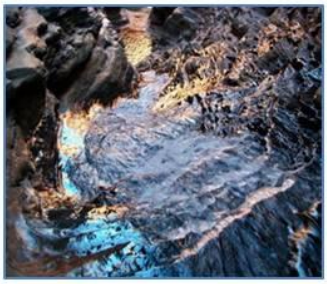

Northern Minerals Limited

Browns Range Project

Terrestrial Vertebrate Fauna Impact Assessment

June 2014

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Terrestrial Vertebrate Fauna Impact Assessment

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Executive Summary

Northern Minerals Limited (Northern Minerals) commissioned Outback Ecology to undertake a vertebrate fauna baseline survey, targeted survey and impact assessment of the proposed Browns Range Project (the Project), which is located approximately 150 km southeast of Halls Creek in the Tanami bioregion of Western Australia. The baseline survey was performed in May 2012 and is the subject of a previous, standalone report prepared for Northern Minerals by Outback Ecology (2012) – *Browns Range Project: Terrestrial Vertebrate Fauna Baseline Survey*. A targeted vertebrate fauna survey was performed in December 2013, and is also the subject of a previous standalone report by Outback Ecology (2014) – *Browns Range Project: Targeted Vertebrate Fauna Survey*. The vertebrate fauna impact assessment for the Project (this Assessment) is the focus of the present report.

The Study Area considered by this Assessment consisted of approximately 16,294 ha containing a Development Envelope of approximately 2,590 ha. Northern Minerals have committed to locating the Project within the Development Envelope and the indicative footprint provided to Outback Ecology ('Proposed Development Footprint') has a total area of approximately 711 ha. Calculations of impacts to habitat have been made using this indicative footprint to provide scale and context to the impact assessment.

The objective of this Assessment was to assess the potential impacts of the Project on terrestrial vertebrate fauna assemblages, fauna habitats and fauna of conservation significance that possibly occur or are likely, very likely or known to occur within the Study Area. This Assessment also considered the significance of impacts on matters of national environmental significance, which, for the purposes of this Assessment, were defined as fauna that are listed under the *Environment Protection and Biodiversity Conservation Act 1999* and possibly occur or are likely, very likely or known to occur within the Study Area.

The vertebrate fauna assemblages found in the Development Envelope and the broader Study Area are consistent with those known to occur in the surrounding landscape. Land clearance associated with the Project is likely to result in the direct loss of individuals and habitats in the Development Envelope during initial clearance activities. However, as most assemblages in the Development Envelope occur across a range of habitats or are found in widespread and well-connected habitats, the broad vertebrate fauna assemblages of the Development Envelope are unlikely to be significantly impacted by the Project beyond the local scale at which land clearing may occur. From a regional perspective, the impacts of the Project on fauna assemblages in general are unlikely to be significant.

All of the fauna habitats identified in the Study Area are present to some extent in the Development Envelope and hence may be impacted by the Project. Clearing vegetation is an aspect of the Project with the greatest potential to impact on fauna habitats and assemblages. The Open Shrubland over Mixed Grassland on Sandy Plain habitat will be subject to the greatest clearing impact from the Project in terms of the amount of habitat affected – 1,900 ha of this habitat type occurs within the Development Envelope – but this habitat is widespread in the Study Area and wider region and is

considered to be of limited significance. The Hummock Grassland on Rocky Hill and Hummock Grassland on Stony Plain habitat types occur in relatively small, disconnected patches across the Study Area. Drainage Line habitat is likely to play an important role in facilitating the dispersal of fauna across the Study Area and wider region. Clearing and fragmentation of these habitat types should be minimised where possible.

A total of 16 species of conservation significance were identified by the baseline survey as potentially being present in the Study Area. Seven of these are known to occur or have occurred in the Development Envelope:

- Greater Bilby (*Macrotis lagotis*) – Vulnerable (EPBC Act) and Schedule 1 (WC Act);
- Major Mitchell's Cockatoo (*Lophochroa leadbeateri*) – Schedule 4 (WC Act);
- Spectacled Hare-wallaby (mainland subspecies) (*Lagorchestes conspicillatus leichardti*) – Priority 3 (DPaW Priority Fauna list);
- Lakeland Downs Mouse (*Leggadina lakedownensis*) – Priority 4 (DPaW Priority Fauna list);
- Bush Stone-curlew (*Burhinus grallarius*) – Priority 4 (DPaW Priority Fauna list);
- Australian Bustard (*Ardeotis australis*) – Priority 4 (DPaW Priority Fauna list); and
- Oriental Plover (*Charadrius veredus*) – Migratory (EPBC Act) and Schedule 3 (WC Act).

This Assessment considered the potential impacts of the Project on those fauna of conservation significance that are known to be present in the Development Envelope, as well as those that possibly occur or are likely or very likely to occur. Of all the species considered, the potential impacts of the Project are expected to be the greatest for:

- Greater Bilby;
- Spectacled Hare-wallaby (mainland subspecies); and
- Bush Stone-curlew.

Each of these species is susceptible to habitat removal via land clearance, identified as a key direct impact of the Project. In the absence of effective impact mitigation strategies, the localised impact on each of these species is expected to be low, ie short-term population decline is expected, but populations are expected to recover after the life of the Project.

Impacts on all other species of vertebrate fauna of conservation significance identified in this Assessment are considered to be negligible to minimal. The proposed Project is not expected to have significant impacts on matters of national environmental significance. Nonetheless, the 16 species of conservation significance identified in this Assessment should be carefully considered in planning, operation and closure of the Project.

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APPENDIX

1. INTRODUCTION

Northern Minerals Limited (Northern Minerals) commissioned Outback Ecology to undertake a vertebrate fauna impact assessment of the proposed Browns Range Project (the Project). It is understood that this document will be used to inform future approvals and permitting documentation for the Project. This Assessment is based on data obtained during a terrestrial vertebrate fauna baseline survey conducted in May 2012 (Outback Ecology 2012), a vegetation and flora survey conducted in May 2012 and May 2013 (Outback Ecology 2013, in prep-a), and a targeted vertebrate fauna survey conducted in December 2013 (Outback Ecology in prep-b).

1.1. Project Location and Description

The Project is located approximately 150 kilometres (km) south-east of Halls Creek in the Tanami region of Western Australia (WA), adjacent to the Western Australia/Northern Territory border (**Figure 1**). The area considered during this Assessment (the Study Area) consists of approximately 16,294 hectares (ha) of land, containing a Development Envelope of approximately 2,590 ha (**Figure 2**). Northern Minerals have committed to locating the Project entirely within the Development Envelope. The indicative footprint provided to Outback Ecology ('Proposed Development Footprint') has a total area of approximately 711 ha. Calculations of impacts to habitat have been made using this footprint to provide scale and context to the impact assessment.

The Proposed Development Footprint will consist of two components: the mining infrastructure and the access road. The mining infrastructure will likely include pits, waste rock landforms, a crushing, grinding and separation facility, tailings storage facility, roads, borefield, pipelines, magazine, ROM pad, gravel pit, evaporation pond, parking and laydown areas, a workshop, fuel and water storage, accommodation village, airstrip, and administration buildings (**Figure 3**). Mining activities will consist of open pit mining, with crushing, grinding and separation being conducted on site. The construction of the access road between the Project and Gordon Downs Road (see **Figure 2**) will involve upgrading existing roads. Concentrate will be transported from the Project to the distribution point via the access road (included in this Assessment) and public roads.

1.2. Report Scope and Objectives

The objective of this Assessment was to assess the potential impacts of the Project on terrestrial vertebrate fauna assemblages, fauna habitats and fauna of conservation significance. This Assessment is based on data obtained during previous surveys (Outback Ecology 2012, 2013, in prep-a, b). Details of the methods applied and the areas surveyed are provided within the relevant reports and summarised in **Section 2.1**.

This Assessment, and the previous surveys, were conducted in accordance with Environmental Protection Authority (EPA), Department of Parks and Wildlife (DPaW, formerly DEC) and Department of the Environment (DoE) guidelines and policy statements for terrestrial vertebrate fauna surveys and impact assessments (DoE 2013, EPA and DEC 2010, EPA 2002, EPA 2004). There were no limitations to this assessment arising from the requirements of Northern Minerals.

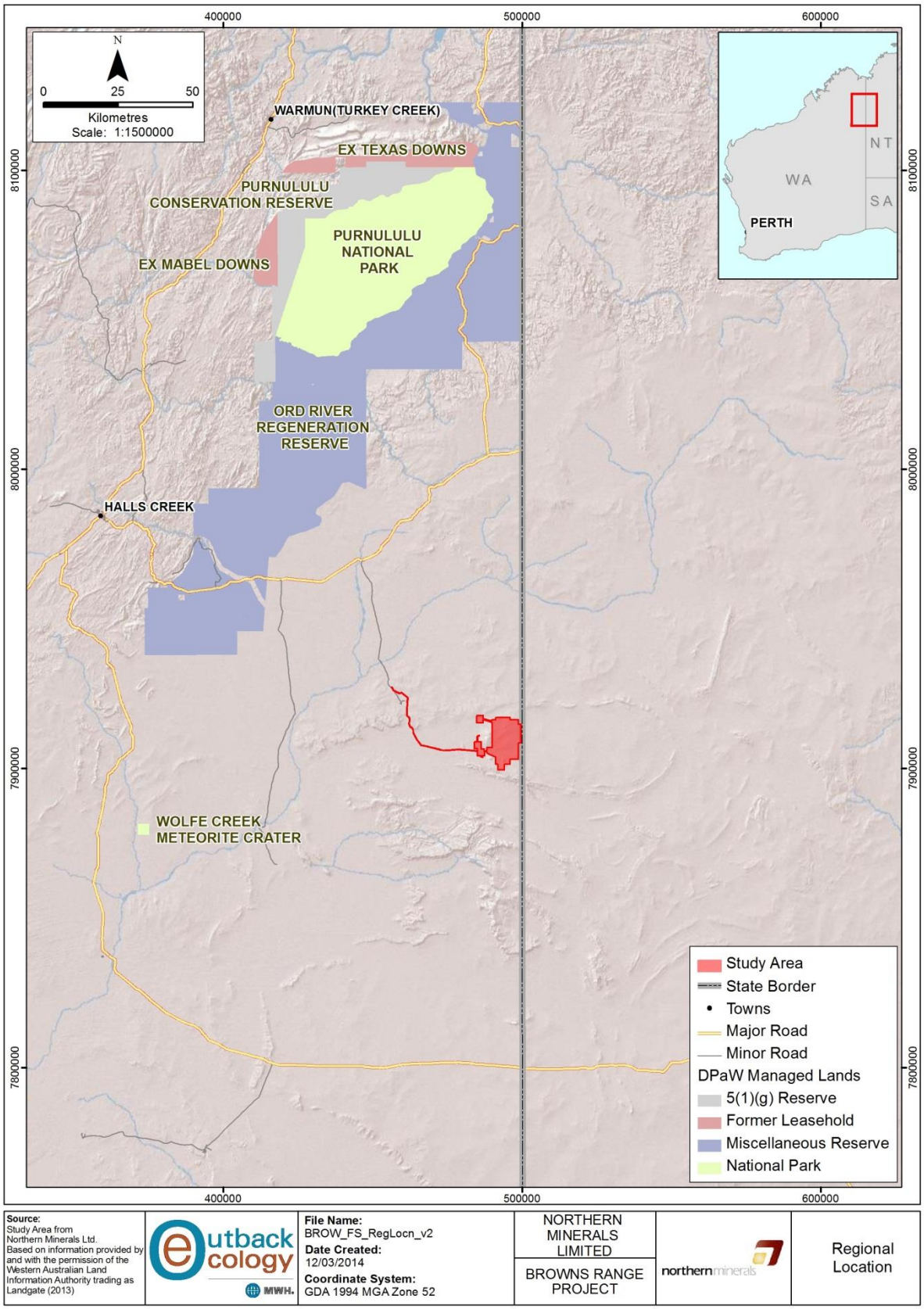

Figure 1: Regional location of the Browns Range Project Study Area

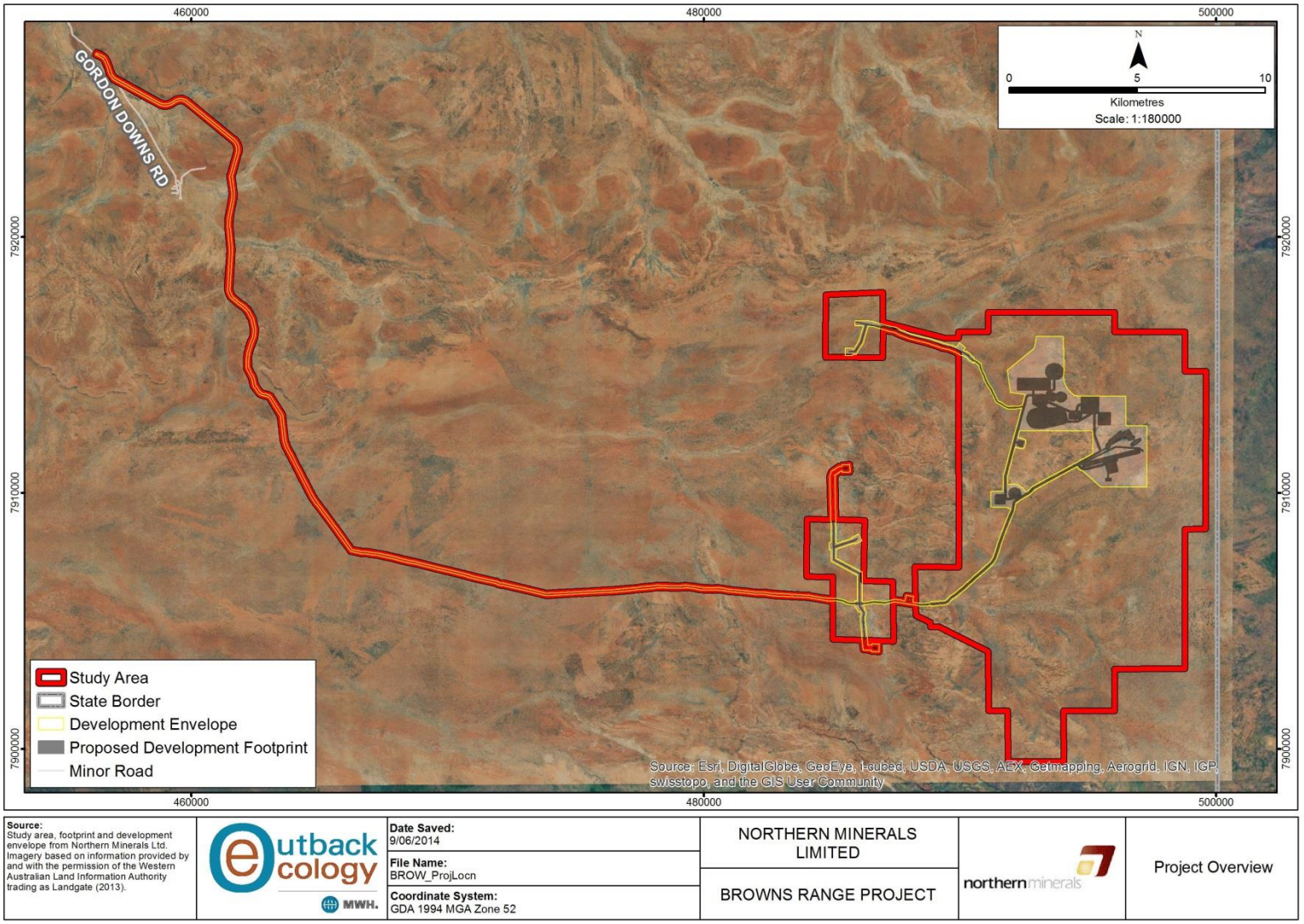

Figure 2: Study Area and Proposed Development Envelope

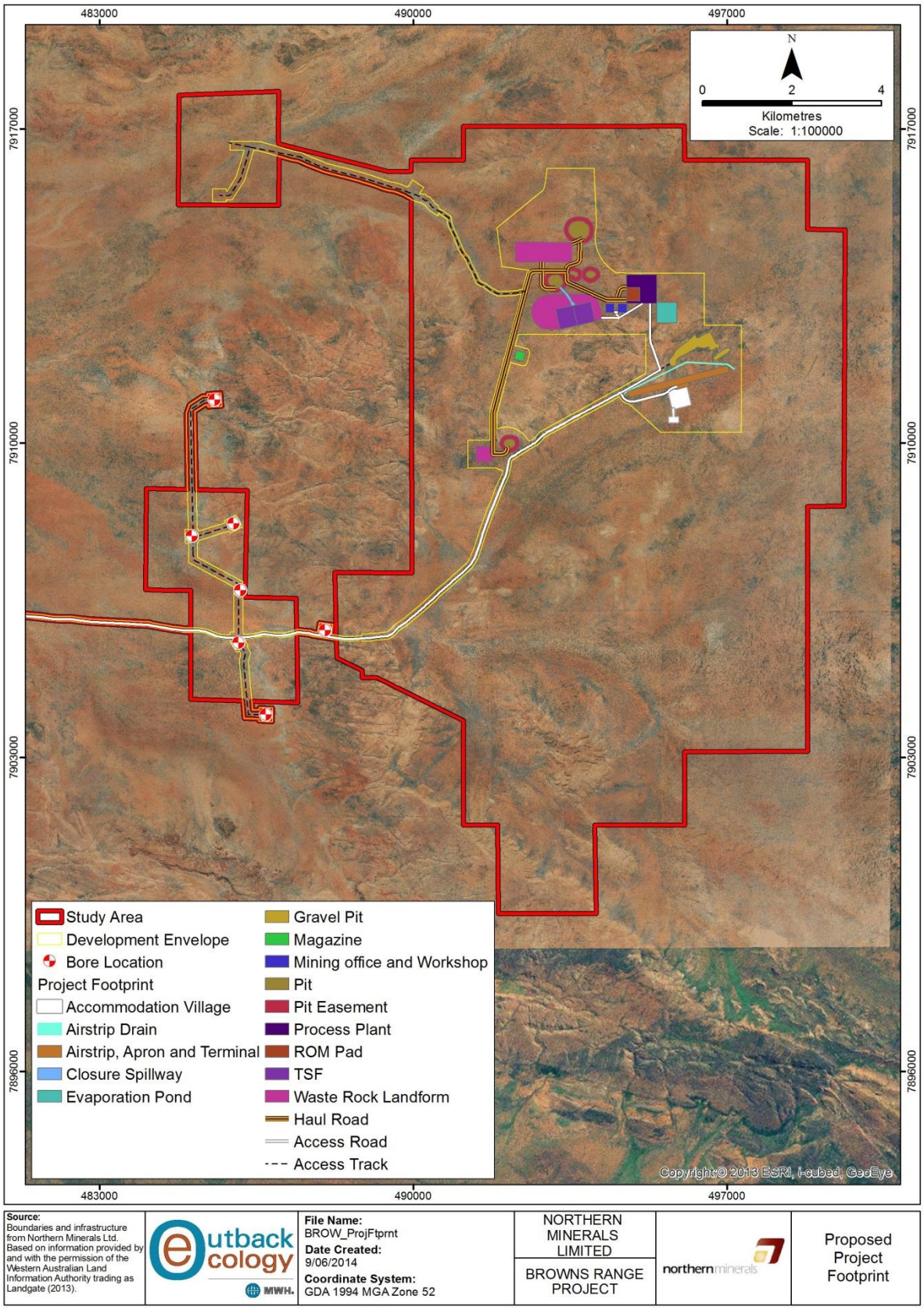

Figure 3: Conceptual layout of Project infrastructure within the Development Envelope

2. ADDENDUM TO THE BASELINE SURVEY

2.1. Revision of the Extent of the Study Area

This Assessment is based on data obtained during a terrestrial vertebrate fauna baseline survey (Outback Ecology 2012), a vegetation and flora survey (Outback Ecology 2013, in prep-a), and a targeted vertebrate fauna survey (Outback Ecology in prep-b). Subsequent to the completion of the baseline fauna survey (May 2012), the Development Envelope for the Project was extended outside the original fauna baseline survey area. Consequently, it was necessary for the Study Area to be extended (by 8,622 ha; **Figure 4**) to include the expanded Development Envelope. The Study Area was extended to incorporate mining infrastructure comprising an accommodation village, airstrip, clay deposit, gravel deposit and borefield locations. Additionally, the Study Area was extended to the northwest for approximately 50 km to incorporate the access road between the Project and Gordon Downs Road.

Detailed habitat mapping was completed over the extensions to the Study Area to inform this Assessment. This habitat mapping was based upon detailed vegetation mapping of the extended areas completed in May 2013 (Outback Ecology 2013, in prep-a) (**Figure 4**). No new habitats or land systems were found to occur in the extended areas and consequently, information from the baseline fauna survey was considered adequate to predict species occurrence in the extended areas and was therefore appropriate for informing this Assessment.

2.2. Implications of the Study Area Revisions

The enlargement of the Study Area subsequent to the completion of the baseline fauna survey necessitated revision of the extent of land systems (**Section 2.3**) and vertebrate fauna habitats occurring within it (**Section 2.4**). This new information, when reviewed with the other baseline survey data, provides an adequate baseline for this Assessment.

Of the 8,622 ha of additions to the Study Area, 159 ha in five small sections have not been verified through ground surveys and have been characterised instead through analysis of aerial imagery and consideration of on-ground expert knowledge held by Outback Ecology zoologists (**Figure 4**). It is recommended that prior to any works being conducted in these areas, these areas are ground-truthed to ensure the habitats present, and therefore their potential fauna assemblages, are consistent with those determined from these desktop analyses ('Area to be Ground-truthed'; **Figure 4**).

2.3. Land Systems in the Study Area

The 8,622 ha portion of land added to create the Study Area extends into the Coolindie and Winnecke Land Systems, which were identified as occurring in the area originally surveyed during the baseline survey. While the types of land systems occurring in the Study Area have not changed as a result of the addition, their extents are now different from those presented in the baseline survey report (see Table 1 and Figure 6 in Outback Ecology 2012) (**Table 1**, **Figure 5**). The Coolindie land system remains the dominant land system in the Study Area.

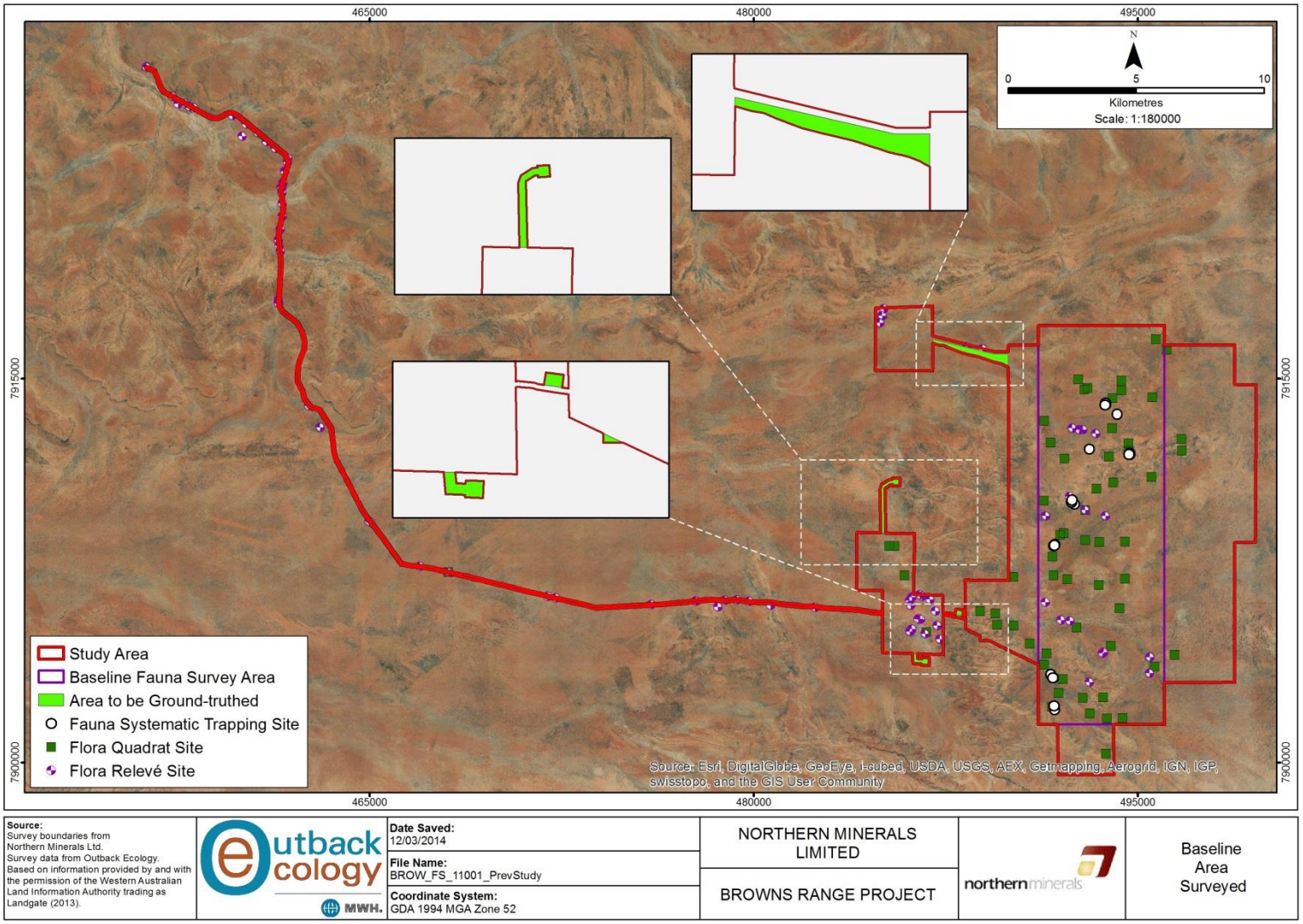

Figure 4: Flora and fauna survey effort within the boundaries of the Study Area relative to those of the baseline fauna survey area

Table 1: Land systems in the Study Area

Land System	Description[1]	Extent in Study Area[1]
Coolindie	Consists of gently undulating red desert sandplains and dunes supporting *Acacia* shrublands, *Eucalyptus* woodlands and soft spinifex (*Triodia pungens*) grasslands. These grasslands are subject to frequent fires that cause short-term changes in floristic composition and abundance. Drainage lines are shallow, widely spaced and infrequent, and erosion is minimal.	13,276 ha 81.48%
Winnecke	Consists of stony hills and lowlands associated with red desert sands that support *Acacia* and *Eucalyptus* woodlands and soft spinifex (*Triodia pungens*) grasslands. These grasslands are subject to frequent fires that cause short-term changes in floristic composition and abundance. Intensive parallel drainage lines occur on upper slopes, while widely spaced angular drainage lines occur on lower slopes and terminate at the base of hills. Erosion is generally minimal, though some drainage floors are moderately susceptible.	3018 ha 18.52%
	Total	16,294 ha

[1]Source: Payne and Schoknecht (2011)

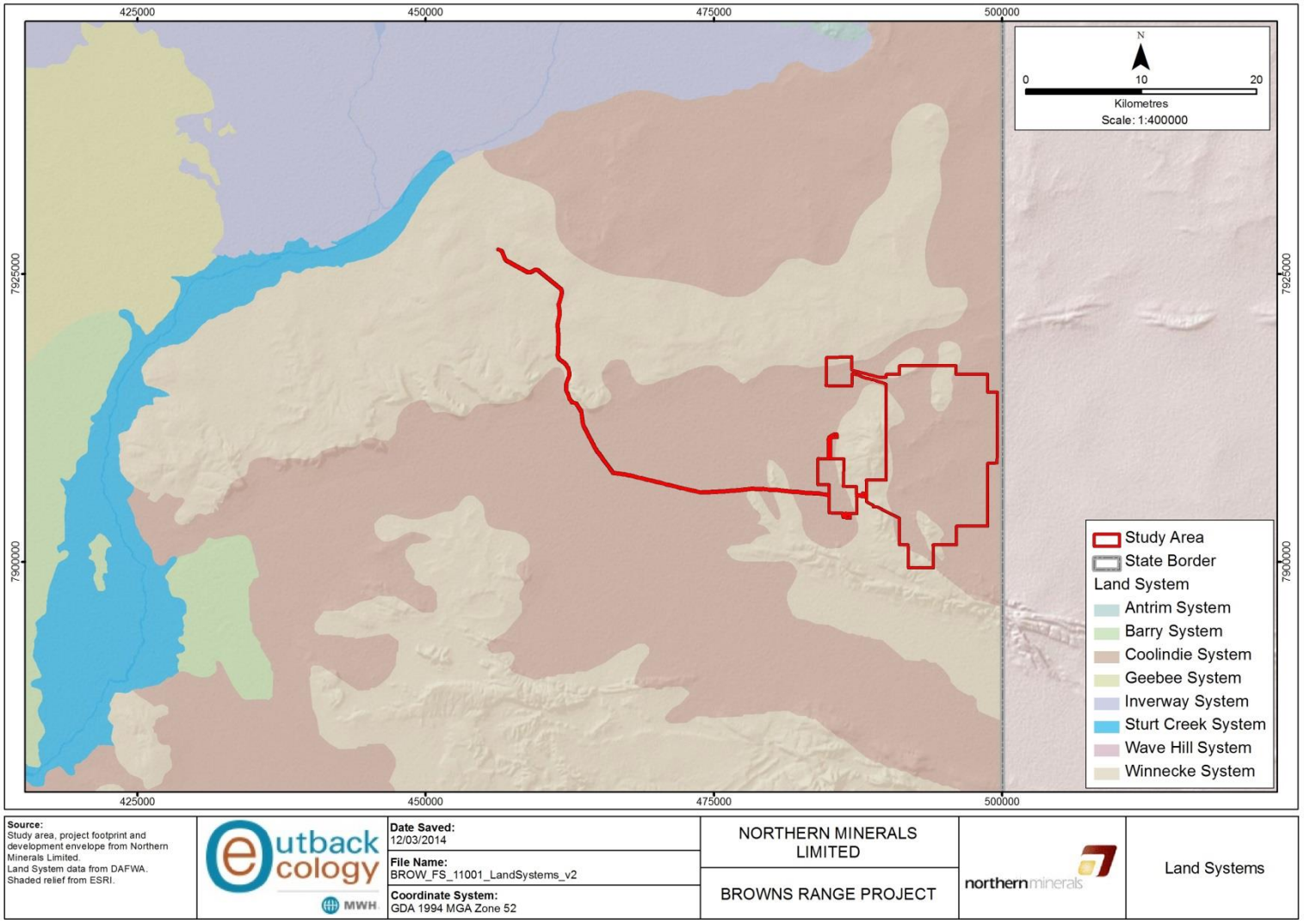

Figure 5: Land systems within and surrounding the Study Area

2.4. Fauna Habitats in the Study Area

The 8,622 ha portion of land added to create the Study Area contains extensions of three fauna habitats previously defined by Outback Ecology (2012):

- Open Shrubland over Mixed Grassland on Sandy Plain;
- Drainage Line; and
- Hummock Grassland on Rocky Hill.

The total extents of all habitats within the Study Area are presented in **Table 2**.

Table 2: Extents of fauna habitat types present in the Study Area

Fauna habitat	Summary description[1]	Extent[2]
Open Shrubland over Mixed Grassland on Sandy Plain	Occupies greatest proportion of the Study Area and is well represented in the surrounding landscape (*Acacia* shrublands are common in the Winnecke land system)	12,557 ha 77.1%
Drainage Line	Large swathes across the Study Area, with smaller drainage lines common at the base of instances of the Hummock Grassland on Rocky Hill habitat type	2,221 ha 13.6%
Hummock Grassland on Rocky Hill	Isolated patches throughout the Study Area, with more extensive patches toward the north. Corresponds with the well-represented Winnecke land system	1,219 ha 7.5%
Hummock Grassland on Stony Rise	Small, isolated patches throughout the Study Area, comprising gently sloping rises covered by small rocks but with very limited outcropping	211 ha 1.3%
Acacia Heath Over Mixed Grassland On Sandy Plain	Occurs in only one part of the Study Area. The dense, low cover provided by this habitat to fauna is unique within the Study Area but not regionally significant	69 ha 0.4%
Mixed Grassland On Sandy Plain	Of limited extent in the Study Area, and considered unlikely to support faunal assemblages substantially different to those found in other habitat types	16 ha 0.1%
	Total	16,294 ha 100.0%

[1]See Outback Ecology (2012) for complete habitat descriptions, plates and summaries of survey effort per habitat type;
[2]Newly calculated habitat extents for the Study Area following revision of its size – these figures supersede those provided in the baseline survey report for the Project (Table 7 in Outback Ecology 2012).

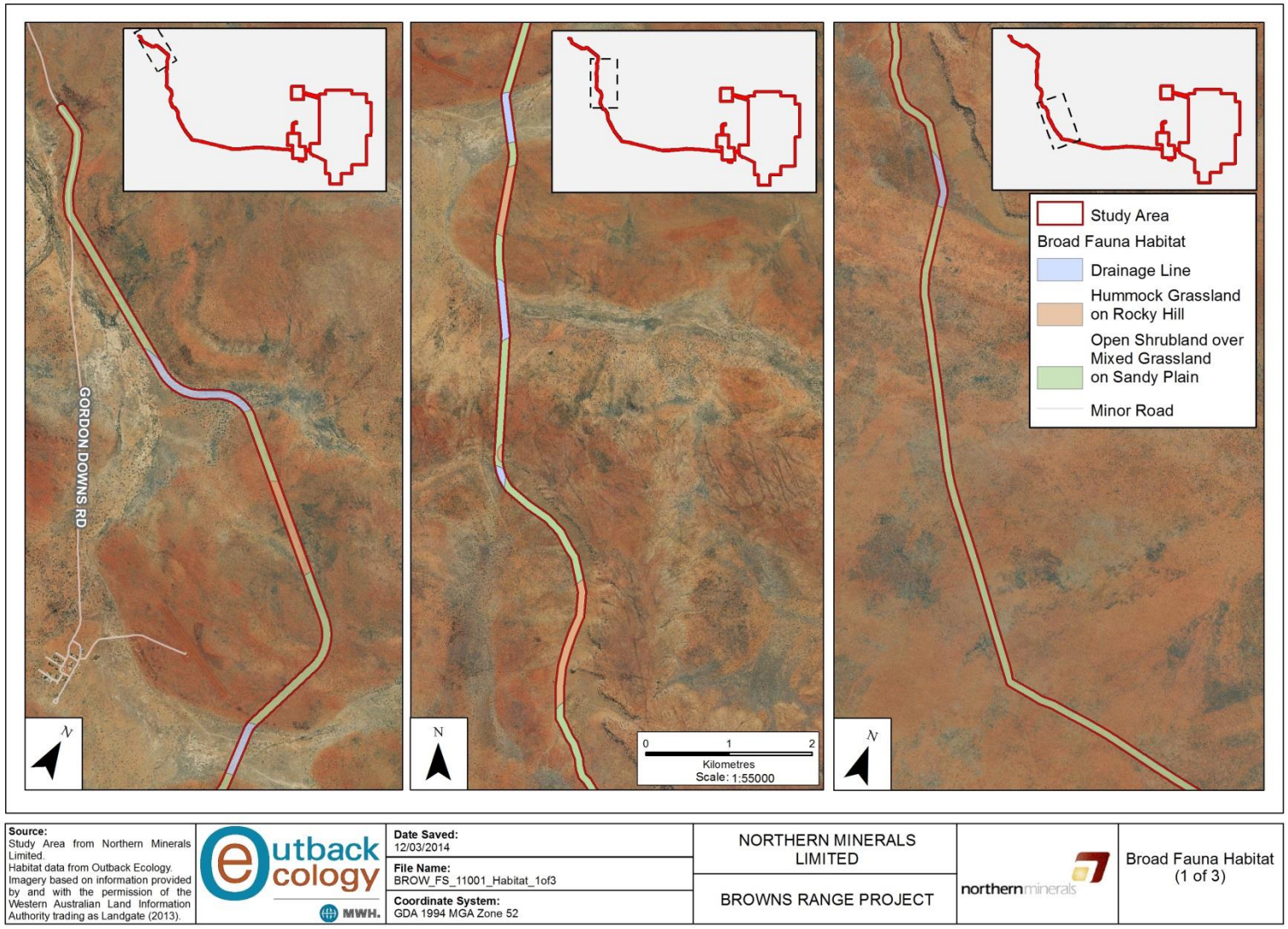

Figure 6: Fauna habitats in the Study Area (1 of 3)

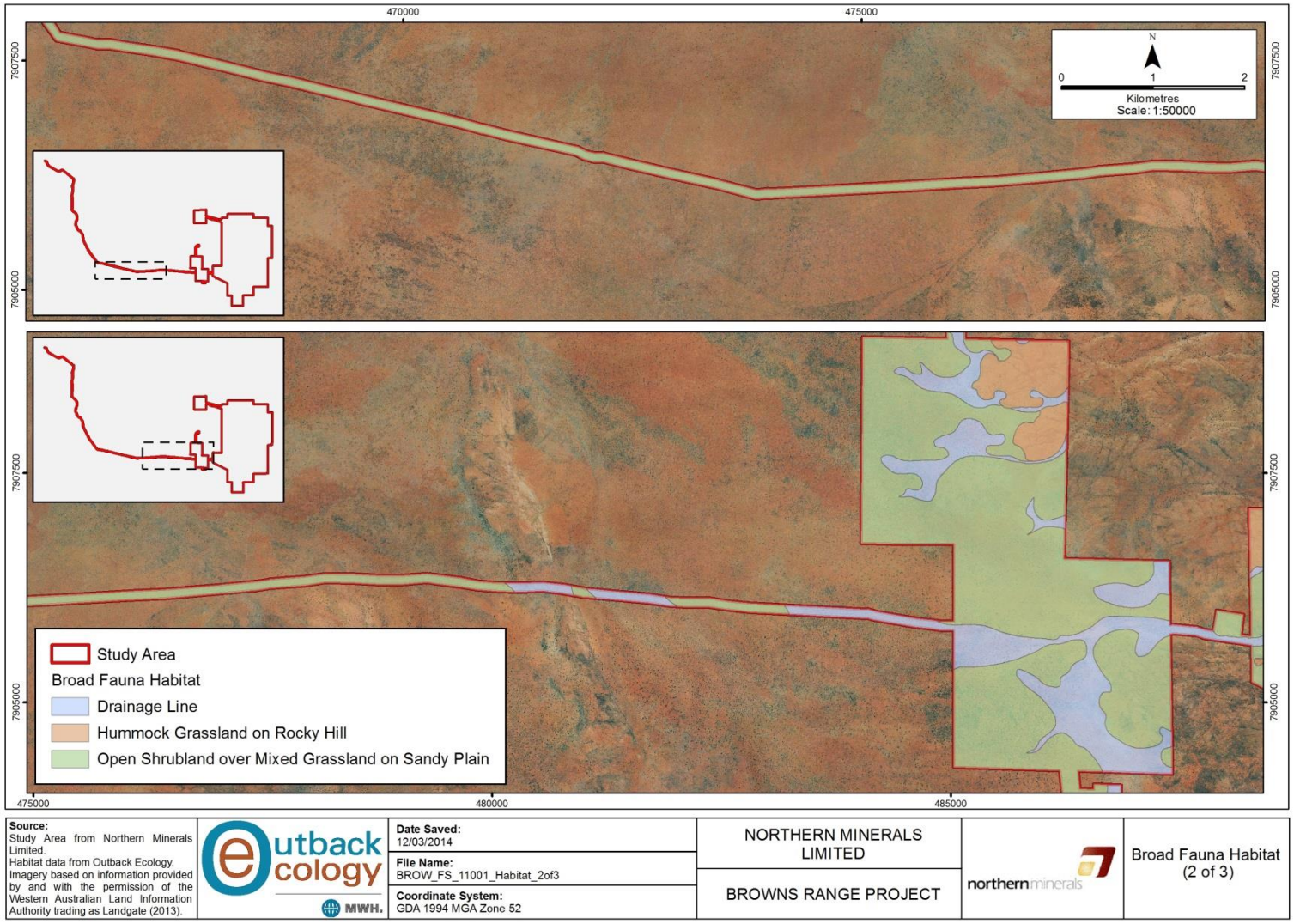

Figure 7: Fauna habitats in the Study Area (2 of 3)

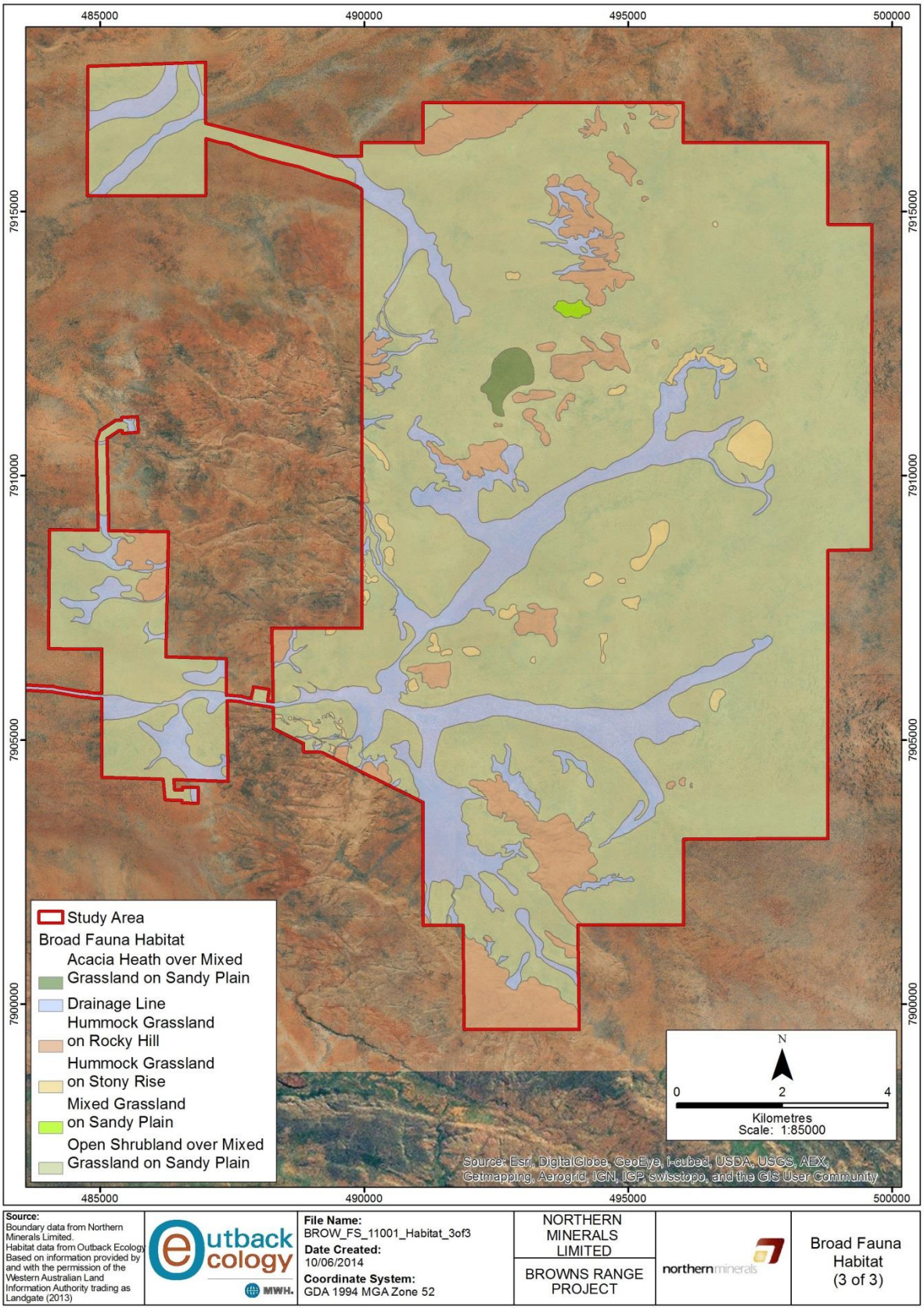

Figure 8: Fauna habitats in the Study Area (3 of 3)

3. POTENTIAL IMPACTS

3.1. Threatening Processes

Threatening processes relevant to the Tanami bioregion, in which the Project lies, have been identified by the Australian Natural Resources Audit (ANRA) and include feral predators, inappropriate fire regimes, grazing by introduced herbivores, and invasive weeds (ANRA 2009a, ANRA 2009b). Aspects of the Project that constitute threatening processes with potential to impact upon fauna or fauna habitats include the following:

- habitat removal and modification;
- collision with vehicles;
- inappropriate fire regimes;
- altered hydrology;
- noise and vibration;
- artificial light exposure;
- dust emissions;
- introduced flora; and
- introduced fauna.

The aspect of the Project with greatest potential to impact upon fauna or fauna habitat is the removal and modification of habitat through land clearing. The other aspects of the Project listed above have potential to impact on fauna, however the extent of the impacts are likely to be localised and have negligible to no effect at a regional scale.

3.1.1. Habitat Removal and Modification

Clearing vegetation is a necessary aspect of the Project with the greatest potential to impact upon fauna habitats and fauna assemblages present in the Study Area. The development of the Project will result in the loss of 711 ha of habitat via land clearance within the 2,590 ha Development Envelope. It should be noted that the Proposed Development Footprint may not represent the final Project footprint and that minor changes to the boundaries of the Proposed Development Footprint may still be made (with total amount of clearing capped at 711 ha). Land clearance will result in a reduction in the size of habitats and may reduce the quality of those habitats due to increased edge effects and habitat fragmentation (Davis *et al.* in press, Watson *et al.* 2003). At mine closure, some habitats, such as those with rocky features or drainage lines, may be slower or more difficult to rehabilitate than other habitats in the Study Area.

All of the fauna habitats identified in the Study Area have the potential to be affected by land clearing during the construction and operation of the Project, as instances of each fall within the Development Envelope (**Table 3**, **Figure 9, 10, 11**). The consequences of any clearing in the Study Area within the regional context of the Project, however, are likely to be low as all fauna habitats identified in the Study Area are of limited significance and are widespread (**Table 3**). These habitats are relatively extensive in the region, are well represented outside the Study Area and were not found to support

exceptionally high biodiversity in the Study Area, particularly with respect to fauna of conservation significance.

Land clearance is likely to result in the direct loss of individual animals. Although more mobile fauna may be able to avoid immediate impact from development of the Project and ongoing operations, the degree of subsequent impact is dependent on the availability of suitable habitat elsewhere in the vicinity and the ability of individual species to disperse to these habitats. Nesting birds and their young may also be directly affected by clearing, although this potential impact can be reduced by considering the timing of clearance activities.

Species utilising the *Acacia* Heath over Mixed Grassland on Sandy Plain and Mixed Grassland on Sandy Plain habitat types are unlikely to be impacted substantially by clearing as they are very likely to also utilise the Open Shrubland over Mixed Grassland on Sandy Plain habitat type, which is widespread within and surrounding the Study Area. Conversely, species utilising Hummock Grassland on Rocky Hill and Hummock Grassland on Stony Rise habitat types are more likely to be impacted by clearing, as these habitat types provide microhabitats that are unavailable in other parts of the Study Area (this is discussed further in **Section 3.2**). There are also a number of drainage lines in the Study Area that are likely to be bisected by the access road and this may increase the level of fragmentation of the Drainage Line habitat within the Study Area.

Table 3: Habitats in the Study Area, Development Envelope and Proposed Development Footprint

Fauna habitat	Context[1]	Extent in		
		Study Area[3]	Development[4] Envelope	Proposed Development Footprint[4]
Open Shrubland over Mixed Grassland on Sandy Plain	Widespread Limited significance	12,557 ha 77.1%	1,900 ha 15.1%	517 ha 4.1%
Drainage Line	Widespread Limited significance[2]	2,221 ha 13.6%	457 ha 20.6%	111 ha 5.0%
Hummock Grassland on Rocky Hill	Widespread Limited significance[2]	1,219 ha 7.5%	158 ha 12.9%	46 ha 3.8%
Hummock Grassland on Stony Rise	Limited extent Limited significance[2]	211 ha 1.3%	52 ha 24.7%	23 ha 10.8%
Acacia Heath Over Mixed Grassland On Sandy Plain	Limited extent Limited significance	69 ha 0.4%	7 ha 10.1%	1 ha 1.8%
Mixed Grassland On Sandy Plain	Limited extent Limited significance	16 ha 0.1%	16 ha 100 %	13 ha 83.3%
Totals[5]		16,294 ha 100.0%	2,590 ha 15.90%	711 ha 4.36%

[1]Widespread habitats are those occupying more than 5% of the Study Area while habitats of limited extent are those occupying less than 5% of the Study Area, and significant habitats are those capable of supporting fauna of conservation significance or distinct faunal assemblages while habitats of limited significance are those considered of no particular value in supporting fauna of conservation significance or distinct faunal assemblages;
[2]While all of the fauna habitat types are of limited significance at a regional scale, these habitat types are vulnerable to Project impacts at a local scale – this is addressed elsewhere in this Assessment (e.g. Section 3.2).
[3]Percentages indicate total proportion of the Study Area made up of that habitat type.
[4]Percentages indicate the amount of each habitat present in the Development Envelope and Proposed Development Footprint, respectively, as a proportion of the amount of that habitat type known to occur in the Study Area.
[5]Due to small rounding margins, individuals habitat areas may not sum exactly to total habitat areas

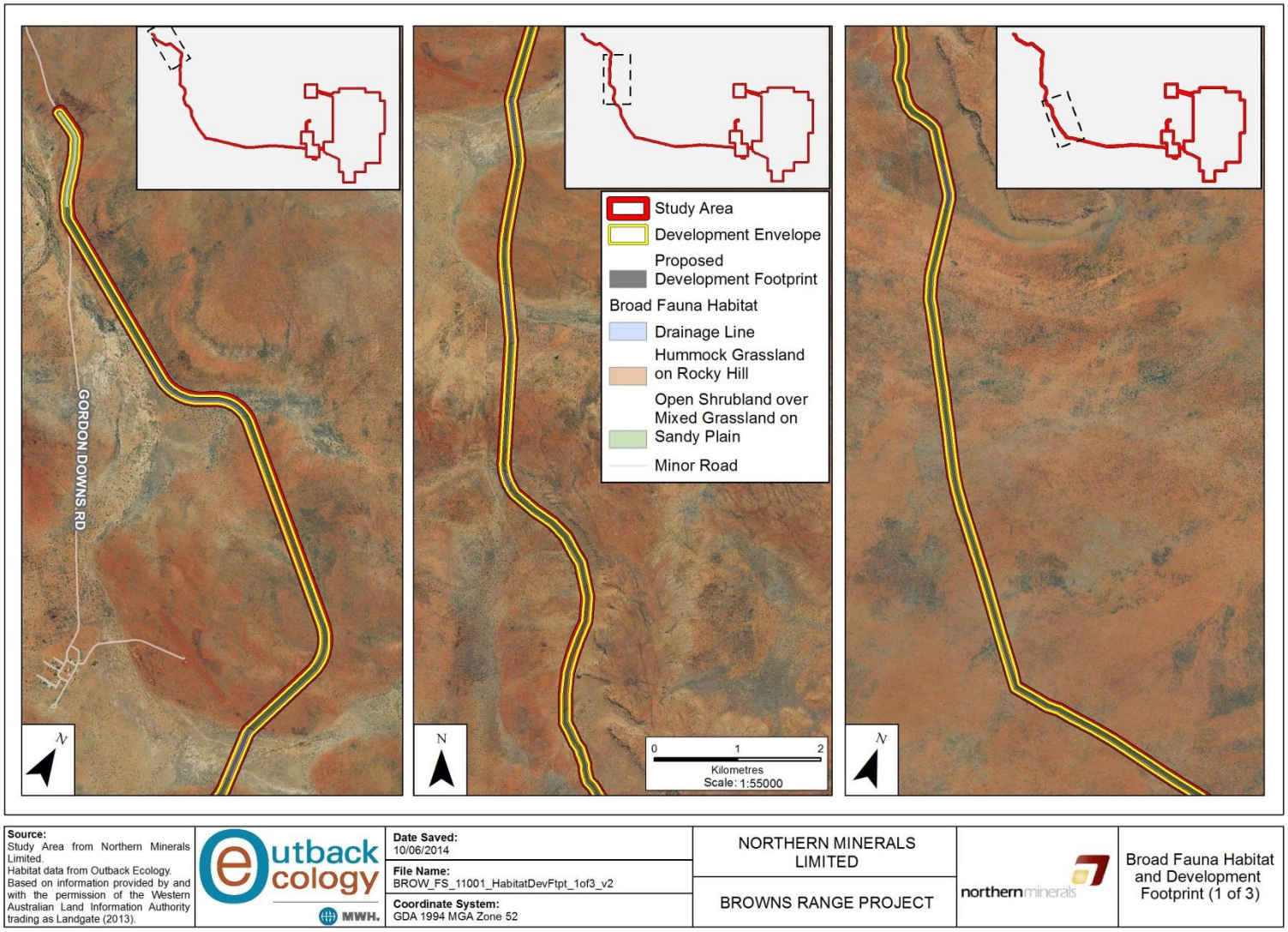

Figure 9: Fauna habitats in the Development Envelope and Proposed Development Footprint (1 of 3)

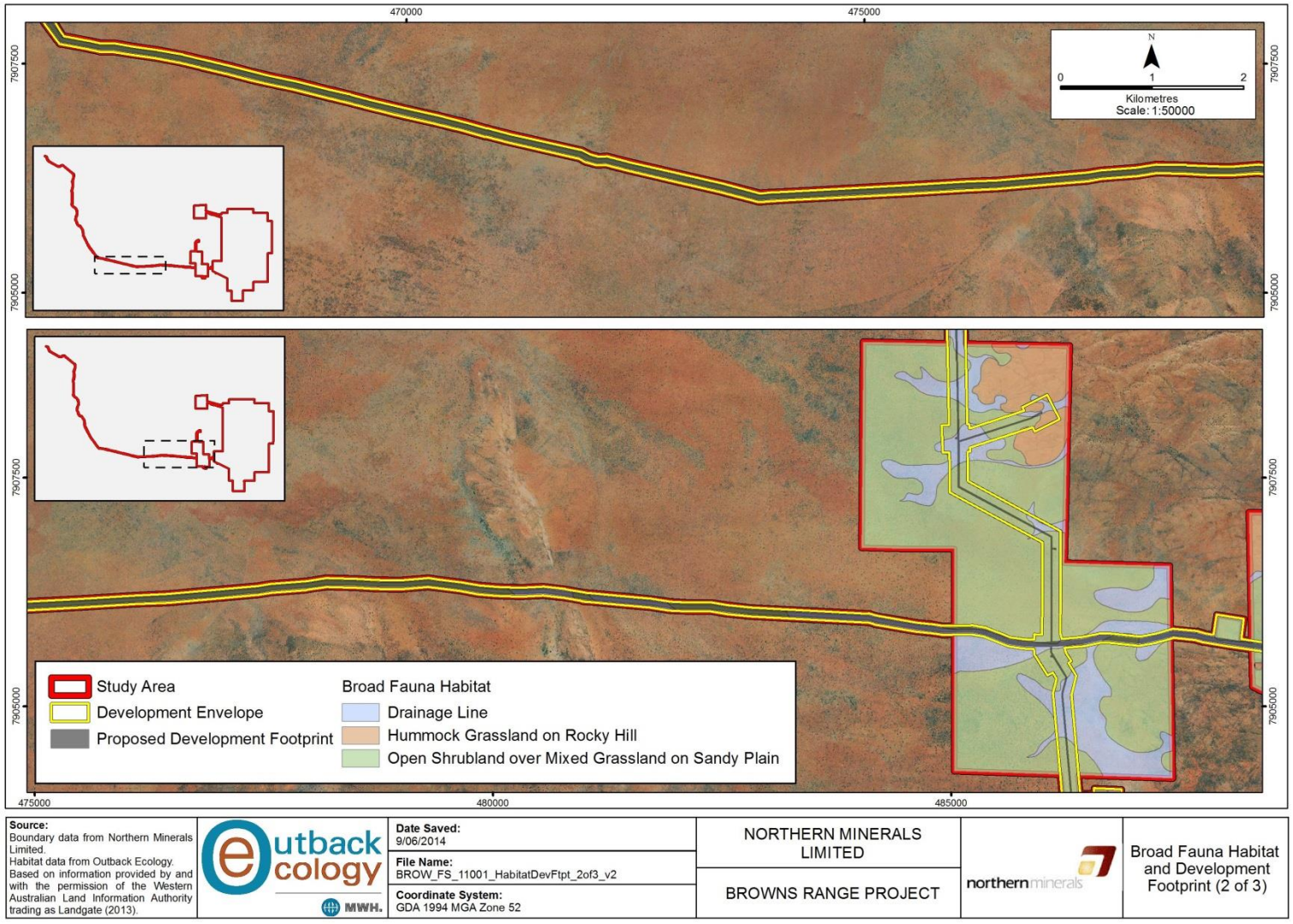

Figure 10: Fauna habitats in the Development Envelope and Proposed Development Footprint (2 of 3)

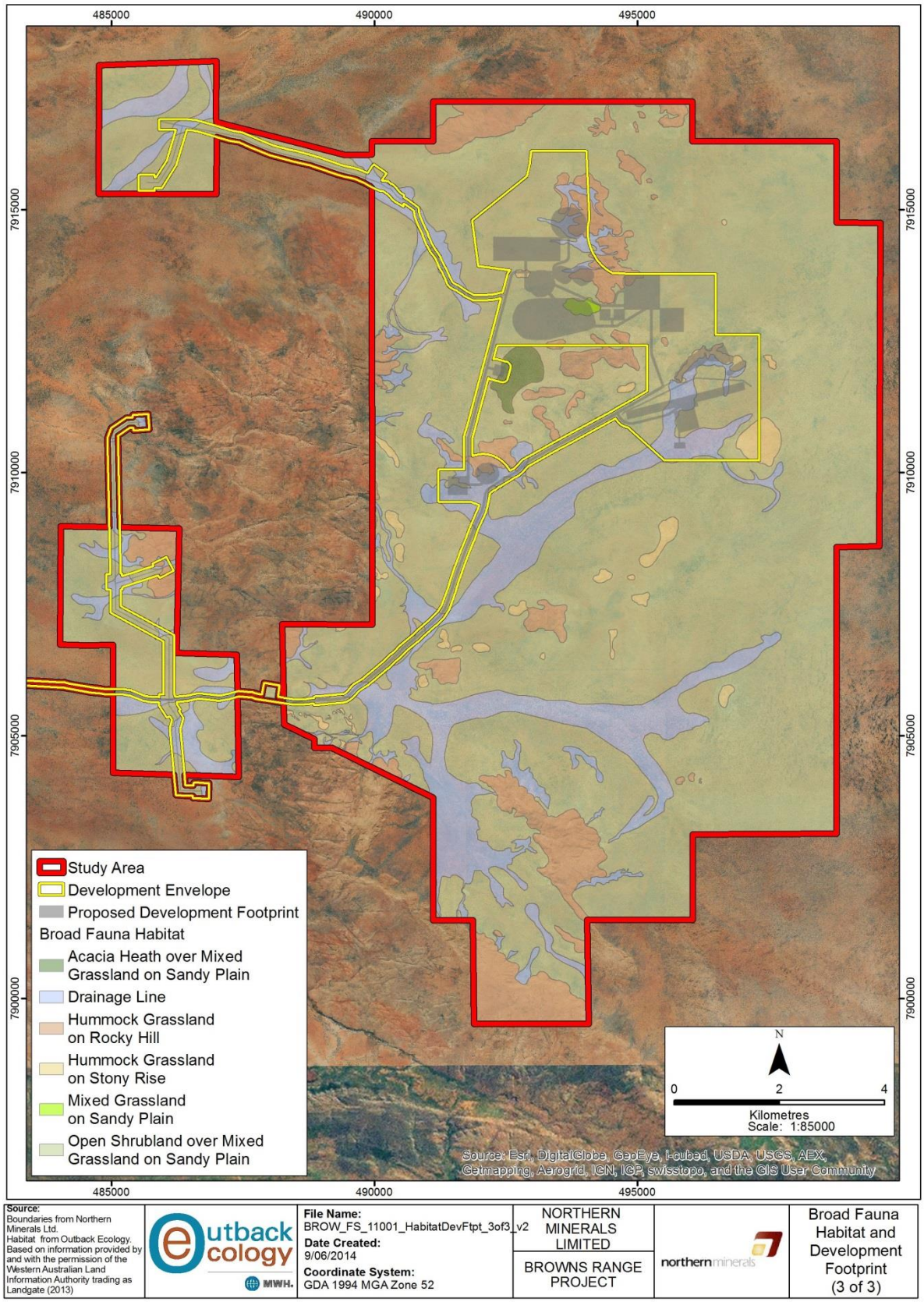

Figure 11: Fauna habitats in the Development Envelope and Proposed Development Footprint (3 of 3)

3.1.2. Collision With Vehicles

Once constructed, the Project would involve vehicle movements on a continuous basis on roads within the Proposed Development Footprint. Consequently, vehicle collisions may have an impact on some fauna. Collisions typically only involve individual animals and are considerably more likely to occur at night (Rowden *et al.* 2008).

The roads within Proposed Development Footprint traverse five out of the six (ie. all except Mixed Grassland over Sandy Plain habitat) fauna habitat types in the Study Area. Ground-dwelling species of conservation significance that have been recorded from these habitats in the Study Area include the Greater Bilby (*Macrotis lagotis*), Spectacled Hare-wallaby (mainland subspecies) (*Lagorchestes conspicillatus leichardti*), Lakeland Downs Mouse (*Leggadina lakedownensis*), Bush Stone-curlew (*Burhinus grallarius*) and Australian Bustard (*Ardeotis australis*). Individuals of these species may be at risk when in the vicinity of roads.

3.1.3. Inappropriate Fire Regimes

The development and ongoing operation of the Project may alter the fire regime of the Study Area through the introduction of unplanned fire resulting from vehicle movements and/or other Project activities (e.g. hot work). Fire may impact fauna via direct contact, or indirectly by long-term habitat modification brought about by inappropriate fire frequency and intensity. The value of many habitats to fauna lies in the mosaic of ages since fire that exist in those habitats as a result of traditional land management practices and/or natural fire regimes (Parr and Andersen 2006, Southgate *et al.* 2007, Woinarski 1999). Introduction of too frequent, hot or extensive fires during hot dry times of the year can eliminate this mosaic, and reduce the capacity of these habitats to support diverse vertebrate and invertebrate fauna.

Consistent with the nature of the Coolindie and Winnecke land systems within which the Study Area occurs, fire is a common event within the Study Area and surrounding landscape (Burrows *et al.* 2006, Turner *et al.* 2008). Signs of fire (e.g. recovering vegetation) were observed during the baseline survey and there have been fire events within the Study Area since. Appropriate management of fire in the Study Area can reduce the frequency of hot extensive fires which have a greater impact upon fauna and fauna habitat than low-intensity introduced fires. Indeed, small, low intensity fires occurring early in the dry season may even have positive impacts on vertebrate fauna habitats in the Study Area.

Inappropriate fire regimes (i.e. large, hot fires late in the dry season) are likely to have adverse effects on fauna habitat that could alter fauna assemblages present in the Study Area. For example, fire regime is known to be of fundamental importance in driving habitat suitability for the Greater Bilby (Van Dyck and Strahan 2008). Species most at risk of direct contact impacts by fire include, but are not limited to, small, sedentary species such as the Great Desert Skink, Woma and Lakeland Downs Mouse. The impact of inappropriate fire regimes may be reduced through the implementation of an appropriate fire management plan.

3.1.4. Altered Hydrology

Availability of water and nutrients is the primary limiting factor in arid and semi-arid environments (James *et al.* 1995). The degree to which ecosystems depend on groundwater (Hatton and Evans 1998), and on retention of water after substantial rainfall, varies with the particular structure and function of ecosystems, which in turn are likely to vary over time. For example, floodplains, flood-outs and riparian fringes are the most productive habitats in the landscape because soils are fertile and water supply is relatively continuous as a result of reliable run-on and accessible ground water.

Rainfall in the Tanami bioregion can be highly localized and unpredictable, with substantial fluctuations occurring spatially and temporally (BOM 2014). Consequently, the vast majority of ecosystems present do not feature accessible water for any length of time. However, small occurrences of productive, water-dependent ecosystems are distributed within the region and these provide critical refuge and habitat for organisms in times of drought (James *et al.* 1995). Water-dependent ecosystems are those that are totally, partially or seasonally dependent on groundwater (Nevill *et al.* 2010), or on the retention of accessible surface water following substantial rainfall; that is, they require the input of water to maintain their current composition and functioning (Murray *et al.* 2003). These ecosystems are typically limited in their extent, but they represent a key resource to a diversity of fauna (Murray *et al.* 2003).

Water-dependent ecosystems in the Study Area comprise vegetation that is dependent upon surface water and vegetation that may be dependent upon groundwater. Surface water dependent vegetation within the Study Area, is likely to occur within the Drainage Line habitat type and, to a lesser extent, Hummock Grassland on Rocky Hill habitat where small, internal drainage features may result in the temporary formation of surface water pools (see **Figure 6**). Groundwater dependent vegetation within the Study Area may occur within Drainage Line habitat and include deep rooted species such as *Eucalyptus victrix*.

The Drainage Line and Hummock Grassland on Rocky Hill habitat types encompass 2,221 ha and 1,219 ha within the Study Area, respectively. Both of these habitat types occur in the Development Envelope and Proposed Development Footprint, and have potential to be impacted by altered hydrology. Removal of water from these habitat types, or a change in the timing, quantity, quality or distribution of water available to them (see Kingsford *et al.* 2004), may impact negatively upon Drainage Line and Hummock Grassland on Rocky Hill habitats, thereby affecting the fauna assemblages within.

With the context of this Assessment, the term ‘altered hydrology’ also relates to the creation of artificial water bodies, such as residual, water-filled mine pits, which may attract migratory water birds that would not otherwise inhabit the Study Area (Braithwaite and Stewart 1975, Hamilton *et al.* 2005). Thirteen species of water bird listed as Migratory under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) and listed under Schedule 3 of the *Wildlife Conservation Act 1950* (WA) (WC Act) were identified as potentially occurring in the Study Area (Outback Ecology 2012). Of these 13 species, the Oriental Plover (*Charadrius veredus*) has

been observed in the Study Area and the Australian Painted Snipe (*Rostratula australis*) is considered to possibly occur but has not been observed in the Study Area (Outback Ecology 2012, 2014). The closest recorded location of the Australian Painted Snipe is approximately 150 km southwest of the Development Envelope (DPaW 2013), while the Oriental Plover has also been recorded approximately 85 km south of the Development Envelopment (Biota 2005). The remaining 11 species of water bird are considered unlikely to occur and have also not been observed in the Study Area.

Although migratory birds may fly over the Study Area from time to time, any pit lakes will be poor habitat for waterbirds, due to a lack of supporting habitat (e.g. riparian vegetation) and food. Consequently, water birds are unlikely to use pit lakes for a substantial period of time and the likelihood of any negative impacts to these species as a result of the pits is considered to be minor. Despite concentrations of some metals potentially exceeding the ANZECC livestock drinking water threshold values (KCB in prep), it is considered unlikely that a significant proportion of any population of water birds would be impacted by poor water quality.

3.1.5. Noise and Vibration

The development and ongoing operation of the Project is likely to generate noise and vibration due to blasting, general operation of heavy machinery and vehicles, diesel generators and the presence of personnel. The effects of noise on wildlife have been well studied, although responses vary depending on the species and on the age and sex of the individual animal (for comprehensive summaries, see Larkin *et al.* 1996, Radle 2007). General responses to noise, across a wide variety of animal species, range from interruptions in feeding and resting behaviour to complete abandonment of a habitat area. Noise may lead to reduced population densities in small mammals, nest failure and decreased population densities in birds (Slabbekoorn and Ripmeester 2008), and abandoning of roost sites and a reduced hunting efficiency in bats due to disturbance of their echolocation system.

Constant levels of noise also interfere with species communication, via acoustic interference (Parris and Schneider 2009). Species that may be especially at risk of disturbed communication are those that use calls to communicate over larger distances, such as the Bush Stone-curlew, tracks of which were observed in two habitat types within the Development Envelope: Open Shrubland over Mixed Grassland on Sandy Plan habitat and Hummock Grassland on Rocky Hill habitat (Outback Ecology 2012). These aspects of the Project are likely to be highly localised, and may impact on fauna at a local scale but at a regional scale, the impact is likely to be negligible to non-existent.

3.1.6. Artificial Light Exposure

Exposure of fauna to artificial light may interfere with biological and behavioural activities that are governed by the length of day or photoperiod, including reproduction, dormancy, foraging and migration (Bradshaw and Holzapfel 2007, Le Corre *et al.* 2002, Stone *et al.* 2009). Some examples include reduced foraging activity in nocturnal mice following exposure to artificial light (Bird *et al.* 2004), suspension of normal feeding and reproductive behaviour in nocturnal frogs exposed to artificial light (Harder 2002) .

Light pollution has also been shown to interfere with timing of songbird choruses, potentially leading to reduction in breeding success or survival (Miller 2006). See Longcore and Rich (2004) for a broad review of some of the ecological consequences of light pollution. This artificial light may have detrimental effects on resident bird, mammal and reptile species, and it is likely to have an adverse effect on the natural foraging behaviour of bats. This aspect of the Project is likely to result in highly localised impacts to fauna, however, these impacts will range from negligible to nonexistent effects on fauna at a regional scale.

3.1.7. Dust Emissions

The development and operation of the Project will create dust emissions due to construction, blasting, haulage and general traffic activities. Dust emissions may affect surrounding vegetation. High levels of dust have been associated with a reduction in plant growth and productivity, resulting in degradation of the overall ecosystem and an increased risk of disease in plants (Farmer 1993). Dust has also been linked to changes in soil chemistry and the structure of vegetation communities (Farmer 1993). Changes in vegetation as a result of dust may reduce the suitability of some habitats for fauna within close proximity to the Project; however, effects on fauna and fauna habitat are expected to be negligible to non-existent on a regional scale.

3.1.8. Introduced Flora

Environmental weeds may be brought in by mobile equipment during construction and operation of the Project. Weed invasion is widely recognised as having a negative impact on fauna species, as it can fundamentally alter the composition and structure of native vegetation communities (Cowie and Werner 1993, Gordon 1998). In the extreme, entire ecosystems can be modified (Sodhi and Ehrlich 2010). Invasion by non-native species typically results in declines in native plant species richness, but the response of fauna may be more complicated with individual invasions potentially resulting in increase, decrease or no-change scenarios for different assemblages (Grice 2006). For example, even at low densities, Buffel Grass (*Cenchrus ciliaris*) can affect the composition of ground vegetation, birds and ant fauna, leading to declines in some species (Binks *et al.* 2005, Smyth *et al.* 2009). There is potential for substantial change to occur to vegetation communities in the Study Area, should invasive flora be introduced and become established.

Several weed species were recorded in low numbers and frequency within the Study Area: *Malvastrum americanum* (Spiked Malvastrum), *Panicum antidotale* (Giant Panic Grass), *Echinochloa colona* (Awnless Barnyard Grass) and *Portulaca oleracea* (Purslane) (Outback Ecology, in prep). These species are unlikely to diminish the biological diversity of the Study Area as the majority are generally found in low numbers and are spread by fauna and water vectors. However along the access road, two additional species *Cenchrus setiger* (Birdwood Grass) and *Stylosanthes hamata* (Verano Stylo) were recorded in patches, mostly alongside the road verge and sometimes in very large populations.

Introduced flora is an aspect of the Project that has potential to have localised impacts upon fauna and fauna habitat, however, the effects on fauna and fauna habitat are likely to be negligible to non-

existent at a regional scale. Management practices which will minimise the risk of spread of *Cenchrus setiger* and *Stylosanthes hamata* should include ensuring that any machinery (particularly for earthworks) entering the Study Area should be subject to quarantine/hygiene measures that ensure that no contaminated soils or weed seeds enter the area. Typically this would involve using a wash down bay or station, and educating the workforce with environmental inductions. Within the Study Area, machinery used in earthworks in areas with known populations of the less aggressive weeds should also be cleaned prior to entering uncontaminated areas and where practical larger populations of these species should be controlled.

3.1.9. Introduced Fauna

Introduced fauna, both herbivorous and predatory, cause fundamental changes to ecosystems and are thought to have contributed to the decline and extinction of many species in Australia (Abbott 2002, Burbidge and McKenzie 1989, Dickman 1996, Ford *et al.* 2001, Short and Smith 1994). Of the 19 key threatening processes listed under the EPBC Act, 11 are concerned with introduced flora and fauna. Predation of native fauna by the Fox (*Vulpes vulpes*) and the Feral Cat (*Felis catus*) are key threatening processes of high prominence. Predation by Feral Cats predominantly affects mammals and birds, and has little or negligible impact on reptiles, amphibians and fishes (Dickman 1996). Recent research suggests that the presence of the naturalized Dingo (*Canis lupis dingo*), as a top-order predator, may act to reduce the impact of mesopredators, such as the Fox, on smaller native fauna (Letnic *et al.* 2009, Letnic and Dworjanyn 2011). Introduced herbivores have been responsible for widespread degradation of much of semi-arid Australia due to overgrazing (Morton 1990, Newsome 1971).

Five species of introduced fauna were recorded in the area surveyed during the baseline survey: European Cattle (*Bos taurus*), Dromedary Camel (*Camelus dromedarius*), Dingo/Dog (*Canis lupis*), Feral Cat and House Mouse (*Mus musculus*). The Project may provide additional resources or habitat which attract and support a greater abundance of these species in the Study Area. Introduced predators like the Feral Cat and Dingo/Dog may also be attracted into the Study Area as a result of the scavenging opportunities generated by the presence of road kill along the access road. Introduced animals may also be attracted to the area or increase in population due to the introduction of artificial water sources into the landscape. This may in turn adversely affect populations of native fauna. Of particular concern would be an increase in the size of the local population of Feral Cat, which is not only a direct predator of the Lakeland Downs Mouse, Brush-tailed Mulgara, Bush Stone-curlew, Australian Bustard and other ground-dwelling fauna, but also compete for food resources and habitat requirements with these and other species. This aspect of the Project is likely to result in localised impacts to fauna, although at a regional scale these impacts will range from negligible to non-existent, depending on the efficacy of measures implemented by the Project to limit the introduction or spread of introduced fauna.

3.2. Impacts on Fauna Habitats

Fauna habitat loss as a direct result of land clearing and excavation is considered to be the primary impact of the Project on terrestrial vertebrate fauna. Land clearance is listed as a key threatening process under the EPBC Act, although it is also recognised as a necessary component of developing a resources project in an undeveloped/greenfield area. It is likely that sedentary fauna (e.g. small mammals, small herpetofauna and ground-dwelling birds) residing within areas to be cleared would be lost and more mobile fauna (e.g. birds, bats, large mammals and large reptiles) would be displaced.

A total of 711 ha of fauna habitat within the Development Envelope will be removed for the Project, potentially affecting instances of all of the fauna habitats present in the Study Area (**Table 3**). However, from a regional perspective, all fauna habitat types present in the Study Area are considered to be of limited significance, as they are typical components of the Coolinde and Winnecke land systems and are relatively extensive and well represented outside the Study Area. Although *Acacia* Heath over Mixed Grassland on Sandy Plain and Mixed Grassland on Sandy Plain habitat types have the least extensive coverage in the Study Area, any loss of these habitat types is likely to have a low impact on vertebrate fauna present as those species utilising these habitat types will very likely also utilise Open Shrubland over Mixed Grassland on Sandy Plain habitat, which is abundant within and surrounding the Study Area.

Although no fauna habitats are expected to be substantially impacted by the Project from a regional perspective, the Project could impact on three fauna habitat types at a local level:

- Drainage Line (**Section 3.2.1**);
- Hummock Grassland on Rocky Hill (**Section 3.2.2**); and
- Hummock Grassland on Stony Rise (**Section 3.2.3**).

The Mixed Grassland on Sandy Plain habitat type could be impacted at a local scale, as 83% of the habitat type in the Study Area occurs within the Proposed Development Footprint. However, this habitat type is considered to be of limited significance as it does not provide unique microhabitats for vertebrate fauna – microhabitats present can also be found within the more extensive Open Shrubland over Mixed Grassland on Sandy Plain habitat type.

The other fauna habitat types that occur within the Study Area are unlikely to be impacted by the Project at a regional or at a local level:

- Open Shrubland over Mixed Grassland on Sandy Plain; and
- Acacia Heath over Mixed Grassland on Sandy Plain.

3.2.1. Drainage Line

Drainage Line habitat consists of minor watercourses, creeks and channels that support grassy *Eucalyptus* woodlands subject to regular flooding and seasonal ponding. This is a significant habitat for fauna as it provides a range of microhabitats, such as water pools, moist depressions, sedges and rushes on alluvial soil. The Drainage Line habitat type is scattered throughout the Study Area (**Figure**

6), and its linear arrangement provides linkages between other, more permanent sources of food and water. This habitat type is important for allowing fauna to move about the Study Area and the broader surrounding landscape. During the baseline survey, the Lakeland Downs Mouse, Australian Bustard and Rainbow Bee-eater were recorded in Drainage Line habitat (Outback Ecology 2012). Other fauna of conservation significance not recorded in this habitat type during field surveys but nonetheless likely to occur include the Greater Bilby, Spectacled Hare-wallaby and Bush Stone-curlew.

The Development Envelope encompasses 457 ha of Drainage Line habitat, which represents 20.6% of the total amount of this habitat present in the Study Area (**Table 3**). The Proposed Development Footprint encompasses 111 ha of this habitat type, which represents 5% of the total amount of this habitat present in the Study Area. Drainage Line habitat is widespread in the broader landscape and those portions within the Development Envelope are contiguous with surrounding occurrences of Drainage Line habitat. Fauna occurring within this habitat type are therefore unlikely to be impacted by the Project from a regional perspective. Nonetheless, by dissecting sections of the habitat type, the Project may limit the ability of fauna to disperse across the Study Area and wider region.

3.2.2. Hummock Grassland on Rocky Hill

Hummock Grassland on Rocky Hill habitat consists of rocky hills and slopes supporting *Triodia* sp. under sparsely distributed *Acacia* and *Eucalyptus* trees. This habitat type provides microhabitats that are unavailable in other habitats present in the Study Area, such as expanses of stony surfaces, rocky-grassy mosaics and small crevices. Shallow gullies in this habitat type can support small, internal drainage features that result in the temporary formation of surface water pools. All of these features are considered important for fauna and may support a number of species of conservation significance including the Lakeland Downs Mouse and the Bush Stone-curlew. Both of these species were observed within this habitat type during the baseline survey.

The Development Envelope encompasses a total of 158 ha of Hummock Grassland on Rocky Hill habitat, which represents 12.9% of the total amount present in the Study Area (**Table 3**). The Proposed Development Footprint encompasses 45.9 ha of this habitat type, which represents 3.8% of the total amount present in the Study Area. While Hummock Grassland on Rocky Hill habitat is widespread in the broader landscape and broadly corresponds with the Winnecke Land System, this habitat type usually occurs in disconnected patches. Development of the Project may therefore result in removal of discrete instances of this habitat type in their entirety, rather than the fragmentation which will occur with the instances of more widespread habitat types; the impact of this on a regional scale, however, is unlikely to be significant.

3.2.3. Hummock Grassland on Stony Rise

Hummock Grassland on Stony Rise habitat consists of low stony hills supporting *Triodia* sp. under very sparsely distributed *Eucalyptus* trees. The Development Envelope encompasses a total of 52 ha of Hummock Grassland on Stony Rise habitat, which represents 24.7% of the total amount present in the Study Area (**Table 3**). The Proposed Development Footprint encompasses 22.7 ha of this habitat

type, which represents 10.8% of the total amount present in the Study Area. Hummock Grassland on Stony Rise habitat provides microhabitats that can also be found on the lower slopes of Hummock Grassland on Rocky Hill habitat, including stony inclines with some outcropping. As described above for Hummock Grassland on Rocky Hill habitat (**Section 3.2.2**), these microhabitats occur in small isolated patches. Development of the Project may therefore result in removal of discrete instances of this habitat type in their entirety, rather than the fragmentation which will occur with the instances of more widespread habitat types; the impact of this on a regional scale, however, is unlikely to be significant.

3.3. Impacts on Terrestrial Vertebrate Fauna Assemblages

A total of 309 species of native terrestrial vertebrate fauna – 33 mammals, 185 birds, 78 reptiles and 13 amphibians – was identified as potentially occurring in the Study Area during the desktop study component of the baseline fauna survey (Outback Ecology 2012). The field survey component of the baseline survey recorded a total of 122 species, including 12 species that were not identified by the desktop study (Outback Ecology 2012). The targeted vertebrate fauna survey (Outback Ecology in prep-b) confirmed the occurrence of Greater Bilby (*Macrotis lagotis*), Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*), and Oriental Plover (*Charadrius veredus*), all of which were suggested as potentially occurring by the desktop study.

The total number of species of native terrestrial vertebrate fauna known to occur or potentially occurring in the Study Area is 321. The majority of these species form assemblages that occur across a variety of the habitats present within and surrounding the Study Area. These assemblages are similar to those found in the surrounding landscape, as identified by previous surveys (Outback Ecology 2012).

In terms of vertebrate fauna assemblages, the Study Area was not determined to be an area of exceptionally high biodiversity from a regional point of view. Clearing vegetation is likely to result in the direct loss of individuals during initial clearing activities; however, at an assemblage-level, those assemblages occurring across a range of habitats or those occurring in widespread habitats are unlikely to be significantly impacted by the Project. From a regional perspective, the impacts of the Project on fauna assemblages in general are unlikely to be substantial. Impacts to fauna assemblages may be reduced by considering the timing and location of land clearing activities and other proposed works.

3.4. Impacts on Fauna of Conservation Significance

The desktop study component of the baseline survey identified 32 species of conservation significance – i.e. species listed as Threatened and/or Migratory under the EPBC Act, listed as Threatened, Specially Protected and/or Migratory under the WC Act, and/or listed by DPaW as Priority fauna – as potentially occurring in the Study Area (Outback Ecology 2012). During the baseline survey, one species of conservation significance was recorded that was not identified by the desktop study as potentially occurring in the Study Area: the Bush Stone-curlew. Therefore, the total number of species of conservation significance known to occur or potentially occurring in the Study

Area is 33. Of these 33 species, 17 are unlikely to occur in the Study Area and are not discussed further in this Assessment (see Outback Ecology 2012 for these species and their assessment of likelihood of occurrence). The other 16 species, which possibly occur or are likely, very likely or known to occur within the Study Area, are:

- Australian Painted Snipe – Endangered and Migratory (EPBC Act), Schedule 1 (as *Rostratula benghalensis australis*) and Schedule 3 (WC Act);
- Greater Bilby – Vulnerable (EPBC Act) and Schedule 1 (WC Act);
- Great Desert Skink – Vulnerable (EPBC Act) and Schedule 1 (WC Act);
- Grey Falcon (*Falco hypoleucos*) – Schedule 1 (WC Act);
- Peregrine Falcon (*Falco peregrinus*) – Schedule 4 (WC Act);
- Major Mitchell's Cockatoo (*Lophochroa leadbeateri*) – Schedule 4 (WC Act);
- Woma – Schedule 4 (WC Act);
- Spectacled Hare-wallaby (mainland subspecies) – Priority 3 (DPaW Priority Fauna list);
- Brush-tailed Mulgara – Priority 4 (DPaW Priority Fauna list);
- Lakeland Downs Mouse – Priority 4 (DPaW Priority Fauna list);
- Bush Stone-curlew – Priority 4 (DPaW Priority Fauna list);
- Australian Bustard – Priority 4 (DPaW Priority Fauna list);
- Pictorella Mannikin (*Heteromunia pectoralis*) – Priority 4 (DPaW Priority Fauna list);
- Flock Bronzewing (*Phaps histrionica*) – Priority 4 (DPaW Priority Fauna list);
- Rainbow Bee-eater (*Merops ornatus*) – Migratory (EPBC Act) and Schedule 3 (WC Act); and
- Oriental Plover – Migratory (EPBC Act) and Schedule 3 (WC Act).

Since the publication of the baseline survey, the conservation status of some species identified as possibly occurring, or as likely, very likely or known to occur, in the Study Area has changed. The list above, and the remainder of this Assessment, reflects the following changes:

- Australian Painted Snipe – upgraded from Vulnerable to Endangered under the EPBC Act; and
- Grey Falcon – upgraded from Priority 4 under the DPaW Priority Fauna list to Schedule 1 under the WC Act.

Pre-determined categories (**Table 4**) were used to rank the likely impacts of the Project on fauna of conservation significance from a local perspective (**Table 5**). The regional context of any impacts are also described (**Table 5**). For the purpose of this impact assessment, local impacts are considered to be those that occur within the Study Area or within 10 km of the Study Area, and regional context is considered to be context drawn from within 150 km of the Study Area. Impacts were ranked based on the assumption that no management actions or mitigation strategies would be implemented. The species in this section have been assessed in approximate order of conservation significance and potential level of impact (highest to lowest).

Recommended management actions and strategies to manage the impacts of the Project on fauna of conservation significance were also developed (**Table 5**). The level of impact of the Project on these

species is likely to be reduced should the recommended actions and strategies be implemented. More general management recommendations for fauna habitats and native fauna assemblages are provided later in this report (**Section** 4).

Table 4: Ranking criteria for Project impacts on fauna of conservation significance

Local Impact	Description[1]
Negligible	No discernible effect on population
Minimal	No population decline expected
Low	Short-term population decline expected within Development Envelope (recovery expected after life of the Project)
Moderate	Permanent population decline expected – no perceived threat to population persistence
High	Permanent population decline expected – persistence of local population threatened
Extreme	Local population extinction likely

[1]These impacts can be expected within the Development Envelope and surrounding 10 km

Table 5: Project impacts on fauna of conservation significance with suggested actions

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Greater Bilby	*Macrotis lagotis*	VU	S1	Confirmed

Localised impact: LOW

- Open Shrubland over Mixed Grassland on Sandy Plain, *Acacia* Heath over Mixed Grassland on Sandy Plain and Mixed Grassland on Sandy Plain may be used for foraging by the species, but are unlikely to support resident populations due to substrates being unsuitable for burrowing
- These habitat types encompass 1,923 ha within the Development Envelope and 531 ha within the Proposal Development Footprint
- A single scat deposit was recorded in Open Shrubland over Mixed Grassland on Sandy Plains. This deposit was several months old and was the only evidence found of this species during targeted surveys
- Development of the Project will result in some loss of foraging habitat for the Bilby
- There is increased potential for road kill of individuals, particularly during night-time hours
- The species is sensitive to changes in fire regime, and the Project may result in an increase in fire extent and frequency in the local area
- Individuals using the habitats in the Development Envelope for foraging only (as opposed to burrowing or breeding) are likely to be able to readily use adjacent habitat patches in the local area or broader surrounds following development of the Project

Regional context

- Evidence of the species has been recorded on site (single scat deposit)
- Evidence of the species (i.e. burrows, tracks and diggings) has been recorded by multiple surveys within 50 km of the Development Envelope (Biota 2005, Ecotec 2010a, b)
- Suitable habitat within the Development Envelope is small relative to available habitat in the wider region
- Suitable habitat within the Development Envelope is well-connected to similar habitat in the wider region
- Bilbies are capable of covering large distances while foraging and in the process of dispersal
- Following project closure and site rehabilitation, assuming that rehabilitation practice replaces the topsoil profile in a manner conducive to use by burrowing fauna, individuals could move into the Study Area from suitable habitat in the wider surrounds

Suggested management actions

- Educate site personnel and contractors regarding the conservation status of the species
- Implement measures to reduce road kill and/or to encourage the dispersal of animals by means other than roads (e.g. maintain habitat corridors, provide underpasses on roads, etc.)
- Enforce vehicle speed limits in the Development Envelope
- Develop and implement a policy limiting or removing night driving from Project operations
- Monitor and control feral animals, particularly feral predators
- Implement fire management where possible to reduce the scale, frequency and intensity of fires within spinifex habitat
- Report sightings of this species to DPaW

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Australian Painted Snipe	*Rostratula australis*	EN, M	S1, S3	Possible
Localised impact: MINIMAL • The Development Envelope does not contain habitat likely to support the species (i.e. well-vegetated margins of wetlands and other water bodies) • Creation of artificial water bodies in the Development Envelope, such as residual water-filled mine pits, may attract the species to the Study Area	**Regional context** • Suitable habitat for the species is not widespread or common in the wider region – its presence in the region is sporadic and due to irregular, temporary periods of habitat availability following good seasonal conditions • The closest recorded location of the species on the DPaW NatureMap database is approximately 150 km southwest of the Development Envelope. The species has also been recorded historically over 100 km to the south east and south west of the Development Envelope (Barrett *et al.* 2003), but the details of these records are unknown.			**Suggested management actions** • Avoid the creation of permanent artificial water sources where possible, to prevent attracting migratory birds to the Study Area • Where creation of water sources (other than pit lakes post-closure) is unavoidable, minimise surface area of water and locate them away from mining and vehicular activity • Monitor the quality of water within artificial water sources, particularly within residual mine pits
Great Desert Skink	*Liopholis kintorei*	VU	S1	Possible
Localised impact: MINIMAL • Open Shrubland over Mixed Grassland on Sandy Plain, Drainage Line, *Acacia* Heath over Mixed Grassland on Sandy Plain and Mixed Grassland on Sandy Plain habitat types may support this species within the Development Envelope • These habitat types encompass 1,923 ha within the Development Envelope and 531 ha within the Proposal Development Footprint • There will be some localised habitat loss, with direct mortality possible • Due to their limited mobility and burrowing habit, individuals may not be able to relocate in advance of progressive clearing • There is increased potential for road kill of individuals, particularly during twilight and night-time hours	**Regional context** • The closest recorded historical location of the species on the DPaW NatureMap database is approximately 150 km southwest of the Development Envelope • The species is characterised by a patchy, localised distribution. Currently, the species is known from only seven main populations, the closest of which is approximately 185 km south-east of the Study Area, in the vicinity of Rabbit Flat in the Tanami Desert. • Suitable habitat within the Development Envelope is small relative to available habitat in the wider region • Suitable habitat within the Development Envelope is well-connected to similar habitat in the wider region			**Suggested management actions** • Educate site personnel and contractors regarding the conservation status of the species • Implement measures to reduce road kill • Enforce vehicle speed limits in the Development Envelope • Implement fire management where possible i.e. reduce the scale, frequency and intensity of fires within spinifex habitat • Monitor and control feral animals, particularly feral predators • Report sightings of this species to DPAW

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Brush-tailed Mulgara	*Dasycercus blythi*	-	P4	Possible

Localised impact: MINIMAL

- Open Shrubland over Mixed Grassland on Sandy Plain, Drainage Line, *Acacia* Heath over Mixed Grassland on Sandy Plain and Mixed Grassland on Sandy Plain habitat types may be used for foraging by the species, but are unlikely to support resident populations due to substrates being unsuitable for burrowing
- These habitat types encompass 1,923 ha within the Development Envelope and 531 ha within the Proposed Development Footprint
- A targeted survey was found no evidence of Brush-tailed Mulgara in the Study Area
- There will be localised habitat loss, with direct mortality possible
- Due to their limited mobility, any individuals present may not be able to relocate in advance of progressive clearing
- There is increased potential for road kill of individuals, particularly during night-time hours
- Individuals using the habitats in the Development Envelope for foraging only (as opposed to burrowing or breeding) are likely to be able to readily use adjacent habitat patches in the local area or broader surrounds following development of the Project

Regional context

- The Study Area is on the edge of the distribution of this species
- One animal captured and identified as Crest-tailed Mulgara (Biota 2005) is likely a Brush-tailed Mulgara (refer to pages 46-47 in Outback Ecology 2012 for reasoning). This animal was captured approximately 100 km south of the Development Envelope, where further evidence of the species (e.g. burrows, diggings, tracks and scats) was also observed
- Despite intensive searches, no evidence of this species was found on site
- Suitable habitat within the Development Envelope is small relative to available habitat in the wider region
- Suitable habitat within the Development Envelope is well-connected to similar habitat in the wider region
- Following project closure and site rehabilitation, assuming that rehabilitation practice replaces the topsoil profile in a manner conducive to use by burrowing fauna, it is likely that individuals would recolonise the Study Area from suitable habitat in the wider surrounds

Suggested management actions

- Educate site personnel and contractors regarding the conservation status of the species
- Implement measures to reduce road kill
- Enforce vehicle speed limits in the Development Envelope
- Implement fire management where possible i.e. alter timing of fires and reduce the scale, frequency and intensity of fires within spinifex habitat
- Monitor and control feral animals, particularly feral predators
- Report sightings of this species to DPAW

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Lakeland Downs Mouse	*Leggadina lakedownensis*	-	P4	Confirmed

Localised impact: MINIMAL

- The species was recorded in the Development Envelope within Hummock Grassland on Rocky Hill habitat (one record), and elsewhere in the Study Area within Drainage Line habitat (two records) (Outback Ecology 2012). All other habitat types present in the Development Envelope are likely to also support this species; however, the species is most likely to be found in Open Shrubland over Mixed Shrubland on Sandy Plain and Drainage Line habitat due to a preference for habitat on seasonally inundated sandy-clay soils
- There will be localised habitat loss, with direct mortality possible
- Alterations of hydrology in the Development Envelope may have implications for the extent and quality of seasonally inundated habitat, which is preferred by the species
- Due to their small size, individuals may not be able to relocate in advance of progressive clearing

Regional context

- Suitable habitat within the Development Envelope is small relative to available habitat in the wider region
- Suitable habitat within the Development Envelope is well-connected to similar habitat in the wider region
- While some individuals would be lost from the direct impacts of land clearing, this is unlikely to have a perceivable effect on the local population given the marginal nature of the habitats present
- The well-connected nature and the extent of suitable habitat outside of the Study Area suggest that adequate corridors exist for recolonisation of the Study Area following rehabilitation

Suggested management actions

- Implement fire management where possible to reduce the scale, frequency and intensity of fires within grassland habitat
- Monitor and control feral animals, particularly feral predators
- Avoid fragmentation of Drainage Line habitat in the Development Envelope

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Spectacled Hare-wallaby (mainland subspecies)	*Lagorchestes conspicillatus leichardti*	-	P3	Confirmed

Localised impact: LOW

- Open Shrubland over Mixed Grassland on Sandy Plain, Drainage Line, Acacia Heath over Mixed Grassland on Sandy Plain and Mixed Grassland on Sandy Plain habitat types may be used for foraging by the species, but are unlikely to support resident populations due to a lack of daytime refugia in the form of large, mature spinifex hummocks
- These habitat types encompass 1,923 ha within the Development Envelope and 531 ha within the Proposed Development Footprint
- Scats were recorded in Open Shrubland over Mixed Grassland on Sandy Plains, one set fresh and the other quite old. Given the intensity of searches and small amount of evidence found it is likely these records represent foraging animals moving through the site
- There will be localised habitat loss
- This species has dispersal capability sufficient to remove itself from the Development Envelope when necessary
- There is increased potential for road kill of individuals, particularly during night-time hours, but also during the day

Regional context

- Evidence of the species has been recorded on site (scats)
- The species is known to occur within 50 km of the Development Envelope, with individuals being sighted and other evidence (e.g. scats and tracks) observed (Biota 2005, Ecotec 2008a, b, 2010a, b)
- Suitable habitat within the Development Envelope is small relative to available habitat in the wider region
- Suitable habitat within the Development Envelope is well-connected to similar habitat in the wider region

Suggested management actions

- Educate site personnel and contractors regarding the conservation status of the species
- Monitor and control feral animals, particularly feral predators
- Implement measures to reduce road kill
- Implement fire management where possible to reduce the scale, frequency and intensity of fires within spinifex habitat
- Enforce vehicle speed limits in the Development Envelope
- Report sightings of this species to DPAW

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Bush Stone-curlew	*Burhinus grallarius*	-	P4	Confirmed

Localised impact: LOW

- Tracks of the species were recorded in the Development Envelope within Open Shrubland over Mixed Grassland on Sandy Plain and within an area of the Hummock Grassland on Rocky Hill habitat that transitions into sandy plain habitat (Outback Ecology 2012). Drainage Line habitat in the Development Envelope is also likely to support this species
- These habitat types encompass 2,515 ha within the Development Envelope and 674 ha within the Proposed Development Footprint
- There will be localised habitat loss
- This species has dispersal capability sufficient to remove itself from the Development Envelope when necessary
- There is increased potential for road kill of individuals, particularly during night-time hours
- There is potential for localised disturbance near operations in the Development Envelope due to noise

Regional context

- Suitable habitat within the Development Envelope is small relative to available habitat in the wider region
- Suitable habitat within the Development Envelope is well-connected to similar habitat in the wider region

Suggested management actions

- Educate site personnel and contractors regarding the conservation status of the species
- Monitor and control feral animals, particularly feral predators
- Implement measures to reduce road kill
- Enforce vehicle speed limits in the Development Envelope
- Develop and implement a policy limiting or removing night driving from Project operations
- Avoid fragmenting Drainage Line habitat in the Development Envelope

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Australian Bustard	*Ardeotis australis*	-	P4	Confirmed

Localised impact: MINIMAL

- The species was recorded in the Development Envelope within Open Shrubland over Mixed Grassland on Sandy Plain and Drainage Line habitat types (Outback Ecology 2012). *Acacia* Heath over Mixed Grassland on Sandy Plain and Mixed Grassland on Sandy Plain habitat types is likely to also support this species
- These habitat types encompass 2,380 ha within the Development Envelope and 642 ha within the Proposed Development Footprint
- There will be localised habitat loss
- There is increased potential for road kill of individuals, particularly during daytime hours, but also during the night
- The species has dispersal capability sufficient to remove itself from the Development Envelope when necessary

Regional context

- Suitable habitat within the Development Envelope is small relative to available habitat in the wider region
- Suitable habitat within the Development Envelope is well-connected to similar habitat in the wider region
- This species is relatively common within the Tanami bioregion

Suggested management actions

- Educate site personnel and contractors regarding the conservation status of the species
- Implement measures to reduce road kill
- Enforce vehicle speed limits in the Development Envelope

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Major Mitchell's Cockatoo	*Lophochroa leadbeateri*	-	S4	Confirmed

Localised impact: MINIMAL

- Recorded in the Development Envelope flying over Open Shrubland over Mixed Grassland on Sandy Plain habitat (Outback Ecology 2012)
- These habitat types encompass 1,900 ha within the Development Envelope and 517 ha within the Proposed Development Footprint
- Suitable nesting sites (i.e. hollow-bearing trees) could be found in all habitats types within the Development Envelope but are likely to be scattered and in low abundance
- There may be loss of a minimal amount of potential nesting habitat
- The species may forage widely over the Development Envelope and wider region and is unlikely to be solely reliant on the foraging habitats provided by the Development Envelope
- The species is highly mobile and adults, during the non-breeding season, would be expected to disperse ahead of clearing

Regional context

- The species is widespread across much of arid and semi-arid Australia, and the Development Envelope comprises only a small portion of its range
- Foraging and nesting habitat is widespread across the wider region surrounding the Development Envelope

Suggested management actions

- Minimise destruction of mature trees with hollows, or potential to bear hollows

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Woma	*Aspidites ramsayi*	-	S4	Possible

Localised impact: MINIMAL

- Open Shrubland over Mixed Grassland on Sandy Plain, Drainage Line, and *Acacia* Heath over Mixed Grassland on Sandy Plain habitat types may support this species within the Development Envelope
- These habitat types encompass 1,907 ha within the Development Envelope and 518 ha within the Proposed Development Footprint
- There will be localised habitat loss, with direct mortality possible
- There is increased potential for road kill of individuals, particularly during night-time hours, but also during the day

Regional context

- The species is thought to be widespread in the Tanami bioregion, whereas it is the south-western (Wheatbelt) population that is thought to be threatened (Storr *et al.* 2002)
- Suitable habitat within the Development Envelope is small relative to available habitat in the wider region
- Suitable habitat within the Development Envelope is well-connected to similar habitat in the wider region

Suggested management actions

- Educate site personnel and contractors regarding the conservation status of the species
- If encountered in areas close to infrastructure, authorised snake handlers should relocate Womas to areas of undisturbed suitable habitat
- Implement measures to reduce road kill
- Enforce vehicle speed limits in the Development Envelope
- Develop and implement a policy limiting or removing night driving from Project operations

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Grey Falcon	*Falco hypoleucos*	-	S1	Possible

Localised impact: NEGLIGIBLE

- Hummock Grassland on Rocky Hill habitat in the Development Envelope may contain suitable nest sites, such as trees in elevated locations
- Drainage Line habitat may also be used by this species (Garnett and Crowley 2000), and nesting may occur here if suitable trees are present
- 158 and 457 ha of Hummock Grassland on Rocky Hill habitat and Drainage Line habitat occurs within the Development Envelope, respectively
- Loss of a minimal amount of potential nesting habitat may occur, but the species is sparsely distributed and there is only an outside chance of its occurrence in the Development Envelope
- The species may forage widely over the Development Envelope and wider region and is unlikely to be solely reliant on the foraging habitats provided by the Development Envelope
- The species is highly mobile and adults, during the non-breeding season, would be expected to disperse ahead of clearing

Regional context

- Foraging and nesting habitat is widespread across the wider region surrounding the Development Envelope
- The species is widespread across much of Australia, and the Development Envelope comprises only a small portion of its range
- There is only an outside chance of the occurrence of the species in the Development Envelope

Suggested management actions

- Minimise destruction of cliff lines within Hummock Grassland on Rocky Hill habitat wherever possible
- Minimise destruction of mature trees with hollows, or potential to bear hollows, whenever possible
- Report sightings of this species to DPAW

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Peregrine Falcon	*Falco peregrinus*	-	S4	Possible

Localised impact: NEGLIGIBLE

- Hummock Grassland on Rocky Hill habitat in the Development Envelope may contain suitable nest sites (optimal nesting locations are cliff faces, but tree hollows may also be used)
- 158 ha and 50 ha of Hummock Grassland on Rocky Hill habitat occurs within the Development Envelope and Proposed Development Footprint, respectively
- Loss of a minimal amount of potential nesting habitat may occur
- The species may forage widely over the Development Envelope and wider region and is unlikely to be solely reliant on the foraging habitats provided by the Development Envelope
- The species is highly mobile and adults, during the non-breeding season, would be expected to disperse ahead of clearing

Regional context

- The species is widespread across much of Australia, and the Development Envelope comprises only a small portion of its range
- Foraging and nesting habitat is widespread across the wider region surrounding the Development Envelope

Suggested management actions

- Minimise destruction of cliff lines within Hummock Grassland on Rocky Hill habitat wherever possible
- Minimise destruction of mature trees with hollows, or potential to bear hollows, whenever possible

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Oriental Plover	*Charadrius veredus*	M	S3	Confirmed

Localised impact: NEGLIGIBLE

- The species is nomadic and tends to move according to conditions
- This migratory bird may utilise water pools and plains within the Development Envelope intermittently, particularly after heavy rains
- Such features are most likely to develop within the Drainage Line habitat type, which encompasses 457 ha of the Development Envelope and 111 ha within the Proposed Development Footprint
- This species would not be expected to utilise habitat within the Development Envelope for a significant period of time
- The species has dispersal capability sufficient to remove itself from the Development Envelope when necessary
- Creation of artificial water bodies in the Development Envelope, such as residual water-filled mine pits, may attract the species to the Study Area

Regional context

- The closest recorded location of the species is approximately 85 km south of the Development Envelope (Biota 2005)
- Potentially suitable habitat within the Development Envelope is small relative to available habitat in the wider region

Suggested management actions

- Implement fire management where possible to reduce the scale, frequency and intensity of fires within tussock grassland, thereby reducing the risk of loss of potential nesting sites

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Pictorella Mannikin	*Heteromunia pectoralis*	-	P4	Possible
Localised impact: MINIMAL • Drainage Line, *Acacia* Heath over Mixed Grassland on Sandy Plain and Mixed Grassland on Sandy Plain habitat types may support his species within the Development Envelope • These habitat types encompass 480 ha within the Development Envelope and 125 ha within the Proposed Development Footprint • The species is likely to make greatest use of these habitat types during the summer wet season when surface water is more likely to be present • There will be localised habitat loss • The species has dispersal capability sufficient to remove itself from the Development Envelope when necessary	**Regional context** • The species has been recorded within 50 km of the Development Envelope (Ecotec 2010a) • Suitable habitat within the Development Envelope is small relative to available habitat in the wider region • Suitable habitat within the Development Envelope is well-connected to similar habitat in the wider region		**Suggested management actions** • Implement fire management where possible to reduce the scale, frequency and intensity of fires within grassland habitat, thereby reducing the risk of loss of potential nesting sites	
Flock Bronzewing	*Phaps histrionica*	-	P4	Possible
Localised impact: NEGLIGIBLE • *Acacia* Heath over Mixed Grassland on Sandy Plain and Mixed Grassland on Sandy Plain habitat types may support his species within the Development Envelope • These habitat types encompass 23 ha within the Development Envelope and 14 ha within the Proposed Development Footprint • There will be localised habitat loss • The species has dispersal capability sufficient to remove itself from the Development Envelope when necessary	**Regional context** • The closest recorded location of the species on the DPaW NatureMap database is approximately 60 km from Development Envelope • Suitable habitat within the Development Envelope is small relative to available habitat in the wider region • Suitable habitat within the Development Envelope is well-connected to similar habitat in the wider region		**Suggested management actions** • Implement fire management where possible to reduce the scale, frequency and intensity of fires within tussock grassland, thereby reducing the risk of loss of potential nesting sites	

Common name	Species name	Conservation status		Likelihood of occurrence in Study Area
		EPBC[1]	In WA[2]	
Rainbow Bee-eater	*Merops ornatus*	M	S3	Confirmed

Localised impact: NEGLIGIBLE

- The species was recorded in the Study Area (but outside the Development Envelope) within Open Shrubland over Mixed Grassland on Sandy Plain and Drainage Line habitat types (Outback Ecology 2012)
- The species is very likely to be common throughout the entire Development Envelope and wider region

Regional context

- The species is common and widespread in the wider region and occupies a wide variety of habitats
- Suitable habitat within the Development Envelope is small relative to available habitat in the wider region
- Suitable habitat within the Development Envelope is well-connected to similar habitat in the wider region

Suggested management actions

- None

[1]Status under the EPBC Act – EN: Endangered; VU: Vulnerable; M: Migratory. [2]Status under the WC Act (S1: Schedule 1; S3: Schedule 3; S4: Schedule 4) or DPAW Priority Fauna List (P3: Priority 3 Fauna; P4: Priority 4 Fauna); see Outback Ecology (2012) for full definitions of conservation status

3.5. Impacts on Matters of National Environmental Significance

This section describes whether actions associated with the proposed Project are likely to have a significant impact on matters of national environmental significance. For the purposes of this section, matters of national environmental significance are defined as fauna that are listed under the EPBC Act and possibly occur or are likely, very likely or known to occur within the Study Area (DoE 2013). Fauna that are listed under the EPBC Act but are unlikely to occur in the Study Area are not considered. It should be noted that no threatened ecological communities or wetalnds of international important (i.e. Ramsar wetlands) occur within the Study Area.

The terminology and rationale used and criteria for determining whether an impact is significant are consistent with those presented in the Commonwealth Significant Impact Guidelines (DoE 2013). The following key definitions are directly relevant to the information presented below (**Table 6**). Additional definitions relevant to this Section are contained within the Guidelines (DoE 2013). Impacts were assessed based on the assumption that no management actions or mitigation strategies would be implemented.

- **What is an important population of a 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:

a. key source populations either for breeding or dispersal,
b. populations that are necessary for maintaining genetic diversity, and/or
c. populations that are near the limit of the species range.

- **What is habitat critical to the survival of a species?**

'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:

a. for activities such as foraging, breeding, roosting, or dispersal,
b. for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators),
c. to maintain genetic diversity and long term evolutionary development, or
d. for the reintroduction of populations or recovery of the species or ecological community.

Such habitat may be, but is not limited to: habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or habitat listed on the Register of Critical Habitat maintained by the minister under the EPBC Act.

- **What is important habitat for a migratory species?**

An area of 'important habitat' for a migratory species is:

a. habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or
b. habitat that is of critical importance to the species at particular life-cycle stages, and/or
c. habitat utilised by a migratory species which is at the limit of the species range, and/or
d. habitat within an area where the species is declining.

Table 6: Significance of impacts to matters of national environmental significance

Common name (Species name)	Status under EPBC Act[1]	Likelihood of occurrence within Study Area	Nature of impact	Rationale for nature of impact
Australian Painted Snipe (*Rostratula australis*)	EN, M	Possible	Not significant	The Australian Painted Snipe has not been recorded in the Development Envelope and, although it is considered possible that the species may occur, it is likely that its presence would be intermittent and unlikely that any population of the species depends solely on the habitats within the Development Envelope. Therefore, there is no 'real chance or possibility that' the Project will: • 'lead to a long-term decrease in the size of a population'; • 'reduce the area of occupancy of a population'; • 'fragment an existing population'; • 'disrupt the breeding cycle of a population'; or • 'seriously disrupt the lifecycle (breeding, feeding, migration or resting behavior) of an ecologically significant proportion of the population' of this migratory species. Habitat for the Australian Painted Snipe does not occur in the Development Envelope and therefore there is no 'real chance or possibility that' the Project will: • 'adversely affect habitat critical to the survival of the species'; • 'modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline'; • 'result in invasive species that are harmful to a vulnerable species becoming established in the endangered species' habitat'; • 'substantially modify (including fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat' for this migratory species; or • 'result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat' for this migratory species. Finally, there is no 'real chance or possibility that' the Project will: • 'introduce disease that may cause the species to decline'; or • 'interfere substantially with the recovery of the species'.

Common name (Species name)	Status under EPBC Act[1]	Likelihood of occurrence within Study Area	Nature of impact	Rationale for nature of impact
Greater Bilby (*Macrotis lagotis*)	VU	Confirmed	Not significant	The Greater Bilby has been recorded within the Development Envelope. It is very unlikely that the Development Envelope contains an 'ecologically significant proportion' of the population of the species, as only a single scat deposit was found during an intensive targeted search for the species. If a population were present, it could not be considered an 'important population' as it would not be 'near the limit of the species range' and would very unlikely be a 'key source population either for breeding or dispersal' or 'necessary for maintaining genetic diversity'. Therefore, there is no 'real chance or possibility that' the Project will: • 'lead to a long-term decrease in the size of an important population'; • 'reduce the area of occupancy of an important population'; • 'fragment an existing important population'; or • 'disrupt the breeding cycle of an important population'. Preferred habitat for the Greater Bilby exists in the Development Envelope within the following habitat types: Open Shrubland over Mixed Grassland on Sandy Plain; Drainage Line; *Acacia* Heath over Mixed Grassland on Sandy Plain; and Mixed Grassland On Sandy Plain. Marginally suitable habitat for the Greater Bilby exists in the Development Envelope within Hummock Grassland on Stony Rise habitat. However, as these habitats are widespread outside of the Development Envelope and the instances inside the Development Envelope are well-linked to those outside, the instances within the Development Envelope cannot be considered 'habitat critical to the survival' of this species as they cannot be considered exclusively necessary: • 'for activities such as foraging, breeding, roosting, or dispersal'; • 'for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)'; • 'to maintain genetic diversity and long term evolutionary development'; or • 'for the reintroduction of populations or recovery of the species or ecological community'. Therefore, there is no 'real chance or possibility that' the Project will: • 'adversely affect habitat critical to the survival of a species'; • 'modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline'; • 'result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat'. Finally, there is no 'real chance or possibility that' the Project will: • 'introduce disease that may cause the species to decline'; or • 'interfere substantially with the recovery of the species'.

Common name (Species name)	Status under EPBC Act[1]	Likelihood of occurrence within Study Area	Nature of impact	Rationale for nature of impact
Great Desert Skink (*Liopholis kintorei*)	VU	Possible	Not significant	The Great Desert Skink has not been recorded in the Development Envelope and only marginally suitable habitat for the species occurs there. Currently, the species is known from only seven main populations, the closest of which is approximately 185 km south-east of the Study Area, in the vicinity of Rabbit Flat in the Tanami Desert. The species is characterised by a patchy, localised distribution. Therefore, there is no 'real chance or possibility that' the Project will: • 'lead to a long-term decrease in the size of an important population'; • 'reduce the area of occupancy of an important population'; • 'fragment an existing important population'; or • 'disrupt the breeding cycle of an important population'. Marginally suitable habitat for the Great Desert Skink occurs in the Development Envelope within the following habitat types: Open Shrubland over Mixed Grassland on Sandy Plain; Drainage line; Hummock Grassland on Stony Rise; Acacia Heath over Mixed Grassland on Sandy Plain; and Mixed Grassland On Sandy Plain. However, given the sparse distribution of the species this habitat cannot be considered 'habitat critical to the survival' of this species as it cannot be considered exclusively necessary: • 'for activities such as foraging, breeding, roosting, or dispersal'; • 'for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)'; • 'to maintain genetic diversity and long term evolutionary development'; or • 'for the reintroduction of populations or recovery of the species or ecological community'. Therefore, there is no 'real chance or possibility that' the Project will: • 'adversely affect habitat critical to the survival of a species'; • 'modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline'; • 'result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat'. Finally, there is no 'real chance or possibility that' the Project will: • 'introduce disease that may cause the species to decline'; or • 'interfere substantially with the recovery of the species'.

Common name (Species name)	Status under EPBC Act[1]	Likelihood of occurrence within Study Area	Nature of impact	Rationale for nature of impact
Oriental Plover (*Charadrius veredus*)	M	Confirmed	Not significant	The Oriental Plover has been recorded twice within the Development Envelope. Given the sparseness of records on the site, it is unlikely that the site represents significant habitat for a population of Oriental Plovers, and there is no 'real chance or possibility that' the Project will: • 'seriously disrupt the lifecycle (breeding, feeding, migration or resting behavior) of an ecologically significant proportion of the population' of this migratory species. Preferred habitat for the Oriental Plover occurs in the Development Envelope within the following habitat types: Open Shrubland over Mixed Grassland on Sandy Plain; Drainage line; *Acacia* Heath over Mixed Grassland on Sandy Plain; and Mixed Grassland On Sandy Plain. However, this habitat cannot be considered 'important habitat' for this species as it cannot be considered: • 'habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species'; and/or • 'habitat that is of critical importance to the species at particular life-cycle stages'; and/or • 'habitat utilised by a migratory species which is at the limit of the species range'; and/or • 'habitat within an area where the species is declining'. Therefore, there is no 'real chance or possibility that' the Project will: • 'substantially modify (including fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat' for this migratory species; or • 'result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat' for this migratory species.

Common name (Species name)	Status under EPBC Act[1]	Likelihood of occurrence within Study Area	Nature of impact	Rationale for nature of impact
Rainbow Bee-eater (*Merops ornatus*)	M	Confirmed	Not significant	The Rainbow Bee-eater has been recorded in the Study Area and is likely to also occur within the Development Envelope. However, it is very unlikely that the Development Envelope contains an 'ecologically significant proportion' of the population of the species. Therefore, there is no 'real chance or possibility that' the Project will: • 'seriously disrupt the lifecycle (breeding, feeding, migration or resting behavior) of an ecologically significant proportion of the population' of this migratory species. Preferred habitat for the Rainbow Bee-eater exists in the Development Envelope within all habitat types ie. Open Shrubland over Mixed Grassland on Sandy Plain, Drainage line, Hummock Grassland on Rocky Hill, Hummock Grassland on Stony Rise, *Acacia* Heath over Mixed Grassland on Sandy Plain, and Mixed Grassland On Sandy Plain. However, this habitat cannot be considered 'important habitat' for this species as it cannot be considered: • 'habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species'; and/or • 'habitat that is of critical importance to the species at particular life-cycle stages'; and/or • 'habitat utilised by a migratory species which is at the limit of the species range'; and/or • 'habitat within an area where the species is declining'. Therefore, there is no 'real chance or possibility that' the Project will: • 'substantially modify (including fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat' for this migratory species; or • 'result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat' for this migratory species.

[1]Status under the EPBC Act – EN: Endangered; VU: Vulnerable; M: Migratory

4. GENERAL MANAGEMENT RECOMMENDATIONS

The following broad management recommendations have been developed as a guide for mitigating the potential impacts of the Project to fauna habitat and native fauna assemblages in general. Management recommendations specific to fauna of conservation significance are listed previously in this report (**Table 5**).

4.1. Project Design

- During Project design, consider options for aligning infrastructure footprints to avoid or minimise clearing of habitats that are known to or have been identified as likely to support species of conservation significance, such as Drainage Line and Hummock Grassland on Rocky Hill habitats;
- artificial lighting should be designed to illuminate designated operations areas and limit illumination of the surrounding landscape using ecologically sensitive methods such as ensuring outside lighting is shielded and directed;
- ensure that operational areas and transport routes are designed to avoid inadvertent illumination of important habitat features such as substantial rocky outcrops – consider the principles behind methods used for protecting marine turtles from light impacts (EPA 2010; although methods themselves differ, the principles are consistent between aquatic and terrestrial environments); and
- where possible, avoid creating permanent water sources; or if unavoidable, restrict access for non-volant terrestrial fauna where possible (e.g. by means of fencing or bunding).

4.2. Land Disturbance and Clearing Activities

- Where practicable, minimise land disturbance and clearing activities in habitat known to or likely to support species of conservation significance, such as Drainage Line and Hummock Grassland on Rocky Hill habitats;
- clearing boundaries should be demarcated in the field by Northern Minerals environmental personnel or appropriate representatives;
- stockpile cleared vegetation, topsoil and oversize waste overburden separately to ensure maximum reuse of these resources in subsequent rehabilitation;
- minimise and manage impacts to natural surface hydrology to ensure the quality of Drainage Line habitat is maintained and to minimise potential for waterbirds to be attracted to artificial water sources – roads, borrow pits and mine pits should be designed to minimise hydrological impacts;
- wherever possible, undertake clearing progressively over time to allow fauna to disperse to other suitable habitats within the surrounds;
- retain corridors or linkages, for example culverts underneath roads in key habitat areas, so that individuals can move between remaining habitat patches; and
- consider timing of clearing activities to reduce the impact on nesting birds.

4.3. Project Operation

- Implement dust suppression measures to reduce the effects of dust on vegetation and hence on fauna habitats and assemblages – this should include management of vehicle speed on unsealed roads;
- prepare and implement a weed management strategy to prevent the spread of existing weed species and the establishment of new weeds;
- conduct monitoring and control of feral animals in participation with surrounding land managers such as pastoralists and DPaW;
- management measures to prevent the increase of feral species numbers and control the attraction of any new feral species to the Project should be implemented, including proper hygiene practices and appropriate disposal of waste;
- prepare and implement a strategy for prevention of unplanned fires, which should include all vehicles being fitted with fire extinguishers and all personnel being trained in their use;
- prepare and implement a fire management strategy to reduce the scale, frequency and intensity of large, late dry-season fires within fauna habitats, especially Hummock Grassland on Rocky Hill and Hummock Grassland on Stony Plain habitat – fire has the potential to completely remove vegetation cover within these habitats, and as these habitats occur in small patches in the Development Envelope, species present may have limited capacity to relocate to similar unburnt habitat – but note that small, low-intensity fires early in the dry season may assist in fire management and provide biodiversity benefits;
- educate personnel and implement measures to minimise road kill, especially for nocturnal species or those prone to vehicle collisions – such measures could include changing the speed and times at which vehicles travel and/or erecting fences, barriers or alternative routes for fauna in strategic areas where fauna are known to cross major transport routes; and
- investigate strategies to reduce impacts of high frequency traffic on fauna and barriers to fauna dispersal created by the access road corridors.

4.4. Rehabilitation and Closure

- Implement a progressive rehabilitation and closure plan to ensure disturbed areas are rehabilitated as soon as practicable; and
- reconstruct linkages among fragmented fauna habitats.

5. CONCLUSIONS

The inventory of fauna developed from the desktop and field components of the baseline survey suggests that vertebrate fauna assemblages and habitats in the Study Area are representative of those present within equivalent parts of the wider Tanami bioregion, and that the Study Area does not represent an area of particularly high biodiversity from a regional point of view (Outback Ecology 2012). Nonetheless, the baseline survey confirmed the presence of seven species of fauna of conservation significance within the Development Envelope:

- Greater Bilby - Vulnerable (EPBC Act) and Schedule 1 (WC Act);
- Major Mitchell's Cockatoo - Schedule 4 (WC Act);
- Spectacled Hare-wallaby (mainland subspecies) - Priority 3 (DPaW Priority Fauna list);
- Lakeland Downs Mouse - Priority 4 (DPaW Priority Fauna list);
- Bush Stone-curlew - Priority 4 (DPaW Priority Fauna list);
- Australian Bustard - Priority 4 (DPaW Priority Fauna list); and
- Oriental Plover - Migratory (EPBC Act) and Schedule 3 (WC Act).

One species of conservation significance, the Rainbow Bee-eater (Migratory EPBC Act and Schedule 3 WC Act), was recorded in the Study Area just outside of the Development Envelope and is very likely to also occur in the Development Envelope. Eight other species of conservation significance are considered to possibly occur, or are likely or very likely to occur in the Study Area, but have not been recorded: Brush-tailed Mulgara, Australian Painted Snipe, Great Desert Skink, Woma, Grey Falcon, Peregrine Falcon, Pictorella Mannikin and Flock Bronzewing.

Impacts of the Project on fauna of conservation significance are expected to be greatest for the Greater Bilby, Spectacled Hare-wallaby and Bush Stone-curlew. The localised impact on each of these species is expected to be low, when considered within a regional context of habitat availability and ecological information for the species concerned. Impacts on all other species of vertebrate fauna of conservation significance identified in this Assessment are considered to be negligible to minimal. The Project is not expected to have any significant impact on matters of national environmental significance.

Habitats in the Development Envelope, and their condition, are consistent with those known to occur elsewhere in the Tanami bioregion. Of the fauna habitat types in the Study Area, impacts of the Project on vertebrate fauna are expected to be the greatest within Drainage Line, Hummock Grassland on Rocky Hill and Hummock Grassland on Stony Rise habitat types. Drainage Line habitat, which occupies 457 ha within the Development Envelope, is likely to represent an important linkage habitat both within the Study Area and between the Study Area and wider region. The Lakeland Downs Mouse, Australian Bustard and Rainbow Bee-eater were recorded in Drainage Line habitat, and the habitat type is likely to be utilised by several other species of conservation significance for foraging and dispersal throughout the Study Area and wider region.

The Hummock Grassland on Rocky Hill and Hummock Grassland on Stony Rise habitat types, which occupy 158 and 52 ha within the Development Envelope, respectively, occur in relatively small isolated patches. The Lakeland Downs Mouse and Bush Stone-curlew were recorded in Hummock Grassland on Rocky Hill habitat, and the habitat type, along with the Hummock Grassland on Stony Rise habitat type, is possibly used by other species of conservation significance for foraging and/or breeding.

There will be local impacts to the Mixed Grassland on Sandy Plain habitat type; however, this habitat is of limited significance as it does not provide unique microhabitats for vertebrate fauna. Clearing within the other fauna habitat types known to occur in the Development Envelope is unlikely to impact vertebrate fauna at a localised scale, as these habitat types are more widespread and are well connected to similar habitat in the wider region. From a regional perspective, the potential impacts of the Project are not considered to be significant for any of the habitats known to occur in the Development Envelope.

Clearing is an aspect of the Project with the greatest potential to impact upon fauna habitats and assemblages. Wherever possible, use of existing tracks, access roads and other disturbed areas should be promoted and clearing of vegetation and landforms for the purposes of the Project should be minimised wherever practicable.

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Appendix A

Baseline survey report (Outback Ecology 2012)

This Assessment was based in part on the results of a single-phase terrestrial vertebrate fauna baseline survey, performed in May 2012 by Outback Ecology – *Browns Range Project: Terrestrial Vertebrate Fauna Baseline Survey*. The standalone, baseline survey report is contained in this appendix.

Northern Minerals Limited

Browns Range Project

Terrestrial Vertebrate Fauna Baseline Survey

October 2012

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Terrestrial Vertebrate Fauna Baseline Survey

Distribution:

Company	Copies	Contact Name
Northern Minerals Limited	One electronic	Robin Wilson

Document Control for Job Number: BROW-FS-11001

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Final Report	M. Gresser	M. Young	MY	17/10/2012

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Executive Summary

Northern Minerals Limited commissioned Outback Ecology to undertake a baseline terrestrial vertebrate fauna survey of the Browns Range Study Area, which consists of 7,672 hectares of land in north-east Western Australia. This report documents the results of a detailed vertebrate fauna survey conducted within the Study Area from 5 to 13 May 2012. This report also presents a summary of species of terrestrial vertebrate fauna recorded from database searches and relevant surveys conducted near the Study Area from 2005 to 2010.

The primary objective of the baseline survey was to document the terrestrial vertebrate fauna and fauna habitats of the Study Area. The specific objectives were to:

- develop an inventory of the terrestrial vertebrate fauna species identified or likely to occur within the Study Area and surrounds;
- assess the likelihood of occurrence and likely distribution of vertebrate fauna of conservation significance within the Study Area;
- identify, describe and map vertebrate fauna habitat and any significant habitat occurring within the Study Area;
- assess survey findings in a regional context, by comparing them with available data from other localities within the Kimberley bioregion; and
- assess the potential impacts of the Project on the terrestrial fauna assemblages and habitat in the Study Area.

Habitat assessments and systematic, targeted and opportunistic sampling were undertaken across the Study Area. Systematic sampling methods comprised pitfall, Elliott, funnel and cage trapping, hand searching, spotlighting and avifauna census. Targeted search methods comprised active searching and the use of motion-sensor cameras and bat echolocation recording devices.

Six broad fauna habitat types were identified within the Study Area:

- Open Shrubland over Mixed Grassland on Sandy Plain;
- Drainage Line;
- Hummock Grassland on Rocky Hill;
- Hummock Grassland on Stony Plain;
- *Acacia* Heath over Mixed Grassland on Sandy Plain; and
- Mixed Grassland on Sandy Plain.

The habitat types identified within the Study Area were consistent with habitat types known to occur within the Winnecke and Coolindie Land Systems, within which the Study Area is located. No habitat types identified within the Study Area were considered regionally significant and none were found to contain an exceptional diversity of vertebrate fauna.

A total of 122 vertebrate species was recorded during the field survey of the Study Area – 19 native mammal, five introduced mammal, 61 bird, 34 reptile and three amphibian species. Of the 122 species, five are of conservation significance, i.e. listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) and/or the *Wildlife Conservation Act 1950* (Western Australia) (WC Act) and/or are included on the WA Department of Environment and Conservation (DEC) Priority Fauna list:

- Major Mitchell's Cockatoo (*Lophochroa leadbeateri*) – WC Act, Schedule 4;
- Lakeland Downs Mouse (*Leggadina lakedownensis*) – DEC, Priority 4;
- Australian Bustard (*Ardeotis australis*) – DEC, Priority 4;
- Bush Stone-curlew (*Burhinus grallarius*) – DEC, Priority 4; and
- Rainbow Bee-eater (*Merops ornatus*) – EPBC, Migratory; WC Act, Schedule 3.

Of the 122 species recorded during the field survey, 12 were not identified by the database searches or literature review as potentially occurring within the Study Area. Records of four species within the Study Area (none of which is of conservation significance) may represent range extensions, as they lie well outside published distributions.

The database searches and literature review identified 32 species of conservation significance that have the potential to occur within the Study Area. Of these:

- 12 species are listed as Threatened under the EPBC Act and/or Schedule 1 or Schedule 4 under the WC Act;
- eight species are recognized by the DEC as being Priority Fauna (including two also listed as Threatened under the EPBC Act); and
- 15 species of migratory birds (including one species also listed as Threatened under the EPBC Act and Schedule 1 or Schedule 4 under the WC Act).

While four of these 32 species were observed during the field survey, one species of conservation significance, the Bush Stone-curlew, was observed during the field survey but was not identified by the database searches or literature review as potentially occurring within the Study Area. Therefore, the total number of species of conservation significance potentially occurring within the Study Area is 33. Of the 28 species of conservation significance that were identified by the database searches and literature review, but were not observed during the field survey, 11 were considered to possibly occur, or likely or very likely to occur within the Study Area.

The inventory of 122 species of terrestrial vertebrate fauna obtained during the field survey was broadly consistent with vertebrate fauna inventories obtained during the desktop study. The field survey recorded more mammals, birds and amphibians than each of the previous surveys considered in the literature review, but fewer reptiles in the case of one previous survey. However, it is unlikely that the field survey documented the entire suite of species present within the Study Area at the time of sampling. This is because database searches and previous surveys in the vicinity of the Study

Area documented faunal assemblages that were slightly different to those recorded during the field survey, possibly due to a number of factors such as survey scope, timing and effort. In addition, species accumulation curves for avifauna, and to lesser extent reptiles, did not reach asymptotes during the survey period.

Although vertebrate fauna assemblages and vertebrate fauna habitats were adequately documented, further survey effort would almost certainly add to existing species lists for the Study Area. Expansion of these species lists would be unlikely to substantially alter conclusions regarding either the likelihood of occurrence of fauna of conservation significance, or the local and regional importance of vertebrate fauna habitats.

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1. INTRODUCTION

1.1. Project Background and Location

Northern Minerals Ltd (Northern Minerals) is an ASX-listed company focused on the development of heavy rare earth elements (REE). The Browns Range Project (the Project) consists of three granted exploration licenses E80/3547, E80/3548, E80/4393 and one tenement application E80/4479. The Project previously formed part of the Gardiner-Tanami Project, but since 2009 has become a focus for Northern Minerals' REE exploration program. The Project covers an area of 7,672 hectares within Western Australia, located adjacent to the Western Australia/Northern Territory border approximately 150 km southeast of Halls Creek (**Figure 1**). The Project is located on Gordon Downs Station in the Shire of Halls Creek.

Four rare earth prospects with xenotime mineralisation have been identified at the Browns Range Project: Wolverine, Gambit, Area 5 and Area 5 North (**Figure 2**). The xenotime mineralisation is hosted within hydrothermal quartz veins and quartz vein breccias. Exploration activities conducted in 2010 have returned anomalous rock and soil samples, followed by detailed mapping and radiometrics to identify multiple targets that require drill testing. Petrologic studies and metallurgical test work has identified the xenotime to be clean and amenable to flotation and beneficiation techniques.

Activities on site to date have focused on development and expansion of an extensive exploration program to evaluate REE resources. Current exploration work includes the expansion of a recently implemented diamond drilling program to further define the orientation and extent of the resource. Mining activities will be by open pit, with crushing, grinding and separation on site. Concentrate will be transported to a port for export. Mining infrastructure will likely include pits, waste rock landforms, a crushing, grinding and separation facility, tailings storage facility, roads, borefield, pipelines, parking and laydown areas, a workshop, fuel and water storage, accommodation village and administration buildings.

1.2. Report Scope and Objectives

This report documents the results of a terrestrial vertebrate fauna baseline survey conducted within the Browns Range Study Area (the Study Area; see **Figure 1**, **Figure** 2 and **Figure** 3) between 5 and 13 May 2012. The survey was designed and conducted in accordance with WA Department of Environment and Conservation (DEC) and WA Office of the Environmental Protection Authority (EPA) guidelines (EPA and DEC 2010, EPA 2002, EPA 2004). The overarching objective of the survey was to document the terrestrial vertebrate fauna and fauna habitats of areas proposed to be impacted or potentially impacted by mining activities conducted by Northern Minerals within the Study Area.

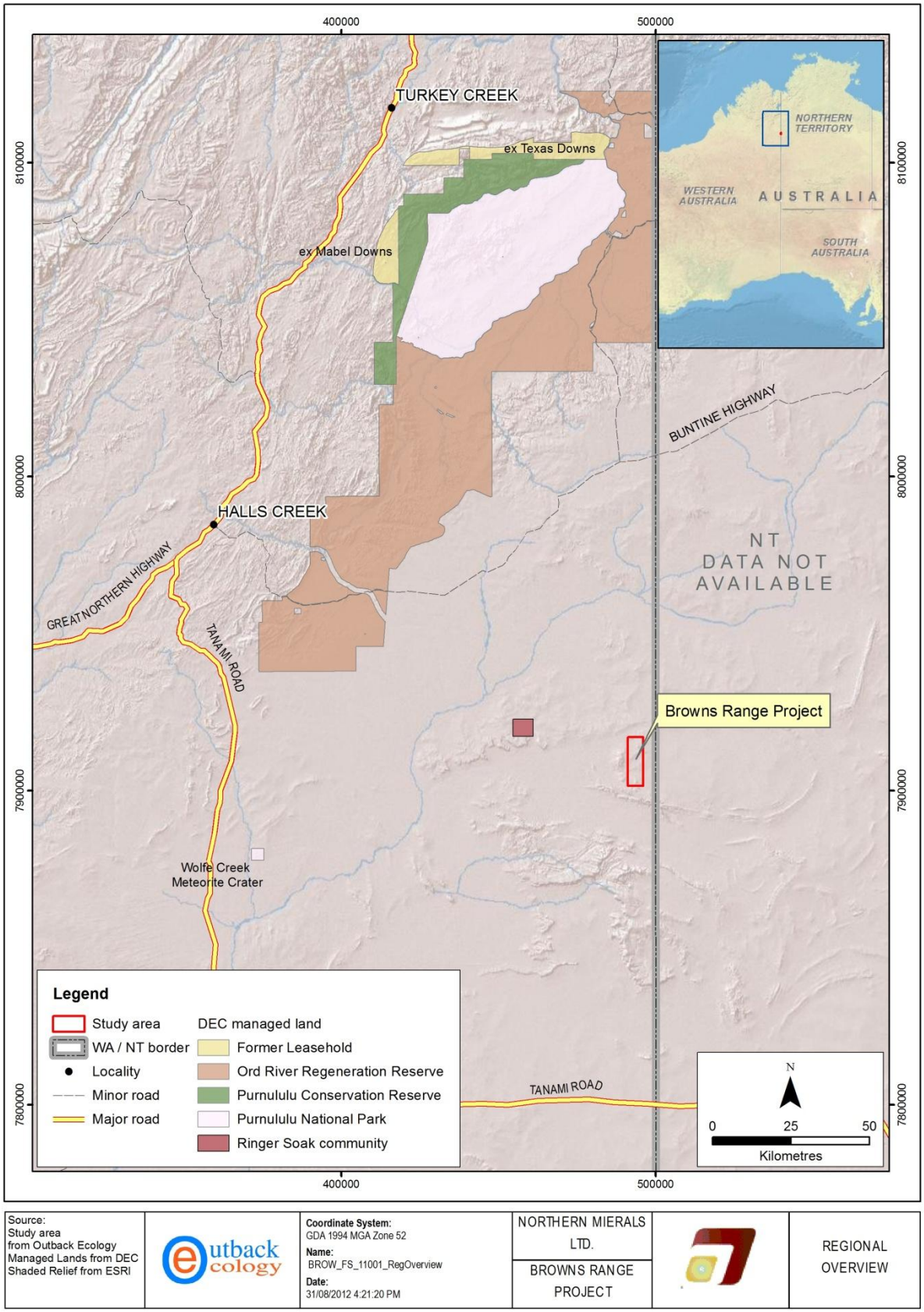

Figure 1: Regional location of the Browns Range Project

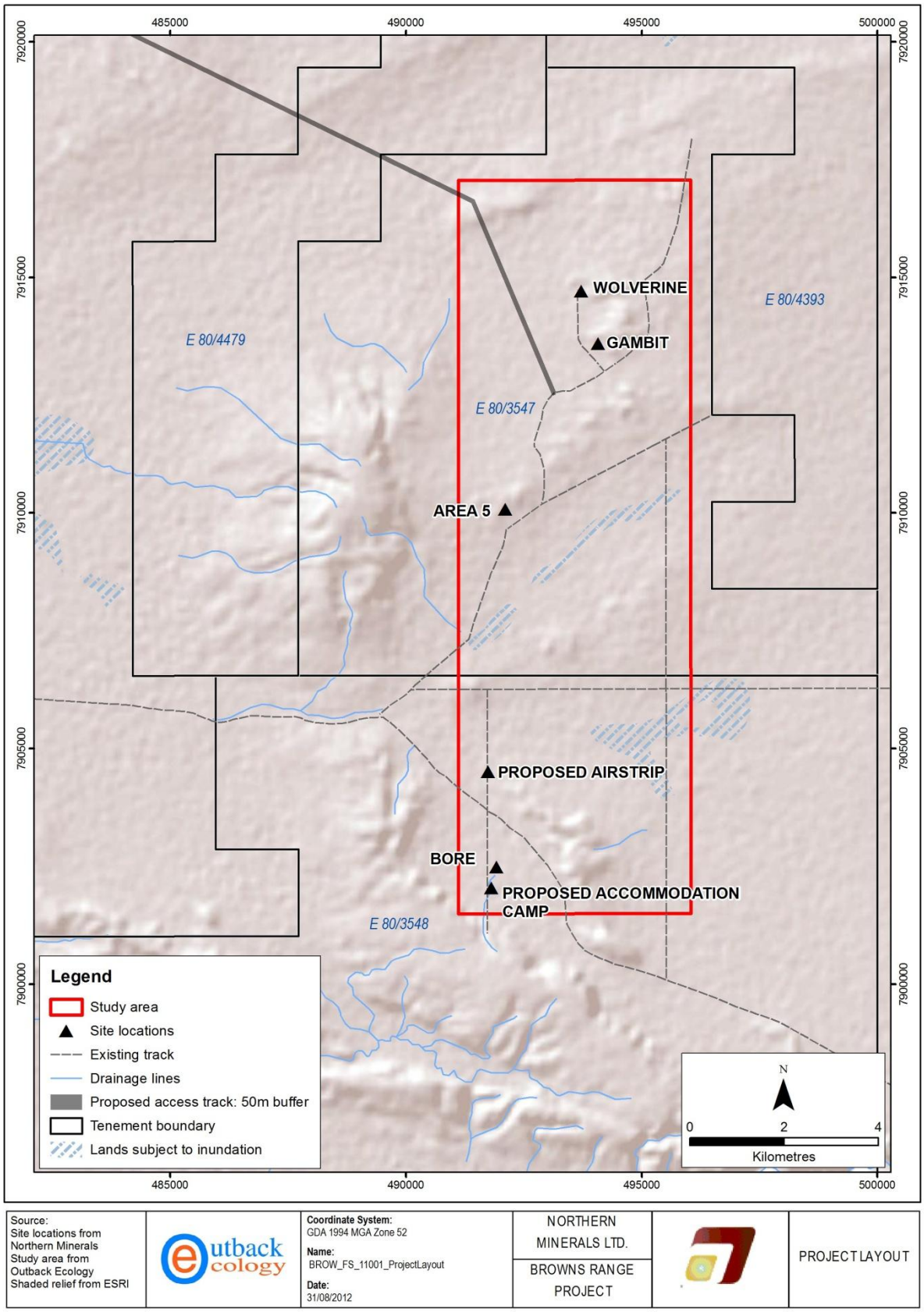

Figure 2: Browns Range Project layout

The specific objectives of this Study were to:

- develop an inventory of the terrestrial vertebrate fauna species identified or likely to occur within the Study Area and surrounds;
- assess the occurrence and likely distribution of vertebrate fauna of conservation significance within the Study Area;
- identify, describe and map vertebrate fauna habitat and any significant habitat occurring within the Study Area; and
- assess survey findings within a regional context by comparing them with available data from other localities within the Tanami bioregion.

2. EXISTING ENVIRONMENT

2.1. Biogeographic Region

The Study Area is located at the northern edge of the Tanami Desert. It lies within the Tanami bioregion, as defined by the Interim Bioregions of Australia (IBRA) classification system (Graham 2001) (**Figure 3**). The majority of the Tanami bioregion extends eastward into the central Northern Territory, but a small portion of the bioregion extends westward into Western Australia and contains the Study Area. The Tanami bioregion is composed of three sub-bioregions: Tanami 1, Tanami 2 and Tanami 3. The Study Area occurs in Tanami 1, which is the largest of the three sub-bioregions (**Figure 3**).

The Tanami 1 sub-bioregion is 3,214,599 ha in size and 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). Drainage occurs via Sturt Creek (the largest river system in the Tanami bioregion) and other ephemeral watercourses such as the Lander and Hanson Rivers and Winnecke Creek (ANRA 2009a). The Tanami 1 sub-bioregion incorporates large areas of relatively untouched desert ecological communities, and as such is an important refuge area for biodiversity (ANRA 2009a).

The sub-bioregion supports a number of threatened fauna species and contains two wetlands of national significance: the Lake Gregory system in Western Australia and Lake Surprise in the Northern Territory, which are approximately 125 km southwest and 325 km east-southeast of the Study Area, respectively (ANRA 2009a, DSEWPaC 2009). While the sub-bioregion is generally in good ecological condition, significant threatening processes include feral predators, changing fire regimes and weeds (ANRA 2009a, Graham 2001). Apart from some vertebrate fauna sampling conducted in the Northern Territory portion of the Tanami 1 sub-bioregion more than 15 years ago, there has been no systematic review of biodiversity within the sub-bioregion (ANRA 2009a, Graham 2001). Consequently, little baseline information is available to land managers and in particular, there are notable gaps in information relating to the distribution and status of native flora and fauna, the distribution, status and impact of weed species, and the identification of appropriate fire regimes (ANRA 2009a, Graham 2001).

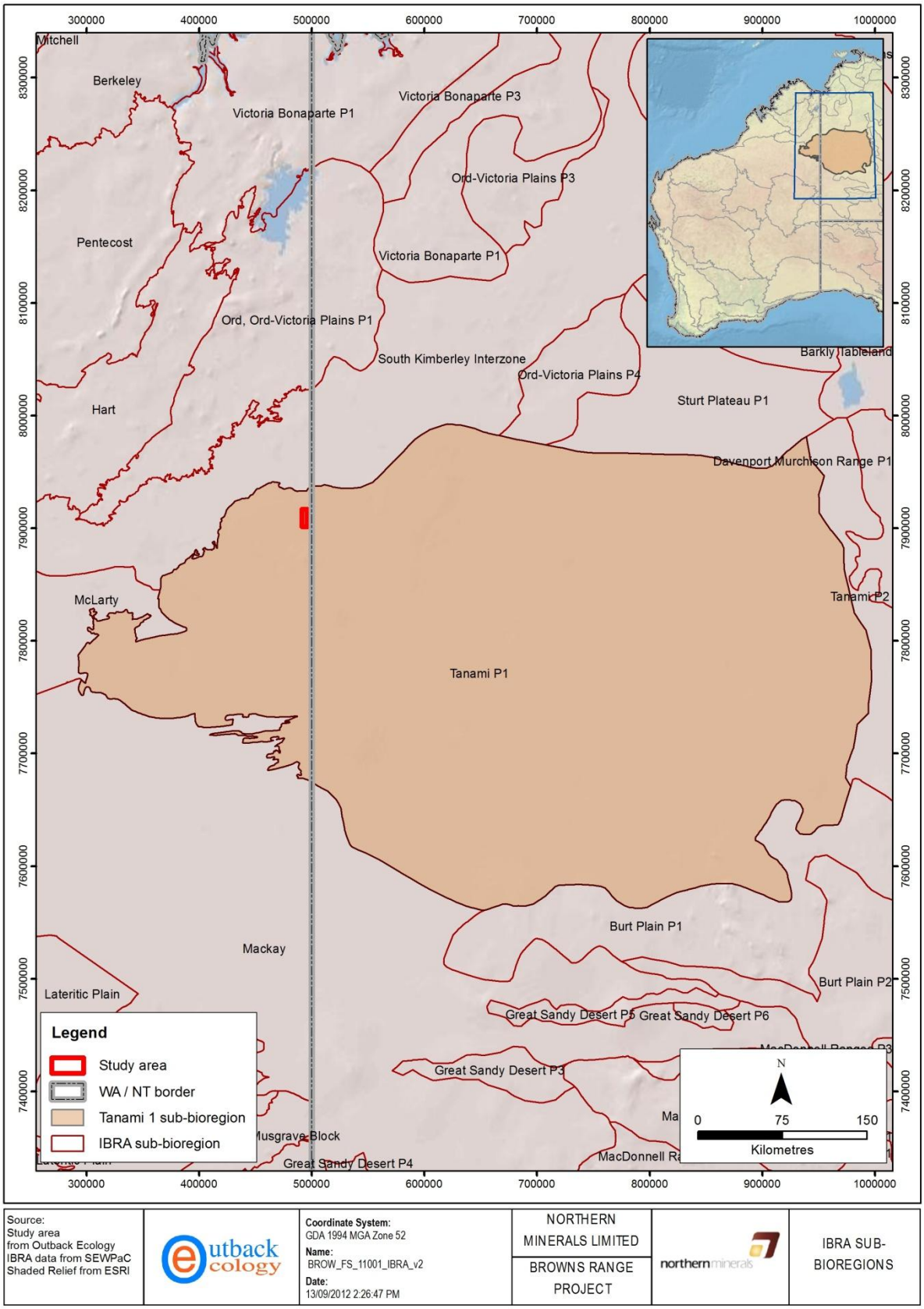

Figure 3: Location of the Study Area relative to the Tanami 1 sub-bioregion

2.2. Climate

The Tanami 1 sub-bioregion, which encompasses the Browns Range Study Area , experiences an arid-tropical climate with mainly summer rainfall due to a monsoonal influence (Graham 2001). The Bureau of Meteorology (BOM) weather station at Halls Creek Airport, which is located approximately 150 km north-west of the Study Area, is the closest locality with comprehensive climate data available and consequently provides climate information most relevant to the Study Area (**Figure 4**).

Mean maximum temperatures at Halls Creek Airport range from 27.2°C in July to 38.4°C in November, and peak temperatures are recorded from September to April (**Figure 4**). Mean minimum temperatures in winter months range from 12.6 to 14.8°C. Halls Creek Airport has a mean annual rainfall of 635.8 mm and an average of 49 rain days per year (BOM 2012). The majority of rainfall consistently occurs between November and March (the 'wet season'), whereas very little rainfall is typically recorded in winter months (the 'dry season') (**Figure 4**). However, rainfall in the region can be highly localised and unpredictable, with substantial fluctuations occurring spatially and temporally (BOM 2012). For example, an unusually wet Dry Season was experienced by northern Australia (including the Study Area) in 2010, with many locations in the region measuring their highest Dry Season rainfall on record (National Climate Centre 2010). Monthly rainfall at Halls Creek Airport was highly variable over the period 2008 to 2012. For example, for the month of March, 379.8 mm of rain was recorded in 2011, but only 69 mm was recorded in 2010 and only 11 mm was recorded in 2008 (**Figure 5**).

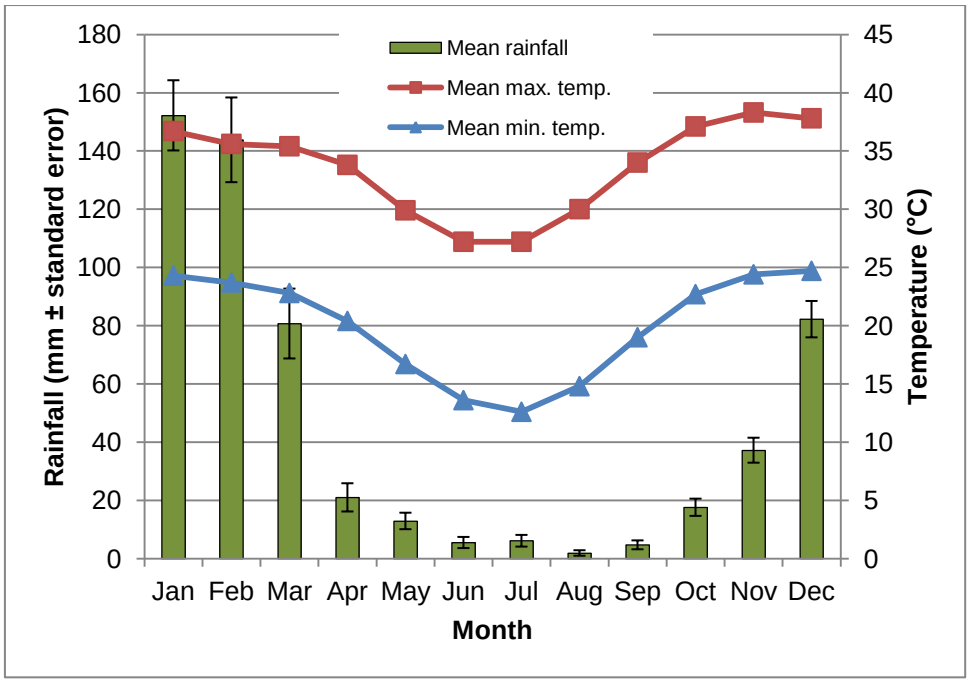

Figure 4: Climate data for Halls Creek Airport

Source data: BOM (2012), weather station 002012, 1944 to 2012

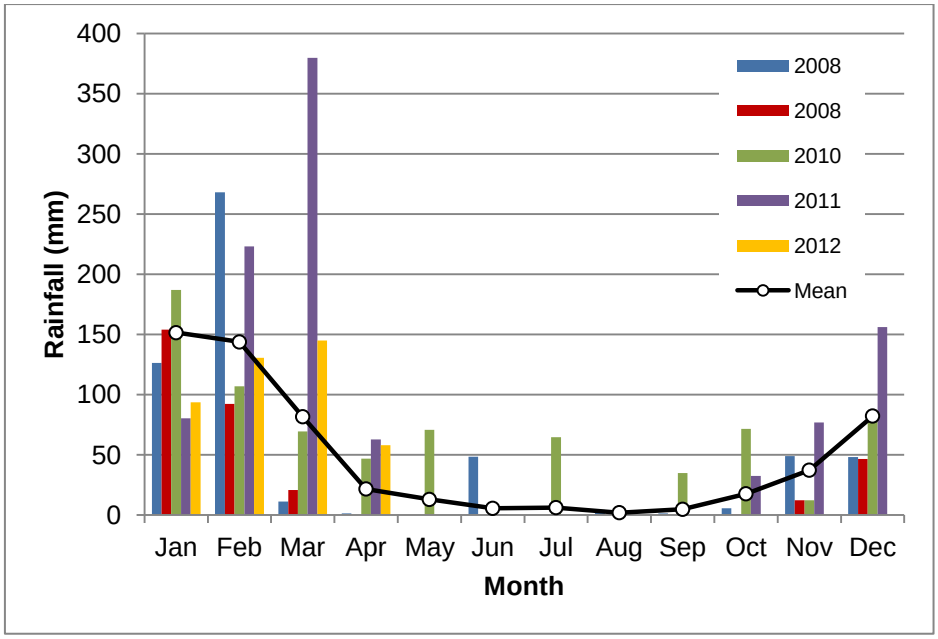

Figure 5: Monthly rainfall for Halls Creek Airport
Source data: BOM (2012), weather station 002012, 1944 to 2012

2.3. Land Systems

The Study Area lies within the Kimberley region of Western Australia. Numerous rangelands resource surveys conducted since the 1940s have contributed to a comprehensive description of biophysical resources present within the Kimberley region, including the condition of soil and vegetation (Payne and Schoknecht 2011). This information has been used to classify and map the land systems of the Kimberley region based on landforms, soils, vegetation, geology and geomorphology. An assessment of these land systems provides an indication of the occurrence and distribution of relevant natural resources present within and surrounding the Study Area. The Study Area contains two land systems: Coolindie and Winnecke (**Table 1**). Of these, the Coolindie land system occupies the majority of the Study Area (**Figure 6**).

Table 1: Land systems within and surrounding the Study Area

Land System	Description	Area within Study Area (hectares)	Proportion of Study Area (%)
Coolindie	Consists of gently undulating red desert sandplains and dunes supporting *Acacia* shrublands, *Eucalyptus* woodlands and soft spinifex (*Triodia pungens*) grasslands. These grasslands are subject to frequent fires that cause short-term changes in floristic composition and abundance. Drainage lines are shallow, widely spaced and insequent, and erosion is minimal.	6,473	84.3
Winnecke	Consists of stony hills and lowlands associated with red desert sands that support *Acacia* and *Eucalyptus* woodlands and soft spinifex (*Triodia pungens*) grasslands. These grasslands are subject to frequent fires that cause short-term changes in floristic composition and abundance. Intensive parallel drainage lines occur on upper slopes, while widely spaced angular drainage lines occur on lower slopes and terminate at the base of hills. Erosion is generally minimal, though some drainage floors are moderately susceptible.	1,203	15.7

Source: Payne and Schoknecht (2011)

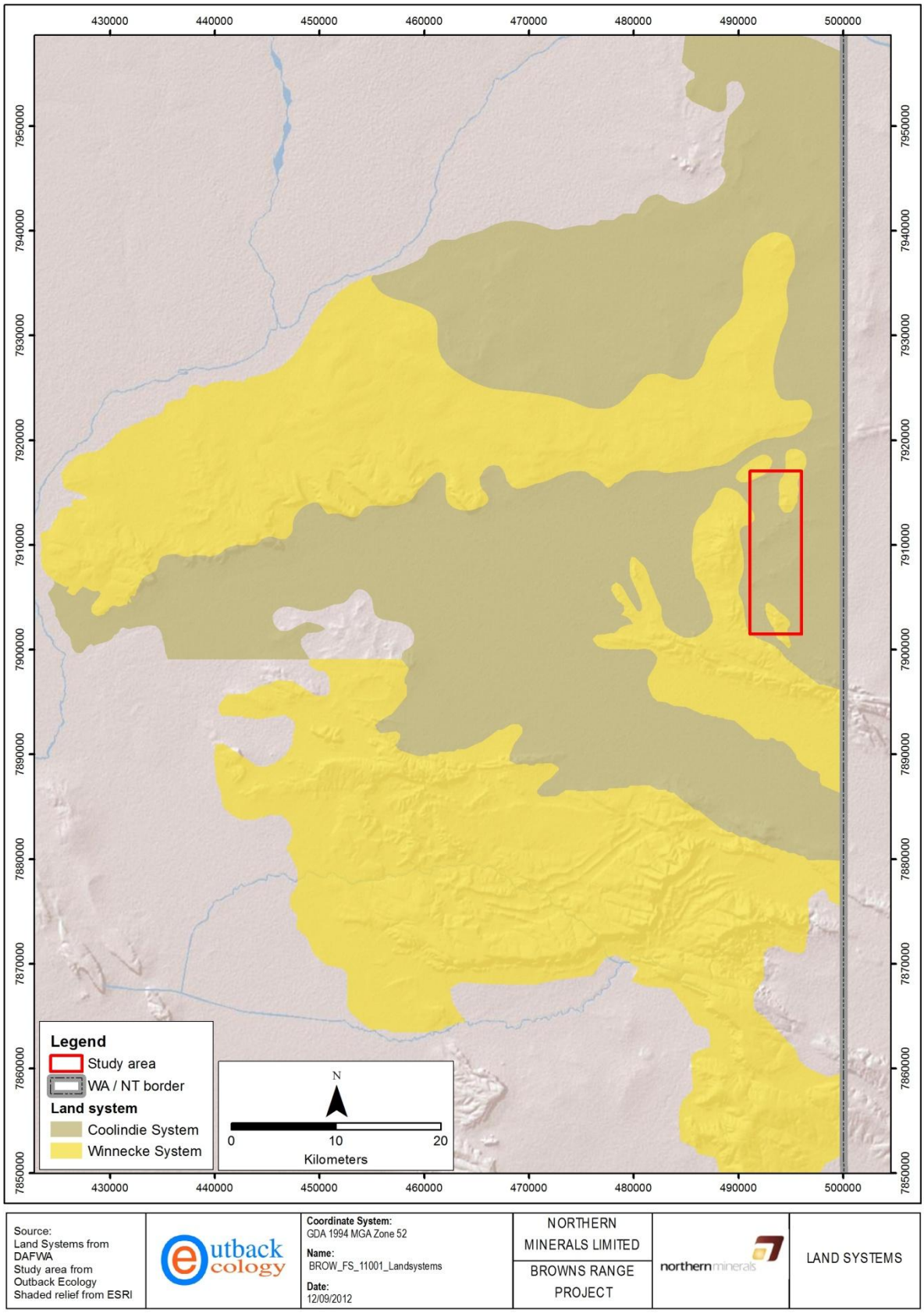

Figure 6: Land systems within and surrounding the Study Area

2.4. Land Use

The majority of the land within the Tanami bioregion is Aboriginal freehold. This land continues to be used by traditional Aboriginal landowners for the hunting and gathering of food, and the practice of cultural ceremonies associated with the land (Stoll *et al.* 2005). The remaining land within the bioregion is Unallocated Crown Land or Crown leasehold used for pastoral leases and conservation reserves (ANRA 2009b). Grazing occurs throughout one quarter of the bioregion, and mining (predominantly for gold) and tourism are also important industries (ANRA 2009b).

The Study Area is located within the Gordon Downs pastoral lease in the Shire of Halls Creek (**Figure 7**). While the land is primarily used for grazing cattle, pastoral activity within the Study Area is limited by poor pasture production and inadequate water supplies. More suitable soils for pastoral activity are found north of the Study Area. Located approximately 10 km south of the Study Area, the closest protected area is Gardiner Range Conservation Reserve, an EPA Red Book Recommended Conservation Reserve managed by Western Australia's DEC (DMP 1998). Gardiner Range is a little studied area that contains permanent springs that are a source of water for Lake Wilson, which is an important refuge for wildlife during drought (Graham 2001). Other DEC-managed lands nearby include the Ord River Regeneration Reserve, approximately 100 km north-west of the Study Area, and the Wolfe Creek Crater National Park, approximately 120 km west-southwest. The Ord River Regeneration Reserve has been rehabilitated since the 1960s to combat erosion and high sediment load in the Ord River, which occurs from overgrazing and can limit the opportunity for irrigated agriculture within the region (Novelly and Watson 2007). The Wolfe Creek Crater National Park is a significant tourist attraction as it contains a well-preserved meteorite impact crater. Across the border in the Northern Territory (four kilometres east of the Study Area) is land held by a number of Aboriginal Land Trusts for the use and occupation by traditional Aboriginal landowners. The closest Western Australian Aboriginal community to the Study Area is Ringer Soak (also known as Kundjat Djaru), located 40 km west.

2.5. Geology

The Study Area is located on the western side of the Browns Range Dome, a Paleoproterozoic dome formed by a granitic core intruding the Paleoproterozoic "Browns Range Metamorphics" (meta-arkoses, feldspathic metasandstones and schists) and an Archaean orthogneiss and schist unit to the south. The dome and its aureole of metamorphics are surrounded by the Paleoproterozoic (1735-1640 Ma) Gardiner Sandstone (Birrindudu Group). Middle-Devonian to (likely) Ordovician sandstones from the Eastern Canning Basin margin (Billiluna Shelf) of uncertain age have also been interpreted to occur over the Gardiner Sandstone to the south-west of the dome (Das 2012).

The Browns Range Study area is primarily covered with transported soil and low-lying vegetation. The dominant geological unit throughout the Project area consists of arkose and meta-arkose outcrops. Other rock types include quartz mica schists, Banded Iron Formation/Quartz pebble conglomerate, dolerite and calc-silicate rocks.

Minor occurrences of quartzite, silcrete, ferricrete and ironstone have also been identified. The Gardiner Sandstone is seen to flank the western margins of the Project area and unconformably overlies the older Browns Range metamorphic rocks (Das 2012).

Mapping has identified both mineralised and non-mineralised occurrences of quartz veins and quartz breccia veins occur as elongated discontinuous bodies, up to several metres wide and tens of metres long, and intruding along possible shear or faults trending 320˚ (north-west) and 270˚ (east-west) (Das 2012).

3. DATABASE SEARCHES AND LITERATURE REVIEW

To place the survey within a broader context, database searches and a literature review were performed prior to the fauna survey. Database searches (**Section 3.1**) were conducted to generate a list of vertebrate fauna species potentially occurring within the Study Area, whilst a literature review (**Section 3.2**) was conducted to generate a list of vertebrate fauna species known to occur near the Study Area, based on data from previous surveys.

3.1. Database Searches

Five databases were searched. For each search, the Study Area was defined as a central point with coordinates 493191 mE 7908626 mN (WGS 1984, UTM 52K). The databases and search areas used were:

- the Threatened and Priority Fauna Database (DEC 2012c), with a circular search area with a radius of 100 km surrounding the central point. This search only provided data from the Western Australian portion of the search area;
- the NRETAS database (NRETAS 2012), with a search area consisting of a box surrounding the central point and delineated by the coordinates (clockwise, from the north-west corner) 8008626 mN 393191 mE, 8008626 mN 593191 mE, 7808626 mN 593191 mE, 7808626 mN 393191 mE. This search only provided data for the Northern Territorian portion of the search area;
- a Birdata Custom Atlas Bird List (Birds Australia 2012), with a circular search area with a radius of 100 km surrounding the central point;
- the NatureMap database (DEC 2012a). As this database limits search areas to a circular area of 40 km radius, five separate searches were conducted in an attempt to cover a circular area with an approximate radius of 90 km around the central point. Searches were conducted around the central point as well as each of the four points 528133 mE 7943656 mN, 528174 mE 7873640 mN, 458133 mE 7873645 mN and 458151 mE 794360 mN. These searches only provided data from the Western Australian portion of the search area; and
- the Protected Matters Search Tool (DSEWPaC 2012a), with a search area consisting of a box surrounding the central point and delineated by the coordinates (clockwise, from the north-west corner) 8008626 mN 393191 mE, 8008626 mN 593191 mE, 7808626 mN 593191 mE, 7808626 mN 393191 mE;

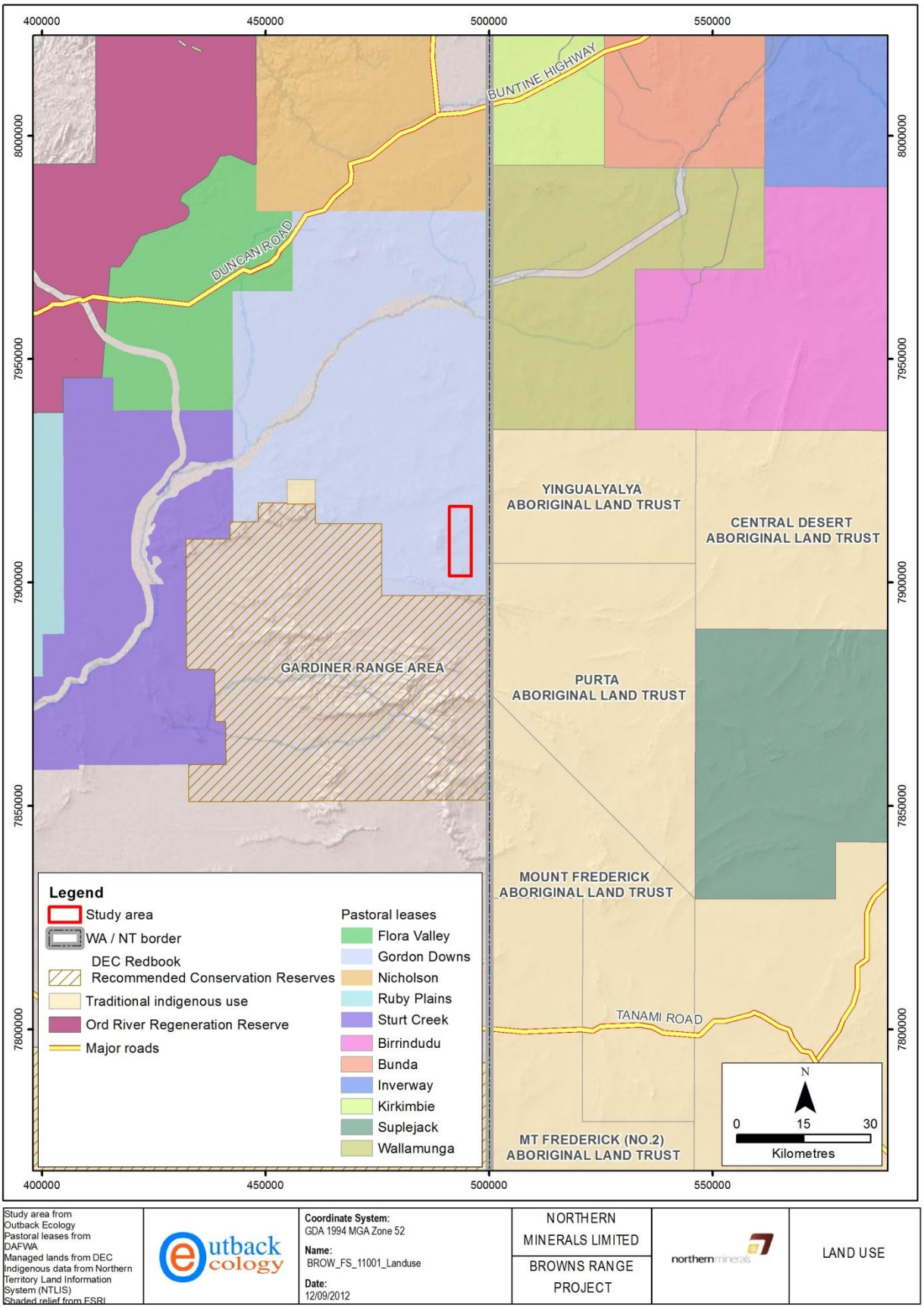

Figure 7: Land use within and surrounding the Study Area

These databases reported a total of 289 species of native vertebrate fauna (**Table 2**, **Appendix A**), 32 of which are of conservation significance (see **Appendix G** for full definitions of conservation status):

- the Northern Marsupial Mole (*Notoryctes caurinus*), Central Marsupial Mole (*Notoryctes typhlops*) and Crest-tailed Mulgara (*Dasycercus cristicauda*), which are listed as Endangered (EPBC Act) and Schedule 1 (WC Act);
- the Australian Painted Snipe (*Rostratula australis* – Vulnerable and Migratory, EPBC Act; Schedule 1 and Schedule 3, WC Act);
- the Greater Bilby (*Macrotis lagotis* – Vulnerable, EPBC Act; Schedule 1, WC Act);
- the Brush-tailed Mulgara (*Dasycercus blythi*) and Purple-crowned Fairy-wren (western subspecies) (*Malurus coronatus coronatus*), which are listed as Vulnerable (EPBC Act) and Priority 4 (DEC Priority Fauna List);
- the Peregrine Falcon (*Falco peregrinus*), Major Mitchell's Cockatoo (*Lophochroa leadbeateri*), Woma (*Aspidites ramsayi*), Freshwater Crocodile (*Crocodylus johnstoni*) and Great Desert Skink (*Liopholis kintorei*), which are listed as Schedule 4 (WC Act);
- the Spectacled Hare-wallaby (mainland subspecies) (*Lagorchestes conspicillatus leichardti*), which is listed as Priority 3 (DEC Priority Fauna List);
- the Australian Bustard (*Ardeotis australis*), Grey Falcon (*Falco hypoleucos*), Pictorella Mannikin (*Heteromunia pectoralis*), Flock Bronzewing (*Phaps histrionica*) and Lakeland Downs Mouse (*Leggadina lakedownensis*), which are listed as Priority 4 (DEC Priority Fauna List); and
- 14 species of migratory bird, which are listed as Migratory (EPBC Act) and Schedule 3 (WC Act) and are protected under international agreements (see **Appendix A** for full list).

Table 2: Vertebrate species richness from previous studies and database searches

Fauna	This study	Literature review					Database searches						Total
		C	D	E	F	Total	G	H	I	J	K	Total	
Native mammals	19	6	6	5	14	17	4	0	7	3	27	31	37
Introduced mammals	5	4	5	3	4	6	0	0	2	4	6	9	9
Birds	61	51	35	26	58	81	6	80	153	7	139	183	186
Reptiles	34	6	3	1	43	45	0	0	31	2	49	62	83
Amphibians	3	2	0	0	1	3	0	0	9	0	8	13	14
Total native fauna	**117**	**65**	**44**	**32**	**116**	**146**	**10**	**80**	**200**	**12**	**223**	**289**	**320**
Total fauna	**122**	**69**	**49**	**35**	**120**	**152**	**10**	**80**	**202**	**16**	**229**	**298**	**329**

[1]See **Table 4** and/or **Appendix A** for keys to literature review studies, and database searches

3.2. Literature Review

The literature review identified seven previous studies undertaken near the Study Area, including two desktop studies and four field surveys, (**Table 4**, **Figure 8**). The results of the four previous field surveys were collated to generate an inventory of the vertebrate fauna known to occur near the Study Area (see **Table 2**, **Table 4**, **Appendix A**).

The four previous field surveys conducted near the Study Area reported a total of 146 species of native, terrestrial fauna (**Table 2**, **Appendix A**), nine of which are of conservation significance. Each of these species of conservation significance was previously identified during the database searches (**Section 3.1**, but see **Table 4** for individual survey accounts).

4. FAUNA SURVEY METHODOLOGY

4.1. Survey Timing And Weather

The field survey was conducted from 5 May to 13 May 2012. Weather during this time was considered appropriate for fauna sampling. Maximum temperatures recorded from the Halls Creek meteorological station (the closest weather station with comprehensive climate data available) during the field survey ranged between 28.9ºC and 32.0ºC, and minimum temperatures ranged between 14.6ºC and 19.6ºC (**Table 3**). Monthly rainfall at Halls Creek was higher than average rainfall for four of the six months preceding the survey period (**Figure 9**). No rain was experienced during the field survey (**Table 3**).

Seasonal activity for vertebrate fauna is strongly influenced by temperature and rainfall. As outlined in EPA Guidance Statement 56, the optimal time for a fauna survey is following the period of maximum rainfall for the region (EPA 2004, EPA/DEC 2010). For the Tanami bioregion, this period coincides with March to May, following the typical summer wet season, and this field survey was conducted during this time (**Figure 4**).

Table 3: Daily weather at Halls Creek Airport during the field survey

Survey Dates 2012	Temperature (°C)		Total Rainfall (mm)	Relative Humidity (%)	
	Min	Max		9.00 am	3.00 pm
5/5/2012	16.6	28.9	0	34	31
6/5/2012	15.0	29.7	0	29	25
7/5/2012	15.0	29.8	0	30	22
8/5/2012	14.6	30.4	0	34	19
9/5/2012	15.7	31.4	0	34	20
10/5/2012	16.8	31.6	0	35	30
11/5/2012	19.6	32.0	0	40	27
12/5/2012	18.5	31.3	0	40	26
13/5/2012	17.5	30.5	0	27	16

Source: BOM (2012), weather station 002012

Table 4: Summary of findings from fauna surveys surrounding the Study Area

Figure 8 code	Reference	Study details	Proximity to Study Area	Methods	Habitats	Fauna recorded	Species of conservation significance[1]	Relevant notes
A	Outback Ecology (2010)	*Project:* Birrindudu Project *Client:* Toro Energy Ltd *Type:* Desktop Study *Date:* April 2010	Covers the surrounding area as far as approx. 100 km from the Study Area.	• No field component	• Ridges • Low Hills • Riverine • Alluvial Plains • Red Sandplains • Drainage Lines • Spinifex Shrubland	325 species of terrestrial vertebrate fauna: • 45 mammal (35 native); • 177 bird; • 86 reptile; • 17 amphibian.	Threatened • Crest-tailed Mulgara (EPBC Act – EN; WC Act – S1); • Northern Marsupial Mole (EPBC Act – EN; WC Act – S1); • Central Marsupial Mole (EPBC Act – EN; WC Act – S1); • Greater Bilby (EPBC Act – VU; WC Act – S1); • Brush-tailed Mulgara (EPBC Act – VU; DEC – Priority 4); • Great Desert Skink (WC Act – S4); • Major Mitchell's Cockatoo (WC Act – S4). Priority • Gravel Dragon (DEC – Priority 1); • Spectacled Hare-wallaby (western) (DEC – Priority 3); • Australian Bustard (DEC – Priority 4); • Bush Stone-curlew (DEC – Priority 4); • Ghost bat (DEC – Priority 4); • Grey Falcon (DEC – Priority 4); • Western Pebble-mound Mouse (DEC – Priority 4). Migratory • Cattle Egret (EPBC Act – M; WC Act – S3); • Fork-tailed Swift (EPBC Act – M; WC Act – S3); • Eastern Great Egret (EPBC Act – M; WC Act – S3); • Rainbow Bee-eater (EPBC Act – M; WC Act – S3).	This study was a desktop analysis of terrestrial vertebrate fauna potentially occurring within 100km of a point that was approx. 20 km west of the Study Area. Species lists generated from this study were not included as part of the overall dataset for this study

Figure 8 code	Reference	Study details	Proximity to Study Area	Methods	Habitats	Fauna recorded	Species of conservation significance[1]	Relevant notes
B	Ecotec (2010b)	*Project:* Browns Range Project *Client:* Northern Uranium Ltd *Type:* Desktop Study *Date:* May 2010	Covers the surrounding area as far as approx. 100 km from the Study Area.	• No field component	• None identified	113 species of terrestrial vertebrate fauna: • 14 mammal (12 native); • 67 bird; • 25 reptile; • 7 amphibian.	Threatened • Crest-tailed Mulgara (EPBC Act – EN; WC Act – S1); • Northern Marsupial Mole (EPBC Act – EN; WC Act – S1); • Greater Bilby (EPBC Act – VU; WC Act – S1); • Australian Painted Snipe (EPBC Act – VU; WC Act – S1); • Brush-tailed Mulgara (EPBC Act – VU; DEC – Priority 4); • Purple-crowned Fairy-wren (western) (EPBC Act – VU; DEC – Priority 4); • Great Desert Skink (WC Act – S4); • Major Mitchell's Cockatoo (WC Act – S4); • Peregrine Falcon (WC Act – S4); • Woma (WC Act – S4). Priority • Gravel Dragon (DEC – Priority 1); • Spectacled Hare-wallaby (western) (DEC – Priority 3); • Australian Bustard (DEC – Priority 4); • Bush Stone-curlew (DEC – Priority 4); • Ghost bat (DEC – Priority 4); • Western Pebble-mound Mouse (DEC – Priority 4). Migratory • Cattle Egret (EPBC Act – M; WC Act – S3); • Eastern Great Egret (EPBC Act – M; WC Act – S3); • Oriental Plover (EPBC Act – M; WC Act – S3); • Oriental Pratincole (EPBC Act – M; WC Act – S3); • Rainbow Bee-eater (EPBC Act – M; WC Act – S3).	This study was a desktop analysis of terrestrial vertebrate fauna potentially occurring within 100km of a point that was located within the mining tenement E80/3547, which is one of the two tenements the Study Area is situated within. Species lists generated from this study were not included as part of the overall dataset for this study

Figure 8 code	Reference	Study details	Proximity to Study Area	Methods	Habitats	Fauna recorded	Species of conservation significance[1]	Relevant notes
C	Ecotec (2010a)	*Project:* Gardner Range *Client:* Afmeco Mining and Exploration Pty Ltd *Type:* Level 1 flora and fauna survey *Date:* August 2010	As close as approx. 25 km south-west	• Desktop study • Opportunistic sightings during vehicle and foot traverses • Targeted searches	• *Acacia*/*Grevillea* Shrubland • Hummock Grassland • Rocky Outcrop/Hill • Laterite Rise • Drainage Line • Open *Eucalypt* Woodland	69 species of terrestrial vertebrate fauna : • 10 mammal (6 native); • 51 bird; • 6 reptile; • 2 amphibian.	Threatened • Brush-tailed Mulgara (EPBC Act – VU; DEC – Priority 4); • Greater Bilby (EPBC Act – VU; WC Act – S1); • Major Mitchell's Cockatoo (WC Act – S4). Priority • Australian Bustard (DEC – Priority 4); • Spectacled Hare-wallaby (western) (DEC – Priority 3). Migratory • Rainbow Bee-eater (EPBC Act – M; WC Act – S3); • Pictorella Mannikin (DEC – Priority 4).	A Pebble-mound Mouse mound was found and noted as either belonging to the Western Pebble-mound Mouse (DEC Priority 4 Fauna) or the Central Pebble-mound Mouse (*Pseudomys johnsoni* - not of conservation significance). Published distributions suggest the Western Pebble-mound Mouse only occurs within the Pilbara region of Western Australia and not near the Study Area and therefore it is likely that the mound belonged to the Central Pebble-mound Mouse (Van Dyck and Strahan 2008). The record was not included in the dataset for this Study.
D	Ecotec (2008b)	*Project:* Gardner Range *Client:* Afmeco Mining and Exploration Pty Ltd *Type:* Level 1 survey *Date:* June 2008	As close as approx. 25 km south-west	• Opportunistic sightings during vehicle and foot traverses	• Shrubland • Hummock Grassland • Rocky Outcrop • Laterite Rise • Laterite/Stony Hill • Drainage Lines	49 species of terrestrial vertebrate fauna: • 11 mammal (6 native); • 35 bird; • 3 reptile.	Threatened • Greater Bilby (EPBC Act – VU; WC Act – S1); • Major Mitchell's Cockatoo (WC Act – S4). Priority • Australian Bustard (DEC – Priority 4); • Spectacled Hare-wallaby (western) (DEC – Priority 3).	Although none were observed during the survey, several other terrestrial vertebrate fauna of conservation significance were noted as potentially occurring or likely to occur in the area and these were the Woma, Gravel Dragon, Bush Stone-curlew and Western Pebble-mound Mouse.

Figure 8 code	Reference	Study details	Proximity to Study Area	Methods	Habitats	Fauna recorded	Species of conservation significance[1]	Relevant notes
E	Ecotec (2008a)	*Project:* Gardner Range *Client:* Uranio Ltd *Type:* Level 1 survey *Date:* June 2008	Approx. 25 km south	• Opportunistic sightings during vehicle and foot traverses	• Shrubland • Hummock Grassland • Rocky Outcrop • Laterite Rise • Laterite/Stony Hill • Drainage Lines	35 species of terrestrial vertebrate fauna: • 8 mammal (5 native); • 26 bird; • 1 reptile.	Threatened • Greater Bilby (EPBC Act – VU; WC Act – S1); • Major Mitchell's Cockatoo (WC Act – S4). Priority • Australian Bustard (DEC – Priority 4); • Spectacled Hare-wallaby (western) (DEC – Priority 3). Migratory • Rainbow Bee-eater (EPBC Act – M; WC Act – S3).	Although none were observed during the survey, several other terrestrial vertebrate fauna of conservation significance were considered likely to occur in the area and these were the Woma, Gravel Dragon and Bush Stone-curlew. Tree hollows, temporary waterholes, overhangs and crevices were identified as important terrestrial vertebrate fauna habitat.

F	Biota (2005)	*Project:* Western Tanami Project *Client:* Tanami Gold NL *Type:* Fauna habitat and assemblage survey *Date:* September 2004 and June 2005	Approx. 85 km south	• Systematic trapping (pit, cage, funnel and Elliott traps) • Systematic avifauna sampling • Echolocation recording for bats • Targeted searches • Opportunistic sightings	• Savanna • *Triodia* Hillslope • *Triodia* Sandplain • *Triodia* Flat • *Triodia* Dune • Minor Drainage Line	120 species of terrestrial vertebrate fauna: • 18 mammal (14 native); • 58 bird • 43 reptile; • 1 amphibian.	Threatened • Crest-tailed Mulgara (EPBC Act – EN; WC Act – S1); • Greater Bilby (EPBC Act – VU; WC Act – S1); • Major Mitchell's Cockatoo (WC Act – S4). Priority • Australian Bustard (DEC – Priority 4); • Spectacled Hare-wallaby (western) (DEC – Priority 3). Migratory • Oriental Plover (EPBC Act – M; WC Act – S3).	Evidence (burrows, diggings and scats) of the Crest-tailed Mulgara (WC Act – S1), was recorded at a location approximately 70km south of the Browns Range Study Area. It is likely that these burrows, diggings and scats are attributable to the Brush-tailed Mulgara (EPBC Act - VU; DEC P4), and not the Crest-tailed Mulgara (see **Table 16**). Range extensions were recorded for a number of species (Striated Pardalote, Golden-headed Cisticola, Kimberley Pebble-mound Mouse [now considered con-specific with Central Pebble-mound Mouse] and Western Chestnut Mouse) and although none of these species are of conservation significance, this highlights the fact that the biodiversity of the Tanami bioregion is generally under-studied.

[1]See **Appendix G** for full definitions of conservation status

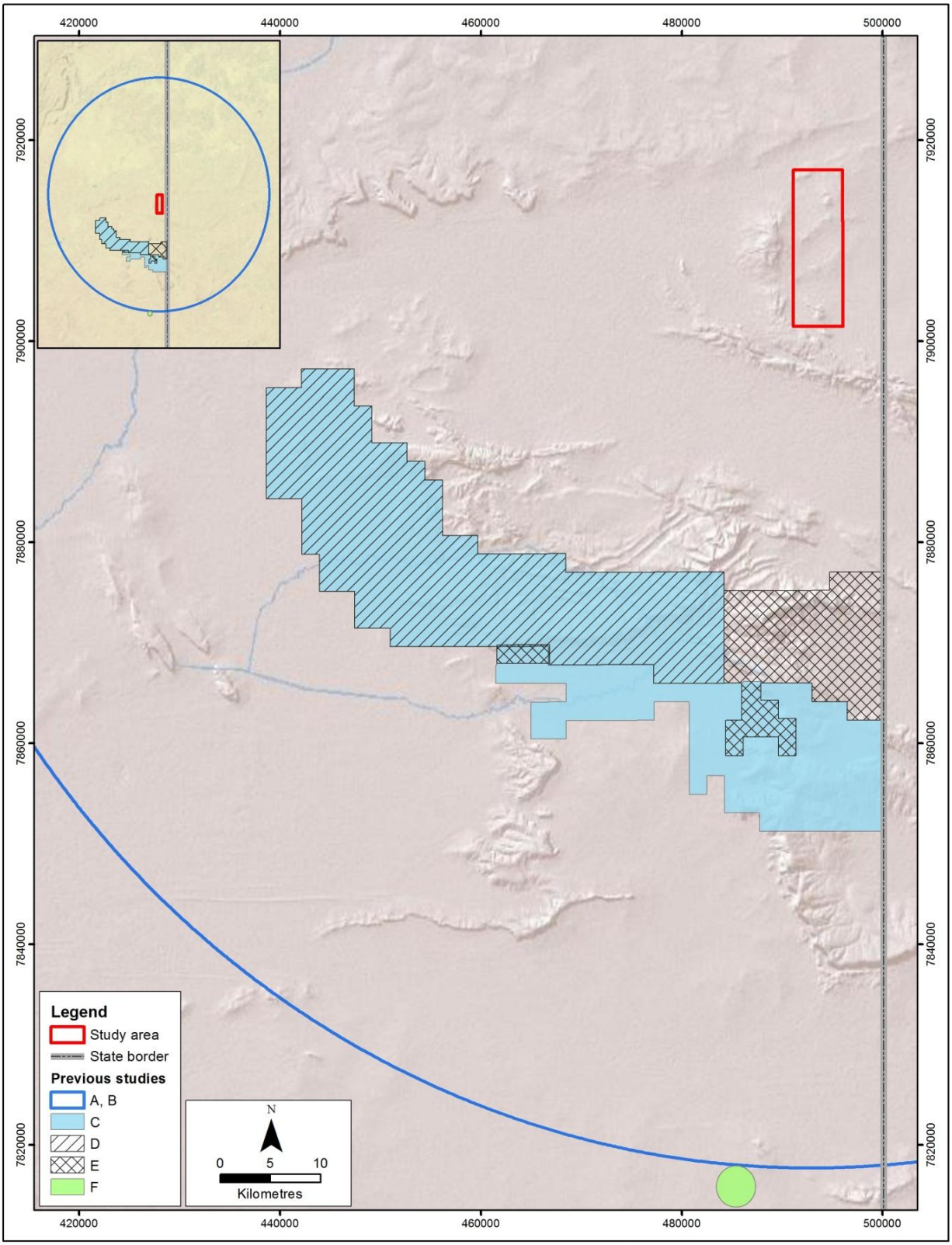

Figure 8: Location of previous surveys undertaken near the Study Area
(Refer to Table 4 for a key to the previous studies)

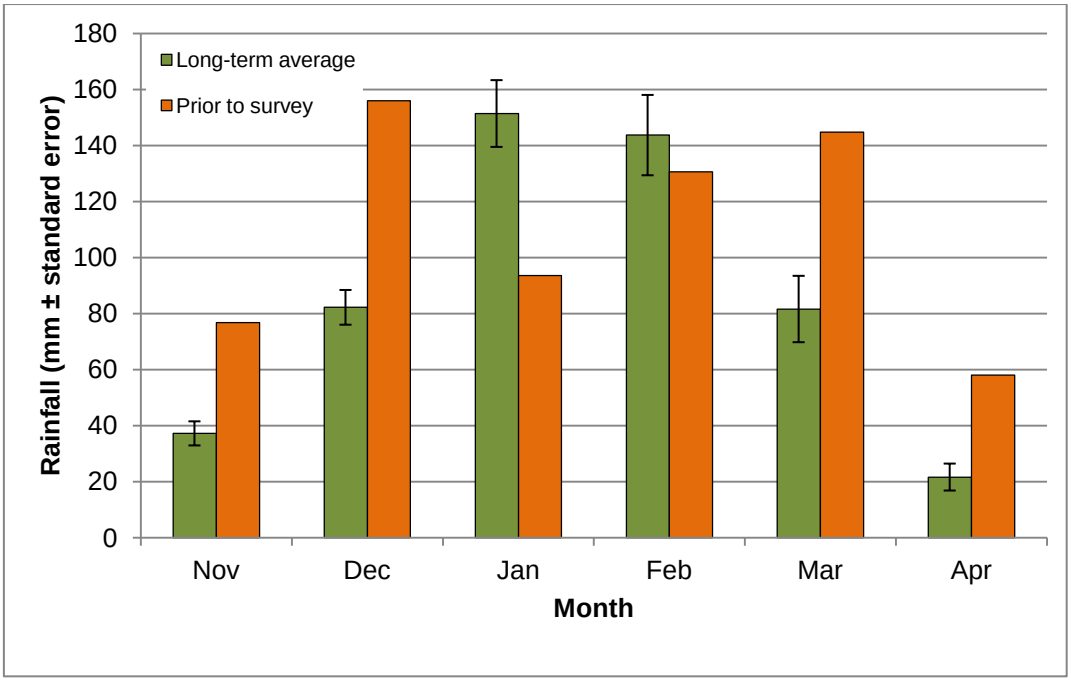

Figure 9: Rainfall at Halls Creek Airport prior to the field survey vs the long-term average

Source: BOM (2012), weather station 002012. 'Prior to' data are from November 2011 to April 2012 (i.e. the six months prior to the May 2012 field survey). 'Long-term' data are from 1944-2012.

4.2. Habitat Assessment and Site Selection

Prior to the field survey, broad habitat types within the Study Area were identified from the literature review and from analysis of aerial imagery and topographical maps. Once in the field, these habitat types were ground-truthed and representative areas were chosen for habitat assessment. The purpose of the habitat assessments was to characterise the quality and complexity of habitat provided for fauna, with a focus on species of conservation significance. The following information was recorded:

- landscape and soil features;
- the presence or absence of logs or other habitat structures;
- vegetation cover, condition and species composition;
- estimate of leaf litter cover percentage and type;
- the presence or absence of water; and
- types and levels of disturbance.

Each of the representative areas was given a rating of excellent, very good, good, moderate, degraded or completely degraded based on the overall condition of the habitat for fauna. Once the broad habitat types were identified and ground-truthed, sites for systematic sampling (**Section 4.3**) were identified. Sites were chosen based on their being characteristic of the major or significant fauna habitats present within the Study Area, their geographic distribution within the Study Area, and their likelihood of hosting species of conservation significance.

It should be noted that fauna habitats were mapped at a broad scale; microhabitats are not likely to be evenly distributed within them and habitat boundaries are likely to be accurate only to within 50 to 100 m. It was not feasible to survey all specialised microhabitats present within the Study Area; however, site selection based upon broad fauna habitats characteristic of the Study Area, or those of particular relevance to conservation significant fauna, provides a valid framework within which to assess species occurrence.

4.3. Systematic Sampling

Within the Study Area, five systematic sites were established(**Figure 10; Appendix B**). The systematic sampling program consisted of trapping (**Section 4.3.1**), systematic hand searching (**Section 4.3.2**), avifauna census (**Section 4.3.3**) and night spotlight searches (**Section 4.3.4**).

4.3.1. Trapping

A standard trapping grid (**Figure 11**), aimed at catching terrestrial mammals, reptiles and amphibians, was established at each site (**Figure 10**). Each trapping grid consisted of two drift fences, which were 40 centimetres (cm) high and 50 metres (m) long, set into the substrate. Two types of pit trap were installed along the drift fences: five standard 20 litre (L) PVC buckets and five PVC pipe traps 15 cm in diameter and 50 cm deep. The pit traps were set flush with the surface of the ground, with the drift fence running across the middle. Ten funnel traps measuring 75 cm x 18 cm x 18 cm were also placed along each drift fence, with one side pressed firmly against the fence. Twenty baited Elliott box traps and two Sheffield cage traps were positioned in two lines on either side of the trap lines. To protect animals from heat stress, traps were placed in as much shade as possible and covered with spinifex, leaf litter or custom shade covers. In bucket and pipe pitfall traps, egg cartons were placed at the bottom to provide shade for captured animals.

All traps were left open over night and checked early the following morning, for seven consecutive nights; therefore the total trapping effort for this field survey was 1,820 trap nights (i.e. one trap open for one night).

4.3.2. Systematic Searches

Systematic searching for vertebrate species was conducted during the day at each site (**Figure 10**) to identify species that are unlikely to be trapped (e.g. diurnal species). Search methods used included identifying active animals, investigating caves and crevices, overturning logs and stones, searching beneath the bark of dead trees, investigating burrows and recording tracks, diggings, scats and observing any other indirect signs.

One systematic search was performed at each site for 1.5 person hours. Therefore, the total systematic searching effort for this field survey was 7.5 person hours.

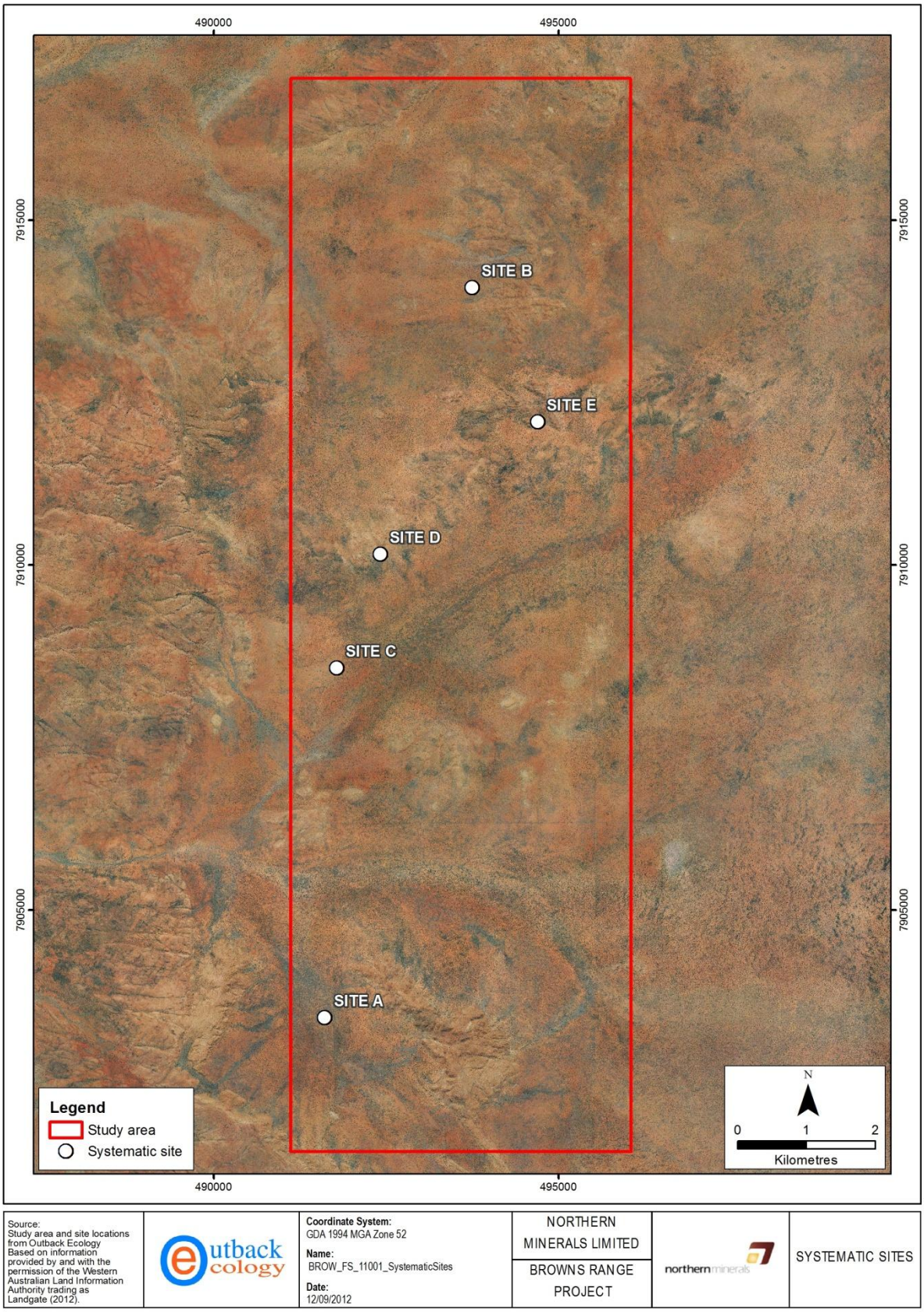

Figure 10: Location of systematic sites within the Study Area

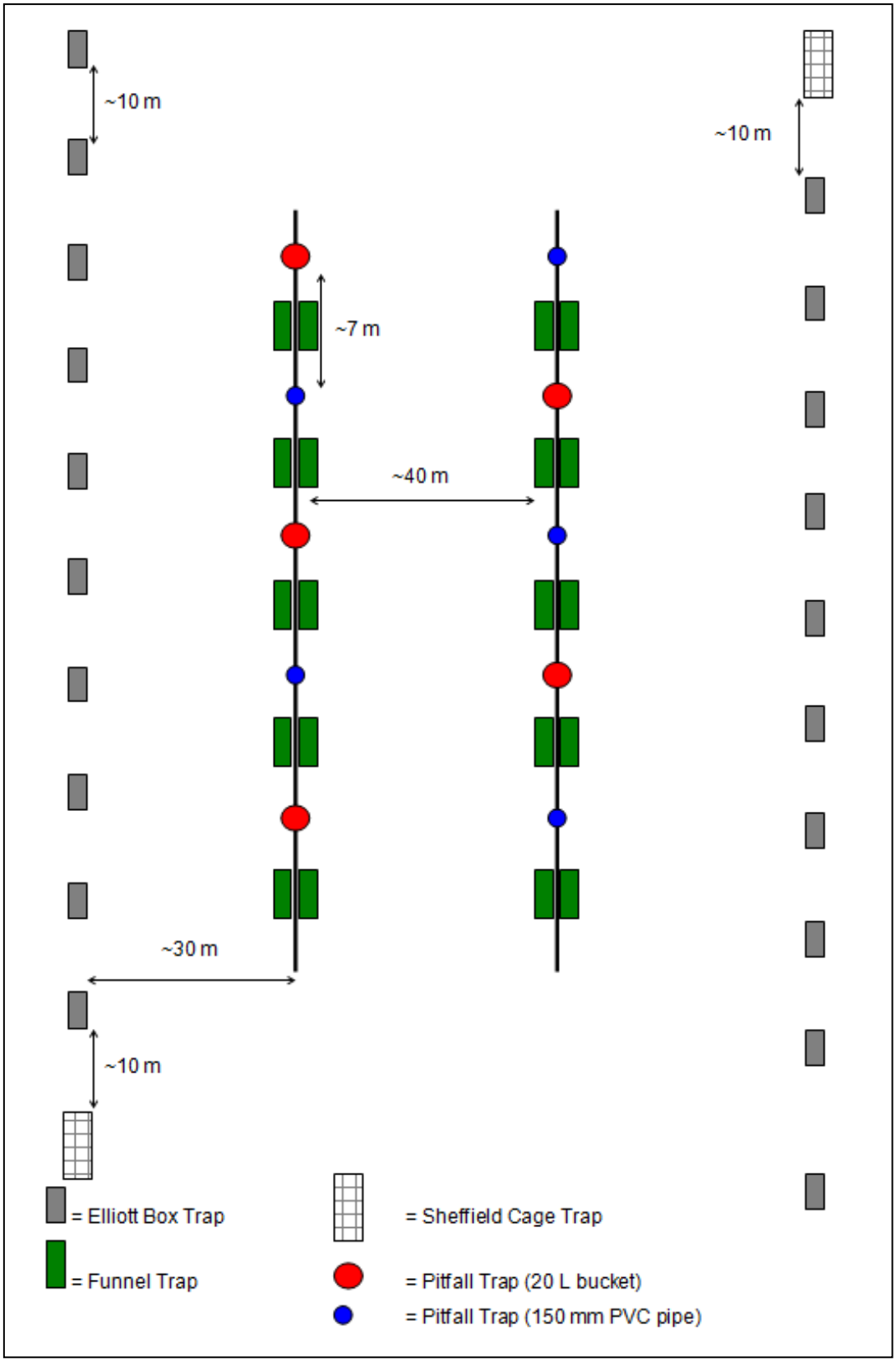

Figure 11: Layout of the standard trapping grid deployed at each systematic sampling site

4.3.3. Avifauna Census

Bird presence was described at each site (**Figure 10**) using avifauna census, which involves the visual and/or aural identification of each bird observed. Avifauna census was carried out as soon after dawn as practicable, with each site being surveyed within two hours of dawn at least three times. The census for each site was limited to the habitat type that contained the trapping grid itself, within 500 m of the grid.

Seven 20-minute avifauna census sessions were conducted at each site (i.e. one per day) and therefore the total avifauna census effort for this field survey was 2.33 person hours.

4.3.4. Spotlighting

Spotlighting, using head torches and hand-held spotlights, was conducted at each site (**Figure 12**) to identify nocturnal species that are unlikely to be trapped, such as the Bush Stone-curlew (*Burhinus* grallarius), Spectacled Hare Wallaby (*Lagorchestes conspicillatus leichardti*), owls, nightjars, and some species of frog and gecko. Additional spotlighting effort was invested when driving along roads and tracks within the Study Area, and records obtained in this way were listed as opportunistic (see **Section 4.6**).

One spotlighting search was performed at each site for a duration of one person hour. Therefore, the total spotlighting effort for this field survey was five person hours.

4.4. Targeted Sampling

Habitats with the potential to support fauna species of conservation significance (species listed under the EPBC Act, the WC Act or DEC's Priority Fauna List) were identified during the desktop study (see **Section 3**) and during field reconnaissance of the Study Area. To increase the likelihood that species of conservation significance were detected within the Study Area, targeted sampling was conducted to assess faunal assemblages in unique habitats that were not covered by systematic sampling methods (**Section 4.3**). Targeted sampling methods used were targeted searches (**Section 4.4.1**), deployment of motion-sensor cameras (**Section 4.4.2**) and deployment of SM2 bat echolocation recorders (**Section 4.4.3**).

4.4.1. Targeted Searches

Targeted searches recorded the presence of fauna species by direct fauna observation as well as by the assessment of indirect fauna signs such as scats, tracks, mammal runways, bat odours and pebble mounds. Five targeted searches were conducted within the Study Area (**Figure 12**, **Table 5**). Each targeted search was of 1.5 person hours duration; therefore, the total targeted search effort for this field survey was 7.5 person hours.

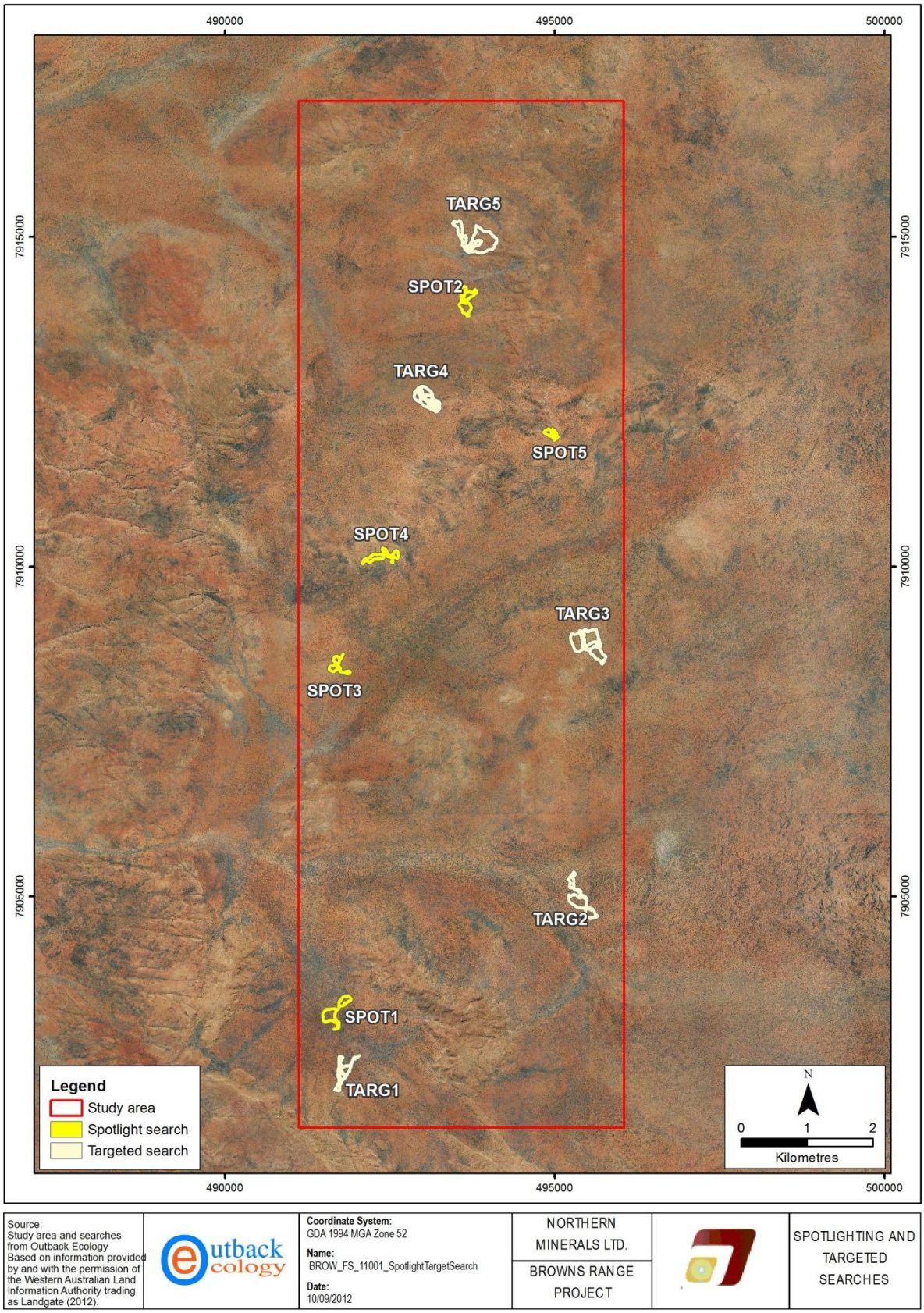

Figure 12: Location of spotlighting and targeted searches within the Study Area

Table 5: Description of targeted search areas within the Study Area

Targeted Search	Location Description
TARG1	Undulating terrain comprising drainage depressions, creekline and small rocky outcrops with mixed grassland and sparsely distributed trees and shrubs
TARG2	Low-lying floodplain habitat comprising tussock grassland with sparsely distributed trees and shrubs
TARG3	Slightly elevated area comprising spinifex grassland over stony ground with small areas of outcropping
TARG4	*Acacia* shrubland and mixed grassland following part of the proposed haul road in the northern section of the Study Area
TARG5	Rocky ridge in the northern end of the Study Area, comprising relatively large (compared with the low-lying plain country covering the majority of the Study Area) hills and ridges

4.4.2. Motion-sensor cameras

Motion-sensor cameras (three Bushnell Trophycam and one Scoutguard SG560P) were used to record the presence of any fauna that are unlikely to be trapped, such as the Bush Stone-curlew (*Burhinus grallarius*), Spectacled Hare Wallaby (*Lagorchestes conspicillatus leichardti*), owls, nightjars, and some species of frog and gecko. Cameras were placed in locations where high levels of fauna activity are expected, such as around burrows and crevices from which fauna may emerge, at the bases of trees, and around water bodies where animals drink or forage. One camera was deployed at each of nine separate locations for two nights, including one at each of the five systematic sites (**Figure 13; Appendix B**).

4.4.3. Targeted Bat Sampling

SM2 echolocation recorders (SongMeter SM2Bat by Wildlife Acoustics) (SM2s) were used to capture information about the presence and activity of bats within the Study Area. SM2s record ultrasonic echolocation bat calls directly onto removable storage media for later analysis. Information about any species was gathered, but techniques were optimised to gather information about bat species of conservation significance, specifically the Ghost Bat (*Macroderma gigas*), which is listed as Priority 4 on the DEC Priority Fauna List.

SM2s were placed in locations comprising potential nesting and foraging areas most conducive to Ghost Bat activity. Where possible, SM2 locations were chosen within or around caves or rocky ridges, as bats are known to shelter in these habitats, or around water bodies where bats drink or forage after emerging from shelter at dusk. An SM2 unit was placed at each of eight locations for two nights, including one at each of the five systematic sites (**Figure 13; Appendix B**).

To identify bat species recorded by the SM2s, echolocation recordings were analysed by Robert Bullen of Bat Call WA Pty Ltd. The timing of echolocation recordings was also considered to gain a better understanding of whether each species detected was using caves in the Study Area as roosting sites, or using the caves intermittently whilst foraging.

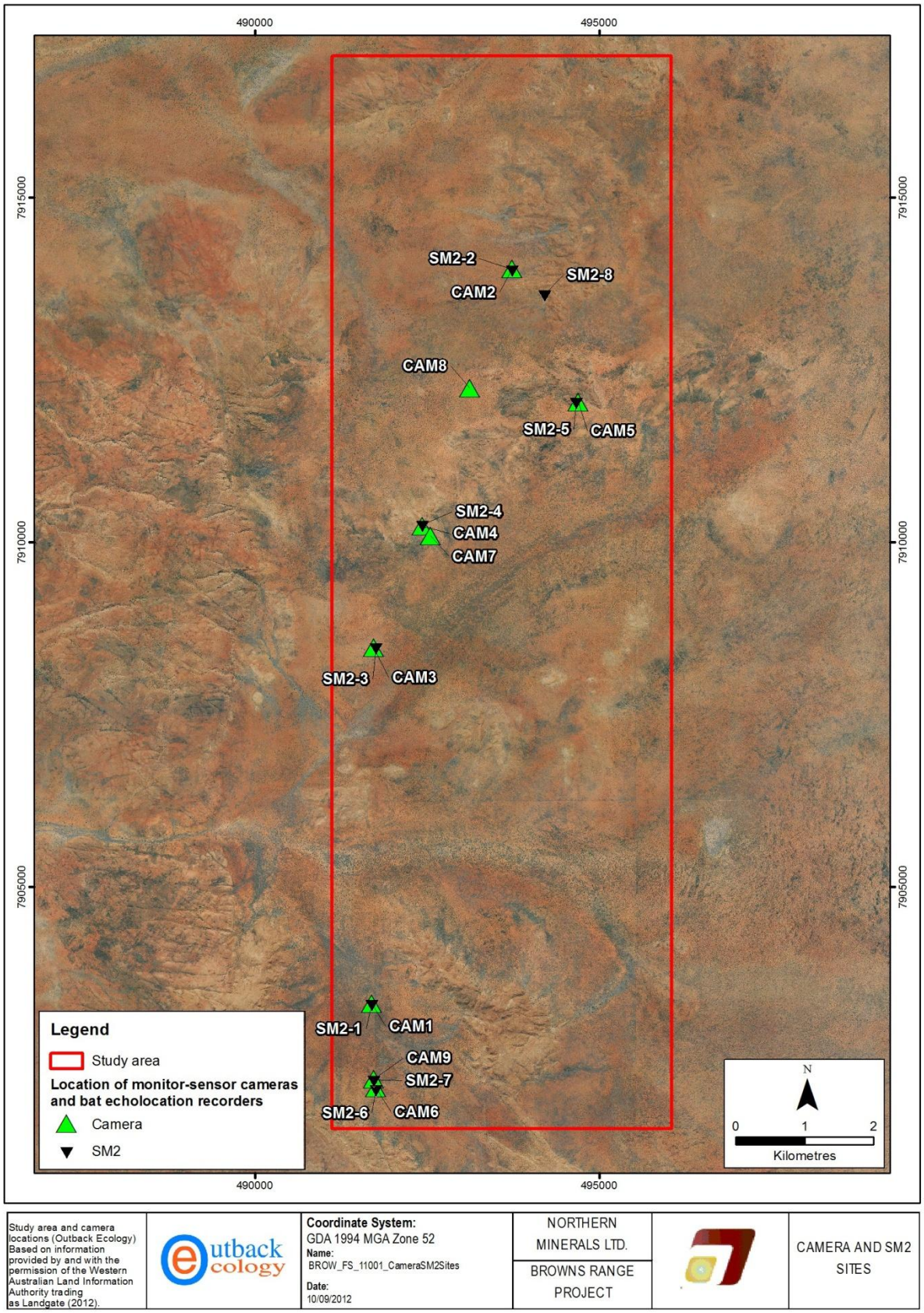

Figure 13: Location of cameras and SM2s within the Study Area

4.5. Targeted Short-range Endemic Invertebrate Fauna Sampling

As part of a separate, short-range endemic (SRE) terrestrial invertebrate survey, Outback Ecology established a series of invertebrate wet pitfall sites within and around the Browns Range Project Study Area (Outback Ecology in prep). Fifteen systematic SRE trapping sites were established within the Study Area and left open for approximately eight weeks between 14 January and 13 March 2012.

At each SRE trapping site, five wet pitfall traps were dug into the ground. Each wet pitfall trap consisted of a plastic container slotted into a buried cylindrical pvc pipe (10 cm x 25 cm). Each container was filled with approximately 500 mL of a preserving agent (100% propylene glycol) and a cover was suspended approximately 2 cm above the trap, to reduce vertebrate by-catch and to limit rain entering the trap. To increase the effectiveness of the pitfall traps, two drift fences (flywire mesh) measuring approximately 75 cm in length and 15 cm in height were set on both sides of each trap. Traps were placed at five to ten metre intervals where possible. For further details of the SRE sampling methodology and survey design, refer to Outback Ecology (in prep).

Although the traps were designed to collect invertebrates, a number of vertebrate specimens were collected as by-catch (**Appendix F**). These specimens have been included as part of the overall vertebrate fauna dataset for this field survey.

4.6. Opportunistic Sampling

Within the Study Area and survey period, vertebrate fauna that were observed outside of the systematic sampling and targeted search programmes were documented and the resulting records were classified as 'opportunistic'. These records may have been generated as a result of direct or indirect fauna observations made:

- before or after the fixed-time active searches or bird censuses;
- during reconnaissance visits to the Study Area;
- during trap line establishment;
- while travelling to and from survey sites; and
- at any other time whilst working in or travelling within the Study Area.

4.7. Taxonomy and Nomenclature

The nomenclature and taxonomy of all mammals, reptiles and amphibians in this report follow the *Checklist of the Vertebrates of Western Australia* (WAM 2009), and that of all birds follow the *Birds Australia Checklist of Australian Birds* (based on Christidis and Boles 2008). Relevant texts, from which information on more recent taxonomic updates and general patterns of distribution are available, were also considered for:

- Non-volant mammals (Menkhorst and Knight 2004, Van Dyck and Strahan 2008);
- Bats (Churchill 2008);
- Birds (Johnstone and Storr 1998, 2004, Morcombe 2003, Pizzey and Knight 2007);
- Reptiles (Cogger 2000, Storr *et al.* 1999, 2002, Wilson and Swan 2010); and
- Amphibians (Cogger 2000, Tyler and Doughty 2009).

4.8. Study Team

The field survey was conducted by qualified staff and subcontractors of Outback Ecology, all with backgrounds in zoology or environmental science (**Table 6**). Echolocation recordings from SM2s were analysed by Robert Bullen, a bat specialist from Bat Call WA Pty Ltd. The field survey was conducted under a Licence to Take Fauna for Scientific Purposes (DEC Regulation 17 Licence) with details as follows:

- licence number SF008474;
- issue date 16 February 2012;
- valid from 31 March 2012; and
- valid to 31 July 2012.

Table 6: Study team for the May 2012 survey of the Browns Range Study Area

Person	Discipline	Qualifications	Position
Mark Gresser	Zoologist	BSc (Hons) Biol. Sci.	Outback Ecology Environmental Scientist
Jen Wilcox	Zoologist	BSc (Hons) Env. Sci.	Sub-contracting Zoologist
Glen Murray	Zoologist	BSc (Hons) Env. Sci.	Sub-contracting Zoologist

5. RESULTS AND DISCUSSION

5.1. Vertebrate Fauna Habitats

Six broad fauna habitat types were identified within the Study Area (**Figure 14**; **Table 7**):

- Open Shrubland over Mixed Grassland on Sandy Plain;
- Drainage Line;
- Hummock Grassland on Rocky Hill;
- Hummock Grassland on Stony Plain;
- *Acacia* Heath over Mixed Grassland on Sandy Plain; and
- Mixed Grassland on Sandy Plain.

The majority of the Study Area ranges from Very Good to Pristine condition (**Appendix C**; Keighery 1994), any disturbance being limited to small areas. Obvious signs of disturbance included introduced fauna (sightings, captures and tracks – see **Section 5.2.5**), vehicle tracks (ranging from very old to recently constructed), a cleared area around a bore at the southern end of the Study Area, and habitats undergoing succession following past fire events. Consistent with the nature of the Coolinde and Winnecke Land Systems (see **Section 2.3**), fire is a common event within the Study Area and surrounding landscape (Burrows *et al.* 2006, Turner *et al.* 2008), and parts of the Study Area (eg around Site C) had experienced fire in the twelve months prior to the field survey (Dave Brinsden, Northern Minerals, pers. comm.).

No habitat types present within the Study Area were considered regionally significant to fauna as all are relatively extensive and well represented outside the Study Area, and all were considered equally important in providing a range of microhabitats for fauna to forage within and find refuge.

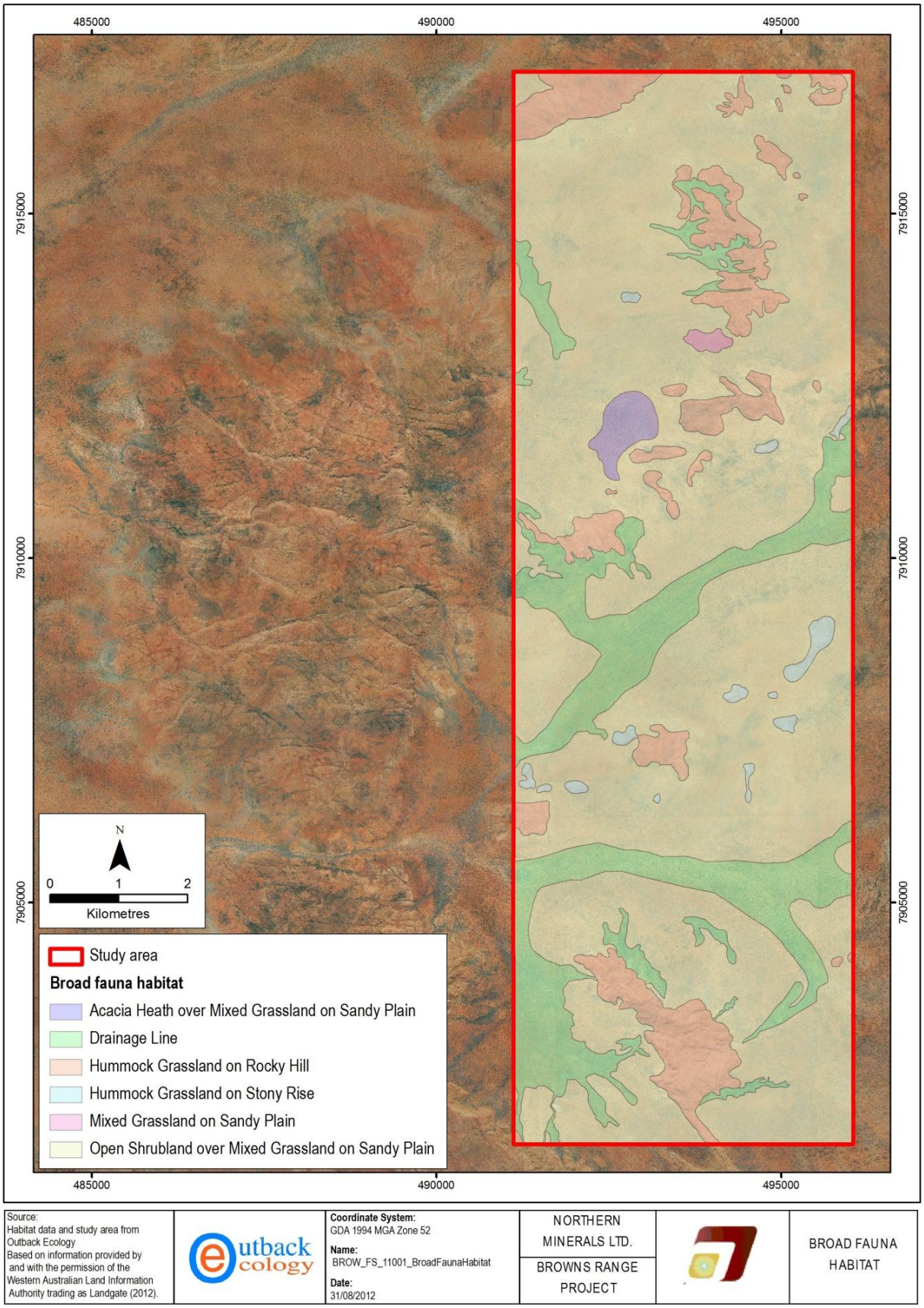

Figure 14: Broad fauna habitat types within the Study Area

Table 7: Habitat assessment summary for broad fauna habitat types within the Study Area

Fauna habitat	References	Extent[1]	Survey effort	Vegetation features			Physical features
				Upper stratum	Middle stratum	Lower stratum	
Open Shrubland over Mixed Grassland on Sandy Plain	**Figure 14 Plate 1 Plate 2[2] Appendix D**	5,532 ha 72%	• Systematic sampling at Site B and Site C (trapping, avifauna census, spotlighting [SPOT2, SPOT3] and systematic searches) • Targeted searches (part of TARG1) • Motion-sensor cameras (CAM2, CAM3 and CAM7) • SM2s (SM2-2 and SM2-3)	Areas of no upper stratum, otherwise sparsely distributed *Eucalyptus/Corymbia* spp. up to 8 m high, with up to 15% cover	Typically *Acacia* spp. up to 3 m high, with up to 80% cover (typically around 40%); but some areas (eg around Site C) with notable proportion of *Hakea* sp.	Tussock and hummock grasses, and low *Acacia* spp. up to 1.5 m high, with up to 80% cover	Fine red/brown loamy sand subject to water logging. No exposed bedrock. Landform typically flat
				Other comments: Comprises the greatest proportion of the Study Area and is well represented in the surrounding landscape (*Acacia* shrubland is a common feature within the Coolinde land System - see **Section 2.3**). Generally undisturbed with camel tracks around Site C the only sign of feral animals. Clear evidence of fire, with burnt standing shrubs common throughout. Form of vegetation varies depending on elevation (and therefore proximity to drainage lines) and time since fire. Taller, more densely growing (compared with other parts of the habitat type) shrubs occur in lower areas that transition into Drainage Line habitat (**Plate 1**), whereas more sparsely distributed shrubs are more common with increasing distance away from Drainage Line habitat (**Plate 2**). An abundance of young shrubs and trees are common in areas more recently affected by fire. Taller shrubs provide opportunity for nest building by birds, and refuge for other arboreal fauna, while the grasses and smaller shrubs offer cover to ground-dwelling fauna.			
Drainage Line	**Figure 14 Plate 3 Plate 4 Plate 5[2] Appendix D**	1,214 ha 16%	• Systematic sampling at Site A (trapping, avifauna census, spotlighting [SPOT1] and systematic searches) • Targeted searches (TARG2, part of TARG1) • Motion-sensor cameras (CAM1, CAM6, CAM9) • SM2s (SM2-1, SM2-6, SM2-7)	Typically eucalypts up to 8 m high, with up to 20% cover, otherwise tall shrubs up to 4 m high, with up to 40% cover	*Acacia* sp. and young eucalypts up to 3 m high, with up to 30% cover	Tussock grasses up to 1 m high, with up to 100% cover	Fine brown loamy sand subject to water logging. No exposed bedrock. Landform low lying flats/floodplain. One instance of well-defined watercourse (creek)
				Other comments: Occurs as large swathes across the Study Area, with smaller drainage lines common at the base of the Hummock Grassland on Rocky Hill habitat type. Well represented in the surrounding landscape (shallow, widely-spaced drainage lines are common features within the Coolinde Land System – see **Section 2.3**). Generally undisturbed with no evidence of introduced fauna; however, one obvious flow line in the southern end of the Study Area has been filled as part of track construction. Majority of habitat type contains damp soils and is likely to be inundated in the wet season. Bent grasses and accumulation of vegetation debris against trees shows evidence of flowing water. No signs of erosion and only one instance of a well-defined watercourse: a creek in the southwest corner of the Study Area (**Plate 5**). Contains the greatest abundance of large trees of all the habitat types within the Study Area. Form of vegetation varies depending on elevation (and therefore proximity to main drainage line) – relatively densely treed areas with sparsely distributed middle storey shrubs are typical in lower areas directly around the main drainage line (**Plate 3**); relatively densely growing (compared with the rest of the Study Area) large shrubs (typically *Acacia* spp.) replace large trees as the dominant upper storey vegetation further away from the main drainage line (**Plate 4**); and habitat transitions into Open Shrubland over Mixed Grassland on Sandy Plain habitat with increasing distance away from main drainage line. Wide variety of microhabitats are present throughout, including fallen logs and other coarse woody debris; piles of leafy matter accumulated around the bases of tree trunks; shrubs and dense grass; and large trees that may contain hollows.			
Hummock Grassland on Rocky Hill	**Figure 14 Plate 6 Appendix D**	767 ha 10%	• Systematic sampling at Site D and Site E (trapping, avifauna census, spotlighting [SPOT4, SPOT5] and systematic searches) • Targeted search (TARG5) • Motion-sensor cameras (CAM4, CAM5) • SM2s (SM2-4, SM2-5, SM2-8)	Areas of no upper stratum, otherwise sparsely distributed eucalypts up to 7 m high, with up to 5% cover	Areas of no middle stratum, other *Acacia* spp. and young eucalypts up to 4 m high, with up to 30 % cover (typically around 5 %)	*Triodia* sp. up to 1 m high, with up to 60% cover	Red sand with rocks throughout and areas of exposed bedrock. Landform typically low hills, though steeper sections and small breakaways sometimes present
				Other comments: Occurs in isolated patches throughout the Study Area, with more extensive patches occurring towards the northern end. Corresponds with the Winnecke Land System (see **Section 2.3**), which is well-represented throughout the surrounding landscape. Generally undisturbed and in very good condition with camel tracks around Site D, the only sign of feral animals. Some parts (eg around Site D) have been recently burnt (≤ two years previously), reducing the abundance of larger, older *Triodia* hummocks that are relied upon by fauna for cover from predators. Fire however, can play an important role in developing the quality of this habitat type by creating a mosaic of fire ages, where newly burnt habitats can be important for foraging, while long unburnt areas can be important for shelter and breeding (Parr and Andersen 2006, Southgate *et al.* 2007, Woinarski 1999).			
Hummock Grassland on Stony Rise	**Figure 14 Plate 7**	76 ha 1%	• Targeted search (TARG3)	Areas of no upper stratum, otherwise sparsely distributed eucalypts up to 7 m high, with up to 5% cover	Areas of no middle stratum, otherwise young eucalypts up to 3 m high, with up to 10 % cover	*Triodia* sp. up to 1 m high, with up to 50% cover	Red-brown sand with stones throughout. Few areas of exposed bedrock. Landform low rise
				Other comments: Occurs in small isolated patches throughout the Study Area, comprising gently sloping rises covered by small rocks but with very limited outcropping. Systematic sites were not established within this habitat type as the habitat was of limited extent within the Study Area and it is likely that fauna species utilising this habitat type would also utilise similar areas (such as lower slopes) of the Hummock Grassland on Rocky Hill habitat type.			
Acacia Heath Over Mixed Grassland On Sandy Plain	**Figure 14 Plate 8**	67 ha <1%	• Targeted search (TARG4) • Motion-sensor camera (CAM8)	Generally no upper stratum, otherwise scattered eucalypts up to 8 m high, with up to 5% cover	Generally no middle stratum, though young eucalypts up to 3 m high are occasional	Hummock and tussock grasses, and *Acacia* sp. up to 1.5 m high, with up to 100% cover	Fine brown loamy sand. No exposed bedrock. Landform flat
				Other comments: Occurs in one part of the Study Area. The low, dense cover provided to fauna by vegetation within this habitat type is unique within the Study Area. Evidence of native fauna activity included numerous diggings and small burrows at the base of shrubs. Systematic sites were not established within this habitat type as the habitat was of limited extent within the Study Area and it is likely that fauna species utilising this habitat type would also utilise areas of the Open Shrubland over Mixed Grassland on Sandy Plain habitat type.			
Mixed Grassland On Sandy Plain	**Figure 14 Plate 9**	16 ha <1%	• No systematic targeted search methods were employed as this habitat type is of limited extent within the Study Area and considered unlikely to support a faunal assemblage different from that of other habitat types,	Generally no upper stratum, otherwise scattered eucalypts up to 10 m high, with up to 5% cover	No middle stratum	Typically tussock grasses, but also hummock, up to 2 m high, with up to 100% cover	Fine brown loamy sand subject to water logging. No exposed bedrock. Landform typically flat
				Systematic sites were not established within this habitat type as the habitat was of limited extent within the Study Area and it is likely that fauna species utilising this habitat type would also utilise grassy areas of the Drainage Line and Open Shrubland over Mixed Grassland on Sandy Plain.			

[1]Area (hectares) and proportion of Study Area; [2]Multiple plates have been included to show the variation within the broad habitat types occurring within the Study Area

Plate 1: Open Shrubland over Mixed Grassland on Sandy Plain
(1 of 2)

Plate 2: Open Shrubland over Mixed Grassland on Sandy Plain
(2 of 2)

Plate 3: Drainage Line
(1 of 3)

Plate 4: Drainage Line
(2 of 3)

Plate 5: Creek within Drainage Line habitat
(3 of 3)

Plate 6: Hummock Grassland on Rocky Hill

Plate 7: Hummock Grassland on Stony Rise

Plate 8: *Acacia* Heath over Mixed Grassland on Sandy Plain

Plate 9: Mixed Grassland on Sandy Plain

5.2. Vertebrate Fauna Assemblages

A total of 317 vertebrate species – including 41 mammals (33 of which are native), 185 birds, 78 reptiles and 13 amphibians – was identified by the database searches and literature review as potentially occurring within the Study Area (**Table 8**, **Appendix A**). Of this total, the database searches identified 298 species, and the literature review identified 152 species, with substantial overlap between the two subsets (**Table 8**). This field survey recorded 122 species (**Table 8**). Of the 122 species recorded during the field survey, 12 species were not identified by the literature review or database searches as potentially occurring within the Study Area, including five mammals (see **Section 0**), one bird (see **Section 1.1.1**), five reptiles (see **Section 5.2.3**) and one amphibian (see **Section 0**). Therefore, this field survey recorded approximately 35% of the total number of species identified by the database searches and literature review as potentially occurring within the Study Area, and has increased the potential species for the Study Area from 317 to 329 species.

Table 8: Summary of vertebrate species recorded within and around the Study Area

Fauna	This study	Previous surveys	Database searches	Studies and databases	Total[1]
Native Mammals	19	18	31	32	37
Introduced Mammals	5	6	9	9	9
Birds	61	81	183	185	186
Reptiles	34	45	62	78	83
Amphibians	3	3	13	13	14
Total Native Fauna	**117**	**146**	**289**	**308**	**320**
Total Fauna	**122**	**152**	**298**	**317**	**329**

[1]Total number of species recorded during this field survey, previous studies and database searches

5.2.1. Mammals

The database searches and literature review identified 41 mammal species (32 of which are native) that potentially occur within the Study Area (**Table 8**, **Appendix A**). This Study recorded 24 mammal species during the field survey (19 of which are native); one of these, the Lakeland Downs Mouse (*Leggadina lakedownensis*), is of conservation significance (see **Section 5.3** for more information about this species). Of the 24 mammal species identified during the field survey, eight were bat species that were detected from recordings obtained from SM2 bat echolocation devices (**Appendix E**).

The number of mammal species recorded during this field survey is greater than that for all previous surveys considered in the literature review, including one survey (Biota 2005) that utilized a greater trapping effort and similar sampling techniques within similar habitats to this survey.

Of the 24 mammals species identified during the field survey, five were not identified by the database searches and literature review as potentially occurring within the Study Area. These were four bats and one dasyurid (carnivorous marsupial):

- Northern Freetail-bat (*Chaerephon jobensis*);
- Beccari's Freetail-bat (*Mormopterus beccarii*);
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*);
- Hill's Sheathtail-bat (*Taphozous hilli*); and
- Ooldea Dunnart (*Sminthopsis ooldea*).

The presence of the four bat species within the Study Area was not considered unusual as they comprise the local Tanami Desert bat community (see **Appendix E**) and the Study Area lies either within (for the Northern Freetail-bat, Beccari's Freetail-bat and Yellow-bellied Sheathtail-bat) or near the edge of (for Hill's Sheathtail-bat) their published distributions (Churchill 2008, Van Dyck and Strahan 2008). For the Ooldea Dunnart, along with another mammal species – the Fat-tailed Antechinus (*Pseudantechinus macdonnellensis*) – records within the Study Area occur well outside their respective published distributions and therefore may represent potential range extensions (**Table 9**).

A total of 201 native mammal observations were recorded during the field survey and the majority (77%) of these were from systematic sampling methods (**Appendix F**). The most commonly observed mammal species was the Western Chestnut Mouse (*Pseudomys nanus*), for which there were 36 records. Three native mammal species were recorded only once during the field survey. These were the Delicate Mouse (*Pseudomys delicatulus*), Beccari's Freetail-bat (*Mormopterus beccarii*) and Hill's Sheathtail-bat (*Taphozous hilli*). The greatest number of mammal species and mammal observations were recorded within the Open Shrubland over Tussock Grassland on Sandy Plain habitat type (**Table 10**).

Table 9: Potential range extensions for mammal species recorded within the Study Area

	Ooldea Dunnart (*Sminthopsis ooldea*)	**Fat-tailed Antechinus (*Pseudantechinus macdonnellensis*)**
Distribution[1]	Central and mid-western Australia (but not as far northwest as the Study Area)	Central Australia (but not as far northwest as the Study Area)
Typical habitat[1]	Mulga shrublands and woodlands over tussock grassland	Rocky hills and breakaways, and red sandplains like the Tanami Desert
Closest Record[2]	Approx. 680 km southwest of the Study Area at Clutterbuck Hills in the Gibson Desert (2007) (DEC 2012b)	Approx. 75 km south of the Study Area at Coomarie Springs, NT (1981) (NRETAS 2012). Closest WA record is approx. 80 km south of the Study Area (2004) (DEC 2012b)
Broad fauna habitat	Drainage Line and Open Shrubland over Tussock Grassland on Sandy Plain	Hummock Grassland on Rocky Hill
Number of observations	Six captures	15 captures and one sighting during a spotlighting search

[1]Sources include Van Dyck and Strahan (2008) and Menkhorst and Knight (2004); [2]Based on information available from the database searches and literature review conducted as part of the desktop study, and an additional and search of the NatureMap database (DEC 2012b)

Table 10: Mammal species richness and abundance within the Study Area

Habitat type	**No. of species recorded**	**Relative abundance[1]**
Drainage Line	5	18
Hummock Grassland on Rocky Hill	7	16
Open Shrubland over Tussock Grassland on Sandy Plain	8	55

[1]Total abundance divided by the number of systematic sampling sites within each habitat type; NB – table includes trapping data only

5.2.2. Birds

The database searches and literature review identified 185 bird species that potentially occur within the Study Area (**Table 8**, **Appendix A**). The field survey recorded 61 bird species and one of these, the Bush Stone-curlew (*Burhinus grallarius*), was not identified by the database searches and literature review as potentially occurring within the Study Area. This species is discussed further in **Section 5.3**.

Of the 61 bird species recorded during the field survey, four are of conservation significance: the Major Mitchell's Cockatoo (*Lophochroa leadbeateri*), Australian Bustard (*Ardeotis australis*), Bush Stone-curlew (*Burhinus grallarius*) and Rainbow Bee-eater (*Merops ornatus*) (see **Section 5.3** for more information about these species). The number of bird species recorded during the field survey is greater than that of all previous surveys considered in the literature review, including one survey (Biota 2005) that utilized a greater trapping effort and similar sampling techniques within similar habitats to this survey.

A total of 1,550 bird observations were recorded during the field survey and the majority (82%) of these were from systematic sampling methods (**Appendix F**). The most commonly observed bird species was the Budgerigar (*Melopsittacus undulatus*), for which there were 328 records. Six bird species were recorded only once during the field survey: Brown Goshawk (*Accipiter fasciatus*), Spotted Harrier (*Circus assimilis*), Black-breasted Buzzard (*Hamirostra melanosternon*), Horsfield's Bushlark (*Mirafra javanica*), Little Crow (*Corvus bennetti*) and Australian Hobby (*Falco longipennis*). The greatest number of bird species and bird observations were recorded within the Open Shrubland over Tussock Grassland on Sandy Plain habitat type (**Table 11**).

Table 11: Bird species richness and abundance within the Study Area

Habitat type	No. of species recorded	Relative abundance[1]
Drainage Line	46	265
Hummock Grassland on Rocky Hill	50	206
Open Shrubland over Tussock Grassland on Sandy Plain	62	301

[1]Total abundance divided by the number of systematic sampling sites within each habitat type; NB – table includes avifauna census data only

5.2.3. Reptiles

The database searches and literature review identified 78 reptile species that potentially occur within the Study Area (**Table 8**, **Appendix A**). The field survey recorded 34 reptile species, none of which are of conservation significance.

Of the 34 reptile species recorded during the field survey, five were not identified by the database searches or literature review as potentially occurring within the Study Area: the Inland Snake-eyed Skink (*Cryptoblepharus australis*), Shine's Whipsnake (*Demansia shinei*), Northern Spotted Rock Dtella (*Gehyra nana*), Northern Soil-crevice Skink (*Proablepharus tenuis*) and Rosen's Snake (*Suta fasciata*).

For the Shine's Whipsnake, Northern Spotted Rock Dtella and Northern Soil-crevice Skink, along with 13 other reptile species observed during the field survey, the Study Area lies on the edge of or just outside published distributions (DEC 2012b, Storr *et al.* 1999, 2002, Wilson and Swan 2010) (**Table 12**). The presence of these species within the Study Area was not considered unusual as the Study Area is located in an area of overlap between typically arid inland species and more northern tropical species; however, it is important to note that for these species, the populations within the Study Area potentially represent the outside extent of their known distribution. Also noteworthy is that the distribution of the North-eastern Orange-tailed Slider (*Lerista orientalis*) extends far across the northern Northern Territory, but its distribution within Western Australia is restricted to a very small area in which the Study Area is situated. Consequently, individuals of this species within the Study Area are likely part of only a small number of populations present within Western Australia.

For the remaining two species that were recorded during the field survey but not identified by the database searches or literature review as potentially occurring within the Study Area (the Inland Snake-eyed Skink and Rosen's Snake), records within the Study Area occur well outside published distributions and therefore may represent range extensions (**Table 13**).

Table 12: Reptile species for which the Study Area lies close to the edge of published distributions

Common name	Species name
Long-nosed Dragon	*Amphibolurus longirostris*
Northern Shovel-nosed Snake	*Brachyurophis roperi*
Shaded-litter Rainbow-skink	*Carlia munda*
Grand Ctenotus	*Ctenotus grandis*
Spotted-necked Ctenotus	*Ctenotus greeri*
Clay-soil Ctenotus	*Ctenotus helenae*
Bar-shouldered Ctenotus	*Ctenotus inornatus*
Robust Ctenotus	*Ctenotus robustus*
Shine's Whipsnake	*Demansia shinei*
Northern Spotted Rock Dtella	*Gehyra nana*
North-western Sandslider	*Lerista bipes*
North-eastern Orange-tailed Slider	*Lerista orientalis*
Dwarf Bearded Dragon	*Pogona minor minor*
Thorny Devil	*Moloch horridus*
Northern Soil-crevice Skink	*Proablepharus tenuis*
Pygmy Desert Monitor	*Varanus eremius*

Sources: DEC (2012b), Storr *et al.* (1999, 2002), Wilson and Swan (2010)

While the number of reptile species recorded during the field survey is greater than that of three out of the four previous surveys considered in the literature review; it is lower than that of one previous survey (Biota 2005) that utilized a greater trapping effort and similar sampling techniques within similar habitats to this survey. This is possibly because this previous survey including September sampling when warmer temperatures (compared with the May survey period of this field survey – see **Figure 4**) are more conducive to reptile activity. Indeed, the majority of reptile species recorded by Biota (2005) were observed during its September sampling period rather than its June sampling period, and the September sampling period experienced warmer temperatures and more rainfall than this field survey.

Table 13: Potential range extensions for reptile species recorded within the Study Area

	Inland Snake-eyed Skink (*Cryptoblepharus australis*)	**Rosen's Snake (*Suta fasciata*)**
Distribution[1]	South-eastern WA, southern NT, most of SA and most inland areas of eastern Australia	Endemic to WA. Pilbara to southern wheatbelt, east to Gibson Desert
Typical habitat[1]	Arboreal habitats in arid Australia	Shrubland and woodland over sandy to loamy (often stony) soil
Closest Record[2]	Approx. 630 km south of the Study Area at Kutjuntari Rockhole in the Walter James Range (2006) (DEC 2012b)	Approx. 780 km southwest of the Study Area at the Gibson Desert Nature Reserve (1993) (DEC 2012b)
Broad fauna habitat	Unknown	Open Shrubland over Mixed Grassland on Sandy Plain
Number of observations	One capture by SRE wet pitfall trapping	One capture

[1]Sources: Storr *et al.* (2002) and Wilson and Swan (2010); [2]Based on information available from the database searches and literature review conducted as part of the desktop study, and an additional and search of the NatureMap database (DEC 2012b)

A total of 204 reptile observations were made during the field survey and the majority (77%) of these, were from systematic sampling methods (**Appendix F**). The most commonly observed reptile species was the Robust Ctenotus (*Ctenotus robustus*) for which there were 98 records. The greatest number of reptile species was recorded within the Open Shrubland over Tussock Grassland on Sandy Plain habitat type, whereas the greatest number of reptile observations was recorded within the Drainage Line habitat type (**Table 14**). The high number of reptile observations within the Drainage Line habitat type is largely attributable to high capture numbers for the Robust Ctenotus (66 observations). Thirteen reptile species were recorded only once during the field survey: Long-nosed Dragon (*Amphibolurus longirostris*), Ring-tailed Dragon (*Ctenophorus caudicinctus*), Thorny Devil (*Moloch horridus*), Northern Shovel-nosed Snake, Orange-naped Snake (*Furina ornata*), Rosen's Snake, Spiny-tailed Gecko (*Strophurus ciliaris*), Inland Snake-eyed Skink, Grand Ctenotus (*Ctenotus grandis*), Spotted-necked Ctenotus (*Ctenotus greeri*), Coarse Sands Ctenotus (*Ctenotus piankai*), North-western Sandslider (*Lerista bipes*) and Common Dwarf Skink (*Menetia greyii*).

Table 14: Reptile species richness and abundance within the Study Area

Habitat type	No. of species recorded	Relative abundance[1]
Drainage Line	9	83
Hummock Grassland on Rocky Hill	13	12
Open Shrubland over Tussock Grassland on Sandy Plain	17	26

[1]Total abundance divided by the number of systematic sampling sites within each habitat type; NB – table includes trapping data only

5.2.4. Amphibians

The database searches and literature review identified 14 amphibian species that potentially occur within the Study Area (**Appendix A**). The field survey recorded three amphibian species, none of which is of conservation significance. Furthermore, no amphibian species of conservation significance is known from the Tanami 1 sub-bioregion, which encompasses the Study Area (ANRA 2009a, ANRA 2009b, Graham 2001).

Of the three amphibian species recorded during the field survey, one was not identified by the database searches or literature review as potentially occurring within the Study Area: the Long-footed Frog (*Cyclorana longipes*). This species occurs in the Kimberley region of Western Australia and northern Northern Territory, and although it is usually recorded further north than the Study Area, it has been recorded several times further south. The closest record is located approximately 160 km southwest of the Study Area (DEC 2012b, Tyler and Doughty 2009).

The number of amphibian species recorded during the field survey is greater than that of all previous surveys considered in the literature review, including one survey (Biota 2005) that utilized a greater trapping effort and similar sampling techniques within similar habitats to this survey.

The three amphibian species recorded during the field survey were all recorded as part of the targeted short-range endemic invertebrate fauna sampling component of the survey (see **Section 4.5**), from which four separate amphibian observations were made: one individual of the Long-footed Frog, two individuals of the Desert Tree Frog (*Litoria rubella*) and one individual of the Northern Toadlet (*Uperoleia borealis*) (**Appendix F**). A lack of rainfall during and immediately prior to the field survey is likely responsible for the fact that other sampling methods did not detect amphibians within the Study Area.

5.2.5. Introduced Fauna

The field survey recorded five species of introduced fauna: European Cattle (*Bos taurus,* one individual seen), Dromedary camel (*Camelus dromedaries,* numerous tracks found), Dog (*Canis lupis,* up to two individuals seen), Cat (*Felis catus,* several tracks observed) and House Mouse (*Mus musculus,* numerous individuals trapped) (**Appendix A**).

The database searches and literature review indicate that a further four introduced species potentially occur within the Study Area: Donkey (*Equus asinus*), Rabbit (*Oryctolagus cuniculus*), Pig (*Sus scrofa*) and Fox (*Vulpes vulpes*) (**Appendix A**). With the exception of European Cattle (*Bos taurus*), the Cat (*Felis catus*) and the House Mouse (*Mus musculus*) – all of these species are listed as 'Declared Animals' under the *Agriculture and Related Resources Protection Act 1976* (WA), which calls for reductions in their numbers when they are running wild or feral. The Cat, the House Mouse, and European Cattle are excluded from declaration, as specific management programmes exist that outline the areas and conditions under which controls may be applied.

5.3. Fauna of Conservation Significance

Five species of conservation significance were encountered during the field survey (one mammal and four birds) and a total of 21 observations of conservation significant species were recorded (**Table 15**, **Figure 15**, **Appendix H**). The most commonly observed conservation significance species was the Australian Bustard (seven observations), whilst the least commonly observed was the Rainbow Bee-eater (two observations) (**Table 15**).

Of the five species of conservation significance recorded during the field survey, one was not identified by database searches and the literature review as potentially occurring within the Study Area: the Bush Stone-curlew (*Burhinus grallarius*). Four sets of tracks of the Bush Stone-curlew were observed within the Study Area, three within Open Shrubland over Mixed Grassland on Sandy Plain habitat (including two at Site B and one at Site A) and one within an area of the Hummock Grassland on Rocky Hill habitat type that transitions into sandy plain habitat (near Site D). The Study Area lies within the known distribution of the Bush Stone-curlew and contains suitable habitat of open woodland, sparse grass and sandplains with hummock grass (Pizzey and Knight 2007). The online NatureMap database search tool indicates there have been previous records of the species as close as approximately 110 km south of the Study Area (DEC 2012b).

Table 15: Conservation significant vertebrate fauna observed within the Study Area

Common name (Scientific name)	Number of records	Nature of records	Conservation status	
			EPBC Act[1]	In WA[2]
Major Mitchell's Cockatoo (*Lophochroa leadbeateri*)	5	Sighted		S4
Lakeland Downs Mouse (*Leggadina lakedownensis*)	3	Trapped		P4
Australian Bustard (*Ardeotis australis*)	7	Sighted		P4
Bush Stone-curlew (*Burhinus grallarius*)	4	Tracks found		P4
Rainbow Bee-eater (*Merops ornatus*)	2	Sighted	M	S3

[1]Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* – M (Migratory). [2] Status under the Western Australian Wildlife Conservation Act 1950 –S3 (Schedule 3 - Migratory birds), S4 (Schedule 4 – Specially Protected Fauna); or the DEC Priority Fauna List – P4 (Priority 4). See Appendix G for full definitions of conservation status

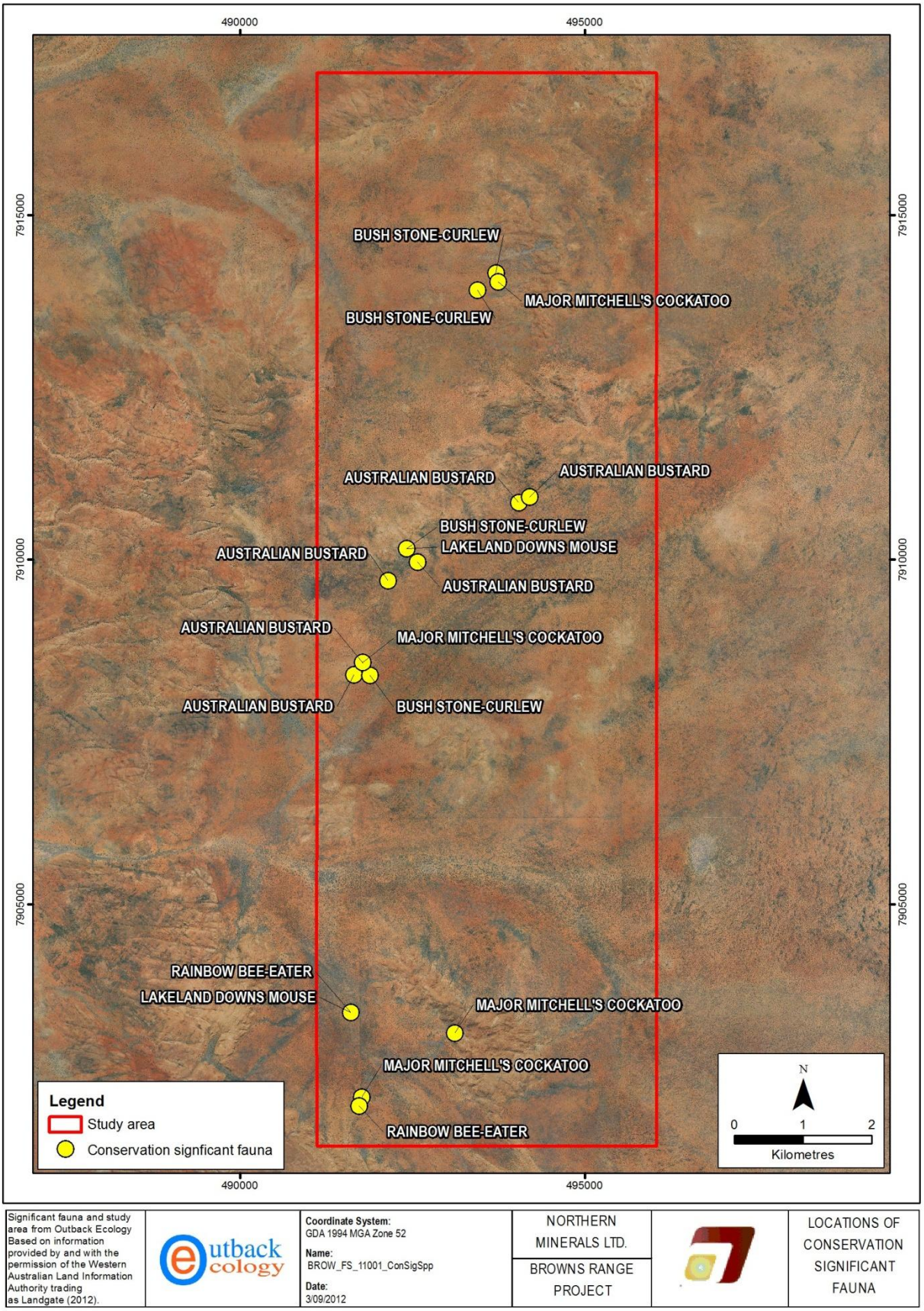

Figure 15: Locations of fauna of conservation significance recorded within the Study Area

The database searches and literature review identified 32 species of conservation significance that potentially occur within the Study Area (**Appendix A**). Of these:

- 12 species are listed as Threatened under the EPBC Act and/or Schedule 1 under the WC Act (**Section 5.3.1**);
- eight species are recognized as DEC Priority Fauna (including two species also listed under the EPBC Act) (**Section 5.3.2**); and
- 15 species (including one species also listed under the EPBC and WC Acts) are listed as Migratory under the EPBC Act, being subject to international agreements such as the Japan-Australia Migratory Bird Agreement (JAMBA), the China- Australia Migratory Bird Agreement (CAMBA), the Republic of Korea Australia Migratory Bird Agreement (ROKAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals) (**Section 5.3.3**).

In **Sections 5.3.1** to **Section 5.3.3**, the likelihood of each of these species of conservation significance occurring in the Study Area has been assessed and ranked. The rankings were assigned using the following definitions:

Confirmed – the presence of the species in the Study Area has been recorded unambiguously during the last ten years (i.e. during recent surveys of the Study Area or from recent records obtained via database searches);

Very likely – the Study Area lies within the known distribution of the species and contains suitable habitat(s), plus the species generally occurs in suitable habitat and has been recorded nearby within the last 20 years;

Likely – the Study Area lies within the known distribution of the species and the species has been recorded nearby within the last 20 years; however, either:

a. the Study Area contains only a small area of suitable habitat, or habitat that is only marginally suitable; or
b. the species is generally rare and patchily distributed in suitable habitat;

Possible – there is an outside chance of occurrence, because:

a. the Study Area is just outside the known distribution of the species, but it does contain suitable and sufficient habitat (the species may be common, rare, or patchily distributed); or
b. the Study Area lies within the known distribution of the species, but the species is very rare and/or patchily distributed; or
c. the Study Area lies on the edge of, or within, the known distribution and has suitable habitat, but the species has not been recorded in the area for over 20 years; or

Unlikely – the Study Area lies outside the known distribution of the species, the Study Area does not contain suitable habitat, and the species has not been recorded in the area for over 20 years.

For each conservation significant species identified by the literature review and database searches as potentially occurring within the Study Area, the reason why a particular rank was assigned is explained and additional species information is provided for those species that could Possibly occur or are Likely, Very Likely or Confirmed as occurring within the Study Area.

5.3.1. Threatened Fauna

Legislation has been developed at a Commonwealth (EPBC Act) and State (WC Act) level to protect fauna species that have been formally recognised as rare, threatened with extinction or having high conservation value. For the full definitions of conservation significance under these Acts, see **Appendix G**. The database searches and literature review identified 12 Threatened species that potentially occur within the Study Area, one of which was recorded during this study (**Table 16**).

Table 16: Threatened vertebrate fauna potentially occurring within the Study Area

Common name (species name)	Conservation status		Number of		Likelihood of occurrence
	EPBC[1]	In WA[2]	Surveys	Databases	
Northern Marsupial Mole (*Notoryctes caurinus*)	EN	S1	0	1	Unlikely
Reason for likelihood rank: The Study Area lies on the edge of the known distribution of the Northern Marsupial Mole and does not contain suitable habitat of sand dunes (Van Dyck and Strahan 2008). No previous surveys recorded the species and the closest recorded location is approximately 150 km southwest of the Study Area (DEC 2012b).					
Central Marsupial Mole (*Notoryctes typhlops*)	EN	S1	0	1	Unlikely
Reason for likelihood rank: The Study Area lies outside the known distribution of the Northern Marsupial Mole and does not contain suitable habitat of sand dune country (Van Dyck and Strahan 2008). No previous surveys recorded the species and the closest recorded location is approximately 170 km southwest of the Study Area (DEC 2012b).					
Crest-tailed Mulgara (*Dasycercus cristicauda*)	EN	S1	1	2	Unlikely
Reason for likelihood rank: The Study Area lies well outside the current distribution of the Crest-tailed Mulgara and does not contain suitable habitat of sand dunes (Van Dyck and Strahan 2008). Observations of the Crest-tailed Mulgara from one previous survey conducted near the Study Area were derived from the discovery of burrows, diggings, tracks and scats, and the capture of one individual (Biota 2005). Because of taxonomic uncertainty, the Crest-tailed Mulgara has historically been confused with the Brush-tailed Mulgara and consequently it is difficult to know which species is actually being referred to when the Mulgara is reported by database searches and literature reviews. It is likely that these records can be attributed to the Brush-tailed Mulgara (see below), whose known distribution includes the Study Area, and for which the Study Area contains suitable habitat of spinifex grasslands and sandplains (Van Dyck and Strahan 2008).					
Greater Bilby (*Macrotis lagotis*)	VU	S1	4	4	Very Likely
Reason for likelihood rank: The Study Area lies within the known distribution of the Greater Bilby and contains suitable habitat of sandplains with hummock grassland and *Acacia* shrubland (Van Dyck and Strahan 2008). Although the species is rare within its distribution (Van Dyck and Strahan 2008), it was recorded by all previous studies considered in the literature review. Actual observations during previous studies included burrows, tracks and diggings (Biota 2005, Ecotec 2010a, b). **Species information:** Distribution/habitat: The Greater Bilby was formerly associated with a variety of inland habitats, including desert sandplains, dune fields with hummock grasslands, and massive red earths and Acacia shrublands (Maxwell et al. 1996), but populations underwent a sudden and widespread collapse in the early 1900s (Van					

Common name (species name)	Conservation status		Number of		Likelihood of occurrence
	EPBC[1]	In WA[2]	Surveys	Databases	
Dyck and Strahan 2008). The species is now restricted to approximately 20% of its former range, with wild populations restricted predominantly to the Tanami Desert in the Northern Territory, the Great Sandy and Gibson Deserts in Western Australia, and an outlying population in south-west Queensland (Van Dyck and Strahan 2008). Biology/ecology: Bilbies are not reliant on surface water and receive most of their water requirements from food sources. Their diet consists of insects, larvae, seeds, bulbs, fruit and fungi (Van Dyck and Strahan 2008). Bilbies dig large burrows in sandy substrates, which can reach up to 3 m long and 1.8 m deep (Van Dyck and Strahan 2008). Threats: The species has undergone a widespread population decline, as a result of altered fire regimes, grazing pressure from introduced herbivores and livestock, and predation by the European Red Fox (Vulpes vulpes) and the Cat (Felis catus).					
Australian Painted Snipe (*Rostratula australis*)	VU	S1	0	1	Possible
Reason for likelihood rank: The Study Area lies outside the distribution of the Australian Painted Snipe described in Pizzey and Knight (2007), but within the distribution described by DSEWPaC (2012b). The Study Area does not contain suitable habitat for the species, which prefers well-vegetated margins of wetlands and other water bodies (Pizzey and Knight 2007). No previous surveys recorded the species. The closest recorded location on the NatureMap database is approximately 150 km southwest of the Study Area (DEC 2012b). Barrett *et al.* (2003) suggests the closest recorded location is approximately 80 km southeast of the Study Area. **Species information:** Taxonomy: The Australian Painted Snipe was previously considered part of the Greater Painted Snipe species that also occurs in Africa and Asia, but is now considered a separate species. This has resulted in several names being used for the species including *Rostratula benghalensis* (as used on the EPBC Act's list of migratory birds), *Rostratula australis* (as used on the EPBC Act's list of Vulnerable species and the WC Act's Schedule 3) and *Rostratula benghalensis australis* (as used on the WC Act's Schedule 1) (DSEWPaC 2011, DSEWPaC 2012b). Distribution/habitat: The Australian Painted Snipe typically occurs in northern and eastern Australia, inhabiting well-vegetated margins of wetlands, dams, marshes, as well as tea tree scrub and open timber (Pizzey and Knight 2007). Biology/ecology: The Australian Painted Snipe constructs nests comprising a saucer of twigs, reeds and grasses, and is known to feed on beetles and other insects (Pizzey and Knight 2007). Threats: The species is threatened by the loss and degradation of wetlands through drainage and the diversion of water for agriculture (Garnett et al. 2011).					
Great Desert Skink (*Liopholis kintorei*)	VU	S1	0	1	Possible
Reason for likelihood rank: The Study Area lies just outside the known distribution of the Great Desert Skink and contains marginally suitable habitat of arid sand flats and loamy soils with spinifex (Wilson and Swan 2010). No previous surveys recorded the species and the closest recorded location is approximately 150 west-southwest of the Study Area (DEC 2012b). **Species information:** Distribution/habitat: The Great Desert Skink occurs in the mid-west of Australia, inhabiting arid sand-flats and clay-based or loamy soils with spinifex (Wilson and Swan 2010). Biology/ecology: The Great Desert Skink is crepuscular to nocturnal and takes refuge during the day in complex, multi-entranced, communal burrow systems (Wilson and Swan 2010).					
Brush-tailed Mulgara (*Dasycercus blythi*)	VU	P4	1	2	Very Likely
Reason for likelihood rank: The Study Area lies within the known distribution of the Brush-tailed Mulgara and contains suitable habitat of spinifex grasslands and sandplains (Van Dyck and Strahan 2008). Records of Crest-tailed Mulgara near the Study Area are also likely attributable to					

Common name (species name)	Conservation status		Number of		Likelihood of occurrence
	EPBC[1]	In WA[2]	Surveys	Databases	
this species (see above). **Species information:** Taxonomy: Until recently the Brush-tailed Mulgara (Dasycercus blythi) was considered the same species as the Crest-tailed Mulgara (*Dasycercus cristicauda*) (Van Dyck and Strahan 2008). The Crest-tailed Mulgara is currently listed under the EPBC Act as Endangered using a now defunct taxonomic pseudonym *Dasycercus hillieri*, and as Schedule 1 under the WC Act using the current name *Dasycercus cristicauda*. The Brush-tailed Mulgara is currently listed under the EPBC Act as Vulnerable using the old name for this species *Dasycercus cristicauda*, and as Priority 4 by the DEC using the current name *Dasycercus blythi*. Distribution/habitat: The Brush-tailed Mulgara is found in central-western and central Australia, inhabiting spinifex grasslands, often between low sand dunes; however, due to taxonomic uncertainty of historical records, the current distribution of both species of Mulgara (Dasycercus blythi and Dasycercus cristicauda) is uncertain and can only be confirmed following the correct identification and analysis of museum specimens (Pavey et al. 2012). Current knowledge suggests that the vast majority of Mulgara captured in Western Australia are the Brush-tailed Mulgara, Dasycercus blythi, and not the Crest-tailed Mulgara (Ric How, WA Museum, pers. comm..), though it is possible that Crest-tailed Mulgara still occur in WA (Pavey et al. 2012). Threats: Introduced grazers, namely cattle and rabbits, altered fire regimes and predation by cats and foxes have contributed to the population declines of both species of Mulgara (Maxwell et al. 1996, Van Dyck and Strahan 2008).					
Purple-crowned Fairy-wren (western subspecies) (*Malurus coronatus coronatus*)		S1, P4	0	1	Unlikely
Reason for likelihood rank: The Study Area lies outside the known distribution of the Purple-crowned Fairy-wren and does not contain suitable habitat of pandanus and paperbark thickets fringing rivers, creeks and lakes (Pizzey and Knight 2007). No previous surveys recorded the species and the closest recorded location is approximately 110 km north-northwest at the Marella Gorge, along the Nicholson River (DEC 2012b).					
Peregrine Falcon (*Falco peregrinus*)		S4	0	1	Possible
Reason for likelihood rank: The Study Area lies within the known distribution of the Peregrine Falcon (the species can be found in a variety of habitats throughout Australia), however the species is generally rare or uncommon within its range (Pizzey and Knight 2007). No previous surveys recorded the species and the closest recorded location is approximately 60 km northeast of the Study Area (NRETAS 2012). **Species information:** Distribution/habitat: In arid Australia, Peregrine Falcons are sparsely distributed and closely associated with waterholes, range and gorge environments, although they do range widely over riverine and Acacia woodland habitats when hunting (Garnett and Crowley 2000). Biology/ecology: The Peregrine Falcon is an aerial carnivore, which in the Australian arid zone nests on inland cliffs, in tree hollows and in steep-sided rocky outcrops near water (Pizzey and Knight 2007). The species has a home range of approximately 20 to 30 km^2.					
Major Mitchell's Cockatoo (*Lophochroa leadbeateri*)		S4	4	3	Confirmed
Reason for likelihood rank: The Study Area lies within the known distribution of the Major Mitchell's Cockatoo (Pizzey and Knight 2007) and up to 21 individuals of the species was observed flying over the Study Area above Open Shrubland over Mixed Grassland on Sandy Plain habitat (eight on one occasion, five on two occasions, two on one occasion and one on another occasion). All previous surveys also recorded this species.					

Common name (species name)	Conservation status		Number of		Likelihood of occurrence
	EPBC[1]	In WA[2]	Surveys	Databases	
Species information: Distribution/habitat: The Major Mitchell's Cockatoo is widespread but unevenly distributed across arid Australia, inhabiting lightly wooded country near water and tall eucalypts, which are relied upon for hollows (Johnstone and Storr 1998). Biology/ecology: The Major Mitchell's Cockatoo nests in hollows of mature eucalypts and feeds predominantly on seeds, but also the roots, flowers and fruit of some plant species (Johnstone and Storr 1998). Threats: The species is threatened by loss of hollow-bearing trees, and also by competition for hollows with Galahs (Garnett et al. 2011).					
Woma (*Aspidites ramsayi*)		S4	0	1	Possible
Reason for likelihood rank: The Study Area lies on the edge of the known distribution of the Woma and contains suitable habitat of heaths and shrublands, often with spinifex (Storr *et al.* 2002, Wilson and Swan 2010). No previous surveys recorded the species and the closest recorded location is within approximately 50 km from Study Area (precise location unavailable) (NRETAS 2012). **Species information:** Distribution/habitat: The Woma occurs across central Australia and the southwest inhabiting woodlands, heaths and shrublands, often with spinifex (Wilson and Swan 2010). Threats: While populations within central Australia are likely secure, it is the southwestern populations that appear to be declining, threatened by land clearing and predation by introduced animals (Storr *et al.* 2002, Wilson and Swan 2010).					
Freshwater Crocodile (*Crocodylus johnstoni*)		S4	0	1	Unlikely
Reason for likelihood rank: The Study Area lies outside the known distribution of the Freshwater Crocodile and does not contain suitable habitat of freshwater rivers and billabongs (Wilson and Swan 2010). No previous surveys recorded the species and the closest recorded location is approximately 150 km northwest of the Study Area (DEC 2012b).					

[1]Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* – EN (Endangered), VU (Vulnerable), M (Migratory). [2] Status under the Western Australian Wildlife Conservation Act 1950 – S1 (Schedule 1), S3 (Schedule 3 - Migratory birds), S4 (Schedule 4); or the DEC Priority Fauna List – P1 (Priority 1), P2 (Priority 2), P3 (Priority 3), P4 (Priority 4). See Appendix G for full definitions of conservation status

5.3.2. Priority Fauna Species

The WA DEC recognises several species that are not listed under the WC Act or the EPBC Act but for which there is some conservation concern, and has produced a supplementary list of Priority Fauna. For the full definitions of Priority Fauna rankings, see **Appendix G**. The database searches and literature review identified eight species of Priority Fauna that potentially occur within the Study Area, two of which were recorded during the survey (**Table 17**).

Table 17: DEC Priority vertebrate fauna potentially occurring within the Study Area

Common name (species name)	Conservation status		Number of		Likelihood of occurrence
	EPBC[1]	In WA[2]	Surveys	Databases	
Brush-tailed Mulgara (*Dasycercus blythi*)	VU	P4	1	2	Very Likely
Reason for likelihood rank: See **Section 5.3.1**					

Common name (species name)	Conservation status		Number of		Likelihood of occurrence
	EPBC[1]	In WA[2]	Surveys	Databases	
Purple-crowned Fairy-wren (western subspecies) (*Malurus coronatus coronatus*)		S1, P4	0	1	Unlikely
Reason for likelihood rank: See **Section 5.3.1**					
Spectacled Hare-wallaby (mainland subspecies) (*Lagorchestes conspicillatus leichardti*)		P3	4	2	Very Likely
Reason for likelihood rank: The Study Area lies within the known distribution of the Spectacled Hare-wallaby (mainland subspecies) and contains suitable habitat of hummock grassland and *Acacia* shrubland (Van Dyck and Strahan 2008). Although it occurs sparsely throughout the Tanami Desert (Van Dyck and Strahan 2008), the species was recorded by all previous surveys considered in the literature review. Actual observations during previous surveys included scats (Ecotec 2008a, b, 2010a), tracks (Ecotec 2010a) and sightings (Biota 2005, Ecotec 2010b). **Species information:** Distribution/habitat: The Spectacled Hare-wallaby (mainland subspecies) is found across northern Australia (a Barrow Island population also has subspecies status – Lagorchestes conspicillatus conspicillatus), inhabiting open forests and woodlands, hummock and tussock grasslands and Acacia shrubland (Van Dyck and Strahan 2008). Threats: Species abundance has declined dramatically, especially within the Pilbara region, possibly due to fox predation and inappropriate fire regimes, which have prevented the development of the large, mature grasslands it requires for shelter (Van Dyck and Strahan 2008).					
Lakeland Downs Mouse (*Leggadina lakedownensis*)		P4	0	1	Confirmed
Reason for likelihood rank: The Study Area lies within the known distribution of the Lakeland Downs Mouse and contains suitable habitat of hummock and tussock grassland, *Acacia* shrubland, and stony ranges. The species was captured three times within the Study Area, twice at Site A within Drainage Line habitat, and once at Site D in Hummock Grassland on Rocky Hill habitat (**Appendix F**). **Species information:** Distribution/habitat: The Lakeland Downs Mouse (also commonly known as the Northern Short-tailed Mouse) is found across northern Australia, inhabiting a variety of different habitats including spinifex and tussock grasslands, samphire and sedgelands, Acacia shrublands, tropical Eucalyptus woodlands and stony ranges; the species prefers habitat that is seasonally inundated on red or white sandy-clay soils (Van Dyck and Strahan 2008). Biology/ecology: Lakeland Downs Mice are nocturnal, largely solitary and individuals spend the day in simple, single-chambered burrows before emerging to forage predominantly on insectivores (Van Dyck and Strahan 2008).					
Australian Bustard (*Ardeotis australis*)		P4	4	4	Confirmed

Common name (species name)	Conservation status		Number of		Likelihood of occurrence
	EPBC[1]	In WA[2]	Surveys	Databases	
Reason for likelihood rank: The Study Area lies within the known distribution of the Australian Bustard and contains suitable habitat of tussock grassland and arid scrub (Pizzey and Knight 2007). Up to ten individuals of the species (two on three occasions and one on four occasions) were observed within the Study Area in Open Shrubland over Tussock Grassland on Sandy Plain and Drainage Line habitats (**Appendix F**). All previous surveys also recorded the species. **Species information:** Distribution/habitat: The Australian Bustard occurs over much of Western Australia, with the exception of the more heavily wooded southern portions of the state (Johnstone and Storr 1998). The species also occurs in eastern Australia and New Guinea. The Australian Bustard inhabits open dry woodlands of Mulga, arid shrublands and tussock grasslands supporting spinifex species (Johnstone and Storr 1998, Morcombe 2003), along with grasslands and drainage areas particularly after a series of years of above average rainfall (Johnstone and Storr 1998). Biology/ecology: Generally, this species is considered scarce to common depending on season and habitat. It has an omnivorous diet but appears to have some preference for grasshoppers and is often attracted to recently burnt areas (Marchant and Higgins 1993).					
Grey Falcon (*Falco hypoleucos*)		P4	0	2	Possible
Reason for likelihood rank: The Study Area lies outside the core distribution of the Grey Falcon (however the species is nomadic and has some potential to visit the Study Area or surrounding area) and the species is considered rare to very rare (Morcombe 2003, Pizzey and Knight 2007). No previous surveys recorded the species. The closest records of the Grey Falcon to the Study Area are 80 km northwest (Birds Australia 2012) and 75 km west-southwest (DEC 2012b). **Species information:** Distribution/habitat: The Grey Falcon mainly occurs around inland ephemeral and permanent drainage systems where annual rainfall is less than 500 mm (Garnett et al. 2011). The species typically inhabits lightly wooded countryside, especially stony plains and Acacia scrublands (Morcombe 2003). Biology/ecology: The Grey Falcon species can be rare, resident or nomadic to most of the semi-arid interior of Western Australia (Pizzey and Knight 2007).					
Pictorella Mannikin (*Heteromunia pectoralis*)		P4	1	4	Possible
Reason for likelihood rank: The Study Area lies on the edge of the known distribution of the Pictorella Mannikin (Morcombe 2003, Pizzey and Knight 2007) and contains suitable habitat of tussock and hummock grassland, and open country with scattered trees (Morcombe 2003). the closest records from the four database searches are 70 km northwest (Birds Australia 2012), 85 km northwest (DEC 2012c), 75 km northwest (DEC 2012a) and 80 km south-southeast (NRETAS 2012) from the Study Area; and the one previous survey that recorded the species was conducted approximately 25 km southwest of the Study Area (Ecotec 2010a). **Species information:** Distribution/habitat: The Pictorella Mannikin is found in the Kimberley region of Western Australia and northern parts of the Northern Territory and Queensland, typically occurring within lightly wooded grasslands, especially hard country with short grass and spinifex on heavy red soils (Johnstone and Storr 2004). It is a nomadic species and is uncommon to moderately common within its range (Johnstone and Storr 2004). Biology/ecology: The species typically constructs nests in grass tussocks often close to the ground. It forages mainly on the ground, feeding on fallen seeds and small insects (Johnstone and Storr 2004). Threats: Likely impacted by changing fire regimes and the introduction of stock (Garnett and Crowley 2000).					
Flock Bronzewing		P4	0	3	Possible

Common name (species name)	Conservation status		Number of		Likelihood of occurrence
	EPBC[1]	In WA[2]	Surveys	Databases	
(*Phaps histrionica*)					
Reason for likelihood rank: The Study Area lies within the known distribution of the Flock Bronzewing and contains suitable habitat of open grassland plains and small shrubs with open spaces (Morcombe 2003, Pizzey and Knight 2007). However, the species has not been recorded near the Study Area: database searches indicate that the closest records of the species to the Study Area are 60 km northwest (DEC 2012a) and 60 km northeast (NRETAS 2012). **Species information:** Distribution/habitat: The Flock Bronzewing occurs across the northern third of Western Australia (excluding the northern Kimberley) and also inland eastern Australia, inhabiting treeless or sparsely wooded grassy plains near water (Johnstone and Storr 1998, Pizzey and Knight 2007). Biology/ecology: The Flock Bronzewing forages in groups and constructs nests near others; nests usually consist of a scrape on the ground by a shrub or tussock (Pizzey and Knight 2007). Threats: The species is threatened by habitat destruction through the expansion of pastoralism and agriculture (Garnett and Crowley 2000).					
Brush-tailed Mulgara (*Dasycercus blythi*)	VU	P4	1	2	Very Likely
Reason for likelihood rank: See **Section 5.3.1**					
Purple-crowned Fairy-wren (western subspecies) (*Malurus coronatus coronatus*)		S1, P4	0	1	Unlikely
Reason for likelihood rank: See **Section 5.3.1**					
Spectacled Hare-wallaby (mainland subspecies) (*Lagorchestes conspicillatus leichardti*)		P3	4	2	Very Likely
Reason for likelihood rank: The Study Area lies within the known distribution of the Spectacled Hare-wallaby (mainland subspecies) and contains suitable habitat of hummock grassland and *Acacia* shrubland (Van Dyck and Strahan 2008). Although it occurs sparsely throughout the Tanami Desert (Van Dyck and Strahan 2008), the species was recorded by all previous surveys considered in the literature review. Actual observations during previous surveys included scats (Ecotec 2008a, b, 2010a), tracks (Ecotec 2010a) and sightings (Biota 2005, Ecotec 2010b). **Species information:** Distribution/habitat: The Spectacled Hare-wallaby (mainland subspecies) is found across northern Australia (a Barrow Island population also has subspecies status – Lagorchestes conspicillatus conspicillatus), inhabiting open forests and woodlands, hummock and tussock grasslands and Acacia shrubland (Van Dyck and Strahan 2008). Threats: Species abundance has declined dramatically, especially within the Pilbara region, possibly due to fox predation and inappropriate fire regimes, which have prevented the development of the large, mature grasslands it requires for shelter (Van Dyck and Strahan 2008).					
Lakeland Downs Mouse (*Leggadina lakedownensis*)		P4	0	1	Confirmed
Reason for likelihood rank: The Study Area lies within the known distribution of the Lakeland Downs Mouse and contains suitable habitat of hummock and tussock grassland, *Acacia* shrubland, and stony ranges. The species was captured three times within the Study Area, twice at Site A within Drainage Line habitat, and once at Site D in Hummock Grassland on Rocky Hill habitat (**Appendix F**).					

Common name (species name)	Conservation status		Number of		Likelihood of occurrence
	EPBC[1]	In WA[2]	Surveys	Databases	
Species information: Distribution/habitat: The Lakeland Downs Mouse (also commonly known as the Northern Short-tailed Mouse) is found across northern Australia, inhabiting a variety of different habitats including spinifex and tussock grasslands, samphire and sedgelands, Acacia shrublands, tropical Eucalyptus woodlands and stony ranges; the species prefers habitat that is seasonally inundated on red or white sandy-clay soils (Van Dyck and Strahan 2008). Biology/ecology: Lakeland Downs Mice are nocturnal, largely solitary and individuals spend the day in simple, single-chambered burrows before emerging to forage predominantly on insectivores (Van Dyck and Strahan 2008).					
Australian Bustard (*Ardeotis australis*)		P4	4	4	Confirmed
Reason for likelihood rank: The Study Area lies within the known distribution of the Australian Bustard and contains suitable habitat of tussock grassland and arid scrub (Pizzey and Knight 2007). Up to ten individuals of the species (two on three occasions and one on four occasions) were observed within the Study Area in Open Shrubland over Tussock Grassland on Sandy Plain and Drainage Line habitats (**Appendix F**). All previous surveys also recorded the species. **Species information:** Distribution/habitat: The Australian Bustard occurs over much of Western Australia, with the exception of the more heavily wooded southern portions of the state (Johnstone and Storr 1998). The species also occurs in eastern Australia and New Guinea. The Australian Bustard inhabits open dry woodlands of Mulga, arid shrublands and tussock grasslands supporting spinifex species (Johnstone and Storr 1998, Morcombe 2003), along with grasslands and drainage areas particularly after a series of years of above average rainfall (Johnstone and Storr 1998). Biology/ecology: Generally, this species is considered scarce to common depending on season and habitat. It has an omnivorous diet but appears to have some preference for grasshoppers and is often attracted to recently burnt areas (Marchant and Higgins 1993).					
Grey Falcon (*Falco hypoleucos*)		P4	0	2	Possible
Reason for likelihood rank: The Study Area lies outside the core distribution of the Grey Falcon (however the species is nomadic and has some potential to visit the Study Area or surrounding area) and the species is considered rare to very rare (Morcombe 2003, Pizzey and Knight 2007). No previous surveys recorded the species. The closest records of the Grey Falcon to the Study Area are 80 km northwest (Birds Australia 2012) and 75 km west-southwest (DEC 2012b). **Species information:** Distribution/habitat: The Grey Falcon mainly occurs around inland ephemeral and permanent drainage systems where annual rainfall is less than 500 mm (Garnett et al. 2011). The species typically inhabits lightly wooded countryside, especially stony plains and Acacia scrublands (Morcombe 2003). Biology/ecology: The Grey Falcon species can be rare, resident or nomadic to most of the semi-arid interior of Western Australia (Pizzey and Knight 2007).					
Pictorella Mannikin (*Heteromunia pectoralis*)		P4	1	4	Possible
Reason for likelihood rank: The Study Area lies on the edge of the known distribution of the Pictorella Mannikin (Morcombe 2003, Pizzey and Knight 2007) and contains suitable habitat of tussock and hummock grassland, and open country with scattered trees (Morcombe 2003). the closest records from the four database searches are 70 km northwest (Birds Australia 2012), 85 km northwest (DEC 2012c), 75 km northwest (DEC 2012a) and 80 km south-southeast (NRETAS 2012) from the Study Area; and the one previous survey that recorded the species was conducted approximately 25 km southwest of the Study Area (Ecotec 2010a).					

Common name (species name)	Conservation status		Number of		Likelihood of occurrence
	EPBC[1]	In WA[2]	Surveys	Databases	
Species information: Distribution/habitat: The Pictorella Mannikin is found in the Kimberley region of Western Australia and northern parts of the Northern Territory and Queensland, typically occurring within lightly wooded grasslands, especially hard country with short grass and spinifex on heavy red soils (Johnstone and Storr 2004). It is a nomadic species and is uncommon to moderately common within its range (Johnstone and Storr 2004). Biology/ecology: The species typically constructs nests in grass tussocks often close to the ground. It forages mainly on the ground, feeding on fallen seeds and small insects (Johnstone and Storr 2004). Threats: Likely impacted by changing fire regimes and the introduction of stock (Garnett and Crowley 2000).					
Flock Bronzewing (*Phaps histrionica*)		P4	0	3	Possible
Reason for likelihood rank: The Study Area lies within the known distribution of the Flock Bronzewing and contains suitable habitat of open grassland plains and small shrubs with open spaces (Morcombe 2003, Pizzey and Knight 2007). However, the species has not been recorded near the Study Area: database searches indicate that the closest records of the species to the Study Area are 60 km northwest (DEC 2012a) and 60 km northeast (NRETAS 2012). **Species information:** Distribution/habitat: The Flock Bronzewing occurs across the northern third of Western Australia (excluding the northern Kimberley) and also inland eastern Australia, inhabiting treeless or sparsely wooded grassy plains near water (Johnstone and Storr 1998, Pizzey and Knight 2007). Biology/ecology: The Flock Bronzewing forages in groups and constructs nests near others; nests usually consist of a scrape on the ground by a shrub or tussock (Pizzey and Knight 2007). Threats: The species is threatened by habitat destruction through the expansion of pastoralism and agriculture (Garnett and Crowley 2000).					

[1]Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* – EN (Endangered), VU (Vulnerable), M (Migratory). [2] Status under the Western Australian Wildlife Conservation Act 1950 – S1 (Schedule 1), S3 (Schedule 3 - Migratory birds), S4 (Schedule 4); or the DEC Priority Fauna List – P1 (Priority 1), P2 (Priority 2), P3 (Priority 3), P4 (Priority 4). See Appendix G for full definitions of conservation status

5.3.3. Migratory Birds

Many species of migratory bird are listed under the EPBC Act, the WC Act and international agreements including the Japan-Australia Migratory Bird Agreement, the China-Australia Migratory Bird Agreement, Republic of Korea Australia Migratory Bird Agreement and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals).

The database searches and literature review identified 15 listed Migratory species that potentially occur within the Study Area and its surrounds (i.e. within 100 km of Study Area), one of which was recorded during the survey (**Table 18**). Broadly speaking, the occurrence of migratory waterbirds in arid Australia is highly sporadic and many species are only likely to be present in favourable seasons when water is plentiful (Halse *et al.* 1998, Kingsford and Norman 2002, Kingsford *et al.* 2010). The database searches and literature review identified a large number of migratory waterbirds as potentially occurring within the Study Area because they encompassed riverine habitat associated with the Sturt Creek to the northwest of the Study Area. As no major wetlands or natural water bodies were found within the Study Area, the occurrence of most migratory waterbirds within the Study Area would be occasional only, and they are unlikely to be dependent on the habitats present.

Table 18: Migratory birds potentially occurring within the Study Area

Common name (species name)	Conservation status		Number of		Likelihood of occurrence
	EPBC[1]	In WA[2]	Surveys	Databases	
Australian Painted Snipe (*Rostratula australis*)	M, VU	S3, VU	0	1	Possible
Reason for likelihood rank: See **Section 5.3.1**					
Rainbow Bee-eater (*Merops ornatus*)	M	S3	1	3	Confirmed
Reason for likelihood rank: The Study Area lies within the known distribution of the Rainbow Bee-eater and contains suitable habitat of lightly wooded sandy country (Johnstone and Storr 1998, Pizzey and Knight 2007). Up to three individuals of the species were observed within the Study Area during the field survey, one observation within Drainage Line habitat and two within Open Shrubland over Mixed Grassland on Sandy Plain habitat. The species was also observed nearby by Ecotec (2010a). **Species information:** The Rainbow-Bee-eater is found across much of mainland Australia (not in some inland arid areas), typically occurring in lightly wooded sandy country near water, but also in rainforest and mangroves (Johnstone and Storr 1998). The species breeds in Australia and New Guinea (constructing nests comprising a burrow in flat sandy ground or into sandy banks) and migrates to northern parts of its range during the southern winter. It feeds mainly on insects (Johnstone and Storr 1998).					
Common Sandpiper (*Actitis hypoleucos*)	M	S3	0	3	Unlikely
Reason for likelihood rank: The Common Sandpiper is a waterbird found around rivers, streams, lakes, beaches and mangroves (Pizzey and Knight 2007). The closest records to the Study Area is 80 km northeast are at Wallamunga Pool within the Sturt Creek (Birds Australia 2012, NRETAS: Natural Resources 2012).					
Fork-tailed Swift (*Apus pacificus*)	M	S3	0	2	Unlikely
Reason for likelihood rank: The Fork-tailed Swift can be found throughout Australia and although it could be possibly observed flying over the Study Area, it is unlikely that the species will specifically use the Study Area (Pizzey and Knight 2007). The desktop study does not indicate the species has been recorded close to the Study Area.					
Cattle Egret (*Ardea ibis*)	M	S3	0	1	Unlikely
Reason for likelihood rank: The Cattle Egret is a waterbird found around wetlands (Pizzey and Knight 2007). The desktop study does not indicate the species has been recorded close to the Study Area.					
Sharp-tailed Sandpiper (*Calidris acuminate*)	M	S3	0	1	Unlikely
Reason for likelihood rank: The Sharp-tailed Sandpiper is a waterbird found around a variety of waterways from mudflats and saltmarshes to wetlands and floodwaters (Pizzey and Knight 2007). The desktop study does not indicate the species has been recorded close to the Study Area.					
Oriental Plover (*Charadrius veredus*)	M	S3	1	2	Possible
Reason for likelihood rank: The Study Area lies within the known distribution of the Oriental Plover and contains suitable habitat of opens plains and bare, rolling country, often far from water (Pizzey and Knight 2007). The closest record of the species to the Study Area comes from Biota (2005), which indicates the species has been recorded approximately 85 km south of the Study Area. **Species information:**					

Common name (species name)	Conservation status		Number of		Likelihood of occurrence
	EPBC[1]	In WA[2]	Surveys	Databases	
The Oriental Plover is typically found across northern Australia, occurring mainly in sparsely vegetated plains, but also in beaches and tidal flats (Johnstone and Storr 1998). The species breeds in Mongolia, south Siberia and north China in the northern summer and migrates to Australia for the southern summer, where it has been known to feed on insects (Johnstone and Storr 1998).					
Swinhoe's Snipe (*Gallinago megala*)	M	S3	0	1	Unlikely
Reason for likelihood rank: The Swinhoe's Snipe is a waterbird found around reedy swamps (Pizzey and Knight 2007). The desktop study does not indicate the species has been recorded close to the Study Area.					
Oriental Pratincole (*Glareola maldivarum*)	M	S3	0	2	Unlikely
Reason for likelihood rank: The Oriental Pratincole is a waterbird found around wetlands, mudflats and beaches (Pizzey and Knight 2007). The desktop study does not indicate the species has been recorded close to the Study Area.					
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	M	S3	0	1	Unlikely
Reason for likelihood rank: The White-bellied Sea-eagle is typically a coastal bird, but can also be found around large inland rivers and lakes (Pizzey and Knight 2007). The desktop study does not indicate the species has been recorded close to the Study Area.					
Caspian Tern (*Hydroprogne caspia*)	M	S3	0	1	Unlikely
Reason for likelihood rank: The Caspian Tern is a waterbird found along the coast and around some large inland lakes and rivers (Pizzey and Knight 2007). The desktop study does not indicate the species has been recorded close to the Study Area.					
Little Curlew (*Numenius minutus*)	M	S3	0	1	Unlikely
Reason for likelihood rank: The Little Curlew is a waterbird found around floodplains, swamps and tidal mudflats, but also known to inhabit dry grasslands (Pizzey and Knight 2007). The desktop study does not indicate the species has been recorded close to the Study Area.					
Glossy Ibis (*Plegadis falcinellus*)	M	S3	0	1	Unlikely
Reason for likelihood rank: The Glossy Ibis is a waterbird found around a variety of well-vegetated waterways from wetlands and floodwaters to mangroves and mudflats (Pizzey and Knight 2007). The desktop study does not indicate the species has been recorded close to the Study Area.					
Wood Sandpiper (*Tringa glareola*)	M	S3	0	2	Unlikely
Reason for likelihood rank: The Wood Sandpiper is a waterbird found around the muddy margins of wetlands, mangroves, mudflats and saltmarshes (Pizzey and Knight 2007). The closest record to the Study Area is 70 km northeast at the Sturt Creek (NRETAS 2012).					
Common Greenshank (*Tringa rebularia*)	M	S3	0	1	Unlikely
Reason for likelihood rank: The Common Greenshank is a waterbird found around a variety of waterways from wetlands and lakes to mudflats, estuaries, saltmarshes and claypans (Pizzey and Knight 2007). The desktop study does not indicate the species has been recorded close to the Study Area.					

[1]Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* – EN (Endangered), VU (Vulnerable), M (Migratory). [2] Status under the Western Australian Wildlife Conservation Act 1950 – S1 (Schedule 1), S3 (Schedule 3 - Migratory birds), S4 (Schedule 4); or the DEC Priority Fauna List – P1 (Priority 1), P2 (Priority 2), P3 (Priority 3), P4 (Priority 4). See Appendix G for full definitions of conservation status

5.4. Sampling Adequacy

It is important to consider the efficacy of sampling techniques employed during the field survey in detecting the total faunal assemblage present within the Study Area. This can be achieved by comparing the results of this field survey with those of previous surveys conducted near the Study Area, to provide information about survey-to-survey differences that could be based on factors such as survey intensity, timing and weather, fire, and habitat diversity and quality (**Section 5.4.1**). It can also be achieved by analyzing species accumulation curves to determine what proportion of fauna actually present within the Study Area during the survey period were detected during the field survey (**Section 5.4.2**).

5.4.1. Comparison with Previous Studies

The field survey recorded a relatively low proportion (35%) of the total number of species that could potentially occur within the Study Area according to the database searches and literature review. This could be attributable to the fact that the survey was conducted over a relatively short period of time within a single season, and many species that potentially occur within the Study Area may only be present there at specific times of year (eg dry season, after substantial rainfall). It could also be attributable to the fact that the Study Area contained only a subset of the total number of habitat types present in the region and consequently some species recorded in the database searches and literature review are not likely to occur within the Study Area. For example, the search areas used for the database searches encompassed major riverine habitat to the northwest, as well as large bodies of water to the southeast. These habitats typically attract species that are not present in drier habitats, such as those occurring within the Study Area. Alternatively, the low proportion of species recorded could be attributable to the fact that not all habitat types present within the Study Area received equal survey effort. For example, the northern end of the Study Area is characterized by rocky hills with few or no access tracks and as such, this habitat did not receive intensive survey effort besides a targeted search. Consequently, it is possible that this area was under-sampled, reducing the potential species count.

Although this field survey recorded a relatively low proportion of the total number of species that could potentially occur within the Study Area, it recorded more species than the four previous surveys considered in the literature review (see **Table 2**). Survey-to-survey differences in species richness for vertebrate fauna can be attributed to various factors such as survey intensity, timing and weather, fire, and habitat diversity and quality. The total number of species recorded during this field survey is most similar to a previous survey (Biota 2005) that utilized similar sampling techniques within similar habitats. It should be noted that this Biota survey had a greater trapping effort due to more sampling sites comprising more traps that were sampled over a longer period of time and at different times of the year (Biota 2005, see Table 2). In terms of individual taxa, this survey recorded more native mammals, birds and amphibians, but less reptiles, than Biota (2005) (**Figure 16**). A lower number of reptiles may be attributable to the relatively cool, dry conditions experienced during the survey period (see (**Table 3**), whereas Biota (2005) included a September sampling period that experienced warmer temperatures and more rainfall than this field survey, conditions which are more conducive to reptile activity.

Although relatively similar species richness were recorded for all taxa between this field survey and Biota (2005) (**Figure 16**), the species assemblages recorded were quite different. Specifically, this field survey recorded 46 species that were not recorded by Biota (2005) (including 11 mammals [ten of which are native], 18 birds, 14 reptiles and three amphibians) and Biota (2005) recorded 44 species that were not recorded during this field survey (including five native mammals, 15 birds, 23 reptiles and one amphibian). This highlights the variability in capture rates across different years and different seasons.

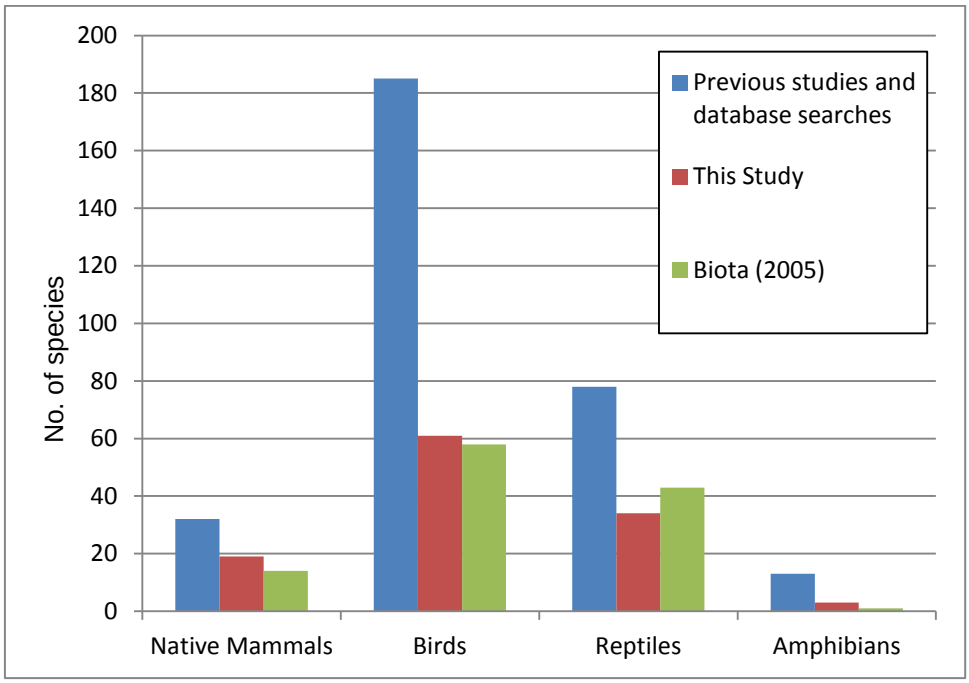

Figure 16: Species richness of field survey vs Biota (2005)

5.4.2. Species Accumulation Curves

Species accumulation curves can be used to estimate the sampling adequacy of systematic sampling techniques for a survey. When a curve approaches an asymptote it suggests that sampling effort has been sufficient to adequately collect the species comprising the faunal assemblage at the location(s) sampled. The value at which the curve asymptotes also represents an approximate measure of the total size of the species complement at that location.

Species accumulation curves for this assessment were calculated using systematic trapping data for herpetofauna and mammals, and timed census survey data for avifauna.

The species accumulation curve for herpetofauna does not appear to reach an asymptote (**Figure 17**). This indicates although the trapping effort during this survey was adequate to detect a range of herpetofauna species present at that time, additional trapping effort is likely to result in the capture of additional species. This survey recorded 34 out of the 91 reptiles species (37%) identified by the database searches and literature review as potentially occurring within the Study Area (**Table 8**).

In contrast, the species accumulation curve for avifauna approached an asymptote by the final day of trapping (**Figure 18**). This indicates that the avifauna census effort during this survey was adequate to detect the bulk of avifauna species present during that season. However, avifauna are known to be seasonal in their occurrence, and consequently additional effort in a different season (eg dry season: Sep - Nov) is likely to result in the observation of more species. This survey recorded 61 out of the 197 bird species (31%) identified by the database searches and literature review as potentially occurring within the Study Area (**Table 8**).

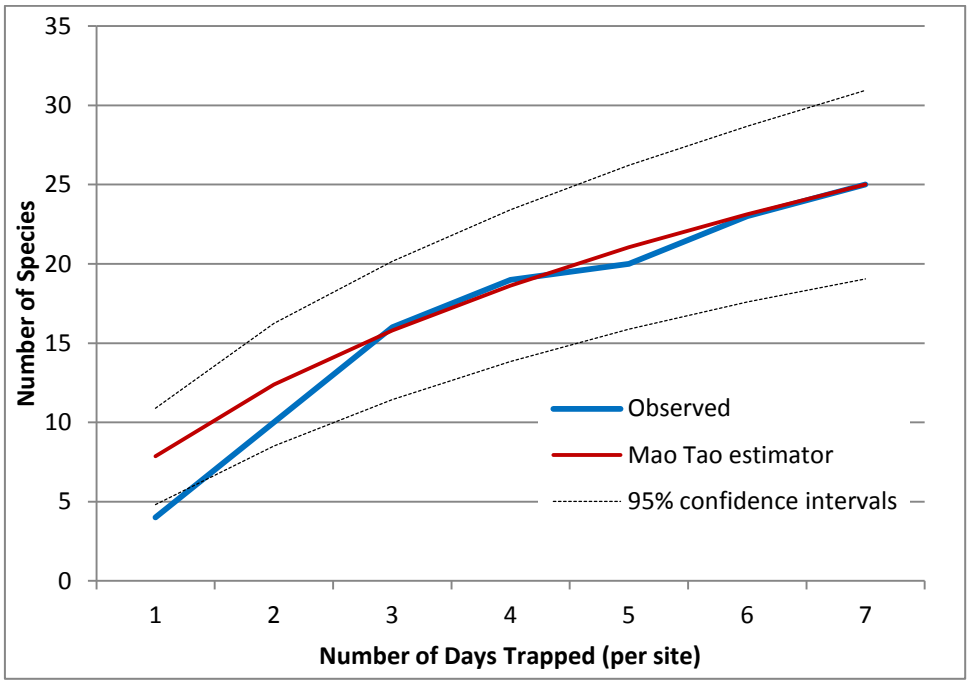

Figure 17: Species accumulation curve for herpetofauna recorded within the Study Area

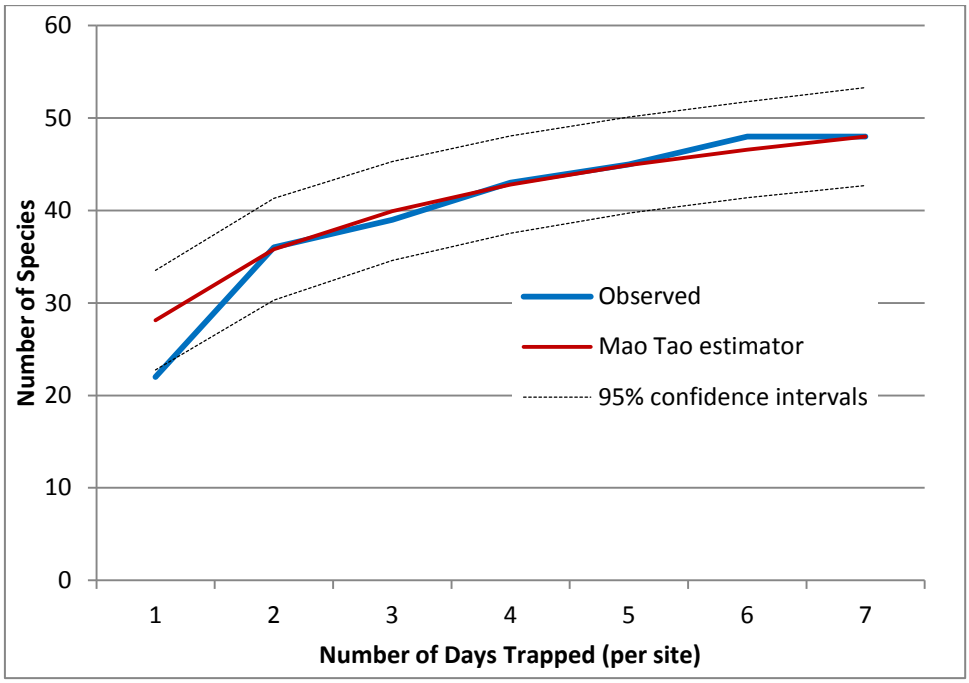

Figure 18: Species accumulation curve for avifauna recorded within the Study Area

The species accumulation curve reaches an asymptote after the second day of trapping, suggesting that additional trapping beyond the May 2012 survey period is unlikely to substantially increase the species count for mammals (**Figure 19**). This survey recorded 19 out of the 36 native mammal species (53%) identified by the database searches and literature review as potentially occurring within the Study Area (**Table 8**).

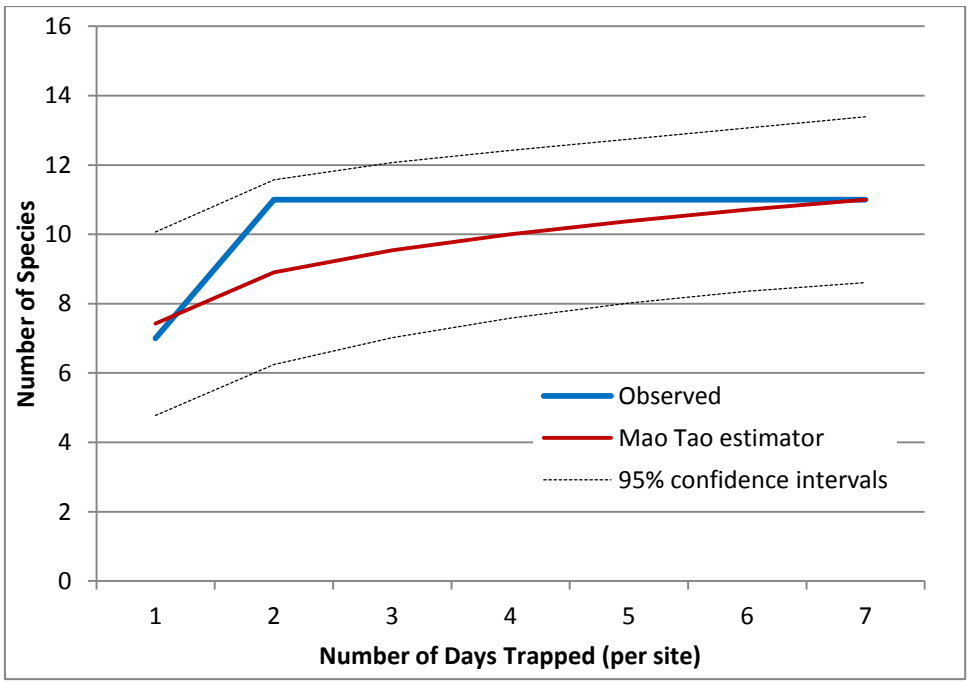

Figure 19: Species accumulation curve for mammals recorded within the Study Area

It must be noted that the use of species accumulation curves assumes that the methodology of the fauna survey was capable of recording every species present at every site, whereas this is rarely true in practice. In the case of species of conservation significance, for example, an assessment of the methods used during this survey suggested that each species could potentially have been detected by at least one of the methods used (**Table 19**); however, not all species of conservation significance were recorded, even those identified as likely or very likely to occur within the Study Area (see **Section 5.3**). Possible reasons for this include:

- variation in detectability (i.e. some species are easy to trap, see or hear, but others are not);
- survey timing, because species such as migratory birds may not occur within the Study Area during certain times of the year;
- weather patterns, because species such as frogs may occur within the Study Area year round but are not detectable in the absence of specific climatic events that trigger emergence; and
- species rarity, because species with restricted distributions or population sizes may not be detectable without a major, resource-intensive targeted survey.

Table 19: Survey methods with the ability to detect species of conservation significance

Scientific Name	Common Name	Conservation status		Survey method						
		EPBC Act	In WA	Trapping	Systematic searching	Targeted searching	Avifauna census	Spotlighting	SM2s	Motion-sensor cameras
MAMMALS										
Dasycercus blythei	Brush-tailed Mulgara	VU	P4	•	•	•		•		•
Dasycercus cristicauda	Crest-tailed Mulgara	EN	VU	•	•	•		•		•
Lagorchestes conspicillatus leichardti	Spectacled Hare-wallaby (mainland)		P3		•	•		•		•
Leggadina lakedownensis	Lakeland Downs Mouse		P4	•	•	•		•		•
Macrotis lagotis	Greater Bilby	VU	VU	•	•	•		•		•
Notoryctes caurinus	Northern Marsupial Mole	EN	EN		•	•				
Notoryctes typhlops	Central Marsupial Mole	EN	EN		•	•				
BIRDS										
Actitis hypoleucos	Common Sandpiper	M	S3		•	•	•			•
Apus pacificus	Fork-tailed Swift	M	S3		•	•	•			•
Ardea ibis	Cattle Egret	M	S3		•	•	•			•
Ardeotis australis	Australian Bustard		P4		•	•	•	•		•
Burhinus grallarius	Bush Stone-curlew		P4		•	•	•	•		•
Calidris acuminata	Sharp-tailed Sandpiper	M	S3		•	•	•			•
Charadrius veredus	Oriental Plover	M	S3		•	•	•			•
Falco hypoleucos	Grey Falcon		P4		•	•	•			•
Falco peregrinus	Peregrine Falcon		S4		•	•	•			•
Gallinago megala	Swinhoe's Snipe	M	S3		•	•	•			•
Glareola maldivarum	Oriental Pratincole	M	S3		•	•	•			•
Haliaeetus leucogaster	White-bellied Sea-Eagle	M	S3		•	•	•			•

Scientific Name	Common Name	Conservation status		Survey method						
		EPBC Act	In WA	Trapping	Systematic searching	Targeted searching	Avifauna census	Spotlighting	SM2s	Motion-sensor cameras
Heteromunia pectoralis	Pictorella Mannikin		P4		•	•	•			•
Hydroprogne caspia	Caspian Tern	M	S3		•	•	•			•
Lophochroa leadbeateri	Major Mitchell's Cockatoo		S4		•	•	•			•
Malurus coronatus coronatus	Purple-crowned Fairy-wren (western)	VU	P4		•	•	•			•
Merops ornatus	Rainbow Bee-eater	M	S3		•	•	•			•
Numenius minutus	Little Curlew	M	S3		•	•	•			•
Phaps histrionica	Flock Bronzewing		P4		•	•	•			•
Plegadis falcinellus	Glossy Ibis	M	S3		•	•	•			•
Rostratula australis	Australian Painted Snipe	VU, M	VU, S3		•	•	•			•
Tringa glareola	Wood Sandpiper	M	S3		•	•	•			•
Tringa nebularia	Common Greenshank	M	S3		•	•	•			•
REPTILES										
Aspidites ramsayi	Woma		S4		•	•		•		•
Crocodylus johnstoni	Freshwater Crocodile		S4		•	•				•
Liopholis kintorei	Great Desert Skink	VU	VU	•	•	•				•

5.5. Limitations and Constraints

There are a number of possible limitations and constraints that can impinge on the adequacy of flora, vegetation and fauna assessments (EPA 2004). These are discussed below, with respect to this Study (**Table 20**). All flora and fauna surveys are limited to some degree by time and seasonal factors, and ideally multiple surveys of an area would be undertaken over a number of years and within a number of different seasons.

Table 20: Discussion of potential limitations and constraints of this study

Factor	Constraint (Yes or No)	Comments
Competency and experience of consultants	No	Survey team members were fauna specialists employed by Outback Ecology, or were subcontracting zoologists. All team members possessed relevant post-graduate qualifications and have previous experience undertaking fauna surveys of this nature in Western Australia
Scope	No	The scope was clearly defined and realistically achievable. All terrestrial vertebrate fauna groups were surveyed using standardised and well-established techniques, and previous survey work local to and in the wider region of the Study Area was reviewed. Bat echolocation recordings were analysed by Robert Bullen of Bat Call WA Pty Ltd.
Proportion of fauna identified	No	This survey recorded 35% of the species recorded by database searches and a literature review as potentially occurring within the Study Area. This survey also recorded 12 additional species not recorded by database searches and a literature review as potentially occurring within the Study Area. The total of 122 species recorded during the field survey was higher than that recorded by all previous surveys considered in the literature review. It remains possible that a longer survey period would have increased the number of avifauna and herpetofauna recorded within the Study Area (see **Section 5.4**).
Information sources (eg historic or recent)	Partial Constraint	Regional knowledge about the biodiversity occurring within the Tanami 1 sub-bioregion is scarce due to a lack of a systematic survey work across the region (ANRA 2009a, Graham 2001); however, the Study Area is located in a relatively well surveyed area, due predominantly to previous surveys undertaken for mining operations.
Proportion of task achieved, and further work which might be needed	No	All planned survey works were conducted according to scope, and the conservation value of vertebrate fauna within the Study Area has been demonstrated by this study. It is reasonably possible that undetected species occur within the Study Area, some of which may be of conservation significance, and further studies at other times of the year may verify this.
Timing / weather / season / cycle	No	This report details the results of a survey conducted within the Study Area in May 2012, which is appropriate timing when regional rainfall patterns are considered.
Disturbances	No	Apart from a few anthropogenic disturbances (eg access

Factor	Constraint (Yes or No)	Comments
		tracks throughout the Study Area and a bore at the southern end), the Study Area was generally in good condition and it is unlikely that fauna assemblages would have been significantly altered by disturbances present at the time of the survey.
Intensity	No	The Study Area was sampled for a total of 1,820 trap nights across five sites (systematic trapping), with an additional 34 trap nights covered by the use of motion-sensor cameras and SM2 bat echolocation recorders. Further, a total of 22.5 person hours was spent undertaking a combination of systematic searching, targeted searching, spotlighting and avifauna census.
Completeness	No	The survey was complete. A comprehensive fauna assessment comprising systematic trapping, habitat assessment, systematic searching, targeted searching, spotlighting, avifauna census and recording of bat echolocation data was successfully executed. Habitats likely to yield the greatest diversity and abundance of captures were targeted for systematic site establishment, and the majority of the Study Area was adequately covered geographically.
Resources	No	Resources were adequate to carry out the survey satisfactorily, and the survey participants were competent in identification of species present
Remoteness / access problems	Partial constraint	Access to the majority of the Study Area was good and adequate survey coverage was achieved; however some parts of the Study Area (eg large rocky hills to the north) were not accessible to conduct intensive sampling techniques such as trapping. Consequently, it is possible that such areas contained species not recorded during this survey.
Availability of contextual information	No	Data were available for the Tanami 1 sub-bioregion from several sources (ANRA 2009a, ANRA 2009b, Birds Australia 2012, DEC 2012a, DEC 2012c, DSEWPaC2012a, Graham 2001, NRETAS 2012)

6. CONCLUSION

The inventory of 122 species of terrestrial vertebrate fauna obtained during the field survey was broadly consistent with vertebrate fauna inventories obtained during the desktop study, although 12 species found during the field survey were not predicted to be present by the desktop study. Records of four species during the field survey may represent range extensions, although none of these species are of conservation significance. This highlights the lack of background information for the fauna of the wider region; the Study Area is relatively remote, and few systematic biological surveys have been conducted to which the results of this study can be compared.

The six habitat types found within the Study Area are well represented throughout the surrounding landscape. Within the Study Area, the Hummock Grassland on Rocky Hill and Hummock Grassland on Stony Rise habitat types were found to be of limited extent, but these habitat types correspond with the Winnecke Land System, which is widespread in the surrounding region. None of the habitat types were found to be correlated with high numbers of records of species of conservation significance during the field survey. Of the fauna of conservation significance identified during the desktop study, many are known to be associated with habitat types on sandy plains. Such habitat types (Open Shrubland over Mixed Grassland on Sandy Plain, Mixed Grassland on Sandy Plain and Acacia Heath over Mixed Grassland on Sandy Plain) collectively encompass over 72% of the Study Area and are also well represented outside of the Study Area.

Of the 32 species of fauna of conservation significance identified by the desktop study as potentially occurring within the Study Area, four were recorded during the field survey:

- the Major Mitchell's Cockatoo (WC Act – Schedule 4);
- the Lakeland Downs Mouse and Australian Bustard (DEC Priority Fauna List – Priority 4); and
- the Rainbow Bee-eater (EPBC Act – Migratory, WC Act – Schedule 3).

An additional species of conservation significance, the Bush Stone-curlew (DEC Priority Fauna List – Priority 4) was recorded during the field survey but not identified by the desktop study as potentially occurring within the Study Area. Therefore, the total number of conservation significance potentially occurring within the Study Area is 33.

Of the 28 species of fauna of conservation significance that were identified by the desktop study as potentially occurring within the Study Area, but were not recorded during the field survey, 11 were determined to possibly occur or were determined to be likely or very likely to occur:

- Greater Bilby, Australian Painted Snipe and Great Desert Skink (EPBC Act – Vulnerable, WC Act – Schedule 1);
- Brush-tailed Mulgara (EPBC Act – Vulnerable, DEC Priority Fauna List – Priority 4);
- Peregrine Falcon and Woma (WC Act – Schedule 4);
- Spectacled Hare-Wallaby (DEC Priority Fauna List – Priority 3);
- Grey Falcon, Flock Bronzewing and Pictorella Mannikin (DEC Priority Fauna List – Priority 4); and
- Oriental Plover (EPBC Act – Migratory, WC Act – Schedule 3).

Although vertebrate fauna assemblages and vertebrate fauna habitats were adequately documented, further survey effort would almost certainly add to existing species lists for the Study Area. This is because previous surveys in the vicinity of the Study Area documented faunal assemblages that were slightly different to those reported here, and species accumulation curves for avifauna, and to lesser extent reptiles, did not reach asymptotes during the survey period. However, expansion of the species list for the Study Area would be unlikely to substantially alter conclusions regarding either the likelihood of occurrence of fauna of conservation significance, or the local and regional importance of vertebrate fauna habitats.

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Appendix A

Terrestrial Vertebrate Fauna Recorded Within and Surrounding the Browns Range Study Area

This Appendix contains a species list comprising all vertebrate fauna recorded during the field survey, literature review and database searches

Legend

Abbreviations and symbols

* Introduced species.

X Recorded during a field survey, or as part of a database or regional information search.

EPBC Act – Entries in this column indicate the status of each species under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act): CR, Critically Endangered; E, Endangered; VU, Vulnerable; and M, Migratory. If a cell is empty, the species is not listed as Threatened under the EPBC Act.

In WA – Entries in this column indicate the status of each species in Western Australia. If a species is listed as Threatened under Schedule 1, 3 or 4 of the *Wildlife Conservation Act 1950* (WA) (WC Act), the Schedule on which it is listed is provided: S1, Schedule 1, Fauna that is rare or is likely to become extinct; S3, Schedule 3, Migratory birds protected under an international agreement; and S4, Schedule 4, Other specially protected fauna. Species not listed under the WC Act may be listed on the Department of Environment and Conservation's list of Priority Fauna. In these cases, their rankings are provided: P1, Priority 1; P2, Priority 2; P3, Priority 3; and P4, Priority 4.

Surveys considered in literature review

A Desktop study for the Birrindudu Project (Outback Ecology 2010)

B Desktop study for the Browns Range Project (Ecotec 2010b)

C Level 1 fauna survey for the Gardner Range Project (Ecotec 2010a)

D Level 1 fauna survey for the Gardner range Project (Ecotec 2008b)

E Level 1 fauna survey for the Gardner range Project (Ecotec 2008a)

F Fauna habitat and assemblage survey for the Western Tanami Project (Biota 2005)

Database searches

G Threatened and Priority Fauna Database (DEC 2012c)

H Birdata: Custom Atlas Bird List (Birds Australia 2012)

I NatureMap Database (DEC 2012a)

J Protected Matters Search Tool (DSEWPaC 2012a)

K NRETAS Database (NRETAS 2012)

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
MAMMALS													
BOVIDAE													
*Bos taurus**	European Cattle			x	x	x							x
CAMELIDAE													
*Camelus dromedarius**	Dromedary			x	x	x	x	x					x
CANIDAE													
*Canis lupus**	Dingo			x	x	x	x	x					x
*Vulpes vulpes**	Fox											x	
DASYURIDAE													
Dasycercus blythei	Brush-tailed Mulgara		P4		x				x				x
Dasycercus cristicauda	Crest-tailed Mulgara	EN	VU					x	x			x	
Ningaui ridei	Wongai Ningaui							x					
Planigale ingrami	Long-tailed Planigale												x
Pseudantechinus macdonnellensis	Fat-tailed False Antechinus			x									x
Sminthopsis macroura	Stripe-faced Dunnart			x				x			x		x
Sminthopsis ooldea	Ooldea Dunnart			x									
Sminthopsis youngsoni	Lesser hairy-footed Dunnart			x				x					x
EMBALLONURIDAE													
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat			x									
Taphozous georgianus	Common Sheathtail-bat										x		
Taphozous hilli	Hill's Sheathtail-bat			x									
EQUIDAE													
*Equus asinus**	Donkey					x							x
FELIDAE													
*Felis catus**	Cat			x	x	x	x	x			x	x	x
LEPORIDAE													
*Oryctolagus cuniculus**	Rabbit											x	x
MACROPODIDAE													

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
Lagorchestes conspicillatus leichardti	Spectacled Hare-wallaby (mainland)		P3		x	x	x	x	x				x
Macropus robustus	Common Wallaroo				x	x	x						x
Macropus rufus	Red Kangaroo			x		x	x	x					x
Onychogalea unguifera	Northern Nailtail Wallaby				x	x							x
Petrogale lateralis	Black-flanked rock-wallaby												x
MOLOSSIDAE													
Chaerephon jobensis	Northern Freetail-bat			x									
Mormopterus beccarii	Beccari's Freetail-bat			x									
MURIDAE													
Leggadina forresti	Forrest's Mouse												x
Leggadina lakedownensis	Lakeland Downs Mouse		P4	x									x
*Mus musculus**	House Mouse			x				x			x		
Notomys alexis	Spinifex Hopping-mouse			x	x	x	x	x					x
Pseudomys delicatulus	Delicate Mouse			x									x
Pseudomys desertor	Desert Mouse			x				x					x
Pseudomys hermannsburgensis	Sandy Inland Mouse			x				x					x
Pseudomys johnsoni	Central Pebble-mound Mouse							x			x		
Pseudomys nanus	Western Chestnut Mouse			x				x					x
Rattus villosissimus	Long-haired Rat												x
NOTORYCTIDAE													
Notoryctes caurinus	Northern Marsupial Mole	EN	EN									x	
Notoryctes typhlops	Central Marsupial Mole	EN	EN										x
PHALANGERIDAE													
Trichosurus vulpecula	Common Brushtail Possum												x
PTEROPODIDAE													
Pteropus scapulatus	Little Red Flying-fox												x
SUIDAE													
*Sus scrofa**	Pig											x	

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
TACHYGLOSSIDAE													
Tachyglossus aculeatus	Short-beaked Echidna												x
THYLACOMYIDAE													
Macrotis lagotis	Greater Bilby	VU	VU		x	x	x	x	x		x	x	x
VESPERTILIONIDAE													
Chalinolobus gouldii	Gould's Wattled Bat			x				x			x		x
Nyctophilus geoffroyi	Lesser Long-eared Bat			x				x					x
Scotorepens greyii	Little Broad-nosed Bat			x							x		x
Vespadelus finlaysoni	Inland Cave Bat			x							x		x
BIRDS													
ACANTHIZIDAE													
Acanthiza apicalis	Inland Thornbill							x					x
Acanthiza chrysorrhoa	Yellow-rumped Thornbill												x
Gerygone fusca	Western Gerygone					x							x
Smicrornis brevirostris	Weebill			x	x						x		x
ACCIPITRIDAE													
Accipiter cirrocephalus	Collared Sparrowhawk									x	x		x
Accipiter fasciatus	Brown Goshawk			x						x	x		x
Aquila audax	Wedge-tailed Eagle				x			x		x	x		x
Circus approximans	Swamp Harrier										x		x
Circus assimilis	Spotted Harrier			x				x		x	x		x
Elanus axillaris	Black-shouldered Kite			x		x	x	x			x		x
Elanus scriptus	Letter-winged Kite												x
Haliaeetus leucogaster	White-bellied Sea-Eagle	M	S3										x
Haliastur sphenurus	Whistling Kite				x	x				x	x		x
Hamirostra melanosternon	Black-breasted Buzzard			x	x					x	x		x
Hieraaetus morphnoides	Little Eagle									x	x		x
Milvus migrans	Black Kite				x	x	x				x		x

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
ACROCEPHALIDAE													
Acrocephalus australis	Australian Reed-Warbler									x			
AEGOTHELIDAE													
Aegotheles cristatus	Australian Owlet-nightjar			x						x	x		x
ALAUDIDAE													
Mirafra javanica	Horsfield's Bushlark			x				x			x		x
ALCEDINIDAE													
Ceyx azureus	Azure Kingfisher									x			
ANATIDAE													
Anas gracilis	Grey Teal									x	x		x
Anas superciliosa	Pacific Black Duck									x	x		x
Aythya australis	Hardhead									x	x		x
Chenonetta jubata	Australian Wood Duck									x	x		
Cygnus atratus	Black Swan										x		x
Dendrocygna eytoni	Plumed Whistling-Duck										x		x
Malacorhynchus membranaceus	Pink-eared Duck										x		x
Tadorna radjah	Radjah Shelduck										x		
ANHINGIDAE													
Anhinga novaehollandiae	Australasian Darter				x					x	x		x
ANSERANATIDAE													
Anseranas semipalmata	Magpie Goose									x	x		
APODIDAE													
Apus pacificus	Fork-tailed Swift	M	S3								x	x	
ARDEIDAE													
Ardea ibis	Cattle Egret	M	S3									x	
Ardea intermedia	Intermediate Egret									x	x		x
Ardea modesta	Eastern Great Egret									x	x	x	
Ardea pacifica	White-necked Heron				x	x	x			x	x		x

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
Egretta garzetta	Little Egret				x	x							
Egretta novaehollandiae	White-faced Heron				x					x	x		
Nycticorax caledonicus	Nankeen Night Heron										x		x
ARTAMIDAE													
Artamus cinereus	Black-faced Woodswallow			x	x	x	x	x		x	x		x
Artamus leucorynchus	White-breasted Woodswallow									x	x		x
Artamus minor	Little Woodswallow							x		x	x		x
Artamus personatus	Masked Woodswallow			x	x					x	x		x
Cracticus nigrogularis	Pied Butcherbird			x	x			x		x	x		x
Cracticus tibicen	Australian Magpie			x		x				x	x		x
Cracticus torquatus	Grey Butcherbird												x
BURHINIDAE													
Burhinus grallarius	Bush Stone-curlew		P4	x									
CACATUIDAE													
Cacatua sanguinea	Little Corella			x	x	x		x		x	x		x
Calyptorhynchus banksii	Red-tailed Black-Cockatoo			x						x	x		x
Eolophus roseicapillus	Galah			x	x	x				x	x		x
Lophochroa leadbeateri	Major Mitchell's Cockatoo		S4	x	x	x	x	x	x		x		x
Nymphicus hollandicus	Cockatiel			x		x	x	x			x		x
CAMPEPHAGIDAE													
Coracina maxima	Ground Cuckoo-shrike									x	x		x
Coracina novaehollandiae	Black-faced Cuckoo-shrike			x	x	x	x	x		x	x		x
Coracina papuensis	White-bellied Cuckoo-shrike									x	x		
Lalage sueurii	White-winged Triller			x				x		x	x		x
CASUARIIDAE													
Dromaius novaehollandiae	Emu				x	x		x		x	x		x
CHARADRIIDAE													
Charadrius ruficapillus	Red-capped Plover												x

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
Charadrius veredus	Oriental Plover	M	S3					x			x	x	
Elseyornis melanops	Black-fronted Dotterel									x	x		x
Erythrogonys cinctus	Red-kneed Dotterel									x	x		
Vanellus miles	Masked Lapwing										x		x
CICONIIDAE													
Ephippiorhynchus asiaticus	Black-necked Stork					x					x		x
CISTICOLIDAE													
Cisticola exilis	Golden-headed Cisticola							x		x	x		x
CLIMACTERIDAE													
Climacteris melanura	Black-tailed Treecreeper												x
COLUMBIDAE													
Geopelia cuneata	Diamond Dove			x	x	x	x	x		x	x		x
Geopelia humeralis	Bar-shouldered Dove									x			
Geopelia striata	Peaceful Dove									x	x		x
Geophaps plumifera	Spinifex Pigeon				x		x	x		x	x		x
Ocyphaps lophotes	Crested Pigeon			x	x	x	x	x			x		x
Phaps chalcoptera	Common Bronzewing												x
Phaps histrionica	Flock Bronzewing		P4						x		x		x
CORACIIDAE													
Eurystomus orientalis	Dollarbird									x	x		
CORVIDAE													
Corvus bennetti	Little Crow			x			x	x		x	x		x
Corvus orru	Torresian Crow			x		x	x			x	x		x
CUCULIDAE													
Cacomantis pallidus	Pallid Cuckoo			x						x	x		x
Centropus phasianinus	Pheasant Coucal				x								
Chalcites basalis	Horsfield's Bronze-Cuckoo			x				x		x	x		x
Chalcites osculans	Black-eared Cuckoo									x			

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
Scythrops novaehollandiae	Channel-billed Cuckoo										x		
ESTRILDIDAE													
Emblema pictum	Painted Finch									x	x		x
Heteromunia pectoralis	Pictorella Mannikin		P4		x				x	x	x		x
Lonchura castaneothorax	Chestnut-breasted Munia												x
Poephila personata	Masked Finch										x		
Taeniopygia guttata	Zebra Finch			x	x	x	x	x			x		x
EUROSTOPODIDAE													
Eurostopodus argus	Spotted Nightjar			x		x				x	x		x
FALCONIDAE													
Falco berigora	Brown Falcon			x	x	x	x	x		x	x		x
Falco cenchroides	Nankeen Kestrel			x	x	x	x	x		x	x		x
Falco hypoleucos	Grey Falcon		P4						x	x			
Falco longipennis	Australian Hobby			x	x			x					x
Falco peregrinus	Peregrine Falcon		S4										x
Falco subniger	Black Falcon									x	x		x
GLAREOLIDAE													
Glareola maldivarum	Oriental Pratincole	M	S3								x	x	
Stiltia isabella	Australian Pratincole										x		
GRUIDAE													
Grus rubicunda	Brolga				x					x	x		x
HALCYONIDAE													
Dacelo leachii	Blue-winged Kookaburra									x	x		
Todiramphus pyrrhopygius	Red-backed Kingfisher			x				x			x		x
Todiramphus sanctus	Sacred Kingfisher				x	x	x				x		x
HIRUNDINIDAE													
Petrochelidon ariel	Fairy Martin										x		x
Petrochelidon nigricans	Tree Martin												x

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
LARIDAE													
Chlidonias hybrida	Whiskered Tern									x	x		x
Gelochelidon nilotica	Gull-billed Tern									x	x		x
Hydroprogne caspia	Caspian Tern	M	S3								x		
MALURIDAE													
Malurus coronatus coronatus	Purple-crowned Fairy-wren (western)	VU	P4						x				
Malurus lamberti	Variegated Fairy-wren			x	x			x			x		x
Malurus leucopterus	White-winged Fairy-wren				x	x		x					x
Malurus melanocephalus	Red-backed Fairy-wren			x							x		x
Stipiturus ruficeps	Rufous-crowned Emu-wren							x			x		
MEGALURIDAE													
Cincloramphus cruralis	Brown Songlark							x			x		x
Cincloramphus mathewsi	Rufous Songlark			x	x			x		x	x		x
Eremiornis carteri	Spinifexbird							x			x		x
MELIPHAGIDAE													
Acanthagenys rufogularis	Spiny-cheeked Honeyeater			x	x	x	x	x			x		x
Certhionyx variegatus	Pied Honeyeater									x	x		x
Cissomela pectoralis	Banded Honeyeater									x	x		
Conopophila rufogularis	Rufous-throated Honeyeater									x	x		x
Epthianura aurifrons	Orange Chat												x
Epthianura crocea	Yellow Chat												x
Epthianura tricolor	Crimson Chat			x				x		x	x		x
Lichenostomus flavescens	Yellow-tinted Honeyeater									x	x		x
Lichenostomus keartlandi	Grey-headed Honeyeater			x	x	x	x	x		x	x		x
Lichenostomus penicillatus	White-plumed Honeyeater				x			x		x	x		x
Lichenostomus plumulus	Grey-fronted Honeyeater									x	x		x
Lichenostomus unicolor	White-gaped Honeyeater									x	x		x
Lichenostomus virescens	Singing Honeyeater			x	x	x	x	x			x		x

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
Lichmera indistincta	Brown Honeyeater			x				x			x		x
Manorina flavigula	Yellow-throated Miner			x	x	x	x	x			x		x
Melithreptus gularis	Black-chinned Honeyeater			x	x			x			x		x
Philemon citreogularis	Little Friarbird										x		x
Purnella albifrons	White-fronted Honeyeater							x			x		x
Sugomel niger	Black Honeyeater			x	x			x			x		x
MEROPIDAE													
Merops ornatus	Rainbow Bee-eater	M	S3	x	x						x	x	x
MONARCHIDAE													
Grallina cyanoleuca	Magpie-lark			x	x	x	x	x		x	x		x
Myiagra inquieta	Restless Flycatcher										x		x
MOTACILLIDAE													
Anthus novaeseelandiae	Australasian Pipit			x				x		x	x		x
NECTARINIIDAE													
Dicaeum hirundinaceum	Mistletoebird			x				x		x	x		x
NEOSITTIDAE													
Daphoenositta chrysoptera	Varied Sittella												x
ORIOLIDAE													
Oriolus sagittatus	Olive-backed Oriole										x		
OTIDIDAE													
Ardeotis australis	Australian Bustard		P4	x	x	x	x	x	x	x	x		x
PACHYCEPHALIDAE													
Colluricincla harmonica	Grey Shrike-thrush			x	x			x		x	x		x
Colluricincla woodwardi	Sandstone Shrike-thrush									x	x		
Oreoica gutturalis	Crested Bellbird			x				x			x		x
Pachycephala rufiventris	Rufous Whistler			x				x			x		x
PARDALOTIDAE													
Pardalotus rubricatus	Red-browed Pardalote			x				x			x		x

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
Pardalotus striatus	Striated Pardalote							x			x		x
PELECANIDAE													
Pelecanus conspicillatus	Australian Pelican										x		x
PETROICIDAE													
Melanodryas cucullata	Hooded Robin			x	x			x					x
Microeca fascinans	Jacky Winter										x		x
Petroica goodenovii	Red-capped Robin				x			x					x
PHALACROCORACIDAE													
Microcarbo melanoleucos	Little Pied Cormorant										x		x
Phalacrocorax sulcirostris	Little Black Cormorant										x		x
Phalacrocorax varius	Pied Cormorant										x		
PHASIANIDAE													
Coturnix pectoralis	Stubble Quail												x
Coturnix ypsilophora	Brown Quail			x	x	x	x			x	x		x
PODARGIDAE													
Podargus strigoides	Tawny Frogmouth			x							x		x
PODICIPEDIDAE													
Podiceps cristatus	Great Crested Grebe										x		
Poliocephalus poliocephalus	Hoary-headed Grebe										x		
Tachybaptus novaehollandiae	Australasian Grebe										x		
POMATOSTOMIDAE													
Pomatostomus temporalis	Grey-crowned Babbler			x	x	x					x		x
PSITTACIDAE													
Aprosmictus erythropterus	Red-winged Parrot									x	x		x
Barnardius zonarius	Australian Ringneck			x	x	x	x	x		x	x		x
Melopsittacus undulatus	Budgerigar			x	x	x	x	x			x		x
Psitteuteles versicolor	Varied Lorikeet										x		x
Purpureicephalus spurius	Red-capped Parrot										x		

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
Trichoglossus haematodus	Rainbow Lorikeet										x		
PTILONORHYNCHIDAE													
Ptilonorhynchus nuchalis	Great Bowerbird										x		
RALLIDAE													
Fulica atra	Eurasian Coot									x	x		
Tribonyx ventralis	Black-tailed Native-hen										x		x
RECURVIROSTRIDAE													
Himantopus himantopus	Black-winged Stilt									x	x		x
RHIPIDURIDAE													
Rhipidura albiscapa	Grey Fantail												x
Rhipidura leucophrys	Willie Wagtail			x	x	x	x	x			x		x
Rhipidura rufiventris	Northern Fantail										x		
ROSTRATULIDAE													
Rostratula australis	Australian Painted Snipe	VU, M	S1, S3									x	
SCOLOPACIDAE													
Actitis hypoleucos	Common Sandpiper	M	S3							x	x		x
Calidris acuminata	Sharp-tailed Sandpiper	M	S3								x		
Gallinago megala	Swinhoe's Snipe	M	S3								x		
Numenius minutus	Little Curlew	M	S3								x		
Tringa glareola	Wood Sandpiper	M	S3								x		x
Tringa nebularia	Common Greenshank	M	S3								x		
STRIGIDAE													
Ninox novaeseelandiae	Southern Boobook Owl			x				x			x		x
THRESKIORNITHIDAE													
Platalea flavipes	Yellow-billed Spoonbill										x		x
Platalea regia	Royal Spoonbill										x		
Plegadis falcinellus	Glossy Ibis	M	S3								x		
Threskiornis molucca	Australian White Ibis										x		

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
Threskiornis spinicollis	Straw-necked Ibis				x						x		x
TURNICIDAE													
Turnix pyrrhothorax	Red-chested Button-quail			x									x
Turnix velox	Little Button-quail			x	x			x			x		x
TYTONIDAE													
Tyto javanica	Eastern Barn Owl										x		x
REPTILES													
AGAMIDAE													
Amphibolurus burnsi	Burns' Dragon							x					
Amphibolurus gilberti	Gilbert's Dragon												x
Amphibolurus longirostris	Long-nosed Dragon			x				x			x		x
Ctenophorus caudicinctus	Ring-tailed Dragon			x	x						x		x
Ctenophorus isolepis	Central Military Dragon			x	x	x	x	x			x		x
Ctenophorus nuchalis	Central Netted Dragon				x			x			x		x
Diporiphora bennettii	Robust Two-line Dragon										x		
Diporiphora lalliae	Lally's Two-line Dragon			x				x			x		x
Diporiphora winneckei	Canegrass Dragon												x
Moloch horridus	Thorny Devil			x				x					
Pogona minor minor	Dwarf Bearded Dragon			x				x					x
Tympanocryptis lineata	Lined Earless Dragon												x
CROCODYLIDAE													
Crocodylus johnstoni	Freshwater Crocodile		S4									x	
ELAPIDAE													
Brachyurophis roperi	Northern Shovel-nosed Snake			x				x					
Demansia shinei				x									
Furina ornata	Orange-naped Snake			x									x
Pseudechis australis	King Brown Snake										x		x
Pseudonaja nuchalis	Western Brown Snake												x

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
Simoselaps anomalus	Desert Banded Snake							x					
Suta fasciata	Rosen's Snake			x									
Suta ordensis	Ord Snake										x		
Suta punctata	Little Spotted Snake			x				x					
GEKKONIDAE													
Diplodactylus conspicillatus	Fat-tailed Diplodactylus							x					
Gehyra koira													x
Gehyra nana	Northern Spotted Rock Dtella			x									
Gehyra pilbara	Pilbara Dtella										x		
Gehyra purpurascens	Purplish Dtella							x			x		x
Gehyra variegata	Tree Dtella							x			x		x
Heteronotia binoei	Bynoe's Gecko							x			x		x
Lucasium stenodactylum	Crowned Gecko			x				x					x
Nephrurus levis	Three-lined Knob-tail							x					x
Oedura rhombifer	Zigzag Velvet Gecko										x		
Rhynchoedura ornata	Beaked Gecko							x					
Strophurus ciliaris	Spiny-tailed Gecko			x				x			x		x
Strophurus jeanae	Southern Phasmid Gecko							x					
PYGOPODIDAE													
Delma borea	Rusty-topped Delma							x			x		
Lialis burtonis	Burton's Snake-lizard							x					x
Pygopus nigriceps	Hooded Scaly-foot							x					
PYTHONIDAE													
Antaresia stimsoni	Stimson's Python												x
Aspidites melanocephalus	Black-headed Python				x								x
Aspidites ramsayi	Woma		S4										x
SCINCIDAE													
Carlia munda	Shaded-litter Rainbow-skink			x				x					x

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
Carlia triacantha	Desert Rainbow-skink							x					
Cryptoblepharus australis				x									
Cryptoblepharus buchananii											x		
Cryptoblepharus metallicus													x
Cryptoblepharus plagiocephalus	Callose-palmed Shinning-skink												x
Cryptoblepharus ruber											x		
Ctenotus grandis	Grand Ctenotus			x				x					x
Ctenotus greeri	Spotted-necked Ctenotus			x									x
Ctenotus helenae	Clay-soil Ctenotus			x				x			x		x
Ctenotus inornatus	Bar-shouldered Ctenotus			x							x		
Ctenotus leonhardii	Leonhardi's Ctenotus												x
Ctenotus militaris	Soldier Ctenotus										x		
Ctenotus pantherinus	Leopard Ctenotus			x				x			x		x
Ctenotus piankai	Coarse Sands Ctenotus			x	x			x					
Ctenotus quattuordecimlineatus	Fourteen-lined Ctenotus							x					
Ctenotus robustus	Robust Ctenotus			x									x
Ctenotus saxatilis	Stony-soil Ctenotus			x							x		x
Ctenotus schomburgkii	Barred Wedgesnout Ctenotus							x					x
Ctenotus tanamiensis	Tanami Ctenotus				x			x					
Eremiascincus fasciolatus	Narrow-banded Sand-swimmer			x							x		x
Eremiascincus richardsonii	Broad-banded Sand-swimmer												x
Lerista bipes	North-western Sandslider			x				x					
Lerista greeri	South-eastern Kimberley Sandslider			x				x			x		
Lerista orientalis	North-eastern Orange-tailed Slider			x							x		
Liopholis kintorei	Great Desert Skink	VU	S1									x	
Liopholis striata	Nocturnal Desert-skink												x
Menetia greyii	Common Dwarf Skink			x				x					x
Morethia ruficauda	Lined Firetail Skink			x				x			x		x

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
Notoscincus ornatus	Ornate Soil-crevice Skink										x		x
Proablepharus reginae	Western Soil-crevice Skink												x
Proablepharus tenuis	Northern Soil-crevice Skink			x									
Tiliqua multifasciata	Centralian Blue-tongue					x		x			x		x
TYPHLOPIDAE													
Ramphotyphlops diversus	Northern Blind Snake							x			x		x
Ramphotyphlops grypus	Long-beaked Blind Snake							x					
VARANIDAE													
Varanus acanthurus	Ridge-tailed Monitor			x				x			x		x
Varanus brevicauda	Short-tailed Pygmy Monitor							x					
Varanus eremius	Pygmy Desert Monitor			x				x					x
Varanus giganteus	Perentie												x
Varanus gilleni	Pygmy Mulga Monitor							x					x
Varanus gouldii	Gould's Goanna					x		x					x
Varanus tristis	Black-headed Monitor			x							x		x
AMPHIBIANS													
HYLIDAE													
Cyclorana australis	Giant Frog										x		x
Cyclorana longipes	Long-footed Frog			x									
Cyclorana maini	Main's Frog												x
Litoria caerulea	Green Tree Frog				x						x		
Litoria coplandi	Copland's Rock Frog										x		x
Litoria inermis	Peters' Frog										x		
Litoria meiriana	Rockhole Frog												x
Litoria pallida	Pale Frog										x		
Litoria rothii	Roth's Tree Frog												x
Litoria rubella	Desert Tree Frog			x	x						x		
Litoria watjulumensis	Wotjulum Frog										x		x

Species name	Common name	Conservation status		This survey	Literature review				Database searches				
		EPBC Act	In WA		C	D	E	F	G	H	I	J	K
LIMNODYNASTIDAE													
Neobatrachus aquilonius	Northern Burrowing Frog												x
Notaden nichollsi	Desert Spadefoot Toad							x			x		x
MYOBATRACHIDAE													
Uperoleia borealis	Northern Toadlet			x							x		

Appendix B

GPS Coordinates for Systematic Sites, Cameras and SM2s

This Appendix contains specific locations and descriptions for each of the five systematic sites sampled during the field survey, along with the nine motion-sensor cameras and eight SM2 bat echolocation recorders deployed across the Study Area.

Systematic sites

Site ID	Location Coordinates (WGS84 UTM 52K)	
	Easting	Northing
Site A	491603	7903433
Site B	493745	7914027
Site C	491778	7908510
Site D	492414	7910158
Site E	494694	7912077

Motion-sensor cameras

Camera	Location Description	Location Coordinates (WGS84 UTM 52K)	
		Easting	Northing
CAM1	Site A	491693	7903303
CAM2	Site B	493734	7913870
CAM3	Site C	491720	7908475
CAM4	Site D	492428	7910236
CAM5	Site E	494691	7912033
CAM6	Overlooking pool of water amidst degraded area within Open Shrubland over Mixed Grassland on Sandy Plain habitat close to Drainage Line habitat	491753	7902082
CAM7	Base of tree in Open Shrubland over Mixed Grassland on Sandy Plain habitats at the bottom of a hill comprising Hummock Grassland on Rocky Hill habitat	492544	7910092
CAM8	Overlooking track through *Acacia* Heath over Mixed Grassland on Sandy Plain habitat	493120	7912234
CAM9	In dry creekline within Drainage Line habitat	491725	7902210

SM2 bat echolocation recorders

SM2	Location Description	Location Coordinates (WGS84 UTM 52K)	
		Easting	Northing
SM2-1	Site A	491688	7903302
SM2-2	Site B	493732	7913961
SM2-3	Site C	491749	7908481
SM2-4	Site D	429429	7910259
SM2-5	Site E	494663	7912040
SM2-6	Overlooking pool of water amidst degraded area within Open Shrubland over Mixed Grassland on Sandy Plain habitat close to Drainage Line habitat	491754	7902069
SM2-7	In dry creekline within Drainage Line habitat	491725	7902202
SM2-8	Top of rocky ridge in Hummock Grassland on Rocky Hill habitat (higher and more rocky than systematic sampling sites within this habitat type)	494204	7913602

Appendix C

Classification of Habitat Condition

This Appendix contains a description of definitions used within this report to describe the condition of fauna habitat within the Study Area. The table has been taken from:

Keighery, B.J. (1994) *Bushland Plant Survey. A Guide to Plant Community Survey fo the Community Wildflower Society of WA (Inc).* Nedlands, Western Australia.

Classification of Habitat Condition

Code	Description
Pristine	Pristine or nearly so. No obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as ‘parkland cleared’ with the flora comprising weed or crop species with isolated native trees or shrubs.

Appendix D

Formal Habitat Assessments Conducted at Systematic Sites

This Appendix contains the raw data obtained from habitat assessments conducted at each of the five trapping sites used during this survey. Two habitat assessments were conducted at each trapping site to capture local variations in habitat.

Site A Transect 1

Study Area: Browns Range Project Study Area
Site Name: Site A
Habitat Type: Drainage Line
Assessment Date: 05/05/2012

Coordinates (WGS84 UTM 52K):
Transect start point: 491650 E, 7903396 N
Transect end point: 491650 E, 7903420 N

Vegetation:

Stratum	Height		Percent cover		Growth Form	Dom spp.
	min (m)	max (m)	min (%)	max (%)		
Upper	2	5	10	20	Tree	*Eucalyptus* sp.
Middle	1	2	10	30	Shrub	*Acacia* spp.
Ground	0.3	1	90	95	Tussock grass	Various grasses

Ground Cover (percent):

Bare soil	Litter	Perennial	Annuals
<5	<2	95	0

Soils: Type: fine sandy loam
Colour: brown-brown/red
Exposed bedrock: none

Coarse Surface Particles: none

Water Impacts:
Waterlogging: yes
Inundation: yes
Flooding: yes

Fire impacts: none

Other Impacts:
Erosion: slightly disturbed
Human disturbance: undisturbed
Introduced species: no evidence
Weeds: none

Other Environmental Variables:
Slope: flat
Aspect: N/A
Landform: riparian floodplain
Large trees (>20cm DBH): none
Visible hollows: none
Coarse woody debris: occasional

Site A Transect 2

Study Area: Browns Range Project Study Area
Site Name: Site A
Habitat Type: Drainage Line
Assessment Date: 06/05/2012

Coordinates (WGS84 UTM 52K):
Transect start point: 491633 E, 7903478 N
Transect end point: 491667 E, 7903459 N

Vegetation:

Stratum	Height		Percent cover		Growth Form	Dom spp.
	min (m)	max (m)	min (%)	max (%)		
Upper	3	8	10	20	Tree	*Eucalyptus* sp.
Middle	1	3	5	10	Tree	Young *Eucalypt* sp., *Acacia* sp.
Ground	0.5	1	95	100	Tussock grass	Various grasses

Ground Cover (percent):

Bare soil	Litter	Perennial	Annuals
<5	<2	95	0

Soils: Type: fine sandy loam
Colour: brown
Exposed bedrock: none

Coarse Surface Particles: none

Water Impacts:
Waterlogging: yes
Inundation: yes
Flooding: yes

Fire impacts: none

Other Impacts:
Erosion: slightly disturbed
Human disturbance: undisturbed
Introduced species: no evidence
Weeds: none

Other Environmental Variables:
Slope: flat
Aspect: N/A
Landform: riparian floodplain
Large trees (>20cm DBH): none
Visible hollows: none
Coarse woody debris:: occasional

Site B Transect 1

Study Area: Browns Range Project Study Area
Site Name: Site B
Habitat Type: Open Shrubland over Mixed Grassland on Sandy Plain
Assessment Date: 06/05/2012

Coordinates (WGS84 UTM 52K):
Transect start point: 493766 E, 7913942 N
Transect end point: 493762 E, 7913985 N

Vegetation:

Stratum	Height		Percent cover		Growth Form	Dom spp.
	min (m)	max (m)	min (%)	max (%)		
Upper	3	8	10	15	Tree	*Eucalyptus* sp.
Middle	2	3	5	10	Tree, shrub	*Acacia* spp.
Ground	1	1.5	70	80	Shrub, mixed grass	*Acacia* sp.

Ground Cover (percent):

Bare soil	Litter	Perennial	Annuals
30	<2	70	0

Soils: Type: fine sandy loam
Colour: red/brown
Exposed bedrock: none

Coarse Surface Particles: none

Water Impacts:
Waterlogging: prone (moist soil patches)
Inundation: none
Flooding: none

Fire impacts: burnt, dead standing *Acacia* spp.; recruitment of trees/shrubs

Other Impacts:
Erosion: undisturbed
Human disturbance: undisturbed
Introduced species: no evidence
Weeds: none

Other Environmental Variables:
Slope: flat
Aspect: N/A
Landform: plain
Large trees (>20cm DBH): occasional
Visible hollows: none
Coarse woody debris: occasional

Site B Transect 2

Study Area: Browns Range Project Study Area
Site Name: Site B
Habitat Type: Open Shrubland over Mixed Grassland on Sandy Plain
Assessment Date: 07/05/2012

Coordinates (WGS84 UTM 52K):
Transect start point: 493773 E, 7914071 N
Transect end point: 493808 E, 7914095 N

Vegetation:

Stratum	Height		Percent cover		Growth Form	Dom spp.
	min (m)	max (m)	min (%)	max (%)		
Upper	5	7	2	5	Tree	*Corymbia* sp.
Middle	1	2	50	80	Shrub	*Acacia* sp.
Ground	0.5	1	50	80	Mixed grass	Various grasses

Ground Cover (percent):

Bare soil	Litter	Perennial	Annuals
20	0	75	5

Soils: Type: sandy loam
Colour: red
Exposed bedrock: none

Coarse Surface Particles: none

Water Impacts:
Waterlogging: none
Inundation: none
Flooding: none

Fire impacts: burnt, dead standing *Acacia* spp.

Other Impacts:
Erosion: undisturbed
Human disturbance: undisturbed
Introduced species: no evidence
Weeds: none

Other Environmental Variables:
Slope: flat
Aspect: N/A
Landform: plain
Large trees (>20cm DBH): none
Visible hollows: none
Coarse woody debris: occasional

Site C Transect 1

Study Area: Browns Range Project Study Area
Site Name: Site C
Habitat Type: Open Shrubland over Mixed Grassland on Sandy Plain
Assessment Date: 09/05/2012

Coordinates (WGS84 UTM 52K):
Transect start point: 491787 E, 7908499 N
Transect end point: 491813 E, 7908526 N

Vegetation:

Stratum	Height		Percent cover		Growth Form	Dom spp.
	min (m)	max (m)	min (%)	max (%)		
Upper	-	-	-	-	-	-
Middle	1	2	30	40	Shrub	*Acacia* sp.
Ground	0.5	0.8	50	70	Mixed grass	Various grasses

Ground Cover (percent):

Bare soil	Litter	Perennial	Annuals
23	15	60	2

Soils: Type: sandy loam
Colour: red/brown
Exposed bedrock: none

Coarse Surface Particles: none

Water Impacts:
Waterlogging: none
Inundation: none
Flooding: none

Fire impacts: burnt sticks and Spinifex bases

Other Impacts:
Erosion: undisturbed
Human disturbance: undisturbed
Introduced species: no evidence
Weeds: none

Other Environmental Variables:
Slope: flat
Aspect: N/A
Landform: plain
Large trees (>20cm DBH): none
Visible hollows: none
Coarse woody debris: none

Site C Transect 2

Study Area: Browns Range Project Study Area
Site Name: Site C
Habitat Type: Open Shrubland over Mixed Grassland on Sandy Plain
Assessment Date: 09/05/2012

Coordinates (WGS84 UTM 52K):
Transect start point: 491797 E, 7908495 N
Transect end point: 491833 E, 7908470 N

Vegetation:

Stratum	Height		Percent cover		Growth Form	Dom spp.
	min (m)	max (m)	min (%)	max (%)		
Upper	-	-	-	-	-	-
Middle	2	2.5	40	60	Shrub	*Acacia* sp.
Ground	0.3	1	30	60	Mixed grass	Various grasses

Ground Cover (percent):

Bare soil	Litter	Perennial	Annuals
40	10	50	0

Soils: Type: sandy loam
Colour: red/brown
Exposed bedrock: none

Coarse Surface Particles: none

Water Impacts:
Waterlogging: none
Inundation: none
Flooding: none

Fire impacts: burnt tree and burnt, dead shrubs

Other Impacts:
Erosion: slightly disturbed
Human disturbance: undisturbed
Introduced species: camel tracks
Weeds: none

Other Environmental Variables:
Slope: flat
Aspect: N/A
Landform: plain
Large trees (>20cm DBH): none
Visible hollows: none
Coarse woody debris: one fallen branch from dead tree

Site D Transect 1

Study Area: Browns Range Project Study Area
Site Name: Site D
Habitat Type: Hummock Grassland on Rocky Hill
Assessment Date: 13/05/2012

Coordinates (WGS84 UTM 52K):
Transect start point: 492431 E, 7910179 N
Transect end point: 492401 E, 7910206 N

Vegetation:

Stratum	Height		Percent cover		Growth Form	Dom spp.
	min (m)	max (m)	min (%)	max (%)		
Upper	3	5	0	5	Tree	*Eucalyptus* sp.
Middle	1.5	2	0	5	Tree	Young *Eucalyptus* sp.
Ground	0.2	0.5	30	40	Hummock grass	*Triodia* sp.

Ground Cover (percent):

Bare soil	Litter	Perennial	Annuals
70	0	30	0

Soils: Type: rocky sand
Colour: red
Exposed bedrock: 20-50% site has exposed bedrock

Coarse Surface Particles (CSP):
% cover over transect: >60%
% cover on ground: >50%
CSP sizes: 6-600 mm

Water Impacts:
Waterlogging: none
Inundation: none
Flooding: none

Fire impacts: sparse vegetation cover; burnt dead shrubs, *Triodia* sp. recruitment

Other Impacts:
Erosion: undisturbed
Human disturbance: undisturbed
Introduced species: no evidence
Weeds: none

Other Environmental Variables:
Slope: moderately inclined (5-15^{o})
Aspect: east
Landform: mid-slope
Large trees (>20cm DBH): none
Visible hollows: none
Coarse woody debris: none

Site D Transect 2

Study Area: Browns Range Project Study Area
Site Name: Site D
Habitat Type: Hummock Grassland on Rocky Hill
Assessment Date: 13/05/2012

Coordinates (WGS84 UTM 52K):
Transect start point: 492432 E, 7910135 N
Transect end point: 492392 E, 7910124 N

Vegetation:

Stratum	Height		Percent cover		Growth Form	Dom spp.
	min (m)	max (m)	min (%)	max (%)		
Upper	-	-	-	-	-	-
Middle	-	-	-	-	-	-
Ground	0.2	0.6	10	50	Hummock grass	*Triodia* sp.

Ground Cover (percent):

Bare soil	Litter	Perennial	Annuals
60	0	40	0

Soils: Type: rocky sand
Colour: red
Exposed bedrock: <20% site has exposed bedrock

Coarse Surface Particles (CSP):
% cover over transect: >60%
% cover on ground: >50%
CSP sizes: 6-200 mm

Water Impacts:
Waterlogging: none
Inundation: none
Flooding: none

Fire impacts: sparse vegetation cover; *Triodia* sp. recruitment

Other Impacts:
Erosion: undisturbed
Human disturbance: undisturbed
Introduced species: no evidence
Weeds: none

Other Environmental Variables:
Slope: almost flat (3-5^{o})
Aspect: south-west
Landform: lower slope
Large trees (>20cm DBH): none
Visible hollows: none
Coarse woody debris: none

Site E Transect 1

Study Area: Browns Range Project Study Area
Site Name: Site E
Habitat Type: Hummock Grassland on Rocky Hill
Assessment Date: 08/05/2012

Coordinates (WGS84 UTM 52K):
Transect start point: 494683 E, 7912084 N
Transect end point: 494666 E, 7912116 N

Vegetation:

Stratum	Height		Percent cover		Growth Form	Dom spp.
	min (m)	max (m)	min (%)	max (%)		
Upper	4	6	2	5	Tree	*Eucalyptus* sp.
Middle	1	4	15	30	Shrub	*Acacia* spp.
Ground	0.5	1	20	50	Hummock grass	*Triodia* sp.

Ground Cover (percent):

Bare soil	Litter	Perennial	Annuals
23	2	75	0

Soils: Type: rocky sand
Colour: red
Exposed bedrock: <20% site has exposed bedrock

Coarse Surface Particles (CSP):
% cover over transect: >60%
% cover on ground: >50%
CSP sizes: 2-2000 mm

Water Impacts:
Waterlogging: prone
Inundation: prone
Flooding: not prone

Fire impacts: none recent

Other Impacts:
Erosion: undisturbed
Human disturbance: undisturbed
Introduced species: camel tracks
Weeds: none

Other Environmental Variables:
Slope: moderately inclined (5-15^{o})
Aspect: east
Landform: lower slope
Large trees (>20cm DBH): none
Visible hollows: none
Coarse woody debris: occasional

Site E Transect 2

Study Area: Browns Range Project Study Area
Site Name: Site E
Habitat Type: Hummock Grassland on Rocky Hill
Assessment Date: 08/05/2012

Coordinates (WGS84 UTM 52K):
Transect start point: 494683 E, 7912058 N
Transect end point: 494641 E, 7912055 N

Vegetation:

Stratum	Height		Percent cover		Growth Form	Dom spp.
	min (m)	max (m)	min (%)	max (%)		
Upper	3	7	0	5	Tree	*Eucalyptus* sp.
Middle	2	3	0	5	Tree	*Acacia* sp.
Ground	0.2	0.5	40	60	Mixed grass	*Triodia* sp., *Acacia* sp.

Ground Cover (percent):

Bare soil	Litter	Perennial	Annuals
50	<2	50	0

Soils: Type: rocky sand
Colour: red
Exposed bedrock: <20% site has exposed bedrock

Coarse Surface Particles (CSP):
% cover over transect: >60%
% cover on ground: >50%
CSP sizes: 6-600 mm

Water Impacts:
Waterlogging: prone
Inundation: prone
Flooding: not prone

Fire impacts: some burnt trees

Other Impacts:
Erosion: undisturbed
Human disturbance: undisturbed
Introduced species: no evidence
Weeds: none

Other Environmental Variables:
Slope: moderately inclined (5-15^{o})
Aspect: north
Landform: mid-slope
Large trees (>20cm DBH): occasional
Visible hollows: none
Coarse woody debris: none

Appendix E

Echolocation Survey of Bat Activity within the Browns Range Study Area

This Appendix comprises the report produced by Bat Call WA Pty Ltd following the analysis of SM2 bat echolocation recordings obtained within the Study Area.

Brown Range WA Fauna Survey, May 2012

Echolocation Survey of Bat Activity.

Prepared for Outback Ecology

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Issue 1
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3 June 2012

Background

Chiroptera species presence, with an estimate of activity level, is presented for a study area in the Browns Range in the Tanami Desert, WA. Outback Ecology carried out an echolocation based survey using full spectrum Songmeter SM2 bat detectors during May 2012. Bat Call WA has reviewed the recordings made and provided species lists for the bats present.

Habitats

The sites for the Chiroptera survey were chosen by Outback Ecology. All were thin shrubland sites on flat ground or with rocky ridges or dune systems close by. Recordings from two nights at each site were collected and analysed.

Site specific details are presented in Table 1.

Bat Fauna

A microbat list of eight insectivorous species was confirmed as present by their echolocation calls.

The species detected comprise the complete local Tanami Desert community. No Kimberley or Northern Territory mesic top end endemic species were detected and these are not expected to be present at the study area. No *Tadarida australis* were detected although the timing in early May would preclude its arrival from the south (Bullen and McKenzie 2005).

Characteristics of the calls recorded are presented in Table 2. Results are presented in Table 3.

Survey Timing, Moon Phase and Weather

The echolocation survey was conducted between the 4th to 12th May 2012. The survey was conducted in a warm and dry period. Sampling evenings were fine and clear. Minimum overnight temperatures were cool with temperatures around 15 deg C. The moon in this period was between full and last quarter. These conditions would typically result in lower than average bat activity and echolocation call detections.

Survey Team

The bat sampling work was conducted by staff of Outback Ecology. No activities were conducted that directly impacted upon the bat fauna present.

R.D. Bullen of Bat Call WA completed analysis of echolocation recordings.

Systematic Sampling

The six overnight recordings analysed were made with SM2BAT detectors (Wildlife Acoustics, USA). The jumper and audio settings used for the SM2BAT followed the

manufacturers recommendations for bat detection contained in the user manual (Wildlife Acoustics 2010), Table 4. Selectable filters and triggers were also set using the manufacturers recommendations.

For all recordings, once reformatted as .wav files, COOL EDIT 2000 (Now available as AUDITION from Adobe Systems Inc.) was used to display each "continuous call" sequence (EPA and DEC 2010) for identification. Only good quality call sequences were used. Details of calls analysed are provided in Table 2 as recommended by Australasian Bat Society (ABS 2006). Reference data for the species identified are available in Bullen and McKenzie 2002, McKenzie and Bullen 2003, McKenzie and Bullen 2009 and McKenzie and Bullen 2012.

Bat activity was then characterised as "Low", "Medium" or "High" based on the rate of call sequences recorded.

- Low species activity is referred when a species is recorded with call spacing less often than ten minutes,
- Medium species activity refers to call recordings more often than 10 minutes but less often than two minutes apart for a significant time period followed by sporadic records for the remainder of the session.
- High species activity refers to call recording more often than two minutes apart for significant periods followed by reasonably regular records for the remainder of the session.

Further details of the calls analysed including graphical presentations are available from Bat Call WA on request.

Survey Limitations

The sites surveyed were accessible on foot and the recorders were set at ground level with the antenna horizontal. The omni antenna fitted to the SM2 detector will successfully record all bats that pass within range under these conditions. Bat sound recordings began at sunset and continued until sunrise.

Bat species density is impossible to estimate from echolocation records. Bat activity is therefore substituted as an approximate guide to the relative numbers of each species using the study area.

References

ABS (2006). Recommendations of the Australasian Bat Society Inc for reporting standards for insectivorous bat surveys using bat detectors. *The Australasian Bat Society Newsletter* 27: 6-9.

Bullen R.D. and McKenzie N.L. (2002). Differentiating Western Australian Nyctophilus (Chiroptera: Vespertilionidae) echolocation calls. *Australian Mammalogy*. 23: 89-93

Bullen, R.D. and McKenzie, N.L. (2005). Seasonal range variation of Tadarida australis (Chiroptera: Molossidae) in western Australia: the impact of enthalpy. *Australian Journal of Zoology* **53**, 145-156.

EPA and DEC (2010). Technical guide – terrestrial vertebrate fauna surveys for environmental impact assessment (eds B.M. Hyder, J. Dell and M.A. Cowan). Environmental Protection Authority and Department of Environment and Conservation, Perth Western Australia.

McKenzie N.L. and Bullen R.D. (2003). Identifying Little Sandy Desert bat species from their echolocation calls. *Australian Mammalogy* 25: 73-80.

McKenzie, N.L. and Bullen R.D. (2009). The echolocation calls, habitat relationships, foraging niches and communities of Pilbara microbats. *Records of the Western Australian Museum (Supplement)* 78: 123-155.

McKenzie, N.L. and Bullen R.D. (2012). An acoustic survey of bats on islands in the Kimberley, western Australia, including data on the echolocation ecology, organisation and habitat relationships of regional communities. *Records of the Western Australian Museum (Supplement*) In press.

Wildlife Acoustics (2010). Song Meter User Manual, Model SM2, with Song Meter SM2BAT 192kHz Stereo or 384kHz Mono Ultrasonic Recorders addendum.

Table 1 Site Specific details.

Location	Site description	Easting	Northing
OBRbat01	Drainage, outwash plain	491687	7903301
OBRbat02	High bare ground	492428	7910259
OBRbat03	Flat bare ground	491748	7908481
OBRbat04	Rocky high ground	494204	7913602
OBRbat05	Flat bare ground	493731	7913961
OBRbat06	Rocky high ground	494663	7912040
OBRbat07	Drainage, outwash plain	491754	7902069
OBRbat08	Drainage, outwash plain	491725	7902202

Table 2: Summary of Echolocation call characteristics for microbat species present.

Genus species Authority	Common name	Typical F_{peakC} kHz	Ave. Q	Typical Duration msec	Typical Call Shape
Chaerephon jobensis (Miller 1902)	Northern free-tailed bat	22	5	8 - 15	Shallow FM
Chalinolobus gouldii (Grey 1841)	Gould's wattled bat	32	10	7 - 11	FM
Mormopterus beccarii (Peters 1881)	Beccari's free-tailed bat	26	11	8 - 13	Shallow FM
Nyctophilus geoffroyi Leach 1821	Lesser long-eared bat	47	2.5	5	Steep FM
Saccolaimus flaviventris (Peters 1867)	Yellow-bellied sheath-tailed bat	18	9	12 - 21	CF - FM
Scotorepens greyii (Gray 1843)	Little broad-nosed bat	38	10	7 - 13	FM
Taphozous hilli Thomas 1915	Hills sheath-tailed bat	26	14	9 - 18	CF– shallow FM
Vespadelus finlaysoni (Kitchener, Jones and Caputi 1987)	Inland cave bat	55	14	4 - 8	FM

Note: FpeakC and Q are defined in McKenzie and Bullen 2003, 2009.

Table 3. Microbat lists obtained

Date	**Site**	**Detector/Recorder**	***Chaerephon jobensis***	***Chalinolobus gouldii***	***Mormopterus beccarii***	*Nyctophilus geoffroyi*	*Saccolaimus flaviventris*	***Scotorepens greyii***	*Taphozous hilli*	***Vespadelus finlaysoni***
4-5 May	OBRbat01	Two overnight recording using SM2BAT detector		Low						Low
6-7 May	OBRbat02	"		Low	Low	Low	Low	Low		
8-9 May	OBRbat03	"								
10-11 May	OBRbat04	"		Low		Low	Low	Low		Low
5-6 May	OBRbat05	"								
7-8 May	OBRbat06	"	Low	Low			Low	Low	Low	

Date	Site	Detector/Recorder	*Chaerephon jobensis*	*Chalinolobus gouldii*	*Mormopterus beccarii*	*Nyctophilus geoffroyi*	*Saccolaimus flaviventris*	*Scotorepens greyii*	*Taphozous hilli*	*Vespadelus finlaysoni*
9-10 May	OBRbat07	"		Low		Med		Med		Low
11-12 May	OBRbat08	"	Low			Low		Low		Low

Note 1: Low activity refers to call spacings that repeat less often than 10 minutes.
Med activity refers to call records that repeat more often than 10 minutes but less often than 2 minutes for significant periods of time then sporadically for the duration of the recording.
High activity refers to calls that repeat more often than 2 minutes for significant periods of time then periodically for the duration of the recording.

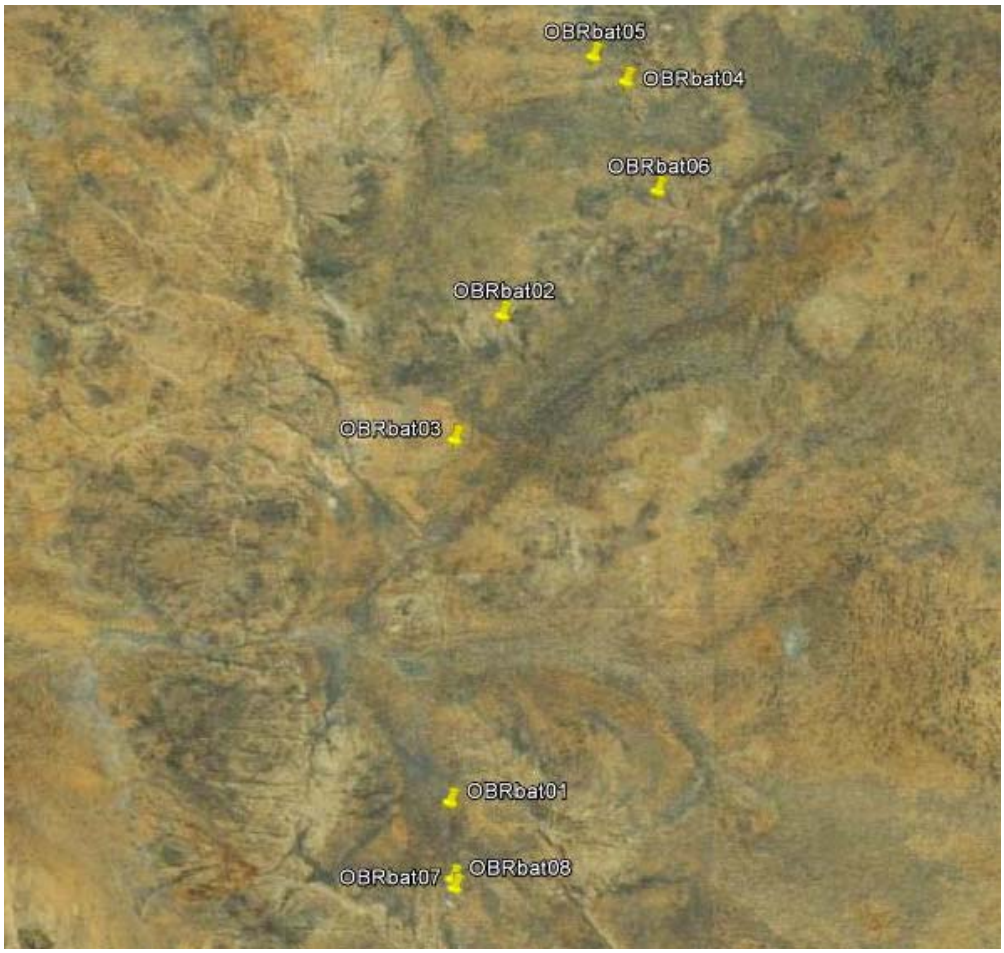
Note 2: No bats were recorded at this site.

Table 4 SM2 Audio settings used during survey.

Parameter	Setting
Sample rate	Fs = 384,000 kHz
Channel used	Left
Compression protocol	WAC4 (12 bit audio samples)
Gain - left channel	0.00
Digital high pass filter Left channel	Fs / 48
Digital low pass filter Left channel	Off
Triggering level Left channel	8SNR (adaptive +8 dB triggering)
Triggering window Left channel	1.0 sec.

Note: These settings are as recommended in Wildlife Acoustics (2010) except the high pass filter. This is set at 8 kHz to record any *Tadarida australis* that may be present

Figure 1. Location of study area sites in relation to local features



Appendix F

Observations of Terrestrial Vertebrate Fauna Recorded within the Browns Range Study Area

This Appendix describes the number observations for all vertebrate fauna recorded by systematic methods during the field survey. It also records which vertebrate fauna were detected by non-systematic methods. Separate species lists are provided for mammals, birds, reptiles and amphibians.

Legend

* Introduced species

X Species recorded

Numbers within the table are the number of observations

EPBC Act – Entries in this column indicate the status of each species under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act): CR, Critically Endangered; E, Endangered; VU, Vulnerable; and M, Migratory. If a cell is empty, the species is not listed as Threatened under the EPBC Act.

In WA – Entries in this column indicate the status of each species in Western Australia. If a species is listed as Threatened under Schedule 1, 3 or 4 of the *Wildlife Conservation Act 1950* (WA) (WC Act), the Schedule on which it is listed is provided: S1, Schedule 1, Fauna that is rare or is likely to become extinct; S3, Schedule 3, Migratory birds protected under an international agreement; and S4, Schedule 4, Other specially protected fauna. Species not listed under the WC Act may be listed on the Department of Environment and Conservation's list of Priority Fauna. In these cases, their rankings are provided: P1, Priority 1; P2, Priority 2; P3, Priority 3; and P4, Priority 4.

MAMMALS

Scientific Name	Common Name	Conservation Status		Systematic Sites					Targeted searches	Opportunistic sightings	SM2	Motion Sensor Camera	SRE Wet Pitfall
		EPBC Act	In WA	Site A	Site B	Site C	Site D	Site E					
BOVIDAE													
*Bos taurus**	European Cattle									X			
CAMELIDAE													
*Camelus dromedarius**	Dromedary			1	2	1		1	X	X			
CANIDAE													
*Canis lupus**	Dingo					1	1		X	X		X	
DASYURIDAE													
Pseudantechinus macdonnellensis	Fat-tailed False Antechinus						2	13					X
Sminthopsis macroura	Stripe-faced Dunnart				2								X
Sminthopsis ooldea	Ooldea Dunnart			2	3								X
Sminthopsis youngsoni	Lesser hairy-footed Dunnart			3	3	1							X
EMBALLONURIDAE													
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat										X		
Taphozous hilli	Hill's Sheathtail-bat										X		
FELIDAE													
*Felis catus**	Cat			1	1								
MACROPODIDAE													
Macropus rufus	Red Kangaroo							1		X			
MOLOSSIDAE													
Chaerephon jobensis	Northern Freetail-bat										X		
Mormopterus beccarii	Beccari's Freetail-bat										X		
MURIDAE													
Leggadina lakedownensis	Lakeland Downs Mouse		P4	2			1						

Scientific Name	Common Name	Conservation Status		Systematic Sites					Targeted searches	Opportunistic sightings	SM2	Motion Sensor Camera	SRE Wet Pitfall
		EPBC Act	In WA	Site A	Site B	Site C	Site D	Site E					
*Mus musculus**	House Mouse				4	7	1						
Notomys alexis	Spinifex Hopping-mouse				6	10						X	X
Pseudomys delicatulus	Delicate Mouse				1								
Pseudomys desertor	Desert Mouse			1	13	13		2					X
Pseudomys hermannsburgensis	Sandy Inland Mouse				11	12	2	1					
Pseudomys nanus	Western Chestnut Mouse			8	9	9		6	X				X
VESPERTILIONIDAE													
Chalinolobus gouldii	Gould's Wattled Bat			1			1	2			X		
Nyctophilus geoffroyi	Lesser Long-eared Bat						1				X		
Scotorepens greyii	Little Broad-nosed Bat						2	2			X		
Vespadelus finlaysoni	Inland Cave Bat			2							X		

BIRDS

Scientific Name	Common Name	Conservation Status		Systematic Sites					Targeted searches	Opportunistic sightings
		EPBC Act	In WA	Site A	Site B	Site C	Site D	Site E		
ACANTHIZIDAE										
Smicrornis brevirostris	Weebill			8	9	3	2	3	X	
ACCIPITRIDAE										
Accipiter fasciatus	Brown Goshawk						1			
Circus assimilis	Spotted Harrier									X
Elanus axillaris	Black-shouldered Kite			2		4			X	X
Hamirostra melanosternon	Black-breasted Buzzard					1				
AEGOTHELIDAE										
Aegotheles cristatus	Australian Owlet-nightjar							1		X
ALAUDIDAE										
Mirafra javanica	Horsfield's Bushlark									X
ARTAMIDAE										
Artamus cinereus	Black-faced Woodswallow			16	10	6	6	22	X	
Artamus personatus	Masked Woodswallow			1	1	45	7	38	X	
Cracticus nigrogularis	Pied Butcherbird			4	3	4	4	1	X	X
Cracticus tibicen	Australian Magpie									X
BURHINIDAE										
Burhinus grallarius	Bush Stone-curlew		P4		2	1	1			
CACATUIDAE										
Cacatua sanguinea	Little Corella					2				
Calyptorhynchus banksii	Red-tailed Black-Cockatoo						5			
Eolophus roseicapillus	Galah				10	7	54	3		X
Lophochroa leadbeateri	Major Mitchell's Cockatoo		S4			1			X	X
Nymphicus hollandicus	Cockatiel			7					X	
CAMPEPHAGIDAE										

Scientific Name	Common Name	Conservation Status		Systematic Sites					Targeted searches	Opportunistic sightings
		EPBC Act	In WA	Site A	Site B	Site C	Site D	Site E		
Coracina novaehollandiae	Black-faced Cuckoo-shrike			6		1	1	3	X	
Lalage sueurii	White-winged Triller			1	4	2	1	1	X	X
COLUMBIDAE										
Geopelia cuneata	Diamond Dove			10	26	2	38	13	X	X
Ocyphaps lophotes	Crested Pigeon				7	3	10			X
CORVIDAE										
Corvus bennetti	Little Crow				1					
Corvus orru	Torresian Crow						2			
CUCULIDAE										
Cacomantis pallidus	Pallid Cuckoo				5	1	1	1	X	
Chalcites basalis	Horsfield's Bronze-Cuckoo				3	2			X	
ESTRILDIDAE										
Taeniopygia guttata	Zebra Finch			25	21	8	1	6	X	X
EUROSTOPODIDAE										
Eurostopodus argus	Spotted Nightjar									X
FALCONIDAE										
Falco berigora	Brown Falcon				1	1				X
Falco cenchroides	Nankeen Kestrel					2	1			X
Falco longipennis	Australian Hobby								X	
HALCYONIDAE										
Todiramphus pyrrhopygius	Red-backed Kingfisher			1	5		1			
MALURIDAE										
Malurus lamberti	Variegated Fairy-wren			7					X	
Malurus melanocephalus	Red-backed Fairy-wren			3	7	13				
MEGALURIDAE										
Cincloramphus mathewsi	Rufous Songlark			12	6	1		1	X	X

Scientific Name	Common Name	Conservation Status		Systematic Sites					Targeted searches	Opportunistic sightings
		EPBC Act	In WA	Site A	Site B	Site C	Site D	Site E		
MELIPHAGIDAE										
Acanthagenys rufogularis	Spiny-cheeked Honeyeater								X	X
Epthianura tricolor	Crimson Chat						5	1	X	
Lichenostomus keartlandi	Grey-headed Honeyeater			13	13	8	9	20	X	X
Lichenostomus virescens	Singing Honeyeater			10	2	16	7	1	X	X
Lichmera indistincta	Brown Honeyeater			6	13	26	14	2	X	X
Manorina flavigula	Yellow-throated Miner			7	11	4	39	11	X	X
Melithreptus gularis	Black-chinned Honeyeater			4	2	2		1	X	
Sugomel niger	Black Honeyeater			1		2	4		X	X
MEROPIDAE										
Merops ornatus	Rainbow Bee-eater	M	S3	1						X
MONARCHIDAE										
Grallina cyanoleuca	Magpie-lark				1		2			
NECTARINIIDAE										
Dicaeum hirundinaceum	Mistletoebird			8	2	4	1	2	X	
OTIDIDAE										
Ardeotis australis	Australian Bustard		P4			2				X
PACHYCEPHALIDAE										
Colluricincla harmonica	Grey Shrike-thrush			1				3		
Oreoica gutturalis	Crested Bellbird			4	7	2	8	6	X	
Pachycephala rufiventris	Rufous Whistler			8		3		1	X	
PARDALOTIDAE										
Pardalotus rubricatus	Red-browed Pardalote			7	5		3	2	X	
PETROICIDAE										
Melanodryas cucullata	Hooded Robin			1		2				
PHASIANIDAE										

Scientific Name	Common Name	Conservation Status		Systematic Sites					Targeted searches	Opportunistic sightings
		EPBC Act	In WA	Site A	Site B	Site C	Site D	Site E		
Coturnix ypsilophora	Brown Quail			5			11			
PODARGIDAE										
Podargus strigoides	Tawny Frogmouth						1			X
POMATOSTOMIDAE										
Pomatostomus temporalis	Grey-crowned Babbler			12		1				
PSITTACIDAE										
Barnardius zonarius	Australian Ringneck				2		2			X
Melopsittacus undulatus	Budgerigar			62	124	98	13	6	X	X
RHIPIDURIDAE										
Rhipidura leucophrys	Willie Wagtail			7	4	6	2	2	X	X
STRIGIDAE										
Ninox novaeseelandiae	Southern Boobook Owl									X
TURNICIDAE										
Turnix velox	Little Button-quail			2	2	2	4		X	X

REPTILES

Scientific Name	Common Name	Conservation Status		Systematic Sites					Targeted searches	Opportunistic sightings	SRE Wet Pitfall
		EPBC Act	In WA	Site A	Site B	Site C	Site D	Site E			
AGAMIDAE											
Amphibolurus longirostris	Long-nosed Dragon								X		
Ctenophorus caudicinctus	Ring-tailed Dragon							1			
Ctenophorus isolepis	Central Military Dragon					2			X	X	
Diporiphora lalliae	Lally's Two-line Dragon			1							X
Moloch horridus	Thorny Devil									X	

Scientific Name	Common Name	Conservation Status		Systematic Sites					Targeted searches	Opportunistic sightings	SRE Wet Pitfall
		EPBC Act	In WA	Site A	Site B	Site C	Site D	Site E			
Pogona minor minor	Dwarf Bearded Dragon						2				
ELAPIDAE											
Brachyurophis roperi	Northern Shovel-nosed Snake					1					
Demansia shinei				1			2				
Furina ornata	Orange-naped Snake				1						
Suta fasciata	Rosen's Snake				1						
Suta punctata	Little Spotted Snake			8	4	1	2				
GEKKONIDAE											
Gehyra nana	Northern Spotted Rock Dtella						2				X
Lucasium stenodactylum	Crowned Gecko						2				X
Strophurus ciliaris	Spiny-tailed Gecko				1						
SCINCIDAE											
Carlia munda	Shaded-litter Rainbow-skink					2	1				X
Cryptoblepharus australis											X
Ctenotus grandis	Grand Ctenotus					1					
Ctenotus greeri	Spotted-necked Ctenotus										X
Ctenotus helenae	Clay-soil Ctenotus										X
Ctenotus inornatus	Bar-shouldered Ctenotus							2			X
Ctenotus pantherinus	Leopard Ctenotus					3					
Ctenotus piankai	Coarse Sands Ctenotus						1				
Ctenotus robustus	Robust Ctenotus			66	9	18					X
Ctenotus saxatilis	Stony-soil Ctenotus				2			3			X
Eremiascincus fasciolatus	Narrow-banded Sand-swimmer										X
Lerista bipes	North-western Sandslider										X
Lerista greeri	South-eastern Kimberley Sandslider					1					X
Lerista orientalis	North-eastern Orange-tailed Slider										X

Scientific Name	Common Name	Conservation Status		Systematic Sites					Targeted searches	Opportunistic sightings	SRE Wet Pitfall
		EPBC Act	In WA	Site A	Site B	Site C	Site D	Site E			
Menetia greyii	Common Dwarf Skink				1						
Morethia ruficauda	Lined Firetail Skink			1			3				X
Proablepharus tenuis	Northern Soil-crevice Skink			1							X
VARANIDAE											
Varanus acanthurus	Ridge-tailed Monitor			4	1			2			
Varanus eremius	Pygmy Desert Monitor					2					
Varanus tristis	Black-headed Monitor			1						X	

AMPHIBIANS

Scientific Name	Common Name	Conservation Status		SRE Wet Pitfall
		EPBC	In WA	
HYLIDAE				
Cyclorana longipes	Long-footed Frog			X
Litoria rubella	Desert Tree Frog			X
MYOBATRACHIDAE				
Uperoleia borealis	Northern Toadlet			X

Appendix G

Definitions of Codes and Terms Used to Describe Fauna of Conservation Significance

Fauna may be accorded legislative protection by being listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) and/or the *Wildlife Conservation Act 1950* (WA) (WC Act), or by being listed on the WA Department of Environment and Conservation's *Priority Species List*. This Appendix presents a summary of the different rankings and listings used to describe conservation status. Some categories, such as 'extinct', 'extinct in the wild' and 'conservation dependent' (EPBC Act) are not presented here, as the table includes only the information needed to fully understand the codes presented in the preceding report. Refer to the relevant legislation for a full description of all codes in use, as well as their associated criteria.

Definitions of Codes and Terms Used to Describe Conservation Significance Status

Status	Code	Description
Categories used under the EPBC Act		
Critically Endangered	CR	Fauna that is considered to be facing an extremely high risk of extinction in the wild in the immediate future
Endangered	EN	Fauna that is considered to be facing a very high risk of extinction in the wild in the near future
Vulnerable	VU	Fauna that is considered to be facing a high risk of extinction in the wild in the medium-term future
Migratory	M	Species that migrate to, over and within Australia and its external territories.
Schedules used under the WC Act		
Schedule 1	S1	Fauna that is rare or likely to become extinct. Threatened fauna listed under Schedule 1 of the WC Act are further ranked by the DEC, according to the level of threat facing each species. The ranks are CR, EN and VU.
	CR	Critically endangered: considered to be facing an extremely high risk of extinction in the wild
	EN	Endangered: considered to be facing a very high risk of extinction in the wild
	VU	Vulnerable: considered to be facing a high risk of extinction in the wild
Schedule 2	S2	Fauna that is presumed to be extinct
Schedule 3	S3	Birds that are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds
Schedule 4	S4	Fauna that is in need of special protection, other than for reasons mentioned above
DEC Priority Fauna Lists		
Priority 1	P1	Taxa with few, poorly known populations on threatened lands. These are known from few specimens or sight records from one or a few localities on lands not managed for conservation, eg agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 2	P2	Taxa with few, poorly known populations on conservation lands. These are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, eg national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands. These are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 4	P4	Taxa in need of monitoring. These are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.
Priority 5	P5	Taxa in need of monitoring. These are not considered threatened but are subject to a specific conservation programme, the cessation of which would result in the species becoming threatened within five years.

Appendix H

Species of Conservation Significance

This Appendix contains specific locations for each record of a species of conservation significance within the Study Area. See Appendix G for full definitions of conservation status.

Conservation significant species

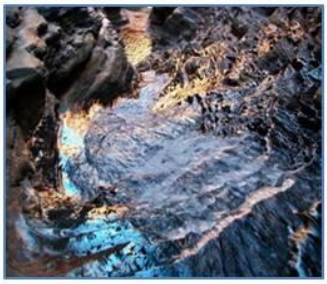
Scientific Name	Common Name	Conservation status[1]		Date of record	GPS coordinates (WGS84 UTM52K)		Site	Sampling method	Observation type	Number recorded
		EPBC Act	In WA		Easting	Northing				
Ardeotis australis	Australian Bustard		P4	6/05/2012	491650	7908328	N/A	Opportunistic	Heard/sighted	1
Ardeotis australis	Australian Bustard		P4	8/05/2012	491778	7908510	Site C	Avifauna census	Heard/sighted	2
Ardeotis australis	Australian Bustard		P4	5/05/2012	491650	7908328	N/A	Opportunistic	Heard/sighted	1
Ardeotis australis	Australian Bustard		P4	8/05/2012	494040	7910829	N/A	Opportunistic	Heard/sighted	2
Ardeotis australis	Australian Bustard		P4	10/05/2012	494197	7910912	N/A	Opportunistic	Heard/sighted	1
Ardeotis australis	Australian Bustard		P4	12/05/2012	492145	7909692	N/A	Opportunistic	Heard/sighted	1
Ardeotis australis	Australian Bustard		P4	13/05/2012	492576	7909966	N/A	Opportunistic	Heard/sighted	2
Burhinus grallarius	Bush Stone-curlew		P4	9/05/2012	491884	7908324	Site C	Systematic search	Tracks	1
Burhinus grallarius	Bush Stone-curlew		P4	5/05/2012	492414	7910158	Site D	Systematic search	Tracks	1
Burhinus grallarius	Bush Stone-curlew		P4	7/05/2012	493713	7914157	Site B	Systematic search	Tracks	1
Burhinus grallarius	Bush Stone-curlew		P4	7/05/2012	493440	7913910	Site B	Systematic search	Tracks	1
Leggadina lakedownensis	Lakeland Downs Mouse		P4	9/05/2012	492414	7910158	Site D	Trapping	Capture	1
Leggadina lakedownensis	Lakeland Downs Mouse		P4	8/05/2012	491603	7903433	Site A	Trapping	Capture	1
Leggadina lakedownensis	Lakeland Downs Mouse		P4	6/05/2012	491603	7903433	Site A	Trapping	Capture	1
Lophochroa leadbeateri	Major Mitchell's Cockatoo		S4	11/05/2012	491760	7902200	N/A	Targeted search	Heard/sighted	2
Lophochroa leadbeateri	Major Mitchell's Cockatoo		S4	11/05/2012	493745	7914027	N/A	Opportunistic	Heard/sighted	5
Lophochroa leadbeateri	Major Mitchell's Cockatoo		S4	12/05/2012	491778	7908510	Site C	Avifauna census	Heard/sighted	1
Lophochroa leadbeateri	Major Mitchell's Cockatoo		S4	7/05/2012	493745	7914027	N/A	Opportunistic	Heard/sighted	8
Lophochroa leadbeateri	Major Mitchell's Cockatoo		S4	13/05/2012	493114	7903135	N/A	Opportunistic	Heard/sighted	5
Merops ornatus	Rainbow Bee-eater	M	S3	9/05/2012	491727	7902075	N/A	Opportunistic	Heard/sighted	2
Merops ornatus	Rainbow Bee-eater	M	S3	9/05/2012	491603	7903433	Site A	Active search	Heard/sighted	1

[1]See Appendix G for full definitions of conservation status

Appendix B

Targeted vertebrate fauna survey report (Outback Ecology 2014)

This Assessment was based in part on the results of a targeted vertebrate fauna survey report, performed in December 2014 by Outback Ecology – *Browns Range Project: Targeted Vertebrate Fauna Survey*. The standalone, targeted survey report is contained in this appendix.



Northern Minerals Limited

Browns Range Project

Targeted Vertebrate Fauna Survey

January 2014

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Targeted Vertebrate Fauna Survey

Distribution:

Company	Copies	Contact Name
Northern Minerals Limited	1 electronic	Lisa Chandler, Robin Jones

Document Control for Job Number: BROW-FS-13001

Document Status	Author	Reviewer	Signature	Date of Issue
Draft Report	B. Wingfield	P.Bolton M. Young B.Parsons	M Young	31/01/2014
Final Report	B. Wingfield	P. Bolton	P. Bolton	21/2/2014

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Executive Summary

The Browns Range Project (the Project) is located approximately 150 km south-east of Halls Creek in the Tanami bioregion of Western Australia. The vertebrate fauna baseline study and fauna impact assessment, previously undertaken for the Project, indicated some potential for three conservation significant species to occur; the Greater Bilby (*Macrotis lagotis*), the Brush-tailed Mulgara, (*Dasycercus blythi*) and the Spectacled Hare-wallaby (*Lagorchestes conspicillatus*). Some uncertainty existed with regards to the likelihood of occurrence of these species and greater survey effort was required to be able to adequately determine this likelihood to inform the impact assessment for the Project. Consequently, Northern Minerals Limited (Northern Minerals) commissioned Outback Ecology (a divison of MWH Australia Pty Ltd) to conduct a Targeted Vertebrate Fauna Survey, within an area of approximately 16, 135 ha (the Study Area). The Study Area fully encompasses the development envelope for the Project.

The Survey was conducted from 11 to 18 December 2013. Targeted searches were performed at 24 target sites for any primary or secondary evidence (i.e. tracks, burrows, scats) of the target species on foot. Habitats were assessed at each target site. 18 baited, motion sensor cameras were set at target sites, whilst trapping for Brush-tailed Mulgara was undertaken at three sites. Spotlighting was undertaken over two nights.

The majority of the Study Area was found to be of marginal quality at best for all of the three targeted species. Specifically, the majority of the Study Area was found to be unsuitable for Bilby and Brush-tailed Mulgara, due to the substrate consisting of a thin loose, friable sandy surface ofver a relatively dense sandy subsoil with a massive structure and strong consistence unsuitable for the construction of burrows. Additionally, portions of the Study Area supporting tussock and hummock grasslands and *Acacia* shrublands may have been suitable for grazing by Spectacled Hare-wallaby; however, these areas would not have been suitable for providing shelter (day nesting) for this species due to a lack of suitably large spinifex hummocks. The lack of large spinifex hummocks is a consequence of a historical and ongoing fire regime that promotes regular, large scale fires across large portions of the Study Area.

Evidence of two of the three target species were recorded at only two sites within the Study Area. Bilby scats (one deposit, several months old) were collected at one site and scats of the Spectacled Hare-wallaby (two deposits, several months old) were collected at another site. These scats were verified by comparing them with reference material from captive animals. Diggings of various ages were encountered at most sites, but in all cases these were clearly distinguishable as those of varanid activity rather than that of the Bilby or Brush-tailed Mulgara. The limited evidence of Bilby and Spectacled Hare-wallaby within the Study Area suggests that the Study Area is unlikely to support resident populations of these species, however individuals of these species may forage in, or traverse, the Study Area from time to time. It is considered unlikely that any of the habitats in the Study Area represent important or core habitat for any of the three target species, and therefore that there are unlikely to be any substantial impacts of the Project on these species at either a local or a regional scale.

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1. INTRODUCTION

1.1. Project Background And Location

Northern Minerals Limited (Northern Minerals) proposes to develop the Browns Range Project (the Project). The Project is located approximately 150 kilometres (km) south-east of Halls Creek in the Tanami bioregion of Western Australia (WA), immediately west of the Western Australia/Northern Territory border (**Figure 1**).

In 2012, a Level 2 vertebrate fauna baseline survey was undertaken for the Project over an area consisting of approximately 16,135 hectares (ha) (the Study Area; **Figure 2**) (Outback Ecology 2012b). A subsequent impact assessment was undertaken in 2013 (Outback Ecology in prep). These studies indicated some potential for three conservation significant species to occur; the Greater Bilby (Bilby; *Macrotis lagotis*), the Brush-tailed Mulgara, (*Dasycercus blythi*) and the Spectacled Hare-wallaby (*Lagorchestes conspicillatus*).

The 2012 field survey did not detect any of these species, either directly or indirectly via secondary evidence (i.e. burrows, scats, tracks, diggings), but habitat present was deemed capable of supporting these species and the Study Area lies within their known distribution. Consequently, Northern Minerals commissioned Outback Ecology (a division of MWH Australia Pty Ltd) to conduct a Targeted Vertebrate Fauna Survey to further assess the likelihood of occurrence (this Survey). This Survey used the same Study Area as the previous baseline survey and impact assessment (**Figure 2**). The Study Area fully encompasses the development envelope for the Project.

1.2. Report Scope And Objectives

The objective of this Survey was to determine the extent to which the Bilby, Spectacled Hare-wallaby and Brush-tailed Mulgara, and suitable habitat for these species, occur in the Study Area. The survey plan and methods to target the three conservation significant species were designed by Outback Ecology, in consultation with the Office of the Environmental Protection Authority (OEPA), and in accordance with Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), WA Department of Parks and Wildlife (DPaW) and WA Environmental Protection Authority (EPA) guidelines, including EPA Guidance Statement 56 and Position Statement 3 (DEWHA 2011, EPA and DEC 2010, EPA 2002, EPA 2004). The specific objectives of this Survey were to:

- inspect the Study Area for primary or secondary evidence (i.e. tracks, burrows, scats) of the Greater Bilby, Brush-tailed Mulgara and Spectacled Hare-wallaby, and report any observations;
- describe the quality and amount of habitat in terms of its potential to support local populations of these three species; and
- provide data that allow for adequate assessment of the potential impacts of the Project on the three species.

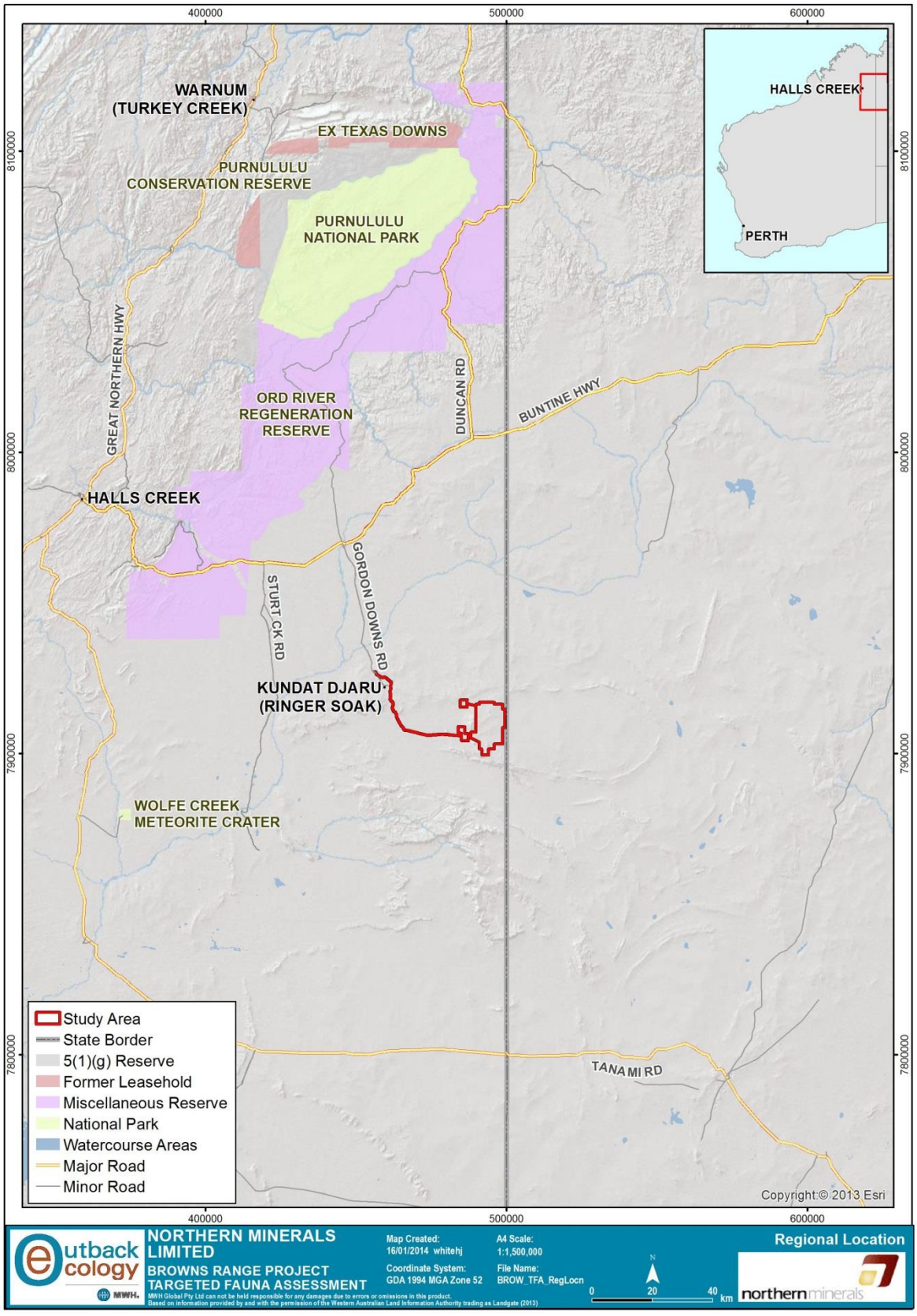

Figure 1: Regional location of the Browns Range Project Study Area

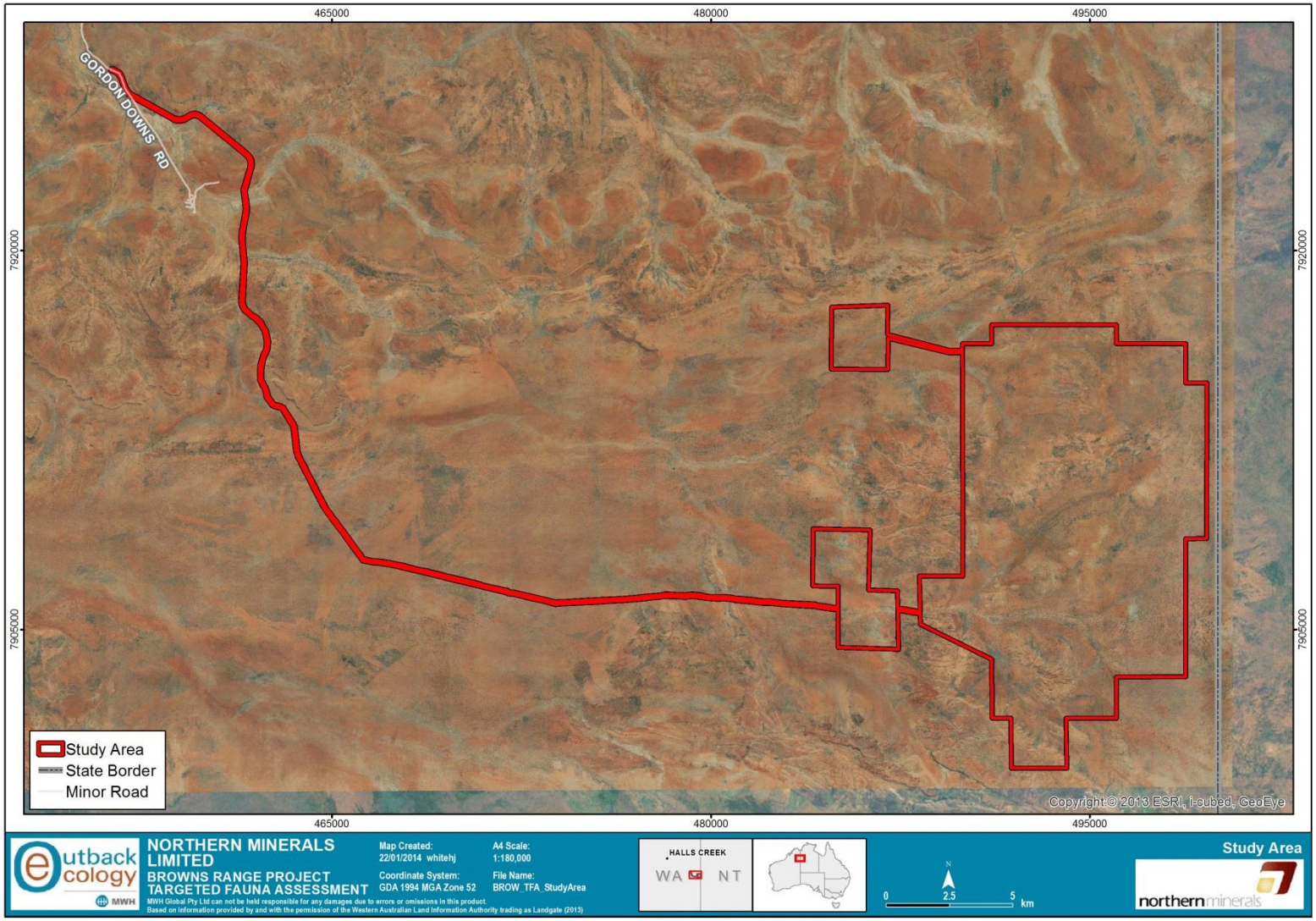

Figure 2: The Study Area

2. BACKGROUND INFORMATION

2.1. Existing Environment

For full details of the existing environment, including climate, soil landscapes, land use and bioregion, refer to the Terrestrial Vertebrate Fauna Baseline Survey (2012b) and Terrestrial Vertebrate Fauna Impact Assessment (Outback Ecology in prep).

2.2. Ecology of the Bilby

The Bilby is a distinctive, delicately built desert bandicoot (Menkhorst and Knight 2010, Van Dyck *et al.* 2013), listed as Vulnerable under the *Environmental Protection and Biodiversity Act 1999* (EPBC Act) and as Schedule 1 fauna under the *Wildlife Conservation Act 1950* (WA) (WC Act). The Bilby was once widely distributed (DSEWPaC 2012b) but is now restricted to a portion of its former range, with wild populations restricted primarily to the Tanami Desert in the Northern Territory, the Great Sandy and Gibson Deserts in Western Australia, and an outlying population in south-west Queensland (**Figure 3**). This decline is thought to be primarily associated with predation by the European Red Fox (*Vulpes vulpes*) and the Feral Cat (*Felis catus*), although the role of the latter is uncertain (DSEWPaC 2012b, Pavey 2006, Van Dyck and Strahan 2008). In addition to predation, habitat degradation and competition from introduced herbivores, drought, unsuitable fire regimes and habitat destruction have been identified as threats (Pavey 2006).

Historically, the Greater Bilby used a variety of habitat types, including eucalypt open forests and woodlands, tall shrublands and open woodlands, tablelands and hummock grasslands (DSEWPaC 2012b). As the range of this species has contracted, it is now more often found in inland habitat types such as desert sandplains, dune fields with hummock grasslands, and massive red earths and *Acacia* shrublands (Maxwell *et al.* 1996). It is thought that the areas the species currently inhabits are the least favourable portions of its former range (Pavey 2006). The Greater Bilby digs large burrows in sandy substrates that can reach up to 3 m long and 1.8 m deep and its distribution may be limited by the availability of suitable burrowing habitat (DSEWPaC 2012b). Its distribution also appears to halt abruptly when pastoral land begins (DSEWPaC 2012b), suggesting that habitat modification as a result of grazing renders these areas unsuitable for the species.

The Greater Bilby is not reliant on surface water, as individuals are thought to meet most of their water requirements from food sources (Van Dyck and Strahan 2008). Its diet consists of insects, larvae, seeds, bulbs, fruit and fungi (Van Dyck and Strahan 2008), which it consumes whilst foraging well after dark. The Greater Bilby digs for much of its food, and in the process produces diggings of different sizes and shapes (see Moseby *et al.* 2009). The presence of these diggings, along with scats and tracks, can be sufficient to determine the presence of the species in an area (although inactive burrows may persist in the landscape for extended periods; see Lavery and Kirkpatrick 1997).

2.4. Ecology Of The Brush-Tailed Mulgara

Mulgara records consist of a mix of two species, the Brush-tailed Mulgara and the Crest-tailed Mulgara, in part due to taxonomic confusion and misidentification of captured specimens. Collectively, the two species occur across arid, inland Australia.

In addition to the complex taxonomy, there has been uncertainty as to the conservation significance of each species. In July 2013, DSEWPaC acknowledged Woolley's (2013) review, which clarified the distributions and confirmed that the two species are distinct. DSEWPaC also confirmed that the Crest-tailed Mulgara is listed as Vulnerable under the EPBC Act, and that the Brush-tailed Mulgara is not listed under the EPBC Act. In WA, the Crest-tailed Mulgara is listed under Schedule 1 of the WC Act, and the Brush-tailed Mulgara is not listed under the WC Act but is listed as Priority 4 by DPaW.

The Brush-tailed Mulgara is a small, robustly-built dasyurid possessing a short tail that is typically fattened at the base and covered in black hairs for most of its length (Van Dyck and Strahan 2008). Historically it occurred across much of the arid interior (Van Dyck *et al.* 2013), but since European settlement its abundance has declined (**Figure 4**) (Menkhorst and Knight 2004, Pavey *et al.* 2012). The Brush-tailed Mulgara is susceptible to predation by the Feral Cat and European Red Fox, which readily prey on Mulgara in arid Australia (Pavey *et al.* 2012).

The Brush-tailed Mulgara occurs in arid zone habitats, often in association with dune systems; it has been reported to occur on sand ridges (Menkhorst and Knight 2004) and from spinifex grasslands in dune swales (Van Dyck and Strahan 2008). The species has also been reported from gibber plains and sand plains with only poorly developed, low dunes (Pavey *et al.* 2012), as well as from mulga shrublands with loamy soils (Menkhorst and Knight 2004). Within its distribution the Brush-tailed Mulgara constructs burrows, with multiple side-tunnels and pop-holes. Burrow entrances are usually characterised by having an approximately equal height and width, a rounded base and a high arch (Moseby *et al.* 2009). Scats are also usually present at entrances (Moseby *et al.* 2009).

A nocturnal hunter, the Brush-tailed Mulgara is one of the largest native predatory mammals remaining in Australia's deserts (Pavey *et al.* 2012). Its diet consists of a wide variety of insects, other arthropods and vertebrates such as small rodents and even small birds (Menkhorst and Knight 2004, Pavey *et al.* 2012, Van Dyck and Strahan 2008). Like many other desert marsupials, the species is thought to be able to live without free water (Menkhorst and Knight 2004).

2.6. Ecology of the Spectacled Hare-Wallaby

The Spectacled Hare-wallaby is a stocky marsupial with distinctive bright orange rings around its eyes (Van Dyck *et al.* 2013), listed as Priority 3 under DPaW Priority List. This species is found across northern Australia, inhabiting open forests and woodlands, hummock and tussock grasslands and Acacia shrublands (Van Dyck and Strahan 2008).

Species abundance has declined dramatically from its once wide distribution across the lower latitudes of northern Australia (**Figure 5**), possibly due to fox predation and inappropriate fire regimes in spinifex grasslands, which have prevented the development of the large, mature hummocks which it requires for shelter (Van Dyck and Strahan 2008). Despite a decline over much of its former range, it is still known to occur sparsely in the Tanami Desert in *Acacia* shrubland and spinifex (Van Dyck and Strahan 2008).

A nocturnal opportunist, the Spectacled Hare-wallaby's diet consists of mainly herbs and grasses (e.g. the tips of *Triodia* leaves in long-unburnt areas) but it is also known to feed on certain fruits. These wallabies visit areas where there has been surface scraping, such as edges of clearings, to feed on moisture rich re-sprouting plants such as *Bonamia* spp. (How *et al.* 1991). They shelter during the day in tussocks of *Triodia*, in one of several shelter sites within a home range of 8 – 10 ha (Short and Turner 1991). These shelter sites are likely to provide some thermoregulatory advantage to the wallabies in addition to concealing them from predators (Short and Turner 1991).

2.7. Species Records In And Around The Study Area

A vertebrate fauna baseline survey undertaken in the Study Area in March 2012 determined that fauna habitats capable of supporting Bilby, Brush-tailed Mulgara and Spectacled Hare-wallaby were present, but the survey did not detect the species either directly or indirectly via secondary evidence (i.e. burrows, scats, tracks, diggings) (Outback Ecology 2012b).

Spectacled Hare-wallaby and Bilby have been recorded in four previous surveys conducted in the region (Biota 2005, Ecotec 2008a, b, 2010) and all species were recorded in at least two database searches (DEC 2012a, DEC 2012b, DSEWPaC 2012a, NRETAS 2012, ; in Outback Ecology 2012b), suggesting that they potentially occur in the Study Area. For further information on database searches and surveys in the vicinity of the Study Area, see Outback Ecology (2012b).

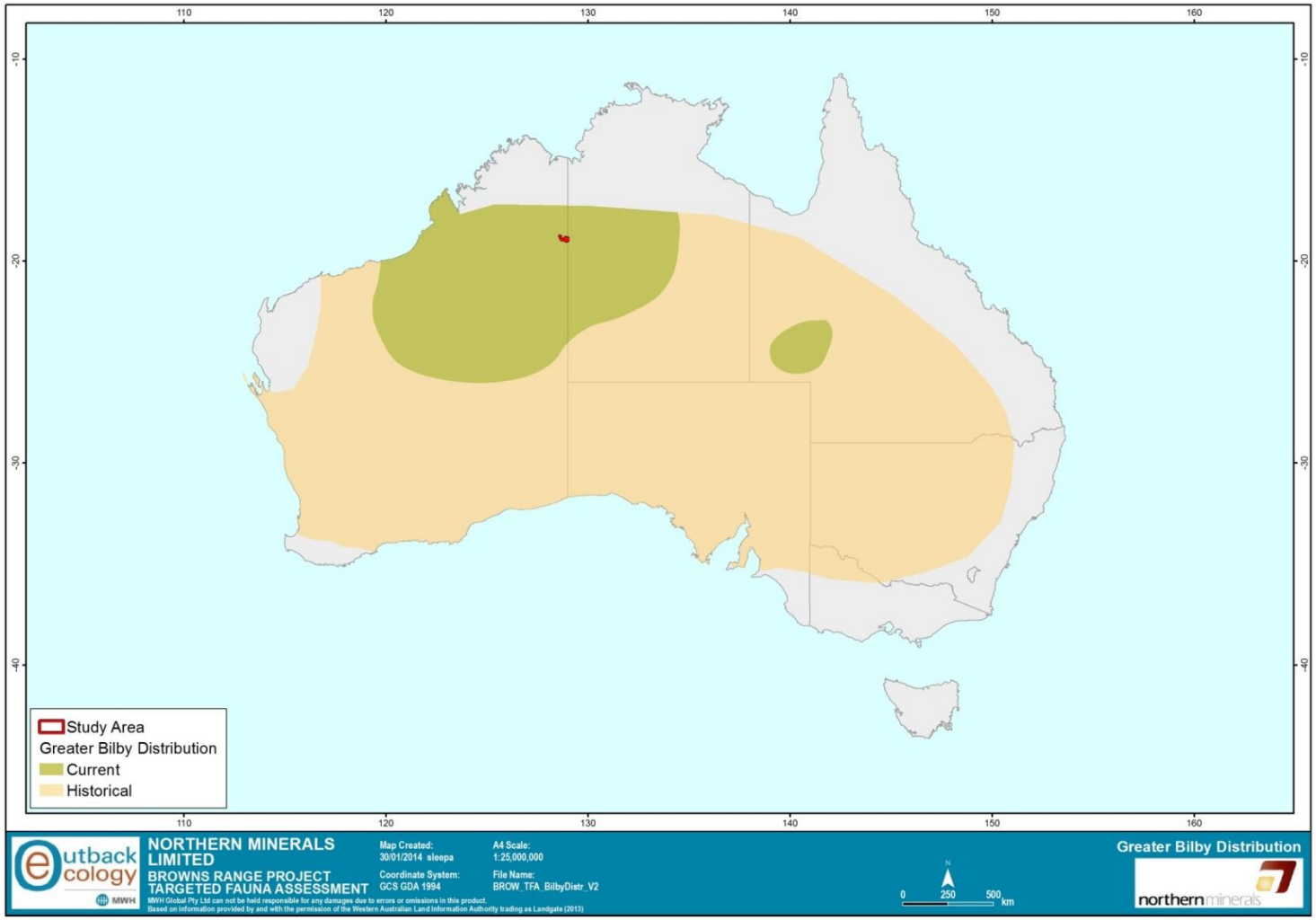

Figure 3: Distribution of the Bilby

Source: Distribution adapted from van Dyck *et al.* (2013)

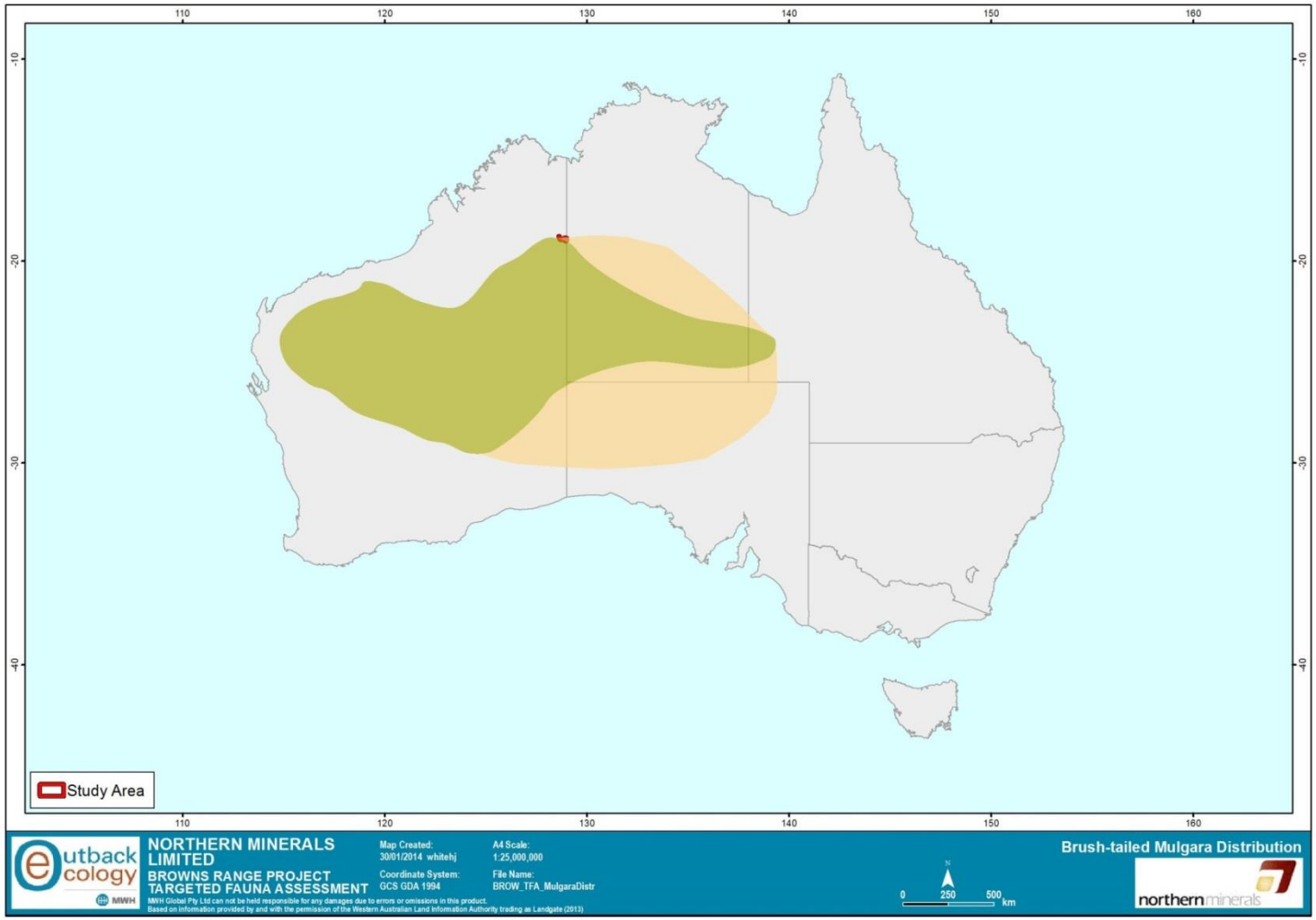

Figure 4: Distribution of Brush-tailed Mulgara

Source: Distribution adapted from van Dyck *et al.* (2013)

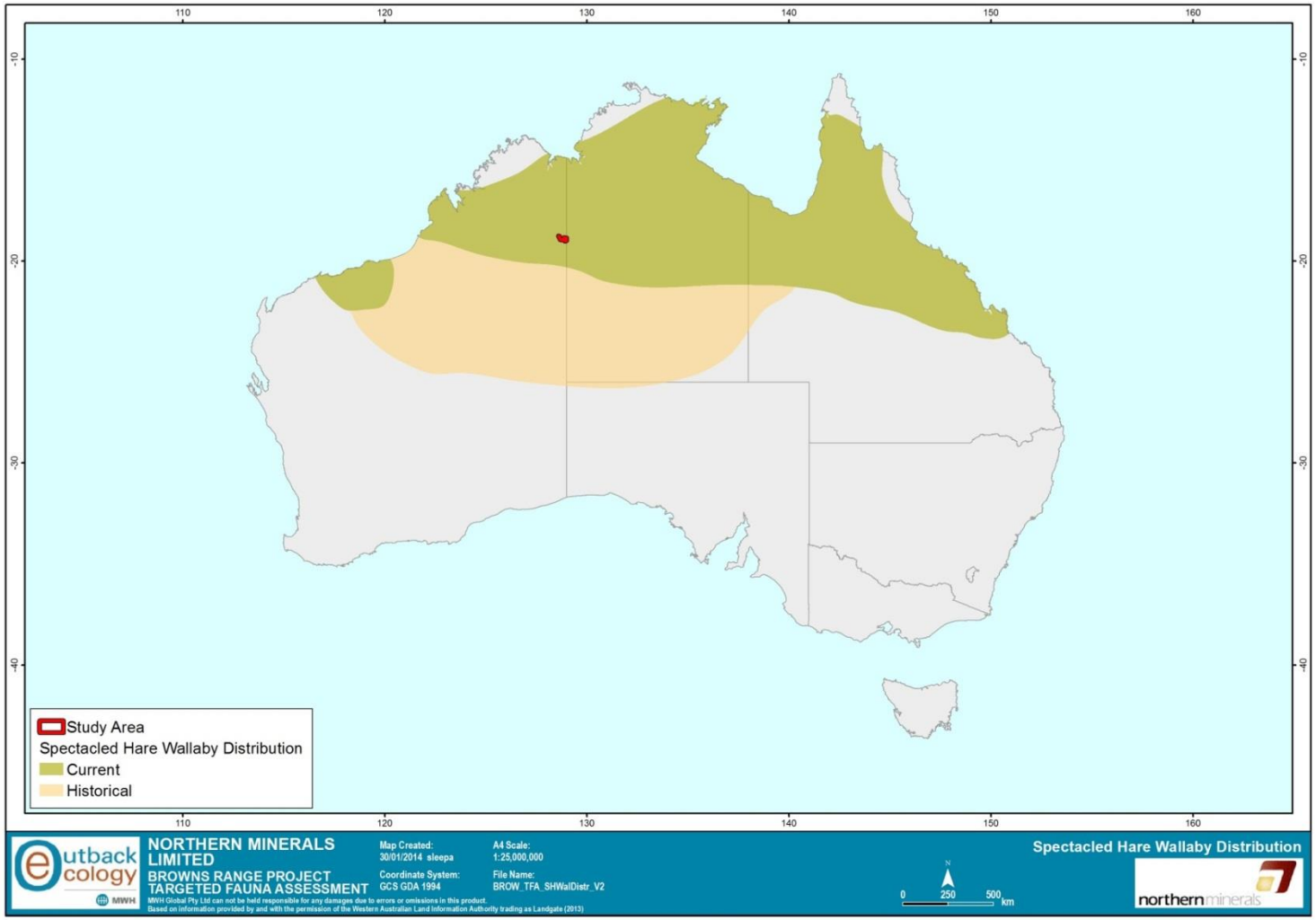

Figure 5: Distribution of the Spectacled Hare-wallaby

Source: Distribution adapted from van Dyck *et al.* (2013)

3. METHODOLOGY

3.1. Background Information

3.1.1. Survey Timing And Weather

The field survey was conducted from 11 to 18 December 2013, and weather experienced was appropriate to conduct the survey. Maximum and minimum temperatures at Browns Range meteorological station during the field survey ranged between 34.7°C and 40.2°C and 23.2°C and 26.9°C respectively (**Table 1**). No rain fell at Browns Range during the survey period (**Table 1**). Rainfall at Halls Creek (the closest weather station with comprehensive climate data available) was less than the long term average from June to October and three times the long term average in November 2013 (**Figure 6**). Such variability is typical of rainfall patterns for the area.

Table 1: Daily weather observations at Browns Range meteorological station, for the survey period

Date	Temperature (°C)		Rainfall (mm)	Relative humidity (%)	
	Min	Max		Minimum	Maximum
11/12/2013	25.3	34.7	0.0	29.1	82.8
12/12/2013	26.9	36.2	0.0	26.2	84.0
13/12/2013	25.9	36.5	0.0	20.8	73.7
14/12/2013	25.4	37.9	0.0	10.8	64.0
15/12/2013	25.8	37.6	0.0	8.9	60.1
16/12/2013	26.4	40.2	0.0	7.8	47.1
17/12/2013	25.1	36.4	0.0	20.1	59.8
18/12/2013	23.2	37.8	0.7	18.8	79.9

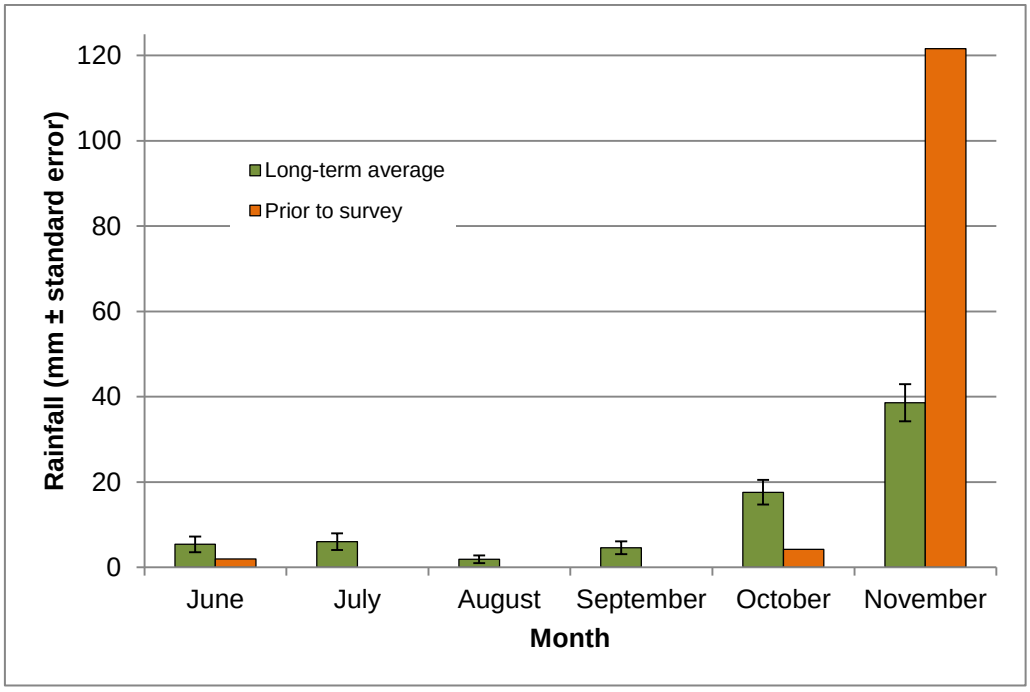

Figure 6: Rainfall at Halls Creek Airport prior to the field survey vs the long-term average

Source: BOM (2014), weather station 002012. 'Prior to' data are from June to November 2013 (i.e. the six months prior to the December 2013 field survey). 'Long-term' data are from 1944-2013.

3.1.3. Study Team And Licensing

The field survey of the Study Area was conducted by Outback Ecology (**Table 2**). The field survey was conducted under a Licence to Take Fauna for Scientific Purposes (DPaW, Regulation 17 licence) with details as follows:

- Licence number: SF009609;
- issue date: 6/12/2013; and
- valid from: 8/12/2013.

Table 2: Study team for the targeted field survey of the Study Area

Person	Discipline	Qualifications	Position
Mark Carter	Zoologist	B. Sc Hons (Econ), PG. Dip (Ecotourism & Wildl. Man.)	Outback Ecology Environmental Scientist
Paul Bolton	Zoologist	B. Sc Hons (Zool.)	Outback Ecology Principal Environmental Scientist

3.2. Fauna Surveying

3.2.1. Site Selection

Prior to the survey, potential locations to target in the field were identified using existing habitat mapping and aerial photography. Once in the field, these potential target sites were ground-truthed and alternative locations identified if required. In total, 24 target site locations were selected within the Study Area based on the following criteria:

- presence of landscape features suitable for Bilby, Brush-tailed Mulgara or Spectacled Hare-wallaby occupation;
- adequate spatial coverage of the Study Area; and
- accessibility by the survey team.

3.2.2. Targeted Searches

A targeted search was conducted at each of the 24 sites. Targeted searches consisted of visual survey along transects walked by two observers at each site (**Figure 7**). Search effort was standardised by time, rather than distance, so the length of transects varied. Observers walked 25 m apart on each transect and searched areas of sandy substrate and mature spinifex hummocks for secondary evidence of the Bilby, Brush-tailed Mulgara or Spectacled Hare-wallaby, including burrows, tracks, scats or diggings (recommended by Moseby *et al.* 2009). A total of 24 targeted searches were conducted, for two person hours each. The total targeted search effort was 48 person hours.

3.2.3. Habitat Assessments

A detailed habitat assessment was conducted at each of the 24 sites (**Appendix A**). Based on the resulting data, the individual sites were ranked in terms of their potential suitability to support the three

target species (i.e. poor, marginal or good habitat) and the likelihood of the Study Area as a whole supporting each of the three species was assessed. Briefly, habitat assessments consisted of photographic documentation combined with descriptions related to the following parameters:

- landscape and soil features;
- coarse woody debris or other habitat structures;
- vegetation cover, condition and species composition;
- leaf litter cover;
- types of disturbance and levels of disturbance, and
- when present, species specific habitat requirements were specifically noted for each of the targeted species e.g. presence of deep sandy substrate (Bilby and Brush-tailed Mulgara) or the presence of large spinifex hummocks (Spectacled Hare-wallaby).

3.2.4. Targeted Trapping

Targeted trap grids were established at three of the 24 sites, for Brush-tailed Mulgara only (**Figure 7**). Two of these were selected due to their extensive cover of mature spinifex, and one for its free-draining substrate. None of the other sites possessed either of these characteristics, and none of the sites possessed both of these characteristics. The trap grids consisted of 20 medium Elliot traps at 10 m intervals baited with universal bait. To protect animals from heat stress, traps were placed in as much shade as possible under the cover of spinifex. By-catch was also recorded. All traps were left open overnight and checked early the following morning for three consecutive nights. The total targeted trapping effort was 180 trap nights.

3.2.5. Motion-sensor Cameras

Based on the habitat assessments, motion-sensor cameras (Reconyx Hyperfire HC600) were deployed at target sites within habitats with the greatest potential to support the target species (**Figure 7; Appendix B**). Each camera was baited with universal bait containing rolled oats and peanut butter. In total, 18 motion-sensor cameras were deployed, varying from seven to ten nights each. The total motion-camera effort was 142 trap nights.

3.2.6. Spotlighting

Spotlighting was conducted by vehicles along the tracks over two nights (**Figure 7**), and intended to identify Bilby and Spectacled Hare-wallaby, which are both species unlikely to be trapped. The total spotlighting effort was six person hours.

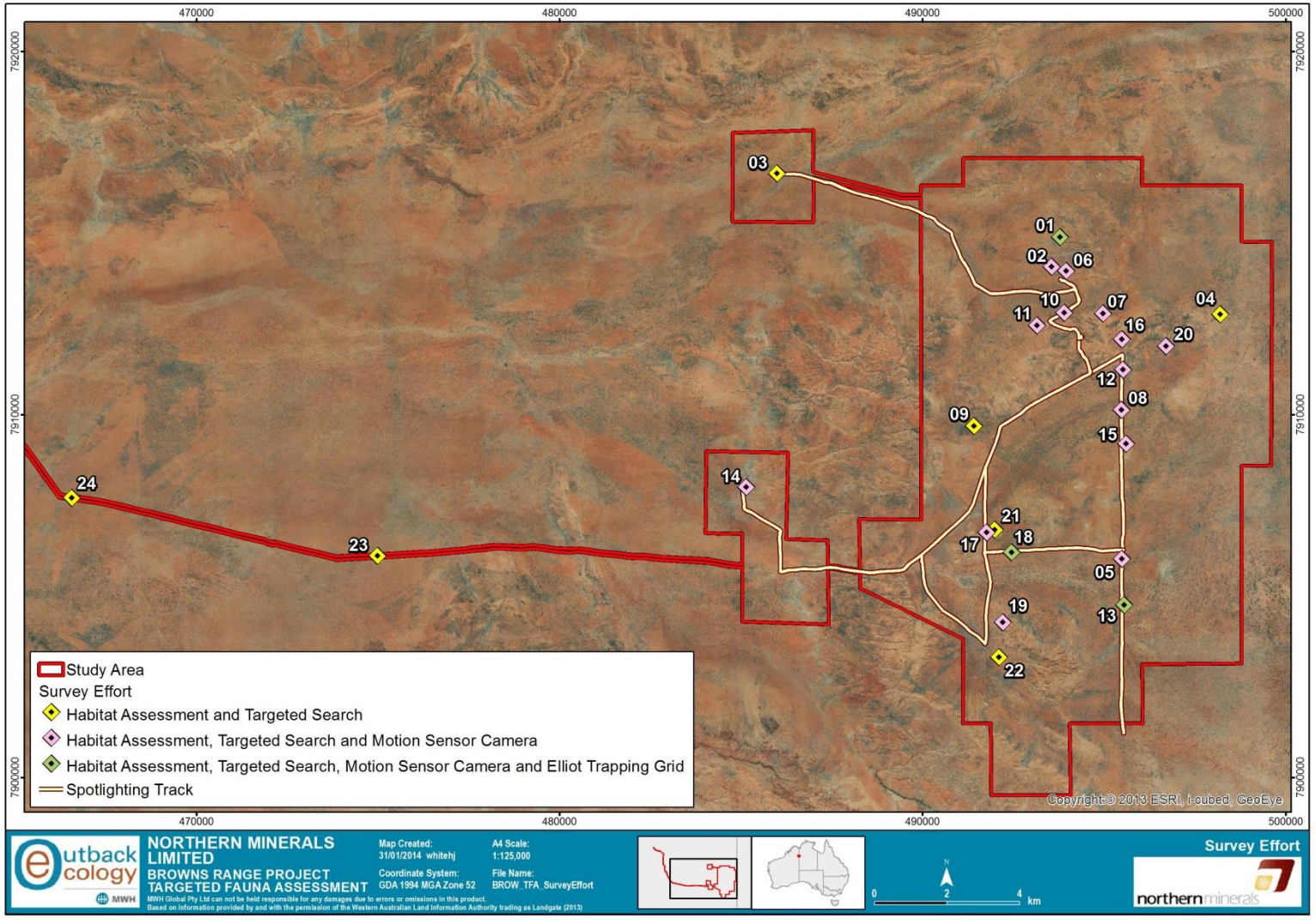

Figure 7: Survey effort in the Study Area

3.3. Survey Limitations

There are a number of possible limitations and constraints that can impinge on the adequacy of fauna surveys (EPA 2004). These are discussed below, with respect to the December survey of the Study Area (**Table 3**).

Table 3: Survey limitations and constraints

Aspect	Limitation / Constraint	Comment Regarding This Survey
Competency/experience of consultants	No	Members of the survey team were fauna specialists with extensive experience executing fauna surveys and monitoring programs in Western Australia. The survey team had previous experience searching for evidence of the target species (e.g. burrows, scats, tracks, diggings).
Scope	No	The survey was conducted in accordance with the EPA Position Statement No. 3, EPA Guidance No. 56 and EPA and DEC Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment. The survey was adequate to meet the required objectives; with the survey plan and methods to target the three conservation significant species designed by Outback Ecology, in liaison with the Office of the Environmental Protection Authority (OEPA).
Information sources (e.g. historic or recent)	No	Adequate information was available to inform the design and conduct of this survey (see References section).
Proportion of task achieved, and further work which might be needed	No	The monitoring survey was completed successfully.
Timing / weather / season / cycle	Partial Limitation	The December survey timing was ideal for monitoring the target species because the weather was typically dry, providing optimum tracking conditions. However, a rain event prior to the survey reduced the detectability of more subtle tracks.
Disturbances	No	Whilst the Study Area has been subject to disturbance (e.g. clearing, ongoing exploration activities) this did not impinge on the objectives of the survey; conversely, it facilitated access within the Study Area
Intensity	No	24 target sites were target searched, 180 Elliot trap nights undertaken, 18 camera traps were used and 6 hours of spotlighting were undertaken. This survey effort is considered more than adequate given the size of the Study Area and the habitats present.
Resources	No	Resources were adequate to execute this survey.
Knowledge gaps	Partial Limitation	Limited information is available on the biology and ecology of the Bilby, Brush-tailed Mulgara and Spectacled Hare-wallaby, and more specifically, within the vicinity of the Browns Range Study area
Remoteness / accessibility	No	All sites and search locations within the Study Area were accessible.
Availability of contextual information	Partial Limitation	Some information is available for the IBRA subregion including, NatureMap, DEC lists, as well as regional fauna surveys. There is a general lack of knowledge on Bilby, Brush-tailed Mulgara and Spectacled Hare-wallaby however at a subregional scale.

4. RESULTS AND DISCUSSION

4.1. Targeted Fauna Habitat

Habitat types in the Study Area were previously mapped by Outback Ecology (2012b, in prep) with the majority of the Study Area comprising Open Shrubland over Mixed Grassland on Sandy Plain. Additionally, soil profiles were described and mapped in the baseline soil and landform assessment (Outback Ecology 2012a). Of the soil-landform associations that occur within the Study Area, the 'Deep Sandy Plain' soil-landform closely aligns with the Open Shrubland over Mixed Grassland on Sandy Plain habitat. The soil profiles within the 'Deep Sandy Plain' soil-landform association typically increased in the consistence and strength of the soil below the loose, friable surface. The Sandy Plain substrate was found to consist of a thin loose, friable sandy surface over relatively dense sandy subsoil with a massive structure and strong consistence (Outback Ecology 2012a; see **Appendix A**).

Although the majority of the Study Area comprises of Open Shrubland over Mixed Grassland on Sandy Plain, upon closer inspection during the field survey and with reference to the baseline soil and landform assessment, the majority of substrates in the Study Area were found to be unsuitable for supporting resident populations of burrowing mammals, including the Bilby and Brush-tailed Mulgara (**Figure 8** - **Figure 11**). This is because dense sandy subsoil with a strong consistence is undesirable for constructing burrows (Van Dyck and Strahan 2008). The habitats within the Study Area may be suitable as intermittent, poor-to-marginal quality foraging habitat for Bilbies however (**Figure 8, Figure 9**), and Brush-tailed Mulgara (**Figure 10**, **11**).

The majority of the Study Area was found to be of marginal quality for the Spectacled Hare-wallaby. Tussock and hummock grasslands and *Acacia* shrublands are present in the Study Area and these areas may be suitable for grazing by Spectacled Hare-wallaby (Van Dyck and Strahan 2008). Further, although the herbaceous plant *Bonamia* sp., a known feeding source of the Spectacled Hare-wallaby, was not encountered during the Study, regrowth of other soft plant species suitable for wallaby grazing was present in the Study Area from the recent rains. These data suggest that areas within the Study Area may be suitable as intermittent, poor-to-marginal (rarely good) quality habitat for grazing by the Spectacled Hare-wallaby, seasonal conditions permitting (**Figure 12**, **Figure 13**).

The lack of large, mature spinifex hummocks in these habitats means that daytime refugia for the Spectacled Hare-wallaby are not present. The lack of large, mature spinifex hummocks is likely to be a consequence of an ongoing and historical fire regime that promotes large, regular fires across large portions of the Study Area (for example the large fire in 2013, **Figure 14**). Given the bioregion and fire history of the Study Area, the high frequency and uncontrolled nature of fires occurring in the Study Area is likely to be a permanent factor preventing the establishment of old-growth spinifex. A resident population of Spectacled Hare-wallabies in the Study Area is considered unlikely to be present.

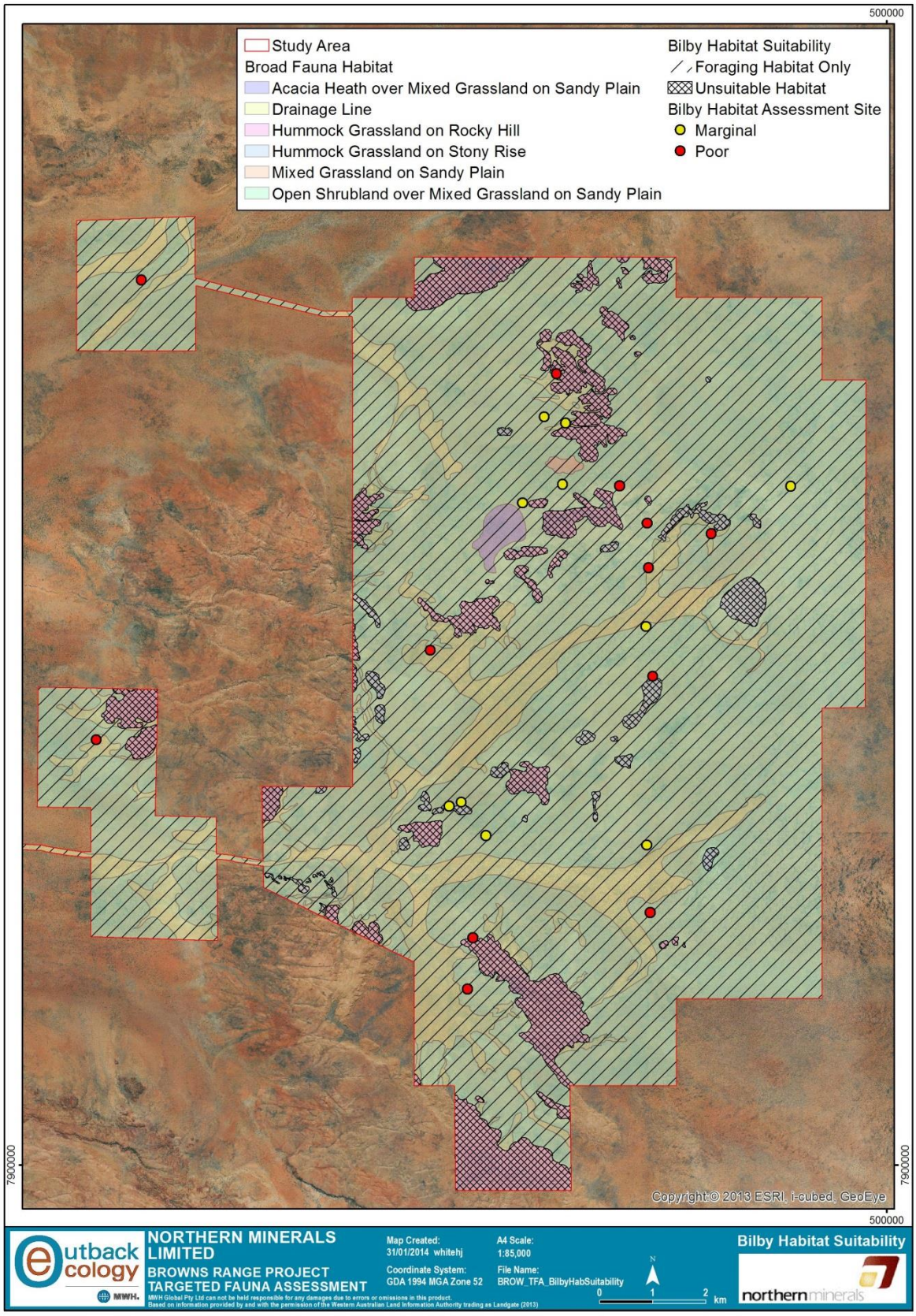

Figure 8: Bilby habitat suitability in the Study Area

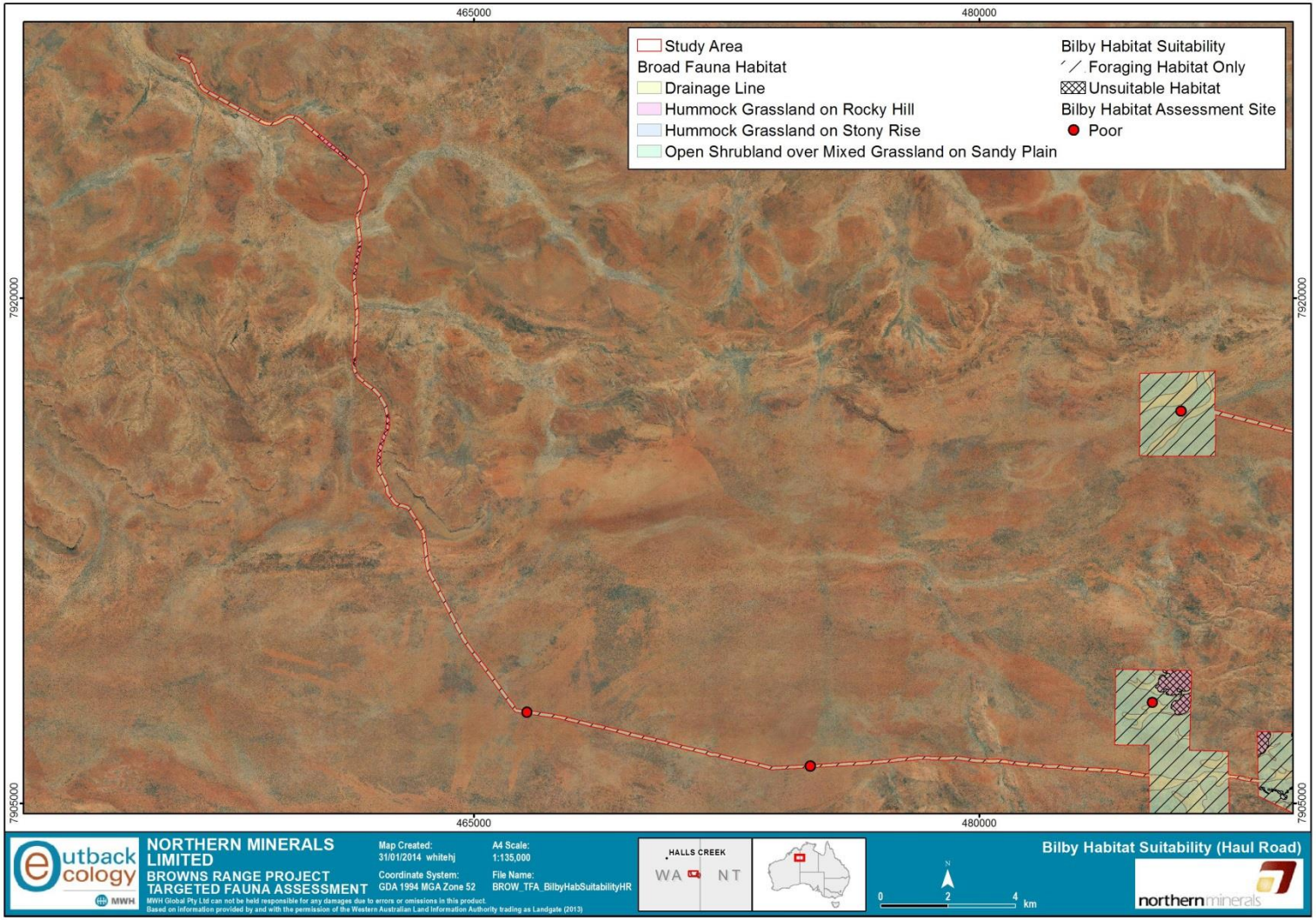

Figure 9: Bilby habitat suitability in the Study Area (Haul Road)

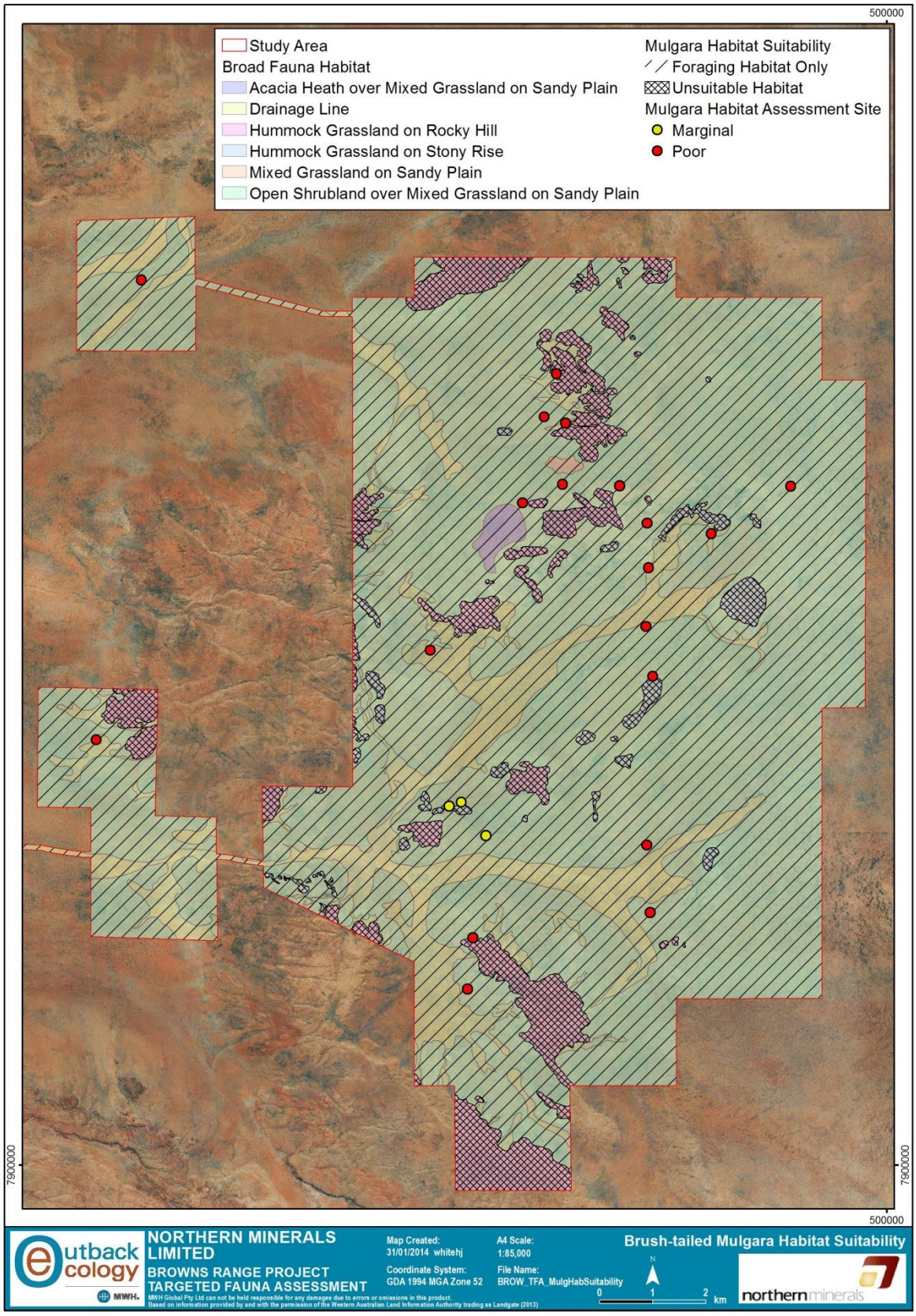

Figure 10: Brush-tailed Mulgara habitat suitability in the Study Area

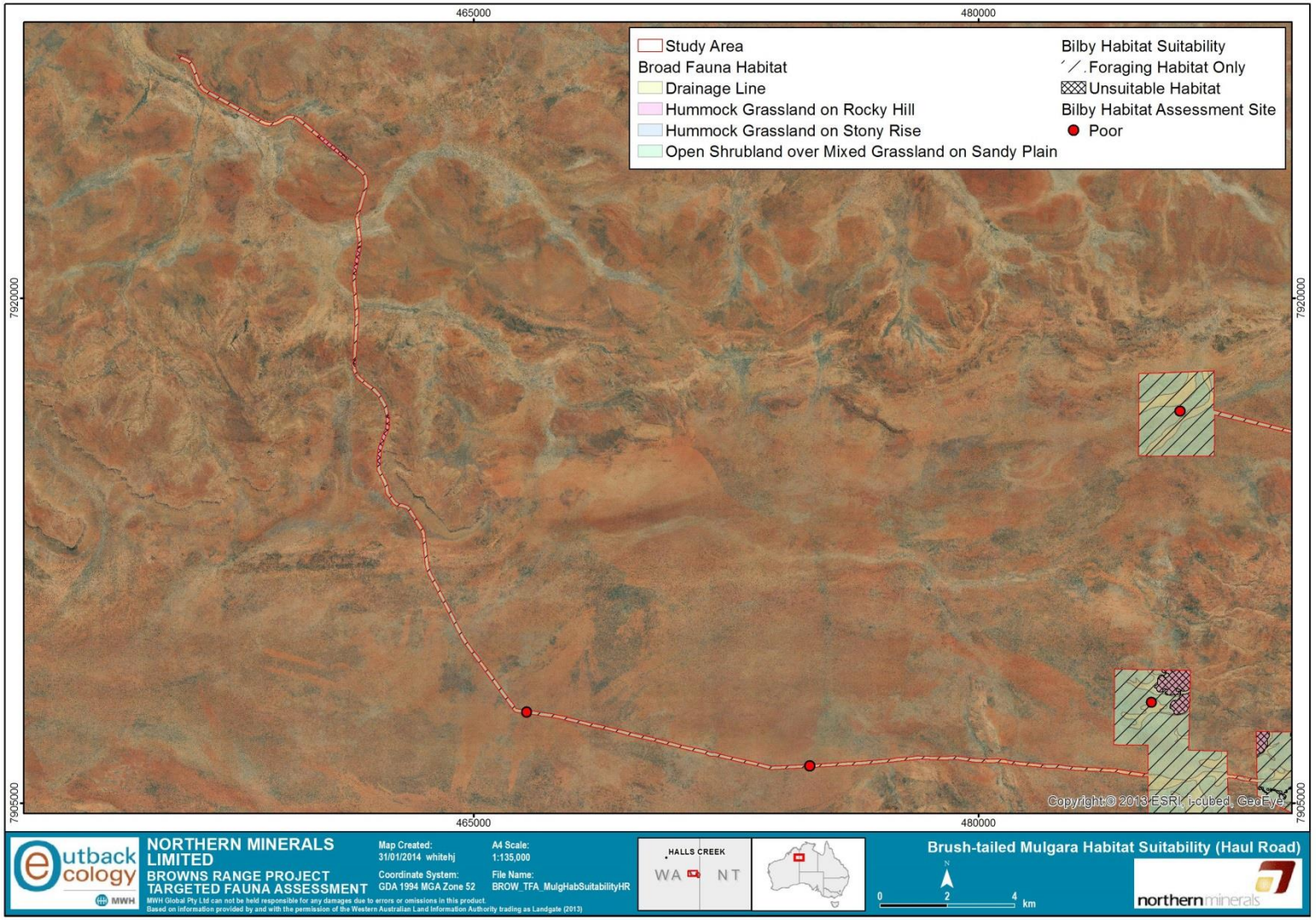

Figure 11: Brush-tailed Mulgara habitat suitability in the Study Area (Haul Road)

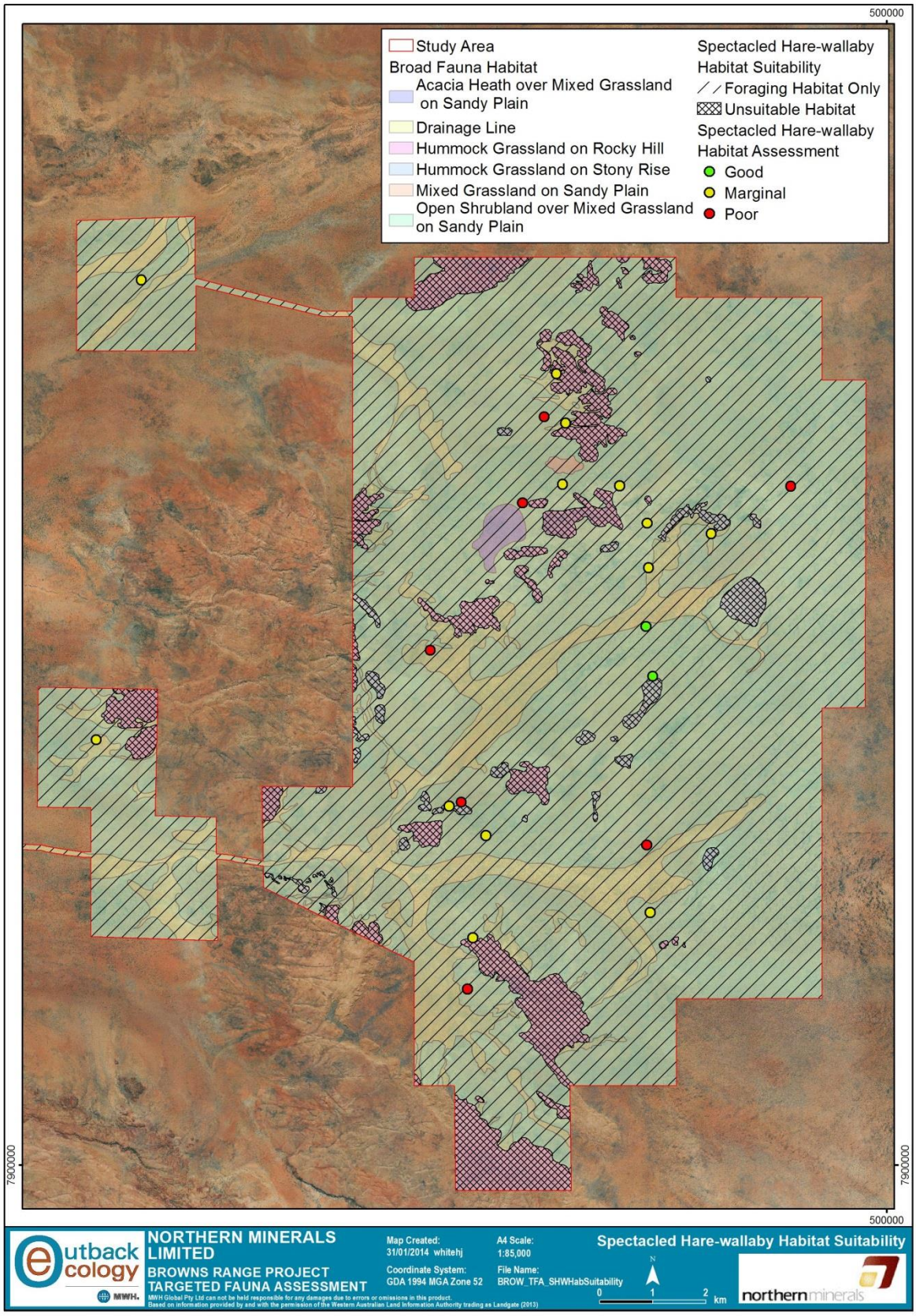

Figure 12: Spectacled Hare-wallaby habitat suitability in the Study Area

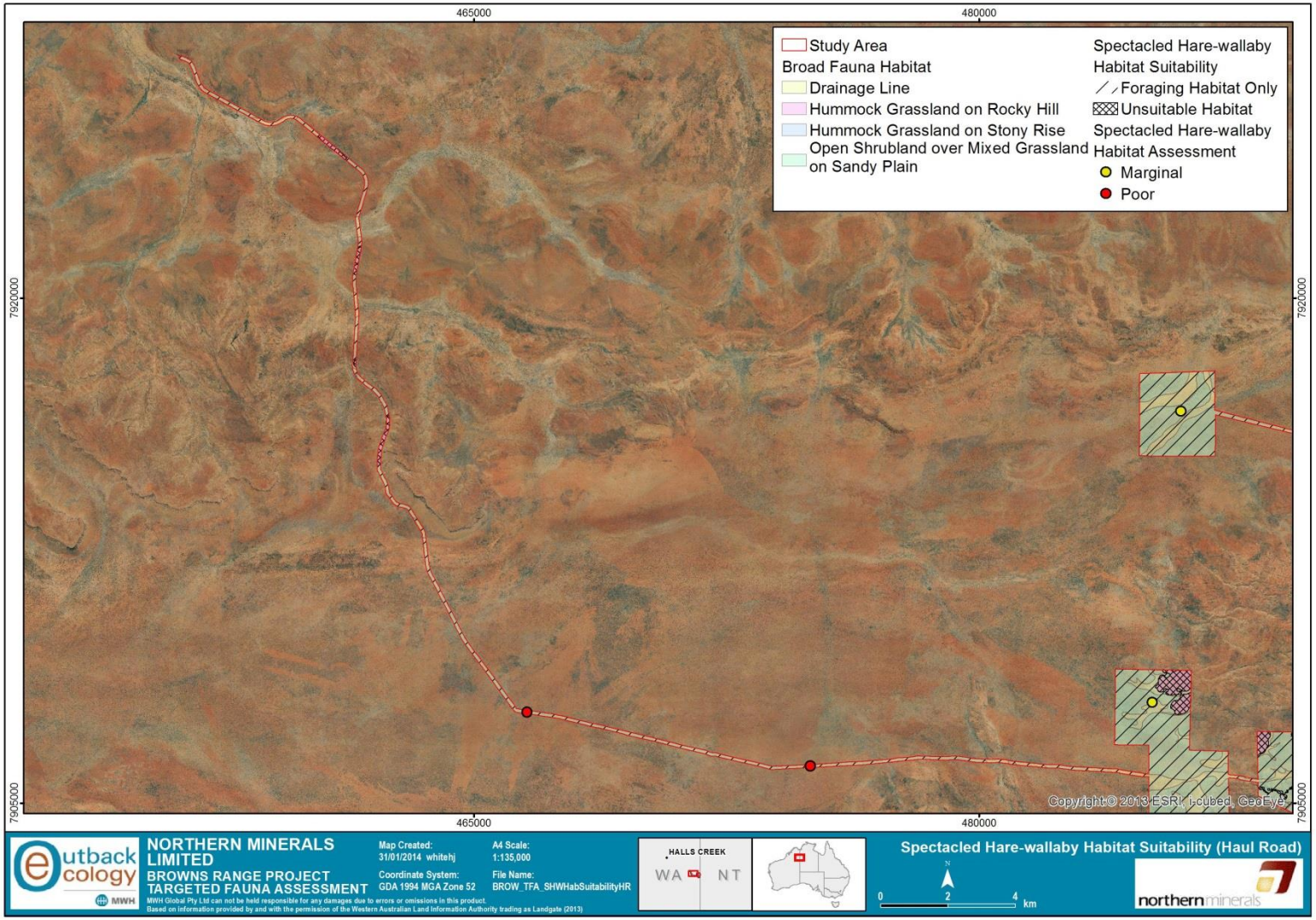

Figure 13: Spectacled Hare-wallaby habitat suitability in the Study Area (Haul Road)

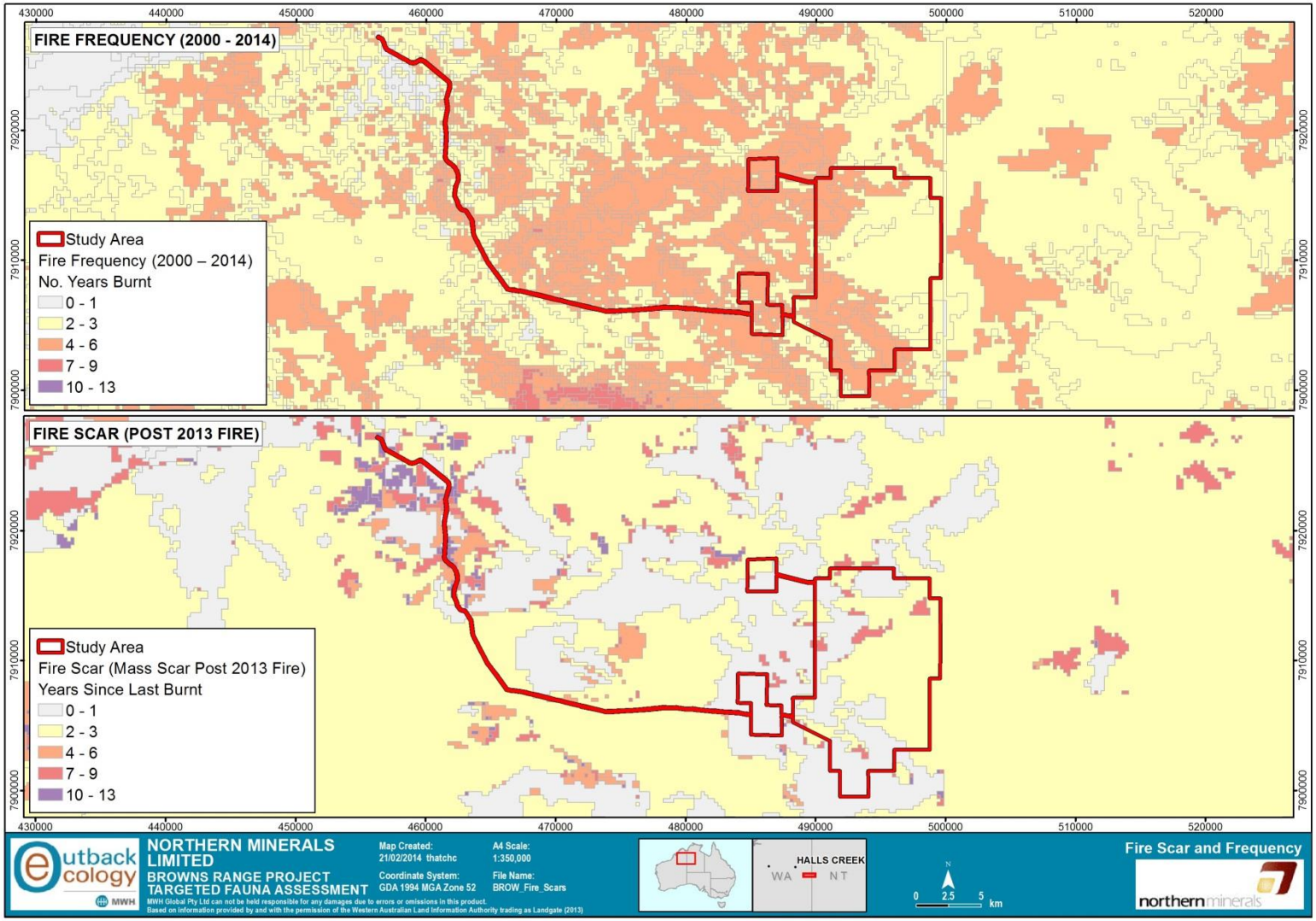

Figure 14: Fire Scar and Frequency in the Study Area

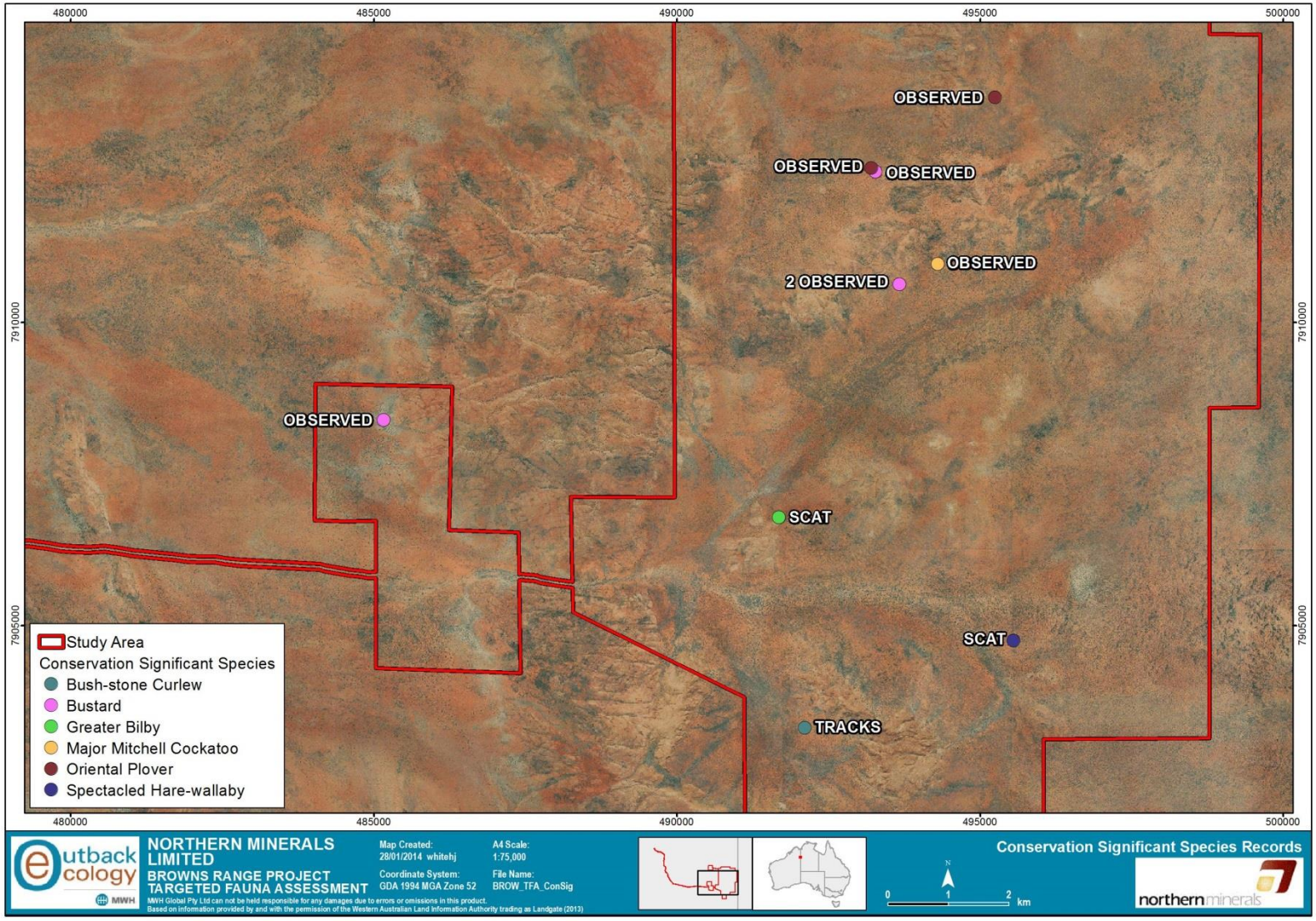

Figure 15: Conservation significant species records

4.2. Targeted Fauna

4.2.1. Records Obtained During The Survey

The vast majority of methods used to detect Bilby, Brush-tailed Mulgara and Spectacled Hare-wallaby did not obtain any records for the target species (**Table 4**). Evidence of the target species was only recorded on two occurrences at two of the 24 sites during targeted searches (**Figure 15**; and see **Appendix C** for coordinates).

Table 4: Number of target species records obtained via methods used in this survey

Species	Number of records from each survey method			
	Targeted Searches	Targeted Trapping	Motion-sensor Cameras	Spotlighting
Bilby	1	N/A	0	0
Brush-tailed Mulgara	0	0	0	0
Spectacled Hare-wallaby	1	N/A	0	0

The single record for the Bilby (**Table 4**) was the detection of scats at Site 17 only. The Bilby scats were estimated to be several months old as they were severely eroded by recent rains and faded by the sun. No additional evidence, for example burrows, were found in the Study Area.

The single record for the Spectacled Hare-wallaby (**Table 4**) was the detection of scats at Site 13 only. The Spectacled Hare-wallaby scats consisted of two small deposits; one was estimated as being several months old (eroded and faded) whilst the other was more recent (black in colour and largely intact). No additional evidence, for example tracks, was found in the Study Area.

Both collections of scats were compared against reference material from captive animals in order to ensure that accurate identifications were made (see **Appendix D**). Spectacled Hare-wallaby scats were identified as distinctive of Northern Nailtail Wallaby (*Onychogalea unguifera*) scats which were also found in the Study Area.

Brush-tailed Mulgara evidence was not found in the Study Area. This includes no presence of scats or burrows.

Diggings of various ages were encountered at most sites, but in all cases these were clearly distinguishable as those of varanid (lizard) activity rather than those of the target species.

4.2.2. Likelihood Of Occurrence

The purpose of this survey was to better understand the likelihood of occurrence of the targeted species in the Study Area, to inform the impact assessment for the Project (Outback Ecology in prep). Based on the additional data provided by this Survey, the likelihoods of occurrence as originally stated in the baseline survey report for the Study Area (Outback Ecology 2012b) have been re-assessed for each target species. The rankings were assessed using the following definitions:

Confirmed – the presence of the species in the Study Area has been recorded unambiguously during the last ten years (i.e. during recent surveys of the Study Area or from recent records obtained via database searches);

Very likely – the Study Area lies within the known distribution of the species and contains suitable habitat(s), plus the species generally occurs in suitable habitat and has been recorded nearby within the last 20 years;

Likely – the Study Area lies within the known distribution of the species and the species has been recorded nearby within the last 20 years; however, either:

a. the Study Area contains only a small area of suitable habitat, or habitat that is only marginally suitable; or
b. the species is generally rare and patchily distributed in suitable habitat;

Possible – there is an outside chance of occurrence, because:

a. the Study Area is just outside the known distribution of the species, but it does contain suitable and sufficient habitat (the species may be common, rare, or patchily distributed); or
b. the Study Area lies within the known distribution of the species, but the species is very rare and/or patchily distributed; or
c. the Study Area lies on the edge of, or within, the known distribution and has suitable habitat, but the species has not been recorded in the area for over 20 years; or

Unlikely – the Study Area lies outside the known distribution of the species, the Study Area does not contain suitable habitat, and the species has not been recorded in the area for over 20 years.

4.2.2.1. Bilby

The Bilby is now confirmed to occur in the Study Area; however the records obtained were scats, which can persist in the landscape for moderate amounts of time and do not necessarily indicate contemporary presence of these species. The lack of direct observations, lack of important secondary evidence such as burrows and lack of geographic spread in the records which were obtained combine to suggest that the Study Area is unlikely to support any resident population of this species.

Whilst the Study Area lies within the current known distribution of the Bilby (Van Dyck *et al.* 2013), the habitat was found to be unsuitable as the substrate was dense with strong consistence and was undesirable for constructing burrows (**Section 4.1**) (Outback Ecology 2012a). Any individuals that were present in the Study Area are likely to be transient or dispersing from more appropriate habitats in the broader landscape.

4.2.2.2. Brush-tailed Mulgara

Brush-tailed Mulgara are considered to possibly occur in the Study Area. This is a revision of the original conclusions of the baseline survey regarding the likelihood of occurrence of this species (very likely; Outback Ecology 2012b). This is based on several new pieces of information: the current survey specifically targeted this species and detected no evidence of its presence; the habitats in the

Study Area are marginally suitable for foraging and unsuitable for burrowing; the distribution of the Brush-tailed Mulgara has been updated since the baseline survey (Van Dyck *et al.* 2013); and, Woolley *et al.* (2013) have now clearly assessed historical Mulgara records in Australia. All of these data suggest it should only be considered 'possible' that the Brush-tailed Mulgara could occur in the Study Area.

As the habitat present was found to be unsuitable for burrows due to the substrate being dense with strong consistence **(Section 4.1**) (Outback Ecology 2012a) . In the event that any individuals were present it is likely to be only in a transient sense.

4.2.2.3. Spectacled Hare-Wallaby

The Spectacled Hare-wallaby is now confirmed to occur in the Study Area; however the records obtained were scats, which can persist in the landscape for moderate amounts of time and do not necessarily indicate contemporary presence of this species. The lack of direct observations and lack of geographic spread in the records which were obtained combine to suggest that the Study Area is unlikely to support resident populations of these species.

While the Study Area lies within the current known distribution of the Spectacled Hare-wallaby (Van Dyck *et al.* 2013) the lack of large, mature spinifex hummocks in the habitats of the Study Area means that daytime refugia for the Spectacled Hare-wallaby are not present. Any individuals present are likely to be transient or dispersing from more appropriate habitats in the broader landscape.

4.3. Other Fauna

During this Study, four non-target species of conservation significance were observed during targeted searches or opportunistically (see **Figure 15; Appendix C**). These species were:

- Bush Stone-curlew (*Burhinus grallarius*);
- Australian Bustard (*Ardeotis australis*);
- Oriental Plover (*Charadrius veredus*); and
- Major Mitchell Cockatoo (*Lophochroa leadbeateri*).

All of these species have been previously recorded from the Study Area except for the Oriental Plover (Outback Ecology 2012b). Species observed during trapping or motion sensor camera work are described in **Appendix E**.

Evidence of feral species such as camels and cats was recorded during the Survey (i.e. photographs using motion-sensor cameras, tracks, scats). This is noteworthy, as the presence of each of these introduced species is indicative of areas that are less suitable for inhabitation by the Bilby and Brush-tailed Mulgara. Predation by the Feral Cat is thought to have played a role in the decline of the Bilby and Brush-tailed Mulgara across their distributions, although the degree of importance of this process is not certain (DSEWPaC: Department of Sustainability 2012b, Pavey 2006, Pavey *et al.* 2012, Van Dyck and Strahan 2008). Habitat degradation by introduced herbivores is considered to be a factor in the decline of the Bilby (Pavey 2006), and it is not unreasonable to assume that the same may be true for the Brush-tailed Mulgara and Spectacled Hare-wallaby.

5. CONCLUSION AND RECOMMENDATIONS

This survey detected the presence of the Bilby and Spectacled Hare-wallaby in the Study Area; however, despite the extensive survey effort, targeted methods and appropriate timing of this Survey, only one indirect record for each of the two species was obtained. The records obtained were scats, which can persist in the landscape for moderate amounts of time and do not necessarily indicate contemporary presence of these species. The lack of direct observations, lack of important secondary evidence such as burrows and lack of geographic spread in the records which were obtained combine to suggest that the Study Area is unlikely to support resident populations of these species. Rather, any individuals present are likely to be transient or dispersing from more appropriate habitats in the broader landscape. Thus, although these two species were confirmed to occur, the Study Area is not considered to contain significant habitat for the Bilby or Spectacled Hare-wallaby.

No records of the Brush-tailed Mulgara, indirect or otherwise, were recorded during this Survey. This, combined with current knowledge of the distribution and habitat preferences of this species, suggests that it is only 'possible' that the Brush-tailed Mulgara may occur in the Study Area. This represents a decrease in the calculated likelihood of its occurrence since the original baseline study (Outback Ecology 2012b).

Habitats in the Study Area were found to be unsuitable to support resident populations of Bilby and Brush-tailed Mulgara, due to the substrate consisting of a thin loose, friable sandy surface over a relatively dense sandy subsoil with a massive structure and strong consistence unsuitable for the construction of burrows. Additionally, while portions of the Study Area support tussock and hummock grasslands and *Acacia* shrublands that may be suitable for grazing by Spectacled Hare-wallaby, these areas are not suitable for providing daytime refugia for this species due to a lack of suitably large spinifex hummocks. Given the bioregion and fire history of the Study Area, the high frequency and uncontrolled nature of fires occurring in the Study Area is likely to be a permanent factor preventing the establishment of old-growth spinifex.

Overall, the habitats in the Study Area are considered to be only poor-to-marginal quality foraging habitat, and not significant or breeding habitat, for the target species. In addition, landscape-scale threatening processes such as predation, grazing and trampling by cattle (confined to river corridor in south-west of the Study Area) and inadequate fire management limit the suitability of the habitats in the Study Area for the Bilby, Spectacled Hare-wallaby and Brush-tailed Mulgara even further.

As the Study Area does not represent significant habitat for the target species, it is unlikely that the Project will have any substantial impacts on the Bilby, Spectacled Hare-wallaby and/or Brush-tailed Mulgara at a local or a regional scale. Thus, specific management actions for these species are unlikely to be of great value during development, operation or closure of the Project. Adoption of generic management measures, however, may benefit the target species in the unlikely event that they regularly forage in the Study Area. Such measures would provide more overarching biodiversity benefits for the Study Area and may include, but are not limited to:

- education of site personnel and contractors regarding the status of species of conservation significance in the Study Area;
- implementation ofmeasures to reduce road kill, and/or encourage the dispersal of animals by means other than roads (e.g. maintain habitat corridors, provide underpasses on roads, etc.);
- enforcement of vehicle speed limits;
- monitoring and control of feral animals, particularly feral predators;
- implementation of fire management where possible to reduce the scale, frequency and intensity of fires; and
- reporting sightings of species of conservation significance to the DPaW.

6. REFERENCES

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Appendix A

GPS Coordinates and Habitat Assessments for each Target Site

Site	Coordinates (WGS84 52K)		Photo	Environmental variables		Habitat suitability			Fauna records
	Easting	Northing		Soil	Vegetation	Bilby	Mulgara[1]	SHW[2]	
1	493790	7914874		Clay loam with sandy patches, seasonally waterlogged	*Melaleuca* sp., *Hakea* sp., *Corymbia* sp., over thick riparian grasses	Poor	Poor	Marginal	none
				2/3 of the site cleared (c. 6 months prior); SHW habitat may have been suitable pre-clearance with a greater cover of mature spinifex hummocks					
2	493557	7914064		Fine compacted sand, loamy/silty, limited drainage	*Corymbia* sp., *Eucalyptus* sp., *Acacia* sp., over soft spinifex	Marginal	Poor	Poor	goanna diggings, old camel scat
				Habitat closer to the road open and burnt, thick stands of old growth to the west; marginal feeding habitat for Bilby only, habitat may become suitable for SHW when spinifex hummocks re-establish and mature providing shelter for SHW					
3	485982	7916638		Grey red loam, seasonally waterlogged	*Corymbia* sp., *Grevillea* sp., *Acacia* sp., over annual grasses, large Mitchell grass	Poor	Poor	Marginal	goanna diggings, camel scat
				Fire scar on south side, little cover present for target species					

[1] Mulgara in this table refers to the Brush-tailed Mulgara (*Dasycercus blythi*)
[2] SHW in this table refers to the Spectacled Hare-wallaby (*Lagorchestes conspicillatus*)

<table>
<tr><th rowspan="2">Site</th><th colspan="2">Coordinates (WGS84 52K)</th><th rowspan="2">Photo</th><th colspan="2">Environmental variables</th><th colspan="3">Habitat suitability</th><th rowspan="2">Fauna records</th></tr>
<tr><th>Easting</th><th>Northing</th><th>Soil</th><th>Vegetation</th><th>Bilby</th><th>Mulgara[1]</th><th>SHW[2]</th></tr>
<tr><td rowspan="2">4</td><td rowspan="2">498197</td><td rowspan="2">7912759</td><td rowspan="2">  </td><td>Sandstone bedrock close to surface, free draining</td><td>Hakea sp., Corymbia sp., over soft spinifex</td><td>Marginal</td><td>Poor</td><td>Poor</td><td rowspan="2">goanna diggings, camel tracks, emu scat</td></tr>
<tr><td colspan="5">Marginal feeding habitat for Bilby and Mulgara only; fire scar (c. 3 yrs old), habitat may become suitable for SHW when spinifex hummocks re-establish and mature providing shelter for SHW</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">495489</td><td rowspan="2">7906014</td><td rowspan="2">  </td><td>Red clay loam, heavy soil, prone to waterlogging</td><td>Eucalyptus sp., Acacia sp., Hakea sp., over annual grasses, scattered soft spinifex</td><td>Marginal</td><td>Poor</td><td>Poor</td><td rowspan="2">goanna diggings</td></tr>
<tr><td colspan="5">Marginal feeding habitat for Bilby only; limited cover present for target species</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">493962</td><td rowspan="2">7913951</td><td rowspan="2">  </td><td>Red loamy sand, clay patches</td><td>Eucalyptus sp., Corymbia sp., over spinifex, Acacia shrubs</td><td>Marginal</td><td>Poor</td><td>Marginal</td><td rowspan="2">camel tracks</td></tr>
<tr><td colspan="5">Few open areas, good SHW nesting potential; marginal feeding habitat for Bilby only</td></tr>
</table>

Site	Coordinates (WGS84 52K)		Photo	Environmental variables		Habitat suitability			Fauna records
	Easting	Northing		Soil	Vegetation	Bilby	Mulgara[1]	SHW[2]	
7	494979	7912770		Clay loam, sandy near hills (south), heavy soil	Scattered *Acacia* sp., dense pockets of soft spinifex, Mitchell grass	Poor	Poor	Marginal	goanna diggings, dog tracks
				Grassy regrowth from fire (c. 2 yrs old); pockets of dense soft spinifex suitable cover for SHW, heavy soils unsuitable for Mulgara and Bilby					
8	495477	7910122		Red sandy loam becoming clay in patches	*Eucalyptus* sp., *Acacia* sp., over soft spinifex, annual grasses	Marginal	Poor	Good	Nailtail wallaby scat, goanna diggings, camel tracks
				Long unburnt patches of thick fire-sensitive species surrounded by fire scars of various ages; marginal feeding habitat for Bilby only					
9	491421	7909677		Red sand over loam in the east, clay loam in centre and west	*Hakea* sp., *Eucalyptus* sp., thin *Acacia* sp., some small spinifex, annual grasses	Poor	Poor	Poor	goanna diggings
				East section has good sandy substrate, but recent fire has taken all large spinifex so now unsuitable for all species; habitat may become suitable for SHW when spinifex hummocks re-establish and mature providing shelter for SHW					

Site	Coordinates (WGS84 52K)		Photo	Environmental variables		Habitat suitability			Fauna records
	Easting	Northing		Soil	Vegetation	Bilby	Mulgara[1]	SHW[2]	
10	493907	7912797		Red sand over clay loam	*Eucalyptus* sp., *Corymbia* sp., patches of *Acacia* sp. with modest spinifex	Marginal	Poor	Marginal	goanna diggings, emu scat
				Fragmented burnt site with surviving remnants of small spinifex hummocks, not enough cover for SHW; burnt areas feeding habitat for Bilby and SHW only; soil unsuitable for Bilby burrowing					
11	493153	7912442		Red sand over clay loam, occasional rocky outcrops and sandstone patches	*Eucalyptus* sp., *Acacia* sp. with small spinifex cover	Marginal	Poor	Poor	goanna diggings, Bustard sighting
				Extensive fire scars, not enough cover for SHW or Mulgara; marginal feeding habitat for Bilby only					
12	495525	7911233		Red sand over clay loam	*Hakea* sp., *Eucalyptus* sp., *Acacia* sp. over annual grasses, Mitchell grass	Poor	Poor	Marginal	goanna diggings, Nailtail wallaby scat
				Poor habitat for Bilby and Mulgara due to heavy soil, little cover for SHW but some grazing potential					

Site	Coordinates (WGS84 52K)		Photo	Environmental variables		Habitat suitability			Fauna records
	Easting	Northing		Soil	Vegetation	Bilby	Mulgara[1]	SHW[2]	
13	495554	7904750		Red sandy loam, clay loam in places	*Corymbia* sp., *Acacia* sp., *Hakea* sp., *Eucalyptus* sp., over spinifex, annual grasses	Poor	Poor	Marginal	goanna diggings, Nailtail wallaby sighting (spotlighting), SWH scat
				Soil less clayey/silty but unsuitable for Bilby and Mulgara, little cover for SHW but some grazing potential					
14	485135	7907991		Red silty loam, waterlogged soil	*Eucalyptus* sp., *Corymbia* sp., over annual riparian grasses	Poor	Poor	Marginal	Nailtail wallaby scat, Bustard tracks, Major Mitchell Cockatoos, lots of bird life
				Soil unsuitable for Bilby and Mulgara, little cover for SHW but some grazing potential					
15	495605	7909185		Clay loam with stony patches, grey clay patches	*Eucalyptus* sp., *Hakea* sp., *Acacia* sp., over spinifex hummocks	Poor	Poor	Good	goanna diggings, camel tracks
				Poor soil for Bilby/Mulgara due to waterlogging heavy soil, good thick cover for SHW					

Site	Coordinates (WGS84 52K)		Photo	Environmental variables		Habitat suitability			Fauna records
	Easting	Northing		Soil	Vegetation	Bilby	Mulgara[1]	SHW[2]	
16	495495	7912066		Sandy loam, prone to waterlogging, stony patches	*Eucalyptus* sp., *Corymbia* sp., *Acacia* sp., over spinifex hummocks	Poor	Poor	Marginal	goanna diggings
				1/2 site burnt in last month, SHW may shelter in hummocks and habitat may become suitable; poor habitat for Bilby and Mulgara, soil prone to waterlogging and too thin for burrowing					
17	491998	7906820		Sand loam, layer of sand on top	Lush growth of green fire-sensitive vegetation, mixed animal grasses and spinifex, remnant spinifex hummocks	Marginal	Marginal	Marginal	goanna diggings, camel tracks, Nailtail scats, Bilby scat
				Sandiest site targeted, burrowing potential for Bilby and Mulgara; some cover for SHW					
18	492460	7906194		Red sandy layer over sandy loam, becomes loam to north	Used to be spinifex with open Acacia overstorey, few hummock remnants	Marginal	Marginal	Marginal	goanna diggings
				Burnt in past few years but spinifex regrowing, habitat may become suitable for SHW; marginal habitat for Bilby and Mulgara, sandier than previous sites					

Site	Coordinates (WGS84 52K)		Photo	Environmental variables		Habitat suitability			Fauna records
	Easting	Northing		Soil	Vegetation	Bilby	Mulgara[1]	SHW[2]	
19	492216	7904272		Red sandy loam becoming heavy clay to north, waterlogged	*Eucalyptus* sp., over *Acacia* heath and hummock spinifex, animal grasses	Poor	Poor	Marginal	goanna diggings
				Little cover for SHW but some grazing potential; poor habitat for Bilby and Mulgara, soil prone to waterlogging and too thin for burrowing					
20	496704	7911872		Clay loam on flats, stony clay on slopes	Slopes are dominated by small spinifex, flats/drainage lines dominated by annual grasses	Poor	Poor	Marginal	camel and dog tracks, old pebble mound
				No cover, poor soils for target species					
21	491998	7906820		Clay loam to the west, sandy patches, area to the east is sandy loam	Annual grasses, small patches of remnant spinifex hummocks, regenerated to the west	Marginal	Marginal	Poor	goanna diggings, camel tracks
				Post fire (c. 1 yo) with regeneration present, habitat may become suitable for SHW; marginal Bilby and Mulgara habitat with sandy patches present					

Site	Coordinates (WGS84 52K)		Photo	Environmental variables		Habitat suitability			Fauna records
	Easting	Northing		Soil	Vegetation	Bilby	Mulgara[1]	SHW[2]	
22	492113	7903308		Sandy clay loam, waterlogged seasonally	*Eucalyptus* sp., *Hakea* sp., over annual grasses	Poor	Poor	Poor	Bush-stone curlew, Nailtail wallaby tracks
				Post fire (c. 1 year old) with regeneration present, habitat may become suitable for SHW; poor habitat for Bilby and Mulgara, soil prone to waterlogging and too thin for burrowing					
23	474988	7906105		Sandy loam, seasonally waterlogged, bedrock exposed in spots	*Acacia* sp., *Grevillea* sp., over spinifex regrowth	Poor	Poor	Poor	goanna diggings, emu scat
				Post fire (c. 1 month) with regeneration present, habitat may become suitable for SHW; poor habitat for Bilby and Mulgara, soil prone to waterlogging and too thin for burrowing					
24	466574	7907704		Sandy loam, seasonally waterlogged, bedrock exposed in spots	*Eucalyptus* sp., *Grevillea* sp., over annual grasses, few forbes,	Poor	Poor	Poor	goanna diggings, camel tracks
				Burnt scar (c. 2 months) on 1/2 the site; poor soil and no spinifex cover for target species					

Appendix B

GPS Coordinates and Description for each Motion-sensor Camera Deployment

Camera	Location Description	Coordinates (WGS84 52K)		Deployment	Retrieval
		Easting	Northing		
REC02	Tree-mounted overlooking cleared patch	492437	7906211	15/12/2013	22/12/2013
REC03	Lower lying over Eucalypts, spinifex, loamy soil	493440	7914127	15/12/2013	
REC08	Drainage from rocky slopes, lush riparian vegetation near cleared area	493820	7914887	15/12/2013	
REC10	Tree-mounted, intergraded between burnt and unburnt habitat	493111	7912440	14/12/2013	
REC13	Tree-mounted, unburnt area of spinifex hummocks, burnt area nearby	493916	7912749	14/12/2013	
REC14	Tree-mounted overlooking cleared patch	491772	7906751	15/12/2013	
REC15	Tall trees over fresh sprouting riparian grasses, wallaby scats and tracks in the area	485150	7908018	14/12/2013	
REC16	Tree-mounted close to spinifex hummocks	495479	7912055	15/12/2013	
REC17	Tall trees over fresh sprouting riparian grasses, wallaby scats and tracks in the area	485168	7908093	14/12/2013	
REC19	Small stand of trees with sign of wallaby use	495554	7904750	14/12/2013	
REC20	Small stand of trees with sign of wallaby use	496266	7911409	14/12/2013	
REC21	Tree-mounted overlooking track through site	495481	7905903	15/12/2013	
REC22	Vegetated minor drain near spinifex stony slopes and sandplain, on animal trail	496698	7911868	12/12/2013	
REC23	Tree-mounted, overlooking track	495455	7909187	14/12/2013	
REC24	Tree-mounted overlooking grasses	492215	7904246	15/12/2013	
REC26	Soft spinifex hummocks near rocky hills, heavy soils	494977	7912770	13/12/2013	
REC27	Long unburnt area of fire sensitive vegetation (bush plum, mallee, thick spinifex)	495511	7910117	13/12/2013	
REC28	Old growth spinifex, on animal trail	493969	7914030	13/12/2013	

Appendix C

GPS Coordinates for Conservation Significant Species

Scientific Name	Common Name	Conservation status		Type	Coordinates (WGS84 52K)	
		EPBC Act	in WA		Easting	Northing
Target species						
Macrotis lagotis	Greater Bilby	VU	VU	scat	491683	7906785
Lagorchestes conspicillatus leichardti	Spectacled Hare-wallaby	-	P3	scat	495550	7904752
Other conservation significant species						
Burhinus grallarius	Bush-stone Curlew		P4	tracks	492111	7903310
Ardeotis australis	Australian Bustard		P4	seen	493277	7912496
				seen	485159	7908391
				seen	493672	7910632
Charadrius veredus	Oriental Plover	M	S3	seen	495248	7913718
				seen	493203	7912557
Lophochroa leadbeateri	Major Mitchell Cockatoo	-	S4	2 seen	494306	7910972

Appendix D

Confirmation of Spectacled Hare-wallaby and Bilby scat in comparison to reference scats

Figure D1: Spectacled Hare-wallaby scats from the field (left, middle) vs. reference scats (right)

Figure D1: Bilby scats from the field (left) vs. reference scats (right)

Appendix E

Trapping By-catch and Motion Sensor Camera Results

Trapping by-catch		
Scientific Name	**Common Name**	**Number**
Pseudomys desertor	Desert Mouse	8
Notomys alexis	Spinifex hopping mouse	1
Tiliqua centralis	-	2
Ctenotus sp.	-	3

Motion sensor camera trapping		
Scientific Name	**Common Name**	**Number**
Canis lupus dingo	Dingo	2
Notomys alexis	Spinifex hopping mouse	1
Felis catus	Cat	2
Varanus sp.	-	1