Northern Resource
CONSULTANTS

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Flora and Fauna Technical Report

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prepared for

TM Gold Pty Ltd

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Introduction

1. Background

The Spring Hill mining lease (ML) 23812 is located approximately 200km southeast of Darwin in the Northern Territory. The current proposed action is located in the central-eastern portion of the ML and includes open-pit mining and trucking ore offsite for processing at the Union Reefs mill.

The proposed site infrastructure will include pits, a waste rock dump, a ROM pad, a sediment dam, workshops and demountable offices and ablution blocks along with onsite access and haul roads. There will be no onsite accommodation, with workers accommodated at nearby Pine Creek and Emerald Springs. A map of the proposed infrastructure layout is included in Appendix A of this report.

The resource areas identified are centred on an area of approximately 75ha in the central-eastern portion of the mining lease. The current project design includes three open-cut pits identified as Hong Kong 1, Hong Kong 3 and Main Pit 2 (see map in Appendix A).

2. Purpose

A number of baseline environmental surveys have been completed within the Spring Hill project area over a substantial period of time. Previous flora and fauna baseline studies for the Spring Hill project area were conducted in 1995 by Low Ecological Services (LES), with additional generic and targeted survey techniques employed in subsequent site visits. Northern Resource Consultants (NRC) conducted a systematic baseline survey in October 2016 to add to the existing body of baseline information and to provide data on current site conditions and to consolidate relevant findings from all baseline surveys conducted to date. NRC conducted additional targeted surveys during July 2017 to provide additional baseline data relevant to the proposed action. The impact assessment section of this *Technical Report* also provides assessment of potential impacts to native flora and fauna based on the current legislative framework, which includes updates to the status of threatened species.

In addition to providing details on relevant components of previous baseline surveys, this report details the following aspects of the two flora and fauna assessment, conducted in October 2016 and July 2017 by NRC, for the proposed action at Spring Hill:

- Methodologies employed for assessing terrestrial flora and fauna within the study area.
- The presence and current status of species and communities within the local area.
- Potential ecological impacts of the project and recommendations for mitigating impacts, with a focus on species of conservation concern, such as those listed under Territory and Commonwealth legislation.

NRC recorded echolocation call data from several threatened or near threatened bat species during the baseline survey in October 2016. A subsequent targeted threatened bat species and

habitat survey was conducted in July 2017. This targeted survey was aimed at identifying any areas of important habitat features for threatened bat species and obtaining baseline information on populations of threatened bat species present within the project area. A separate report has been produced detailing the methodologies and outcomes of the targeted threatened bat survey program. This *Terrestrial Flora and Fauna Technical Report*, in conjunction with the report on the *Targeted Microbat Survey Report*, provides a complete overview of the current baseline ecological survey data available for the project area.

3. Study area

The study area is located approximately 25km north of Pine Creek. The entire mining lease encompasses over 1,000 hectares of mixed eucalypt woodland on steep ridges to undulating hills with small ephemeral drainage lines and watercourses. The study area for the current survey program was centred on an area of approximately 75ha encompassing the disturbance footprint for the currently proposed action and the habitat surrounding these areas (see maps in Appendix A). The majority of survey effort for this current baseline study was concentrated in the proposed disturbance areas, which are located in an area of historic gold workings that have been the subject of exploration activities by various operators over at least the last 130 years (Appendix A).

4. Regulatory framework

4.1 Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Australian Government Department of the Environment and Energy (DEE). The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, which are defined in the EPBC Act as matters of national environmental significance (MNES). The MNES listed in the EPBC Act that are relevant to this report are:

- nationally threatened species and ecological communities
- migratory species.

Database searches and field assessments should be conducted as part of any flora and fauna impact assessment. The results of these assessments can be used to determine the presence or likelihood of the presence of any MNES within a proposed project area. If any species or communities listed under the EPBC Act are present or likely to be present, an assessment of significance is required. If the proposed action may have a significant impact on a MNES, it must be referred to DEE for assessment. If DEE determines that the proposed action is likely to have significant impacts, the project will be considered as a controlled action and will require formal assessment and approval. If the proposed action is not likely to be significant, approval is

not required if the action is taken in accordance with the referral. Consequently, the action can proceed, subject to any state or local government requirements.

4.2 Territory legislation

Territory Parks and Wildlife Conservation Act 2006

The *Territory Parks and Wildlife Conservation Act 2006* (TPWC Act) is administered by the Northern Territory Department of Land Resource Management (NT DLRM). The TPWC Act makes provisions for the establishment of Territory Parks and other Parks and Reserves and promotes the study, protection, conservation and sustainable utilisation of wildlife. This Act also covers the classification and management of wildlife, classification and control of feral animals, permits for taking wildlife and entering land, and designation and management of protected areas and private sanctuaries.

Wildlife management

The management of wildlife under this Act is to be carried out in a manner that promotes:

- the survival of wildlife in its natural habitat
- the conservation of biological diversity within the Territory
- the management of identified areas of habitat, vegetation, ecosystem or landscape to ensure the survival of populations of wildlife within those areas
- the control or prohibition of:
  - the introduction or release of prohibited entrants into the Territory; and
  - any other act, omission or thing that adversely affects, or will or is likely to adversely affect, the capacity of wildlife to sustain its natural processes
- the sustainable use of wildlife and its habitat.

Feral animals are to be managed in a manner that reduces their population and the extent of their distribution within the Territory, and controls any detrimental effect they have on wildlife and the land.

Protected wildlife

All wildlife that:

- is in a park, reserve, sanctuary, wilderness zone or area of essential habitat; or
- is a vertebrate that is indigenous to Australia,

is protected wildlife.

The TPWC Act uses the International Union for the Conservation of Nature (IUCN) criteria to classify species. IUCN criteria classify wildlife into conservation categories as follows:

- Extinct
- Extinct in the Wild
- Critically Endangered
- Endangered

- Vulnerable
- Near Threatened
- Least Concern
- Data Deficient
- Not Evaluated.

Threatened wildlife under the TPWC Act is any wildlife that is Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN) or Vulnerable (V). Threatened wildlife is automatically given protected wildlife status.

Environmental Assessment Act

The Environmental Assessment Act (EA Act) is administered by the Northern Territory Environment Protection Authority (NT EPA). The EA Act establishes the framework for the assessment of potential or anticipated environmental impacts of development. Each matter affecting the environment, which could be considered to have a significant effect on the environment, is examined and considered. Safeguards to mitigate potential environmental impacts and recommendations can be put forth to ensure all aspects of the works are managed in an environmentally sound manner. Specifically, in:

- proposals
- carrying out of works and other projects
- negotiation operation and enforcement of agreements and arrangements
- making decisions and recommendations.

This will determine if assessment is at the level of a Public Environmental Report (PER) or an Environmental Impact Statement (EIS).

Mining Management Act

The *Mining Management Act* (MM Act) provides for:

- the authorisation of mining activities
- the management of mining sites
- the protection of the environment on mining sites
- the provision of economic and social benefits to communities affected by mining activities, and for related purposes.

The MM Act ensures the development of the Territory's mineral resources in accordance with environmental standards consistent with best practice in the mining industry and protects the environment. Any company that would cause ‘substantial disturbance’ is required to have an Authorisation through the MM Act. Authorisation of operational activities on mining tenements is granted through the Mining Environmental Complicate Group in the Northern Territory Department of Mines and Energy. Remediation of mines and ensuring operators comply with approved mining management plans, is also controlled by this group.

Mining projects require an Authorisation under the MM Act, which is granted once the Environmental Impact Assessment process has been completed (see below).

Weeds Management Act 2001

The *Weeds Management Act 2001* (WM Act) is administered by the NT DLRM and was introduced to '*prevent the spread of weeds in, into and out of the Territory and to ensure that the management of weeds is an integral component of land management in accordance with the Northern Territory Weeds Management Strategy 1996-2005 or any other strategy adopted to control weeds in the Territory'*. It also ensures there is community consultation in the creation of weed management plans and ensures that there is community responsibility in implementing weed management plans. A declared weed is a plant or species of plant, which has been identified for control, eradication or prevention of entry in all or part of the Territory under the WM Act.

A classification of weeds is as follows:

- Class A: to be eradicated
- Class B:growth and spread to be controlled
- Class C: not to be introduced to the Territory.

All Class A and Class B weeds are also considered to be Class C weeds.

Land clearing guidelines

The Northern Territory land clearing guidelines (Department of Natural Resources, Environment, The Arts and Sport [NRETAS], 2010) is administered by the NT DLRM and establishes standards for native vegetation clearing. These guidelines manage the clearing of native vegetation in the most beneficial way as it is recognised that clearing of native vegetation leads to a decrease in landscape function.

Clearing of native vegetation for development is controlled by the Northern Territory *Planning Act*. However, clearing of vegetation for mining activities fall under the MM Act. These guidelines are not required for mining but provide useful information on significant or sensitive vegetation communities.

Flora and Fauna Assessment Methodology

1. Overall assessment methodology

NRC employed a joint approach of desktop analysis and field surveys in this study. The study team implemented best practice recommendations from sources such as:

- Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping (Brocklehurst *et al*., 2007)
- Guidelines for Assessment of Impacts on Terrestrial Biodiversity (NT EPA, 2013)

The methodology encompassed two phases—scoping and field survey.

The scoping phase encompassed:

- project planning and definition of objectives
- assignment of qualified ecologists
- detailed desktop studies
- review of previous studies
- collation of existing records
- literature review of species and potential threats and impacts.

The field survey phase encompassed:

- systematic, targeted and incidental flora surveys
- vegetation community mapping and assessments
- systematic, targeted and incidental fauna surveys.

NRC is a registered scientific user with ethics approval to conduct fauna studies from the Queensland Department of Agriculture and Fisheries Animal Ethics Committee. The survey work involved in this report was conducted under the Northern Territory permit to interfere with protected wildlife number 57846.

2. Desktop analysis

2.1 Literature review and previous studies

A report by LES detailing the outcomes of previous flora and fauna studies associated with the Spring Hill project was available for review as part of this flora and fauna assessment:

- 'Updated Environmental Assessment of Landscape, Flora and Fauna of Spring Hill Project Area' (LES, 2013).

The baseline report by Low Ecological Services details the flora, fauna and land units present within the study with a focus on the data obtained from the main survey period in 1995. Four different land units were located within the study area for that survey and these were identified through geology, topography, soils and vegetation composition. Four fauna trapping sites representing the four land units were established in the study area. Each trapping site consisted of a trap line with 25 Elliott traps (open for two nights, except for the 'hill' site, which was open for three nights). Spotlighting occurred over three nights along a 10km section of road from the hill crest to the lowlands. Bat populations were assessed by examining abandoned mine adits and spotlighting drives. Bird species were surveyed for one morning in each of the three land units through observation and listening to dawn activity for approximately one hour. Opportunistic sightings throughout the survey were recorded by land unit

Vegetation for each land unit was examined opportunistically throughout the survey. Dominant species were noted and voucher specimens collected for confirmation of identification (LES, 2013).

Some short observation-based surveys were conducted by LES since the 1995 survey including a one-day survey in September 2011. This involved a visit to assess if any significant changes to the site had occurred since the 1995 visit. The methodology for this assessment included:

- All tracks driven at a slow pace.
- Lower main adit examined in detail on foot (and found to be blocked completely).
- Items of interest such as threatened flora, potential weeds or erosion were examined on foot and photographs taken.
- All fauna observed, heard or identified by tracks or scats were noted.

2.2 Database searches

The DEE Protected Matters Search Tool and the Northern Territory Natural Resource Management Report were utilised to determine species, communities and areas of conservation significance with potential relevance to the proposed action. Both searches included a 30km buffer around a central co-ordinate within the study area (-13.60597°S, 131.71788°E), which includes the entire study area as well as a large buffer incorporating similar habitat in the surrounding landscape.

The results of the database searches and their relevance to the proposed development are discussed in the Results section of this report. NRC has developed an approach for ranking threatened species and communities recorded from the desktop searches in terms of their likelihood of occurring within the study area. The approach is based on the presence of local records and the habitat requirements for each species. Details of the criteria used to assess the likelihood of occurrence for threatened and near threatened species are provided in Table 1. The potential impacts to threatened species that may occur within the study area are discussed in the Impact Assessment section of this report.

It is possible that some locally occurring near threatened or threatened species may not be recorded in the Territory and Commonwealth databases. The comprehensive field survey component of this assessment is therefore an important aspect of the impact assessment

process to determine the presence of any threatened species that have not been previously recorded in the local area.

Table 1: Key assessment criteria for likelihood of occurrence of threatened and near threatened species

LIKELIHOOD OF OCCURRENCE	KEY CRITERIA	DEFINITION
Present	Present during survey or historical records in the study area	Species was recorded during field surveys or a historical record of the species was located in the study area
High	Known records (<30km) or within species known range AND Suitable habitat of high quality is present	Historical records of the species occur within a 30km radius of the study area or the study area is within the species known range Suitable habitat of high quality exists with the study area
Moderate	Known records (<30km) or within species known range AND Suitable habitat is present, but degraded	Historical records of the species occur within a 30km radius of the study area or the study area is within the species known range Suitable habitat is present but is significantly degraded or fragmented
Low	No records (<30km) and not within species known range OR Habitat present is unsuitable, absent, or highly degraded	No historical records of this species occur within a 30km radius of the study area or within the known range for this species or: OR The habitat within the study area is not suitable and/or is in extremely poor condition, or is absent for the species

3. Nomenclature and taxonomy

With the exception of technical descriptions and tables, all flora and fauna species are referred to by their common names throughout this report, with their scientific name given in brackets after the first reference. Where no common name is provided in reference texts, a search was conducted for other accepted common names, and if none were found then the species name only was used. An asterisk is used to denote species that are not native to Australia.

The use of scientific and common names for fauna species is in accordance with the following:

- Birds: Pizzey and Knight (2012).
- Amphibians: Tyler and Knight (2011).
- Reptiles: Wilson and Swan (2013).
- Mammals (except microbats): Van Dyck and Strahan (2008).
- Microbats: Reardon *et al*. (2015).

4. Flora survey methodology

4.1 Overall methodology

Techniques described in the *Guidelines and Field Methodology for Vegetation Survey and Mapping* (Brocklehurst *et al*., 2007) were used to collect sufficient data during the field vegetation assessments to validate the vegetation communities identified in the baseline study. The key features recorded in the field relevant to this report are:

- Vegetation structure and composition.
- Key species within each stratum.
- Geology, landform and other land unit characteristics.

Land unit classification was compared to the outcomes provided in LES (2013) for previous flora surveys conducted in the study area, which are based on geology, topography, soils and vegetation composition.

Vegetation surveys were conducted in the early wet season between 17 and 21 October 2016. Some additional vegetation community surveys were conducted during the July 2017 survey to provide additional data on areas relevant to the proposed action. The purpose of these survey was to:

- Determine the extent of vegetation communities throughout the study area.
- Validate vegetation communities identified previously (LES, 2013).
- Perform targeted searches for threatened flora species identified during desktop analyses, including ‘meander’ searches.
- Compile a flora species inventory for the study area.

4.2 Vegetation assessment

Site selection

Ground-truthing and validation of the previously mapped land units involved assessment of vegetation characteristics at multiple transect locations within the study area. Assessment sites were selected where they would provide representative data for the vegetation type that was the subject of the assessment. Focus was also given to areas located within the disturbance footprint of the proposed action.

Assessment methodology

Vegetation assessment plots (50m × 10m) were established within different land units within the study area. Within these transects, a combination of quantitative and qualitative techniques was employed. The vegetation survey techniques employed and attributes recorded during the assessments are detailed in Table 2. Quantitative measurements such as basal area (using the Bitterlich stick methodology, Grosenbaugh, 1952) and canopy height and cover were used to describe the structural form of each community based on the structural formation classes.

Rapid assessment sites were also conducted to validate the vegetation community mapping and to capture any variability in the structure and composition of the community. Data collected at rapid assessment sites include all location, environmental and structural information for the dominant and conspicuous species in each layer. In general, focus was given to the dominant species, crown cover and median height of the ecologically dominant layer, which is used to define each community.

Table 2: Vegetation attributes measured in tertiary survey transects

SURVEY METHOD	ATTRIBUTES MEASURED
Survey Plot 50m × 10m	Key species of each stratum Median height of each stratum Weed species and cover Complete species list Central coordinate
Transect 50m	Percentage cover of each stratum
Quadrats (×5) 1m × 1m	Ground cover species and percentage of cover
Greater area encompassing the present vegetation community	Tree basal area Incidental species observed Additional relevant notes

4.3 Vegetation mapping

Mapping of vegetation communities was performed using a combination of vegetation traverses, aerial imagery and topographical data. Using the information gained at each of the vegetation assessment sites, and observations made when traversing the study area, the boundaries of vegetation communities were recorded using a handheld GPS device. Some vegetation mapping was also refined using current, high-resolution aerial images.

4.4 Random meander technique

Various parts of the study area were traversed using the random meander technique documented by Cropper (1993). This technique was applied to supplement other survey techniques and to:

- locate and record any flora species not identified in the vegetation assessment transects
- target threatened flora species
- validate vegetation community mapping
- determine the presence and extent of pest species.

NRC conducted random meanders as part of the approach to develop a flora species inventory and target locally occurring Endangered, Vulnerable and Near Threatened (EVNT) species identified during the desktop assessment. One threatened species of *Acacia* was considered to have potential to occur within the study area (see Desktop Analysis Results section below and Appendix D) and this species was targeted using the random meander technique. Further details on the presence/absence of threatened flora species and the likelihood of impacts to these species are discussed in the sections below. During the meander searches, all species identified were recorded with respect to the habitat type (land unit) within which they were located.

5. Fauna survey methodology

5.1 Survey timing and environmental conditions for the 2016 survey

The timing of the fauna surveys incorporated survey timing and effort recommendations outlined in the *Environmental Assessment Guidelines for the Northern Territory: Terrestrial Fauna Survey* (NRETAS, 2011). The fauna surveys were conducted between 17 and 21 October 2016. This timing is suited to the detection of most faunal groups as it coincides with an increase in temperatures and the onset of rainfall, which are important triggers for peak activity periods.

Weather data relevant to the fauna survey period were obtained from the Bureau of Meteorology (BoM) Pine Creek weather station (014933) for rainfall and the Douglas River station (014901) for temperature (Table 3). The weather before and during the fauna survey period was characterised by hot humid days, warm nights and scattered rain. Overall, the weather conditions for the survey period were considered favourable for detecting most vertebrate fauna groups.

Table 3: Weather conditions relevant to the survey period

PERIOD	DATE	RAINFALL (MM)	TEMPERATURE (°C)		HUMIDITY (9AM)
			MINIMUM	MAXIMUM	
Pre-survey	10/10/2016	0	21.4	38.8	69
	11/10/2016	0	23.1	37.9	68
	12/10/2016	0	22.3	39.2	62
	13/10/2016	0	19.1	38.7	28
	14/10/2016	4.5	16.5	38.3	27
	15/10/2016	0	17.1	38.3	59
	16/10/2016	0.3	20.6	38.0	56
	17/10/2016	0	22.0	39.5	61
	18/10/2016	18.0	25.4	38.7	69

PERIOD	DATE	RAINFALL (MM)	TEMPERATURE (°C)		HUMIDITY (9AM)
			MINIMUM	MAXIMUM	
During October 2016 Survey	19/10/2016	0.3	24.1	37.3	80
	20/10/2016	0	23.8	37.8	57
	21/10/2016	0	23.1	37.6	78

5.2 Systematic survey sites

During the October 2016 survey period, three systematic survey sites were established where an array of fauna trapping and surveying techniques were employed. Sites 1 and 3 were located in the ridge crests and slopes land unit in the proposed disturbance footprint for waste rock dump and mine pit domains, respectively. Site 2 was located within the 'riparian' land unit on the banks of a seasonal watercourse where an existing site access track is located. Overall, the three systematic survey sites were positioned to provide an appropriate spatial distribution within the study area with a focus on encompassing the different habitat types and disturbance areas.

A description of the habitat present at each systematic survey site is provided in Table 4. The location of each systematic trapping site is depicted in the fauna survey map in Appendix A.

Table 4: Habitat descriptions for systematic fauna survey sites

SITE NUMBER AND LOCATION	HABITAT DESCRIPTION	PHOTOGRAPH OF HABITAT
1. North western section of the study area on top of ridge in 'ridge crests and slopes' land unit. Proposed location for waste rock dump	Steep slopes and ridge crests. Mixed eucalypt woodland dominated by species such as *Eucalyptus tintinnans* and Corymbia *dichromophloia,* with *Erythrophleum chlorostachys* often associated. Shallow soils with rocky groundcover and sparse to mid-dense native grass cover.	

SITE NUMBER AND LOCATION	HABITAT DESCRIPTION	PHOTOGRAPH OF HABITAT
2. Southern section of the study area on 'riparian' land unit Location of existing access track (outside project disturbance footprint)	Season watercourse habitat and surrounding lower/flatter terrain. The canopy layer of the broader area includes species such as *Corymbia confertifolia, Erythrophleum chlorostachys* and *Corymbia latifolia*. The bed and banks also support species distinct from other areas such as *Lophostemon grandiflorus* and *Pandanus spiralis*.	
3. North section of the study area on top of ridge in 'ridge crests and slopes' land unit. Proposed location for open cut pit.	Same habitat type as Site 1	

5.3 Survey techniques

The survey techniques employed at each systematic survey site are detailed in Table 5. Some of these techniques were also used at other locations throughout the study area and these are discussed in the following sections.

Table 5: Fauna survey methods employed at systematic survey sites

SURVEY METHOD	DESCRIPTION
Elliott traps	A total of 20 type A Elliott style traps were placed on the ground approximately 5–10m apart in a straight line for 3 nights at each of the 3 systematic trapping sites. All traps were baited with a mixture of rolled oats, peanut butter and honey.
Pitfall and funnel traps	Drift fence lines incorporating pitfall and/or funnel traps were established for three nights at each of the systematic survey sites. At 'Site 2', three pitfall traps (20L buckets) were buried flush with the ground surface with the drift fence intersecting the centre of each bucket. Six funnel traps were located along the drift fencing at all systematic trapping sites. A shade cloth covering each funnel trap was deployed to protect trapped fauna from exposure.
Cage traps	Four cage traps were placed at each site and baited with a mixture of rolled oats and a variety of different meats.
Bat detector	A SongMeter SM4 detector was deployed in various locations throughout the proposed disturbance footprint to determine the presence of bat species in this area and give an indication of habitat use.
Active diurnal searches	Active diurnal searches were undertaken within each of the sites. This technique involved intensive investigation of ground layer habitat features (such as under logs, rocks and leaf litter), low vegetation (under bark and tree stumps) for cryptic fauna, particularly reptiles. Searches were focussed during the parts of the day when reptile activity was likely to be at its peak.
Diurnal bird surveys	Birds were surveyed within each vegetation community for a total of at least one hour at multiple periods throughout the day, but with a particular focus during peak activity in the morning. Incidental observations made whilst conducting other survey techniques were also recorded. Birds were identified from either direct observation or by their calls.
Nocturnal surveys	High-powered spotlights were used to survey nocturnal mammals (flying, arboreal and terrestrial), birds (active nocturnal species, and roosting diurnal species), reptiles and frogs in each of the main trapping sites, as well as other locations throughout the study area.

5.4 Additional survey areas and techniques

During the fauna survey period, the bat detector was deployed and active diurnal search, diurnal bird survey and nocturnal survey techniques were performed at additional locations

outside the systematic survey sites. The locations are depicted in the Fauna Trapping Location map in Appendix A.

In addition to the techniques outlined previously, camera traps (motion-sensing infrared cameras) were utilised at multiple locations within the study area to target fauna that may be too large or 'shy' to be detected by other trapping techniques or that were utilising areas outside of the main trapping sites. Camera traps were baited with the rolled oat mixture, fruit, nuts and a variety of meats.

Targeted nocturnal searches for arboreal mammals, quolls and nocturnal predatory birds were performed in areas considered higher quality habitat for such species. These areas included the granite outcrop and rainforest habitats.

Spotlighting surveys were also conducted while driving slowly over multiple parts of the study site and local area, where it was safe to do so.

Fauna species were continually observed throughout the survey period and records were frequently obtained outside of the systematic methodology of the survey. Any observations, tracks, scats or other signs of fauna were recorded with reference to the location and habitat type.

5.5 Targeted techniques

Northern Quoll

Targeted techniques were used to increase the likelihood of detection for the Northern Quoll (*Dasyurus hallucatus*), including use of baited cage traps with a variety of meats and placement of meat-based bait adjacent to camera traps.

Northern Masked Owl

Call play-back techniques were used during nocturnal surveys to target the Northern Masked Owl (*Tyto novaehollandiae kimberli*), as this is known to be an effective method for increasing the likelihood of detecting this species. Call play-back for the Northern Masked Owl was typically conducted at the beginning of each spotlighting (nocturnal survey) session, using the methodology recommended by Ward (2010), as follows:

1. The call of the Northern Masked Owl was broadcast.
2. For the first five minutes of the broadcast, the survey team listened for calls of Masked Owls and watched for birds flying in to the area around the speaker (without the use of spotlights).
3. During the second five minutes, the survey team continued to listen for owl calls and spotlights were also used to look for owls in the trees around the site.

During subsequent spotlighting surveys, the survey team continued to listen and spotlight for owls, while also searching for other nocturnal species.

Partridge Pigeon

This species was targeted as part of the surveys in October 2016 and July 2017 using techniques described for this species in the *Survey guidelines for Australia's threatened birds (Guidelines for detecting birds listed as threatened under the EPBC Act)*. The recommended methods from these guidelines include area searches, flushing surveys and targeted searches of waterholes in suitable habitat during the dry season. The disturbance footprint for the project is less than 50ha and therefore area searches and flushing surveys are appropriate targeted methods for this species within the project area. During the October 2016 survey, two observers conducted area searches for a minimum of two hours each day by dividing the project area into six different domains of approximately equal size and systematically traversing the habitat within each of these domains. This methodology allowed for Partridge Pigeons to be targeted through either direct observation or through flushing. This survey methodology was repeated for a minimum of two hours each day by three observers during the July 2017 surveys. Overall, the targeted survey effort for the Partridge Pigeon within the project area was well in excess of the survey effort guide in the survey guidelines.

There were no suitable waterholes within the project area for conducting 'targeted searches' as per the survey guidelines during the October 2016 survey. However, there was a stock water dam located in lower terrain, approximately 1km southwest of the ridge habitat associated with the project area. This feature was targeted for Partridge Pigeons as part of the October 2016 survey to determine if this species was utilising the feature and was therefore present in the surrounding habitat. Details on the outcomes of the targeted surveys for Partridge Pigeons are provided in the Results and Impact Assessment sections below.

5.6 Survey effort

The survey effort employed for each of the aforementioned systematic techniques is outlined in Table 6, showing the effort employed at each systematic survey site and the total survey effort over the period (including effort outside the systematic surveys).

Table 6: Fauna survey effort for each technique

METHOD	EFFORT PER SITE	TOTAL SURVEY EFFORT
Pitfall trapping	Nine trap nights* (array of three pits for three nights) *PITS ESTABLISHED AT SITE 2 ONLY	Nine trap nights
Funnel trapping	18 trap nights (array of six funnels for three nights)	54 trap nights
Diurnal active search	Two person hours (60 minute search × two people)	Approx. 11 person hours (three × systematic surveys sites plus five additional one person hour survey sites)

METHOD	EFFORT PER SITE	TOTAL SURVEY EFFORT
Elliott trapping	60 trap nights (array of 20 traps for five nights)	180 trap nights
Cage trapping	12 trap nights (array of four cages for three nights)	36 trap nights
Diurnal bird survey	1.3 person hours (Two × 20 minute surveys x two people)	Approx. 12 person hours (three × systematic surveys sites plus eight × additional one person hour survey sites)
Camera Trapping	Three trap nights (One camera × three nights)	9 trap nights (Three cameras × three nights)
Spotlight/ nocturnal searches	Three person hours (Two people × 1.5 hours)	9 person hours
Echolocation call detection	One detector night (One detector for one night)	Three detector nights (One detectors for three nights)

Desktop Analysis Results

1. Literature review

The following sections provide a summary of the outcomes detailed in the report by LES (2013), which were primarily based on the baseline survey conducted in 1995. Specific focus is given to the outcomes and descriptions pertaining to the disturbance area for the current proposed action.

1.1 Land units

The land units relevant to the Spring Hill project area, identified in the previous baseline flora and fauna assessment (LES, 2013), include 'ridge crests and slopes', 'low undulating hills' and 'tall open woodland riparian'. A summary of the descriptions provided in LES (2013) is included in Table 7. The disturbance footprint for proposed action is primarily restricted to the ridge crests and slopes land unit. The floristic structure and composition within these land units is described in the following section.

Table 7: Summary of relevant land units identified in previous surveys (from LES, 2013).

LAND UNIT	DESCRIPTION
Ridge crests and slopes	This land unit covers the entire mining area domains of the proposed action. It comprises rocky hills approximately 140m high (260m above sea level), with steep slopes of up to 60° and a narrow crest of approximately 30m. Soils of this land unit are shallow and skeletal with sandy loams in depressions.
Low undulating hills	This land unit mainly encompasses areas to the south and west of the proposed action. It includes gentle rounded hills associated with alluvial washouts and channels which occasionally become inundated during the wet season. Hills have a local relief of less than 20m (up to 120m above sea level) and an incline less than 5°. Soils are sandy loams with silt stone sediment and quartz intrusions and are generally shallow except in depressions where clayey loams predominate.
Tall open woodland riparian	The relevant section of this land unit is located to the south of the proposed action on an existing access track. It is associated with low-lying creeks and drainage from hill slopes. Soils of this land unit are clayey loamy with loamy clays in larger depressions and coarse to fine sands in Creek beds.

1.2 Flora

The previous baseline survey by LES (2013) did not find any flora listed as threatened or near threatened under the TPWC Act or the EPBC Act within the survey area. Species recorded were generally widespread in the local area and typical of the Wet-Dry Tropics and the Pine Creek Region.

The floristic composition and structure of the vegetation communities within each of the identified land units, as described by LES (2013), is provided below.

Ridge crests and slopes were described by LES (2013) as low woodland dominated by mid to tall eucalypts over mid to tall grasses and scattered forbs. The upper canopy was dominated by *Eucaclyptus bigalerita* (Northern Salmon Gum), *Eucalyptus tintinnans* (Salmon Gum) and *Corymbia dichromophloia* (Variable Barked Bloodwood), with subdominant species including *Corymbia papuana (*Ghost Gum), *Corymbia polycarpa* (Long Fruited Bloodwood), *Corymbia setosa* (Rough Leafed bloodwood), *Corymbia grandifolia* (Large Leaved Cabbage Gum) and *Xanthostemon parodoxus* (Bridal Tree).

The understorey consisted of locally dominant grass species: *Sehima nervosum* (Rats Tail Grass), *Cymbopogon obtectus* (Silky Heads), *Herteropogon contortus* (Black spear grass), *Sorghum plumosum* (Plume Sorghum) and *Themeda triandra* (Kangaroo Grass). Forb species included *Gomphrena* spp., *Thecanthes punicea* and *Haemodorum coccineum* (Scarlet Bloodroot).

The low undulating hills unit was described as low woodland and was distinct from the ridge crest and slopes unit in that the canopy layer was generally more sparse, with the understorey and canopy becoming dense in depression areas. The canopy layer was generally similar to that of ridge crests and slopes, but with dominant species being *Corymbia latifolia* (Rough Leafed Bloodwood), *Eucalyptus miniata* (Darwin Woollybutt) and *Eucalyptus tectifica* (Darwin Box). Ground cover species were similar to that of the ridge crest and slopes.

The riparian land unit was described as low open eucalypt forest of eucalypt trees (5–10m high) vines, a dense shrub layer and dense ground cover of a mix of grasses and forbs. Species were generally consistent with the low undulating hills land unit, but occurred in greater abundance in the riparian zone. There were also additional species adapted to the riparian conditions such as *Pandanus spiralis* (Screw Palm) and *Nauclea orientalis* (Leichhardt tree).

Some exotic species were identified during the previous baseline flora surveys, including *Hyptis suaveolens* (Hyptis), *Pennisetum polystachyion* (Mission Grass), *Melinis repens* (Red Natal Grass) and *Passiflora foetida* (Stinking Passion Flower). Weed species were not prolific and tended to be confined to previously disturbed sites (LES, 2013).

1.3 Fauna

The 1995 baseline survey identified an array of birds, mammal, reptiles and amphibian species present within the project area. This section focuses on conservation significant species identified during the previous baseline surveys to facilitate the impact assessment component of this technical report.

One mammal species of conservation concern was recorded during the 1995 baseline survey. A juvenile Northern Quoll (*Dasyurus hallucatus*) was captured in the ridge crest unit. This species has suffered significant declines across its entire distribution and is now listed as endangered under the EPBC Act and critically endangered under the TPWC Act. No evidence of this species was detected during any of the subsequent site visits by LES.

One notable bird species was recorded during the 1995 baseline surveys (LES, 1996). The Partridge Pigeon (*Geophaps smithii smithii*) was recorded frequently throughout the entire mine lease area during the 1995 baseline survey. LES (2013) reported this species was most common in the open woodland of the low undulating hills land unit. This species is listed as vulnerable under the EPBC Act and the TPWC Act.

These records from the 1995 baseline surveys informed the survey design and targeted survey approaches for the current baseline surveys conducted by NRC in 2016.

1.4 Existing disturbance

The baseline survey report from LES (2013) identified substantial areas of existing disturbance within the project area, particularly from historical mining activities. LES (2013) identified significant disturbance from historical alluvial mining in the low undulating hills land unit and significant disturbance from exploration activities and abandoned mine shafts in the ridge crests and slopes land unit.

2. Database searches

The EPBC Act Protected Matters Report (DEE, 2016a) and Northern Territory Natural Resource Management Report (NT NRM, 2016) incorporating a 30km buffer around the study area are included in Appendix B and Appendix C of this document, respectively. The NT NRM Report and Protected Matters Report identified 3 threatened flora species, 30 threatened fauna species and 15 migratory fauna species with potential relevance to the current study area. The results of all desktop searches for determining conservation significant flora and fauna species of relevance to the proposed development are discussed in the following sections of this report.

2.1 Wetlands of international importance

The EPBC Act Protected Matters Report identifies Kakadu National Park as a (Ramsar) wetland of international of importance occurring within the 30km buffer zone. The boundary of Kakadu National Park is located 30km east of the study area.

2.2 Threatened flora species

A total of four threatened flora species were returned in the database searches. The EPBC Act Protected Matters Report identified two threatened plant species potentially occurring within a 30km radius of the study area (DEE, 2016a, see Appendix B). The Northern Territory NRM Report contains records of three threatened plant species within a 30km radius of the study

area (NT NRM, 2016, see Appendix C). The results of these searches have been combined in Table 8 to show all near threatened and threatened flora species recorded from the database searches and their status under Territory and Commonwealth legislation, as well as their likelihood of occurring within the study area.

Table D1 in Appendix D provides a justification for how the likelihood of occurrence was determined for each species. Of the four threatened flora species returned in the desktop analyses, all were considered to have a low likelihood of occurring within the study area.

2.3 Threatened fauna species

A total of 27 near threatened and threatened fauna species were returned from the database searches within a 30km radius surrounding the study area. These included 18 from the Protected Matters Report (DEE, 2016a, see Appendix B), and 17 from the Northern Territory NRM Report (NT NRM, 2016, see Appendix C). The results of these searches have been combined in Table 9, which also provides an interpretation on the likelihood that each of these species would occur within the study area. Table D2 in Appendix D provides justification for how the likelihood of occurrence was determined for each species.

Eleven species were considered to have a moderate or high likelihood of occurring within the study area; the remaining sixteen species were considered to have a low likelihood of occurring. All species that were considered to have a moderate or high likelihood of occurring within the study area are discussed in further detail in the Impact Assessment section of this report.

2.4 Migratory species

The EPBC Act Protected Matters Search Tool identified 15 migratory species with potential to occur within 30km of the study area. The results of this search are included in Table 10 along with interpretation on the likelihood that each of these species would occur within the study area. Table D3 in Appendix D provides a justification for how the likelihood of occurrence was determined for each species.

Three species listed as migratory were considered to have a moderate likelihood of occurring within the study area; the remaining twelve species were considered to have a low likelihood of occurring. All species that were considered to have a moderate or high likelihood of occurring within the study area are discussed in further detail in the Impact Assessment section of this report.

Table 8: Near threatened and threatened flora species identified from database searches

STATUS[1]		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE[2]	RECORDS	LIKELIHOOD OF OCCURRENCE
TPWC	EPBC						
V	–	Cycadaceae	*Cycas armstrongii*	Armstrongs's Cycad	NRM	–	Low
V	V	Fabaceae	*Acacia praetermissa*	Wattle	PM/NRM	28	Moderate
E	E	Stylidiaceae	*Stylidium ensatum*	Triggerplant	PM	–	Low
E	E	Malvaceae	*Helicteres macrothrix*	Helicteres	NRM	–	Low

1. Status: V = Vulnerable, E = Endangered
2. NRM = NT Natural Resource Management, PM = EPBC Act Protected Matters Report

Table 9: Near threatened and threatened fauna species identified from database searches

STATUS[1]		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE[2]	NRM RECORDS	LIKELIHOOD OF OCCURRENCE
TPWC	EPBC						
		BIRDS					
E	V	Accipitridae	*Erythrotriorchis radiatus*	Red Goshawk	PM	–	Moderate
V	V, M	Charadriidae	*Charadrius leschenaultii*	Greater Sand Plover	NRM	–	Low
V	V	Columbidae	*Geophaps smithii*	Partridge Pigeon	PM/NRM	19	Present
V	–	Falconidae	*Falco hypoleucos*	Grey Falcon	NRM	1	High
NT	V	Pachycephalidae	*Falcunculus frontatus whitei*	Crested Shrike-tit	PM	–	Low
V	E	Passeridae	*Erythrura gouldiae*	Gouldian Finch	PM/NRM	18	High
V	E, M	Rostratulidae	*Rostratula australis*	Australian Painted Snipe	PM	–	Low
V	CE, M	Scolopacidae	*Calidris terruginea*	Curlew Sandpiper	PM	–	Low
V	CE, M	Scolopacidae	*Numenius madagascariensis*	Eastern Curlew	PM	–	Low
V	V	Tytonidae	*Tyto novaehollandiae kimberli*	Masked Owl	PM	–	Moderate
		MAMMALS					
CE	E	Dasyuridae	*Dasyurus hallucatus*	Northern Quoll	PM/NRM	9	High
E	V	Dasyuridae	*Phascogale pirata*	Northern Brush-tailed Phascogale	PM/NRM	1	High
E	V	Dasyuridae	*Antechinus bellus*	Fawn Antechinus	PM/NRM	1	High
NT	CE	Emballonuridae	*Saccolaimus saccolaimus nudicluniatus*	Bare-rumped Sheathtail Bat	PM	–	Low

STATUS[1]		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE[2]	NRM RECORDS	LIKELIHOOD OF OCCURRENCE
TPWC	EPBC						
V	E	Hipposideridae	*Hipposideros inornata*	Arnhem Leaf-nosed Bat	PM/NRM	–	Low
V	-	Hipposideridae	*Hipposideros stenotis*	Northern Leaf-nosed Bat	NRM	–	Present
V	E	Macropodidae	*Petrogale concinna canescens*	Nabarlek	PM	–	Low
NT	V	Megadermatidae	*Macroderma gigas*	Ghost Bat	PM/NRM	5	Present
E	V	Muridae	*Conilurus penicillatus*	Brush-tailed Rabbit-rat	PM	–	Low
V	E	Muridae	*Mesembriomys gouldii gouldii*	Black-footed Tree-rat	PM/NRM	–	Low
CE	V	Muridae	*Mesembriomys macrurus*	Golden-backed Tree-rat	NRM	1	Low
V	-	Muridae	*Rattus tunneyi*	Pale Field-rat	NRM	2	High
		REPTILES					
V	V	Elapidae	*Acanthophis hawkei*	Plains Death Adder	PM	–	Low
V	E	Gekkonidae	*Lucasium occultum*	Yellow-snouted Gecko	NRM	1	Low
V	-	Varanidae	*Varanus mertensi*	Mertens Water Monitor	NRM	–	Low
V	-	Varanidae	*Varanus michelli*	Mitchell's Water Monitor	NRM	–	Low
V	-	Varanidae	*Varanus panoptes*	Yellow-spotted Monitor	NRM	1	High

1. Status: V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory, NT = Near Threatened.
2. NRM = NT Natural Resource Management, PM = EPBC Act Protected Matters Report

Table 10: EPBC Act listed migratory species from the Protected Matters Search Tool results

STATUS[1]		FAMILY	SCIENTIFIC NAME	COMMON NAME	LIKELIHOOD OF OCCURRENCE
TPWC	EPBC				
LC	M	Accipitridae	*Pandion haliaetus*	Eastern Osprey	Moderate
LC	M	Apodidae	*Apus pacificus*	Fork-tailed Swift	Moderate
LC	M	Charadriidae	*Charadrius veredus*	Oriental Plover	Moderate
NT	M	Charadriidae	*Pluvialis squatarola*	Grey Plover	Low
LC	M	Cuculidae	*Cuculus optatus*	Oriental Cuckoo	Low
LC	M	Glareolidae	*Glareola maldivarum*	Oriental Pratincole	Low
NE	M	Hirundindae	*Hirundo rustica*	Barn Swallow	Low
NE	M	Hirundinidae	*Cecropis daurica*	Red-rumped Swallow	Low
NE	M	Motacillidae	*Motacilla cinerea*	Grey Wagtail	Low
NE	M	Motacillidae	*Motacilla flava*	Yellow Wagtail	Low
LC	M	Rhipiduridae	*Rhipidura rufifrons*	Rufous Fantail	Low
LC	M	Scolopacidae	*Calidris ferruginea*	Curlew Sandpiper	Low
LC	M	Scolopacidae	*Numenius madagascariensis*	Eastern Curlew	Low
NE	M	Sylviidae	*Acrocephalus orientalis*	Oriental reed-warbler	Low
LC	M	Crocodylidae	*Crocodylus porosus*	Estuarine Crocodile	Low
V	M, V	Pristidae	*Pristis pristis*	Largetooth Sawfish	Low

1. Status: NT = Near Threatened, V = Vulnerable, M = Migratory, NE = Not Evaluated

Flora Survey Results

1. Vegetation communities

1.1 Community descriptions and structural form

The vegetation communities identified in each land unit were found to be generally consistent with the descriptions provided in the original baseline survey report by LES (2013). A summary of the dominant vegetation within each mapped land unit is provided in Table 11.

The October 2016 survey focussed on describing vegetation communities present within the proposed disturbance are for the project and nearby surrounding areas. This survey revealed significant disturbance from historical mining and exploration activities in the proposed pit and waste rock dump domains on the ridge crests unit. While there is significant disturbance within this unit, the overall dominant species composition and structure was consistent with the descriptions provided in LES (2013). Some additional species were identified in various parts of the study area, but none of these formed significant structural components to the communities described (see further details on flora species below).

Table 11: Dominant vegetation recorded for each land unit (from LES (1996) and NRC (2016))

LAND UNIT	DOMINANT CANOPY AND SUB-CANOPY VEGETATION
Ridge crests and slopes (low woodland)	Dominant: *Eucalyptus tintinans, Corymbia dichromophloia, Erythrophleum chlorostachys.* Associated: *Gardenia megasperma, Terminalia ferdinandiana, Xanthostemon paradoxus, Vachellia pachyphloia, Corymbia setosa.* (Dominant groundcover species include *Sehima nervosum, Cymbopogon obtectus, Themeda triandra, Sorghum plumosum,* and *Heteropogon contortus*).
Low undulating hills (low woodland to open woodland)	Same as for ridge crests and slopes but also with *Corymbia latifolia, Eucalyptus miniata* and *Eucalyptus tectifica* often dominating the canopy layer.
Riparian (open woodland)	The area specifically surveyed in detail where the existing road occurs within this unit was dominated by *Erythrophleum chlorostachys*, *Corymbia confertiflora, Corymbia latifolia*, and *Lophostemon grandiflorus* with species such as *Pandanus spiralis*, *Xanthostemon paradoxus, Acacia holosericea, Flueggea virosa and Brachchiton megaphyllus.*

1.2 Riparian monsoon forest

It has been suggested a community of riparian monsoon forest approximately 0.5ha in size is located in a gully on the western side of the project area. Monsoon forest patches are regarded as a significant habitat type under the NT Land Clearing Guidelines (NRETAS, 2010) due to their high species diversity. As monsoon forests are generally isolated, their removal is likely to result in localised species extinction and should be avoided wherever possible.

The vegetation community located in the western gully was specifically targeted for vegetation community assessments during the targeted survey program in July 2017. The targeted survey included description of the species structure and composition of the vegetation at this location. The western slopes of the ridge throughout this area are characteristic of the ridge crests and slopes land unit described above, with a mix of *Eucalyptus tintinans, Corymbia dichromophloia, Erythrophleum chlorostachys* forming the canopy layer. The western gully itself is characterised by a steep rocky drainage line descending from the ridge crest, with steep sides joining with the surrounding ridge slopes. The full length of this gully was traversed, with vegetation community surveys conducted at regular intervals to describe the community present. The vegetation throughout the majority of this gully is consistent with the surrounding ridge crests and slopes land unit, with *Erythrophleum chlorostachys* being slightly more prevalent in the canopy layer within the gully. There is one steeper and rockier section of the gully that appears to be more sheltered from fire. This fire-sheltered rocky section covers an area of approximately 0.16ha, and is approximately 80m long by 20m wide. Within the fire-sheltered section, as for the surrounding steep slopes, *Erythrophleum chlorostachys* becomes more prevalent in the canopy layer. Three individual specimens of *Ficus atricha* occur within this section of the gully and form a small component of the canopy layer. The shrub layer is denser in the fire-sheltered section and includes two species not recorded in the surrounding landscape—*Strychnos lucida* and *Sersalisia sericea*. Both of these species are indicative of lower frequency or intensity of fires in this small section of the gully. The shrub layer on the ‘banks’ of the gully is typically dominated by *Calytrix exstipulata*, which is characteristic of the steep slopes in the broader area.

Overall, the majority of vegetation in the western gully area is characteristic of the ridge crests and slopes land unit described previously. There is a small section that appears to be more sheltered from fire due to the steep terrain and rocky substrate, and this section supports a small number of flora species not recorded from the surrounding ridge crests and slopes land unit. However, the spatial extent of this community is very small (approximately 0.16ha), and the species diversity is not significantly greater than the surrounding non-riparian communities. The biodiversity value of this small area is therefore assessed to be relatively low, and it is unlikely to be providing any significant habitat values for any local flora and fauna species.

1.3 EPBC Act threatened ecological communities

None of the vegetation communities observed equate to a threatened ecological community listed under the EPBC Act.

2. Flora species

The majority of flora species observed throughout the study area are common and widespread throughout the region in eucalypt woodland communities. Apart from differences between riparian and non-riparian areas, the floristic composition is highly consistent throughout the study area, with some variation due to changes in geology and topography. None of the species observed during the most recent survey formed significant components of any of the communities within which they were observed and therefore did not result in significant alteration of previous community descriptions provided by LES (2006). A list of flora species identified during the baseline flora survey is included in Appendix E.

2.1 Threatened flora species

No threatened or near threatened flora species (as listed under the EPBC Act or TPWC Act) were identified during the vegetation surveys. The potential for impacts to threatened and near threatened flora species is discussed further in the Impact Assessment section of this report.

2.2 Pest plant species

The report by LES (2013) identified *Hyptis suaveolens* (Hyptis), *Pennisetum polystachyion* (Mission Grass), *Melinis repens* (Red Natal Grass) and *Passiflora foetida* (Stinking Passion Flower) were present in previously disturbed areas. This was supported by the more recent survey data whereby Hyptis and Stinking Passion Flower were commonly recorded in areas of existing disturbance within the project area. Relevant measures to minimise and manage impacts of pest plant species are provided in the Recommendations section of this report.

Fauna Survey Results

1. Fauna habitat

1.1 General habitat description

The disturbance footprint of proposed action is largely restricted to the ridge-top and adjacent slopes, which support eucalypt woodland habitat on skeletal soils. The slopes are rocky with a generally sparse grassy groundcover and very sparse shrub layer. Areas on top of the ridge have been subject to substantial disturbance from exploration activities and historical mining. These areas are mostly cleared of vegetation and consequently have relatively low habitat value. The disturbance footprint of the proposed action is largely centred on these areas of existing disturbance on top of the ridge, with proposed pit locations occurring in areas of significant existing disturbance from exploration activities. Loss of habitat values associated with woodland communities on the ridge crests and slopes land unit will therefore be minor. This vegetation community and land unit association occurs over a broad area at the locality.

1.2 Habitat features

The vegetation type throughout the majority of the study area is relatively homogenous and comprises mixed eucalypt low open woodland. At the time of the survey, sporadic canopy trees were flowering and hollow bearing trees were observed throughout the study area.

Due to the prevalence of fire at the locality, woody debris features including hollow bearing logs were minimal in most areas. Increased frequency and intensity of fires has been shown to lead to a reduction in small mammal populations by reducing resources, decreasing cover and increasing predation and competition (Andersen *et al*., 2012; Spencer *et al*., 2005; Plavsic, 2014). Small mammals are the most sensitive faunal group to fire and can take a long time before populations begin to recover (Andersen *et al*., 2005; Kelly *et al*., 2011).

Some of the steeper drainage gullies likely contain rocky microhabitat providing refuge for reptile and small mammal species. These areas are likely more sheltered from impacts of fires, but occupy only a relatively small portion of the study area.

There are several historical mineshafts present within the project area that remain open and consequently provide potential habitat for microbat species.

1.3 Watercourse and wetland habitat

The disturbance footprint for mining activities does not contain any permanent watercourses or wetland habitats. There are multiple drainage lines draining from the ridgetop of the project area, but these ephemeral features likely only flow for a short time after rainfall events. There are seasonal watercourses in the lower sections of the area that would support substantial flows

during the wet season. These areas are represented by the riparian land unit in the map provided in Appendix A. This land unit was surveyed as part of the systematic survey design to capture the diversity of habitats and species present in the area. However, direct disturbance to this land unit has been avoided by design. There are no wetland features within the study area or the nearby surrounding landscape. There are some dams present in the surrounding low hills terrain that provide a potential drinking water source for local fauna species.

1.4 Existing disturbance and habitat condition

The Spring Hill project area has a long history of various mining and exploration activities. The survey effort for the most recent study was focussed on the proposed disturbance footprint, within which various forms of existing disturbance were observed. The proposed disturbance footprint for the open cut pits contains areas of disturbance from old mine workings, including open shafts. There is existing disturbance from exploration activities with substantial areas of cleared vegetation for drill pads and access tracks throughout the proposed disturbance footprint for the currently proposed project. Recent reworkings of old waste material have resulted in these sites being maintained as cleared areas.

2. Fauna species

A total of 73 fauna species from 41 families were positively identified within the study area using a variety of different observation and trapping techniques. This included 42 birds, 13 reptiles, at least 14 native mammals and 4 native amphibian species. At least 10, and possibly 11, bat species were recorded during the survey, with 2 species unable to be reliably differentiated from call data. Most of the native fauna recorded are common in tropical savannah habitats throughout much of the Northern Territory. A combined list of all species identified during the survey period is included in Appendix F. The following sections provide a brief discussion of the species observed for each taxonomic group. Potential impacts to fauna are discussed in the latter sections of this report, with a focus on conservation significant species.

2.1 Mammals

A total of 14 mammals were recorded within the study area over the survey period. No small ground-dwelling mammals were captured during the 2016 systematic trapping program, which may be due to fire disturbance and clearing, or may be reflective of high survey effort requirements to detect some of these species. Only one individual, the Common Rock Rat (*Zyzomys argurus*), was captured during the 1995 baseline survey and one individual was observed during the targeted surveys in 2017. The combined results of the baseline surveys suggest a very low diversity and abundance of small mammal species within the project area.

Several macropod species were observed, including the Short-eared Rock Wallaby (*Petrogale brachyotis*), which was recorded on a motion-sensing camera at Site 1.

Bat diversity recorded during the 2016 systematic survey was relatively high, with at least 10 and possibly 11 microbat species recorded from the call data. Microbat call detection was focussed around identifying the potential use of old mine shaft habitats within the project area.

On three of the nights the detector was placed near the entrance to shafts considered to be potentially suitable habitat located within the proposed disturbance footprint or immediately adjacent areas. Five of the species recorded are considered 'cave-dependent' species and are therefore likely to be utilising the old mine workings as roosting habitat. Two of these species are listed as threatened under Territory or Commonwealth legislation. The Ghost Bat (*Macroderma gigas*; Vulnerable, EPBC Act) and The Northern Leaf-nosed Bat (*Hipposideros stenotis*; Vulnerable, TPWC Act) were recorded on multiple nights during the October 2016 survey. The Orange Leaf-nosed Bat (*Rhinonicteris aurantia*; Near Threatened, TPWC Act) was also recorded from multiple locations within the project area. Further discussion on potential impacts to these, and other cave-dependent species, is included in the impact assessment section of this report. However, the targeted microbat survey in July 2017 provides more detailed analysis of the presence of microbat species and habitat within the project area. This report should be considered in conjunction with the *Targeted Microbat Survey Report* (NRC, 2017), which provides a comprehensive assessment of microbat species within the project area (with a focus on conservation-significant species) and includes a detailed impact assessment and relevant management strategies.

The *Microbat Call Interpretation Reports* from the bat detector data collected during the 2016 systematic fauna survey and the 2017 targeted fauna survey periods are included in Appendix G.

No evidence of any other mammals listed as threatened or near threatened was observed within the study area during the fauna survey.

2.2 Reptiles

Thirteen species of reptiles from seven families were observed within the study area (see Appendix F). The majority of reptile species recorded are common and widespread throughout the region and in many cases distributed over a large expanse of tropical savannah in the Northern Territory.

No evidence of any reptiles listed as near threatened or threatened was observed within the study area.

2.3 Amphibians

Four amphibian species were recorded within the study area, as well as the introduced pest species, Cane Toad (*Rhinella marina*).* There is suitable habitat within the study area for many locally occurring amphibian species. The study area likely supports a higher diversity of amphibian species than detected during this survey period. Due to small amount of standing water throughout the study area, many species were not active or breeding.

No evidence of any amphibian listed as near threatened or threatened was observed within the study area.

2.4 Birds

A total of 42 species of birds were observed within the study area during the survey period. This species assemblage includes a number of sedentary, nomadic and migratory species. The majority of species observed are common in eucalypt woodland habitat throughout the region. The Partridge Pigeon (*Geophaps smithii smithii*) was observed at a nearby location outside the study area during the survey period. The likelihood of impacts to this species and other species listed under Territory and Commonwealth legislation are discussed in the Impact Assessment section of this report.

2.5 Pest species

Evidence or direct observation of two pest species were detected during the fauna surveys, both of which commonly occur in disturbed habitats throughout the Northern Territory. The following species were observed within the study area:

- Horse (*Equus caballus**)
- Cane Toad (*Rhinella marina**)

Cane toads spread through the area around 2003 and were observed at site 2 near the watercourse during the current survey period.

Impact Assessment

1. General biodiversity values

1.1 Vegetation regarded as sensitive to disturbance

The eucalypt woodland community that occupies the majority of the study area is broadly represented in the region and is not considered sensitive to disturbance. One area of riparian vegetation supports some plant species that are less represented in the surrounding landscape and supports additional biodiversity values to the eucalypt woodland communities. Direct disturbance to this community has been avoided by design, with all infrastructure located to avoid vegetation clearing in this riparian community. In general, waste rock stockpiles or other mine infrastructure are located in the ridge crests and slopes land unit in areas of existing disturbance and it is therefore unlikely there will be any significant impacts to the biodiversity values of this community.

The small area of a fire-sheltered vegetation community in the western gully supports a small number of flora species not recorded from the surrounding ridge crests and slopes land unit. However, the spatial extent of this community is very small (approximately 0.16ha) and the species diversity is not significantly greater than in the surrounding non-riparian communities. The biodiversity value of this small area is therefore assessed to be relatively low, and it is unlikely to be providing any significant habitat values for any local flora and fauna species. Direct disturbance to this community has been avoided by design and it is therefore unlikely there will be any significant impacts to the biodiversity values associated with this community.

1.2 Critical habitats and important congregation sites

The only form of important habitat or congregation sites recorded within the project area is the areas of old mine workings providing habitat for cave-dependent bat species. Five cave-dependent species bat species were confirmed within the area from echolocation data recorded during the October 2016 survey. It is recommended that further field-based assessment be conducted to determine the extent of roosting habitat for cave-dependent bat species and potential impacts to these species through the development of the project area.

2. Matters of national environmental significance

The following sections detail the presence of MNES and potential impacts to these matters as assessed with reference to the Matters of National Environmental Significance – Significant Impact Guidelines 1.1 (DEE, 2013). Listed threatened species and ecological communities are discussed in Section 2.1; however, further details regarding the potential occurrence of conservation significant species is provided in Sections 3 and 4.

2.1 Listed threatened ecological communities and threatened species

There are no threatened ecological communities mapped or ground-truthed within the study area or the broader locality. The only threatened ecological community known to occur in the region is the Arnhem Plateau Sandstone Shrubland Complex TEC. The study area and broader locality does not support habitat suitable for this ecological community. This community is restricted to the Arnhem Plateau and surrounding outcrops and is therefore unlikely to be significantly impacted by the proposed action.

One fauna species listed as threatened under the EPBC Act was detected within the study area during the current survey – the Ghost Bat. One other species listed as threatened under the EPBC Act (the Northern Quoll) was recorded during the 1995 baseline ecology survey. The Partridge Pigeon (listed vulnerable) was recorded at a location outside the study area during the 2016 survey program. The likelihood of occurrence and potential impact to threatened flora and fauna species is discussed further in sections 3 and 4 below. This section includes specific assessment of the two EPBC Act listed species identified above.

2.2 Listed migratory species

The desktop assessment identified 16 listed migratory bird species that have the potential to occur in the study area. Of these 16 species, only a few are likely to occur within the study area, with the rest unlikely to occur due to a lack of suitable habitat. The listed migratory bird species are common and widespread throughout coastal and inland areas of the Northern Territory. These species also occur in a broad range of habitats and the study area does not exhibit any unique habitat features for any of these species. Similar habitat is abundant in the local area and throughout the region

The highly mobile nature, large distribution and broad habitat requirements of these migratory bird species indicate the proposed development is unlikely to have a significant impact on individuals or populations of the listed migratory species. Table D3 in Appendix D includes a list of all migratory species that have the potential to occur within the study area and their likelihood of occurrence.

2.3 Wetlands of international importance

No wetlands of international importance (Ramsar wetlands) are located within the study area or nearby areas. The wetlands in Kakadu National Park are the nearest wetlands of international importance. This National Park is located over 30km from the proposed action. Given the small scale of the proposed action and the substantial distance to the wetland areas, it is unlikely the action will have a significant impact on the ecological character of the declared Ramsar wetland area.

2.4 World Heritage properties

The proposed action is located at least 30km from the Kakadu National Park World Heritage Area (WHA). Given the relatively small disturbance area and substantial distance from the

National Park, with respect to ecological values for World Heritage properties it is unlikely the proposed action will:

- Reduce the diversity or modify the composition of plant and animal species in all or part of the WHA.
- Fragment, isolate or substantially damage habitat important for the conservation of biological diversity in the WHA.
- Cause a long-term reduction in rare, endemic or unique plant or animal populations or species in the WHA.
- Fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in the WHA.

3. Conservation significant flora species

No threatened or near threatened flora species were found within the study area, despite the use of targeted threatened flora survey methods. Four conservation significant flora species with potential relevance to the study area were identified in the desktop analyses, and the likelihood of their occurrence within the study area was assessed using key criteria such as local records and habitat suitability/quality. From this, three of the species were considered to have a low likelihood of occurring within the study area. It is considered unlikely any of these three threatened species would occur within the study area due to a lack of suitable habitat and/or a lack of local records. Appendix D provides further details of the likelihood of occurrence assessment for the conservation significant species identified in the desktop assessment.

Acacia praetermissa was identified during the desktop assessment as having moderate potential for occurrence within the project area, as per the criteria outlined within the methodology section above. This species was specifically targeted over multiple survey programs incorporating various seasonal conditions. During the most recent survey (July 2017), specimens were located in the region (multiple sites near Emerald Springs) prior to the survey to confirm diagnostic characteristics and current reproductive stage at the time of the survey to facilitate detection. The species was flowering at the time of the July 2017 survey, which increases the detectability of this species (see Figure 1). Three suitably qualified observers conducted random meander searches and the entire proposed disturbance footprint on the ridge crest was traversed. This species was not detected anywhere within the project area during any of the baseline ecological surveys to date, including during comprehensive targeted searches. Given the lack of evidence for this species occurring within the project area and the extent of existing disturbance from historical mine workings, it is unlikely the construction and operation of the proposed project will:

- lead to a long-term decrease in the size of the population of the species
- reduce the area of occupancy of the population
- fragment any population into multiple populations
- adversely affect habitat critical to the survival of the species
- disrupt the breeding cycle of an important population
- modify, destroy, remove or isolate; or decrease the availability or quality of habitat to the extent that the species is likely to decline

- result in invasive species that are harmful to Koalas becoming established in Koala habitat
- introduce disease that may cause the species to decline
- interfere substantially with the recovery of the species.

Overall, in consideration of the above EPBC Act Significant Impact Guideline criteria, it is unlikely there will be any significant impacts to the vulnerable population of *Acacia praetermissa* because of the proposed action.

Multiple survey and targeted search techniques were conducted throughout the study area over the current survey period, as well as previous baseline surveys. These surveys have incorporated different seasonal conditions to maximise the likelihood of detecting conservation significant flora species. Numerous flora surveys were conducted throughout the study area, with an emphasis on encompassing all of the vegetation communities present in the study area, and random meanders were performed to further increase the likelihood of detecting threatened flora. Despite these efforts, no threatened or near threatened flora species were found within the study area. Given the extent of the study area covered over the survey periods, and the fact that surveys were conducted over multiple seasonal conditions, suggests that these species are unlikely to be present with the study area. Furthermore, the study area does not support any habitat unique to these species, but rather, the habitat is generally consistent with larger areas of similar habitat in the broader region. Given the lack of evidence for any conservation significant flora species and the abundance of similar habitat in the broader area, it is unlikely there will be a significant impact to any threatened or near threatened flora species because of the proposed development.

Early flowering stage for *Acacia praetermissa* specimen observed near Emerald Springs after recent fire (July 2017)

Slightly later flowering stage for *Acacia praetermissa* specimen observed near Emerald Springs with no recent fire disturbance (July 2017)

Figure 1: Flowering stages of *Acacia praetermissa* specimens observed near Emerald Springs at the time of the July 2017 survey

4. Conservation significant fauna species

Two threatened bat species were recorded from within the project area using a microbat call detection device. The Ghost Bat (*Macroderma gigas*; vulnerable, EPBC Act) and The Northern Leaf-nosed Bat (*Hipposideros stenotis*; vulnerable, TPWC Act) were recorded on multiple nights during the October 2016 survey.

One individual Northern Quoll was captured within the ridgetop land unit during the 1995 baseline surveys. This species is listed as endangered under the EPBC Act and critically endangered under the TPWC Act.

The potential for impacts to all threatened species recorded within the study area over the various baseline surveys is discussed in the following sections. Other conservation significant species determined to have a moderate or high likelihood of occurrence during the desktop assessment are also discussed, including those species identified during previous surveys, but not detected during the current study. Conservation significant species with a low likelihood of occurrence are not included in the following impact assessment. However, justification

regarding the low likelihood of occurrence determination for each species is provided in Appendix D.

4.1 Red Goshawk

The Red Goshawk (*Erythrotriorchis radiatus*) is listed as vulnerable under the EPBC Act and the TPWC Act. This species is very sparsely distributed from the western Kimberly area in Western Australia to north eastern New South Wales (Marchant & Higgins, 1993). It typically occurs in coastal and sub-coastal areas in wooded and forested lands of tropical and warm-temperate Australia (Marchant & Higgins, 1993). It nests in large trees, typically less than one kilometre from a permanent water source (Aumann & Baker-Gabb, 1991).

There are no records of the Red Goshawk shown in the NT NRM Report for the local area around Spring Hill. The nearest record on the Atlas of Living Australia is approximately 50km east of the study area. The home range for this species is very large, between 50 and 220 square kilometres (Debus & Czechura, 1988).

No evidence of this species was detected during the fauna surveys. Given that this species is sparsely distributed and occupies large ranges, it is possible that this species may fly over the study area, or use the area as part of a much larger home range. However, the study site does not contain any unique habitat features for the Red Goshawk. Rather, the study area is characteristic of the vast expanses of eucalypt woodland in the surrounding landscape. It is unlikely this species would be significantly impacted by the relatively minor loss of potential habitat associated with the proposed development.

4.2 Partridge Pigeon

The Partridge Pigeon (*Geophaps smithii smithii*) is listed as vulnerable under the EPBC Act and the TPWC Act. The Partridge Pigeon occurs in sub coastal areas of the Northern Territory with the majority of records in Kakadu National Park and between Katherine and Darwin (DoE, 2016). Changed fire regimes in the Northern Territory are the leading cause of decline for this species with a population reduction estimated at 50% since the 1800s (Franklin, 1999; Fraser, 2001; Garnett & Crowley, 2000; Higgins & Davies, 1996). There are multiple records of this species in the local area and the study area is within its known range.

Partridge Pigeons were recorded at multiple locations within the lease area during the 1995 survey and were most common in the low undulating hills land unit (LES, 2013). During the 2016 survey, a large flock of approximately 30 individuals was observed drinking at a dam located about 800m southwest of the project area in the low undulating hills land unit. No Partridge Pigeons were detected within the proposed disturbance footprint or any of the surrounding habitat in the ridge crests and slopes land unit. Diurnal bird surveys were conducted at two systematic sites within this land unit, for 30 minutes over a period of five days (total = two ecologists × 2.5 hours of systematic surveys per site). In addition to the systematic bird surveys, targeted surveys for Partridge Pigeons were conducted daily. Targeted surveys were undertaken by listening for calls and walking through vegetation to try and flush birds from cover. During the targeted survey program in July 2017, three observers traversed the entire proposed disturbance footprint on the ridge crests and slopes. These targeted area searches

were conducted for a minimum of three hours each day for three days. No sightings of Partridge Pigeons were recorded during the systematic or targeted surveys. Collectively, the total survey effort targeting the Partridge Pigeon significantly exceeds the survey effort guide in the Survey guidelines for Australia's threatened birds (Commonwealth of Australia, 2010).

Habitat requirements for the Partridge Pigeon are not fully understood, but at local scales an important component of their habitat requirements appears to be the presence of a structurally diverse understory comprised of native grasses. At broader scales, they require a mosaic of habitat types including dense grassy areas and open sparse areas (Fraser *et al.*, 2003). This mosaic of habitats is an important component of their habitat requirements, since they prefer to nest in dense grassy areas with structurally complex ground cover, but will move to open areas to feed. Foraging birds favour sites that have been burned, which allows them to pick up fallen seed from the ground (Whitehead *et al.*, 2003).

In terms of the habitat within the broader Spring Hill study area, the unit mapped as low undulating hills would be potential suitable for the Partridge Pigeon for foraging. This unit is woodland to open woodland with a sparse understorey of medium grasses. The steep rocky areas of the ridge crests and slopes land unit would generally not be attractive to the species as foraging habitat. The dense, grassy areas and structurally complex ground cover preferred for nesting are not a feature of the ground-truthed habitat within the proposed disturbance footprint. It is therefore unlikely this species would be significantly impacted by the proposed action. The most likely interaction between project activities and local populations of this species is through traffic movement on the haul road in the lower terrain. General fauna management approaches, as well as management strategies to minimise potential impacts from interaction with traffic should be incorporated into the management plan sections of the Mine Management Plan. Traffic interaction management strategies are proposed in the Recommendations section below to minimise potential impacts to individuals of this species. Adoption of these management strategies will reduce the risk of impacts to this species in the low undulating hills land unit. Through the use of these impact mitigation measures, it is unlikely there would be a significant impact to the Partridge Pigeon as a result of this short-term project.

4.3 Grey Falcon

This species is not listed under the EPBC Act, but is listed as vulnerable under the TPWC Act. The Grey Falcon (*Falco hypoleucos*) has been recorded in all states and territories but is found in low densities throughout Australia. In the Northern Territory, the majority of records occur in the south but there are scattered records all the way north to Darwin. This species inhabits arid and semi-arid areas that are lightly timbered and occurs in lowland plains where rainfall is typically below 500mm a year (DLRM, 2012d).

The landscape around the Spring Hill area is within the known range of this species with one record in the Pine Creek area. This species has not been observed within the study area in any of the surveys conducted to date. This species is uncommon across a very broad distribution within Australia. While it is possible this species may occur within the study area or broader locality, the study area does not contain any significant habitat for this species. It is unlikely this species would be significantly impacted by the relatively minor loss of potential habitat associated with the proposed development.

4.4 Gouldian Finch

The Gouldian Finch (*Erythrura gouldiae*) is listed as endangered under the EPBC Act and vulnerable under the TPWC Act. This species occurs in Northern Australia from the Kimberley region east to north-central Queensland. There are multiple sightings of this species in the broader local area as identified from a number of sources in the desktop assessment. This species preferred habitat is *Eucalyptus* woodland with an understorey of *Sorghum* and other grasses. The presence of water is a limiting factor for this species as they frequent waterholes, watercourses, soaks and springs (DoE, 2016; O'Malley, 2006).

This species feeds almost exclusively on grass seeds. Seeds of annual grasses are consumed more frequently in the dry season whereas perennial grass seeds are sought out in the wet season. Broad declines of this species have been attributed to increased livestock grazing and changed fire regimes, both of which reduce available grass seeds (DoE, 2016).

This species has potential to occur within the study area as preferred habitat is present and there are multiple records within the broader area. Permanent water sources are not present within the disturbance footprint, but there is a dam that appears to permanently hold water located approximately 800m southwest of the proposed disturbance area that is accessible for wildlife drinking. The proposed action includes relatively small-scale clearing of native vegetation that includes preferred habitat for the Gouldian Finch. However, this habitat type is common in the surrounding landscape and the proposed disturbance areas do not represent significant areas or critical habitat. Given this species has not been recorded within the study area, despite targeted surveys, and that habitat loss is minor in the context of the local area, it is unlikely this species would be significantly impacted by the proposed action.

4.5 Masked Owl

The Masked Owl (*Tyto novaehollandiae kimberli*) is listed as vulnerable under the EPBC Act and the TPWC Act. In the Northern Territory, this subspecies occurs from the Cobourg Peninsula down to Katherine and the Victoria River area, and to the east at McArthur River (Threatened Species Scientific Committee [TSSC], 2015).

This species has been recorded in a variety of habitats including riverside forests, rainforest, open forest and paperbark swamps (Garnett *et al*., 2011). This subspecies is known to occupy home-ranges of over 1000ha in the non-breeding season (Higgins, 1999; Kavanagh & Murray, 1996). Given the large home range that would encompass a variety of habitats, it is considered possible that this subspecies may occur within the study area. However, there are no records of the Masked Owl in the local area. The nearest record on the Atlas of Living Australia is more than 60km to the northwest of the study area. The proposed project will not cause a significant decline in the availability and quality of the habitat for this species and is therefore unlikely to lead to a decline in the size of the population or the area of occupancy of this species. It is unlikely this species will be significantly impacted by the proposed development.

4.6 Northern Quoll

The Northern Quoll (*Dasyurus hallucatus*) is listed as endangered under the EPBC Act and critically endangered under the TPWC Act. There are many records of this species within the broader area. As previously identified, one individual was captured within the project area during the 1995 baseline survey (LES, 2013).

This species was formerly distributed across much of northern Australia, but its distribution has contracted significantly since European settlement to several disjunct populations (Oakwood, 1997). Poisoning from eating the introduced Cane Toad is a major mechanism for the decline of this species (Oakwood, 1997). Large scale monitoring in Kakadu National Park reported highly significant declines and local extinctions of northern quolls since the invasion of Cane Toads across the park (Woinarski *et al.,* 2010). These declines appear to have occurred throughout the top end and there are no recent records from the broader Spring Hill or Pine Creek locality, despite multiple surveys and assessments for other mining projects in the area.

A report by Oakwood (2000) suggests the following factors are important for the persistence of Northern Quoll in parts of the Northern Territory:

- rocky areas
- tall open coastal eucalypt forests
- sandstone escarpment
- open forests and woodlands containing *Eucalyptus tetrodonta*, *E. minata* and *E. tectifica*
- open woodland on low rocky hills containing *Corymbia setosa* and *C. bleeseri*
- riparian areas dominated by *Melaleuca virdiflora* and *Pandanus spiralis.*

Based on these habitat attributes, the field assessments confirmed the study area contains habitat that is potentially suitable for the Northern Quoll. However, it is unlikely this species still persists in the area as there are no recent records from the broader locality.

Multiple survey techniques targeted detection of this species during the October 2016 survey period. Areas containing preferred habitat attributes, such as the rocky slopes and outcrops within the study area were targeted in particular using techniques such as cage trapping and motion-sensing infrared cameras. All traps were baited with material targeted at attracting Northern Quolls, including a mix of rolled oats and a variety of meats. Latrine searches in potentially suitable habitat areas were also conducted to supplement the trapping program.

No evidence of the Northern Quoll was detected during the recent field survey program despite targeted effort using multiple techniques. Suitable habitat for the Northern quoll occurs within the proposed disturbance footprint for the project, but this habitat is not unique to the project area. Rocky outcrops and ridges are found throughout the local area. Given the lack of recent records in the area, and the lack of any evidence observed during the recent survey period, it is unlikely this species would be significantly impacted by the proposed action.

4.7 Northern Brush-tailed Phascogale

The Northern Brush-tailed Phascogale (*Phascogale pirata*) is a small carnivorous marsupial found in the Top End of the Northern Territory and is listed as vulnerable under the EPBC Act

and endangered under the TPWC Act. Historically common, this species is thought to have declined due to the introduction of Cane Toads and domestic cats. Habitat loss from changed fire regimes has also lead to a reduction in this species by decreasing the number of hollow bearing trees and a reduction in forest structure (Liedloff & Cook, 2007; Williams *et al*., 1999). Kakadu, Katherine Gorge and Litchfield National Parks form the boundary of the known range of this species with few scattered records between each National Park (TSSC, 2010).

This species has not been observed within the study area during any of the field surveys to date. There is one record from 2001 at a location approximately 30km west of the study area, and potentially suitable habitat of eucalypt woodland with trees containing hollows is present within the study area. There have been few recent records of this species in the Northern Territory but there is potential for this species to occur within the study area. However, the study area does not contain any unique habitat features for the Northern Brush-tailed Phascogale. Rather, the study area is characteristic of the eucalypt woodland in the surrounding landscape. It is unlikely this species would be significantly impacted by the relatively minor loss of potential habitat associated with the proposed development.

4.8 Fawn Antechinus

The Fawn Antechinus (*Antechinus bellus*) is a small carnivorous marsupial found in the Top End of the Northern Territory. It is listed as endangered under the TPWC Act and vulnerable under the EPBC Act. The majority of records for this species occur in Garig Gunak Barlu, Kakadu and Litchfield National Parks. Preferred habitat for this species includes savannah woodland and tall open forests with eucalypts that contain hollows or hollow woody debris in the leaf litter (DLRM, 2012e). The Fawn Antechinus has not been detected during any of the baseline ecological surveys.

This species is endemic to the Northern Territory, and while no specific threats have been demonstrated to cause declines for this species, feral cats and changed fire regimes are thought to be the main causes. Feral cats actively hunt small native marsupials and increased fire frequency and intensity reduces woody debris and hollow bearing trees, which are used for dens and foraging. Small mammals in northern Australia have been shown to be fire sensitive and decrease in abundance after a fire. The time it takes to repopulate a burnt area may be longer than most faunal groups (Andersen *et al*., 2005). This species could occur within the project area, but current fire regimes would have likely impacted any local populations.

It is possible that this species is present within the study area in low numbers or could recolonise the area once conditions become more suitable, assuming more suitable fire regimes ensue, when ground layers regenerate and woody microhabitat feature become more prevalent. However, the apparent prevalence of burning in the surrounding landscape suggests a potential lack of source areas.

While it is possible this threatened species may occur within the study area, the proposed action involves minimal loss of habitat for this species. Furthermore, potential refuge areas such as the riparian land unit have been avoided by design. Given the scale of habitat loss is minor, and the current habitat condition for this species is poor, it is unlikely this species would be significantly impacted by the proposed development.

4.9 Pale Field-rat

The Pale Field-rat (*Rattus tunneyi*) is found in higher rainfall areas of northern Australia. This species is listed as vulnerable under the TPWC Act and is mainly found in the Top End of the Northern Territory. This small nocturnal mammal occurs in dense vegetation along creeks and shelters in shallow burrows during the day. Like other small mammals, such as the Fawn Antechinus discussed previously, significant population declines have occurred for this species in the last decade. No specific threats have been demonstrated to cause these declines, but they have been attributed to inappropriate fire regimes and predation by feral cats (DLRM, 2012a).

This species has not been recorded during the baseline surveys, despite the use of appropriate trapping techniques within areas of potentially suitable habitat. It is likely that the prevalence of fire in the area has impacted the local population of this species, and indeed the current fire regime in the broader area may have caused broader scale declines. Recent fire has substantially reduced shrub and ground cover, and the quantity and habitat quality of coarse woody debris, which is important habitat for Pale Field-rat and many native small mammals. It has been shown in the Northern Territory that Pale Field-rat populations rapidly decline with inappropriate fire regimes (Andersen *et al*., 2005). The impacts from fire also are likely to act synergistically with other threats, particularly feral cats (Andersen *et al*., 2005). Given the extent of occurrence for frequent fires in the region, it is likely there is a lack of source areas for this species to readily recolonise the study area.

It is possible this species is currently persisting in the study area in low numbers or may recolonise the area when more suitable habitat conditions, including fire regimes, prevail. In any case, the proposed habitat loss resulting from development of the site is minimal, and while the habitat is apparently degraded in its current state, similar habitat is abundant in the broader area. It is considered unlikely this species would be significantly impacted by the relatively minor loss of potential habitat associated with the proposed development.

4.10 Yellow-spotted Monitor

The Yellow-spotted Monitor (*Varanus panoptes*) is listed as vulnerable under the TPWC Act. This is a robust, terrestrial monitor, which ranges throughout the Top End of Australia and extends south through much of Queensland. This species inhabits a variety of habitats including coastal beaches, riverine flats, grasslands, and woodlands (DLRM, 2012c; Wilson & Swan, 2013). The Yellow-spotted Monitor preys on small vertebrates and insects and the arrival of Cane toads is the major factor for the decline of this species in the Northern Territory. Some areas have reported up to a 90% reduction in population size after the arrival of Cane Toads. There are few records of this species within the local area of the Spring Hill project.

Habitat requirements for this species are found within the study area; however, these habitats are common in the local area and within the Yellow-spotted Monitors range. It is unlikely this species would be significantly impacted by the relatively minor loss of potential habitat associated with the proposed development.

4.11 Ghost Bat

The Ghost Bat is listed as vulnerable under the EPBC Act and near threatened under the TPWC Act. It is the largest microchiropteran bat in Australia and is Australia's only carnivorous bat. Since European settlement, Ghost Bats have contracted further northwards, with much of their arid zone distribution disappearing in the past few decades (Molnar *et al*., 1984; Churchill & Helman, 1990). The species current range is discontinuous, with geographically distinct colonies in parts of Queensland, the Northern Territory and Western Australia. Churchill (2008) identifies that this species is common in the Top End, whereas elsewhere they occur only in small or widely scattered colonies.

Ghost Bats occupy a variety of habitats in northern Australia, including tropical savanna woodlands. During the daytime they roost in caves, rock crevices and old mines. Roost sites used permanently are generally deep natural caves or disused mines with a relatively stable temperature (TSSC, 2016, and references therein). In the Top End, they have a preference for caves with microclimates of 27–29°C and 80% relative humidity (Churchill, 2008).

The *Approved Conservation Advice* for the Ghost Bat from the Threatened Species Scientific Committee (2016), identifies the following attributes of roost habitats from a variety of cited sources. Ghost Bats move between a number of caves seasonally or as dictated by weather conditions, and require a range of cave sites. Most breeding sites appear to require multiple entranced caves. Ghost Bats disperse widely when not breeding, but concentrate in a relatively few roost sites when breeding. Habitat loss from mining and reworking of old mine adits are recognised as threats to the Ghost Bat.

A targeted survey for this species was conducted in July 2017 with the specific aim of identifying habitat for this species within the study area and the significance of the Ghost Bat population present. Further information into the extent to which this species occurs within the study area, the extent this species may be impacted by the proposed action and species-specific management plans are presented in the *Targeted Microbat Survey Report*.

4.12 Northern Leaf-nosed Bat

The Northern Leaf-nosed Bat is not listed under the EPBC Act, but is listed as vulnerable under the TPWC Act. It has been recorded in locations associated with high sandstone escarpment areas in the Top End. It also occurs in the eastern and western Kimberly, and in Queensland around the southern Gulf of Carpentaria (DLRM, 2012g). In the Northern Territory, they roost in sandstone caves, boulder piles, road culverts and disused mines. They roost alone or in well-separated pairs in the less humid twilight zone, with a roost temperature of 27°C and 46% humidity (Churchill, 2008). Most caves are shallow overhangs or splits in sandstone cliffs (Churchill, 2008).

The ecology and status of this species is problematic as records in the Northern Territory are infrequent, and therefore it is poorly known (DLRM, 2012g). Threats to this species are not described and there is no management program for this species in the Northern Territory (DLRM, 2012g). As for the Ghost Bat, further information into the extent to which this species occurs within the study area, the extent this species may be impacted by the proposed action, and species-specific management plans are located in the *Targeted Microbat Survey Report*.

5. Pest species

The number of significant pest flora and fauna species observed within the study area was generally low. Development within the study area is therefore unlikely to significantly modify the landscape in a way that would increase the occurrence of pest animal species or the threat they represent to local biodiversity values. However, recommendations to minimise threats from pest species are provided in the following section of this report.

Recommendations

1. Clearing and vegetation management

During construction activities, the following measures should be implemented to minimise disturbance impacts and the potential harm to habitat values, flora and fauna present within the area:

- The boundary of areas to be cleared should be clearly marked, to ensure the disturbance footprint is minimised.
- Clearing should occur in a sequential manner to allow any fauna present in the area to escape to areas away from construction activities.

Vegetation stockpiles will provide habitat for small ground dwelling mammals and reptiles during the construction phase. It is important to locate these stockpiles away from high traffic areas, and ensure they are not isolated from contiguous vegetation at the edge of the site. This will reduce the likelihood of fauna travelling across the site.

Cleared vegetation should be managed according to the following best practice principles:

- Where possible, logs and large branches with hollows should be preserved, and stockpiled separately (at the edge of the site) for rehabilitation purposes.
- Any mulching should occur as near as possible to the time of clearing to prevent the establishment of stockpiles as fauna habitat.

2. Soil management

During construction, soil stockpiles should be managed to maximise suitability for future use in rehabilitation processes. Topsoil should be stockpiled separately from sub-soils and stockpiled to a maximum height of two metres. This will improve the likelihood of retention of a seed bank within the topsoil, which will increase the effectiveness of its use for rehabilitation in the future. Stockpiles should also be managed to allow passage for fauna by leaving a sufficient gap between stockpiles.

3. Pest management

3.1 Pest plants

Soil disturbance is a major contributor to weed establishment and invasion. A number of pest plant species were identified in the flora surveys.

The following recommendations are relevant to the construction phase as well as ongoing monitoring and management post-construction:

- Wherever possible construction activities should work from areas with fewer weed species and smaller infestations towards areas where there is a greater abundance of weeds.
- Vehicles and machinery brought on site should be clean and free of weeds, dirt and other material that may contain weed seeds and cause exotic species to become established within the works areas.
- Where appropriate, weed spread should attempt to be minimised by implementing some control measures within the proposed works areas prior to construction.
- Regular observation of disturbance sites and stockpiles for incidence of weed species.
- Disturbance areas should be rehabilitated as soon as possible to minimise the establishment of weed species.
- Vegetation rehabilitation should incorporate a mix of native species, including multiple species of grass, shrub and tree seeds.
- Where any weed establishment is identified, appropriate control measures should be implemented as soon as possible to minimise the impacts of weeds on native habitat.

3.2 Pest animals

Given the proposed short duration of operations, it is not considered necessary that feral animal control programs be implemented, provided appropriate measures are taken to avoid encouraging or increasing pest animal populations in construction and operation areas. Onsite waste, particularly food waste, should be managed so as not to encourage scavenging wildlife to the area. Bins should be fitted with lids and these should remain closed between rubbish deposits. Any onsite landfill should be buried deep and covered as soon as possible.

4. Dust management

Excavation and vehicle movements produce increased levels of dust, which can have a cumulative impact on plant function. Dust suppression techniques should be implemented where significant dust is being produced, including (but not limited to):

- Application of water on trafficable surfaces.
- Limiting activities in high wind conditions.
- Application of water/ binding agent to construction sites during construction.

5. Fauna management

Excavated areas can pose a risk to native fauna through entrapment and exposure. Excavated areas should be checked regularly for trapped fauna, with inspection occurring at least twice daily. These areas should be checked early in the morning for fauna that has become trapped overnight, and again in the late afternoon for fauna that has become trapped over the course of the day.

Safe egress points should be included to allow fauna to escape of their own accord. Any fauna that cannot escape of its own accord should be removed in a manner that is safe for both the animal and the person handling the animal. Dangerous fauna species such as snakes should only be handled by a suitably qualified and experienced person. The use of a fauna spotter-catcher during the vegetation-clearing and construction period is recommended to minimise the chances of injury to native fauna. The fauna spotter-catcher should hold all relevant permits for handling and relocating wildlife, and should be present during clearing activities. The role of the spotter-catcher would be to advise on appropriate clearing methods to ensure animal escape paths are maintained and relocate fauna located within the disturbance area accordingly.

Vehicle strike represents a general threat to native fauna species. This threat is particularly relevant to the Partridge Pigeon, which is listed as vulnerable under Territory and Commonwealth legislation is considered to have potential to occur within the study area. The following controls are recommended to minimise the likelihood of vehicle strike in general, with a focus on reducing the likelihood of death or injury to Partridge Pigeons if present:

- Site inductions or toolbox meetings will include information about sensitive aspects of the environment in which personnel are working, including the risk of injury or death to Partridge Pigeons from vehicles.
- Due to the ground dwelling nature of the species, all vehicles will remain on existing access tracks and roads wherever possible.
- Clearing works will be carried out in a sequential manner that allows fauna to escape to natural areas away from construction works.
- Speed limits will be implemented as appropriate for the condition of the roads and access tracks on site. Locations of Partridge Pigeon sightings should be recorded and a limit of 20km/hr is recommended within 200m of locations where Partridge Pigeons have been regularly observed.

It is recommended native flora species consistent with the surrounding landscape be used for rehabilitation purposes in general. The site currently supports habitat areas comprising species consistent with preferred habitat for the endangered Gouldian Finch. While this species has not been observed within the project area, the rehabilitation approach should ensure the suitability of the habitat is maintained. Native grasses used for rehabilitation should include species of *Sorghum* and other native grasses that are known food species for the Gouldian finch. A mixture of wet and dry season grass species should be used to maintain suitable habitat throughout the year for the Gouldian finch. Preferred food grasses for the Gouldian Finch recorded during baseline surveys include *Sorghum* spp. and Kangaroo grass (*Themeda traindra*).

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