



HAYES CREEK FLORA AND FAUNA REPORT

Report Prepared for PNX Metals
Pty Ltd

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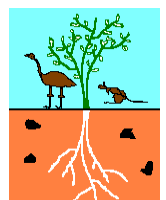
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LIST OF ABBREVIATIONS

Abbreviation	Definition
ASC	Australian Soil Classification
BMP	Biodiversity Management Plan
BFMP	Bush Fire Management Plan
BoM	Bureau of Meteorology
CR	Critically Endangered
DD	Data Deficient
DENR	Department of Environment and Natural Resources (Northern Territory)
DLRM	Department of Land Resource Management (Northern Territory) (no DENR)
DME	Department of Mines and Energy (Northern Territory) (now DPIR)
DoE	Department of Environment (Commonwealth), now Department of Environment and Energy
DoEE	Department of the Environment and Energy (Commonwealth)
DoSWPC	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth), Department of the Environment and Energy (now DoEE)
DPIR	Department of Primary Industries and Resources (Northern Territory)
EA Act	Environmental Assessment Act 1982 (Northern Territory)
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EN	Endangered
EPBC Act	Environment Protection and Biodiversity Conservation Act (Commonwealth)
ESCP	Erosion and Sediment Control Plan
FFMP	Flora and Fauna Management Plan
IBRA	Interim Biogeographic Regionalisation of Australia
Km	Kilometres
LES	Low Ecological Services P/L
Ma	Marine
Mi	Migratory
MM Act	Mine Management Act
MMP	Mine Management Plan
MNES	Matters of National Environmental Significance
MP	Management Plan

NA	Not applicable
Nt	Near Threatened
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NTVIS	Northern Territory Vegetation Information System
PMST	EPBC Protected Matters Search Tool
PPL	Perpetual Pastoral Lease
SoBS	Sites of Botanical Significance
SoCS	Sites of Conservation Significance
TPWC Act	Territory Parks and Wildlife Conservation Act
VU	Vulnerable
WoNS	Weed of National Significance

DOCUMENT CONTROL

DISCLAIMER

This document has been prepared by Low Ecological Services (LES) for PNX Metals Ltd in accordance with an agreement with PNX Metals Ltd. LES has prepared this document using the skill and care expected from professional scientists to provide factual and technical information and reasonable solutions to identified risks. It does not constitute legal advice.

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PREFACE

All information on proposed operations contained in this document has been supplied by PNX Metals via ERIAS Group.

1 EXECUTIVE SUMMARY

Mt Bonnie, Iron Blow and Fountain Head are existing, non-operational mine sites located in the Pine Creek region approximately 170 km south of Darwin, Northern Territory (NT) and approximately 6 km east of the Stuart Highway. Historic mining activities have occurred at both Mt Bonnie and Iron Blow between 1912 and 1916 followed by a second phase in 1983 and 1985 when an open cut mine was established. In 2014, PNX Metals acquired the 13 mining leases (MLs) containing Iron Blow and Mt Bonnie polymetallic deposits and entered into a separate agreement with Newmarket Gold Australia to utilise the 4 MLs on which the Fountain Head site are located. PNX Metals aim to develop the Hayes Creek Zinc, Gold and Silver Project ('the Project') at the Mt Bonnie and Iron Blow deposits and use Fountain Head as the processing site. Project Roads will link the three sites. All three sites are previously disturbed from historic mining activities.

PNX Metals commissioned Low Ecological Services P/L (LES) through ERIAS Group to undertake an on-ground flora and fauna survey at Hayes Creek to accompany an NOI to develop the project. A desktop assessment was undertaken to provide prior information of the existing environment within the survey areas and the likelihood that threatened species may occur in the areas.

An on-site flora and fauna survey of the Hayes Creek survey area was undertaken from 15th – 18th May 2017 to assess flora and fauna presence post wet-season. This survey was designed to gain a detailed understanding of the environment of the survey areas, as well as to target survey species of conservation significance identified by desktop review. Survey sites were chosen to incorporate the main habitat types in each area. Riparian and aquatic habitat was surveyed and assessed for species of conservation significance, with no fish, two water varanids and fresh water crocodiles expected in the area. Trapping, spotlighting, bird surveying and vegetation assessments were undertaken at each survey site in line with NT EPA *Guidelines for Assessment of Impacts on Terrestrial Biodiversity* (NT EPA, 2013). Additionally, motion-sensing cameras, spotlighting, call playback, night time area searches and bat detectors were used to detect species that are difficult to detect by other employed methods.

Six main habitats were surveyed during the post-wet season survey of the Hayes Creek area. *Eucalyptus* woodland on sandstone plains and *Eucalyptus* woodland on low sandstone hills were the predominant habitats in the survey area. 170 flora species from 41 families were identified across five of these habitats in the survey area. No flora species of conservation significance were identified during the survey. In particular, targeted threatened species, *Acacia praetermissa* and *Stylidium ensatum* were not recorded in habitat deemed to be appropriate to those species. Sixteen introduced species were recorded throughout the survey. including 2 declared Weeds of National Significance (WoNS). WoNS recorded within the survey sites included gamba grass (*Andropogon gayanus*) and Olive hymenachne (*Hymenachne amplexicaulis*). Flora species recorded during the survey and declared as weeds in the NT were snakeweed (*Stachytarpheta jamaicensis*), hyptis (*Hyptis suaveolens*), candlestick bush (*Senna alata*) and spinyhead sida (*Sida acuta*).

Eighty-six native fauna species were recorded during the on-ground survey of the Hayes Creek project. This included five amphibians, 66 bird species, nine mammals and nine reptile species. Two threatened fauna species were recorded during targeted survey effort for 22 potential threatened species identified by the NT Fauna Atlas and PMST. The Gouldian finch (*Erythrura gouldiae*), listed as endangered under the EPBC Act, was recorded north of the Mt Bonnie site. Merten's water monitor (*Varanus mertensii*), listed as vulnerable under the TPWC Act, was recorded through anecdotal

evidence (confirmed via photograph) in the existing Iron Blow pit. No fauna species listed as migratory were recorded during the May 2017 on-ground survey. Four species listed as near-threatened under the TPWC Act were recorded during the survey; buff-sided robin (*Poecilodryas cerviniventris*), bush-stone curlew (*Burhinus grallarius*), orange leaf-nosed bat (*Rhinonictis aurantia*) and northern ridge-tailed monitor (*Varanus primordius*). Three EPBC listed marine species were recorded within the survey area during the May 2017 survey; freshwater crocodile (*Crocodylus johnsoni*), great egret (*Ardea alba*) and cattle egret (*Ardea ibis*). Six introduced fauna species were recorded during the survey. These were black rat (*Rattus rattus*), cane toad (*Rhinella marina*), cat (*Felis catus*) cattle (*Bos taurus*), feral pig (*Sus scrofa*) and water buffalo (*Bubalus bubalis*).

The potential for significant impacts was assessed on 35 threatened, migratory and marine species listed under the EPBC Act and/or TPWC Act that were recorded during surveys or have a moderate to high likelihood of occurring in the Project area. These species were assessed using the criteria set out in the *Significant Impact Guidelines 1.1-Matters of National Environmental Significance* (Department of Environment, 2013). No species was determined likely to be significantly impacted by the development of the Hayes Creek Project.

Risks to biodiversity were identified, including direct and indirect impacts. These risks to biodiversity included vegetation clearing, weeds, bushfires, impact of grazing species, impact of introduced predators, changes to surface water, sedimentation and erosion and risks to riparian zones. Preliminary management and mitigation recommendations are summarised, addressing the risks to biodiversity and threats to matters of national environmental significance (MNES) identified as potentially occurring within the Project area.

Seasonal variation in plant and fauna occurrence is common in northern Australia. It is therefore proposed that a late dry season survey is conducted to determine if any threatened species are present or detectable in the survey area seasonally. In addition, further fine-scale characterisation of potential Gouldian Finch breeding habitat within the project area is recommended to be incorporated into the dry season survey activities, to confirm the potential impacts of the proposed project on Gouldian Finches. Based on the results of the May 2017 survey, it is assessed as being unlikely that the Project development will result in significant impact to threatened species and communities and migratory species listed under the EPBC Act, and species listed under the TPWC Act.

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1 INTRODUCTION

1.1 Overview

Mt Bonnie, Iron Blow and Fountain Head are existing, non-operational mine sites located in the Pine Creek region approximately 170 km south of Darwin, Northern Territory (NT) and approximately 6 km east of the Stuart Highway (Figure 1). The Fountain Head lease area falls within the Ban Ban Springs pastoral station. Historic mining activities occurred at both Mt Bonnie and Iron Blow between 1912 and 1916 and a second phase of mining occurred between 1983 and 1985 when an open cut mine was established. In 2014, PNX Metals acquired 13 mining leases (MLs) containing Iron Blow and Mt Bonnie polymetallic deposits and entered into a separate agreement with Newmarket Gold Australia to utilise the 4 MLs on which the Fountain Head site are located. PNX Metals aim to develop the Hayes Creek Zinc, Gold and Silver Project ('the Project') at the Mt Bonnie and Iron Blow deposits and use Fountain as the processing site. The Project Roads will link the three sites. All three sites are previously disturbed from historic mining activities.

Existing infrastructure and disturbance at the sites includes Mt Bonnie open pit, Mt Bonnie waste rock dump (WRD), historical exploration disturbance, tailing storage facilities, dams (containing freshwater and contaminated water), process plant site and associated access roads. Planned developments within the Project area include the expansion and mining of the existing open pit at Mt Bonnie, development of an underground mine at Iron Blow, development of a processing plant at Fountain Head and expansion of existing haul roads connecting production areas.

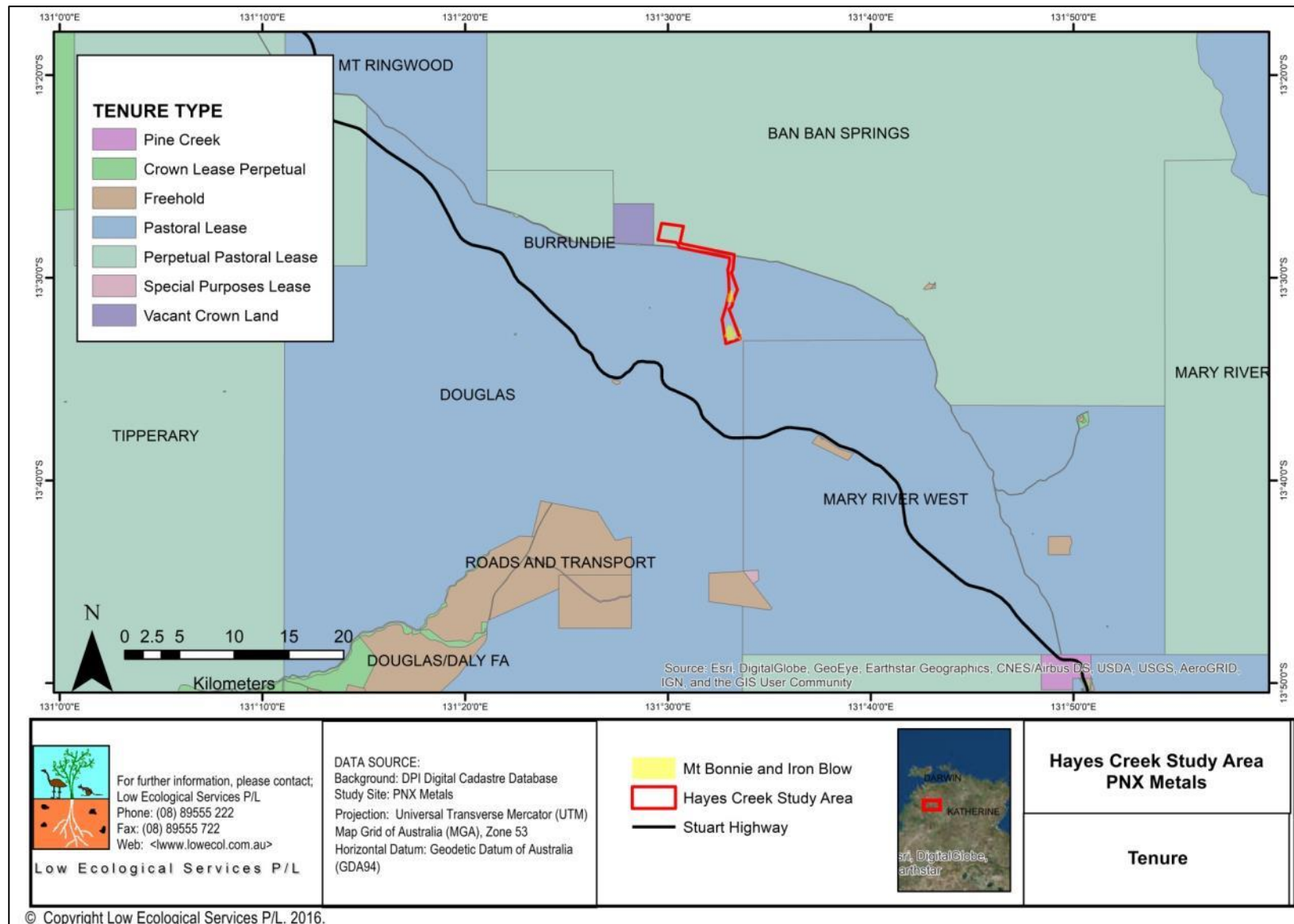


Figure 1: Location of the Hayes Creek study area in relation to crown lease, freehold land, pastoral lease and vacant crown land

1.2 Purpose of this report

PNX Metals commissioned Low Ecological Services P/L (LES) through ERIAS Group to undertake an on-ground flora and fauna survey across areas defined by PNX Metals at Mt Bonnie, Iron Blow and Fountain Head, as well as along proposed haul road expansion areas (referred to as 'the study area') (Figure 1). A desktop assessment was undertaken to provide prior information of the existing environment of the survey areas and the likelihood that threatened species may occur in the areas.

The on-ground survey was based on the findings of the desktop assessment. Flora and fauna species observed in all major habitat types were recorded, and targeted surveying for threatened species identified in the desktop assessment was undertaken. Introduced flora and fauna species and existing disturbance within the survey area were also recorded. Surveys were designed in line with the NT EPA "*Guidelines for Assessment of Impacts on Terrestrial Biodiversity*", the "*Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping*" and the EPBC guidelines for threatened species including *Survey guidelines for Australia's threatened mammals* (Department of Sustainability, Environment, Water, Population and Communities, 2011) and *Survey guidelines for Australia's threatened reptiles* (Department of Sustainability, Environment, Water, Population and Communities, 2011).

The scope of the assessment was to:

- Characterise the vegetation and habitat types;
- Identify any flora and fauna species listed under the Environmental Protection and Biodiversity Conservation Act (EPBC Act) or Territory Parks and Wildlife Conservation Act (TPWC Act) present or likely to be present in the Project area;
- Identify any introduced flora and fauna, assess their abundance and identify any potential source populations that may impact the Project area;
- Identify survey control sites for future monitoring programs;
- Assess the impact of introduced herbivores to the project area and outline mitigation measures;
- Assess the potential for any significant impacts on threatened (as classified by the EPBC Act or TPWC Act) flora and fauna species and communities as a result of the project, including initial assessment of aquatic ecology;
- Recommend management and mitigation measures specific to any species at risk from the project as well as significant species;
- Assess residual impacts of historical disturbance; and
- Outline the impacts of bushfires to flora and fauna in the region and identify threatened species potentially at risk from bushfire.

1.3 Legislative context

1.3.1 Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act is the Australian Government's key piece of environmental legislation which commenced on July 16, 2000. The objects of the EPBC Act are to provide for the protection of matters of national environmental significance (MNES) and to promote the conservation of biodiversity. The EPBC Act focuses Australian Government interests on the protection of MNES, with the states and territories having responsibility for matters of state and local significance. The EPBC Act identifies MNES as:

- World heritage properties;
- National heritage places;
- Wetlands of international importance (Ramsar wetlands);
- Threatened species and ecological communities;
- Migratory species;
- Commonwealth marine areas;
- Great Barrier Reef Marine Park;
- Nuclear actions (including uranium mining); and
- A water resource, in relation to coal seam gas development and large coal mining development.

1.3.2 State legislation

Northern Territory Parks and Wildlife Conservation Act 2000

The NT *Parks and Wildlife Conservation Act 2000* (TPWC Act) is “an Act to make provision for and in relation to the establishment of Territory Parks and other Parks and Reserves, and the study, protection, conservation and sustainable utilisation of wildlife”. Under the TPWC Act, all threatened species are classed as protected wildlife. The Act includes ‘Principles of Management’, which require that a threatened species be managed in a manner that “maintains or increases their population or the extent of their distribution at or to a sustainable level.

Environmental Assessment Act 1982 (EA Act) and Environmental Assessment Administrative Procedures 1984

The EA Act and the Environmental Assessment Administrative Procedures 1984 is administered by the NT Environmental Protection Agency (EPA). The Act provides a framework for the assessment of potential environmental impacts of developments. The object of the Act is to ensure that matters affecting the environment to a significant extent are fully examined and taken into account in decisions by the Northern Territory Government. The assessment process also evaluates the effectiveness of the proposed safeguards to mitigate these impacts during construction and operational phases of the development.

Mining Management Act 2001

The *Mining Management Act 2001* (MM Act) is administered by the Department of Primary Industry and Resources (DPIR). The objectives of the MM Act are to ensure that mining in the NT is conducted in accordance with best practice standards for health, safety and the environment. Under the MM Act, an application for authorisation to carry out mining activities must include a Mining Management Plan (MMP).

Weeds Management Act 2001

The *Weeds Management Act 2001* is administered by the NT Department of Environment and Natural Resources (DENR). The objective of the Act is to prevent the spread of weeds in, into and out of the NT and to ensure that the management of weeds is an integral component of land management. The Act is linked to the *Northern Territory Weeds Management Strategy 1996-2005* which led to a series of Statutory Plans being developed for each declared weed. Declared weeds are grouped into three categories; Schedule A (weeds to be eradicated), Schedule B (Weeds which growth and spread must be controlled) and Schedule C (weeds not to be introduced to the Territory).

Other legislation that may be applicable to the proposed mine includes:

General:

- *Mineral Titles Act 2016.*

- *Northern Territory Environmental Protection Authority Act 2012.*

Land Use:

- *Planning Act 2016.*
- *Aboriginal Land Act 2013.*
- *Crown Lands Act 2014.*
- *Soil Conservation and Land Utilization Act 2016.*
- *Bushfires Act 2014.*
- *Pastoral Land Act 2016.*

Cultural and Heritage:

- *Northern Territory Aboriginal Sacred Sites Act 2013.*
- *Heritage Act 2016.*

Water Quality and Biodiversity Conservation:

- *Water Act 2016.*
- *Biological Control Act 2016.*
- *Public and Environmental Health Act 2016.*
- *Weeds Management Act 2013.*

Air Quality, Noise and Waste Management:

- *Waste Management and Pollution Control Act 2016.*
- *Public and Environmental Health Act 2016.*

Safety and Environmental Compliance:

- *Work Health and Safety (National Uniform Legislation) Act 2016.*
- *Environmental Offences and Penalties Act 2011.*
- *Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act 2016.*
Dangerous Goods Act 2012.

2 METHODS

2.1 Desktop review

Literature and database searches were undertaken to gain an understanding of the ecological context of the survey areas. Data collated from database searches provided information on the fauna and flora species known to occur in the region, particularly those of conservation significance. GIS mapping and a search of Australian Bureau of Meteorology (BoM) climate data were undertaken to provide an overview of the climate, soils, vegetation and habitats of the lease areas and surrounds. A literature review was performed to obtain an understanding of data available and validity thereof, within and surrounding the lease areas.

2.1.1 Database review

A database review including GIS mapping was undertaken using several data sources to provide an ecological context of the landscape, vegetation, habitats and climate of the lease areas. The sources include:

- Climate data online (BoM, 2016);
- Interim Biogeographic Regionalisation of Australia (IBRA) (Thackway & Cresswell, 1995);
- Digital Atlas of Australian Soils (Northcote, 1968);
- NTVIS - NT Data Compilation for the National Vegetation Information System to determine vegetation communities present in the lease areas (ESCAVI, 2003)
- Vegetation Survey of the Northern Territory Australia: Notes to accompany 1: 100, 000 Map Sheets (Wilson, et al., 1990);
- Report on the land systems of Northern Australia (Lynch, et al., 2012);
- Fire history from the North Australia and Rangelands Fire Information (2017);
- Google Earth imagery;
- North Australian Fish Atlas (JCU, 2017); and

Database searches provide lists of species of conservation significance that occur or are likely to occur within the vicinity of the survey area. Species of conservation significance are those that are listed as such under the EPBC Act and/or TPWC Act.

Geology, soil, land system and vegetation mapping were studied to identify habitats present within the survey areas. This was then cross-referenced with information on threatened species habitat requirements obtained from the published literature and habitats in which mapped records occur, to determine if threatened species habitat is present or likely to be present. Each species listed as threatened was then given a likelihood of occurrence in the lease areas of either: none, low, moderate, high or present (Table 1).

The Commonwealth Government Department of the Environment and Energy (DoEE) Protected Matters Search Tool (PMST) identifies Matters of National Environmental Significance (MNES) that may occur in a given area. The PMST is based on predicted distributions of EPBC listed flora and fauna species and communities and/or their habitat, rather than known records. The PMST may predict the occurrence of a species or community in an area when there are no documented records from the area. A PMST search was conducted within a 20 km radius around the survey area (see Appendix 1 for full PMST report) to provide potential lists of species which could still exist in the local areas of interest.

The same area was searched on the NT Species Atlas which is maintained by the Department of Environment and Natural Resources (DENR) and includes the NT Fauna Atlas, NT Flora Atlas, Sites of Conservation Significance (SoCS) and Sites of Botanical Significance (SoBS), the NT Fauna and Flora Atlas search provided a list of records of threatened, non-threatened and introduced fauna and flora species. A search of Sites of Conservation Significance (SoCS) and Sites of Botanical Significance (SoBS) was also undertaken to determine any SoCS or SoBS in the vicinity of the survey area.

Table 1. Likelihood of occurrence ranking criteria for EPBC and TPWC listed species.

Likelihood of occurrence	Threatened flora criteria	Threatened fauna criteria
Present	The species was observed within the study area	The species was observed within the study area
High	It is likely that the species inhabits or utilises habitat within the study area	It is likely that the species inhabits or utilises habitat within the project area
Moderate	Potential habitat for species occurs within the area. Field surveys will determine whether there is a 'high' or 'low' likelihood of species presence in the study area.	Potential habitat for a species occurs on the site and the species may occasionally utilise that habitat. Species unlikely to be wholly dependent on the habitat present within the study area.
Low	It is unlikely the species inhabits the project area	It is unlikely the species inhabits the project area. If present the species is likely only a transient visitor due to lack of adequate resources such as limited breeding habitat areas.
None	The species has not been recorded within the habitat area and habitat within the study area is unsuitable for species.	The species has not been recorded within the habitat area and habitat within the study area is unsuitable for species.

2.1.2 Literature review

A literature review provided information on the species occurring or potentially occurring within the lease areas and surrounds. Information was collated to assess the potential for species of conservation significance to occur within the lease areas and surrounds, and the likelihood that proposed operations would impact on these species of conservation significance. Sources of literature reviewed include:

- Species Profile and Threats Database (DoEb, 2015) for information about species listed in the EPBC Act including information sheets, survey guidelines, recovery plans, and Threat Abatement Plans for Key Threatening Processes;
- Northern Territory Threatened Species fact sheets published by DENR;
- DENR Sensitive vegetation in the Northern Territory Factsheets (DLRM, Undated); and
- Scientific literature.

2.2 Field surveys

An on-site flora and fauna survey of the Hayes Creek study area was undertaken from 15th-18th of May 2017, allowing for traps to be set for three consecutive nights. This survey was designed to gain a more detailed understanding of the environment of the survey area, as well as to survey for species of conservation significance. Six survey sites in total were chosen for detailed surveying and establishment of trapping grids (

Figure 2). Three of these sites were situated in the production areas, one in each area targeting habitat types potentially important to targeted species. Three additional sites were established as control sites in undisturbed habitat types corresponding to those identified within production areas. Control sites were placed adjacent to the survey areas identified by PNX in order to avoid habitat already disturbed by previous mining activity. Motion-sensing cameras were set up in habitats identified as potentially suitable for one or more targeted threatened species. Three were located at live-trapping sites whilst four were placed in other sites (

Figure 2, Table 2). Co-ordinates for the survey sites are provided in Appendix 2.

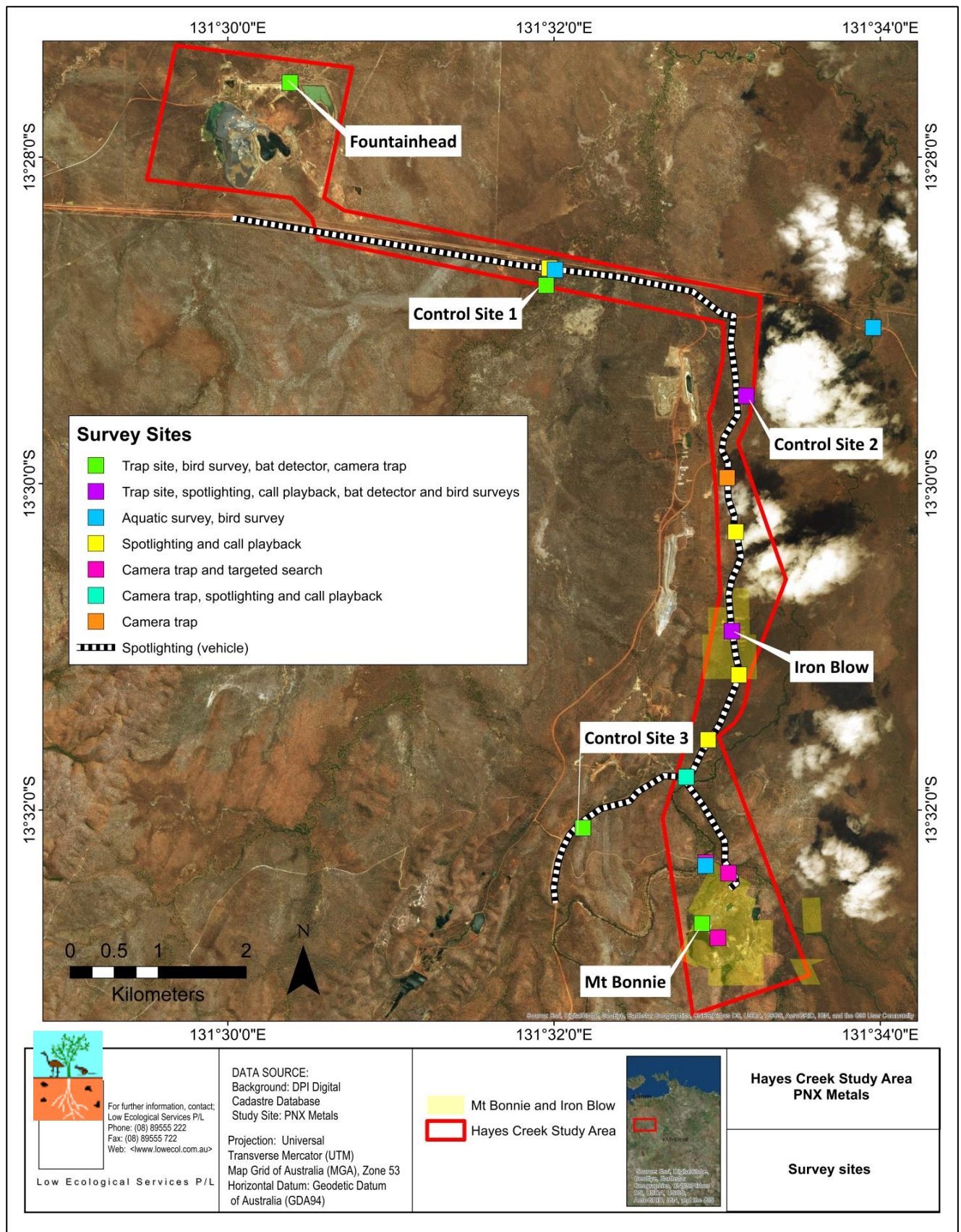


Figure 2: Location of trapping, camera, bat detector, bird, targeted search, aquatic and spotlight sites for surveys undertaken by LES of the Hayes Creek Project area.

Table 2. Habitat type methodology used at each site during the May 2017 on-ground survey of the Hayes Creek Project area

Land System/Habitat	Site	Location	Vegetation Transect	Site Description	Trapping	Bat detector	Bird Surveys	Secondary sign survey	Area search	Motion-sensing camera	Spotlighting	Call playback	Aquatic survey
Alluvial floodplain, swamps, drainage depressions; <i>Melaleuca</i> forest	Fountain Head trap site	Pastoral bordering creek, north side of cleared production site	X	X	X	X	X	X	X	X			
	Control trap site 1	South of haul road, adjacent to Yam Creek	X	X	X	X	X	X	X	X	X	X	
	Spotlighting	Haul road and adjacent areas					X	X	X		X	X	
	Targeted bird site	North-west edge of Fountain Head dam					X						
	Aquatic assessment	Yam Creek		X			X	X	X				X
Sandstone plains and rises; <i>Eucalyptus tectifica</i> woodland over <i>Sorghum</i> spp. grassland	Iron Blow trap site	East of existing pit	X	X	X	X	X	X	X		X	X	
	Control trap site 2	North end of Mt Bonnie-Iron Blow haul road	X	X	X	X	X	X	X				
	Nocturnal survey site	South end of haul road							X		X	X	
	Plains camera site	North end of haul road		X			X		X	X	X	X	
Sandstone hills; <i>Eucalyptus tintinnans</i> woodland over <i>Sorghum</i> sp. And <i>Heteropogon</i> sp. grassland	Mt Bonnie trapping site	South-west of existing pit	X	X	X	X	X	X	X	X	X		
	Control trap site 3	North-west of Mt Bonnie	X	X	X	X	X	X	X	X			
	Nocturnal survey site	South end of haul road and 1 st creek crossing									X	X	
	Gouldian camera site	South end of haul road, turn-off to Mt		X			X		X	X			

Land System/Habitat	Site	Location	Vegetation Transect	Site Description	Trapping	Bat detector	Bird Surveys	Secondary sign survey	Area search	Motion-sensing camera	Spotlighting	Call playback	Aquatic survey
Alluvial floodplain, swamps, drainage depressions; <i>Melaleuca</i> forest	Fountain Head trap site	Pastoral bordering creek, north side of cleared production site	X	X	X	X	X	X	X	X			
	Control trap site 1	South of haul road, adjacent to Yam Creek	X	X	X	X	X	X	X	X	X	X	
	Spotlighting	Haul road and adjacent areas					X	X	X		X	X	
	Targeted bird site	North-west edge of Fountain Head dam					X						
	Aquatic assessment	Yam Creek		X			X	X	X				X
		Bonnie											
Creeks and riparian areas;	Targeted bird survey	East side of Mt Bonnie dam					X	X	X				
	Targeted quoll search	Waste rock dump south of existing pit						X	X				
	Riparian camera	Creek crossing 2 – north of Mt Bonnie site		X			X	X	X	X	X		
	Aquatic survey/Riparian camera	Under rail bridge north-west of Mt Bonnie production site		X			X	X	X	X			X
	Targeted riparian fauna search	Creek crossing 1 – north of Mt Bonnie site					X	X	X		X	X	

2.2.1 Landscape, vegetation and flora surveys

Characterisation of vegetation communities across the site was undertaken using a combination of vegetation quadrats, transects and driving transects or walking meanders across the site according to standard survey requirements.

A site description was carried out within a 50 m x 50 m quadrat at each of the six survey sites as well as the four camera trapping sites and eight additional sites of interest (Table 2). Site descriptions provided an overall snapshot of the landscape, geology, soil, dominant flora species and vegetation structure and density at each site (see Appendix 3). The presence of termite mounds and woody debris, impact from disturbance, weeds and current vegetation condition were also noted. Photographs were taken at each site representative of the landscape and vegetation community, facing north, south, east and west. A complete list of all flora species present within each quadrat was collated by doing a walkover of the quadrat. Voucher specimens were taken where plants could not be identified in the field. Botanists at the Northern Territory Herbarium, Darwin, identified voucher specimens.

At each of the six trapping sites, 100 m vegetation transects were conducted. Flora species present were recorded at 1 m intervals and classified according to height class (see Appendix 4). Percentage vegetation cover by height class was calculated providing a representative vegetation cover assessment for each site.

2.2.2 Fauna surveys

General survey methodology follows the NT EPA *Guidelines for Assessment of Impacts on Terrestrial Biodiversity* (NT EPA, 2013).

Survey methods used to determine the presence of threatened species follow those suggested in the *Survey Guidelines for Australia's Threatened Mammals* (Department of Sustainability, Environment, Water, Population and Communities, 2011a) *Survey Guidelines for Australia's Threatened Bats* (Department of the Environment, Water, Heritage and the Arts, 2010), *Survey Guidelines for Australia's threatened reptiles* (Department of Sustainability, Environment, Water, Population and Communities, 2011) and *Survey Guidelines for Australia's Threatened Birds* (Department of the Environment, Water, Heritage and the Arts, 2010). Targeted searches were conducted on-ground for threatened species that may occur within the appropriate habitat in the survey area as identified by the PMST and NT Flora and Fauna Atlases.

Surveys were also undertaken to target other species listed as threatened under the EPBC Act and TPWC Act identified by the PMST and NT Fauna Atlas as occurring or potentially occurring within the survey areas (Table 3).

Table 3. Type of survey undertaken to target species listed as threatened under the EPBC Act and TPWC Act potentially occurring within the survey areas

Scientific name	Common name	Habitat search	Trapping	Bat detector	Secondary sign survey	Area search	Motion-sensing camera	Spotlighting	Call playback
<i>Erythrorchris radiatus</i>	Red goshawk	X				X			
<i>Erythrura gouldiae</i>	Gouldian finch	X				X	X		
<i>Geohaps smithii</i>	Partridge pigeon	X				X	X		
<i>Rostratula australis</i>	Australian painted snipe	X				X			
<i>Tyto novaehollandiae kimberli</i>	Masked owl	X						X	X
<i>Antechinus bellus</i>	Fawn antechinus	X	X				X	X	
<i>Dasyurus hallucatus</i>	Northern quoll	X	X		X		X	X	
<i>Macroderma gigas</i>	Ghost bat	X		X					
<i>Mesembriomys gouldii gouldii</i>	Black-footed tree-rat	X	X		X		X	X	
<i>Phascogale pirata</i>	Northern brush-tailed phascogale	X	X				X	X	
<i>Rattus tunneyi</i>	Pale field-rat	X	X				X	X	
<i>Saccolaimus saccolaimus nudiclunatus</i>	Bare-rumped sheath-tailed bat	X		X					
<i>Varanus mertensi</i>	Merten's water monitor	X	X			X	X		
<i>Varanus mitchelli</i>	Mitchell's water monitor	X	X			X	X		
<i>Varanus panoptes</i>	Floodplain monitor	X	X			X	X		

Habitat search

Searches for potentially suitable habitat for threatened species were undertaken while traversing the survey area.

Trapping

Elliott, cage and funnel traps were used at all sites. A box of 20 Elliott traps at 10 m spacing was laid out at each of the trapping sites with a cage trap placed on the outside of each box corner (NT EPA, 2013). Layout of Elliott traps was modified slightly at sites falling within the alluvial floodplain areas (Fountain Head site and control site 1). A grid pattern replaced the standard box pattern in order to incorporate more of the site variation including creek banks, creek beds and floodplain areas. Both Elliott traps were baited with a mixture of peanut butter and oats. Cage traps were baited with sardines or tuna. Eight funnel traps were placed randomly within the grid of Elliott traps in pairs of two. Each pair of funnel traps was situated along a 10 m drift fence. When possible, pitfall traps were used, with a 10 m drift fence centred over the trap and two of the funnel traps placed at either end. Pitfall traps were installed at two of the six survey sites due to the difficulty of digging in the rocky substrate. All traps were checked each morning and animals processed (i.e. noting species, sex, reproductive status, body length and tail length) and released at the point of capture. Elliott traps were closed during the day and then opened in late afternoon when pitfall and funnel traps were re-checked.

Bat detectors

Two bat detectors were deployed at six sites encompassing the six trapping survey areas. The bat detectors were used to identify the bat species using each habitat and to determine if the threatened species, bare-rumped sheath-tailed bat and ghost bat were present. Echolocation calls recorded were identified for each species when possible and assigned to a species group when echolocation call structure overlapped. Bats were identified from the recordings by bat expert, Dennis Matthews.

Secondary sign surveys

Searches for secondary sign of fauna species (e.g. tracks and scats) were undertaken within a 250 m x 200 m quadrat at each site.

Area search

Area searches were undertaken at each of the trapping sites and camera sites while vegetation surveys were being undertaken and opportunistically while checking and setting traps. Additional targeted area searches were conducted in habitat types identified for a number of target threatened species (Table 3).

Motion-sensing camera surveys

Motion-sensing cameras were deployed at seven sites in total to increase the likelihood of recording species not detected by other methods or verify species presence. Three camera sites fell within live-trapping survey sites whilst four were placed in additional habitat areas. Cameras were set to take pictures when triggered by movement. Camera traps were baited with either peanut butter and oats or sardines depending on the targeted species. Six cameras were set facing vertically, and one was set facing horizontally. Vertically oriented cameras are useful for the detection of larger animals including dingoes, cats and monitors whilst horizontally oriented cameras target smaller animals where body measurements are required for identification purposes.

Spotlighting

2-3 hours of spotlighting was conducted on each night of the survey, by vehicle and on foot. Vehicle spotlighting was undertaken along a transect spanning the full survey area (utilising existing tracks only).

Spotlighting on foot was undertaken at 9 sites within the survey areas. At each site, a walkover was undertaken while searching for eye-shine or movement of animals with a torch.

Call-playback

Call-playback was undertaken for masked owls following the method of Ward (2010), whereby:

- i) The call of the masked owl is broadcast
- ii) For the first five minutes after the broadcast, surveyors listen for calls of masked owls and watch for silhouettes of birds flying in the area around the speaker without a spotlight
- iii) In the second five minutes surveyors keep listening for owl calls but use a spotlight to look for owls in the trees around the site
- iv) When spotlighting, the surveyors do an initial scan of all the nearby trees, then spend the rest of the five minutes doing a more-careful search of the trees for owls and small mammals (potential prey)

Incidental observations

Incidental observations of fauna species were recorded at all times and all habitats during the field surveys.

2.2.3 Aquatic and riparian habitat assessments

Streams and waterbodies within the survey area were categorised according to stream order (DLRM, Undated). The Strahler stream classification system was utilised where waterways are given an 'order' according to the number of additional tributaries associated with each waterway (DLRM, 2016b) (Figure 3). Stream order was then used to determine recommendations for riparian zone buffers around affected waterways within the Project area (Table 4).

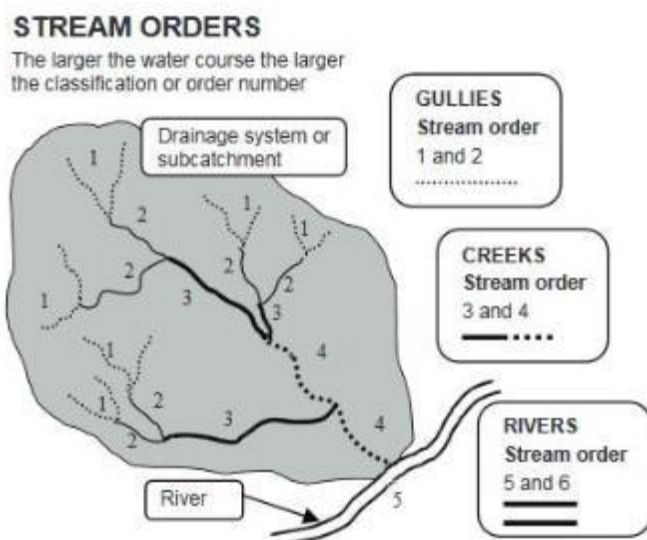


Figure 3. Stream orders as defined by the Strahler stream classification system (DLRM, Undated)

Table 4. Waterway buffers according to stream order (DLRM, Undated).

Waterway	Stream order	Minimum buffer width (m)	Measure from
Drainage area	Not applicable	25	The outer edge of the seepage zone
Intermittent streams	First	25	The outer edge of riparian vegetation, where mapped otherwise the primary bank of the outer stream channel where there is more than one channel or the stream is braided
Intermittent streams	Second	50	As above
Creeks	Third and fourth	100	As above
Rivers	Fifth and sixth	250	As above
Wetlands (e.g. swamps, lakes, billabongs) and mangroves	Not applicable	200	The outer edge of areas that are inundated or saturated at a frequency to at times support plants and/or animals adapted to saturated and/or inundated conditions. The water may be static or flowing fresh, brackish or salt, including areas of coastal marine waters.

Aquatic habitat assessments followed relevant sections extracted from the NT AusRivAS Manual. The assessment considered the suitability of habitats in terms of habitat diversity and extent, suitability for aquatic fauna groups, existing disturbances/modifications and riparian condition. Specific habitat features were recorded including substrate characteristics, habitat attributes and variety, vegetation and streamside cover, bank stability and presence of erosion. One site was assessed in the south and north of the study area and a downstream site was assessed for comparison (Figure 4).

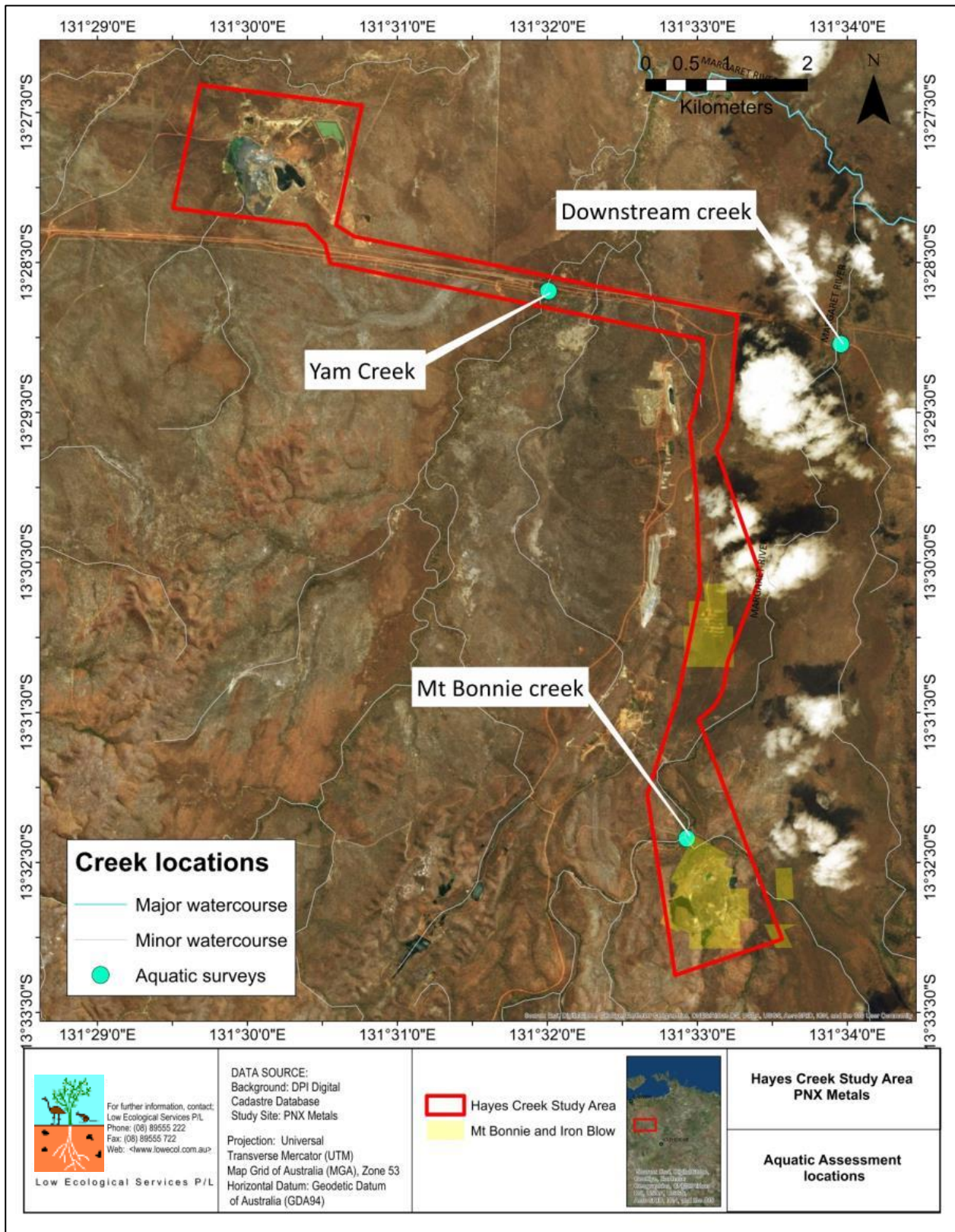


Figure 4. Location of aquatic habitats assessed during the May 2017 on-ground survey of the Hayes Creek Project Area

2.2.4 Other

GPS locations and extent of weed infestations were recorded. Where possible, GPS locations of large mature trees of cultural significance were taken.

2.2.5 Limitations of the surveys

Records obtained from the NT Fauna and Flora Atlases display records from areas which have been surveyed previously. The lack of records at a locality commonly represents a lack of survey effort as opposed to the absence of various species in the area.

While invertebrates captured in traps were recorded, there are limited existing data and identification tools available for terrestrial invertebrates in the Top End. Therefore, only casual attempt was made to identify any trapped invertebrates to group, genus or species level. No targeted survey for invertebrates was undertaken during the on-ground survey, as this was not a part of the scope of works.

LES has attempted to carry out surveys at an appropriate spatial scale for the proposed development. While this will increase the chances of obtaining sufficient data required to detect the presence of threatened species, it cannot be guaranteed that the species lists are complete.

Surveys were aimed at detecting appropriate landscapes and assessing the potential presence of threatened species within the survey areas. Population surveys for abundance and density were not conducted within the survey areas and surrounds.

2.3 Calculation of habitat loss

The layout of the Project footprint (synonymous with the 'area' provided by PNX Metals) was overlaid on habitat, vegetation and soil mapping of the Project area. The area of each habitat was calculated in ArcGIS along with the area of habitat to be affected by proposed developments. Proposed clearing was assumed to be restricted to the proposed expansion of the haul road connecting the Mt Bonnie and Iron Blow production sites with existing haul roads in the north and south of the Project area based on information provided by PNX Metals. All additional developments associated with the project are proposed to be restricted to previously disturbed areas within the Project area.

2.4 Significant impact assessment methods

An impact assessment was conducted in accordance with the Threatened Species Assessment Guidelines (DoE, 2013), assessing impacts on MNES and on state-listed threatened species from the construction, operation and decommissioning and rehabilitation of the project. Species considered further in assessments of significance relevant to legislation, were those in the 'Known' to 'Moderate' categories and where impacts could reasonably occur to identified threatened species. Threatened species identified in the desktop assessment were assessed for their likelihood of occurrence based on appraisal of NT Fauna and Flora Atlas and PMST search tool, assessment of habitat present in the study area, literature review concerning identified threatened species and field survey results.

Following DoE (2013), an action is likely to have a significant impact on a **critically endangered** or **endangered** species if there is a real chance or possibility that it will:

- Lead to a long-term decrease in the size of a population;
- Reduce the area of occupancy of the species;
- Fragment an existing population into two or more populations;

- Adversely affect habitat critical to the survival of a species;
- Disrupt the breeding cycle of a population;
- Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;
- Introduce disease that may cause the species to decline; or
- Interfere with the recovery of the species.

Following DoE (2013), an action is likely to have a significant impact on a **vulnerable** species if there is a real chance or possibility that it will:

- Lead to a long-term decrease in the size of an important population of a species;
- Reduce the area of occupancy of an important population;
- Fragment an existing important population into two or more populations;
- Adversely affect habitat critical to the survival of a species;
- Disrupt the breeding cycle of an important population;
- Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;
- Introduce disease that may cause the species to decline; or
- Interfere substantially with the recovery of the species.

Following DoE (2013), an action is likely to have a significant impact on a **migratory** species if there is a real chance or possibility that it will:

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

Assessment of other impacts methods have been based on LES's extensive experience in mining, petroleum and other land clearing and rehabilitation projects in central and northern Australia, including but not limited to work with:

- Frances Creek Mine;
- Tellus holdings;
- Newmont Gold Mine; and
- ABM Resources Twin Bonanza Mine.

3 EXISTING ENVIRONMENT

3.1 Climate

The project area has a tropical monsoonal climate, with distinct wet and dry seasons. The closest Australian Bureau of Meteorology (BoM) climate station to the project area with consistent records is the Pine Creek station, located approximately 54 km south of the project. Mean total annual rainfall recorded at Pine Creek station (2011 to 2016) is 1,423 mm, with a wet season from December to March and dry season from May to September (Figure 5). Average temperatures vary little over the year, with mean maximum temperatures being 33.4°C (2000-2011) (Figure 5) and warmest months September to December. Coolest temperatures are during the driest months of June and July with the mean minimum being 30.2°C.

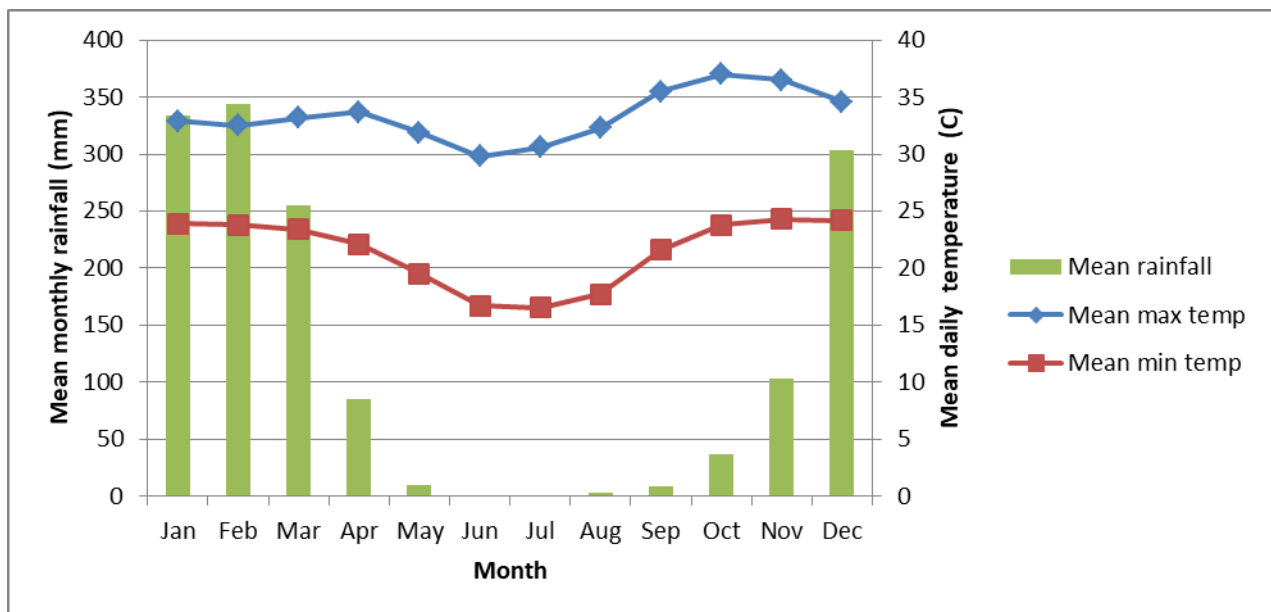


Figure 5: Monthly average rainfall (2000-2016) and average monthly minimum and maximum (2000-2011) temperature at Pine Creek based on data from the BoM's Climate Data Online (Bureau of Meteorology, 2017).

3.2 Bioregion

The Interim Biogeographic Regionalisation of Australia (IBRA) provides a division of Australia into geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information (Department of Sustainability, Environment, Water, Population and Communities, 2012a). The project lies within the Pine Creek bioregion (Figure 6).

The Pine Creek Bioregion consists mainly of rugged ridges with undulating plains (Bastin & ACRIS Management Committee, 2008). Land use types in the bioregion include conservation, pastoralism, intensive rural freehold blocks, horticulture and mining. The bioregion also contains Aboriginal land (Bastin & ACRIS Management Committee, 2008). The Pine Creek bioregion is characterised by extensive and high frequency fire (Bastin & ACRIS Management Committee, 2008).

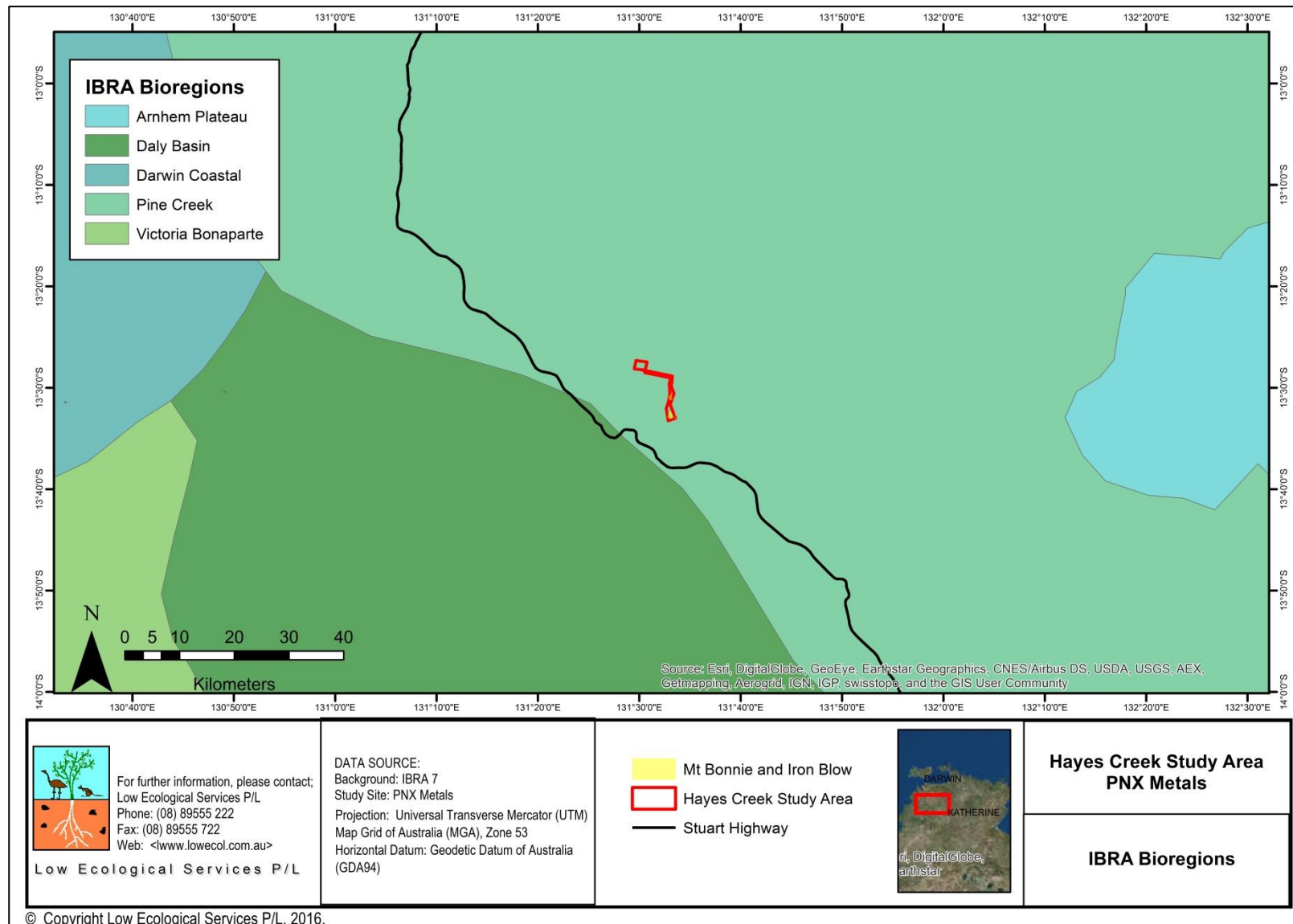


Figure 6: Interim Biogeographic Regionalisation for Australia (IBRA) bioregions in relation to Hayes Creek study area (Department of Sustainability, Environment, Water, Population and Communities, 2012a).

3.3 Hydrology

The surface hydrology of the Project area consists of ephemeral watercourses and waterbodies as well as a number of man-made areas of permanent standing water. All three production sites fall within the Adelaide River catchment area. The Margaret River, a large tributary of the Adelaide River, is situated within a kilometre of the north-east corner of the project area (Figure 7). Tributaries of the Mary River pass through the project area at multiple points along the Mt Wells Haul Road (the existing east-west haul road south of the Fountain Head site) and north of the Mt Bonnie site. These smaller watercourses are ephemeral and can result in large scale flows and associated flooding onto surrounding flood outs during high rainfalls, primarily during the December – March wet season. Smaller creeklines, drainage depressions and ephemeral standing water bodies within the project area provide important water sources for biodiversity during wet periods.

There are no Nationally Important Wetlands within the Project area. The nearest Nationally Important Wetland is Kakadu National Park 42 km east and the Daly River Middle Reaches 49km south-west of the project area. There are no Ramsar Wetlands or Wetlands of National Significance located within the Project area. The nearest Ramsar Wetland is Kakadu National Park, located 42 km east of the Project.

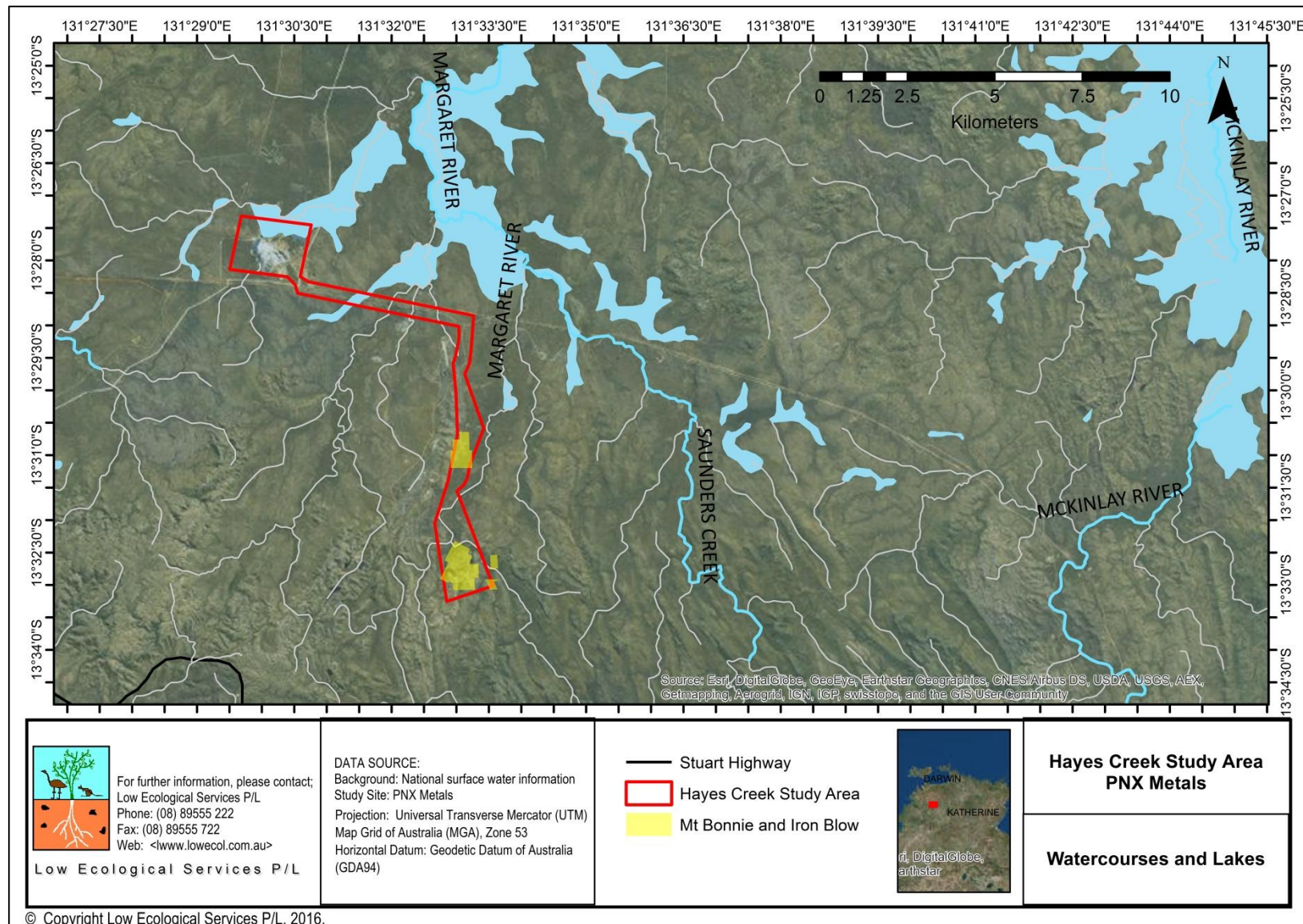


Figure 7: Location of Hayes Creek study area in relation to watercourses.

3.4 Geology

The geological units of the Project area are described in Table 5 and mapped in Figure 8. The Fountain Head area consists of geological unit P4. The Iron Blow and Mt Bonnie production sites sit over geological unit P3.

Table 5: Description of geological units within the Hayes Creek Project Area as described by Ahmad (2000).

Map unit	Rock type	Description
P3	Sedimentary	Greywacke, shale, siltstone, tuff, phyllite, chert, carbonaceous shale, banded iron formation (BIF), dolostone
P4	Sedimentary	Greywacke, shale, siltstone, sandstone
d4	Igneous	Mafic intrusives
g5	Igneous	Granite

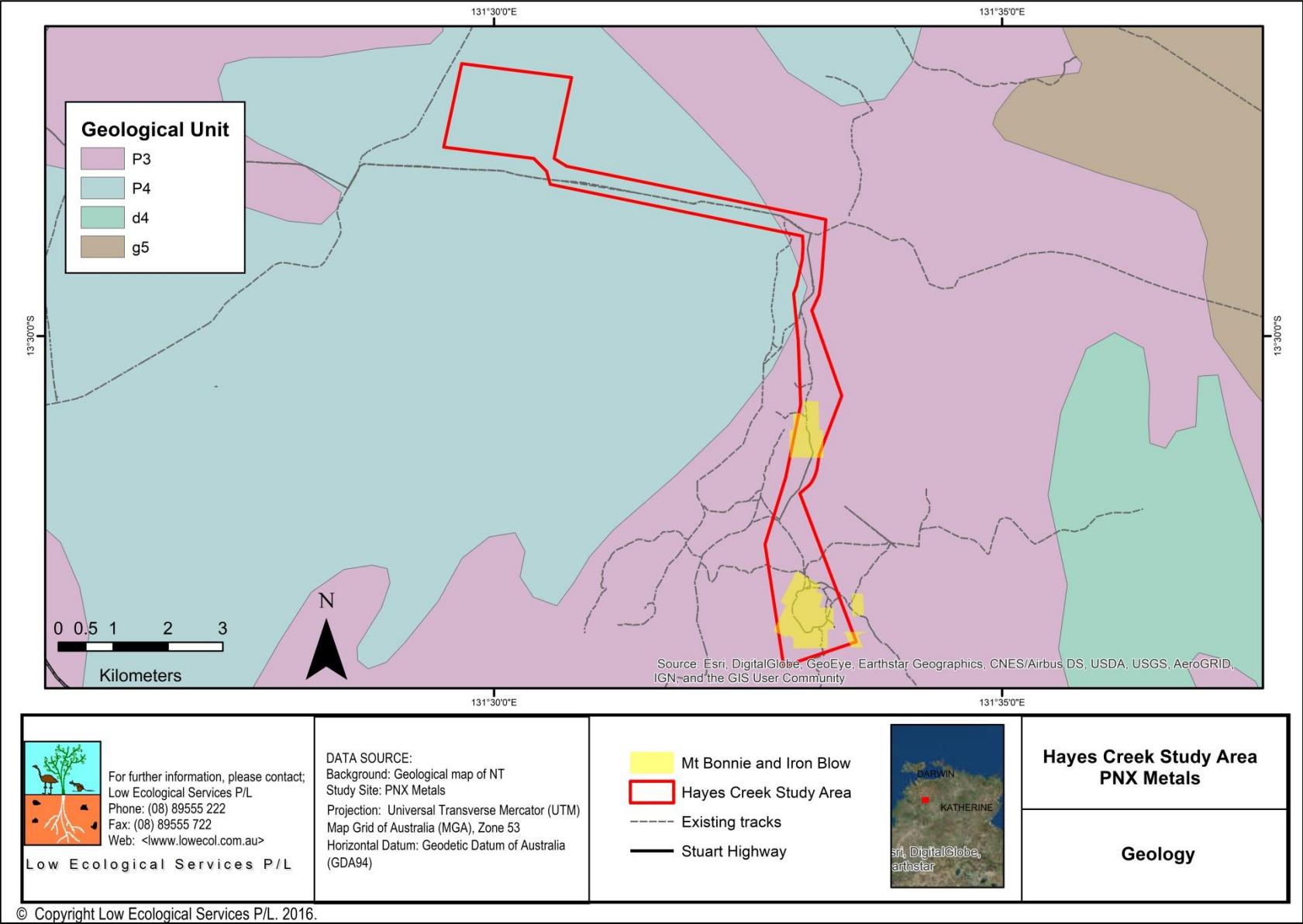


Figure 8: The Geological Map of the Northern Territory (Ahmad 2000) within and surrounding the Hayes Creek study area. Geological units within the area are described in Table 5.

3.5 Soils

Soil types in the project area have been mapped using the Atlas of Australian Soils (mapped by Bureau of Rural Sciences after Commonwealth Scientific and Industrial Research Organisation, 1991; described by Northcote et al., 1968). However, because the currently accepted classification system is the Australian Soil Classification (ASC) (Isbell & National Committee on Soil and Terrain, 2016) a conversion from the Atlas of Australian Soils to Australian Soil Classification was developed by (Ashton & McKenzie, 2001). Soil units within the project area include Tb134 and JJ28. The soil units are described along with the ASC conversion in Table 6 and mapped in relation to the study area in

Figure 9.

Table 6: Description of soil types in the Hayes Creek Project Area, including Australian Soils Atlas Description by Northcote (1968) and Australian Soil Classification conversion by Ashton & McKenzie (2001)

Map unit	Australian Soils Atlas Description	ASC Conversion
Tb134	Strongly undulating to hilly lands on greywacke, siltstones, and sandstones with rock outcrops, and interspersed with gently sloping to flat-floored valleys of variable size and extent: soil dominance varies markedly between the valleys and the hilly portions. Chief soils of the basal hill slopes and the valleys are hard acidic, and also neutral, yellow mottled soils, including hard settling bleached acid and neutral soils, sometimes alkaline and usually in association with yellow and grey earths such as non-calcareous yellow acid earths and grey bleached neutral earths. Chief soils of the hill slopes are shallow stony and gravelly loams including pale grey-brown and firm shallow siliceous loams and sands such as hard-settling red duplex soils and yellow and yellow grey acid soils; and yellow earths such as acid bleached and acid mottled yellow bleached massive earths. Small areas of other soils, such as red acid massive earths, occur on included andesites and dolerite sills.	Sodosol: Soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is sodic and not strongly acidic. Hydrosols and soils with strongly subplastic upper B2 horizons are excluded.
JJ28	Low to steep hills, ridges and cuervas intersperse with small sandy plain areas, mainly on sandstones, with some shales; rock outcrops common; narrow valleys: chief soils are probably shallow stony sands pale sands without b-horizons, firm siliceous sand with pale sands with colour b horizons. Associated are slopes and plains of yellow earth sands with coherent earth subsoils, with gravelly ironstone and red non-calcareous massive earths, yellow neutral massive earths and mottled yellow earth soils; and narrow valley plains of yellow earths such as mottled yellow bleached acid soils. Small areas of adjoining units may be included.	Tenosol: Soils with generally only weak pedologic organisation apart from the A horizons. Encompasses a diverse range of soils that do not fit the requirements of any other soil orders and generally with one or more of the following: i. A peaty horizon. ii. A lumose, melacic or melanic horizon, or conspicuously bleached A2 horizon, which overlays a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite or unconsolidated mineral materials. iii. A horizons which meet all the conditions for a peaty, humose, melacic or melanic horizon except the depth requirement, and directly overlie a calcrete pan, hard unweathered rock or

		other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials. iv. A1 horizons which have a more than weak development of structure and directly overlie a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials. v. An A2 horizon which overlies a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials. vi. Either a tenic B horizon, or a B2 horizon with 15% clay (SL) or less, or a transitional horizon (C/B) occurring in fissures in the parent rock or saprolite which contains between 10 and 50% of B horizon material (including pedogenic carbonate). vii. A ferric or bauxitic horizon >0.2 m thick. viii. A calcareous horizon >0.2 m thick.
Wd13	Undulating to rolling and hill terrain on granites; many rock outcrops and tors on crests and upper slopes. Chief soils are sandy acidic yellow mottles soils.	Tenosol: Soils with generally only weak pedologic organisation apart from the A horizons. Encompasses a diverse range of soils that do not fit the requirements of any other soil orders and generally with one or more of the following: ix. A peaty horizon. x. A lumose, melacic or melanic horizon, or conspicuously bleached A2 horizon, which overlays a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite or unconsolidated mineral materials. xi. A horizons which meet all the conditions for a peaty, humose, melacic or melanic horizon except the depth requirement, and directly overlie a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials. xii. A1 horizons which have a more than weak development of structure and directly overlie a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials. xiii. An A2 horizon which overlies a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials. xiv. Either a tenic B horizon, or a B2 horizon with 15% clay (SL) or less, or a transitional horizon (C/B) occurring in fissures in the parent rock or saprolite which contains between 10 and 50% of B horizon material (including pedogenic carbonate). xv. A ferric or bauxitic horizon >0.2 m thick. A calcareous horizon >0.2 m thick.

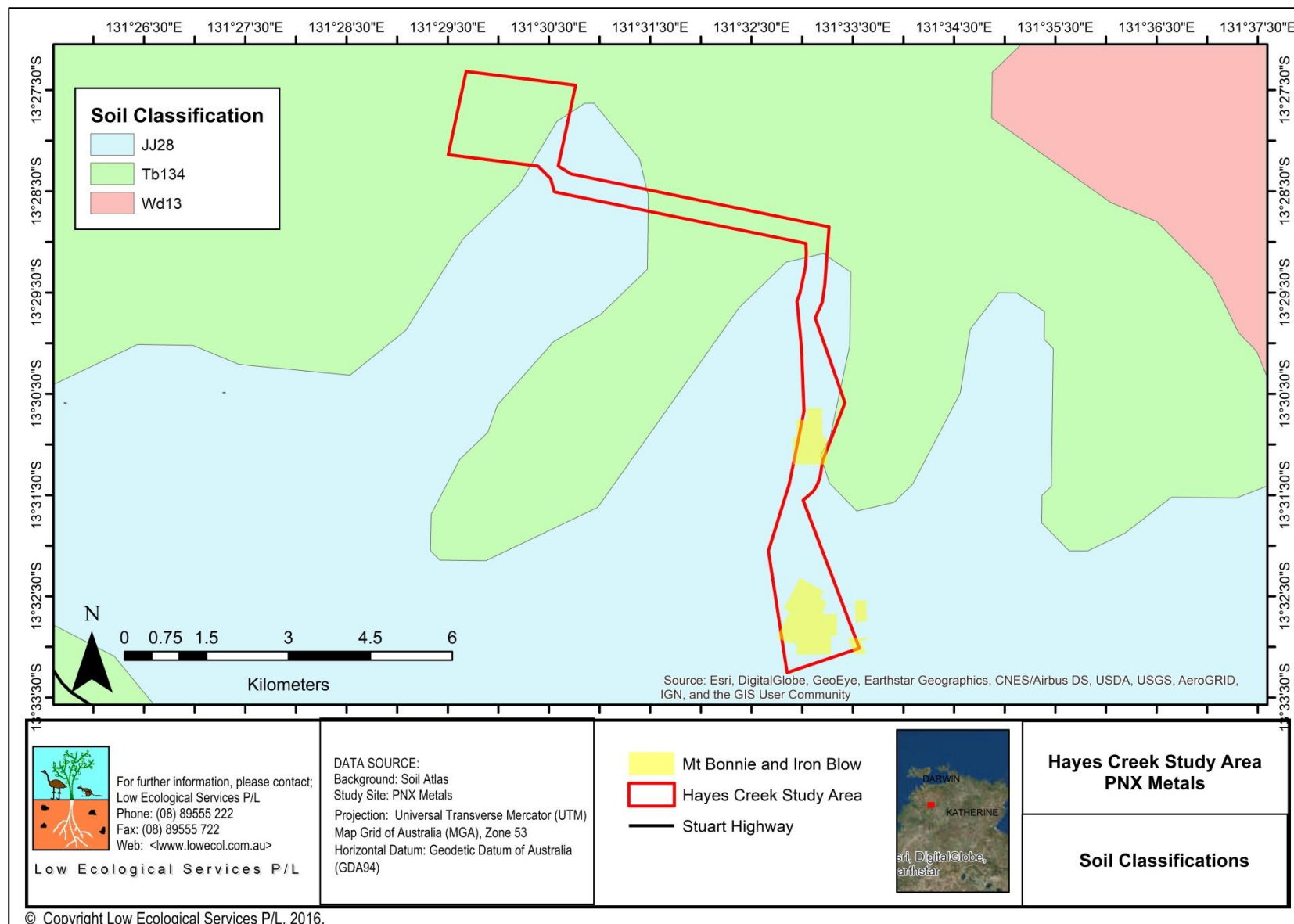


Figure 9. Soil Atlas classifications within and around the Hayes Creek Project Area (Northcote, 1968)

3.6 Land systems

Land system mapping of the area by (Lynch, et al., 2012) is available at a scale of 1:250,000. Land systems in the Hayes Creek survey area are described in Table 7 and mapped in Figure 10.

Table 7: Description of land units within the Fountain Head (FH), Iron Blow (IB) and Mt Bonnie (MB) survey areas of the Hayes Creek Project Area (Lynch, et al., 2012).

Land Unit	Site	Landform	Soil description	Vegetation
Baker	MB, IB	Rugged hills and strike ridges with intervening narrow valleys and short lower slopes on folded Burrels Creek greywacke, sandstone and siltstone	Skeletal soils and outcrop with minor sandy red and yellow gradational soils	Mid-high woodland of <i>C. dichromophloia</i> , <i>E.miniata</i> , <i>C.bleeseri</i> , <i>E.tectifca</i> and <i>C.terminalis</i> over <i>Sorghum spp.</i> , <i>Themeda triandra</i> and <i>Chrysopogon spp.</i>
McKinlay	FH	Alluvial floodplains, swamps, drainage depressions and alluvial fans; sandy, silty and clay soils on Quaternary alluvium	Silicesous sands, silty brown and yellow earths, yellow podzolics	Mid-high grassland of <i>Chrysopogon spp.</i> , <i>Themeda triandra</i> , <i>Cyperus spp.</i> with minor areas of woodland (<i>C. papuana</i> , <i>C. polycarpa</i> , <i>Pandanus sp.</i> , <i>Melaleuca spp.</i> , <i>E. apodophylla</i>)
Rumwaggen	IB, MB	Low rounded hills and low gravelly ridges with intervening broad alluvial flats; developed on highly weathered rocks of Lower Proterozoic age.	Lithosols on rises, yellow pozolics on alluvial areas.	Mid-high open woodland of <i>E.polysciadia</i> , <i>C.ferruginea</i> , <i>C.foelscheana</i> , <i>E.tectifca</i> , <i>Xanthostemon paradoxus</i> over <i>Chrysopogon spp.</i> , <i>Sorghum spp.</i> , <i>Eriachne triseta</i>

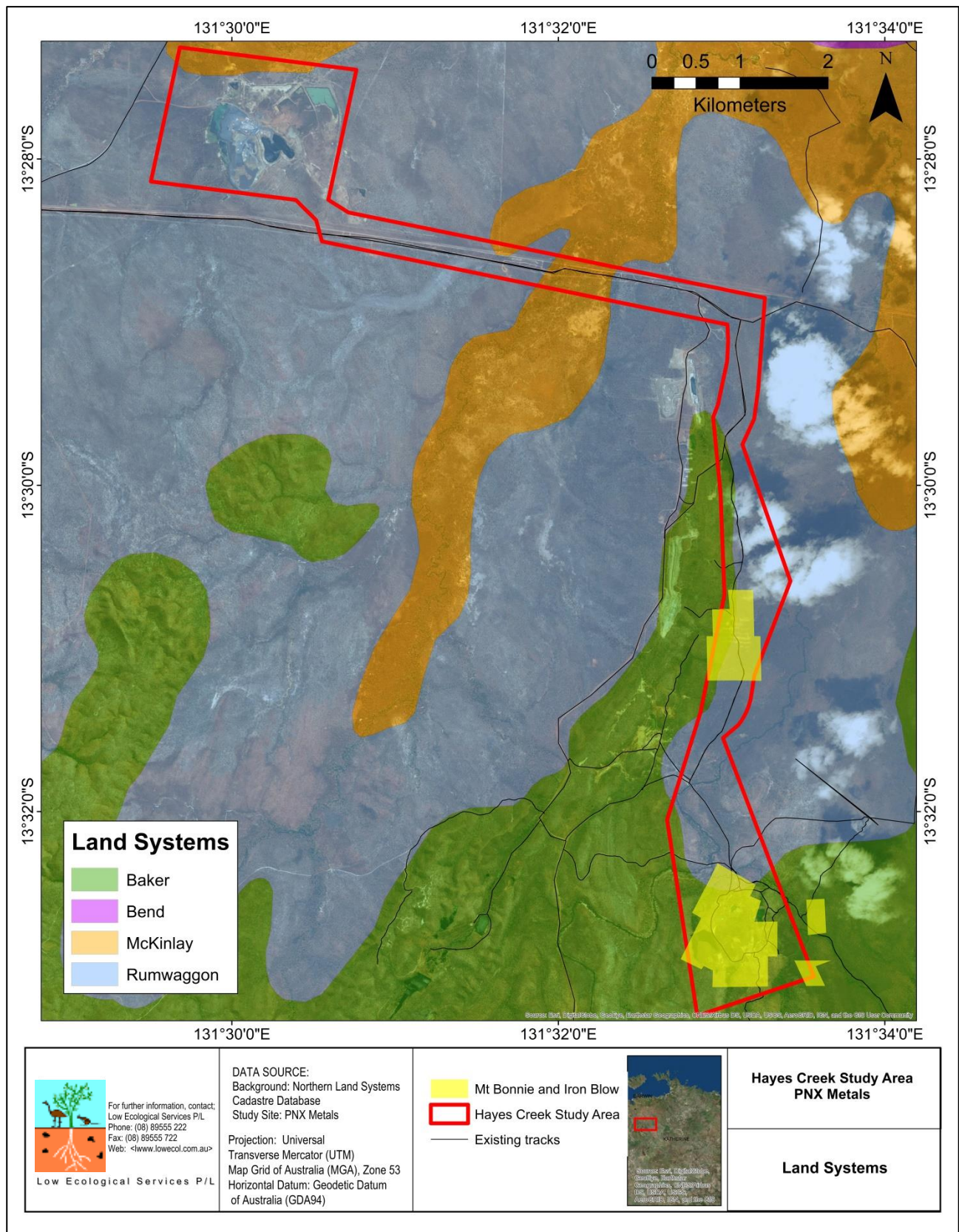


Figure 10: Land system mapping for the Hayes Creek study area (Lynch, et al., 2012). Descriptions of each land system are provided in Table 7.

3.7 Vegetation types

Vegetation in the project area has been mapped at a scale of 1: 100 000 in the Vegetation Survey of the Northern Territory (Wilson, et al., 1990). There are four vegetation types occurring within the survey areas and these are described in Table 8 and mapped in Figure 11.

Table 8: Description of vegetation types within the Mt Bonnie (MB), Iron Blow (IB) and Fountain Head (FH) survey areas of the Hayes Creek Project Area as mapped by Wilson et al. (1990)

Vegetation unit	Sites	Broad vegetation classification	Structural formation	Fine vegetation description
316	FH	<i>Melaleuca</i> woodland	Woodland	<i>Melaleuca viridiflora/leucadendra</i> +/- <i>Melaleuca argentea</i> , <i>Barringtonia acutangula</i> , <i>Pandanus aquaticus</i> , <i>Chrysopogon fallax</i> , <i>Heteropogon contortus</i> , <i>Pseudoraphis spinescens</i>
320	-	<i>Melaleuca</i> low woodland	Woodland	<i>Melaleuca viridiflora</i> , <i>Melaleuca cajupati</i> , <i>Melaleuca dealbata</i> , <i>Pandanus spiralis</i> , <i>Barringtonia acutangula</i> , <i>Eleocharis brassi</i> , <i>Eleocharis sphacelata</i> , <i>Hymenachne acutigluma</i>
333	MB	<i>Eucalyptus</i> low woodland	Woodland	<i>Eucalyptus tintinnans</i> , <i>Corymbia dichromophloia</i> , <i>Erythrophleum chlorostachys</i> , <i>Livistonia humilis</i> , <i>Gardenia megasperma</i> , <i>Sorghum stipoides</i> , <i>Heteropogon triticeus</i> , <i>Sorghum plumosum</i>
572	IB, FH	<i>Eucalyptus</i> woodland	Woodland	<i>Eucalyptus tectifica</i> , <i>Erythrophleum chlorostachys</i> , <i>Corymbia latifolia</i> , <i>Terminalia ferdinandiana</i> , <i>Petalostigma pubescens</i> , <i>Sorghum</i> spp. <i>Heteropogon triticeus</i> , <i>Chrysopogon fallax</i>
1061	-	<i>Canarium</i> (mixed) mid closed forest	Mid closed forest	<i>Canarium australicum</i> +/- <i>Diospyros</i> spp.
1064	FH, IB, MB	Pastoral/ Horticultural/Roads	-	-

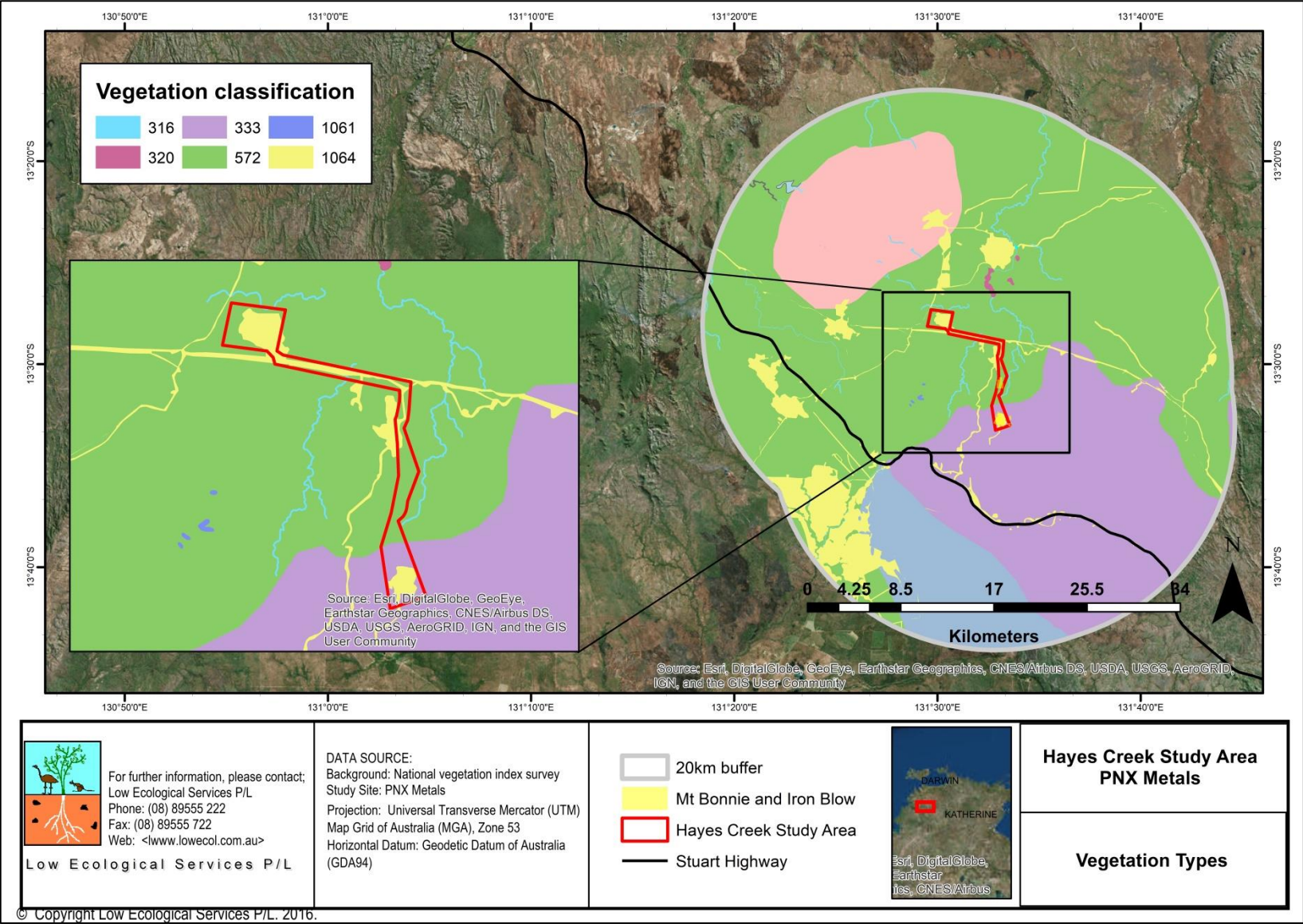


Figure 11: Vegetation types within Mt Bonnie, Iron Blow and Fountain Head mapped by Wilson et al. (1990). Vegetation types are described in Table 8.

3.8 Sites of Conservation Significance

Sites of Conservation significance (SoCS) are 67 sites in the Northern Territory identified as the most important for biodiversity, and that require further protection. Sites of Botanical Significance (SoBS) are defined as areas that have botanical features distinguishing them from the surrounding landscape, and that are important for general plant conservation and for specifically mentioned species (White, et al., 2000a). There are no SoCs or SoBs within 20 km of the survey area. The nearest SoCs are the Daly River middle reaches, Western Arnhem Plateau and Yinberrie Hills; located approximately 40 km south-west, 40 km west and 60 km south-east of the study area respectively. SoCs are mapped below however no further descriptions are provided as these areas are considered outside the impacts of the Project (Figure 12).

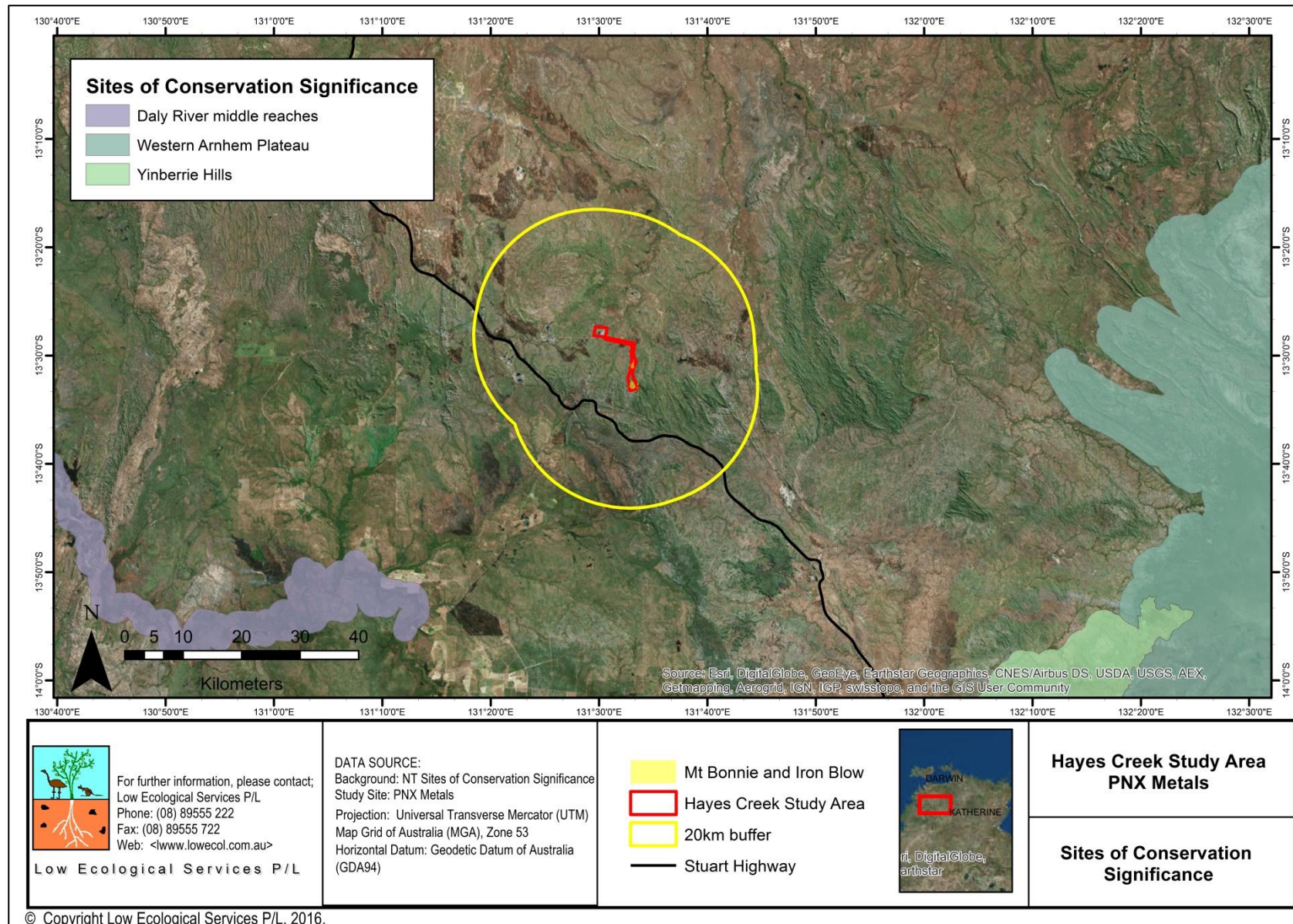


Figure 12: Sites of conservation significance in the area surrounding Hayes Creek Project Area.

3.9 Fire history

Mapping obtained from the North Australia Fire Information (NAFI) website (North Australia and Rangelands Fire Information, 2017) indicates that fire occurs within the project area on an annual basis (Table 9, Figure 13). Over 95% of the site has been burnt since 2000 with an average 58% of the survey area affected by fire every year.

Table 9: Fires occurring in the project areas between 2010 and 2017, with the area (km²) and percentage of the survey area burnt (%) during those years (North Australia and Rangeland Fire Information, 2017). The total size of the Project area is 12.06 ha.

Year	Area	%
2010	5.96	49.70
2011	6.83	56.61
2012	7.69	63.80
2013	7.78	64.49
2014	7.94	65.86
2015	5.34	44.25
2016	7.02	58.22
2017	1.65	13.70

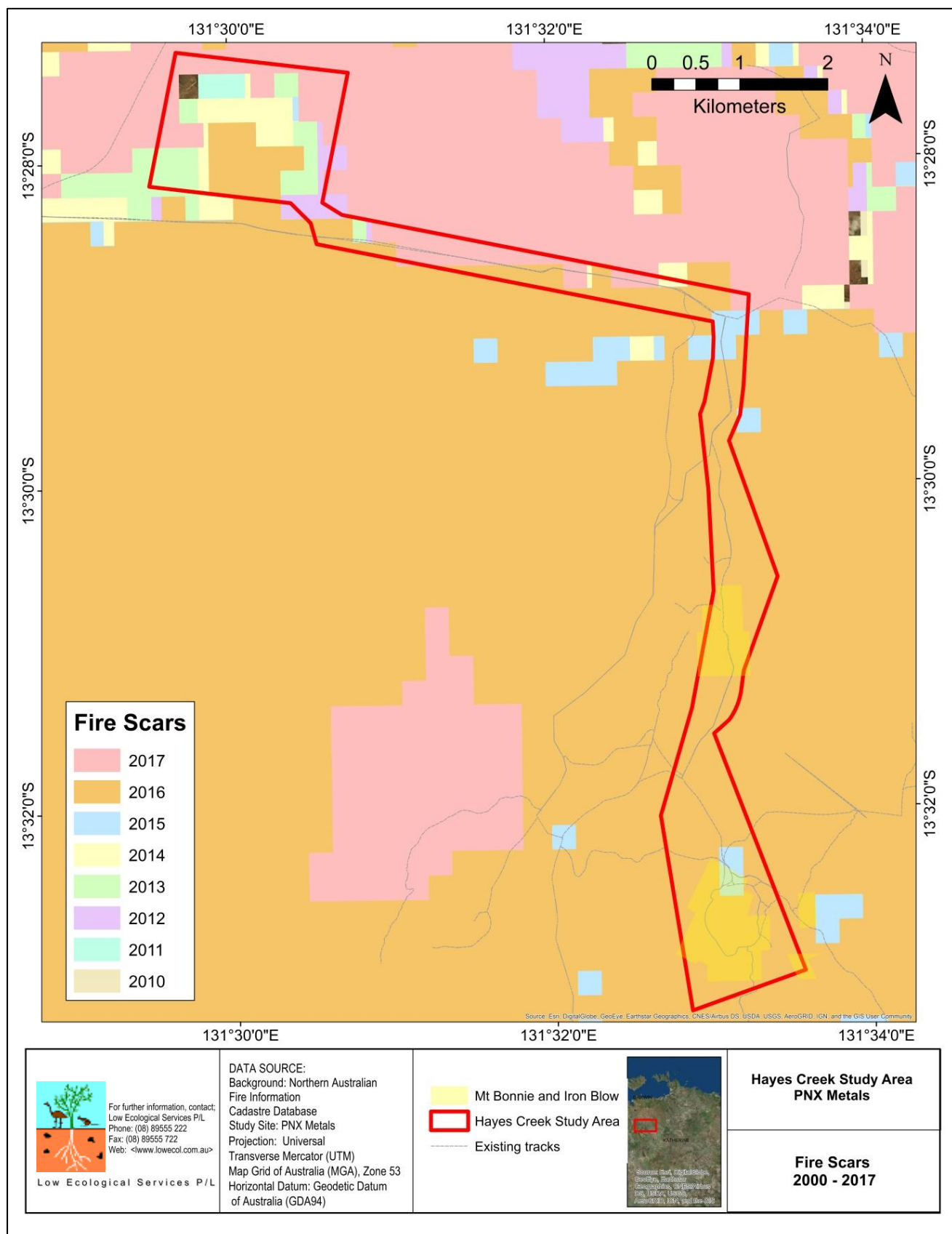


Figure 13: Fire history for the years 2010 – 2017 in the Hayes Creek Project area (North Australia and Rangelands Fire Information, 2017)

3.10 Flora

3.10.1 Flora records

The NT Flora Atlas identified 2777 records of 362 flora species within 20 km of the survey areas.

3.10.2 Threatened Flora Species

Two species of conservation significance were identified by the EPBC PMST or TWPC Flora Atlas as occurring or potentially occurring within a 20 km radius of the survey areas (Table 10, Figure 14). The EPBC PMST identified one endangered flora species, *Stylidium ensatum*, and one vulnerable flora species, *Acacia praetermissa*, as potentially occurring within 20 km of the survey areas. Interrogation of the NT Flora Atlas identified 192 records of *A. praetermissa* within the same search area. Further descriptions of these threatened species and assessment of their likelihood of occurrence are provided below. Three species listed as near threatened under the TPWCA; *Goodenia glandulosa*, *Pittosporum moluccanum* and *Pentapetes Phoenicia* and one data-deficient species; *Eriachne squarrosa* were identified by the NT Flora Atlas as occurring within 20 km of the survey areas (Figure 14).

Acacia praetermissa

Acacia praetermissa is known from two general locations in the Northern Territory, near Emerald Springs and Hayes Creek. The species is known to have an extremely restricted area of occupancy, approximately 2.5 ha (Northern Territory Herbarium, 2013). *Acacia praetermissa* is a shrub, often multi-stemmed with stems 50 cm – 2 m high (Northern Territory Herbarium, 2013). The species grows on upper to lower slopes with various aspects in stoney skeletal or sandy soils on sandstone or laterite substrates. Associated dominant vegetation includes *Eucalyptus tetradonta*/*Corymbia dichromophloia* woodland (Northern Territory Herbarium, 2013). The foliage is bluish and narrow (Northern Territory Herbarium, 2013). Flowers are in bright yellow spikes on simple axillary stalks, mostly two per axil (Northern Territory Herbarium, 2013). Flowering occurs from January – September and fruiting in January, March, July and October (Northern Territory Herbarium, 2013).

The known population of *A. praetermissa* occurs along the Stuart Highway, near Emerald Springs and Hayes Creek. The Hayes Creek population is approximately 10 km south-south-east of the study area. Slopes with various aspects on sandstone exist within the study area. Therefore, there is a high likelihood that *A. praetermissa* occurs within the survey areas. This species was not recorded within the project area during the May 2017 survey (see section 4.3 for further detail).

Stylidium ensatum

Stylidium ensatum is an annual herb to 22 cm tall with broad sessile leaves on a short basal stem (Northern Territory Herbarium, 2013). The flowers are pink, with both upper and lower petals bilobed at the apex (Northern Territory Herbarium, 2013). *Stylidium ensatum* flowers and fruits from June to August (Northern Territory Herbarium, 2013).

Stylidium ensatum grows on poorly drained grassy flats that stay wet into the dry season. (Northern Territory Herbarium, 2013). It is often found with *Eriachne burkitii*, *Pandanus* spp., *Osbeckia* spp. and *Fimbristylis furva* (Northern Territory Herbarium, 2013). There are no records of the species within 100 km of the study area. There is potential habitat for this species in a small section of alluvial floodplains on the southern side of the Mt Wells haul road (running in an E-W direction south of Fountain Head). However, it is unclear how long these areas stay inundated past the end of the wet

season. Therefore there is a moderate likelihood that *S. ensatum* occurs within the survey areas. This species was not recorded within the project area during the May 2017 survey (see section 4.3 for further detail).

Table 10: Flora species of conservation significance identified by the EPBC PMST and/or the TPWC act as occurring or potentially occurring within a 20 km radius of the survey area.

Family	Scientific Name	Status		PMST	NT Flora Atlas
		TPWC	EPBC		
Fabaceae	<i>Acacia praetermissa</i>	VU	VU	X	X
Goodeniaceae	<i>Goodenia glandulosa</i>	NT			X
Malvaceae	<i>Pentapetes phoenicea</i>	NT			X
Poaceae	<i>Eriachne squarrosa</i>	DD			X
Pittosporaceae	<i>Pittosporum moluccanum</i>	DD			X
Rutaceae	<i>Citrus gracilis</i>	NT			X
Stylidiaceae	<i>Stylidium ensatum</i>		En	X	

En: endangered, Vu: vulnerable, DD: data deficient, NT: near threatened

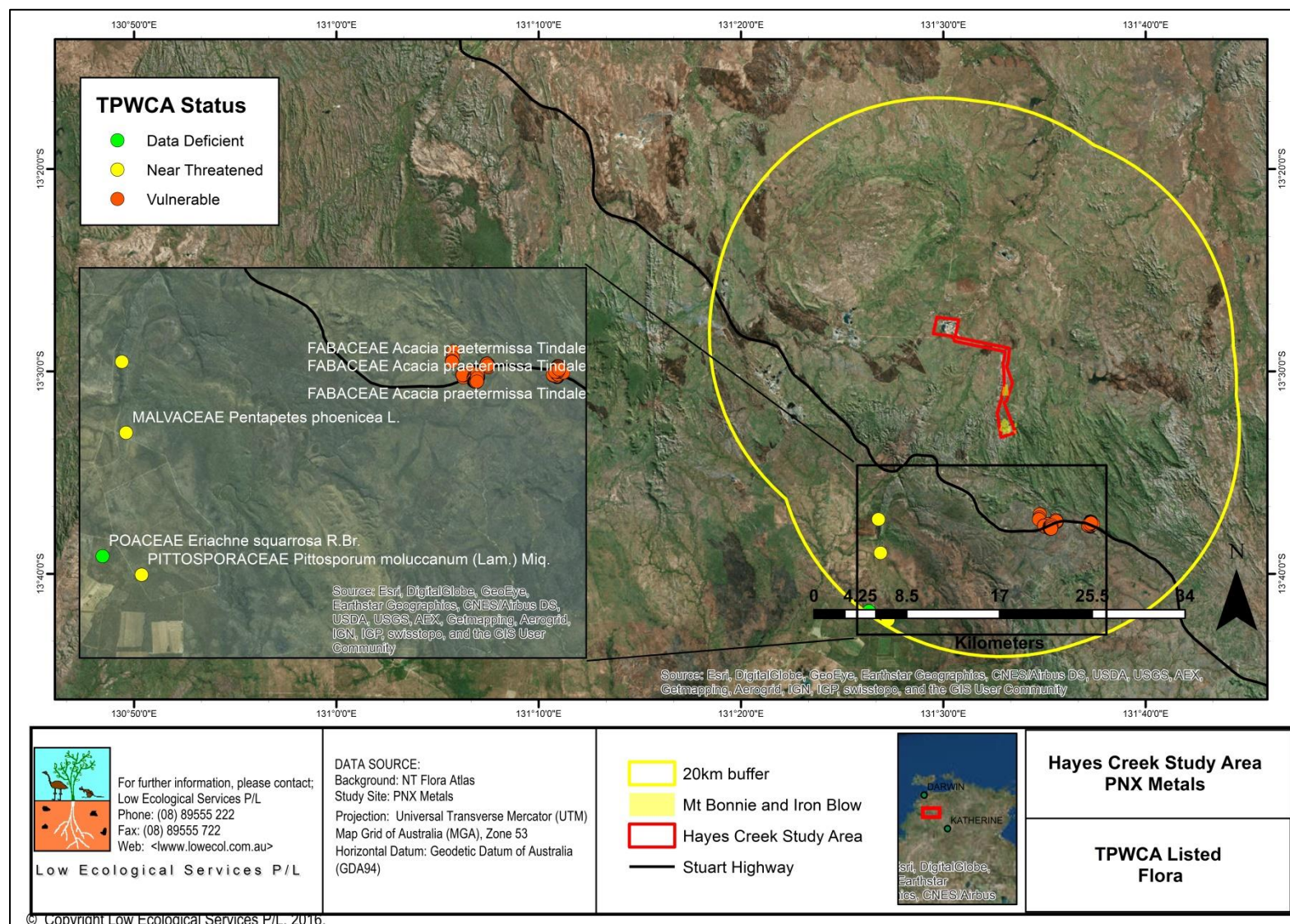


Figure 14: Location of records of flora species of conservation significance listed under the TPWC Act within 20 km of the Hayes Creek Project Area ((DLRM, 2015)

3.10.3 Threatened Ecological Communities

No threatened ecological communities were identified within 20 km of the lease areas.

3.10.4 Introduced and weed species

Weeds of National Significance (WoNS) are declared based on invasiveness, potential for spread and environmental, social and economic impacts. Strategic plans for WoNS are developed as a result of their declaration, which define responsibilities and identifies strategies and actions to control the species. Landholders and managers are ultimately responsible for managing WoNS, and the state/territory government is responsible for overall legislation and administration (Department of Sustainability, Environment, Water, Population and Communities, 2012).

In the NT, a plant is declared a weed if it has been identified for control, eradication or prevention of entry into the NT. All landholders, land managers and land users must comply with the declaration classification. Based on the risk of harm they could cause and how difficult they are to control, weeds are placed into the following classes:

- Class A – to be eradicated
- Class B – growth and spread to be controlled
- Class C – not to be introduced into the NT

Fifty-six introduced flora species were identified as occurring or potentially occurring within 20 km of the survey areas by the EPBC PMST, NT Weeds public database or both (Table 11 and Figure 15). Eight of these species are WoNS and are described in further detail below, including information on identification and habitat. Other weeds known to occur in the Pine Creek bioregion are *Barleria prionitis*, cabomba (*Cabomba caroliniana*), creeping lantana (*Lantana montevidensis*), giant rats-tail grass (*Sporobolus natalensis* and *S. pyramidalis*), grader grass (*Themeda quadrivalvis*), *Senna tora* and snakeweed (*Stachytarpheta* spp.) (Bastin & ACRIS Management Committee, 2008).

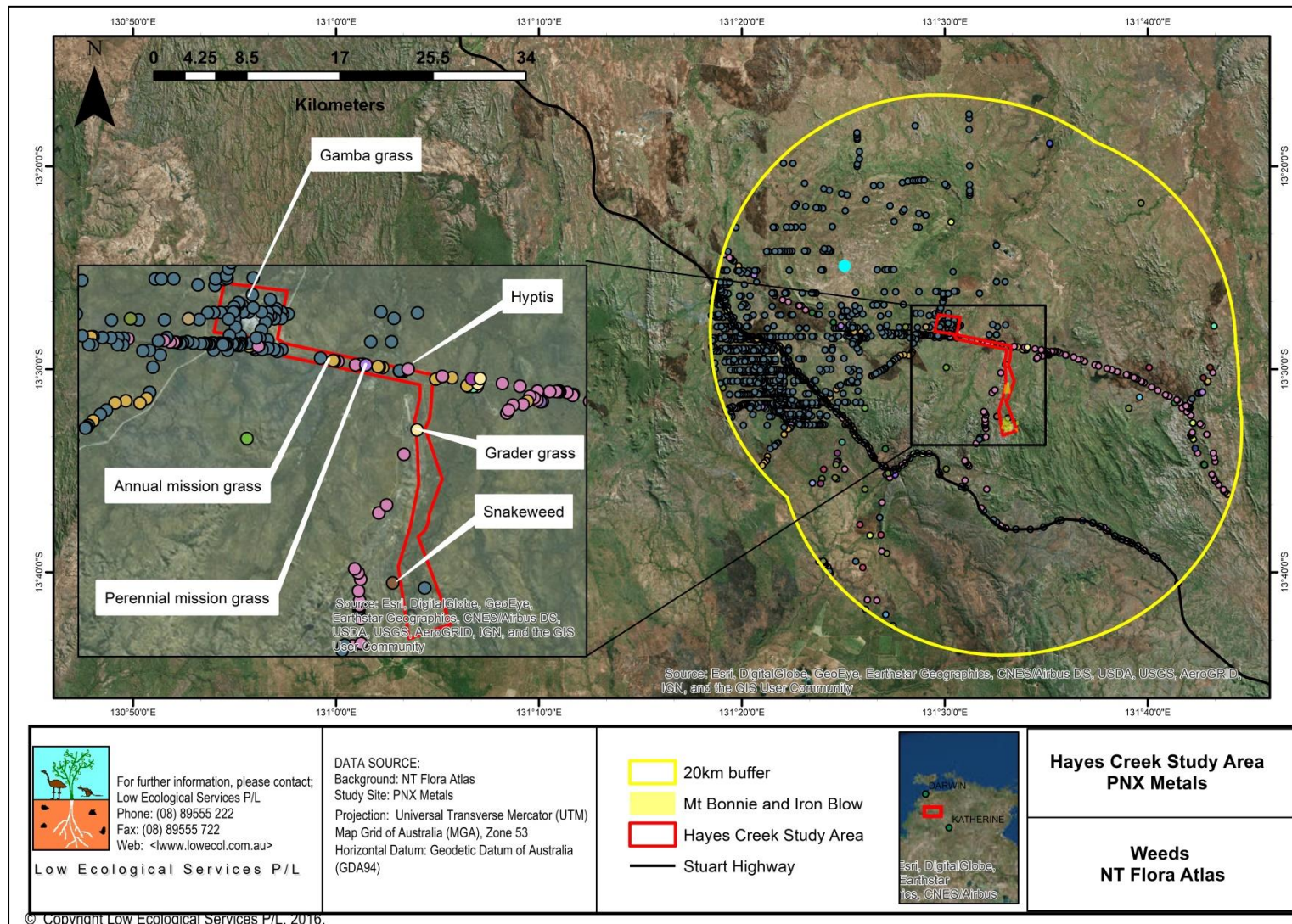


Figure 15. Location of weeds identified during the desktop assessment within a 20 km radius of the Hayes Creek Project Area. Inset: Introduced species identified within the Project area.

Table 11: Introduced flora species identified by the desktop study of the Hayes Creek Project Area and/or recorded during the May 2017 on-ground survey, including if the species is a WoNS and the class it is declared under in the NT within.

Species name	Common name	Status			PMST	NT Flora Atlas
		NT	EPBC	WoNS		
<i>Aeschynomene villosa</i>						X
<i>Alysicarpus vaginalis</i>						X
<i>Andropogon gayanus</i>	Gamba grass	B,C	Inv	X	X	X
<i>Antigonon leptopus</i>	Coral vine					X
<i>Azadirachta indica</i>	Neem	B,C				X
<i>Brachiaria mutica</i>	Para grass				X	
<i>Bidens pilosa</i>	Cobblers peg					X
<i>Calopogonium mucunoides</i>	Calopo					X
<i>Calotropis procera</i>	Rubber bush					X
<i>Cabomba caroliniana</i>	Carolina fanwort	A,C	Inv	X	X	
<i>Cenchrus pedicellatus</i>	Mission grass (annual)					X
<i>Corchorus olitorius</i>	Bush okra					X
<i>Crotalaria goreensis</i>	Gambia pea					X
<i>Cynodon dactylon</i>	Couch grass					X
<i>Dactyloctenium aegyptium</i>						
<i>Digitaria bicornis</i>	Crab grass					X
<i>Digitaria ciliaris</i>	Summer grass					X
<i>Echinochloa colona</i>	Barnyard grass					X
<i>Euphorbia heterophylla</i>						X
<i>Euphorbia hirta</i>						X
<i>Grewia asiatica</i>						X
<i>Gomphrena celosioides</i>						X
<i>Heliotropium indicum</i>						X
<i>Hibiscus sabdariffa</i>						X
<i>Hymenachne amplexicaulis</i>	Olive hymenachne	B, C	Inv	X	X	
<i>Hyptis suaveolens</i>	Hyptis	B,C				X
<i>Jatropha curcas</i>	Physic nut	A,C				X
<i>Jatropha gossypifolia</i>	Bellyache bush	A,B,C	Inv	X	X	
<i>Lantana camara</i>	Common lantana	B,C	Inv	X	X	
<i>Leonotis nepetifolia</i>	Lions tail	B,C				X
<i>Martynia annua</i>	Devils claw					X
<i>Melinis repens</i>	Red natal grass					X
<i>Merremia aegyptia</i>	Hairy merremia					X
<i>Mimosa pigra</i>	Mimosa	B,C	Inv	X	X	X

Species name	Common name	Status			PMST	NT Flora Atlas
		NT	EPBC	WoNS		
<i>Mitracarpus hirtus</i>						X
<i>Murdannia nudiflora</i>						X
<i>Passiflora foetida</i>						X
<i>Paspalum dilatatum</i>						X
<i>Passiflora foetida</i>						X
<i>Pennisetum polystachyon</i>	Perennial mission grass	B,C			X	X
<i>Rottboellia cochinchinensis</i>	Itch grass					X
<i>Salvinia molesta</i>	Giant salvinia	B,C	Inv	X	X	
<i>Scoparia dulcis</i>						X
<i>Senna obtusifolia</i>	Sicklepod	B,C				X
<i>Senna occidentalis</i>	Coffee senna	B,C				X
<i>Sida acuta</i>	Spinyhead sida	B,C				X
<i>Sida cordifolia</i>	Flannel weed	B,C				X
<i>Stachytarpheta jamaicensis</i>	Snakeweed	B,C				X
<i>Stylosanthes hamata</i>	Stylo					X
<i>Stylosanthes scabra</i>	Shrubby stylo					X
<i>Themeda quadrivalvis</i>	Grader grass	B,C				X
<i>Trianthema portulacastrum</i>						
<i>Triumfetta rhomboidea</i>						X
<i>Urochloa mutica</i>						X
<i>Vachellia nilotica</i>	Prickly acacia	A,C	Inv	X	X	
<i>Ziziphus mauritiana</i>	Chinee apple	A,C				X

Classes: A – to be eradicated, B – growth and spread controlled, C – not to be introduced in NT

Gamba grass (*Andropogon gayanus*)

Gamba grass is a perennial tussock grass that grows up to 70 cm diameter and 4 m tall (DSEWPac, 2013a). The leaf blades are up to 60 cm long and 1.5-5 cm wide with a prominent white midrib (DSEWPac, 2013a). The flowering stems have up to six groups of 2-18 loosely branched primary branches (DSEWPac, 2013a). The flower spikelets are arranged in pairs, with one spikelet sessile and the other stalked (DSEWPac, 2013a). The seeds of gamba grass are light brown to brownish-black, 2-3 mm long and 1 mm wide (DSEWPac, 2013a).

Gamba grass mostly grows in pastures and along roads, but can be invasive in other habitats such as savanna (DSEWPac, 2013a). Gamba grass invasion leads to dramatically increased fire intensity, which are harder to control and can result in a reduction in the woody component of a vegetation community (DSEWPac, 2013a). Gamba grass seed is dispersed by wind or water, and can also be spread during hay transport or in mud attached to vehicles and machinery (DSEWPac, 2013a).

Gamba grass can be controlled by herbicide application of young and regrowing plants before seed maturity (DSEWPaC, 2013a).

Carolina fanwort (*Cabomba caroliniana*)

Carolina fanwort is fast growing, perennial aquatic weed that grows from 1-2 m long and is usually rooted to the water body floor (DPoEH, 2003). Cabomba grows quickly and produces a large amount of plant material, with branched stems that have white or reddish brown hair growing on them (DPoEH, 2003). The plant is fully submerged, except for the occasional floating leaves and flowers (DPoEH, 2003). The underwater leaves are divided into fine branches giving them a feather-fan appearance (DPoEH, 2003). Cabomba is sensitive to drying out and requires permanent shallow water, usually less than 3 m but up to 10 m deep (DSEWPaC, 2013a).

The plant does not produce fertile seed or fruit but reproduces and spread by movement of small plant pieces (DPoEH, 2003). Plant fragments may survive in water for 6 – 8 weeks with pieces as short as 10 mm potentially viable (DPoEH, 2003). Infestations have been recorded in the Darwin region. Whilst distribution is currently isolated to relatively few water bodies, the potential for spread is high based on climate and the availability of water. Current strategies for control include physical cutting and removal, hand pulling and drying or shading cabomba (DPoEH, 2003). Chemical control is in most cases considered problematic due to the associated difficulties of applying chemicals in water and the potential to affect non-target species (DPoEH, 2003).

Hymenachne (*Hymenachne amplexicaulis*)

Hymenachne is a perennial grass, usually growing to 1-2.5 m tall, but occasionally to 3.5 m tall. Its above ground stems are upright or semi-upright from a creeping base or floating on shallow water, are up to 12 mm or more thick and regularly produce roots at the joints (DSEWPaC, 2013b). The leaf blades are 10-45 cm long and 2-6 cm wide, hairy or hairless and partially enclose the stem, and are large and spreading (DSEWPaC, 2013b). The inflorescence is elongated, dense and spike like, and is 10 -50 cm long and 8-20 mm wide (DSEWPaC, 2013b).

Hymenachne occurs in swamps, wetlands, seasonally flooded areas, waterways, riverbanks, drainage channels and other water bodies in wetter tropical and sub-tropical environments (DSEWPaC, 2013b). Hymenachne can block waterways, potentially causing flooding and threatening drinking water, block drainage and irrigation channels in cropping areas, displace native plants and increase the density of vegetation, which can alter habitat suitability for biodiversity (DSEWPaC, 2013b). Hymenachne can reproduce by seed or vegetatively, with spread being attributed to flooding, mud attached to animals and vehicles, in contaminated agricultural produce and by birds (DSEWPaC, 2013b).

Bellyache bush (*Jatropha gossypifolia*)

Bellyache bush a shrub or small tree 1-3 m tall (DSEWPaC, 2011b). Older stems of bellyache bush are relatively thick and contain a watery or soapy sap (DSEWPaC, 2011b). Younger stems and growing points are purplish in colour and have a dense covering of hairs (DSEWPaC, 2011b). The leaves are alternately arranged, purplish and covered in sticky hairs when immature, bright or dark green as they are, 4.5-10 cm long and 5-13 cm wide and have three or five deep lobes (DSEWPaC, 2011b). The flowers are arranged in clusters with 2-8 female and 27-54 male flowers in each cluster (DSEWPaC,

2011b). The flowers are deep purple to bright red (DSEWPac, 2011b). The fruit is slightly three lobed and faintly hairy (DSEWPac, 2011b).

Bellyache bush occurs in degraded pastures, open woodlands, monsoon vine forests, grasslands, waterways, coastal foreshores, roadsides, disturbed sites, waste areas and old or abandoned gardens (DSEWPac, 2011b). It occurs mainly in drier tropical environments, but also sometimes in sub-tropical and semi-arid regions (DSEWPac, 2011b). Bellyache bush can form dense thickets, which reduces the productivity of pastures, displaces native vegetation, and may reduce biodiversity, preventing the regeneration of trees and shrubs (DSEWPac, 2011b). Bellyache bush reproduces by seed and vegetatively (DSEWPac, 2011b). Seeds may be dispersed in water and mud, and by ants (DSEWPac, 2011b).

Lantana (*Lantana camara*)

Lantana is a sprawling or climbing shrub or vine 1-3 m high, sometimes to 6 m high in favourable conditions (DSEWPac, 2011c). The stems and branches often have recurved prickles and sometimes glands or glandular hairs (DSEWPac, 2011c). The leaves are in opposite pairs, are ovate to oblong-ovate, often covered with coarse hairs on the upper surface, strongly aromatic and 4-10 cm long and 3-6 cm wide (DSEWPac, 2011c). The inflorescence consists of 20-40 flowers ranging from yellow, orange-yellow, deep orange, deep red, pink, rose-pink to white (DSEWPac, 2011c).

Lantana occurs in disturbed sites such as roadsides, cultivated pastures and fencelines on rich organic soils and well-drained clay and basalt soils (DSEWPac, 2011c). Lantana forms dense thickets, which changes the structure of native bushland and pasture, increases fuel loads and adversely affects the species richness of soil biodiversity (DSEWPac, 2011c). Lantana can reproduce vegetatively and by seed, which can be spread by animals (DSEWPac, 2011c).

Mimosa (*Mimosa pigra*)

Mimosa is a shrub 5-6 m tall with touch sensitive compound leaves 12-22 cm long with up to 45 pairs of leaflets (DSEWPac, 2011d). Mimosa has thorns 5-12 mm long scattered along the stems and branches (DSEWPac, 2011d). The flower heads are round, 10-20 mm diameter and comprised of about 100 pink or mauve flowers (DSEWPac, 2011d). The seed pods are flat, 30-120 mm long, 7-14 mm wide and densely hairy (DSEWPac, 2011d).

Mimosa occurs in moist areas such as riverbanks, coastal plains and floodplains, particularly in humid and sub-humid tropical regions (DSEWPac, 2011d). Mimosa produces copious amounts of seed, which are dispersed by water, humans, animals, mud on vehicles and movement of contaminated soils (DSEWPac, 2011d). Mimosa forms dense monoculture stands, replacing all native vegetation (DSEWPac, 2011d). The invasion of mimosa threatens productive industry and cultural and conservation values of wetlands, including nationally and internationally significant wetlands, where it reduces biodiversity by out-competing native plants and reducing habitat suitability for native fauna (DSEWPac, 2011d).

Salvinia (*Salvinia molesta*)

Salvinia is a free-floating aquatic fern, which forms a thick mat of vegetation (DSEWPac, 2011f). The fronds of salvinia are arranged along the stem in three, with two fronds being leaf like and the third frond being root-like and submerged in the water (DSEWPac, 2011f). The leaf-like fronds are round in shape, 4-40 mm long and 7-25 mm wide, covered in hairs pale green to greenish brown and

folded along the mid-rib (DSEWPaC, 2011f). The root-like fronds are up to 30 cm long and covered with fine brown hairs (DSEWPaC, 2011f).

Salvinia occurs in still or slow-moving water bodies with high nutrient levels (DSEWPaC, 2011f). Salvinia modifies aquatic fauna habitats, excludes light and reduces oxygen levels leading to water stagnation and pollution, impedes water flow, and can harbour mosquitoes (DSEWPaC, 2011f).

Prickly acacia (*Vachellia nilotica*)

Prickly acacia is a thorny shrub or spreading tree, which grows to 4-7 m high and occasionally to 10 m (DSEWPaC, 2011g). Young trees have bark with a tinge of orange and/or green, and usually have long white straight spines 10-50 mm long in pairs at the base of each leaf (DSEWPaC, 2011g). Older trees have dark, rough bark and lose most of their thorns (DSEWPaC, 2011g). Prickly acacia has compound leaves 30-40 mm long, with 10-25 pairs of leaflets along their length (DSEWPaC, 2011g). Flowerheads are globular, golden-yellow, about 10 mm diameter and in groups of 2-6 in the leaf axils (DSEWPaC, 2011g). The seed pods are a distinguishing feature, being grey-green, covered in fine hairs, 100-200 mm long and having deep constrictions between the seeds to give them a necklace like appearance (DSEWPaC, 2011g).

Prickly acacia occurs on cracking clay soils with high water holding capacity, but can also occur on sandy soils in areas of higher rainfall (DSEWPaC, 2011g). It grows best around waterways and on seasonally inundated floodplains with 350-1500 mm of annual rainfall (DSEWPaC, 2011g). Established stands of prickly acacia form impenetrable dense thorny thickets, reducing primary productivity, interfering with stock mustering and access to water, and changing the structure and composition of grasslands which impacts the overall ecology of the system (DSEWPaC, 2011g). Prickly acacia reproduces only by seeds, which are dispersed by flowing water and consumption by cattle (DSEWPaC, 2011g).

3.11 Fauna

3.11.1 Fauna records

The NT Fauna Atlas identified 737 records of 169 fauna taxa identified to species level and a further three fauna taxa identified to genus level, within 20 km of the survey areas.

3.11.2 Fauna species of conservation significance

The EPBC PMST identified 21 fauna species listed as threatened under the EPBC Act as occurring or potentially occurring within 20 km of study area. Two are listed as critically endangered, seven as endangered and 12 as vulnerable. Records of three species listed as endangered and four species listed as vulnerable under the EPBC Act were identified by the NT Fauna Atlas within a 20 km radius of the survey areas. The NT Fauna Atlas also identified records of 12 species listed as threatened under the TPWC Act within a 20 km radius of the survey areas (**Figure 16**). Two of these species are listed as critically endangered, one as endangered and nine as vulnerable. Records of an additional 11 species listed as near threatened and six listed as data deficient under the TPWC Act, were found within 20km of the survey area.

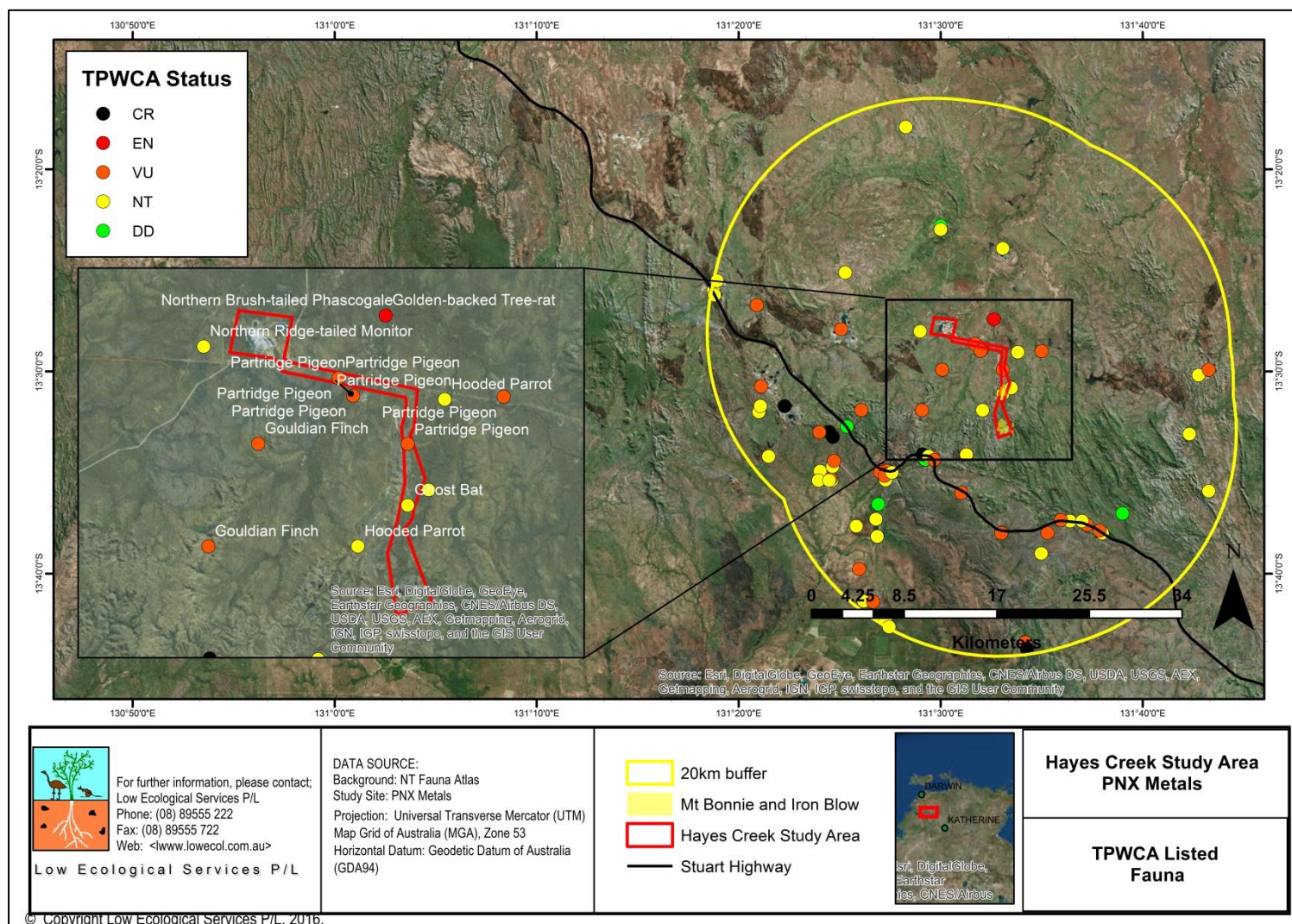


Figure 16: Location of records of fauna species of conservation significance listed under the TPWC Act with records in the NT Flora Atlas within 20 km of the Hayes Creek study area; CR: critical, EN: endangered, VU: vulnerable, NT: near threatened, DD: data deficient

Bird species of conservation significance

Eight bird species of conservation significance were identified by the PMST and/or NT Fauna Atlas as occurring or potentially occurring within a 20 km radius of the survey area (Table 12). All of these species are listed as threatened under the EPBC Act; two as critically endangered, two as endangered and four as vulnerable. Three of these species listed as threatened under the EPBC Act were identified by the NT Fauna Atlas within a 20 km radius of the survey areas. Under the TPWC Act one of these birds is listed as endangered and two are listed as vulnerable. Records of a further four species listed as near threatened and one species listed as data deficient under the TPWC Act were identified by the NT Fauna Atlas within a 20 km radius of the survey areas. All NT Fauna Atlas records within 20 km of the survey areas are mapped in **Figure 16**. Further information on relevant to assessment of likelihood of occurrence of threatened bird species in the survey areas is provided below.

Table 12: Bird species of conservation significance identified by the EPBC PMST and NT Fauna Atlas within a 20 km radius of the Hayes Creek Project Area.

Species name	Common name	Status		PMST	NT Fauna Atlas	Likelihood of Occurrence
		TPWC	EPBC			
<i>Ardeotis australis</i>	Australian bustard	NT			X	High
<i>Burhinus grallarius</i>	Bush stone-curlew	NT			X	High
<i>Calidris ferruginea</i>	Curlew sandpiper	Vu	Cr	X		Moderate
<i>Erythrotriorchis radiatus</i>	Red goshawk	Vu	Vu	X	X	Moderate
<i>Erythrura gouldiae</i>	Gouldian finch	Vu	En	X	X	High
<i>Flacunculus frontatus whitei</i>	Crested shrike-tit (northern)	NT	Vu	X		Low
<i>Geophaps smithii smithii</i>	Partridge pigeon (eastern)	Vu	Vu	X	X	High
<i>Numenius madagascariensis</i>	Eastern curlew	Vu	Cr	X		Low
<i>Poecilodryas cerviniventris</i>	Buff-sided robin	NT			X	High
<i>Psephotus dissimilis</i>	Hooded parrot	NT			X	High
<i>Rostratula australis</i>	Australian painted snipe	Vu	En	X		Moderate
<i>Turnix castanotus</i>	Chestnut-backed button-quail	DD			X	Moderate
<i>Tyto novaehollandiae kimberli</i>	Masked owl (northern)	Vu	Vu	X		High

Cr: critical, En: endangered, Vu: vulnerable, NT: near threatened, DD: data deficient

Curlew sandpiper (*Calidris ferruginea*) – The curlew sandpiper (*Calidris ferruginea*) is a small to medium sized shorebird that is present in Australia during the non-breeding season from late August to April and is listed as vulnerable under the TPWC Act and critically endangered under the EPBC Act (Department of the Environment, 2017). In Australia, the curlew sandpiper inhabit coastal and brackish lagoons, intertidal mud and sand flats, estuaries, saltmarshes and occasionally inland freshwater wetlands (Ward, 2012). The closest record of this species to the survey areas is

approximately 117 km west of the Project area. There is a moderate likelihood that this species will be present in the survey areas during annual migration.

Red goshawk (*Erythrotriorchis radiatus*) – The red goshawk is a large reddish-brown hawk with conspicuous dark streaks from chin to belly and barring on the underwing and tail (Woinarski, 2006b). It is listed as vulnerable under the TPWC Act and EPBC Act. It occurs across much of northern Australia where it generally occurs in tall open eucalypt forest and riparian areas characteristic of higher rainfall areas (Woinarski, 2006b). The closest record of the red goshawk to the survey areas is 32 km north-west of Fountain Head. Given the large territory size of this species (up to 200 km²) (Woinarski, 2006b) and the relatively close proximity of prior records, there is a high likelihood that this species occurs in the survey areas.

Gouldian finch (*Erythrura gouldiae*) – The Gouldian finch is an easily recognised colourful finch that is restricted to isolated areas of tropical savannas in the NT and the Kimberley (Department of Environment and Natural Resources, 2017). It is listed as vulnerable under the TPWC Act and endangered under the EPBC Act. In the late wet season and dry season (February to October) the Gouldian finch inhabits wooded hills containing a group of eucalypts called snappy or salmon gums, with hollows for nesting sites (Department of Environment and Natural Resources, 2017). In the wet season, the Gouldian finch inhabits lowland drainages to feed on seeds on perennial grasses (Department of Environment and Natural Resources, 2017). The closest record of the Gouldian finch to the survey areas is 3 km south of Fountain Head. Given the proximity of prior records and potentially suitable habitat in the survey areas, there is a high likelihood that the Gouldian finch is present in the survey areas.

Crested shrike-tit (northern) (*Falcunculus frontatus whitei*) – The crested shrike-tit is a distinctive medium-sized bird that occurs between the south-west Kimberley east to Borroloola and north into north-east Arnhem Land (Woinarski & Ward, 2012). It is listed as near threatened under the TPWC Act and vulnerable under the EPBC Act. This subspecies inhabits a range of eucalypt and melaleuca woodlands, from relatively wet to strongly seasonal areas in Arnhem Land to semi-arid woodland in the southern Victoria River District (Woinarski & Ward, 2012). The closest record of the crested shrike-tit to the survey areas is 78 km south-west of the project. There is a low likelihood of the species occurring within the survey area.

Partridge pigeon (*Geophaps smithii smithii*) – Partridge pigeons are a medium-sized ground dwelling pigeon listed as vulnerable under both the TPWC Act and EPBC Act (Woinarski, 2006a). It is distributed across the Top End NT and Kimberley but has disappeared from the lower rainfall parts of its range (Woinarski, 2006a). Partridge pigeons mainly inhabit lowland eucalypt open forest and woodland with grassy understorey (Woinarski, 2006a). This species has been recorded within the Hayes Creek survey area, during a 2006 survey of the project area; therefore there is a high likelihood of it occurring in the survey areas.

Eastern curlew (*Numenius madagascariensis*) – The eastern curlew is a very large shorebird that is a non-breeding migrant in Australia for the austral summer (Ward, 2012c). It is listed as vulnerable under the TPWC Act and critically endangered under the EPBC Act. The species has been recorded along the coast and offshore islands of the NT, and are most common in mangrove areas but can also be found on intertidal flats and saltmarshes (Ward, 2012c). The closest record of this species to the survey areas is 113 km north-east of Iron Blow. Given that this species inhabits coastal areas there is a low likelihood that it occurs within the survey areas.

Australian painted snipe (*Rostratula australis*) – The Australian painted snipe is a wading bird that is found throughout Australia, though mostly recorded in south-east Australia (Taylor, et al., 2013). It is listed as vulnerable under the TPWC Act and endangered under the EPBC Act. The species inhabits shallow, vegetated, freshwater swamps, claypans or inundated grassland (Taylor, et al., 2013). The closest record of the Australian painted snipe to the survey areas is 127 km north-east of Fountain Head. Whilst the nearest record is over a hundred km away, there is suitable habitat within the survey area and there is a moderate likelihood that the Australian painted snipe will occur.

Masked owl (northern) (*Tyto novaehollandiae kimberli*) – The masked owl is a large dark owl occurring on the north Australian mainland (Woinarski & Ward, 2012). It is listed as vulnerable under the TPWC Act and EPBC Act. The species occurs mainly in eucalypt tall open forest, but also roosts in monsoon rainforests and forages in more open vegetation types including grasslands (Woinarski & Ward, 2012). The closest record of the masked owl to the survey areas is 8 km west of Fountain Head. As there is potentially suitable habitat for the masked owl present in the survey areas and a record close by, there is a high likelihood that this species is present.

Mammals of conservation significance

Sixteen mammal species of conservation significance were identified by the PMST and/or NT Fauna Atlas as occurring within a 20 km radius of the survey areas (Table 13). Nine of these species are listed as threatened under the EPBC Act; four as endangered and five as vulnerable. Five of these EPBC listed species were identified by the NT Fauna Atlas within a 20 km radius of the survey area. Records of four mammal species listed as threatened under the TPWC Act; one as critically endangered, one as endangered and two as vulnerable, were also identified by the NT Fauna Atlas within a 20 km radius of the survey areas. Records of a further five species listed as near threatened under the TPWC Act were identified by the NT Fauna Atlas within a 20 km radius of the survey areas. All NT Fauna Atlas records of conservation significant mammals within 20km of the survey areas are mapped in **Figure 16**. Further information relevant to assessment of likelihood of occurrence of threatened mammal species in the survey areas is provided below.

Table 13: Mammal species of conservation significance identified by the EPBC PMST and NT Fauna Atlas within the Hayes Creek Project Area.

Species name	Common name	Status		PMST	NT Fauna Atlas	Likelihood
		TPWC	EPBC			
<i>Antechinus bellus</i>	Fawn antechinus	En	Vu	X		Moderate
<i>Conilurus penicillatus</i>	Brush-tailed rabbit-rat	En	Vu	X		Low
<i>Dasyurus hallucatus</i>	Northern quoll	Cr	En	X	X	Moderate
<i>Hipposideros inornatus</i>	Arnhem leaf-nosed bat	Vu	En	X		Low
<i>Hipposideros stenotis</i>	Northern leaf-nosed bat	NT			X	Moderate
<i>Isodon macrourus</i>	Northern brown bandicoot	NT			X	High
<i>Macroderma gigas</i>	Ghost bat	NT	Vu	X		High
<i>Mesembriomys gouldii gouldii</i>	Black-footed tree-rat	Vu	En	X	X	High
<i>Mesembriomys macrurus</i>	Golden-backed tree rat	Cr	Vu			Low
<i>Petrogale concinna canescens</i>	Nabarlek (Top End)	Vu	En	X		Low
<i>Phascogale pirata</i>	Northern brush-tailed phascogale	En	Vu	X	X	Moderate

Species name	Common name	Status		PMST	NT Fauna Atlas	Likelihood
		TPWC	EPBC			
<i>Pseudomys nanus</i>	Western chestnut mouse	NT			X	High
<i>Rattus tunneyi</i>	Pale field-rat	Vu			X	High
<i>Rhinonictis aurantia</i>	Orange leaf-nosed bat	NT			X	High
<i>Saccolaimus saccolaimus nudiclunatus</i>	Bare-rumped sheath-tailed bat	DD	Cr	X		Moderate
<i>Trichosurus vulpecula arnhemensis</i>	Common brushtail possum (Top End)	NT			X	Moderate

Cr: critical, En: endangered, Vu: vulnerable, NT: near threatened, DD: data deficient

Fawn antechinus (Antechinus bellus) – The fawn antechinus is a small dayurid marsupial found in the savannah woodland and tall open forest on the Top End NT (Young, 2012). It is listed as endangered under the TPWC Act and vulnerable under the EPBC Act. The closest record of the fawn antechinus to the survey areas is 30 km north-east of Fountain Head. Given the proximity of prior records, and the presence of potentially suitable habitat, there is a moderate likelihood that the fawn antechinus occurs within the survey areas.

Brush-tailed rabbit-rat (Conilurus penicillatus) –The brush-tailed rabbit rat is a moderate-sized, partly arboreal rat, only known to currently persist in the NT on the Cobourg Peninsula, Bathurst, Melville and Inglis Islands, and Groote Eylandt (Woinarski & Hill, 2012). It is listed as endangered under the TPWC Act and vulnerable under the EPBC Act. The preferred habitat of the species is eucalypt tall-open forest, but, at least on the Cobourg Peninsula, it also occurs on coastal grasslands (Woinarski & Hill, 2012). The closest record of this species is 66 km west of Fountain Head; however this was before 1971. Given the high survey effort for this species in recent years and associated observed declines in populations (see Woinarski & Hill, 2012), and a lack of recent records within the immediate area surrounding the survey areas, there is a low likelihood that the brush-tailed rabbit rat occurs within the survey areas.

Northern quoll (Dasyurus hallucatus) – Northern quolls are distinctive carnivorous marsupials, about the size of a small cat, occurring across much of northern Australia (Woinarski & Hill, 2012b). It is listed as critically endangered under the TPWC Act and endangered under the EPBC Act. The northern quoll occurs in a wide range of habitat, but rocky areas appear to be most suitable (Woinarski & Hill, 2012b). It was common in many eucalypt open forests (Woinarski & Hill, 2012b), however large scale declines and local extinctions have been recorded in Kakadu National Park since the invasion of cane toads (*Rhinella marina*) and similar declines are assumed across the rest of the species range (Woinarski, et al., 2010). A northern quoll was recorded in a 2006 survey of the Project area, 5 km north-east of Fountain Head at North Point mine site. However, taking into account broad-scale decline of the species since this observation as a result of cane toads moving into the region there is a moderate likelihood of the northern quoll being present in the survey areas.

Arnhem leaf-nosed bat (Hipposideros inornatus) – The Arnhem leaf-nosed bat is a moderately large insectivorous bat (DoEE, 2015). It's distribution is one of the most limited of any Australian bat taxon, known only from the Kakadu escarpment on the western edge of the Arnhem land plateau

(DoEE, 2015). In 1978 a population was discovered in a cave at Tolmer Falls, Litchfield National Park; 81 km north-west of the Project (DoEE, 2015). However no bats have been recorded in this cave or the surrounding area since 1983. Based on the lack of current records near the Project, there is a low likelihood that the Arnhem leaf-nosed bat is present within the survey area.

Ghost bat (Macroderma gigas) – Ghost bats are a large species of bat, currently distributed across northern Australia (Ward & Milne, 2016). It is listed as near threatened under the TPWC Act and vulnerable under the EPBC Act. The distribution is influenced by the availability of suitable caves and mines for roost sites, with one of the largest colonies occurring in gold mine workings at Pine Creek NT (Ward & Milne, 2016). Ghost bats were recorded in the survey areas in 1988 and 5 km north-east of the survey area in 2007. There is the potential for caves and suitable disturbed mining areas to be present in the rocky areas within the survey areas, therefore there is a high likelihood that ghost bats are present.

Black-footed tree-rat (Mesembriomys gouldii gouldii) – The black-footed tree-rat is one of the largest rodents in Australia and is found in the Top End NT (Hill, 2012). The species inhabits tropical woodlands and open forests in coastal areas, sheltering in tree hollows and pandanus stands during the day (Hill, 2012). The closest record of *M. g. gouldii* is 14 km south-east of Mt Bonnie. Given the proximity of prior records and potentially suitable habitat in the area, there is a high likelihood that this species occurs in the survey areas.

Golden-backed tree rat (Mesembriomys macrurus) – The golden-backed tree-rat is a large rodent, midway in size between the Territory's other two semi-arboreal species (Woinarski, et al., 2012). It is known only from three records in the Northern Territory; at "Balanbrinni" in the upper McArthur in 1901; from Nellie Creek (in the upper Mary) in 1903; and from Deaf Adder Gorge in 1969 (DLRM, 2015). It is listed as critically endangered under the TPWC Act and vulnerable under the EPBC Act. Whilst there is a record 5 km east of the survey area, the record is from prior to 1970. Given that the species is considered possibly extinct in the wild, there is a low likelihood this species occurs in the survey area.

Nabarlek (Top End) (Petrogale concinna canescens) – The nabarlek is a very small rock-wallaby that has been recorded in scattered populations from the Arafura Swamp in the east to the Daly River catchment in the west (Ward & Woinarski, 2012). The species is restricted to rocky sandstone or granite areas, especially on steep slopes, with large boulders, caves and crevices, and may move to forage in adjacent flat areas (Ward & Woinarski, 2012). The closest record of a Nabarlek is 38 km west of Fountain Head. However given the lack of suitable habitat within the survey area, there is a low likelihood that this species is present.

Northern brush-tailed phascogale (Phascogale pirata) – The northern brush-tailed phascogale is a mid-sized carnivorous marsupial restricted to the Top End NT (Woinarski & Ward, 2012b). Little is known of the ecology of *P. pirata*, but most records are from tall open forest dominated by *E. miniata* and *E. tertodonta* (Woinarski & Ward, 2012b). The closest record of this *P. pirata* to the survey areas is 5 km east of study area at Yam Creek however this record is dated prior to 1971. Given the potentially suitable habitat in the survey areas, there is a moderate likelihood that this species occurs in the survey area.

Pale field-rat (Rattus tunneyi) – The pale field rat is a medium sized rodent found in higher rainfall areas of northern Australia (Young & Hill, 2012). It is listed as vulnerable under the TPWC Act. *Rattus*

tunneyi inhabits dense vegetation along creeks (Young & Hill, 2012). The closest record of the species is 6 km south-west of Mt Bonnie. Given the potentially suitable habitat and the proximity of prior records, there is a high likelihood that this species is present in the survey areas.

Bare-rumped sheath-tailed bat (Saccolaimus saccolaimus nudicluniatus) – The bare-rumped sheath-tailed bat is a large, high-flying, insectivorous bat distributed across north-eastern Australia, including Top End NT (Milne & Woinarski, 2006). It is listed as data deficient under the TPWC Act and critically endangered under the EPBC Act. The species has been recorded in open pandanus woodland and eucalypt tall open forests (Milne & Woinarski, 2006). The closest record of this species to the survey areas is greater than 60 km outside the survey area. Given the difficulty associated with recording the species and potentially suitable habitat, there is a moderate likelihood that this species occurs within the survey areas.

Reptile species of conservation significance

Thirteen reptile species of conservation significance were identified by the PMST and/or NT Fauna Atlas as occurring within a 20 km radius of the survey areas (Table 14). One of these species is listed as vulnerable under the EPBC Act. Records of four reptile species listed as vulnerable under the TPWC Act, were also identified by the NT Fauna Atlas within a 20 km radius of the survey areas. Records of a further two species listed as near threatened and six species listed as data deficient under the TPWC Act were identified by the NT Fauna Atlas within a 20 km radius of the survey areas. All NT Fauna Atlas records of conservation significant reptiles within 20km of the survey areas are mapped in **Figure 16**. Further information relevant to assessment of likelihood of occurrence of threatened reptile species in the survey areas is provided below.

Table 14: Reptile species of conservation significance identified by the EPBC PMST and NT Fauna Atlas within 20 km of the Hayes Creek Project Area.

Species name	Common name	Status		PMST	NT Fauna Atlas	Likelihood
		TPWC	EPBC			
<i>Acanthophis hawkei</i>	Plains death adder	Vu	Vu	X		Low
<i>Demansia olivacea</i>	Olive whip snake	DD			X	High
<i>Dendrelaphis punctulatus</i>	Green tree snake	DD			X	High
<i>Pseudechis australis</i>	King brown snake	NT			X	High
<i>Tiliqua scincoides</i>	Common blue-tongued lizard	DD			X	Moderate
<i>Varanus baritji</i>	Black-spotted ridge-tailed monitor	DD			X	Moderate
<i>Varanus glebopalma</i>	Long-tailed rock monitor	DD			X	Low
<i>Varanus mertensi</i>	Mertens' water monitor	Vu			X	High
<i>Varanus mitchelli</i>	Mitchell's water monitor	Vu			X	High
<i>Varanus panoptes</i>	Floodplain monitor	Vu			X	High
<i>Varanus primordius</i>	Northern ridge-tailed monitor	NT			X	High
<i>Varanus scalaris</i>	Spotted tree monitor	DD			X	High

Cr: critical, En: endangered, Vu: vulnerable, NT: near threatened, DD: data deficient

Plains death adder (*Acanthophis hawkei*) – The plains death adder has a disjointed distribution on the floodplains of the Adelaide, Mary and Alligator Rivers, and the Barkly Tableland (Ward & Phillips, 2012). It is listed as vulnerable under the TPWC Act and EPBC Act. *Acanthophis hawkei* inhabits flat, treeless, cracking soil plains of northern Australia (Ward & Phillips, 2012). The closest record of the plains death adder to the survey areas is 80 km north the project area. As any potentially suitable habitat is likely to be limited in extent in the survey areas, there is a low likelihood of this species occurring.

Merten's water monitor (*Varanus mertensi*) – Merten's water monitor is a medium- to large-sized semi-aquatic monitor found across far north Australia from the Kimberly to the west side of Cape York Peninsula (Ward, et al., 2006). It is listed as vulnerable under the TPWC Act. Merten's water monitor inhabits coastal and inland waters in all river systems of the Top End (Ward, et al., 2006). The closest record of this species to the survey areas is 6 km south of Mt Bonnie. Given the presence of potentially suitable habitat, there is a high likelihood that the species occurs within the survey areas.

Mitchell's water monitor (*Varanus mitchelli*) – Mitchell's water monitor is a slender, medium-sized monitor found across the Kimberly and the Top End, and an isolated population in north-western Queensland (Ward, 2012d). It is listed as vulnerable under the TPWC Act. Mitchell's water monitor inhabits margins of watercourses, swamps and lagoons (Ward, 2012d). The closest record of the species to the survey areas is 10 km south-east of Mt Bonnie. Given the presence of potentially suitable habitat, there is a high likelihood that Mitchell's water monitor occurs in the survey areas.

Floodplain monitor (*Varanus panoptes*) – The Floodplain monitor is a large, heavy-built terrestrial monitor with a broad geographic range across far northern Australia (Ward, et al., 2012b). It is listed as vulnerable under the TPWC Act. The species occurs in a variety of habitats, including coastal beaches, floodplains, grasslands and woodlands (Ward, et al., 2012b). The nearest record of a floodplain monitor is 8 km north of the Fountain Head site. Given the presence of suitable habitat and proximity of records, there is a high likelihood that the species occurs within the survey areas.

Fish and shark species of conservation significance

One fish and shark species of conservation significance was identified by the PMST and/or NT Fauna Atlas as occurring within a 20 km radius of the survey areas (Table 15). This species is listed as vulnerable under both the EPBC Act and TPWC Act. Further information relevant to assessment of likelihood of occurrence of threatened reptile species in the survey areas is provided below.

Table 15: Fish and shark species of conservation significance identified by the EPBC PMST and NT Fauna Atlas within the Hayes Creek Project Area.

Species name	Common name	Status		PMST	NT Fauna Atlas	Likelihood
		TPWC	EPBC			
<i>Pristis pristis</i>	Largetooth sawfish	Vu	Vu	X		Low

Vu: vulnerable

Largetooth sawfish (*Pristis pristis (microdon)*) – The largetooth sawfish is a medium-sized sawfish known from several drainages in northern Australia from Western Australia to Queensland (Larson,

et al., 2006). It is listed as vulnerable under both the TPWC Act, as *P. microdon*, and the EPBC Act, as *P. pristis*. The largemouth sawfish prefers muddy bottoms of freshwater areas and upper reaches of estuaries, but has been reported to be primarily a marine/estuarine species that spends its first 3-4 years in freshwater (Larson, et al., 2006). The closest record of the species to the survey areas is more than 60 km away. The creeks running through the survey areas are relatively small and probably do not provide habitat for an animal as large as the largemouth sawfish. Therefore, there is a low likelihood that it occurs within the survey areas.

3.11.3 Migratory & Marine species

The EPBC PMST and NT Fauna Atlas identified 18 migratory species and 24 marine species as occurring or potentially occurring within 20 km of the survey areas (Table 16).

Table 16: Fauna species listed as migratory under the EPBC Act as identified by the PMST and the NT Fauna Atlas as occurring or having potentially suitable habitat within 20 km of the project area, their conservation status, listing under international agreements and likelihood of occurrence (Likelihood) in the survey area.

Scientific name	Common name	EPBC	PMST	NT Fauna Atlas	International agreement	Likelihood
<i>Acrocephalus orientalis</i>	Oriental reed-warbler	MiMa	X		J, C, B	Low
<i>Anseranas semipalmata</i>	Magpie goose	Ma	X			High
<i>Apus pacificus</i>	Fork-tailed swift	MiMa	X	X	J, C, R	High
<i>Ardea alba</i>	Great egret	Ma	X			Known
<i>Ardea ibis</i>	Cattle egret	Ma	X			Known
<i>Calidris acuminata</i>	Sharp-tailed sandpiper	MiMa		X	J, C, R, B	High
<i>Calidris ferruginea</i>	Curlew sandpiper	MiMa	X		J, C, R, B	Moderate
<i>Cecropis daurica</i> (<i>Hirundo daurica</i>)	Red-rumped swallow	MiMa	X		J, C, R	Moderate
<i>Charadrius veredus</i>	Oriental plover	MiMa	X		J, C, R, B	Moderate
<i>Crocodylus johnstoni</i>	Freshwater crocodile	Ma	X	X		High
<i>Crocodylus porosus</i>	Saltwater crocodile	MiMa	X	X	B	Low
<i>Cuculus optatus</i>	Oriental cuckoo	MiMa	X	X	J, C, R	Moderate
<i>Cuculus saturates</i>	Himalayan cuckoo	Ma				Moderate
<i>Glareola maldivarum</i>	Oriental pratincole	MiMa	X		J, C, R	Moderate
<i>Haliaeetus leucogaster</i>	White-bellied sea eagle	Ma	X			Moderate
<i>Hirundo rustica</i>	Barn swallow	MiMa	X		J, C, R	Moderate
<i>Merops ornatus</i>	Rainbow bee-eater	Ma	X			High
<i>Motacilla cinerea</i>	Grey wagtail	MiMa	X		J, C, R	Moderate
<i>Motacilla flava</i>	Yellow wagtail	MiMa	X		J, C, R	Moderate
<i>Numenius madagascariensis</i>	Eastern curlew	MiMa	X		J, C, R, B	Low
<i>Pandion haliaetus</i>	Osprey	MiMa	X		B	Low
<i>Pristis pristis</i>	Largetooth sawfish	Mi	X		B	Low
<i>Rhipidura rufifrons</i>	Rufous fantail	MiMa	X		B	Low
<i>Rostratula benghalensis</i>	Painted Snipe	MiMa	X			Moderate

Scientific name	Common name	EPBC	PMST	NT Fauna Atlas	International agreement	Likelihood
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Mi: Migratory; Ma: Marine, J: Japan-Australia Migratory Bird Agreement; C: China-Australia Migratory Bird Agreement; R: Republic of Korea-Australia Migratory Bird Agreement; B: Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals)

3.11.4 Other aquatic fauna

Creeks within the study area primarily consist of small tributaries of the Margaret River, a larger river of the Adelaide River catchment. An interrogation of the Fish Atlas of Northern Australia (JCU, 2017) list of fish species found in the Adelaide river catchment found 32 species potentially occurring in the 7,470 km² catchment area. The majority of waterways passing through the area categorised as Stream order 3 and 4. Like most waterways in the top end, they are highly seasonal in nature with flows mostly ceasing between May and November each year (DLRM, Undated). Streams of the order 3 and 4 are classed as minimal to moderate fish habitat. The majority of streams are ephemeral and dry into a series of pools by the end of the dry season. As such the species likely present within the waterway would vary significantly depending on the time of year, stream flow and associated depth and width of the habitat. A full list of potential species present in the wider Adelaide River catchment is summarised below in Table 17. None of these species are species of conservation significance, listed under the EPBC Act, TPWC Act or protected under regulations of the NT Fisheries Act.

Table 17. Fish species identified by the North Australian Fish Atlas as potentially present in the wider Adelaide River Catchment (JCU, 2017).

Species	Common Name
<i>Ambassis agrammys</i>	Sailfin Glassfish
<i>Ambassis macleayi</i>	Macleay's Glassfish
<i>Ambassis</i> sp.	Glassfish
<i>Amniataba percoides</i>	Barred Grunter
<i>Anodontiglanis dahli</i>	Toothless Catfish
<i>Arius leptaspis</i>	Triangular Shield Catfish, Salmon Catfish
<i>Arius</i> sp.	Fork-tailed Catfish
<i>Aseraggodes klunzingeri</i>	Tailed Sole
<i>Craterocephalus stercusmuscarum</i>	Fly-specked Hardyhead
<i>Denariusa bandata</i>	Pennyfish
<i>Glossamia aprion</i>	Mouth Almighty
<i>Glossogobius giurus</i>	Flathead Goby
<i>Hephaestus fuliginosus</i>	Sooty Grunter
<i>Lates calcarifer</i>	Barramundi
<i>Leiopotherapon unicolor</i>	Spangled Perch

Species	Common Name
<i>Megalops cyprinoides</i>	Oxeye Herring
<i>Melanotaenia nigrans</i>	Black-banded Rainbowfish
<i>Melanotaenia splendida inornata</i>	Chequered Rainbowfish
<i>Melanotaenia</i> sp.	Rainbowfish
<i>Magurnda mogurnda</i>	Northern Trout Gudgeon
<i>Mugil</i> sp.	Mullet
<i>Nematalosa erebi</i>	Bony Bream
<i>Neosilurus ater</i>	Black Catfish, Butter Jew, Narrow-Fronted Tandan
<i>Neosilurus Hyrtlii</i>	Hyrtl's Tandan
<i>Neosilurus</i> sp.	Catfish
<i>Oxyeleotris lineolatus</i>	Sleepy Cod
<i>Oxyeleotris selheimi</i>	Giant Gudgeon
<i>Pseudomugil tennellus</i>	Delicate Blue-eye
<i>Scleropages jardinii</i>	Gulf Saratoga
<i>Strongylura krefftii</i>	Freshwater Longtom
<i>Syncomistes butleri</i>	Butler's Grunter
<i>Toxotes chatareus</i>	Seven-spot Archerfish

3.11.5 Introduced fauna species

Twelve introduced fauna species were identified by the EPBC PMST as occurring or potentially occurring within 20 km of the survey areas (Table 18). Eight introduced fauna species were identified by the NT Fauna Atlas within 20 km of the survey area.

Table 18: Introduced fauna species identified as occurring or potentially occurring within 20 km of the Hayes Creek Project Area by the EPBC PMST or NT Fauna Atlas, and observed during the May 2017 on-ground survey.

Scientific name	Common name	PMST	NT Fauna Atlas	On-ground
<i>Bos Taurus</i>	Cattle	X	X	X
<i>Bubalus bubalis</i>	Water buffalo	X	X	X
<i>Canis lupis familiaris</i>	Domestic dog	X		
<i>Columba livia</i>	Rock dove	X	X	

Scientific name	Common name	PMST	NT Fauna Atlas	On-ground
<i>Equus asinus</i>	Donkey	X	X	
<i>Equus caballus</i>	Horse	X		
<i>Felis catus</i>	Cat	X	X	X
<i>Hemidactylus frenatus</i>	Asian house gecko	X	X	
<i>Mus musculus</i>	House mouse	X		X
<i>Rattus rattus</i>	Black rat	X		X
<i>Rhinella marina</i>	Cane toad	X	X	X
<i>Sus scrofa</i>	Pig	X	X	X

3.12 State and Territory Reserves

No Territory reserves were identified in the area surrounding the Hayes Creek Project area.

4 FIELD SURVEY RESULTS

4.1 Survey Conditions

The survey was conducted after the 2016/2017 wet season, from May 15th – 18th. Climatic conditions during the survey were warm and mildly humid. Rainfall in the month preceding the survey, was higher than average, with 64.4 mm of rain recorded at the Douglas River weather station located 49.5 km SW of the survey sites (BOM, 2017).

4.2 Flora species

There were 170 species from 41 families identified during the May 2017 on-ground survey (Appendix 5). These included no species of conservation significance and sixteen introduced species. A number of flora species present could not be identified to species level due to a lack of seed heads, fruit or flowers, these were identified to genus and efforts will be made to identify these species during the late dry season survey.

4.2.1 Conservation significant flora

No flora species of conservation significance were recorded in the survey areas during the May 2017 on-ground survey. Several flora species could not be identified to species level; however all were determined not to be threatened species due to their identified genus, description or and/or location.

4.2.2 Introduced flora species

A total of 16 introduced flora species were recorded during the survey, two of which are listed federally as WoNS and an additional five listed under the NT Weeds Management Act (Table 19, Figure 17). The majority of introduced species observed were within or immediately adjacent to riparian zones around creeklines in the south and north of the survey areas. Dominant introduced species in these areas included snakeweed and hyptis with scattered patches of candlestick bush, spinyhead sida, gamba pea, morning glory vine, red natal grass, couch grass and stylo. One patch of olive hymenachne (*Hymenachne amplexicaulis*), a WoNS, was observed on a creek bank in the south-east of the study area (see Figure 18). Other significant areas of weed growth were noted along the Mt Wells haul road in the north of the study area where gamba grass, a WoNS, and mission grass (*Cenchrus pedicellatus/polystachios*) were prevalent. Two species were identified at study sites in the Fountain Head area, including gamba grass and rubberbush. In the Fountain Head area gamba grass was prevalent around most of the edge of the existing pit and scattered throughout the disturbed area. One weed species were recorded in the Iron Blow site, Rosella. Two weed species were recorded in the Mt Bonnie area including rubberbush and stylo.

Table 19. Introduced flora species identified in the Hayes Creek Project Area, including status under the NT Weeds Act, EPBC Act and WoNSlist.

Species name	Common name	Status			Survey area
		NT	EPBC	WoNS	
<i>Aescynomene americana</i>	American jointvetch				Mt Bonnie creeks
<i>Andropogon gayanus</i>	Gamba grass	B	Inv	X	Fountain Head, northern haul road
<i>Calotropis procera</i>	Rubberbush				Fountain Head, Mt Bonnie creeks
<i>Cenchrus pedicellatus</i>	Mission grass (annual)				Mt Wells haul road, Yam creek
<i>Crotalaria goreensis</i>	Gambia pea				Mt Bonnie creeks, Yam creek
<i>Cynodon dactylon</i>	Couch grass				Yam creek
<i>Hibiscus sabdariffa</i>	Rosella				Iron Blow
<i>Hymenachne amplexicaulis</i>	Olive hymenachne	B,C	Inv	X	Mt Bonnie creek
<i>Hyptis suaveolens</i>	Hyptis	B,C			Mt Wells haul road, Yam creek, Mt Bonnie creeks
<i>Ipomoea</i> spp.	Morning glory vine				Mt Bonnie creeks
<i>Melinis repens</i>	Red natal grass				Mt Bonnie creeks
<i>Senna alata</i>	Candlestick bush	B,C			Mt Bonnie creeks
<i>Sida acuta</i>	Spinyhead sida	B,C			Mt Bonnie creeks
<i>Stachytarpheta</i> sp.	Snakeweed	B,C			Mt Bonnie creeks
<i>Stylosanthes viscosa</i>					Mt Bonnie creeks
<i>Themeda quadrivalvis</i>	Grader grass	B,C			Mt Bonnie creeks, proposed haul road

Classes: A – to be eradicated, B – growth and spread controlled, C – not to be introduced in NT

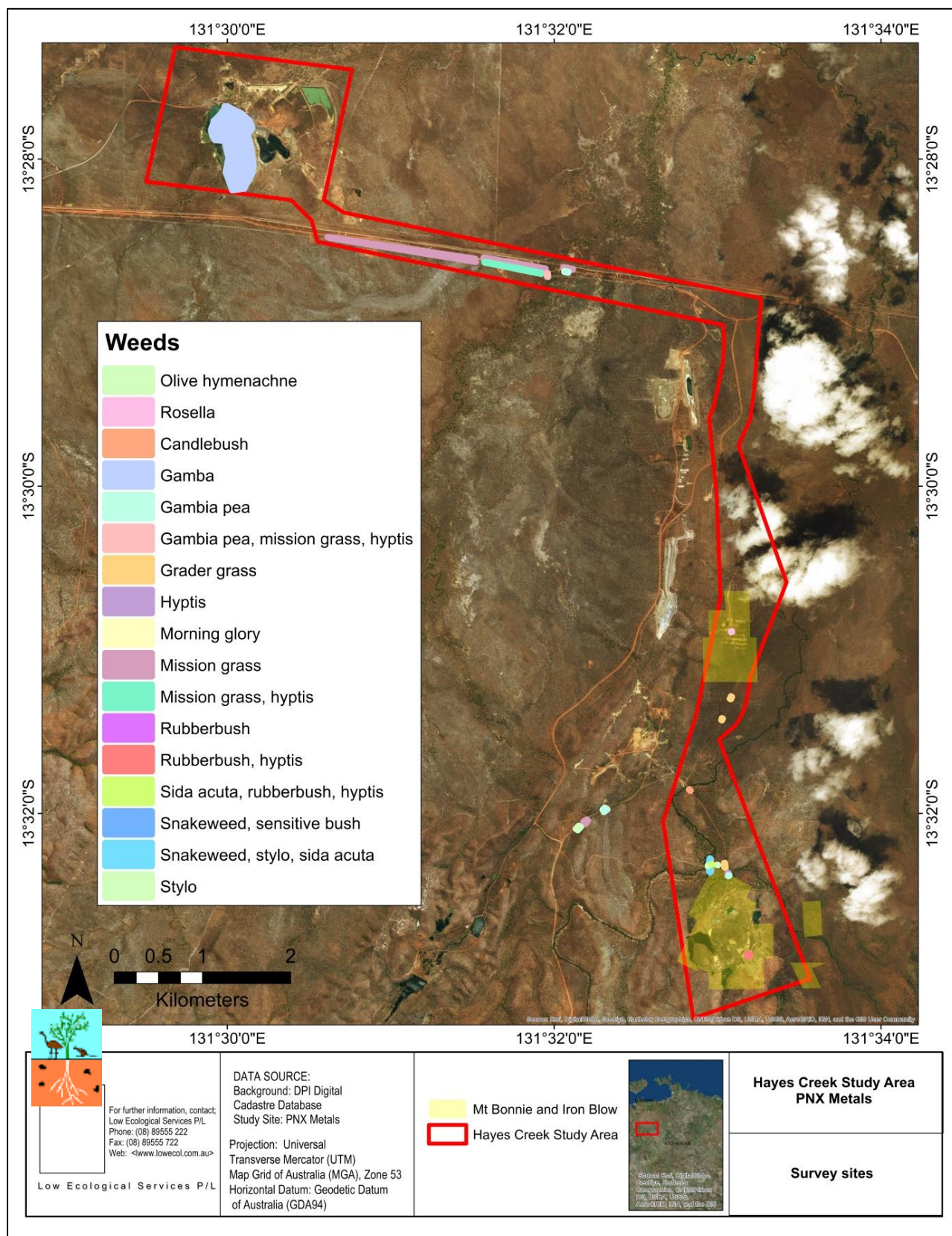


Figure 17. Location of introduced flora species identified during on-ground field survey of Hayes Creek Project Area

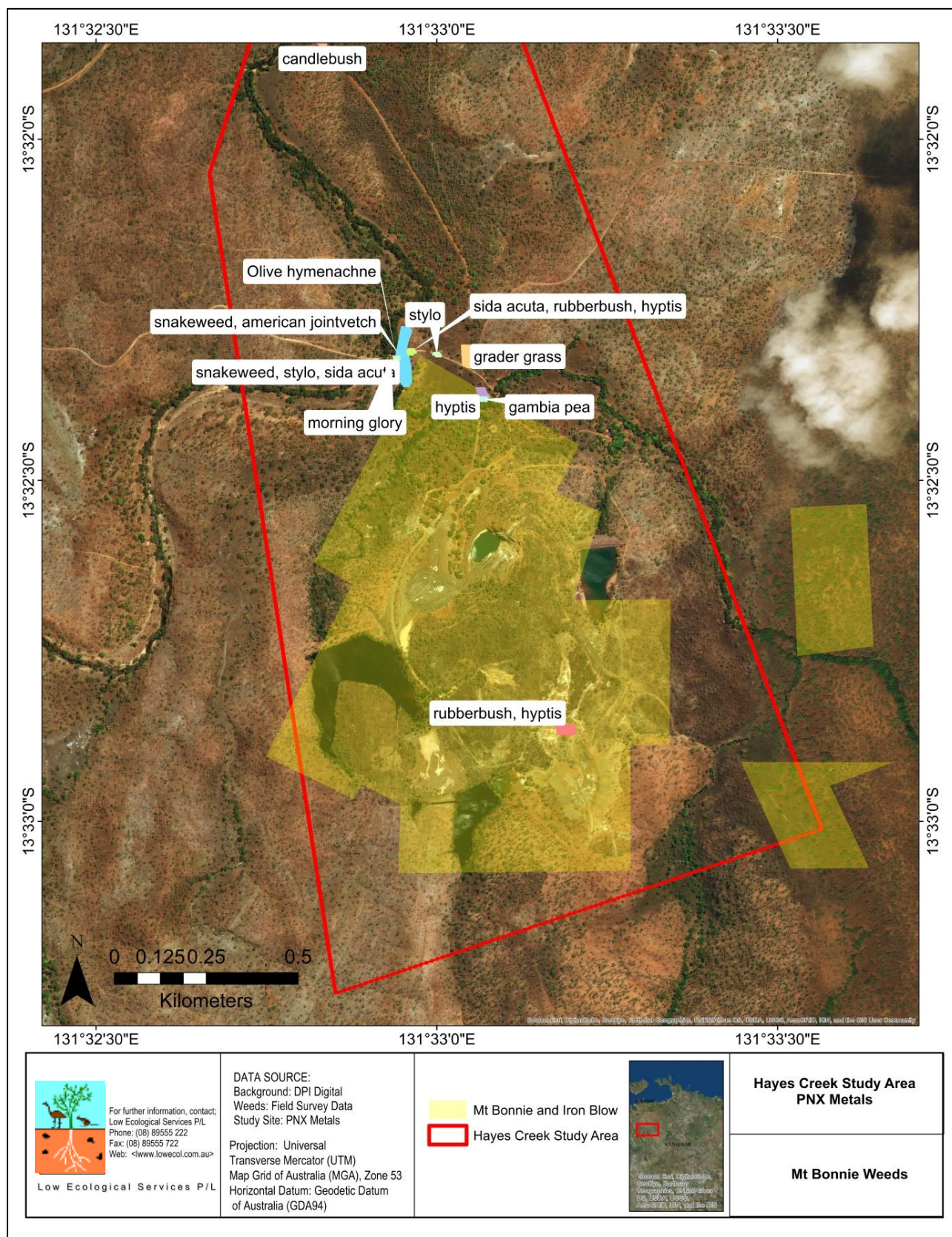


Figure 18. Weed species identified in south of Project area, predominantly situated around creeklines and in riparian zones north of Mt Bonnie site

4.3 Habitat types in the survey area

Five habitats were identified during the on-ground survey. These habitat types are described in detail in the table below (Table 20). Habitat areas identified during the on-ground survey correlated with existing land classifications by Lynch, Cuff & Green (2012) and the vegetation classes described by Wilson et al. (1990) for the Hayes Creek study area. The three land system classifications and four vegetation classes were ground truthed and combined resulting in a total of five key habitats within the study area (Figure 19). Detailed descriptions of each habitat type identified in the survey area are provided in sections 4.4.1 to 4.4.5.

Table 20. Habitat types identified during the onground survey and corresponding Northern Land System and/or NVIS vegetation class.

Northern Land systems (Lynch, et al., 2012)	Vegetation class (Wilson et al. 1990)	Habitat and land classification	Survey area	Primary vegetation recorded	Extent of vegetation community within study area	
					ha	%
McKinley	-	Open forest on alluvial floodplain	Fountain Head trapping site Control site 1 Mt Wells haul road	<i>Melaleuca viridifolia</i> , <i>Corymbia polycarpa</i> , <i>Eucalyptus confertifolia</i> , <i>Corymbia apodophylla</i> , <i>Lophostemon leectifluus</i> , <i>Acacia auriculiformis</i>	59.75	5.82
Rumwaggen	572	Eucalyptus woodland on sandstone plain	Iron Blow trapping site Control site 2 Northern haul road	<i>Corymbialatifolia</i> , <i>Erythrophleum chlorostachys</i> , <i>Eucalyptus tectifera</i> , <i>Eucalyptus miniata</i> and <i>Eucalyptus tintinnans</i>	438.45	42.73
Baker	333	Eucalyptus woodland on low sandstone hills	Mt Bonnie trapping site Control site 3 Southern haul road	<i>Erythrophleum chlorostachys</i> , <i>Eucalyptus tintinnans</i> and <i>Eucalyptus clavigera</i> , <i>Erythrophleum chlorostachys</i> (mid-storey) and <i>Corymbia bleeseri</i>	134.25	13.08
-	320	Creeklines and riparian zones	Yam creek aquatic assessment Mary river tributary aquatic assessment	<i>Nauclea orientalis</i> , <i>Bambus arnhemica</i> , <i>Ficus sp.</i> and <i>Melaleuca leucadendra</i>	25.07	2.44
	1024	Disturbed areas (pastoral/mining/tracks)		Disturbed areas were a combination of cleared tracks, pits and gravel patches with little to no vegetation and revegetated areas consisting of <i>Eucalyptus tectifera</i> , <i>Acacia holosericea</i> and <i>Calytrix sp.</i>	368.75	35.94

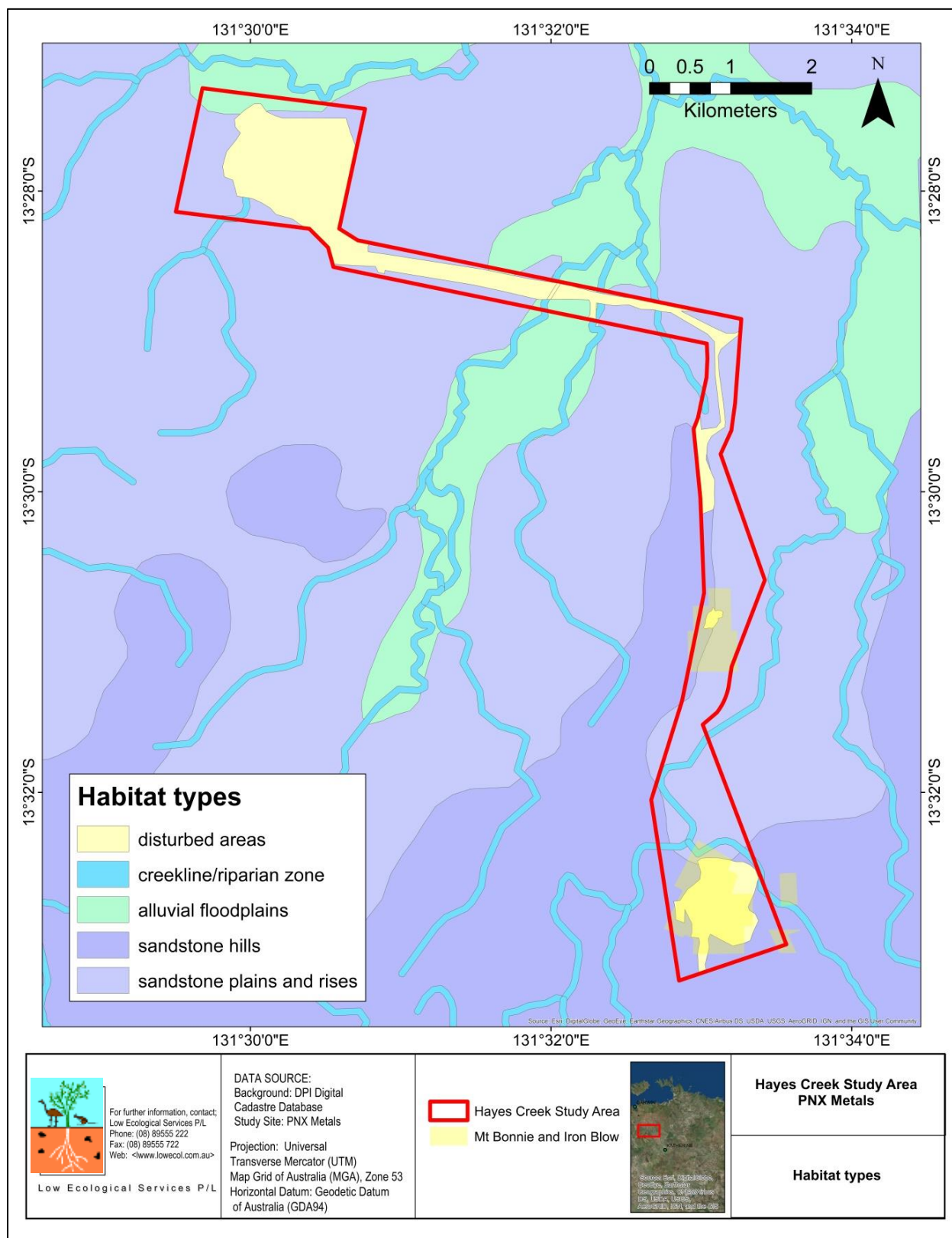


Figure 19. Habitat types identified within the survey area, classified according to vegetation community (Wilson, et al., 1990), soil class (Northcote, 1968) and ground truthed floristic composition.

4.3.1 Open forest on alluvial floodplain

Habitat: Open forest on alluvial floodplain

Structure/Characteristics: Open woodland of Broad-leaved Paperbark (*Melaleuca viridiflora*), Long-fruited Bloodwood (*Corymbia polycarpa*), Broad-leaved Carbeen (*Eucalyptus confertiflora*), (*Corymbia calophylla*) to 12 metres in height. Dense lower storey vegetation consisted primarily of grasses including *Eriachne burkittii*, *Heteropogon* sp, *Fimbristylis* sp., and *Cynodon* sp. as well as forbs including *Spermacoce* sp. and *Stylidium* sp. Soils were grey/brown and yellow with a texture of clay loam with a relatively deep soil depth (>40 cm). Stones were up to 6 cm in size.

Distribution within project area: 59.75ha

Condition and presence of weeds: Weeds were moderately common at both the disturbed and control alluvial floodplain sites. Weeds within the control alluvial site were attributed to adjacent creeklines and existing haul roads.

Stratum	Height (m)	% cover	Dominant species
Tree layer	19.5	<10	<i>C. polycarpha</i> , <i>E. apodophylla</i> , <i>Acacia auriculiformis</i>
Shrub layer	15.5	10-30	<i>Melaleuca viridiflora</i> , <i>A. auriculiformis</i>
Ground layer	2	>70	<i>Themedia triandra</i> , <i>Cynodon</i> sp., <i>Eriachne burkittii</i>



Image 1: Fountain Head trapping site; alluvial floodplain



Image 2: Control site 1; alluvial floodplain

4.3.2 Open woodland on sandstone plain

Habitat: Open woodland on sandstone plain

Structure/Characteristics: Sandstone plains with low rounded hills and open woodland. A sparse overstorey dominated by Darwin stringybark (*Eucalyptus tectifica*) and/or *Eucalyptus foelshiana*, *Eucalyptus tintinnans* and ironwood (*Erythrophleum chlorostachys*) over a midstorey of round-leaf bloodwood (*Corymbia latifolia*), green plum (*Buchanania obovata*) and billygoat plum (*Terminalia ferdinandiana*) and a dense understorey of *heteropogon sp.*, kangaroo grass (*Themeda triandra*) and *Chrysopogon fallax* with mixed forbs and sedges. Soils were light brown to grey loamy clay with a moderate to deep depth (40 to >40 cm) with black to clear crust. Sandstone rocks were likely dug up and dumped on site, small stones were up to 10 cm in size.

Distribution within project area: 438.45ha

Condition and presence of weeds: A moderate level of disturbance by weeds was recorded at the Iron Blow site whilst a negligible presence of weeds was recorded in other areas of similar habitat type along the haul road and at control site 2.

Stratum	Height (m)	% cover	Dominant species
Tree layer	12	15	<i>E.tectifica</i> , <i>E.tintinnans</i> , <i>Erythrophleum chlorostachys</i> , <i>E.miniata</i> and <i>E.foelshiana</i>
Shrub layer	4.9	10-30	<i>Buchanania obovata</i> , <i>Terminalia ferdinandiana</i> , <i>Corymbia latifolia</i> and <i>Erythrophleum chlorostachys</i>
Ground layer	1.8	>70	<i>Themeda triandra</i> , <i>Heteropogon sp.</i> , <i>Chrysopogon fallax</i> , <i>Stylidium sp.</i> , <i>Goodenia sp.</i> , <i>Spermocoe sp.</i>



Image 3: Control site 2; open woodland on sandstone plain

4.3.3 Woodland on low sandstone hills

Habitat: Woodland on low sandstone hills

Structure/Characteristics: Low rounded hills with rock outcrop. Woodland community consisting of sparse overstorey dominated by *Eucalyptus tintinnans*, *E.foelshiana*, *E.clavigera* and *Erythrophleum chlorostachys* over a Midstorey dominated of *Cochlospermum fraseri*, *Buchanania obovatus* and *Erythrophleum chlorostachys*. Dense grassy understorey comprised predominantly of *Heteropogon* sp., *Themeda triandra* and a range of forbs and sedges.

Distribution within project area: 134.25

Condition and presence of weeds: Weeds at all sites in this habitat type were recorded as negligible (1 on a scale of 0-5).

Stratum	Height (m)	% cover	Dominant species
Tree layer	12.5	10-30	<i>E. foelshiana</i> , <i>E.tintinnans</i> , <i>E.clavigera</i> , <i>Erythrophleum chlorostachys</i>
Shrub layer	3.1	10-30	<i>Cochlospermum fraseri</i> , <i>Buchanania obovatus</i> , <i>Erythrophleum chlorostachys</i>
Ground layer	1	>70	<i>Heteropogon</i> sp., <i>Themeda triandra</i>



Image 5: Mt Bonnie trapping site; open woodland on low sandstone hills



Image 6: Control site 3; open woodland on low sandstone hills

4.3.4 Creekline and riparian zone

Habitat: Creekline and riparian zone

Structure/Characteristics: Open forest with overstorey dominated by *Nauclea orientalis*, *Ficus racemosa* and *Melaleuca leucadendra* over a dense Midstorey characterised by *Lophostemon lactifluus*, *Pandanus aquatic* and *Bambusa arnhemica* with an understorey predominantly made up of weed species including snakeweed (*Stachytarpheta* sp.), hyptis (*Hyptis suaveolens*) and grader grass (*Themeda quadrivalvis*) interspersed with *Heteropogon contortus* and *Themeda triandra*.

Distribution within project area: 25.07

Condition and presence of weeds: Weeds disturbance was recorded as high in most riparian zone vegetation communities recorded within the survey area

Stratum	Height (m)	% cover	Dominant species
Tree layer	Up to 20m	10.30	<i>Melaleuca leucadendra</i> , <i>Nauclea orientalis</i> , <i>Ficus racemosa</i>
Shrub layer	1.5	30-70	<i>Bambusa arnhemica</i> , <i>Lophostemon lactifluus</i>
Ground layer	0.5	10	Snakeweed (<i>Stachytarpheta</i> sp.), Grader grass (<i>Themeda quadrivalvis</i>), <i>Heteropogon contortus</i>



Image 7: Mary River tributary, north of Mt Bonnie



Image 8: Snakeweed (*Stachytarpheta* spp.) and Candle bush (*Senna alata*) adjacent to Mary River tributary, north of Mt Bonnie

4.3.5 Pastoral/Disturbed areas

Habitat: Areas disturbed by pastoralism, mining, existing haul roads and tracks

Structure/Characteristics: Primarily no vegetation (some areas of rehabilitation), some waste rock dumps, erosion, open cut pits, tailings dams etc.

Distribution within project area: 368.75ha

Condition and presence of weeds: Weeds disturbance was observed to be moderate – high, predominantly in the Fountain Head disturbed area, along the Mt Wells Road (running E-W, south of Fountain Head), along existing tracks through the study area and patchily in the Iron Blow and Mt Bonnie disturbed areas.

Stratum	Height (m)	% cover	Dominant species
Tree layer	-	-	
Shrub layer	Varied	Varied	<i>Acacia holesericea</i> , <i>Calytrix</i> sp.
Ground layer	Varied	Varied	Gamba grass (<i>Andropogon gayanus</i>) hyptis (<i>Hyptis suaveolens</i>), mission grass (<i>Cenchrus pedicellatus</i>)



Image 9: Pastoral and mining affected land in Fountain Head lease area.



Image 10: Mining affected land at Iron Blow, adjacent to trapping site.

4.4 Fauna

Eighty-six native fauna species were recorded during the on-ground survey of the Hayes Creek project (see Appendix 7 for full species list). The highest number of fauna species was recorded in the Fountain Head survey area, followed by Iron Blow, then Mt Bonnie (Table 21). A copy of the bat identification report provided by Dennis Matthews can be found in Appendix 8. A summary of the number of species recorded at each site and its equivalent control site is provided below in Table 21. Native species recorded at trapping sites and equivalent land system control sites within the Hayes Creek survey area..

Table 21. Native species recorded at trapping sites and equivalent land system control sites within the Hayes Creek survey area.

Species	Alluvial floodplain sites		Sandstone plain sites		Sandstone hill sites	
	Fountain Head	Control 1	Iron Blow	Control 2	Mt Bonnie	Control 3
Amphibians	3	0	0	0	0	0
Birds	21	15	19	11	9	15
Mammals	6	4	6	4	7	4
Reptiles	1	2	4	2	0	2
Total	31	21	29	17	16	21

Amphibians

Amphibians were only observed in the Fountain Head survey area. The dominant amphibian species recorded in the Fountain Head area was the introduced cane toad (*Rhinella marina*) with 12 recorded observations. Other frog species included the ornate burrowing frog (*Ophithodon ornatus*), the marbled marsh frog (*Limnodynastes convexiusculus*) and the pale frog (*Litoria pallida*).

Birds

Birds were recorded most commonly across all sites with 67 bird species recorded across all sites. Bar-shouldered doves (*Geopelia humeralis*) and peaceful doves (*Geopelia placida*) were the most common species, recorded at all sites. Other commonly recorded birds included sulphur-crested cockatoos (*Cactua galerita*), red-tailed black cockatoos (*Calyptorhynchus banksia*), rainbow bee-eaters (*Merops ornatus*), torresian crows (*Corvus orru*) and white-bellied cuckoo shrikes (*Coracina papuensis*). A number of water birds were observed in the Fountain Head survey site, including magpie geese (*Anseranas semipalmata*) cattle egrets (*Ardea ibis*), white-necked herons (*Ardea pacifica*), black-winged stilts (*Himantopus himantopus*), radjah shelduck (*Tadorna radjah*), straw-necked ibis (*Threskiornis spinicollis*) and masked lapwing (*Vanellus miles*). Most water birds were observed in or close to a swamp area that appeared to be ephemerally inundated by run-off from the adjacent Fountain Head production site.

Mammals

The large majority of mammal species recorded across the survey area were bat species or introduced species. The orange leaf-nosed bat (*Rhinocnictus aurantia*) was the most commonly recorded species at all sites and during spotlighting. Evidence of feral pigs was recorded across the survey area whilst cattle and water buffalo were recorded in the north of the survey area. Black rats were recorded in the riparian zone north of Mt Bonnie. Sign of dingoes was recorded in the Mt Bonnie area.

Reptiles

Nine reptile species across five sites were recorded in the survey area. The robust ctenotus (*Ctenotus robustus*) was the most commonly recorded reptile species. The northern ridge-tailed monitor (*Varanus panoptes*) was recorded at two sites in the sandstone plain habitat area. Other reptile species recorded included a western brown snake (*Pseudonaja nuchalis*), greater black whip snake (*Demansia papuensis*) and a northern hooded scaly-foot (*Pygopus steelescotti*). On reptile, merten's water monitor (*Varanus mertensii*) was anecdotally recorded from the Iron Blow production site.

4.4.1 Threatened fauna

One fauna species listed as endangered (EPBC)/vulnerable (TPWC), Gouldian finch (*Erythrura gouldiae*), was recorded during on-ground survey of the Hayes Creek study area, following targeted survey effort for threatened species identified by the NT Fauna Atlas and PMST (see section 2.2 for a description of the methods employed for each identified threatened species). One species listed as vulnerable under the TPWC Act, Merten's water monitor (*Varanus mertensi*) was anecdotally recorded in the survey area earlier in the year (see below). Coordinates for locations of observations are recorded in Table 22.

A group of Gouldian finches were observed at the southern junction to the haul road between Mt Bonnie and Iron Blow production sites (Figure 20). Approximately 12 individuals were observed including males, females and juveniles. The group were initially observed on the haul road, foraging for grass seeds (Lat -13.530168, Long 131.546203). During further observations over the following two days, the group were noted to move between the woodland immediately adjacent the haul road and the haul road. The group were also heard down towards the creekline north of Mt Bonnie, immediately adjacent their observed location. The area was dominated by *Eucalyptus tectifica* and *Corymbia foelishiana/latifolia*. Dominant grasses in the area included *Alloteropsis semialata*, *Heteropogon contortus* and *Themeda triandra*. Gouldian finches are known to preferentially feed on these grass species during the wet season, at which time they forage sites within a radius of up to 10km from breeding area (Dostine, et al., 2001). Breeding areas are typically characterised by *Eucalyptus tintinnans* and/or *E.brevifolia*, *E.leucophloia* and *E.dicromophloia* with an understorey of *Sorghum*. Whilst these species were not recorded in the immediate area the Gouldian finches were observed, *E.tintinnans* and *Sorghum* sp. grasses were recorded widely across the project area including in the Iron Blow and Mt Bonnie areas (see section 4.3 for characterisation of habitat types at survey sites).

One species listed as vulnerable under the TPWC Act, Merten's water monitor was informally recorded in the project area via conversation with a Kirkland Lake Gold (KL Gold) employee accompanying LES staff during the on-ground survey. The KL Gold employee reported observing a

Merten's water monitor in the Iron Blow production area earlier in the year. LES staff confirmed the identification through a photo taken of the species.

4.4.2 Fauna species of other conservation significance

No fauna species listed as migratory were recorded during the May 2017 on-ground survey. Four species listed as near-threatened under the TPWC Act were observed; buff-sided robin (*Poecilodryas cerviniventris*), bush-stone curlew (*Burhinus grallarius*), orange leaf-nosed bat (*Rhinonictis hipposideridae*) and northern ridge-tailed monitor (*Varanus primordius*). Three EPBC listed marine species were observed within the survey area, including freshwater crocodile (*Crocodylus johnsoni*), great egret (*Ardea alba*) and cattle egret (*Ardea ibis*) (Figure 20). The locations of all fauna species of conservation significance observed throughout the survey are recorded below in Table 22.

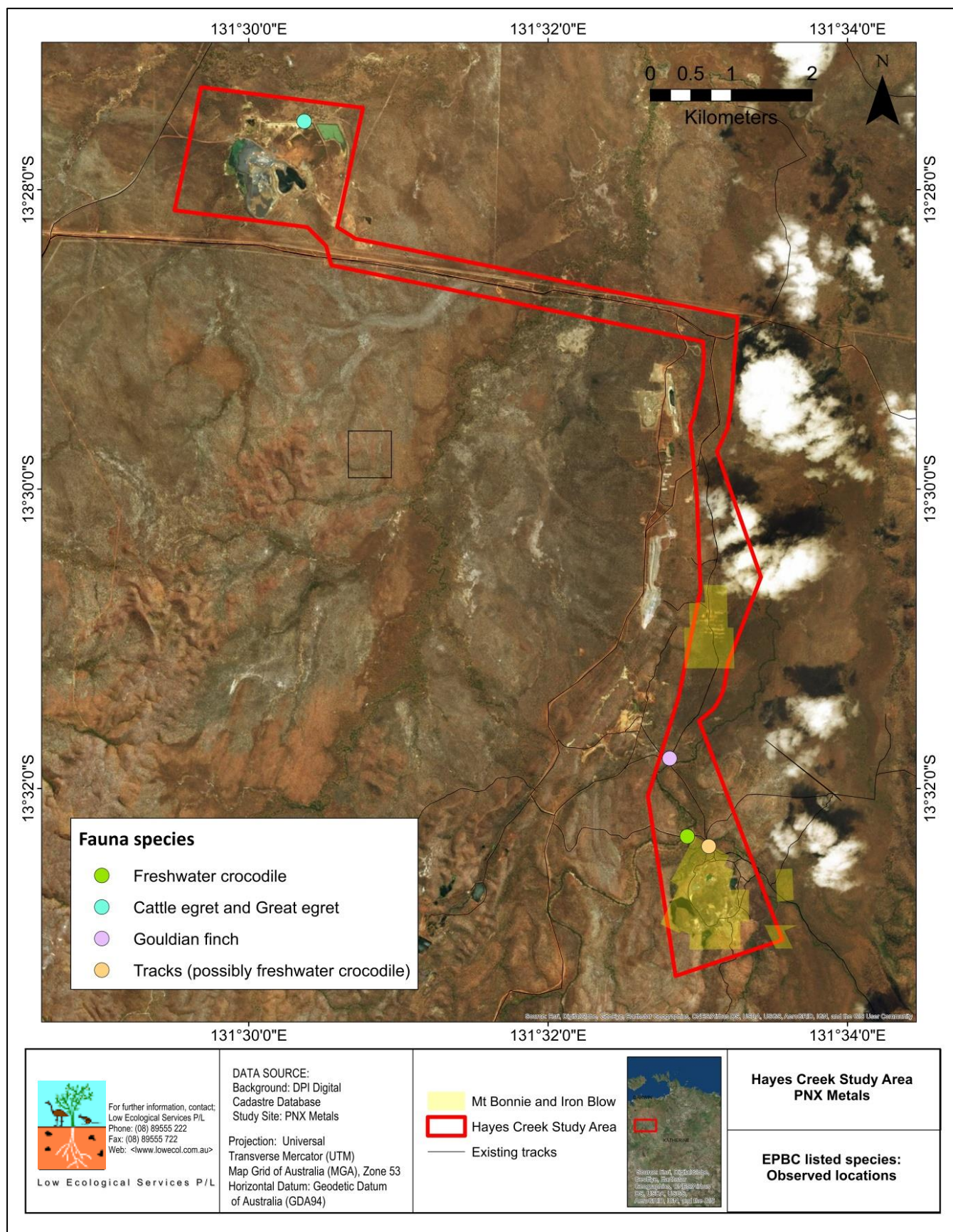


Figure 20. Location of Gouldian Finch group observed during on-ground field survey of Hayes Creek Project

Table 22. Location of threatened species and other species of conservation significance recorded during on-ground survey of the Hayes Creek Project area

Species		Status		Location	Date	Coordinates	
Common name	Scientific name	EPBC	TPWC			Lat	Long
Buff-sided robin	<i>Poecilodryas cerviniventris</i>		NT	Yam creek	17.5	-13.477681	131.532994
Bush-stone curlew	<i>Burhinus grallarius</i>		NT	Mt Wells haul road (running E-W, south of Fountain Head)	16.5, 17.5, 18.5	-13.476929	131.526045
Cattle egret	<i>Ardea ibis</i>	Ma		Waterbody adjacent to Fountain Head trapping site	16.5, 17.5, 18.5	-13.459304	131.505837
Freshwater crocodile	<i>Crocodylus johnsoni</i>	Ma		Creek north-west of Mt Bonnie site	17.5	-13.538662	131.548880
Gouldian finch	<i>Erythrura gouldiae</i>	En	Vu	Proposed haul road track north of Mt Bonnie production site	17.5, 18.5	-13.530168	131.546203
Great egret	<i>Ardrea alba</i>	Ma		Waterbody adjacent to Fountain Head trapping site	16.5, 17.5, 18.5	-13.459304	131.505837
Merten's water monitor	<i>Varanus mertensii</i>		Vu	Iron blow pit – anecdotal evidence from KL Gold employee with species identification confirmed via photo by LES staff	Early 2017	-13.54792	131.551244
Northern ridge-tailed monitor	<i>Varanus primordius</i>		NT	Funnel traps at Iron Blow trapping site and Control site 2.	17.5, 18.5	-13.515193 -13.491322	131.552031 131.553657
Orange leaf-nosed bat	<i>Rhinonictis hipposideridae</i>		NT	Across the survey area	17.5, 18.5, 19.5	All	All

EPBC status - Ma: marine, En: endangered; TPWC status – Vu: vulnerable, NT: near threatened

4.4.3 Introduced fauna

Six introduced fauna species were recorded during surveys of the Hayes Creek project. These were black rat (*Rattus rattus*), cane toad (*Rhinella marina*), cattle (*Bos taurus*), feral pig (*Sus scrofa*), cat (*Felis catus*) and water buffalo (*Bubalus bubalis*). Cattle were recorded in the Fountain Head area. Water buffalo were recorded crossing the Mt Wells Road in the north of the survey area. Cat tracks were recorded along the proposed haul road. Cane toads were ubiquitous throughout all survey areas. Black rat was recorded along the creeklines north of the Mt Bonnie production area. Pigs were recorded across all three project sites.

4.5 Aquatic and Riparian Habitat areas

4.5.1 Classification of waterways in the survey area

Waterways within the survey area were identified and classified using Straler's stream order classification system (Table 23, Figure 21).

Table 23. Stream orders of waterways identified within the Hayes Creek survey area (Strahler, 1952)

Waterway	Location	Stream Order	Description	Coordinates	
				Lat	Long
Mt Bonnie Creek	North of Mt Bonnie	3	Waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event.	-13.538662°	131.548880°
Yam Creek	Mt Wells haul road	4	Permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting area.	-13.478989°	131.532593°
Downstream creek	Mt Wells haul road East	4	Permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting area.	-13.482082°	131.566009°
Ephemerally inundated swamp	North of Fountain Head	-	Areas that are inundated or saturated at a frequency to at times support plants and/or animals adapted to saturated and/or inundated conditions. The water may be static or flowing fresh, brackish or salt.	-13.459620°	131.505073°

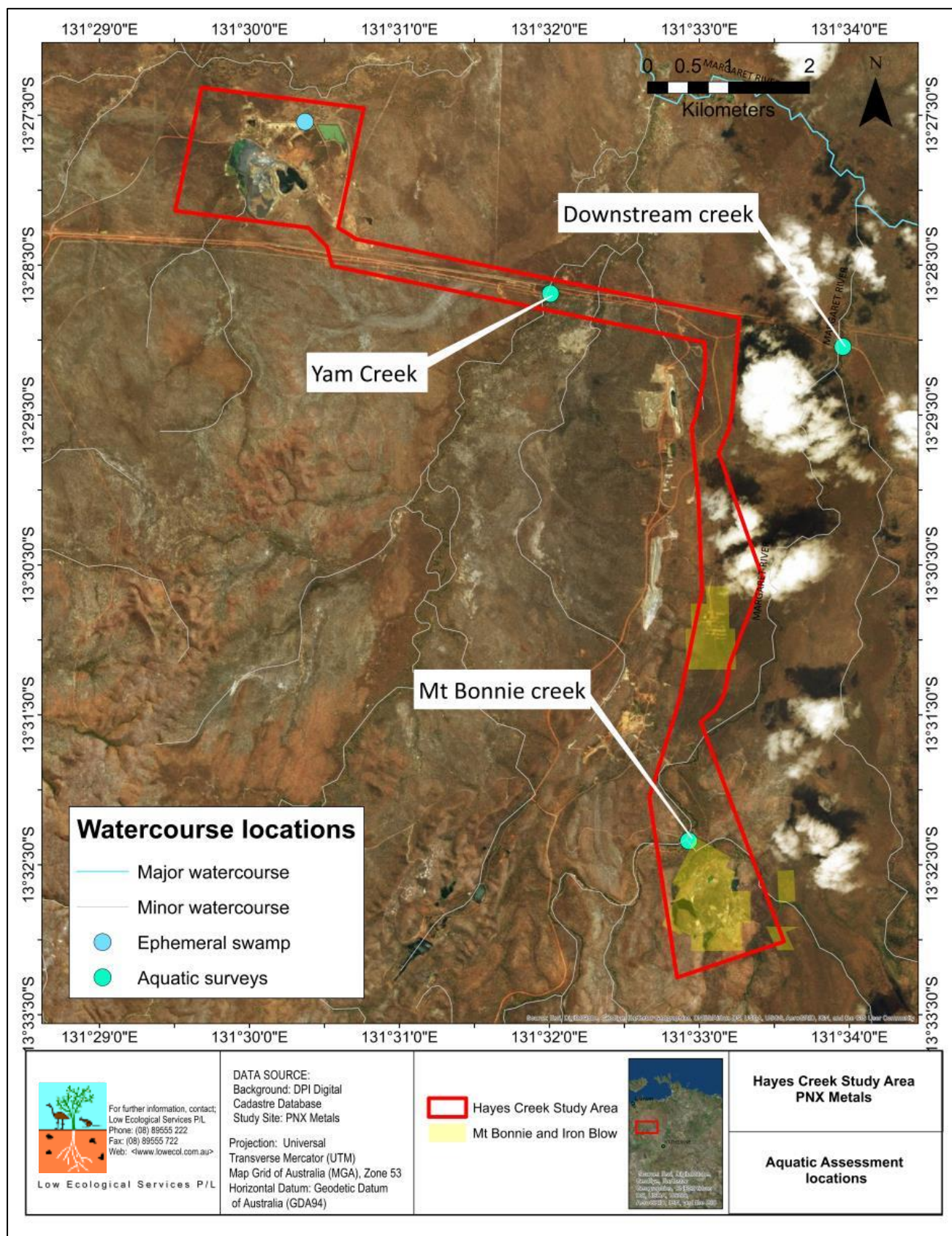


Figure 21. Location of waterways assessed including “Mt Bonnie” creek, Yam creek and a downstream creek.

4.5.2 Characterisation of habitat areas

Creeklines within the Project area are vegetated primarily with forest and woodland communities (see section 4.4). Evidence of disturbance is present along the banks of all creeks adjacent to existing tracks and haul roads. Creeks in the south of the Project, north of Mt Bonnie site have significant weed growth on the banks (see section 4.3.2) and evidence of infrastructure including old culverts and bridges that are no longer structurally sound. Additional waste was observed in creeks adjacent to existing tracks including old fans and airconditioners (Image 11 and Image 12).



Image 11: Waste observed in and adjacent to creeks north of Mt Bonnie



Image 12: waste observed in Yam Creek

All three creeks assessed contained flowing water at the time of the post-wet season survey. Freshwater habitat was present in a number of small scattered pools (see Images 13-18). Habitat substratum consisted of predominantly sand/silt with some rocky sections. Deep pools were observed at both Yam creek and the downstream creek location whilst smaller pools were observed at the Mt Bonnie creek. Cover was available within all waterways in the form of logs, undercut banks and vegetation roots. Moderate erosion was evident at all creek sites, likely due to large influxes of water during wet season flows.

Bank vegetation cover was moderately dense at all sites, approximately 51-75%. All three creeks were characterised by predominantly native vegetation (85-92%) however large dense patches of weed cover was noted at all sites. Weeds observed included snakeweed (*Stachytarpheta sp.*), gamba grass (*Andropogon gayanus*), *Sida acuta*, candle bush (*Senna alata*), hyptis (*Hyptis suaveolens*), gambia pea (*Crotalaria goreensis*), mission grass (*Cenchrus pedicellatus*) and olive hymenachne (*Hymenachne amplexicaulis*) (see section 4.3.2).



Image13: Mt Bonnie Creek



Image 14: Mt Bonnie Creek



Image 15: Yam Creek



Image 16: Yam Creek



Image 17: Downstream Creek

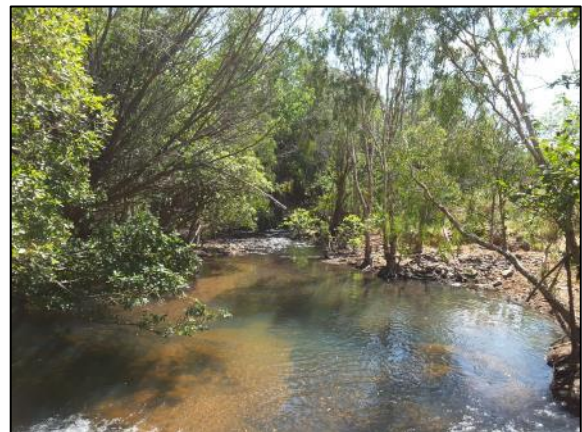


Image 18: Downstream Creek

4.5.3 Aquatic and terrestrial fauna species

Fauna species were recorded at all three sites based on observation, tracks and scats. No trapping or macroinvertebrate assessments were conducted. Fish and yabbies were observed in shallow and deep pools at all aquatic assessment sites. Fauna species observed are summarised in Table 24. Terrestrial fauna species observed at creek locations within the study area were incorporated into the fauna species assessment (4.5.2) and recorded as incidental sightings (Appendix 6).

Table 24. Terrestrial and aquatic species observed at aquatic assessment sites

Location	Native fauna	Introduced fauna
Mt Bonnie creek	Forest kingfisher, rainbow bee-eater, Brown honeyeater, yellow bellied flycatcher, willy wagtail, northern fantail, double barred finch, crimson finch, freshwater crocodile, tata lizard, skink tracks, monitor tracks, rainbow fish (<i>Melanotaeniidae species</i>), Yabby species (<i>Cherax species</i>)	Cane toad, cat tracks
Yam creek	Buff-sided robin, sulfure crested cockatoo, striated pardalote, radjah duck, tawny frogmouth, robust ctenotus, tata lizard, rainbow fish	Buffalo, cane toads
Downstream creek	Rainbow fish (<i>Melanotaeniidae species</i>), yabbie (<i>Cherax species</i>)	

5 IMPACT ASSESSMENT

The main impacts on biodiversity are the clearing of native vegetation and removal of habitat including threatened species habitat within the disturbance area. PNX Metals plan to minimise impacts on biodiversity resulting from clearing of native vegetation and habitat, by restricting the majority of development to areas already disturbed by previous mining activities. Approximately 33ha of intact vegetation will require removal if clearing is restricted to expansion of the haul road connecting Mt Bonnie and Iron Blow production sites with existing haul roads at the north and south of the Project area. Proposed clearing falls within two dominant habitat types, Eucalyptus woodland on sandstone plains and Eucalyptus woodland on low sandstone hills and rises (see section 4.4). Proposed haul road expansion would result in the removal of 3.25% of these habitat areas (Figure 22, Table 25).

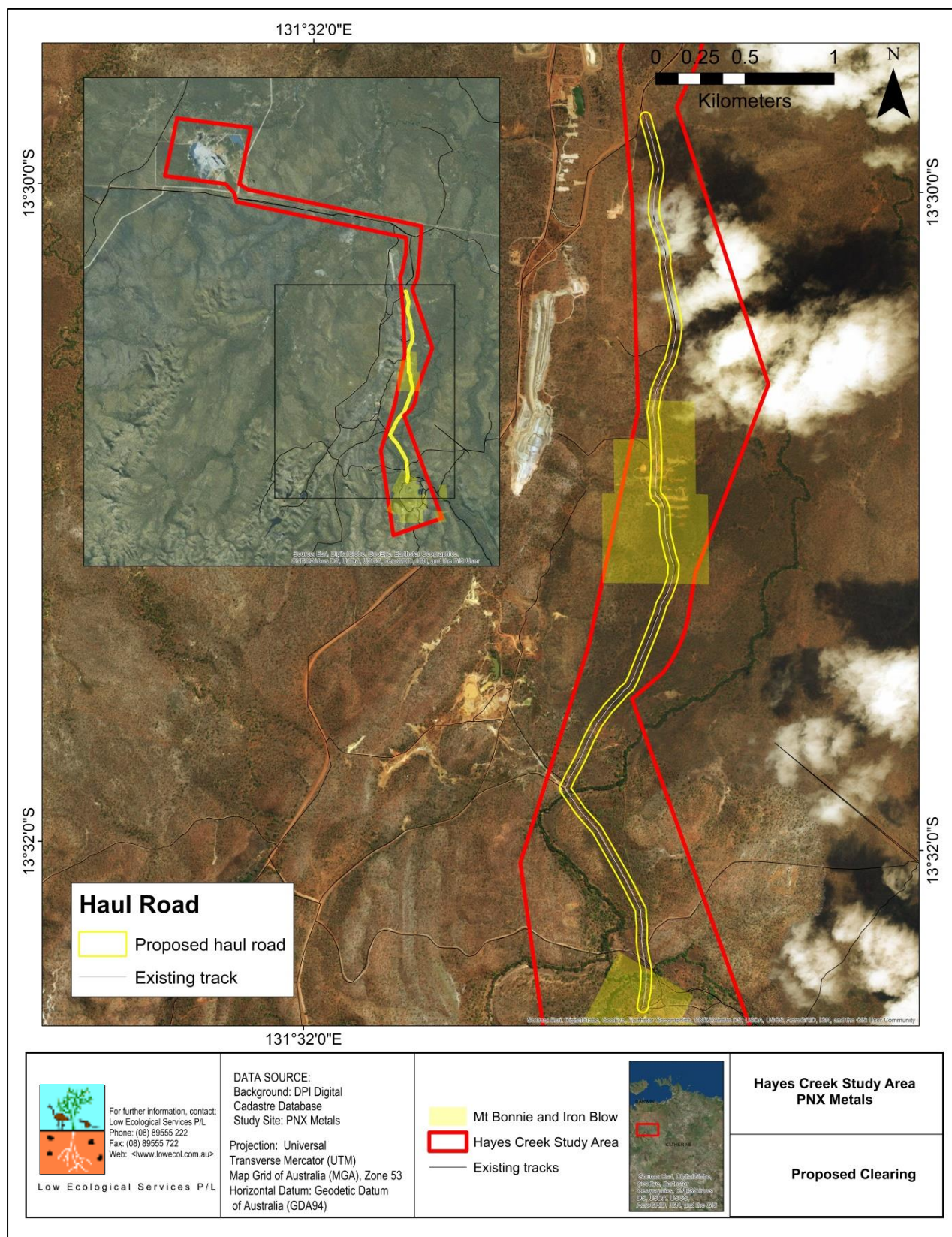


Figure 22. Proposed areas to be cleared along haul road connecting Mt Bonnie and Iron Blow sites with existing haul roads in the north and south of the Project area.

Table 25. Proportion of habitat area, grouped by land system (Lynch, Cuff & Green, 2012) and vegetation class (Wilson et al. 1990) to be cleared within the total survey area based on clearing estimates in Figure 22 (hectares cleared and percent of total habitat area within project area)

Northern Land systems	Vegetation class	Habitat and land classification	Survey area	Primary vegetation recorded	Extent of vegetation community within study area		Vegetation community effected by proposed clearing	
					ha	%	ha	%
McKinley	-	Open forest on alluvial floodplain	Fountain Head trapping site Control site 1 Mt Wells haul road	<i>Melaleuca viridifolia</i> , <i>Corymbia polycarpa</i> , <i>Eucalyptus confertifolia</i> , <i>Corymbia apodophylla</i> , <i>Lophostemon leccifluus</i> , <i>Acacia auriculiformis</i>	59.75	5.82	0	0
Rumwaggen	572	Eucalyptus woodland on sandstone plain	Iron Blow trapping site Control site 2 Northern haul road	<i>Corymbialatifolia</i> , <i>Erythrophleum chlorostachys</i> , <i>Eucalyptus tectifia</i> , <i>Eucalyptus miniata</i> and <i>Eucalyptus tintinnans</i>	438.45	42.73	25.35	5.78
Baker	333	Eucalyptus woodland on low sandstone hills	Mt Bonnie trapping site Control site 3 Southern haul road	<i>Erythrophleum chlorostachys</i> , <i>Eucalyptus tintinnans</i> and <i>Eucalyptus clavigera</i> , <i>Erythrophleum chlorostachys</i> (mid-storey) and <i>Corymbia bleeseri</i>	134.25	13.08	7.02	5.22
-	320	Creeklines and riparian zones	Yam creek aquatic assessment Mary river tributary aquatic assessment	<i>Nauclea orientalis</i> , <i>Bambus arnhemica</i> , <i>Ficus sp.</i> and <i>Melaleuca leucadendra</i>	25.07	2.44	1	3.99
	1024	Disturbed areas (pastoral/mining/tracks)		Disturbed areas were a combination of cleared tracks, pits and gravel patches with little to no vegetation and revegetated areas consisting of <i>Eucalyptus tectifia</i> , <i>Acacia holosericea</i> and <i>Calytrix sp.</i>	368.75	35.94	-	-
Total proposed clearing (estimate)							33.37	3.25

5.1 Affected threatened flora

A significant impact assessment was conducted for all flora species listed under the EPBC or TPWC Act deemed to have a moderate likelihood of occurrence or greater with the Project footprint. The project footprint was determined prior to the on-ground field survey by PNX Metals and is synonymous with the “study area”. Of the two species assessed, no species were determined likely to be significantly impacted by development of the Hayes creek project (Table 26). Details of the assessment of each threatened flora species considered are provided below.

5.1.1 Endangered flora

Stylidium ensatum grows on poorly drained grassy flats that stay wet into the dry season. (Northern Territory Herbarium, 2013). It is often found with *Eriachne burkitii*, *Pandanus* spp., *Osbeckia* spp. and *Fimbristylis furva* (Northern Territory Herbarium, 2013). There are no records of the species within 100km of the study area. There is potential habitat for this species in a small section of alluvial floodplains on the southern side of the Mt Wells haul road and north of the Fountain Head production site within the lease area, however no species were recorded during the May Survey. No additional clearing is proposed along the Mt Wells haul road (existing E-W road south of Fountain Head). Increased traffic of large vehicles along the road may increase dust produced, potentially impacting growth of the species if it were to occur in the inundated grassland area adjacent to the haul road. However the potential area of suitable habitat is small and the likelihood that indirect impacts of mining vehicle movement would lead to a long-term decrease in the size of a population should it occur or modify/decrease the availability of quality habitat in the long-term is unlikely.

Additional potential habitat areas exist north of the Fountain Head production site within the lease area. These areas are already heavily disturbed by cattle from Ban Ban Springs station and the potential for occupancy within this area is low.

Development of the Hayes Creek project is considered unlikely to have a significant impact on the species.

5.1.2 Vulnerable flora

Acacia praetermissa is known from two general locations in the Northern Territory, near Emerald Springs and Hayes Creek, with the Hayes Creek population located approximately 10km SSE of the study area. It grows on upper to lower slopes with various aspects in stoney skeletal or sandy soils on sandstone or laterite substrates. Associated dominant vegetation includes *Eucalyptus tetrodonta*/*Corymbia dichromophloia* woodland (Northern Territory Herbarium, 2013). Suitable undisturbed habitat was identified in over 55% of the survey area however no evidence of the species was recorded during the on-ground survey of the study area despite targeted area searches along the proposed haul road.

It is unlikely the development of the Hayes Creek project will significantly impact the species.

Table 26. Significant impact assessment of threatened flora species considered moderately likely, highly likely or know to occur within the Hayes Creek project area.

Scientific name	TPWC Act	EPBC Act	Likelihood of occurrence	Potential for impact	Significant impact
<i>Acacia praetermissa</i>	Vu	Vu	High	Moderate	Significant impact unlikely
<i>Stylidium ensatum</i>		En	Mod	Low	Significant impact unlikely

En: endangered, Vu: vulnerable (EPBC Act and TPWC Act)

5.2 Affected threatened fauna

A significant impact assessment was conducted for all fauna species listed under the EPBC or TPWC Act deemed to have a moderate likelihood of occurrence or greater within the Project footprint. The project footprint was determined prior to the on-ground field survey by PNX Metals and is synonymous with the “study area”. Of the species assessed, no species were determined likely to be significantly impacted by development of the Hayes Creek project. Details of the assessment of each threatened fauna species considered are provided below in sections 5.2.1 – 5.2.4 and summarised in Table 27.

A significant impact assessment was also conducted for migratory species identified as having a moderate likelihood of occurrence or greater within the project area. No species were determined as likely to be significantly impacted by project developments. Assessment of identified species is summarised below in Table 28.

Table 27. Significant impact assessment of threatened fauna species considered moderately likely, highly likely or know to occur within the Hayes Creek project area.

Scientific name	Common name	TPWC Act	EPBC Act	Likelihood of occurrence	Potential for impact	Significant Impact
Bird						
<i>Calidris ferruginea</i>	Curlew sandpiper	Vu	Cr	Moderate	Moderate	Significant impact unlikely
<i>Erythrotriorchis radiatus</i>	Red goshawk	Vu	Vu	Moderate	Low	Significant impact unlikely
<i>Erythrura gouldiae</i>	Gouldian finch	Vu	En	Known	Known	Significant impact unlikely
<i>Geophaps smithii smithii</i>	Partridge pigeon (eastern)	Vu	Vu	High	Known	Significant impact unlikely
<i>Rostratula australis</i>	Australian painted snipe	Vu	En	Moderate	Moderate	Significant impact unlikely
<i>Tyto novaehollandiae kimberli</i>	Masked owl (northern)	Vu	Vu	Moderate	Low	Significant impact unlikely
Mammals						
<i>Antechinus bellus</i>	Fawn antechinus	En	Vu	High	Moderate	Significant impact unlikely
<i>Dasyurus hallucatus</i>	Northern quoll	Cr	En	Moderate	High	Significant impact unlikely
<i>Macroderma gigas</i>	Ghost bat	NT	Vu	Moderate	Moderate	Significant impact unlikely
<i>Mesembriomys gouldii gouldii</i>	Black-footed tree-rat	Vu	En	Moderate	Moderate	Significant impact unlikely
<i>Phascogale pirata</i>	Northern brush-tailed phascogale	En	Vu	Moderate	Moderate	Significant impact unlikely
<i>Rattus tunneyi</i>	Pale field-rat	Vu		High	High	Significant impact unlikely
Reptiles						
<i>Varanus mertensi</i>	Mertens' water monitor	Vu		High	Known	Significant impact unlikely
<i>Varanus mitchelli</i>	Mitchell's water monitor	Vu		High	High	Significant impact unlikely
<i>Varanus panoptes</i>	Floodplain monitor	Vu		High	Moderate	Significant impact unlikely

Cr: critically endangered (EPBC act). En: endangered, Vu: vulnerable (EPBC Act and TPWC Act). NT: near threatened (TPWC Act)

5.2.1 Critically endangered fauna (EPBC Act)

The only fauna species listed as critically endangered under the EPBC Act assessed for significant impacts was the curlew sandpiper (*Calidris ferruginea*). It is unlikely the project will result in a significant impact on this species.

Curlew sandpiper (*Calidris ferruginea*)

The curlew sandpiper generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland, salt marsh, dams, rice crops, sewerage farms and bore drains (Ward, 2012). The nearest record of Curlew sandpiper to the project is 117km west. In the north of the study area potentially suitable habitat exists in the form of several small run-off areas forming ephemerally inundated wetlands, where several species of waterbirds were observed. Whilst this habitat may be suitable, it is restricted to a small area that is not considered regionally important for the species and is unlikely to be suitable for breeding habitat. The area is surrounded by disturbance including the old Fountain Head mine site and associated cleared areas as well as areas heavily utilised by cattle from Ban Ban Springs Station. No species were observed during the May 2017 survey. Occurrence of the species at this site is likely to be temporary, as migrants passing through. Impacts leading to reduced occupancy of the species, fragmentation or long-term decreases in population size are unlikely. Given the small size of potentially suitable habitat and the transiency of likely occupancy, any significant impact on this species is considered unlikely.

5.2.2 Endangered fauna (EPBC Act)

Fauna listed as endangered under the EPBC Act assessed for significant impacts included;

- Northern quoll (*Dasyurus hallucatus*).
- Gouldian finch (*Erythrura gouldiae*);
- Black-footed tree-rat (*Mesembriomys gouldii gouldii*)
- Australian painted snipe (*Rostratula australis*); and

No species listed as endangered were determined likely to be significantly impacted by the proposed project developments.

Gouldian finch (*Erythrura gouldiae*):

Over 55% of the project area has been identified as suitable gouldian finch habitat (Figure 23), characterised by a combination of rocky hills in proximity to flatter country with a predominance of annual spear grasses or perennial sorghum in the understorey during the dry season (O'Malley, 2006). Within this habitat, hollow bearing *Eucalypt* species were common. Of this suitable habitat, 32ha is proposed to be cleared, primarily situated along the haul road connecting the Mt Bonnie and Iron Blow sites, with the existing haul roads north and south-west of the Project area. Clearing of this vegetation is likely to reduce the potential area of occupancy of Gouldian finches by 5.58% within the project area (see Figure 23 for proposed clearing areas), potentially impacting foraging and breeding habitat.

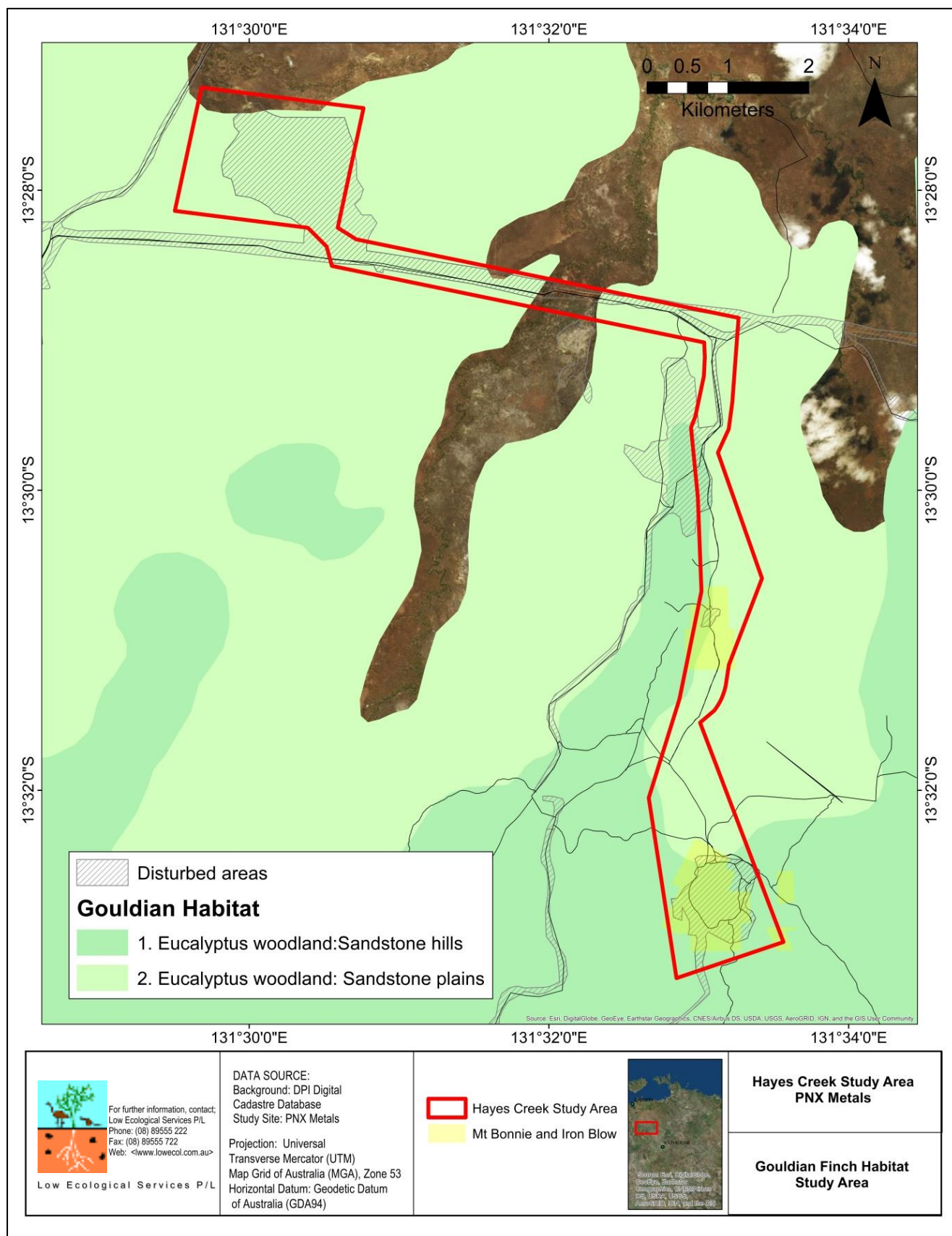


Figure 23. Gouldian finch habitat and existing disturbance within the Hayes Creek study area.

Gouldian finches are known to have a narrow niche with respect to the selection of nesting sites, making them more vulnerable to detrimental effects of reduced availability of appropriate nesting cavities. Tree species preferentially selected by Gouldian finches for breeding purposes include *Eucalyptus tintinnans*, *E. brevifolia*, *E. leucophloia* and *E. dicromophloia* (Tidemann, et al., 1992). Suitable habitat area including potential breeding habitat for the Gouldian finch is common in the region surrounding the project, with sandstone plains and low hills characterised by *Eucalyptus* woodland (including *E. tintinnans*) present across more than 60% (3828km²) of a 6000km² area around the project (Figure 24). Clearing associated with the proposed development is likely to affect 0.8% of the 3828km² identified potentially suitable habitat around the project. On a regional scale the removal of 0.8% of suitable habitat area is not considered likely to significantly reduce the availability of breeding habitat or lead to a long-term decrease in the size of a population. Within the project area, clearing of vegetation will remove approximately 32ha of suitable habitat leaving 540.7ha of suitable remnant habitat within the project area. Whilst only 5.58% of Gouldian habitat is likely to be affected by proposed clearing, retention of suitable nesting habitat is recognised as an integral component of conservation strategies for the species (Brazil-Boast, et al., 2010). *Eucalyptus tintinnans*, a species known to produce cavities preferentially selected by Gouldian finches for breeding (Brazil-Boast, et al., 2011), were characteristic of the *Eucalyptus* woodland recorded in over 55% of the project area in particular around the Mt Bonnie site and the proposed haul road. No other preferred cavity producing tree species were recorded. Considering the time needed to replace older, hollow bearing trees (approximately 100 years from sprouting to cavity production) (Brazil-Boast, et al., 2011), it is recommended that clearing of identified hollow bearing trees in tree species associated with Gouldian finch breeding is, where practicable, avoided to protect breeding habitat of the Gouldian finch and minimise impacts of the project on reproductive capacity of the species. It is therefore recommended that fine scale mapping of suitable cavity bearing trees within the proposed clearing areas is undertaken prior to construction to avoid clearing of potential niche nesting habitat of the Gouldian finch. As Gouldian finches have been observed moving between breeding sites and show low seasonal site fidelity (Weier, et al., 2016), maintenance of these cavity bearing trees as future breeding sites is considered adequate to minimise significant impacts on the species, given the widespread availability of potential breeding habitat both within the project area and in the surrounding region.

The availability of suitable grass seed year round, including *Sorghum* species during dry season breeding times and a diversity of perennial grasses during the wet season, can influence breeding outcomes of Gouldian finches. In particular, the availability of grass seed during the onset of the wet season, when *Sorghum* seeds germinate and are unavailable as a food source and the first of the wet season grasses is yet to produce seed; is a time of critical importance for the species. The availability and production of seed is affected by habitat degradation, grazing, weeds, rainfall patterns in the wet season and fire regimes in the dry season (Dostine, et al., 2001). Annual *Sorghum* species depended on by gouldians during the dry season and perennial wet season grasses including *Themeda triandra*, *Alloteropsis semialata*, *Chrysopogon fallax* and *Heteropogon* species were widespread within the project area. It is considered unlikely that the clearing of 32ha of potentially suitable grasses for the Gouldian finch will disrupt the breeding cycle of the population or adversely affect habitat to an extent that the species is likely to decline, given the widespread presence of *Sorghum* species as well as wet season grasses both within the project area and in the adjacent landscape. Gouldians have been observed tracking seed resources provided by perennial grasses

over an extensive area of lowland grassy woodland, favouring small patches of grassy woodland for brief periods until seed fall (Dostine, et al., 2001). This suggests the clearing of narrow tracts of grass food resources along the proposed haul road and existing disturbed mine sites is unlikely to inhibit the capacity of the species to access other intact grass seed sources within the project area and adjacent landscape.

Changes to fire regimes, in particular frequent and extensive fires, have been implicated in population declines in Gouldian finches due to the impacts of fire on grass seed availability (Weier, et al., 2016). Fire history of the area suggests patchy burns occur across the project area annually or every 2-3 years. Maintaining an effective fire regime and avoiding large hot fires, will be necessary to minimise negative effects on potential Gouldian habitat and ensure grass seed resources are available year round. Finches appear to breed at sites burnt in the last 12-24 mths, thought to be a result of the positive influence of fire on *Sorghum* grass seed availability – a vital resource during dry season breeding (Weier, et al., 2016). Highest seed production of wet season grass resources tends to occur with cool burns, occurring approximately every 2-3 years (Lewis, 2007). Patch sizes of the order of tens of hectares (<50ha), greater than 500m apart at a fire return time of 2-3 years is considered an appropriate fire regime for the species, providing a mosaic of different aged grasses in varying densities (Weier, et al., 2016). Implementation of an appropriate fire regime for the species that will maintain the quality of intact habitat in the project area is considered necessary to minimise potential negative impacts of changes to fire regime in the project area and subsequent changes in grass seed availability for the Gouldian finch.

Whilst proposed expansion of the haul road will reduce the potential area of occupancy, suitable habitat occurs widely across the landscape and project area (Figure 24). Clearing of vegetation will remove approximately 32ha of suitable habitat leaving 540.7ha of remnant habitat within the project area. In the 6000km² around the project area, proposed clearing of 32ha of Gouldian finch habitat represents clearing of approximately 0.8% of identified suitable habitat leaving 98.2% of 3828km² potentially suitable habitat intact. Access to small, shallow water sources, preferably with cover from overhead predators and safety perches is critical for Gouldian finches. Clearing in the project area around riparian zones and creeklines is restricted to two haul road crossings north of Mt Bonnie. The majority of riparian zone habitat will remain intact and unaffected by development and therefore available for Gouldian finch continued use. Water contamination, erosion and sedimentation of waterways is a risk, particularly at haul road crossings. However this risk is considered moderate with adequate erosion control planning and design of creek crossings to minimise sedimentation and water contamination from run-off. It is considered unlikely that the development will reduce the area of occupancy of the species, or modify destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

The development is unlikely to fragment an existing population into two or more populations. The group of birds were observed foraging on an existing track within the project area. The proposed project development is primarily constrained to the area previously disturbed by historical mining activity. Proposed clearing will predominantly be concentrated along the haul road, expanding the existing track to accommodate mining vehicles. Whilst the expansion of the track and associated additional noise, light and vibration and vehicles may discourage finches from accessing the area, the expansion of the existing track to a haul road is unlikely to create a complete barrier to movement of the gouldian finch group between remnant habitat areas on either side of the

proposed haul road. Implementation of traffic control measures in areas identified as Gouldian finch habitat will be required to minimise risk to individuals when moving across disturbance areas including the proposed haul road.

The proposed project is unlikely to result in invasive species or introduce any diseases that are harmful to the species or result in its declines. The group was observed in an area previously disturbed by mining activity. Numerous weed species were observed within the vicinity of the group, primarily in riparian zones and adjacent to existing main haul roads (e.g. Mt Wells Road and Grove Hill Road). Whilst the project may exacerbate existing invasive species (including weeds and introduced predators) it is unlikely that it will result in the establishment of an invasive species that is harmful to the Gouldian finch group within the project area. Development in the project area may facilitate spread of existing weeds. Existing weed species in the project area were predominantly situated around creeklines in the South of the project area. Dominant weed species such as snakeweed (*Stachytarpheta* sp.) are unlikely to spread far from creek banks. The most common weed species observed away from creeklines was Grader grass (*Themeda quadrivalvis*). This species was already observed in the area along the proposed haul road where the Gouldian finches were observed. The species was observed only in areas adjacent to the road and is unlikely to spread away from the road into areas dominated by preferred native grass species for Gouldian finch feeding. It is considered unlikely that the spread of invasive species already existing within the project area will significantly impact or reduce the availability of suitable Gouldian finch habitat or availability of preferred native grass species for seed.

A significant impact on the species as a result of development of the Hayes Creek Project is considered unlikely. However further assessment of dry-season activity of Gouldian finches within the project area is recommended to determine their distribution and foraging areas. In addition, further characterisation of potential breeding habitat and surveying of potential nesting sites based on published characteristics, particularly within areas affected by proposed clearing, is recommended. This will assist in confirming whether a significant impact on the species as a result of development is unlikely and identify any areas (e.g. nesting sites) that will need to be avoided

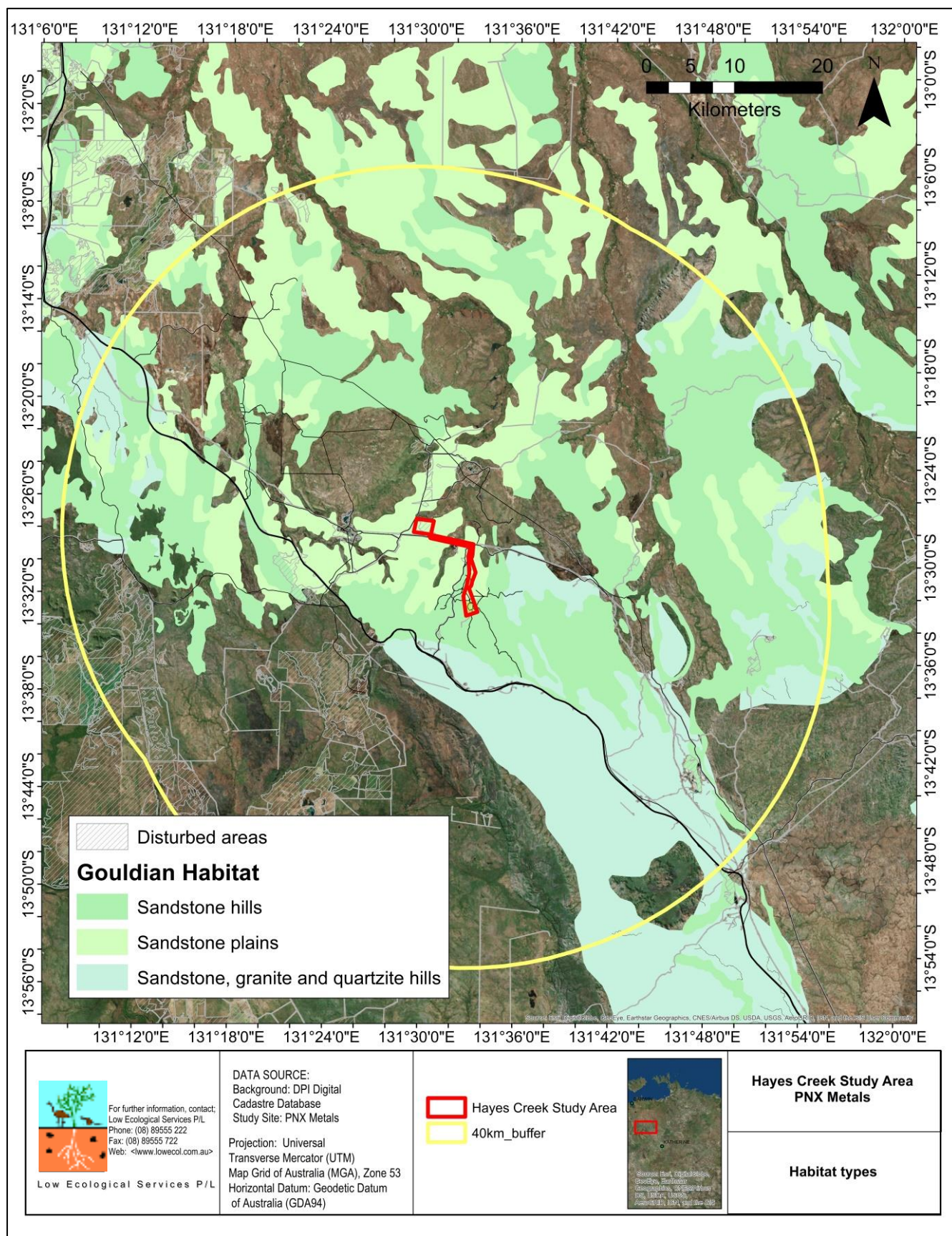


Figure 24. Potential Gouldian finch habitat within a 40km buffer zone surrounding the Hayes Creek project.

Australian painted snipe (*Rostratula australis*):

Australian painted snipe typically inhabit shallow, vegetated, freshwater swamps, claypans or inundated grassland (Taylor, et al., 2013). The closest record of *R. australis* to the survey areas is 127km north-east of the Project area. Potential habitat for the species occurs in the northern portion of the study area, adjacent to the Fountain Head disturbed mine site, where a small patch of seasonally inundated grassland was observed hosting a number of waterbird species. Nest records of the Australian painted snipe are all, or nearly all, from or near small islands in fresh water, with specific characteristics including shallow water, exposed mud, dense low cover and sometimes tall dense cover (Department of the Environment, 2016b). Given the small size of potential habitat with no islands within it, the presence of significant disturbance on all sides of the water body (from both historical mining and ongoing pastoral land use) and the lack of dense low or tall vegetation around the edges, it is not considered to be significant habitat for the species and unlikely to be a breeding site. In the Northern Territory, Australian painted snipe appear to be nomadic, with no known sites where the species is resident (Taylor, et al., 2013). Therefore any occurrence of the species within the study area is likely to be temporary, as a passing migrant. Impacts leading to reduced occupancy of the species, fragmentation or long-term decreases in population size are unlikely. There were no sign of this species recorded during the survey. The likelihood of a significant impact on the species is considered unlikely.

Northern quoll (*Dasyurus hallucatus*):

The northern quoll was recorded in a 2006 survey of the project area, 5km north east of Fountain Head at North Point mine site (a mine site located nearby, that is not part of the Hayes Creek project). Since this time, cane toads have moved into the region and the population of northern quolls is considered to have reduced significantly (Woinarski et al. 2010). In the May 2017 survey, no sign of the northern quoll was recorded in the study area. Appropriate habitat areas were restricted to 134ha at the southern end of the study area, near the Mt Bonnie site. The majority of this habitat area was considered previously disturbed by mining activity and unlikely to be a habitat preference for the northern quoll given the widespread availability of appropriate habitat in the region. Given that any appropriate habitat within the study area is already disturbed, it is unlikely further development will reduce, fragment or adversely affect habitat areas critical to the survival of the species, particular as developments are planned to be constrained to previously disturbed areas.

5.2.3 Vulnerable fauna (EPBC Act)

The following fauna listed as Vulnerable under the EPBC Act were recorded or have a moderate or high likelihood of occurring within the project area:

- Red goshawk (*Erythrotriorchis radiatus*)
- Partridge pigeon (*Geophaps smithii smithii*)
- Masked owl (*Tyto novaehollandiae kimberli*)
- Fawn antechinus (*Antechinus bellus*)
- Ghost bat (*Macroderma gigas*)
- Northern brush-tailed phascogale (*Phascogale pirate*)

The proposed developments are not likely to have a significant impact on these species

Red goshawk (*Erythrorchis radiatus*):

Red goshawks are known to generally occur in tall open eucalypt forests and riparian areas characteristic of higher rainfall (Woinarski, 2006b). Within the study area, riparian areas occur across 25.07ha, approximately 2.44% of the total project area, with the closest known record of Red goshawk 32 km north-west of Fountain Head however no sign of the species was recorded during the May 2017 survey. Nesting is restricted to trees greater than 20m along watercourses or wetlands. Trees greater than 20m high are scarce in the riparian zones within the project area however do have potential to occur. The species is known to rarely breed in areas with fragmented native vegetation. Given the proximity of creeklines and riparian areas to vegetation disturbed by previous mining activity, it is unlikely that they would utilise the large trees within the project area for breeding. Individuals occurring within the project area are likely to be passing through or hunting. With the species occupying a large home range (up to 200km²), existing habitat within the project area is unlikely to be suitable for breeding and with only a small amount of riparian area within the project (25.07ha); the likelihood for significant impact on important habitat areas to an extent where the population is impacted is unlikely.

Partridge pigeon (*Geophaps smithii smithii*):

The partridge pigeon mainly inhabits lowland eucalypt open forest and woodland dominated by Darwin stringybark (*Eucalyptus tetradonta*) and Darwin woollybutt (*E.miniata*) with a structurally diverse grassy understorey (Woinarski, 2006a). Intact habitat occurs across 42.73% of the project area, primarily along the proposed haul road expansion route and adjacent areas. The species was recorded within the project area during a 2006 survey conducted by Indicus Biological Consultants (Firth, et al., 2006) however no sign of the species was recorded during the May 2017 survey.

Proposed clearing for the project's development along the central haul road, occurs primarily within potential habitat areas of the Partridge pigeon. Approximately 32ha of suitable habitat will be removed through development of the project. Extensive areas of suitable vegetation communities exist adjacent to proposed disturbance and throughout the locality and should the species occur they are likely to be able to continue utilising available habitat. On a regional level the habitat type preferred by partridge pigeons is widespread, intact and readily available. Given the availability of similar habitat in the immediate locality and broader region, the clearing of 32ha of suitable habitat is unlikely to significantly reduce the availability or quality of habitat to an extent that the species is likely to decline. Development is unlikely to lead to a fragment an existing population, adversely affect habitat critical for survival or disrupt breeding cycle of the species.

Invasive species such as Gamba grass (*Andropogon gayanus*) are a known threat to partridge pigeon, impacting the suitability of habitat and enhancing the threat of wildfires to the species. Whilst distribution of gamba grass within the project area is currently limited to along a portion of Mt Wells Haul Road, there is potential for the spread of invasive species along proposed haul roads throughout the project area. However given the widespread availability of intact habitat away from disturbed areas, it is unlikely that invasive species will have a significant impact on the species. Appropriate weed management and fire management strategies should be employed to reduce the potential for impact of invasive species on remaining partridge pigeon habitat within the project area.

The project is considered unlikely to significantly impact local populations of partridge pigeon such that local populations are placed at risk of extinction.

Masked owl (*Tyto novaehollandiae kimberli*):

The masked owl occurs mainly in eucalypt tall open forest, but also roosts in monsoon rainforests and forages in more open vegetation types including grasslands (Woinarski & Ward, 2012). The closest record of this species to the survey areas is 8 km west of Fountain Head. No sign of the species was recorded during the May 2017 survey. Suitable habitat for the species occurs across over 55% of the project area. The species is thought to primarily roost in tree hollows. Given the history of disturbance across a large amount of the project area, the presence of trees old enough to host large tree hollows is limited, however they may occur sparsely throughout the project area. Clearing of the proposed haul road may therefore reduce availability of suitable nesting and foraging habitat for the masked owl. However the vegetation community within the project area preferred by the masked owl, is abundant both within the locality (Over 55% of Project area) and regionally. With the home range of the species presumed large, estimated at 5-10km², it is unlikely that the proposed clearing will significantly impact the species should it occur within the project area.

Fawn antechinus (*Antechinus bellus*):

Fawn antechinus are typically found in the savannah woodland and tall open forests of the Top End NT (Young, 2012). The nearest record to the project area is 30 km away, however potentially suitable habitat for the species covers over 50% of the project area. No sign of the species was recorded during the May 2017 survey. With proposed clearing primarily occurring along the central haul road, approximately 32ha of Eucalyptus woodland habitat which is suitable habitat for the species, would be removed as a result of the proposal. Habitat areas extend outside the project area within the Hayes Creek and Grove Hill locality as well as more broadly in the region. Therefore the proposed clearing of habitat within the project area should not be such that the species would be at risk of extinction.

Should species occur within the project area, there may be a risk of local loss of individuals within the project footprint, however the species is unlikely to be placed at risk of extinction as a result of the project.

Ghost bat (*Macroderma gigas*):

The distribution of the ghost bat is influenced by the availability of suitable caves and mines for roost sites, with one of the largest colonies occurring in gold mine workings at Pine Creek NT (Ward & Milne, 2016). Ghost bats were recorded within the survey areas in 1988. A 2007 survey of the North Point mine site for GBS Gold, north-east of the current project area recorded at least fifteen individuals within a mine adit (Firth, et al., 2007). No sign of the species was recorded in the May 2017 survey. Potentially suitable habitat areas were located in the Mt Bonnie production area around the old pit and waste rock dump however exploration of these sites did not reveal any currently being utilised as roosts. These areas are likely to be affected by development of the project. Suitable breeding habitat was not observed within the project area, with breeding habitat generally requiring larger, multiple entrance caves. It is therefore likely that any suitable habitat within the project area would be utilised transiently by ghost bats between breeding times with breeding unlikely to be affected by development activities. Ghost bats are known to move between a number of cave sites seasonally or as dictated by weather conditions (Ward & Milne, 2016). Given

the mobility of this species and the proximity to appropriate habitat in adjacent rocky-hill areas and other disturbed mine sites in the locality and the broader region, it is unlikely the development activities within the project area will significantly impact the species.

Northern brush-tailed phascogale (*Phascogale pirate*):

Little is known of the ecology of northern brush-tailed phascogale, but most records are from tall open forest dominated by *E. miniata* and *E. tertodonta* (Woinarski & Ward, 2012b). The closest record of this species to the survey areas is 5 km east of study area at Yam Creek however this record is dated back to pre 1971. No sign of the species was recorded during the May 2017 survey. Whilst there are no recent records of the species near the project area, suitable habitat occurs across over more than 50% of the project area and we therefore assume that clearing of this habitat area along the haul road has potential to reduce the area of occupancy of the species. However, as development is primarily limited to areas already disturbed by historical mining activity, proposed habitat that will be affected by clearing is only 5.58% of the total intact habitat available within the locality. Clearing of habitat areas is unlikely to result in a decrease in habitat to the extent that the species is likely to decline and should not lead to a long-term decrease in the size of the population. Given the abundance of available habitat adjacent to proposed clearing and in the broader locality, proposed clearing is unlikely to significantly impact the species should it occur within the project area.

5.2.4 Vulnerable fauna (TPWC Act)

The following fauna are listed as VU under the TPWC Act and were either recorded or have a moderate or high likelihood of occurring within the proposal area:

- Pale field rat (*Rattus tunneyi*)
- Mertens water monitor (*Varanus mertensi*),
- Mitchell's water monitor (*Varanus mitchelli*),
- Floodplain monitor (*Varanus panoptes*)

The proposed developments are not likely to have a significant impact on these species.

Pale field rat (*Rattus tunneyi*):

The pale field rat is known to inhabit dense vegetation along creeks, tall grassland and some modified habitats (Young & Hill, 2012). The closest record of the species is 6 km south-west of Mt Bonnie. Creeklines, associated riparian zones and adjacent dense grassland were identified as potentially suitable habitat areas for the species, covering approximately 4% of the project area. Clearing within the project area is proposed to be restricted to the haul road north of Mt Bonnie, with creeklines primarily located at the southern end of the proposed haul road expansion and in the north of the project area, adjacent to the existing Mt Wells haul road. If clearing is restricted to the haul road expansion, approximately 1ha of riparian zone vegetation may be removed during development of the project. Intact riparian habitat is widely available adjacent to the development and it is unlikely clearing of 1ha will significantly reduce the occupancy of the pale field rat or result in a decrease in habitat size to the extent that the population decreases significantly. Breeding cycles are unlikely to be disrupted as habitat immediately adjacent to the existing track is considered moderately disturbed and unlikely to be utilised for breeding purposes given the availability of undisturbed habitat further downstream.

Creeklines and riparian zones were noted as sites of significant weed growth from historical disturbance in the area. Further spread of weeds along creeklines and haul roads through movement of vehicles and materials during project operations, could reduce the availability of already restricted habitat areas. However given the pre-existing disturbance within these areas it is unlikely further impacts would be significant as to reduce the area of occupancy of the species or lead to any long-term decreases in the size of the pale field rat population. A significant impact is therefore considered unlikely.

Mertens water monitor (*Varanus mertensi*), Mitchell's water monitor (*Varanus mitchelli*), Floodplain monitor (*Varanus panoptes*):

Mertens water monitor inhabits coastal and inland waters in all river systems of the Top End (Ward, et al., 2006). A Merten's water monitor was observed on site in 2016 by a KL Gold employee. The species identification was confirmed by LES staff through a photo taken of the species. The individual was recorded utilising the water filled pit at the Iron Blow site.

Mitchell's water monitor inhabits margins of watercourses, swamps and lagoons (Ward, 2012d), with the closest record to the project area 10km south-east of Mt Bonnie.

Floodplain monitor (*Varanus panoptes*) occurs in a variety of habitats, including coastal beaches, floodplains, grasslands and woodlands (Ward, et al., 2012b). The nearest official record of the species is 8km north of the Fountain Head site.

Identified habitat areas across the site for all three species included creeklines and adjacent riparian zones, inundated grassland and man-made water bodies in both the south and north of the project area, cover approximately 15% of the project area. Whilst these habitat areas are likely to be affected by development within the project area, the species' are known to be widespread in the NT, occupying all of the Top End river systems and much of the Gulf region. The species' are known to be mobile and though neither moves far from water, creeklines within the project area are contiguous with habitat areas extending beyond the project area offering alternative habitat within the locality.

Haul roads crossing creeklines may increase the risk of local loss of individuals, however given the abundance of the species across the region and the presence of habitat areas immediately adjacent the project area and extending further afield within the locality, it is unlikely project development will significantly impact the species.

5.3 Affected Migratory and Marine fauna

The assessment of significant impacts on species listed as Migratory and Marine under the EPBC Act recorded or with a moderate to high likelihood of occurring in the Proposal area are presented as one assessment below. This is due to the commonalities between assessments of the species. Species assessed include:

- Magpie goose (*Anseranas semipalmata*)
- Fork-tailed swift *Apus pacificus*
- Great egret *Ardea alba*
- Cattle egret *Ardea ibis*
- Sharp-tailed sandpiper *Calidris acuminata*
- Red-rumped swallow *Cecropis daurica* (*Hirundo daurica*)
- Oriental plover *Charadrius veredus*
- Oriental cuckoo *Cuculus optatus*
- Himalayan cuckoo *Cuculus saturates*
- Oriental pratincole *Glareola maldivarum*
- White-bellied sea eagle *Haliaeetus leucogaster*
- Barn swallow *Hirundo rustica*
- Rainbow bee-eater *Merops ornatus*
- Grey wagtail *Motacilla cinerea*
- Yellow wagtail *Motacilla flava*
- Painted Snipe *Rostratula benghalensis*
- Freshwater crocodile *Crocodylus johnstoni*

Results for the species assessed are summarised below in Table 28 and expanded in sections 5.3.1 – 5.3.5.

Table 28. Significant impact assessment of migratory and marine species considered moderately likely, highly likely or known to occur within the Hayes Creek project area.

Scientific name	Common name	EPBC Act	Likelihood of occurrence	Significant impact
Birds				
<i>Anseranas semipalmata</i>	Magpie goose	Ma	Moderate	Significant impact unlikely
<i>Apus pacificus</i>	Fork-tailed swift	MiMa	Moderate	Significant impact unlikely
<i>Ardea alba</i>	Great egret	Ma	Known	Significant impact unlikely
<i>Ardea ibis</i>	Cattle egret	Ma	High	Significant impact unlikely
<i>Calidris acuminata</i>	Sharp-tailed sandpiper	MiMa	Moderate	Significant impact unlikely
<i>Cecropis daurica</i> (<i>Hirundo daurica</i>)	Red-rumped swallow	MiMa	Moderate	Significant impact unlikely
<i>Charadrius veredus</i>	Oriental plover	MiMa	Moderate	Significant impact unlikely
<i>Cuculus optatus</i>	Oriental cuckoo	MiMa	Moderate	Significant impact unlikely
<i>Cuculus saturates</i>	Himalayan cuckoo	Ma	Moderate	Significant impact unlikely
<i>Glareola maldivarum</i>	Oriental pratincole	MiMa	Moderate	Significant impact unlikely
<i>Haliaeetus leucogaster</i>	White-bellied sea eagle	Ma	Moderate	Significant impact unlikely
<i>Hirundo rustica</i>	Barn swallow	MiMa	Moderate	Significant impact unlikely
<i>Merops ornatus</i>	Rainbow bee-eater	Ma	High	Significant impact unlikely
<i>Motacilla cinerea</i>	Grey wagtail	MiMa	Moderate	Significant impact unlikely
<i>Motacilla flava</i>	Yellow wagtail	MiMa	Moderate	Significant impact unlikely
<i>Rostratula benghalensis</i>	Painted Snipe	MiMa	Moderate	Significant impact unlikely
Reptiles				
<i>Crocodylus johnstoni</i>	Freshwater crocodile	Ma	Known	Significant impact unlikely

5.3.1 Aerial species; Fork-tailed swift (*Apus pacificus*), White-bellied sea eagle (*Haliaeetus leucogaster*)

These species occupy airspace over varied habitat. Fork-tailed swift stay airborne day and night, whilst white-bellied sea eagles nest in large trees adjacent to waterways or on clifftops or headlands in coastal areas. Both highly mobile species, the habitat within the project area is not considered significant for the species, is not of critical importance to the species at particular life-cycle stages and does not at the limit of the range of these species. The habitat therefore does not meet the criteria for being classified as important habitat for these species and any modifications to habitat areas will not significantly impact the species.

5.3.2 Wetlands/Riparian species; Magpie goose (*Anseranas semipalmata*), Great egret (*Ardea alba*), Cattle egret (*Ardea ibis*), Sharp-tailed sandpiper (*Calidris acuminata*), Grey wagtail (*Motacilla flava*), Yellow wagtail (*Motacilla flava*), Painted snipe (*Rostratula benghalensis*)

The great egret, cattle egret and sharp-tailed sandpiper are known to occupy areas including wetlands, flooded crops, dams, roadside ditches, estuarine mudflats, mangroves and reefs. Grey wagtails and yellow wagtails have a strong association with water, found primarily on the banks of creeks, rivers, lakes and marshes, as well as artificial wetlands (DoEE, 2015). Within the project, suitable habitat is restricted to a small run-off area adjacent to the Fountain Head production site and a number of riparian zones throughout the project footprint.

Available habitat within the project is not considered key habitat for any of these species. No potential breeding habitat was identified. No vegetation clearing is planned for areas utilised as habitat by these species. As such, any habitat loss associated with indirect impacts of development activities will be short term, negligible and unlikely to significantly impact the species.

5.3.3 Dense shrubland species; Oriental cuckoo (*Cuculus optatus*), Himalayan cuckoo (*Cuculus saturates*)

These species are regular migrants to Australia for their non-breeding seasons in the winter of the northern hemisphere. The species occupies a range of densely vegetated habitats including monsoon rainforest, wet sclerophyll forest, open woodlands and often on the edge between ecotones (DoEE, 2015).

Potential habitat areas were identified across more than 55% of the project area however no key habitats were identified. The species is known not to breed in Australia and its ranges extends beyond the limits of the project. Any modification of potential habitat area is not considered likely to significantly impact the species.

5.3.4 Open woodland/ open shrubland species; Red-rumped swallow (*Cecropis daurica* (*Hirundo daurica*)), Barn swallow (*Hirundo rustica*), Rainbow bee-eater (*Merops ornatus*)

The red-rumped swallow and barn swallow are globally populous and widespread birds, visiting Australia during the northern hemisphere winter. They occur patchily in northern Australia with

vagrants occasionally recorded as far south as Sydney (DoEE, 2015). Neither species breed in Australia. The Rainbow bee-eater is distributed across most of mainland Australia and are thought to be a highly mobile species. They are known to breed in southern Australia and migrate to northern Australia during winter.

These species primarily occupy open woodland and open shrubland habitats as well as various cleared or semi-cleared habitats. They forage on the wing and spend large portions of time in the air above vegetated areas. Potential habitat was identified across over 55% of the project area however no key habitat areas were identified within the project. As all species are known to breed in other locations, breeding cycles will not be affected by development activities. Given the wide spread nature of these populations and their mobility, any modifications to potential habitat within the project are not considered likely to significantly impact the species.

5.3.5 Open/sparsely wooded plains species; Oriental plover (*Charadrius veredus*), Oriental pratincole (*Glareola maldivarum*)

These birds are non-breeding visitors to Australia during the northern hemisphere's winter. In Australia, they occur mostly in northern Australia occasionally inhabiting coastal habitats but more commonly are recorded at inland sites in open plains with sparse, short grass cover and patches of hard bare ground.

The habitat within the project area is not considered significant for the species, is not of critical importance to the species at particular life-cycle stages and does not at the limit of the range of these species. Any occurrence of the species within the project is likely to be temporary, is transient migratory visitors. Any modification of habitat areas will not significantly impact these species.

6 OTHER THREATS TO BIODIVERSITY

6.1 Direct and Indirect impacts

Construction and operation of the Hayes Creek project will impact biodiversity both directly and indirectly, with clearing of vegetation and associated impacts on habitat considered the primary threat to biodiversity. Both direct and indirect impacts associated with the development and operations of the project are considered below.

6.1.1 Direct impacts

Primary impact of the Hayes Creek project on biodiversity will be the clearing of native vegetation and associated reduction of habitat, including threatened species habitat, within the project area. PNX Metals aim to minimise disturbance by restricting the majority of developments to areas that have previously been disturbed by mining activity at all three primary production sites. The majority of clearing that will still be required falls along the haul road joining the Mt Bonnie production area with Iron Blow and the existing haul roads in the north of the project area (Grove Hill Road and Mt Wells Road). The extent of clearing of native vegetation is conservatively estimated at approximately 33 ha of undisturbed vegetation if clearing is restricted to expanding the haul road and in previously disturbed areas only (Table 29). The impact of clearing of native vegetation and associated habitat on identified threatened species listed under the EPBC Act and TPWC Act are addressed in sections 5.1, 5.2 and 5.3.

Table 29. Conservative estimates of potential habitat loss as a result of clearing of intact vegetation in the Hayes Creek Project area.

Habitat type	Potentially supports threatened or migratory species	Total area (ha)	Total area impacted (ha)	% Total area
Open forest on alluvial floodplain	Red goshawk, masked owl, black-footed tree-rat, floodplain monitor	59.75	0	0
Eucalyptus woodland on sandstone plain	Gouldian finch, partridge pigeon, masked owl, fawn antechinus, northern brush-tailed phascogale	438.45	25.35	5.78
Eucalyptus woodland on low sandstone hills	Gouldian finch, masked owl, fawn antechinus, northern quoll, northern brush-tailed phascogale	134.25	7.02	5.22
Creeklines and riparian zones	Red goshawk, masked owl, Australian painted snipe, curlew sandpiper, eastern curlew, pale field-rat, merten's water monitor, mitchell's water monitor, floodplain monitor	25.07	1	3.99
Disturbed areas	-	368.75	35.94	
Total (ha)		1026.7	33.38	3.25

In addition to vegetation clearing and habitat loss, fauna strike or injury from construction vehicles during initial clearing works and throughout the mine's operation may directly impact fauna within the project area. Fauna were observed both directly and via observation of tracks and scats, utilising

the existing haul road through the project area. The highest likelihood of fauna strike would be during the hours of dusk and dawn, which coincides with high activity for crepuscular species, accompanied with low visibility (Rowden, et al., 2008).

6.1.2 Indirect impacts

Indirect impacts will occur both within the project area and in immediately adjacent areas as a result of mine construction and operation. These impacts are likely to extend to the short and medium term and include the following:

- Increased lighting, noise and vibration – disturbing local fauna;
- Increased dust from mine construction and operational activities – impacting flora growth and fauna;
- Erosion or sedimentation in areas adjoining development areas;
- Changes to fire regimes as a result of increased or decreased fire frequency resulting in changes to vegetation communities and habitat;
- Introduction and spread of weed propagules via movement of vehicles on site – potentially impacting vegetation communities and habitat areas;
- Increased edge-effects for surrounding vegetation;
- Altered surface hydrology, increased sedimentation and/or run off and potential changes to stream flow effecting downstream flora and fauna;
- Increased introduced fauna; and
- Poor waste management

6.2 Riparian zones and Aquatic habitats

The haul road connecting Mt Bonnie and Iron Blow production sites is proposed to cross two watercourses in the south of the project area, adjacent to Mt Bonnie site. Development in these areas may result in disturbance of sensitive riparian zone and aquatic habitat.

Riparian zones are recognised as areas of importance, providing restricted habitat areas for a range of native fauna, supporting distinct and diverse vegetation and providing important services to the adjacent aquatic ecosystem (DLRM, 2016b). Riparian vegetation communities support a distinct and diverse suite of plant and animal species when compared with adjacent habitats. It plays a number of significant roles in the maintenance of a healthy aquatic ecosystem including:

- Providing shade and moderating temperature fluctuations in streams;
- Creating suitable conditions for breeding in aquatic species;
- Maintaining dissolved oxygen levels;
- Restricting the occurrence of algal blooms; and
- Protecting stream banks from erosion and reducing sedimentation of aquatic habitats.

Riparian zones are particularly vulnerable to disturbance including weed invasion, feral animal, fire, over-grazing and erosion; many of which are indirect impacts associated with development of mining activities.

Aquatic habitats were observed to small a number of small fish and yabbie species, freshwater crocodiles and aquatic macroinvertebrates. Potential habitat was observed for water monitors listed as threatened under the TPWC Act. Potential impacts of the proposed haul road development on aquatic habitats include:

- Disturbance to and loss of aquatic habitats;
- Changes to aquatic species composition;
- Reduced fecundity and death of aquatic species;
- Restriction of fish passage;
- Translocation of pests and diseases; and
- Increased sediment loadings and chemical contamination of water bodies.

Particular consideration should be given to the maintenance of riparian zone and aquatic habits around areas where the proposed haul road expansion will cross creeklines; these considerations are addressed in sections 7.1-7.4 and 7.8.

6.3 Weeds

A desktop survey assessment identified 56 invasive flora species as occurring or potentially occurring within the proposal area, with 16 species recording during the on-ground survey. Two species are WoNs and declared weeds in the NT. An additional 5 species are declared weeds in the NT and the remaining 9 are introduced but not declared weeds. Descriptions of weeds recorded in the survey area can be found in section 4.3.2.

The majority of weeds recorded in the survey area were in areas already disturbed, including along haul roads and around areas previously disturbed by mining. Creeklines and riparian zones were also recorded as sites with significant weed presence.

The Hayes Creek project has potential to increase the spread of weed species or introduce additional weed species where they do not currently exist through the operation of machinery during construction and operation. New and existing weed species can be spread as a result of movement of vehicles and materials across the project area. Large tracts of land adjacent to the haul road proposed for development are currently weed-free. Development and mining activity in the production areas, expansion of the haul road and movement of vehicles between sites will increase the risk of weed spread and expose areas adjacent to edge effects, leaving them more weed exposed.

6.4 Fire

The foraging efficiency, food availability and habitat quality of a number of native fauna species in the top end, including numerous target threatened species, are affected by fire (e.g. Woinarski 1990). Alterations in fire regimes as a result of the Project may negative impact a number of species including the Gouldian finch, partridge pigeon and other ground-dwelling species. Alterations in fire regime may result from either increased fire risk during construction (e.g. from increased ignition sources, large stockpiles of vegetation, open flame or hot works) or the exclusion of fire from habitat areas previously burnt intermittently. In order to minimise potential negative impacts on native flora and fauna as a result of alterations in fire regime, implementation of an effective fire management approach will be necessary.

6.5 Impact of introduced fauna species

Expanding existing tracks, opening up new tracks and large cleared spaces has been shown to increase predator and introduced herbivore species across the environment (Claridge, 1990).

Creation of artificial water sources increases the occurrence of predator species locally (DeStefano, et al., 2000) and potential food sources (e.g. waste bins) and sources of heat and shade can cause predators to habituate to an area; increasing stress on local prey. Increases in predator species e.g. cats and foxes, are recognised as key threatening processes for a number of target threatened species and poses significant threat to biodiversity of existing fauna species.

Increased presence of introduced grazing species such as cattle and feral pigs can cause a range of issues. Grazing intensity has been shown to be correlated with granivorous bird decline across the northern savannas (O'Malley, 2006) with key Gouldian finch wet season grasses selectively grazed by

cattle leading to reductions in their incidence and extent. Feral pigs have also been shown to cause damage to important wet season grasses. Opening up new access through the landscape, introduced species can more easily access previously undisturbed environments, increasing grazing pressure and negatively impacting native flora and fauna. Other issues associated with increased presence of grazing species includes spread of weeds and pathogens, impacts on surface water topography, increased fauna activity and potential strike and potential destruction of property.

7 MANAGEMENT AND MITIGATION

7.1 Threatened species mitigation measures

Mitigation measures specifically applying to threatened species considered to have a moderate likelihood of occurrence or greater within the project area are summarised below in Table 30.

Table 30. Threatened species mitigation measures for all species listed under the EPBC and TPWC Acts with a moderate likelihood of occurrence or higher within the Hayes Creek project area

Species	Potential Impacts from the Proposal	Mitigation measures	Monitoring
EPBC Listed species			
Curlew Sandpiper (<i>Calidris ferruginea</i>)	The curlew sandpiper would not be significantly impacted by the project (see Section 5.3.3 curlew sandpiper) however individuals may be impacted by the Proposal. Potential impacts from the Proposal may include: • Increased predator species; • Reduced water availability • Contaminated water runoff	• Undertake pre-construction survey targeting curlew sandpiper to determine the presence or absence of the species. • Restrict development to ensure adequate required buffer zone is maintained around riparian habitat (see section 7.2). • Manage introduced predators – see section 7.3 below • Manage surface water run off – see section 7.8 below	• Fauna incident register. • Fauna sightings register. • Flora and Fauna Monitoring Program would be conducted annually including: - Targeted bird surveys and area searches, particularly near waterbodies; - Camera traps; and - Vegetation health (habitat) monitoring
Red goshawk (<i>Erythroriorchis radiatus</i>)	If the red goshawk is present in the project area, the species would not be significantly impacted by the Proposal (see Section 5.3.3 red goshawk) however individuals may be impacted by the Proposal. Potential impacts from the	• Undertake pre-construction survey targeting red goshawk to determine the presence or absence of the species. • If the species is found to be present, avoid clearing large trees with diameter greater than 15cm, particularly those along water courses that may	• Fauna sightings register • Flora and Fauna Monitoring Program would be conducted annually: - Targeted bird surveys and area searches, particularly near creeks and waterbodies with trees greater than 20m; and - Vegetation health (habitat)

Species	Potential Impacts from the Proposal	Mitigation measures	Monitoring
	Proposal may include: • Loss of nesting habitat	provide suitable breeding habitat.	monitoring
Gouldian finch (<i>Erythrura gouldiae</i>)	A group of twelve individuals were observed during the late wet season survey of the Project area. The species is unlikely to be significantly impacted by the Project (see section 5.3.2 gouldian finch) however individuals may be impacted by the project. Potential impacts include: • Loss of foraging habitat through vegetation clearing; • Loss of breeding habitat through vegetation clearing; • Increased grazing by introduced species, altering foraging habitat; • Increased predation from introduced species • Weed species invading foraging habitat; • Increased vehicle traffic leading to collisions with fauna • Increased vehicle traffic leading to increased dust generation; • Increased light and noise vibrations impacting species behaviour • Acid metalliferous drainage entering	• Undertake late dry season survey assessing seasonal distribution and habitat use of Gouldian finch group observed during late wet/ early dry season • Undertake survey to characterise <i>Eucalyptus</i> woodland habitat, identify and map potential nesting sites within project footprint. • Undertake pre-construction survey targeting the gouldian finch to determine the presence or absence and distribution of the species. • Where practicable avoid removal of mature trees with trunk diameter greater than 15cm or suitable nesting cavities (according to published nesting characteristics) • Where avoidance of clearing is not practicable, assess trees to be removed for active nests. If nests are found, relocate to similar tree outside clearing envelope • Manage grazing by introduced species – see section 7.3 below • Manage introduced predators – see section 7.3 below • Weed management – see section 7.4 • Fauna strike – see section 7.5 below regarding driving at dusk and dawn and speed restrictions in targeted locations • Dust – see section 7.6 below • Light and noise – see section 7.7 below • Surface water – see section 7.8 below • Bushfires – see section 7.9 below	• Fauna incident register. • Fauna sighting register • Flora and fauna monitoring program would be conducted annually including: - Standard EPBC guideline survey tailored to dry season or wet season habitat appropriateness; - Camera traps; and - Vegetation health monitoring for habitat monitoring

Species	Potential Impacts from the Proposal	Mitigation measures	Monitoring
	waterways used as drinking sources for the Gouldian finch; - Uncontrolled discharge of contaminated surface water into waterways used as drinking sources for the Gouldian finch; - Altered fire regimes reducing habitat quality		
Partridge pigeon (<i>Geophaps smithii smithii</i>)	If the Partridge pigeon is present in the project area, the species would not be significantly impacted by the project (see Section 5.3.3 partridge pigeon) however individuals may be impacted by the Proposal. Potential impacts from the Proposal may include: - Loss of foraging habitat - Loss of nesting habitat - Increasing grazing by introduced species, altering foraging habitat; - Increased predation from introduced species - Weed species invade foraging habitat; - Increased vehicle traffic leading to collisions with fauna - Increased vehicle traffic leading to increased dust generation; - Increased light and noise vibrations impacting	- Undertake pre-construction survey targeting the gouldian finch to determine the presence or absence and distribution of the species. - Manage grazing by introduced species – see section 7.3 below - Manage introduced predators – see section 7.3 below - Weed management – see section 7.4 - Fauna strike – see section 7.5 below regarding driving at dusk and dawn and speed restrictions in targeted locations - Dust – see section 7.6 below - Light and noise – see section 7.7 below - Surface water – see section 7.8 below - Bushfires – see section 7.9 below	- Fauna incident register. - Fauna sighting register - Flora and fauna monitoring program would be conducted annually including: - Targeted bird surveys and area searches; - Camera traps - Vegetation health (habitat) monitoring

Species	Potential Impacts from the Proposal	Mitigation measures	Monitoring
	species behaviour; Altered fire regimes affecting foraging and nesting habitat;		
Australian painted snipe (<i>Rostratula australis</i>)	If the Australian painted snipe is present in the Proposal area, the species would not be significantly impacted by the Proposal however individuals may be impacted by the Proposal. Potential impacts from the Proposal may include: - Increased predator species. - Reduced water availability - Contaminated water runoff	- Undertake pre-construction survey targeting Australian painted snipe to determine the presence or absence of the species. See Flora and Fauna Monitoring Program (within Biodiversity management plan – Appendix 6). - Restrict development to ensure adequate required buffer zone is maintained around riparian habitat (see section 7.2). - Manage introduced predators – see section 7.3 below - Manage surface water run off – see section 7.8 below	- Fauna incident register. - Fauna sighting register - Flora and fauna monitoring program would be conducted annually including: - Targeted bird surveys and area searches, particularly near waterbodies; - Camera traps; and - Vegetation health (habitat) monitoring
Masked owl (<i>Tyto novaehollandiae kimberli</i>)	If the masked owl is present in the Proposal area, the species would not be significantly impacted by the Proposal (see Section 5.3.2 masked owl) however individuals may be impacted by the Proposal. Potential impacts from the Proposal may include: Loss of foraging habitat	- Undertake pre-construction survey targeting masked owls to determine the presence or absence of the species. - If the species is found to be present, avoid clearing large trees with diameter greater than 15cm in the areas it may frequent.	- Fauna incident register. - Fauna sighting register - Flora and fauna monitoring program would be conducted annually including: - Standard EPBC guideline call/playback spotlighting survey - Vegetation health (habitat) monitoring
Fawn antechinus (<i>Antechinus bellus</i>)	If the fawn antechinus is present in the Proposal area, the species would not be significantly impacted by the Proposal (see Section 5.3.3 fawn antechinus) however individuals may be impacted by the Proposal. Potential impacts from the	- Undertake pre-construction survey targeting fawn antechinus to determine the presence or absence of the species. - If the species is found to be present, avoid clearing large trees with diameter greater than 15cm, particularly those along water courses that may provide suitable breeding habitat.	- Fauna incident register. - Fauna sighting register - Flora and fauna monitoring program would be conducted annually including: - Trapping; - Camera traps; - Area searches for sign of tracks or

Species	Potential Impacts from the Proposal	Mitigation measures	Monitoring
	Proposal may include: • Loss of foraging habitat • Loss of nesting habitat • Increasing grazing by introduced species, altering foraging habitat; • Increased predation from introduced species • Weed species invade foraging habitat; • Increased vehicle traffic leading to collisions with fauna • Increased vehicle traffic leading to increased dust generation; • Increased light and noise vibrations impacting species behaviour; • Altered fire regimes	• Manage grazing by introduced species – see section 7.3 below • Manage introduced predators – see section 7.3 below • Weed management – see section 7.4 • Fauna strike – see section 7.5 below regarding nighttime driving restrictions • Dust – see section 7.6 below • Light and noise – see section 7.7 below • Surface water – see section 7.8 below • Bushfires – see section 7.9 below	- scats; and Vegetation health (habitat) monitoring.
Northern quoll (<i>Dasyurus hallucatus</i>)	If the northern quoll is present in the Proposal area, the species is unlikely to be significantly impacted by the Proposal (see Section 5.3.2 northern quoll) however individuals may be impacted by the Proposal. Potential impacts from the Proposal may include: • Vehicle strike • Availability of cane toads eaten by Quolls causing death	• Undertake pre-construction survey targeting northern quolls to determine the presence or absence of the species. • Fauna strike – see section 7.5 below regarding nighttime driving restrictions • Control of Cane toads	• Fauna incident register. • Fauna sighting register • Flora and fauna monitoring program would be conducted annually including: - Trapping; - Camera traps; - Area searches for sign of tracks or scats; and - Vegetation health (habitat) monitoring.
Ghost bat (<i>Macroderma gigas</i>)	If the ghost bat is present in the Proposal area, the species would not be significantly impacted by	• Undertake pre-construction survey targeting ghost bats to determine the presence or absence of the species.	• Fauna incident register. • Fauna sighting register

Species		Potential Impacts from the Proposal	Mitigation measures	Monitoring
		the Proposal (see 5.3.3 ghost bat) however individuals may be impacted by the Proposal. Potential impacts from the Proposal may include: • Loss of roosting habitat • Vehicle strike	• If present, disturb to move elsewhere during the wet season prior to construction commencement • Fauna strike – see section 7.5 below regarding nighttime driving restrictions	• Flora and fauna monitoring program would be conducted annually including: - Bat detector surveys - Area searches for signs - Habitat monitoring
Black-footed tree-rat (<i>Mesembriomys gouldii</i>)		If the black-footed tree-rat is present in the Proposal area, the species would not be significantly impacted by the Proposal (see 5.3.2 black-footed tree-rat) however individuals may be impacted by the Proposal. Potential impacts from the Proposal may include: • Loss of foraging habitat • Loss of nesting habitat • Increasing grazing by introduced species, altering foraging habitat; • Increased predation from introduced species • Weed species invade foraging habitat; • Increased vehicle traffic leading to collisions with fauna • Increased vehicle traffic leading to increased dust generation; • Increased light and noise vibrations impacting species; • Altered fire regimes	• Undertake pre-construction survey targeting black-footed tree-rats to determine the presence or absence of the species. • If the species is found to be present, avoid clearing large trees with diameter greater than 15cm, particularly those along water courses that may provide suitable breeding habitat. • Manage grazing by introduced species – see section 7.3 below • Manage introduced predators – see section 7.3 below • Weed management – see section 7.4 • Fauna strike – see section 7.5 below regarding night time driving restrictions • Dust – see section 7.6 below • Light and noise – see section 7.7 below • Surface water – see section 7.8 below • Bushfires – see section 7.9 below	• Fauna incident register. • Fauna sighting register • Flora and fauna monitoring program would be conducted annually including: - Trapping; - Camera traps; - Area searches for sign of tracks or scats; and - Vegetation health (habitat) monitoring.

Species	Potential Impacts from the Proposal	Mitigation measures	Monitoring
Northern brush-tailed phascogale (<i>Phascogale pirate</i>)	If the northern brush-tailed phascogale is present in the Proposal area, the species would not be significantly impacted by the Proposal (see 5.3.3 northern brush-tailed phascogale) however individuals may be impacted by the Proposal. Potential impacts from the Proposal may include: • Loss of foraging habitat • Loss of nesting habitat • Increasing grazing by introduced species, altering foraging habitat; • Increased predation from introduced species • Weed species invade foraging habitat; • Increased vehicle traffic leading to collisions with fauna • Increased vehicle traffic leading to increased dust generation; • Increased light and noise vibrations impacting species; • Altered fire regimes	• Undertake pre-construction survey targeting northern brush-tailed phascogales to determine the presence or absence of the species. • If the species is found to be present, avoid clearing large trees with diameter greater than 15cm, particularly those along water courses that may provide suitable breeding habitat. • Manage grazing by introduced species – see section 7.3 below • Manage introduced predators – see section 7.3 below • Weed management – see section 7.4 • Fauna strike – see section 7.5 below • Dust – see section 7.6 below • Light and noise – see section 7.7 below • Surface water – see section 7.8 below • Bushfires – see section 7.9 below	• Fauna incident register. • Fauna sighting register • Flora and fauna monitoring program would be conducted annually including: - Trapping; - Camera traps; - Area searches for sign of tracks or scats; and - Vegetation health (habitat) monitoring.
Migratory and Marine Species (Magpie goose (<i>Anseranas semipalmata</i>), fork-tailed swift (<i>Apus pacificus</i>), Eastern great egret (<i>Ardea</i>	As habitat within the Proposal area is not in a region that supports an ecologically significant proportion of any migratory species potentially occurring in the Proposal area; is not of critical importance to any	• Undertake pre-construction survey targeting marine and migratory species to determine the presence or absence of the species • Restrict development to ensure adequate required buffer zone is maintained around riparian habitat (see section 7.2). • Manage introduced predators – see section 7.3	• Fauna incident register. • Fauna sighting register • Flora and fauna monitoring program would be conducted annually including: - Targeted bird surveys and area searches, particularly near

Species	Potential Impacts from the Proposal	Mitigation measures	Monitoring
<i>alba</i>), Cattle egret (<i>Ardea ibis</i>), Sharp tailed sandpiper (<i>Calidris acuminata</i>), Red-rumped swallow (<i>Cecropis daurica</i>) red-rumped swallow (<i>Hirundo daurica</i>), oriental plover (<i>Charadrius veredus</i>) oriental cuckoo (<i>Cuculus optatus</i>), Himalayan cuckoo (<i>Cuculus saturates</i>), oriental pratincole (<i>Glareola maldivarum</i>), white-bellied sea eagle (<i>Haliaeetus leucogaster</i>), barn swallow (<i>Hirundo rustica</i>), rainbow bee-eater (<i>Merops ornatus</i>), grey wagtail (<i>Motacilla cinerea</i>), yellow wagtail (<i>Motacilla flava</i>), greater painted snipe (<i>Rostratula benghalensis</i>), freshwater crocodile (<i>Crocodylus johnstoni</i>)	of these species at particular life-cycle stages; is not at the limit of the range of any of these species; and is not within an area where any of these species is declining, the Proposal would not significantly impact any migratory species (see Section 5.3). However, individuals may be impacted by the Proposal. Potential impacts from the Proposal may include: • Increased predator species. • Reduced water availability • Contaminated water runoff	below • Manage surface water run off – see section 7.8 below	waterbodies; - Camera traps; and - Vegetation health (habitat) monitoring
Pale field rat (<i>Rattus tunneyi</i>)	• Loss of foraging habitat • Loss of nesting habitat • Increasing grazing by introduced species, altering foraging habitat; • Increased predation from introduced species • Weed species invade foraging habitat; • Increased vehicle traffic leading to collisions with fauna • Increased vehicle traffic	• Undertake pre-construction survey targeting pale field-rats to determine the presence or absence of the species. • Restrict development to ensure adequate required buffer zone is maintained around riparian habitat (section 7.2). • Manage grazing by introduced species – see section 7.3 below • Manage introduced predators – see section 7.3 below • Weed management – see section 7.4 • Fauna strike – see section 7.5 below • Dust – see section 7.6 below	• Fauna incident register. • Fauna sighting register • Flora and fauna monitoring program would be conducted annually including: - Trapping; - Camera traps; - Area searches for sign of tracks or scats; and - Vegetation health (habitat) monitoring.

Species	Potential Impacts from the Proposal	Mitigation measures	Monitoring
	leading to increased dust generation; - Increased light and noise vibrations impacting species; - Altered fire regimes	- Light and noise – see section 7.7 below - Surface water – see section 7.8 below - Bushfires – see section 7.9 below	
Merten's water monitor (<i>Varanus mertensi</i>), Mitchell's water monitor (<i>Varanus mitchelli</i>) and Floodplain monitor (<i>Varanus panoptes</i>)	These species would not be significantly impacted by the Proposal, however individuals may be impacted by the Proposal. Potential impacts from the Proposal may include: - Increased predator species; and - Increased erosion and sedimentation of waterways	- Undertake pre-construction survey targeting monitor species to determine the presence or absence of the species. - Restrict development to ensure adequate required buffer zone is maintained around riparian habitat (section 7.2). - Manage surface water run off – see section 7.8 below - Fauna strike – see section 7.5 below regarding riparian zone restrictions	- Fauna incident register. - Fauna sighting register - Flora and fauna monitoring program would be conducted annually including: - Targeted area searches, particularly near waterbodies; - Camera traps; and - Vegetation health (habitat) monitoring

7.2 Riparian Zones and Aquatic Habitats

Waterways and wetlands within the Project footprint should be buffered to assist in maintaining surface and ground water quality and the health of aquatic plants and animals (DLRM, 2016b). The minimum widths of waterway buffers are based on stream order classification. Streams within the study area have been classified as 3rd order creeks and wetlands (see section 4.6). Recommendations for buffers around these areas is summarized below in Table 31 and mapped in Figure 25 and Figure 26. Buffer boundaries are approximate and pre-development targeted assessment of water flow and waterbodies and plant species changes which may indicate buffer width is recommended to determine accurate locations of buffer boundaries required to preserve riparian habitat areas.

Table 31. Recommended waterway buffers according to stream order (DLRM, Undated).

Waterway	Stream order	Minimum buffer width (m)	Measure from:
Creeks	Third and Fourth	100	The outer edge of riparian vegetation, where mapped otherwise the primary bank of the outer stream channel where there is more than one channel or the stream is braided
Wetlands (e.g. swamps, lakes, billabongs) and mangroves	First	200	The outer edge of areas that are inundated or saturated at a frequency to at times support plants and/or animals adapted to saturated and/or inundated conditions. The water may be static or flowing fresh, brackish or salt, including areas of coastal marine waters.

7.2.1 Riparian Zones and Aquatic Habitats

Monitoring of riparian zone and aquatic habitats should be undertaken, at sites affected by developments. Monitoring should include:

- Inspection of haul road crossings of watercourses throughout construction phase to confirm that appropriate erosion and sediment controls are in place
- Periodic inspections (i.e. monthly during the wet season) should be undertaken following construction to confirm that erosion and sediment control mechanisms are operating effectively;
- Ongoing surface water quality monitoring should be implemented including upstream and downstream monitoring;
- An erosion and sediment control plan should be prepared for the project including detailed mitigation measures to minimise erosion and release of sediment; and
- Annual monitoring of aquatic habitats should be undertaken following AusRivAS guidelines.

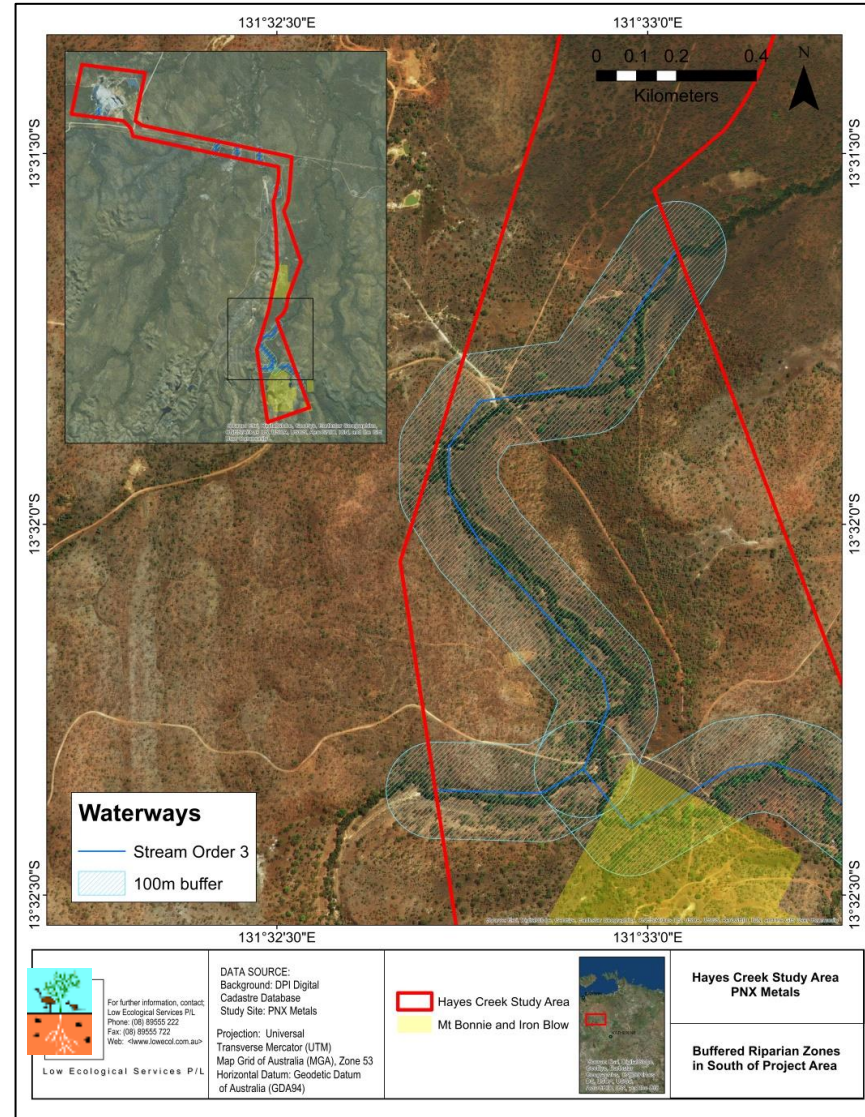
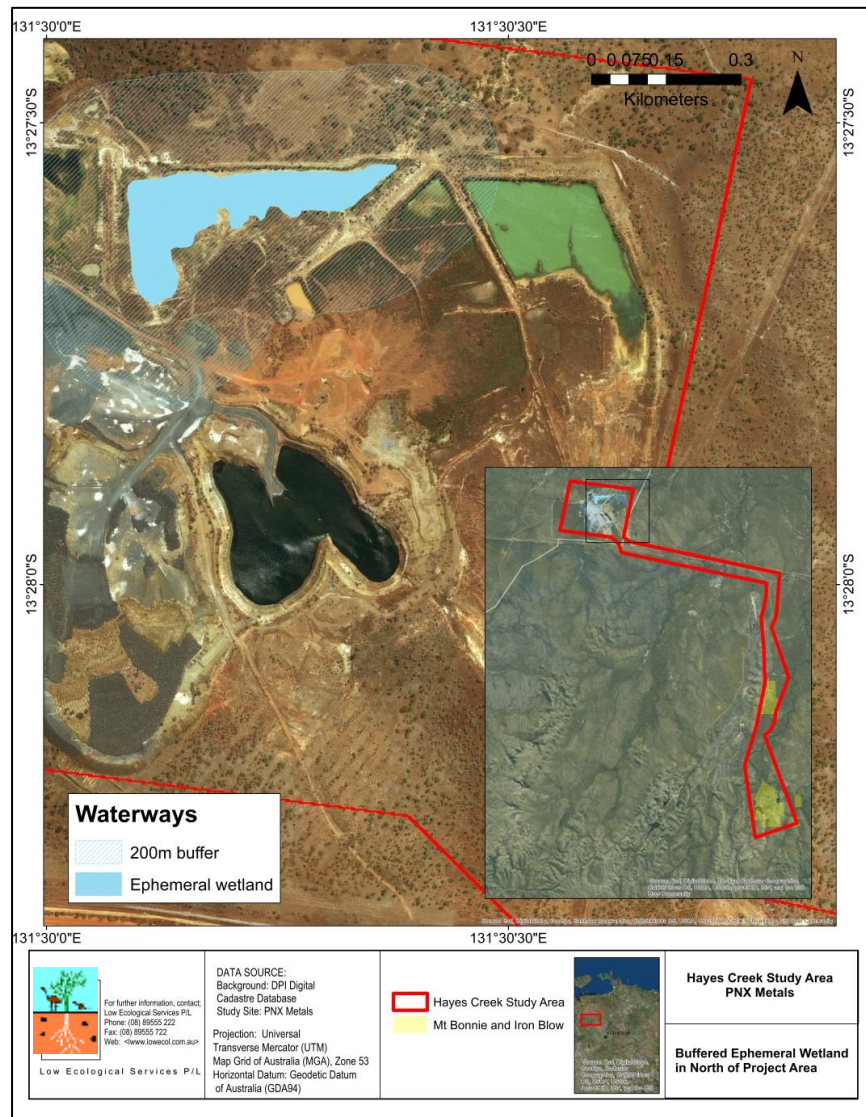


Figure 25 and Figure 26. Waterways identified in Hayes Creek field survey and recommended buffer zones (DLRM, Undated).

7.3 Introduced fauna species

Disturbance from introduced fauna species can pose a hazard to both threatened and other native fauna and flora. Introduced herbivorous species (e.g. pig, cattle and horse) can pose a threat to those species dependent on dense grass understoreys including the gouldian finch and partridge pigeon (see section 6.5). Introduced carnivorous species (e.g. feral cat and dog) and other introduced species (e.g. cane toads) are recognised as key threatening processes for a number of MNES. Recommendations for introduced fauna management strategies include:

- Develop and implement a no tolerance policy to the introduction of pest species by contractors, suppliers and personnel;
- Restrict access of cattle to mine site;
- Develop and implement an introduced fauna control program;
- Reduce artificial standing water;
- Prevent access to artificial water and heat sources through construction of fences;
- No feeding of fauna, native or introduced, on site; and
- Targeted feral animal control around riparian zones
 - Fencing to control stock access (if stock have access to the site)
 - Feral cat and cane toad control should be considered

7.4 Weed management

Invasive weed species can pose a hazard to a number of MNES, including the Gouldian finch and partridge pigeon. Recommendations for weed management include:

- Remove weeds following specialist advice from qualified ecologist or Weeds Branch, NT Government. Remove weeds before seeding times, where possible;
- Undertake annual weed mapping in the vicinity of the proposed development footprint;
- All vehicles should be weed free before entering site for the first time. Weed wash down will be required if leaving a contaminated to uncontaminated area;
- Provide workers with environmental induction in regards to weeds, as dictated by a weed management plan:
 - Include identification guides and photos for common weeds on site;
 - Register for reporting any sightings of weeds or potential weeds; and
- Targeted weed control around riparian zones

7.5 Fauna Strike

Increase vehicle movement within the project area may pose a hazard to MNES and other species. Recommendations to avoid vehicle strike or injury include:

- Implement and adhere to traffic/vehicle management plan and induct all staff in accordance with it's guidelines;
- Avoid driving during high-risk times;
 - Dawn and dusk to avoid collisions with gouldian finch, partridge pigeon and other listed bird species if found to be present within the project area.

- Night time to avoid collisions with northern quolls, ghost bats, fawn antechinus, black-footed tree-rat, northern brush-tailed phascogale and other listed species if found to be present within the project area.
- Restrict speeds in high risk locations identified through pre-clearing surveys including:
 - Riparian zones
 - Gouldian finch known sites
 - Partridge pigeon known sites
 - Permanent standing water sites utilised by migratory and/or marine birds
- Restrict vehicle use around site by filling up with passengers going to the same destination;
- Prohibit off-road driving, in particular prevent off-road access to sensitive riparian zones;
- Ensure traffic adheres to speed limits; and
- Develop and maintain fauna sightings register to be kept onsite and filled in daily.

7.6 Dust

Recommendations for minimising the impact of dust on flora and fauna include:

- Water trucks to be run daily or as required during construction to limit the visible dust levels. Not required after rain events:
 - Target areas identified as key habitat for MNES identified on site in pre-construction surveys e.g. Gouldian finch
- Dust monitoring around areas identified as potential habitat for Gouldian finches, partridge pigeons and other MNES identified in pre-construction surveys;
- Avoid clearing during windy conditions; and
- Leave troot stock and ground cover on firebreaks and non-crucial tracks. Ground cover should be left to at least 10cm in height.

7.7 Light and Noise

Recommendations for minimising impact of noise, vibrations and light pollution on fauna include:

- All operations to be restricted to daylight hours where possible;
- Turn off machinery when not in use;
- Only have minimal lights on needed for safe operation of facilities;
- Turn lights off when not in use;
- Use lower intensity lights e.g. yellow or red lighting, where possible; and
- All lighting to be angled towards the ground to avoid unnecessary lighting of areas outside the clearing envelope.

7.8 Surface water contamination/alteration

- During construction ensure water through flow not detrimentally impacted;
- Any unavoidable creek crossing to be developed to the natural base of the creek;
- If all season crossing is required, adequate culverts must be installed to handle peak flow events;

- Any drain installed to be constructed with a flat bottom and unobstructed exit to allow surface flow to flood out onto surrounding areas. All drains and water diversion devices to be checked and maintained following significant rainfall event;
- Any runoff down roads and mine sites must be controlled using rollover diversion banks to direct water off roads;
- Implement sediment collection and control measures to manage runoff during construction of watercourses and mitigate downstream sedimentation effects;
- Wherever potential run-off from development areas to any long standing water bodies (e.g. swamps, inundated grassland etc.) installation of a sedimentation basin with downstream rock bed preventing wash-out, may be appropriate if there is potential for sediment transport;
- Where possible, avoid disturbance of any long-standing water bodies e.g. swamps, inundated grassland etc;
- Undertake monitoring to confirm measures are effective and identify any necessary remedial actions; and
- Road construction materials need to be considered for heavy metal contamination to avoid contamination of water pools that may develop at roadside.

7.9 Bushfires

A key threatening process for a number of MNES potentially occurring or occurring within the project area is alterations to fire regimes. Fires of inappropriate intensity or timing can have detrimental impacts on native flora and fauna and are likely contributors to local extinctions of some species. Recommendations in regards to fire regimes include:

- Developing a comprehensive bushfire management plan including targeted fire management enhancing suitability of residual habitat suitable for MNES occurring or likely to occur within the project area:
 - Conduct seasonal controlled burning at as deemed appropriate by a suitably qualified fire ecologist, traditional owners and Northern Land Council;
- Daily checking of bushfire websites and weather bureau data including BOM and NAFI websites;
- Construct and maintain firebreaks around infrastructure and significant habitats;
- No open flames outside of designated areas unless hot works permit is approved;
- Ensure firefighting equipment stored on site suitable for flammable materials used on site; and
- Designated smoking areas to be position upwind of dominant wind direction greater than 50-100m from any flammable material.

8 CONCLUSION

Flora and fauna within the project area and potential risks to biodiversity as a result of the Project have been preliminarily assessed by LES. .

This flora and fauna assessment combines information from desktop studies and an on-ground late wet-season survey conducted in May 2017. Desktop studies included database and literature review of broad scale and fine scale environmental information relating to the Project area including climate, bioregions, soil types, vegetation types, land systems, hydrology, vegetation types, weeds and invasive species, flora and fauna species of conservation significance under TWPC Act and EPBC Act, introduced fauna and MNES. A literature review provided information on the species occurring or potentially occurring within the Project area.

A field survey was conducted from May 15th-18th 2017 at the Project, encompassing all proposed development areas. Surveys included habitat searches, vegetation surveys, landscape description, fauna trapping, secondary sign searches, area search bird surveys, spotlighting, motion sensing camera trapping, and bat call detection. Survey methods for vegetation surveys and landscape description are based on *Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping* (Brocklehurst, et al., 2007). Survey methodology for fauna follows the *Standard terrestrial vertebrate survey methods used by the DLRM* (in Northern Territory Environmental Protection Agency, 2013). Survey methods used to determine the presence of threatened species followed those suggested in the *Survey Guidelines for Australia's Threatened Mammals* (Department of Sustainability, Environment, Water, Population and Communities, 2011a), *Survey Guidelines for Australia's Threatened Reptiles* (Department of Sustainability, Environment, Water, Population and Communities, 2011b) and *Survey Guidelines for Australia's Threatened Birds* (Department of Environment, Water, Heritage and the Arts, 2010).

No threatened flora species were recorded in the Project area. There are no threatened ecological communities or sensitive vegetation communities within the Proposal area.

One threatened fauna species was recorded in the Proposal area during the on ground survey:

- Gouldian finch (*Erythrura gouldiae*), listed as endangered (EN) under the EPBC Act and vulnerable (VU) under the TPWC Act, was north of the Mt Bonnie site at the beginning of the proposed haul road expansion.

One additional threatened fauna species was anecdotally recorded from a KL Gold employee however staff did not observe this species during the on-ground survey:

- Merten's water monitor (*Varanus mertensii*) listed as vulnerable (VU) under the TPWC Act was reportedly observed by a KL Gold employee in the Iron Blow pit.

Ten threatened fauna species were not recorded during the on-ground surveys but have a moderate or high likelihood of occurring within the Proposal area:

- Curlew sandpiper (*Calidris ferruginea*)(Cr EPBC Act, VU TPWC Act);
- Red goshawk (*Erythrotriorchis radiatus*)(VU EPBC Act, VU TPWC Act);
- Partridge pigeon (eastern) (*Geophaps smithii smithii*)(VU EPBC Act, VU TPWC Act);

- Australian painted snipe (*Rostratula australis*)(VU EPBC Act, EN TPWC Act) and;
- Masked owl (northern) (*Tyto novaehollandiae kimberli*)(VU EPBC Act, VU TPWC Act);
- Fawn antechinus (*Antechinus bellus*) (EN EPBC Act, VU TPWC Act);
- Northern quoll (*Dasyurus hallucatus*) (EN EPBC Act, VU TPWC Act);
- Ghost bat (*Macroderma gigas*) (VU EPBC Act, NT TPWC Act);
- Northern brush-tailed phascogale (*Phascogale pirata*) (EN EPBC Act, VU TPWC Act);
- Pale field-rat (*Rattus tunneyi*) (VU TPWC Act);

Four fauna species listed as Nt under the TPWC Act were recorded during the on-ground survey:

- Buff-sided robin (*Poecilodryas cerviniventris*)
- Bush-stone curlew (*Burhinus grallarius*)
- Orange leaf-nosed bat (*Rhinonictis hipposideridae*) *Dromaius novaehollandiae* (Nt under TPWC Act); and
- Northern ridge-tailed monitor (*Varanus primordius*) *Pyrrholaemus brunneus* (Nt under TPWC Act).

Four species listed as migratory and marine under the EPBC Act were recorded in the Proposal area during surveys:

- Freshwater crocodile (*Crocodylus johnsoni*) was observed in the creek north of Mt Bonnie and possible tracks were observed adjacent to the haul road crossing of the creek;
- Great egrets (*Ardea alba*) and Cattle egrets (*Ardea ibis*) were observed both on the ground and flying overhead at the Fountain Head trap site.
- Rainbow bee-eaters (*Merops ornatus*) were commonly recorded across the Project area

An additional thirteen species have a moderate to high likelihood of occurring in the Proposal area:

- Magpie goose (*Anseranas semipalmata*) (Ma under the EBPC Act);
- Fork-tailed swift (*Apus pacificus*) (Mi and Ma under the EBPC Act);
- Sharp-tailed sandpiper (*Calidris acuminata*)(Mi and Ma under the EBPC Act);
- Curlew sandpiper (*Calidris ferruginea*)(Mi and Ma under the EBPC Act);
- Red-rumped swallow (*Cecropis daurica* (*Hirundo daurica*))(Mi and Ma under the EBPC Act).
- Oriental plover (*Charadrius veredus*) (Mi and Ma under the EBPC Act);
- Oriental cuckoo (*Cuculus optatus*) (Mi and Ma under the EBPC Act);
- Himalayan cuckoo (*Cuculus saturates*) (Ma under the EBPC Act);
- White-bellied sea eagle (*Haliaetus leucogaster*) (Ma under the EBPC Act);
- Barn swallow (*Hirundo rustica*) (Mi and Ma under the EBPC Act);
- Grey wagtail (*Motacilla cinerea*) (Mi and Ma under the EBPC Act);
- Yellow wagtail (*Motacilla flava*) (Mi and Ma under the EBPC Act);
- Painted Snipe (*Rostratula benghalensis*) (Mi and Ma under the EBPC Act);

Sixteen introduced flora species were recorded in the Project area. Of these species, two species are a Weed of National Significance (WoNs) and declared weed (Class B and Class C) in the NT; gamba grass (*Andropogon gayanus*) and olive hymenachne (*Hymenachne amplexicaulis*). Five additional

weeds are declared weed (Class B and Class C) in the NT; snakeweed (*Stachytarpheta* sp.), hyptis (*Hyptis suaveolens*) (Class B,C), candlestick bush (*Senna alata*), spinyhead sida (*Sida acuta*) (Class B,C), and Grader grass (*Themeda quadrivalvis*).

Six introduced fauna species were recorded during the on-ground survey of the Project area. These include black rat (*Rattus rattus*), cane toad (*Rhinella marina*), cattle (*Bos taurus*), feral pig (*Sus scrofa*), cat (*Felis catus*) and water buffalo (*Bubalus bubalis*).

Assessment of significance of impact

The potential for significant impacts on 34 threatened, migratory and marine species listed under the EPBC Act and TPWC Act that were recorded during surveys or have a moderate to high likelihood of occurring in the Proposal area, (2 flora species and 32 fauna species) were assessed using the criteria set out in the *Significant Impact Guidelines 1.1-Matters of National Environmental Significance* (Department of Environment, 2013):

Based on a projected clearing of approximately 32ha predominantly along the proposed haul road connecting Mt Bonnie and Iron Blow sites with existing haul roads in the north and south of the project are; no species are considered likely to be significantly impacted by the proposed project.

The significant impact assessment of the Gouldian finch however is dependent on results from a proposed late dry season survey and ongoing consultation with specialists in the area. The result of the significant impact assessment may alter depending on the findings of the disturbance of potential breeding habitat of Gouldian finches in the project area during the late dry season survey.

Additional risks to biodiversity associated with the project development

- Weeds spread and introduction;
- Increase in introduced species;
- Increased predator species; and
- Fire.

Mitigation and monitoring measures were suggested to reduce risks. These measures are preliminary suggestions subject to further assessment.

Based on the results of this initial flora and fauna survey, it is recommended a late-dry season survey is conducted to account for seasonal variation in flora and fauna present within the project area. In addition a late-dry season survey would allow for further assessment of the Gouldian finches observed within the project area and more detailed assessment of existing habitat, including characterisation of potential breeding areas within the project area that would be affected by proposed clearing. Results of the significant impact assessment would need to be revisited following this additional survey and recommendations may alter dependent on the findings.

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10 APPENDICES

APPENDIX 1. EPBC PMST Report for the Hayes Creek study area



Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about [Environment Assessments](#) and the EPBC Act including significance guidelines, forms and application process details.

Report created: 30/05/17 10:21:32

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[Details](#)

[Matters of NES](#)

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[Acknowledgements](#)



This map may contain data which are
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[Coordinates](#)

Buffer: 20.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the [Administrative Guidelines on Significance](#).

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	21
Listed Migratory Species:	18

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at <http://www.environment.gov.au/heritage>

A [permit](#) may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	24
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	22
Nationally Important Wetlands:	None
Key Ecological Features (Marine):	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
<i>Calidris ferruginea</i> Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
<i>Erythrotriorchis radiatus</i> Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
<i>Erythrura gouldiae</i> Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
<i>Falcunculus frontatus whitei</i> Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
<i>Geophaps smithii smithii</i> Partridge Pigeon (eastern) [64441]	Vulnerable	Species or species habitat known to occur within area
<i>Numenius madagascariensis</i> Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
<i>Rostratula australis</i> Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
<i>Tyto novaehollandiae kimberli</i> Masked Owl (northern) [26048]	Vulnerable	Species or species habitat likely to occur within area
Mammals		
<i>Antechinus bellus</i> Fawn Antechinus [344]	Vulnerable	Species or species habitat likely to occur within area
<i>Conilurus penicillatus</i> Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat may occur within area
<i>Dasyurus hallucatus</i> Northern Quoll, Digul [331]	Endangered	Species or species habitat known to occur within area
<i>Hipposideros inornatus</i> Arnhem Leaf-nosed Bat [86675]	Endangered	Species or species habitat likely to occur within area

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Name	Status	Type of Presence
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Mesembriomys gouldii gouldii Black-footed Tree-rat (Kimberley and mainland Northern Territory), Djintamoonga, Manbul [87618]	Endangered	Species or species habitat known to occur within area
Petrogale concinna canescens Nabarlek (Top End) [87606]	Endangered	Species or species habitat likely to occur within area
Phascogale pirata Northern Brush-tailed Phascogale [82954]	Vulnerable	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudiclunatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheath-tail Bat [66889]	Vulnerable	Species or species habitat may occur within area
Plants		
Acacia praetermissa a shrub [14840]	Vulnerable	Species or species habitat likely to occur within area
Stylidium ensatum a triggerplant [86366]	Endangered	Species or species habitat known to occur within area
Reptiles		
Acanthophsis hawkei Plains Death Adder [83821]	Vulnerable	Species or species habitat likely to occur within area
Sharks		
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat likely to occur within area
Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Marine Species		
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cecropis daurica Red-rumped Swallow [80610]		Species or species habitat may occur within area
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species

Name	Threatened	Type of Presence
<i>Motacilla flava</i> Yellow Wagtail [644]		habitat may occur within area Species or species habitat may occur within area
<i>Rhipidura rufifrons</i> Rufous Fantail [592]		Species or species habitat may occur within area
Migratory Wetlands Species		
<i>Acrocephalus orientalis</i> Oriental Reed-Warbler [59570]		Species or species habitat may occur within area
<i>Actitis hypoleucos</i> Common Sandpiper [59309]		Species or species habitat may occur within area
<i>Calidris acuminata</i> Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
<i>Calidris ferruginea</i> Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
<i>Calidris melanotos</i> Pectoral Sandpiper [858]		Species or species habitat may occur within area
<i>Charadrius veredus</i> Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
<i>Glareola maldivarum</i> Oriental Pratincole [840]		Species or species habitat may occur within area
<i>Numenius madagascariensis</i> Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
<i>Pandion haliaetus</i> Osprey [952]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
<i>Acrocephalus orientalis</i> Oriental Reed-Warbler [59570]		Species or species habitat may occur within area
<i>Actitis hypoleucos</i> Common Sandpiper [59309]		Species or species habitat may occur within area
<i>Anseranas semipalmata</i> Magpie Goose [978]		Species or species habitat may occur within area
<i>Apus pacificus</i> Fork-tailed Swift [678]		Species or species

Name	Threatened	Type of Presence
<i>Ardea alba</i> Great Egret, White Egret [59541]		habitat likely to occur within area Species or species habitat known to occur within area
<i>Ardea ibis</i> Cattle Egret [59542]		Species or species habitat may occur within area
<i>Calidris acuminata</i> Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
<i>Calidris ferruginea</i> Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
<i>Calidris melanotos</i> Pectoral Sandpiper [858]		Species or species habitat may occur within area
<i>Charadrius veredus</i> Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
<i>Cuculus saturatus</i> Oriental Cuckoo, Himalayan Cuckoo [710]		Species or species habitat may occur within area
<i>Glaucola maldivarum</i> Oriental Pratincole [840]		Species or species habitat may occur within area
<i>Haliaeetus leucogaster</i> White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
<i>Hirundo daurica</i> Red-rumped Swallow [59480]		Species or species habitat may occur within area
<i>Hirundo rustica</i> Barn Swallow [662]		Species or species habitat may occur within area
<i>Merops ornatus</i> Rainbow Bee-eater [670]		Species or species habitat may occur within area
<i>Motacilla cinerea</i> Grey Wagtail [642]		Species or species habitat may occur within area
<i>Motacilla flava</i> Yellow Wagtail [644]		Species or species habitat may occur within area
<i>Numenius madagascariensis</i> Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
<i>Pandion haliaetus</i> Osprey [952]		Species or species habitat likely to occur within area
<i>Rhipidura rufifrons</i> Rufous Fantail [592]		Species or species habitat may occur within area
<i>Rostratula benghalensis (sensu lato)</i> Painted Snipe [889]	Endangered*	Species or species habitat

Name	Threatened	Type of Presence area
Reptiles		
<u>Crocodylus johnstoni</u>		
Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area
<u>Crocodylus porosus</u>		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area

Extra Information

Invasive Species	[Resource Information]
Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resources Audit, 2001.	

Name	Status	Type of Presence
Birds		
<i>Columba livia</i>		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Frogs		
<i>Rhinella marina</i>		
Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
<i>Bos taurus</i>		
Domestic Cattle [16]		Species or species habitat likely to occur within area
<i>Bubalus bubalis</i>		
Water Buffalo, Swamp Buffalo [1]		Species or species habitat likely to occur within area
<i>Canis lupus familiaris</i>		
Domestic Dog [82654]		Species or species habitat likely to occur within area
<i>Equus asinus</i>		
Donkey, Ass [4]		Species or species habitat likely to occur within area
<i>Equus caballus</i>		
Horse [5]		Species or species habitat likely to occur within area
<i>Felis catus</i>		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
<i>Mus musculus</i>		
House Mouse [120]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
<i>Rattus rattus</i> Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
<i>Sus scrofa</i> Pig [6]		Species or species habitat likely to occur within area
Plants		
<i>Andropogon gayanus</i> Gamba Grass [66895]		Species or species habitat likely to occur within area
<i>Brachiaria mutica</i> Para Grass [5879]		Species or species habitat may occur within area
<i>Cabomba caroliniana</i> Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat may occur within area
<i>Hymenachne amplexicaulis</i> Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
<i>Jatropha gossypifolia</i> Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
<i>Lantana camara</i> Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
<i>Mimosa pigra</i> Mimosa, Giant Mimosa, Giant Sensitive Plant, Thorny Sensitive Plant, Black Mimosa, Catclaw Mimosa, Bashful Plant [11223]		Species or species habitat likely to occur within area
<i>Pennisetum polystachyon</i> Mission Grass, Perennial Mission Grass, Missiongrass, Feathery Pennisetum, Feather Pennisetum, Thin Napier Grass, West Indian Pennisetum, Blue Buffel Grass [21194]		Species or species habitat likely to occur within area
<i>Salvinia molesta</i> Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
<i>Vachellia nilotica</i> Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat may occur within area
Reptiles		
<i>Hemidactylus frenatus</i> Asian House Gecko [1708]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-13.45555 131.49456,-13.46903 131.49181,-13.48349 131.55047,-13.55373 131.54753,-13.55007 131.55951,-13.48102 131.55439,-13.47084 131.51002,-13.45779 131.51254,-13.45555 131.49456

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- [Department of Land and Resource Management, Northern Territory](#)
- [Department of Environmental and Heritage Protection, Queensland](#)
- [Department of Parks and Wildlife, Western Australia](#)
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- [Australian Bird and Bat Banding Scheme](#)
- [Australian National Wildlife Collection](#)
- [Natural history museums of Australia](#)
- [Museum Victoria](#)
- [Australian Museum](#)
- [South Australian Museum](#)
- [Queensland Museum](#)
- [Online Zoological Collections of Australian Museums](#)
- [Queensland Herbarium](#)
- [National Herbarium of NSW](#)
- [Royal Botanic Gardens and National Herbarium of Victoria](#)
- [Tasmanian Herbarium](#)
- [State Herbarium of South Australia](#)
- [Northern Territory Herbarium](#)
- [Western Australian Herbarium](#)
- [Australian National Herbarium, Canberra](#)
- [University of New England](#)
- [Ocean Biogeographic Information System](#)
- [Australian Government, Department of Defence Forestry Corporation, NSW](#)
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- [Australian Tropical Herbarium, Cairns](#)
- [eBird Australia](#)
- [Australian Government – Australian Antarctic Data Centre](#)
- [Museum and Art Gallery of the Northern Territory](#)
- [Australian Government National Environmental Science Program](#)
- [Australian Institute of Marine Science](#)
- [Reef Life Survey Australia](#)
- [American Museum of Natural History](#)
- [Queen Victoria Museum and Art Gallery, Inveresk, Tasmania](#)
- [Tasmanian Museum and Art Gallery, Hobart, Tasmania](#)
- Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the [Contact Us](#) page.

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APPENDIX 2. Location of sites, in GDA94 co-ordinate system, surveyed during the May on-ground survey by LES

Survey area	Site	Latitude	Longitude
Fountain Head	Trapping site/Bat detector	-13.458501 °	131.506179 °
	Camera site	-13.458237 °	131.506079 °
	Targeted bird survey	-13.461233 °	131.499044
Iron Blow	Trapping site/Bat detector	-13.515338 °	131.551706 °
	Spotlighting	-13.514792 °	131.551244 °
Mt Bonnie	Trapping site/Bat detector	-13.544725 °	131.548681 °
	Camera site	-13.544849 °	131.548381 °
	Targeted quoll search	-13.546069 °	131.550158 °
	Targeted bird survey	-13.546162 °	131.549190 °
Haul Road (proposed)	Cam site (N)	-13.499406 °	131.551013 °
	Cam site (Gouldian)	-13.529965 °	131.546848 °
	Spotlighting (N)	-13.503232 °	131.551742 °
	Spotlighting (S)	-13.530168 °	131.546803 °
Creeklines	Creek cam	-13.538684 °	131.549070 °
	Riparian Camera	-13.540060 °	131.550887 °
	Targeted search	-13.539849 °	131.550903 °
	Yam Creek bird survey	-13.476540 °	131.534224 °
	Mt Bonnie creek aquatic assessment		
	Yam creek aquatic assessment		
	Upstream aquatic assessment		
Control Sites	Control site 1/Bat detector	-13.479023 °	131.532370 °
	Control site 2/Bat detector	-13.491025 °	131.552970 °
	Control site 3/Bat detector	-13.535200 °	131.536614 °
Mt Wells Haul Road	Camera site	-13.478255 °	131.532290 °
	Spotlighting	-13.477913 °	131.534669 °

APPENDIX 3. Site Description data sheets

Site No.:	Survey number:		Quad. size: other:	
Date:		Observer:		
Site description & location details:			Landform pattern:	
Zone:	GPS AMG:	E	N	Datum: AGD66
Precision:		GPS level:		
Topographic position:		Photo ref. no.:		
Land unit:	Run: on off plain		Patch size (ha): <1 1-5 5-50 50-500 500+	
Edge: ecotone or closest distance:				
Perm. Water: 0 <50m 50-500m 0.5-5km >5km		Curr. water: 0 <50m 50-500m 0.5-5km >5km		
Climate: 1 = Dry, plant stress 2 = Dry, no plant stress 3 = Recent rain, no vegetation response 4 = Recent rain, noticeable vegetation response				
Disturbance: 0 = no visible impact 1 = disturbance present but negligible impact 2 = low level of disturbance throughout quadrat, or moderate level in patches in the quadrat 3 = moderate level of disturbance throughout quadrat, or high level in patches in the quadrat 4 = high level of disturbance throughout quadrat, or major level in patches in the quadrat 5 = major impact affecting all of quadrat				
Fire impact: 0 1 2 3 4 5		Last fire: this year last year 2+ years ago long unburnt		
Rabbit damage: 0 1 2 3 4 5		Introduced herbivores: 0 1 2 3 4 5		Camels: 0 1 2 3 4 5
Weeds: 0 1 2 3 4 5		Other: 0 1 2 3 4 5 describe:		
Bare soil (%):	%	Vegetation Litter (%):	%	Rock type
Rock cover (%):	%	Ground Vegetation (%):	%	Sandstone Conglomerate Other sedimentary: Metamorphic Granite Quartzite Limestone Basalt Colluvium Other:
Outcrop: %	Rock / stone: %	Bare ground: %		
Pebbles (<0.6cm):	0 <2 2-10 10-20 20-50 50-70 70-90 >90			
Small stones (0.6-2cm):	0 <2 2-10 10-20 20-50 50-70 70-90 >90			
Stones (2-6cm):	0 <2 2-10 10-20 20-50 50-70 70-90 >90			
Small rocks (6-20cm):	0 <2 2-10 10-20 20-50 50-70 70-90 >90			
Rocks (20-60cm):	0 <2 2-10 10-20 20-50 50-70 70-90 >90			
Big rocks (60cm-2m):	0 <2 2-10 10-20 20-50 50-70 70-90 >90			Lithology:
Boulders (>2m):	0 <2 2-10 10-20 20-50 50-70 70-90 >90			
Outcrop / slab:	0 <2 2-10 10-20 20-50 50-70 70-90 >90			

Soil texture: sand sandy loam <u>loam</u> clay loam clay cracking clay peat rock other:			
Soil depth (cm): 0 <10 10-40 >40		Soil pH - surface: ____cm:	
Soil crust, termites, log habitat and vegetation strata structure			
Crust present: no black green clear		Crust cover (%): %	Crust pH:
Termite mounds (no.):	Max. ht. (m):	Profile: tower dome underground	
Number of fallen logs >15cm diameter in the quadrat:			

Vegetation community: (Circle one)	Percentage foliage cover of tallest plant layer			
Life form and height of tallest stratum	Dense (70-100%)	Mid-dense (30-70%)	Sparse (10-30%)	Very sparse (<10%)
Trees > 30 m	Tall closed-forest	Tall open-forest	Tall woodland	Tall open-woodland
Trees 10-30 m	Closed-forest	Open -forest	Woodland	Open-woodland
Trees 5-10 m	Low closed-forest	Low open-forest	Low woodland	Low open-woodland
Shrubs 2-8 m	Closed -scrub	Open-scrub	Tall shrubland	Tall open-shrubland
Shrubs 0-2 m	Closed -heath	Open-heath	Low shrubland	Low open-shrubland
Three most dominant species:				
Overstorey	Midstorey		Lower storey	
1.	1.		1.	
2.	2.		2.	
3.	3.		3.	

Strata	Dominant species (record in order of dominance)	Average ht. (m) of strata	Cover (%) of strata (% cover classes)
Emergent tree layer:			<10 10-30 30-70 >70
Upper shrub layer:			<10 10-30 30-70 >70
Lower shrub layer:			<10 10-30 30-70 >70
Ground layer:			<10 10-30 30-70 >70

Floristics, cover and phenology			
	Phenology (flowering / fruiting) codes: 0 = no plants of that species with flowers / fruits 1 = isolated plants of that species with flowers / fruits 2 = low – moderate plants of that species with flowers / fruits 3 = many – most plants of that species with flowers / fruits		
Plant species	Cover (%)	Flowering (b = mature buds; f = flowers)	Fruiting (i = immature fruit; m = mature fruit)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
	Phenology (flowering / fruiting) codes: 0 = no plants of that species with flowers / fruits 1 = isolated plants of that species with flowers / fruits 2 = low – moderate plants of that species with flowers / fruits 3 = many – most plants of that species with flowers / fruits		
Plant species	Cover (%)	Flowering	Fruiting
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			
21.			
22.			

APPENDIX 4. Vegetation height class categories

Height	
Height Class	Height Range (m)
6	>2
5	1-2
4	0.5-1.0
3	0.2-0.5
2	0.1-0.1
1	0-0.1

APPENDIX 5. Flora list from on-ground survey of the survey area showing site where species was observed and incidental observation (Inc.)

Flora		Trapping Sites						Camera Sites			Aquatic Assessment Sites			Disturbed site	Incidental
Family	Species	MKC	MKI	RWC	RWI	BAC	BAI	RIP CAM	RW CAM	FIN CAM	Up Creek	Rail Creek	Yam Creek	FH	Incidental
Acanthaceae	Hygrophila angustifolia	X	X												
	Nelsonia campestris	X	X	X											
Anacardiaceae	Buchanania obovata	X		X	X		X								
Apocynaceae	Calotropis procera*							X							
	Gymnanthera oblonga							X							
Arecaceae	Livistona humilis				X										
	Livistona species						X								
Asteraceae	?Blumea saxatilis							X							
	Blumea species		X												
	Cyanthillium cinereum							X							
	Pterocaulon species						X								
	Sphaeromorphaea littoralis		X	X	X										
Bixaceae	Cochlospermum fraseri			X			X								
Campanulaceae	Lobelia diocia			X						X					
Caryophyllaceae	Polycarpaea holtzei			X											
Celastraceae	Stackhausia species			X											
Combretaceae	Terminalia carpentariae							X							
	Terminalia fernandiana			X		X									
	Terminalia microcarpa							X							
	Terminalia species						X								
Convolvulaceae	Evolvulus nummularius							X							
	Ipomoea eriocarpa	X													
	Ipomoea species*							X							X
Cyperaceae	Cyperus species	X													
	Scleria novaehollandiae			X											
Droseraceae	Drosera petiolaris									X					

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Flora		Trapping Sites						Camera Sites			Aquatic Assessment Sites			Disturbed site	Incidental
Family	Species	MKC	MKI	RWC	RWI	BAC	BAI	RIP CAM	RW CAM	FIN CAM	Up Creek	Rail Creek	Yam Creek	FH	Incidental
Euphorbiaceae	Euphorbia species					X									
Fabaceae	Acacia auriculiformis		X					X			X	X	X		
	Acacia hemignosta			X											
	Acacia holosericea												X	X	
	Acacia species				X	X	X								
	Acacia stipuligera	X													
	Aeschynomene americana*														X
	Aeschynomene indica							X							
	Alysicarpus species			X											
	Chamaecrista species	X		X											
	Crotalaria goreensis*							X		X	X	X	X		X
	Crotalaria species				X	X			X						
	Desmodium species				X		X								
	Eriosema chinense				X										
	Erythrophleum chlorostachys			X	X	X	X		X	X					
	Flemingia parviflora				X										
	Galactia species				X										
	Pycnospora lutescens				X		X			X					
	Senna alata*							X			X	X			
	Senna obtusifolia							X							
	Stylosanthes viscosa*				X			X							
	Tephrosia polyzya			X		X									
	Vigna species									X					
	Zornia species				X		X								
Gentianaceae	Canscora diffusa							X							
Goodeniaceae	Goodenia pumilis	X													
	Goodenia species			X	X		X		X	X					

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Flora		Trapping Sites						Camera Sites			Aquatic Assessment Sites			Disturbed site	Incidental
Family	Species	MKC	MKI	RWC	RWI	BAC	BAI	RIP CAM	RW CAM	FIN CAM	Up Creek	Rail Creek	Yam Creek	FH	Incidental
Lamiaceae	Hyptis suaveolens*						X	X					X		
Lythraceae	Rotala mexicana			X											
Lythraceae	Rotala occultaflora	X													
Malvaceae	Brachychiton megaphyllus				X		X								
	Brachychiton paradoxus					X									
	Hibiscus sabdariffa*				X										
	Hibiscus zonatus	X													
	Sida acuta*							X			X	X			
Meliaceae	Owenia vernicosa								X						
Moraceae	Ficus coronulata	X													
	Ficus hispida							X			X	X			
	Ficus opposita					X									
	Ficus scobina						X						X		
Myrtaceae	Calytrix acutifolia													X	
	Calytrix exstipulata						X							X	
	Corymbia bleeseri					X									
	Corymbia dysjuncta/ confertiflora				X										
	Corymbia latifolia/ foelscheana			X	X		X			X					
	Corymbia polycarpa	X	X												
	Corymbia setosa					X				X					
	Eucalyptus alba							X							
	Eucalyptus apodophylla		X												
	Eucalyptus clavigera						X			X					
	Eucalyptus confertiflora		X												
	Eucalyptus grandiflora				X										
	Eucalyptus miniata			X					X						
	Eucalyptus tectifica			X					X						

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Flora		Trapping Sites						Camera Sites			Aquatic Assessment Sites			Disturbed site	Incidental
Family	Species	MKC	MKI	RWC	RWI	BAC	BAI	RIP CAM	RW CAM	FIN CAM	Up Creek	Rail Creek	Yam Creek	FH	Incidental
	Eucalyptus tetradonta									X					
	Eucalyptus tintinnans			X		X	X		X						
	Lophostemon lactifluus										X		X		
	Melaleuca leucodendra							X			X	X			
	Melaleuca viridiflora		X										X		
	Syzygium nervosum							X			X	X			
	Xanthostemon paradoxus					X									
Onagraceae	Ludwigia octovalvis							X				X			
	Ludwigia perennis		X												
	Ludwigia species		X		X		X								
Pandanaceae	Pandanus aquaticus							X				X	X		
Passifloraceae	Passiflora foetida													X	
Phyllanthaceae	Antidesma ghesaembilla				X										
	Breynia cernua							X							
	Bridelia tomentosa							X							
	Flueggea virosa subsp. melanthesoides	X													
	Phyllanthus baccatus							X							
Picrodendraceae	Petalostigma pubescens					X	X		X	X	X	X	X		
	Petalostigma quadriloculare			X				X							
Plantaginaceae	Limnophila fragrans	X													
Poaceae	Alloteropsis or Chrysopogon									X					
	Alloteropsis semialata				X										
	Andropogon gayanus*													X	
	Aristida latifolia	X					X						X		
	Aristida species													X	
	Arundinella nepalensis							X							
	Bambusa arnhemica							X			X	X	X		

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Flora		Trapping Sites						Camera Sites			Aquatic Assessment Sites			Disturbed site	Incidental
Family	Species	MKC	MKI	RWC	RWI	BAC	BAI	RIP CAM	RW CAM	FIN CAM	Up Creek	Rail Creek	Yam Creek	FH	Incidental
Poaceae	Bothriochloa bladhii							X							
	Bothriochloa bladhii											X			
	Cenchrus pedicellatus/polystachios*	X											X		X
	Chrysopogon fallax			X											
	Cynodon dactylon*		X										X		
	Cynodon radiatus							X							
	Cynodon species			X											
	Dimonia species			X											
	Ectrosia leporina				X										
	Eleocharis brassii	X													
	Eragrostis species		X	X	X					X					
	Eriachne avenacea								X						
	Eriachne burkittii	X	X												
	Eriachne ciliata						X				X			X	
	Eriachne species					X									
	Fimbristylis species		X												
	Grass species				X										
	Grass species 2										X	X			
	Heteropogon contortus	X	X		X					X	X	X	X		
	Heteropogon species 1			X			X								
	Heteropogon species 2		X		X		X			X					
	Heteropogon triticeus								X						
	Hymenachne amplexicaulis											X			
	Ischaemum rugosum		X												
	Iseilema vaginiflorum														
	Melinis repens														X
	Mnesithea rottboeloides		X		X		X				X			X	

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Flora		Trapping Sites						Camera Sites			Aquatic Assessment Sites			Disturbed site	Incidental
Family	Species	MKC	MKI	RWC	RWI	BAC	BAI	RIP CAM	RW CAM	FIN CAM	Up Creek	Rail Creek	Yam Creek	FH	Incidental
	Panacum species	X													
	Pseudopogonatherum				X										
	Pseudopogonatherum contortum	X	X												
	Sacciolepis myosuroides	X													
	Schizachyrium pseudoulalia									X					
Poaceae	Sorghum species				X										
	Sorghum species (annual)		X			X			X						
	Sporobolus australasicus				X										
	Themeda quadrivalvis*									X		X			
	Themeda triandra	X		X	X	X	X		X	X					
Polygalaceae	Polygala longifolia	X		X											
	Polygala species	X				X									
Proteaceae	Grevillea decurrens						X		X						
	Hakea arborescens														X
Pteridaceae	Adiantum species							X							
	Cheilanthes nitida					X									
Rubiaceae	Gardenia megasperma					X			X						
	Nauclea orientalis											X			
	Spermacoce species		X	X	X	X	X		X	X					
Santalaceae	Santalum lanceolatum													X	
Scrophulariaceae	Buchnera linearis	X		X	X	X	X		X	X					
Stylidiaceae	Stylidium species		X	X	X	X	X		X	X					
Thymelaeaceae	Thecanthes piunicea			X						X					
Unknown	Forb species 2					X									
	Forb species 3	X													
	Forb species 4	X													
	Forb species 5	X													

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Flora		Trapping Sites						Camera Sites			Aquatic Assessment Sites			Disturbed site	Incidental
Family	Species	MKC	MKI	RWC	RWI	BAC	BAI	RIP CAM	RW CAM	FIN CAM	Up Creek	Rail Creek	Yam Creek	FH	Incidental
Unkown	Forb species 6				X										
	Forb species 1					X									
	Vine species 1					X									
	Vine species 2										X				
Verbenaceae	?Phyla nodiflora		X												
	Stachytarpheta species*							X			X	X			
Vitaceae	Ampelocissus acetosa	X													
	Ampelocissus frutescens	X													
Xyridaceae	Xyris complanata							X							
Total		31	24	32	36	25	30	33	17	23	16	18	14	9	6

Site codes : MKC: Control site 1, MKI: Fountain Head trap site, RWC: Control site 2, RWI: Iron Blow trap site, BAC: Control site 3, BAI: Mt Bonnie trap site, RIPCAM: Riparian camera, RWCAM: Haul road camera, FINCAM: Gouldian finch camera, UpCreek: Upstream creek site, Rail Creek: Mt Bonnie Creek, Yam Creek: Mt Wells Haul road creek, FH: Fountain Head disturbed area, Incidental: Incidental flora observations

* weed species.

APPENDIX 6. Fauna list from on-ground survey of the Hayes Creek survey area from trapping sites (BAC, BAI, MKC, MKI, RWC and RWI), camera sites (CAMRip), incidental (Inc.) and spotlighting (Spot) observations

Fauna species		Site								
Scientific Name	Common Name	BAC	BAI	MKC	MKI	RWC	RWI	CAM Rip	Inc	Spot
<i>Accipiter cirrhocephalus</i>	Collared sparrowhawk								X	
<i>Amphibolurus gilberti</i>	Ta-ta lizard	X			X					
<i>Anseranas semipalmata</i>	Magpie goose				X					
<i>Antaresia childreni</i>	Children's python									X
<i>Aprosmictus erythropterus</i>	Red-winged parrot			X	X		X		X	
<i>Aquila audax</i>	Wedge-tailed eagle								X	
<i>Ardea alba</i>	Great egret			X	X				X	
<i>Ardea ibis</i>	Cattle egret				X				X	
<i>Ardea intermedia</i>	Intermediate egret								X	
<i>Ardea pacifica</i>	White-necked heron			X	X					
<i>Artamus leucorhynchus</i>	White-breasted woodswallow		X	X	X					
<i>Artamus minor</i>	Little woodswallow			X		X				
<i>Artamus personatus</i>	Masked woodswallow								X	
<i>Bos taurus</i>	Cattle				X					
<i>Bufo marinus</i>	Cane toad			X	X					X
<i>Burhinus grallarius</i>	Bush stone curlew								X	X
<i>Cacatua galerita</i>	Sulphur-crested cockatoo	X		X	X	X	X			
<i>Cacatua roseicapilla</i>	Galah			X	X		X		X	
<i>Calyptorhynchus banksii</i>	Red-tailed Black-cockatoo	X		X			X	X	X	
<i>Canis lupus</i>	Dingo								X	X
<i>Carlia sp.</i>	Carlia species		X							
<i>Centropus phasianinus</i>	Pheasant coucal	X							X	
<i>Chaerephon jobensis</i>	Greater northern freetail bat	X		X						

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Fauna species		Site								
Scientific Name	Common Name	BAC	BAI	MKC	MKI	RWC	RWI	CAM Rip	Inc	Spot
<i>Chalinolobus gouldii</i>	Gould's wattled bat	X	X	X	X	X	X			
<i>Chlamydera nuchalis</i>	Great bowerbird				X		X		X	
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike								X	
<i>Coracina papuensis</i>	White-bellied Cuckoo-shrike	X		X		X	X		X	
<i>Corvus orru</i>	Torresian crow	X	X		X	X			X	
<i>Crocodylus johnsoni</i>	Freshwater crocodile								X	
<i>Ctenophorus caudicinctus</i>	Ring-tailed dragon								X	
<i>Ctenotus robustus</i>	Robust ctenotus			X	X	X	X			
<i>Dacelo leachii</i>	Blue-winged Kookaburra	X		X	X		X		X	
<i>Demansia papuensis</i>	Greater black whip snake						X			
<i>Egretta garzetta</i>	Little egret								X	
<i>Egretta novaehollandiae</i>	White-faced heron				X				X	X
<i>Entomyzon cyanotis</i>	Blue-faced honeyeater						X			
<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork								X	
<i>Erythrura gouldiae</i>	Gouldian finch								X	
<i>Falco berigora</i>	Brown falcon					X			X	
<i>Felis catus</i>	Cat								X	
<i>Geopelia humeralis</i>	Bar-shouldered Dove	X	X	X	X	X	X			
<i>Geopelia placida</i>	Peaceful Dove	X	X	X	X	X	X		X	
<i>Grallina cyanoleuca</i>	Magpie-lark				X		X		X	
<i>Grus rubicunda</i>	Brolga				X					
<i>Haliastur sphenurus</i>	Whistling Kite			X	X		X		X	
<i>Himantopus himantopus</i>	Black-winged stilt				X				X	
<i>Lichenostomus unicolor</i>	White-gaped Honeyeater			X					X	
<i>Lichmera indistincta</i>	Brown honeyeater		X	X		X	X	X	X	
<i>Limnodynastes convexiusculus</i>	Marbled frog									X

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Fauna species		Site								
Scientific Name	Common Name	BAC	BAI	MKC	MKI	RWC	RWI	CAM Rip	Inc	Spot
<i>Litoria bicolor</i>	Northern dwarf tree frog									X
<i>Litoria nasuta</i>	Rocket frog				X					X
<i>Litoria pallida</i>	Pale frog				X					X
<i>Lonchura castaneothora</i>	Chestnut-breasted mannikin		X							
<i>Macropus agilis</i>	Agile wallaby				X				X	X
<i>Malurus melanocephalus</i>	Red-backed Fairy-wren								X	
<i>Megalurus timoriensis</i>	Tawny grassbird								X	
<i>Melithreptus albogularis</i>	White-throated Honeyeater								X	
<i>Merops ornatus</i>	Rainbow Bee-eater	X	X	X	X	X	X		X	
<i>Microeca flavigaster</i>	Lemon-bellied flycatcher								X	
<i>Milvus migrans</i>	Black Kite								X	
<i>Myiagra alecto</i>	Shining flycatcher							X		
<i>Myiagra rubecula</i>	Leaden Flycatcher				X			X	X	
<i>Neochmia phaeton</i>	Crimson Finch								X	
<i>Ninox novaeseelandiae</i>	Boobook owl								X	X
<i>Nyctophilus sp.</i>	Vesper bat species	X	X	X	X	X	X			
<i>Opisthodon ornatus</i>	Ornate burrowing frog				X					
<i>Pachycephala lanioides</i>	White-breasted whistler				X					
<i>Pachycephala rufiventris</i>	Rufous Whistler	X	X		X	X				
<i>Pardalotus striatus</i>	Striated pardalote			X	X		X		X	
<i>Philemon argenticeps</i>	Silver-crowned friarbird			X						
<i>Philemon buceroides</i>	Helmeted friarbird						X		X	
<i>Philemon citreogularis</i>	Little Friarbird						X			
<i>Podargus strigoides</i>	Tawny frogmouth			X	X	X			X	X
<i>Poephila personata</i>	Masked finch						X		X	
<i>Pseudonaja nuchalis</i>	Western brown snake			X						

PNX Metals Ltd. Hayes Creek Gold, Silver and Zinc Project
Flora and Fauna Survey Report, 2017

Fauna species		Site								
Scientific Name	Common Name	BAC	BAI	MKC	MKI	RWC	RWI	CAM Rip	Inc	Spot
<i>Pygopus steelescotti</i>	Northern hooded scaly-foot	X								
<i>Rattus rattus</i>	Black rat							X		
<i>Rhinonictes aurantia</i>	Orange leaf-nosed bat	X	X	X	X	X	X		X	X
<i>Rhipidura leucophrys</i>	Willie Wagtail			X	X				X	
<i>Rhipidura rufiventris</i>	Northern fantail							X	X	
<i>Saccolaimus flaviventris</i>	Yellow-bellied sheath-tailed bat	X	X	X	X	X	X			
<i>Smicrornis brevirostris</i>	Weebill			X						
<i>Species 1 bat</i>		X	X	X	X	X	X			
<i>Species 9 bat</i>			X	X		X	X			
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe								X	
<i>Tadorna radjah</i>	Radjah shelduck			X	X					
<i>Taeniopygia bichenovii</i>	Double-barred Finch								X	
<i>Threskiornis spinicollis</i>	Straw-necked Ibis			X	X				X	
<i>Todiramphus macleayi</i>	Forest kingfisher								X	
<i>Todiramphus sanctus</i>	Sacred kingfisher								X	
<i>Trichoglossus haematodus</i>	Rainbow lorikeet				X					
<i>Trichoglossus rubritrochis</i>	Red-collared lorikeet		X				X			
<i>Vanellus miles</i>	Masked Lapwing				X					
<i>Varanus mertensii</i>	Merten's water monitor						X*			
<i>Varanus primordius</i>	Northern ridge-tailed monitor					X	X			
Total		17	15	33	42	19	30	6	51	12
Site codes : MKC: Control site 1, MKI: Fountain Head trap site, RWC: Control site 2, RWI: Iron Blow trap site, BAC: Control site 3, BAI: Mt Bonnie trap site, RIPCAM: Riparian camera, Inc: Incidentals, Spot: Spotlighting * Anecdotally recorded										

Echolocation call identification report

Client: Bill Low Ecological Services

Contact: Nicola Hanrahan

Date 23/6/2017

Project: Mary River and Hayes Creek – North Australia

Important information about the call identifications presented in this report.

Echolocation call analysis is complex and many species cannot be identified by call alone. It is highly recommended for most surveys that echolocation call recording be accompanied by trapping. Call analysis normally shows the specific species that need to be trapped for confirmation of that species in the study area.

Call analysis is affected by many factors, these include the suite of species present, the quality of calls recorded (equipment settings, microphone quality, background noise from wind, insects, echoes), the quality of the reference call database for the region and the experience of the analyst.

The time taken to identify calls depends on the above and the needs of the client. Deriving a simple species inventory for each detector night is much quicker than attempting to identify every call for each detector night.

In many projects, a very low proportion of all calls recorded may be of sufficient quality to allow identification. It is a sign of the competence of the analyst to reject calls based on poor quality.

The identifications in this report are based on a combination of manual and automated methods using either reference calls from the region or from species calls recorded outside the region if they are likely to represent the calls from species in the survey region. Any doubt on species' identifications is always explained.

Species identified per night is at a very high standard and is only identified if I am sure that a species occurs in the recordings for that night. For the table data the proportion of calls (files) identified in this report is very high but with a lower reliability. That is to say that once I am sure of a species presents I lower the standard to best identify as many files as possible. This lowering is hard to put a value on but would be higher than 80% confidence. This is to allow for data on Bat Passes per night as represented in the Results Table.

This data in no way represents abundance of species per night. The bat detector microphone will record a bat file when it is loud enough to trigger the electronics. The volume of space sampled by the microphone varies, due to loudness of the call, frequency of the call, temperature and humidity. Additionally one bat may feed around a detector many times or not. Additionally the detection of Anabat detectors varies between detectors due to the sensitivity setting – there is no information as to the calibration of the Detectors.

There is NO abundance data from a Anabat Detector.

This report includes the recommendations set out in the reporting standards for echolocation call analysis developed by the Australasian Bat Society.

Dennis Matthews – dennis.matthews@bigpond.com - 0885621555

Data

Species likely to be present in the area with Codes used in the table below

<i>Chaerephon jobensis</i>	CHJO
<i>Chalinolobus gouldii</i>	CHGO
<i>Chalinolobus nigrogriseus</i>	CHNI
<i>Hipposideros ater</i>	HIAT
<i>Hipposideros stenotis</i>	HIST
<i>Macroderma gigas</i>	MAGI
<i>Miniopterus orianae orianae</i>	MIOROR
<i>Myotis macropus</i>	MYMA
<i>Mormopterus beccarii</i>	MOBE
<i>Mormopterus cobourgiana</i>	MOCO
<i>Nyctophilus arnhemensis</i>	NYAR
<i>Nyctophilus daedalus</i>	NYDA
<i>Nyctophilus geoffroyi</i>	NYGE
<i>Nyctophilus walkeri</i>	NYWA
<i>Pipistrellus adamsi</i>	PIAD
<i>Pipistrellus westralis</i>	PIWE
<i>Rhinocnictus aurantia</i>	RHAU
<i>Saccolaimus flaviventris</i>	SAFL
<i>Saccolaimus saccolaimus</i>	SASA
<i>Scotorepens greyii</i>	SCGR
<i>Taphozous georgianus</i>	TAGE
<i>Taphozous kapalgensis</i>	TAKA
<i>Vespadelus caurinus</i>	VECA
<i>Vespadelus finlaysoni</i>	VEFI

Species that do not echolocate that are in the area (Blossum bats and Fuitbats)

Macroglossus minimus

Pteropus alecto

Pteropus scapulatus

A good list... but Bat detectors cannot separate all these species. In the Table the species groups are listed.

Results

Species found to be present (there were over 18,000 bat files)

	4/5	5/5	6/5	7/5	8/5	9/5	14/5	15/5	16/5	17/5
HayesCk_bats								X	X	X
CHGO								X		X
CHJO								X	X	X
NYSP								X	X	X
RHAU								X	X	X
SAFL								X	X	X
Species1								X	X	X
Species9								X	X	
VECA									X	
Mary_River_bats										
CHGO	X	X	X							
CHJO	X	X	X	X	X	X				
MOBE		X								
NYSP	X	X	X	X	X	X	X	X		
RHAU	X		X							
SAFL	X	X	X	X	X	X				
Species1	X	X	X	X	X	X				
Species9	X	X	X	X	X	X	X	X		
TAGE		X	X	X						
TAKA			X							
VECA			X		X					

Species 1 – *Scotorepens greyii* (or *S. sanborni*) or *Chalinolobus nigrogriseus*

Species 9 – *Pipistrellus westralis* or *Miniopterus orianae orianae*

NYsp – *Nyctophilus* species includes *Nyctophilus arnhemensis* or *Nyctophilus daedalus* or *Nyctophilus geoffroyi* or *Nyctophilus walkeri*

Identification

The calls were manually scanned in AnalookW and compared with known reference calls for the region held by myself and Damian Milne's "Key to the Bats of the Top End of the Northern Territory". The identification is my responsibility. A species inventory was tabulated for each detector night.

Comments

Species1 dominates the calls with possibly more than 30% of all calls. There could easily be 2 or the three species represented in the calls, but could not be separated.

Species9 was the second most common call, both species in this group could be represented in the calls, but can not be separated.

Taphozous kapalgensis calls were not well recorded, but I am confident that the species was present on the sites recorded in the table.

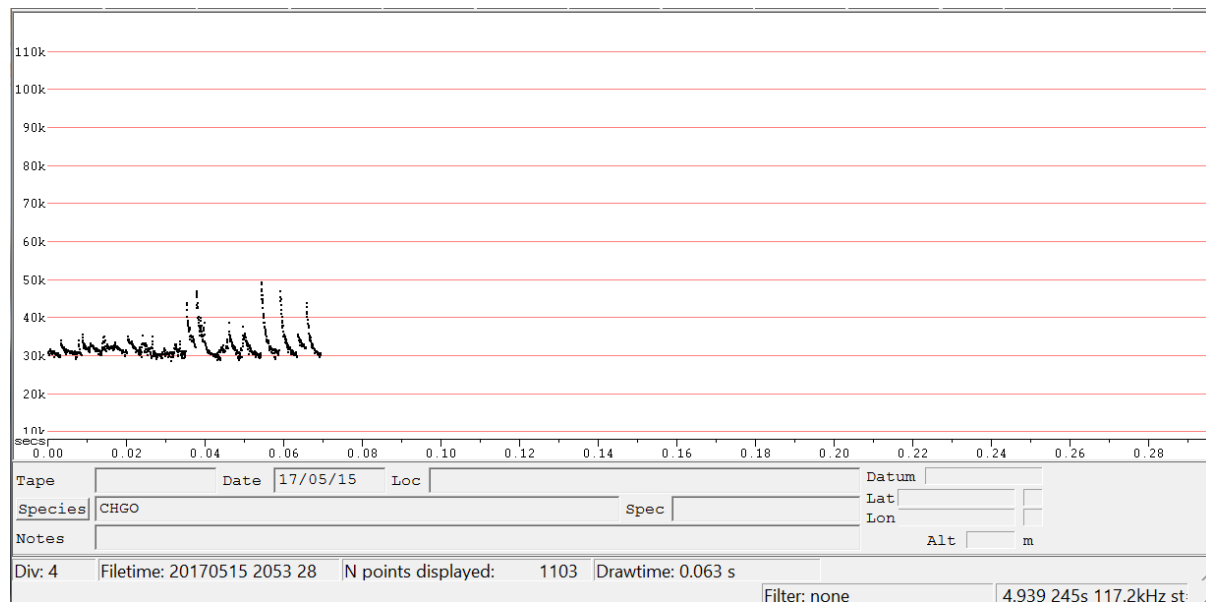
Nyctophilus species cannot be separated at this stage with a bat detector, these calls could represent any number of these species. Less than 5% of calls where *Nyctophilus* species.

All other species were recorded by less than 5% of the total calls.

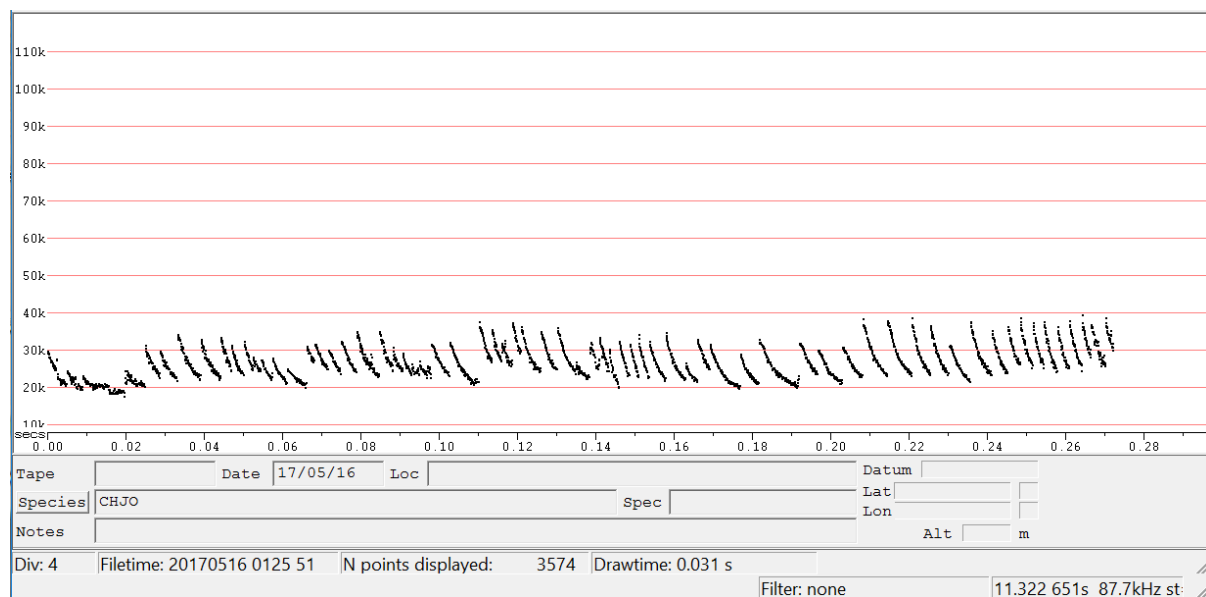
All the issues of species Id can only be resolved by trapping, with so many species overlapping in calls in the Top End, this report is the best I can do from calls alone. There were strange calls that I think are the issue of the SM3 and the conversion to ZCA files.

SAMPLE ANABAT FILES

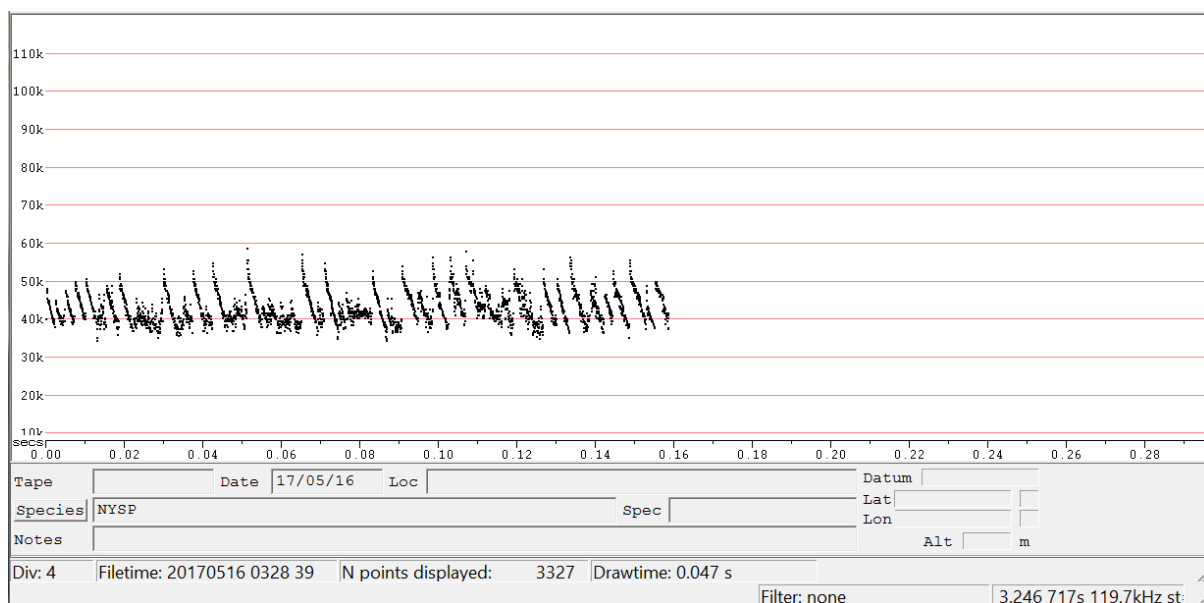
Chalinolobus gouldii



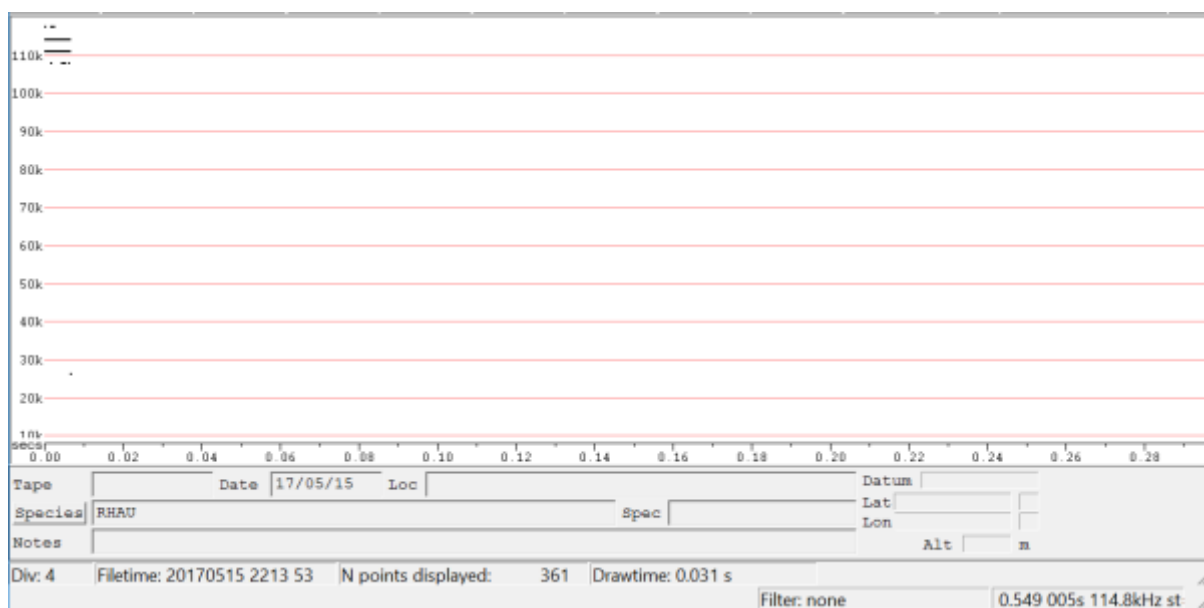
Chalinolobus jobensis



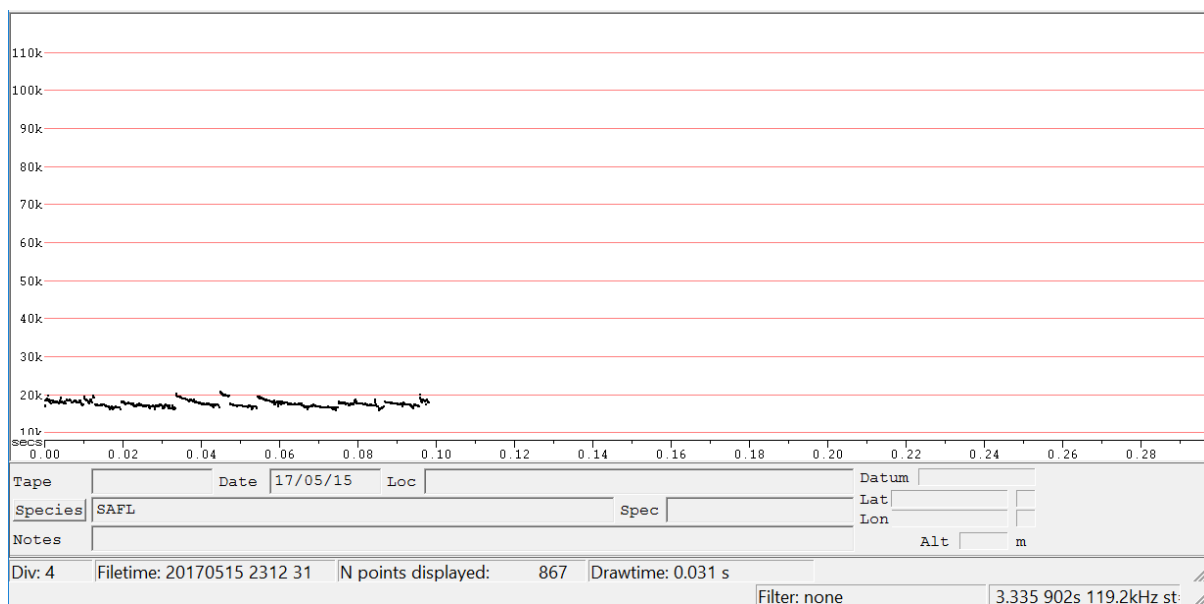
Nyctophilus species



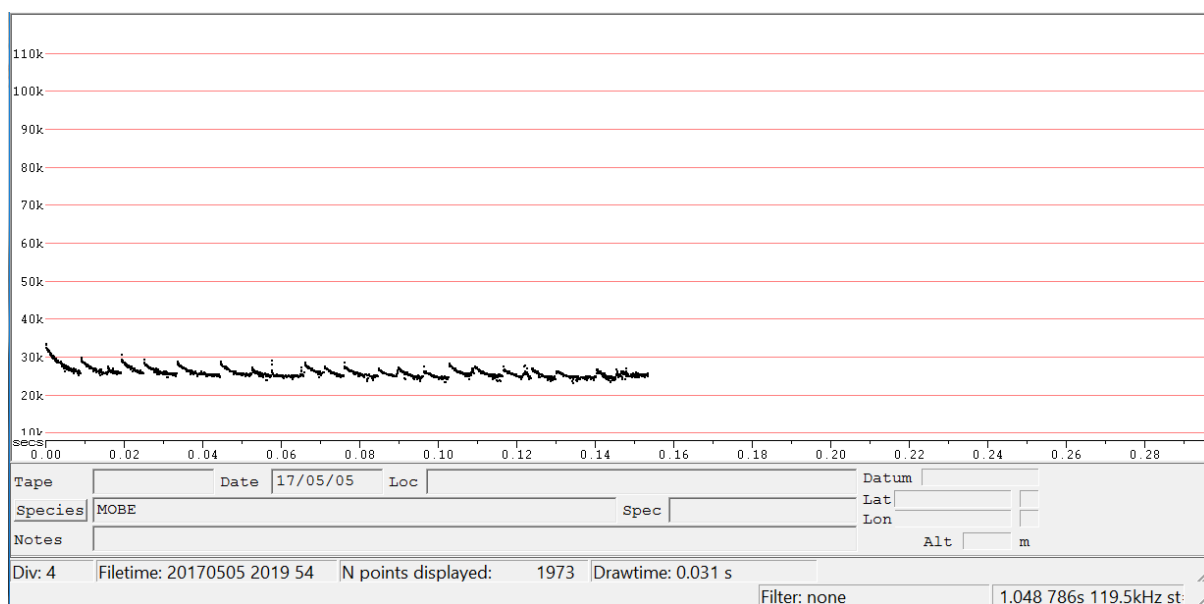
Rhinonicteris aurantius



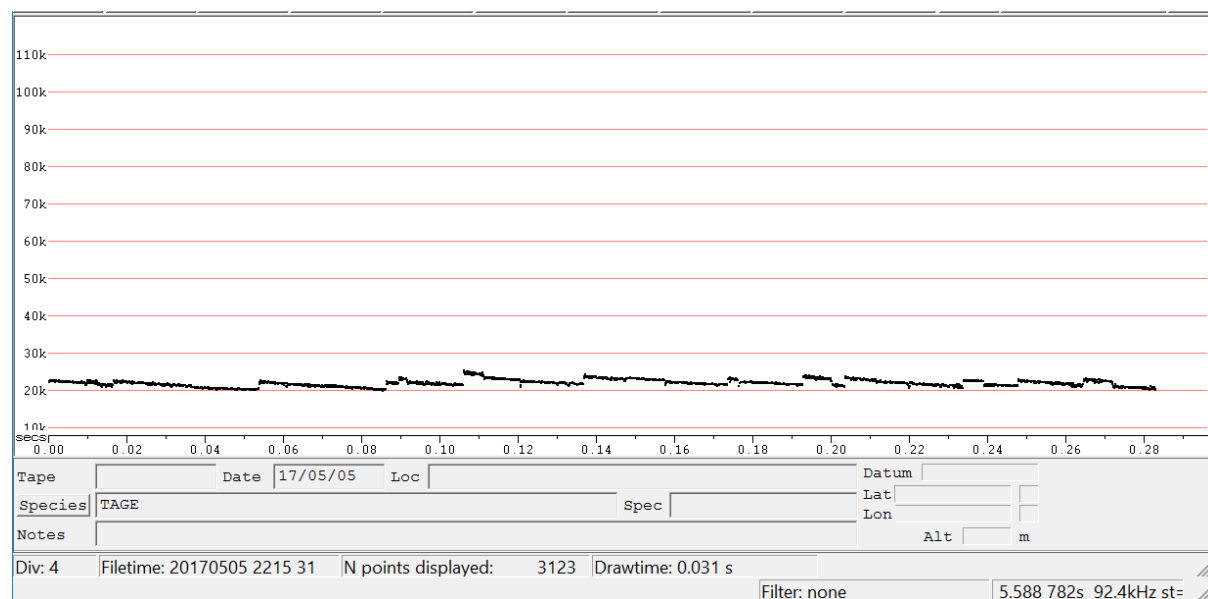
Saccolaimus flaviventris



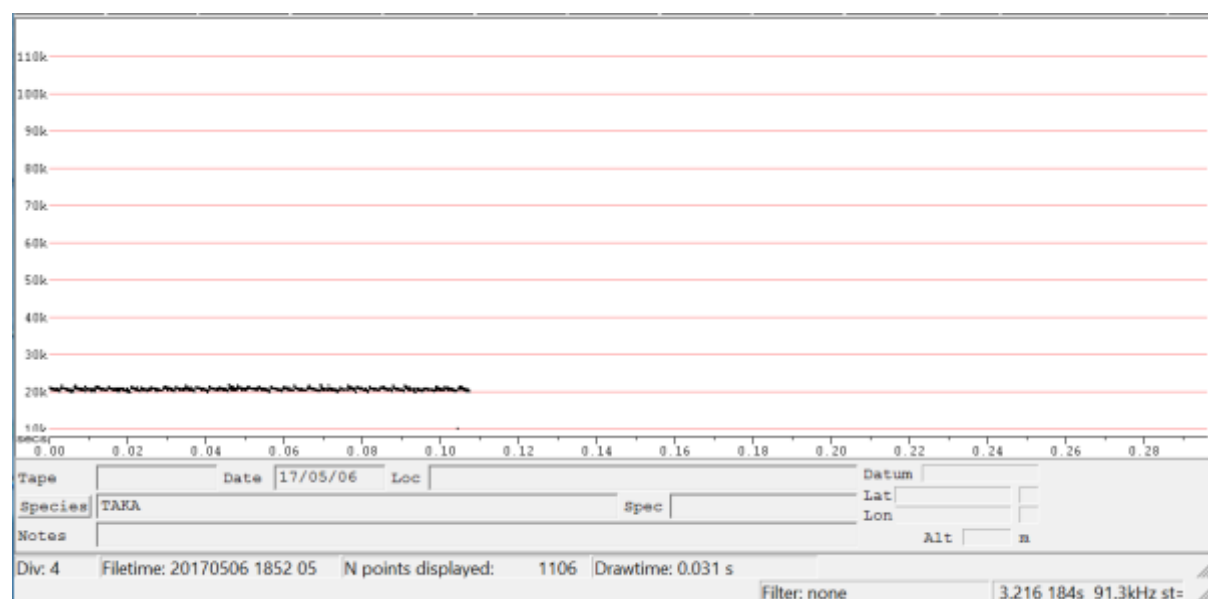
Mormopterus beccarii



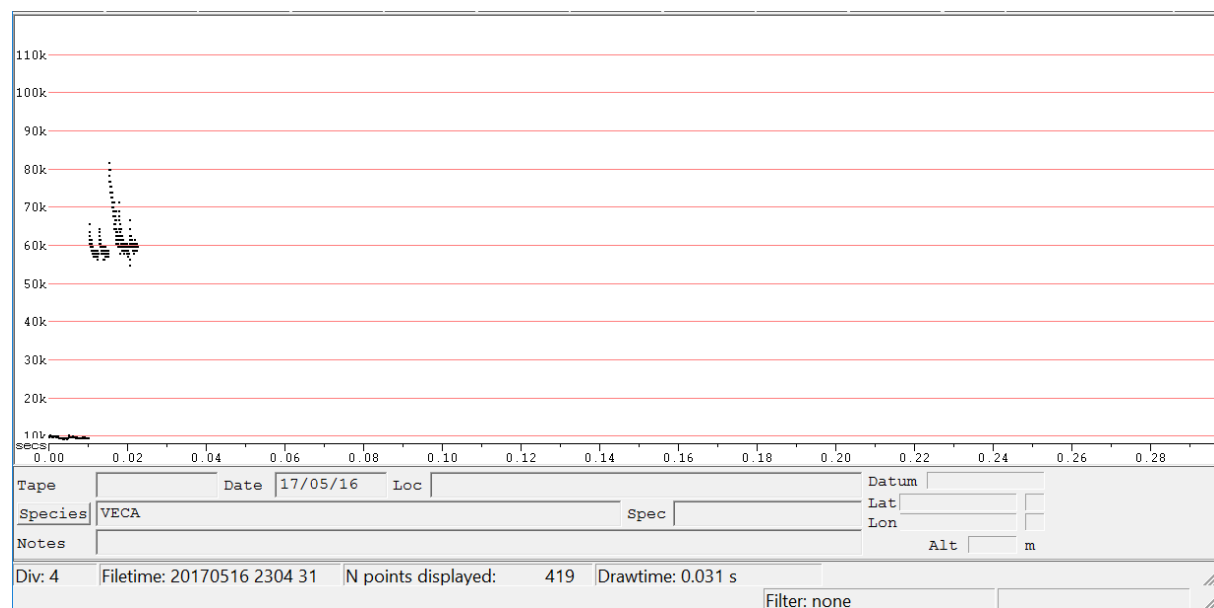
Taphozous georgianus



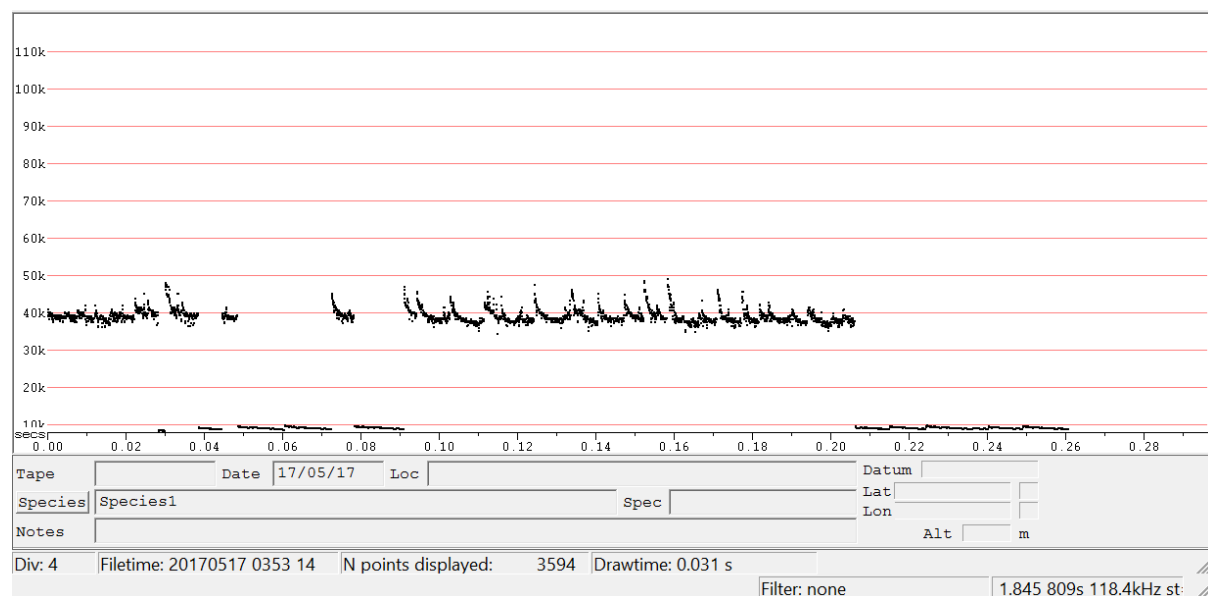
Taphozous kapalgensis



Vespadelus caurinus



Species1



Species9

