath-tailed Bat	*Saccolaimus saccolaimus*	Mammal	Vulnerable
Masked Owl (northern)	*Tyto novaehollandiae kimberli*	Bird	Vulnerable
Common Sandpiper	*Actitis hypoleucos*	Bird	Migratory
Fork-tailed Swift	*Apus pacificus*	Bird	Migratory
Sharp-tailed Sandpiper	*Calidris acuminata*	Bird	Migratory
Long-toed Stint	*Calidris subminuta*	Bird	Migratory
Red-rumped Swallow	*Cecropis daurica*	Bird	Migratory
Oriental Plover	*Charadrius veredus*	Bird	Migratory
Estuarine Crocodile	*Crocodylus porosus*	Reptile	Migratory
Oriental Cuckoo	*Cuculus optatus*	Bird	Migratory
Snipe species	*Gallinago* spp.	Bird	Migratory
Oriental Pratincole	*Glareola maldivarum*	Bird	Migratory
Barn Swallow	*Hirundo rustica*	Bird	Migratory
Caspian Tern	*Hydroprogne caspia*	Bird	Migratory
Grey Wagtail	*Motacilla cinerea*	Bird	Migratory
Eastern Yellow Wagtail	*Motacilla tshutschensis**	Bird	Migratory
Little Curlew	*Numenius minutus*	Bird	Migratory
Eastern Osprey	*Pandion cristatus***	Bird	Migratory

Common name	Scientific Name	Taxon	Status under the EPBC Act
Glossy Ibis	*Plegadis falcinellus*	Bird	Migratory
Arafura Fantail	*Rhipidura dryas*†	Bird	Migratory
Common Greenshank	*Tringa nebularia*	Bird	Migratory
Marsh Sandpiper	*Tringa stagnatilis*	Bird	Migratory

*Listed under the EPBC Act as *Motacilla flava.*
**Listed under the EPBC Act as *Pandion haliaetus.*
†Listed under the EPBC Act as *Rhipidura rufifrons.*

10.3 Survey Effort

The MRM and surrounding areas have been the subject of numerous ecological surveys over many decades. These are detailed within **Chapter 9 – Biodiversity, Appendix X – Terrestrial Ecology Report** and **Appendix W – Aquatic Ecology Report**. As a result of this extensive survey effort, the environmental values of the area are well characterised.

Table 10-2 assesses how the survey effort meets the standards specified in the various guidelines, published by the Commonwealth Government in 2010-2011, for surveying species protected under the EPBC Act. These guidelines are not mandatory, but alternative survey approaches must be supported by an evidence-based rationale. Failure to survey appropriately for threatened species could result in the Australian Government applying the precautionary principle with regard to significant impact determinations.

Not all species protected by the EPBC Act are addressed by the current survey guidelines. For species not covered by guidelines, survey techniques were specially tailored to maximise detection, and the survey effort is summarised under each species' account in **Section 10.5**.

Table 10-2 Compliance with Commonwealth Survey Guidelines

Specifications of the Guidelines	How this has been met by the Project
Generic prescriptions of all survey guidelines for Australia's threatened species	
Identify the taxa that may occur in the study area by characterising the habitat(s) present, and consulting a range of data sources.	Detailed, ground-truthed vegetation maps were prepared for the entire MRM mineral leases. A range of publicly accessible databases, reports, recovery plans and reference books were consulted to inform assessments of the likelihood that threatened bats may be present.
Conduct surveys at optimal times for the target species.	Surveys were undertaken in all seasons and across several decades. This encompassed years with both above-average and below-average rainfall. The broad range of seasonal conditions surveyed facilitated detection of maximum biodiversity.
Conduct surveys at optimal locations for detecting the target species. Sampling units should be sufficiently far apart that individuals are unlikely to be detected from more than one sampling location.	The sampling design for each survey type was tailored specifically to the target taxon. In general, sampling sites were spaced relatively evenly across potential habitat for the target taxon, with spacing dictated by the known home ranges or territories of the taxon.
Sampling should be undertaken over several seasons and/or years.	Ecological surveys within the MRM mineral leases and the broader region have been carried out over many decades and across all seasons.

Specifications of the Guidelines	How this has been met by the Project
Surveys should be conducted by competent and experienced observers	A large number of different surveys have been undertaken over the past decades, including some by CSIRO scientists, Charles Darwin University researchers and consultant ecologists. The most recent surveys were undertaken by fully qualified ecologists with 23 years' experience, including 19 years' experience within the Gulf region and 15 years' direct experience within the area local to the MRM mineral leases covering birds, reptiles, amphibians, bats, other mammals, aquatic invertebrates and flora (see **Appendix X – Terrestrial Ecology Report**). Observers had a comprehensive knowledge of the calls of local birds, including threatened species. Where specialist knowledge was required for surveying certain taxa (e.g., sawfish, bat call analysis), experts were consulted.
The survey methods and results should be clearly documented. This should include descriptions of habitats sampled, all taxa recorded, and evidence of threatened species in the form of measurements, photos or spectrograms of calls.	The methodology used and results obtained during surveys are documented within **Appendix X – Terrestrial Ecology Report** and **Appendix W – Aquatic Ecology Report.**
Relevant requirements prescribed by the *Survey Guidelines for Australia's Threatened Bats*	
For detecting *Saccolaimus saccolaimus* ultrasonic call recordings should be made. Unattended detectors should be located in forest or woodland and ideally placed several metres above the ground, orientated upwards towards gaps in the vegetation, and at waterholes. Detectors should be left overnight. A minimum of 16 detector-nights over at least four separate nights is required.	Full-spectrum recordings were made over 31 detector-nights and zero-crossing recordings were made over an additional 31 detector-nights. These surveys spanned multiple years (2005, 2012 and 2015-2016).
For detecting *Saccolaimus saccolaimus*, mist nets should be set above the canopy and over isolated waterholes. The species has never been caught in harp traps. A minimum of 16 mist-net nights over at least four separate nights is required.	Given the lack of favoured habitat (open forests dominated by *Eucalyptus tetrodonta* and *Eucalyptus miniata*) within the mineral leases, the lack of records from the Gulf region, the failure of ultrasonic call recordings to detect the species, the relative difficulty of capturing the species with nets and the expertise required for using mist nets to capture bats, use of this technique was not warranted.
Hollow-bearing trees should be investigated by observing and recording bats emerging at dusk, or by inspecting lower hollows with a small video camera.	Targeted searches for potential bat roosts in hollow trees were undertaken between 2011 and 2016. Several roosts were located in large *Eucalyptus camaldulensis* along the banks of the McArthur River, although only other bat species (i.e., *Chaerephon jobensis*) were recorded utilising these roosts.
Relevant requirements prescribed by the *Survey Guidelines for Australia's Threatened Birds*	
For surveying Australian Painted Snipe, at least 10 hours over five days should be spent observing wetlands from a stationary position at dawn and dusk. In addition, at least 10 hours over three days should be spent undertaking area searches or transects through suitable wetlands.	No wetland habitat is contained within the footprint of the Project. The only aquatic habitats present (stream channels) have been intensively surveyed, with a total of 1,080 hours during bi-annual surveys undertaken between 2006 and 2016.

Specifications of the Guidelines	How this has been met by the Project
For surveying Northern Crested Shrike-tits, call broadcast surveys should be undertaken over a minimum of four hours over three days during September-March. In addition, at least eight hours over four days should be spent undertaking area searches or line transects in suitable habitat.	A total of 126 hours between 1992 and 2016 have been spent undertaking bird surveys (1 ha area searches and point counts) in open woodland habitats that may be used by the species. Between 2006 and 2016, a further 1,080 hours of searching have been undertaken in riparian habitats that may be used occasionally by the species. Given the intensity of survey effort across the mineral leases, the lack of records from anywhere in the Borroloola region since 1914 and the absence of preferred habitat, call broadcast surveys were not considered necessary to infer likely absence.
For surveying Gouldian Finches, at least 12 hours over four days should be spent watching waterholes late in the dry season. In addition, 20 hours over five days should be spent undertaking area searches in suitable habitat.	Surveys during 1992-2016, across multiple seasons, included timed area searches (10 min, 1 ha) at 652 sites and 5 min stationary counts at 220 sites across the mineral leases. This equates to 126 hours of search effort. In addition, remote-sensory cameras were deployed at ten natural and artificial water points (140 camera trap days).
For surveying Northern Masked Owls, at least eight hours over four days should be spent broadcasting calls in suitable habitat.	Masked Owl calls were broadcast at seven sites in 2005, four sites in 2012 and 46 sites in 2015. At each site, calls were broadcast for five minutes, followed by five minutes of listening and spotlighting. This equates to a search effort of 9.5 hours.
For surveying Eastern Partridge Pigeons, at least 20 hours over five days should be spent undertaking area searches or transect surveys in suitable habitat. An additional 15 hours over five days should be spent undertaking flushing surveys, with groups of people walking in a line. At least 20 hours over ten days should be spent watching waterholes in the late dry season.	Between 1992 and 2016, bird surveys undertaken on the MRM mineral leases have included 126 hours of searching across woodland sites, 1,080 hours of searching in riparian areas and 140 camera trap days at natural and artificial water points.
For surveying Red Goshawks, a minimum of 80 hours over 10 days should be spent searching river banks for nests in the tallest trees.	A total of 1,080 hours of riparian bird surveys have been undertaken between 2006 and 2016. All raptor nests found during these surveys were checked, but none were used by Red Goshawks.
Relevant requirements prescribed by the *Survey Guidelines for Australia's Threatened Reptiles*	
Gulf Snapping Turtles are best detected by diving, where this technique can be safely employed.	Diving could not be safely employed within the McArthur River due to the presence of Estuarine Crocodiles. A wide range of trapping methods were employed to sample turtles, including fyke trapping, electrofishing transects, gill netting and seine netting. The total survey effort to date exceeds 300 hours of aquatic fauna sampling.
Relevant requirements prescribed by the *Survey Guidelines for Australia's Threatened Mammals*	
For surveying the Carpentarian Antechinus, a combination of techniques should be employed, including: • daytime searches for tracks or scats among rocks and rock ledges; • collection of predator scats, owl casts or remains at nests; • pitfall trapping; • Elliott trapping; and • camera traps in suitable habitat.	11,053 trap-nights of Elliott trapping, 560 trap-nights of hair funnel trapping 174 trap-nights of pitfall trapping, 538 trap nights using remote-sensory cameras have been employed across the MRM mineral leases and nearby areas.

Specifications of the Guidelines	How this has been met by the Project
For surveying Northern Quolls, cage traps or large Elliott traps should be installed primarily in rocky habitat. This can be supplemented with sand traps, remote cameras, hair tubes, spotlighting and/or daytime searches for scats.	Only one patch of potential denning habitat for Northern Quolls was present within the survey area. This was subjected to 80 trap-nights of cage traps and 80 trap-nights with large Elliott traps. This was conducted over two four-night periods in November 2015 and August 2016. Remote cameras with bait stations were also installed at the rock outcrop, with a total of 378 trap-nights between November 2015 and August 2016. In addition, 160 trap-nights of remote cameras were installed elsewhere on the MRM mineral leases between 2012 and 2016.
Relevant requirements prescribed by the *Survey Guidelines for Australia's Threatened Fish*	
For surveying Largetooth Sawfish, cord gillnets should be employed, and soak times of 4-5 hours should ensure sufficient time to capture animals while preventing accidental mortality. Nets should be cut and sacrificed to free caught sawfish.	Targeted monitoring and tagging of Largetooth Sawfish populations within the McArthur River have been undertaken over the past ten years. These involved electrofishing transects, gill netting and direct observations in shallow water.

10.4 General Impacts of the Project

The following potential effects of the Project were assessed with respect to their potential impact on MNES:

- habitat clearance;
- habitat fragmentation;
- contaminated run-off;
- 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 effect is described in **Sections 10.4.1** to **10.4.11**. The risks posed to each matter of national environmental significance from each effect are discussed in **Section 10.5**.

10.4.1 Habitat Clearance

Land clearance is listed as a key threatening process under the EPBC Act. The removal of habitat reduces the size of local populations of flora and fauna dependent on that habitat. These impacts are immediate and significant in the short term and may persist in the long term if habitat created by 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 total habitat contained within the mineral leases that is affected by clearing, 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 vegetation mapping units (VMUs) affected by clearing are listed in **Table 10-3**. Disturbance largely avoids riparian vegetation and escarpment areas that are important for several MNES. The two VMUs that will be most affected by the Project are 5 and 6 (**Table 10-3**). These are the same two VMUs that would have been most affected by the completion of 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, depending on the domain, and have a low likelihood of restoring vegetation communities with an equivalent diversity of flora and habitat values for fauna (Gould 2011; Cristescu *et al.* 2012).

10.4.2 Habitat Fragmentation

All else being equal, 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 10-1**). 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 10.4.5**. The overall risk of this arising as a result of the Project is low.

Table 10-3 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 footslopes**		**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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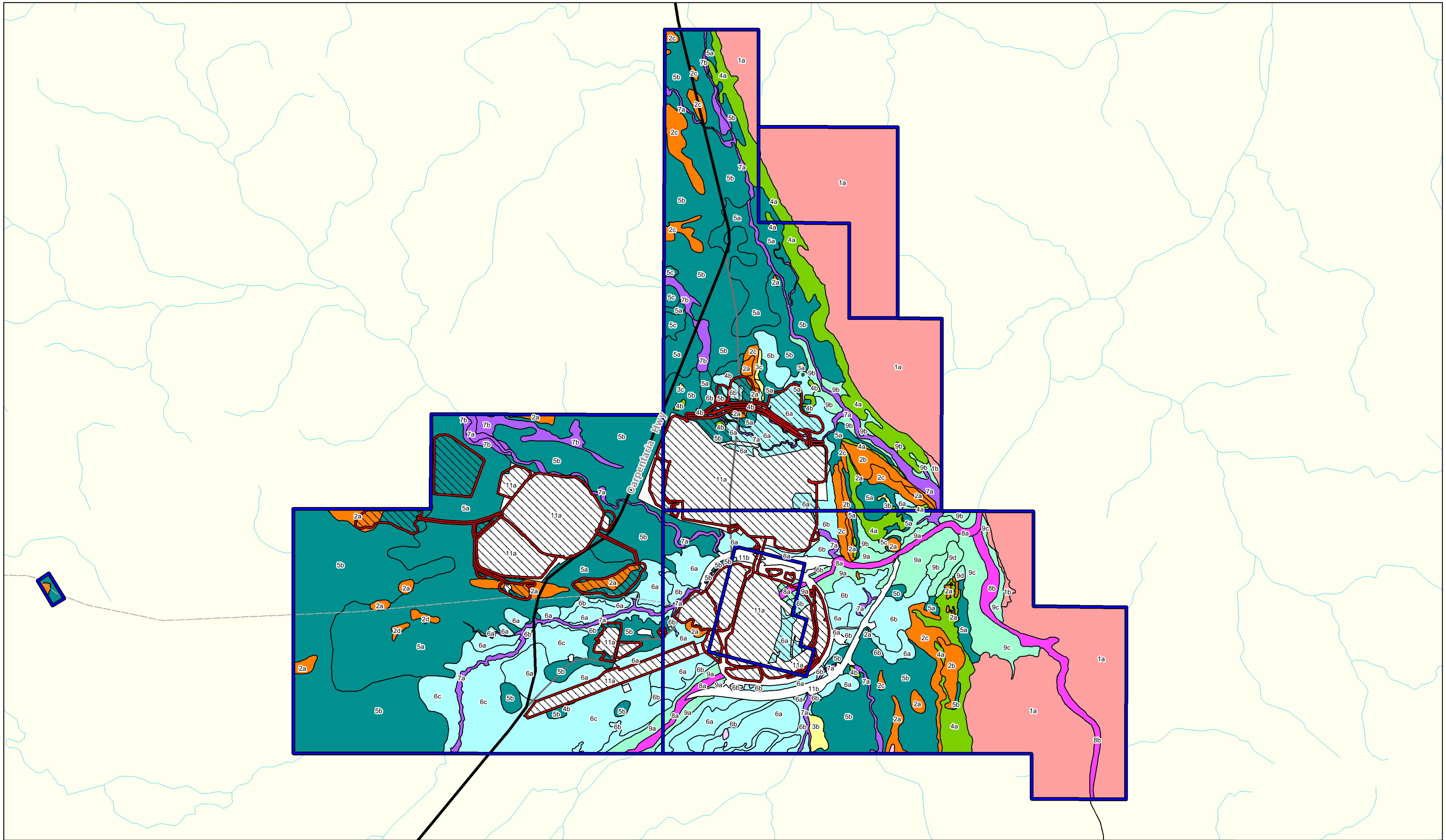

METSERVE Mining & Energy Technical Services Pty Ltd

McArthur River Mining
A GLENCORE COMPANY

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 10-1

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10.4.3 Contaminated Groundwater

McArthur River Mining has allocated significant resources to geochemical studies and waste characterisation since the Phase 3 EIS (**Chapter 6 – Materials Characterisation**). There is a strong understanding of the potential effects to 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 waste 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 revealed the following key predictions:

- 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 the 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 but benign 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 following closure and the relocation of the tailings to the final void of the open cut are predicted to reduce over time as groundwater quality is restored by gradual dilution through 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 will 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 MNES. The potential impacts of reduced water quality within Barney Creek and Surprise Creek on each MNES are discussed in **Section 10.5**.

10.4.4 Contaminated Run-off

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

Run-off, as a source of contamination, was assessed as part of the surface water models (**Section 10.4.3**). With controls in place 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.

10.4.5 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 affected groundwater adjacent to the TSF and NOEF, to prevent this mine-affected water from entering local creeks and the McArthur River. This could also act to lower the water table.

Loss of surface pools can reduce potential drinking sites for fauna species such as the Gouldian Finch. Reduction in the amount of water within the McArthur River within the dry season could also result in the possible reduction in the size of pools containing the Largetooth Sawfish.

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 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 temporarily decrease by 0.7 m, during the mining operation, compared to historical levels. Once the open cut void is filled with water, water levels within neighbouring waterways will return to their original levels. Water levels within the upper reaches of Surprise Creek and Emu Creek (known drinking sites for Gouldian Finches) 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 approved for Phase 3. This is expected as the open cut geometries are similar. Based on the predictions of water models, impacts on MNES of draw-down are expected to be minor.

10.4.6 Erosion and Sedimentation

A lack of vegetation on exposed surfaces such as 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 available drinking water for MNES species such as Gouldian Finches, as well as habitat for the Largetooth Sawfish.

Models of surface water quality throughout the duration of the Project reveal that, with various mitigation 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, providing adequate mitigation measures, such as sediment traps, run-off dams and bund walls, erosion of sediment into waterways is considered a low risk to MNES.

10.4.7 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 other mining activities.

A total of 31 species of weeds (non-native plants) have been recorded on the MRM mineral 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 MNES in northern Australia are exotic grasses that out-compete the native understorey and lead to more frequent and intense fires (TSSC 2009). Invasion of northern Australia by introduced grasses constitutes a key threatening process under the EPBC Act (TSSC 2009), due to its potential impact on the Gouldian Finch (*Erythrura gouldiae*) and other threatened species. Introduced grasses are currently scarce within the MRM mineral leases, with Annual Mission Grass being the only species present that is listed as a constituent of the key threatened process. 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 hazard posed by weeds for MNES 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 habitat for MNES.

There are nine feral animal species that have been recorded on the MRM mineral leases. Five of these (horse, donkey, cattle, water buffalo and pig) are herbivores that pose a hazard to fauna dependent on dense, grassy understoreys. Such fauna include MNES such as the Gouldian Finch, Australian Painted Snipe (*Rostratula australis*) and Partridge Pigeon (*Geophaps smithii*). 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 hazards posed by grazing feral animals on MNES.

Predation by Feral Cats (*Felis catus*) and Dingos (*Canis lupus dingo*) represents a hazard to some species of MNES. The former pest species represents a key threatening process under the EPBC Act. No actions proposed as part of the Project are expected to result in the proliferation of either species.

The Cane Toad (*Rhinella marina*) is a threat to certain MNES that are poisoned after attempting to consume them. This constitutes a key threatening process under the EPBC Act. Two MNES formerly present on-site, the Northern Quoll (*Dasyurus hallucatus*) and Plains Death Adder (*Acanthophis hawkei*), have already likely become locally extinct since the arrival of Cane Toads. No other MNES still present on-site are known to be threatened by Cane Toads. The Project will create new surface water, in the form of sediment traps and run-off dams, which provide potential new breeding sites for Cane Toads. However, due to potential sulphate concentrations in runoff and seepage, the electrical conductivity of the waters collected in run-off 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 number approved in 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 MNES.

10.4.8 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, which results 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 MNES (Carpentarian Grasswren *Amytornis dorotheae*, Partridge Pigeon *Geophaps smithii smithii*, Northern Quoll *Dasyurus hallucatus* and Masked Owl *Tyto novaehollandiae kimberli*). One other MNES still present in the local area, the Gouldian Finch (*Erythrura gouldiae*), is also susceptible to excessively 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, favouring MNES. McArthur River Mining manages fire on-site through a Fire Management Plan. The objectives of this plan do not currently include improving habitat value to MNES. Revising this plan offers scope for providing benefits to the Gouldian Finch via the Project.

10.4.9 Collisions with Vehicles

Slow-moving or easily startled fauna (mammals, ground-dwelling birds, reptiles and amphibians) 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 MNES 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.

10.4.10 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 within close proximity (< 100 m) of operational areas. No important habitat for MNES is located in such places. The risk posed to MNES from lighting and noise will not increase above that approved for Phase 3.

10.4.11 Dust

Earthworks and vehicular traffic associated with mining can generate 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 elevated concentrations of metals such as lead, which is potentially toxic in moderate doses. Lead-rich dust is primarily 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**). No important habitat for MNES exists in these areas. A past on-site incident involved contamination of Barney Creek, in the vicinity of the main haul road and SW19, with levels of lead within fluvial sediments (**Appendix W – Aquatic Ecology Report**). This was detected via regular water quality testing and successful remediation was undertaken. Such localised incidents have potential to reoccur in the future. Regular monitoring is required to allow any contamination to be remediated before this enters the McArthur River, where lead could accumulate in the tissues of fish and in sediment downstream. Ongoing monitoring of lead levels in fish tissues suggests that early remediation of localised contamination is highly effective at preventing widespread impact (**Appendix W – Aquatic Ecology Report**).

10.5 Potential Impacts to MNES

10.5.1 Curlew Sandpiper

The Curlew Sandpiper (*Calidris ferruginea*) is a small, migratory shorebird that is a non-breeding summer visitor to Australia. While in Australia, Curlew Sandpipers inhabit muddy shorelines, both freshwater and saline. Curlew Sandpipers have never been recorded within the MRM mineral leases, and the habitat present on-site is sub-optimal for the species. Over the past ten years, approximately 700 hours of bird surveys have been undertaken along the McArthur River channel during the summer months when the species potentially visits. The species is highly detectable if present, preferring to forage in open environments.

Small numbers of Curlew Sandpipers visit the McArthur River estuary and the Gulf of Carpentaria shoreline each year. However, no sites of international importance for the species are found within the NT, with the key foraging and staging areas being located along the western and southern coasts of Australia (Bamford *et al.* 2008).

Given the absence of the species from the MRM mineral leases, the likelihood of the Project impacting the Curlew Sandpiper is low. The only potential impact on the species from the Project is elevated levels of metals in sediment in the feeding habitat at the mouth of the McArthur River. Metals are naturally transferred from solution through precipitation into the sediments that settle in estuary environments (Nordmyr *et al.* 2008). The consequences of such an effect on the Curlew Sandpiper are expected to be negligible due to the relative unimportance of the estuary for the species (Bamford *et al.* 2008) and the low metal concentrations within the McArthur River, as predicted by detailed surface water models and shown by monitoring results for fluvial sediments (**Chapter 8 – Water Resources**).

10.5.2 Eastern Curlew

The Eastern Curlew (*Numenius madagascariensis*) is a large, migratory shorebird that is a non-breeding summer visitor to Australia. While in Australia, Eastern Curlews inhabit intertidal mudflats.

Potential habitat for the Eastern Curlew is not present within the MRM mineral leases and the species has never been recorded there, despite approximately 700 hours of bird surveys along the McArthur River during summer. The Eastern Curlew is an annual visitor to the McArthur River estuary (approximately 90 km downstream of the Project) and nearby shorelines of the Gulf of the Carpentaria. The numbers of Eastern Curlews that have been reported in the McArthur River estuary qualify the location as a site of international importance for Eastern Curlews (Bamford *et al.* 2008). There is a low risk that either acid and metalliferous drainage and/or seepage of contaminated water could negatively impact the McArthur River and lead to further impacts downstream. When metal-rich river water enters estuaries with higher salinity, the metals are likely to be removed from solution through precipitation into the sediments (Nordmyr *et al.* 2008). If shorebirds such as the Eastern Curlew are exposed to toxic concentrations of metals, via the invertebrates they feed on within the sediment, there is a potential for mortality or sub-lethal effects on health or fitness (Hargreaves *et al.* 2011; Lucia *et al.* 2012).

Concentrations of acids, sulphates and metals in the McArthur River are predicted to remain at benign levels as a result of mitigation measures. Models of surface water flows over the next 1,000 years (**Chapter 8 – Water Resources**) suggest any impact on this species as a result of the Project to be highly unlikely. Highly localised contamination (lead, zinc and sulphates) of smaller tributaries such as Barney Creek and Surprise Creek has occurred in the past, due to surface runoff and dust from adjacent operations (**Appendix W – Aquatic Ecology Report**). Surveys of metal concentrations within the creek sediments and in the tissues of fish have demonstrated that remedial efforts were highly effective at removing this contamination (**Appendix W – Aquatic Ecology Report**). Ongoing monitoring will be required into the future, and active remediation employed if necessary, to limit potential future contamination from entering the McArthur River and affecting downstream ecosystems, including foraging habitat for Eastern Curlews.

10.5.3 Carpentarian Grasswren

The Carpentarian Grasswren (*Amytornis dorotheae*) was formerly common in the Borroloola region, where it inhabited unburnt spinifex (*Triodia burbidgeana*) growing on sandstone escarpments (Hill 1913; Ward and Woinarski 2016). By 1976, due to widespread fires, its local distribution had contracted to escarpments in the vicinity of the Glyde River (CSIRO 1976). This population is thought to have become extinct in the mid-1980s (Martin and McKean 1986; Harrington and Murphy 2015). Despite numerous targeted surveys for the species across the entire region (Perry 2005; URS 2007; Garnett *et al.* 2011; Perry *et al.* 2011; Harrington and Murphy 2015), there have been no records of the species from the Borroloola region since 1986.

Extensive and frequent fires have caused the large-scale loss of habitat for the species across the region. It is likely that the species previously occurred throughout the Bukalara Range, immediately east of the Project, but it is also highly likely that this population is extinct.

Given the local extinction of the Carpentarian Grasswren, the Project will not impact on the species.

10.5.4 Northern Quoll

The Northern Quoll (*Dasyurus hallucatus*) once inhabited rocky escarpments in the vicinity of the Project. The area, however, probably always constituted marginal habitat for the species, as Northern Quolls were not detected during ecological surveys undertaken in the 1970s (CSIRO 1976) and there are relatively few records across the Gulf of Carpentaria (**Appendix X—Terrestrial Ecology Report**). A survey by Ecostudy (1992) detected scats and dens in rocky areas on Barney Hill, located in the vicinity of the current administration buildings. This was shortly after the invasion of the region by Cane Toads (*Rhinella marinus*) and pre-dated the construction of infrastructure that currently encompasses this location. Lethality after ingestion of Cane Toads is a leading cause of local extinction of Northern Quolls (Woinarski *et al.* 2008). By 1994, approximately five years after colonisation by Cane Toads, Northern Quolls were thought to have become extinct across the Gulf of Carpentaria (Braithwaite and Griffiths 1994).

Despite this, a single quoll scat was located in a cave in the Glyde River gorge (5 km southeast of the Project) in 2002 (URS 2005). It is possible that a small population of Northern Quolls persists in the local region following the establishment of Cane Toads, as occurs in other regions (Woinarski *et al.* 2008; Ujvari *et al.* 2013). Elsewhere, persistence of populations in the presence of toads only occurs in rugged, well-watered landscapes (Woinarski *et al.* 2008), which were always the preferred habitat of the species (Braithwaite and Griffiths 1994).

Only one small area of potential quoll habitat—rock outcrops near water—is to be potentially disturbed by the Project, although it occurs 2.5 km north of the Project footprint. This isolated patch of habitat was intensely surveyed using cage traps and remote-sensory cameras in 2015-2016, without any quolls being detected (**Appendix X—Terrestrial Ecology Report**). It is unlikely that the Northern Quoll utilises this habitat fragment, and even more unlikely that, if it did, any part of the home range of a Northern Quoll will be disturbed by the Project. Females quolls have an average home range of 35 ha (approximate radius of 334 m) and male quolls can range over 100 ha (approximately radius of 564 m) (Oakwood 2002). Consequently, even if the closest potential quoll habitat was occupied, there is no reason to expect any quolls to be utilising habitat to be removed by the Project.

The most likely local habitats to still support Northern Quolls are remote parts of the Glyde River Gorge, where the most recent record occurred. This is upstream of any effects of the Project, and removed from any potential impacts arising from it.

10.5.5 Gulf Snapping Turtle

The Gulf Snapping Turtle (*Elseya lavarackorum*) is a freshwater turtle confined to the larger river systems of the Gulf of Carpentaria. It occurs within the Nicholson River, Gregory River, Calvert River and Robinson River (all east of the McArthur River), as well as in the Roper River and Limmen Bight River (west of the McArthur River) (Department of the Environment 2017a). The species has never been recorded within the McArthur River system.

Gulf Snapping Turtles inhabit deep permanent freshwater pools within the middle reaches of these river systems, where they feed on plant matter and algae. Steep rocky gorges and banks with intact vegetation are favoured (Department of the Environment 2017a). It is unlikely that habitat within the MRM mineral leases is favourable for the species. In the vicinity of the Project, the McArthur River dries to small, isolated pools in the late dry season, which are probably insufficient in area and depth to support Gulf Snapping Turtles. Gorges are absent within the vicinity of the Project. A total of over 300 days of survey effort have been undertaken over the past ten years within the McArthur River, which has included fyke trapping, electrofishing transects, gill netting and seine netting (**Appendix W – Aquatic Ecology Report**). All of these methods have the potential to detect freshwater turtles, and two other freshwater turtle species were regularly recorded during these surveys. The Gulf Snapping Turtle was not detected by these surveys. Given the high trap effort to date and the lack of records of the species from the MRM mineral leases and anywhere else in the McArthur River catchment, the probability that the species occurs in waters within the Project area is low.

Downstream from the Project, the McArthur River passes through gorges within the Bukalara Plateau, where it forms a series of permanent pools. If Gulf Snapping Turtles were present within the McArthur River, this is the most likely location. This is an area that has been poorly surveyed due to a lack of access. There is therefore a slight possibility that the species occurs in these remote sections of the McArthur River. Such populations may be susceptible to downstream impacts of the Project. Surface water modelling undertaken for this EIS (**Chapter 8 – Water Resources**), which takes into account predicted flows of contaminated groundwater and surface water, indicates that water entering the McArthur River downstream from the Project will have benign concentrations of metals, acids and sulphate salts.

Overall, the risk that there will be any impact of the Project on the Gulf Snapping Turtle is low, given the likely absence of the species from the McArthur River. However, should the species be present downstream, the impact is predicted to be minor given that concentrations of contaminants in downstream waters are expected to be too low to affect the Gulf Snapping Turtle or its food.

10.5.6 Gouldian Finch

The Gouldian Finch (*Erythrura gouldiae*) is a small, seed-eating parrot finch that was once widely distributed across the savannas of northern Australia, but has declined significantly over the past few decades as a result of increasingly intense grazing practices and altered fire regimes. Current estimates suggest a national population of fewer than 2,500 adults. (Pryke 2010).

The Gouldian Finch occurs widely across the region surrounding the Project. Limmen National Park, approximately 120 km northwest of the Project, supports a population of around 100 adult Gouldian Finches (O'Malley 2006). Gouldian Finches also occur in small flocks throughout the sandstone ranges and grassy woodlands along creeks of the McArthur River catchment (CSIRO 1976), with recent records at Cape Crawford (46 km southwest of the Project), Caranbirini (15 km north of the Project) and Borroloola.

The Gouldian Finch is a regular visitor to the MRM mineral leases, in very small numbers. It was not recorded on-site prior to 2013 despite avian surveys at 184 sites (30 hours). However, between 2013 and 2016, targeted surveys detected a total of nine Gouldian Finches within the mineral leases during 78 hours of surveys. The largest flock contained three individuals. To date, the species has been recorded at two main locations within the mineral leases: *Corymbia terminalis*-dominated woodland west of the TSF and woodland dominated by *Eucalyptus tectifica* and *Eucalyptus chlorophylla* alongside Emu Creek. Sightings have occurred across multiple seasons (March, April, August and October). These habitats are widespread across the mineral leases, and Gouldian Finches were only present at each location for a short period of time. This suggests that small numbers probably utilise extensive areas of the mineral leases sporadically, but the short periods Gouldian Finches spend in each place limits their detectability. This prevents precise mapping of the occupancy of the mineral leases by Gouldian Finches.

Among the MNES assessed for this EIS, the Gouldian Finch is the most at risk of experiencing potential impacts, as they are known to occur on-site and potential habitat will be removed for the Project. In light of these risks, a detailed review of the species' ecology is provided below to clarify the scale and nature of the potential Project impacts on the species.

10.5.6.1 Ecological Requirements

Gouldian Finches commence breeding in the mid to late wet season (February-April, depending on rainfall) and continue breeding until May-July (Tidemann *et al.* 1992, 1999; Brazill-Boast *et al.* 2010). Gouldian Finches breed in the hollow limbs of smooth-barked species of *Eucalyptus* and *Corymbia*. Across the Gulf of Carpentaria, *Eucalyptus leucophloia* is the principal tree species used for nesting (Tidemann *et al.* 1992, 1999), although other species are utilised further west (Tidemann *et al.* 1992; Dostine *et al.* 2001; Brazill-Boast *et al.* 2010). Preferred nest trees such as *E. leucophloia* typically grow on low, rocky hills. Optimal breeding habitats adjoin more level ground used for feeding (Tidemann *et al.* 1992) and are near water. Nests are built an average of 190 metres (m) from water, but up to 2 km (Pryke 2011) and possibly even as much as 4 km (Department of the Environment 2017b). On occasions when Gouldian Finches undergo population booms (in response to successive productive breeding seasons), breeding may also occur in small numbers away from the hill habitats usually associated with the species (Eussen 2009). Considering their unimportance for Gouldian Finches during times of low productivity (key periods in the boom-bust cycle), these secondary breeding habitats are probably inconsequential for the long-term success of populations.

In addition to breeding sites within *E. leucophloia* woodlands in hilly areas, local Gouldian Finch populations are dependent on a year-round supply of grass seed. Throughout most of the dry season, Gouldian Finches feed on the fallen seeds of annual grasses (*Sorghum* and *Schizachyrium* spp.) (Dostine *et al.* 2001). Annual *Sorghum* (e.g., *S. intrans*, *S. stipoideum* and *S. timorense*) is especially important, and is the main food source fed to nestlings (Dostine *et al.* 2001). These grass species are common, widespread and resistant to heavy grazing and frequent fires.

At the commencement of wet season rains (November-January), there is a bottleneck in seed supply, as any seed remaining on the ground germinates, rots or is washed away. At this time, Gouldian Finches shift their diet to early-seeding perennial grasses (e.g., *Chrysopogon fallax*, *Alloteropsis semialata*, *Triodia* spp.), and may travel far to find these (Dostine *et al.* 2001). The sensitivity of these perennial grasses to over-grazing and frequent fires is thought to be the leading cause of the widespread declines of Gouldian Finches (Crowley and Garnet 2001; O'Malley 2006).

Gouldian Finches are highly mobile and can undergo large seasonal movements in response to the availability of grass seed and surface water. Their wing morphology is adapted for dispersal (Woinarski and Tidemann 1992), and a low proportion of each population remains at the same location between years (AWC 2005) or even months (Woinarski and Tidemann 1992). Banded juveniles have been recorded moving over 100 km (Shedley 2012). Within a single year, Gouldian Finches undertake regular shifts in habitat, from breeding areas in hill woodland during the early dry season to adjacent lowlands during the early wet season (Dostine *et al.* 2001). Between years, shifts in habitats are frequent but less predictable (AWC 2005). These likely follow the productivity of seeding grasses, which varies in response to fire history, timing and amount of rainfall, and grazing pressure. The daily movements of Gouldian Finches are also extensive. Breeding individuals can commute 5 km (each way) between nest sites and feeding areas (Murphy 2011), and Gouldian Finches regularly commute over 3 km between water sources and feeding areas (Woinarski and Tidemann 1992). Despite this capacity for movement, most Gouldian Finches feed in the same area in which they breed (Pryke 2012), and breeding areas dominated by suitable food grasses are likely to be favoured over others requiring a commute.

10.5.6.2 Potential Impacts

Nesting Habitat

Potential nesting habitat for Gouldian Finches—*Eucalyptus leucophloia* growing on rocky hills—will largely be avoided by the Project. Of 445.3 ha of vegetation mapping units 4a and 4b contained within the MRM mineral leases, less than 1% (4.02 ha) is contained within the proposed Project footprint. The 4.02 ha of *E. leucophloia* woodland to be removed for the Project comprise tiny fragments (about 1 ha each), surrounded by non-nesting habitat. These fragments occur 1.5 to 3 km from water, which is within commuting distance for Gouldian Finches, albeit considerably further than average (Pryke 2011). These small areas of potential nesting habitat were surveyed intensively for Gouldian Finches between 2014 and 2016 (**Appendix X—Terrestrial Ecology Report**), without any being detected there. In light of the small areas of habitat, the distance of this habitat from water and the lack of records of Gouldian Finches from this habitat, it is unlikely that Gouldian Finches utilise areas within the Project footprint for nesting.

Potential nesting habitat for Gouldian Finches is widespread in the region. Cuff *et al.* (2009) estimate that 291,353 ha of *E. leucophloia* woodland on hills and low rises occur within the McArthur River catchment. Not all of this represents potential nesting habitat, due to distance from water and absence of hollow limbs. However, the McArthur and Glyde Rivers, and their tributaries, create numerous gorges and water holes within the sandstone plateaux of the Bukalara system. It is therefore expected that Gouldian Finches breed widely across the local region.

Overall, the Project represents a negligible risk to nesting habitat of Gouldian Finches. In the event that an impact does occur, the magnitude of this impact will be small (the loss of 4 ha of habitat, which is < 1% of the habitat within the MRM mineral leases).

Feeding Habitat

Gouldian Finches utilise three main types of feeding habitats during each annual cycle (Dostine *et al.* 2001):

- feeding habitat during the breeding season (~February-July) is dominated by annual *Sorghum* spp., and to a lesser extent, *Alloteropsis semialata*, *Chrysopogon fallax*, *Heteropogon triticeus, Sehima nervosum* and *Triodia* spp.;
- feeding habitat during the non-breeding season (~August-November) is dominated by *Sorghum* spp. or *Schizachyrium* spp. and
- feeding habitat during food-limiting periods in the early wet season (~December-January) is dominated by the perennial grasses, *Triodia* spp., *Chrysopogon fallax* and/or *Alloteropsis semialata*.

A total of 10,031 ha of potential feeding habitat is contained within the MRM mineral leases and 5% (489 ha) will be removed for the Project. This entire habitat contains grass species eaten during the breeding season and food-limiting periods in the early wet season. A subset (6,132 ha, of which 426 ha will be removed for the Project) also contains grass species eaten during the non-breeding season.

In addition to the grass species that are dominant, distance to water influences the value of a feeding habitat to Gouldian Finches. However, as 99.8% of the MRM mineral leases are within 5 km of permanent water, this was not considered further in calculations.

The extent of feeding habitat loss resulting from the Project that is estimated within the above paragraphs is a worst-case scenario, as not all available habitat is used by the species.

In addition to loss of feeding habitat due to clearing for the Project, further indirect losses are possible via the spread of weeds or deposition of dust on foliage. Weeds and dust primarily affect the close vicinity of roads and other disturbed areas. In a highly conservative situation where 10 m buffers around all disturbances will be 'removed' as Gouldian Finch habitat due to dust and weeds, this would result in a potential loss of 45 ha of additional feeding habitat. This constitutes only 0.4% of the feeding habitat available within the mineral leases.

Water Sources

Given that the extent of potential nesting and feeding habitat is constrained by proximity to water sources, any loss or contamination of drinking sites has the potential to reduce the availability of other habitats for Gouldian Finches.

Gouldian Finches have never been observed to drink along the McArthur River in the vicinity of the Project, despite over ten years (1,080 survey hours) of riparian bird surveys in this habitat. Instead, Gouldian Finches prefer to drink at smaller, isolated water holes, and all local records come from the upper reaches of smaller tributaries such as Surprise Creek, Barney Creek and Emu Creek. Any changes to the water quality or water level within these three creeks as a result of the Project have the potential to impact Gouldian Finches. The lower reaches of all three creeks lie downstream from the Project, although for Emu Creek and Barney Creek only relatively small sections are potentially affected. Surprise Creek passes alongside the TSF and the NOEF, and measures are required to manage the impact of acid and metalliferous drainage from the NOEF and/or seepage of contaminated water from the TSF.

Water quality over the next 1,000 years has been modelled for all the drainage systems within the MRM mineral leases. The lower Surprise Creek, and Barney Creek downstream from its confluence with Surprise Creek, may experience elevated sulphate levels as a result of the Project. Median concentrations of 300-2,000 milligrams of sulphate per litre (mg SO_4^{2-}/L) are predicted in these worst-affected drainage lines (**Chapter 8 – Water Resources**). Such concentrations are associated with minor diarrhoea in humans and other animals, but no other signs of toxicity (World Health Organization 2004). Given the transient use of any one water source by Gouldian Finches and the mild health effects of the concentrations of sulphate predicted, there are no anticipated impacts on Gouldian Finches from elevated sulphate concentrations within Surprise and Barney Creeks. Other downstream waterways are not expected to contain sulphate concentrations at levels that affect the health of wildlife (**Chapter 8 – Water Resources**).

Some leaching of heavy metals may occur from the NOEF and TSF into local areas of neighbouring creeks, and this has the potential to be a health risk to Gouldian Finches using these creeks as a water source. Detailed water modelling (**Chapter 8 – Water Resources**) has revealed that zinc is the principal metal expected to be elevated in local waterways as a result of the Project. Zinc is an essential nutrient that plays a role in enzyme function (Lindh 2005). It is also highly regulated by the body, but when exposure rates overwhelm physiologic control mechanisms, zinc poisoning may occur (Stahl *et al.* 1989; van der Merwe *et al.* 2011). The lower Surprise Creek and lower Barney Creek will be the worst affected areas. Here, zinc concentrations are forecast to rarely (< 5% of the time) go above 90 micrograms per litre (μg/L), and exceptionally (in certain weather combinations during February-April) reach as high as 2,000 μg/L (**Chapter 8 – Water Resources**). These concentrations are higher than the trigger limits set in the MRM site Waste Discharge Licence (WDL) (62.7 μg/L), but are lower than the maximum concentration deemed fit for human consumption by the World Health Organization of 3,000 μg/L. Most diets for poultry and pet birds contain 35 to 110 milligrams of zinc per kilogram (mg_{Zn}/kg) and toxic effects occur when diets contain greater than 2,000-3,000 mg_{Zn}/kg (Stahl *et al.* 1989; Puschner and Poppenga 2009). The concentrations of zinc that may occur within Surprise and Barney Creeks are therefore 1,000 times lower than toxic levels and are even 17 to 55 times lower than is contained in commercial bird food. While sensitivity of Gouldian Finches to zinc is unknown, based on data from captive birds, no zinc poisoning of Gouldian Finches is expected to occur as a result of the Project.

In addition to zinc, localised increases in lead can potentially occur in pools close to haul roads and earthworks, where lead-rich dust is generated. Moderate quantities of lead are neuro-toxic to birds and other wildlife. The lethal doses for Gouldian Finches are not known, but a chronic cumulative lead dose of 2 milligrams of lead per kilogram per day (mg_{Pb}/kg/day) is toxic for ducks (Puschner and Poppenga 2009). Gouldian Finches weigh an average of 14 g, implying that 0.028 mg_{Pb}/day is toxic. Gouldian Finches drink approximately 4.2 mL of water per day (Pollock 2012), suggesting that lead concentrations of 6.67mg_{Pb}/L in drinking water would be toxic if consumed for an extended period. The concentrations of lead reported within the previously contaminated pool within Barney Creek (a guide to what might be expected in future contamination events) were as high as 0.06 mg_{Pb}/L, which is three orders of magnitude lower than levels toxic to birds. While it is possible that prolonged exposure at this concentration may lead to eventual health problems, this is unlikely to occur given the high mobility of Gouldian Finches and their frequent dispersal to new areas/drinking locations. Exposure of Gouldian Finches to lead as a result of the Project is further reduced by the species generally avoiding high-traffic areas, where lead contamination is most likely. Models indicate that other sources of lead, such as seepage of contaminated groundwater, are expected to be insignificant (**Chapter 8 – Water Resources**). Consequently, waterholes most likely to be important to Gouldian Finches, away from the close proximity of mining operations, will not contain elevated lead levels. The site-specific trigger value for lead concentrations downstream of the Project, as specified in the WDL, is 0.0166 milligrams per litre (mg/L), which is far lower (two orders of magnitude) than concentrations toxic to birds.

A decrease in water level within re-channelled sections of the McArthur River and Barney Creek is expected to result from open cut dewatering and contaminated groundwater interception and recovery at Surprise and Barney Creeks (**Appendix T – Groundwater Report**). Gouldian Finches have never been observed to drink at these locations, despite these being among the most intensively surveyed parts of the MRM mineral leases (**Appendix X – Terrestrial Ecology Report**). Water levels within the upper reaches of Emu Creek and Surprise Creek (known drinking sites for Gouldian Finches) are not expected to be affected by the Project, as any drawdown of the water table caused by dewatering of the open cut is balanced by water table mounding beneath the TSF (**Appendix T – Groundwater Report**).

Overall, any reduction in the local availability of surface water as a result of the Project is not predicted to affect Gouldian Finches. A reduction in water quality (elevated sulphate levels) within the lower reaches of Barney Creek and Surprise Creek could affect the health of Gouldian Finches that attempt to drink there. Despite ten years of riparian bird surveys along Barney Creek and targeted finch surveys along both creeks, Gouldian Finches have never been recorded utilising the reaches of these creeks that are likely to be compromised by seepage of contaminated water. This suggests that the overall risk to the Gouldian Finch of loss of drinking sites is low.

10.5.7 Australian Painted Snipe

Australian Painted Snipe (*Rostratula australis*) are nomadic birds inhabiting shallow, vegetated swamps and flooded grasslands across the eastern half of Australia. They are most often recorded in the southeast quarter of the country, but occasionally appear in the NT and the Kimberley region. The species was recorded on a few occasions in 1999 on coastal plains north of Borroloola, and there are earlier records from the Barkly Tablelands, 200 km south of the Project. They are likely to be occasional visitors to the general region.

Australian Painted Snipe have not been recorded on the MRM mineral leases, despite extensive survey effort over several decades. Suitable habitat for the species—seasonally flooded wetlands—are scarce within the mineral leases, and no habitat will be removed for the Project.

Given the lack of disturbance to potential habitat and the low importance of the region to the species, there is considered to be negligible risk to the Australian Painted Snipe of the Project.

10.5.8 Plains Death Adder

Plains Death Adders (*Acanthophis hawkei*) are snakes that inhabit cracking-soil, riverine floodplains of northern Australia. They are sedentary and difficult to locate in the dry season, but are mobile during wet weather, when they are most likely to be detected (TSSC 2012). The principal threat to the species is lethality after ingestion of Cane Toads (*Rhinella marinus*) (TSSC 2012). Population densities are low in areas invaded by Cane Toads, where detection rates can be as low as one individual per 30-60 hours of surveying (TSSC 2012).

A single specimen of the Plains Death Adder was recorded within the MRM mineral leases in the 1970s (CSIRO 1976). It was found in rocky "sandstone spinifex" habitat at the confluence of the McArthur and Glyde Rivers, in habitat that is more appropriate for the closely related Northern Death Adder (*A. rugosa*). Review of the specimen confirmed its identity, and it likely represented an individual that was funnelled into rocky habitats when following the McArthur River floodplain northwards. There are no other known records of the species in the Gulf of Carpentaria north of the Barkly Tablelands.

Cane Toads arrived to the region in the 1980s, and since this time there have been no local records of the Plains Death Adder. This is a species that, if present, is highly likely to be reported if observed on mine roads or in the vicinity of the accommodation village. Death adders die in large numbers when Cane Toads colonise an area, and there is no evidence that populations recover after this initial crash (Ward and Phillips 2012).

Given the lack of records of the species since the arrival of Cane Toads, it is highly likely that the Plains Death Adder is locally extinct and will therefore not be impacted by the Project. In the unlikely event that the Project does impact the species, the magnitude of these impacts will be the clearing of 212.2 ha of possible habitat (vegetation mapping units 6, 7 and 9: **Appendix X—Terrestrial Ecology Report**). This represents a loss of 7.6% of the 2,776.9 ha of habitat available within the mineral leases.

10.5.9 Red Goshawk

The Red Goshawk (*Erythrotriorchis radiatus*) is a bird of prey that inhabits forested coastal and near-coastal north and east Australia. They require large areas of intact native vegetation and favour mosaics of open and closed forests (monsoon forests, paperbark swamps, riparian vegetation, eucalypt woodlands), especially near permanent freshwater (Department of Environment and Resource Management 2012). They are solitary, secretive and generally silent, making them difficult to detect (Department of Environment and Resource Management 2012). They are also frequently misidentified and many erroneous reports have to be discounted (Department of Environment and Resource Management 2012). Red Goshawks have large home ranges. Parents routinely forage 5-10 km from their nest, and when not breeding can wander over an area up to 200 square kilometres (km^2) (Department of Environment and Resource Management 2012). Red Goshawks occur at very low densities throughout their distribution. Some authors have argued that there may be a break in the Red Goshawk's breeding distribution across the Gulf of Carpentaria (Aumann and Baker-Gabb 1991; Czechura and Hobson 2000), although a nest has been recorded on the Leichhardt River (near Mount Isa) (Barrett *et al.* 2003), suggesting that small numbers may inhabit some of the larger river systems in the Gulf.

Red Goshawks were recorded along the lower reaches of the McArthur River at Borroloola by Barnard (1914). They were considered a "rare resident" in denser woodlands lining the McArthur River in the 1970s (CSIRO 1976). It is likely that the lower reaches of the McArthur River still support a population of the species. Based on average densities of one pair per 20 km of river, suggested by Aumann and Baker-Gabb (1991), the McArthur River may support up to three pairs downstream from the Project.

No confirmed sightings of a Red Goshawk have occurred on the MRM mineral leases. A possible Red Goshawk was seen along Barney Creek, within the mineral lease, in 1992 (Ecostudy 1992), but its identity was not confirmed. Bi-annual monitoring of riparian birds over the last ten years (1,080 survey hours) has failed to detect the species on-site. Furthermore, searches for raptor nests along the McArthur River have also failed to detect the species. Based on the intensity of survey effort that has failed to result in detection, it is highly improbable that Red Goshawks breed within the Project area. However, the species may occasionally travel from territories downstream to forage along riparian corridors on-site.

Overall, in light of the Project not occurring within a breeding territory, the risk to the Red Goshawk from the Project is minimal. The only conceivable impact is if there is loss of riparian vegetation downstream from the Project, as a result of metalliferous drainage and/or seepage of contaminated water. In a worst case scenario, this could affect up to three pairs of Red Goshawks. However, detailed surface water models suggest that the levels of downstream contamination expected to arise due to the Project will not affect the condition of habitat for Red Goshawks. Risks to the Red Goshawk are therefore considered negligible.

10.5.10 Crested Shrike-tit (Northern)

The northern subspecies of the Crested Shrike-tit (*Falcunculus frontatus whitei*) is a bird that inhabits open forests and woodlands across sub-coastal parts of the NT and Kimberley region. The subspecies has never been recorded in the vicinity of the Project, despite intensive survey effort over several decades. The species is relatively easy to detect when present, as it calls regularly and forages in open environments. Nevertheless, the subspecies is rarely recorded anywhere within its distribution (Woinarski 2004a), indicating that it occurs at very low densities.

The closest record of the subspecies to the Project is near the township of Borroloola where it was collected by Barnard in 1914. Barnard described it as "…rare, with only a few pairs seen. These were always on dry stringy bark ridges" (CSIRO 1976). It is not known which species of tree Barnard was referring to, but it is likely to be *Eucalyptus tetrodonta*, which occurs in the vicinity of Borroloola but not south to the Project area. *Eucalyptus phoenicea* is the only other local species of eucalypt that could be described as having stringy bark. It grows on rocky ridges immediately east of the Project, but will not be impacted by the Project. Other tree species used by the species elsewhere in northern Australia include *Eucalyptus tectifica, Eucalyptus miniata, Corymbia terminalis, Corymbia bleeseri* and *Corymbia confertifolia* (Department of the Environment, Water, Heritage and the Arts 2010). Within the mineral leases, vegetation mapping units 5a and 5b support these tree species and may represent potential habitat for the Crested Shrike-tit (**Appendix X—Terrestrial Ecology Report**). These habitats have been subjected to intensive avian survey effort over many years, with no shrike-tits being detected.

Considering the high detectability of the species and the survey effort to date, it is unlikely that Crested Shrike-tits occur within the Project area. In the unlikely event that the Project does impact the species, the magnitude of these impacts will be the clearing of 222 ha of vegetation mapping units 5a and 5b. This constitutes a loss of 3.4% of the 6,504.9 ha of potential habitat contained within the mineral leases (units 5a and 5b, as well as the undisturbed units 1a and 2b: **Appendix X—Terrestrial Ecology Report**).

10.5.11 Partridge Pigeon (Eastern)

The Borroloola region historically was at the eastern edge of the distribution of the eastern subspecies of the Partridge Pigeon (*Geophaps smithii smithii*) (Woinarski 2004a). There have been no confirmed records of the species from the region since 1913, despite extensive survey effort and it being relatively detectable when present. The species feeds on the ground in open, grassy woodlands and is often observed on roads, where present. Partridge Pigeons are sedentary and are not likely to undergo large-scale movements outside their known distribution.

The subspecies is currently only found in the northwest of the Top End and is long-thought to be extinct within the Gulf region (Storr 1977; Woinarski 2004a). Given the local extinction of the subspecies, the Project will not have any impacts on the Partridge Pigeon.

10.5.12 Painted Honeyeater

The Painted Honeyeater (*Grantiella picta*) is a wide-ranging, nomadic bird occurring across the eastern states of Australia. They are an irregular, non-breeding visitor to the NT (Ward 2012). Two Painted Honeyeaters were collected from near the Project in 1913, but the species has only been recorded once since, despite extensive search effort (**Appendix X—Terrestrial Ecology Report**). The latest sighting was in 1986, just south of the Project (Higgins *et al.* 2001).

Painted Honeyeaters feed primarily on flowering and fruiting mistletoes. In the northern half of Australia, Painted Honeyeaters are heavily tied to *Acacia*-dominated woodlands on heavy clay soils, as this tends to support their favoured mistletoe species (Rowland 2012). The 1913 record of Painted Honeyeaters from the Project area was on black clay soil plains, where they were feeding not on mistletoe, but on flowering *Bauhinia cunninghamii*. The habitat that supported Painted Honeyeater in 1986 was not recorded.

Global populations of Painted Honeyeaters are thought to be limited by habitat clearance in south eastern Australia, where they breed (Ward 2012). In contrast, the largely intact woodlands across northern Australia, which are used by the species sparingly as a feeding resource in the non-breeding season, are unlikely to be a limiting resource to the species.

Overall, the Project is considered to have a low risk of impact to the Painted Honeyeater, given the low importance of the region for the species. The magnitude of any impact that does occur is expected to be minor. Of the 1,881.6 ha of black clay plains (supporting *Bauhinia cunninghamii*, a potential food source) within the mineral leases, 199.5 ha (10.6%) will be cleared to accommodate the Project. Cuff *et al.* (2009) mapped 788,380 ha of vegetation containing *B. cunninghamii* within the McArthur River catchment. Of this, 29,838 ha comprised woodlands where *B. cunninghamii* was the dominant species. Therefore, the loss of 199.5 ha constitutes a loss of 0.02% of the total habitat and 0.67% of the highest quality habitat for Pained Honeyeaters within the McArthur River catchment. The small scale of this loss, combined with the understanding that non-breeding habitats within northern Australia are not a limiting resource for the species, suggest that habitat loss as a result of the Project will not impact Painted Honeyeater populations.

10.5.13 Ghost Bat

The Ghost Bat (*Macroderma gigas*) is a large, carnivorous bat that roosts in caves and forages an average of 1.9 km from roosts in nearby forests (Tidemann *et al.* 1985). It is known to occur in the Sir Edward Pellew Islands (100 km northeast of the Project), at Pungalina-Seven Emu Wildlife Sanctuary (150 km east of the Project) and at Wollogorang/Redbank (100 km east of the Project). Rugged escarpments and gorges within the Bukalara Range, immediately east of the Project, could provide potential roost habitat for Ghost Bats; however, searches for roosts conducted between 2002 and 2016 have failed to detect the species.

Surveys within the Project area have failed to detect Ghost Bats, despite employing methods (spotlighting, harp traps, echolocation call recordings) that would be expected to detect the species, if present (Hourigan 2011).

The Project will not remove or disturb any sites containing caves that could potentially provide roosts for Ghost Bats. Considering the lack of disturbance to potential roost sites, and the low probability that the species occurs in the local area, there is no anticipated impact of the Project on Ghost Bats.

10.5.14 Largetooth Sawfish

The Largetooth Sawfish (*Pristis pristis*) is a large fish that breeds in marine and estuarine waters but migrates as juveniles into the upper freshwater reaches of rivers, where they develop away from the threat of predators. Juvenile Largetooth Sawfish prefer waters less than 10 m deep (Thorburn *et al.* 2003; Kyne *et al.* 2013), and spend most of their time in waters less than 1 m deep (Whitty *et al.* 2008). Turbid waters and soft, muddy substrates are preferred (Allen 1991). They feed on small fish and benthic invertebrates, which are stunned using their saw (Allen 1982; Whitty *et al.* 2008).

Juvenile sawfish generally occur at densities of one per 30,000-70,000 square metres (m^2) (**Appendix W – Aquatic Ecology Report**). This naturally low density, along with a low reproduction rate (Peverell 2009) and female philopatry (i.e. females return to their natal river systems to give birth) (Phillips *et al.* 2011; Phillips 2012), causes the species to recover slowly from population crashes, with recovery taking decades (Musick 2000, Simpfendorfer 2000).

The Largetooth Sawfish has been the subject of several targeted surveys within the McArthur River (**Appendix W – Aquatic Ecology Report**). These include an ongoing monitoring program and a tagging program, designed to investigate the movements of sawfish through the river system. A total of 44 records of Largetooth Sawfish have been obtained within the freshwater reaches of the McArthur River between March 2006 and October 2016 (**Appendix W – Aquatic Ecology Report**), both upstream and downstream of the Project. This suggests that the species is a regular migrant through the MRM mineral leases. Most individuals captured in the vicinity, and upstream, of the Project were one to two years old. While Largetooth Sawfish are regularly recorded in the McArthur River, none have been observed in smaller tributaries, such as Barney Creek, Surprise Creek or Emu Creek. The lack of permanent waterholes in these creeks limits their suitability as habitat for the Largetooth Sawfish.

Capture rates of Largetooth Sawfish within the McArthur River vary between years, depending on the magnitude and duration of the wet season (**Appendix W – Aquatic Ecology Report**). Large flows are required for significant numbers of sawfish to enter the upper reaches of the McArthur River in the vicinity of the Project.

The population of Largetooth Sawfish within the McArthur River is connected to others in the Gulf of Carpentaria by the dispersal of males. However, the philopatry displayed by females suggests that each river system is best treated as a partly isolated population (Phillips *et al.* 2011; Phillips 2012).

The Largetooth Sawfish may be impacted by the Project in the following ways:

- Erosion from exposed surfaces, including the NOEF, may cause sedimentation within the McArthur River, which could increase turbidity and reduce the size and/or connectivity of pools, impeding migration of the species. Largetooth Sawfish are unlikely to be affected by increased turbidity, as the species prefers to forage in turbid waters (Allen 1991). However, any reduction in the size or connectivity of pools could affect the species. Surface water models predict a negligible impact of the Project on suspended sediments within the McArthur River (**Chapter 8 – Water Resources**). In fact, 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.

- Mining below groundwater levels leads to a drawdown of water levels in the adjacent McArthur River. This is unlikely to affect the migration of Largetooth Sawfish, as this primarily occurs following heavy rainfall events (**Appendix W – Aquatic Ecology Report**), when surface flows are the principal source of water. However, reduced volumes of dry season pools may limit their potential for supporting Largetooth Sawfish. The closest, and most affected, permanent pool to the Project is the Djirrinmini Waterhole. Between zero and three sawfish (mean = 0.6) are recorded in this pool each dry season (**Appendix W – Aquatic Ecology Report**). Water models indicate that during the mining and void-filling phases of the Project (up to 2047), Djirrinmini Waterhole could experience a drawdown of up to 0.7 m. Most of the pool is currently less than 2 m deep in the late dry season (**Appendix W – Aquatic Ecology Report**), suggesting that the area of habitat for sawfish could be reduced within this pool. Mitigation measures will be adopted to ensure that the extent of reduction in waterhole size does not compromise the Largetooth Sawfish. Any impacts to Djirrinmini Waterhole are not expected to persist into the long term, as models predict that drawdown ceases rapidly after the void-filling commences.
- Detailed surface water models have determined that only two contaminants (sulphates and zinc) are expected to have elevated concentrations within the McArthur River (**Chapter 8 – Water Resources**). Median sulphate concentrations are expected to peak within the McArthur River immediately downstream from the Project during the late dry season at about 45.5 mg/L (the 95^{th} percentile is 138.7 mg/L). This is highly unlikely to affect Largetooth Sawfish given their broad tolerance of salinity; sea water contains an average sulphate concentration of 2,700 mg/L, which is 20 times higher than would be experienced in the McArthur River as a result of the Project. Zinc concentrations are forecast to remain below 0.009 mg/L within the McArthur River immediately downstream from the Project.
- Models predict very limited vertical mixing within the mine pit lake below 50 m depth. Water modelling predicts elevated sulphate (up to 1,087 mg/L) and zinc (up to 0.159 mg/L) in water flowing from the mine pit lake into the McArthur River for the first years after the downstream levee is opened (2060-2069) (**Chapter 8 – Water Resources**). The timing of these releases to coincide with peak flows in the McArthur River dilutes these contaminants such that water modelling predicts that sulphates, zinc, lead and arsenic will remain below site-specific trigger values immediately downstream from the Project (**Chapter 8 – Water Resources**). Consequently, the risk to the Largetooth Sawfish of contaminated water entering the McArthur River from the mine pit lake is considered to be low.
- To prevent bioaccumulation of mine-derived metals, such as lead accumulating in the liver and other organs of Largetooth Sawfish, a monitoring program of metals in fish tissue has been in place on the MRM mineral leases for the past ten years (**Appendix W – Aquatic Ecology Report**). No tissue samples (including from liver) taken from fish in the McArthur River have contained lead in excess of the 0.5 milligrams per kilogram (mg/kg) maximum permissible concentration for fish (FSANZ 2009). While no sawfish have been sampled, due to ethical reasons, other predatory fish such as Barramundi (*Lates calcarifer*) possess low lead concentrations. This suggests that bioaccumulation of lead is a low risk while lead concentrations within the McArthur River are maintained at the current, low levels. Detailed surface water modelling of runoff and seepage suggests that no increase in lead concentrations is anticipated within the McArthur River as a result of the Project (**Chapter 8 – Water Resources**).

- Extraction of water from the McArthur River to fill the final void will be managed so that it will not adversely affect flows. Mitigation measures will be put in place to limit the reduction of downstream flows to such an extent that migration of juvenile sawfish upstream is impeded. Surface water models predict that flooding of the mine pit lake will only occur when flow rates exceed $10m^3/s$ and for a limited duration each year (average of 12 days). During this period, annual net water loss to the mine pit lake from the McArthur River is predicted to be an average of 2300 ML annually, or 0.3% of the total flow measured upstream of the mine pit lake (**Chapter 8 – Water Resources**). This slight reduction in flow rate is far less than annual variation observed due to rainfall, and is therefore unlikely to affect migration of the Largetooth Sawfish. Furthermore, any impacts will be short term, as they are restricted to a five-year period over which the lake will be filled.
- Extraction of water from the McArthur River to fill the mine pit lake will be managed to prevent loss of nutrients downstream. Mitigation measures will be put in place to limit removal of suspended detritus and sediment from the river that would otherwise have provided energy/nutrients to the downstream food chain. Models predict that net loss of total suspended solids in waters downstream of the mine, due to deposition within the mine pit lake, is low (approximately 8%) (**Appendix W – Aquatic Ecology Report**). This decrease is negligible, compared with annual variation in sediment loads experienced within the river due to fluctuating rainfall, and is unlikely to affect sawfish living downstream.
- Individuals may enter the mine pit lake during initial flooding and connection with the downstream levee opening (due to occur in 2060-2069). At such times, they may be susceptible to mortality or injury through vertical falls, which will be mitigated through the careful design of spillways.
- Individuals may become stranded within the mine pit lake during the dry seasons of 2060 and onwards. If the habitat present is not suitable (e.g., too steeply sided, insufficient food, poor water quality), there will potentially be mortality of stranded individuals.

Overall, the above impacts can be divided into three main classes: (a) reduced water quality, (b) shrinkage of dry season pools, and (c) entrapment within the mine pit lake. Models suggest that the likely extent of (a) and (b) is predicted to be minor and unlikely to compromise the viability of local populations of the Largetooth Sawfish. The risk of (c) is less well understood as there is no analogous river system that has been studied to provide insight. Given that sawfish migration tends to coincide with peak river flows (**Appendix W – Aquatic Ecology Report**), which is when the mine pit lake will be connected to the McArthur River, entry of Largetooth Sawfish into the lake is considered likely unless measures are in place to impede access. The consequences of sawfish entering the mine pit lake, however, are difficult to ascertain with confidence. Models suggest that it is likely that water quality within the mine pit lake will be suitable for sawfish; however, the physical environment (deep water and steep sides) is unlikely to represent favourable foraging habitat for the species. Furthermore, if the mine pit lake is colonised by large predators (Bull Sharks *Carcharhinus leucas* or crocodiles), its suitability as a nursery for juvenile sawfish may be compromised. Measures will be adopted to reduce the potential for sawfish, sharks and crocodiles to enter the mine pit lake and to improve habitat within the lake for any sawfish that become stranded there (see **Section 10.8.2**).

10.5.15 Carpentarian Antechinus

The Carpentarian Antechinus (*Pseudantechinus mimulus*) is a small, carnivorous marsupial that occurs in three apparently discrete populations across the Gulf of Carpentaria: the Sir Edward Pellew Islands (100 km northeast of the Project), the Pungalina-Seven Emu Wildlife Sanctuary (150 km east of the Project) and the Mount Isa region (560 km southeast of the Project) (Woinarski 2004b). The Carpentarian Antechinus inhabits rocky escarpments (Lloyd *et al.* 2013), which occur widely across the Gulf of Carpentaria beyond the known populations. Despite this, the species has never been recorded in these intervening areas, even though many of these (e.g., Lawn Hill National Park) have been subjected to intensive survey effort (Woinarski 2004b).

The species has never been recorded in the vicinity of the Project. Favoured habitat—rocky outcrops with hummock grasses (*Triodia* spp.) and scattered low woodland or shrubland—occurs within the mineral leases (vegetation mapping units 1a, 1b and 4a: **Appendix X—Terrestrial Ecology Report**). However, only one small area of this habitat will be cleared to accommodate the Project, comprising 1.5% (4.1 ha) of the 2,676.3 ha of potential habitat contained within the mineral leases. This small area of rocky habitat to be disturbed was surveyed with Elliot traps and remote-sensory cameras, without detecting Carpentarian Antechinus (**Appendix X—Terrestrial Ecology Report**).

Overall, the probability that Carpentarian Antechinus will be disturbed by the Project is low, due to the species' likely absence from the region. In any case, only a negligible amount of potential habitat will be removed by the Project.

10.5.16 Bare-rumped Sheathtail Bat

The Bare-rumped Sheathtail Bat (*Saccolaimus saccolaimus*) is a poorly known species that has been recorded at widely scattered locations across coastal and subcoastal northern Australia. It is a relatively large species of microbat (Suborder Microchiroptera) that has proven very difficult to detect (Milne *et al.* 2009). It is high-flying, and is therefore unlikely to be caught by nets. In addition, its calls overlap extensively with those of related species, making detection via echolocation recordings difficult (Milne *et al.* 2009). Most records of the species within Australia occur incidentally when roost trees are felled, either deliberately or by storms.

Echolocation data are most useful when full-spectrum calls are recorded, rather than the zero-crossing technique adopted by most bat detectors, because the species has lower frequency calls than most other microbats. Full-spectrum recordings were taken in 2015 and 2016 throughout the Project area, but none matched the known calls of Bare-rumped Sheathtail Bats (**Appendix X – Terrestrial Ecology Report**). Searches for potential roost sites in large, hollow trees revealed these to be scarce on-site. There was no evidence that the species utilised any of the hollows detected.

There are no records of Bare-rumped Sheathtail Bats from the Gulf of Carpentaria east of the Roper River. The species is recorded occasionally in the Wet Tropics of Queensland and in coastal areas of the Top End of NT (Schulz and Thomson 2007). Elsewhere within Australia, the species has been recorded foraging over open eucalypt forests, rainforests and the edges of wetlands (Schulz and Thomson 2007). They may prefer habitat edges (e.g., ecotone between rainforest and eucalypt forest). Known roosts have been hollow limbs of *Eucalyptus platyphylla, Eucalyptus tetrodonta* and *Eucalyptus miniata* (Schulz and Thomson 2007). These tree species are absent from the Project area, although *E. miniata* occurs in the foothills of the nearby Bukalara Range. The woodlands contained within the mineral leases are drier, lower and more open than at locations where the species is known to occur.

Given the lack of nearby records, the absence of favoured habitat on-site and the low number of potential roost sites, it is unlikely that Bare-rumped Sheathtail Bats occur within the Project area. Furthermore, only two large hollow trees are contained within the footprint of the Project. This suggests that any potential impact to the species as a result of the Project will be small.

10.5.17 Masked Owl (Northern)

The northern subspecies of the Masked Owl, *Tyto novaehollandiae kimberli*, occurs patchily across the forests of northern Australia (Woinarski 2004a). There was a specimen collected from near Borroloola in 1914, but no confirmed records of the species from the region since. The species has declined markedly due to the large-scale collapse in the populations of their prey, medium-sized mammals (Woinarski 2004a). A *Tyto* owl that may have been this species was recorded near the MRM in 1976; however, numerous surveys since have detected only the morphologically similar Eastern Barn Owl (*Tyto javanica*).

Northern Masked Owls inhabit tall eucalypt forests typically dominated by *Eucalyptus miniata, E. tetrodonta* and *Corymbia nesophila*, especially near rainforests or mangroves that provide roost sites (Ward 2010). The low, open woodlands that comprise the vast majority of the Project area are unlikely to be suitable habitat for the species. Nevertheless, it is possible that dispersing individuals may utilise dense vegetation corridors along the McArthur River.

Masked Owls occupy large home ranges and are difficult to detect. Surveys elsewhere in the NT detected them at 1.4% to 18.7% (mean = 8.0%) of sites surveyed using call broadcasts (Ward 2010). Assuming similar detectability at the Project, it is expected that the species should have been detected, if present, given the survey effort to date (57 sites surveyed).

Overall, the Project is considered to have a low risk of impact on the northern subspecies of the Masked Owl, given the low likelihood that the species occurs in the region, and any impact is expected to be small. If present, the species would be confined to the tallest, densest forests (vegetation mapping units 7, 8 and 9) along the seasonally flooded alluvial terraces of the McArthur River. Only 21.2 ha of this habitat, out of 1,072.7 ha present within the mineral leases (a 2% reduction), will be removed to accommodate the Project.

10.5.18 Migratory Shorebirds

Populations of Common Sandpipers (*Actitis hypoleucos*) within the East Asian-Australian flyway are thought to be limited by habitat available in stopover locations in the Philippines, Myanmar, China, Russia and Southeast Asia (Bamford *et al.* 2008). Few sites in Australia constitute important habitat for the species, due to the extensive amount of suitable habitat for the species (Bamford *et al.* 2008). The species visits the re-channelled section of the McArthur River annually in small numbers (< 10 individuals). This habitat will not be removed for the Project.

Sharp-tailed Sandpipers (*Calidris acuminata*) and Marsh Sandpipers (*Tringa stagnatilis*) have also been recorded as regular, non-breeding, summer visitors in small numbers (< 10 annually) along the re-channelled section of the McArthur River within the mineral leases. No habitat for these species will be removed as a result of the Project.

The Long-toed Stint (*Calidris subminuta*) and Common Greenshank (*Tringa nebularia*) are scarce non-breeding visitors to the re-channelled section of the McArthur River. Wetland habitats present on-site are marginal for these species. No habitat for these species will be removed for the Project.

An unidentified snipe (*Gallinago* sp.) has been recorded within the mineral leases on a single occasion. This is most likely to have been either a Swinhoe's Snipe (*G. megala*) or Latham's Snipe (*G. hardwickii*), both of which are listed as migratory species under the EPBC Act. Both species are likely to be occasional vagrants to the Project area. The wetland habitat available constitutes marginal habitat for both species. No important sites for either species occur within the Gulf region. No potential habitat will be removed for the Project.

The Little Curlew (*Numenius minutus*) is a scarce, non-breeding visitor to the Project area. Little Curlews inhabit open, damp grasslands, and habitat availability is therefore highly dependent on recent weather conditions. Potential habitat for the species exists seasonally at the mine airstrip and along re-channelled sections of the McArthur River. None of this habitat will be removed for the Project. The general region does not contain any internationally important areas for the species (Bamford *et al.* 2008).

Unlike other shorebird species, Oriental Plovers (*Charadrius veredus*) and Oriental Pratincoles (*Glareola maldivarum*) inhabit dry grasslands and plains. Small numbers of these species occasionally visit artificial habitats within the mineral leases, such as the aerodrome and accommodation village. The Project will not reduce the extent of these habitats. No internationally important sites for these species occur within or near the Project (Bamford *et al.* 2008).

The Glossy Ibis (*Plegadis falcinellus*) differs from the other migratory shorebirds in that it breeds within Australia and has less regular, predictable movements based on season. Glossy Ibis occur across much of Australia in flooded grasslands, wetlands, rivers, estuaries and saltmarshes. They move widely in response to rainfall or lack thereof. Habitat present within the Project area is marginal for the species. Apart from a short period in November 2015, when the species turned up at several sites along the McArthur River, it is a scarce visitor to the site. No wetland habitat for the species will be removed for the Project.

The McArthur River estuary is of international importance for the Sharp-tailed Sandpiper, Marsh Sandpiper and Common Greenshank (Bamford *et al.* 2008), and if impacted could affect a significant proportion of the Asian-Australian population. Mitigation measures will be put in place to protect water quality within the McArthur River and limit heavy metals being deposited in the McArthur River estuary. Detailed surface water and groundwater models (**Chapter 8 – Water Resources**) predict that mine-derived contaminants (sulphates, zinc, lead, arsenic and cadmium) in the McArthur River downstream of the Project will remain at benign concentrations that will not exceed site-specific trigger levels. Therefore, a negligible impact of the Project on shorebird habitat within the McArthur River estuary is predicted.

10.5.19 Migratory Swallows

Two species of migratory swallows protected under the EPBC Act, the Barn Swallow (*Hirundo rustica*) and Red-rumped Swallow (*Cecropis daurica*), were flagged by the protected matters search tool as potentially occurring within the Project area. Both are irregular visitors to the Gulf region, and are primarily observed in coastal wetland habitats. Neither species has been recorded in or near the Project area. Both species are highly detectable when present, and given the extensive avian survey effort on-site, it is highly unlikely that the area is visited often by either species. Given the small numbers of individuals visiting Australia, relative to the total population, no site in Australia constitutes significant habitat for the species (Department of the Environment 2015b).

10.5.20 Migratory Wagtails

Two species of migratory wagtails protected under the EPBC Act, the Eastern Yellow Wagtail (*Motacilla tshutschensis*) and Grey Wagtail (*Motacilla cinerea*), were identified by the protected matters search tool as potentially occurring within the Project area. One Eastern Yellow Wagtail has been recorded on-site, in 2007, and both species probably occur as occasional vagrants to streamside habitats along the McArthur River. No potential habitat will be removed for the Project. Given the small numbers of individuals visiting Australia, relative to the total population, no site in Australia constitutes significant habitat for the species (Department of the Environment 2015b).

10.5.21 Fork-tailed Swift

Fork-tailed Swifts (*Apus pacificus*) are non-breeding visitors to Australia during the summer months. The species is almost exclusively aerial while in Australia, and follow/precede low pressure systems in search of flying insects (Higgins 1999). They are highly mobile and do not remain long at any one location; at any one place, flocks may pass three or four times over the summer months (Higgins 1999). The species has been recorded on only three occasions within the MRM mineral leases, with over 1,189 hours of survey effort during the past ten years. There are no significant threats to this species within Australia (Department of the Environment 2017c), and it is unlikely that the Project will affect the species.

10.5.22 Oriental Cuckoo

The Oriental Cuckoo (*Cuculus optatus*) is a non-breeding summer migrant from Asia to northern and eastern Australia. It primarily inhabits the ecotones between closed (rainforest, vine forest, mangroves) and open (eucalypt forests, coastal dunes) habitats. Away from the coast, it primarily utilises riparian forests. Despite vegetation along the McArthur River constituting potential habitat and 700 hours of avian surveys undertaken in these habitats over the past ten summers, the species has never been recorded on-site. It was recorded in the 1970s elsewhere within the McArthur River catchment. It is possible that the occasional individual may visit the Project area; however, the Project area does not support a population of 1,000 or more, considered to be the lower threshold for an 'ecologically significant proportion of a population' under the significant impact guidelines (Department of the Environment 2015b). Consequently, the Project is not considered to significantly impact the species.

10.5.23 Arafura Fantail

The Arafura Fantail (*Rhipidura dryas*) was formerly a subspecies of the Rufous Fantail (*Rhipidura rufifrons*) and is protected as a migratory species under the former taxonomy. Arafura Fantails occur in small numbers in riparian forest along the McArthur River. During avian surveys in suitable habitat between 2006 and 2016, the species was detected in 0.3% of surveys at 4.6% of sites. A maximum of 1-5 individuals may utilise the mineral leases at any one time. Only 4.5 ha of habitat for the species is contained within the proposed footprint of the Project. Actions that potentially affect ≥219 individuals or ≥450 ha of habitat may constitute a significant impact under Government guidelines (Department of the Environment 2015b). Surface water models suggest that acid and metalliferous drainage and/or seepage of contaminated water polluting the McArthur River leading to loss of riparian vegetation downstream of the mine over large tracts of the McArthur River will not occur over the next 1,000 years (**Chapter 8 – Water Resources**). Consequently, the Project is not considered to significantly impact the species.

10.5.24 Caspian Tern

The Caspian Tern (*Hydroprogne caspia*) is an occasional visitor to the Project area. The species inhabits coasts, estuaries, large rivers and inland lakes, and the habitat present on-site is marginal. No wetland habitat will be removed for the Project. No Government guidelines exist to define what constitutes an important population of, or important habitat for, the species under the EPBC Act. Despite this, it is considered unlikely that the Project will affect the species.

10.5.25 Eastern Osprey

The Eastern Osprey (*Pandion cristatus*) inhabits coastal estuaries, tidal rivers, mangroves, and coral and rock reefs. They also range inland along rivers, and have been recorded occasionally within the Project area. The Project will not remove riverine habitats used by the species.

Eastern Ospreys are susceptible to bioaccumulation of metals. Being apex predators within estuarine ecosystems, Eastern Ospreys are prone to accumulate mercury, copper, lead, zinc and arsenic in their tissues (Lounsbury-Billie *et al.* 2008; Langner *et al.* 2011). This can have lethal and sub-lethal effects on health and reproduction (Burger and Gochfield 1997). Detailed surface water models have predicted the concentrations of metals within the McArthur River as it leaves the MRM mineral leases (**Chapter 8 – Water Resources**). These models suggest that most contaminants (except zinc and sulphates) will not increase above background concentrations as a result of the Project.

Sulphates are not a concern for Eastern Ospreys and other fauna inhabiting the estuarine zone of the McArthur River, as the natural concentration of sulphates in seawater (2,700 mg/L: Hitchcock 1975) is two orders of magnitude higher than average concentrations predicted to occur within the McArthur River as a result of the Project (**Chapter 8 – Water Resources**). It is one order of magnitude higher than the maximum concentrations predicted to occur within the McArthur River immediately downstream from operations.

Zinc is a potential threat to Eastern Ospreys as it can be transported to estuarine areas where it accumulates in the tissues of fish eaten by the species. Large quantities of zinc (several grams for an animal weighing over 1 kilogram (kg)) are required for acute zinc toxicosis (World Health Organization 2003). However, prolonged exposure to excessive zinc can lead to copper deficiency and hypocalcaemia (World Health Organization 2003). Surface water models predict that zinc concentrations in the McArthur River, where it leaves the MRM mineral leases, will rarely (< 5% of the time) exceed 9.3 μg/L will not exceed 49.9 μg/L. These concentrations are lower than the trigger limits set in the MRM WDL (62.7 μg/L), the U.S.A.'s Environmental Protection Agency's Aquatic Life Use Water Quality Standards (120 μg/L) and the maximum concentration deemed fit for human consumption by the World Health Organization (3,000 μg/L). These concentrations are also expected to be further diluted downstream (Jeffree *et al.* 2016). The low concentrations of zinc expected to be released by the Project are within the range of background levels observed in other Australian rivers and are not associated with elevated zinc levels within the muscle tissue of fish (Jeffree *et al.* 2016), the food of the Eastern Osprey. Overall, there is negligible risk to the Eastern Osprey of zinc toxicosis resulting from the Project.

The lower threshold for a significant impact to the Eastern Osprey, as defined by the Department of the Environment (2015b), is potential disturbance to 84 km of coastline or a potential loss of 24 individuals. The only possibility that the Project could cause such an impact is if the entire McArthur River, which is over 84 km in length downstream of the mine, was rendered uninhabitable by Eastern Ospreys. Mitigation strategies and water models indicate that no such impacts will occur.

10.5.26 Estuarine Crocodile

Estuarine Crocodiles (*Crocodylus porosus*) are common in the lower McArthur River catchment and nearby coastal areas. Small numbers occasionally move upstream to the vicinity of the Project. No habitat for Estuarine Crocodiles will be removed for the Project. No Government guidelines exist to define what constitutes an important population of, or important habitat for, the species under the EPBC Act.

Elevated concentrations of metals are a potential threat to the Estuarine Crocodile. Being long-lived apex predators, crocodiles are susceptible to bioaccumulation of metals. While adult crocodiles have a high tolerance of lead and other metals (Warner *et al.* 2016), lead can affect the development of crocodile eggs and hatchlings (Lance *et al.* 2006). Water models suggest that water leaving the MRM mineral leases within the McArthur River will not contain metal concentrations exceeding background levels, except for zinc (**Chapter 8 – Water Resources**). Surface water models predict that zinc concentrations in the McArthur River, where it leaves the MRM mineral leases, will rarely (< 5% of the time) exceed 9.3 µg/L and not exceed 49.9 µg/L. These concentrations are lower than the trigger limits set in the MRM WDL (62.7 µg/L), the U.S.A.'s Environmental Protection Agency's Aquatic Life Use Water Quality Standards (120 µg/L) and the maximum concentration deemed fit for human consumption by the World Health Organization (3,000 µg/L). These concentrations are also expected to be further diluted downstream (Jeffree *et al.* 2016). The low concentrations of zinc expected to be released by the Project are within the range of background levels observed in other Australian rivers and are not associated with elevated zinc levels within the muscle tissue of fish (Jeffree *et al.* 2016), a food of the Estuarine Crocodile. Overall, there is negligible risk to the Estuarine Crocodile of zinc toxicosis or other heavy metal poisoning as a result of the Project.

Minor impacts of the Project on Estuarine Crocodiles could potentially include:

- Sedimentation within the McArthur River, which could reduce the size and/or connectivity of pools in the late dry season. Small pools are rarely utilised by Estuarine Crocodiles, and their ability to traverse sections of dry river bed in search of water means that Estuarine Crocodiles are unlikely to be affected by sedimentation.
- Mining below groundwater levels, which could potentially lead to a drawdown of water levels in the adjacent McArthur River. These small pools currently constitute marginal, temporary habitat for Estuarine Crocodiles and the ability of crocodiles to traverse across land to locate new water sources means that there is negligible anticipated impact of localised water table drawdown on the Estuarine Crocodile.
- Individuals may enter the mine pit lake during initial flooding and connection with the downstream levee opening (due to occur in 2060-2069). At such times, engineering controls will be in place to reduce the risk of mortality or injury through vertical falls. The same hazard will be managed for the Largetooth Sawfish and no additional measures are required for the Estuarine Crocodile.

10.6 Risk Assessment

The Glencore Corporate Risk Framework was applied to assess the overall risk of the Project to each matter of national environmental significance. This risk framework is summarised in **Table 10-4**. The risk posed by the Project for each matter of national environmental significance is listed in **Table 10-5**.

Table 10-4 Glencore Corporate Risk Framework, adapted for MNES

Consequence* of impact	Likelihood of impact				
	Rare	**Unlikely**	**Possible**	**Likely**	**Almost certain**
	Unlikely to occur during a 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 MNES, have been adapted to align the assessment of risks with significant impact guidelines under the EPBC Act.

Table 10-5 Inherent Risks MNES

Species	Scientific Name	Likelihood	Consequence	Overall Risk
Curlew Sandpiper	*Calidris ferruginea*	Rare	Minor	**Low**
Eastern Curlew	*Numenius madagascariensis*	Rare	Major	**Medium**
Carpentarian Grasswren	*Amytornis dorotheae*	Rare	Negligible	**Low**
Northern Quoll	*Dasyurus hallucatus*	Unlikely	Negligible	**Low**
Gulf Snapping Turtle	*Elseya lavarackorum*	Rare	Negligible	**Low**
Gouldian Finch	*Erythrura gouldiae*	Almost certain	Moderate	**High**
Australian Painted Snipe	*Rostratula australis*	Rare	Negligible	**Low**
Plains Death Adder	*Acanthophis hawkei*	Unlikely	Negligible	**Low**
Red Goshawk	*Erythrotriorchis radiatus*	Unlikely	Negligible	**Low**
Crested Shrike-tit (northern)	*Falcunculus frontatus whitei*	Rare	Negligible	**Low**
Partridge Pigeon (eastern)	*Geophaps smithii smithii*	Rare	Negligible	**Low**
Painted Honeyeater	*Grantiella picta*	Possible	Negligible	**Low**
Ghost Bat	*Macroderma gigas*	Rare	Negligible	**Low**
Largetooth Sawfish	*Pristis pristis*	Almost certain	Minor	**Medium**
Carpentarian Antechinus	*Pseudantechinus mimulus*	Rare	Negligible	**Low**
Bare-rumped Sheath-tailed Bat	*Saccolaimus saccolaimus*	Unlikely	Negligible	**Low**
Masked Owl (northern)	*Tyto novaehollandiae kimberli*	Rare	Negligible	**Low**
Common Sandpiper	*Actitis hypoleucos*	Rare	Minor	**Low**
Fork-tailed Swift	*Apus pacificus*	Rare	Negligible	**Low**
Sharp-tailed Sandpiper	*Calidris acuminata*	Rare	Major	**Medium**
Long-toed Stint	*Calidris subminuta*	Rare	Minor	**Low**

Species	Scientific Name	Likelihood	Consequence	Overall Risk
Red-rumped Swallow	*Cecropis daurica*	Rare	Negligible	**Low**
Oriental Plover	*Charadrius veredus*	Rare	Negligible	**Low**
Estuarine Crocodile	*Crocodylus porosus*	Unlikely	Minor	**Low**
Oriental Cuckoo	*Cuculus optatus*	Rare	Negligible	**Low**
Snipe species	*Gallinago* spp.	Rare	Negligible	**Low**
Oriental Pratincole	*Glareola maldivarum*	Rare	Negligible	**Low**
Barn Swallow	*Hirundo rustica*	Rare	Negligible	**Low**
Caspian Tern	*Hydroprogne caspia*	Rare	Negligible	**Low**
Grey Wagtail	*Motacilla cinerea*	Rare	Negligible	**Low**
Eastern Yellow Wagtail	*Motacilla tshutschensis*	Rare	Negligible	**Low**
Little Curlew	*Numenius minutus*	Rare	Negligible	**Low**
Eastern Osprey	*Pandion cristatus*	Rare	Moderate	**Low**
Glossy Ibis	*Plegadis falcinellus*	Rare	Negligible	**Low**
Arafura Fantail	*Rhipidura dryas*	Rare	Negligible	**Low**
Common Greenshank	*Tringa nebularia*	Rare	Major	**Medium**
Marsh Sandpiper	*Tringa stagnatilis*	Rare	Major	**Medium**

10.7 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 MNES is discussed in the following subsections.

10.7.1 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 MNES. Due to the nature of the ore body, large volumes of waste material need to be removed over the first 10-11 years of the Project's life in order to access the economic ore. The safe storage of this waste 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.

10.7.2 Alternatives for the Open Cut Domain

Underground mining is not a viable alternative 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 waste material after processing, and the extent to which water in the final void interacts with the McArthur River.

At the cessation of mining, the Project plans to dispose of tailings within the open cut. An 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 MNES, especially those 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 MNES. This will reduce the long-term footprint of the project whilst meeting closure objectives. Maximising the extent of waste material in-pit dumping limits the need for external overburden emplacement facilities (OEFs), reducing the overall footprint of the Project. The geometry of the open cut and the geotechnical properties of the rock precludes 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 waste material within the final void.

A variety of alternatives were considered relating to how much the final void should be isolated versus connected to the McArthur River. Water quality within an isolated void 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 void 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 void. However, this would expose the void to extreme flooding events, with unpredictable impacts, and certain MNES such as the Largetooth Sawfish may become trapped within the void during the dry season. The alternative to be adopted by the Project is an intermediate degree of interaction between the mine pit lake with the McArthur River, which is expected to offer the lowest risks to MNES dependent on water quality downstream from the mine.

10.7.3 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 MNES. The optimal slope design of the NOEF was a compromise between ensuring adequate stability, ability to provide maintenance 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 MNES.

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.

10.7.4 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 key considerations when deciding on the chosen alternative were:

- limiting seepage from the individual cells;
- 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 MNES are minimised by the proposed TSF design.

10.8 Mitigation Measures

For each matter of national environmental significance that was deemed to have anything other than a low inherent risk of impact in the risk assessment (**Section 10.6**), management measures are proposed to limit the likelihood or consequences of potential impacts. These mitigation measures are discussed in the following subsections.

The risk matrix presented in **Section 10.6** 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 hazard being mitigated, a likelihood and consequence score is generated, which combine to determine the category of risk (high, medium or low).

10.8.1 Gouldian Finch

Gouldian Finches experience a low to medium residual risk of being affected by a range of potential impacts posed by the Project, including clearing of potential breeding habitat, weed invasion, failure of rehabilitation to restore food plants, lead-rich dust, loss of drinking sites due to the lowering of the water table, and contamination of drinking sites through mine-affected seepage or runoff. Management measures proposed to mitigate each of these risks are listed in **Table 10-6**.

In addition to the above potential impacts, there is a high inherent risk that Gouldian Finches will lose some feeding habitat as a result of the Project. Extensive areas of habitat within the MRM mineral leases, including areas within the Project footprint constitute potential feeding areas for the Gouldian Finch. However, these habitats are only utilised by Gouldian Finches in very small numbers and transiently, implying a marginal importance of these areas for the species. Nevertheless, impacts to these habitats are unavoidable, and mitigation measures are proposed to improve the quality of remaining habitats for the Gouldian Finch (**Table 10-6**).

Table 10-6 Mitigation Measures and Residual Risk Assessment for the Gouldian Finch

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments /Justification
Potential breeding habitat is cleared to accommodate the Project	- 4 ha of potential nesting habitat, none of which is currently used by Gouldian Finches, will be removed.	N/A	Low	- Expansions of the NOEF and TSF were designed to avoid potential nesting habitat of the Gouldian Finch.	Low	The extremely low likelihood that any Gouldian Finches nest in the habitat being removed meant that specific mitigation measures were not warranted.
Potential feeding habitat is cleared to accommodate the Project	- 489 ha of grassy woodlands, some of which is used by small numbers of feeding Gouldian Finches in a transient capacity, will be removed.	N/A	High	- 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. - The Fire Management Plan will be updated in order to manage the remaining potential feeding habitat within the mineral leases to promote the growth and seeding of grasses critical as food sources to Gouldian Finches. - Livestock will be excluded from an additional 452.4 ha of potential feeding habitat. - Rehabilitation of the TSF and NOEF after decommissioning will reintroduce native grasses important as food for Gouldian Finches. Successful establishment of these grasses will be incorporated into rehabilitation completion criteria.	Medium	The overall loss of potential feeding habitat for Gouldian Finches as a result of the Project is less than the disturbance approved in the Phase 3 EIS. Effective fire management at Mornington Sanctuary (central Kimberley) increased the amount of seeding *Triodia* (> 2 years old) by approximately 250% within two years (AWC 2009). Simulated grazing on another grass eaten by Gouldian Finches, *Alloteropsis semialata*, reduced flowering rates by 67% (Crowley and Garnett 2001). Grazing by cattle reduced the density of *Chrysopogon fallax* by 20-60% over a 12-year period, depending on grazing intensity (Orr and Reagain 2011). Available data, , suggests it is possible to double the value of existing feeding habitat for Gouldian Finches by removing livestock and managing fire effectively.
Weeds invade the edges of potential feeding habitat	- Weeds can outcompete native grasses, reducing the total extent of feeding habitat available to Gouldian Finches.	- A weed control program is in place, involving monthly inspections of operational sites and downstream areas. - Any infestations of declared weeds are controlled as these are detected. - The source of any infestations is investigated and the most appropriate control technique applied, depending on the situation and weed involved.	Low	- All existing mitigation measures will be maintained.	Low	The Project is unlikely to pose a risk to Gouldian Finches through weed invasion that substantially exceeds the risks posed in Phase 3. As a result, the current mitigation measures are considered sufficient.
Rehabilitation of disturbed areas post-operation fails to establish natural grass communities	- The physical environment in disturbed areas may be unfavourable for grass establishment. - Weeds can prevent successful re-establishment of native grasses in rehabilitated sites. - The loss of potential feeding 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 finch food 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.

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments /Justification
Increased vehicular traffic leading to increased dust generation	- Increased concentrations of metals such as lead in water sources of Gouldian Finches and on the grass seeds important as food. - Reduced seed production of grasses growing adjacent to roads and earthworks, due to dust deposition on leaves.	- 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 sediments are monitored monthly at points across the Project to determine metal loads and whether additional management is warranted. - The McArthur River water quality is monitored from a network of surface water sites including downstream at SW11 where site-specific trigger values are 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 and removal of 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. Models predict that lead-rich dust will mostly be confined to the vicinity of the processing mill (**Appendix AA – Air Quality Report**). Past studies have demonstrated that existing mitigation measures employed to suppress dust and capture run-off 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 contamination, 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 Gouldian Finches over the existing risks inherent in current operations is only slight. Therefore, existing measures are deemed adequate for mitigating risks to Gouldian Finches from contamination of waterways with lead-rich dust. Gouldian Finches have never been observed to forage in close proximity to high-traffic operations, where effects of dust on food and water are most likely (**Appendix X – Terrestrial Ecology Report**).
Dewatering of the open cut and groundwater recovery, leading to loss of drinking sites	- Pools fed by groundwater are reduced in extent by drawdown of the water table. - Loss of pools potentially reduces the amount of feeding and nesting habitat for Gouldian Finches that is within commuting distance to water.	- 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 persistence of pools used by Gouldian Finches, 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. The waterholes that models predict to be most affected by drawdown (**Appendix T – Groundwater Report**) are not known to be utilised by Gouldian Finches. In the long term (closure), 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 and metalliferous drainage, arising from reactive material stored within the NOEF, TSF and mine pit lake, entering waterways used as drinking sources for the Gouldian Finch	- 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 groundwater-fed waterways where water quality may be affected. - The concentrations of sulphates predicted to occur in the lower reaches of Barney Creek and Surprise Creek may cause health problems for Gouldian Finches.	- 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 encapsulating 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 waste 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 pit void 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 lake floor above reactive material. - The mine pit lake will be isolated from the McArthur River during the initial period after closure. 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 layer (CCL) 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 through various lift heights to meet objectives of a low net percolation and low oxygen ingress. - 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 this is only expected to occur in areas of the mineral leases where Gouldian Finches are not known to drink. Provided the site-specific trigger levels at the water monitoring point SW11 are not exceeded (as models predict), there are no anticipated impacts to Gouldian Finches beyond the boundaries of the mineral leases.

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments /Justification
Uncontrolled discharge of contaminated surface water into waterways used as drinking sources for the Gouldian Finch	- 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 mine pit lake.	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: - The WDL 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. - The MRM has a WDL that specifies maximum concentrations of contaminants permitted at the downstream water monitoring point, SW11.	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 (PWD) 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 Maximum 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) perimeter runoff dams (referred to as PRODS) will be installed on and surrounding the NOEF to capture runoff. Run off dams' capacities are 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 only contaminants expected to be elevated above background levels, and this is only expected to occur in areas of the mineral leases where Gouldian Finches are not known to drink. Provided the site-specific trigger levels at the water monitoring point SW11 are not exceeded (as models predict), there are no anticipated impacts to Gouldian Finches beyond the boundaries of the MRM mineral leases.

10.8.2 Largetooth Sawfish

The Largetooth Sawfish occupies most of the McArthur River, including sections within the MRM mineral leases. Mitigation measures are therefore required to limit any impacts of the Project on the quality, quantity or connectivity of habitat for the Largetooth Sawfish. These mitigation measures are assessed in detail within **Appendix W – Aquatic Ecology Report** and are summarised in **Table 10-7**.

Models indicate that the mitigation measures proposed are sufficient for maintaining water quality within the McArthur River at levels suitable for the Largetooth Sawfish. There will be minor reductions in the size of at least one dry season pool, which is inhabited by juvenile Largetooth Sawfish in some years. This minor impact will cease following the closure of the open cut and filling of the mine pit lake. Measures are proposed to mitigate potential mortality or stranding of sawfish entering the mine pit lake when it is connected to the McArthur River. Further measures may be applied to minimise impacts to Largetooth Sawfish in the event that ongoing monitoring suggests that the measures adopted are insufficient.

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Table 10-7 Mitigation Measures and Residual Risk Assessment for the Largetooth Sawfish

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments /Justification
Increased vehicular traffic leading to increased dust generation	- Increased dust being deposited into Barney Creek and Surprise Creek. - Increased concentrations of metals such as lead in sediments within the local waterways. - Bioaccumulation of lead within the food chain, having the greatest impact on predatory species such as the Largetooth Sawfish.	- The Dust Management Plan is adhered to, which includes ongoing dust monitoring and contingency for increased management. - Dust is suppressed using watercarts. - Water quality and fluvial sediment are monitored monthly at points across the Project to determine metal loads and whether additional management is warranted. - Fauna tissues are monitored annually 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 and removal of 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 run-off 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 contamination, 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 Largetooth Sawfish over the existing risks inherent in current operations is only slight. Therefore, existing measures are deemed adequate for mitigating risks to Largetooth Sawfish from contamination of waterways with lead-rich dust.
Filling of the mine pit lake exposes sawfish to risk of falls.	- Sawfish may experience mortality due to vertical falls as the mine pit lake is being filled following the opening of the downstream	N/A	Medium	- The period of connectivity between the McArthur River and the mine pit lake is limited by ramp design, which reduces opportunity for fauna to enter. - There will be barriers engineered to restrict the entry of Largetooth Sawfish into the mine pit lake. - Inlets into the mine pit lake will be engineered with a gradual slope to prevent vertical drops.	Low	Barrages have been demonstrated to be effective at impeding upstream movement of Largetooth Sawfish (Thorburn *et al*. 2003, 2004, 2007). The sloped design of the lake side of the inlets will reduce vertical relief (fall). Ramped design of ~1:30 slope has been demonstrated to be sufficient for the up and downstream movement of Largetooth Sawfish (Kirby *et al*. 2009).

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 re-channelled sections of the McArthur River, will be reduced in the dry season. - The ability of these pools to sustain Largetooth Sawfish during the dry season 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.	Medium	- 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 Largetooth Sawfish, remedial action (enlargement of pools or supplementary watering) will be implemented.	Medium	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**). However, this will only be evident in the dry season, and wet season flows (when sawfish migrate) will not be compromised (**Appendix U – Surface Water Report**). In the long term (closure), recovery of water levels is predicted to be complete ten years following the flooding of the void.

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments /Justification
Acid and metalliferous drainage, arising from reactive material stored within the NOEF, TSF and final 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. - Sulphates in the concentrations predicted are unlikely to have any effect on sawfish, given their high tolerance of salinity, but metals accumulating in sediments may lead to health problems.	- 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 waste 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 closure. 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 CCL 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 through various lift heights to meet objectives of a low net percolation and low oxygen ingress. - A 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 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 Largetooth Sawfish. Provided the site-specific trigger levels at the water monitoring point SW11 are not exceeded (as models predict), there are no anticipated impacts to Largetooth Sawfish from acid and metalliferous 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 Largetooth Sawfish.	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: - The WDL 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. - The MRM has a WDL that specifies maximum concentrations of contaminants permitted at the downstream water monitoring point, SW11.	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 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 PWD 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 MDE and 1:500 AEP 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) PRODS will be installed on and surrounding the NOEF to capture runoff. Runoff dams' capacities are 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 only contaminants expected to be elevated above background levels, and even these are not predicted to reach levels damaging to the Largetooth Sawfish. Provided the site-specific trigger levels at the water monitoring point SW11 are not exceeded (as models predict), there are no anticipated impacts to Largetooth Sawfish from uncontrolled discharge.

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments /Justification
Erosion from exposed surfaces introduces excessive sediment into the McArthur River	- Erosion leads to elevated total suspended solids in the McArthur River. - If this suspended material is deposited in downstream pools, the size of these pools and their suitability for sawfish, may be reduced.	- Sediment-containing runoff from all exposed surfaces is collected through numerous silt/sediment traps. - There is ongoing monitoring of total suspended solids contained within surface waters across the mineral leases.	Medium	- There will be ongoing and indefinite monitoring and maintenance of existing surface water runoff collection systems and infrastructure. - Design of the NOEF (including armouring, angling compaction and permeability) focused on controlling erosion and sediment loss due to surface runoff. This includes stilling basins to dissipate energy from high flows generated as runoff is directed down steep embankments. - Numerous drainage channels, sumps and lined PRODS will be installed around the NOEF to capture runoff. The capacity of runoff dams is set to have a less than 5% probability of exceedance (spill) over the operating life of the dam. - Total dissolved solids in runoff are expected to be elevated for some time following placement of the cover system on the NOEF. Surface water at this time will be directed into sediment dams to remove sediment by gravity separation. - Runoff dams will be constructed in accordance with relevant ANCOLD Guidelines on Tailings Dam Planning, Design, Construction, Operation and Closure (ANCOLD, 2012). Runoff dams have been designed to have an earthquake loading of 1:1,000AEP MDE and 1:500 AEP OBE. - The water quality within runoff dams and adjacent creeks and the McArthur River will be subjected to ongoing and indefinite monitoring to assess the need for additional measures to intercept sediment.	Low	Models indicate that the amount of total dissolved solids within the McArthur River is not expected to significantly increase as a result of erosion (**Appendix U – Surface Water Report**). In fact, there will be a slight net loss of sediments within the McArthur River once the mine pit lake is connected to the river, due to sediment deposition within the mine pit lake. Any loss of habitat for the Largetooth Sawfish due to sedimentation resulting from the Project is expected to be negligible.

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments /Justification
Sawfish may be trapped within the mine pit lake during each dry season	- Any sawfish entering the mine pit lake during periods of connection with the McArthur River will be stranded there for the duration of the dry season. - The habitat present may not be physically suitable (no shallow waters), chemically suitable (excessive concentrations of contaminants) or contain sufficient prey for sawfish, leading to mortality.	N/A	Medium	- The mine pit lake will only be connected to the McArthur River once water testing has confirmed that levels of contamination within the lake's waters are not a threat to aquatic life. - The period of connectivity between the McArthur River and mine pit lake is limited by ramp design, which reduces opportunity for fauna to enter. - Benches will be constructed into the edges of the pit lake to provide strips of shallow foraging habitat for Largetooth Sawfish. - Large woody debris will be installed and riparian vegetation will be established around the mine pit lake's margins to provide habitat for fish that comprise the prey of sawfish. - There will be barriers engineered to restrict the entry of Largetooth Sawfish into the mine pit lake. - Fish way ramps will be installed on lake inlets and outlets to facilitate aquatic fauna exiting the mine pit lake. - Monitoring of fauna entering and exiting the mine pit lake is to be undertaken to understand the effectiveness of fish ways and the role of the mine pit lake as a trap.	Low	Modelling predicts that connection between the mine pit lake and the McArthur River (beyond 2070) will only occur during wet season flows for an average of 10 days per year (**Chapter 8 – Water Resources**). As such, opportunity for fauna to enter the mine pit lake is low. Barrages are known to be effective at impeding upstream movement of Largetooth Sawfish (Thorburn *et al.* 2003, 2004, 2007). Juvenile Largetooth Sawfish and most of their favoured prey prefer shallow waters less than 10 m (Horppila *et al.* 2000, Pusey and Arthington 2003, Storey and Creagh 2014). It is likely that an artificial bench constructed around the edge of the mine pit lake will be required to create habitat suitable for these species. The installation of woody debris in rehabilitated sections of the McArthur River channel has proven to greatly increase populations of prey fish species (**Appendix W – Aquatic Ecology Report**). Modelling predicts very limited mixing across water depths within the mine pit lake, and outflows will largely reflect river water contributions (inflow) for 20 years post-flooding (Caballero and Boland 2016). Modelling also predicts that a moderate salinity, neutral pH and low metal (Zn, As and Pb) Pit Lake can be maintained (**Chapter 8 – Water Resources**). It is therefore expected that water quality within the mine pit lake will be suitable for Largetooth Sawfish, given their ability to acclimatise to a wide range of saline and fresh waters.

10.8.3 Shorebirds

For the Eastern Curlew, Common Greenshank, Marsh Sandpiper and Sharp-tailed Sandpiper, the McArthur River estuary constitutes a feeding area for an internationally important proportion of the Asian-Australian population (Bamford *et al.* 2008). All four species are exposed to the same set of risks from the Project and are therefore discussed together.

As the key habitats for all four species (tidal mudflats) are located far downstream from the MRM mineral leases, the only potential impacts to these species that require mitigation are those that influence water quality within the McArthur River. While the likelihood of these impacts is considered very low ('Rare' according to the risk assessment, **Section 10.6**), mitigation measures are required due to the potential consequences for a significant proportion of each species' population. Mitigation measures for impacts to water quality are described in detail within **Chapter 3 – Project Description and Justification** and **Chapter 8 – Water Resources**. Measures that pertain to shorebirds are summarised in **Table 10-8.** There are three main sources of contaminants within the McArthur River (air, surface water and groundwater), and each will be managed separately.

Models indicate that, with the proposed mitigation measures in place, concentrations of metals within the McArthur River downstream from the Project will remain at levels harmless for shorebirds and other wildlife. Regular monitoring of water quality within the McArthur River will allow for an early detection of contamination exceeding the trigger levels, well before any impacts to the McArthur River estuary are likely. Taken together, the residual risks to the Eastern Curlew, Common Greenshank, Marsh Sandpiper and Sharp-tailed Sandpiper from the Project are considered Low.

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Table 10-8 Mitigation Measures and Residual Risk Assessment for Shorebirds

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments /Justification
Increased vehicular traffic leading to increased dust generation	- Increased dust being deposited into Barney Creek and Surprise Creek. - Increased concentrations of metals such as lead in sediments within the local waterways. - Lead deposition within the McArthur River estuary could cause health problems for shorebirds that forage in those sediments.	- The Dust Management Plan is adhered to, which includes ongoing dust monitoring and contingency for increased management. - Dust is suppressed using watercarts. - Water quality and fluvial sediment are monitored monthly at points across the Project to determine metal loads and whether additional management is warranted. - Fauna tissues are monitored annually 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 and removal of 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 run-off 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 contamination, 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 shorebirds over the existing risks inherent in current operations is only slight. Therefore, existing measures are deemed adequate for mitigating risks to shorebirds from contamination of waterways with lead-rich dust.

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 mine pit lake. - Metals deposited in the McArthur River estuary could affect the health of shorebirds.	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: - The WDL 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. - The MRM has a WDL that specifies maximum concentrations of contaminants permitted at the downstream water monitoring point, SW11.	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 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 PWD 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 MDE and 1:500 AEP 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) 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 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 only contaminants expected to be elevated above background levels, and even these are not predicted to reach levels damaging to shorebirds. Provided the site-specific trigger levels at the water monitoring point SW11 are not exceeded (as models predict), there are no anticipated impacts to shorebirds of the Project.

Hazard	Potential Impact	Existing Mitigation	Inherent Risk	Proposed Mitigation	Residual Risk	Comments /Justification
Acid and metalliferous 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. - Sulphates are unlikely to have any effect on shorebirds feeding in tidal mudflats of the McArthur River Estuary, but metals accumulating in sediments may lead to health problems.	- 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 encapsulating 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 waste 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 lake floor above reactive material. - The mine pit lake will be isolated from the McArthur River during the initial period after closure. 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 CCL 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 through various lift heights to meet objectives of a low net percolation and low oxygen ingress. - 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 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 shorebirds. Provided the site-specific trigger levels at the water monitoring point SW11 are not exceeded (as models predict), there are no anticipated impacts to shorebirds of the Project.

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10.9 Residual Impacts

'Residual impacts' are defined as those that are likely to remain after all avoidance and mitigation measures are implemented. If residual adverse impacts on MNES qualify as 'significant', offsets are required under the EPBC Act's *Environmental Offsets Policy*. 'Significance' is defined by the *Matters of National Environmental Significance: Significant Impact Guidelines 1.1*.

For **critically endangered and endangered** species, an action is likely to have a significant impact if there is a real chance or possibility that it will:

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

For **vulnerable** species, an action is likely to have a significant impact if there is a real chance or possibility that it will:

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

For **listed** migratory species, an action is likely to have a significant impact if there is a real chance or possibility that it will:

- substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;
- result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or
- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

An assessment of residual impacts in relation to the *Matters of National Environmental Significance: Significant Impact Guidelines 1.1* has been undertaken for each of the MNES potentially affected by the Project (**Table 10-9, Table 10-10** and **Table 10-11**).

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Table 10-9 Significance of Residual Impacts to Critically Endangered and Endangered Species

Species	Lead to a long-term decrease in the size of a population	Reduce the area of occupancy	Fragment an existing population	Adversely affect habitat critical to the survival of a species	Affect habitat to the extent that the species is likely to decline	Result in the establishment of harmful invasive species	Introduce disease that may cause the species to decline	Interfere with the recovery of the species	Rationale
Curlew Sandpiper	No	No	No	No	No	No	No	No	The species' preferred habitat is not present on-site. Habitat for the species downstream from the Project will be protected via comprehensive mitigation measures to maintain water quality within the McArthur River.
Eastern Curlew	No	No	No	No	No	No	No	No	The species' preferred habitat is not present on-site. Habitat for the species downstream from the Project will be protected via comprehensive mitigation measures to maintain water quality within the McArthur River.
Carpentarian Grasswren	No	No	No	No	No	No	No	No	All evidence suggests that the species is locally extinct. No potential habitat for the species will be disturbed by the Project.
Northern Quoll	No	No	No	No	No	No	No	No	All evidence suggests that the species is locally extinct.
Gulf Snapping Turtle	No	No	No	No	No	No	No	No	The species is probably absent from the McArthur River catchment.
Gouldian Finch	No	No	No	No	No	No	No	No	The feeding habitat removed as part of the Project is unlikely to be limiting local populations given the extensive area of such habitat and the small size of local populations. Effective fire and cattle management of unaffected habitat is expected to counter any losses of feeding habitat incurred. The small amounts of potential breeding habitat or drinking sites that may be lost as a result of the Project are located in areas that don't appear to be used by Gouldian Finches, and these habitat features are highly unlikely to be critical to the survival of the species. Harmful invasive species (weed grasses) have the potential to be introduced as part of the Project, but mitigation measures in place are expected to be sufficient for preventing impacts to the Gouldian Finch.
Australian Painted Snipe	No	No	No	No	No	No	No	No	The species' preferred habitat is mostly absent from site and there are no nearby records of the species. No potential habitat will be disturbed by the Project.

Table 10-10 Significance of Residual Impacts to Vulnerable Species

Species	Lead to a long-term decrease in the size of an important population	Reduce the area of occupancy of an important population	Fragment an existing important population	Adversely affect habitat critical to the survival of a species	Disrupt the breeding cycle of an important population	Affect habitat to the extent that the species is likely to decline	Result in the establishment of harmful invasive species	Introduce disease that may cause the species to decline	Interfere substantially with the recovery of the species	Rationale
Plains Death Adder	No	No	No	No	No	No	No	No	No	The Project probably always constituted marginal habitat for the species, and the species is probably locally extinct.
Red Goshawk	No	No	No	No	No	No	No	No	No	This species is possibly a transient visitor to the Project, with no confirmed records and only a single tentative observation in 1992, despite very intensive survey effort within its preferred habitat. It is highly unlikely that local habitat is within the territory of a resident pair and these habitats are therefore considered unimportant to the species.
Crested Shrike-tit (northern)	No	No	No	No	No	No	No	No	No	All evidence suggests that the species is locally extinct. It may have never occurred on-site.
Partridge Pigeon (eastern)	No	No	No	No	No	No	No	No	No	All evidence suggests that the species is locally extinct.
Painted Honeyeater	No	No	No	No	No	No	No	No	No	Habitat within the Project area constitutes marginal habitat for this highly nomadic species, and is used rarely (no records since 1986) and by very few individuals.
Ghost Bat	No	No	No	No	No	No	No	No	No	The species has never been detected in the Project area and no potential roost habitat will be affected by the Project.
Largetooth Sawfish	No	No	No	No	No	No	No	No	No	The losses of juvenile Largetooth Sawfish anticipated as a result of the Project are unlikely to exceed natural mortality providing the models of water quality are accurate and permanent barriers to movement within the McArthur River are not created. In the event that the impacts to water quality and level substantially exceed model predictions, there is the potential that habitat critical to the survival of the species (predator-free nursery habitat for juveniles) is affected. If this happens, a long-term decrease in the size of the McArthur River population is possible, unless remediation efforts are implemented. Any north Australian populations of the species can be considered 'important populations', given that they are among the last viable populations of the species remaining in the world.
Carpentarian Antechinus	No	No	No	No	No	No	No	No	No	This species has never been recorded in the Project area or in nearby habitat. Potential habitat for the species will not be disturbed by the project.
Bare-rumped Sheathtail Bat	No	No	No	No	No	No	No	No	No	The species' preferred habitat is not present on-site and there are no nearby records of the species. Surveys on-site failed to detect the species.
Masked Owl (northern)	No	No	No	No	No	No	No	No	No	All evidence suggests that the species is locally extinct. It may have never occurred on-site.

Table 10-11 Significance of Residual Impacts to Migratory Species

Species	Substantially modify, destroy or isolate an area of important habitat	Result in the establishment of harmful invasive species within important habitat	Seriously disrupt the lifecycle of an ecologically significant proportion of the population	Rationale
Common Sandpiper	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Fork-tailed Swift	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Sharp-tailed Sandpiper	No	No	No	No internationally important habitat for the species is contained within the MRM area. Internationally important habitat for the species downstream from the Project will be protected via comprehensive mitigation measures to maintain water quality within the McArthur River.
Long-toed Stint	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Red-rumped Swallow	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Oriental Plover	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Estuarine Crocodile	No	No	No	Habitat for the species downstream from the Project will be protected via comprehensive mitigation measures to maintain water quality within the McArthur River.
Oriental Cuckoo	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Snipe species	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Oriental Pratincole	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Barn Swallow	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Caspian Tern	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Grey Wagtail	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Eastern Yellow Wagtail	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Little Curlew	No	No	No	No internationally important habitat for the species is contained within the MRM area, or downstream.
Eastern Osprey	No	No	No	Habitat for the species downstream from the Project will be protected via comprehensive mitigation measures to maintain water quality within the McArthur River.
Glossy Ibis	No	No	No	Only marginal habitat for this species exists within the MRM area, and this will be protected via comprehensive mitigation measures to maintain water quality within the McArthur River.
Common Greenshank	No	No	No	No internationally important habitat for the species is contained within the MRM area. Internationally important habitat for the species downstream from the Project will be protected via comprehensive mitigation measures to maintain water quality within the McArthur River.
Marsh Sandpiper	No	No	No	No internationally important habitat for the species is contained within the MRM area. Internationally important habitat for the species downstream from the Project will be protected via comprehensive mitigation measures to maintain water quality within the McArthur River.

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10.10 Environmental Offsets

The EPBC Act *Environmental Offsets Policy 2012* specifies offsetting requirements when projects are judged by the Australia Government to have residual impacts on MNES. This policy specifies that offsets must:

1. deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environmental that is protected by national environmental law and affected by the proposed actions;
2. be built around direct offsets but may include other compensatory measures;
3. be in proportion to the level of statutory protection that applies to the protected matter;
4. be of a size and scale proportionate to the residual impacts on the protected matter;
5. effectively account for and manage the risks of the offset not succeeding;
6. be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude the recognition of state or territory offsets that may be suitable as offsets under the EPBC Act for the same action);
7. be efficient, effective, timely, transparent, scientifically robust and reasonable; and
8. have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.

According to the EPBC Act *Environmental Offsets Policy 2012*, avoidance and mitigation measures can remove the need for offsets if the residual impact is not significant. The significance of impacts is defined under the *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance*.

Based on the impact assessments undertaken in **Sections 10.5**, **10.6**, **10.8** and **10.9**, five species constituting MNES (Largetooth Sawfish, Eastern Curlew, Common Greenshank, Marsh Sandpiper and Sharp-tailed Sandpiper) have the potential to experience significant residual impacts if mitigation measures are inadequate for protecting water quality within the McArthur River. Detailed groundwater and surface water models suggest that such impacts are unlikely.

A sixth species constituting an MNES (Gouldian Finch) may experience a significant residual impact if:

- the feeding habitat lost as a result of the Project is a limiting resource for local populations;
- the improvements to feeding habitat that are achieved by cattle exclusion do not sufficiently counteract the losses incurred through clearing; and
- the scale of habitat loss is sufficient to affect population viability.

Available data suggest that these situations are unlikely (see **Sections 10.5.6** and **10.8.1**).

10.11 Monitoring

Monitoring programs in place to determine whether the impacts to MNES from the Project deviate from predictions made in this chapter are discussed in **Chapter 9 – Biodiversity**.