Biota Environmental Sciences

Central Tanami Project Flora and Fauna Reconnaissance Survey







Prepared for Northern Star Resources Ltd

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Biota Environmental Sciences

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1.0 Introduction

1.1 Project Background

The Tanami Regional Exploration Project (TRE) is located in western Northern Territory (NT), approximately 650 km northwest of Alice Springs and 850 km southwest of Darwin. The study area incorporates five main localities: Boulder Ridge, Browns Range, Cave Hill, Farrands Hill, and Suplejack (Figure 1.1).

As a part of Northern Star's 2017 exploration in its Tanami regional tenure, several geochemical sampling programs are proposed to test the gold mineralisation potential of target areas within the region (Northern Star (Tanami) Pty Ltd 2017). Northern Star wishes to identify the key flora and fauna attributes of its Tanami regional tenure to inform management measures relating to the exploration programme.

1.2 Project Exploration Activities

Northern Star's exploration strategy involves a series of sampling programs to test the prospective gold mineralisation of the Tanami regional tenure. Based on these programs, and a review of extensive historical drilling and surface data, target areas will be ranked based on geological criteria, with subsequent identification of priority exploration areas.

A significant work program consisting of field reconnaissance, rock sampling, and soil sampling (both manual and mechanised) will be undertaken throughout various areas of the five leases. The proposed early-phase exploration activities, as outlined in Northern Star's *Mining Management Plan* (Northern Star (Tanami) Pty Ltd 2017), involve:

- field reconnaissance;
- soil sampling;
- manual soil sampling;
- auger soil sampling;
- vacuum soil sampling; and
- mantis soil sampling.

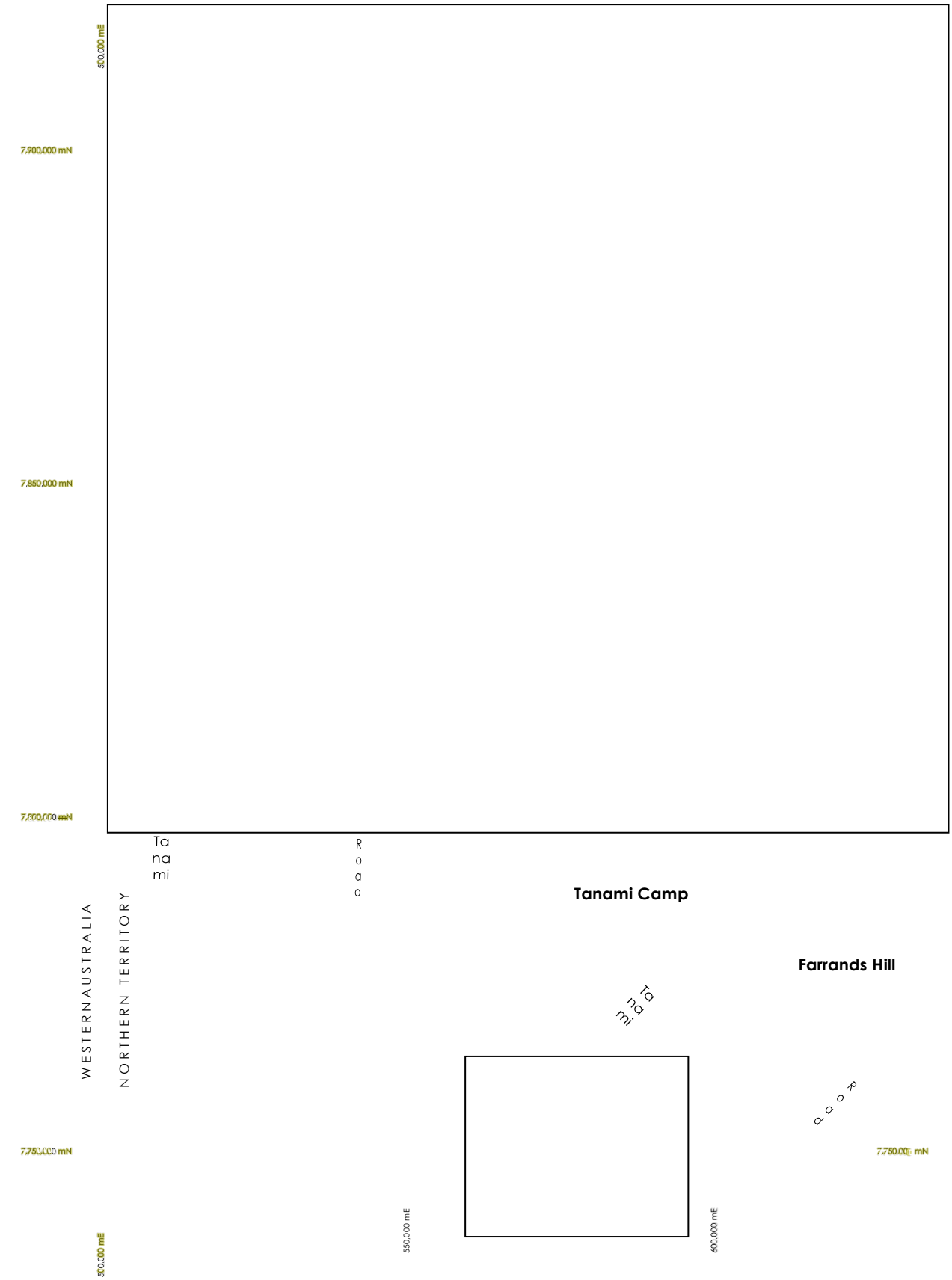
The key environmental risks surrounding exploration activities have also been outlined in Northern Star's Mining Management Plan (Northern Star (Tanami) Pty Ltd 2017). The environmental risks currently identified from the project risk assessment are:

- the spread of weeds;
- hydrocarbon spills;
- bushfire incidence due to vehicles and/or personnel;
- inappropriate disposal of waste;
- unauthorised clearing; and
- unauthorised access to culturally significant areas.

Northern Star currently has approval for early phase programs, including the exploration activities listed above. In anticipation of more advance exploration however, Northern Start determined that additional environmental investigations were necessary.

1.3 Purpose and Scope of this Report

Biota Environmental Sciences (Biota) was engaged by Northern Star Resources Ltd (Northern Star) to undertake a desktop assessment and subsequent fauna and flora reconnaissance survey of several leases within the Tanami Regional Exploration Project (TRE; hereafter referred to as the 'study area') in 2017 (Figure 1.1).


500,000 mE
7,900,000 mN
7,850,000 mN
7,800,000 mN
Tanami
Road
WESTERN AUSTRALIA
NORTHERN TERRITORY
Tanami Camp
Farrands Hill
Tanami
Road
7,750,000 mN
550,000 mE
600,000 mE
500,000 mE
Location Map
DARWIN
NORTHERN TERRITORY
BROOME
Map Area
WESTERN AUSTRALIA
ALICE SPRINGS
Tanami lease area
Area of Tanami operations
Unsealed road, track
0
15
30
kilometres
Tanami Projects
Flora & Fauna Survey
Location Map
Author: S Werner
Drawn: M Robinson
Job No.: 1302
Date: 07 Aug 2017
Revised:
Projection: MGA Z52 (GDA94)
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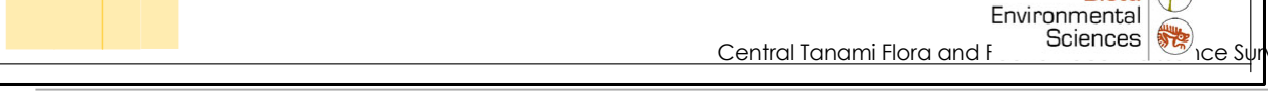

Figure 1.1: Location of the Tanami Regional Exploration Project (TRE) study area.

The principal aims of the study were to:

1. broadly characterise the ecology of the area;
2. identify threatened species of flora and fauna present, or likely to be present in the study area;
3. assess the significance of the study area's landforms and associated vegetation with respect to both flora and fauna;
4. identify key issues arising from the potential impact of exploration activities on the flora and fauna within the study area; and
5. provide broad recommendations to avoid, minimise, mitigate and offset potential impacts on ecological values within the Tanami Regional Exploration Project.

These aims were met by conducting a desktop review of existing surveys and supporting data sets (see Section 2.1), together with a review of information available for the locality and greater Tanami bioregion (see Section 3.0). This was supplemented by a field survey in June 2017 by a zoologist and botanist to further identify flora and fauna values of significance.

The approach and methodology used for the survey was carried out with consideration of the following:

- *Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping* (Brocklehurst et al. 2007);
- *Territory Parks and Wildlife Conservation Act 2006* (TPWC Act); and
- the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

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2.0 Methodology

2.1 Desktop Assessment

A desktop assessment was undertaken to identify features of ecological significance known from the study area or the broader locality. The desktop assessment was also used to place the study area into context with the regional significance of the Tanami bioregion, which subsequently informed the design and field effort applied to the current reconnaissance level survey (see Section 4.0).

The desktop review considered regional information, previous biological surveys in the locality, and the results of various database searches, as discussed in the following sections.

2.1.1 Database Searches

The following databases were searched to assist in the determination of the potential flora and fauna assemblages of the study area:

1. The NT Herbarium Database (Flora NT[1]) was searched to identify flora species that have been previously recorded within the locality (defined as a 20 km buffer on the study area).
2. Atlas of Living Australia (ALA): a collaborative project between academic collecting institutions, private individual collectors and community groups. ALA contains records, environmental data, images and the conservation status of species throughout Australia.
3. The NT Natural Resource Maps spatial interrogator website for land systems mapping and broad vegetation types previously mapped within the bioregion[2].
4. The Commonwealth EPBC Act Protected Matters Database was searched to identify flora and fauna species and other Matters of National Environmental Significance (MNES) that may occur in the locality.

Given that western side of the study area lies on the Western Australia (WA) – NT border, several WA-specific ecological databases were also searched, including:

1. NatureMap was searched to identify flora and fauna species that had previously been recorded in the locality. This database is the most comprehensive source of information on the distribution of WA's flora and fauna, and comprises records from the Fauna Survey Returns Database, the WA Threatened and Priority Flora Database and the WA Herbarium Specimen Database (all maintained by the WA Department of Biodiversity, Conservation and Attractions (DBCA)), the WA Museum Specimen Database, and BirdLife Australia's Atlas of Australian Birds.
2. The DBCA database of Threatened Ecological Communities (TECs), Priority Ecological Communities (PECs) and Environmentally Sensitive Areas (ESAs) was searched to identify significant communities known to occur in the locality.

The searches were centred on the point 19° 30' 00" S, 129° 35' 00" E (central to the study area).

In addition, outputs from Biota internal databases of conservation significant records and weeds from previous studies in the locality were reviewed.

2.1.2 Literature Review

Published and unpublished reports relevant to the study area were reviewed (see Section 3.1). Several regional-scale reports and data sets were also reviewed as part of the desktop assessment, including summaries of bioregional data, land systems mapping and vegetation mapping. Additionally, a number of biological surveys previously undertaken in the vicinity of the study area were reviewed (see Section ·).

[1] http://eflora.nt.gov.au/

[2] Department of Environment and Natural Resources – http://nrmaps.nt.gov.au

2.2 Field Survey

2.2.1 Survey Team

The field survey was undertaken between the 24th and 29th of June 2017 by Roy Teale (Principal Zoologist) and Scott Werner (Botanist), both of Biota. Both team members have extensive survey experience in the arid zone of Northern Australia (Table 2.1). A total of 12 person-days were spent on the field component of this study. A summary of the personnel and their respective roles in the survey is provided in Table 2.1.

Table 2.1: Summary of personnel involved in the Central Tanami survey.

Name	Position at Biota	Qualification	Years of Survey Experience	Survey Role	Permit No.[3]
Roy Teale	Principal Zoologist	BSc (Zoology & Botany) (Hons)	27	Project Manager Fauna assessment	N/A
Scott Werner	Level 1 Botanist	BSc (Conservation Biology & Management) (Hons)	6	Vegetation mapping Flora assessment	60961

2.2.2 Survey Timing and Climatic Conditions

The weather (particularly rainfall) leading up to a field survey is an important consideration influencing the number and type of flora and fauna species that are recorded from an area. To characterise rainfall leading up to the current survey, total monthly rainfall was sourced from the closest Bureau of Meteorology (BoM) recording station with data for 2016/2017. This station is located at Rabbit Flat (station 015666, approximately 137 km SE of Browns Range, the most distant part of the study area from the recording station). Data for the 12 months preceding the field survey are compared to long-term temperature data and median rainfall for the years 1996-2017 in Figure 2.1.

From a meteorological perspective, the median is usually the preferred measure of the 'typical' rainfall. This is related to the high temporal variability of rainfall in most regions. As an example, an extreme rainfall event (such as a severe thunderstorm) can result in the mean being 'skewed' for that month. However, such an event will have less effect on the monthly median than it will have on the arithmetic mean (Bureau of Meteorology 2007).

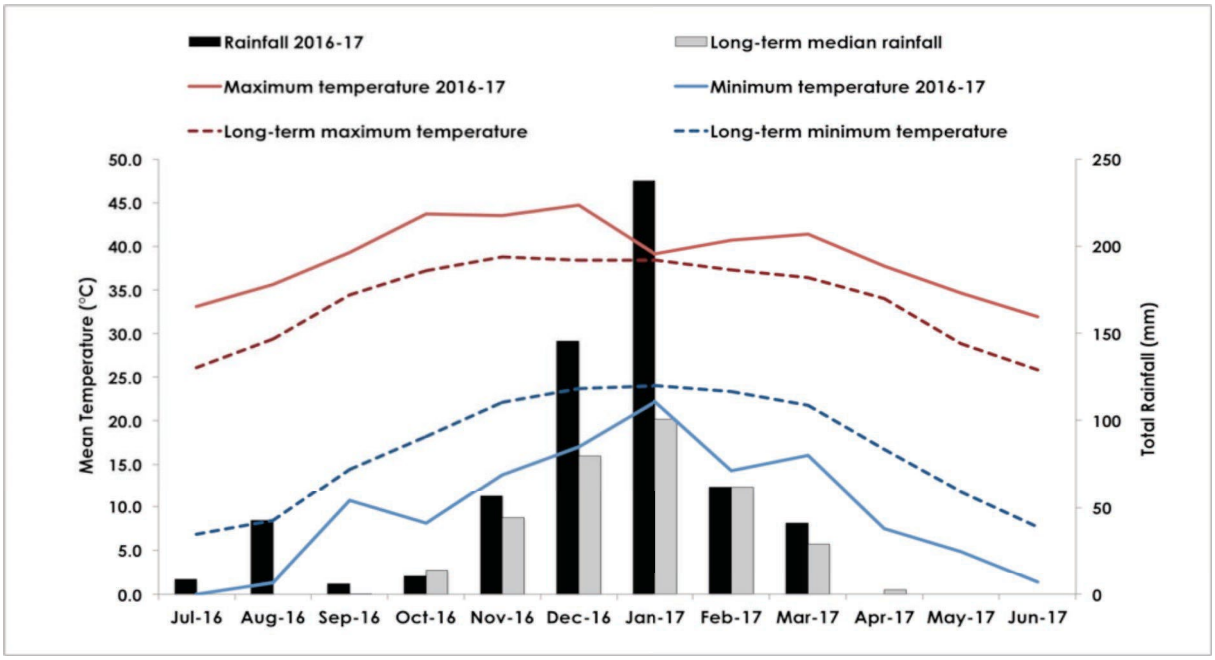

Figure 2.1: Monthly rainfall and temperature at the Rabbit Flat weather station for the 12 months prior to the field survey, compared to the long-term temperature data and monthly median rainfall. Data sourced from the Bureau of Meteorology.

[3] Permit to Take Wildlife for Commercial Purposes

The Tanami Desert has a semi-arid climate with a distinct wet and dry season, high daytime temperatures and low overnight minimums. Rainfall is monsoonal with the majority of rain falling in summer. During the months preceding the survey, Rabbit Flats, and by inference the study area, received rainfall well above the long-term median. Similarly, temperatures in 2016-2017 appear to be more extreme than the long-term trends, with maximum daytime temperatures above long-term average and minimum temperatures consistently falling below average.

2.2.3 Site Selection and Foot Traverses

Aerial imagery, together with results from the desktop assessment, were used to divide each of the five leases into relatively discrete zones for field reconnaissance, with indicative survey sites selected throughout the study area based on landform, geology and accessibility. Multiple foot traverses were undertaken throughout the study area, typically between these prospective sites, or centred around a helicopter landing point (see Appendix 3 for locations and foot traverse tracks).

2.2.4 Floristic Data Collection

Two types of floristic survey methods were used to collect flora data in the field:

- A relevé is an unbounded sampling site (i.e. a site without a rigorously defined boundary) in which similar levels of information are recorded as for a quadrat, however sampling of the flora species is typically not as intensive. Relevés were used due to the level of survey effort required and limitations surrounding the size of the study area, access, and time constraints.
- Opportunistic observations (and collection of specimens) were carried out during traverses of the study area.

The following parameters were recorded for all relevés:

1. Location: MGA coordinates recorded in WGS84 datum (Zone 52) using a hand-held Global Positioning System (GPS) unit; at a minimum the central point of the relevé was recorded.
2. Vegetation Description: A broad description based on the height and estimated cover of dominant species after Aplin's (1979) modification of the vegetation classification system of Specht (1970) (see Appendix 1);
3. Habitat: A description of the landform and habitat;
4. Associated Species: A list of non-dominant species within the survey area;
5. Fire History: An estimate of time since last fire;
6. Disturbance Details: Vegetation condition was ranked according to the scale developed by Trudgen (1988), considering evidence of grazing, physical disturbance, weed invasion etc. (see Appendix 1); and
7. Photographs: Representative digital photographs of the vegetation and/or landform was taken.

2.2.5 Vegetation Description and Landform Mapping

The scale of vegetation mapping can be influenced by a range of factors including spatial characteristics of the survey area, such as its area and the variety of habitats present, and other factors such as the scope of the survey and the availability of current, aerial photography of appropriate quality. The vegetation units for this study were described at the sub-association level (level VI as per the National Vegetation Information System; NVIS)[4], which is the most detailed level under the NVIS. In some cases, minor variations in the vegetation were not clearly defined on aerial photography or were not practical to accurately map in the field (e.g. minor drainage lines). These minor variations were incorporated into the surrounding 'parent' vegetation unit.

[4] http://www.environment.gov.au/erin/nvis/publications/avam/section-2-1.html

As is the case for the majority of the NT, existing vegetation mapping for the study area and surrounding bioregions is very limited due to the lack of previous detailed vegetation surveys. Vegetation mapping that does exist for the area is limited to that which has been completed for the whole Territory at a very broad 1:1,000,000 scale (Wilson et al. 1990). There is moderate to high floristic variation within each of the vegetation types identified during the current survey, and it is therefore likely that there will be patches of vegetation within each land unit that will not fit with the broader descriptions of Wilson et al. (1990). For example, there are several Mulga (*Acacia aneura*) patches within each lease that are not clearly delineated at the scale of mapping used in the Wilson et al. (1990) study.

Vegetation communities and land units across five separate leases were sampled with 16 relevés during the current survey, and also in the form of mapping notes at 74 locations. Mapping notes were utilised to mark the boundaries of vegetation units in the field to allow for more accurate delineation of mapping boundaries in the office.

Vegetation and landform units and boundaries were verified in the office using the data collected in the field together with digital imagery.

2.2.6 Searches for Threatened Flora, Priority Flora and Weeds

Targeted non-systematic searches were conducted on foot in areas considered to be potential habitat for conservation significant flora. The routes of the foot traverses attempted to intersect all major vegetation/landform units in the study area and additional searches were also undertaken to increase survey effort in areas that were recognised as having a high potential to support conservation significant or restricted species.

Locations of species of conservation significance or unknown taxa were recorded using a handheld GPS unit (WGS84 datum). The number of individuals and extent of the population were also recorded for each location, along with the habitat and associated species.

Introduced flora species (weed) locations were also recorded during the foot traverses, along with an estimate of their population size.

2.2.7 Fauna Habitat Field Assessment and Targeted Searches

A limitation of any habitat classification system is that it is not specific to any one species. Rather, the classification provides a convenient framework within which to summarise species occurrence. We have chosen to adopt the physiographic classification, in which vegetation, geology and landform, are used to classify physiographic units. This framework also provides uniformity in assessment between the thematic layers of vegetation mapping and fauna habitat. The physiographic approach is broadly relevant to most vertebrate fauna groups with the limitations already discussed above.

The following criteria were used when assessing whether a habitat was of conservation significance for fauna: they are uncommon, support unique faunal assemblages, support fauna of special conservation significance, or any combination of these three factors.

Targeted non-systematic searches were conducted on foot in areas considered to be potential habitat for conservation significant fauna (i.e. Threatened and Vulnerable species). Locations of species of conservation significance were recorded using a handheld GPS unit (WGS84 datum).

2.3 Specimen Identification, Nomenclature and Data

2.3.1 Flora

Common taxa that were well known to the survey botanist were confirmed in the field. A voucher specimen was collected if the taxon was either difficult to determine, belonged to a

recognised species complex, was poorly collected or otherwise unusual. Specimens were pressed in the field and then returned to Perth for further examination and confirmation.

Voucher specimens were identified using flora keys, consulting appropriate publications and checking reference collections. Biota botanists identified most specimens, the majority of which were confirmed by Biota's Level 2 Botanist Pierre-Louis de Kock and Principal Botanist (Michi Maier).

A full list of the vascular flora species recorded during the survey is provided in Appendix 2. Nomenclature and conservation significance rankings used in this report are consistent with the current listing of NT flora recognised by the NT Herbarium[5] at the time of preparation of this report.

2.3.2 Spatial Data

Spatial data were overseen and managed by Paul Sawers (GIS Data Manager) and Melissa Robinson (GIS Cartographer), with all maps and figures in this report prepared using MapInfo Professional (version 11).

2.4 Limitations of the Study

Potential constraints and subsequent limitations of this flora and fauna assessment include:

- The range of land units surveyed, and consequently, vegetation communities, was restricted to those accessible via helicopter within the allocated survey duration. Large distances, the size of the exploration leases, logistics, and time constraints, were all factors that limited survey effort.
- Due to quarantine restrictions imposed by both the WA and NT State Governments, several specimens were unable to be identified within the reporting timeframe. Due to the level of detail required for this assessment (broad vegetation and land unit mapping), the identification of these few specimen are not seen to have any significant effect on the reporting outcome.

Despite these limitations, the study provides an adequate characterisation of the fauna and flora of the study area for the current requirements.

5 http://eflora.nt.gov.au/

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3.0 Desktop Review

3.1 Literature Review

The following key reports and technical studies of relevance to the current scope were identified and reviewed as part of the literature review:

- An inventory of sites of international and national significance for biodiversity values in the Northern Territory (Harrison et al. 2009);
- Browns Range Project: Level 2 Vegetation and Flora Survey and Impact Assessment (Outback Ecology 2014);
- Fauna Habitats and Fauna Assemblage Survey of the Western Tanami Project Area (Biota 2005a);
- Fauna Habitats and Fauna Assemblage Survey of the Western Tanami Project Area (Coyote and Larranganni Deposits) (Biota 2005b);
- Flora and Fauna Report Dry Season: Twin Bonanza Gold Project (EcOz 2013);
- Nolans Project Environmental Impact Statement: Biodiversity - Flora and Vegetation Assessment (GHD 2016);
- Northern Territory Parks and Conservation Master Plan: Tanami Bioregion (Fritz 2004);
- Plant Species and Sites of Botanical Significance in the Southern Bioregions of the Northern Territory (Vol. 2) (White et al. 2000);
- Recognising sites of conservation significance for biodiversity values in the Northern Territory (Ward and Harrison 2009); and
- Vegetation survey of the Northern Territory Australia (Wilson et al. 1990);

3.2 Previous Biological Surveys in the Locality

Prior to the biological surveys of the Tanami Desert by Gibson (1986), flora and fauna records for the bioregion were mostly non-existent. Biological surveys were conducted throughout the 1960s in an area then known as the Tanami Desert Wildlife Sanctuary, with later surveys in the 1970s and 1980s focusing on specific rare and endangered wildlife of the area (Gibson 1986).

Since then a flora and fauna assessment of the Central Tanami Project (CTP) has been completed (LES 2016) with a number of environmental studies completed within the vicinity of the current study area and the broader Tanami Bioregion. These studies were associated with various mining developments and were largely centred around broad vegetation descriptions and opportunistic fauna observations, but did not involve systematic fauna trapping, targeted species searches, or detailed vegetation community mapping.

The Central Land Council and various mining companies within the Tanami Bioregion are involved in the Tanami Regional Biodiversity Monitoring Program. The program conducts annual surveys across a selection of land from types situated in close proximity to mining or exploration areas with the aim of monitoring possible impacts on species biodiversity over time.

Where appropriate, these previous biological assessments, together with relevant literature (Section 3.1), were reviewed with a focus on identifying vegetation of ecological importance, and flora and fauna species of conservation significance that may occur within the study area.

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4.0 Regional Significance of the Tanami Bioregion

The Tanami Bioregion comprises an area of 298,100 km^2 and extends from the NT through into WA. It consists of red desert sand plains that support mixed shrub steppes and hummock grasslands, as well as hills and ranges that support wattle scrub and hummock grasslands (Graham 2001).

The Tanami Desert is known as "…*one of the most important biological areas in Australia particularly as it provides a refuge for several of Australia's rare and endangered species.*" (Gibson 1986). The area was also noted in Morton et al. (1995) as a refuge for biological diversity in arid and semiarid Australia. Despite its arid climate, the bioregion is also home to two nationally significant wetlands: Lake Surprise and the Lake Gregory area. Additionally there are several smaller ephemeral wetlands throughout the sub-bioregion.

While the sub-bioregion is generally in good ecological condition, significant threatening processes include feral predators, changing fire regimes and weeds (Graham 2001).

4.1 Botanical Significance

The characteristic vegetation on sandplains in the bioregion is dominated by *Hakea*, *Acacia*, *Corymbia* and *Grevillea* spp. over *Triodia pungens* and *Triodia schinzii* hummock grasslands, with large areas of halophytic vegetation occurring around salt lakes and within paleodrainage systems (White et al. 2000). Currently there are 288 vascular plants of conservation significance in the NT section of the Tanami Bioregion.

A number of Botanical Sites of Regional or National Significance exist within the Tanami Bioregion. They are generally quite large, encompassing broad areas of similar terrain, and range in size from a few square kilometres to thousands of square kilometres. The predominant factor influencing the level of significance of the sites is the conservation significance of the plant taxa known to occur there (White et al. 2000).

The following Botanical Sites of Conservation Significance (BOCS), as outlined in greater detail in White et al. (2000), lie either within the TRE locality, or show close affinities to vegetation communities occurring within the study area:

20-1-3: Western Tanami Paleodrainage System (National Significance)

"*This site incorporates several of the large paleo-drainage features in the central Tanami Desert. The landscape is a complex mosaic of evaporates…aeolian deposits of sand, playa deposits in salinas and claypans, and outcrops of silicified calcrete and laterite capping*." (White et al. 2000).

19-1-1: Gardiner Range (Bioregional Significance)

"*This site includes the Gardiner Ranges, Pingidijarra Hills and Mallee Hill and their internal catchments and floodouts….The site is bounded to the west by the Western Australian border. The ranges are predominantly composed of Gardiner sandstone*." (White et al. 2000). This BOCS site is thought to support rare and restricted plant communities.

19-1-4: Tanami Range (Bioregional Significance)

"This site is broadly delineated by the extent of outcropping sandstone, which forms the Tanami Range and the Black Hills and consists of two discrete polygons. The site includes part of the surrounding and intervening sandplain, which includes calcrete and laterite rises. These ranges are low, rarely rising more than 50 m above the surrounding sandplain." (White et al. 2000). This area is particularly important for the conservation of *Acacia abbreviata* where it grows on laterite rises beneath sandstone ranges.

18-1-PL1: Browns Range (Undetermined Significance)

"*This notional site of botanical interest includes a series of low sandstone hills (composed of Gardiner Sandstone) to the south west of the Birrindudu Range and a series of fringing, sub-linear ephemeral lakes. These physiographic features approximate the margins of a large granite dome*

(the Browns Range Dome), which, apart from minor outcropping is thinly covered by sand." (White et al. 2000). White et al. (2000) note that this large area warrants further investigation due to its geological characteristics (low sandstone ranges bordering a large granite exclusion).

19-2-PL1: Central Tanami Paleodrainage Depression (Undetermined Significance)

"*Large area broadly circumscribed by the extent of recent alluvial and lacustrine deposition."* (White et al. 2000). This area is geomorphologically similar to the Western Tanami Paleodrainage System which, as a whole, requires considerable further botanical investigation.

20-1-PL1: Bluebush Hills (Undetermined Significance)

"Diverse landscape of sandplain, prior stream channels, sandstone and chert hills and laterite rises." (White et al. 2000). This BOCS occurs 25 km south of the Tanami mine site.

20-1-PL2: Tanami Paleodrainage System Extension (Undetermined Significance)

"This site includes an extensive paleodrainage landscape contiguous with site 20-1-3 (Tanami Paleodrainage Systems)." (White et al. 2000). The botanical values of this BOCS has not been documented appropriately and has only been assumed, thus requiring further botanical exploration.

21-3-PL1: Central Tanami Remnant Mulga (Undetermined Significance)

"*This site has very few confirmed botanical values. The somewhat arbitrary boundary of this site follows the outline of a cluster of stands of mature Mulga (Acacia aneura) on the plains around the Arthur, Wanabanda, Walangawanu, Wini, Mulyugaridji and Studholme Hills."* (White et al. 2000).

4.2 Zoological Significance

Fourteen threatened species have been recorded in the region, including Bilby (*Macrotis lagotis*), Brush-tailed Mulgara (*Dasycercus blythi*), Great Desert Skink (*Liopholis kintorei*) and one historical record of the Night Parrot (*Pezoporus occidentalis*). The Tanami bioregion has experienced some of highest extinction rates for native mammals, with thirteen species now classified as extinct.

This area is recognised as being a stronghold for the Bilby (*Macrotis lagotis*), Brush-tailed Mulgara (*Dasycercus blythi*), Crest-tailed Mulgara (*Dasycercus cristicauda*) and Great Desert Skink (*Liopholis kintorei*) (Ward and Harrison 2009).

Paleodrainage systems in the Tanami and in arid settings elsewhere are recognised as important habitat for many mammal species because of the accumulation of nutrients and the supply of water to plants is more reliable than that of sandplain and laterite substrates (Stafford Smith and Morton 1990). As such, paleodrainage habitats offer refugia to many species, especially in times of severe drought. By way of example; the bulb of the sedge *Cyperus bulbosus*, common to paleodrainage systems, represents an important food item for the Bilby (Southgate and Carthew 2006).

Lateritic substrates are also important to a variety of threatened taxa, though the reasons behind this are not well documented. One plausible reason is that lateritic surfaces are typically somewhat elevated in the landscape and are therefore likely to generate areas of small-scale and localised runoff and run-on that may be sufficient to stimulate plant responses more readily than sandplain areas with flat topography. The composition of plant species on laterite substrates is also distinctive. *Acacia hilliana* is a common feature on laterite and this plant is amongst a group of *Acacia* species that are occupied by root-dwelling larvae (M. Dziminski, DBCA, pers. comm. 2017).

5.0 Flora and Fauna

5.1 Flora

5.1.1 Overview

A total of 154 native vascular flora species from 79 genera and 29 families were recorded from the study area during the current survey (see Appendix 2).

No flora species of conservation significance were recorded during the current survey.

In addition to the above, two introduced flora species (weeds) from two genera and two families were recorded in the study area during the current survey (see Section 5.1.2).

5.1.2 Introduced Flora (Weeds)

Two introduced flora (weed) species, **Calotropis procera* and **Flaveria trinervia*, were recorded within the study area during the current survey. Locations of the weed species are presented in Table 5.1 with brief descriptions provided below.

- ****Flaveria trinervia*** (Speedy Weed) is an annual daisy that is common and widespread in various habitats with sandy or loamy soils throughout the north of Australia. The inflorescence consists of a large dense cluster of yellow flower heads (see Plate 5.1).

  A total of 88 individuals of this species were recorded opportunistically from several locations in the southeastern section of the Farrands Hill lease.

- ****Calotropis procera*** (Rubber Bush) (Plate 5.2) is a spreading shrub or small tree, native to Africa and Asia. Rubber Bush first became established in the Katherine area and has since spread into WA and through the Barkly Tablelands. The species can form dense thickets on disturbed and degraded soils, and competes with, and smothers, native species.

  Two individuals of this species were recorded opportunistically from a single location in the drainage system land unit of Suplejack lease, where there was evidence of high cattle use.

Table 5.1: Locations of introduced species recorded from the study area during the current survey (see Appendix 3 for mapped locations).

Species	Easting	Northing	No. of Individuals
**Flaveria trinervia*	624380	7771624	1
	624727	7771586	85
	624802	7771795	1
	624828	7771792	1
**Calotropis procera*	612419	7883969	1
	612473	7884032	1



Plate 5.1: **Flaveria trinervia* at Farrands Hill lease.



Plate 5.2: **Calotropis procera* at Suplejack.

5.2 Fauna

Three fauna species of conservation significance were recorded from the study area during the current survey:

Bilby *Macrotis lagotis* (EPBC Act 1999 – Vulnerable; NT – Vulnerable) formerly occurred over 70% of the Australian mainland, however the species now occurs over less than 20% of its former range and is confined to *Triodia* hummock grassland and *Acacia* scrub across northern Australia (Woinarski et al. 2014). This medium-sized mammal has been documented as holding temporary home ranges and showing relatively rapid changes in distribution in response to variation in habitat resources (van Dyck and Strahan 2008).

Multiple secondary evidence (digging, burrows or scats) of the Bilby was recorded within the study area during the current field survey. Evidence of the species' presence was recorded from 37 locations, mostly associated with the Low Lateritic Rises and Ephemeral Wetlands and Saline Flats land units (Section 6.0), and it is likely that species occurs more widely within similar habitats in the study area.

Brush-tailed Mulgara *Dasycercus blythi* (NT – Vulnerable) is a is a medium sized (60 – 110 g) carnivorous marsupial that has a characteristic short tail, which is generally fattened at the base and covered in black hairs for much of its length. This species is known to inhabit spinifex grasslands on sand plains and sandy swale between low dunes from south-western Queensland across the Simpson, Tanami, and Great Sandy Deserts of southern and central Northern Territory and central Western Australia (van Dyck and Strahan 2008, Pavey et al. 2011). It is also known to inhabit areas on gibber (rock and pebble covered flat plains), and is closely associated with gently sloping to flat topographic positions rather than steep-sided sand ridges (Pavey et al. 2011). The presence of *Triodia* hummocks are not a requirement of the Brush-tailed Mulgara habitat (Pavey et al. 2011). Little is known about the breeding of this species in the wild, although females in central Australia have been captured in September with up to six young in the pouch. It is thought to be generally solitary, males and females being found in the same burrow only during the mating season.

Mulgara diggings were recorded from a single location during the current survey at Cave Hill in the Colluvial Plains land unit (Table 5.2; Appendix 3; Section 6.3).

Table 5.2: Locations of fauna of conservation significance recorded from the study area during the current survey (see Appendix 3 for mapped locations).

Species	Easting	Northing	Type of record)
Bilby *Macrotis lagotis*	624591	7771520	Diggings
	624672	7771411	Active burrow
	624726	7771585	Diggings
	624856	7771655	Active burrow
	624827	7771792	Old burrow
	624802	7771794	Active burrow
	624739	7771830	Active burrow
	519606	7807340	Diggings; Scats
	519694	7807267	Multiple fresh diggings
	519729	7807267	Diggings (into ant nest)
	519961	7807158	Active burrow
	520042	7807044	Diggings
	520208	7807033	Tracks
	519753	7807276	Active burrow
	519967	7807229	Multiple fresh diggings
	519960	7807220	Multiple fresh diggings
	578443	7759550	Diggings
	578642	7759596	Active Burrow; Fresh tracks; Multiple old burrows; Multiple diggings within a 150 m radius
	578772	7759325	Tracks
	578768	7759298	Active Burrow
	578920	7759669	Multiple diggings; Scats
	579006	7759195	Multiple diggings
	579148	7759148	Multiple diggings; Old burrow
	579304	7759241	Multiple diggings
	579346	7759259	Active burrow; Multiple diggings
	579273	7759355	Diggings; Tracks
	579098	7759654	Diggings (into base of *Senna notabilis*)
	585152	7760650	Diggings
	584748	7760567	Diggings
	584740	7760543	Old burrow
	584608	7760458	Diggings
	584781	7759842	Scats
	576280	7752026	Diggings
	521111	7804713	Diggings and scats
	521116	7804716	Diggings and scats
	521125	7804597	Diggings (into base of *Acacia*)
	521083	7804597	Digging (into ant nest)
Brush-tailed Mulgara *Dasycercus blythi*	576698	7752304	1 (diggings)

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6.0 Landforms of the Study Area

The study area was categorised into seven broad land units, primarily defined by geology, landform, vegetation and soils (Appendix 3):

- Low Lateritic Rises;
- Stony Hills and Slopes;
- Colluvial Plains;
- Isolated Mulga (*Acacia aneura*) Stands;
- Drainage Systems;
- Alluvial Floodplains; and
- Ephemeral Wetlands and Saline Flats.

These land units were assessed against their likelihood to support either vegetation communities or flora of botanical significance, or represent core habitat for conservation significant fauna; with the latter defined as habitat that represents primary foraging, sheltering or breeding habitat (as per Department of the Environment (2013)). The ecological values of each land unit is discussed in the following sections, together with key environmental issues and threats. Recommended management practices associated with exploration activities relevant to each land unit are discussed in Section 7.0.

6.1 Low Lateritic Rises

This land unit is characterised by low, gravelly, lateritic rises, scarps and side-slopes with typically scattered *Eucalyptus* mallees over a mosaic of low *Acacia* shrubs (Plate 6.1 and Plate 6.2). There are several low exposed lateritic areas within the study area, comprising lateritic gravel with a sandy soil profile and high rock/pebble content. These low rises often contain areas of minor rock outcropping.

Areas of low lateritic rises were mainly located in the Cave Hill, Suplejack, and Boulder Ridge leases (see Appendix 3), and covered a total of 3,984 ha across the entire study area.

Table 6.1: Ecological values of the Low Lateritic Rises land unit.

Vegetation and Flora	
Vegetation Communities	*Acacia hilliana* (*Acacia adoxa* var. *adoxa*) low shrubland over *Triodia epactia* hummock grassland.
	Eucalyptus odontocarpa low open mallee woodland over *Acacia lysiphloia* (*Grevillea wickhamii*) tall open shrubland over *Acacia adoxa* var. *adoxa* low shrubland over *Triodia epactia* very open hummock grassland.
	Eucalyptus brevifolia low open woodland over *Triodia spicatum* open hummock grassland.
Wilson et al. (1990) Units	Mapping Unit 43
Associated species:	Trees and Tall Shrubs: *Senna glutinosa* subsp. *pruinosa.* Low Shrubs: *Ptilotus schwartzii, Acacia hilliana, Dampiera candicans, Ptilotus calostachyus, Ptilotus astrolasius, Senna notabilis, Sida arenicola.* Grasses: *Sporobolus australasicus, Eriachne pulchella* var. *pulchella, Triodia basedowii, Bulbostylis barbata, Paraneurachne muelleri, Aristida latifolia, Aristida holathera* var. *holathera, Eulalia aurea, Schizachyrium fragile, Cymbopogon obtectus.* Herbs: *Polycarpaea longiflora, Polycarpaea corymbosa, Mollugo molluginea.*

Vegetation Condition and Fire Age:	Variable vegetation condition: Good to Excellent; evidence of cattle throughout Suplejack lease. Variable fire age: No sign of recent fire, Burnt 1-2 years ago.
Botanical Significance	Close affinities to BOCS 19-1-4: Tanami Range (bioregional significance).
Fauna	
Zoological Significance	Regionally, known to support Bilby *Macrotis lagotis*, Great Desert Skink *Liopholis kintorei* and potentially the Gravel Dragon *Cryptogama aurita*. During the survey, a possible old burrow system of the Great Desert Skink was recorded from this unit (unconfirmed), as were numerous active and old Bilby burrows (with associated tracks, scats and diggings) (see mapping in Appendix 3). Tracks of the Australian Bustard *Ardeotis australis* and cat were also commonly encountered (Appendix 3).



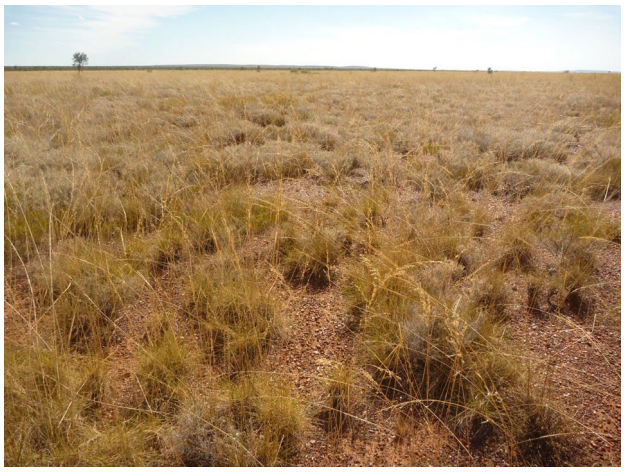

Plate 6.1 and Plate 6.2: Typical vegetation of the Low Lateritic Rise land unit.

6.1.1 Key Issues and Known Threats

The ecological significance of this land unit in the study area is based on it:

1. having close affinities to BOCS 19-1-4: Tanami Range;
2. providing known habitat for fauna species of conservation significance; and
3. supporting plants species and key vegetation relating to and supporting fauna of conservation significance.

Known threats relating to exploration activities for this land unit include susceptibility to:

1. weed invasion; and
2. land degradation/erosion.

The relevant management measures for this land unit based on the above attributes and threats, from amongst those identified in Northern Star's Mining Management Plan (Northern Star (Tanami) Pty Ltd 2017) and other recommendations, are discussed in Section 7.0.

6.2 Stony Hills and Slopes

This land unit predominantly comprised undulating and gently domed low hills and slopes rising to the crest of occasional plateaus (Plate 6.3 and Plate 6.35). The land unit also included a single breakaway section with an elevated plateau in the southeast corner of the Suplejack lease.

Areas of stony hills and slopes were present throughout all five leases with the exception of Farrands Hill in the (see Appendix 3). This land unit covered a total of 35,563 ha across the entire study area. An additional 119,136 ha throughout the study area consisted of a variable mosaic of the Stony Hills and Slopes and the Colluvial Plain land unit (Section 6.3) that could not be separately distinguished and verified due to ground-truthing limitations.

Table 6.2: Ecological values of the Stony Hills and Slopes land unit.

Vegetation and Flora	
Vegetation Communities	*Eucalyptus brevifolia* scattered low trees over *Grevillea refracta* subsp. *refracta* tall open shrubland over *Acacia spondylophylla* scattered low shrubs over *Triodia schinzii* open hummock grassland.
	Corymbia aspera scattered low trees over *Grevillea refracta* subsp. *refracta* scattered tall shrubs over *Acacia minutifolia* low open shrubland over *Triodia spicatum* open hummock grassland.
	Eucalyptus brevifolia (*Corymbia aspera*) scattered low trees over *Grevillea wickhamii* scattered tall shrubs over *Acacia adoxa* var. *adoxa* low open shrubland over *Triodia basedowii* (*T. spicatum*) open hummock grassland.
Wilson et al. (1990) Units	Mapping Units 35, 37
Associated species:	Trees and Tall Shrubs: *Acacia stipuligera, A. lysiphloia, A. monticola, Senna venusta, Eucalyptus pachyphylla.* Low Shrubs: *Mirbelia viminalis, Hibiscus sturtii* var. *platychlamys, Acacia hilliana, Isotropis parviflora, Ptilotus astrolasius, Ptilotus calostachyus, Corchorus sidoides.* Grasses: *Schizachyrium fragile, Eriachne mucronata, Triodia wiseana.* Herbs: *Polycarpaea longifolia, Hybanthus aurantiacus.*
Vegetation Condition and Fire Age:	Variable vegetation condition: Very Good (evidence of cattle) in Suplejack lease; Excellent in all other leases. No sign of recent fire.
Botanical Significance	Areas of this land unit occurring throughout the Browns Range lease show some affinities to BOCS 18-1-PL1: Browns Range (undetermined significance).
Fauna	
Zoological Significance	Evidence of Bilby was recorded from this unit within the Cave Hill tenements. However, it was typically in areas contiguous with lateritic rises and the fauna records are most likely attributable to that land unit rather than being reliant on Stony Hills and Slopes (see Appendix 3).





Plate 6.3 and Plate 6.4 Typical vegetation of the Stony Hills and Slopes land unit.

6.2.1 Key Issues and Known Threats

This vegetation unit is widespread in the locality and is not considered to be of particular ecological significance. No specific management measures are therefore identified for this land unit and the general environmental management measures applying to all exploration activities under Northern Star's Mining Management Plan (Northern Star (Tanami) Pty Ltd 2017) suffice for activities in this land unit (see Section 7.0).

6.3 Colluvial Plains (Stony and/or Sandy)

This unit constituted red sands with a deep soil profile and it is the most widespread land unit in this part of the Tanami. This land unit generally has either no rock content and a low clay content (sandy colluvial plains), or deep red sands with a high level of gravel within the upper soil profile.

This land unit is characterised by level to very gently undulating plains and fans, often covered in hummock grassland with a patchy mosaic of Acacia and isolated *Corymbia* sp. or *Eucalyptus* sp. trees. Two distinct substrate profiles are generally observed throughout this land unit:

- Red-brown sands with a gravelly/stony surface layer, supporting sparse trees over 'hard' spinifex grassland (Plate 6.5 and Plate 6.5); and
- Deep red sands with very minimal or no surface rocks, and low clay content. Often supports 'soft' spinifex open hummock grassland with a mosaic shrubland of *Acacia* and isolated (often taller) trees (Plate 6.7 and Plate 6.7).

Both sandy and stony colluvial plains were located throughout all five leases (see Appendix 3). Colluvial plains with a sandy substrate covered a total of 108,262 ha across the entire study area, whereas colluvial plains with a stony mantle covered a total of 111,529 ha. An additional 119,136 ha throughout the study area consisted of a variable mosaic of the Stony Hills and Slopes unit (Section 6.2) and Colluvial Plain land units that that could not be separately distinguished and verified due to ground-truthing limitations.

Table 6.3: Ecological values of the Colluvial Plains land unit.

Vegetation and Flora	
Vegetation Communities	Sandy: *Corymbia terminalis (Eucalyptus brevifolia)* low open woodland over *Acacia estrophiolata* scattered tall shrubs over *Triodia schinzii* open hummock grassland and occasional *Eulalia aurea*, *Chrysopogon fallax* scattered tussock grasses. Sandy: *Corymbia terminalis* scattered low trees over *Eucalyptus pachyphylla* low open mallee woodland over *Triodia epactia* open hummock grassland.
	Stony: *Eucalyptus brevifolia* scattered low trees over *Acacia lysiphloia* (*Grevillea wickhamii*) tall open shrubland over *A. adoxa* var. *adoxa* (*A. hilliana*) low open shrubland over *Triodia epactia* open hummock grassland. Stony: *Corymbia terminalis* scattered low trees over *Eucalyptus gamophylla* (*E. pruinosa*) scattered low mallees over *Acacia lysiphloia* tall open shrubland over *Triodia epactia* open hummock grassland.
Wilson et al. (1990) Units	Mapping Units 38, 76, 77
Associated species:	Trees and Tall Shrubs: *Acacia stipuligera, Gossypium australe, Petalostylis cassioides, Grevillea wickhamii, Acacia lysiphloia, Senna artemisioides* subsp. *oligophylla*. Low Shrubs: *Ptilotus astrolasius, Leptosema anomalum, Dicrastylis lewellinii, Ptilotus calostachyus, Scaevola amblyanthera, Dampiera candicans*. Grasses: *Aristida holathera* var. *holathera*, *Paraneurachne muelleri*, *Triodia wiseana*. Herbs: *Mollugo molluginea, Evolvulus alsinoides* var. *villosicalyx*
Vegetation Condition and Fire Age:	Variable vegetation condition: Good to Excellent (evidence of Camels in Cave Hill lease). Variable fire age: Burnt 3-5 years, No sign of recent fire.
Botanical Significance	This land unit is common and widespread throughout the Tanami Bioregion and the Northern Territory. It does not specifically exhibit any features of botanical significance.
Fauna	
Zoological Significance	Evidence of the Brush-tailed Mulgara *Dasycercus blythi* was recorded from this unit within the Cave Hill tenement (see Appendix 3).





Plate 6.5 and Plate 6.6: Typical vegetation of the Colluvial Plains land unit with a stony mantle.





Plate 6.7 and Plate 6.8: Typical vegetation of the Colluvial Plains land unit with a sandy soil profile.

6.3.1 Key Issues and Known Threats

The ecological significance of this land unit in the study area is based on it:

1. providing known habitat for fauna species of conservation significance; and
2. supporting plants species and key vegetation relating to and supporting fauna of conservation significance.

Known threats relating to exploration activities for this land unit include susceptibility to:

1. weed invasion; and
2. land degradation/erosion.

The relevant management measures for this land unit based on the above attributes and threats, from amongst those identified in Northern Star's Mining Management Plan (Northern Star (Tanami) Pty Ltd 2017) and other recommended management measures, are discussed in Section 7.0.

6.4 Isolated Mulga (*Acacia aneura*) Stands

This land unit is characterised by a distinct vegetation type of Mulga groves occurring on a specific soil profile of predominantly clay loam with persistent water holding capacity (Plate 6.9 and Plate 6.9). These areas of isolated Mulga occurred in the northeast of the southern half of Farrands Hill lease, and in the southwestern portion of Cave Hill lease (see Appendix 3). In total this land unit covered an area of 200 ha across the entire study area.

Table 6.4: Ecological values of Isolated Mulga (*Acacia aneura*) stands.

Vegetation and Flora	
Vegetation Communities	*Acacia aptaneura* woodland over *A. ayersiana* scattered tall shrubs over *Triodia epactia* very open hummock grassland and *Chrysopogon fallax* scattered tussock grasses, with mixed bunch grassland.
	Acacia aptaneura low open forest over *Eremophila latrobei* subsp. *latrobei* open shrubland over mixed herbland (dominated by *Cleome viscosa*) and mixed bunch grassland (dominated by *Bulbostylis barbata*).
Wilson et al. (1990) Units	Mapping Unit 65, 69
Associated species:	Trees and Tall Shrubs: *Ehretia saligna, Acacia victoriae, Acacia craspedocarpa, Acacia bivenosa, Eremophila longifolia, Eremophila latrobei* subsp. *filiformis.* Low Shrubs: *Ptilotus obovatus, Rhagodia eremaea, Senna artemisioides subsp. helmsii, Senna artemisioides* subsp. *oligophylla, Pterocaulon sphacelatum, Senna notabilis.* Grasses: *Aristida latifolia, Bulbostylis barbata, Eragrostis cumingii, Enneapogon polyphyllus, Sporobolus australasicus, Cymbopogon procerus, Aristida holathera* var. *holathera, Eulalia aurea, Triodia wiseana.* Herbs: *Polycarpaea corymbosa, Evolvulus alsinoides* var. *villosicalyx, Cleome viscosa, Cucumis variabilis, Polycarpaea longifolia, Ptilotus macrocephalus.*
Vegetation condition and Fire Age:	Excellent (no weeds present). Areas of very long unburnt vegetation and areas where there is no sign of recent fire.
Botanical Significance	Mature, larger stands of this land unit have affinities to the BOCS 21-3-PL1: Central Tanami Remnant Mulga (undetermined significance). Areas such as these have very few confirmed botanical values (White et al. 2000).
Fauna	
Zoological Significance	No fauna species of conservation significance were recorded from this unit.





Plate 6.9 and Plate 6.10: Mulga (*A. aneura)* vegetation.

6.4.1 Key Issues and Known Threats

While not supporting any known threatened species or being of floristic significance in its own right, the land unit has ecological significance based on it being a vegetation type that occurs as isolated patches in the landscape, is identified as a BOCS by White et al. (2000) (Section 4.1), and is susceptible to both too frequent fires and changes to surface hydrology.

Known threats relating to exploration activities for this land unit include susceptibility to:

1. weed invasion;
2. land degradation/erosion; and
3. alterations to surface hydrology.

The relevant management measures for this land unit based on the above attributes and threats, from amongst those identified in Northern Star's Mining Management Plan (Northern Star (Tanami) Pty Ltd 2017) and other recommended management measures, are discussed in Section 7.0.

6.5 Drainage Systems

This land unit is characterised by narrow to broad drainage depressions and drainage lines in alluvial floodplains consisting of Coolibah (*Eucalyptus victrix*) dominated vegetation (Plate 6.11, Plate 6.12). The soils of this land unit are typically moderately deep red and brown earths, and deep brown coarse sands. This landform was situated through the central area of the Suplejack lease (see Appendix 3), and covered a total of 152 ha across the entire study area.

Table 6.5: Ecological values of the Drainage Systems land unit.

Vegetation and Flora	
Vegetation Communities	*Eucalyptus victrix* open forest over *Acacia holosericea* scattered tall shrubs over *Chrysopogon fallax* very open tussock grassland, with mixed bunch grassland (dominated by *Eragrostis eriopoda*).
Wilson *et al*. (1990) Units	Mapping Unit 27a
Associated species:	Trees and Tall Shrubs: *Acacia lysiphloia, Atalaya hemiglauca, Gossypium australe.* Low Shrubs: *Melhania oblongifolia.* Grasses: *Bothriochloa bladhii* subsp. *bladhii, Enneapogon polyphyllus, Elytrophorus spicatus Eragrostis tenellula, Eulalia aurea, Themeda triandra.* Herbs: *Alternanthera nodiflora, Centipeda minima* subsp. *macrocephala, Rostellularia adscendens* var. *adscendens, Streptoglossa bubakii.*
Vegetation Condition and Fire Age:	Good to Poor (presence of cattle throughout lease; heavy levels of grazing evident). Several individuals of **Calotropis procera* (Rubber Tree) recorded within this land unit. No sign of recent fire.
Botanical Significance	No relation to any current BOCS (White et al. 2000). Vegetation condition of this land unit within the Suplejack lease contributes to its relatively low botanical significance locally.
Fauna	
Zoological Significance	No fauna species of conservation significance were recorded from this land unit.



Plate 6.11: Banks of drainage dominated by *Eucalyptus* spp.



Plate 6.12: Island of drainage system dominated by *Eucalyptus* and *Acacia* spp.

6.5.1 Key Issues and Known Threats

While not supporting any known threatened species, the land unit has ecological significance based on drainage lines being centres of moisture in an arid landscape, being relatively limited in occurrence and offering refugia in drought periods.

Known threats relating to exploration activities for this land unit include susceptibility to:

1. weed invasion (particularly with respect to the spread of weeds via livestock);
2. land degradation/erosion; and
3. alterations to surface hydrology.

The relevant management measures for this land unit based on the above attributes and threats, from amongst those identified in Northern Star's Mining Management Plan (Northern Star (Tanami) Pty Ltd 2017) and other recommended management measures, are discussed in Section 7.0.

6.6 Alluvial Floodplains

The Alluvial Floodplains land units support a continuous but variable vegetation community with differing proportions of flora species determined by variation in the landscape. Complex mosaics are often formed between numerous vegetation types.

This land unit is characterised by deep valleys covered with deeper sands in usually more elevated situations than the saline paleochannel areas (see Section 6.7). These areas are often the historical path of ancient watercourses, with vegetation types more similar to the surrounding colluvial sandplains (Plate 6.13, and Plate 6.14). The soils of this diffuse drainage landform are typically sandy red-brown earths, being richer and better watered than the adjacent surrounding landscape, often with a higher clay content.

This land unit was located in the Cave Hill, Farrands Hill, Browns Range, and Boulder Ridge leases (see Appendix 3), and covered a total of 9,270 ha across the entire study area.

Table 6.6: Ecological values of the Alluvial Floodplains land unit.

Vegetation and Flora	
Vegetation Communities	*Eucalyptus pruinosa* low woodland over *Sehima nervosum* (*Eulalia aurea*) tussock grassland.
	Eucalyptus victrix open woodland over *Melaleuca nervosa* (*Acacia stipuligera*) tall open shrubland over mixed tussock grassland and *Triodia epactia* scattered hummock grasses.
	Eucalyptus microtheca open woodland over *Chrysopogon fallax* tussock grassland and *Triodia epactia* scattered hummock grasses.
	Corymbia opaca low open woodland over *Acacia estrophiolata* scattered tall shrubs over *Triodia schinzii* open hummock grassland.
Wilson *et al*. (1990) Units	Mapping Units 25, 26, 27, 45, 46, 98 (affinities to each).
Associated species:	Trees and Tall Shrubs: *Eremophila longifolia, Gossypium australe, Acacia synchronicia, Grevillea wickhamii, Eremophila latrobei* subsp. *latrobei, Petalostylis cassioides, Acacia stipuligera, Acacia melleodora.* Low Shrubs: *Scaevola acacioides, Sida fibulifera, Senna notabilis, Senna artemisioides* subsp. *helmsii, Ptilotus calostachyus, Ptilotus astrolasius* Grasses: *Panicum effusum, Cymbopogon ambiguus, Aristida holathera* var. *holathera, Chrysopogon fallax, Themeda triandra, Triodia epactia, Aristida inaequiglumis, Aristida latifolia, Astrebla pectinata, Dactyloctenium radulans, Eragrostis xerophila, Paraneurachne muelleri, Aristida contorta.* Herbs: *Pterocaulon serrulatum, Alternanthera nodiflora, Evolvulus alsinoides* var. *villosicalyx, Cleome viscosa, Polycarpaea longifolia, Pterocaulon sphacelatum, Salsola australis, Alternanthera denticulata, Mollugo molluginea.*

Vegetation Condition and Fire Age:	Very Good to Excellent. Some signs of cattle in Browns Range lease. Mosaic of fire history ranging from Burnt 5-7 years ago to No sign of recent fire.
Botanical Significance	Areas of this land unit identified throughout the central area of Browns Range lease and the northwest section of Boulder Ridge lease exhibit close affinities to two BOCS: the 19-2-PL1: Central Tanami Paleodrainage Depression and 20-1-PL2: Tanami Paleodrainage System Extension (both of undetermined significance). The botanical values of both these BOCS have not been documented appropriately and require considerable further investigation (White et al. 2000).
Fauna	
Zoological Significance	No fauna species of conservation significance were recorded from this land unit.





Plate 6.13 and Plate 6.14 Typical vegetation of Alluvial Floodplains land unit.

6.6.1 Key Issues and Known Threats

This land unit has ecological significance based on it being a vegetation type that equates in areas to vegetation types identified as a BOCS by White et al. (2000) (Section 4.1; Table 6.6).

Known threats relating to exploration activities for this land unit include susceptibility to:

1. weed invasion;
2. land degradation/erosion; and
3. alterations to surface hydrology.

The relevant management measures for this land unit based on the above attributes and threats, from amongst those identified in Northern Star's Mining Management Plan (Northern Star (Tanami) Pty Ltd 2017) and other recommended management measures, are discussed in Section 7.0.

6.7 Ephemeral Wetlands and Saline Flats

This land unit is characterised by being the surface expressions of ancient river systems and watercourses (paleochannels or paleodrainage systems). This largely saline landform system is associated with intermittently inundated salt lakes, and surrounding saline flats with cracking and non-cracking saline clays and soils. Samphire vegetation with a bunch grassland understorey typically exists on the fringes of the salt lakes (Plate 6.15, Plate 6.16). Large termite mounds (*Nasutitemes triodiae*) are also frequently found in this paleochannel land unit.

The high biodiversity values of this land unit are due to high flora species diversity and abundance, the support of microhabitats, and it being a well-known refugia habitat for many fauna species, including threatened species.

There were limited floristic data for the Saline Flats and Ephemeral Wetlands land unit due to a lack of landform present in the study area. This land unit occurred in the Farrands Hill, Boulder Ridge, and Browns Range leases (see Appendix 3) and covered a total of 6,104 ha across the entire study area. An ecologically significant area of this land unit was identified in the southeastern corner of Farrands Hill lease, totalling 343 ha.

Table 6.7: Ecological values of the Ephemeral Wetlands and Saline Flats.

Vegetation and Flora	
Vegetation Communities	*Tecticornia indica* low samphire shrubland over mixed open bunch grassland.
Wilson et al. (1990) Units	Mapping Units 100, 106, 107, 111.
Associated species:	Trees and Tall Shrubs: *Melaleuca lasiandra, Gossypium sturtianum.* Low Shrubs: *Pterocaulon sphacelatum, Salsola australis, Chenopodium auricomum, Sida fibulifera, Atriplex limbata, Pterocaulon serrulatum, Tecticornia verrucosa.* Grasses: *Sporobolus mitchellii, Eragrostis falcata, Eragrostis xerophila, Triodia schinzii.* Herbs: *Cleome viscosa, Dysphania kalpari.*
Vegetation Condition and Fire Age:	Good: Signs of cattle; **Flaveria trinervia* (n=95) present in this vegetation unit. No sign of recent fire.
Botanical Significance	This land unit and its locally restricted vegetation communities show close affinity to the nationally significant BOCS: 20-1-3: Western Tanami Paleodrainage System.
Fauna	
Zoological Significance	A significant population of Bilby were recorded from this habitat. Numerous active burrows as well as tracks and scats in multiple locations (Appendix 3).



Plate 6.15: Fringing samphire vegetation surrounding salt lakes.



Plate 6.16: *Eragrostis* spp. bunch grassland throughout the saline flats land unit.



Plate 6.17: **Flaveria trinervia* present in the land unit.

6.7.1 Key Issues and Known Threats

The ecological significance of this land unit in the study area is based on it:

1. having very close affinities to the nationally significant Western Tanami Paleodrainage System BOCS;
2. providing known habitat for fauna species of conservation significance; and
3. supporting plants species and key vegetation relating to and supporting fauna of conservation significance.

Known threats relating to exploration activities for this land unit include susceptibility to:

1. weed invasion;
2. land degradation/erosion; and
3. alterations to surface hydrology.

The relevant management measures for this land unit based on the above attributes and threats, from amongst those identified in Northern Star's Mining Management Plan (Northern Star (Tanami) Pty Ltd 2017) and other recommended management measures, are discussed in Section 7.0.

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7.0 Conclusions and Management Measures

7.1 Key Findings by Tenure

Table 7.1 presents a summary of key fauna and flora attributes identified for each of the tenements comprising the TRE study area. Given the preliminary nature of the current survey, these results should be considered indicative rather than exhaustive, but do provide guidance on the likely presence of key ecological factors relevant to the planned exploration activities by tenure, and the related management measures that should be implemented in response to these (see Section 7.2). The representation of each key ecological attribute is largely a function of the land units occurring within each tenement (Section 6.0 and Appendix 3), and the management measures that Northern Star should consider within each land unit are summarised in Section 7.2. Spatial data have also been supplied with this report to facilitate tenement-specific planning for exploration environmental management on the basis of land unit occurrence.

Table 7.1: **Summary of key ecological attributes currently identified for each TRE tenement** ('?' denotes unconfirmed or unground-truthed record).

	Tenement				
Ecological Attribute	Boulder Ridge	Browns Range	Cave Hill	Farrands Hill	Suplejack
BOCS affinity vegetation - Mulga	-	-	✓	✓	-
BOCS affinity vegetation – Ephemeral wetlands	✓	✓	-	✓	-
Threatened fauna – Bilby	✓	-	✓	✓	-
Threatened fauna – Brush-tailed Mulgara	-	-	✓	-	-

7.2 Management Measure to Minimise Exploration Impacts

While a range of key ecological attributes and related land units occur across the TRE tenure, many of the relevant threatening processes and potential impacts of exploration activities remain similar in nature. Appropriate environmental management measures are also thereby common to many of the tenements and can be summarised into a series of management measures that provides Northern Star with a toolbox of actions that may be applied as needed across the study area.

Table 7.2 summarises these actions by land unit, with more detail on the specifics of the recommended actions provided below. The representation of land units by tenement is mapped in Appendix 3 and has also been supplied as a spatial data set to allow for more efficient use in exploration planning.

1. Avoidance of known key ecological attributes: the locations of land units of conservation significance and known threatened fauna records (Table 7.1) should be taken into account in the design of access and sampling locations for the exploration programme, with these avoided wherever practicable. This should include the mapped areas of Mulga and Ephemeral Wetlands and Saline Flats land units, based on the mapping provided in Appendix 3: where access to these land units is unavoidable, additional site specific planning and management will need to be implemented to manage for weed spread and erosion, and to minimise ground disturbance to the minimum possible.

2. Pre-clearance targeted threatened fauna surveys and management: given the preliminary nature of the current survey, and the very large spatial scale of the TRE project, targeted searches for Bilby and Mulgara evidence should be undertaken once planned track access and sampling for the exploration programme have been designed. This is consistent with Northern Star's existing disturbance permit procedure, which requires tracks or burrows of these species to be documented in any proposed works areas. Should evidence of the species' occurrence be recorded, then the design of that part of the sampling programme should be revisited with a view to revising the design to avoid ground disturbance in the area. In the event that this is not possible within the constraints of the project, a fauna management plan, specific to the species in questions, will need to be developed and implemented prior to the commencement of ground disturbance. This may include measures such as trapping and fauna translocation or other direct means of managing the individual animals and should be developed in consultation with the relevant conservation agencies at NT and Commonwealth levels.

Table 7.2: Summary of relevant environmental management measures by land units present within the study area.

	Applicable Land Unit						
Management Measure	Low Lateritic Rises	Stony Hills and Slopes	Colluvial Plains	Isolated Mulga Stands	Drainage Systems	Alluvial Floodplains	Ephemeral Wetlands & Saline Flats
1. Avoidance of known key ecological attributes	✓	-	✓	✓	✓	✓	✓
2. Pre-clearance targeted threatened fauna surveys	✓	-	✓	-	-	-	✓
3. Pre-clearance targeted weed management	-	-	-	-	✓	-	✓
4. Minimum footprint access planning	✓	✓	✓	✓	✓	✓	✓
5. Minimum soil disturbance for temporary access	✓	✓	✓	-	-	✓	✓
6. Weed hygiene protocols	-	-	✓	✓	✓	✓	✓
7. Vegetation clearing controls	✓	✓	✓	✓	✓	✓	✓
8. Lowered vehicle speed limits	✓	-	✓	-	-	-	✓
9. Fire management	✓	✓	✓	✓	✓	✓	✓
10. Environmental inductions	✓	-	✓	✓	✓	-	✓

3. Maintain ongoing pre-clearance targeted weed management: the vegetation of the study area appears to be in very good condition in general, with only two weed species of limited occurrence recorded during the current survey. Should planned track access and sampling for the exploration programme require ground disturbance in the locations of these known weed records, it would be advisable to control the existing infestations prior to commencing ground disturbance to minimise risks of spreading the weeds. This can be achieved via mechanical removal of plants and scalping of topsoil for small infestations, or via chemical control for more widespread species. Such measures are consistent with, and can form an extension of, Northern Star's ongoing weed hygiene procedures (Northern Star (Tanami) Pty Ltd 2017).

4. Minimum footprint access planning: all clearing of vegetation for track access and sampling for the exploration programme should be kept to the minimum possible for safe vehicle and plant movement. The alignment and location of access tracks should also take account of existing surface hydrology, to ensure any disruption to natural surface water flow is minimised or avoided entirely, particularly if in proximity to drainage-sensitive land units (Isolated Mulga Stands, Drainage Systems, Alluvial Floodplains, and Ephemeral Wetlands & Saline Flats). These considerations could be incorporated into Northern Star's existing site disturbance permit procedure to ensure the minimum disturbance areas required are cleared.

5. Minimum soil disturbance for temporary access: significant disturbance to the soil profile exacerbates the risk of erosion occurring, the spread of weed propagules (if present) and results in more extended rehabilitation timeframes. Wherever feasible within each land unit, consideration should be given to the use of scrub-rolling or other low-intensity methods to create access where conditions permit. In the event this is not possible, then blade depth on mobile plant used for access track and pad formation should be kept to the minimum feasible. Again, these approaches are consistent with existing clearing protocols identified in Northern Star's Mining Management Plan (Northern Star (Tanami) Pty Ltd 2017).

6. Weed hygiene protocols: given the intact condition of the vegetation of the study area and the very low levels of existing weed infestation, the existing weed hygiene protocols identified in Northern Star's Mining Management Plan (Northern Star (Tanami) Pty Ltd 2017) should be implemented for all activities. This is of particular importance for any works conducted within the land units most susceptible to weed invasion, including those with existing weed records (Table 7.2).

7. Vegetation clearing controls: once planned track access and sampling pad locations for the exploration programme are complete, the extent of all vegetation clearing areas should be demarcated on plans and specified in writing to plant operators. Prior to the commencement of ground disturbance, these should be demarcated in the field, by means of GPS or other surveying equipment to ensure spatial and extent accuracy. This will serve to reduce the overall footprint of the TRE project in general and is of particular importance in land units containing habitat for threatened fauna or those equivalent to BOCs vegetation types (Table 7.2).

8. Vehicle speed limits: given the presence of Bilby in the study area, reduced speed limits should be enforced on any tracks traversing land units containing habitat for this species (Table 7.2). These should be in force from one hour prior to dusk until one hour after dawn.

9. Fire risk management and contingency response: measures to reduce the risk of bushfires commencing as a result of the exploration programme should be developed and implemented, including any contingency responses that may be appropriate. Typical measures included in such risk reduction management include prohibiting the lighting of fires on-site, ensuring any grinding or welding is done in dedicated facilities or on clear ground behind spark shields and that spot fire control equipment is on hand and serviceable in all exploration plant and equipment.

10. Environmental inductions: all aspects of management measures 1 to 9 above that are relevant to the wider on-site workforce should be incorporated into site environmental inductions. In particular this should address the presence of threatened fauna species and BOCs vegetation types, and that they represent the basis on which the environmental management measures are being implemented.

Finally, there would be value in Northern Star conducting a review and revision of its existing disturbance permit procedure, to align the above recommendations with existing environmental management measures in place to achieve improvements in on-site environmental risk reduction in the implementation of the TRE Project.

8.0 Glossary and Acronyms

*	Used prior to a species name to denote a weed species.
Annual (plant)	A plant that lives for only one year.
EPBC Act	The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.
Ephemeral (plant)	A plant that lives a very short time; less than one year, usually less than six months.
GIS	Geographic Information System.
IBRA	Interim Biogeographic Regionalisation for Australia.
Relevé	An unbounded flora sampling site.
sp. (plural: spp.)	Abbreviation of 'species'.
subsp.	Abbreviation of 'subspecies'.
TPCW Act	*Territory Parks and Wildlife Conservation Act 2006*.
Threatened species	Flora and fauna species protected by legislation, either listed under the Commonwealth EPBC Act or the *Territory Parks and Wildlife Conservation Act 2006*.
TRE	Tanami Regional Exploration Project
var.	Abbreviation of 'variety'.

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Appendix 1

Vegetation Structural Classes and Condition Scale

Vegetation Structural Classes*

Stratum	Canopy Cover (%)				
	70-100%	**30-70%**	**10-30%**	**2-10%**	**<2%**
Trees over 30 m	Tall closed forest	Tall open forest	Tall woodland	Tall open woodland	Scattered tall trees
Trees 10-30 m	Closed forest	Open forest	Woodland	Open woodland	Scattered trees
Trees under 10 m	Low closed forest	Low open forest	Low woodland	Low open woodland	Scattered low trees
Shrubs over 2 m	Tall closed scrub	Tall open scrub	Tall shrubland	Tall open shrubland	Scattered tall shrubs
Shrubs 1-2 m	Closed heath	Open heath	Shrubland	Open shrubland	Scattered shrubs
Shrubs under 1 m	Low closed heath	Low open heath	Low shrubland	Low open shrubland	Scattered low shrubs
Hummock grasses	Closed hummock grassland	Hummock grassland	Open hummock grassland	Very open hummock grassland	Scattered hummock grasses
Grasses, Sedges, Herbs	Closed tussock grassland / bunch grassland / sedgeland / herbland	Tussock grassland / bunch grassland / sedgeland / herbland	Open tussock grassland / bunch grassland / sedgeland / herbland	Very open tussock grassland / bunch grassland / sedgeland / herbland	Scattered tussock grasses / bunch grasses / sedges / herbs

* Based on Muir (1977) and Aplin's (1979) modification of the vegetation classification system of Specht (1970):

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Vegetation Condition Scale*

E = Excellent (=Pristine of BushForever) Pristine or nearly so; no obvious signs of damage caused by the activities of European man.
VG = Very Good (= Excellent of BushForever) Some relatively slight signs of damage caused by the activities of European man. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds such as **Sonchus oleraceus* or **Cucumis* spp., or occasional vehicle tracks.
G = Good (= Very Good of BushForever) More obvious signs of damage caused by the activities of European man, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or by selective logging. Weeds as above, possibly plus some more aggressive ones such as **Cenchrus* spp.
P = Poor (= Good of BushForever) Still retains basic vegetation structure or ability to regenerate to it after very obvious impacts of activities of European man, such as grazing, partial clearing (chaining) or frequent fires. Weeds as above, probably plus some more aggressive ones such as **Cenchrus* spp.
VP = Very Poor (= Degraded of BushForever) Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species including very aggressive species such as **Prosopis* spp.
D = Completely Degraded (= Completely Degraded of BushForever) Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

* Based on Trudgen M.E. (1988). A Report on the Flora and Vegetation of the Port Kennedy Area. Unpublished report prepared for Bowman Bishaw and Associates, West Perth.

Appendix 2

Vascular Flora List

Family	Species
Acanthaceae	*Rostellularia adscendens* var. *adscendens*
Amaranthaceae	*Alternanthera denticulata*
	Alternanthera nodiflora
	Gomphrena cunninghamii
	Ptilotus astrolasius
	Ptilotus calostachyus
	Ptilotus fusiformis
	Ptilotus macrocephalus
	Ptilotus nobilis
	Ptilotus obovatus
	Ptilotus schwartzii
Apocynaceae	**Calotropis procera*
Asteraceae	*Centipeda minima* subsp. *macrocephala*
	**Flaveria trinervia*
	Pterocaulon serrulatum
	Pterocaulon sphacelatum
	Streptoglossa bubakii
Boraginaceae	*Ehretia saligna*
	Heliotropium crispatum
	Trichodesma zeylanicum var. *zeylanicum*
Caryophyllaceae	*Polycarpaea corymbosa*
	Polycarpaea longifolia
Chenopodiaceae	*Atriplex limbata*
	Chenopodium auricomum
	Dysphania kalpari
	Maireana georgei
	Rhagodia eremaea
	Salsola australis
	Sclerolaena bicornis
	Sclerolaena eriacantha
	Tecticornia halocnemoides subsp. *tenuis*
	Tecticornia verrucosa
Cleomaceae	*Cleome viscosa*
Convolvulaceae	*Duperreya commixta*
	Evolvulus alsinoides var. *villosicalyx*
Cucurbitaceae	*Cucumis variabilis*
Cyperaceae	*Bulbostylis barbata*
	Fimbristylis simulans
Fabaceae	*Acacia adoxa* var. *adoxa*
	Acacia aptaneura
	Acacia arida
	Acacia ayersiana
	Acacia bivenosa
	Acacia caesaneura
	Acacia craspedocarpa
	Acacia colei var. *colei*
	Acacia cuthbertsonii subsp. *cuthbertsonii*

Family	Species
Fabaceae (continued)	*Acacia elachantha*
	Acacia estrophiolata
	Acacia gonoclada
	Acacia hilliana
	Acacia holosericea
	Acacia lysiphloia
	Acacia melleodora
	Acacia minutifolia
	Acacia monticola
	Acacia retivenea
	Acacia spondylophylla
	Acacia stipuligera
	Acacia synchronicia
	Acacia torulosa
	Acacia victoriae
	Isotropis parviflora
	Leptosema anomalum
	Mirbelia viminalis
	Petalostylis cassioides
	Senna artemisioides subsp. *helmsii*
	Senna artemisioides subsp. *oligophylla*
	Senna glutinosa subsp. *glutinosa*
	Senna glutinosa subsp. *pruinosa*
	Senna notabilis
	Senna venusta
Frankeniaceae	*Frankenia cordata*
Goodeniaceae	*Dampiera candicans*
	Goodenia microptera
	Scaevola acacioides
	Scaevola amblyanthera
	Scaevola parviflora
Gyrostemonaceae	*Codonocarpus cotinifolius*
Lamiaceae	*Dicrastylis lewellinii*
Lauraceae	*Cassytha capillaris*
Malvaceae	*Corchorus sidoides*
	Gossypium australe
	Gossypium sturtianum
	Hibiscus leptocladus
	Hibiscus sturtii var. *platychlamys*
	Melhania oblongifolia
	Seringia nephrosperma
	Sida arenicola
	Sida fibulifera
	Waltheria virgata
Marsileaceae	*Marsilea hirsuta*
Molluginaceae	*Mollugo molluginea*

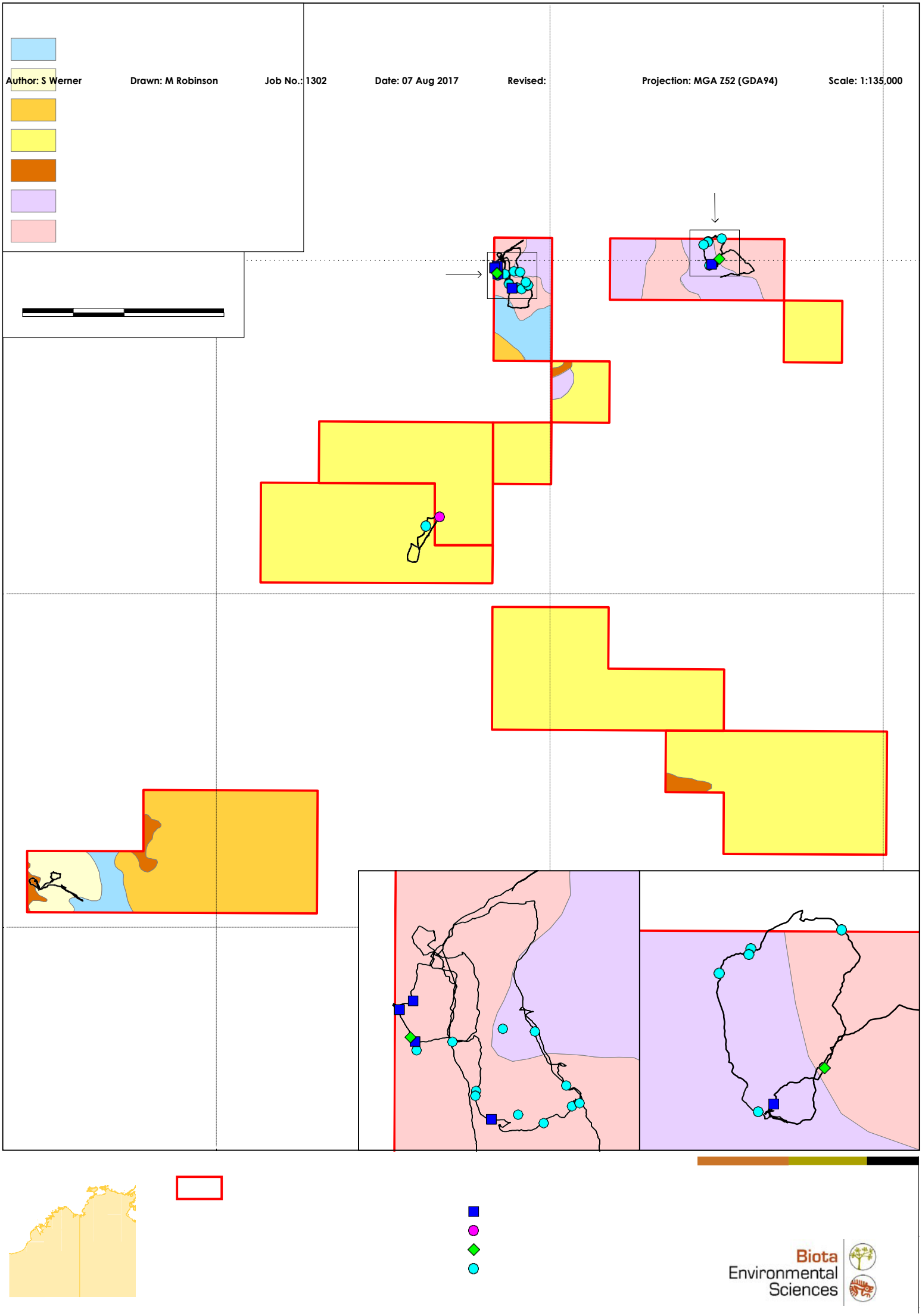
Family	Species
Myrtaceae	*Corymbia aspera*
	Corymbia opaca
	Corymbia terminalis
	Cucumis variabilis
	Eucalyptus brevifolia
	Eucalyptus gamophylla
	Eucalyptus microtheca
	Eucalyptus odontocarpa
	Eucalyptus pachyphylla
	Eucalyptus pruinosa
	Eucalyptus victrix
	Melaleuca lasiandra
	Melaleuca nervosa
Nyctaginaceae	*Boerhavia coccinea*
Oleaceae	*Jasminum didymum* subsp. *lineare*
Poaceae	*Amphipogon sericeus*
	Aristida contorta
	Aristida holathera var. *holathera*
	Aristida inaequiglumis
	Aristida latifolia
	Astrebla pectinata
	Bothriochloa bladhii subsp. *bladhii*
	Chrysopogon fallax
	Cymbopogon ambiguus
	Cymbopogon obtectus
	Cymbopogon procerus
	Dactyloctenium radulans
	Elytrophorus spicatus
	Enneapogon polyphyllus
	Eragrostis cumingii
	Eragrostis eriopoda
	Eragrostis falcata
	Eragrostis tenellula
	Eragrostis xerophila
	Eriachne aristidea
	Eriachne mucronata
	Eriachne pulchella var. *pulchella*
	Eulalia aurea
	Panicum effusum
	Paraneurachne muelleri
	Schizachyrium fragile
	Sehima nervosum
	Setaria surgens
	Sporobolus australasicus
	Sporobolus mitchellii
	Themeda avenacea
	Themeda triandra

Family	Species
Poaceae (continued)	*Triodia basedowii*
	Triodia epactia
	Triodia melvillei
	Triodia pungens
	Triodia schinzii
	Triodia spicatum
	Triodia wiseana
Proteaceae	*Grevillea refracta* subsp. *refracta*
	Grevillea wickhamii
Pteridaceae	*Cheilanthes brownii*
Rhamnaceae	*Ventilago viminalis*
Sapindaceae	*Atalaya hemiglauca*
Scrophulariaceae	*Eremophila latrobei* subsp. *filiformis*
	Eremophila latrobei subsp. *latrobei*
	Eremophila longifolia
Solanaceae	*Halgania gustafsenii*
Violaceae	*Hybanthus aurantiacus*

Appendix 3

Land Unit Mapping, Survey Sites and Locations of Fauna Records


Landform Mapping
Alluvial Floodplain
Colluvial Plain (Sandy)
Colluvial Plain (Stony)
Colluvial Plain (Stony/Sandy)
Isolated Mulga
Low Lateritic Rise
Stony Hills and Slopes
580,000 mE
590,000 mE
See Enlargement 2
7,760,000 mN
See Enlargement 1
0
3
6
kilometres
7,750,000 mN
Enlargement 1
Enlargement 2
7,740,000 mN
570,000 mE
mE
000
590,
Location Map
DARWIN
NORTHERN TERRITORY
BROOME
Map Area
WESTERN AUSTRALIA
ALICE
Cave Hill lease area
Survey Effort
Walk transect
Evidence of Fauna
Ardeotis australis
Dasycercus blythi
*Felis catus
Macrotis lagotis
Tanami Projects
Flora & Fauna Survey
Landforms


Author: S Werner
Drawn: M Robinson
Job No.: 1302
Date: 07 Aug 2017
Revised:
Projection: MGA Z52 (GDA94)
Scale: 1:135,000
Biota
Environmental
Sciences


Landform Mapping
Alluvial Floodplain
Colluvial Plain (Sandy)
Colluvial Plain (Stony)
Ephemeral Wetlands and Saline Flats
Isolated Mulga
Low Lateritic Rise
620,000 mE
630,000 mE
7,790,000 mN
7,780,000 mN
7,770,000 mN
Location Map
DARWIN
NORTHERN TERRITORY
BROOME
Map Area
WESTERN AUSTRALIA
ALICE SPRINGS
Farrands Hill lease area
Survey Effort
Walk transect
Flora Recorded
*Flaveria trinervia
Evidence of Fauna
M acrotis lago
0 2.5 5
Tanami Projects
Flora & Fauna Survey
Landforms

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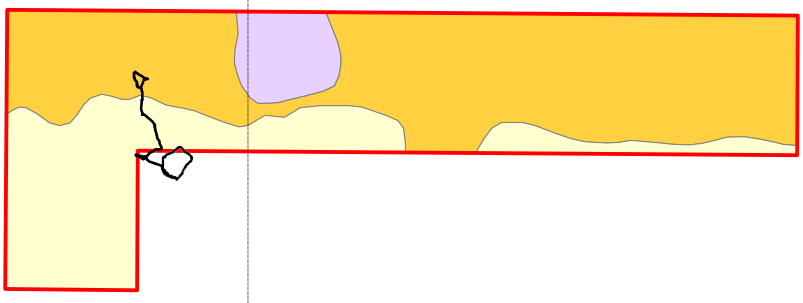

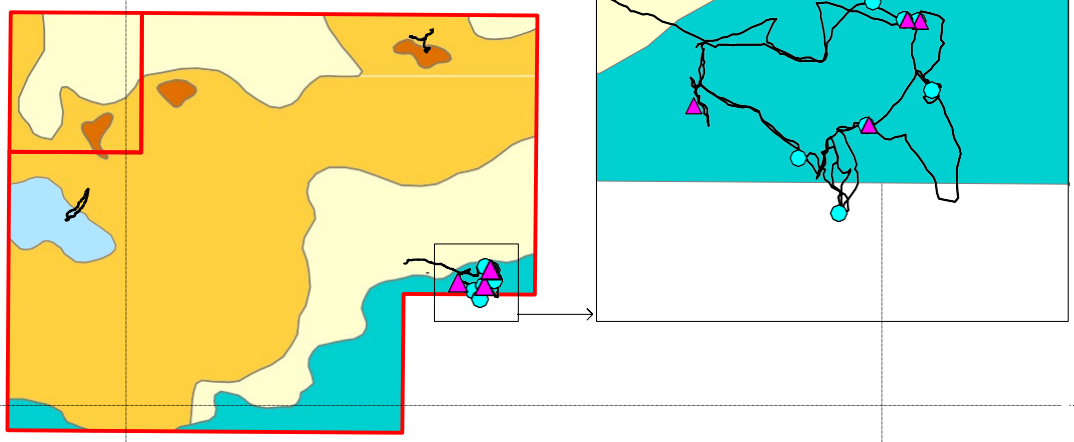

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