5 THREATENED SPECIES SURVEYS

This chapter outlines the process to determine the likelihood of occurrence of Northern Territory and/or nationally listed threatened species occurring within the Project footprint. For each threatened species determined to have a High or Medium chance of occurrence, field surveys were undertaken. This chapter describes the methodologies to survey these species. Those methodologies are compared to existing survey guidelines and any divergences are justified. Survey results are then presented and discussed.

5.1 CONTEXT

The International Union for the Conservation of Nature nominates a set of criteria used to identify species at risk of extinction. These criteria are used to define categories of risk – see Figure 5-1 – which are used by the Northern Territory Government to determine which threatened species are listed under the *TPWC Act,* and by the Commonwealth Government to determine which threatened species are listed under the *EPBC Act*. This report focusses on species that are listed as Vulnerable, Endangered or Critically Endangered under the *TPWC Act,* the *EPBC Act,* or both.

Species that are only listed as threatened in Queensland are not discussed in this report, but will be addressed as part of the biodiversity assessments that will be undertaken later in 2016 as required under the pipeline Environmental Authority issued by the Queensland DEHP.

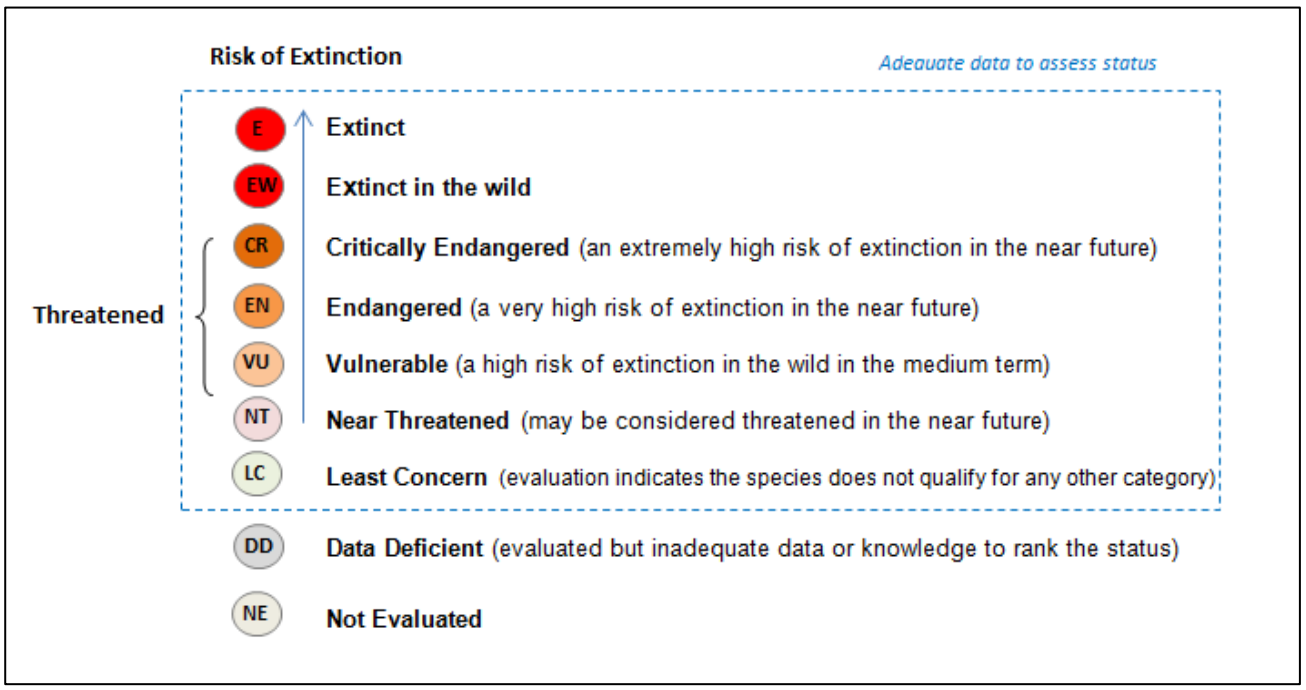


Figure 5-1. The IUCN red list categories of risk for threatened species

5.2 DESKTOP 'LIKELIHOOD OF OCCURRENCE' ASSESSMENT

5.2.1 Background

To determine which threatened species may occur within the Project footprint, a desktop analysis of threatened species databases was undertaken. This resulted in 22 threatened species (National and/or Northern Territory-listed) that have the potential to occur in the region of the Project footprint.

This section describes the process for determining which of these threatened species have a realistic chance of occurring within the Project footprint; these species were the focus of field studies (some targeted to detect presence/absence and some to quantify areas of suitable habitat within the Project footprint). The results of the field surveys are then used in Section 8.1 to determine which species are known to, or are likely to, occur within the Project footprint in an 'important population' (as defined in the *EPBC Significant Impact Guidelines 1.1* (DOE 2013).

5.2.2 Procedure

Twenty-two threatened species (Commonwealth and/or Northern Territory-listed) that have the potential to occur in the region of the Project footprint. Records of these species within the region containing the Project footprint are depicted in Figure 5-2. For each of these, the likelihood that the species occurs within the Project footprint was assessed based on habitat requirements, distribution, and the number and dates of proximate records. The purpose of such an assessment was to identify those species that required further consideration, and those that can be reasonably excluded from further assessment because they are unlikely to occur within the Project footprint.

The following procedure was used to determine the occurrence likelihood of threatened species:

1) Identify potential habitat features within the Project footprint using available desktop information (i.e. land system mapping, existing vegetation mapping, aerial imagery, fire history etc.).
2) Search within a 50 km buffer of the pipeline alignment for
    a. Matters of National Environmental Significance (MNES) using the Protected Matters Search Tool (most recently undertaken 9 May 2016) (Appendix C).
    b. Northern Territory threatened species listed under the *Territory Parks and Wildlife Conservation Act* using the online tool *Northern Territory NRM Infonet* (Appendix D).
3) Collate the following details for each of those species – conservation status (Northern Territory and Commonwealth), habitat requirements, distribution and number of records within the search area.
4) Analyse the likelihood that each species will occur in the Project footprint by applying the following likelihood classifications:
    a. HIGH – it is expected that this species will be within the Project footprint because of the presence of suitable habitat, and/or there are recent proximate records (i.e. post-2000).
    b. MEDIUM – this species may occur within the Project footprint; however, there is evidence that lowers its likelihood of occurrence (i.e. lack of critical habitat, no recent records within the search area, habitat degradation etc.).
    c. LOW – it is not expected that this species occurs within the Project footprint, as there is no suitable habitat for the species and/or current threats in the region are known to have significantly impacted the species.
    d. NONE – there is strong evidence that this species will not occur within the Project footprint.

Note: For many threatened species, the Atlas of Living Australia provides 'likely' and 'possible' modelled expert distributions. These distributions are referred to throughout this document and mostly come from the Species of National Environmental Significance Database maintained by the Commonwealth Department of the Environment.

5.2.3 Assessment results

The results of the desktop 'likelihood of occurrence' assessment are presented in Table 5-1 and can be summarised as follows:

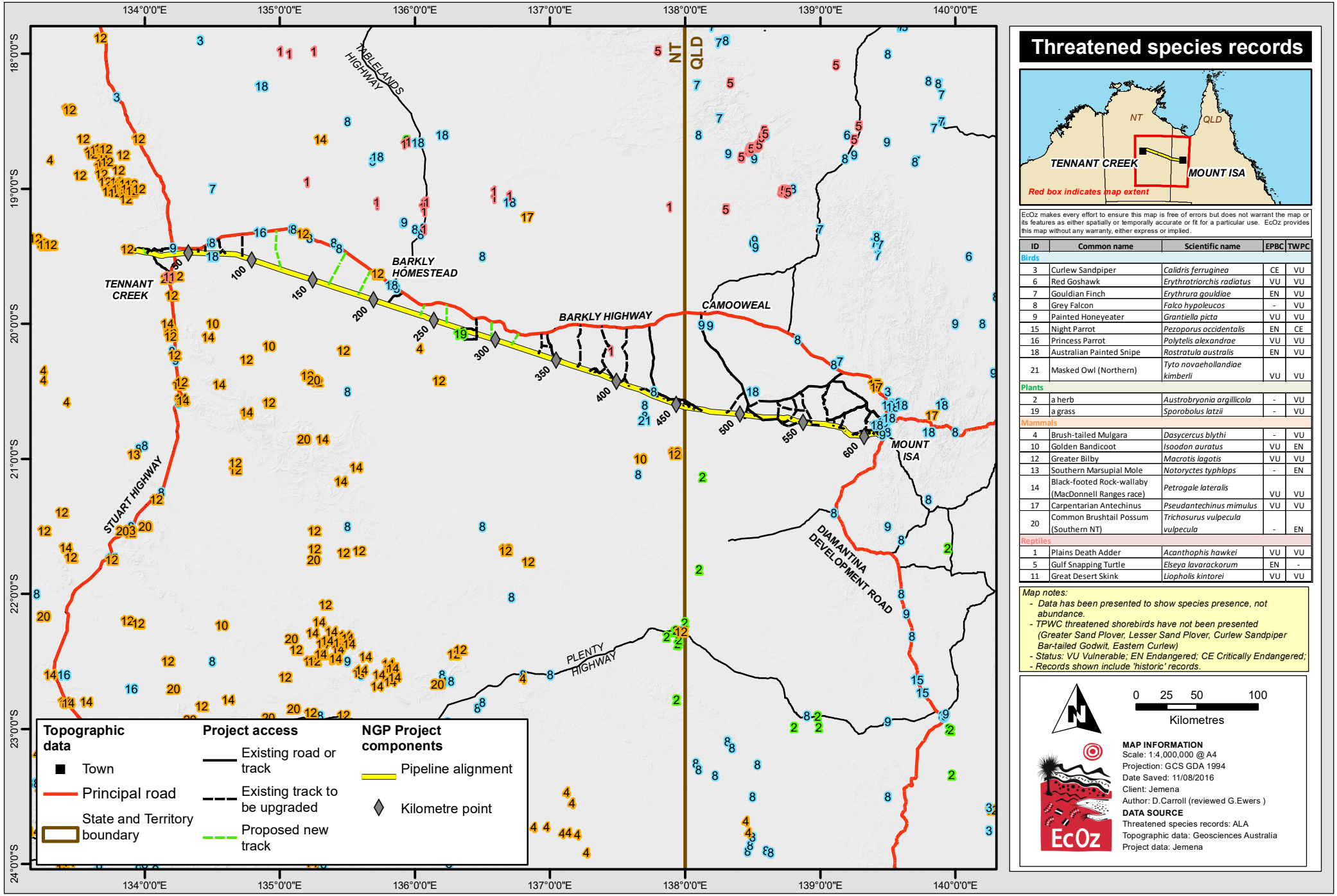
- Nine species were ranked as having a 'high' or 'medium' chance of occurring within the Project footprint. Therefore, these species were the focus of field studies (some targeted to detect presence/absence and some to quantify areas of suitable habitat within the Project footprint) and are discussed further in this report.
- Five species were ranked as having a 'low' chance of occurring within the Project footprint and so no specific surveys were carried out.
- Eight species were considered to not occur within the Project footprint as it does not support important habitat features for these species, or they are considered to be locally extirpated.

A meeting was held with the Flora and Fauna Division of the Department of Land Resource Management (DLRM) on the 8 March 2016 to ensure that these desktop results aligned with the concerns of the department.

Table 5-1. Desktop threatened species' likelihood of occurrence assessment

Likelihood	Common name	Scientific name	*EPBC* status	*TPWC* status
High	Carpentarian Antechinus*	*Pseudantechinus mimulus*	VU	VU
	Plains Death Adder	*Acanthophis hawkei*	VU	VU
	Tobermorey Melon [#]	*Austrobryonia argillicola*	-	VU
	Grey Falcon	*Falco hypoleucos*	-	VU
	Painted Honeyeater[†]	*Grantiella picta*	VU	VU
Medium	Gouldian Finch*	*Erythrura gouldiae*	EN	VU
	Latz's Grass [#]	*Sporobolus latzii*	-	VU
	Brush-tailed Mulgara	*Dasycercus blythi*	-	VU
	Greater Bilby**	*Macrotis lagotis*	VU	VU
Low	Red Goshawk	*Erythrotriorchis radiata*	VU	VU
	Australian Painted Snipe	*Rostratula australis*	EN	VU
	Curlew Sandpiper	*Calidris ferruginea*	CE	VU
	Black-footed Rock-wallaby (MacDonnell Ranges race)	*Petrogale lateralis*	VU	VU
	Night Parrot	*Pezoporus occidentalis*	EN	CE
	Princess Parrot	*Polytelis alexandrae*	VU	VU
None	Masked Owl (Northern)	*Tyto novaehollandiae kimberli*	VU	VU
	Southern Marsupial Mole	*Notoryctes typhlops*	-	EN
	Golden Bandicoot	*Isoodon auratus*	VU	EN
	Common Brushtail Possum (Southern Northern Territory)	*Trichosurus vulpecula vulpecula*	-	EN
	Great Desert Skink	*Liopholis kintorei*	VU	VU
	Gulf Snapping Turtle	*Elseya lavarackorum*	EN	-
	Spencer's Land Snail	*Bothriembryon spenceri*	-	VU

*[†] In Queensland only (likelihood is 'Low' in Northern Territory), * In Queensland only (likelihood is 'None' in Northern Territory), ** In Northern Territory only (likelihood is 'None' in Queensland); [#] not official common name for the species.*



Threatened species records

EcOz makes every effort to ensure this map is free of errors but does not warrant the map or its features as either spatially or temporally accurate or fit for a particular use. EcOz provides this map without any warranty, either express or implied.

ID	Common name	Scientific name	EPBC	TWPC
Birds				
3	Curlew Sandpiper	*Calidris ferruginea*	CE	VU
6	Red Goshawk	*Erythrotriorchis radiatus*	VU	VU
7	Gouldian Finch	*Erythrura gouldiae*	EN	VU
8	Grey Falcon	*Falco hypoleucos*	-	VU
9	Painted Honeyeater	*Grantiella picta*	VU	VU
15	Night Parrot	*Pezoporus occidentalis*	EN	CE
16	Princess Parrot	*Polytelis alexandrae*	VU	VU
18	Australian Painted Snipe	*Rostratula australis*	EN	VU
21	Masked Owl (Northern)	*Tyto novaehollandiae kimberli*	VU	VU
Plants				
2	a herb	*Austrobryonia argillicola*	-	VU
19	a grass	*Sporobolus latzii*	-	VU
Mammals				
4	Brush-tailed Mulgara	*Dasycercus blythi*	-	VU
10	Golden Bandicoot	*Isoodon auratus*	VU	EN
12	Greater Bilby	*Macrotis lagotis*	VU	VU
13	Southern Marsupial Mole	*Notoryctes typhlops*	-	EN
14	Black-footed Rock-wallaby (MacDonnell Ranges race)	*Petrogale lateralis*	VU	VU
17	Carpentarian Antechinus	*Pseudantechinus mimulus*	VU	VU
20	Common Brushtail Possum (Southern NT)	*Trichosurus vulpecula vulpecula*	-	EN
Reptiles				
1	Plains Death Adder	*Acanthophis hawkei*	VU	VU
5	Gulf Snapping Turtle	*Elseya lavarackorum*	EN	-
11	Great Desert Skink	*Liopholis kintorei*	VU	VU

Map notes:
- *Data has been presented to show species presence, not abundance.*
- *TPWC threatened shorebirds have not been presented (Greater Sand Plover, Lesser Sand Plover, Curlew Sandpiper Bar-tailed Godwit, Eastern Curlew)*
- *Status: VU Vulnerable; EN Endangered; CE Critically Endangered;*
- *Records shown include 'historic' records.*

0 25 50 100
Kilometres

MAP INFORMATION
Scale: 1:4,000,000 @ A4
Projection: GCS GDA 1994
Date Saved: 11/08/2016
Client: Jemena
Author: D.Carroll (reviewed G.Ewers)

DATA SOURCE
Threatened species records: ALA
Topographic data: Geosciences Australia
Project data: Jemena

Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\JEMENA\EIS (NT)\01 Project Files\Ch6\Figure 5-2. Map of threatened species records for the region surrounding Project footprint.mxd

Figure 5-2. Map of threatened species records for the region surrounding Project footprint

5.3 SPECIFICS

5.3.1 Personnel

The survey team consisted of experienced ecologists:

- **Tom Reilly** BSc – Natural Resource Management (Hons)

  Tom led the Northern Territory survey which focussed on Greater Bilby, Brush-tailed Mulgara, *Sporobolus latzii* and *Austrobryonia argillicola.*

  Tom has worked as an ecological consultant in Alice Springs and Darwin since 2002, leading numerous fauna surveys (general and targeting threatened species). In this time, he has gained survey expertise from the central deserts to the Top End. Tom has also undertaken a variety of targeted threatened flora surveys, general vegetation surveys and vegetation community mapping Projects (at a range of scales) throughout the Northern Territory, and is proficient at ArcGIS (ESRI).

  Relevant to this Project, Tom has conducted targeted Greater Bilby and mulgara surveys within the Tanami Desert for Newmont Tanami Operations (Oberon), CLC/Newmont Regional Biodiversity Monitoring, ABM Resources (Old Pirate) and Ord River Resources (SuppleJack) – many of which were successful in identifying the presence of the species.

  Tom is experienced in survey methodology design, and ensures that appropriate consultation with specialists within the government and private enterprises occurs for all Projects.

- **Mark Carter** Grad. Dip. Ecotourism & Wildlife Management; BSc / BE (Hons)

  Mark accompanied Tom on the Northern Territory survey which focussed on Greater Bilby, Brush-tailed Mulgara, *Sporobolus latzii* and *Austrobryonia argillicola.*

  Mark is a skilled arid zone fauna surveyor with widespread experience conducting targeted surveys for Greater Bilby. He has designed, led and authored reports on Greater Bilby surveys, including:

  - Yulleroo Targeted Bilby Surveys 2012 and 2013 (for Buru Energy)
  - McPhee Creek Targeted Bilby Survey 2013 (for Atlas Iron)
  - Browns Range Targeted Bilby and Spectacled Hare-wallaby Tracking Survey 2013 (for Northern Minerals)

  In addition to this direct field experience, Mark was employed as a zookeeper at the Alice Springs Desert Park between 2007 and 2011 where Greater Bilby was one of the key mammal species in his care. This gives Mark a strong understanding of the animal's anatomy, behaviour and biology, and extensive first-hand experience of the species field signs such as tracks and droppings.

- **Brett Taylor** BSc – Ecol. & Cons. Biol. (Hons)

  Brett led the Queensland survey which focussed on Carpentarian Antechinus, Painted Honeyeater and Gouldian Finch.

  Brett is a senior ecologist specialising with over nine years' field experience. He has carried out ecological surveys in a wide variety of habitats throughout Queensland. Brett was involved in the assessment of habitat and potential impacts on identified terrestrial ecological values associated with the proposed Copperstring powerline corridor Project (Townsville to Mount Isa) in northern Queensland. He carried out successful targeted surveys for conservation-significant species – including Carpentarian Antechinus – thereby expanding the known distribution for that species.

Advice on survey methodology was received from the following threatened species experts:

- **Associate Professor Sarah Legge**

  Sarah was engaged to provide advice and comment on survey methodology and results for the Gouldian Finch survey program.

  Sarah is a wildlife ecologist with over 20 years of research and conservation management experience. She is a Deputy Director of the Threatened Species Recovery Hub (part of the National Environmental Science Program), based out of the University of Queensland. She sits on a number of advisory groups, including the Commonwealth Government's Threatened Species Scientific Committee (since 2012), Birdlife Australia's Threatened Species Committee, and the National Feral Cat Taskforce. Previously, Sarah worked for the Australian Wildlife Conservancy, where she developed and led its Conservation and Science program for many years. One of the more substantial research Projects aimed to understand and adaptively manage key threats to seed-eating finch species of the northern savannahs, including the Gouldian Finch. The finch research (carried out in the Kimberley, Northern Territory and Queensland) led to several international publications and had profound implications for fire management regionally. Sarah has authored a book, over 90 peer-reviewed publications (in the fields of evolutionary ecology, wildlife ecology and threat management), and many dozens of technical reports and popular articles.

- **Dr Rick Southgate**

  Richard was engaged to provide advice and comment on survey methodology and results for the Greater Bilby survey program.

  Richard is a wildlife ecologist with over 30 years of research experience working with mammals in Australia's arid zone. Richard completed his doctorate investigating the suitability of habitat for the Greater Bilby in the Tanami region of central Australia. He has extensive experience developing and working with sign-based techniques to detect for and monitor wildlife, including Greater Bilby and Brush-tailed Mulgara. He has numerous publications detailing this work in peer reviewed scientific literature, technical reports and book chapters. Through his work, Richard has become the foremost expert in track-based monitoring of the Greater Bilby. Richard has held expert advisor roles for the Department of Environment regarding Greater Bilby habitat suitability and impact of clearance, and acted as expert advisor and peer reviewer to industry on Greater Bilby related projects.

Dr Catherine Nano (DLRM – Senior Scientist), Peter Jobson (Alice Springs Herbarium Curator), and Peter Latz (a freelance botany consultant who first identified *S. latzii*) for the two threatened plant species, and from Peter Macdonald (DLRM) for Greater Bilby.

5.3.2 Permits

All surveys were conducted under current Animal Ethics and Northern Territory Parks & Wildlife permits:

- Animal Ethics Project: A12005 '*Fauna Studies in the Northern Territory*'. Expires 17/02/2020.
- Animal Ethics Project: CA 2016/01/934. Expires 9/1/2019.
- Permit to Interfere with Protected Wildlife Northern Territory: 58158. Expires 1/4/2018.
- Scientific Purposes Permit (Queensland): WISP17062316. Expires 1/01/2020.

No permits are required for the flora surveys and vegetation mapping.

5.3.3 Nomenclature

Nomenclature and classification of flora species are taken from the *Checklist of Vascular Plants of the Northern Territory* (Short et al. 2011). Nomenclature and classification of fauna species use lists provided by the Northern Territory Government (https://nt.gov.au/environment/animals/list-of-native-animals-in-nt).

5.4 LATZ'S GRASS (*SPOROBOLUS LATZII*)

5.4.1 Conservation status

- Northern Territory: Vulnerable
- Queensland: Not Listed
- National: Not Listed

5.4.2 Background information

Description

Sporobolus latzii (referred to as Latz's Grass in this report) is a fairly robust, erect tufted perennial grass with flowering stems to almost 1 m high and leaves that are minutely roughened, flat and up to 16 cm long and 3.5 mm wide. Flowering has been observed in May.

Ecology

Latz's Grass is only known from one location, on clay soil at the edge of a seasonal swamp surrounded by Coolabah (*Eucalyptus coolabah*) (Albrecht et al. 2012). Associated flora species included *Cullen cinereum* and *Leptochloa fusca* (Albrecht et al. 2012). The seasonal swamp supported mature Coolabah (single trunks up to 7 m in height), which was a unique feature as many of the other swamps in the region had mallee-like (small multi-stemmed) Coolabah trees, indicating that wildfire is common throughout the region (Latz 2007). The swamp also had a higher diversity of flora species compared to other swamps in the region. Habitat observations of the swamp indicated that it has been subjected to a lower frequency of less intense fires, most probably due to the absence of dense hummock grasslands on its boundary. Instead, the swamp was bounded by low rocky (limestone) rises that were covered with small tussock grasses, which present a lower fuel-load than spinifex hummocks (Gibson et al. 1994; Latz 2007). Therefore, it is expected that Latz's Grass habitat requires a history of low level fire impact for the species to be present.

A description of the type locality is provided below (as per results listed for Site 27 in Gibson et al. 1994):

- **Landform** – claypan.
- **Description** – understorey of relatively dense *Enneapogon polyphyllus* (30%) and *Fimbristylis dichotoma* (25%) with a variety of perennial and annual grasses and herbs (10%). Upper storey primarily of low *Eucalyptus microtheca* (5%) with scattered *Eremophila latrobei* (1%).
- **Other flora species** (lower stratum only (<10% cover) as there were no other flora species recorded within the upper or mid strata).
    - Shrubs – *Sida platycalyx, Indigofera colutea*
    - Graminoids – *Aristida holathera, Aristida contorta, Aristida hygrometrica, Aristida inaequiglumis, Eragrostis eriopoda, Perotis rara, Dactyloctenium radulans*
    - Herbs – *Evolvulus alsinoides, Portulaca oleracea, Portulaca pilosa, Salsola kali, Ptilotus polystachyus, Cleome viscosa, Boerhavia coccinea, Boerhavia schomburgkiana, Heliotropium tenuifolium, Euphorbia drummondii*
    - Vine – *Bonamia media*

The type locality was also visited during aerial surveys undertaken during the reconnaissance survey in March 2016 (see Section 3 for an observation notes and representative photographs).

Distribution

Latz's Grass is endemic to the Northern Territory. It is only known from one site in the Wakaya Desert (Northern Territory) (recorded in 1993; Gibson et al. 1994), 4 km south of the construction ROW (near KP 273) – see Figure 5-5. Less than 200 individuals were found (Albrecht et al. 2012; pers. comm. P. Latz). Although Latz's Grass is considered to potentially occur in seasonal swamps throughout the Wakaya Desert (Albrecht et al. 2012), the 1993 survey included searches in approximately 40 swamps, none of which recorded other populations of the species (Albrecht et al. 2012). It is estimated that one-third to one-half of the potential swamps in the region were surveyed for the species during the 1993 surveys (pers. comm. P. Latz).

A return visit to the type locality in 2009 to target identification of the species (as part of the Wonarah Phosphate Project environmental approvals) did not record Latz's Grass as present (Low Ecological Services 2009), perhaps due to a broad-scale fire that occurred in 2007.

Threatening processes

According to Albrecht et al. (2012):

> *The Wakaya Desert experiences frequent, short-interval wildfire that may result in surface sand deposition into clay depressions, potentially making them unsuitable habitat for this species (see Latz 2007). In addition, competition from Buffel Grass (Cenchrus ciliaris) is a potential future threat as this species is becoming more common in Wakaya Desert just to the north of the Sporobolus latzii population (P. Latz pers. comm.).*

5.4.3 Survey context

Purpose

If present within the Project footprint, Latz's Grass could be impacted by Project construction works – primarily by land clearing. The purpose of the survey was to identify whether this species occurs within 500 m of the Project footprint.

Overview

To achieve the abovementioned purpose, the survey was designed to:

a) Identify locations containing potentially-suitable habitat using desktop mapping datasets.

b) Visit those locations by helicopter to confirm whether they contain suitable habitat.

c) If suitable habitat is present, undertake surveys for the species to determine presence/absence and extent.

5.4.4 Survey methodology

Existing survey guidelines

There are no species-specific guidelines for surveying Latz's Grass.

Survey design

Consultation with DLRM (Dr Catherine Nano – Senior Scientist), Alice Springs Herbarium (Peter Jobson – Alice Springs Herbarium Curator), and Peter Latz (botanist who first identified Latz's Grass) indicated that the survey methodology described below was sufficient in ensuring any previously undetected occurrences of Latz's Grass in proximity to the Project footprint would be identified.

Aerial footage of swamps within the region of the Project footprint was replayed to Peter Jobson and Peter Latz (footage recorded during the reconnaissance survey, described in Section 3). The footage included a

fly-over of the 'type locality' so surveyors could familiarise themselves with habitat features that occur at the only known location of Latz's Grass. Peter Jobson and Peter Latz advised particular areas where field surveys should be focused (i.e. on the swamp edges near unburnt Coolabah, 'likes' clay loam soils, typically not associated with sedges), and agreed that the small swamps within the Project footprint area were likely to only be marginally suitable for Latz's Grass. They advised that field surveys should prioritise swamps or depressions that support mature Coolabah trees.

Voucher specimens of Latz's Grass were photographed at the Alice Springs Herbarium (courtesy of Peter Jobson) to aid in field identification of the species.

Survey area and target habitat

Latz's Grass is only listed in the Northern Territory and its distribution is thought to be restricted to seasonal swamps in the Wakaya Desert. As there is no formal boundary of Wakaya Desert (Latz 2007; see approximate boundary in map inset of Figure 5-5), a conservative survey area has been applied for Latz's Grass to include any seasonal swamps encountered within 500 m of the following Project components (see Figure 5-5):

- Construction ROW between KP 200 to the edge of the Barkly Clay Plains (KP 350). This area was selected based on an initial review of aerial imagery which indicated that temporary swamps / playas are restricted to eastern area of Lateritic Plain and Rises.
- Proposed access roads within the region of KP 200 and KP 350.

Locations for Latz's Grass surveys sites were pre-selected prior to field surveys based on habitat advice from Peter Jobson and Peter Latz (see above), habitat mapping results of the Project footprint (see Section 4), review of aerial imagery (Google Earth Pro and ESRI Online Imagery) at a scale of 1:3,000, and observations made during the reconnaissance survey (see Section 3). This review resulted in the following:

- Habitat mapping in Section 4 identified that the Project footprint intersects one playa (i.e. seasonal claypan or swamp) at KP 242.
- No seasonal, Coolabah-fringed swamps of similar size to Latz's Grass type locality that are crossed, or are within 500 m, of the Project footprint (a description of the type locality is provided in Section 5.4.2 and photographs in Figure 3-2).
- Eight (potential) swamp / claypan are located within 500 m of the construction ROW.
- Numerous (potential) small depressions occur within 500 m of the construction ROW. These are considered to have low chance of habitat suitability and require field confirmation.
- Small depressions were not observed within 500 m of proposed access tracks.

Sites will be checked during field studies for either habitat suitability or presence of Latz's Grass (or both).

Habitat suitability assessment

The intent of habitat suitability surveys was to field-check pre-selected Latz's Grass sites (see above), and to search the Project footprint between KP 150 and KP 350 for any additional sites not detected during these activities.

Surveys for Latz's Grass were conducted on the 8 and 9 May 2016, and included aerial (helicopter) inspections of each site, and ground surveys of sites within 500 m of the Project footprint that were considered to be potentially-suitable for Latz's Grass. The following data attributes were collected:

- Photographs at high altitude (> 500 m) above ground)
- Photographs at low altitude to record habitat characteristics (15 m above ground)

- The edge of each swamp was flown at low altitude to inspect if it supported habitat features suitable for Latz's Grass, such as presence of mature Coolabah trees (or large trees in general) and evidence of low fire impact.
- General habitat description – landform, vegetation, dominant species. evidence of surface water
- Size of swamp (using GPS track log and aerial imagery)
- Surrounding landform and habitat type, particularly in relation to presence of spinifex-dominated hummock grasslands
- Evidence of cattle impact.

Targeted ground searches

Targeted ground searches for Latz's Grass were conducted on the 8 and 9 May 2016 at sites identified as potential habitat in the abovementioned habitat suitability assessment survey. Searches occurred at suitable swamps within 500 m of the Project footprint.

As per advice from Peter Jobson (Alice Springs Herbarium) and Peter Latz (consulting botanist), searches for Latz's Grass occurred along the clay-loam based soils that occur at the swamp edge. Survey effort was particularly focused where these soils were found at the base of (mature) Coolabah trees, or where many Coolabah were situated.

The following data were to be collected (at minimum) if a suspected identification of Latz's Grass occurred (which was not the case – see Section 5.4.5):

- Site geo-located
- Number of plants counted in the patch
- Size estimate of patch (walked with GPS with active track-log)
- Plant and micro-habitat photographed
- Vegetation description (detailed), particularly flora species in associated with *S. latzii*
- Assessment of fire history at the site
- Presence of weeds and native fire-promoting grasses
- Surface and sub-soil (to 250 mm) described and photographed
- Collection of a representative voucher specimen for verification by the Alice Springs Herbarium
- Description of surrounding habitat and fuel-load estimate (including photograph).

5.4.5 Results

Habitat suitability surveys

The Latz's Grass surveys field-checked eight (potential) seasonal swamps and inspected the numerous drainage depressions that were identified by desktop studies and/or the reconnaissance survey that may be suitable for Latz's Grass (Figure 5-5).

The findings are as follows:

- Aerial inspections of all pre-selected drainage depression sites concluded that these sites did not support habitat features typical of Latz's Grass, and that ground-searches for Latz's Grass was not required. These areas were small, indistinct, had no surface water evidence, and did not support Coolabah trees.

- Aerial inspections of the eight (potential) seasonal swamp sites identified the following:
  - Two of the nine (potential) seasonal swamps (sites SL2 and SL7) were re-defined as drainage depressions when observed during targeted aerial surveys (see Appendix F).
  - One of the nine (potential) seasonal swamps (SL6) was re-defined as a sinkhole when observed during targeted aerial surveys (see Appendix F).
  - Five of the nine (potential) seasonal swamps (SL3, SL4, SL5, SL8, and SL9) were identified as seasonal swamps / claypans. In all circumstances, Coolabah trees (*Eucalyptus microtheca* or *E. victrix*) were present, but often only in mallee-form (indicates history of high fire impacts). When larger trees were present (observed in low numbers at sites SL1, SL3, SL4, and SL9) they were often standing within the central parts of the swamp, therefore in a more fire-protected location.
- Habitat descriptions for the nine (potential) seasonal swamp sites are provided in Appendix F.
- Site SL5 was the only swamp within 500 m of the Project footprint that supported habitat features potentially-suitable for Latz's Grass (i.e. Coolabah trees were observed lining the swamp edge, although they were all reduced to mallee-form i.e. multi-stemmed shrubs – an indicator that they have experience repeated wildfire events over a long time-period) (see photographs in Figure 5-3 and Figure 5-4). Surface water was present within the central depression of the swamp, albeit a small pool with dimensions of ~ 5 x 5 m. A ground-based search for Latz's Grass was conducted at this site because of presence of habitat indicators and the potential risk of impact (if present) due to close proximity to construction ROW (described below).
- Most tussock grasses established along the edge of each swamp were flowering/seeding; grasses such as *Eulalia aurea, Aristida* sp., *Eragrostis* sp. were observed. No grasses with features similar to *Sporobolus* sp. were observed during these inspections (which was confirmed by several ground-based check-sites, described below).
- All swamps were surrounded by hummock grasslands with dense cover of Acacia shrubs and isolated trees (often *Corymbia opaca*).
- None of the swamps were surrounded by low rocky rise landform types, which is what occurs at the 'type locality' of Latz's Grass
- All swamps were small (ranging from 0.2 ha to 15.2 ha), and had a lower variety of micro-habitats compared to the 'type locality' (171.2 ha).
- No cattle impact was observed, which was expected as all swamps were within Aboriginal Land ('Wakaya Land Trust' and 'Arruwurra Aboriginal Corporation') (see Figure 2-12 for property boundaries).

On-ground searches

One swamp (SL5) required a ground-based targeted search for Latz's Grass. This was the only swamp that occurred within 500 m of the Project footprint that supported potentially-suitable habitat features (based on aerial assessment). Surveyors circumnavigated the edge of the swamp, and ran a search transect diagonally across the centre. The following lists the main findings from the survey:

- Latz's Grass was not observed.
- The clay loam swamp edge where 'mallee-like' Coolabah were established was overlain with approximately 100 mm of sandy red earth. Although the site has not burnt since 2011, these observations are typical of an area that has experienced a long history of fire impact, whereby fires open up the vegetation and winds transport, then deposit, sand (from the surrounding sand plain) into the claypan depressions.

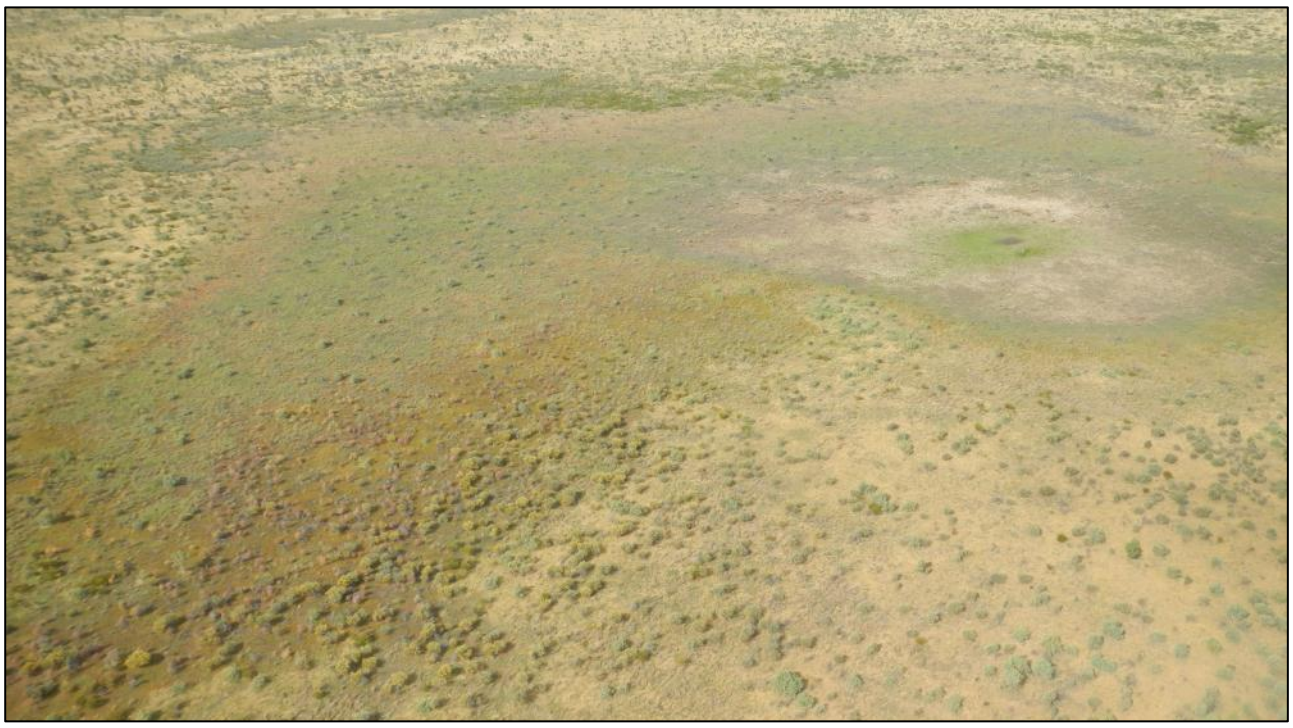
- The edge of the swamp was dominated by large tussocks of *Eulalia aurea*, which can cumulatively hold a high fuel-load when tussocks dry out and connect as a closed grassland.
- No Buffel Grass (*Cenchrus ciliaris*) was observed.
- The swamp was surrounded by desert sandplains that supported an Acacia shrubland with a spinifex-dominated grassland.
- The swamp is small compared with the type locality (15.2 ha compared to 171.2 ha), and does not present a similar variety of habitat features (see Section 3 for description and photographs of 'type locality').

5.4.6 Discussion

The survey did not identify Latz's Grass or suitable habitat within, or immediately surrounding, the Project footprint. Based on survey evidence, it is assumed that Latz's Grass is absent from the Project footprint.

Five swamps were found near the Project footprint. All were shallow and small (ranging from 0.2 ha to 15.2 ha), and considered to be in poor condition (in regards to Latz's Grass habitat requirements) when compared to the 'type locality'. None supported tall, single-stemmed, Coolabah trees. The Latz's Grass 'type locality' is comparably large (171.2 ha) and contains a complex surface hydrological pattern which likely provides fire-protection, additional to the surrounding low rocky rises that support a low fuel-load tussock grassland (Gibson et al. 1993; Latz 2007) (see Section 3 for description and photographs of 'type locality').

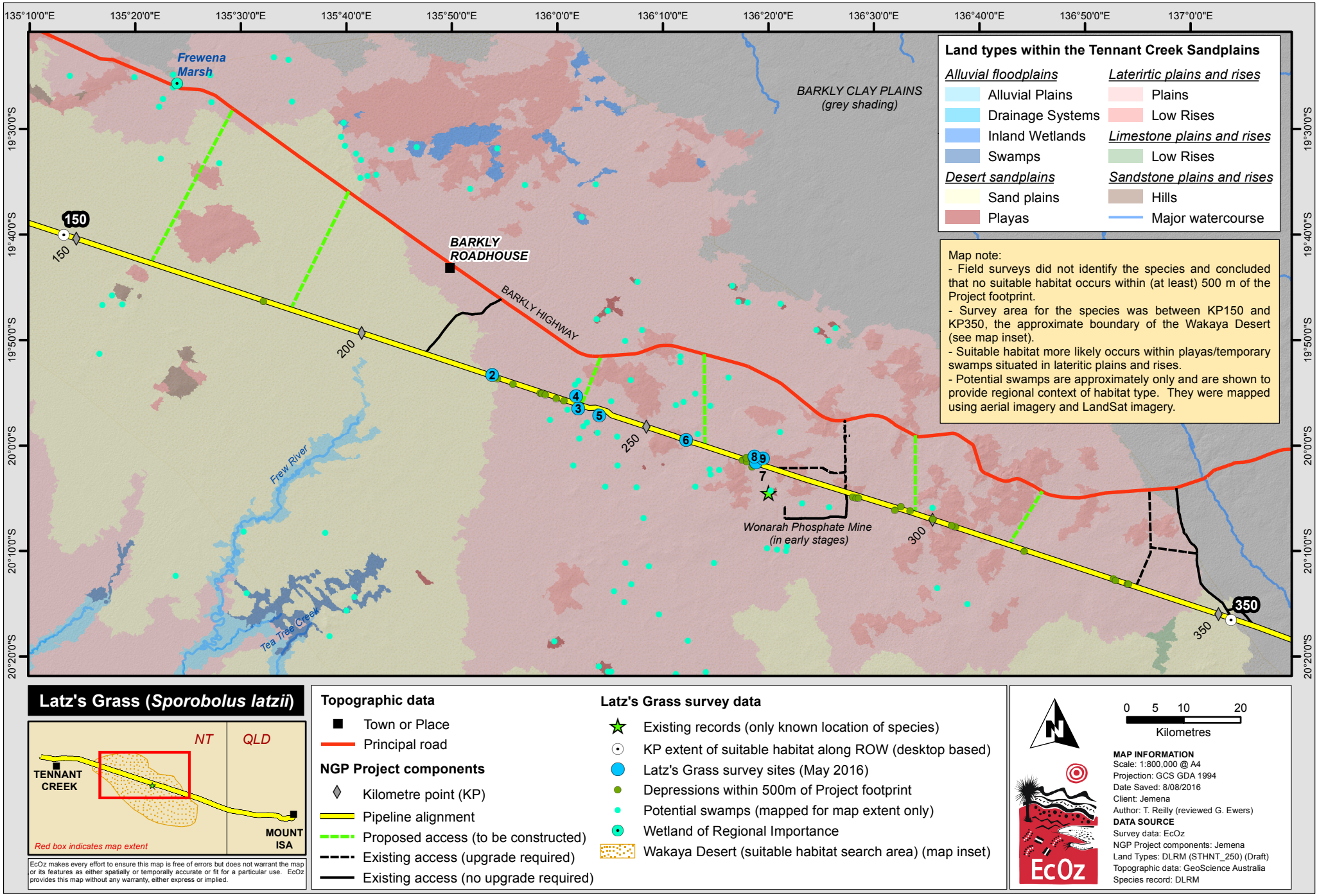
One swamp (SL5) was located within 500 m of the construction ROW (within the Latz's Grass survey area) (KP 273). However, on-ground searches for Latz's Grass at the site did not find the species. A habitat assessment indicated it is unlikely that Latz's Grass persists at the site due evidence of long-term fire impact (i.e. presence of red sandy loam over-topping clay soils, and mallee-like Coolabah). Repeated fire events are considered a major threat to the species (see threatening processes in Section 5.4.2). NAFI fire scar mapping indicates the swamp has burnt three times in the last 15 years (2011 most recent burn), which is a high fire frequency for the region.



Site SL5: *Easterly view. Construction ROW crosses within 500 m of the swamp edge (which is the left side of photograph, north side of temporary swamp). Note absence of large Coolabah trees.*

Figure 5-3. Photograph (aerial) of the Latz's Grass site SL5

Figure 5-4. Photographs (on-ground) of the Latz's Grass site SL5



Path: C:\01. EcOz GIS Projects (TR)\Jemena\Project files\SL_SurveySites_v2 with swamps2.mxd

Figure 5-5. Map of Latz's Grass survey results

5.5 TOBERMOREY MELON (*AUSTROBRYONIA ARGILLICOLA*)

5.5.1 Conservation status

- Northern Territory: Vulnerable
- Queensland: Least Concern
- National: Not Listed

Tobermorey Melon (*Austrobryonia argillicola*) was previously listed as Endangered under the *EPBC Act.* In 2010, the Commonwealth Threatened Species Scientific Committee determined that this species was eligible for delisting due to recent information that better defines its taxonomic status, and consequently establishes a much larger known range and number of populations. Furthermore, the TSSC stated that there are no listed threatening factors known to affect this species. Tobermorey Melon was subsequently de-listed as an *EPBC*-listed threatened species in December 2013.

5.5.2 Background information

Description

Tobermorey Melon is a prostrate herb with a thickened, perennial rootstock and annual stems to 1 m long (Nano et al. 2012). The leaves have a heart-shaped base and serrated edges. The pale yellow flowers (1.3 – 1.8 mm long) are often solitary. The fruits are 25 mm in diameter, and are smooth and pale yellow-green with darker stripes.

Ecology

Tobermorey Melon occurs along creeks and poorly-drained areas, mainly Mitchell Grass Downs on cracking clays (dominated by *Astrebla* spp.) (Schaefer et al. 2008). It is most abundant in seasonal swamps, clay pans and run-on areas. It has been recorded from Bluebush (*Maireana* spp.) swamps, Gidgee (*Acacia cambagei*) shrubland and riparian woodlands dominated by River Red Gum (*Eucalyptus camaldulensis*) (Nano et al. 2012).

This species exhibits natural fluctuations and more individuals are likely to be recorded following the wet season (Queensland Herbarium 2009) because the above-ground parts are seasonal or dependent on weather conditions (Schaefer et al. 2008). According to Nano et al. (2012), this species has been observed flowering in March, May, July and October. Schaefer et al. (2008) describe flowering and fruiting as occurring from February – July.

Distribution

Tobermorey Melon is endemic to central-western Queensland, extending to the adjoining Barkly Tableland in the Northern Territory (Schaefer et al. 2008). In Queensland, this species occurs in numerous locations south of the Project footprint (see map inset in Figure 5-8). In the Northern Territory, this species is currently known from six locations (according to records held within DLRM Fauna Atlas and Atlas of Living Australia) (see Figure 5-8 for the full extent of Tobermorey Melon records):

- Four located adjacent to the Northern Territory/Queensland border (near the Plenty Hwy ~200 km south of Project footprint).
- One located near Corella Lake (~200 km north of Project footprint).
- One located on a tributary of Ranken River approximately 15 km north of KP 356. This record is from 2001 and was at a location called Dingo Hole (see Figure 5-8).

The *Commonwealth Listing Advice on Austrobryonia argillicola* (TSSC 2013) states that this species has an extent of occurrence of 800 000 km^2 and an unknown area of occupancy. In 2006, Kerrigan and Albrecht estimated that, in the Northern Territory, Tobermorey Melon has an area of occupancy of 20 km^2; however,

this was before additional records were found and also seems low because the then known population extent only just overlapped into the Northern Territory (see Figure 5-8).

TSSC (2013) asserts that although this species' known distribution is fragmented, this non-continuous distribution may be an artefact of limited collection effort (Kerrigan & Albrecht 2006). This has been re-affirmed during recent discussions with the Northern Territory Herbarium (Peter Jobson pers. comm. 2016). As such, Tobermorey Melon may be a candidate for de-listing as a threatened species in the Northern Territory to align with the current National listing.

Threatening processes

The preferred habitat of this species is favoured by livestock and feral animals. Pastoral and infrastructure (e.g. road and seismic lines) developments in Tobermorey Melon habitat could have a negative impact on this species (Nano et al. 2012); however, there is no supporting evidence of this to date.

5.5.3 Survey context

Purpose

If present, Tobermorey Melon could be impacted by Project construction works – primarily by land clearing within watercourse crossing in the Mitchell Grass Downs bioregion.

The purpose of the survey for Tobermorey Melon was to identify whether this species occurs within the Northern Territory section of the Project footprint.

Overview

To achieve the abovementioned purpose, the survey was designed to:

a) Identify locations containing potentially-suitable habitat using desktop mapping datasets.

b) Visit those locations by helicopter to confirm whether they contain suitable habitat.

c) If suitable habitat is present, undertake surveys for the species to determine presence/absence and extent.

5.5.4 Survey methodology

Existing survey guidelines

There are no species-specific guidelines applicable to surveying Tobermorey Melon. This species exhibits natural fluctuations and more individuals are likely to be recorded following wet seasons (Queensland Herbarium 2009).

Survey design

Consultation with DLRM and Northern Territory Herbarium (Peter Jobson – Alice Springs Herbarium Curator) indicated that the survey methodology described below was sufficient in ensuring any previously undetected locations of Tobermorey Melon proximate to the Project footprint would be identified.

Voucher specimens of Tobermorey Melon (and *Cucumis maderaspatanus,* which is a species commonly confused with Tobermorey Melon) were photographed at the Alice Springs Herbarium (courtesy of Peter Jobson) to aid in field identification of the species.

Aerial footage recorded during the reconnaissance survey (described in Section 3) was shown to Peter Jobson, who noted there is a high chance that the species will be detected within river/creek banks, river/creek flood-outs, and minor drainage channels that are intersected by the Project footprint.

Survey area and target habitat

The survey area for Tobermorey Melon included the following components of the Project footprint (see Figure 5-8):

- Construction ROW between KP 355 (western edge of Mitchell Grass Downs bioregion) to KP 457 (Northern Territory / Queensland border).
- Three proposed access roads within the Mitchell Grass Downs bioregion (all following existing roads or fence lines, and therefore requiring widening and upgrade).

Target habitat types for Tobermorey Melon are drainages, creek and river banks, or run-on areas (such as depressions, swamps, or claypans). Preliminary analysis of potentially suitable habitat for Tobermorey Melon within the Project footprint was determined by referring to habitat mapping results (see Section 4), review of aerial imagery (Google Earth Pro and ESRI Online Imagery) at a scale of 1:3,000, and observations made during the reconnaissance survey (see Section 3). This review resulted in the following:

- Rivers and creeks. Tobermorey Melon may occur on the clay soils on bank crests and adjacent flood-out zones, but is not expected to occur within the riverbed or bank slopes. Preliminary review indicated the construction ROW intersects three rivers and one creek.
- Drainage lines. Tobermorey Melon may occur on the clay soils within or directly adjacent to the drainage. Preliminary review indicated the construction ROW intersects 11 drainage lines.
- Three access tracks (combined length of 108.6 km) intersect numerous creeks and drainages that may support suitable habitat for the species. Preliminary review indicated that access tracks intersect at least 49 watercourses (mostly small drainages).

The surrounding Mitchell Grass (*Astrebla* sp.) 'clay plains' may also support Tobermorey Melon; however, as this area is extensive across the Project footprint and the region, it is not a focus habitat of this survey. Drainage features are considered to be a better indicator of species presence within the Project footprint.

Construction ROW survey

A survey site was selected at each watercourse or drainage that was intersected by the construction ROW (15 sites were identified during preliminary review of habitat, see above, field assessment may record additional sites) (Figure 5-8). All sites were aerially surveyed for habitat suitability, and a ground survey was conducted at a selection of sites to provide a spatial representation across the survey area (noting that a ground inspection occurred at all rivers, creeks, and larger drainages).

Aerial surveys occurred at all sites and included the following data attributes:

- Representative aerial photograph(s)
- General habitat description – landform, vegetation type, dominant species and evidence of surface water
- Existing disturbances at site.

Tobermorey Melon ground-searches were undertaken by two surveyors over an approximate area of 2 ha for each site. Searches occurred up and down gradient of the watercourse / drainage. The following data was collected (at minimum) if a suspected identification of Tobermorey Melon occurred:

- Site geo-located
- Number of plants counted in the patch
- Estimate of patch size (walked with GPS with active track-log)
- Plant and micro-habitat photographed
- Vegetation description, particularly flora species in associated with Tobermorey Melon
- Cattle impact
- Collection of a representative voucher specimen for verification by the Alice Springs Herbarium.

Access track survey

Aerial-based habitat surveys were conducted along three proposed access tracks and targeted crossing points of rivers, creeks, drainages, and depressions (preliminary habitat assessment identified that access tracks intersect at least 49 sites that support suitable habitat for the species, see above). The survey included collection of representative habitat photograph(s), landform description, and assessment of general habitat suitability for Tobermorey Melon. No ground surveys were conducted due to all sites being located within current tracks or fence lines (therefore impact to the species was considered as low.

5.5.5 Results

Construction ROW surveys

Eighteen sites were surveyed along the construction ROW – 3 depressions, 8 drainages, 1 creek bank and 3 river bank (noting that all 15 desktop-selected sites were surveyed, plus three additional sites for which suitable habitat was noted once in the field). Site descriptions are provided in Appendix G and representative habitat photos are provided in Figure 5-7.

The main findings from the survey are:

- Tobermorey Melon was identified at seven sites along the construction ROW (sites AA2, 3, 8, 10, 13, 16 and 17) (see Figure 5-8). In all circumstances, Tobermorey Melon was present in low densities on clays soils (some cracking clay soils), and often foliage was senesced but large fruit was prominent and conspicuous. Voucher specimens were confirmed to be Tobermorey Melon by Peter Jobson at the Alice Springs Herbarium. Representative photographs are provided in Figure 5-6.
- Tobermorey Melon was also identified at Austral Downs airstrip (adjacent Georgina River).
- A moderate to high level of pastoral impact was observed at 17 of the 18 sites (i.e. grazing and trampling). One site (AA17) showed low grazing pressure from cattle.

Access track surveys

Forty-nine sites crossed by access tracks that could support potential habitat for Tobermorey Melon were surveyed. Site descriptions are provided in Appendix H.

The main findings from the survey are:

- Suitable habitat for Tobermorey Melon is common among the three proposed access tracks, with 28 drainages, 7 claypans, 6 creeks, and 8 depressions.
- No rivers were crossed by access tracks.
- All sites have been previously cleared for fence lines, firebreaks, or station access tracks.
- Evidence of cattle grazing and trampling was present at each site.

Table 5-2. Tobermorey Melon sites surveyed along the construction ROW

Sites	Easting	Northing	Survey type	Landform	Local catchment	Species present?
1	744536	7746241	Ground	Minor drainage	Ranken River	No
2	744697	7746414	Ground	River bank	Ranken River	**Yes**
3*	745240	7746342	Ground	Drainage	Ranken River	**Yes**
4	748073	7745292	Ground	Drainage	Ranken River	No
5	749580	7744679	Ground	Minor drainage	Ranken River	No
6	754865	7742228	Aerial	Drainage	Ranken River	No
7	756000	7741656	Aerial	Minor drainage	Ranken River	No
8*	762995	7738432	Ground	Depression	James River	**Yes**
9	769237	7735518	Ground	River bank	James River	No
10	770466	7735156	Ground	Drainage	James River	**Yes**
11	775894	7733150	Ground	Drainage	James River	No
12	776609	7732877	Aerial	Drainage	James River	No
13	781697	7730486	Ground	Drainage	Georgina River	**Yes**
14*	784345	7729073	Aerial	Depression	Georgina River	No
15	788224	7727075	Ground	River bank	Georgina River	No
16	799314	7722781	Ground	Drainage	Bluebush Creek	**Yes**
17	806661	7719502	Ground	Creek bank	Bluebush Creek	**Yes**
18	807792	7719105	Aerial	Depression	Bluebush Creek	No

** Site not identified by desktop studies or reconnaissance surveys, but instead detected during field surveys.*

Figure 5-6. Photographs of Tobermorey Melon taken during field survey

Figure 5-7. Photographs of suitable habitat for Tobermorey Melon

5.5.6 Discussion

Tobermorey Melon as recorded at 58% of ground survey locations (7 of the 12 sites) along the construction ROW, and was incidentally recorded at the Austral Downs airstrip (during helicopter refueling). The species was observed within drainages, depressions and on the upper banks of creeks or rivers. In all circumstances, there was a low number of plants within the 2 ha search area, with 1 to 3 plants being observed at each site. Most plants had senesced foliage; however, the large round-to-oblong fruit was prominent and relatively conspicuous. Records from the survey were spread across four surface water sub-catchments of the Ranken River, James River, Georgina River, and Blue Bush Creek. This suggests that the species is likely to be widespread in drainage habitat within the region, but occurs in low densities at each location.

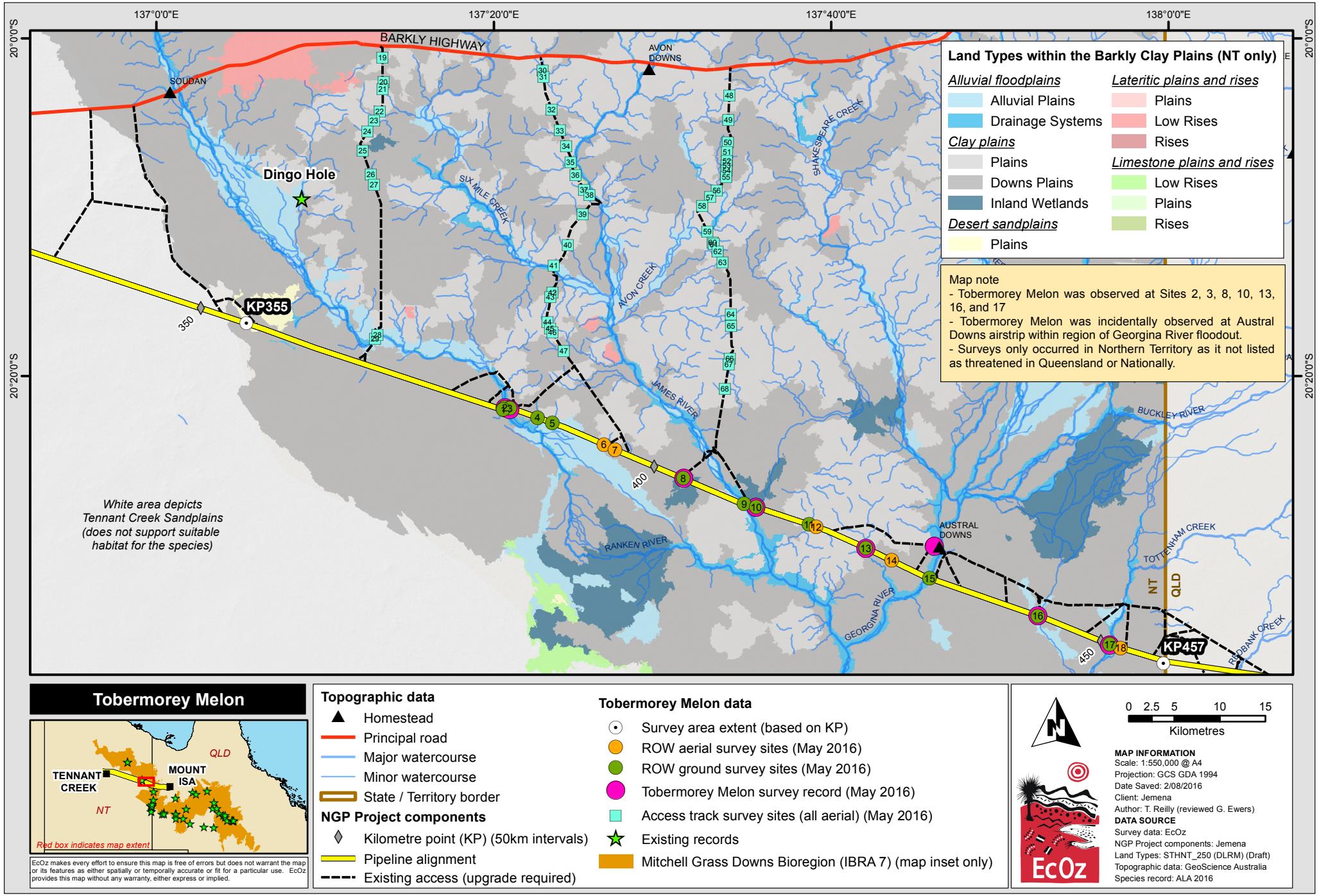
The survey indicated that suitable habitat for Tobermorey Melon is intersected by the construction ROW (at least 18 times) and three proposed access tracks (at least 49 times). Habitat types of particular importance to Tobermorey Melon are:

a) The upper banks and floodouts of large rivers and creeks
b) Small creeks and drainage
c) Seasonally-inundated depressions.

It is also possible the species occurs in low numbers within the extensive clay plains which were not surveyed (pers. comm. Peter Jobson 2016).

As expected, high degrees of pastoral impacts occurred throughout the entire area defined as suitable habitat for Tobermorey Melon, with the exception of one site (AA18 – a creek) that showed low level pastoral impacts. The dominance of pastoralism may be a reason for the scarcity of Tobermorey Melon detected during the surveys; however, current publications only speculate pastoralism as a potential threatening process for the species.

Suitable habitat was common along the three proposed access tracks situated within the Tobermorey Melon survey extent (all 39 sites were considered to be suitable habitat). Ground-searches did not occur at these sites; consequently, the presence or absence of Tobermorey Melon along access tracks cannot be documented. Note that these access tracks occur all along existing linear disturbances, such as fence lines or station tracks, that will require a 5 m maximum widening. Therefore, survey priority was focused on the construction ROW as no existing linear disturbance exists.



Path: C:\01. EcOz GIS Projects (TR)\Jemena\Project files\AA_SurveySites_v1.mxd

Figure 5-8. Map of Tobermorey Melon habitat assessment and field survey

5.6 PLAINS DEATH ADDER (*ACANTHOPHIS HAWKEI*)

5.6.1 Conservation status

- Northern Territory: Vulnerable
- Queensland: Not Listed
- National: Vulnerable

5.6.2 Background information

Description

The Plains Death Adder has a short, stout body, with a head that is triangular and distinct from the neck. The species' coloration varies but usually has wide, lighter bands across the body. The end of its tail tapers rapidly – becoming thin and worm-like – and is used to lure prey within striking distance (Hagman et al. 2008). Adults grow to a maximum length of approximately 1.2 m (Wells and Wellington 1985).

Ecology

This species occurs on floodplains and cracking soil plains (Webb et al. 2002).

According to Ward and Phillips (2012):

> *During the Wet season, individuals move every three to ten days, in apparently random directions, distances ranging from a few metres to a kilometre (Phillips and Webb, unpub. data). When it floods, they simply float in debris or rest on emergent vegetation. During the Dry season, movement is less frequent and they often retreat into deep soil cracks. Radio-tracking suggests that they are nomadic and do not have definable home ranges.*

Plains Death Adder generally breeds from October to November, and produces live young from February to March (TSSC 2012).

Distribution

The exact distribution of Plains Death Adder is unclear. Based upon field experience and encounter rates across its range, the species can be locally common (in the absence of Cane Toads) on the highly productive floodplains of northern Australian rivers. On the Barkly Tableland and Mitchell Grass Downs (where the NGP Project is located), however, the species is less-commonly encountered and can probably be considered scarce in this habitat (TSSC 2012).

There is only one record (from 1978) south of the Barkly Highway (and approximately 22 km north of the construction ROW) in the Northern Territory (see Figure 5-11). There are, however, many records in similar habitat to the north of the Barkly Highway.

According to TSSC (2012), the Plains Death Adder extent of occurrence is estimated to be approximately 720,000 km^2 and its area of occupancy is estimated to be approximately 233,480 km^2.

Threatening processes

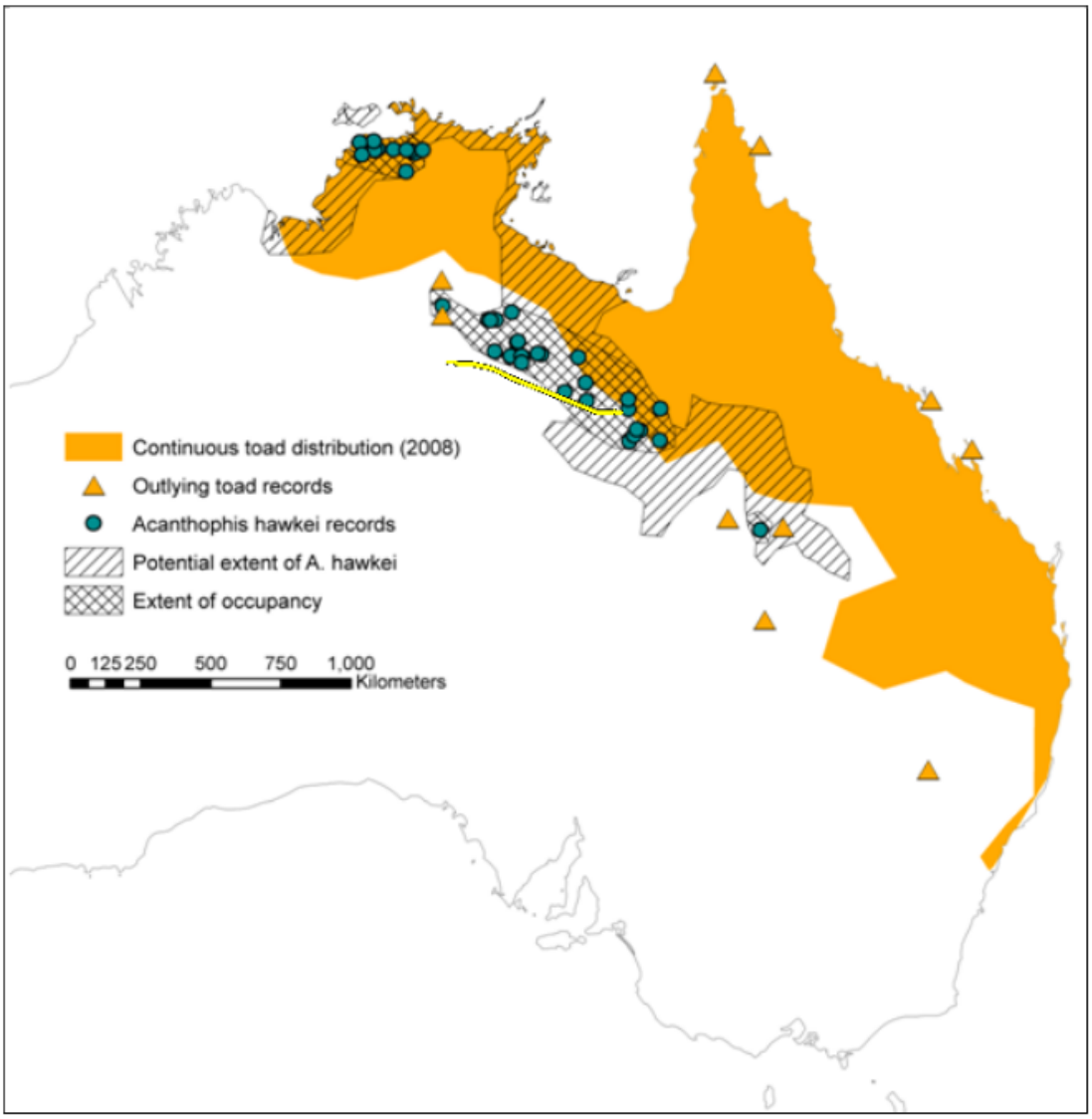
According to TSSC (2012):

> *The main identified threat to the Plains Death Adder is the introduced Cane Toad. The Plains Death Adder is an ambush forager and has a specialised foraging tactic of luring prey by waving the tip of its tail. Native frogs make up a large proportion of the species' diet (Webb et al. 2005). The Cane Toad responds more strongly to this lure than native prey species and Cane Toads are more likely to elicit luring from Plains Death Adders than native prey (Hagman et al. 2008). The species does not appear to have the ability to discriminate between Cane Toads and native frogs (Hagman et al. 2008, 2009). The toxins in Cane*

Toads' skin typically cause death in the Plains Death Adder and individuals have been known to die in large numbers when Cane Toads arrive in an area (Hagman et al. 2008, 2009; Phillips et al. 2010).

Cane Toads are spreading across northern Australia at a rate of approximately 40 – 100 km per year (Phillips et al. 2007, Urban et al. 2008) and are slowly encompassing the geographic distribution of the Plains Death Adder. It has been predicted that by 2030 Cane Toads will have encompassed almost all of the species' range (Phillips et al. 2003) [see Figure 5-9]*. It is possible that the range of the Cane Toad will not completely overlap that of the Plains Death Adder in the south, as the drier conditions would potentially restrict the Cane Toads' spread. However, outlying Cane Toad records suggest that these southern populations already experience Cane Toads, at least sporadically (Phillips et al. 2008).*

Other potential threats to the Plains Death Adder identified by TSSC (2012) are habitat modification due to over-grazing by cattle and inappropriate fire regimes.



Construction ROW depicted by yellow line

Figure 5-9. Map of extent of occurrence and area of occupancy for Plains Death Adder, super-imposed on 2008 distribution of Cane Toad (from TSSC 2012)

5.6.3 Survey context

The Project footprint intersects suitable habitat for the Plains Death Adder. If present, this species could be impacted by Project construction works – particularly land-clearing and trenching.

Consultation with DLRM indicated the likelihood of detecting the species during field surveys would be very low. Therefore, no targeted surveys for Plains Death Adder were undertaken. Instead, an identification of the extent of suitable habitat for this species within the Project footprint was determined using desktop mapping datasets.

5.6.4 Survey methodology

There are no species-specific guidelines applicable to surveying the Plains Death Adder. The Commonwealth *Threatened Reptiles Survey Guidelines* (DSEWPaC 2011d) do not refer to this species.

TSSC (2012) gives some advice on surveying for this species:

> *Within its habitat, this species is well camouflaged. It conceals itself in the substrate when in an ambush position and does not startle when approached. As such, the only reliable way of detecting individuals is to drive slowly on roads that cross or run close to suitable habitat for the species. Survey efforts need to be large, particularly in populations that have been invaded by cane toads, where detection rates can be as low as one individual per 30 – 60 hours of surveying.*

Potential habitat for Plains Death Adder within the Project footprint is considered to be confined to the cracking clay soils within Mitchell Grass Downs bioregion. This habitat occurs in Northern Territory and Queensland and includes the following project components:

- Construction ROW between KP 355 and KP 561 (206 km),
- Three proposed access tracks (approximately 109 km) (all following existing roads or fence lines, and therefore requiring widening and upgrade). (Figure 5-9).

As mentioned in Section 5.6.3, consultation with DLRM indicated the likelihood of detecting the species during field surveys would be very low. As such, the recommended survey effort for determining presence/absence of Plains Death Adder within the Project footprint is not commensurate with the low risk that the Project activities will negatively impact upon this species. Therefore, surveying was limited to habitat mapping (at a scale of 1:10,000, see Section 4) to identify the location and extent of potentially-suitable habitat for Plains Death Adder within the Project footprint in both the Northern Territory and Queensland (because this species is listed under both Northern Territory and Commonwealth legislation).

5.6.5 Results and discussion

Whilst there are no existing records of Plains Death Adder within the Project footprint, there is a Northern Territory record (from 1978) from the area between the Barkly Highway and the construction ROW (Figure 5-11). There are also many other records north of the Barkly Highway that are situated in similar habitat to that which occurs within the Project footprint (Figure 5-11).

Land System mapping (scale of 1:250,000; Christian et al. 1954) was used to broadly assess the occurrence of Plains Death Adder in the region, as this dataset is standardised across Northern Territory and Queensland. The potential Plains Death Adder habitat within the Project footprint comprises five land systems (four of which are black soil clay plains), as shown in Figure 5-11. When the full extent of those land systems is examined, it can be seen that there are at 19 database records of Plains Death Adder – of which 16 are in the Barkly land system. That land system is intersected by the construction ROW between KP 354 and KP 385, between KP 485 and KP 499, and also 18 km of the access track that joins the construction ROW at KP 370. Whether or not the high proportion of records from the Barkly land system is because it constitutes preferred Plains Death Adder habitat is unknown. The nearest record to the

construction ROW is from the Wonardo land system, the only record from that land system, approximately 22 km north of the construction ROW.

Habitat mapping conducted at a scale of 1:10,000 (see Section 4) indicates that the Project footprint intersects approximately 820.1 ha of suitable habitat for Plains Death Adder (see Table 5-3 and Table 5-4 for breakdown of habitat types specific to Plains Death Adder in the Northern Territory and Queensland, respectively).

A selection of photographs that represent black soil plains (i.e. suitable habitat for Plains Death Adder) along the construction ROW are provided in Figure 5-10.

Regardless, the presence of suitable habitat contiguous with that known to support Plains Death Adder indicates a reasonable likelihood that the species occurs within the Project footprint. This would represent an extension of the known south-westerly range of this species.

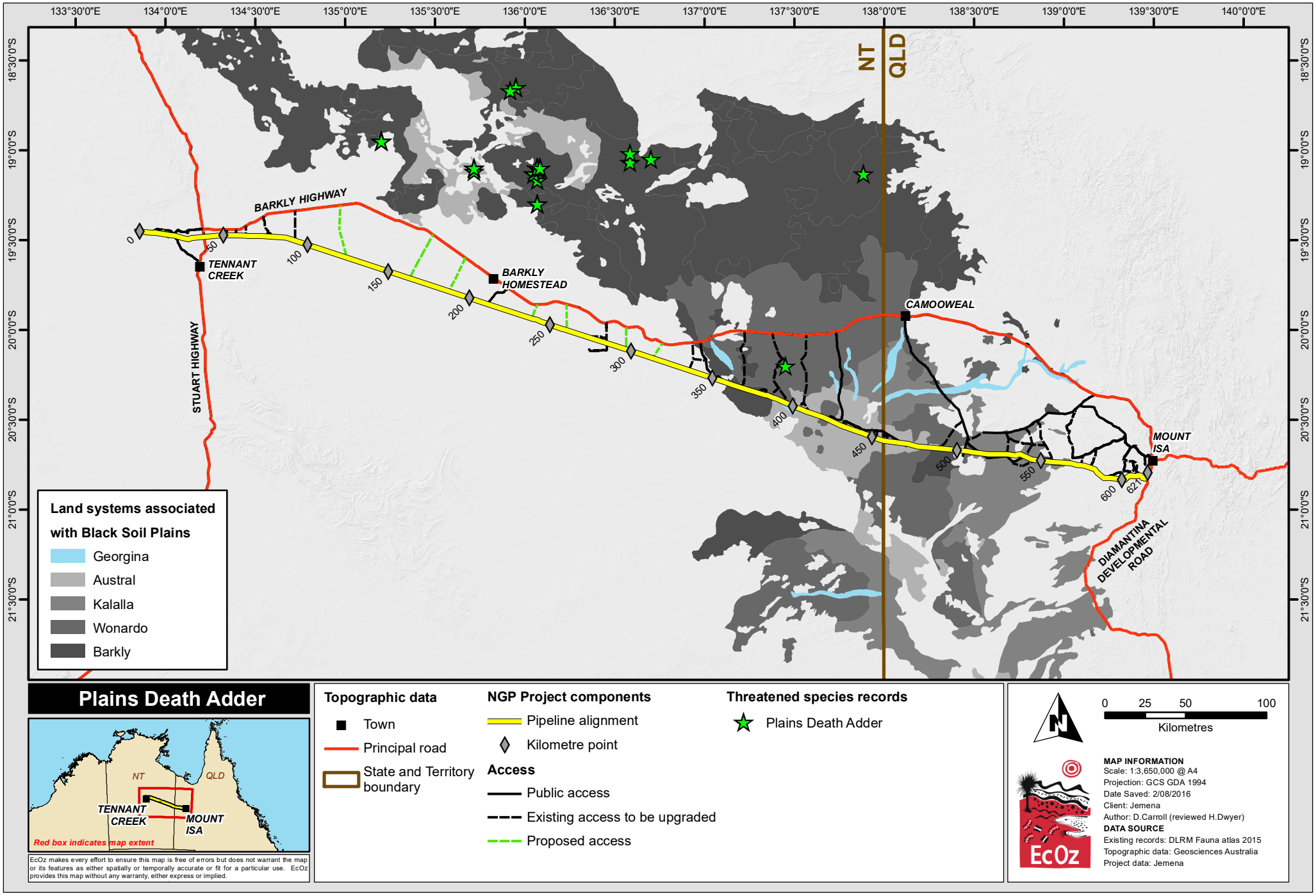
Table 5-3. Potential habitat extent for Plains Death Adder within the Project footprint (NT)

Landscape Class		Disturbance Area (ha)			Grand Total
	Landform Class	**ROW**	**Access tracks**	**Other**	
ALLUVIAL FLOODPLAINS		**64.5**	**13.7**	**28.6**	**106.7**
	Alluvial Plains	*(61.6)*	*(12.8)*	*(28.6)*	***(103.0)***
	Drainage Systems	*(2.9)*	*(0.8)*	*(0.0)*	***(3.7)***
CLAY PLAINS		**243.5**	**71.3**	**29.2**	**344.0**
	Downs Plains	*(200.0)*	*(33.3)*	*(29.2)*	***(262.5)***
	Plains	*(35.9)*	*(37.4)*	*(0.0)*	***(73.3)***
	Inland Wetlands	*(7.7)*	*(0.6)*	*(0.0)*	***(8.3)***
Grand Total		**308.0**	**85.0**	**57.8**	**450.7**

Table 5-4. Potential habitat extent for Plains Death Adder within the Project footprint (Qld)

Land Zone		Disturbance Area (ha)			Grand Total (ha)
	Description	**ROW**	**Access tracks**	**Other**	
3	*Alluvium (river and creek flats)*	34.4	11.4	23.2	**69.0**
4	*Clay plains not associated with current alluvium*	246.5	44.6	9.2	**300.4**
Grand Total		**280.9**	**56**	**32.4**	**369.4**

Figure 5-10. Photographs of potential habitat (clay plains) for Plains Death Adder



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\JEMENA\EIS (NT)\01 Project Files\Ch6\Figure 6□14. Map of Plains Death Adder habitat and records.mxd

Figure 5-11. Map of Plains Death Adder habitat and records

5.7 CARPENTARIAN ANTECHINUS (*PSEUDANTECHINUS MIMULUS*)

5.7.1 Conservation status

- Northern Territory: Vulnerable
- Queensland: Least Concern
- National: Vulnerable

5.7.2 Background information

Description

The Carpentarian Antechinus is a brown, mouse-sized, dasyurid marsupial with a white underside. It has large ears with reddish fur behind them. The species stores fat in its tail, and an individual in good condition has a tail that is swollen to carrot-shaped. Individuals have a head and body length of 63 – 91 mm and a tail length of 56 – 76 mm (Johnson et al. 2008). This species is closely related to, and superficially similar to, other *Pseudantechinus* that typically occupy rocky areas in northern and central Australia (Woinarski 2004).

Ecology

Carpentarian Antechinus occur in a range of vegetation types that are consistently associated with a high cover of rocks and boulders (Johnson et al. 2008; Perry et al. 2011). According to Woolley (2011), the species occurs in open woodland in rocky areas, particularly the side-slopes or bases of sandstone outcrops or hills, and featuring a scattered tree layer that typically includes *Eucalyptus* spp. and a ground layer dominated by spinifex (*Triodia* spp.) hummock grasses.

Lloyd et al. (2013) detail how all the Carpentarian Antechinus they trapped were on rocky ridges and hill-slopes of metamorphic or igneous rock, or weathered granite. The vegetation at these sites comprised a sparse tree layer dominated *by Eucalyptus leucophloia, E. leucophylla, Acacia shirleyi, Terminalia aridicola* and/or *Atalaya hemiglauca*, a sparse shrub layer generally dominated by *Acacia chisholmii*, and a reasonably diverse native grass layer dominated by *Triodia* spp.

The breeding season is thought to be short, occurring sometime between August and October (Curtis et al. 2012). It is nocturnal, hides (roosts/dens) amongst rocks during the day, and does not appear to build a distinctive nest (Van Dyck and Strahan 2008). It feeds on insects and the tail can become fattened when food is in abundance (Van Dyck and Strahan 2008). Little else is known about the ecology of this species, although antechinus typically roost communally.

Distribution

The distribution of Carpentarian Antechinus is poorly understood. In the Northern Territory, this species is only known from Sir Edward Pellew group of islands (Kitchener 1991; Johnson & Kerle 1991; Taylor et al. 2004; Woinarski et al. 2011) and southern Arnhem Land near Borroloola. In Queensland, it was first reported in 1997 (Griffiths 1998), and there are currently only four known records of the species (according to Atlas of Living Australia, all in the Mount Isa Inlier bioregion. There are also some additional recent records of the species from recent surveys (in 2013) associated with the CopperString Project located 50 km east of the Project footprint.

The eastern end of the construction ROW (between KP 522 and KP 622) falls within the *expert distribution (likely)* of the species (Commonwealth of Australia 2016). There are records of Carpentarian Antechinus to the north and east of the Mount Isa end of the Project footprint, approximately 36 km and 40 km respectively (see Figure 5-2). This species is not expected to occur in the Northern Territory portion of the Project footprint as that area falls outside of the known Northern Territory distribution (the closest known occurrence of the species in the Northern Territory is approximately 420 km to the north), and no suitable habitat is intersected.

The extent of occurrence of the Carpentarian Antechinus is 16 000 km² (Curtis et al. 2012). Woinarski et al., 2014 suggest that the mainland area of occupancy is probably >2000 km^2; however, this estimate is of low reliability.

Threatening processes

According to TSSC (2015):

> *Given the lack of specific information [of threatening processes to Carpentarian Antechinus], some assessment of threats likely to be affecting this species may be inferred from evidence of a more general decline in native mammal assemblages across much of northern Australia (Woinarski et al. 2001; Watson & Woinarski 2003; Pardon et al. 2003; McKenzie & Burbidge 2002).*
>
> *The Feral Cat (Felis catus) probably predates the species, but its rocky habitat probably provides some protection (Curtis et al. 2012). Fire regimes in northern Australia have shifted to hot, extensive late dry season fires, and, although it is unlikely that these cause direct mortality to the Carpentarian Antechinus, they may impact on the abundance and availability of their prey (Curtis et al. 2012). Buffel grass invasion could significantly change the ecology of the central Queensland ridges where the species occurs (Lloyd et al. 2013).*

5.7.3 Survey context

Purpose

If present within the Project footprint, Carpentarian Antechinus could be impacted by Project construction works – particularly by land clearing and trenching. The purpose of the survey was to identify whether species occur within the Project footprint.

Overview

To achieve the abovementioned purpose, the survey was designed to:

a) Identify locations containing potentially-suitable habitat using desktop mapping datasets.

b) Visit those locations by helicopter to confirm whether they contain suitable habitat.

c) If suitable habitat is present, undertake surveys for the species to determine both presence/absence and extent.

5.7.4 Survey methodology

Existing survey guidelines

Survey guidelines for the Carpentarian Antechinus are provided in the following reference:

- Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), 2011d, *Survey guidelines for Australia's threatened mammals – Guidelines for detecting mammals listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*. Commonwealth of Australia, 2011.

The guidelines recommend the following survey techniques to detect the presence of the Carpentarian Antechinus in areas up to 5 hectares in size (DSEWPaC 2011d):

- Daytime searches for potentially-suitable habitat resources
- Daytime searches for signs of activity, such as tracks or scats among rocks and rock ledges
- Collection of predator scats, owl casts or remains in predatory bird/mammal nests/dens
- Pitfall trapping surveys

- Elliott A/E trapping survey (as per Gilfillan 2001; Sanders & Slater 2004) (increase Elliott trapping survey effort if pitfall traps are not used in methodology).
- Placement of camera traps in suitable habitat (method and survey effort are not defined).

There is no published information on the best time of year to conduct surveys for the Carpentarian Antechinus. General vertebrate fauna survey guidelines for the bioregions traversed by the Project footprint suggest that survey timing should be following rainfall (late Feb to May).

Survey design

Survey methodology adopted for this species aligns with Commonwealth guidelines for recommended for surveying Carpentarian Antechinus (DSEWPaC 2011d). Aerial footage from the reconnaissance survey (see Section 3) and observation notes on habitat suitability for Carpentarian Antechinus was provided to field ecologist Brett Taylor for his review as he has recently detected this species in the Mount Isa region. Brett validated that there is suitable habitat in the area and provided advice on where survey effort should be focused to determine if species is present.

Survey area and target habitat

Surveys for Carpentarian Antechinus were undertaken within the Queensland section of the Project footprint, and were not required in the Northern Territory for reasons stated above. The survey area within the Project footprint was focused the construction ROW, as other project components will not impact the species due to adequate avoidance of suitable habitat (i.e. rocky hills and outcrops).

The survey area along the Project footprint was between KP 534 and KP 622. This was depicted by reviewing the extent of regional ecosystem land zones within the Project footprint that support rocky habitat features (listed below) and also fits with distribution estimates as referenced on the SPRAT database (see Figure 5-17):

- Land Zone 7: Ironstone Jump-ups
- Land Zone 11: Hills and lowlands (Metamorphic)
- Land Zone 12: Hills and lowlands (Granitic)

Target habitat for the Carpentarian Antechinus survey was rocky hills or outcrops (granitic, metamorphic, or other rock type) intersected by the construction ROW, as surveying these habitat types were considered to provide the highest chance of detecting species presence. The survey area was examined by referring to observations made during the reconnaissance survey (see Section 3), cross-checking habitat mapping results (see Section 4), review of aerial imagery (Google Earth Pro and ESRI Online Imagery) at a scale of 1:3,000, and review of contours (10 m intervals). This identified twelve locations either intersected by, or are near to, the construction ROW that will require field assessment (refer to Figure 5-17).

On-ground habitat suitability assessment

On-ground habitat assessments were conducted on the 11 and 12 May 2016 at eight sites (identified above) to confirm if suitable habitat features were present. The following parameters were collected at each site:

- Photographs and geo-location
- Vegetation community
- Landform
- Presence of potential roost sites (i.e. rock crevices, caves, boulder piles etc.)
- Opportunistic sampling of scats and other potential signs of the species.

Habitat assessments also included daytime searches for signs of Carpentarian Antechinus activity, such as tracks or scats among rocks and rock ledges – and evidence in predator scats (i.e. owl casts or remains in predatory bird/mammal nests/dens).

Detailed rocky habitat mapping

Rocky habitat was mapped within the region of the Project footprint to show the level of connectivity with surrounding rocky ranges and hills where Carpentarian Antechinus has been previously records. This was produced in ArcGIS at a scale of 1:2,000 using ESRI online world imagery and 10m contours to identify ridge lines, rocky hills, and boulder piles – as these areas are considered to be critical habitat for the species.

Elliott trapping

Elliott trapping occurred between 12 and 17 May 2016, during which time there were mild temperatures, calm winds and no rainfall. Elliott trapping occurred at sites that were deemed to potentially support Carpentarian Antechinus (which occurred as part of the abovementioned on-ground habitat suitability assessment) (see Table 5-5 and Figure 5-18 for site names and locations).

The *EPBC* survey guidelines (Commonwealth of Australia 2011) recommend a minimum of two sample sites per 5 ha of suitable habitat within a project area. Therefore, sites that included suitable habitat areas of less than 3 ha were sampled using one trap site, and sites with greater than 3 ha of habitat area were sampled by two traps sites.

Elliott trapping was conducted as per Gilfillan (2001) and Sanders & Slater (2004) as recommended in the EPBC survey guidelines:

- Place 20 Elliott A or E traps at each survey site.
- Place traps 10 m apart in two parallel straight lines (transects) separated by 25 m
- Set traps for four consecutive nights
- Check traps early in the morning and close during the day
- Bait traps with a medium-sized ball of peanut butter, rolled oats, honey and raisins.
- Rebait and open traps in the late afternoon
- Provide within each trap a small amount of nesting material for shade and warmth.

Camera surveillance

Camera surveillance is recommended in the *EPBC* survey guidelines (Commonwealth of Australia 2011); however, method and survey effort are not discussed. Therefore, camera surveillance methods used by the Northern Territory Government for small mammals were adopted for this survey (Gillespie et al. 2015).

Camera surveillance was undertaken between 12 May and 22 June 2016. Surveillance was undertaken at six sites (see Table 5-5 and Figure 5-18). Five of these sites were also surveyed using Elliott traps (described above). CA6 was difficult to access which prevented the use of Elliott traps, therefore camera surveillance (coupled with active search techniques for fauna sign) was used to determine species presence.

Cameras used in this survey were KeepGuard KG690 digital cameras equipped with motion detection and infra-red flash (for dark environments and night). Sites were established based on the following criteria:

- Five cameras per site (referred to as a ‘full spectrum’ in Gillespie et al. 2015)
- Cameras set to operate continually (day and night) for at least 20 days (recommended by Gillespie et al. 2015). Cameras were set for 42 nights per camera (12 May & 22 June 2016).
- Cameras set to high sensitivity and to take three photographs per trigger, with a 10-second interval between triggers.
- Cameras attached to a picket and directed at a habitat feature of interest at a distance of 2 – 4 m. Night image capture was checked to ensure that infra-red reflectance was not an issue.
- A bait canister (filled with peanut butter, rolled oats, honey and raisins) placed within the field of view to attract fauna. The canister is constructed to reduce the chance of fauna and ants eating the bait, allowing it to remain an attractant for several weeks.
- The field of view was cleared of small plants and debris that may result in ‘false triggers’.

Species detected in camera surveillance photos were identified by ecologists. Where required, species' morphometrics were used to identify animals – especially for images with dasyurids and rodents. Analysis of morphometrics was completed using the ImageJ program (Oracle 2011).

Table 5-5. Carpentarian Antechinus survey sites

Site	Coordinates		Elliott site	Camera site	Land zone	Description
CA1	-20.825054	139.456914	Yes	Yes	11 – metamorphic hills	Rocky ridge line
CA2	-20.818794	139.457117	Yes	Yes	11 – metamorphic hills	Rocky gully
CA3	-20.808777	139.416507	Yes	Yes	12 – granite hills	Boulder pile / low ridge
CA4	-20.811935	139.406079	Yes	Yes	12 – granite hills	Boulder pile / low ridge
CA5	-20.800284	139.464886	Yes	Yes	11 – metamorphic hills	Rocky ridge line
CA6	-20.829887	139.296153	No	Yes	11 – metamorphic hills	Rocky ridge line

5.7.5 Results

Habitat suitability assessment

- Of the 12 sites selected as target areas during the preliminary habitat assessment, six were selected as survey sites as they supported habitat features better suited for Carpentarian Antechinus.
- Habitat descriptions of the six survey sites are provided in Appendix I.
- Two main types of rocky hill habitat were recorded:
  - Granitic hills and low ridges with boulder piles that supported a low open woodland of *Eucalyptus leucophylla* and *Corymbia terminalis* or *Eucalyptus leucophloia* in the upper storey over Spinifex (*Triodia* sp.) grassland.
  - Metamorphic hills and ridges with a mixture of scree and outcrop that supported low open woodland *Eucalyptus leucophloia* +/- *Corymbia terminalis* over Spinifex (*Triodia* sp.) grassland.
- All sites supported crevices, caves, cracks etc. that would be suitable for daytime roost opportunities for Carpentarian Antechinus.
- All sites were recent burnt and there is evidence that the site experience high frequency of fire due to presence of mallee-form *Eucalyptus leucophloia* (confirmed by NAFI fire scar mapping).
- Annual Mission Grass (*Pennisetum pedicellatum*) (declared weed known to increase fire frequency and intensity) was observed in granitic low ridge and boulder pile at site CA4.
- Buffel Grass (*Cenchrus ciliaris*) was not evident in any of the rocky hill habitat sites.
- Food availability (insects) was observed in reasonable quantities at each site, it is not expected that food is a limiting factor in terms of habitat suitability.

Rocky habitat mapping

- Rocky hills and boulder outcrops regularly occur between KP 606 and KP 620 (Figure 5-18). Rocky refuge has been mapped as one habitat type rather than separating whether the rocky feature is ridge line, boulder pile or scree, because at this stage – all these rock types are considered to be equally suitable for Carpentarian Antechinus. The rocky habitat shown is indicative only and has not been ground-truthed for the area surrounding the Project footprint.
- The construction ROW intersects rocky habitat on three occasions (see Table 5-6).
- The ROW mostly avoids rocky habitat in the vicinity but intersects a comparably large section at KP 617 (as the alignment travels over a saddle within the ridgeline).
- There are numerous granite boulder piles located between KP 606 and KP 615, of which none are directly intersected by the construction ROW.

Table 5-6. Rocky refugia habitat intersected by the construction ROW – Carpentarian Antechinus

KP	Area (ha)
610.2	0.01
610.6	0.02
617	1.01
Total	**1.04**

Elliott trapping

- Five Elliott trap sites were established as part of the Carpentarian Antechinus surveys (CA1, CA2, CA3, CA4 and CA5) (Figure 5-18).
- Individual Carpentarian Antechinus were trapped at two of the five sites (CA1 and CA2) (see Figure 5-12). These sites are located in the highest rocky hills intersected by the construction ROW and contain cobble-sized, loose scree (metamorphic), with some outcropping. The sites fall within the same ridge; however they are separated by a gap in the ridge due to the flow path of Mica Creek. Both sites were covered with small hummocks of recently-burned spinifex in open formations with an open canopy of Snappy Gum (*Eucalyptus leucophloia*).
- Additionally, Elliott trapping detected the following species:
  - Common Rock Rat (*Zyzomys argurus*) (at CA1 and CA4)
  - Desert Mouse (*Pseudomys desertor*) (at CA2)
  - Sandy Inland Mouse (*Pseudomys hermannsburgensis*) (at CA4)
- No fauna were trapped at two of the five sites (CA3 and CA5).

Camera surveillance

- Six camera surveillance sites were established as part of the Carpentarian Antechinus surveys (CA1, CA2, CA3, CA4, CA5 and CA6) (Figure 5-18).
- Camera traps detected Carpentarian Antechinus at one of the six sites (CA4) – a site where the species was not captured in Elliott traps. This site is comprised of piles of large boulders on low rocky country, with shallow sandy soil and an adjacent drainage line. Boulders (igneous) form many crevices through gaps in stacking (rather than cracking) and there are a number of small caves present. Surrounding vegetation consisted of spinifex (*Triodia* spp.) interspersed with both native and exotic annual tussock grasses.

- Additionally, camera surveillance detected the following species:
  - Common Rock Rat (*Zyzomys argurus*) (at sites CA2 and CA4)
  - Desert Mouse (*Pseudomys desertor*) (at site CA1)
  - Euro (*Macropus robustus*) (at sites CA1, CA2, CA4 and CA5)
  - Red Kangaroo (*macropus rufus*) (at sites CA5 and CA6)
  - Purple-necked Rock Wallaby (*Petrogale purpureicollis*) (at sites CA1, CA2, CA4 and CA5)
  - Short-beaked Echidna (*Tachyglossus aculeatus*) (at sites CA1, CA2, CA3 and CA5)

5.7.6 Discussion

Field surveys identified Carpentarian Antechinus in rocky ridges north and south of Mica Creek (KP 617), and in a granite boulder outcrop to the west of those ridges (KP 610) (see Figure 5-18). Based on this evidence – and the ecology of the species – it is likely that Carpentarian Antechinus occupy any suitable rocky outcrops, boulder piles and rocky ridges/hills between KP 606 to KP 620 of the construction ROW. It is expected that rocky habitat provides daytime refuge as well as night-time foraging habitat – termed 'rocky refugia habitat' – which is considered to be critical habitat for the species.

To maintain gene flow between rocky refugia habitat, it is likely that the species uses the flatter areas surrounding them as dispersion habitat during the breeding season. This is inferred from the observation of the species on an isolated granite boulder pile at CA4 that is likely too small to support a population without any periodic new recruitment. These flatter areas have been termed 'dispersive habitat', and are more likely to be used during the breeding season (which is thought to occur between August and October, Curtis et al. 2012). Such movement would occur at night; however, there is no information regarding the distance to which the species can travel during dispersal periods.

There is a reasonable amount of rocky refugia habitat proximate to the construction ROW, occurring with some regularity between KP 606 and KP 620 (see Figure 5-18). Within this stretch, there are scattered granitic boulder piles and linear metamorphic ridges with varying levels of outcropping, situated among a larger area of flatter lowlands (sandy loams) that may be used as dispersive habitat for Carpentarian Antechinus between rocky refugia.

The construction ROW intersects rocky refugia habitat on three occasions (see Table 5-6). The largest (and most significant) intersection occurs on a metamorphic ridgeline between KP 616 and KP 616.3 (1.01 ha) (see Figure 5-13 and Figure 5-14), of which Carpentarian Antechinus was identified during field surveys. This ridgeline is part of a large contiguous area of rocky habitat connected to areas where the species has been identified in previous studies in the region. As such, it seems reasonable to assume that Carpentarian Antechinus occur throughout the rocky hills and ridges to the north and south of Mica Creek. The remaining two intersections of rocky refugia habitat are small and the construction ROW only traverses the edge of these areas (cumulative total area of 0.03 ha). Therefore, although Carpentarian Antechinus may occupy these areas, direct impact at these locations is possible, but considered as low risk.

The rocky ridge to the south of KP 567 was initially classified as potential habitat; however, due to its significant isolation from other rocky areas and the lack of evidence of Carpentarian Antechinus during field studies (trap site CA6), this location is now considered unlikely to support the species.

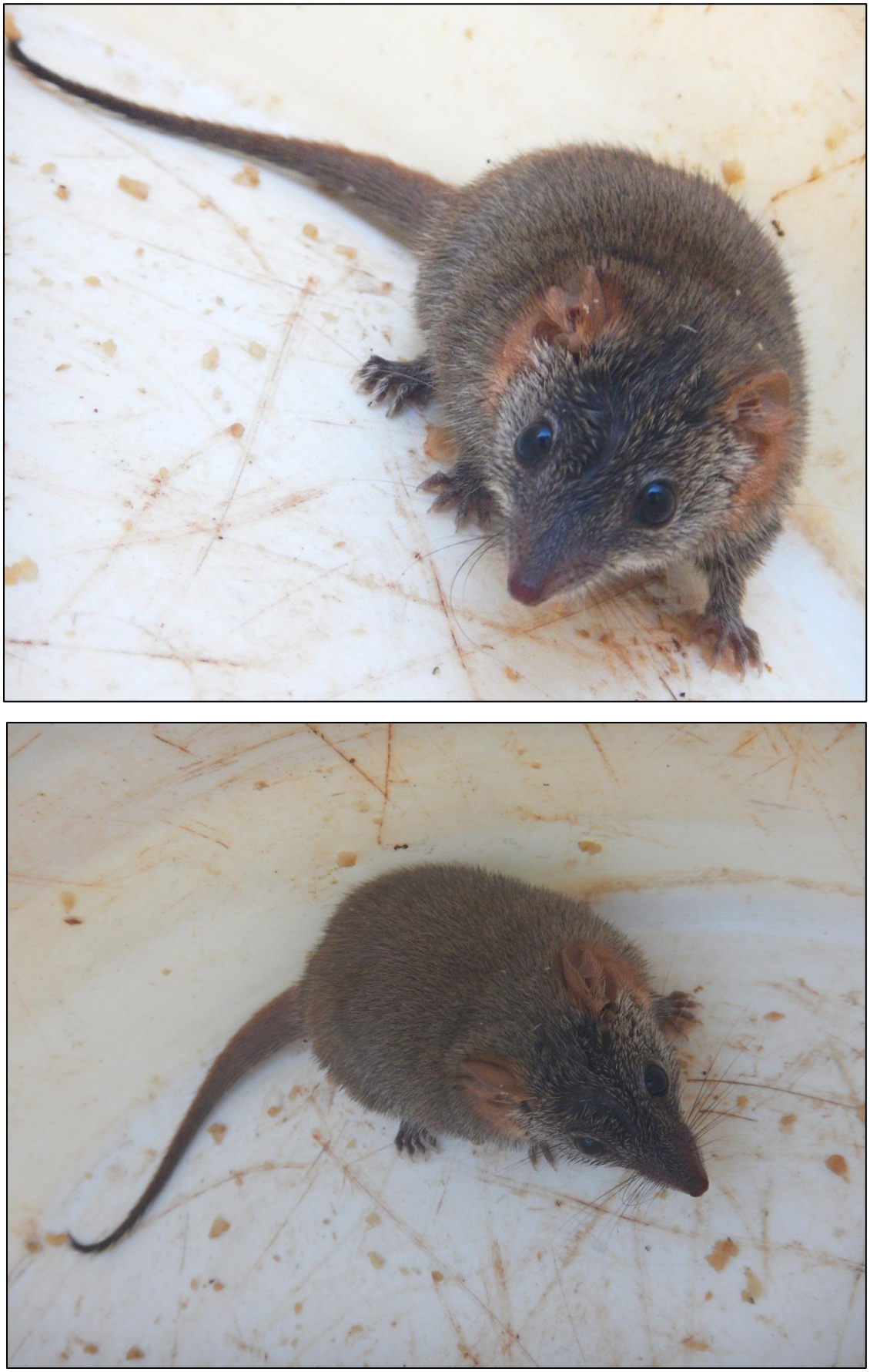


Figure 5-12. Photographs of Carpentarian Antechinus trapped at site CA1

Rocky scree slope at site CA1

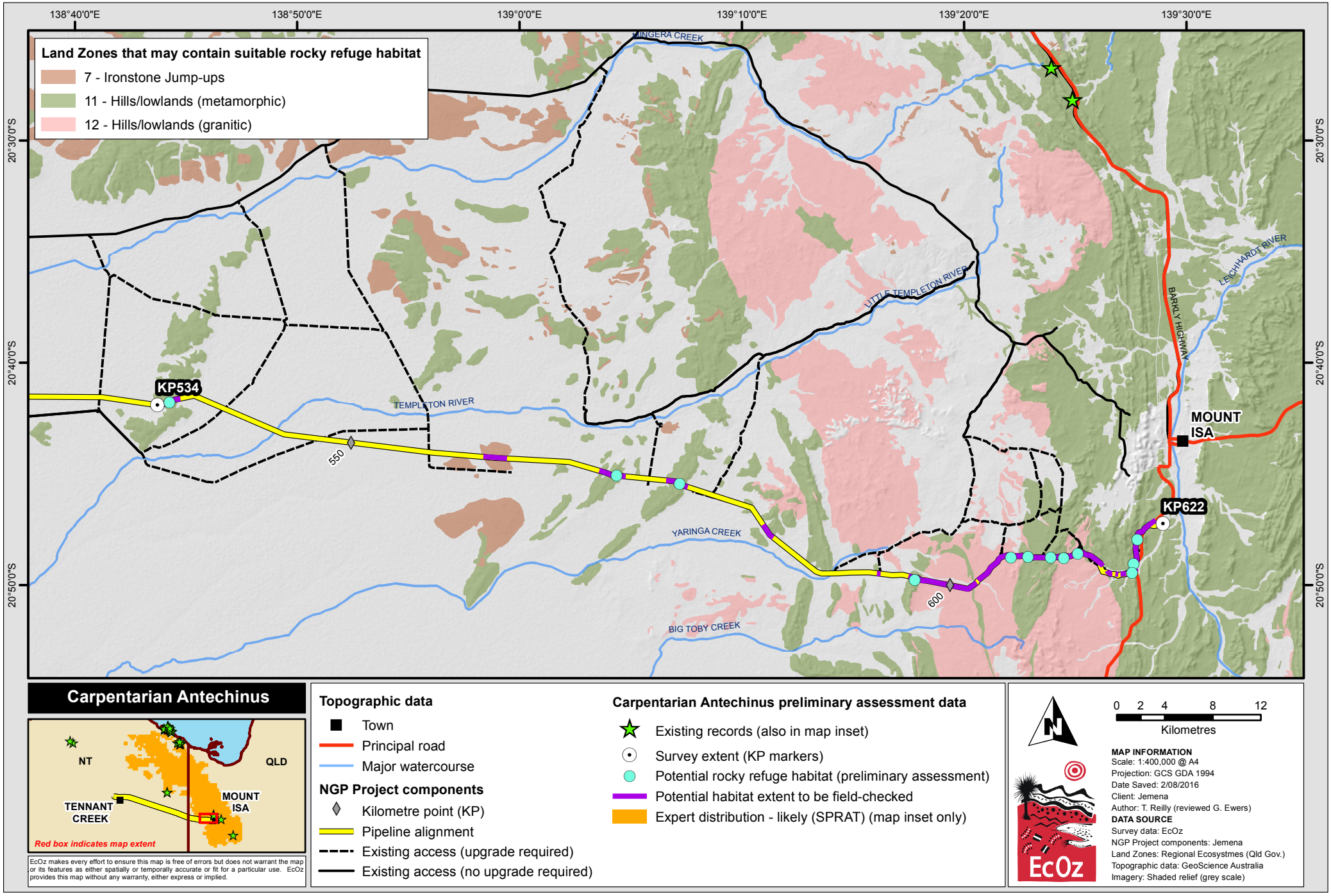
Rocky outcrop at site CA2

Figure 5-13. Photographs of Carpentarian Antechinus Elliott capture sites

Figure 5-14. Photographs of habitat at KP 617 that is likely occupied by Carpentarian Antechinus

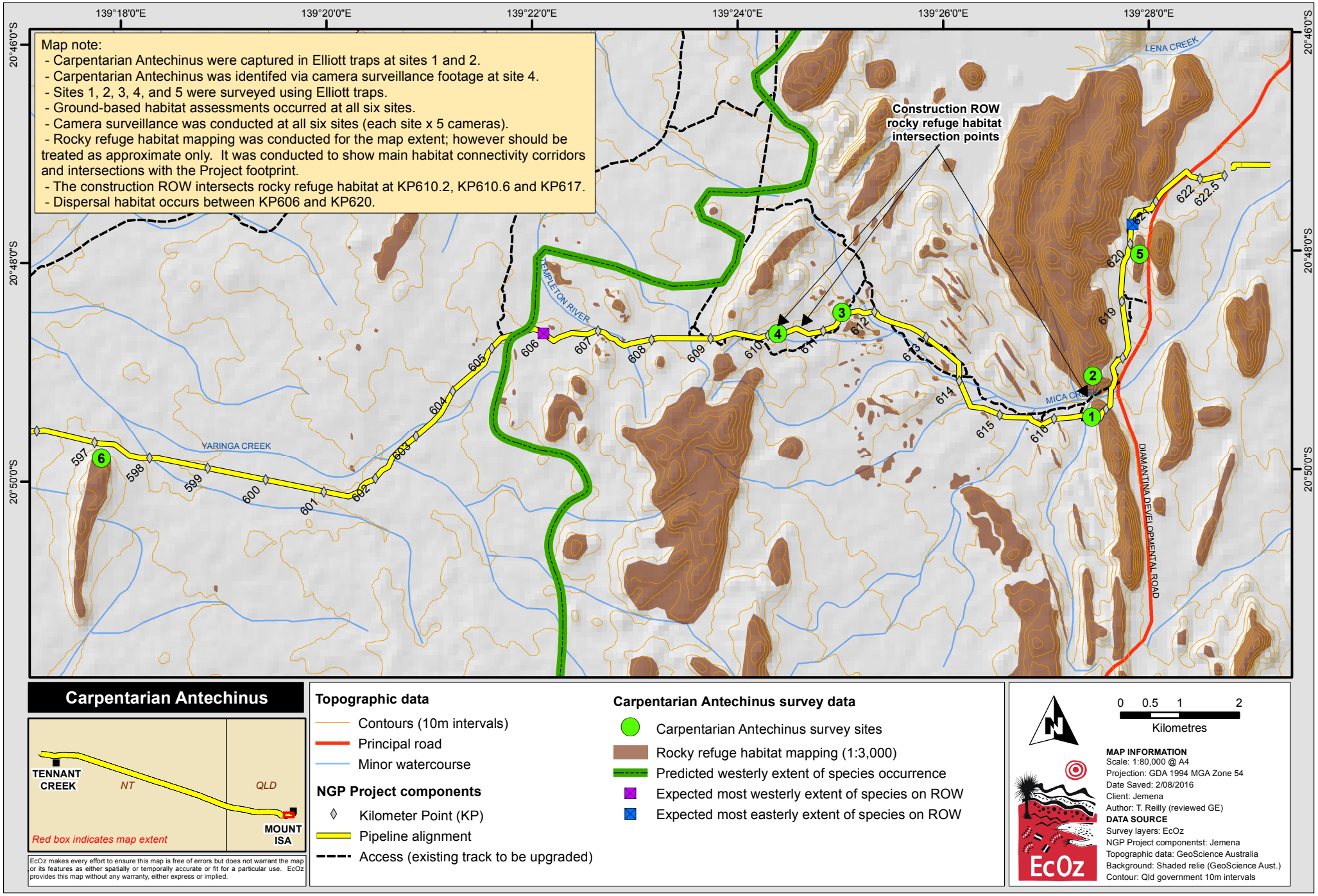
Figure 5-15. Photograph of camera-detected Carpentarian Antechinus at site CA4

Figure 5-16. Photograph of boulder pile where Carpentarian Antechinus was detected at site CA4



Path: C:\01. EcOz GIS Projects (TR)\Jemena\Project files\CA_Habitat_Records_v1.mxd

Figure 5-17. Map of Carpentarian Antechinus preliminary assessment information



Path: C:\01. EcOz GIS Projects (TR)\Jemena\Project files\CA_FieldSurvey_v3.mxd

Figure 5-18. Map of Carpentarian Antechinus field survey and rocky refuge habitat in local area

5.8 GREATER BILBY (*MACROTIS LAGOTIS*)

5.8.1 Conservation status

- Northern Territory: Vulnerable
- Queensland: Endangered
- National: Vulnerable

5.8.2 Background information

Description

The Greater Bilby is a rabbit-sized (up to 55 cm body length; tail up to 29 cm), omnivorous, burrowing marsupial (Pavey 2006a). It has grey-blue fur, large ears, a long pointed snout and a black tail with a white fluffy tip (Van Dyck & Strahan 2008). The forelimbs are relatively strong and have a robust set of claws for burrowing and foraging (Van Dyck & Strahan 2008).

Ecology

In the Northern Territory, Greater Bilby are found in a wide range of habitats including stony uplands, lateritic areas, hummock grassland sand plains, mulga scrub and woodlands, drainage depressions and palaeodrainage systems (Southgate 1987; Southgate 1990). Typical habitat for the species in the Northern Territory consists of sandy soils dominated by hummock grasslands covered predominantly by three species of spinifex – *Triodia basedowii, T. pungens* and *T. schinzii* (Pavey 2006b). Surveys in the Tanami Desert (Northern Territory) indicate that laterite and drainage lines were occupied more frequently than sandplains and dune systems (Southgate et al. 2005). However, when resources are plentiful the species will forage in a variety of habitat types (Southgate et al. 2005). When Greater Bilby occur on sand plain they more frequently occur on recently burnt areas compared to longer unburnt areas (Southgate et al. 2005; Southgate & Carthew 2006).

The Greater Bilby tends to avoid densely-vegetated areas. A patchwork of different post-fire ages of vegetation is preferred (Southgate & Carthew 2007). Fire seems to maintain the sparse vegetation they prefer, and promotes the ephemeral plants used as primary and secondary food sources, such as *Yakirra australiense* (Southgate & Carthew 2006; Southgate & Carthew 2007; Johnson 1989).

The Greater Bilby is nocturnal and generally solitary or in pairs (Van Dyck & Strahan 2008). However, they can aggregate in relatively high densities in areas where favoured food plants become abundant and easy to obtain, and can reach a density of 12 to 16 individuals per km2 in optimal habitat (Pavey 2006b). A density of 1 to 2 individuals per km2 is considered more typical (Pavey 2006b).

Greater Bilby move over a wide area according to available food and vegetation cover conditions (associated with seasons and fires) (Southgate & Carthew 2006; Southgate & Carthew 2007; Southgate 1987; Johnson 1989), and the long-term seasonal home range of a group of Greater Bilby may be large (up to hundreds of square kilometres) (Southgate 1987). Estimates of short-term, home range sizes are up to 3 km2 (Southgate & Paltridge 1998). Depleted food resources are the probable stimulus that results in vacating an area (Southgate 1987). This itinerant nature enables the Greater Bilby to respond to patchy and uneven food availability within the arid zone habitats (Southgate 1987).

The Greater Bilby has an opportunistic foraging strategy and feeds on a wide range of plant and animal taxa with major dietary components varying across seasons and geographic range (Pavey 2006b). Food is either excavated from the soil (holes can be 250 mm in depth; often referred to as diggings or scratchings), live captured on the surface, or seeds 'licked' from the soil surface. In the Tanami Desert, seed and bulb plant foods are a major dietary component of the Greater Bilby, in particular the seed of *Yakirra australiense*, and the bulb of *Cyperus bulbosus* (Southgate & Carthew 2006). Invertebrates (such as grubs and termites) are relied upon when food plants are scarce (Southgate & Carthew 2006).

They live in deep burrows excavated in sand that are 2 to 3 metres long, and 100 to 150 mm in diameter and the entrance is circular. The entrance is usually against a bush or surface irregularity, but may also occur in flat, featureless locations (Johnson 1989). The species appear to vacate burrows and reuse old burrows over time (Johnson 1989). An individual may have over a dozen regularly-used burrows within its home range, and several different burrows may be visited in a single night (SKM 2012; Pavey 2006b). Foraging distance from a burrow ranges from 200 to 600 m (Johnson 1989).

Greater Bilby can breed throughout the year (Pavey 2006b), with litter sizes typically two young and occasionally one or three (Southgate 1987). In good conditions, there is potential for four litters to be produced within a year (Southgate 1987).

Distribution

In the Northern Territory, recent records of the Greater Bilby occur within the Tanami bioregion, southern Sturt Plateau bioregion and the northern Great Sandy Desert bioregion (Pavey 2006a; Van Dyck et al. 2013), all located to the west of the Project footprint (point data presented within map inset in Figure 5-22). In Queensland, Greater Bilby has retracted to the south-west, which is 350 km from the Project footprint. Historically, the Greater Bilby occupied a substantial area of arid and semi-arid Australia. Its range and population declined dramatically following European settlement and it currently occurs across about 20% of its former range (Southgate 1990).

The Project footprint falls entirely within an area mapped by DoE (2016b) as 'species or species habitat likely to occur' (see map inset in Figure 5-22) (noting that the DoE 2016b dataset is not a population distribution map, but indicates the potential areas where Greater Bilby could persist).

Existing records and previous surveys

In the Northern Territory, the DLRM Fauna Atlas (2015 dataset) indicates there are 25 records of Greater Bilby within 50 km of the construction ROW (see Figure 5-22), of which 12 records have occurred between 1990 and 2004 (the remaining records being pre-1990). One of these records (from 1990) is located close to KP 3 on the western end of the construction ROW at 'White Devil Mine' (now decommissioned). The two 2004 records were adjacent to the Stuart Highway approximately 20 km south of Tennant Creek. All recent records of the species are located west of the Stuart Highway.

In the Northern Territory, there have been two relatively recent surveys for Greater Bilby in the region of the Project footprint:

- Gibson et al. (1994) conducted a regional flora and fauna survey of the Wakaya Desert, which included establishment of 28 sites and extensive opportunistic observations – to cover the 'desert sandplains' and eastern area of 'lateritic sand plains and rises' depicted in Figure 5-22. Although none of the sites recorded evidence of Greater Bilby, unequivocal signs of the species was observed at two locations – diggings at the base of Turpentine (*Acacia lysiphloia*) and an un-used burrow adjacent to a low, gravelly rise (Gibson et al. 1994) (both approximately 60 km south of KP 250 – Figure 5-22). The report considered it surprising that no other evidence of Greater Bilby was found despite the prevalence of suitable habitat.
- Low Ecological Services (2009) conducted a flora and fauna survey for the Wonarah Phosphate Project (operated by Minemakers Limited) in the approximate location of KP 270 to KP 285. They targeted Greater Bilby as part of their survey methodology and did not find evidence of the species, but concluded that suitable habitat and food resources are present in the area. The survey report noted that Traditional Owners within the Arruwurra Land Corporation have not observed Greater Bilby on their land.

There are no recent records within the vicinity of the Queensland section of the Project footprint, as the species has retracted to the south-west of Queensland (approximately 350 km from the Project footprint) and so is considered locally-extinct within the Queensland part of the Project footprint.

Threatening processes

Predation is a major threatening process to the Greater Bilby (Abbott 2001; Pavey 2006a; Pavey 2006b; Southgate et al. 2007). Predation by Red Fox (*Vulpes vulpes*) is a major threat to the Greater Bilby, while Feral Cat (*Felis catus*) and Dingo (*Canis lupus dingo*) also predate on the species. There is considerable interaction between these species, as Dingoes may (indirectly) protect the Greater Bilby by restricting Fox and Cat populations in certain areas (Pavey 2006b). It is known that predators persist in the region of the Project footprint – with recent records of Red Fox, Feral Cat, and Dingo (Gibson et al. 1994; Low Ecological Services 2009) (see Figure 5-22).

Competition with Feral Rabbits (*Oryctolagus cuniculus*) is an additional threatening process faced by the Greater Bilby, though the Project footprint falls outside of the known distribution of rabbits. The increase in One-humped Camel (*Camelus dromedarius*) numbers in western Northern Territory is also a potential threat to populations of the Greater Bilby. The large size of camels (up to 1000 kg) combined with their preference for dune systems can cause the destruction of burrows. That species tendency to consume a large portion of available plant species also poses a significant threat to Greater Bilby habitat (Pavey 2006b). It is possible that pastoralism will also have a similar impact.

5.8.3 Survey context

Purpose

If present within the Project footprint, Greater Bilby could be impacted by construction works – particularly by land clearing and facilitation of additional predator access to the region. The purpose of the survey was to identify whether any populations of this species occur within the Project footprint.

Overview

To achieve the abovementioned purpose, the survey was designed to:

a) Identify potentially-suitable habitat using desktop mapping datasets and advice from experts.

b) Conduct an aerial survey to identify signs of Greater Bilby and areas of high value habitat.

c) Conduct a ground-survey at representative sample sites for signs of Greater Bilby and assess habitat quality (specifically impact by cattle and presence of predator species).

5.8.4 Survey methodology

Existing survey guidelines

Commonwealth survey guidelines for the Greater Bilby are provided in the following reference:

- Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) 2011d, *Survey guidelines for Australia's threatened mammals – Guidelines for detecting mammals listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*. Commonwealth of Australia, 2011.

These guidelines are summarised below (noting that these techniques are designed for survey areas up to 5 ha in size; and the Project footprint greatly exceeds this survey area):

- Tracking surveys (1 ha sites with 2 hr survey effort) that involve:
  - Daytime searches for suitable habitat resources, such as hummock grassland in arid regions.
  - Daytime searches for signs of activity, including burrows, tracks, scats and diggings.
  - Collection of predator scats, owl casts or remains, targeting predatory bird/mammal nests/dens.

- Soil plot surveys (1 m^2 sand plots that are raked and checked for 3 consecutive nights).
- If confirmation of the species' presence is required after detection of signs, then spotlight surveys conducted at the entrances of burrows after dusk are a more time- and cost-efficient manner to directly observe the species than conducting a trapping survey.

Guidelines do not recommend a preferred time of year for surveying Greater Bilby

Survey design

Given the linear nature of the Project footprint, coupled with an extensive survey area (> 400 km of construction ROW and access track), survey methodology was designed based on the following information sources:

- Previous landscape-scale surveys within the Northern Territory arid zone (Southgate et al. 2005; Southgate & Carthew 2006; Southgate & Carthew 2007; Southgate et al. 2007)
- DoE guidelines for Greater Bilby (SEWPaC 2011d) (described above)
- Advice from Dr Richard Southgate (private consultant, Greater Bilby specialist), and Peter MacDonald (Fauna Ecologist, Northern Territory Department of Land Resource Management).

The survey methodology adopted for the Project footprint used a combination of aerial-based (helicopter) and on-ground survey methodologies as was advocated by Southgate et al. (2005). Greater Bilby diggings (and occasionally burrows) were able to be seen from the air and larger distances with a wider 'field of view' could be observed compared to ground transects. The on-ground plots were used to ground-truth observations seen from the air and collect additional species occurrence and habitat information.

The following methodology was developed in consultation with, and endorsed by, Dr Southgate.

Survey area and target habitat

It is assumed that Greater Bilby (if still extant in the region) will be restricted to the Tennant Creek Sandplains within the Northern Territory, which encompasses the following components of the Project footprint (see Figure 5-22):

- Construction ROW – KP 0 to 350 (i.e. 350 km)
- Access tracks (existing, requires widening) x 8 – total length of 102 km
- Access tracks (to be constructed) x 8 – total length of 145 km
- Camp locations x 3 – 12 ha each

It is considered more likely that Greater Bilby will occur in the first 150 km of the Project footprint (western end of the ROW) due to the closer proximity to known populations in the Tanami Desert.

Greater Bilby are not expected to occur in the Barkly Clay Plains (of the Northern Territory) nor in Queensland parts of the Project footprint. This was supported by DLRM and Dr Richard Southgate (private consultant, Greater Bilby specialist).

Project footprint habitat mapping (see Section 4), reconnaissance survey aerial footage (see Section 3), and numerous publications on Greater Bilby habitat and diet in the Tanami Desert (Pavey 2006a; Pavey 2006b; Southgate 1990; Southgate et al. 2005; Southgate & Carthew 2006; Southgate & Carthew 2007; Southgate et al. 2007) were reviewed to identify high value habitat types within the survey area. These areas are considered to have a higher chance of Greater Bilby occupancy:

- Alluvial floodplains and playas. Particularly locations that support large termite mounds from the species *Nasutitermes triodiae*, as these are indicative of underlying palaeodrainage channels. Existing land resource mapping indicates that no palaeodrainage channels occur in the vicinity of the Project footprint; however, habitat mapping presented in Section 4 indicates that alluvial plains and playas are present in low densities.

- Rocky rises (particularly lateritic based rises). Habitat mapping (see Section 4) indicates that low rocky rises are crossed by the Project footprint in the western and eastern part of the Greater Bilby survey area (the central part of the survey primarily sand plain with little habitat variation).
- Recently burnt areas (< 1 year) within drainages, sandplains or rocky rises. These areas are known to support post-fire grasses that are foraged by Greater Bilby for seed. The main target post-fire grass species for this survey is Desert Flinders Grass (*Yakirra australiensis*). Land Sat imagery from February 2016 (30 m resolution) and NAFI fire scar mapping from 2015 / 2016 (250 m resolution) were used to help locate recent fire scars prior to conducting field work.
- Shrub lands food plants. Shrublands that contain flora species that are known to support root-eating grubs (target food source for Greater Bilby). Target flora species relevant to the survey area are Turpentine (*Acacia lysiphloia*), Flying-saucer Bush (*Acacia hilliana*) and Cockroach Bush (*Senna notabilis*).

Aerial transects

Aerial transects were conducted to identify Greater Bilby signs and select sites for targeted on-ground searches (on-ground search methodology is described in section below).

A continuous aerial transect was conducted between KP 0 and KP 350, and separate transects were conducted along seven proposed access tracks within the Greater Bilby survey area (see Figure 5-22) covering a distance of approximately 490 km. Fieldwork occurred between the 2 and 7 May 2016 (in conjunction with on-ground surveys, described below).

The helicopter was flown at a speed of 18 – 30 knots (33 to 55 km/hr) and at a height of 15 to 20 m above ground level (photographs in Figure 5-19 and Figure 5-20 provide an example of surveyor observation aspect from the helicopter). Two surveyors (Tom Reilly and Mark Carter, refer to Section 5.3.1 for experience) were seated on either side of the helicopter, each observing a search strip approximately 30 m wide (to make a total search strip of 60 m). The aerial survey recorded the following data:

- **Putative Greater Bilby sign** was identified based on the characteristics:
  - Large burrow that had a round appearance
  - Large spoil heap adjacent to a shrub that obstructed view of burrow or digging
  - Large hole or trench
  - Diggings under Turpentine (*Acacia lysiphloia*) or other shrubs that support root-dwelling larvae
  - Diggings with spoil evenly distributed around the dig

  (see Figure 5-20 for an example of a putative Greater Bilby sign from the survey).
- **Putative goanna sign** was identified based on the characteristics
  - Burrow with crescent / kidney shape
  - Burrows that are wider than they are high
  - Digging with distinct triangular shape
  - Digging with spoil distributed on one side

  (see Figure 5-19 for an example of a putative goanna sign from the survey).

Fresh burrows, diggings and scratching's were relatively easy to see from the air because excavated soil had a richer (red) colour in contrast to the sun-bleached surface soils.

Predator signs (Red Fox, Feral Cat and Dingo) that could be identified from the air were also recorded.

Some fauna observations and signs were able to be validated from the air while hovering. All putative Greater Bilby records and a sample of putative goanna sign was examined using on-ground survey methods (described below).

On-ground survey (i.e. track-plots)

On-ground surveys occurred in conjunction with aerial transects. The survey was primarily designed to determine whether Greater Bilby were present on the proposed Project footprint. While aerial survey can provide a rapid continuous assessment of the area, there are risks that both imperfect detection (false absence) and misclassification (false presence) of Greater Bilby sign. Ground truthing of putative signs and careful examination of habitat considered of high value provides an important step to correctly assess occupancy. The aim of survey results is to produce high true positives and negatives (as this measures data sensitivity and specificity, respectively)

On-ground surveys used track-plot methodology described in Moseby et al. (2012), which is a standardised technique designed to assist in recording information on a range of fauna species in arid and semi-arid habitat types. This method is commonly used in central Australia (pers. comm. Richard Southgate 2016) and information can be readily added to the national database on arid zone fauna (Moseby et al. 2012).

Track-based surveys incorporates the key components of survey guidelines for Greater Bilby advocated by the Commonwealth Government (SEWPAC 2011).

Plots dimensions were ~100 x 200 m (i.e. 2 ha), and avoided existing roads and cleared areas. Each plot was surveyed for a 30-minute period zig-zagging up one side and back down the other. Signs of Greater Bilby, goanna, Echidna, Red Fox, Feral Cat etc. was recorded based on fresh track and gait characteristics. Additionally, Greater Bilby presence could be validated if fresh diggings at the base of shrubs and forbs for root-dwelling larvae and scats were detected.

For each track-plot, the following data were recorded:

- Site location details (i.e. site name, GPS coordinate, time etc.)
- Habitat/vegetation notes and site photograph
- Presence and cover of food indicator species – *Yakirra australiensis, Acacia lysiphloia, Acacia hilliana, Senna notabilis* and *Dactyloctenium radulans*
- Fire history at the site – recent (< 1 year), relatively recent (1 to 3 years), long unburnt (> 3 years)
- Variables that may affect tracking conditions, such as time since rain, cloud cover, surface soil substrate, time of day, time of year etc.
- All tracks, burrows, diggings, sightings, or scats of each species – including an age and abundance estimate of each sign.
    - Age estimate – fresh (1 to 2 days); recent (3 to 7 days); old (> 7 days)
    - Abundance estimate – abundant (signs in all 4 corners of site); common (signs in half the site); uncommon (individual signs only or found in ¼ of site).
- Aim to conduct tracking surveys with sun in front so shadows are not obscured.

Track plot sites were selected based on the following criteria:

- At all instances where putative Greater Bilby signs were identified from the air (aerial survey described above), irrespective of how far the sites were spaced apart. These sites were conducted to verify identification (therefore presence) of aerially-observed Greater Bilby sign.
- Habitat types considered to be of high value (described above) within the Project footprint. These sites were (generally) spaced at 10 km to 15 km intervals to create a spatial representation of the Project footprint. Shorter intervals (i.e. approx. 10 km) occurred between

KP 0 and KP 150 as this stretch is considered to have a higher likelihood of occurrence due to closer proximity to Tanami Desert Greater Bilby populations. High values sites were primarily selected to determine whether Greater Bilby signs were being missed during aerial survey.

- Aerially-recorded putative goanna signs were also ground-truthed at a selection of sites to verify identification is correct.

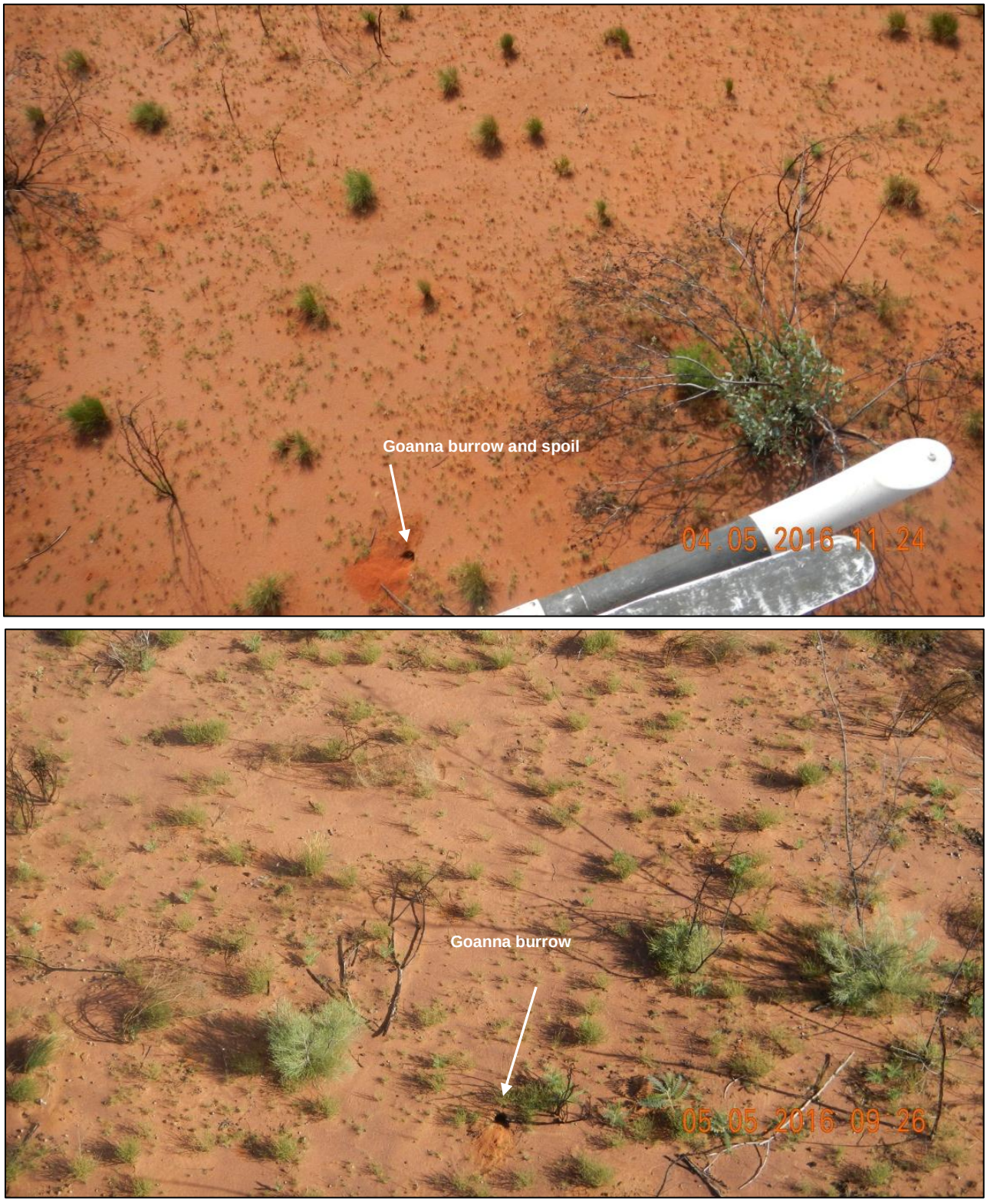


Figure 5-19. Photographs of a putative goanna sign observed during the Greater Bilby aerial survey

5.8.5 Results

Tracking conditions

- Light rainfall occurred across the survey area on the first night of the survey (2 May 2016) (however, no rainfall registered at Tennant Creek Weather Station 015135). Rainfall removed signs of fauna tracks; however, diggings and burrows from a range of fauna (large and small) were still present – which suggests that Greater Bilby signs could be identified, if present.
- Soil substrate varied between sites in terms of identifying fauna tracks. Some sites had gravelly surface or harder loams (in alluvial flood plains); however, the majority of sites had at least 50% red-sand substrate that was highly suitable for detecting fauna tracks. Burrows and diggings were assumed to be visible on 100% of the track-plots.
- Overcast conditions were experienced on the 2 and 3 May 2016, which reduced shadow visibility. Consequentially, track plots were searched for longer periods when those conditions were experienced (to ensure that trackable surfaces had been properly inspected).
- Cattle trampling of soil substrate also reduced the quality of tracking conditions in some areas (mainly reduced the visibility of tracks, not burrows and diggings). Cattle impacts were present in the western portion of the survey area in Phillip Creek Station and Tennant Creek Station (see tracking data in Table 5-7).
- The aerial transects had clear visibility of fauna signs in the recently burnt areas due to the resultant low cover of vegetation; therefore many 'Hover Sites' were used for sign confirmation rather than on-ground survey (see photographs of aerial signs in Figure 5-19 and Figure 5-20).
- Rocky rises often had low and open vegetation cover, which meant that aerial observations were very accurate in these areas.
- In summary , tracking conditions (soil surface and weather) experience during the survey period were suitable for identifying characteristic Greater Bilby sign, as all track-plots showed evidence of general fauna signs (see Table 5-7).
- All track-plots resulted in identification of fauna signs (see Table 5-7).

Aerial transect data

- Eighteen sites were recorded as 'Putative Greater Bilby Sign'. These sites required a ground-check to confirm sign identification, described in track-plot data below). One in particular (site TP60) appeared very much like a Greater Bilby sign (Figure 5-20). This site had numerous diggings and burrows consistent with Greater Bilby.
- There were 1 374 sites recorded as 'Goanna Sign', of which 1 350 were diggings and burrows from large goanna. These records were consistently recorded along the survey transect and in a variety of habitats with differing soil substrates - i.e. sand plains, low rocky rises, and Mulga red earth plains (see Figure 5-22).
- There were 65 'Hover Sites' noted (Figure 5-22). These locations had a sign that was possibly from Greater Bilby; however, it was confirmed to be from another species (in all cases goanna) once the helicopter circled or hovered at each site.
- Other species signs recorded were
    - Feral Cats (*Felis catus*) (12 sites)
    - Dingo (*Canis lupis dingo*) (2 sites)
    - Australian Bustard (*Ardeotis australis*) (7 sites)
    - Bush Stone-curlew (*Burhinus grallarius*) (2 sites)
    - Red Kangaroo (*Macropus rufus*) (1 site).

On-ground survey data

Greater Bilby evidence

- There was no definitive evidence of Greater Bilby observed during the survey.
- None of the 18 locations identified form the air as a putative Greater Bilby sign could be verified with ground-truthing. The most promising location was verified as Sand Goanna, *Varanus gouldii*) (Table 5-7; Figure 5-20). This particular site, TP60, was located within a small depression within an alluvial floodplain and contained many tracks, burrows, diggings and scats from Sand Goanna.
- Of the 17 remaining putative Greater Bilby sites (see Table 5-7), 15 were confirmed to be large goanna once inspected on-ground (likely Sand Goanna, Varanus gouldii). Three sites (TP04, TP21, and TP24) had signs (diggings or burrows) that were not clearly attributed to any species (including Greater Bilby). At these three sites, surveyors concluded that the signs did not belong to Greater Bilby and most probably belonged to goanna (based on lack of other evidence of Greater Bilby and abundance of fresh goanna signs at the sites).
- None of the 35 habitat sites surveyed had evidence of Greater Bilby (see Table 5-7). Habitat assessment is provided in following section.

Goanna sign

- Fifteen 'goanna check sites' were surveyed (all located within 'Habitat Sites'), of which all were confirmed as goanna once assessed on-ground.
- Three out of 53 sites (5.6%) found goanna diggings and burrows during on-ground surveys that were not observed during aerial observations. These three sites (site TP15, TP40 and TP50) were all located in vegetation that had not burnt for at least 3 years (i.e. fauna sign obstructed by denser vegetation cover)
- Of the 53 track-plot sites visited, large goanna burrows, tracks or diggings were observed on 70% of the track-plot sites during the survey – most of these signs were likely from Sand Goanna (*Varanus gouldii*). Signs were spatially spread across the entire Greater Bilby survey area. Surveyors also identified potential signs of Yellow-spotted Monitor (*V. panoptes*) within the Gosse River alluvial floodplains (on Tennant Creek Station) – two large and robust individuals were observed from the helicopter and there was some evidence of large goanna burrows in the area that were assumed to be from Yellow-spotted Monitor. There are no official records of this species in the Tennant Creek region (according to Atlas of Living Australia and Northern Territory Fauna Atlas 2016); however, discussions with local naturalists suggest that the species has been periodically recorded in the alluvial floodplain environments within the region (Jesse Carpenter, pers. comm. 2016).

Predators and other introduced species

- Track-plot surveys recorded a range of introduced fauna species (see Table 5-7). Track type, abundances of sign, and age of the sign are discussed below and provided in Appendix J.
- Dingos (*Canis lupus dingo*) tracks and/or scats were observed in 8% of track-plot sites. When present, signs were uncommon and varied from fresh tracks to old scats.
- One recent Red Fox (*Vulpes vulpes*) track was possibly identified (at site GB32) (see photo in Appendix K) (see Figure 5-22). Total confirmation was not possible due to track quality and absence of other reference tracks within the track-plot.
- Evidence of Feral Cats (*Felis catus*) (either tracks, scats, and sightings) was observed in 25% of track-plot sites. Cats were also 'flushed' out of vegetation by the helicopter on a few occasions.

It is likely that cats occur across the entire survey area as signs of the species were reasonably spaced along the survey transects (see Table 5-7; Figure 5-22).

- Camel (*Camelus dromedarius*) tracks and/or scats were observed in 8% of the track plot sites. When present, signs were uncommon and old.
- As expected, Domestic Cattle (*Bos taurus*) signs (36% of track-plot sites) were fresh and abundant in the western part of the survey area (as that area is within Phillip Creek Station and Tennant Creek Station).
- No signs of Rabbit were detected, which is consistent with other studies and estimated population distribution of the species.

Signs of native species record on track-plot sites

- Track-plot surveys recorded a range of native fauna species. Fresh (and old) fauna signs were identified within each track-plot (see Table 5-7). Track type, abundances of signs, and age of the sign within each track-plot are discussed below and provided in Appendix J.
- Small goannas were observed on 34% of track-plot sites, and are most likely from *V. eremius* and *V. brevicauda*.
- Small lizard signs were commonly observed during the survey, with 7% of the track-plots sites showing evidence (often fresh) of a variety of species. Direct sightings included *Carlia munda, Cryptoblepharus sp., Ctenophorus isolepis, Ctenophorus nuchalis, Ctenotus greeri, Ctenotus leonhardii, Ctenotus pantherinus, Ctenotus piankai, Ctenotus robustus, Delma sp., Diplodactylus conspicillatus, Diporiphora sp., Heteronotia binoei, Lerista sp*. (likely bipes), *Lialis burtonis, Lucasium stenodactylum, Menetia greyii, Morethia ruficauda, Rhynchoedura ornata* and *Strophurus ciliaris*.
- Large snake signs were observed at 6% of the track-plot sites. Two species were observed during the survey – Black-headed Python (*Aspidites melanocephalus*) (photo in Appendix K) and Mulga Snake (*Pseudechis australis*). Small snake tracks were observed in 9% of the track-plot sites (species not identified).
- Centralian Blue-tongued Lizard (*Tiliqua multifasciata*) was observed by tracks and sightings on 6% of the track-plot sites (photo in Appendix K). When present, signs were uncommon but fresh.
- Button-quails tracks and/or day roost sites were observed in 43% of the track-plot sites (photo in Appendix K), and were found to be fairly common and widespread across the 'desert sandplains' and 'lateritic plains and rises' (observed during the aerial transect survey). The bipedal stride of button-quails was often abundant and very fresh at the sites where they were recorded. Little Button-quail (*Turnix velox*) were considered common, and Red-Chested Button-quail (*Turnix pyrrhothorax*) were only observed at three sites (TP11, 13, and 23). Brown Quail (*Coturnix ypsilophora*) was observed at site TP61 (ephemeral playa).
- Australian Bustard tracks (*Ardeotis australis*) were observed on 23% of track-plot sites, and also sighted (in pairs) on many other occasions during the aerial transect survey.
- Hopping bird tracks (i.e. from babblers, robins, finches, wrens, bell-birds etc.) were observed in the sand plains in the latter part of the survey (after initial rains had ceased).
- A large rodent – putatively identified to be Long-haired Rat (*Rattus villosissimus*) – was observed at site TP2 when flushed out of a spinifex hummock.
- Tracks of unidentified moderate to large rodents or dasyurids were observed at three track-plot sites (TP32, TP34 and TP49). Only a few tracks were present, therefore a confident identification to species level was not plausible. They most likely belonged to Long-haired Rat

(*Rattus villosissimus*) (species sighted on multiple occasions during survey), but may be Brush-tailed Mulgara (*Dasycercus blythi*) or Dunnarts (*Sminthopsis* spp.) (of which evidence of both species was not observed during surveys). Brush-tailed Mulgara are discussed further in Section 5.10 (Brush-tailed Mulgara Survey).

- Small rodent signs were observed at 38% of the track-plot sites, mostly in the second half of the survey. It was thought these signs may belong to any of the following species – *Leggadina forresti, Pseudomys desertor, Pseudomys hermannsburgensis* or *Mus musculus*. There was potential evidence of old (inactive) pebble mounds from *Pseudomys johnsoni* on the low rocky rises within the far eastern part of the survey area (photo in Appendix K).
- Spinifex Hopping Mouse (*Notomys alexis*) tracks and/or pop holes were observed in 23% of the track-plot sites. When present, signs were abundant and fresh.
- Red Kangaroo (*Macropus rufus*) tracks and/or scats were observed at 21% of the track-plot sites. When present, signs were uncommon and old.
- Northern Nailtail Wallaby (*Onychogalea unguifera*) scats and tracks were observed at 4% of the track-plot sites. When present, signs were uncommon and old.
- Spectacled Hare-wallaby (*Lagorchestes conspicillatus*) (listed as Near Threatened under the TPWC Act, Northern Territory) scats (a few days old) were recorded (and collected) at one site (TP15). Scats were relatively fresh and scattered along the edge of an existing track over a 20 m distance. This species was found to be widespread in 1993 in the Wakaya desert (Gibson et al. 1994)

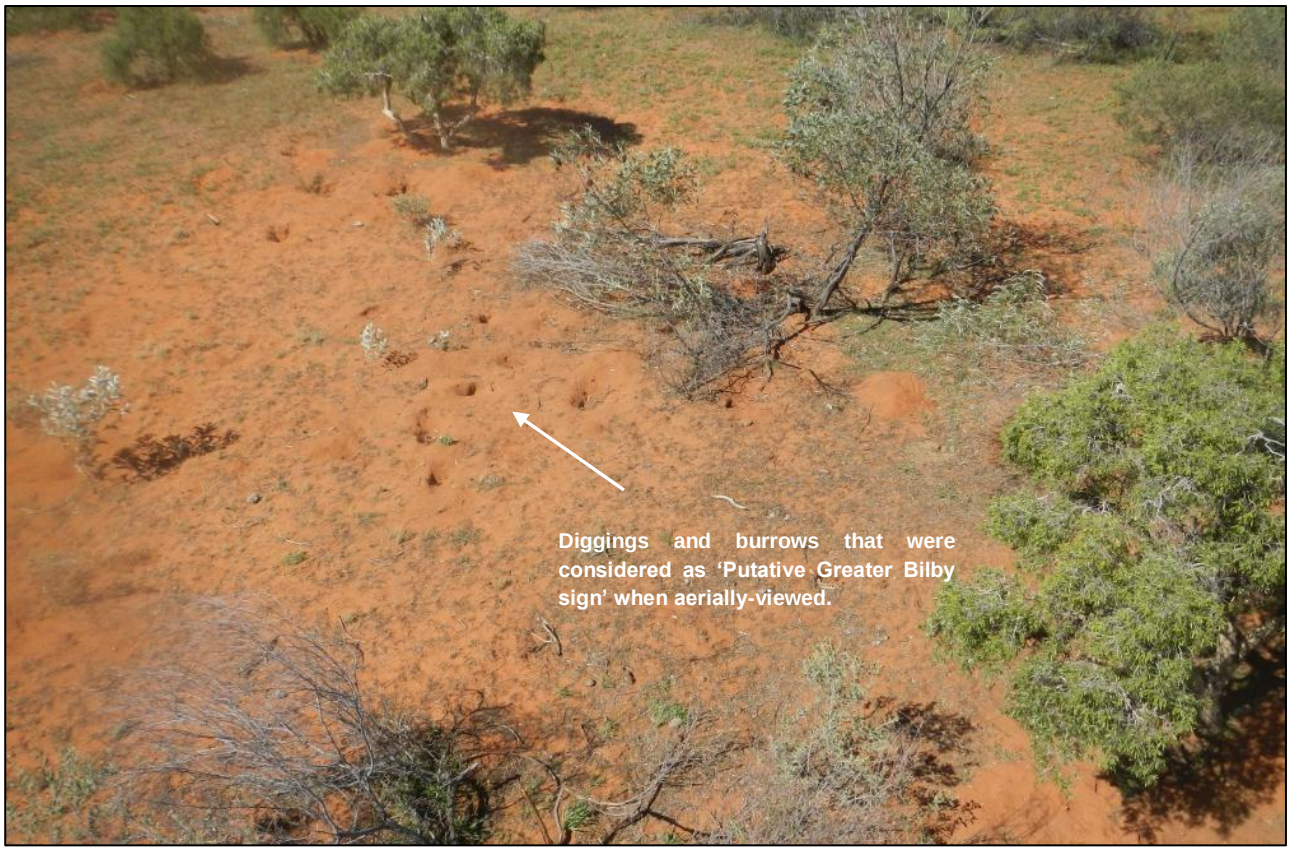


Figure 5-20. Photograph of 'Putative Greater Bilby sign' observed during the aerial survey

Table 5-7. Greater Bilby track-plot summary results

Note – tick points presented in this table indicate that evidence of a species (or group) was recorded at the track-plot site. Data on abundance and age of sign is discussed in the text of this report.

Site category: GB – Confident Greater Bilby (purple shade); Pu – Putative Greater Bilby Site (green shade); Hb – Habitat Site (white shade)

Land form key: Sp – sand plain; Rr – low rocky rise; Al – alluvial floodplain; Dp – depression; Sk – sinkhole; Py – playa.

Fire history key: >3 – more than 3 years since last fire; 2 – between 1 and 3 years since last fire; <1 – less than 1 year since last fire.

Weather conditions (i.e. track visibility) key: Gd – good, clear skies, distinct shadow present; Av – average, cloudy, slight or no shadow present; Pr – poor, raining, no shadow and tracks washed away.

Tracking surface key: Gd – good, > 50% of the site supports sands suitable for tracking a variety of species; Av – average, 20 to 50% of the site supports sands suitable for tracking a variety of species; Pr – poor, < 20% of the site supports sands suitable for tracking a variety of species.

GREATER BILBY SURVEY	TRACK-PLOT SITES																																																					Total (all plots)	
Date	2-May-16								3-May-16											4-May-16								5-May-16						6-May-16								7-May-16													
Site (prefix TP)	1	2	3	4	5	6	7	8	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30	31	32	33	34	35	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	60	61	62		
Site category	Hb	Pu	Pu	Pu	Hb	Pu	Pu	Hb	Hb	Pu	Pu	Hb	Hb	Hb	Pu	Pu	Pu	Hb	Pu	Pu	Pu	Hb	Pu	Hb	Hb	Hb	Hb	Hb	Pu	Pu	Hb	Hb	Pu	Hb	Hb	Hb	Hb	Hb	Hb	Hb	Hb	Hb	Hb	Hb	Hb	Hb	Hb	Hb	Hb	Hb	GB	Hb	Hb		
Landform	*Ls*	*Ls*	*Rr*	*Ls*	*Sp*	*Sp*	*Ls*	*Rr*	*Sp*	*Ls*	*Ls*	*Rr*	*Ls*	*Ls*	*Sp*	*Sp*	*Sp*	*Al*	*Sp*	*Ls*	*Ls*	*Sp*	*Sp*	*Sp*	*Sp*	*Sp*	*Sp*	*Sp*	*Sp*	*Sp*	*Sp*	*Sp*	*Sp*	*Sp*	*Sp*	*Dp*	*Rr*	*Rr*	*Rr*	*Ls*	*Rr*	*Sp*	*Sp*	*Sp*	*Rr*	*Rr*	*Rr*	*Dp*	*Sp*	*Sk*	*Dp*	*Py*	*Py*		
Fire history	*>3*	*>3*	*>3*	*>3*	*>3*	*<1*	*>3*	*>3*	*<1*	*2*	*2*	*>3*	*<1*	*>3*	*>3*	*<1*	*>3*	*>3*	*<1*	*>3*	*2*	*<1*	*<1*	*>3*	*<1*	*<1*	*>3*	*>3*	*>3*	*>3*	*<1*	*<1*	*<1*	*>3*	*2*	*>3*	*>3*	*2*	*>3*	*>3*	*2*	*>3*	*>3*	*>3*	*>3*	*2*	*>3*	*>3*	*>3*	*>3*	*>3*	*>3*	*>3*		
Weather conditions	*Av*	*Av*	*Av*	*Av*	*Gd*	*Av*	*Av*	*Gd*	*Pr*	*Av*	*Av*	*Av*	*Av*	*Gd*	*Av*	*Av*	*Av*	*Av*	*Av*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Av*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Av*	*Av*	#	%
Days since rain	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*3*	*3*	*3*	*3*	*3*	*3*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*		
Tracking surface class	*Av*	*Av*	*Pr*	*Av*	*Av*	*Av*	*Av*	*Pr*	*Gd*	*Gd*	*Av*	*Pr*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Pr*	*Gd*	*Pr*	*Av*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Av*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Av*	*Pr*	*Av*	*Av*	*Av*	*Gd*	*Gd*	*Gd*	*Gd*	*Gd*	*Av*	*Pr*	*Gd*	*Pr*	*Gd*	*Pr*	*Av*		
Native reptiles																																																							
Large goanna	✓	✓	✓	✓		✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										✓	✓				✓		✓	✓	✓	**36**	*68*
Small goanna										✓		✓	✓		✓										✓			✓			✓	✓	✓		✓	✓	✓		✓	✓	✓	✓				✓	✓							**18**	*34*
Small lizard	✓	✓	✓		✓		✓		✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			**41**	*77*
Large snake															✓									✓		✓																												**3**	*6*
Small snake																								✓						✓				✓	✓				✓															**5**	*9*
Centralian Blue Tongue																								✓	✓																		✓											**3**	*6*
Native birds																																																							
Button-quail			✓																✓		✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓				✓	✓	✓	✓	✓	✓		✓					**23**	*43*
Australian Bustard	✓																							✓	✓	✓		✓		✓		✓		✓			✓			✓		✓				✓								**12**	*23*
Bush Stone-curlew																																															✓							**1**	*2*
Hopping bird																																✓	✓		✓		✓	✓	✓	✓	✓			✓					✓		✓			**11**	*21*
Native mammals																																																							
Rodent / large dasyurid																														✓		✓											✓											**3**	*6*
Small rodent																✓				✓		✓		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓			✓	✓						**20**	*38*
Large rat		✓																																																				**1**	*2*
Spinifex Hopping Mouse																✓								✓	✓		✓			✓	✓	✓	✓						✓			✓	✓	✓										**12**	*23*
Red Kangaroo		✓			✓		✓	✓	✓	✓						✓					✓							✓	✓									✓																**11**	*21*
Northern Nailtail Wallaby							✓									✓																																						**2**	*4*
Spectacled Hare-wallaby														✓																																								**1**	*2*
Dingo												✓				✓									✓																									✓				**4**	*8*
Invertebrates																																																							
Insect																									✓							✓		✓	✓							✓	✓		✓	✓	✓				✓			**10**	*19*
Introduced species																																																							
Fox																														✓																								**1**	*2*
Cat							✓						✓			✓								✓	✓					✓	✓	✓		✓	✓				✓			✓					✓							**13**	*25*
Camel										✓			✓		✓	✓																																						**4**	*8*
Cattle	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓							✓																			✓			✓				**19**	*36*
Total within each plot	**4**	**5**	**4**	**2**	**3**	**1**	**4**	**2**	**3**	**6**	**3**	**5**	**6**	**2**	**7**	**9**	**2**	**3**	**3**	**3**	**5**	**3**	**3**	**8**	**11**	**6**	**3**	**8**	**4**	**10**	**7**	**11**	**7**	**8**	**8**	**2**	**3**	**4**	**6**	**3**	**4**	**8**	**7**	**6**	**4**	**5**	**8**	**2**	**4**	**3**	**4**	**1**	**1**		

Habitat assessment data

- Track-plot site descriptions and photographs are provided in Appendix J. Some basic habitat descriptors are provided in Table 5-7.
- The number of track-plot sites of each landform traversed by the Project footprint within the potential Greater Bilby zone are provided in Table 5-8. General landform descriptions are provided in Section 4.
- Despite the absence of Greater Bilby sign, four indicator plant species were observed in 34 of the 53 track-plot sites – *Yakirra australiensis, Senna notabilis, Acacia lysiphloia, Acacia hilliana*. These species provide seeds or grubs that form a key component of the Greater Bilby diet:
    - Desert Flinders Grass (*Yakirra australiensis*) was observed in 8 of the 53 track-plot sites, all in low densities. Six of these sites (TP17, 24, 27, 33, 34, and 35) had burnt < 1 year ago (Desert Flinders Grass is commonly found in recently burnt areas). In the other two sites (TP4 and 21) that had not experienced a recent burn, it was located in open areas.
    - Cockroach Bush (*Senna notabilis*) was observed, and occurred at varying densities, in 6 of the 53 track-plot sites – typically found in freshly burnt areas. Greater Bilby are known to feed on grubs that feed on roots of Cockroach Bush.
    - Turpentine (*Acacia lysiphloia*) was observed, and occurred at varying densities and maturity, in 14 of the 53 track-plot sites. Typically found in sandplains that had not been recently burnt. Greater Bilby are known to feed on grubs that feed on roots of Turpentine.
    - Flying-saucer Bush (*Acacia hilliana*) was observed, and occurred at relatively high densities (although patchy) on low rocky rises, in 10 of the 53 track-plot sites. Greater Bilby are known to feed on grubs that feed on roots of Flying-saucer Bush.
- Twelve track-plot sites were surveyed in areas that had been recently burnt (i.e. < 1 year).
- Aerial transects identified that several large areas that have been recently burnt. NAFI indicates there have been 2 to 3 large-scale fires within the western portion of the survey area within the last 12 years (Figure 2-9).
- Alluvial floodplains within the survey area are not similar to palaeo-drainage channels in the Tanami Desert. They are heavily impacted by cattle and have a woodland community over tussock grasses. These areas are not considered as ideal habitat for Greater Bilby.
- Two locations along the construction ROW supported large bulbous termitaria mounds (see photograph in Figure 5-21), situated in localised depressions rather than palaeo-drainages and only 2 or 3 mounds were present.

Table 5-8. Greater Bilby sites within each habitat type (specific to bilby survey)

Landform	# sites	Track-plot site reference (TP prefix)
Sandplains – desert, lateritic	24	5, 6, 16 -18, 20, 23 - 28, 30 - 35, 40, 41, 48 - 50, 55
Sandplains – loamy, red earths	11	1, 2, 4, 7, 11, 12, 14, 15, 21, 22, 46
Low rocky rises (lateritic)	11	3, 8, 10, 13, 43, 44, 45, 47, 51, 52, 53
Alluvial plains / depressions	4	19, 42, 54, 60
Playas / seasonal swamps	2	61, 62
Sinkhole	1	56

Recently burnt hummock grassland (isolated *Corymbia setosa* trees) with a diversity of post-fire tussock grasses, herbs, and forbs - including low densities of *Yakirra australiensis* and *Senna notabilis*.

Low rocky rise (lateritic) that supports *Acacia hilliana* low shrubland surrounded by sandplains dominated by hummock (*Triodia* sp.) grassland.

Aerial view of low rocky rise within the Arruwurra Land Corporation. This particular rise did not support mature *Acacia hilliana*.

Localised small depression that supported low numbers (three) of large bulbous termitaria mounds.

Figure 5-21. Photographs (selection only) of examples of high value Greater Bilby habitat

Survey limitations

- High vegetation cover in areas that had not burnt for 3 or more years may have obstructed aerial view of burrows and diggings. In these areas, the helicopter was flown at slower speeds to enable more comprehensive aerial search effort.
- No landings were possible on proposed access tracks within the Vacant Crown Land because sacred sites clearances had not been performed in these areas. Aerial surveys and hover sites were performed on these access tracks. There were three hover sites in on the northern part of one of these tracks that was noted to require a ground-check.
- Not all access tracks were surveyed; however, access tracks selected for survey were chosen to be representative for Project footprint.

5.8.6 Discussion

The targeted surveys between KP 0 and KP 350 (plus seven access tracks) (total of 490 km transect) indicate that Greater Bilby do not utilise habitat situated within the Project footprint; however, potentially-suitable habitat is present and widespread (presence of food indicator plants and soil substrate appropriate for burrow construction). Factors that may lower habitat suitability may be lack of palaeodrainage-channels, presence of key predator species (Red Fox, Feral Cat), occurrence (and long-history) of large-scale fires, and high level of cattle impact in the western portion of the footprint.

It is likely that the range of Greater Bilby has contracted considerably since the last (and few) proximate records within the central zone of the Project footprint (KP 150 to 300), such that it is suspected the Wakaya Desert population is now extirpated. Although Greater Bilby signs were not identified along the Project footprint west of the Stuart Highway (KP 0 to KP 40), it is possible that this area is periodically utilised by the species due to the closer proximity to existing populations.

High value habitat types

The absence of large palaeo-drainage channels within the Project footprint could be a major limiting factor in terms of current occupation of Greater Bilby. The only alluvial habitat present within the survey area (associated with Gosse River) was not suitable for Greater Bilby due to high cattle impact and lack of food plants. Other water-based habitat features (i.e. depressions and playas) were marginally suitable due to their comparably small size, isolation within the broader sand plain landscape, and supporting low densities of potential food sources (grub source plants identified only on the edges of these areas).

The low rocky rises (mixture of calcrete, laterite, silcrete and sandstone gravels) within the sand plains provide suitable habitat due to an abundance of *Acacia hilliana* (plant commonly targeted by Greater Bilby for grubs) and presence of a soil substrate appropriate for burrow construction.

Sand plains (including loamy, desert, and lateritic substrates) were widespread within the survey area and habitat suitability varied due to fire frequency and food plant availability. This habitat type included the highest ground-based survey effort (35 track-plot sites). Large-scale fires have occurred within the sandplains, which may possibly reduce the suitability of these areas for Greater Bilby.

Predator species

A potential risk of the Project on Greater Bilby is increased predation pressure or introduction of predators to new areas – as the Project footprint may provide predator access to the area (there is anecdotal evidence that predators of Greater Bilby prefer to use corridors such as tracks and fence lines; Dr Southgate, pers. comm. 2016). It is likely that presence / higher numbers of predators will lower habitat suitability.

A possible Red Fox (*Vulpes vulpes*) track was identified at site TP32, this would be on the far northern extent of the species distribution in the Northern Territory. Previous surveys in the area have also identified the presence of Red Fox (Low Ecological Services 2009; Gibson et al. 1994). Red Fox is a significant predator of the Greater Bilby and its presence in the region may form part of the reason why it was not detected

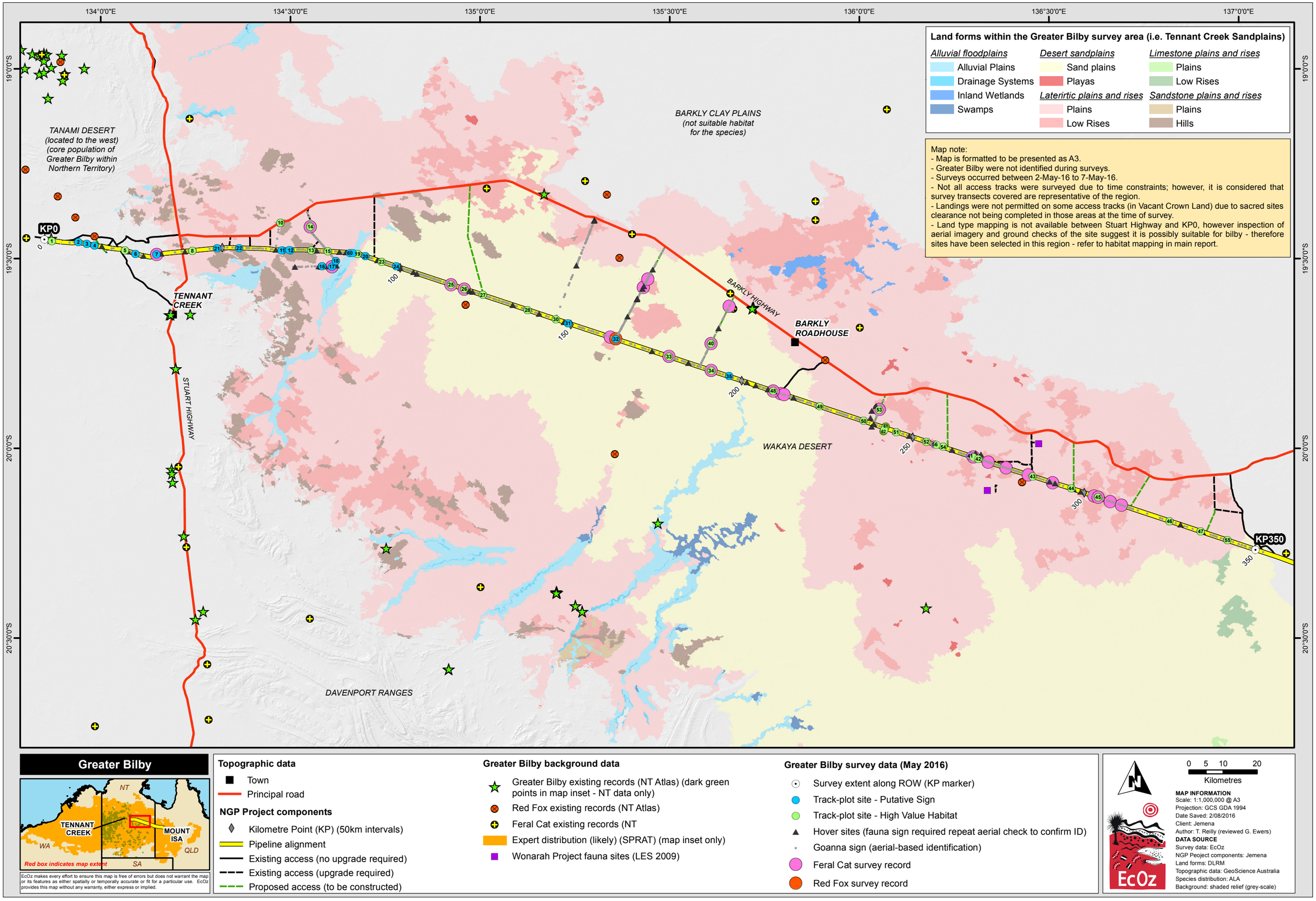
during these surveys. The Project footprint is at the northernmost limit of Red Foxes in the Northern Territory according to recent distribution estimates (National Land & Water Resources Audit 2008).

Feral Cat (*Felis catus*) tracks, scats, and sightings were consistently observed along the Project footprint and were found in a variety of habitats (13 on-ground sites; 12 aerial sites), with particular presence in the sand plains in the Wakaya Desert area (perhaps due the ephemeral playas in the region, which supply water and assumed abundant prey). Feral Cats may contribute to predation pressures on Greater Bilby, especially on females and juveniles (due to their smaller size and less defensive nature than male bilbies). It is expected their presence in the region and population numbers are linked to seasonal conditions and prey abundance, particularly to irruption of the Long-haired Rat *Rattus villosissimus* (Gibson et al. 1994). As their diet includes small mammals, birds and reptiles as well as invertebrates such as grasshoppers (Paltridge et al. 1997), predation by cats in the region likely places significant pressure on populations of native species, particularly when cat density remains high for a period after a crash in Long-haired Rat numbers.

Dingoes were observed in low numbers (6 locations) during the survey (2 aerial sightings and 4 track-plot sites), which is consistent with observations made in previous fauna surveys within the region (Gibson et al. 1994; Low Ecological Services 2009). Low Dingo (*Canis lupus dingo*) numbers may be a reason for widespread Feral Cat population, as there is evidence that areas with high Dingo populations suppress Feral Cat and Red Fox numbers (Woinarski et al. 2014; Christensen and Burrows 1994).

Pastoral impacts

The Project footprint traverses three pastoral properties (Tennant Creek Station, Phillip Creek Station and Dalmore Downs Station) within the Greater Bilby survey region (see Figure 2-12 for pastoral property boundaries). Track-plot sites observed a high presence of cattle tracks and scats in these areas, especially in alluvial areas or locations that support tussock grasses. It is possible that the impact from pastoralism in the area has degraded habitat suitability for Greater Bilby in this area, as it is listed as a potential threat factor in Woinarski et al. 2014).



Path: C:\01. EcOz GIS Projects (TR)\Jemena\Project files\GB_Survey_v4_A3.mxd

Figure 5-22. Map of Greater Bilby habitat assessment and field survey

5.9 BRUSH-TAILED MULGARA (*DASYCERCUS BLYTHI*)

5.9.1 Conservation status

- Northern Territory: Vulnerable
- Queensland: Vulnerable
- National: Least Concern

5.9.2 Background Information

Description

Brush-tailed Mulgara is one of the larger carnivorous marsupials, with a body mass of over 100 g, head body length of 15 cm and tail length of 9 cm (Masters et al. 2003). The species shows sexual dimorphism in size; males are significantly larger than females (Masters et al. 2003). The back is sandy brown and the belly is greyish-white. The short tail is enlarged and reddish near the body, tapering quickly to a point (Pavey et al. 2006c). Brush-tailed Mulgara is closely related to the Crest-tailed Mulgara (*Dasycercus cristicauda*) which lives in sand dunes within the Simpson Desert.

Ecology

Brush-tailed Mulgara is primarily nocturnal, sheltering during the day in burrows that are about 0.5 m deep. The species occurs in a range of vegetation types; however, the principal habitat is sand plains and drainage depressions that support mature hummock grasslands of spinifex, especially *Triodia basedowii* and *T. pungens* (Masters et al. 2003). The only Wakaya Desert record of this species (see below) was from a *T. pungens* hummock grassland with *Eucalyptus odontocarpa* sparse mallee shrubland overstorey. The site was a gravelly rise with light, sandy clay loam (Gibson et al. 1994).

The location of Brush-tailed Mulgara colonies may be influenced by the presence of better-watered areas such as paleo-drainage systems or drainage lines in sandplains or sand dune habitats (Masters et al. 2003; Pavey et al. 2006c). The species breeds once per year – mating in autumn or winter – with litters of 3 to 6 young being produced between October and December. Home range size of its close relative Crest-tailed Mulgara is highly variable, with extremes of 1.0 to 14.4 hectares recorded (Masters 2003), and it is assumed that Brush-tailed Mulgara is similar. Home ranges of individuals overlap extensively. Brush-tailed Mulgara can undergo wide fluctuation in numbers depending on weather conditions (Gibson et al. 1994).

According to SEWPAC 2010:

> *Burrows are found aggregated in complexes that can cover up to a kilometre of suitable habitat. The burrows are constructed under the raised mound of a dead spinifex hummock, and have a number of entrances, with between six to ten pop-holes located around the periphery of the raised mound (C Dickman pers. comm.). When the burrows are active, scoops of sand are seen at the pop-hole entrances and scats will also be scattered randomly around the area, including near the burrow entrances (C Dickman pers. comm.).*

Brush-tailed Mulgara demonstrates remarkable flexibility in its use of resources and aspects of its behaviour and physiology that protect it from periods of food shortage. The species is both carnivorous and insectivorous, taking a range of prey including scorpions, centipedes, rodents, small marsupials and reptiles. Unlike smaller dasyurids, it is able to excavate prey from burrows (Masters and Dickman 2012). Brush-tailed Mulgara reduce energy expenditure *in situ* by entering daily torpor. During periods of drought Brush-tailed Mulgara is able to tolerate reduction in bodyweight and condition by drawing on substantial reserves of fat stored in its tail. The depth of Brush-tailed Mulgara burrows provides additional protection from environmental disturbances, including climatic extremes and intrusions from predators such as the Feral Cat (*Felis catus*) and Red Fox (*Vulpes vulpes*) (Masters and Dickman 2012).

Distribution

Most historical mulgara records did not distinguish between the two species now recognised, and so there is ambiguity about the distribution of both species. The Brush-tailed Mulgara is known from the Western and Simpson Deserts, with confirmed records in the Northern Territory from Haasts Bluff, Uluru, Papunya, Tanami Desert, Illamurta, Charlotte Waters and Crown Point (Woolley 2005; Woolley 2006). The species was once widespread and common throughout the central deserts region of Australia; however, it began to decline in the 1930's, and now has a more restricted and fragmented distribution (Pavey et al. 2006c).

There is one record 25 km south of the Project footprint (KP 240) from the Wakaya Desert fauna survey undertaken in 1993 (Gibson et al. 1994), and two records for Tennant Creek from 1901 and 1904 (see Figure 5-24). Apart from these, all other records are from a significant distance to the south and west of the Project footprint.

Threatening processes

The cause of decline in the Brush-tailed Mulgara is unknown and, therefore, it has not been possible to identify threatening processes. However, it is likely that the processes of environmental degradation and habitat homogenisation that have occurred throughout arid Australia following European settlement have negatively affected the mulgara. Changes in fire regimes, grazing by introduced herbivores including cattle and rabbits, and predation by introduced predators are all likely threatening processes (Pavey et al. 2006c).

5.9.3 Survey context

Purpose

If present within the Project footprint, Brush-tailed Mulgara could be impacted by Project construction works – primarily by land clearing and trenching. The purpose of the survey was to identify whether any populations of this species occur within the vicinity of the Project footprint.

Brush-tailed Mulgara was not listed as a focus species in the NGP Terms of Reference. It has been included in the threatened species survey program due to the results of the comprehensive threatened species 'likelihood of occurrence' assessment (Section 5.1). The species was only surveyed for in the Northern Territory part of the Project footprint because it is not nationally listed.

Overview

To achieve the abovementioned purpose, the survey was designed to:

a) Identify potentially-suitable habitat using desktop mapping datasets.

b) Visit sample sites within that habitat by helicopter to confirm whether it is suitable habitat, and to assess habitat quality (specifically impact by cattle)

c) Ground-survey sample sites within suitable habitat for signs of Brush-tailed Mulgara.

5.9.4 Survey methodology

Survey design

Brush-tailed Mulgara surveys occurred in conjunction with Greater Bilby surveys (described in Section 5.8.4) between the 2 and 7 May 2016, and covered a distance of approximately 490 km (between KP 0 to KP 350, and along 7 proposed access tracks) (Figure 5-24).

A targeted survey program that incorporates existing survey guidelines for Brush-tailed Mulgara was not undertaken because it was considered that the comprehensive Greater Bilby track-based survey (detailed in Section 5.8.4) would also detect (potential) Brush-tail Mulgara signs if present. Burrows and tracks from Brush-tailed Mulgara are readily identifiable to adequately trained personnel. Consequently, the survey

approach focused on tracking for signs and general habitat suitability – particularly tracks and potential burrows. This methodology forms an important part of the standard survey guidelines for the species; however, it is normally supplemented by Elliott and pitfall trapping at a number of sites for a three or four night period.

Survey area and target habitat

It is assumed that Brush-tailed Mulgara (if still extant in the region) will be restricted to the Tennant Creek Sandplains within the Northern Territory, which encompasses the following components of the Project footprint (see Figure 5-24):

- Construction ROW – KP 0 to 350 (i.e. 350 km)
- Access tracks (existing, requires widening) x 8 – total length of 102 km
- Access tracks (to be constructed) x 8 – total length of 145 km
- Camp locations x 3 – 12 ha each

Brush-tailed Mulgara are not expected to occur in the Barkly Clay Plains (of the Northern Territory) nor in Queensland parts of the Project footprint.

Project footprint habitat mapping (see Section 4), reconnaissance survey aerial footage (see Section 3), and publications on Brush-tailed Mulgara habitat and diet (Masters et al. 2003) were reviewed to identify target habitat types within the survey area. These areas are considered to have a higher chance of Brush-tailed Mulgara occupancy in order to infer if the species is present within the Project footprint:

- Sandplains that support mature (long unburnt) hummock grasslands (preferably *Triodia pungens* as *T. basedowii*, the other key spinifex species generally associated with Brush-tailed Mulgara, is not commonly encountered in the region).
- Sandplains that are in close proximity to drainage depressions or seasonal swamps.

NAFI fire scar mapping (250 m resolution) identified that the majority of Tennant Creek Sandplains has burnt at least once within the last 5 years; however, there are large areas of potential habitat within this region that has not burnt for 4 years which may support mature *Triodia pungens* grasslands – a key habitat component for Brush-tailed Mulgara which will be targeted during field studies (Figure 2-9).

Aerial assessment

The intent of aerial assessment was to identify suitable sites for targeted on-ground searches for signs of Brush-tailed Mulgara (discussed below). The aerial assessment allowed for identification of suitable habitat (see above) and was able to observe if small mammal tracks were present on the sandplains.

The aerial assessment was conducted between KP 0 and KP 350, and along seven proposed access tracks within the survey area (see Figure 5-24). The helicopter was flown at a speed of 18 – 30 knots (33 to 55 km/hr) and at a height of 15 to 20 m above ground level. Two surveyors (Tom Reilly and Mark Carter, refer to Section 5.3.1 for experience) were seated on either side of the helicopter, each observing a search strip approximately 30 m wide (to make a total search strip of 60 m).

On-ground survey (i.e. track-plots)

On-ground surveys used track-plot methodology described in Moseby et al. (2012), which is a standardised technique designed to assist in recording information on a range of fauna species in arid and semi-arid habitat types. This method is commonly used in central Australia (pers. comm. Richard Southgate 2016) and information can be readily added to the national database on arid zone fauna (Moseby et al. 2012). Furthermore, Brush-tailed Mulgara produce relatively conspicuous signs (i.e. burrows and tracks) in arid zone habitats, which makes this method applicable for this Project area.

Track-plot sites were selected based on the Greater Bilby field survey methodology (see Section 5.8.4) and aerial assessment (discussed above). Sites were spatially representative within the survey area and included a range of habitat types and fire ages suitable for Brush-tailed Mulgara.

Plots dimensions were ~100 x 200 m (i.e. 2 ha), and avoided existing roads and cleared areas. Each plot was surveyed for a 30-minute period zig-zagging up one side and back down the other. The aim was to conduct tracking surveys with the sun in front so that shadows were not obscured.

For each track-plot, the following data were recorded:

- Site location details (i.e. site name, GPS coordinate, time etc.)
- Habitat/vegetation notes and site photograph
- Fire history at the site – recent (< 1 year), relatively recent (1 to 3 years), long unburnt (> 3 years)
- Variables that may affect tracking conditions, such as time since rain, cloud cover, surface soil substrate, time of day, time of year etc.
- All tracks, burrows, diggings, sightings, or scats of each species – including an age and abundance estimate of each sign.
    - Age estimate – fresh (1 to 2 days); recent (3 to 7 days); old (> 7 days)
    - Abundance estimate – abundant (signs in all 4 corners of site); common (signs in half the site); uncommon (individual sign only or found in ¼ of site).

5.9.5 Results

Tracking conditions

- Tracking conditions for detecting small mammal tracks (such as dasyurids like Brush-tailed Mulgara) were poor at the start of the survey, but became ideal between the 4 and 6 May 2016 – which was when the majority of suitable habitat for Brush-tailed Mulgara was surveyed.
- Refer to Section 5.8.5 (part of Greater Bilby survey) for a more detailed assessment of tracking conditions experienced during the survey.

Track-plot data

Fifty-three track-plot sites were surveyed. Results of the track-plot survey are:

- No definitive evidence of Brush-tailed Mulgara was observed during the survey.
- Fifty-three track-plots were surveyed within the Tennant Creek Sandplains, covering a variety of habitat types and fire scar ages – loamy sandplains, desert sandplains, laterite plains, alluvial plains, low rocky rises, drainage depressions, and seasonal swamps / playas.
- Possible dasyurid tracks were found at three sites – TP32, TP34 and TP49 (Figure 5-24). These tracks were not definitive to one species; however, they all had a quadrupedal bounding overstep track pattern with measurements within the range of Brush-tailed Mulgara (foot length ~ 20 mm; group width ~ 60 mm; group length ~ 120 mm). The track pattern and size could not be separated from the more likely (and ubiquitous) Long-haired Rat (*Rattus villosissimus*), as there were only a few average quality tracks present on the soil surface to make judgement. Long-haired Rat was sighted at several locations during the track-plot surveys. Tracks were scarce at each of these three sites. Searches at these sites did not locate potential burrows for Brush-tailed Mulgara.

- Evidence of Feral Cats (*Felis catus*) (either tracks, scats, and sightings) was observed in 25% of track-plot sites. Cats were also 'flushed' out of vegetation by the helicopter on a few occasions. It is likely that cats occur across the entire survey area.

Habitat assessment data

Track-plot habitat descriptions and photographs are provided in Appendix J.

Results are summarised below:

- Thirty-two of the 53 track-plots supported mature hummock grassland understory:
  - Sandplains (13 sites – TP5, 16, 18, 25, 28, 30, 31, 32, 40, 48, 49, 50 and 55)
  - Loamy sandplains (7 sites – TP1, 2, 4, 7, 15, 21 and 46)
  - Low rocky rises (9 sites – TP3, 8, 13, 43, 44, 45, 47, 51 and 53)
  - Depressions (3 sites – TP42, 54 and 60)
- Two of the three potential Brush-tailed Mulgara tracks were located in areas that had mature spinifex (*Triodia pungens* and/or *Triodia schinzii*). These areas had not burnt for at least 3 to 4 years. The other track was observed in a location that had burnt within the last year; however, the tracks were sighted close to an unburnt area that supports a dense cover of mature spinifex and Acacia shrubland.
- Potential food resources for Brush-tailed Mulgara were commonly observed during the track-plot surveys (i.e. they are carnivorous and insectivorous, taking a range of prey including scorpions, centipedes, rodents, small marsupials and reptiles).
- Broad-scale fires have recently occurred within the potential habitat zone for Brush-tailed Mulgara within the Project footprint. The areas burnt in 2011 now support mature *Triodia pungens* hummock grasslands.
- Seasonal swamps and depressions were present within the extensive sand plain hummock grasslands (many of which has not been burnt for at least 3 to 4 years).

Survey limitations

- Trapping surveys (i.e. Elliott and pitfall traps) – which are a commonly used survey methodology for Brush-tailed Mulgara – were not conducted during the survey program (reasons described in Section 5.9.4).
- Light to moderate rainfall occurred over most of the Project area on the 2 and 3 May 2016 (13.8 mm at Tennant Creek Airport). This may have removed tracks from the soil surface. Conditions improved between the 4 and 7 May 2016, with numerous fauna tracks observed in sandy substrate
- No landings were possible on proposed access tracks within the Vacant Crown Land because land access arrangements were not in place. As expected, numerous small mammal tracks were observed during Greater Bilby aerial surveys; however, surveyors were not able to confidently identify smaller mammal tracks without a ground-based assessment.
- Not all access tracks were surveyed; however, the access tracks selected for the survey were chosen to be representative for Project footprint.

5.9.6 Discussion

Survey results suggest that Brush-tailed Mulgara are absent or scarce within the region of the Project footprint due to the following reasons:

- No track-based evidence of the species within 53 spatially representative ground survey sites
- Presence of marginal habitat quality
- Long-term presence of predator species (mainly associated with Feral Cats, *Felis catus*)
- Paucity of records in the region (i.e. only one recent record from 1993 – Gibson et al. 1994).

Although the weight of evidence suggests that this species is absent in the region, additional trapping effort would be required for a more definite conclusion. Surveys indicated that suitable habitat (i.e. sandplains that support mature hummock grasslands) is present within the Tennant Creek Sandplains of the Project footprint. However, as the region has experienced frequent broad-scale fire activity (i.e. 3 to 4 burns within a 15-year period) it is possible that habitat suitability is only marginal, or perhaps restricted to hummock grasslands that have a lower burning frequency.

The presence of predator species (Red Fox and Feral Cat) and impacts from cattle are likely to reduce the habitat suitability for Brush-tailed Mulgara. In particular, track-plot surveys determined that Feral Cats were present across the entire survey area. Cats were also recorded from previous surveys in 1993 and 2009 (Gibson et al. 1994; Low Ecological Services 2009). The long-term presence of Feral Cats in the region suggests predation pressure may play a significant role in the viability (or indeed presence) of any local Brush-tail Mulgara population.

Figure 5-23. Photographs of habitat considered as suitable for Brush-tailed Mulgara

Map note:
- There was no definitive evidence of Brush-tailed Mulgara found during surveys. It is unlikely that mulgara occupy the Project footprint.
- Surveys occurred between 2-May-16 to 7-May-16.
- Not all access tracks were surveyed due to time constraints; however, it is considered that survey transects covered are representative of the region.
- Land type mapping is not available between Stuart Highway and KP0, however inspection of aerial imagery and ground checks of the site suggest it is suitable for mulgara - therefore survey sites have been selected in this region.

134°0'0"E 134°30'0"E 135°0'0"E 135°30'0"E 136°0'0"E 136°30'0"E 137°0'0"E

19°0'0"S 19°30'0"S 20°0'0"S 20°30'0"S

Tanami Desert (located to the west)

Barkly Clay Plains (not suitable habitat for the species)

Wakaya Desert

Davenport Ranges

STUART HIGHWAY

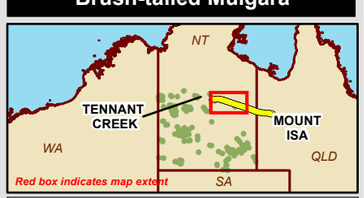
BARKLY HIGHWAY

TENNANT CREEK

BARKLY ROADHOUSE

KP0 0 100 150 200 250 300 KP350 350

Brush-tailed Mulgara



Topographic data
- Town
- Principal road

NGP Project components
- Kilometer point
- Pipeline alignment
- Existing access (no upgrade required)
- Existing access (upgrade required)
- Proposed access (to be constructed)

Brush-tailed Mulgara data
- Survey extent along ROW (KP marker)
- Track-plot sites
- Existing record (green dots in map inset)

Land forms within the Brush-tailed Mulgara survey area (i.e. Tennant Creek Sandplains)

Alluvial floodplains
- Alluvial Plains
- Drainage Systems
- Inland Wetlands
- Swamps

Desert sandplains
- Sand plains
- Playas

Lateritic plains and rises
- Plains

Low Rises

Limestone plains and rises
- Low Rises

Sandstone plains and rises
- Plains
- Hills

0 5 10 20 Kilometres

MAP INFORMATION
Scale: 1:1,000,000 @ A3
Projection: GCS GDA 1994
Date Saved: 2/08/2016
Client: Jemena
Author: T. Reilly (reviewed G. Ewers)

DATA SOURCE
Survey data: EcOz
NGP Peoject components: Jemena
Land forms: DLRM
Topographic data: GeoScience Australia
Species distribution: ALA
Background: shaded relief (grey-scale)

Path: C:\01. EcOz GIS Projects (TR)\Jemena\Project files\BTM_Survey_v2_A3.mxd

Figure 5-24. Map of Brush-tailed Mulgara habitat assessment and field survey

5.10 GOULDIAN FINCH (*ERYTHRURA GOULDIAE*)

5.10.1 Conservation status

- Northern Territory: Vulnerable
- Queensland: Endangered
- National: Endangered

5.10.2 Background information

Description

Gouldian Finch is an easily recognisable bird species due to its bright colours. The species has three distinct colour morphs associated with head colour – black head (most common), red head (moderately common), and yellow head (rarely observed) (Palmer et al. 2012). Juveniles do not present bright plumage and may be mistaken for other finch species (Palmer et al. 2012).

Ecology

The critical components of suitable habitat for the Gouldian Finch vary seasonally. In the dry season, the critical components are hollow-bearing Eucalyptus trees (especially *E. tintinnans, E. brevifolia and E. leucophloia*) (Higgins et al. 2006; O'Malley 2006; Tidemann 1996; Tidemann et al. 1999) with an understorey of the favoured annual grass (*Sorghum* spp., *Schizachyrium* spp.) and a nearby (within 4 km) source of surface water. In the wet season, Gouldian finches rely on a variety of perennial grass species, and birds will move from area to area as the seeds from each species become available (Dostine and Franklin 2002; Dostine et al. 2001).

The breeding season extends from February to April, with a longer season (January to August) in years of extended wet season rainfall (1984; Woinarski & Tidemann 1991; Tidemann & Woinarski 1994; Tidemann et al. 1999). Individuals or groups appear to first select patches of habitat with high densities of potential nesting sites, and breeding pairs then select specific nest sites based on a suite of preferred hollow morphometric attributes (Brazill-Boast et al. 2010).

In the non-breeding season birds can disperse widely (Garnett et al. 2011), greatly increasing the possible range of this species. Gouldian Finches can occur in flocks of hundreds, but are usually observed in much smaller numbers.

Distribution

The Gouldian Finch was formerly widespread across the northern savannas from the Kimberley to eastern Queensland including Cape York (O'Malley 2006). It has disappeared from most of its previous Queensland distribution, and is now only recorded occasionally and in small numbers from a few sites around the Atherton Tableland and Gregory Range, and in far western Queensland (Barrett et al. 2003; Holmes 1995, 1998). A number of breeding populations are known from the Kimberley. In the Northern Territory, most known breeding populations occur in the Top End with some isolated records in the Barkly Tableland and in coastal areas of the Gulf of Carpentaria. Some sources believe that Gouldian Finch populations may have recently stabilised, and perhaps begun to increase and spread (Garnett et al. 2011).

The Northern Territory section of the Project footprint is not considered to be within the Gouldian Finch distribution. In addition, despite the Mount Isa area being fairly heavily surveyed by birders interested in the local, endemic grasswren species, there are only two existing records of Gouldian Finch in the region – one approximately 23 km to the north-east of the construction ROW (although the coordinate uncertainty of this record is 10 km) and the other approximately 54 km to the north (see Figure 5-27). Nevertheless, because of those records, the *expert distribution (likely)* of Gouldian Finch includes the length of pipeline between KP 609 and KP 622 (13 km) (Commonwealth of Australia 2016).

Threatening processes

The main contemporary threats to this species are frequent widespread fires and introduced herbivores, both of which, through different pathways, cause reduced availability of grass seed important in the species' diet. High frequencies of intense fires may also reduce the availability of suitable breeding hollows at local breeding sites (Brazill-Boast et al. 2010), as fires can burn down suitable trees and/or stunt growth.

5.10.3 Survey context

Purpose

The purpose of the survey was to provide field data to inform an assessment of the potential impact of the Project on Gouldian Finch.

If suitable habitat (breeding or non-breeding) is present within the Project footprint, and is being used by Gouldian Finches, Project construction works could impact that population. Specifically, the impacts could include:

- Loss of wet season foraging habitat
- Destruction of nesting trees at breeding sites

It is unlikely that the construction activities could have a significant impact on the dry season foraging habitat for the Gouldian Finch as the grasses relied on during the dry season are very widespread and abundant in the region. However, if potential breeding habitat is present and/or if potential wet season foraging areas are present, vegetation clearing activities associated with construction of the NGP could impact an existing Gouldian Finch population (if present) because, in both cases, the critical resource (trees, perennial grasses) tends to be patchily distributed, and the loss of even a small area could have a disproportionately large impact

Overview

To achieve the abovementioned purpose, the survey was designed to:

a) Identify potentially-suitable habitat using desktop mapping datasets.

b) Identify whether any suitable breeding habitat and/or potential wet season foraging habitat occurs along the construction ROW.

c) If potential habitat was found, evaluate the quality of that habitat

5.10.4 Survey methodology

Existing survey guidelines

Federal survey guidelines for Gouldian Finch are provided in the following references:

- Department of the Environment, Water, Heritage and the Arts (DEWHA) 2010c, *Survey Guidelines for Australia's Threatened Birds*. EPBC Act survey guidelines 6.2 (l), Commonwealth of Australian, 2010.
- Department of the Environment 2016, *Erythrura gouldiae in Species Profile and Threats Database*, Department of the Environment, Canberra.

The method described for Gouldian Finch surveys is to conduct targeted searches and watches at waterholes (for a total of 12 hours over 4 days). It is recommended that such surveys be undertaken in the dry season when Gouldian Finch and other finches congregate around waterholes to drink (Bell 1996; Evans & Bougher 1987). In areas < 50 ha, area searches in suitable habitat may be useful (20 hours over 5 days).

Survey design

Given the linear nature of the NGP Project, EcOz consulted with Gouldian Finch expert – Associate Professor Sarah Legge (University of Queensland and Australian National University) to develop an assessment methodology that ensured survey effort was performed in the most effective and comprehensive manner (see Section 5.3.1 for an overview of her expertise and experience).

The following methodology was developed in consultation with, and endorsed by, Legge.

Survey area and target habitat types

Legge reviewed high-resolution aerial footage collected as part of the reconnaissance survey (see Section 3) to identify potentially suitable breeding areas and/or wet season foraging areas for Gouldian Finch. Legge analysed the footage against the backdrop of Google Earth Pro imagery and regional ecosystem vegetation mapping, to select survey areas to assess habitat suitability for the species within the Project footprint. This resulted in a survey area for Gouldian Finch between KP 580 and KP 622 of the construction ROW (in Queensland) (see Figure 5-27). Gouldian Finch are not expected to occur in the Northern Territory section of the Project footprint.

The survey targeted habitat associated with two main behavioural components of the Gouldian Finch:

- Potentially suitable breeding areas. These areas support mature Snappy Gum (*Eucalyptus leucophloia*), which are trees known to provide nesting hollows for Gouldian Finch in the region.
- Wet season foraging areas. Areas likely to support the range of perennial grass species relied on by Gouldian Finch during the wet season, with key species including *Alloteropsis semialata*, *Triodia* spp. *Chrysopogon fallax, Panicum decompositum* and *Xerochloa laniflora* (O'Malley 2006). The Project footprint falls outside the distribution for *Alloteropsis semialata*.

Legge also provided the following observations (based on review of aerial footage):

- All the potentially-suitable sites were towards the eastern end of the proposed pipeline route.
- The incidence of patches of suitable trees for nesting Gouldian Finch was low.
- The patches of suitable trees were small in extent, and with low tree densities.
- The patches of trees were sometimes in flat areas, but also on land with some slope.
- The eastern end of the pipeline shows signs of a history of frequent and intense fires; this would tend to discourage Gouldian Finches from using those areas (if, indeed, they were present initially).

Ground survey – breeding habitat assessment

Legge identified that the construction ROW intersected four main areas that contained a suitable density of trees that could be used for nesting (i.e. Snappy Gums or equivalent) (see Figure 5-27). These areas were searched for suitable nesting hollows at six survey transects between 11 and 15 May 2016.

Transects were selected via helicopter and were chosen in areas that presented the larger Snappy Gum trees with reasonable densities. Generally, they were located on ridges in the patches of highest density of Snappy Gum, except for one transect that was located through a low-lying area with a higher density of Snappy Gums than the surrounding landscape. Transects were 250 m and surveyed the presence and quality of hollows in Snappy Gums (and equivalent species), and whether these hollows had been used by finches for nesting.

For each transect, surveyors checked every tree within 25 m of the central line, thus covering approximately 1.25 ha. Every tree was examined to check whether a hollow was present or absent. If hollows were present, then data was collected for assessment of the potential suitability of that hollow for Gouldian Finch,

which have relatively specific hollow preferences (Harden et al. 1986, Brazill-Boast 2010 and Brazill-Boast et al. 2011, Tidemann et al. 1992). The following characteristics were collected at each suitable hollow:

- Number of hollows greater than 25 mm diameter entrance
- Hollow height (estimated to ± 0.5 m)
- Whether the hollow is within living tissue
- Angle of hollow entrance (90^o being straight up, 0^o being horizontal)
- Entrance diameter (if possible)

In the few instances in which it was not possible to measure certain characteristics of hollow-bearing trees (due to safety concerns), an estimation of those characteristics was made.

Suitable tree hollows were also checked for evidence of finch use, by examining the hollow for nesting material. Gouldian Finches, Long-tailed Finches, Zebra Finches and Double-barred Finches may all breed in hollows, although only the Gouldian Finch is an obligate hollow-nester. These finches all line the hollows with fine grass to create their nest. Gouldian Finches build the simplest structure – a flat grass platform or shallow cup at the base of the cavity, whereas Long-tailed and Double-barred Finches build a more elaborate grass nest dome with a short tunnel. For all finch species, the presence of nestling faecal material indicates a nest that has successfully produced nestlings.

Ground survey – wet season foraging habitat assessment

Gouldian Finches rely on a number of perennial grass species during the wet season, *Triodia* species are the dominant grasses along the entire route. Given the loss of *Triodia* spp. areas to the pipeline will be very small, this species is not a target species of concern.

Legge identified 10 sites which, based on general terrain, could contain wet season foraging habitat (although none of these could be described as 'classic' areas for foraging habitat). These areas were very small strips besides creeks that are more likely to support the range of perennial grass species relied on by Gouldian Finch during the wet season.

Sites were surveyed between 11 and 15 May. This included collecting the following information:

- Site photographs and geolocation
- Vegetation community assessment
- Landform
- Presence of Gouldian Finch preferred grass species.

If suitable grass species were identified, surveyors extended the assessment for 200 m either side of where the construction ROW crosses the creek to determine the extent of those grasses.

General bird survey

During transects, ecologists also kept a continuous lookout for Gouldian Finches and other birds, and recorded all species encountered.

5.10.5 Results

Breeding site assessment

Vegetation

Field assessment confirmed that, along the construction ROW, Snappy Gum was concentrated towards the rocky hills at the east of the alignment (KP 590 to KP 622). As the construction ROW transitions from the plains to rocky hills landform, areas of Snappy Gum are patchy and interspersed with Gidgee (*Acacia cambagei*) and open hummock grasslands. At the very eastern end, *A. cambagei* gives way to more uniform stands of *E. leucophloia, E. leucophylla* and *Corymbia terminalis*, with *E. camaldulensis* located along watercourses and drainage lines.

All of the sites surveyed were dominated by Snappy Gum (*Eucalyptus leucophloia*) with *E. leucophylla*, *Corymbia terminalis* and *C. aparrerinja* dispersed throughout (see Figure 5-25 and detailed site descriptions in Appendix L). The ground level vegetation was uniformly open hummock grassland of *Triodia pungens* with a limited mid-storey of *Acacia chisholmii* (where any mid-storey was present). At all sites, the *Triodia* hummocks were generally of uniform age and structure. Sites were all rocky, with high quartzite content amongst sandstone and siltstone with outcroppings of laterite.

All of the survey sites and surrounds showed significant impact from fire. The impact of fire has affected both the structure of the trees with potential breeding hollows, and the structure and mosaic of the understory *Triodia* hummocks. The Snappy Gum showed signs of fire impact, with most trees having multiple thin stems around a larger, degraded, burnt stem.

Figure 5-25. Photographs of typical habitat within survey sites for Gouldian Finch breeding habitat

Trees

A summary of trees present at each site is presented in Table 5-9. Trees in site B2S1 – which ran up a low quartzite ridgeline – were the largest of all the sites surveyed (based on average cross-sectional area at breast height per number of trunk stems, Tidemann 1992). Site B3S1 – which was on the western slope of a rocky hill near Mica Creek – also had some larger trees.

Table 5-9. Summary of tree morphometrics from the six Gouldian Finch transects

Site	Coordinates (decimal degrees)		No. trees	Trees per ha	Average tree height (m)	Average no. stems	Average cross-sectional area at breast height (cm^2)	Average cross-sectional area/stem (cm^2)
B1S1	-20.82531	139.25009	52	42	4.0	5	560	112
B1S2	-20.82890	139.29696	21	17	4.5	3	450	150
B1S3	-20.82445	139.26852	60	48	4.8	4	688	172
B2S1	-20.81252	139.39555	63	50	4.5	2	493	246
B3S1	-20.82523	139.45702	73	58	5.6	3	577	192
B4S1	-20.79295	139.46659	53	42	3.9	3	383	127

Hollows

Despite the relatively thin and 'mallee-like' growth of Snappy Gum within the survey areas, there was a relatively high density of hollows (18 to 26 per hectare) compared to other studies – 4.6 hollows per hectare (Brazill-Boast et. al 2011) and 2 to 27 per hectare across all habitats (Gibbons and Lindenmayer 2002) – at all but two sites (see Table 5-10). The hollows were primarily located in burnt, old timber or dead 'spouts' stemming off living trees; only eight hollows were located within living tissue. As the results of previous studies have shown that Gouldian Finches have strong preferences for hollow characteristics (Brazill-Boast 2010, Tidemann et al. 1992), the suitability of nests within transects was assessed against the criteria determined in these earlier studies.

Based on Brazill-Boast et al (2010), Gouldian Finches select hollows that are located in living tissue, are located in robust trees, are higher off the ground, have smaller entrances and are deep into the trunk, and are closer to horizontal. For the purposes of this assessment, potentially-suitable Gouldian Finch hollows were conservatively defined as being in living tissue, being at least 2 m above the ground, and no more than 45° from horizontal. Using this definition, there were only two suitable nesting hollows within the six survey sites (see Table 5-10), out of 115 hollows in total. Neither of these hollows showed evidence of nesting by finches. Approximately 30% of hollows could not be inspected because of their height.

Table 5-10. Summary of hollow characteristics from each of the six Gouldian Finch transects

Site	Trees per ha	Total no. hollows	Hollows per ha	Average hollow height (m)	Average hollow diameter (cm)	Average hollow angle (°)	No. hollows in living tissue	Evidence of breeding	Density of suitable hollows
B1S1	42	31	25	3.1	6.2	45	4	No	1
B1S2	17	4	3	2.8	5.75	80	1	No	0
B1S3	48	33	26	2.7	6	45	1	No	1
B2S1	50	22	18	2.1	5	53	2	No	0
B3S1	58	22	18	2.5	4.9	45	0	No	0
B4S1	42	3	2	3.0	3.7	45	0	No	0

Nests

Across the six sites, only one nest was detected in a hollow. This nest was located in a burnt-out spout 1.5 m above the ground, with an entrance diameter of 15 cm. The nesting material was thick, coarse grass and was not constructed in the arrangements typical of Gouldian Finches. It may have been constructed by a Zebra Finch. In addition, there was no faecal material found within the nest.

Wet season foraging habitat assessment

Searches for potential wet season foraging habitat were undertaken at 10 locations on, or near to, the construction ROW (Table 5-11). Each of these searches was located in low-lying areas associated with banks of drainage lines or watercourses. All sites had sandy soil – graduating from red soil on the surrounding plains, to reddish-brown or grey on the watercourse beds. Soil was generally shallow (except for at Mica Creek) though deeper than the surrounding plains. Descriptions of each of the surveys sites are detailed in Appendix M.

Generally, introduced tussock grasses (Buffel Grass – *Cenchrus ciliaris* and Annual Mission Grass – *Pennisetum pedicellatum*) dominated the areas along drainage lines and watercourses searched. Cattle had heavily grazed the tussock grasses along the banks of most watercourses, and all sites showed a degree of erosion caused by cattle. In addition to the introduced grass species, Kapok Bush (*Aerva javanica*) was common.

Black Spear Grass (*Heteropogon contortus)* and Kangaroo Grass (*Themeda triandra)* were identified at a number of sites. These grasses were confined to the edge of the bank or within the drainage line, and only occupied a small area of the total search area. Apart from *Triodia spp*. – which were abundant – no other grass species that are critical wet season resources for Gouldian Finches were identified at any of the survey sites.

Table 5-11. Wet season Gouldian Finch foraging habitat survey sites

Site	Easting	Northing
GFF1	-20.81188	139.40677
GFF2	-20.81338	139.41005
GFF3	-20.81181	139.41435
GFF4	-20.83126	139.34287
GFF5	-20.80571	139.41926
GFF6	-20.82153	139.43936
GFF7	-20.82094	139.46167
GFF8	-20.81044	139.42471
GFF9	-20.80975	139.42321
GFF10	-20.81473	139.43266

General bird survey

Surveys were carried out for a total of 12.5 hours over 7 days. No Gouldian Finches were detected whilst conducting surveys (nor at any time during the fieldwork 10 – 17 May and 21 – 23 June). Only two species of finch were detected during the surveys – Zebra Finch (*Taeniopygia guttata*) and Painted Finch (*Emblema pictum*).

Figure 5-26. Photographs of typical habitat at survey sites for Gouldian Finch foraging habitat

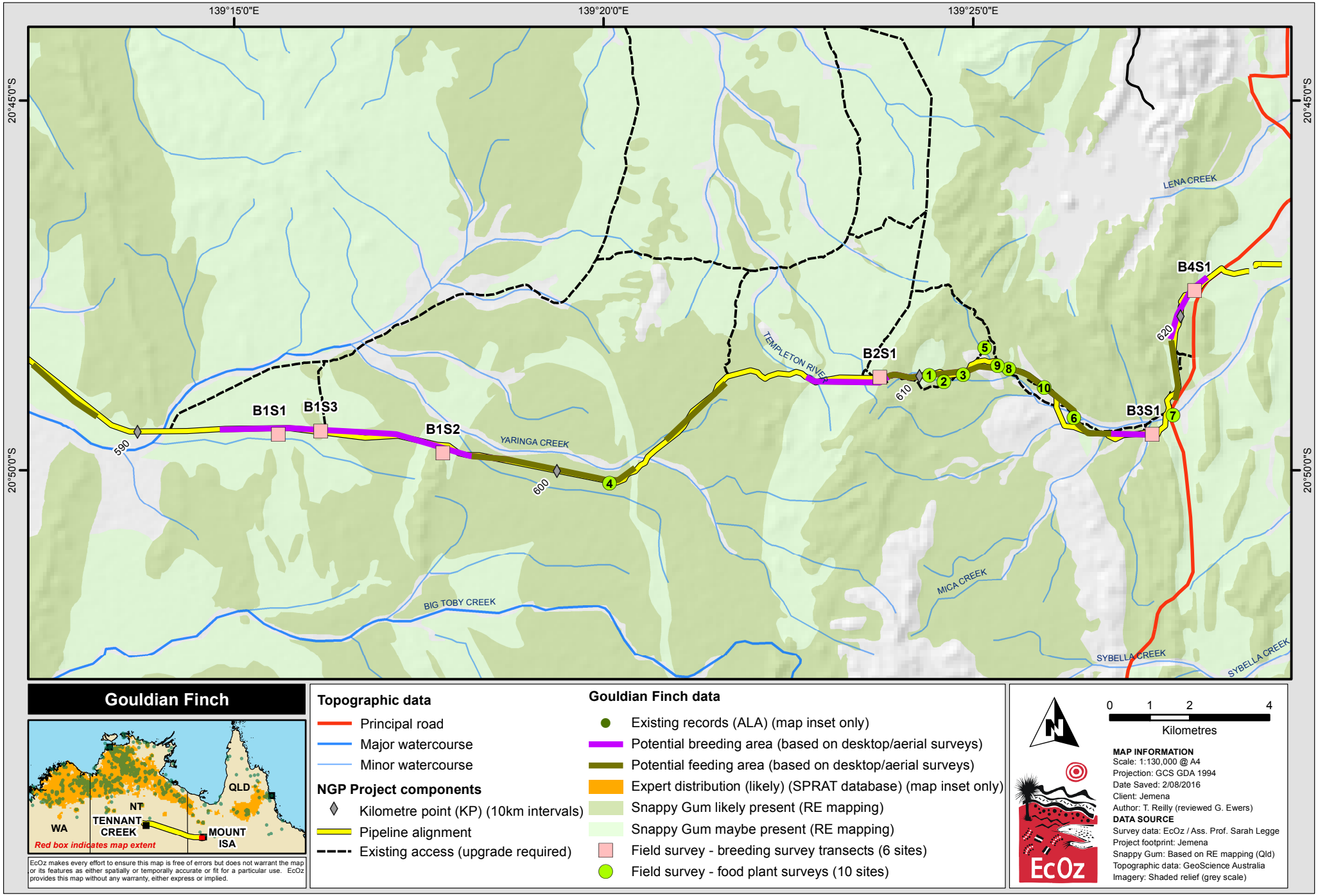
5.10.6 Discussion

As Gouldian Finches are obligate hollow-nesters, hollow limitation (or abundance of nest sites) is a predictor of breeding areas at the landscape scale (Brazill-Boast et al 2011). Surveys of the only sites with clusters of *E. leucophloia* within the construction ROW did not reveal any evidence of breeding use by the Gouldian Finch. This conclusion is based on the very low density of hollows with characteristics preferred by Gouldian Finches, and no evidence of Gouldian finch breeding (indeed, little evidence of any finch species breeding in these hollows).

It is notable that fire impact along the construction ROW is high – few areas showed significant spinifex hummocks and most sites had limited to no mid-storey. At all sites, the preferred nesting species – *E. leucophloia* – exhibited 'mallee-like' growth after fire, with multiple regrowth stems surrounding a central, dead and burnt trunk. These regrowth stems were short and thin, and had formed few hollows. Those hollows that were present were located in dead spouts rather than in the tree's living tissue.

Searches along drainage lines and watercourses for potential wet season foraging habitat indicated that sites were generally dominated by introduced pasture grasses, and were heavily impact by grazing and erosion caused by cattle. Native grasses were confined to within the watercourse or the very margin of the bank. Fire has also influenced the structure (and likely functioning) of the spinifex understory. In surveyed sites, hummocks tended to be small and sparse, having been recently burnt. The site with the greatest availability of wet season foraging grasses was GFF5: native grass species were located at limited spots along the watercourse margin on grey sandy soil.

The pipeline lies south of the southern edge of the Gouldian Finch's known distribution (O'Malley 2006). This, coupled with the absence of any contemporary sightings by bird watchers and survey teams in recent years, makes it seem highly unlikely that Gouldian Finches are present along the route of the pipeline. If finches ever were historically present in the surveyed areas, it is likely that contemporary land management (of cattle and fire) has now made these areas unsuitable.



Path: C:\01. EcOz GIS Projects (TR)\Jemena\Project files\GF_Habitat_Records_v1.mxd

Figure 5-27. Map of Gouldian Finch habitat assessment and field survey

5.11 PAINTED HONEYEATER (*GRANTIELLA PICTA*)

5.11.1 Conservation status

- Northern Territory: Vulnerable
- Queensland: Vulnerable
- National: Vulnerable

5.11.2 Background information

Description

Painted Honeyeater is a medium-sized honeyeater (approximately 16 cm in length) with black upper parts, underparts with black spots on its flanks, and yellow outer edges to the wing primaries, secondaries and coverts and tail feathers. The species has a distinctive pink bill.

Ecology

Painted Honeyeater inhabits Eucalypt forests/woodlands, riparian woodlands of Black Box and River Red Gum, Box Ironbark / Yellow Gum woodlands, Acacia-dominated woodlands, paperbarks, Casuarina, Callitris and trees on farmland or gardens (TSSC 2015b). The species prefers mature trees and is more common in blocks of remnant vegetation rather than narrow strips (Garnett et al. 2011). Unlike other honeyeaters, the species is dependent on mistletoe berries during the breeding season (Barea & Herrera 2009; Watson 2012), although insects and nectar are also taken. The diet relies less on mistletoe and more on other food sources (especially arthropods) during the non-breeding season (Oliver et al. 2003; Garnett et al 2011). Nest selection is concentrated in habitats with high occurrence of mistletoe (Barea 2008); however, nesting success is generally low (Barea and Watson 2013).

Distribution

Painted Honeyeater occurs through the eastern states, from the eastern Northern Territory through south-west Queensland to northern Victoria. Generally uncommon through its range, concentrations of the species are located on the inland slopes of the Victorian and New South Wales alpine regions, and in Roma, Queensland (Morecombe 2003). The species breeds between Victoria and south-east Queensland southern regions between October and March (BirdLife International 2016; Pizzey and Knight 2012) and migrates to the drier interior – including near Mount Isa – outside of these times (Garnett et al 2011). However, the use of habitat in north-west Qld is becoming increasingly uncommon (TSSC 2015b).

There are three records from the Mount Isa region – from 1932, 2006 and date unknown – including one within the Project footprint at Mica Creek (see Figure 5-29). There is a population of the endemic Kalkadoon Grasswren adjacent to Mica Creek which is well-known to birdwatchers wishing to 'sight' the species. As such, there have been 123 documented bird surveys (ALA 2016) at the junction of Mica Creek and the Diamantina Developmental Road, from which there is only a single Painted Honeyeater record. Nevertheless, the Project footprint between KP 570 and the Mica Creek Compressor Station (KP 622) lies within the *expert distribution* of this species (BirdLife International 2016). Records from the Northern Territory are sparse and uncommon, and are expected to be occasional occurrences of the species moving from the critical habitat for a short period.

Threatening processes

The main threat to Painted Honeyeater is habitat loss through the clearing of woodland habitat with the species' preferred mistletoe species (Watson 2012; Garnett et al 2011; TSSC 2015b). Preferred habitat is generally located on rich fertile soils that are also valued as farmland.

Habitat loss through continued degradation of woodland by inappropriate fire and grazing regimes also threatens the species. Frequent fires reduce mistletoe densities through woodland – reducing the key food

source for the Painted Honeyeater (Watson 2012). Inappropriate grazing regimes prevent recruitment of woodland species, causing a change in woodland structure and leading to a future loss of mistletoe resources (Watson 2012; TSSC 2015).

5.11.3 Survey context

Purpose

If present within the Project footprint, Painted Honeyeater could be impacted by Project construction works. It is unlikely that the construction activities will have an impact on breeding of the species, as the closest known breeding area is located in southern Queensland. However, if present, construction activities will disturb woodland areas into which the Painted Honeyeater may occur following breeding.

The purpose of the Painted Honeyeater survey is to determine whether the species occurs within the Project footprint and to assess the suitability of the habitat for use by Painted Honeyeater.

Overview

To achieve the abovementioned purpose, the survey was designed to:

a) Identify areas of potential habitat using desktop mapping datasets.

b) Visit sample sites within that habitat to confirm whether it is suitable habitat, and to assess habitat quality.

c) Undertake bird surveys, searching for Painted Honeyeater and habitat con-specifics.

5.11.4 Survey methodology

Existing survey guidelines

There are no federal survey guidelines for Painted Honeyeater.

The Queensland Government has developed survey guidelines for the Painted Honeyeater (Rowland 2012) which lay out the following survey approach:

> *Area searches (during breeding season) involve systematically searching for birds and signs of their presence (e.g. nesting habitat), as well as listening for their calls, throughout the Project area (DEWHA 2010c). Surveys for this species should be conducted on foot and target foraging and breeding habitat, which includes woodlands where mistletoes are abundant, and in particular, when they are in fruit (Watson 2012).*

Outside of the breeding season, Painted Honeyeater occurs in a wide area outside their critical habitat – usually in association with fruiting mistletoe, but in random locations. The guidelines recommended that survey effort be increased outside of breeding season.

Survey effort recommends a minimum of four hours searching over four days (i.e. 1 hour per day over 4 days) based on a 50 ha Project area.

Survey area and target habitat

Given the *expert distribution* (BirdLife International 2016) of the species does not extend west of KP 570, the survey area was confined to between KP 570 and KP 622. Occurrence of Painted Honeyeater west of this point – including all of the records from the Northern Territory – is sporadic, as the species occasionally moves far away from its breeding range outside of breeding season.

A review of the regional ecosystem mapping datasets for Queensland was undertaken to select mapped polygons containing riparian woodland with Red River Gum (*Eucalyptus camaldulensis*). These areas were selected as they are expected to provide both the most fertile country within the region, the highest density of trees and associated mistletoe, and thus provide the most suitable habitat for the species.

Vegetation mapping indicates that the construction ROW intersects 8.7 km of mapped polygons containing riparian vegetation between KP 570 and KP 622. The area of mapped polygons containing riparian vegetation within the 30 m wide construction ROW is 26.1 ha.

Survey timing

Painted Honeyeater surveys occurred between 14 – 17 May and 21 – 23 June 2016. Although the species is likely only present in the north-west of Queensland seasonally, conducting surveys in May and June was expected to optimise detection probability. The species breeds between October and March (Pizzey and Knight 2012) and migrates to the drier interior outside of these times (including May and June). Additionally, the recent record of the species was from July and, although the dates of the surveys were earlier than the record, the survey dates were comparable in terms of seasonality.

Site selection

Thirteen targeted surveys at seven sites were conducted through open woodland along the construction ROW. Riparian woodland with *E. camaldulensis* bordered by *E. leucophloia, E. leucophylla* and *Acacia spp.* were selected as preferred sites. Details of survey sites are shown in Table 5-12 and locations of surveys are shown on Figure 5-29.

Table 5-12. Dates of targeted Painted Honeyeater surveys

Site	Coordinates		14 May	15 May	16 May	17 May	21 June	22 June	23 June
BC1	-20.82154	139.44061	X	-	X	-	X	-	-
BC2	-20.82638	139.44663	X	-	-	-	-	-	-
BC3	-20.80996	139.42268	-	-	-	X	X	-	-
BC4	-20.81531	139.43190	-	-	-	X	X	-	-
BC5	-20.82113	139.45901	-	-	-	X	-	X	-
BC6	-20.79395	139.46533	-	-	-	X	-	-	X
BC7	-20.8253	139.235	-	-	-	-	-	X	-

Habitat assessment

Habitat features of each site were described to assess the suitability for Painted Honeyeater. The following information was collected:

- Landform
- Vegetation (including regional ecosystem descriptions)
- Habitat values (including the presence of Mistletoe, the presence of water, habitat structure which would provide shelter)
- Level of disturbance (including cattle impact, fire and weed presence)

Targeted survey

Following habitat assessment, surveys were conducted at locations with the most suitable habitat in the local area. Each survey was conducted for 20 minutes on foot by two field ecologists and consistent of walking slow transects (typically along watercourses) covering approximately 200 m. Ecologists recorded all bird species identified along the transects. Surveys totalled 4.3 hours over 6 days, exceeding the recommended survey effort (i.e. 2 hours based on an area 26.1 ha).

5.11.5 Results

Habitat assessment

- Surveys were conducted along riparian margins of watercourses and drainage lines.
- Soils were reddish brown and sandy with high rock content adjacent to the watercourse.
- Dominant vegetation consisted of *Eucalyptus camaldulensis, E. leucophylla and E. leucophloia* with *Acacia cambagei* away from riparian zone.
- Understory consisted of annual tussock grasses at the stream margins (predominately introduced Buffel Grass – *Cenchrus ciliaris*) with *Triodia pungens* forming low, open hummocks beyond (but occasionally extending to the top of the watercourse bank). These sites were selected as they had the highest density of mistletoe observed; however, mistletoe was only scattered through each of the sites.
- Site BC1 had the greatest abundance of mistletoe present and had a small amount of water flowing through the watercourse (see Figure 5-28 for general picture of BC1).
- Details of habitat assessment are provided in Appendix N.
- Sites surveyed along the construction ROW were not significantly different to areas outside the construction ROW.
- There is 8.7 km of preferred habitat (riparian vegetation) for Painted Honeyeater between KP 570 and KP 622 along the construction ROW.
- Very few *Eucalyptus spp.* were observed flowering during the May surveys and no mistletoe was observed to be fruiting. However, pre-flowering bud formation in *Eucalyptus spp.* was observed at the time of surveys (May and June). Mistletoe was observed to be fruiting during the June surveys, however, very few *Eucalyptus* spp. were flowering.

Targeted bird surveys

- Surveys did not detect Painted Honeyeater at any of the search sites, nor was Painted Honeyeater detected at any time during other fieldwork in the area.
- Targeted surveys detected five honeyeater species as well as Mistletoebird.
- Honeyeaters were detected at six of the seven sites, and Mistletoebird was detected at two sites (Table 5-13).
- Although there were no targeted Painted Honeyeater surveys conducted within the Northern Territory, the 65 on-ground surveys conducted for other threatened species did not detect Painted Honeyeater. For a complete list of bird species seen during surveys, see Appendix O.

Table 5-13. Honeyeater species & Mistletoebird records during targeted Painted Honeyeater surveys

	BC1	BC2	BC3	BC4	BC5	BC6	BC7
Grey-headed Honeyeater (*Ptilotula keartlandi*)	2	-	1	1	-	7	-
Grey-fronted Honeyeater (*Ptilotula plumulus*)	-	-	-	-	-	7	-
Yellow-tinted Honeyeater (*Ptilotula flavescens*)	3	-	-	-	2	2	1
White-plumed Honeyeater (*Ptilotula penicillata*)	12	-	-	-	12	1	2
Brown Honeyeater (*Lichmera indistincta*)	-	-	-	-	-	3	-
Mistletoebird (*Dicaeum hirundinaceum*)	2	-	-	-	-	-	1

Figure 5-28. Photograph of most suitable Painted Honeyeater survey site

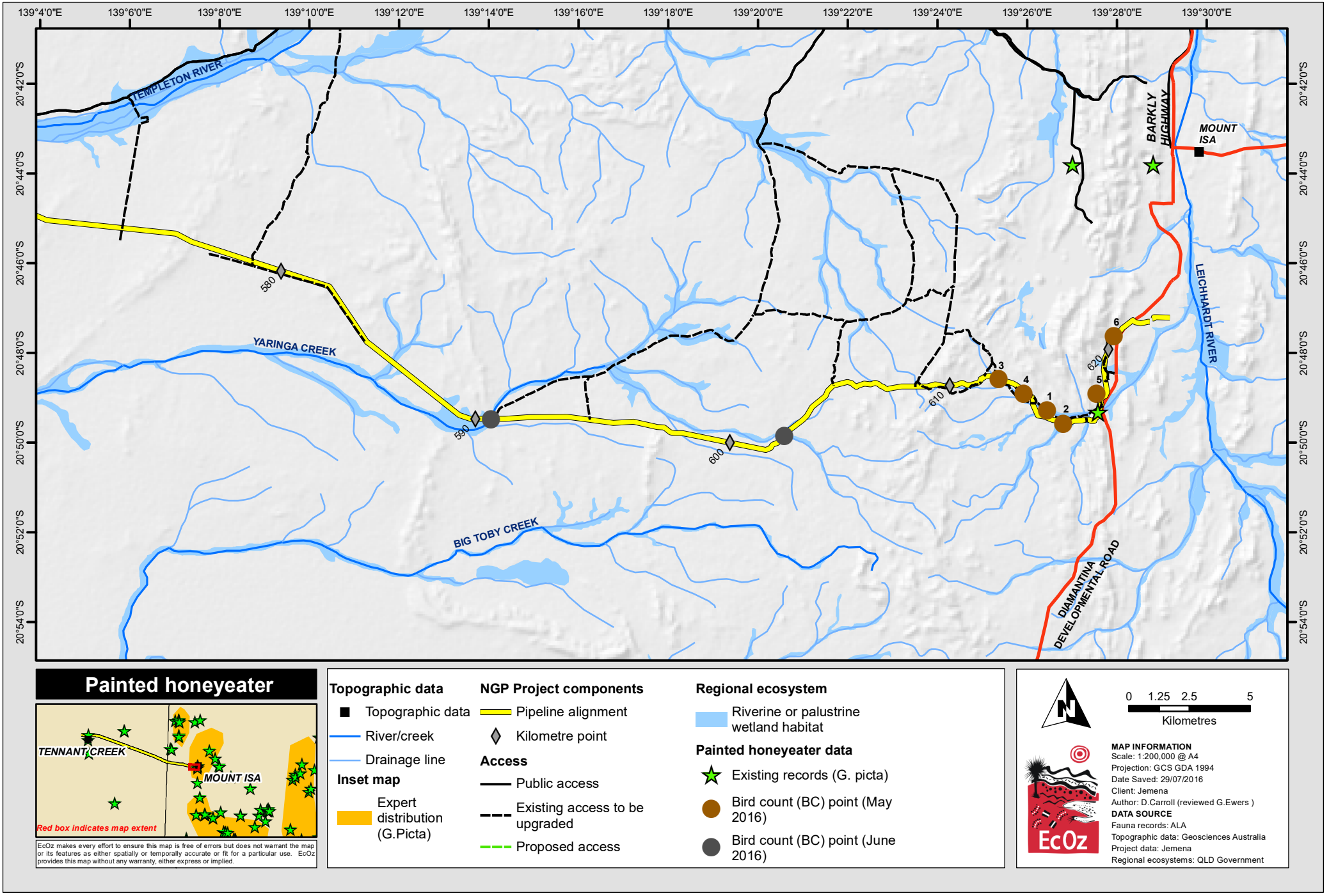
5.11.6 Discussion

Painted Honeyeater was not detected during the targeted surveys in Queensland or general bird surveys in the Northern Territory. Survey effort was above that recommended in the Queensland guidelines for the species.

Site BC6 had the highest number of bird species (including honeyeaters). This was likely due to an established and unburnt understory that provides additional habitat for a range of bird species. Surveys at this site detected four honeyeater species; however, no mistletoe was detected at the site, indicating sub-optimal foraging resource availability for the Painted Honeyeater.

The site with the greatest concentration of mistletoe was BC1. Although the mistletoe was not fruiting at the time of survey, that site presents the most suitable habitat of all the sites. The increased density of mistletoe at this site is likely due to the larger size of the watercourse, presence of permanent to semi-permanent water and the longer time since the last fire.

In general, the sites surveyed contained limited numbers of mistletoe. Although Painted Honeyeater utilises alternative food sources (especially outside the breeding season), the reliance on mistletoe as a primary food source, and the paucity of local records despite a high number of surveys, indicates that the woodland through which the construction ROW passes constitutes only marginal habitat used occasionally by the species. The occurrence of this species (in an ecologically-meaningful way) is considered unlikely.



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\JEMENA\EIS (NT)\01 Project Files\Ch6\Figure 6□21. Map of Painted Honeyeater habitat and records.mxd

Figure 5-29. Map of Painted Honeyeater habitat assessment and field survey

5.12 GREY FALCON (*FALCO HYPOLEUCOS*)

5.12.1 Conservation status

- Northern Territory: Vulnerable
- Queensland: Vulnerable
- National: Not Listed

5.12.2 Background information

Description

The Grey Falcon is a medium-sized, compact, pale falcon. The head and upperparts are a light blue-grey, with darker grey flecking on the wings and barring on the tail. The wing tips are black, the cheeks and chin are white (except for a faint grey tear under each eye), and the underparts are white with fine dark streaks. The bill is grey with a dark tip. The cere, eye-ring and legs are bright yellow. (Ward 2012)

Ecology

The Grey Falcon is known to occur in areas of lightly-timbered lowland plains, typically on inland drainage systems, where the average annual rainfall is less than 500 mm (Ward 2012). This species occupies nests (often built by other bird species) in the tallest trees along watercourses (Garnett et al. 2011), as well as on telecommunications towers. Nesting is normally between June to November (Ward 2012). The Grey Falcon is generally a solitary bird, sometimes found in pairs or family groups (Debus 2012).

Distribution

The Grey Falcon is always found in low densities (Garnett et al. 2011), primarily throughout arid and semi-arid areas (Ward 2012), including the Northern Territory and Queensland. Most records are in the Tanami Desert and in the lower third of the Northern Territory (Northern Territory Fauna Atlas database 2015).

There are six known records proximate to the Northern Territory section of the Project footprint (see Figure 5-2), as well as many others in the Queensland section (mostly concentrated around Mount Isa) and the region in general. Many records are from the Barkly Highway, along which there are many telecommunications towers suitable for Grey Falcon nests.

Threatening processes

According to Ward (2012):

> *Threats to the Grey Falcon are not clearly defined. In the Northern Territory, landscape-scale changes in fire-regimes or grazing by feral or domestic herbivores may, in the long-term, reduce the availability of nesting trees and appropriate prey species. To a lesser extent habitat alteration and destruction through clearing for grazing and agriculture probably lead to declines in the species' southern and eastern ranges early last century, and confined them more to the arid parts of its range.*

5.12.3 Survey context

Purpose

Given the small area of land disturbed during construction, the impact of Project activities on foraging habitat for Grey Falcon will be negligible. This species could only be impacted in the unlikely situation that the Project footprint intersects with an active Grey Falcon nest.

The purpose of the Grey survey is to identify potential nesting habitat, potential nest sites, and assess habitat suitability, within the Project footprint.

Overview

To achieve the abovementioned purpose, the survey was designed to:

a) Identify areas of potential nesting habitat

b) Visit sample sites within that habitat to confirm if active nests are present and whether it is suitable nesting habitat for Grey Falcon.

5.12.4 Survey methodology

There are no species-specific guidelines applicable to surveying Grey Falcon.

The survey area for Grey Falcon includes the entire Project footprint as it is listed as threatened in Northern Territory and Queensland, and the distribution of the species covers most of inland Australia.

Target nesting habitat for Grey Falcon within the Project footprint is considered to be limited to vegetation types associated with drainage systems, as these areas are the only habitat types that consistently provide suitably sized trees that may be utilized as nest sites. All habitat types within the Project footprint are considered as potential foraging habitat for the species, these areas will not be targeted during field studies.

The survey effort required to determine presence/absence of Grey Falcon within the Project footprint is not commensurate with the low risk that the Project activities will negatively impact upon this species. Therefore, targeted bird watching surveys for Grey Falcon was not undertaken (however, opportunistic bird watching occurred as part of other field activities). Instead, the potential presence of Grey Falcon was assessed by undertaking the following activities:

- Review of habitat mapping survey results (see Section 4) to identify alluvial / drainage habitats that may support trees potentially-suitable for nest sites.
- Review of high-resolution aerial footage obtained during the reconnaissance survey (see Section 3)
- Raptor nest sightings made during surveys for other threatened species described in this report, which included visitation of all major watercourses intersected by the construction ROW.

Whilst in the field, ecologists undertaking targeted surveys for other threatened species made a record of all bird species encountered. These ecologists have previous experience in identification of Grey Falcon.

5.12.5 Results

The following points summarise the main results from the Grey Falcon survey:

- No Grey Falcon or nests were identified within the Project footprint.
- Grey Falcon was opportunistically recorded on three occasions during field surveys in May and June 2016. All were single bird observations assumed to be either foraging or transiting (i.e. no nests were seen) (see Figure 5-31):
    - Barkly Homestead airstrip approximately 17 km north of KP 210.
    - Austral Downs Station near Georgina River approximately 21 km north of KP 439.
    - May Downs Station approximately 10 km north of the KP 603. .
- The entire Project footprint constitutes suitable foraging habitat for Grey Falcon.
- The following watercourses supported trees suitable for nesting purposes (tree species included *Eucalyptus microtheca* and *E. camaldulensis*) – Ranken River, James River, Georgina River, Mingera Creek, Templeton River, Yaringa Creek and Mica Creek (see Figure 5-30 for photographs of representative habitat).
- Throughout the region there are also many telecommunications towers which present suitable nesting structures for Grey Falcon.

5.12.6 Discussion

There are many records of Grey Falcon in the region and the entire Project footprint constitutes suitable habitat, including sighting of the species at three locations during field studies (foraging, fly-over observation). However, Grey Falcon is a solitary bird (only occasionally found in pairs or family groups) occurring in low densities throughout its broad distribution. A few individuals may include the Project footprint within their ranges, but there was no evidence of a breeding pair being extant during field surveys.

The entire Project footprint is classed as foraging habitat for the species; however, project impacts to Grey Falcon foraging is regarded to be negligible. Therefore, disturbance of nest sites is a focus in terms of impact assessment for the species. For the region of the Project footprint, nesting habitat is likely to be restricted to larger drainage systems (as these areas may support trees large enough for nests) – which equates to 3.7 ha within the Northern Territory (see Table 5-14). Alluvial plains adjacent to drainage systems may also provide nesting opportunities for the species, this equates to approximately 103 ha (within the Northern Territory) but is regarded as marginal nesting habitat for the species (see Table 5-14). Nesting habitat within Queensland will be assessed under separate documentation relevant to Queensland environmental approvals (note that habitat mapping of alluvial areas indicated that 124.2 ha is proposed to be intersected by the Project footprint within Queensland, see Table 5-14).

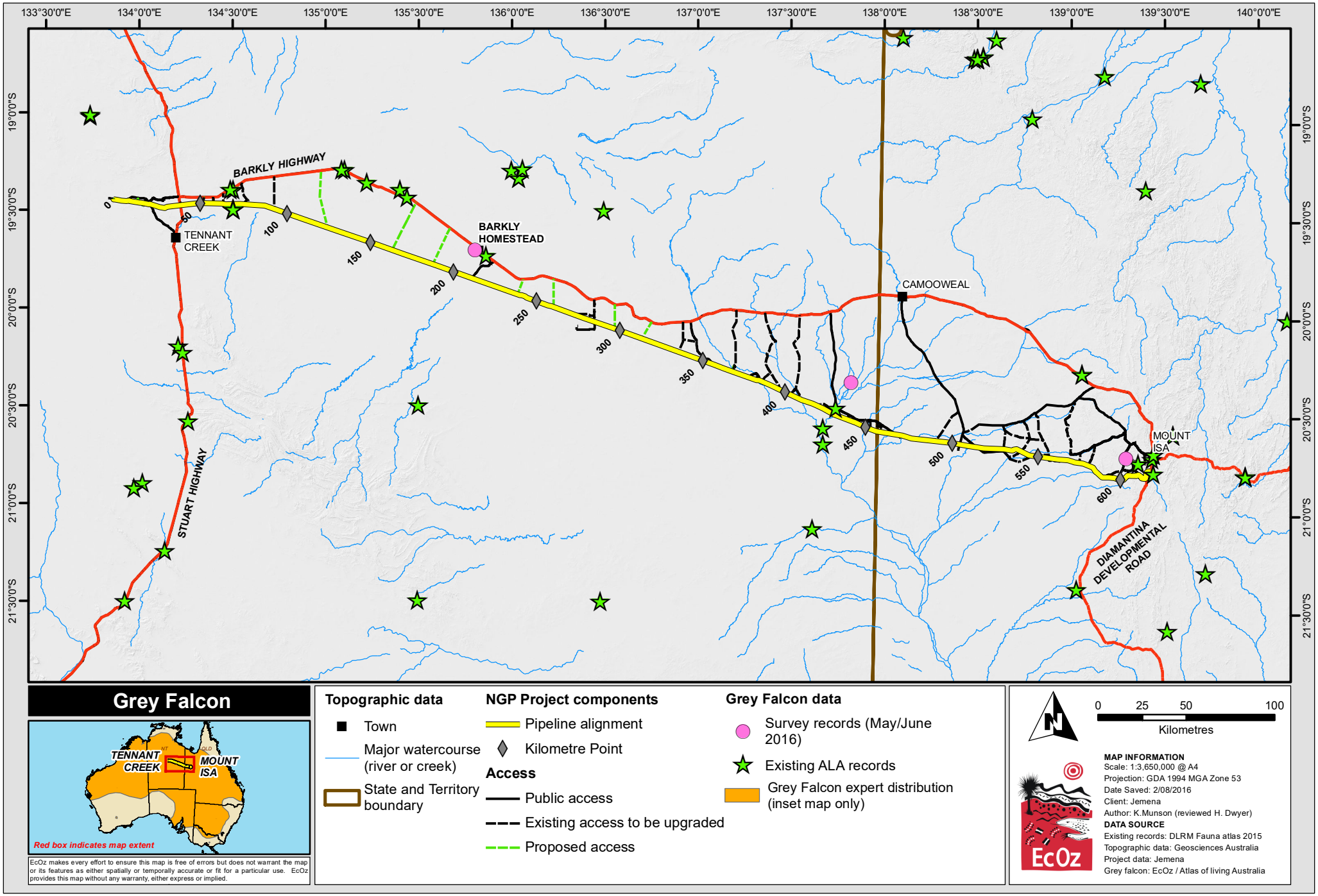
Table 5-14. Potential nesting habitat for Grey Falcon within the Project footprint

Alluvial-based habitat	Disturbance Area (ha)			Grand Total
	ROW	Access tracks	Other	
NORTHERN TERRITORY				
Drainage Systems (nesting habitat)	2.9	0.8	0.0	3.7
Alluvial Plains (marginal nesting habitat)	61.6	12.8	28.6	103.0
QUEENSLAND				
Alluvium (assessed in separate document)	53.2	22.1	48.9	124.2
Grand Total	**117.7**	**35.7**	**77.5**	**230.9**

Ranken River (Northern Territory) – lined by Coolabah (Eucalyptus microtheca)

Templeton River (Queensland) – lined by Red River Gum (Eucalyptus camaldulensis)

Figure 5-30. Photographs of potential Grey Falcon nesting habitat along rivers and creeks



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\JEMENA\EIS (NT)\01 Project Files\Ch6\Figure 6-24. Map of Grey Falcon habitat and records.mxd

Figure 5-31. Map of Grey Falcon habitat assessment and records

6 MIGRATORY SPECIES

The Protected Matters Search Tool (Appendix C) resulted in a list of 20 migratory species that are either known to, or have potential to, occur in the region of the Project footprint.

The likelihood of each migratory species occurring within the Project footprint was determined using the same process as that for threatened species (described in Section 5.2.2). These are summarised in Table 6-1, with a full assessment table provided in Appendix P.

Table 6-1. Summary of migratory species analysis

Likelihood	Common name	Scientific name
High	Rainbow Bee-eater	*Merops ornatus*
	Great Egret	*Ardea alba*
	Cattle Egret	*Ardea ibis*
	Fork-tailed Swift	*Apus pacificus*
	Oriental Plover	*Charadrius veredus*
	Oriental Pratincole	*Glareola maldivarum*
Low	Eastern Osprey	*Pandion cristatus*
	Sharp-tailed Sandpiper	*Calidris acuminata*
	Common Greenshank	*Tringa nebularia*
	Wood Sandpiper	*Tringa glareola*
	Marsh Sandpiper	*Tringa stagnatilis*
	Red-necked Stint	*Calidris ruficollis*
	Black-tailed Godwit	*Limosa limosa*
	Little Curlew	*Numenius minutus*
	Pacific Golden Plover	*Pluvialis fulva*
	Lesser Sand Plover	*Charadrius mongolus*
	Whimbrel	*Numenius phaeopus*
	Barn Swallow	*Hirundo rustica*
	Grey Wagtail	*Motacilla cinerea*
	Yellow Wagtail	*Motacilla flava*

As shown in Table 6-1, six EPBC-listed migratory bird species were identified within the *EPBC Act* Protected Matters Search Report as having a high chance of occurring in the Project footprint:

- Fork-tailed Swift (*Apus pacificus*)
- Rainbow Bee-eater (*Merops ornatus*)
- Oriental Plover (*Charadrius veredus*)
- Oriental Pratincole (*Glareola maldivarum*)
- Great Egret (*Ardea alba*)
- Cattle Egret (*Ardea ibis*)

Each of these species are discussed below

6.1.1 Fork-tailed swift (*Apus pacificus*)

The Fork-tailed Swift is an aerial feeder, flying between 1 m to 300 m above the ground to forage (Higgins 1999). It is a non-breeding visitor to Australia that has been recorded throughout the country (Higgins 1999). Given its wide distribution and high mobility, it is likely that the species will be present from time-to-time in the sky above the Project footprint.

6.1.2 Rainbow Bee-eater (*Merops ornatus*)

The Rainbow Bee-eater is a widely distributed species that uses a range of habitat types – including woodlands, shrublands, and various cleared and semi-cleared habitats (Simpson and Day 2004). It is likely that the woodland vegetation communities within the Project footprint constitute suitable foraging habitat for the Rainbow Bee-eater.

6.1.3 Oriental Plover (*Charadrius veredus*)

The Oriental Plover is a summer migrant in much of northern Australia. The species has a wide distribution and uses a range of habitat types (DOE 2016d). Upon arrival from Northern Hemisphere breeding grounds, the Oriental Plover spends a few weeks in coastal habitats before dispersing further inland (Storr 1977). Whilst in Australia, the species does not maintain territories or home ranges (DOE 2016d). This species could occur throughout the flat areas of the Project footprint (particularly in clay plains of the Barkly Tablelands).

6.1.4 Oriental Pratincole (*Glareola maldivarum*)

The Oriental Pratincole occurs at many widespread sites in northern Australia, especially near the coasts of northern Western Australia and the NT, and in inland areas north of 20° S in those states (Blakers et al. 1984, Barrett et al. 2003). The species is generally gregarious, occurring flocks which, in northern Australia, can comprise thousands of birds (Higgins & Davies 1996). The Oriental Pratincole usually inhabits open plains, floodplains or short grasslands (Garnett 1986). This species could occur throughout the flat areas of the Project footprint (particularly in clay plains of the Barkly Tablelands).

6.1.5 Egret species (Ardea alba & Ardea ibis)

These two egret species are common wetland birds that are widespread across Australia. Individuals of the species occupy large areas and utilise a variety of inundated areas without strong preference for vegetation type (Marchant & Higgins 1990). The black soil plains area at the southern extent of the Barkly Tableland region contain inundated areas during the wet season – which constitute suitable habitat for these species – as does all riverine habitat within the Project footprint.

7 SUMMARY OF THREATENED SPECIES

Preliminary assessment of threatened species occurrence in Section 5.2.3 determined that nine threatened species (relevant to Northern Territory and/or Commonwealth) had potential to occur within the region of the Project footprint. Of these, targeted field surveys and/or habitat suitability assessment determined the following:

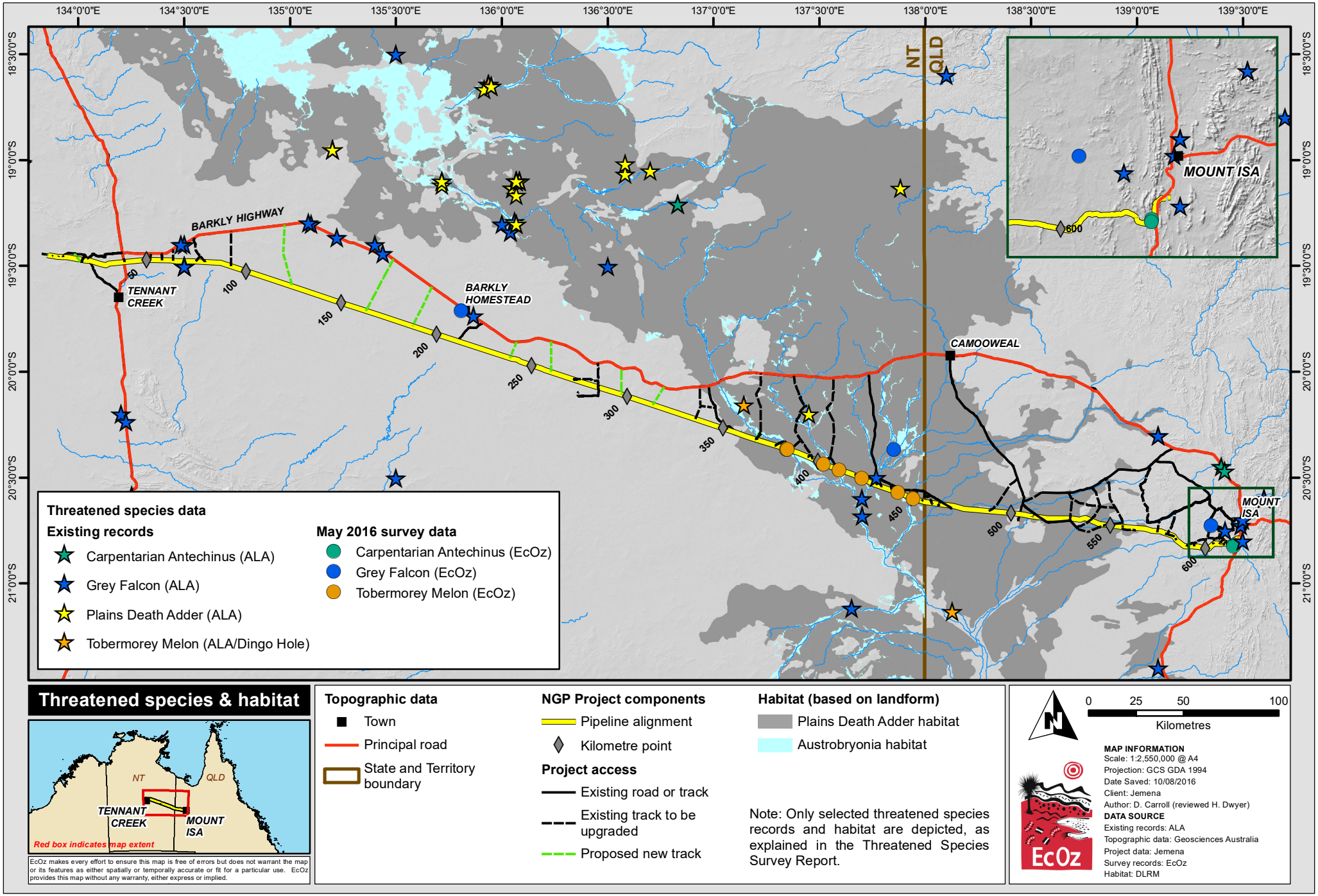
- Two threatened species were recorded within the Project footprint.
- Two threatened species were not identified during the surveys within the Project footprint; however, it is considered likely they occur within the Project footprint.
- Five threatened species that were considered by the likelihood assessment in Section 5.1 to have a medium to high chance of occurring within the Project footprint are – post-field surveys – considered unlikely occur within the Project footprint:

These results are shown in Figure 7-1. These species' 'likelihood of occurrences' have been revised accordingly – see Table 7-1.

Table 7-1. Post-survey threatened species 'likelihood of occurrence' within the Project footprint

Revised likelihood	Species name	*EPBC* status	*TPWC* status	Area of habitat within Project footprint	
				Temporary	Permanent
Known	Carpentarian Antechinus (*Pseudantechinus mimulus*) #	VU	VU	1.04 ha	0 ha
	Tobermorey Melon (*Austrobryonia argillicola*) *	-	VU	106.7 ha	0 ha
Likely	Grey Falcon (*Falco hypoleucos*) *	-	VU	3.7 ha	0 ha
	Plains Death Adder (*Acanthophis hawkei*)	VU	VU	798.8 ha	21.3 ha
Unlikely	Gouldian Finch (*Erythrura gouldiae*)	EN	VU	N/A	
	Painted Honeyeater (*Grantiella picta*)	VU	VU	N/A	
	Brush-tailed Mulgara (*Dasycercus blythi*)	-	VU	N/A	
	Latz's Grass (*Sporobolus latzii*)	-	VU	N/A	
	Greater Bilby (*Macrotis lagotis*)	VU	VU	N/A	

* Relevant to Northern Territory only; # Relevant to Queensland only



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\JEMENA\EIS (NT)\01 Project Files\Ch6\Figure 6-X. Map of records and habitat for species considered as 'known' or 'likely' to occur within the Project footprint.mxd

Figure 6-12. Map of records and habitat for species considered as 'known' or 'likely' to occur within the Project footprint

8 ASSESSMENT OF SIGNIFICANCE

The objective of this chapter is to undertake a qualitative assessment of the importance of biodiversity values that have been identified to occur, or are considered likely to occur within the Project footprint, in order to determine their conservation significance. Such an assessment of conservation significance will inform the EIA process, as well as Project design and management.

The three biodiversity values assessed are:

- Threatened flora and fauna species
- Migratory bird species
- Sensitive vegetation types.

8.1 IMPORTANCE OF THREATENED SPECIES' POPULATIONS

As detailed in Section 4.1, targeted surveys and habitat assessments were undertaken for nine species that are listed under the *TPWC Act* and/or the *EPBC Act*. The result – as summarised in Section 7 – is that five species were not found during the surveys or suitable habitat was not identified within the Project footprint. Therefore, these species are considered unlikely to occur within the Project footprint, and have not been considered further.

Four species were recorded, or are considered likely to occur, within the Project footprint. The importance of the populations of these species is discussed in sections below.

When assessing the risk of impacts to threatened species that are known or likely to occur within the Project footprint, it is necessary to first establish whether local populations are 'important' as defined in *EPBC Significant Impact Guidelines 1.1* (DOE 2013).

All the threatened species that are 'known' or 'likely' to occur within the Project footprint are listed as Vulnerable under NT and/or Commonwealth legislation. In accordance with the guidelines, for Vulnerable species, an 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans and/or that are:

- Key source populations either for breeding or dispersal
- Populations that are necessary for maintaining genetic diversity
- Populations that are near the limit of the species' range.

'Important populations' are considered, within this report, to be of conservation significance and will be addressed in the EIS risk assessment.

8.1.1 Plains Death Adder (*Acanthophis hawkei*)

This species is listed as Vulnerable under the *TPWC Act* and under the *EPBC Act*.

There are no records of Plains Death Adder within the Project footprint. Field surveys confirmed that 206 km of Plains Death Adder habitat is intersected by construction ROW between KP 355 and KP 561 (plus approximately 108 km of existing access tracks that will require 5 m widening) – which equates to approximately 820.1 ha of disturbance (of which 21.3 ha will be permanent). This is part of a continuous band of potentially-suitable habitat for the species which continues for many hundreds of kilometres to the north-west (see Figure 5-11). Within that habitat, there is one record (from 1978) approximately 22 km north of the construction ROW from the Wonardo land system, the only record from that land system. There are also many records 100+ km to the north-west of where the Project footprint intersects with suitable Plains Death Adder habitat. A high proportion of these records occur within the Barkly land system which is relatively uncommon in the Project footprint.

The presence – within the Project footprint – of suitable habitat to that known to support Plains Death Adder indicates a reasonable likelihood that the species occurs within the Project footprint. This would represent an extension (to the southwest) of the known range of an existing population this species. It seems reasonable to infer that such an occurrence would be part of the same population as that containing the record proximate to the Project footprint. What is unclear is whether that population is contiguous with the population that hosts the occurrence records from 100+ km further north in a different land system. Applying the precautionary principle, it is assumed that, if extant, occurrences of Plains Death Adder within the Project footprint would constitute a separate population (i.e. no gene flow) to that containing the multiple records of the species 100+ km to the north. A population of Plains Death Adder within the Project footprint can therefore be considered near the limit of the species' known range and, as such, necessary for maintaining the species genetic diversity.

For these reasons, the likely population of this species within the Project footprint is considered 'important' (as defined in *EPBC Significant Impact Guidelines 1.1*).

Acknowledging the many uncertainties associated with determining the area of occupancy of this population, a conservative estimate of suitable habitat is 1.6 million ha (16 000 km2). This is based on the area of habitat containing the Wonardo land system and all other suitable black soil country to the south of that land system, as per Figure 5-11.

8.1.2 Carpentarian Antechinus (*Pseudantechinus mimulus*)

This species is listed as Vulnerable under the *TPWC Act* and under the *EPBC Act*.

Carpentarian Antechinus were identified near to the construction ROW in the rocky hills near Mica Creek, and at an isolated boulder outcrop (see Figure 5-18). These records represent a range extension to the south and south-west of other known occurrences. It is expected that they could occur throughout the eastern end of the Project footprint (between KP 609.5 and KP 620.5) wherever rocky outcrops, boulder piles or rocky hills are intersected. Habitat mapping indicates that a total area of 1.04 ha is proposed to be directly disturbed by construction activities (of which none will be permanent disturbance). There is a variety of rock types exposed in the region and it is unknown whether some of these comprise more preferred habitat for Carpentarian Antechinus.

It is not clear the degree to which occurrences of Carpentarian Antechinus are connected (in terms of population boundaries) in this part of its distribution (coupled with low level of existing ecological knowledge of the species). Based on survey evidence and advice from experts, it is inferred that all occurrences within the Project footprint form part of one population, as this assumes that there is dispersal and genetic flow between isolated boulder piles and more substantial rocky ridge lines.

Historically, Carpentarian Antechinus has not been widely surveyed for and may be locally common in the rocky country surrounding Mount Isa (given it has often been recorded when suitable habitat is surveyed – such as for this project). Nevertheless, the records of Carpentarian Antechinus within the Project footprint from the targeted survey represent an extension of the known range of this species and, applying the precautionary principle, it cannot be concluded that the population of the species within the Project footprint is contiguous with any other known populations in the Mt Isa area. The population of Carpentarian Antechinus within the Project footprint can therefore be considered near the limit of the species' known range and, as such, necessary for maintaining the species' genetic diversity.

For these reasons, the known population of this species within the Project footprint is considered 'important' (as defined in *EPBC Significant Impact Guidelines 1.1*).

Acknowledging the many uncertainties associated with determining the area of occupancy of this population, a conservative estimate of suitable habitat is 4 369 ha. This is based on the area of rocky habitat depicted in Figure 5-18.

8.1.3 Grey Falcon (*Falco hypoleucos*)

This species is listed as Vulnerable under the *TPWC Act* and is not listed under the *EPBC Act*.

Grey Falcon (Vulnerable *TPWC Act*) or potential nests were not identified within the Project footprint during field surveys; however, the species was incidentally observed (foraging / flyover) on three occasions during field surveys outside the Project footprint – confirming their presence in the region. The entire Project footprint constitutes suitable foraging habitat. However, Grey Falcon is a solitary bird (only occasionally found in pairs or family groups) occurring in low densities throughout its broad distribution. As such, it is likely that a few individuals of this species have home ranges that intersect the Project footprint.

Grey Falcon could conceivably nest within the Project footprint; however, its preference for tall trees means that – regionally – suitable nesting habitat will be restricted to watercourses (or telecommunication towers). The limited number of watercourse crossings, relatively narrow Project footprint and short construction timeframe, all combine to suggest there is a low likelihood that a nest site would occur directly in the construction ROW during construction. Potential nesting habitat within the Northern Territory intersected by the Project footprint equates to 3.7 ha (temporary disturbance). Alluvial plains adjacent to drainage systems may also provide nesting opportunities for the species, this equates to approximately 103 ha (within the Northern Territory) but is regarded as marginal nesting habitat when compared to drainage systems. Nesting habitat within Queensland will be assessed under separate documentation relevant to Queensland environmental approvals.

General occurrence of a Vulnerable species in a region does not meet the definition of an 'important' population of a Vulnerable species as per the *EPBC Significant Impact Guidelines 1.1*. The Project footprint is within the *expert distribution* range of Grey Falcon, but there is no evidence that individual Grey Falcon in central-eastern Northern Territory and/or central-western Queensland constitute a key source population, or one that is necessary for maintaining genetic diversity.

For these reasons, the occurrence of a few individuals of this species within the Project footprint is not considered 'important' (as defined in *EPBC Significant Impact Guidelines 1.1*).

8.1.4 Tobermorey Melon (*Austrobryonia argillicola*)

This species is listed as Vulnerable and was previously listed as Endangered under the *EPBC Act.* The Commonwealth Threatened Species Scientific Committee (in 2010) determined that this species was eligible for delisting due to recent information that better defines its taxonomic status, and consequently establishes a much larger known range and number of occurrences. Furthermore, the TSSC stated that there are no listed threatening factors known to affect this species. Tobermorey Melon was subsequently de-listed as an *EPBC*-listed threatened species in December 2013.

Tobermorey Melon was recorded at 7 out of 12 targeted survey sites within the Project footprint, plus an incidental record adjacent to Austral Downs airstrip (adjacent to Georgina River). These records were spread across four catchments of the Ranken River, James River, Georgina River and Blue Bush Creek. There was one previous record of the species 15 km north of the construction ROW; with the remaining Northern Territory records from approximately 200 km south and 200 km to the north of the Project footprint. In Queensland, in very similar habitat, this species occurs in numerous locations south of the Project footprint. The *Commonwealth Listing Advice on Austrobryonia argillicola* (TSSC 2013) states that this species has an extent of occurrence of 800 000 km^2 and an unknown area of occupancy. In 2006, Kerrigan and Albrecht estimated that, in the Northern Territory, Tobermorey Melon has an area of occupancy of 20 km^2; however, this was before additional records were found and also seems low because the then known population extent only just overlapped into the Northern Territory (see Figure 5-8).

TSSC (2013) asserts that although this species' known distribution appears fragmented, this non-continuous distribution may be an artefact of limited collection effort (Kerrigan & Albrecht 2006). This has been re-affirmed during recent discussions with the Northern Territory Herbarium (Peter Jobson pers. comm. 2016).

As such, Tobermorey Melon could be a candidate for de-listing as a threatened species in the Northern Territory.

Survey results suggest that Tobermorey Melon is likely to be widespread in drainage habitat within the region, but is scarce (i.e. occurs in low densities) at each location. Approximately 106.7 ha of suitable habitat will be temporarily disturbed (no permanent disturbances will occur within drainage habitat). Given the large area of contiguous habitat and multiple records of this species when targeted in surveys, it seems reasonable to infer that there is a single population of Tobermorey Melon dispersed throughout the river systems in the Mitchell Grass Downs area. Occurrences of this species within the Project footprint should not be considered as populations of this species, but individual members of a single population. The criteria for that population being an 'important' one (as defined in the *EPBC Significant Impact Guidelines 1.1*) are not satisfied.

8.1.5 Conclusion

After due assessment, important populations of two threatened species are considered to occur, or likely to occur, within the Project footprint:

- Carpentarian Antechinus (*Pseudantechinus mimulus*) in the rocky country between KP 609.5 and KP 620.5
- Plains Death Adder (*Acanthophis hawkei*) in clay plains of the Mitchell Grass Downs bioregion between KP 355 and KP 561

8.2 IMPORTANCE OF MIGRATORY SPECIES' POPULATIONS

As detailed in Section 5.12.1, six EPBC-listed migratory bird species were also identified within the *EPBC Act* Protected Matters Search Report as having a high chance of occurring within the Project footprint.

When assessing if a project will significantly impact upon a migratory species, the key considerations under the *EPBC Significant Impact Guidelines 1.1* (DOE 2013) are whether an important habitat for a migratory species or an ecologically-significant population of a migratory species is involved.

In the case of migratory shorebirds – in this instance Oriental Plover and Oriental Pratincole – these two considerations are largely inter-related. This is demonstrated in the *EPBC Act Policy Statement 3.21* (DEWHA 2009a) which defines the criteria for important habitat for migratory shorebirds as sites that support any of the following:

- At least 0.1 per cent of the flyway population of a single species.
- At least 2 000 migratory shorebirds.
- At least 15 migratory shorebird species.

Apart from Lake Moondarah near Mount Isa (which is outside of the Project footprint by at least 15 km), there are few records of migratory shorebirds in the region, and none of those criteria are met for any migratory shorebird.

Oriental Plover, and particularly Oriental Pratincole, occur frequently throughout the clay grasslands of the Barkly Tableland at certain times of year (and individual flocks of Pratincoles could number a few thousand individuals). Although this implies that the second criterion for important habitat for migratory shorebirds is met, the occurrence of a flock of Oriental Pratincole could be anywhere in the vast area of the Barkly Tableland, not confined to a particular 'site'. The rationale behind the *EPBC Significant Impact Guidelines* (DOE 2013) criteria for important habitat is to identify sites that require protection. The Barkly Tableland is not a 'site' *per se* and, as such, this criterion is not met for Oriental Pratincole. Moreover, the suitable habitat for these species within the Project footprint is a tiny proportion of the regional total.

The four other relevant migratory bird species have very different habitats and ecologies, they are all similar in that the Project footprint neither represents important habitat for them, nor are ecologically-significant

populations likely to be present. All the species likely occur – seasonally – across the Project footprint in numbers commensurate with the region. Habitat for these species is widespread in the region, including within the Project footprint.

8.3 SENSITIVE VEGETATION (NORTHERN TERRITORY ONLY)

In the Northern Territory, sensitive vegetation types are those considered significant under the *Northern Territory Land Clearing Guidelines* (DNRETAS 2010). These vegetation types are either unique to the region and/or have high biodiversity values. The region of the Northern Territory in which the Project footprint occurs contains two of these sensitive vegetation types – 'riparian vegetation' and 'wetlands'.

Riparian vegetation occurs along the larger creeks and rivers, of which all are located within the Mitchell Grass Downs bioregion (i.e. black soil plains) and were considered to be in relatively poor ecological condition (due to presence of erosion, weeds, and cattle). Four intersection points along the construction ROW were identified (associated with Ranken River, James River, Georgina River and Blue Bush Creek) plus several minor crossings associated with access tracks (noting that proposed access tracks are positioned on existing tracks that require 5 m widening). Vegetation associated with these watercourses is mostly Coolabah (*Eucalyptus microtheca*) woodland along the banks with sparse ground layer of tussock grasses and Blue Bush (*Chenopodium auricomum*). No aquatic vegetation (such as lily pads) was observed within the Project footprint. These areas are currently impacted by cattle, weed infestation (varying levels), and erosion.

Seasonal lakes and swamps (i.e. wetlands) occur in the region of the Project footprint; however, none are intersected or are expected to be impacted upon by construction activities.

9 REFERENCES

Abbott I, 2001, 'The Bilby *Macrotis lagotis* (Marsupialia: Peramelidae) in south-western Australia: original range limits, subsequent decline, and presumed regional extinction', *Records of the Western Australian Museum*, 20, pp. 271-305.

Albrecht D, Latz P & Westaway J, 2012, *Threatened Species of the Northern Territory Information Sheet: Sporobolus latzii B.K. Simon (POACEAE),* Department of Land Resource Management (DLRM). http://lrm.nt.gov.au/__data/assets/pdf_file/0004/143176/Sporobolus_latzii_VU_FINAL.pdf.

Barea LP, 2008, Nest-site selection by the Painted Honeyeater (*Grantiella picta*), a mistletoe specialist, *Emu*, 108, pp. 213-220.

Barea LP, Herrera MLG, 2009, Sources of protein in two semi-arid zone mistletoe specialists: Insights from stable isotopes, *Austral Ecology* 34, pp. 821–828.

Barea LP and Watson DM 2013, Trapped between popular fruit and preferred nest location – cafeterias are poor places to raise a family, *Functional Ecology* 27(3), pp. 766-774.

Barrett G, Silcocks, A. Barry, S, Cunningham, R & Poulter R, 2003, *The New Atlas of Australian Birds*, Birds Australia, Melbourne, Victoria.

Bell PJ, 1996, 'Survey of the nasal mite fauna (Rhinonyssidae and Kytoditidae) of the Gouldian Finch, Erythrura gouldiae, and some co-occurring birds in the Northern Territory'. *Wildlife Research* 23, pp. 675-686.

BirdLife International 2016, Species factsheet: *Grantiella picta*, viewed online 28 May 2016, http://www.birdlife.org/datazone/species/factsheet/22704412.

Blakers M, Davies SJ & Reilly PN, 1984, *The Atlas of Australian Birds,* Melbourne University Press, Melbourne, Victoria.

Brazill-Boast J, Pryke SR and Griffith SC, 2010, 'Nest-site utilisation and niche overlap in two sympatric, cavity-nesting finches', *Emu*, 110, pp. 170-177.

Brazill-Boast J & Pryke SR, 2011, 'Breeding habitat selection in the endangered Gouldian Finch (*Erythrura gouldiae*) at two spatial scales', *Emu*, 111(4) 304-31.

Boland CRJ, 2004, 'Breeding biology of Rainbow Bee-eaters (Merops ornatus): a migratory, colonial, cooperative bird', *Auk*, 121, pp.811-823.

Brock J, 1993, *Native Plants of Northern Australia*, published by Reed, Balgowlah, NSW.

Brocklehurst P, Lewis D, Napier D, & Lynch D, 2007, '*Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping'*, Technical Report No. 02/2007D, Department of Natural Resources, Environment and the Arts, Palmerston, Northern Territory.

Christensen P & Burrows N, 1994, Project desert dreaming: experimental reintroduction of mammals to the Gibson Desert, Western Australia. In: *Reintroduction Biology of Australian and New Zealand Fauna* M. Serena (ed.), Surrey Beatty & Sons, Chipping Norton, pp. 190-207.

Christian CS & Stewart GA, 1953, '*General report on survey of Katherine-Darwin region, 1946'*, CSIRO, Aust. Land Resource Series, No. 1, pp. 1-177.

Christian CS, Noakes, LC, Perry RA, Slatyer RO, Stewart GA & Traves DM, 1954, '*Survey of the Barkly Region, Northern Territory and Queensland', 1947- 48*, CSIRO, Land Research Series, No. 3. pp. 1-198.

Commonwealth of Australia, 2016, *Species of National Environmental Significance*, http://www.environment.gov.au/science/erin/databases-maps/snes

Curtis LK, Dennis AJ, McDonald KR, Kyne PM & Debus SJS, 2012, *Queensland's Threatened Animals*, CSIRO Publishing.

Debus S, 2012, *Birds of Prey of Australia: A Field Guide,* 2nd edn, CSIRO Publishing, Melbourne, Victoria.

Deignan HG, 1964, 'Birds of the Arnhem Land Expedition', *Rec. American-Australian Scientific Expedition to Arnhem Land*, vol. 4, pp. 345-426.

Department of Environment (DoE) 2009, Strategy for Australia's National Reserve System 2009- 2030, Natural Resources Policies and Program Committee, Viewed 11 May, https://www.environment.gov.au/system/files/resources/643fb071-77c0-49e4-ab2f-220733beb30d/files/nrsstrat.pdf>.

Department of the Environment (DoE), 2012, Interim Biogeographic Regionalisation for Australia v. 7 (IBRA) [ESRI shapefile] Available from: http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B3C182B5A-C081-4B56-82CA-DF5AF82F86DD%7D

Department of the Environment (DoE), 2013, Matters of National Environmental Significance guidelines, Significant Impact Guidelines 1.1, Viewed 3 May 2016, http://www.environment.gov.au/epbc/publications/significant-impact-guidelines-11-matters-national-environmental-significance>.

Department of the Environment (DoE), 2016a, *Macrotis lagotis* in Species Profile and Threats Database, Department of Environment, Canberra, viewed online 6 June 2016, http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=282.

Department of Environment (DoE), 2016b, Species of National Environmental Significance 10km Grids, Version 3, Commonwealth of Australia – Greater Bilby *Macrotis lagotis*.

Department of the Environment (DOE), 2016d, *Charadrius veredus* in Species Profile and Threats Database, Department of Environment, Canberra, viewed online 6 June 2016, http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=882.

Department of the Environment (DoE), 2016e, National Vegetation Information System v4.2 (NVIS 4.2) [ESRI geodatabase] Available from: http://www.environment.gov.au/land/native-vegetation/national-vegetation-information-system/data-products#mvsg42

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2009a, Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species http://www.environment.gov.au/epbc/publications/shorebirds-guidelines

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2009b, Assessment of Australia's Terrestrial Biodiversity 2008, report prepared for the Commonwealth of Australia, https://www.environment.gov.au/biodiversity/publications/assessment-australias-terrestrial-biodiversity-2008

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2010a, Viewed 11 May, Fact sheet: The Cane Toad (Bufo marinus), https://www.environment.gov.au/biodiversity/invasive-species/publications/factsheet-cane-toad-bufo-marinus.

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2010b, Camel Fact sheet, Viewed 11 May, http://155.187.2.69/biodiversity/invasive/publications/camel-factsheet.html.

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2010c, Survey Guidelines for Australia's Threatened Birds, EPBC Act survey guidelines 6.2 (l), Commonwealth of Australia.

Department of Land Resource Management (DLRM), 2013, *Sensitive Vegetation in the Northern Territory – Riparian Vegetation*. Department of Land Resource Management. Northern Territory Government. <http://www.lrm.nt.gov.au/__data/assets/pdf_file/0015/5352/Sensitive-Veg-Factsheets_Sandsheet_Feb2013.pdf

Department of Land Resource Management (DLRM) 2016b, Feral Animals in the Northern Territory: Feral Cattle, viewed 19 April 2016, http://www.lrm.nt.gov.au/feral/cattle.

Department of Natural Resources, Environment, The Arts and Sport (DNRETAS), 2010, *Land Clearing Guidelines*, Department of Natural Resources, Environment, The Arts and Sport, Darwin. Northern Territory., https://nt.gov.au/__data/assets/pdf_file/0007/236815/land-clearing-guidelines.pdf

Department of Sustainability, Environment, Water, Population and Communities (SEWPaC), 2011a, Invasive Species Factsheet: Feral Horse (*Equus caballus*) and Feral Donkey (*Equus asinus*): Canberra, Australia, Viewed 11 May, https://www.environment.gov.au/system/files/resources/b32a088c-cd31-4b24-8a7c-70e1880508b5/files/feral-horse.pdf.

Department of Sustainability, Environment, Water, Population and Communities (SEWPaC), 2011b, Invasive Species Fact Sheet: The feral Pig (Sus scrofa), Canberra, Australia, Viewed 11 May 2016, https://www.environment.gov.au/biodiversity/invasive-species/publications/factsheet-feral-pig-sus-scrofa

Department of Sustainability, Environment, Water, Population and Communities (SEWPaC), 2011c, Factsheet: European red fox (*Vulpes vulpes*): Canberra, Australia, Viewed 11 May, https://www.environment.gov.au/biodiversity/invasive-species/publications/factsheet-european-red-fox-vulpes-vulpes>.

Department of Sustainability, Environment, Water, Population and Communities (SEWPaC), 2011d, *Survey guidelines for Australia's threatened reptiles: Guidelines for detecting reptiles listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*, Commonwealth of Australia, 2011

Department of Sustainability, Environment, Water, Population and Communities (SEWPaC), 2011e, *Survey guidelines for Australia's threatened mammals: Guidelines for detecting mammals listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*, Commonwealth of Australia, 2011

Dostine PL and Franklin DC, 2002, A comparison of the diet of three finch species in the Yinberrie Hills area, Northern Territory. *Emu,* 102, 159-164.

Dostine PL, Johnson GC, Franklin DC, Zhang Y and Hempel C, 2001, Seasonal use of savanna landscapes by the Gouldian finch, *Erythrura gouldiae*, in the Yinberrie Hills area, Northern Territory, *Wildlife Research* 28, 445-458.

Duguid A, Barnetson J, Clifford B, Pavey C, Albrecht D, Risler J and McNellie M, 2005, *Wetlands in the arid Northern Territory*, a report to the Australian Government Department of the Environment and Heritage on the inventory and significance of wetlands in the arid NT, Northern Territory Government Department of Natural Resources, Environment and the Arts, Alice Springs.

Edwards GP, Allan G, Brock C, Duguid, Gabrys, and Vaarzon-Morel, 2008, Fire and its management in central Australia, *The Rangeland Journal*, vol. 20, pg. 109-121, published by CSIRO Publishing.

Evans SM and Bougher AR, 1987, 'The abundance of estrildid finches at waterholes in the Kimberley (WA)', *Emu,* 87, pp. 124-127.

Fisher A, Baker B, & Woinarski J, 2002, *Biodiversity Audit – bioregional case study – Mitchell Grass Downs, Northern Territory*, report prepared by the Parks and Wildlife Commission of the Northern Territory for the National Land & Water Audit.

Garnett ST, 1986, 'Seasonal changes in the wader population in the south-east of the Gulf of Carpentaria', *Stilt*, 8, pp. 9--13.

Garnett ST, Szabo JK and Dutson G, 2011, *The action plan for Australian Birds 2010*, CSIRO Publishing/Birds Australia, Melbourne, Victoria.

Gibbons, P & Lindenmayer, D (2002), *Tree Hollows and Wildlife Conservation in Australia*, CSIRO publishing, Collingwood, Victoria.

Gibson D, Latz P, Cole J, and Wurst P, 1994, *Flora and Fauna Survey of the Wakaya Desert, Northern Territory*, report by the Conservation Commission of the Northern Territory, Alice Springs, Northern Territory.

Gilfillan SL, 2001, An ecological study of a population of *Pseudantechinus macdonnellensis* (*Marsupialia: Dasyuridae*) in central Australia. 1 Invertebrate food supply, diet and reproductive strategy, *Wildlife Research*, 28, pp. 469-480.

Gillespie G, Gentles T, Hill B, Low Choy J, Mahney T, Stevens A, and Stokeld D, 2015, *A guide for the use of remote cameras for wildlife surveillance in Northern Australia*, Prepared by the Flora and Fauna Division of the Dept. Land Resource Management, Northern Territory Government.

Griffiths AD, 1998, 'Impact of sulphur dioxide emissions on savanna biodiversity at Mount Isa, Queensland' Report to Mount Isa Mines Ltd, Tropical Savannas Cooperative Research Centre: Darwin.

Hagman M, Phillips BL and Shine R, 2008, Tails of enticement: caudal luring by an ambush-foraging snake (Acanthophis praelongus, Elapidae), *Functional Ecology*, 22, pp. 1134–1139.

Hagman M, Phillips BL and Shine R, 2009, Fatal attraction: adaptations to prey on native frogs imperil snakes after invasion of toxic prey, *Proceedings of the Royal Society B - Biological Sciences* 276, pp. 2813–2818.

Harden RH, Muir RJ and Milledge DR, 1986, 'An evaluation of the strip transect method for censusing bird communities in forests' *Wildlife Research*, 13, pp 203–211.

Higgins PJ (ed), 1999, *Handbook of Australian, New Zealand and Antarctic Birds: Volume Four - Parrots to Dollarbird*, Oxford University Press, Melbourne, Victoria.

Higgins PJ and Davies SJ (eds), 1996, *Handbook of Australian, New Zealand and Antarctic Birds, Volume Three - Snipe to Pigeons*, Oxford University Press, Melbourne, Victoria.

Higgins PJ, Peter JM and Cowling SJ (eds), 2006, 'Boatbill to Starlings', In: *Handbook of Australian, New Zealand and Antarctic Birds Volume 7*, Oxford University Press, Melbourne, Victoria.

Holmes G, 1995, '*Survey of Gouldian Finch in Queensland During Dry Season of 1995 - With Review of Distribution and Status'*, Unpublished report to Conservation Commission of the Northern Territory, Darwin.

Holmes G, 1998, 'A review of the distribution, status and ecology of the Star Finch Neochmia ruficauda in Queensland', *Australian Bird Watcher*, 17, pp. 278-289.

Invasive Animals Cooperative Research Council (IACRC), 2015, *Feral Horse,* viewed online 20 May 2016, http://www.pestsmart.org.au/pest-animal-species/horse/.

Johnson KA, 1989, Thylacomyidae. In: *Fauna of Australia Volume 1B Mammalia* (eds. Walton, D.W. and Richardson, B.J.), pp 1-21, Australia Government Publishing Service, Canberra.

Johnson KA and Kerle JA, 1991, '*Flora and vertebrate fauna of the Sir Edward Pellew group of islands, Northern Territory, Report to the Australian Heritage Commission'*, Conservation Commission of the Northern Territory, Alice Springs.

Johnson KA, and Southgate I, 1990, Present and former status of bandicoots in the Northern Territory, In *Bandicoots and Bilbies* (eds J.H. Seebeck, P.R. Brown, R.L. Wallis and C.M. Kemper.), pp. 85-92, published by Surrey Beatty & Sons, Sydney.

Johnson KA, Woinarski JCZ and Langford DG, 2008, 'Carpentarian Pseudantechinus *Pseudantechinus mimulus*', In Van Dyck, S & Strahan R (eds), *The Mammals of Australia,* Third edition, pp. 71-72, Reed New Holland, Sydney.

Kerrigan R and Albrecht D, 2006, 'Mukia sp. Tobermorey Station', In Woinarski J, Pavey C, Kerrigan R, Cowie I & Ward S 2007 (eds), *Lost from our landscape: threatened species of the Northern Territory*', Northern Territory Department of Natural Resources, Environment and the Arts. Palmerston, Northern Territory.

Kershaw AP, Clark JS, Gill AM, and D'Costa DM, 2002, A history of fire in Australia, In: *'Flammable Australia: the Fire Regimes and Biodiversity of a Continent*', (Eds R. A. Bradstock, J. E. Williams and A. M. Gill.) pp. 3–25. (Cambridge University Press: Cambridge.)

Kitchener D, 1991, 'Pseudantechinus mimulus (Thomas 1906)(Marsupialia: Dasyuridae): rediscovery and redescription', *Records of the Western Australian Museum*, 15, pp. 191-202.

Latz P, 1995, *Bushfires & Bush tucker: Aboriginal plant use in central Australia*, published by IAD Press.

Latz P, 2007, *The Flaming Desert: arid Australia – a fire shaped landscape*, Self-published, Alice Springs.

Lloyd P, Sanders M, Reis T, and Abbott A, 2013, Targeted trapping surveys shed new light on the distribution and habitat characteristics of the Carpentarian pseudantechinus (Pseudantechinus mimulus), a threatened dasyurid marsupial. *Australian Mammalogy*. 35:220-223.

Low Ecological Services (authors Moon E, Newsome T, and Low B), 2009, *Baseline Flora and Fauna Report for the Wonarah Phosphate Project*, report prepared for Coffee Natural Systems on behalf of Minemakers Limited.

McKenzie L, Fontanini L, Lindus NV & Williams MR, 1996, 'Biological inventory of Koolan Island, Western Australia. 2. Zoological notes' *Records of the Western Australian Museum* 17, pp. 249-266.

McKenzie NL and Burbidge AA, 2002,' Australian mammal audit. Report to National Land and Water Resources Biodiversity Audit' *WA Department of Conservation and Land Management*, Perth.

Marchant S and Higgins PJ, 1990, *Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks,* Oxford University Press, Melbourne, Victoria.

Marchant S & Higgins PJ (eds), 1993, *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: raptors and lapwings*, Oxford University Press, Australia.

Masters P, 2003, 'Movement patterns and spatial organization of the mulgara, Dasycercus cristicauda (Marsupialia: Dasyuridae), in central Australia', *Wildlife Research*, 30, pp. 339- 344.

Masters P, Dickman CR, and Crowther M, 2003, 'Effects of cover reduction on mulgara Dasycercus cristicauda (Marsupialia: Dasyuridae), rodent and invertebrate populations in central Australia: implications for land management' *Austral Ecology*, 28, pp. 658-665.

Moseby KE, Nano T, and Southgate R, 2012, *Tales in the Sand; A guide for identifying Australian arid zone fauna using spoor and other signs*, Published by Ecological Horizons, South Australia.

Nano C, Kerrigan R and Albrecht D, 2012 (updated), Threatened Species of the Northern Territory: *Austrobryonia argillicola* I. Tellford (CUCURBITACEAE). Department of Land Resource Management Factsheet, Viewed 20 May 2015, http://lrm.nt.gov.au/__data/assets/pdf_file/0007/353176/austrobryonia_argillicola_vu_v4.pdf>

Natural Resource Management Ministerial Council, 2010, *National Feral Camel Action Plan: A national strategy for the management of feral camels in Australia,* Commonwealth of Australia, viewed online 10 May 2016, https://www.environment.gov.au/system/files/resources/2060c7a8-088f-415d-94c8-5d0d657614e8/files/feral-camel-action-plan.pdf.

Northern Australia Fire Information (NAFI) (website), accessed in 2016 - http://www.firenorth.org.au/nafi3/

Oliver DL, Chambers MA, and Parker DG, 2003, Habitat and resource selection of the Painted Honeyeater (*Grantiella picta*) on the northern floodplains region of New South Wales, *Emu* 103, pp. 171-176.

O'Malley C, 2006, '*National Recovery Plan for the Gouldian Finch (Erythrura gouldiae)*', WWF Australia, Sydney and Parks and Wildlife Northern Territory, Department of Natural Resources, Environment and the Arts, Northern Territory Government, Palmerston.

Palmer C, Woinarksi J, Ward S, 2012, Threatened Species of the Northern Territory Information Sheet: Gouldian Finch *(Erythrura gouldiae),* Department of Land Resource Management (DLRM), Viewed 3 May 2016, https://nt.gov.au/__data/assets/pdf_file/0019/206353/gouldian-finch-vu-final.pdf>

Pardon LG, Brook BW, Griffiths AD & Braithwaite RW, 2003, Determinants of survival for the northern brown bandicoot under a landscape-scale fire experiment, *Journal of Animal Ecology* 72, pp. 106-115.

Pavey C (compiled by), 2006a, Threatened Species of the Northern Territory Information Sheet: Greater Bilby (*Macrotis lagotis*), prepared by the Department of Land Resource Management (DLRM), Viewed 3 May 2016, http://lrm.nt.gov.au/__data/assets/pdf_file/0019/10828/greater_bilby_vu.pdf>

Pavey C, 2006b, *Recovery Plan for the Greater Bilby, Macrotis lagotis, 2006-2011*, prepared by the Dept. of Natural Resources, Environment, and the Arts, Northern Territory Government.

Pavey C, 2006c, *Threatened Species of the Northern Territory Information Sheet: Brush-tailed Mulgara (Dasycercus blythi*), Department of Land Resource Management (DLRM), Viewed 3 May 2016, https://nt.gov.au/__data/assets/pdf_file/0014/205511/brushtailed-mulgara-vu.pdf.

Perry J, Fisher A, and Palmer C, 2011, 'Status and habitat of the Carpentarian Grasswren (*Amytornis dorotheae*) in the Northern Territory', *Emu*, 111, pp. 155-161.

Pizzey G, and Knight F, 2012*, The field guide to the Birds of Australia*, Harper Collins, Sydney, NSW.

Phillips BL, Brown GP, and Shine R, 2003, Assessing the potential impact of cane toads Bufo marinus on Australian snakes, *Conservation Biology*, 16(6), pp. 1738-1747.

Phillips BL, Greenlees MJ, Brown GP and Shine R, 2010, Predator behaviour and morphology mediates the impact of an invasive species: cane toads and death adders in Australia, *Animal Conservation* 13, pp. 53–59.

Queensland Herbarium, 2009, Species label information, Viewed 1 November 2009 (cited in - http://www.environment.gov.au/biodiversity/threatened/species/pubs/83094-listing-advice.pdf)

Rowland J, 2012, 'Painted Honeyeater, *Grantiella picta*, Targeted species survey guidelines' *Queensland Herbarium*, Department of Science, Information Technology and Innovation, Brisbane.

Sanders MG, and Slater L, 2004, New distribution and habitat data for the Carpentarian False Antechinus (*Pseudantechinus mimulus*), Memoirs of the Queensland Museum, 49(2), pp. 740.

Schaefer H, Telford IRH, and Renner SS, 2008, 'Austrobryonia (Cucurbitaceae), A New Australian endemic Genus, is the closest Living Relative to the Eurasian and Mediterranean Bryonia and Ecballium', *Systematic Botany*, vol. 33, no. 1, pp. 125–132.

Short PS, Albrecht DE, Cowie ID, Lewis DL, and Stuckey BM (eds), 2011, *Checklist of vascular plants of the Northern Territory*, Northern Territory Herbarium, Department of Natural Resources, Environment, the Arts and Sport: Palmerston, Northern Territory.

Simpson K, and Day N, 2004, *Field Guide to the Birds of Australia: 8th Edition*, Penguin Books Australia.

SKM (Sinclair Knight Merz), 2012, *Browse Bilby Review- Consolidated information relating to the occurrence of the Bilby (Macrotis lagotis) in the vicinity of the Browse LNG Precinct and more broadly on the Dampier Peninsula*, report prepared for Woodside Energy Limited (Woodside).

Southgate, RI 1987, 'Conservation of the Bilby, Report to World Wildlife Fund', *Conservation Commission of the Northern Territory*, Alice Springs.

Southgate RI, 1990, Habitat and diet of the greater bilby Macrotis lagotis Reid (Marsupialia: Peramelidae), In *Bandicoots and bilbies* (eds. JH Seebeck, PR Brown, RL Wallis, CM Kemper), pp 303-309, published by Surry Beatty & Sons, Sydney.

Southgate RI, Bellchambers K, Romanow K, and Whitfield S, 1994, *Reintroduction of the Greater Bilby Volume 1 A Field Guide*, final report for Project 95, World Wide Fund for Nature, Australia.

Southgate RI & Paltridge R 1998, 'Recovery of the Greater Bilby *Macrotis lagotis,* Final Report for Project Number 185', Nature Australia, Biodiversity Group, Endangered Species Program and Feral Pests Program.

Southgate R, Paltridge R, Masters P, and Nano T, 2005, An evaluation of transect, plot and aerial survey techniques to monitor the spatial pattern and status of the bilby (Macrotis lagotis) in the Tanami Desert, *Wildlife Research*, Vol. 32, pg 43-52, CSIRO Publishing.

Southgate R, & Carthew SM 2006, 'Diet of the bilby (*Macrotis lagotis*) in relation to substrate, fire and rainfall characteristics in the Tanami Desert', *Wildlife Research*, 33, pg 507 – 519.

Southgate R, Carthew S, 2007, Post-fire ephemerals and spinifex-fuelled fires: a decision model for bilby habitat management in the Tanami Desert, Australia, *International Journal of Wildland Fire*, 16, pg 741 – 754, CSIRO publishing.

Southgate R, Paltridge R, Masters P, and Carthew S, 2007, 'Bilby distribution and fire: a test of alternative models of habitat suitability in the Tanami Desert, Australia', *Ecography*, 30, pp. 759 – 776.

Storr GM, 1984, 'Revised list of Queensland birds'. *Records of the Western Australian Museum Supplement*, 19, pp. 1-189.

Taylor R, Woinarski J, Charlie A, Dixon R, Pracy D, and Rhind S, 2004, '*Report on mammal survey of the Pellew Islands 2003*, Lianthawirriyarra Sea Ranger Unit, Department of Infrastructure, Planning and Environment, and Tropical Savannas CRC, Darwin.

Threatened Species Scientific Committee (TSSC), 2012, *Commonwealth Listing Advice on Acanthophis hawkei (Plains Death Adder), [*Conservation Advice]

Threatened Species Scientific Committee (TSSC), 2013, *Commonwealth Listing Advice on Austrobryonia argillicola*, Commonwealth of Australia.

Threatened Species Scientific Committee (TSSC), 2015a *Approved Conservation Advice for Pseudantechinus mimulus (Carpentarian antechinus)* [Conservation Advice].

Threatened Species Scientific Committee (TSSC), 2015b *Approved Conservation Advice for Grantiella picta (Painted Honeyeater)* [Conservation Advice].

Tidemann SC, McOrist S, Woinarski JCZ, and Freeland WJ, 1992, 'Parasitism of wild Gouldian Finches Erythrura gouldiae by the air sac mite (*Sternostoma tracheac*) *Journal of Wildlife Diseases*. 28: pp. 80-84.

Tidemann SC, Boyden J, Elvish R, Elvish J, O'Gorman B, 1992, Comparison of the breeding sites and habitat of two hole-nesting Estrilidid Finches, one endangered, in northern Australia, *Journal of tropical ecology*, 8, pp. 373-388.

Tidemann SC, and Woinarski JCZ, 1994, 'Moult characteristics and breeding seasons of Gouldian Erythrura gouldiae, Masked Poephila personata and Long-tailed Finches P. acuticauda in savannah woodland in the Northern Territory', *Emu*, 94: pp. 46—52

Tidemann SC, 1996, Causes of the decline of the Gouldian Finch (Erythrura gouldiae), *Biological Conservation International*, 6, pp. 49--61

Tidemann SC, Lawson C, Elvish R, Boyden J & Elvish J, 1999, 'Breeding biology of the gouldian finch Erythrura gouldiae, an endangered finch of northern Australia', *Emu,* 99, pp. 191-199.

Urban MC, Phillips BL, Skelly DK and Shine R, 2008, A toad more travelled: the heterogeneous invasion dynamics of cane toads in Australia, *The American Naturalist*, 171, 134–148.

Ward S, and Phillips, B, 2012 (updated), *Threatened Species of the Northern Territory Information Sheet: Plains Death Adder (Acanthopsis hawkei),* Department of Land Resource Management (DLRM). http://lrm.nt.gov.au/__data/assets/pdf_file/0017/143126/Plains_Death_Adder_VU_FINAL.pdf [Accessed 3 May 2016].

Van Dyck S, and Strahan R (eds), 2008, *The Mammals of Australia (3rd Edition),* published by Reed New Holland.

Van Dyck S, Gynther I, and Baker A (eds), 2013, *Field Companion to the Mammals of Australia*, published by New Holland Publsihers.

Ward S, 2012 (updated), *Threatened Species of the Northern Territory Information Sheet: Grey Falcon (Falco hypoleucos),* Department of Land Resource Management (DLRM). http://lrm.nt.gov.au/__data/assets/pdf_file/0014/143114/Grey_falcon_VU_FINAL.pdf [Accessed 3 May 2016]

Watson DM, 2012, Painted Honeyeater, in *Queensland's threatened animals* (eds Curtis LK, Dennis AJ, McDonald KR, Kyne PM & Debus SJS), CSIRO Publishing, Melbourne.

Watson M, and Woinarski J, 2003, Vertebrate monitoring and resampling in Kakadu National Park, 2002, Report to Parks Australia North, Parks and Wildlife Commission of the Northern Territory, Darwin.

Webb JK, Christian KA, and Fisher P, 2002, 'Fast growth and early maturation in a viviparous ambush foraging elapid snake from tropical Australia', *Journal of Herpetology,* 36: pp. 505–509.

Webb JK, Shine R, and Christian KA, 2005, Does intraspecific niche partitioning in a native predator influence its response to an invasion by a toxic prey species? *Austral Ecology* 30: 201–209.

Wells RW, and Wellington CR, 1985, A Classification of the Amphibia and Reptilia of Australia, *Australian Journal of Herpetology*, Supplementary Series 1: pp. 1–61.

West P, 2008, Assessing Invasive Animals in Australia, National Land & Water Resources Audit. http://www.pestsmart.org.au/assessing-invasive-animals-in-australia-2008/

Wilso PR, and Taylor PM, 2012, *Land Zones of Queensland*. Queensland Herbarium, Queensland Department of Science, Information Technology, Innovation and the Arts, Brisbane.

Woinarski JCZ, and Tidemann SC, 1991, 'The bird fauna of a deciduous woodland in the wet-dry tropics of northern Australia', *Wildlife Research*, 18: pp. 479-500.

Woinarski JCZ, 2004, 'National Multi-species Recovery Plan for the Carpentarian Antechinus *Pseudantechinus mimulus,* Butler's Dunnart, *Sminthopsis butleris* and Northern Hopping-mouse *Notomys aquilo,* 2004-2008, [Online], Darwin: Northern Territory Department of Infrastructure Planning and Environment.

Woinarski JCZ, Burbrudge AA, and Harrison P, 2014, *The action plan for Australian mammals 2012*, CSIRO publishing, Collingwood, Victoria.

Woinarski JCZ, Ward S, Mahney T, Bradley J, Brennan K, Ziembicki M, and Fisher A 2011, 'The mammal fauna of the Sir Edward Pellew Islands, Northern Territory: refuge and death-trap', *Wildlife Research*, 38, pp. 307-322.

Woinarski JCZ, Milne DJ, and Wanganeen G, 2001, Changes in mammal populations in relatively intact landscapes of Kakadu National Park, Northern Territory, Australia, *Austral Ecology* 26, pp. 360-370.

Woolley PA, 2005, 'The species of Dasycercus Peters, 1875 (Marsupialia: Dasyuridae)', *Memoirs of Museum Victoria*, 62, pp. 213-221.

Woolley PA, 2006, 'Studies on the crest-tailed mulgara Dasycercus cristicauda and the brush-tailed mulgara D. blythi (Marsupialia: Dasyuridae)', *Australian Mammalogy*, vol 28, pp. 117-120.

Woolley PA, 2011, 'Pseudantechinus mimulus: a little known dasyurid marsupial', *Australia Mammalogy*, vol 33, pp. 57-67.