Chapter 9
Flora and fauna

CONTENTS

FIGURES

TABLES

9 FLORA AND FAUNA

9.1 INTRODUCTION

This chapter presents information on the potential impacts of the Project in relation to flora and fauna. The EIS guidelines for the Project require an adequate assessment of the proposed actions and provision of "details of the vegetation community types occurring on and adjacent to the proposal location, particularly including any species of flora and fauna conservation significance" under Part 3 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or the *Territory Parks and Wildlife Conservation Act 2000* (TPWC Act).

In 2013, ERA engaged Eco Logical Australia to conduct a flora and fauna study, which included a survey in the area adjacent to the proposed Project. The study incorporated the following components, which are presented in this chapter and drawn from the Eco Logical Australia report (**Appendix 12**):

- a literature review to determine the likelihood of occurrence of threatened flora and fauna species and threatened ecology communities (**Section 9.2.1**);
- Characterisation of the potential habitat of threatened species in the study area, including vegetation types and other identifiable features (**Section 9.2.2**);
- baseline surveys for reptiles, birds, and mammals (including microbats), including targeted surveys for threatened EPBC and NT listed fauna species that occur in the study area (**Section 9.2.2**); and
- Determination of the potential impacts of the Project on EPBC and NTPWC listed species, using the EPBC Act MNES Significant Impact Guidelines 1.1 developed by the Commonwealth of Australia (2013) (**Section 9.2.3**).

This chapter also assesses the potential radiation risk to the flora and fauna as a result of the Project. **Section 9.3** presents the outcomes of this assessment undertaken using the ERICA tool.[1]

Eco Logical Australia also participated in the environmental risk assessment workshop (**Appendix 5**) for the Project in December 2013, and contributed to the risks identified in **Section 9.4** and the mitigation measures in **Section 9.5**.

[1] ERICA – Environmental Risk from Ionising Contaminants: Assessment and Management and recommended as an appropriate assessment tool by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA).

9.2 STUDY APPROACH

9.2.1 Likelihood Analysis

An assessment was conducted of the likelihood of each EPBC and TPWC listed threatened flora and fauna species and EPBC listed migratory species occurring within the survey area. The purpose of the assessment was to provide a focus for the species to be targeted in the survey (**Section 9.2.2**) and for the significant impact assessment (**Section 9.2.3)**. Information was sourced from previous surveys on the RPA, and from the following databases.

- Commonwealth Department of the Environment (DoE) Protected Matters database, 28 August 2013;
- Flora Atlas NT, Department of Land Resource Management (DLRM), 30 October 2013; and
- NT Fauna Atlas, DLRM, 30 October 2013.

Full details are available in **Appendix 12**.

9.2.1.1 Threatened Species

All plant species and ecological communities identified were assessed as highly unlikely to occur and are not discussed further (**Table 9-1**).

Table 9-1: Likelihood of occurrence of EPBC and TPWC listed flora species, and EPBC threatened ecological community in the survey area

Name	EPBC status	TPWC status	Likelihood of occurrence*	Distance** to survey area
Arnhem Plateau Sandstone Shrubland Complex	Threatened ecological community	Not listed	Highly unlikely	4 km
Acacia sp. Graveside Gorge	Critically endangered	Critically endangered	Highly unlikely	Incorrect record: 5 km Actual record: 77 km
Hibiscus brennanii	Vulnerable	Vulnerable	Highly unlikely	9 km
Sauropus filicinus	Vulnerable	Data deficient	Highly unlikely	9 km
Hibbertia brennanii	Not listed	Vulnerable	Highly unlikely	9 km
Hibbertia tricornis	Not listed	Vulnerable	Highly unlikely	9 km
Lithomyrtus linariifolia	Not listed	Vulnerable	Highly unlikely	9 km

*Likelihood definitions:
'Known' = the species has been recorded within the survey area within the last decade.
'Likely' = a medium to high probability that a species uses the survey area. The species has been recorded within the local area and habitat within the site is considered to be highly suitable.
'Possible' = a medium to low probability that a species used the survey area. The species has been recorded within the local area or region and habitat within the site is considered to be moderately suitable.
'Unlikely' = a very low to low probability that a species uses the survey area. The species may or may not occur locally or regionally, however based on the known habitat requirements of the species, and habitat available within the site, the site is considered unlikely to be suitable or marginal at best.
'Highly unlikely'= habitat on and in the vicinity is highly unsuitable for the species. Based on the known habitat requirements of the species, the site lacks the required habitat.
**Distance has been recorded to nearest whole kilometre

Four bird and four mammal species were assessed as 'known' or 'likely' within the survey area (**Table 9-2**). An assessment of the potential impact on these species from the Project is discussed in **Section 9.5**. Species that were identified as requiring assessment in the EIS guidelines are also included, such as the plains death adder and yellow chat (Alligator Rivers).

Table 9-2: Likelihood of occurrence of EPBC and TPWC listed fauna species in the survey area

Name	EPBC Act status	TPWC Act status	Likelihood of occurrence
Birds			
Eastern partridge pigeon *Geophaps smithii smithii*	Vulnerable	Vulnerable	Known
Northern masked owl *Tyto novaehollandiae kimberli*	Vulnerable	Vulnerable	Likely
Red goshawk *Erythrotriorchis radiatus*	Vulnerable	Vulnerable	Likely
Yellow chat *Epthianura crocea tunneyi*	Endangered	Endangered	Unlikely (but requires assessment under the EIS guidelines)
Mammals			
Arnhem land rock rat *Zyzomys maini*	Vulnerable	Vulnerable	Unlikely
Bare-rumped sheath-tailed bat *Saccolaimus saccolaimus nudicluniatus*	Critically endangered	Not listed	Likely
Brush-tailed rabbit rat *Conilurus penicillatus*	Vulnerable	Endangered	Possible (formerly known)
Golden-backed tree rat *Mesembriomys macrurus*	Vulnerable	Critically endangered	Possible
Northern brush-tailed phascogale *Phascogale pirate*	Vulnerable	Endangered	Possible
Northern quoll *Dasyurus hallucatus*	Endangered	Critically endangered	Possible (formerly known, but requires assessment under the EIS guidelines)
Fawn Antechinus *Antechinus bellus*	Not listed	Endangered	Known
Reptiles			
Arnhem land egernia *Bellatorias obiri*	Endangered	Endangered	Unlikely

Name	EPBC Act status	TPWC Act status	Likelihood of occurrence
Plains death adder *Acanthophis hawkei*	Vulnerable	Vulnerable	Highly unlikely (but requires assessment under the EIS guidelines)
Fish			
Largetooth sawfish *Pristis pristis*	Vulnerable	Vulnerable	Highly unlikely (but requires assessment under the EIS guidelines)
Dwarf sawfish *Pristis clavata*	Vulnerable	Vulnerable	Highly unlikely (but requires assessment under the EIS guidelines)
Northern river shark *Glyphis garricki*	Endangered	Endangered	Highly unlikely (but requires assessment under the EIS guidelines)
Speartooth shark *Glyphis glyhis*	Critically endangered	Vulnerable	Highly unlikely (but requires assessment under the EIS guidelines)

9.2.1.2 Migratory Species

Seven migratory bird species that breed within Australia, six migratory bird species that do not breed in Australia, and one reptile were assessed as 'known' or 'likely' within the survey area (**Table 9-3**). The regional distribution and ecology of each species is discussed below with an assessment of the likelihood of potential impact.

Table 9-3: Likelihood of occurrence of EPBC listed migratory fauna species

Name	EPBC Act status	TPWC Act status	Likelihood of occurrence
Migratory birds			
Barn swallow *Hirundo rustica*	Migratory	Not listed	Possible
Cattle egret *Ardea ibis*	Migratory	Not listed	Known
Common sandpiper *Actitis hypoleucos*	Migratory	Not listed	Known (but not recorded in 2013 survey)
Derby white-browed robin *Poecilodryas superciliosa cerviniventris*	Migratory	Not listed	Likely
Eastern great egret *Ardea modesta*	Migratory	Not listed	Known

Name	EPBC Act status	TPWC Act status	Likelihood of occurrence
Migratory birds			
Gouldian finch *Erythrura gouldiae*	Endangered, migratory	Vulnerable	Possible
Grey plover *Pluvialis squatarola*	Migratory	Not listed	Possible (but requires assessment under the EIS guidelines)
Marsh sandpiper *Tringa stagnatilis*	Migratory	Not listed	Known (but not recorded in 2013 survey)
Melville cicadabird *Coracina tenuirostris melvillensis*	Migratory	Not listed	Likely
Oriental plover *Charadrius veredus*	Migratory	Not listed	Likely
Oriental pratincole *Glareola maldivarum*	Migratory	Not listed	Likely
Rainbow bee-eater *Merops ornatus*	Migratory	Not listed	Known
Rufous fantail *Rhipidura rufifrons*	Migratory	Not listed	Likely
Terek sandpiper *Xenus cinereus*	Migratory	Not listed	Likely
Whimbrel *Numenius phaeopus*	Migratory	Not listed	Known (but not recorded in 2013 survey)
White-bellied sea-eagle *Haliaeetus leucogaster*	Migratory	Not listed	Known
Migratory reptiles			
Saltwater crocodile *Crocodylus porosus*	Migratory	Not listed	Known

9.2.2 Field Survey

Flora and fauna surveys were conducted over approximately 220 ha to encompass an area of potential interaction with the Project (**Figure 9-1**). The area was selected to include Magela Creek and the associated riverine vegetation corridor, Georgetown Billabong, and the transition between riverine and woodland vegetation. Targeted wetland surveys were also conducted at Retention Pond 1 (RP1) outside the primary survey area, due to the possibility that it could host migratory species that use the area contained within the maximum extent of infrastructure for the Project.

Figure 9-1: Location of flora and fauna survey areas

9.2.2.1 Survey Methods

Flora

Vegetation mapping was undertaken in three stages:

1. An interim vegetation map was developed prior to the field survey, based on a World View 2 satellite image (captured in June 2013). Vegetation community boundaries were delineated from polygons and classified to level 3 of the National Vegetation Information System (NVIS) .[2] A vegetation community is defined under the NVIS as 'an assemblage of plant species which are structurally and floristically similar and form a repeating unit across the landscape' (Brocklehurst*, et al.* 2007: p. 3).

[2] The NVIS is a systematic way to describe vegetation communities at six levels depending on the floristic and structural information available. Level 6 provides the greatest level of detail.

2. Detailed site data were collected during broad and detailed field surveys conducted in September 2013 to validate the interim vegetation map. The surveys followed the 'NT Guidelines and Field Methodology for Vegetation Survey Mapping' (Brocklehurst*, et al.* 2007), which are compatible with the NVIS (Department of the Environment 2013) and 'Australian Vegetation Survey Guidelines' (Hnatiuk*, et al.* 2009). Vegetation units were mapped to NVIS level 5 from the broad vegetation survey and up to NVIS level 6 from the detailed surveys.

3. A final vegetation map was produced, which consisted of vegetation mapping units which were based on the interim map, and amalgamated from the broad and detailed field survey data. The units were mostly at NVIS level 3 (e.g., *Eucalyptus* open woodland), with some at NVIS level 4 (e.g., *Eucalyptus tetrodonta* open woodland).

4. Vegetation mapping units were further amalgamated into vegetation habitat types to reflect the provision of similar fauna habitat resources. For example all grassland mapping groups were amalgamated into the vegetation habitat type 'grassland' since they provide seed resources.

Vegetation condition assessment

Vegetation condition was assessed to take into account past and present land use, disturbances and land management, hence providing an overview of the cumulative effects of these impacts on vegetation communities. The assessment was guided by a desktop review of the survey area's disturbance history, examination of the field survey data and consultation with ERA staff. Separate condition assessments were completed for terrestrial and riparian vegetation communities. The Vegetation Assets, States and Transitions (VAST) framework developed by Thackway and Lesslie (2006) was used to assess the condition of terrestrial vegetation in the survey area (**Table 9-4**).

Riparian vegetation condition was assessed according to the 'Tropical Rapid Appraisal of Riparian Condition (TRARC), described in Dixon*, et al.* (2006). An index of condition was derived from indicators and scored, with final ratings of poor to excellent (**Table 9-5**). An index of pressure was also derived from six indicators (bank stability, animals, fire, tree clearing, flow regime, anthropogenic alterations) which helped to identify the likely causes of change in condition.

Table 9-4: Vegetation Assets, States and Transitions (VAST) vegetation condition descriptors for terrestrial vegetation

Type	Vegetation condition
Residual bare	Areas where native vegetation does not naturally exist
Residual	Native vegetation community structure, composition and regenerative capacity intact – no significant perturbation from land use/land management practice
Modified	Native vegetation community structure, composition and regenerative capacity perturbed
Transformed	Native vegetation community structure, composition and regenerative capacity significantly altered by land use/land management practice
Replaced - adventive	Native vegetation replacement – species alien to locality and spontaneous in occurrence

Type	Vegetation condition
Replaced - managed	Native vegetation replaced with cultivated vegetation
Removed	Vegetation removed

Table 9-5: Indicators and ratings used to assess riparian condition in the survey area

	Vegetation condition	Pressure
Indicators	24 indicators under 4 sub-indices: • Plant cover • Regeneration • Weeds • Erosion	Bank stability Feral animals Fire Tree clearing Flow regimes Anthropogenic alterations
Ratings	Excellent 80 – 100 Good 65 – 79 Moderate 50 – 64 Poor 0 – 49	**High** 50 – 100 **Moderate** 25 – 49 **Low** 0 – 24

Fauna

The survey area represented a range of habitats, including eucalypt woodland, riparian woodland, Magela Creek, and Georgetown Billabong. The selection of the survey sites was a two-step process:

- a desktop review of draft vegetation mapping was used to identify major vegetation types within the survey area; and
- field reconnaissance was undertaken to select specific sites.

The on-ground survey was conducted over eight days between 4 and 11 September 2013 by six Eco Logical Australia ecologists. Remote sensing cameras and hair tubes were deployed, extending the survey by approximately 40 days. A combination of techniques was used as follows, and further context is provided below:

- Elliott, cage and funnel traps;
- bird censuses including those for specific wetland birds;
- call playback for the northern masked owl;
- acoustic recording for bats;

- nocturnal and diurnal active searches;
- remote cameras;
- hair tubes; and
- flushing and area surveys.

The survey targeted fauna species that had been identified in the likelihood assessment in **Section 9.2.1** (refer **Table 9-1**). These species were assessed as likely or possible to occur in the study area or had been recorded on the RPA in previous surveys (known). Two species were assessed as being unlikely (yellow chat and Northern death adder); however, they were targeted as the EIS guidelines require their assessment. The type of survey methods were determined by the identified species. For example tree-mounted traps were used specifically to target the golden-backed tree rat.

The techniques incorporate the Commonwealth Department of the Environment guidelines for the survey of Australia's threatened fauna (DEWHA 2010; 2011; SEWPaC 2011) and EPBC Act requirements, and are briefly described in the following sections. Additional detail is provided in **Appendix 12**.

Trapping was undertaken at six sites (**Figure 9-2**), where a transect was established comprising of:

- 20 small Elliott traps[3] spaced at approximately 10 m intervals;
- 5 large Elliott traps mounted 1.5 m – 1.8 m above the ground on suitable large trees;
- 4 treadle activated wire cage traps (500 mm x 250 mm x 250 mm); and
- 10 funnel traps distributed in pairs along a 30 m drift fence.

Dawn and dusk wetland bird censuses were conducted at Georgetown Billabong between 8 and 11 September, and a dawn census was conducted at RP1 on 10 September. Each census was between 25 minutes and 2 hours in duration. All birds observed or identified from calls within the wetland and the fringing riverine forest were recorded.

All birds observed or heard while working around the survey area were recorded, which included the time during installation of trap lines and cameras and nocturnal surveys. In addition, between 6 and 10 September bird surveys were conducted at each transect while checking traps at dawn.

Call playback for the northern masked owl (*Tyto novaehollandiae kimberli*) was conducted in conjunction with one nocturnal active search per night, for five nights. Masked owl calls were played through car speakers for two minutes, followed by five minutes of observation for a response (either through call or sighting); this procedure was repeated three times.

A Wildlife Acoustics SM2BAT+ bat detector[4] was deployed at three sites for two nights each. The recorded data was provided to Specialised Zoological (Adelaide)[5] who identified the bat species.

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[3] An Elliott trap is a rectangular shaped structure constructed from aluminium, and designed to trap rodents and small marsupials. A trap is usually baited and set in the evening, and checked at dawn.

Nine nocturnal searches were conducted between 5 and 10 September 2013. One search was conducted at Georgetown Billabong and two at the trapping transects. The remaining six searches were independent of other survey sites. During each search, one to four people searched with high-powered head or handheld torches. Searches lasted between half an hour and two hours. Two diurnal searches were conducted by three people for one hour. These searches included recording birds observed and heard, raking through leaf litter, peeling back loose bark and lifting logs and rocks.

A total of 30 motion-activated cameras were deployed in the survey area for approximately 40 nights. Five cameras were placed 50 m apart in six transects. Three habitat types were represented (woodland, riparian areas, and within Magela Land Application Area (Magela LAA) disturbed area) with two transects for each habitat. Cameras were mounted on large trees approximately 60 cm above the ground and each camera was aimed at a baited hair tube.

A total of 60 hair tubes (90 mm diameter) were deployed in conjunction with the motion-activated cameras, in order to attract fauna. Two hair tubes were placed with each camera (50 m apart). The hair tubes were baited with universal bait, and any hair samples on the adhesive tape within the rim of the trap were identified post survey by an external party (Dead Fish, Genoa, Victoria).

Flushing surveys[6] and searches for habitat, signs of activity and predator scats were undertaken by the flora and fauna teams while traversing and working on the site. Signs of animal activity including tracks and diggings that could be associated with particular species were also recorded. Any fauna observed while travelling between survey sites were recorded as incidental observations or opportunistic sightings.

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[4] A device that records high frequency sounds.

[5] http://gaiaresources.com.au/products_anabat.php

[6] A survey method in which a group of observers walk parallel at a short spacing between each other, across an area of suitable habitat in an attempt to flush any birds that may be present.

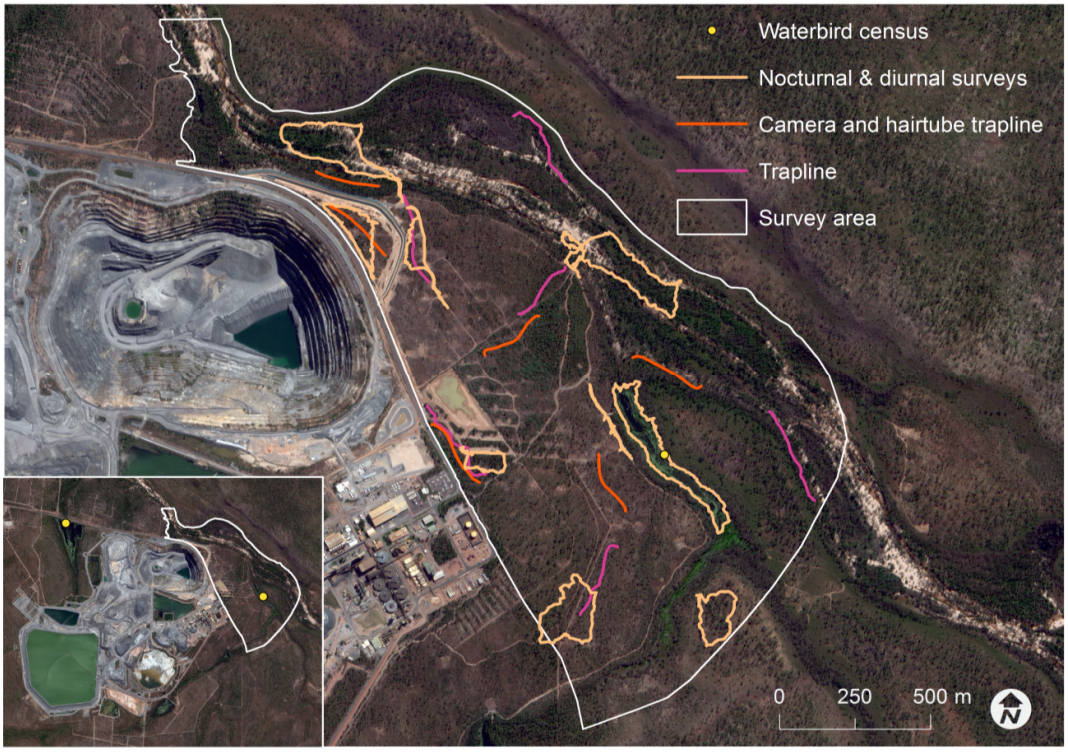

Figure 9-2: Location of 2013 fauna survey sites on the RPA

Fauna habitat resource mapping

The EPBC survey guidelines for mammals, birds and reptiles state that a detailed map of the study area should be developed to reveal the type, locations and condition of important fauna habitat features (DEWHA 2010; 2011; SEWPaC 2011). To address these guidelines, and to establish a broader context for evaluating potential impacts of the project on fauna species, habitat values of the survey area were assessed by integrating information generated from the vegetation mapping, vegetation condition assessment and fauna likelihood analysis.

Vegetation habitat type (from vegetation mapping) and vegetation condition information were used to evaluate the location and condition of relevant habitat resources within the survey area. The method of assessment for each fauna habitat resource is shown in **Table 9-6,** and a summary of how the resources were ranked for each vegetation habitat type is shown in **Table 9-7**.

Table 9-6: Fauna habitat resources assessment

Fauna habitat resource	Method of assessment
Wetlands and other water sources	Distance to water was assessed (e.g., creeks, billabongs, sumps)
Nectar or fleshy fruit bearing flowering tree species	Quality of resource based on the density, variety, and condition of flowering and fruiting trees. Rated 'poor', 'good' or 'excellent'
Tree hollows and hollow logs	Hollows cannot always be identified or evaluated via ground-based inspection, so the quality of available hollows was estimated based on vegetation height, diversity and fire history. Rated 'poor', 'good' or 'excellent'
Seed bearing grasses	The quality of this resource within each polygon was determined based on the range and density of grass species. Rated 'poor', 'good', 'excellent'

Table 9-7: Ranking and broad summary of fauna habitat resources in each vegetation habitat type

Vegetation habitat type	Availability of nectar, fruit and seeds	Availability of hollows	Availability of grass seeds
Acacia shrubland	Poor – Acacia leaf glands secrete nectar which is a food source primarily for invertebrates. Honeyeaters have also been observed feeding on Acacia nectar. Parrots may eat seeds.	Poor – Acacias generally do not form hollows suitable for vertebrate fauna	Poor to good – depending on fire history and openness, Acacia can have a grass seed bearing understorey
Corymbia and Eucalyptus woodland	Poor to excellent – Corymbia and Eucalyptus flowers can provide a good source of nectar used by mammals, birds and occasionally geckos. Gumnuts provide a food source for parrots.	Good to excellent – depending on fire history, mature Eucalyptus and Corymbia woodland can provide suitable hollows in live trees and fallen wood	Poor to excellent – the quality of grassy understory within woodland is determined by the fire history and consequently openness of the vegetation community
Georgetown Billabong surrounds	Poor – the Georgetown Billabong area is populated by perennial species	Poor – the Georgetown Billabong are is populated by perennial species	Excellent – the Georgetown Billabong area supports grasses that seed throughout the year

Vegetation habitat type	Availability of nectar, fruit and seeds	Availability of hollows	Availability of grass seeds
Grasslands	Poor – few species within grasslands produce nectar or fruit	Poor – grasslands may support low densities of hollow bearing trees or fallen logs,	Good to excellent – depending on fire history
Riparian	Good to Excellent- Melaleuca flowers produce nectar that is eaten by birds and mammals, including bats. Many riparian trees including Eucalyptus product fruit.	Good - Hollows occur in riparian Eucalyptus	Good to excellent – Riparian areas support large patches of grasslands and woodlands with grass understorey
Cleared	Poor	Poor	Poor

9.2.2.2 Survey Results

Flora

Thirty-three vegetation mapping units were identified and mapped in the survey area. A detailed description of the vegetation mapping units is given in **Appendix 12**. The vegetation habit types derived from the mapping units are shown in **Figure 9-3** and **Table 9-8**. Photographic examples of these vegetation habitat types are shown in **Figure 9-4**.

- The shrubland group was characterised by variable stages of vegetation regrowth following disturbance (mainly from clearing), and was dominated by *Acacia* sp. (e.g. *Acacia holesericia*), with some regrowth of *Eucalyptus* sp. as shrubs.
- The grassland group was dominated by species such as *Eriachne triseta*, *Heteropogon triticeus*, and *Sorghum* sp., and some small areas of turkey bush (*Calytrix exstipulata*) shrubland.
- The woodland group consisted mostly of *Corymbia* sp. and *Eucalyptus* sp. in particular Darwin stringybark (*E. tetrodonta*) and Darwin woolybutt (*E. miniata*).
- The riparian group consisted of *Melaleuca* sp. in various structural classes – from open forest to open woodland. There were areas of grassland dominated by *Pseudoraphis spinescens* in the creek bed, and *Poacea* sp. in the transition zone between riparian and terrestrial vegetation zones.
- The billabong and billabong fringe classes incorporate inundated and dry areas of Georgetown Billabong respectively. The billabong vegetation consisted of waterlillies (*Nymphaea violacea*) in deeper water areas, and sedges (*Eleocharis dulcis*) in the shallow water. The billabong fringe consisted of cracked soils, fringed by closed grassland of *Leersia hexandra*, and senescent sedgeland comprised of *Eleocharis dulcis*.

No threatened flora species or communities were found during the survey, which was consistent with previous flora surveys on the RPA.

Table 9-8: Mapping units represented under the broad mapping units in **Figure 9-3**

Broad mapping unit	Mapping unit
Shrubland	*Acacia auriculiformis* shrubland, *Acacia holosericea*, open shrubland, *Acacia holosericea* shrubland, *Acacia holosericea* sparse shrubland, *Acacia* open shrubland, *Acacia* shrubland, dead *Acacia* open shrubland, and *Calytrix* open shrubland.
Grassland	Closed grassland, *Eriachne triseta* grassland *Eriachne triseta* open grassland, grassland, *Heteropogon triticeus* open grassland, *Heteropogon triticeus* sparse grassland, *Pseudoraphis spinescens* closed grassland, *Sorghum* grassland, and *Sorghum* open grassland.
Woodland	*Corymbia* open woodland, *Corymbia polycarpa* open woodland, *Eucalyptus* open woodland, *Eucalyptus* shrubland, *Eucalyptus tetrodonta* open woodland, *Eucalyptus tetrodonta* woodland, *Eucalyptus* woodland and *Xanthostemon paradoxus* open shrubland.
Riparian	*Melaleuca argentea* open woodland/woodland, *Melaleuca viridiflora* open forest, *Melaleuca viridiflora* open woodland, *Melaleuca viridiflora* shrubland, *Melaleuca viridiflora* woodland, and mixed riparian.
Cleared	Cleared
Billabong	Billabong
Billabong fringe	Billabong fringe

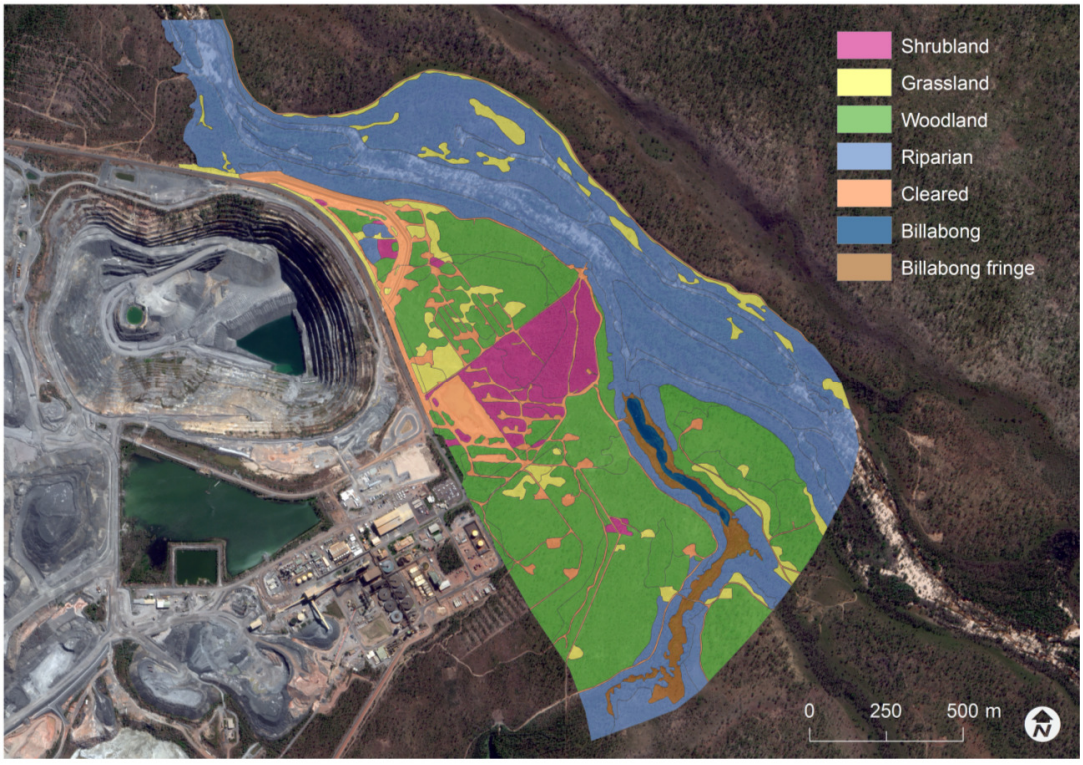

Figure 9-3: Vegetation habitat types units in the survey area

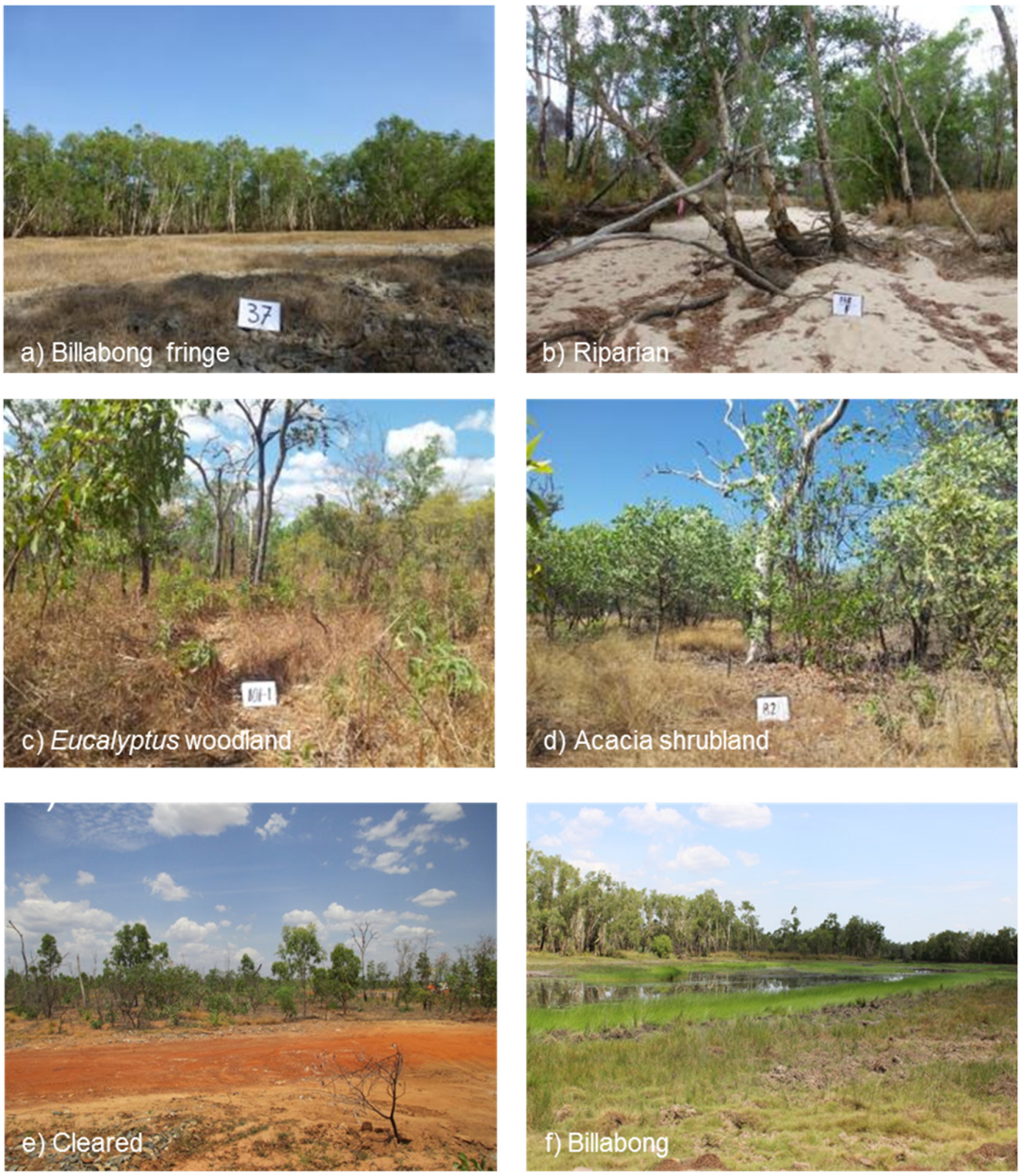

Figure 9-4: Vegetation habitat type examples

Vegetation condition assessment

The outcome of the condition assessment of terrestrial and riparian vegetation communities in the survey area is presented in **Figure 9-5**. The survey area has been subject to significant disturbance ranging from mining related activities such as irrigation by pond water (or land application) and clearing, to naturally occurring events such as fire, flooding and storms/cyclones, and impacts due to feral pigs and weeds.

Terrestrial vegetation communities accounted for 50% of the survey area. The condition of these communities varied from residual to transformed; most vegetation not affected by irrigation was rated as residual, with fire being the only disturbance. Vegetation condition within the Magela LAA varied between modified and transformed. Clearing associated with exploration and other mine-related activities was evident in terrestrial areas. Cleared areas occurred predominantly in the central sections of the survey area and consisted primarily of a network of tracks and drill pads for exploration, and a borrow pit (approximately 2 ha). This clearing has impacted the availability of habitat resources across the broader survey area and results in small-scale habitat fragmentation.

Minor occurrences of the introduced annual mission grass (*Cenchrus pedicellatum*) were recorded during the survey in the Magela LAA. Four of the five patches were equal to or less than 1 m in diameter while one patch was 50 m in diameter. Minor occurrences of passionfruit (*Passiflora foetida*) were also recorded in the area, but the exotic species is regarded as a naturalised vine in the NT (Smith 2002). It should be noted that weed management had recently been undertaken in the area and results from a single survey in September 2013 should not be taken as a comprehensive assessment of all weeds that may be present in the survey area under different seasonal conditions.

Riparian vegetation communities represent the remaining 50% of the survey area. The condition of these communities varied between good and excellent, with most riparian areas rated as excellent. Those areas rated as good were downgraded from excellent based on damage from feral pigs. No clearing was evident in the riparian vegetation communities.

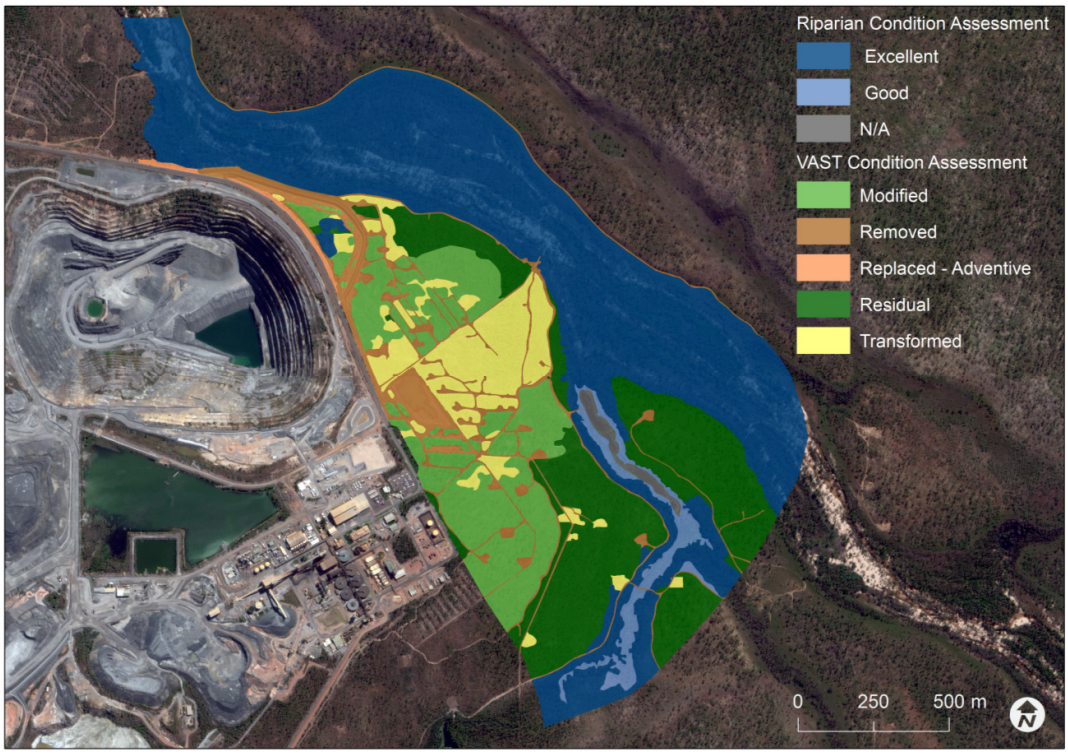

Figure 9-5: Riparian and terrestrial habitat condition assessment

Conclusion

The dominant terrestrial vegetation type within the survey area was *Eucalyptus* sp. woodland, which was consistent with most of the RPA, and the surrounding Kakadu National Park (refer **Section 2.5.4.1**). With the exception of riparian areas and some small areas of residual *Eucalyptus* sp. woodland, most of the survey area has undergone significant modification due to mining related activities over the past 30 years. It highly unlikely that there are threatened flora communities on the RPA, given that none have been found in numerous surveys over the past 20 years.

Fauna

At least[7] 127 species were recorded during the survey, comprising 8 native amphibian species, 79 bird species, at least 17 native mammal species, 20 reptile species and 3 introduced species (**Table 9-9**). Seven EPBC Act or TPWC Act listed species were recorded within the survey area (**Table 9-10** and **Figure 9-6**).

The highest species richness was recorded at Georgetown Billabong. Observations at the billabong and fringing vegetation recorded 2 native amphibians, 57 bird species, 2 native mammal species (including one bat), 6 reptiles and the introduced cane toad (*Rhinella marina*). A breeding pair of EPBC listed migratory white-bellied sea-eagles (*Haliaeetus leucogaster*) was observed during most surveys in the area. A single dawn survey of RP1 recorded 21 bird species.

Three individuals of the endangered fawn antechinus were recorded in *Eucalyptus* woodland, including one recorded in a small patch of highly disturbed woodland in the Magela LAA that had been previously burnt and cleared.

Table 9-9: Number of fauna species recorded by each survey method within the survey area

Survey method/location	Amphibians	Birds	Mammals	Reptiles	Introduced
Trapping - including bird and nocturnal surveys at transects	0	33	3	13	0
Wetland bird survey and nocturnal survey at billabong	0	60	3	0	1
Nocturnal survey (independent of other sites)	6	2	0	6	1
Diurnal survey	2	17	0	1	2
Acoustic analysis*	0	0	9	0	0
Remote camera	0	9	5	2	3
Hair tube**	0	0	1	0	0
Incidental/ other surveys	5	31	2	4	2

* Note: The number of bat species represents a minimum number as there were several bat species whose calls could not be positively identified.

[7] There were several bat species whose calls could not be positively identified.

** Note: Unseasonal rain impacted on the hair tubes, reducing the stickiness of the tape within the first week of the survey period. Two mammal hair samples (each comprising a single hair) were sent for analysis, one was identified as a dingo hair, and the other was a contaminant human hair

Table 9-10: Threatened and migratory fauna species recorded during the survey

Common name	EPBC Act (C'wealth) status	TPWC Act (NT) status	Survey method	Observation notes
Partridge pigeon (*Geophaps smithii smithii*)	Vulnerable	Vulnerable	Incidental observation	Two flocks of Eastern Partridge Pigeons were observed on 7 and 10 September in *Eliocharis* sedgeland in the southern dry section of Georgetown Billabong.
Cattle egret (*Ardea ibis*)	Migratory	None	Wetland bird survey (Georgetown Billabong)	A Cattle Egret was observed at Georgetown Billabong, 11 September.
Eastern great egret (*Ardea modesta*)	Migratory	None	Wetland bird survey (Georgetown Billabong and RP1)	The Eastern Great Egrets were observed at Georgetown Billabong 7, 8, 9 and 11 September, and RP1 on 10 September.
Rainbow bee-eater (*Merops ornatus*)	Migratory	None	Bird census, remote camera, wetland bird survey (Georgetown Billabong, RP1, Magela Creek) incidental observation	Rainbow Bee-eaters were observed at Georgetown Billabong, transects A, B, C, E, and F, and in the Magela Creek bed thought the survey period. Two burrows were observed.
White-bellied sea-eagle (*Haliaeetus leucogaster*)	Migratory	None	Wetland bird survey (Georgetown Billabong), incidental observation	A breeding pair of White-bellied Sea-eagles were observed at Georgetown Billabong throughout the survey period.
Saltwater crocodile (*Crocodylus porosus*)	Migratory	None	Nocturnal survey	A saltwater Crocodile was observed at Georgetown Billabong on 7 and 10 September
Fawn antechinus (*Antechinus bellus*)	None	Endangered	Trapping, remote camera	One female Fawn Antechinus was trapped adjacent to the proposed vent corridor at transect A. A further two were captured on camera at woodland transects H and J.

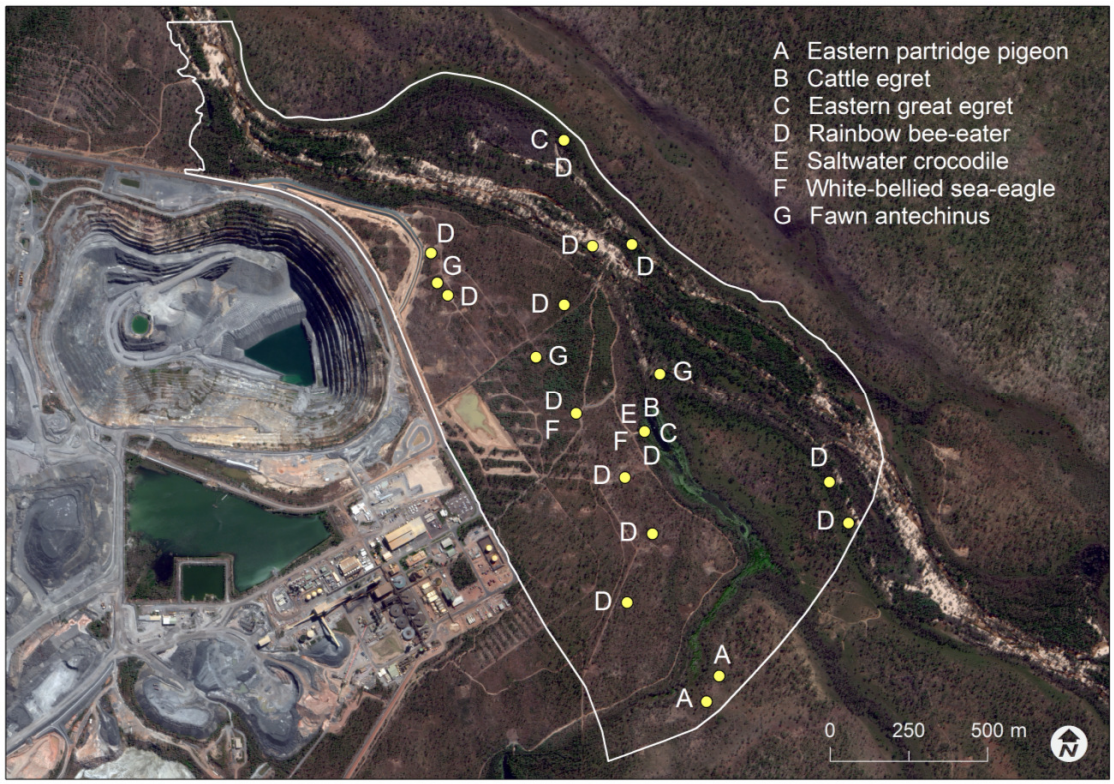

Figure 9-6: EPBC Act and TPWC Act listed fauna species recorded within the survey area

Three species of introduced fauna were recorded during the survey:

- pigs (*Sus scrofa*) and associated damage were observed in the riparian area of Magela Creek and at Georgetown Billabong sites (**Figure 9-7a**);
- a cat (*Felis catus*) was recorded on a remote camera transect (**Figure 9-7b**);
- the cane toad (*Rhinella marina*) was observed at Georgetown Billabong and at some of the camera and trapping transects.

There was evidence of buffalo grazing in riparian grassland in the south west of the survey area, but no significant disturbance was evident.

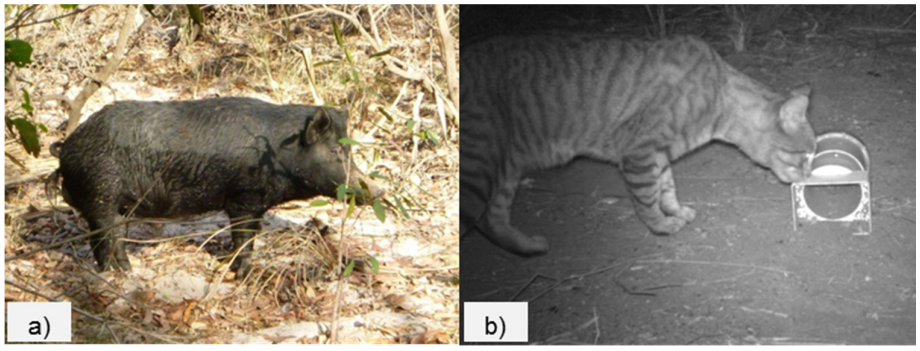

Figure 9-7: Figure 9-7: a) Feral pig (*Sus scrofa*) observed in riparian area of Magela Creek; b) Feral cat (*Felis catus*) recorded on remote camera

Fauna habitat resource mapping

Three of the four fauna habitat resources (values) were mapped within the survey area (**Figure 9-8**):

- nectar, fruit and seeds;
- hollows; and
- grass seeds.

Access to water is excellent across the entire site, due to the proximity of Magela Creek which incorporates both Georgetown Billabong, and a series of permanent pools. Outside of the survey area, water is also available from other creeks, and numerous sumps and constructed wetlands, such as RP1.

Approximately half of the survey area contains riparian vegetation communities, with the majority in excellent condition and providing excellent fauna habitat values in terms of availability of nectar/ fruit/ seed; hollows; and grass seeds. Nectar, fruit and seed availability was highest within the riparian vegetation adjoining Magela Creek.

Figure 9-8: Availability of fauna habitat resources

9.2.3 Significant Impact Assessment

An assessment of the Project on threatened and migratory fauna species against the EPBC Act significant impact criteria is presented below. The assessment is based on those species identified in the likelihood assessment (**Section 9.2.1)** and the flora and fauna survey (**Section 9.2.2)**.

Each significant impact criterion for a species was assessed as 'likely' or 'unlikely', where to be likely, the criterion was considered to have a greater than 50% chance of occurring (DEWHA 2013)

9.2.3.1 Threatened Species

The following section addresses four bird species, four mammals, four fish and one reptile species that are known or considered likely to occur on the RPA, or require assessment under the EIS guidelines

Eastern partridge pigeon (Geophaps smithii smithii)

Regional distribution and ecology

The eastern partridge pigeon is restricted to sub-coastal areas of the Top End of NT where most recent records are from Kakadu National Park and between Katherine and Darwin. The eastern partridge pigeon prefers open forest and woodland dominated by Darwin stringybark (*Eucalyptus tetrodonta*) and Darwin woolybutt (*E. miniata*), with a structurally diverse understorey.

The eastern partridge pigeon is relatively sedentary and, if there is permanent water nearby, will commonly occupy the same area throughout the year. The pigeon nest on the ground, usually in a shallow depression lined with grass or leaves and has been known to lay eggs in all months of the year, although the bulk of nesting occurs in the early to mid-dry season. The bird is known to forage on a wide variety of seeds from grasses, legumes, herbs and also shrubs and trees.

Threats to the pigeon include land use activities, such as vegetation clearing and fire, that result in detrimental floristic and structural changes to the habitat occupied by the bird.

Potential habitat on RPA, survey findings

Critical habitat for the eastern partridge pigeon comprises intricately burnt mosaics within open forests with grassy understorey, where the species nests in patches of unburnt Sorghum in that mosaic. This habitat occurs within the survey area and most of the RPA.

Two flocks (of 8 to 12, and 4 individuals) were observed in *Eliocharis* sedgeland in the dry southern section of Georgetown Billabong during the September 2013 survey.

Assessment of potential impact

The likelihood of impact on the eastern partridge pigeon by the Project for each significant impact criterion is described in **Table 9-11**. It is considered unlikely that there will be significant impacts on partridge pigeons from clearing of native vegetation associated with the proposed development.

Table 9-11: Likelihood of potential impacts on the eastern partridge pigeon

Significant impact criteria	Likelihood	Assessment
Leads to a long-term decrease in the size of an important population of eastern partridge pigeons	Unlikely	It is unlikely that clearing associated with the Project will have any impact on the local population of eastern partridge pigeons as the species remains common in the undisturbed parts of the RPA, and a significant population occurs in neighbouring Kakadu National Park. The above ground impact of the proposed development will be limited to a small amount of clearing within a highly disturbed area and is unlikely to lead to any long term impact on eastern partridge pigeon populations.
Reduce the area of occupancy of an important population of eastern partridge pigeons	Unlikely	Eastern partridge pigeons remain common in the undisturbed parts of the RPA, and a significant population occurs in neighbouring Kakadu National Park. The removal of < 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to reduce the area of habitat used by the local eastern partridge pigeon population.
Fragment an existing important population of eastern partridge pigeons into two or more populations	Unlikely	The proposed location of Project infrastructure will be directly adjacent to the existing mine site and abutting the main access road to the site. It will therefore not fragment any fauna populations or habitat.
Adversely affect habitat critical to the survival of eastern partridge pigeons	Unlikely	Critical habitat for the eastern partridge pigeon comprises intricately burnt mosaics within open forests with grassy understorey (Woinarski 2004). This habitat does not occur within the area to be cleared.
Disrupt the breeding cycle of an important population of eastern partridge pigeons	Unlikely	The area to be cleared does not include suitable breeding or feeding habitat for eastern partridge pigeons, and the scale of the project means it is unlikely to have any impact on the breeding cycles of the adjacent populations.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the eastern partridge pigeons is likely to decline	Unlikely	Clearance of < 1 ha within the heavily impacted Magela LAA will not reduce the availability or quality of habitat within the region.
Result in invasive species that are harmful to eastern partridge Pigeons becoming established in the vulnerable species' habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact eastern partridge pigeon habitat will be introduced.
Introduce disease that may cause the eastern partridge pigeon to decline	Unlikely	The proposed action is unlikely to introduce a disease that would impact eastern partridge pigeons.

Northern masked owl (Tyto novaehollandiae kimberli)

Regional distribution and ecology

The northern masked owl is a subspecies of the masked owl (*Tyto novaehollandiae*) and little is known of the distribution of this species. Three subpopulations have been suggested:

- Kimberley region of Western Australia;
- Top End of the NT; and
- Cape York in far north Queensland.

In northern Australia, the northern masked owl has been recorded from riparian forest, rainforest, open forest, Melaleuca swamps and the edges of mangroves and along sugar cane fields margins. Recorded declines of small mammals in the Top End may have reduced prey availability for masked owls.

The species breeds between March and October, typically nesting in large trees bearing hollows, within patches of closed forest. A study of *T. novaehollandiae* reported that pairs occupy a large home range (approximately 1,000 ha) and occur at low densities. The same study recorded a female spending more than 80% of its time in, or next to, extensively modified environments, frequently using the transition between bushland and open country for foraging.

Threats to the owl include broad-scale changes to the northern Australian environment caused by altered fire regimes, grazing and weed invasion.

Potential habitat on RPA, survey findings

The survey area does not contain old eucalypts with large hollows suitable for breeding; however, the area may be used for foraging.

No northern masked owl responses were heard during the call playback that was conducted during the September 2013 survey.

Assessment of potential impact

The likelihood of impact on the northern masked owl by the Project for each significant impact criterion is described in **Table 9-12**. The maximum extent of infrastructure for the Project in the Magela LAA represents less than 1% of the 1000 ha home range of any Northern Masked Owls in the area and breeding. It is therefore considered unlikely that there will be significant impacts on northern masked owls from the clearing of native vegetation associated with the Project.

Table 9-12: Likelihood of potential impacts on the northern masked owl

Significant impact criteria	Likelihood	Assessment
Lead to a long-term decrease in the size of an important population of northern masked owls	Unlikely	The above ground impact from the Project will be limited to a small amount of clearing within a highly disturbed area, and is unlikely to lead to any long term impact on northern masked owl populations.
Reduce the area of occupancy of an important population of northern masked owls	Unlikely	Northern masked owls have not been recorded within the survey area; the area therefore is unlikely to support an important population of the species. If the area does support northern masked owls, the removal of < 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to reduce the area of habitat being used.
Fragment an existing important population of northern masked owls into two or more populations	Unlikely	The proposed location of Project infrastructure will be directly adjacent to the existing mine site and abuts the main access road to the site. It will therefore not fragment any fauna population or habitat.
Adversely affect habitat critical to the survival of northern masked owls	Unlikely	The northern masked owl typically nests in large trees bearing hollows which do not occur within the proposed area of disturbance. No other critical habitat features for this species have been identified (Woinarski, 2004).
Disrupt the breeding cycle of an important population of northern masked owls	Unlikely	The northern masked owl typically nests in large trees bearing hollows which do not occur within the proposed area of disturbance. Clearance of < 1 ha is unlikely to reduce prey abundance at a level that would impact breeding.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that northern masked owls is likely to decline	Unlikely	Clearance of < 1 ha within the heavily impacted Magela LAA will not reduce the availability or quality of habitat within the region.
Result in invasive species that are harmful to a vulnerable species becoming established in northern masked owls habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact northern masked owl habitat will be introduced.

Significant impact criteria	Likelihood	Assessment
Introduce disease that may cause the northern masked owls to decline	Unlikely	The proposed action is unlikely to introduce a disease that would impact northern masked owls.

Red goshawk (Erythrotriorchis radiates)

Regional distribution and ecology

The red goshawk is endemic to Australia and is sparsely distributed across approximately 15% of coastal and sub-coastal Australia (from the western Kimberley in Western Australia to northeastern NSW) and occasionally found on continental islands.

The species occurs in coastal and sub-coastal areas in wooded and forested lands of tropical and warm-temperate Australia. In the NT, the hawk prefers tall open forest and woodland, or tall fringing woodlands along rivers in grasslands, shrublands, and low open woodlands. The species prefers extensive open forest, open woodlands and riparian vegetation dominated by mature *Eucalyptus tetrodonta*, *E. miniata*, and *Melaleuca leucadendron*. Forests of intermediate density are preferred, or transitions between habitats of differing densities; red goshawks avoid very dense and very open habitats.

The red goshawk is a solitarily breeder, preferring large (over 20 m tall) trees, forested or wooded areas (within large areas of intact native forest and woodland), and proximity to permanent water. Nest trees have always been found located within 1 km of permanent water, often adjacent to rivers or clearings. The hawks hunt and breed in both lowland and rugged terrain, where their diet consists largely of birds. Records indicate that breeding activity occurs from August to November.

Threats to red goshawk include habitat loss and fragmentation, disturbance of nests (including burning), and reduction of prey availability.

Potential habitat on RPA, survey findings

Previous surveys have not found the red goshawk on the RPA. The September 2013 survey did not record any birds nor identify any nests, and there were no large tracts of native forest and woodland within the survey area that the species depends upon.

Assessment of potential impact

The likelihood of impact on the red goshawk by the Project for each significant impact criterion is described in **Table 9-13**. Given that red goshawks are dependent on large tracts of intact native forest and woodland, the maximum extent of infrastructure for the Project in the Magela LAA is unlikely to provide any significant habitat for red goshawks. It is considered unlikely that there will be significant impacts on red goshawk from the clearing of native vegetation associated with the Project.

Table 9-13: Likelihood of potential impacts on the red goshawk

Significant impact criteria	Likelihood	Assessment
Lead to a long-term decrease in the size of an important population of red goshawks	Unlikely	Infrastructure for the Project will be restricted to the heavily disturbed areas of the RPA, and is unlikely to lead to long-term impacts on red goshawk populations.
Reduce the area of occupancy of an important population of red goshawks	Unlikely	The red goshawk has not been reported within the RPA. The removal of < 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to reduce the area of habitat available to red goshawks.
Fragment an existing important population of red goshawks into two or more populations	Unlikely	The proposed location of Project infrastructure is directly adjacent to the existing mine site and abuts the main access road to the site. It will therefore not fragment any fauna populations or habitat.
Adversely affect habitat critical to the survival of red goshawks	Unlikely	Critical habitat for red goshawks comprises large tracts of intact native forest and woodland. The clearing of a small area of heavily impacted habitat directly adjacent to the mine will not affect critical habitat in the region.
Disrupt the breeding cycle of an important population of red goshawks	Unlikely	The small area to be cleared will not reduce the available suitable habitat, and is unlikely to impact prey availability for the species during the breeding season.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the red goshawks is likely to decline	Unlikely	Clearance of < 1 ha within the heavily impacted Magela LAA will not reduce the availability or quality of habitat within the region.
Result in invasive species that are harmful to red goshawks becoming established in the vulnerable species' habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact red goshawk habitat will be introduced.
Introduce disease that may cause the red goshawk to decline	Unlikely	The proposed action is unlikely to introduce a disease that would impact the red goshawk.

Yellow chat (Alligator Rivers) (Epthianura crocea tunneyi)

Regional distribution and ecology

Yellow chats occur patchily across Northern Australia, on alluvial and marine floodplains. The Alligator Rivers yellow chat is endemic to the NT and is restricted to floodplains from the Alligator River to the East Alligator. Yellow chats forage for insects within grasses, herbs and sedges and stands of mangroves, and aggregate around persisting wet areas at the end of the dry season. Breeding behaviour of the yellow chat is undocumented except for single breeding records in September, March and April and a few additional records of nests built near (usually less than one metre above) the ground in low mangroves.

The main threat the yellow chat in the Alligator Rivers Region is habitat alteration due to weeds and feral animals.

Potential habitat on RPA, survey findings

Habitat within the Project area and in the vicinity is highly unsuitable for the species (refer **Table 14.3**). Despite searching for the species, no birds were recorded during the September 2013 survey.

Assessment of potential impact

The likelihood of impact on the yellow chat by the Project for each significant impact criterion is described in **Table 9-14**. It is therefore considered unlikely that there will be significant impacts on the yellow chat from the clearing of native vegetation associated with the Project.

Table 9-14: Likelihood of potential impacts on the yellow chat

Significant impact criteria	Likelihood	Assessment
Lead to a long-term decrease in the size of a population of yellow chat	Unlikely	Infrastructure for the proposed action will be restricted to the heavily disturbed areas of the RPA, and is unlikely to lead to long term impacts on yellow chat populations.
Reduce the area of occupancy of the yellow chat	Unlikely	The yellow chat has not been recorded within the RPA. The removal of < 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to reduce the area of habitat available to yellow chats.
Fragment an existing population into two or more populations of the yellow chat	Unlikely	The proposed Project infrastructure is directly adjacent to the existing mine site and abuts the main access road to the site. It will therefore not fragment any habitat.
Adversely affect habitat critical to the survival of the yellow chat	Unlikely	Critical habitat for yellow chats comprises alluvial and marine floodplains. The clearing of a small area of heavily impacted woodland habitat directly adjacent to the mine will not affect critical habitat in the region.
Disrupt the breeding cycle of a population of yellow chat	Unlikely	The small area to be cleared will not reduce the available suitable habitat, and is unlikely to impact prey availability for the species during the breeding season.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the yellow chat is likely to decline	Unlikely	Critical habitat for yellow chats comprises alluvial and marine floodplains. The clearing of a small area of heavily impacted woodland habitat directly adjacent to the mine will not affect the availability of quality of suitable habitat in the region.

Significant impact criteria	Likelihood	Assessment
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact yellow chat habitat will be introduced.
Introduce disease that may cause the yellow chat to decline	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any disease that could impact yellow chat habitat will be introduced.
Interfere with the recovery of the yellow chat.	Unlikely	The proposed action is unlikely to introduce a disease that would impact the yellow chat.

Bare-rumped sheath-tailed bat (Saccolaimus saccolaimus nudicluniatus)

Regional distribution and ecology

The distribution of the bare-rumped sheath-tailed bat is disjoined and includes an eastern population occurring in a narrow coastal band from approximately Townsville through to northeastern Cape York, and a population in the NT seemingly restricted to the Kakadu lowlands (within Kakadu National Park) and Darwin area.

The preferred habitat for this species is rugged sandstone environments, typically where there are many caves, crevices or boulders; however, the specimens collected in Kakadu National Park were from open Pandanus woodland fringing the sedgelands of the South Alligator River. The ecology of the species is poorly known, although anecdotal evidence suggests they forage primarily for aerial insects over the woodland/forest canopy along vegetation boundaries.

Potential habitat on RPA, survey findings

Critical habitat for the bare-rumped sheath-tailed bat is poorly known; however, the highly impacted vent corridor is unlikely to be important for roosting or foraging.

Full spectrum recordings captured during the September 2013 survey resulted in the identification of at least nine bat species, but did not detect the bare-rumped sheath-tailed bat.

Assessment of potential impact

The likelihood of impact on the bare-rumped sheath-tailed bat by the Project for each significant impact criterion is described in **Table 9-15**. It is considered unlikely that there will be significant impacts on bare-rumped sheath-tailed bats from the clearing of native vegetation associated with the Project.

Table 9-15: Likelihood of potential impacts on the bare-rumped sheath-tailed bat

Significant impact criteria	Likelihood	Assessment
Lead to a long-term decrease in the size of a population of bare-rumped sheath-tailed bats	Unlikely	Infrastructure for the proposed action will be restricted to the heavily disturbed areas of the RPA, and is unlikely to lead to long term impacts on bare-rumped sheath-tailed bat populations.
Reduce the area of occupancy of the bare-rumped sheath-tailed bat	Unlikely	The removal of < 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to reduce the area of roosting or foraging habitat available to the bare-rumped sheath-tailed bat.
Fragment an existing population of bare-rumped sheath-tailed bats into two or more populations	Unlikely	The proposed Project infrastructure will be directly adjacent to the existing mine site and abuts the main access road to the site. It will therefore not fragment any fauna populations or habitat.
Adversely affect habitat critical to the survival of bare-rumped sheath-tailed bats	Unlikely	Critical habitat for the bare-rumped sheath-tailed bat is poorly known; however the highly impacted area adjacent to the Project area is unlikely to be important for roosting or foraging.
Disrupt the breeding cycle of a population of bare-rumped sheath-tailed bats	Unlikely	No suitable roosting habitat occurs within the area to be cleared. Prey availability during the breeding season will not be affected.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the bare-rumped sheath-tailed bat is likely to decline	Unlikely	The removal of < 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to negatively impact any habitat important for bare-rumped sheath-tailed bat.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the bare-rumped sheath-tailed bats habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact bare-rumped sheath-tailed bat habitat will be introduced.
Introduce disease that may cause the bare-rumped sheath-tailed bats to decline, or	Unlikely	The proposed action is unlikely to introduce a disease that would impact bare-rumped sheath-tailed bat.
Interfere with the recovery of the bare-rumped sheath-tailed bat	Unlikely	The recovery plan for the bare-rumped sheath-tailed bat (Schulz & Thomson 2007) is focused on gathering information on the species, and protecting roosting habitat. These goals will not be affected by the proposed clearing.

Brush-tailed rabbit rat (Conilurus penicillatus)

Regional distribution and ecology

The brush-tailed rabbit rat shelters in tree hollows, hollow logs and occasionally in the crowns of Pandanus or sand-palms. This species occurs in Eucalypt tall open forest and in the coastal grasslands. There have been no recent recordings within its historical range in the NT, including Kakadu National Park, and the brush-tailed rabbit rat is currently known to persist in the NT on the Coburg Peninsula (approximately 350 km east of Darwin), Groote Eylandt, and Bathurst, Melville and Inglis islands.

Threats to the rat include feral animals, predators and disease. Altered fire regimes, weeds and grazing may have changed the availability of preferred food sources and habitat.

Potential habitat on RPA, survey findings

Brush-tailed rabbit rat were common throughout Eucalypt woodland in Kakadu National Park, but since the late 1980s have declined to near extinction.

The brush-tailed rabbit rat has not been recorded from pervious fauna surveys on the RPA. Searches for potentially suitable habitat resources, trapping and spotlight surveys during the September 2013 survey did not locate any brush-tailed rabbit rats.

Assessment of potential impact

The likelihood of impact on the brush-tailed rabbit-rat by the Project for each significant impact criterion is described in **Table 9-16**. It is considered unlikely that there will be significant impacts on Brush-tailed Rabbit-rats from the clearing of native vegetation associated with the Project.

Table 9-16: Likelihood of potential impacts on the brush-tailed rabbit-rat

Significant impact criteria	Likelihood	Assessment
Lead to a long-term decrease in the size of an important population of brush-tailed rabbit-rats	Unlikely	The brush-tailed rabbit-rat is thought to have declined to near extinction in Kakadu since the 1980s. Infrastructure for the proposed action will be restricted to the heavily disturbed areas of the RPA, and is unlikely to lead to long term impacts on brush-tailed rabbit-rat populations.
Reduce the area of occupancy of an important population of brush-tailed rabbit-rats	Unlikely	The brush-tailed rabbit-rat has not been reported within the RPA. The removal of < 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to reduce the area of habitat available to brush-tailed rabbit-rats.
Fragment an existing important population of brush-tailed rabbit-rats into two or more populations	Unlikely	The proposed Project infrastructure will be directly adjacent to the existing mine site and abuts the main access road to the site. It will therefore not fragment any fauna populations or habitat.

Significant impact criteria	Likelihood	Assessment
Adversely affect habitat critical to the survival of brush-tailed rabbit-rats	Unlikely	Critical habitat for brush-tailed rabbit-rats comprised mixed Eucalyptus open forest and woodland, or on dunes with Casuarina. The species prefers areas that are not burned frequently. The highly impacted area to be cleared is not critical habitat.
Disrupt the breeding cycle of an important population of brush-tailed rabbit-rats	Unlikely	The small area to be cleared will not reduce the available suitable habitat, and is unlikely to impact food availability for the species during the breeding season.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the brush-tailed rabbit-rats is likely to decline	Unlikely	Clearance of < 1 ha within the heavily impacted Magela Land Application Area will not reduce the availability or quality of habitat within the region.
Result in invasive species that are harmful to brush-tailed rabbit-rats becoming established in the vulnerable species' habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact brush-tailed rabbit-rat habitat will be introduced.
Introduce disease that may cause the brush-tailed rabbit-rat to decline	Unlikely	The proposed action is unlikely to introduce a disease that would impact brush-tailed rabbit-rat.

Northern quoll (Dasyurus hallucatus)

Regional distribution and ecology

Historically, the Northern quoll ranged across northern Australia, almost continuously from the Pilbara in WA to near Brisbane in Queensland. The species is now restricted to five regional distributions: central Queensland coast, northern Queensland, the Kimberley and the Pilbara of Western Australia, and the Top End (including the mainland and smaller islands such as Vanderlin, Marchinbar, Inglis, and Northeast, and Groote Eylandt).

The Northern quoll is the smallest, most arboreal and aggressive of the four Australian quoll species and is a nocturnal, carnivorous marsupial with a moderately large home range. The species reproduces once per year and has on average seven offspring per year. However, both male and female northern quolls have short life spans; the male often dies following the breeding season, due to the intense physical effort from roving, while the female usually survives only one breeding season. This unique life history can exacerbate the effects of population decline and habitat loss, and make population recovery very slow.

Habitat for the Northern quoll comprises some form of rocky area or structurally diverse woodland or forest for shelter purposes, with surrounding vegetated habitats used for foraging and dispersal. Sandstone escarpment is considered prime habitat. Shelter habitat is important for breeding, refuge from fire and/or predation, and long-term viability of the species.

Threats to the northern quoll include predation by feral cats and the cane toad invasion.

Potential habitat on RPA, survey findings

Since the Northern quoll populations declined, the most protected areas, including rocky areas and offshore islands, are considered critical to the survival of the species. Rocky outcrops do not occur within the Magela LAA.

Quolls were recorded on the RPA in three surveys between 1994 and 1998, but have not been recorded since, and are, therefore, likely to be locally extinct. Neither quolls, nor signs of quoll activity (e.g. scats) were recorded during the September 2013 survey.

Assessment of potential impact

The likelihood of impact on the Northern quoll by the Project for each significant impact criterion is described in **Table 9-17**. The Northern quoll appear to be locally extinct within the survey area, and across mainland NT. Northern quolls utilise rocky outcrops for habitat, which do not occur within, or near, the extent of maximum infrastructure for the Project. It is considered unlikely that there will be significant impacts on Northern quolls from the clearing of native vegetation associated with the Project.

Table 9-17: Likelihood of potential impacts on the Northern quoll

Significant impact criteria	Likelihood	Assessment
Lead to a long-term decrease in the size of a population of northern quolls	Unlikely	Quolls have not been recorded in the RPA since 1998 and have undergone major population declines across the NT in the presence of Cane Toads. Clearance of < 1 ha of heavily impacted land within Magela LAA will not lead to further population decreases.
Reduce the area of occupancy of the northern quoll	Unlikely	Quolls have not been recorded in the RPA since 1998; clearing of < 1 ha of heavily impacted land will not affect the area of occupancy of the species.
Fragment an existing population of northern quolls into two or more populations	Unlikely	The proposed Project infrastructure will be directly adjacent to the existing mine site and abuts the main access road to the site. It will therefore not fragment any habitat.
Adversely affect habitat critical to the survival of northern quolls	Unlikely	Habitat critical to the survival of northern quoll generally occurs in rocky areas and on offshore islands (Hill & Ward 2010). These habitats do not occur within the proposed vent corridor, or in the surrounds.
Disrupt the breeding cycle of a population of northern quolls	Unlikely	No suitable habitat occurs within the area to be cleared.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the northern quoll is likely to decline	Unlikely	The removal of < 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to negatively impact any habitat important for northern quolls. The species is unlikely to occur in the area.

Significant impact criteria	Likelihood	Assessment
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in northern quoll habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact northern quoll habitat will be introduced.
Introduce disease that may cause the northern quolls to decline	Unlikely	The proposed action is unlikely to introduce a disease that would impact northern quolls.
Interfere with the recovery of the northern quoll	Unlikely	The recovery plan for the northern quoll (Hill & Ward 2010) focuses on mitigating the threat posed by Cane Toads. The proposed project is unlikely to impact the spread or density of cane toads already present in the RPA.

Fawn antechinus (Antechinus bellus)

Regional distribution and ecology

The fawn antechinus is the only species of Antechinus found in the savanna woodland and tall open forest of the Top End of the NT (Watson & Calaby 2008). The species is restricted to the NT, largely to the mainland but there is one record of the species from the Tiwi Islands. The species has been declining in the NT over the past decade due to ongoing inappropriate fire regimes affecting habitat suitability, and predation by feral cats (Woinarski*, et al.* 2010).

Potential habitat on RPA, survey findings

The fawn antechinus has been recorded during several previous surveys on the RPA (refer **Figure 2-21, Chapter 2** for locations). Three individuals were recorded during the 2013 Eco Logical survey – two from remote cameras in the Magela Creek riparian area, and one from a trap in the Magela LAA (**Section 9.2.2**).

Assessment of potential impact

The Fawn Antechinus is not listed as threatened under EPBC legislation, and as such the significant impact guidelines for MNES do not strictly apply. The guidelines are however, a useful way to address the potential impact of the project on the species and are presented in **Table 9-18**.

Although it is considered likely that the area of occupancy of the species will be reduced by a small amount, the loss of < 1 ha of vegetation is not likely to have a significant impact on the size of the local populations. Fawn Antechinus were recorded at three locations in woodland within the survey site, suggesting that the maximum extent of infrastructure for the Project is not particularly significant habitat for the species, and that there is a population in the surrounding area that is unlikely to be impacted by the Project

While two of the significant impact criteria are technically considered likely or possible (reduction of the area of occupancy, and disruption of the breeding cycle), it is considered unlikely that there will be significant impacts on Fawn antechinus from the clearing of native vegetation associated with the Project.

Table 9-18: Likelihood of potential impacts on the fawn antechinus

Significant impact criteria	Likelihood	Assessment
Lead to a long-term decrease in the size of a population of fawn antechinus	Unlikely	The area to be cleared is a small proportion of suitable habitat within the RPA. If the population is locally reduced by clearing, the long term effects should be mitigated by immigration from the surrounding woodland.
Reduce the area of occupancy of the fawn antechinus	Likely	The area of occupancy of the fawn antechinus will likely be reduced by < 1 ha. This does not represent a significant proportion of suitable habitat in the local area.
Fragment an existing population of fawn antechinus into two or more populations	Unlikely	The proposed Project infrastructure will be directly adjacent to the existing mine site and abuts the main access road to the site. It will therefore not fragment any fauna population or habitat.
Adversely affect habitat critical to the survival of fawn antechinus	Unlikely	Although the habitat to be cleared may be used by fawn antechinus, it is not highly suitable unburnt woodland, and is surrounded by other suitable habitat.
Disrupt the breeding cycle of a population of fawn antechinus	Possible	The species breeds from June to late August, if clearing takes place during this time period, disruption of the breeding cycle may take place on a very local scale within cleared areas.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the fawn antechinus is likely to decline	Unlikely	The area to be cleared represents a small proportion of the habitat locally available.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the fawn antechinus habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact fawn antechinus habitat will be introduced.
Introduce disease that may cause the fawn antechinus to decline	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any disease that could impact fawn antechinus habitat will be introduced.
Interfere with the recovery of the fawn antechinus	Unlikely	Any impact on the fawn antechinus is likely to be limited to short term local impacts with no flow on effects.

Plains death adder (Acanthophis hawkei)

Regional distribution and ecology

The distribution of the plains death adder is poorly understood; however, the species is restricted to cracking black soil riverine plains in the north of Australia, from western Queensland to the northeast of Western Australia. Populations are fragmented, and the species can be locally common.

Radio tracking suggests that individuals are nomadic, with no fixed home range, and that the adder travels further distances during the wet season. The species is an ambush predator, and native frogs make up a large proportion of the diet of smaller individuals, making them susceptible to cane toads.

Threats to the plains death adder include cane toads and possibly habitat modification from overgrazing and altered fire regimes.

Potential habitat on RPA, survey findings

No suitable habitat occurs within the RPA and for this reason the September 2013 survey did not include specific searches for the species.

Assessment of potential impact

The likelihood of impact on the plains death adder by the Project for each significant impact criterion is described in **Table 9-19**. It is considered unlikely that there will be significant impacts on Plains Death Adders from the clearing of native vegetation associated with the Project.

Table 9-19: Likelihood of potential impacts on the plains death adder

Significant impact criteria	Likelihood	Assessment
Lead to a long-term decrease in the size of an important population of plains death adder	Unlikely	The above ground impact of the proposed development will be limited to a small amount of clearing within a highly disturbed area and is unlikely to lead to any long term impact on plains death adders.
Reduce the area of occupancy of an important population of plains death adder	Unlikely	No suitable habitat occurs with the RPA.
Fragment an existing important population of plains death adder into two or more populations	Unlikely	The proposed Project infrastructure will be directly adjacent to the existing mine site and abuts the main access road to the site. It will therefore not fragment any habitat.
Adversely affect habitat critical to the survival of plains death adder	Unlikely	No suitable habitat occurs within the RPA.
Disrupt the breeding cycle of an important population of plains death adder	Unlikely	No suitable habitat occurs within the RPA. Plains death adders have not been reported in the region.

Significant impact criteria	Likelihood	Assessment
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the plains death adder is likely to decline	Unlikely	No suitable habitat occurs within the RPA.
Result in invasive species that are harmful to a vulnerable species becoming established in the plains death adder habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact plains death adders habitat will be introduced.
Introduce disease that may cause the plains death adder to decline	Unlikely	The proposed action is unlikely to introduce a disease that would impact plains death adders.

Largetooth sawfish (Pristis pristis)

Regional distribution and ecology

The largetooth sawfish has a possible distribution across all major rivers in northern Australia, from the Fitzroy River in Western Australia, to west Cape York Peninsula in Queensland (Department of the Environment 2014). The species can be found on sandy or muddy bottoms of shallow coastal waters, estuaries, river mouths and freshwater rivers and lakes; generally juveniles are found in fresh water and adults in coastal waters and estuaries (Stevens*, et al.* 2005).

Potential habitat on RPA, survey findings

Previous surveys have not found the largetooth sawfish on the RPA. Habitat and species do not occur on the RPA.

Assessment of potential impact

The biggest threat to sawfish is getting tangled in commercial fishing nets, due to their rostra (saw), and there is anecdotal evidence of sawfish being caught as by-catch by recreational fishermen (Stevens*, et al.* 2008).

The likelihood of impact on the largetooth sawfish by the Project for each significant impact criterion is described in **Table 9-20**. It is considered unlikely that there will be significant impacts on the largetooth sawfish arising from the Project.

Table 9-20: Likelihood of potential impacts on the largetooth sawfish

Significant impact criteria	Likelihood	Assessment
Leads to a long-term decrease in the size of an important population of largetooth sawfish	Unlikely	Infrastructure for the Project will be restricted to the heavily disturbed areas of the RPA, and is unlikely to lead to long-term impacts on largetooth sawfish populations.
Reduce the area of occupancy of an important population of largetooth sawfish	Unlikely	The largetooth sawfish has not been recorded within the RPA. The removal of < 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to reduce the area of habitat available to largetooth sawfish.
Fragment an existing important population of largetooth sawfish into two or more populations	Unlikely	The proposed Project infrastructure is directly adjacent to the existing mine site and abuts the main access road to the site. It will therefore not fragment any habitat.
Adversely affect habitat critical to the survival of the largetooth sawfish	Unlikely	Critical habitat for the largetooth sawfish comprises muddy freshwater and estuarine river channels. The clearing of a small area of heavily impacted habitat directly adjacent to the mine will not affect critical habitat in the region. Groundwater modelling shows that constituents of potential concern from the Project will have no impact on the downstream aquatic environment, which includes Magela creek and wetlands (**Appendix 11**). The Project is not expected to adversely impact downstream water quality or hydrology due primarily to the effectiveness of ERA's current water management system. The traffic impact assessment (**Appendix 16**) assessed risks to threatened and migratory species as identified under the EPBC Act and the Territory Parks and Wildlife Conservation Act. The assessment identified locations along the transport study corridor that are of greater environmental sensitivity to a spillage of consumables/product or associated with greater than average crash rates. There were no expected combinations of consequence and likelihood resulting in critical (Class IV) risks to listed threatened and migratory species or environmental values. The likelihood of an event associated with threatened and migratory species or environmental values was assessed as rare in the majority of scenarios examined. Habitat for the largetooth sawfish occurred in the study area, but no records of the species were present.
Disrupt the breeding cycle of an important population of largetooth sawfish	Unlikely	The small area to be cleared for the Project will not reduce the available suitable habitat, and is unlikely to impact prey availability for the species during the breeding season.

Significant impact criteria	Likelihood	Assessment
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the largetooth sawfish is likely to decline	Unlikely	Critical habitat for largetooth sawfish comprises muddy freshwater and estuarine river channels. The clearing of a small area of heavily impacted woodland habitat directly adjacent to the mine will not affect the availability of quality of suitable habitat in the region. Groundwater modelling shows that constituents of potential concern from the Project will have no impact on the downstream aquatic environment, which includes Magela Creek and wetlands (**Appendix 11**). The Project is not expected to adversely impact downstream water quality or hydrology due primarily to the effectiveness of ERA's current water management system. The traffic impact assessment (**Appendix 16**) assessed risks to threatened and migratory species as identified under the EPBC Act and the Territory Parks and Wildlife Conservation Act. The assessment identified locations along the transport study corridor that are of greater environmental sensitivity to a spillage of consumables/product or associated with greater than average crash rates. There were no expected combinations of consequence and likelihood resulting in critical (Class IV) risks to listed threatened and migratory species or environmental values. The likelihood of an event associated with threatened and migratory species or environmental values was assessed as rare in the majority of scenarios examined. Habitat for the largetooth sawfish occurred in the study area, but no records of the species were present.
Result in invasive species that are harmful to the largetooth sawfish becoming established in the vulnerable species' habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact largetooth sawfish habitat will be introduced
Introduce disease that may cause the largetooth sawfish to decline	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact largetooth sawfish habitat will be introduced

Dwarf sawfish (Pristis clavata)

Regional distribution and ecology

Usually inhabits shallow (2 – 3 m) coastal waters and estuarine habitats; does not utilise any purely freshwater areas; restricted to brackish and salt water.

Potential habitat on RPA, survey findings

Previous surveys have not found the dwarf sawfish on the RPA. Habitat and species do not occur on the RPA.

Assessment of potential impact

The biggest threat to sawfish is getting tangled in commercial fishing nets, due to their rostra (saw), and there is anecdotal evidence of sawfish being caught as by-catch by recreational fishermen (Stevens*, et al.* 2008).

The likelihood of impact on the dwarf sawfish by the Project for each significant impact criterion is described in **Table 9-21**. It is considered unlikely that there will be significant impacts on the dwarf sawfish arising from the Project.

Table 9-21: Likelihood of potential impacts on the dwarf sawfish

Significant impact criteria	Likelihood	Assessment
Leads to a long-term decrease in the size of an important population of the dwarf sawfish	Unlikely	Infrastructure for the Project will be restricted to the heavily disturbed areas of the RPA, and is unlikely to lead to long-term impacts on dwarf sawfish populations.
Reduce the area of occupancy of an important population of the dwarf sawfish	Unlikely	The dwarf sawfish has not been recorded within the RPA. The removal of < 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to reduce the area of habitat available to dwarf sawfish, which is a least 40 km downstream of the RPA.
Fragment an existing important population of the dwarf sawfish into two or more populations	Unlikely	The proposed Project infrastructure is directly adjacent to the existing mine site and abuts the main access road to the site. It will therefore not fragment any habitat.

Significant impact criteria	Likelihood	Assessment
Adversely affect habitat critical to the survival of the dwarf sawfish	Unlikely	Critical habitat for the dwarf sawfish comprises shallow coastal waters and estuarine habitats, which are located at least 40 km downstream of the RPA. The clearing of a small area of heavily impacted habitat directly adjacent to the mine will not affect critical habitat in the region. Groundwater modelling shows that constituents of potential concern from the Project will have no impact on the downstream aquatic environment, which includes Magela creek and wetlands (**Appendix 11**). The Project is not expected to adversely impact downstream water quality or hydrology due primarily to the effectiveness of ERA's current water management system. The traffic impact assessment (**Appendix 16**) assessed risks to threatened and migratory species as identified under the EPBC Act and the Territory Parks and Wildlife Conservation Act. The assessment identified locations along the transport study corridor that are of greater environmental sensitivity to a spillage of consumables/product or associated with greater than average crash rates. There were no expected combinations of consequence and likelihood resulting in critical (Class IV) risks to listed threatened and migratory species or environmental values. The likelihood of an event associated with threatened and migratory species or environmental values was assessed as rare in the majority of scenarios examined. Habitat for the dwarf sawfish occurred in the study area, but no records of the species were present.
Disrupt the breeding cycle of an important population of the dwarf sawfish	Unlikely	The small area to be cleared for the Project will not reduce the available suitable habitat, and is unlikely to impact prey availability for the species during the breeding season.

Significant impact criteria	Likelihood	Assessment
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the dwarf sawfish is likely to decline	Unlikely	Critical habitat for dwarf sawfish comprises shallow coastal waters and estuarine areas. The clearing of a small area of heavily impacted woodland habitat directly adjacent to the mine will not affect the availability of quality of suitable habitat in the region. Groundwater modelling shows that constituents of potential concern from the Project will have no impact on the downstream aquatic environment, which includes Magela creek and wetlands (**Appendix 11**). The Project is not expected to adversely impact downstream water quality or hydrology due primarily to the effectiveness of ERA's current water management system. The traffic impact assessment (**Appendix 16**) assessed risks to threatened and migratory species as identified under the EPBC Act and the Territory Parks and Wildlife Conservation Act. The assessment identified locations along the transport study corridor that are of greater environmental sensitivity to a spillage of consumables/product or associated with greater than average crash rates. There were no expected combinations of consequence and likelihood resulting in critical (Class IV) risks to listed threatened and migratory species or environmental values. The likelihood of an event associated with threatened and migratory species or environmental values was assessed as rare in the majority of scenarios examined. Habitat for the dwarf sawfish occurred in the study area, but no records of the species were present.
Result in invasive species that are harmful to the dwarf sawfish becoming established in the vulnerable species' habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact dwarf sawfish habitat will be introduced
Introduce disease that may cause the dwarf sawfish to decline	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact dwarf sawfish habitat will be introduced

Northern river shark (Glyphis garricki)

Regional distribution and ecology

The species prefers estuarine habitat. It is known from few records, including in the Northern Territory from the Adelaide and East and South Alligator River systems.

Potential habitat on RPA, survey findings

Previous surveys have not found the northern river shark on the RPA. Habitat and species do not occur on the RPA.

Assessment of potential impact

The likelihood of impact on the northern river shark by the Project for each significant impact criterion is described in **Table 9-22**. It is considered unlikely that there will be significant impacts on the northern river shark arising from the Project.

Table 9-22: Likelihood of potential impacts on the northern river shark

Significant impact criteria	Likelihood	Assessment
Leads to a long-term decrease in the size of an important population of the northern river shark	Unlikely	Infrastructure for the Project will be restricted to the heavily disturbed areas of the RPA, and is unlikely to lead to long-term impacts northern river shark populations.
Reduce the area of occupancy of an important population of the northern river shark	Unlikely	The northern river shark has not been recorded within the RPA. The removal of < 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to reduce the area of habitat available to northern river shark, which is at least 40 km downstream of the RPA.
Fragment an existing important population of the northern river shark into two or more populations	Unlikely	The proposed Project infrastructure is directly adjacent to the existing mine site and abuts the main access road to the site. It will therefore not fragment any habitat.
Adversely affect habitat critical to the survival of the northern river shark	Unlikely	Critical habitat for the northern river shark comprises estuarine river channels. The clearing of a small area of heavily impacted habitat directly adjacent to the mine will not affect critical habitat in the region. Groundwater modelling shows that constituents of potential concern from the Project will have no impact on the downstream aquatic environment, which includes Magela creek and wetlands (**Appendix 11**). The Project is not expected to adversely impact downstream water quality or hydrology due primarily to the effectiveness of ERA's current water management system. The traffic impact assessment (**Appendix 16**) assessed risks to threatened and migratory species as identified under the EPBC Act and the Territory Parks and Wildlife Conservation Act. The assessment identified locations along the transport study corridor that are of greater environmental sensitivity to a spillage of consumables/product or associated with greater than average crash rates. There were no expected combinations of consequence and likelihood resulting in critical (Class IV) risks to listed threatened and migratory species or environmental values. The likelihood of an event associated with threatened and migratory species or environmental values was assessed as rare in the majority of scenarios examined. Habitat for the northern river shark occurred in the study area, but no records of the species were present.

Significant impact criteria	Likelihood	Assessment
Disrupt the breeding cycle of an important population of the northern river shark	Unlikely	The small area to be cleared for the Project will not reduce the available suitable habitat, and is unlikely to impact prey availability for the species during the breeding season.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the northern river shark is likely to decline	Unlikely	Critical habitat for the northern river shark comprises estuarine river channels. The clearing of a small area of heavily impacted woodland habitat directly adjacent to the mine will not affect the availability of quality of suitable habitat in the region. Groundwater modelling shows that constituents of potential concern from the Project will have no impact on the downstream aquatic environment, which includes Magela creek and wetlands (**Appendix 11**). The Project is not expected to adversely impact downstream water quality or hydrology due primarily to the effectiveness of ERA's current water management system. The traffic impact assessment (**Appendix 16**) assessed risks to threatened and migratory species as identified under the EPBC Act and the Territory Parks and Wildlife Conservation Act. The assessment identified locations along the transport study corridor that are of greater environmental sensitivity to a spillage of consumables/product or associated with greater than average crash rates. There were no expected combinations of consequence and likelihood resulting in critical (Class IV) risks to listed threatened and migratory species or environmental values. The likelihood of an event associated with threatened and migratory species or environmental values was assessed as rare in the majority of scenarios examined. Habitat for the northern river shark occurred in the study area, but no records of the species were present.
Result in invasive species that are harmful to the northern river shark becoming established in the vulnerable species' habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact northern river shark habitat will be introduced
Introduce disease that may cause the northern river shark to decline	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact northern river shark habitat will be introduced

Speartooth shark *(Glyphis glyphis)*

Regional distribution and ecology

The species prefers estuarine habitat. It has only been recorded in rivers and estuaries within Queensland and the Northern Territory, including Adelaide River, South, East and West Alligator Rivers, Murganella Creek and Marrakai Creek (Stevens*, et al.* 2005).

Potential habitat on RPA, survey findings

Previous surveys have not found the speartooth shark on the RPA. Habitat and species do not occur on the RPA.

Assessment of potential impact

The likelihood of impact on the speartooth shark by the Project for each significant impact criterion is described in **Table 9-23**. It is considered unlikely that there will be significant impacts on the speartooth shark arising from the Project.

Table 9-23: Likelihood of potential impacts on the freshwater sawfish

Significant impact criteria	Likelihood	Assessment
Leads to a long-term decrease in the size of an important population of the speartooth shark	Unlikely	Infrastructure for the Project will be restricted to the heavily disturbed areas of the RPA, and is unlikely to lead to long-term impacts on speartooth shark populations.
Reduce the area of occupancy of an important population of the speartooth shark	Unlikely	The speartooth shark has not been recorded within the RPA. The removal of < 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to reduce the area of habitat available to speartooth shark, which is at least 40 km downstream of the RPA.
Fragment an existing important population of the speartooth shark into two or more populations	Unlikely	The proposed Project infrastructure is directly adjacent to the existing mine site and abuts the main access road to the site. It will therefore not fragment any habitat.
Adversely affect habitat critical to the survival of the speartooth shark	Unlikely	Critical habitat for the speartooth shark comprises estuarine areas. The clearing of a small area of heavily impacted habitat directly adjacent to the mine will not affect critical habitat in the region. Groundwater modelling shows that constituents of potential concern from the Project will have no impact on the downstream aquatic environment, which includes Magela creek and wetlands (**Appendix 11**). The Project is not expected to adversely impact downstream water quality or hydrology due primarily to the effectiveness of ERA's current water management system.

Significant impact criteria	Likelihood	Assessment
		The traffic impact assessment (**Appendix 16**) assessed risks to threatened and migratory species as identified under the EPBC Act and the Territory Parks and Wildlife Conservation Act. The assessment identified locations along the transport study corridor that are of greater environmental sensitivity to a spillage of consumables/product or associated with greater than average crash rates. There were no expected combinations of consequence and likelihood resulting in critical (Class IV) risks to listed threatened and migratory species or environmental values. The likelihood of an event associated with threatened and migratory species or environmental values was assessed as rare in the majority of scenarios examined. Habitat for the speartooth shark occurred in the study area, but no records of the species were present.
Disrupt the breeding cycle of an important population of the speartooth shark	Unlikely	The small area to be cleared for the Project will not reduce the available suitable habitat, and is unlikely to impact prey availability for the species during the breeding season
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the speartooth shark is likely to decline	Unlikely	Critical habitat for the speartooth shark comprises muddy freshwater and estuarine river channels. The clearing of a small area of heavily impacted woodland habitat directly adjacent to the mine will not affect the availability of quality of suitable habitat in the region. Groundwater modelling shows that constituents of potential concern from the Project will have no impact on the downstream aquatic environment, which includes Magela creek and wetlands (**Appendix 11**). The Project is not expected to adversely impact downstream water quality or hydrology due primarily to the effectiveness of ERA's current water management system. The traffic impact assessment (**Appendix 16**) assessed risks to threatened and migratory species as identified under the EPBC Act and the Territory Parks and Wildlife Conservation Act. The assessment identified locations along the transport study corridor that are of greater environmental sensitivity to a spillage of consumables/product or associated with greater than average crash rates. There were no expected combinations of consequence and likelihood resulting in critical (Class IV) risks to listed threatened and migratory species or environmental values. The likelihood of an event associated with threatened and migratory species or environmental values was assessed as rare in the majority of scenarios examined. Habitat for the speartooth shark occurred in the study area, but no records of the species were present

Significant impact criteria	Likelihood	Assessment
Result in invasive species that are harmful to the speartooth shark becoming established in the vulnerable species' habitat	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact speartooth shark habitat will be introduced
Introduce disease that may cause the speartooth shark to decline	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact speartooth shark habitat will be introduced

9.2.3.2 Migratory Species

A description of the studies and surveys that have been undertaken in the RPA are described in **Section 9.2**. No survey methods specific to the requirements of migratory species were employed.

An assessment was conducted (based on the likelihood assessment) of the migratory species identified that may be impacted by the Project. The following sections address 15 migratory bird and one migratory reptile species that are known or considered likely to occur on the RPA, or require assessment under the EIS guidelines.

Cattle egret (Ardea ibis)

Regional distribution and ecology

The cattle egret occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands around the world. Two major distributions have been located within Australia:

- Northeast Western Australia to the Top End.
- Southeast Australia.

In Western Australia and the NT, the species is located from Wyndham to Arnhem Land, where it breeds in colonies. The species feeds on insects and small reptiles, amphibians and mammals.

Major threats facing the cattle egret include persecution of large colonies in urban areas, loss of breeding habitats through wetland degradation and destruction, hunting, and in Australia, exotic species, especially feral cats.

Potential habitat on RPA, survey findings

The RPA is not key habitat for the cattle egret. However, a cattle egret was observed at Georgetown Billabong on one day during the September 2013 survey. No breeding sites have been identified on the RPA.

Common sandpiper (Actitis hypoleucos)

Regional distribution and ecology

The common sandpiper is broadly distributed internationally and occurs throughout Darwin and Kakadu National Park as well as in Western Australian and Queensland; it is widespread in small numbers. The bird is found along the coastline as well as many inland areas. More specifically, it is found within a wide range of coastal, and some inland, wetlands, with varying levels of salinity, and is mostly found around muddy margins or rocky shores, but rarely on mudflats. The common sandpiper has been recorded in estuaries and stream deltas, as well as on banks farther upstream; around lakes, pools, billabongs, reservoirs, dams and claypans. The muddy margins utilised by the species are often narrow, and may be steep. The species is often associated with mangroves, and sometimes found in areas of mud littered with rocks or snags. The common sandpiper breeds in Eurasia and moves south for the Arctic winter, with the eastern breeding populations wintering in south Asia to Melanesia and Australia.

In Australia, major threats facing the common sandpiper include habitat loss, reduction of quality and quantity of water, global warming and disturbances from human activities, e.g. fishing and aquaculture.

Potential habitat on RPA, survey findings

The RPA is not key habitat for the common sandpiper. No breeding sites have been identified on the RPA and the species was not observed during the September 2013 survey.

Derby white-browed robin (Poecilodryas superciliosa cerviniventris)

Regional distribution and ecology

The Derby white-browed robin has a broad distribution across the northern NT and is found in woodlands, forests and wetlands. Known and perceived threats to the species include agriculture, aquaculture, habitat alteration due to trampling and grazing by livestock, and predation, competition, habitat degradation and/or spread of pathogens by introduced species.

Potential habitat on RPA, survey findings

The RPA is not key habitat for the Derby white-browed robin. No breeding sites have been identified within the survey area and the species was not observed during the September 2013 survey.

Eastern Great Egret (Ardea modesta)

Regional distribution and ecology

The eastern great egret is widespread in Australia, occurring in all states and territories, where the largest breeding colonies, and greatest concentrations of breeding colonies, are located in near-coastal regions of the Top End. This species roosts in large flocks that may consist of hundreds of birds. The Eastern grey egret has been reported in a wide range of wetland habitats, e.g., inland and coastal, freshwater and saline. In Australia, breeding sites are located in wooded and shrubby swamps including mangrove forests (the main habitat of the species in the Top End). The egret has a diverse diet that includes fish, insects, reptiles, small birds and mammals.

In Australia, major threats facing the eastern great egret include loss and/or degradation of foraging, and especially breeding, habitat through alteration of water flows, drainage and/or clearing of wetlands for development, frequent burning of wetland vegetation used as nest sites, salinisation and invasion by exotic plants.

Potential habitat on RPA, survey findings

The RPA is not key habitat for the eastern great egret. However, Eastern great egrets were observed at Georgetown Billabong on four days during the September 2013 survey and at RP1 on one day.

Grey plover (Pluvialis squatarola)

Regional distribution and ecology

The grey plover is a migratory wading species, breeding in tundra at the northern hemisphere and flying south for the boreal winter. In non-breeding grounds in Australia, grey plovers occur almost entirely in coastal areas, where forage on large areas of exposed mudflats and beaches of sheltered coastal shores such as inlets, estuaries and lagoons. The species is also very occasionally recorded further inland, where they occur around wetlands or salt-lakes

In Australia, threats to the grey plover (includes all migratory waders) includes pollution, habitat reduction, disturbance from tourism, recreation, aquaculture, spread of weeds such as *Spartinia* on intertidal mudflats.

Potential habitat on RPA, survey findings

The RPA is not key habitat for the grey plover and the species was not observed during the September 2013 survey.

Marsh sandpiper (Tringa stagnatilis)

Regional distribution and ecology

The marsh sandpiper is found on coastal and inland wetlands throughout Australia. The species is widespread in coastal Queensland, but few records exist north of Cooktown. There are scattered records of the bird in Western Australia and the NT.

The species lives in permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, pools on inundated floodplains, and intertidal mudflats. In north Australia, they prefer intertidal mudflats, although surveys in Kakadu National Park recorded more birds around shallow freshwater lakes than in areas influenced by the tide. In the Top End, they often use ephemeral pools on inundated freshwater and tidal floodplains and are found infrequently around mangroves. They occur singly or in small to large flocks, are often associated with other waders and are often seen with greenshanks, especially in salt fields. The species breeds in areas from eastern European to eastern Siberia.

In Australia, threats to the marsh sandpiper include habitat loss and degradation, disturbance and direct mortality (e.g., as a result of human activities such as wind farm construction).

Potential habitat on RPA, survey findings

The RPA is not key habitat for the marsh sandpiper and the species was not observed during the September 2013 survey.

Melville cicadabird (Coracina tenuirostris melvillensis)

Regional distribution and ecology

The Melville cicadabird occurs in northern Australia from Broome in WA to the far eastern Top End. The bird uses foliage in the canopy of diverse forests and woodlands, including mangroves and paperbark swamps. Melville cicadabirds feed on insects and breed from September to June (peaking during November to February), building high nests below the canopy.

Known and perceived threats to the species include agriculture, aquaculture, land clearing, habitat fragmentation and habitat degradation.

Potential habitat on RPA, survey findings

The RPA is not key habitat for the Melville cicadabird and the species was not observed during the September 2013 survey.

Oriental plover (Charadrius veredus)

Regional distribution and ecology

The oriental plover is widely distributed across Australia during the northern hemisphere's winter as a non-breeding visitor to Australia during this time. The entire world population breeds in a restricted area centred on Mongolia and adjacent areas of south-eastern Siberia and north-eastern China.

In Australia, the species occurs in both coastal and inland areas, mostly in northern Australia. Most records are along the north-western coast, between Exmouth Gulf and Derby in Western Australia, and there are records at a few scattered sites elsewhere, mainly along the northern coast, such as in the Top End, the Gulf of Carpentaria and on Cape York Peninsula. Lake Sylvester, a system of ephemeral lakes about 180 km north east of Tennant Creek, is one of six internationally important sites for the oriental plover within the NT. None of these sites is in a conservation reserve, and two are within commercial salt works.

Although there are no threats that apply specifically to oriental plovers, there are a number of threats that affect all migratory waders. In Australia, the species occurs in sparsely-settled areas, and there are no immediate threats to its survival. Little is known about the inland ephemeral wetlands that occur over vast areas of northern Australia, nor about the effects of grazing on this species' grassland habitat.

Potential habitat on RPA, survey findings

The RPA is not key habitat for the oriental plover and the species was not observed during the September 2013 survey.

Oriental pratincole (Glareola maldivarum)

Regional distribution and ecology

The oriental pratincole is widespread throughout Australia and in the northern areas, especially along the coasts of the Pilbara and Kimberley regions in Western Australia, the Top End of the NT, and parts of the Gulf of Carpentaria. It is also widespread but scattered inland, mostly north of 20°S. The species has also been recorded on various outlying islands, including Lord Howe Island, and Christmas Island and Cocos-Keeling Islands in the Indian Ocean. Within the NT, nationally important sites include Lake De Burgh, Lake Woods and Lake Sylvester.

Most birds are thought to spend the non-breeding season in Australia, arriving between late October and early November, and departing mid-March to early April.

There are no immediate threats to the species as it mostly occurs within sparsely-settled areas.

Potential habitat on RPA, survey findings

The RPA is not key habitat for the oriental pratincole and the species was not observed during the September 2013 survey.

Rainbow bee-eater (Merops ornatus)

Regional distribution and ecology

The rainbow bee-eater is distributed across much of mainland Australia, and occurs on several near-shore islands. The population size has not been determined but is assumed to be reasonably large based on reporting rates for the species.

The rainbow bee-eater occurs mainly in open forests and woodlands, shrublands, various cleared or mangroves. Nests are constructed in an enlarged chamber at the end of long burrow or tunnel that is excavated, by both sexes, in flat or sloping ground, in the banks of rivers, creeks or dams, in roadside cuttings, in the walls of gravel pits or quarries, in mounds of gravel, or in cliff-faces. The rainbow bee-eater mainly feeds on insects.

The only identified threat to the rainbow bee-eater is the cane toad, which reduces the breeding success and productivity of the species by feeding on eggs and especially nestlings, and usurping and occupying nesting burrows.

Potential habitat on RPA, survey findings

Vegetation within and surrounding the RPA provides habitat for the rainbow bee-eater. The species was observed at Georgetown Billabong, in five transects and in the Magela Creek bed throughout the September 2013 survey period; however, no breeding sites were identified.

Rufous fantail (Rhipidura rufifrons)

Regional distribution and ecology

The rufous fantail occurs in coastal and near coastal districts of northern and eastern Australia and has breeding populations occurring from about the South Australia-Victoria border, through to the Cairns-Atherton region of Queensland. The rufous fantail is considered a common and secure species that is usually seen singly or in pairs, but occasionally in small groups. In north and north-eastern Australia, the birds often occur in tropical and monsoon rainforests.

The species breeds from approximately September to February and are insectivorous, foraging mainly in the low to middle strata of forests.

The main threats to rufous fantail populations are habitat fragmentation and loss of core moist forest breeding habitat through land clearing and urbanisation, particularly in forest remnants and corridors along the species' migration routes.

Potential habitat on RPA, survey findings

The RPA is not key habitat for the rufous fantail and the species was not observed during the September 2013 survey.

Terek sandpiper (Xenus cinereus)

Regional distribution and ecology

The Terek sandpiper has a primarily coastal distribution, with occasional records inland. It is more widespread and common in northern and eastern Australia than southern Australia. In the NT, widespread records occur from Darwin, north to Melville Island, and east to the western section of the Gulf of Carpentaria, around Gove Peninsula, Groote Eylandt, Sir Edward Pellew Islands and the mouth of the McArthur River. Sites of international significance in the NT include Chambers Bay, Fog Bay and adjacent islands, and the Milingimbi coast.

The species mostly forages in the open, on soft wet intertidal mudflats or in sheltered estuaries, embayments, harbours or lagoons and has also been recorded on islets, mudbanks, sandbanks and spits, and near mangroves. Terek sandpipers are occasionally sighted around drying sewage ponds and saltpans, if surrounded by mudflats, and less often seen on sandy or shingle beaches, or on rock or coral reefs or platforms. The species is also found around brackish coastal swamps, lagoons and dune-lakes, and also on gravel or rocky edges of estuarine pools and freshwater river pools.

Threats to the species include habitat loss, disturbance and climate change.

Potential habitat on RPA, survey findings

The RPA is not key habitat for the Terek sandpiper and the species was not observed during the September 2013 survey.

Whimbrel (Numenius phaeopus)

Regional distribution and ecology

The whimbrel is a regular migrant to Australia (non-breeding in Australia) and New Zealand, primarily with a coastal distribution, but there are also scattered inland records of the species in all regions. The bird is found in all states but is more common in northern Australia. It has been found around the coasts of the Top End, where it sometimes follows rivers inland and is commonly widespread from Carnarvon to the northeast Kimberley Division, Western Australia. Some of the scattered records elsewhere show the species as a regular visitor to islands off Western Australia, NT, Queensland, New Zealand and France. Chambers Bay in the NT is a site of international significance for the species. The southward migration of the species to Australia is to escape severe winter conditions and the consequent high energy demand that cannot be met by low prey availability.

The species is often found on the intertidal mudflats of sheltered coasts and is found in harbours, lagoons, estuaries and river deltas, often those with mangroves, but also open, unvegetated mudflats. It is occasionally found on sandy or rocky beaches, on coral or rocky islets, or on intertidal reefs and platforms. It has been infrequently recorded using saline or brackish lakes near coastal areas and salt flats with saltmarsh, or saline grasslands with standing water left after high spring tides, and in similar habitats in sewage farms and salt fields.

In Australia, threats to the whimbrel include habitat loss and degradation, disturbance and direct mortality.

Potential habitat on RPA, survey findings

The RPA is not key habitat for the whimbrel and the species was not observed during the September 2013 survey.

White-bellied sea-eagle (Haliaeetus leucogaster)

Regional distribution and ecology

The white-bellied sea-eagle is distributed along the coastline (including offshore islands) of Asia, Oceania and mainland Australia and Tasmania, and also extends inland along some of the larger waterways, especially in eastern Australia. Breeding records are patchily distributed, mainly along the coastline also, especially the eastern coast, extending from Queensland to Victoria, and to Tasmania.

This species is found in coastal habitats and around terrestrial wetlands in tropical and temperate regions of mainland Australia and its offshore islands. Breeding territories are located close to water, and mainly in tall open forest or woodland. The eagle feeds opportunistically on a variety of fish, birds, reptiles, mammals and crustaceans, and on carrion and offal.

The main threats to the species are loss of habitat due to land development, and disturbance of nesting pairs by human activity.

Potential habitat on RPA, survey findings

The RPA provides suitable habitat for the white-bellied sea-eagle. A breeding pair of white-bellied sea-eagles was observed at Georgetown Billabong throughout the September 2013 survey.

Saltwater crocodile (Crocodylus porosus)

Regional distribution and ecology

The saltwater crocodile is a large member of the Crocodylidae family and is found in Australian coastal waters, estuaries, freshwater sections of lakes, inland swamps and marshes. The species' distribution is widespread across northern Australian and ranges from Rockhampton in Queensland throughout coastal NT to King Sound (near Broome) in Western Australia. In the NT, the saltwater crocodile has been found in many rivers including the Mary, Adelaide, Daly and Moyle rivers. Elevated isolated freshwater swamps that are not influenced by the tide are the preferred nesting habitat for the saltwater crocodile.

The species feeds on crustaceans, insects and mammals.

In Australia, threats to the saltwater crocodile include incidental mortality from fishing nets, habitat destruction and, in Arnhem Land, destruction of wetland habitat by feral animals such as pigs and buffalo.

Potential habitat on RPA, survey findings

The RPA provides suitable habitat for the saltwater crocodile. A saltwater crocodile was observed at Georgetown Billabong in October 2013. No breeding sites have been identified on the RPA.

The likelihood of impact on migratory species by the Project for each significant impact criterion is summarised in **Table 9-24**.

Likelihood of impact

Table 9-24: Likelihood of potential impacts on migratory species

Significant impact criteria	Likelihood	Assessment
Substantially modify, destroy or isolate an area of important habitat for migratory species	Unlikely	The removal of disturbed habitat directly adjacent to the mine site is unlikely to negatively impact any habitat important for migratory species
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for migratory species	Unlikely	Current operational pest management systems and procedures will apply to the development. It is unlikely that any pest that could impact migratory species will be introduced.
Seriously disrupt the lifecycle of an ecologically significant proportion of the populations of migratory species	Unlikely	The proposed area of disturbance has not been identified as a key habitat for migratory species

9.3 RADIATION RISKS TO ENVIRONMENT

The risk assessment and management of radionuclides entering or present in the environment has historically been based on human health considerations alone. This approach has been underpinned by the International Commission of Radiological Protection (ICRP) recommendations that state "if man is protected then it can be assumed that the environment is protected" (ICRP 1991).

More recently, there has been increasing awareness of the potential vulnerability of the environment and of the need to be able to demonstrate that it is protected against the effects of industrial pollutants, including radionuclides. The ICRP, in its recent publications (ICRP 2007; 2008), has addressed this issue by recommending that assessments of the risk from radiation to animals and plants be undertaken.

In 2007, the ERICA tool was developed to assist in the assessment of radiological risk to plants and animals (Beresford*, et al.* 2007). The software system is structured on the ERICA Integrated Approach, which is a three tiered system comprising generic screening, detailed screening and site-specific analysis. The tool guides the user through the assessment process, recording information and decisions and allowing the necessary calculations to be performed to estimate risks to selected animals and plants.

In a report by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) (Doering 2010), the ERICA tool was described as a practical framework for assessing risk to non-human species that could potentially be adapted to Australian situations. This included the uranium mining industry as part of the need to integrate best practice standards for assessing environmental impacts.

The ERICA tool has been used to conduct an assessment of radiation risk to both terrestrial and aquatic plants and animals. To quantify the risk, the tool calculates the effective radiation dose rate to a range of representative organisms (plants and animals). This dose rate is then compared to a screening dose-rate of 10 µGy/h [8] to obtain a risk quotient. Risk quotients are presented both for the "expected value" and a "conservative value". The expected value is the ratio of the estimated dose rate to the screening dose rate; the conservative value is three times higher than the expected value and represents the 95th percentile of the dose rate distribution, providing an additional layer of conservatism to the assessment and confidence that the environment will be protected.

Where the ERICA tool shows all risk quotients to be less than one, it can be concluded that there is no increased risk to the environment. Where this is not the case, then a review of effects data specific to that organism should be undertaken to qualify if there is a potential risk. Where the effects data indicate there is a potential risk to that organism, further assessment needs to be undertaken.

The assessment for the terrestrial environment focussed on the highest potential impact area, close to the Project footprint and within the RPA. The aquatic assessment assessed

8 This screening dose rate is also described as the predicted no-effect dose rate. It has been derived from a large radiation effects database and statistically represents the dose rate at which 95% of species will be protected. This screening rate is thus expected to protect the most radiosensitive organisms likely to be present in an environment (Garnier-Laplace*, et al.* 2008).

impact in Magela Creek downstream of Ranger mine at gauging station MG009. The results of both assessments demonstrate the risk to plants and animals in terrestrial and aquatic habitats from the Project are negligible. Full details of the assessment are provided in **Appendix 8 Radiation** with a summary of the results provided herein.

9.3.1 Problem Formulation and Conceptual Models

The first step in any risk assessment is the problem formulation phase, for ecological risk assessments this includes developing conceptual models for transfer of contaminants into the environment. The conceptual models for aquatic and terrestrial pathways that formed the basis for the ERICA assessment are provided in **Figure 9-9** and **Figure 9-10**.

The aquatic pathway for the transfer of radionuclides into the environment is the same as that for current operations; excess water from the underground mining operations will be sent to RP2 and therefore contained within the current water management system, refer **Chapter 8**. As described in **Chapter 8**, excess pond water will be treated; with clean permeate water[9] being irrigated to the land application areas during the dry season and discharged to either RP1 or the Corridor Creek wetland filter during the wet season, ahead of release to the Magela Creek system. During the wet season, surface water runoff from the land application areas discharges into the Magela Creek system. Since the concentration of contaminants in permeate water will remain unchanged with the introduction of Ranger 3 Deeps, it is not possible to distinguish between incremental and existing operational sources. Therefore, a cumulative assessment was undertaken for the aquatic pathway.

The pathway for exposure to the terrestrial environment will be through dust emissions from new Project sources and its deposition onto local soils. Dust deposition from the Project has been predicted through the use of an air quality model; refer **Appendix 6**.

Various organisms present in the environment were also identified as part the conceptual models. This was done by matching the reference organisms in the ERICA tool with organisms known to be in the area surrounding the RPA (Kakadu National Park). Matching is based on the type of species, its habitation, size and shape compared to that of each reference organism.[10] When selecting an example local species for assessment, the following hierarchy was used; endangered or threatened species, species considered to have cultural significance, species known to bioaccumulate radionuclides, or a general example of typical species found in the local area.

Several species in the local area did not match any of the reference organisms and were considered important enough to require the development of a specific “new” organism. One reference organism had no matches to local species; this was the large terrestrial mammal (deer); however, in Australia deer are not (naturally) present and this ecological niche is filled with macropods (kangaroos and wallabies). The assessment was therefore done using data for the agile wallaby (*macropus agilis*), a common species on the RPA.

9 Permeate is a class of mine water that has been treated through one of three existing water treatment plants at Ranger mine.

10 Details of each reference organism are provided in the ERICA tool help file.

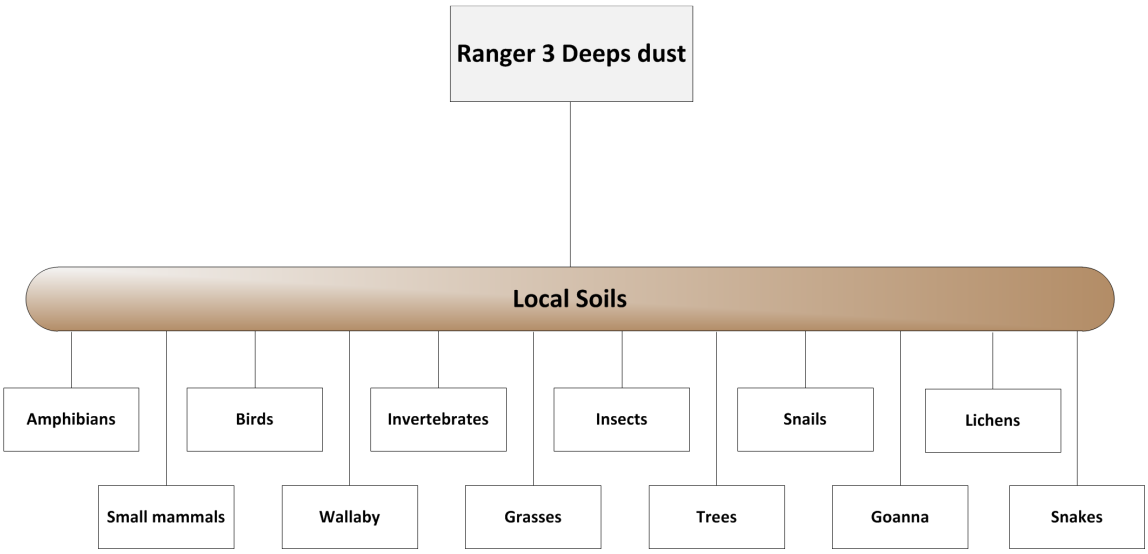

Figure 9-9: Conceptual model for terrestrial assessment

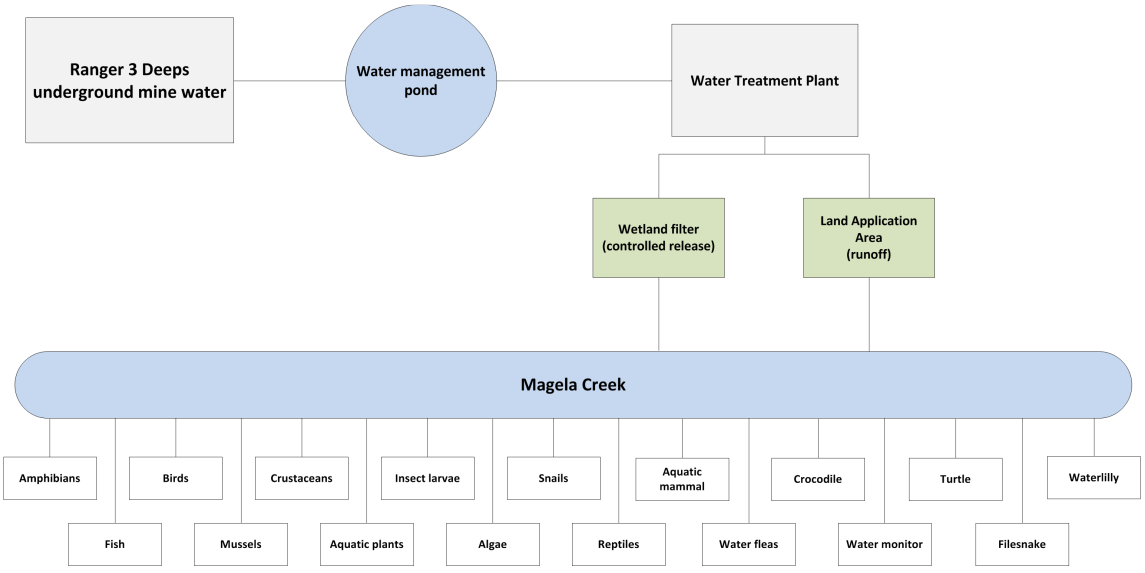

Figure 9-10: Conceptual model for aquatic assessment

9.3.2 Environmental Media Concentrations

The conceptual models were used to estimate the radionuclide concentrations in the soil or water in which the plants and animals live (termed the environmental media concentrations).

For the aquatic assessment, the environmental media concentrations were determined from the historic Magela Creek monitoring data, collected by ERA and the Supervising Scientist, for uranium and radium respectively. This was used to calculate a wet season median difference between upstream and downstream concentrations. The media concentration for this assessment was taken as the worst case (highest) year from the past 11 wet seasons.

In addition to the water concentration, the aquatic assessment requires a media concentration for creek or billabong sediment. This parameter can either be entered or the tool can determine the concentration based on the input water concentration and the use of a water-to-sediment distribution coefficient (K_d). For this assessment a set of site specific K_d values were used (Murray*, et al.* 1992).

For the terrestrial assessment, the increase in soil radionuclide concentrations was estimated from the results of air quality modelling (refer **Appendix 6**). This modelling showed an incremental annual average dust deposition rate over the Project area of 0.2 g/m^2/month. Assuming a five-year Project life and a soil mixing depth of 10 mm, it was estimated that there will be a small Project-related increase of 11 Bq/kg in soils for each radionuclide in the ^{238}U series.

9.3.3 Concentration Ratios

The activity concentrations of radionuclides in biota were predicted in the ERICA tool from media activity concentrations and concentration ratios. Concentration ratios represent the ratio of organism whole body radionuclide activity concentration in fresh weight, compared to the activity concentration of that radionuclide in the media (soil or water) where the organism lives. For a terrestrial assessment, this is the Bq/kg whole organism (fresh weight) per Bq/kg soil (dry weight). For an aquatic assessment, this is the Bq/kg whole organism (fresh weight) per Bq/L in water (filtered).

Where possible, site specific concentration ratios were obtained from the Supervising Scientist (Doering*, et al.* 2012; Ryan*, et al.* 2009). The ERICA tool requires concentration ratios for the whole organism; however, some of the concentration ratios available were for muscle or flesh only. For these cases, the whole organism concentration ratio was obtained by applying whole-body to tissue ratios published by Yankovich *et al* (2010). Where site specific data was not available, the ERICA tool was used to derive appropriate values.[11]

9.3.4 Assessment Results

The results for the aquatic assessment are provided in **Table 9-25**. This shows all organisms to have dose rates below the screening level of 10 µGy/h; however, for one organism (Bivalve mussel, or the local species of freshwater mussel) the conservative risk quotient was greater than 1, indicating a potential risk of radiological effects that requires more detailed review of specific effects data.

Reviewing the specific effects data for mussels in UNSCEAR (1996) shows that cumulative doses of 80 – 88 Gy, at dose rates as high as 9,000 – 10,000 Gy/h, had no effect on juvenile molluscs (scallops and clams). In the same report, it was concluded that for aquatic organisms, dose rates below 400 µGy/h would have not detrimental effects at the population level.

[11] The ERICA tool contains an entire wildlife transfer database which can provide measured concentration ratios for organism-radionuclide combinations or estimate them using one of several accepted methods.

More site specific data for mussels in the Magela Creek system shows that the radium load (and consequently the resulting dose rate) in the population of mussels from Bowerbird Billabong, 20 km upstream of the Ranger mine is substantially greater than that downstream (Bollhöfer*, et al.* 2011). The higher dose rates received by these mussels does not appear to have impacted on their population in this billabong, indicating that the lower dose rates from mine sources to downstream mussels will also not have any effects to the population.

Based on this, it has been concluded that the estimated dose rates of <5 µGy/h will not pose any risk to populations of mussels in Magela Creek downstream of Ranger mine from the cumulative discharges of treated water. Likewise, the potential impact on other aquatic organisms is negligible.

The results for the terrestrial assessment are provided in **Table 9-26**, which shows that the risk to terrestrial organisms from the Project is insignificant, with all organisms having dose rates below the screening level of 10 µGy/h and conservative risk quotients less than 1.

Table 9-25: Dose rates and risk quotients for aquatic pathway

Reference organism	Dose rate (µGy/h)	Risk Quotient (expected value)	Risk Quotient (conservative value)
Bivalve mollusc	4.76	0.476	1.429
Insect larvae	0.54	0.054	0.162
Phytoplankton	0.46	0.046	0.137
Turtle[1]	0.37	0.037	0.112
Vascular plant	0.35	0.035	0.104
Crustacean	0.32	0.032	0.097
Crocodile[1]	0.11	0.011	0.034
Waterlily[1]	0.09	0.009	0.028
Pelagic fish	0.09	0.009	0.027
Water monitor[1]	0.09	0.009	0.028
Filesnake[1]	0.07	0.007	0.020
Aquatic mammal	0.06	0.006	0.019
Bird	0.03	0.003	0.010
Benthic fish	0.03	0.003	0.010
Amphibian	0.01	0.001	0.003

[1] New organism created for site specific assessment

Table 9-26: Dose rates and risk quotients: terrestrial pathway

Reference organism	Dose rate (µGy/h)	Risk Quotient (expected value)	Risk Quotient (conservative value)
Lichen and bryophytes	2.55	0.25	0.76
Mammal (rat)	0.16	0.02	0.05
Detritivorous invertebrate	0.16	0.02	0.05
Soil invertebrate (worm)	0.15	0.02	0.05
Flying insects	0.15	0.01	0.04
Terrestrial goanna[1]	0.13	0.013	0.038
Gastropod	0.08	0.01	0.03
Grasses & herbs	0.06	0.01	0.02
Amphibian	0.06	0.01	0.02
Bird egg	0.06	0.01	0.02
Mammal (macropod)[1]	0.03	0.00	0.01
Tree	0.02	0.00	0.01
Reptile	0.02	0.00	0.01
Bird	0.01	0.00	0.00

[1] New organism created for site specific assessment

9.4 ASSESSMENT OF RISKS

The environmental risk assessment identified a total of 80 risks. The initial identification of hazards was aided by applying a prompt list derived from the major identified risks in the EIS guidelines and augmented by previous and current operational risk registers. Potential impacts to sensitive receptors (e.g., world heritage values of Kakadu, Mount Brockman) were considered when evaluating and rating each risk scenario. Where multiple potential impacts are associated with a risk scenario, the impact with the highest risk rating defines the risk management class. Risk ratings reflect the implementation of appropriate mitigation measures (existing controls and new treatments).

Of the 80 risks referred to above, 18 are associated with flora and fauna (including species of conservation significance).[12] There were no inherent or residual Class III (high) or Class IV (critical) flora and fauna risks identified. The low residual risk ranking is primarily due to the:

[12] This includes listed threatened and migratory species listed under the Commonwealth EPBC Act and listed threatened species under the NT TPWC Act.

- majority of new infrastructure being located on the inside of the mine access road, thereby reducing impacts associated with land disturbance; and
- removal of < 1 ha of disturbed habitat directly adjacent to the mine site, which is unlikely to reduce the area or quality of habitat for flora and fauna.

Section 9.5 discusses flora and fauna risks of particular interest to stakeholders and/or where additional treatments have been identified. A description of the risk assessment method is provided in **Chapter 5**. Additional discussion of the risks associated with the Project is provided in **Appendix 5**.

9.5 MITIGATION

As previously outlined, a number of additional treatments were identified during the risk assessment to further reduce impacts such as habitat degradation and/or habitat loss and injury/mortality to fauna. Only mitigation measures directly associated with flora and fauna are discussed below.

9.5.1 Habitat Degradation and/or Habitat Loss

There are several additional controls to reduce impacts resulting in habitat degradation and/or loss that may occur through emissions (e.g., dust deposition: risks TA1-01 and TA5-02; and noise: risk TA3-02), creek flow issues (risk TB6-03), radiation contamination (risk TF3-02), and clearing (risk TA1-02), and light amenity (risk TA5-03). These include:

- Implementing new monitoring at sensitive receptor sites[13] on the RPA to gain a greater understanding of dust deposition on sensitive vegetation communities e.g. the riparian zone. There are also several additional controls to address potential source dust from the paste plant, including incorporating dust control into the plant (up to 90% containment); and locating the plant in the currently disturbed area (Ranger mine footprint).
- Undertaking active rehabilitation of cleared areas surrounding new infrastructure to reduce impacts from airborne dust associated with clearing during the construction phase.
- Noise modelling at ecologically sensitive receptors (Georgetown Billabong and RP1) (**Appendix 7**), which concluded that it is unlikely that significant noise impacts will be experienced in the nearest ecologically sensitive areas, and fauna tend to avoid being exposed wherever possible to both high levels (potential to cause injury and damage) and low levels of noise. This study was conducted as part of the EIS study by SLR Consulting Australia Pty Ltd. Noise sources were based on the plant and equipment associated with the construction and operation of the Project. The model predicted a maximum noise level during the construction phase of up to 49 dBA at Georgetown Billabong, which is expected to cause occasional disturbance to fauna but will have a minor impact on habitat use for most species. The model also predicted an incremental increase in operational noise levels at Georgetown Billabong area of up to 6 dBA due to the operation of ventilation fans. During the construction phase (clearing and

[13] Monitoring will occur at the R34 cultural heritage site

earthworks), it is expected that species composition may change, with less tolerant species moving away from the noise source. However, some noise tolerant species are expected to remain in the area, as is already the case with existing operations. In order to meet sensitive sensor limits during the construction and operation phases, appropriate equipment selection and noise control technology will be adopted (refer **Section 6.6**).

- Habitat degradation through seepage losses into Magela Creek are considered to be insignificant. Nevertheless, the proposed small stope size which is well below the base of the weathered zone and backfilling of stopes once mined-out, will minimise the likelihood of surface subsidence.
- The risk of radiation contamination to the surrounding environment and associated mitigation measures (e.g., ERICA assessment) are discussed in detail in **Section 9.3**. However a key treatment to reduce the impacts of this risk is the location of the majority of new exhaust shafts and surface infrastructure within the existing mine footprint – i.e. to the west of the main access road.
- Excess lighting of an area and its surrounds can result in a diminished utilisation of nearby habit by native fauna. This risk will be mitigated by incorporating illumination requirements of infrastructure in the design phase, and additional mitigation will be to minimise excessive light by the use of directional lighting. Lighting will also be located in current disturbed areas away from sensitive receptors.

9.5.2 Fauna Injury/Mortality

Three risks are associated with vent raises that may result in fauna injury or mortality, including:

- fauna falling into bore holes during construction of vent raises (risk TA2-01);
- the flight path of birds and bats intersecting the opening of bulk air coolers (that lead into the intake vents) during operation, causing injury or death (risk TA2-02); and
- fauna falling into open (disused) shafts after closure (risk TE1-02) .

Additional treatments associated with these risks include covering bore holes during construction; covering the intakes of the bulk air coolers to prevent debris entering, and the low air velocity will protect against fauna injury in proximity to the fan; and grouting or capping shafts.

Physical or engineered treatments and mitigations outlined above will be incorporated into existing environmental management plans and are discussed further in **Chapter 15**.

9.5.3 Invasive Flora and Fauna

Risks relating to invasive flora (weeds) and fauna (feral animals) were identified as part of the risk assessment (**Chapter 5**). There was one weed related risk (Class 1) - that a further spread of weeds or the introduction of new weed species from land clearing and associated vehicle movements could cause habitat degradation in the Magela LAA. This risk can be controlled by continuing the current practice of inspecting equipment for weeds prior to

entering the mine site, operator training and competency, and a management framework that incorporates the land disturbance permit procedure, five and one year weed management plans, and ERA operating procedures. These management tools have recently been revised to minimise impacts of key threatening processes (which include weeds, fire, and clearing). An additional control for this risk will be that the majority of new infrastructure will be located within the existing mine footprint, which will limit vehicle movements in the Magela LAA.

In order to place risks identified from an assessed project within a framework that is compatible with the EPBC Act, they are considered with reference to a relevant threat abatement plan. Under the EPBC Act, the Australian Government develops threat abatement plans for key threatening processes, and facilitates their implementation. The plans identify research, management and other actions required to ensure the long-term survival of native species and ecological communities. Social and economic factors are also considered in the plans - for example collaboration between different agencies across jurisdictions).

There are three threat abatement plans relevant to feral animals: predation by feral cats; the biological effects, including lethal toxic ingestion, caused by cane toads; and for predation, habitat degradation, competition and disease transmission by pigs. These plans are not applicable to the Project for the following reasons:

- no feral animal risks were identified from the risk assessment in **Chapter 5**;
- feral animals are well established in Kakadu National Park, which surrounds the RPA;
- there are no natural or artificial barriers on the RPA that restrict feral animal access from Kakadu National Park;
- there are no areas on the RPA that can be considered free of feral animals, or where feral animals could be eradicated; and
- many of the actions from the three plans require action by federal, state and territory governments, or pertain to research and development (e.g. control methods and impacts).

For the single weed risk, the relevant plan is the 'threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses' (SEWPaC 2012). The plan was developed to address the key threatening process 'Ecosystem degradation, habitat loss and species decline due to invasion of northern Australia by introduced gamba grass (*Andropogon gayanus*), para grass (*Urochloa mutica*), olive hymenachne (*Hymenachne amplexicaulis*), perennial mission grass (*Cenchrus polystachios*) and annual mission grass (*Cenchrus pedicellatus*)'. The objectives and actions of this plan are summarised below in **Table 9-27**, with reference to ERA's current weed management:

Table 9-27: Five grass species threat abatement plan objectives and actions

Objective	Action	Comment
1: Develop an understanding of the extent and spread pathways of infestation by the five listed grasses	1.1: Undertake mapping of the five listed grasses at a scale that allows for appropriate planning and an adaptive management approach	ERA have conducted annual fine scale weed mapping of the RPA since 2003. The scale of these surveys has been sufficient to allow small outbreaks on the RPA to be controlled (e.g. along drainage lines). It has also enabled ERA to annually assess the effectiveness of their weed management program. The data has also enabled predictive modelling to be conducted to determine potential areas of infestation on the RPA.
	1.2: Develop a better understanding of spread pathways	This is beyond the scope to the Project and ERA's weed management program, given the research focus (e.g. using genetic information to determine weed spread pathways and sources of infestation.
2: Support and facilitate coordinated management strategies through the design of tools, systems and guidelines	2.1: Encourage complementary weed status for the five listed grasses across all jurisdictions to which the threat abatement plan applies	Three species are currently declared under the NT *Weeds Management Act 200* – Olive hypmenachne, perennial mission grass and gamba grass.
	2.2: Develop best-practice guidelines for use and/ or management of the five listed grasses in agricultural and conservation contexts, and encourage their implementation	This objective is only relevant to management of the weeds species as exotic pasture grasses, and is therefore not relevant to the Project
	2.3: Develop hygiene protocols, focusing on high-priority spread pathways	ERA implements this objective through a weed inspection procedure that it enforces on all vehicles leaving weed infested areas on the RPA or entering weed-free areas on the RPA, and on vehicles entering and leaving the RPA.
	2.4: Further develop prioritisation tools to identify high priority areas for monitoring and management actions	ERA uses a weed control priority system where weed management areas are ranked (scored) for priority of weed control using six criteria: risk of weed spread via traffic; phase of invasion; risk of weed spread via water; proximity of weeds to sensitive/high value areas; impact on revegetation areas; and weed quarantine and protection areas

Objective	Action	Comment
	2.5: Include strategic management of the five listed grasses in management plans for all affected land tenures, giving priority to identified key assets.	ERA has a five year weed management plan and associated one year management plans. ERA has a five year revegetation management plan, and management plans are created for each new rehabilitated site. As part of these plans provision is made for controlling weeds within and adjacent to the site Outlier populations of weeds that are identified in the annual survey are given priority over larger more established infestations.
	2.6: Improve and promote understanding of invasive grass control and land rehabilitation methods to maximise native vegetation restoration and minimise site damage.	ERA has five and one year fire management plans. As part of these plans, fire is managed to reduce negative impacts on intact native vegetation (fauna habitat) and decrease the risk of invasion by weeds. Fire is kept out of rehabilitated areas for at least five years to maximise the survival and establishment of revegetation. Weeds within these areas are controlled to reduce the fire hazard and competition. ERA has a land disturbance permit procedure, which provides a means of safeguarding cultural and environmental features on the RPA. Any proposed activity that could affect these features (e.g. fire and land clearing) must have controls in place to minimise disturbance. Post disturbance inspections are mandatory under the permit system.
	2.7: Facilitate collaborative applied research that can be used to inform or support improved management of the five listed grasses.	ERA undertook management trials on Para grass downstream of the RPA on the Magela floodplain (MLN1) in 2012 -2013 (McIntyre 2013). The trials assessed the effect of different treatment options on different densities of Para grass (e.g. herbicide volume, effort, timing of fire). The outcomes from this work have the potential to be applied to the management of the five grassy weeds on the RPA. ERA supported a study (Masters research project) in 2010 to investigate the effect of herbicide (glyphosate) on seed viability and production in annual and perennial mission grass (Hickey 2010). The study found that spraying reduced the viability of seeds by up to 50%, and that spraying was effective in reducing seed viability throughout the seeding phase.
3: Identify and prioritise key assets and areas for strategic management	3.1: Identify key assets for priority protection	ERA identifies assets such as billabongs, riparian areas, and cultural heritage sites as priority areas for controlling weeds. These assets also incorporate habitat for EPBC Act listed species such as partridge pigeons and migratory species. Small outbreaks in these areas are a particular focus of the annual weed surveys, in order to determine and prevent their spread.

Objective	Action	Comment
	3.2: Identify areas at risk of invasion, prioritise for monitoring and determine appropriate management actions	The RPA is divided into weed management zones that are used to prioritise and plan for weed control each year. As part of the annual weed surveys, new outbreaks are mapped and existing outbreaks are monitored for possible spread.
4: Build capacity and raise awareness among stakeholders	4.1: Develop and deliver communication strategies to raise awareness of the threats posed by the five listed grasses	ERA communicates the results of the weed surveys and weed management outcomes to key stakeholders on an annual basis. Weed identification training is mandatory for ERA staff working in areas of the RPA where weed exposure is possible.
	4.2: Better assist the capacity of Indigenous people to participate in the management of the five listed grasses	ERA has used local indigenous contractors to assist in weed control on the RPA where applicable.
5: Implement coordinated, cost-effective on-ground management strategies in high-priority areas	5.1: Foster a coordinated partnership approach to the management of the five listed grasses. Facilitate information sharing and encourage coordination of the implementation of management and monitoring actions across all land tenures to maximise the efficiency and effectiveness of management programs	This action is not relevant to the Project. ERA manages weeds within the RPA with no cooperation from external agencies (e.g. Parks Australia).

Objective	Action	Comment
	5.2: Where feasible, implement immediate management actions in high-priority areas around key assets and spread pathways	ERA implements this action through weed inspections of vehicles, and also by destroying all new gamba grass and para grass infestations on the RPA, in which there are currently no established populations.
	5.3: Where feasible, implement management actions in other infested areas to reduce the area and/or density of occupancy of the five listed grasses	Containment of existing large populations is done through weed quarantine areas on the RPA. Priority is given to existing infestations in proximity to water and other environmental features (e.g. undisturbed vegetation).
	5.4: Where feasible, apply land rehabilitation methods to high-priority areas as they are cleared of the five listed grasses	ERA implements this action through progressive rehabilitation of disturbed areas. Each new area has a revegetation management plan associated with it. ERA has a closure plan which incorporates large scale rehabilitation up to closure in 2026. This will include rehabilitation of large infestations of mission grass.
	5.5: Liaise with land managers of areas containing key assets to identify resources available for the implementation of priority actions	This action is not applicable – ERA does not use external funding sources or other assistance (e.g. volunteers) for managing weeds on the RPA.
6: Monitor, evaluate and report on the effectiveness of management programs	6.1: Ensure that management plans for high-priority areas include recognition of the asset being protected as well as appropriate monitoring of managed sites.	ERA monitors by re-surveying weed management areas on the RPA every 3 - 5 years to evaluate control success. ERA conducts fuel reduction and weed management before June 30, for cooler burns, and to reduce the risk of habitat degradation for threatened species (e.g. fawn antechinus and partridge pigeon).

Objective	Action	Comment
	6.2: Report on progress and effectiveness of management programs against their goals	ERA reports the outcomes of its weed management program to its stakeholders in an annual weed survey report, as well as in the Ranger Annual Environment Report. The annual weed survey report provides recommendations for improvement (adaptive management) and focus for the next year, which considered in the following year's one year weed management plan. The report also assesses progress against targets from the five year weed management plan.

9.6 SUMMARY

The vegetation communities adjacent to the Project have been heavily impacted by past land use practices (e.g. clearing, fire management, and land application), and naturally occurring events such as late dry season fires, flooding and storms/cyclones, and impacts due to feral pigs and weeds. Moreover, these vegetation communities are not uncommon, and are indicative of those that occur in surrounding Kakadu National Park. Significant potential downstream impacts from clearing, including those on drainage lines, watercourses, wetlands, and sensitive or significant vegetation communities (including nearby sections of Magela Creek, Georgetown Billabong and all associated riparian habitats) are considered to be unlikely due to the distance of the proposed development from these water bodies.

There were no EPBC or TPWC Act listed plant species or threatened ecological communities assessed as likely to occur in the vicinity of the Project. A total of 12 EPBC listed threatened species and 14 EPBC migratory species were assessed. For each of these species the following impacts from the Project were considered unlikely:

- long-term decrease in the area of occupancy, or population size or of an important population;
- fragmentation of an important population;
- adverse effects on critical habitat;
- disruption of the breeding cycle of an important population;
- modification, destruction, removal or reduction of availability or quality of habitat; and
- establishment of harmful invasive species, or disease

Given that most of the Project infrastructure will be located on the (disturbed) mine footprint and not in the vicinity of Magela Creek, there is a low risk associated with airborne dust, weeds, and radiation contamination causing habitat degradation in the Magela LAA or surrounding areas. The removal of less than 1 ha of disturbed habitat directly adjacent to the mine site is unlikely to reduce the area or quality of habitat for threatened and migratory species.

In conclusion, the Project is not likely to have a significant impact on the flora and fauna of the RPA (especially threatened or migratory species). Therefore, the environmental values of Kakadu and the Alligator Rivers Region will not be affected by the Project.

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