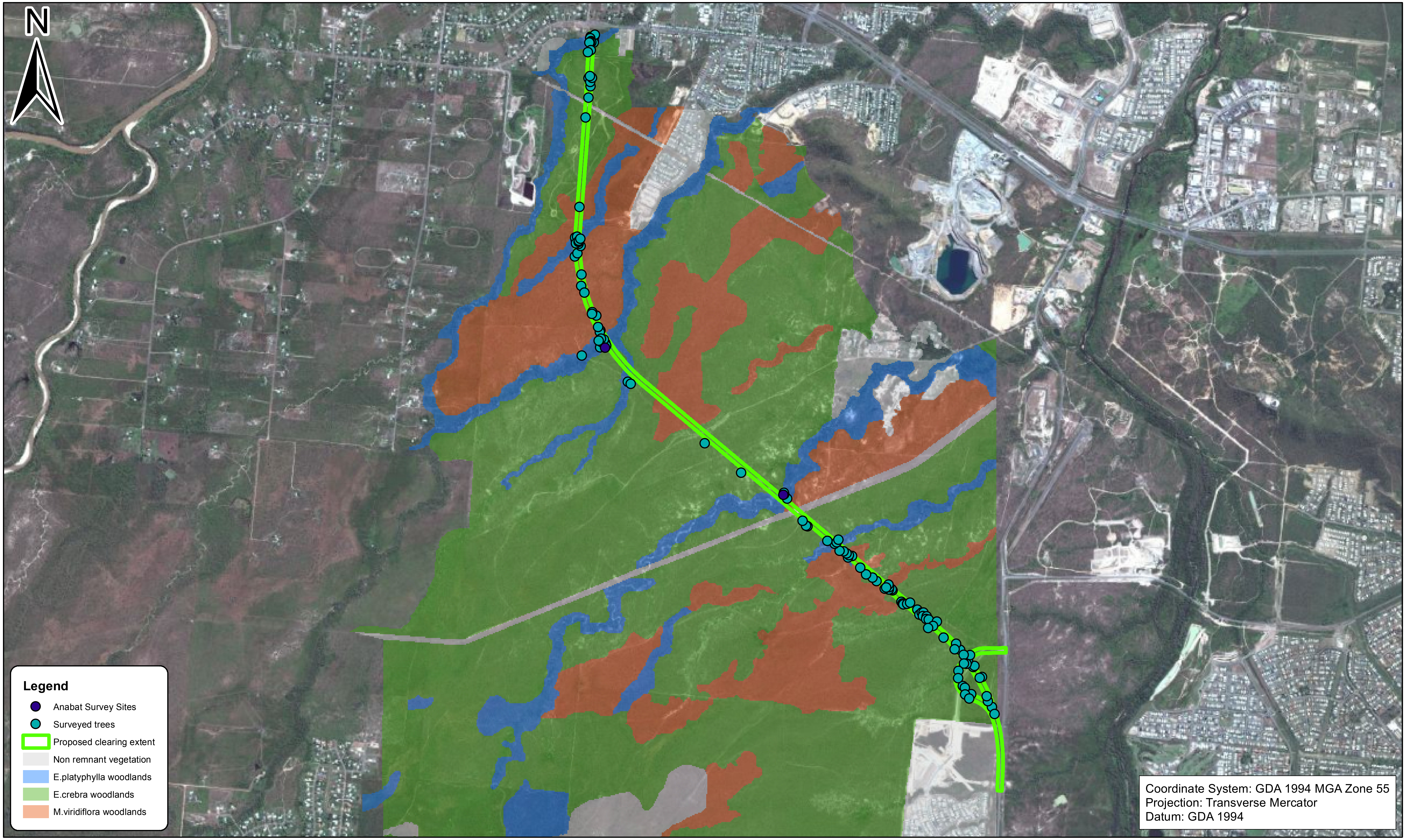


RPS

Figure 4: Location of tree hollows investigated and area of contiguous vegetation analysed for hollow abundance

0 700 1,400 2,800 Meters

Reference Scale: 1:28,104

Client: AECOM

Source: Aerial Photograph © Bing Maps (2012).

Date: 20/03/2013	Compiled by: AF	Project Manager: GC	Reference: Location_of_tree_hollows

2.3.1 LiDAR Data Analysis

LiDAR was used to map the approximate density of tree hollows across the project area. The methodology involved the following steps.

- Establish a project GIS in the TNTmips geospatial modelling software. The GIS included the following data sets:
  - LiDAR point cloud;
  - Updated vegetation mapping;
  - Field data points and quadrate data;
  - Road corridor; and
  - Aerial photography.
- The LiDAR was used to generate a terrain surface (DEM) and tree canopy height model (CHM) (**Figure 5**). Note that the following figures represent a subset of the area analysed, and are provided here only to demonstrate the methodology used in calculations.

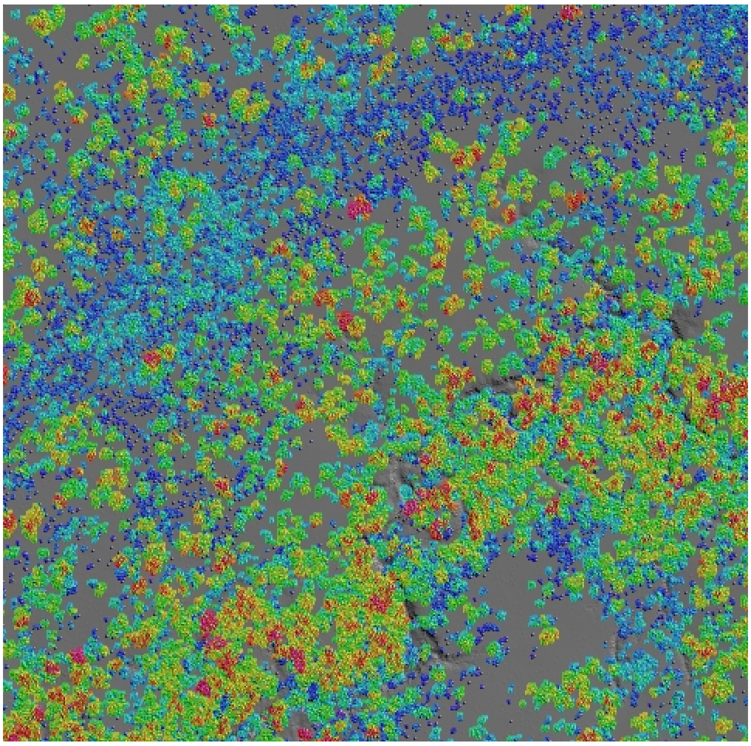


Figure 5 Canopy Height Model (CHM) Image.

- The CHM and aerial imagery were used to produce an updated vegetation map based on the RE codes;
- A GIS map of tree crowns was generated from the LiDAR using RPS in-house algorithms;
- The height of each tree was calculated from the highest LiDAR point falling within the tree crown polygon (**Figure 6**); and
- The tree crowns were converted to points for efficiency of processing (**Figure 7**).

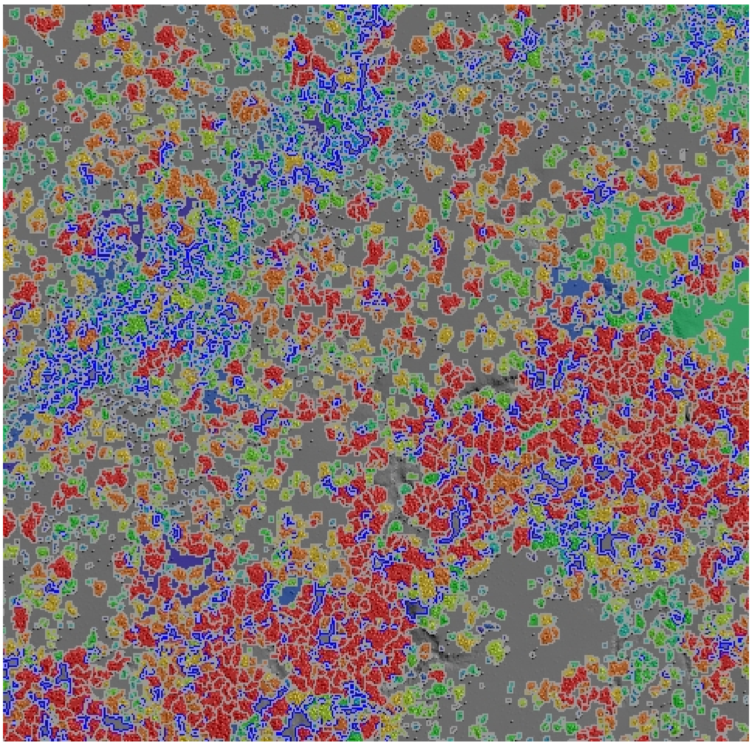


Figure 6 Tree Crowns Map – Colours Represent Tree Height (Arbitrary Classes).

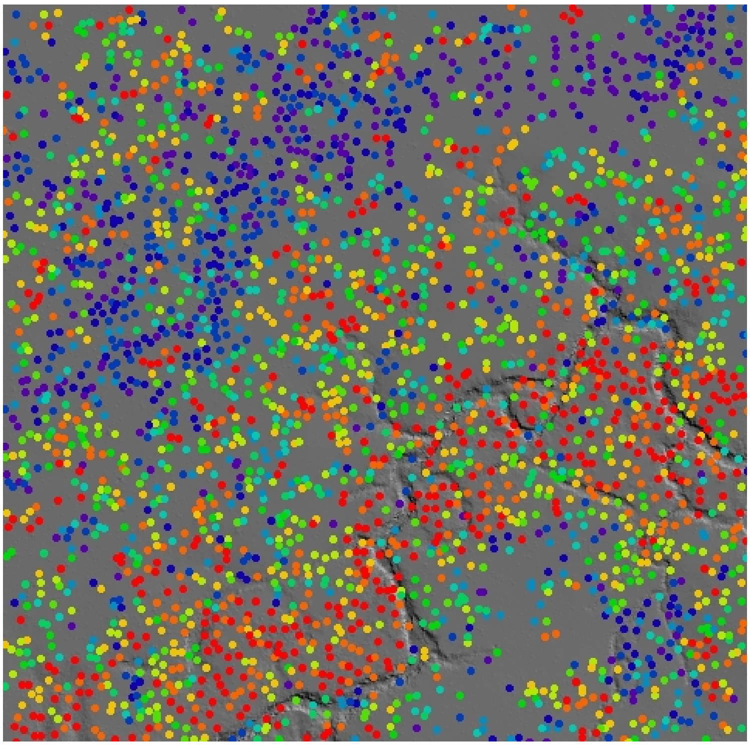


Figure 7 Tree Points, Coloured by Tree Height (Arbitrary Classes)

- The field data points which recorded the species and heights of the trees were related to the tree crowns and exported as a table to excel for analysis (**Table 3** below). The field data were sufficient to determine the approximate number of hollows for three height categories of *E. platyphylla* (**Figure 8**).
  - Height = 5 to 15m 1.3 hollows per tree;
  - Height = 15 to 18m 2.3 hollows per tree; and
  - Height greater than 18m 4.1 hollows per tree.

C. dallachiana showed an average of 1.7 hollows per tree for all heights of 5 metres and above
C. clarksoniana showed an average of 1.4 hollows per tree for all heights of 5 metres and above

Table 3 Number of Hollows Recorded For Each Species by Tree Height

Species	Tree Height (m)													
	5	8	10	11	12	13	14	15	16	17	18	19	21	Mean
C.clarksoniana				2		2	0.5			2				1.4
C.dallachiana		2	1			2	1		2	2				1.7
E.crebra						0	0	0						0.0
E.platyphylla	2		2.333	1	1	1	0.5	1.667	2.667	2.667	4	4.5	4	2.2

Variations in tree hollow abundance in smaller size classes in *E.platyphylla* would not be regarded as statistically significant.

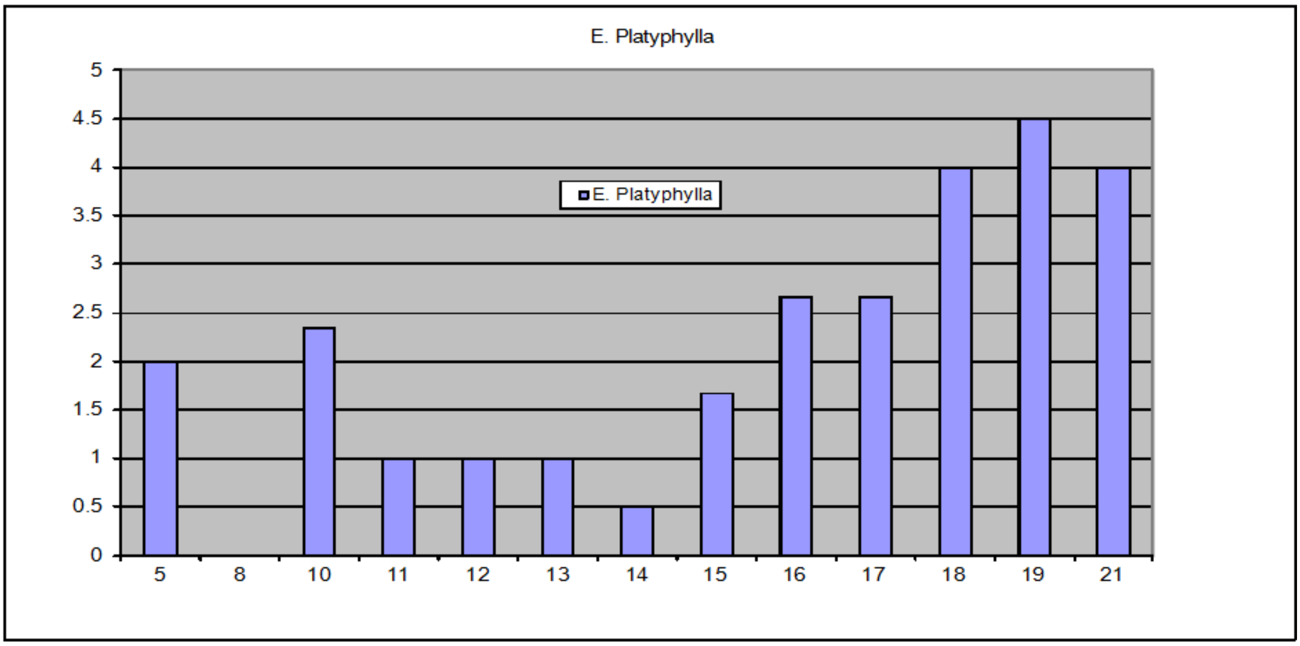


Figure 8 Approximate Number of Hollows for Height Categories of *E. platyphylla*

A GIS model was formulated to express the above information as the expected number of hollows per tree according to the size and the proportion of hollow bearing tree species determined for that vegetation type (RE). The model was applied to each tree crown, based on its size and the vegetation type in which it occurred.

Table 4 Expected Abundance of Hollows by Tree Species and Regional Ecosystem

RE type	Comment	Model for calculating expected hollows per tree
11.3.12	Emergent's over 12m are *E. platyphylla* (78.3%); and	If tree height 12m to 15m then hollows per tree = 1.3 x 78% = 1.014 If tree height 15m to 18m then hollows per tree = 2.3 x 78% = 1.794 If tree height 18m or greater then hollows per tree = 4.1 x 78% = 3.198
	C. dallachiana (21.7%)	If tree height > 12m then hollows = 1.7 x 21.7% = 0.3689
Z. mauritana	No hollow bearing tree species	0.0
Non-remnant	No hollow bearing tree species	0.0
11.3.30	Dominated by non-hollow bearing *E. crebra* with 5.7% *C.dallachiana* – 1.7 hollows per tree.	If tree height > 5m then hollows per tree = 0.057 * 1.7 = 0.1
11.3.35	*E. platyphylla* 30% *C. clarksoniana*	If tree height 5m to 15m then hollows per tree = 1.3 x 30% = 0.39 If tree height 15m to 18m then hollows per tree = 2.3 x 30% = 0.69 If tree height 18m or greater then hollows per tree = 4.1 x 30% = 1.2 + 9.8% * 1.7

- Tree crowns were then intersected with the vegetation map to determine the total number of hollows within each vegetation polygon. This was divided by the polygon area to give the number of hollows per hectare.

3.0 Results

3.1 Acoustic Monitoring

Bat echolocation calls were analysed by call analyst Greg Ford (Balance! Environmental) to specifically determine the presence of *S. saccolaimus,* and the results are described in the Microbat Call Identification Report (**Appendix 1**).

Each of the acoustic devices deployed generated files that were manually identified as 'probable' Bare-rumped sheathtail bat calls, and analyst Greg Ford concluded that "It is highly probable that *Saccolaimus saccolaimus* was present at all sites that were surveyed during this event". No calls identified as 'emergence calls' were recorded. In discussions with Greg Ford, he concluded that this high level of probability is the highest level of certainty possible without a very significant investment of additional time and resources. It is possible that conclusive and irrefutable evidence of occurrence of the Bare-rumped sheathtail bat might require obtaining a specimen, which would require approval from DEHP, SEWPaC and an ethics committee since it may require the animal to be killed in the process. Our recommendation is that the level of probability provided in the Microbat Call Identification Report be adopted as providing justification for assuming the presence of the bat in the proposed corridor, and for the significant impact guidelines to be addressed.

3.2 Burrow Scope Investigations

A total of fifty-six (56) hollow-bearing trees were investigated for the presence of the Bare-rumped sheathtail bat, however, many of the trees mapped by AECOM (2012a) as potential roost trees did not have any identifiable hollows. Of the eighty eight (88) hollows observed, fifty-nine (59) were explored with the burrowscope, with the remainder being beyond the reach of the equipment.

No individuals of the Bare-rumped sheathtail bat or any other microbat species were flushed from any hollows or otherwise observed during the investigations. Observations of tree hollows revealed two (2) juvenile blue-winged kookaburras, an Australian owlet-nightjar and numerous invertebrates including crickets and granny's cloak moth (*Speiredonia spectans*).

Although SEWPaC recommendations and guidelines for minimum search effort includes tree roost inspection with a burrow scope, it was found that there are significant limitations with all burrow scopes currently on the market or available for hire. These include:

- Low resolution cameras (0.3MP is a standard resolution);
- Limited illumination – the small LEDs are unable to illuminate the darker recesses of tree hollows where microbats are likely to be sheltering; and
- Limited camera head flexibility – the rigid nature of the camera head prevents it being inserted far enough into tree hollows to be able to adequately observe the full extent of tree hollows.

Generally, these cameras are designed for assessing artificial nest boxes, which have consistent sized entrances and box widths. It is believed that current advancements in small high resolution cameras coupled with improved illumination and motorised swivel heads will significantly improve the effectiveness of burrow scope investigations over the next couple of years, but currently the technology falls short of aspirations. Any burrow scope will be limited by the height to which a camera can be raised and accurately guided into a tree hollow, having respect for the fragility of the camera housing and its potential for breakage if it collides with a tree branch.

Despite limitations with the burrow scopes, we have a high level of confidence in the nil result obtained. Observation of a colony of Bare-rumped sheathtail bats at Iron Range, Cape York Peninsula (Murphy 2002) suggests that these bats remain very vigilant while roosting and may be prone to disturbance. The population observed were flushed from the tree simply by walking within 5m past the tree (Murphy 2002). This would suggest that if Bare-rumped sheathtail bats were present in any of the tree hollows inspected, that they would be close to the tree hollow entrance and would have been easily detected using the burrow scope method employed here. Additionally, all hollows were observed closely and carefully on approach and any flushed bats would have been observed.

A selection of tree hollow images is provided in **Figure 9** below:

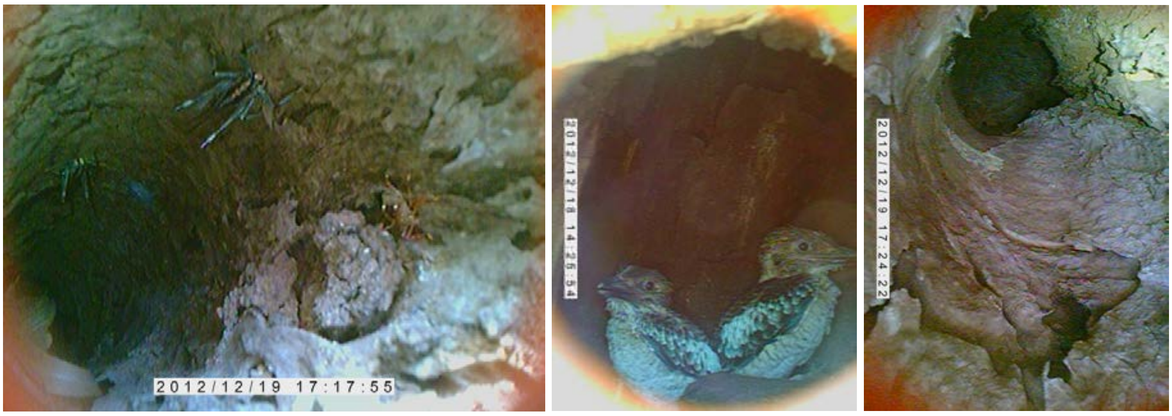


Figure 9 A Selection of Tree Hollow Images Obtained with the Burrowscope

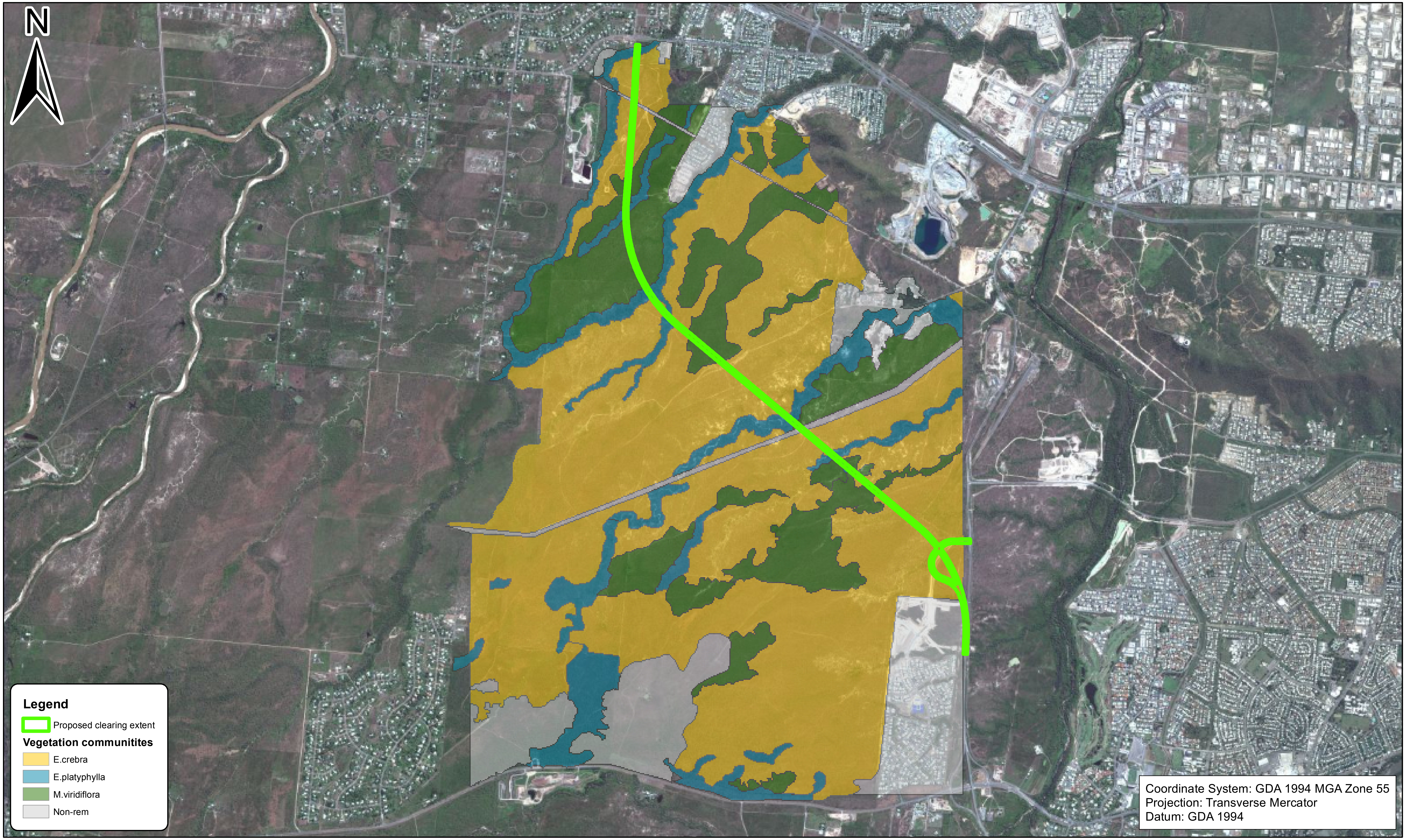
3.3 Habitat Suitability - Tree hollow Abundance

An assessment of Regional Ecosystems was undertaken across the 3,138 ha of remnant vegetation contiguous with the remnant vegetation being traversed by the proposed road alignment. Site inspections showed that vegetation within this area was heterogeneous with regards to providing potential roost sites for the Bare-rumped sheathtail bat. The tree species most likely to contain hollows were mature individuals of poplar gum (*Eucalyptus platyphylla*), however, hollows were also recorded from Grey bloodwood (*Corymbia clarksoniana*) and Dallachy's gum (*Corymbia dallachiana*). Hollows were very rare in Narrow-leaved ironbark (*Eucalyptus crebra*) and Broad-leaved tea tree (*Melaleuca leucadendra*).

Using a combination of existing vegetation mapping (Regional Ecosystems V. 6.1), field data, LiDAR imagery separating trees >10m height, and aerial photo interpretation, the area of contiguous remnant vegetation was divided into the following vegetation polygons:

- 11.3.12 = *Melaleuca viridiflora* woodland;
- 11.3.30 = *Eucalyptus crebra* woodland;
- 11.3.35 = *Eucalyptus platyphylla* woodland (incorporating areas of 11.3.25b - Riverine wetland or fringing riverine wetland, *Melaleuca leucadendra* and/or *M. fluviatilis, Nauclea orientalis* open forest); and
- Non-remnant - including Non-remnant vegetation and chinee apple (*Zizyphus mauritiana*)* dominated vegetation.

Regional Ecosystems 11.3.35 and 11.3.25b were combined as these areas were both dominated by large *Eucalyptus platyphylla*, considered to be the optimal roost tree for the Bare-rumped sheathtail bat, and were functionally inseparable both in aerial photo interpretation and habitat quality for the Bare-rumped sheathtail bat. A map showing the revised boundaries of vegetation communities is shown in **Figure 10** below.



RPS

Figure 10: Revised vegetation communities and proposed ring road clearing footprint

Client: AECOM

Date: 14/03/2013	Compiled by: AF	Project Manager: GC	Reference: Fig_10_Revised_vegetation_communities

0 900 1,800 3,600 Meters

Reference Scale: 1:34,955

Source: Aerial Photograph © Bing Maps (2012).

A summary of Regional ecosystems found to be present along the alignment and in adjacent vegetation are shown in **Table 5**, along with the percentage of those vegetation communities that will be cleared during construction, including clearing necessary for fencing the road easement.

Table 5 Summary of Vegetation Communities and Extent of Proposed Impact

RE	Vegetation Description	Stage 1 clearing	Extent in adjacent area	% total being cleared
11.3.12	*Melaleuca viridiflora* woodland on alluvial plains	18.57	511	3.63%
11.3.25b	Riverine wetland or fringing riverine wetland	2.22	304	1.582 %(4.81ha)
11.3.35	*Eucalyptus platyphylla, Corymbia clarksoniana* woodland on alluvial plains	2.59		
11.3.30	*Eucalyptus crebra, Corymbia dallachiana* woodland on alluvial plains	20.77	1672	1.242%
non remnant		11.29	449	4.526%
remnant		44.14	2487	1.775%

The estimate of tree hollows per unit area was based on field estimates of the number of hollow bearing trees per unit area within a particular regional ecosystem and observed average frequency of hollows for different tree species. As an example of hollow calculations for RE 11.3.35/ 11.3.25, replicated quadrates estimated 36.35 hollows/ ha, which over an area of 304 ha provides an estimate of 11,050 hollows.

This methodology was applied to the remaining regional ecosystems in the contiguous remnant vegetation patch, with the following estimates of tree roost availability (**Table 6**):

Table 6 Estimated Abundance of Tree Hollows by Vegetation Type and Anticipated Impact of Clearing

RE	Vegetation Description	Hollows/ ha	Total area (ha)	Total hollows in remnant area	Proposed clearing (ha)	% total hollows cleared
11.3.12	*Melaleuca viridiflora* woodland on alluvial plains	37.58	511	19,203	18.57	3.63%
11.3.25b	Riverine wetland or fringing riverine wetland	36.35	304	11,050	2.22	1.58% (4.81ha)
11.3.35	*Eucalyptus platyphylla, Corymbia clarksoniana* woodland on alluvial plains				2.59	
11.3.30	*Eucalyptus crebra, Corymbia dallachiana* woodland on alluvial plains	3.78	1672	6,320	20.77	1.24%
non remnant		0	449	0	11.29	N/A

4.0 Discussion and Recommendations

The present report represents the third attempt to confirm the presence of the Bare-rumped sheathtail bat along the proposed road alignment. The similarity in echolocation calls between this and the Yellow-bellied sheathtail bat has always represented a significant hurdle in identifying this species using acoustic monitoring, and despite some significant recent advances in call identification, there is still a degree of uncertainty in attributing some calls to either species. The level of probability given by Greg Ford to acoustic files recorded along the alignment (**Appendix 1**) is the greatest degree of certainty that can realistically be achieved without significant time, expense and the probable death of a specimen for voucher purposes. The Bare-rumped sheathtail bat can also appear very similar to the Yellow-bellied sheathtail bat, and Schulz and Thomson (2007) recommend that caution should be used for sight records based on individuals emerging from tree hollows or seen at roosts without being captured. Since this is a notoriously difficult species to capture, many previous museum specimens were collected using a shotgun; a technique that is no longer employed in bat surveys (Curtis *et al.* 2012). It is recommended that on the basis of a 'highly probable' result from Greg Ford's analysis of the acoustic files, that the Bare-rumped sheathtail bat is assumed to occur within the alignment, however, all results obtained to date suggests the proposed alignment is a foraging zone, with no distinctive emergent calls having been recorded.

The nil result from the burrow scope investigation is consistent with other similar investigations, including a study undertaken at Iron Range (Cape York Peninsula) where 150 tree cavities were searched, including 60 hollows inspected every two months, but failed to detect any colonies of Bare-rumped sheathtail bats (Murphy 2002). It has been assumed that the bat species occurs in naturally low densities across the landscape (Murphy 2002), however, the area occupied by a colony for foraging purposes has never been documented, and it is unknown how many colonies the broader area of contiguous vegetation could potentially contain. Their 'highly probable 'presence at multiple locations across the landscape indicates that a high proportion of the area is being utilised for foraging purposes, including areas that are not dominated by Poplar gum.

The tree hollow investigation utilised a number of techniques to maximise use of field data in extrapolating tree species and hollow abundance across the wider landscape. While difficult to calculate the error margins associated with calculated values, they are useful in demonstrating broad trends in habitat availability across the broader landscape to an extent that cannot be derived from field investigations alone. The use of LiDAR assisted in determining the locations of the larger individual trees most likely to contain hollows, and in separating out lower growing plant species such as Chinee apple and Broad-leaved tea tree that do not provide roosting habitat. An unexpected result of the investigations was the high abundance of suitable hollows in RE 11.3.12, which had not previously been identified as likely habitat for the Bare-rumped sheathtail bats. The additional 511 ha of suitable habitat substantially increases the area over which the Bare-rumped sheathtail bat is likely to occur in the contiguous vegetation patch. The LiDAR data was of limited value in separating tree species of similar height but with different frequency of hollows and habitat value.

Another technique that could be used in future studies to better understand the spatial distribution of individual eucalypt species would be the use of spectral reflectance, using the spectral signatures of different tree species to interpret multi-spectrum satellite imagery.

4.1 Significant Impact Criteria

Under the EPBC Act, an action will require approval from Federal Environment Minister if the action has, will have, or is likely to have a significant impact on a listed species or ecological community. Significant impacts include those that degrade areas of important habitats for listed species, or disrupt the lifecycle of ecologically significant populations of listed species.

Schulz and Thomson (2007) notes that the greatest threat to *S. saccolaimus* is habitat loss, with many areas in its range having been cleared for agriculture and urban development. AECOM (2012a) lists a number of potential impacts of the proposed ring road on *S. saccolaimus* including:

- Direct clearing of large hollow-bearing trees used for roosting and breeding;
- Dust and noise pollution;
- Night time lighting that may interfere with breeding and foraging behaviour;
- Degradation of habitat (e.g. by damage from vehicles and heavy machinery);
- Increased habitat fragmentation;
- Pollution or damage to critical water sources;
- Increased weed infestation;
- Increased feral animal abundance;
- Uncontrolled fires;
- Road mortality during and post construction; and
- Disruption of breeding and/or behaviour by noise pollution and human/ vehicular disturbance.

To determine the potential significance of any impact of the proposed road construction, and to calculate residual impacts following implementation of mitigation measures, it is necessary to address the 'significant impact criteria' set out under *Matters of National Environmental Significance – Significant Impact Guidelines 1.1* (the Guidelines). These criteria are intended to assist in determining whether the impacts of a proposed action on a nationally threatened species are likely to be significant impacts.

The criteria are intended to provide general guidance on the types of actions that will require approval and the types of actions that will not require approval. Comments / responses are provided in relation to each of the significant impact criteria below.

For a Critically Endangered species such as *S. saccolaimus,* an action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

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

In determining whether an impact is likely to be significant, the sensitivity, value, and quality of the environment which is impacted, and the intensity, duration, magnitude and geographic extent of the impacts need to be considered.

These potential actions and impacts are addressed in the following sections:

4.2 Lead to a Long-term Decrease in the Size of a Population

No populations are currently known to be under threat (Schulz and Thomson 2007). A size estimate of the population of Bare-rumped sheathtail bats in the vicinity of the proposed road corridor is not available, nor is an estimate of population density. We do not believe that there is currently a suitable methodology for calculating these parameters. Instead, we assess what is the likelihood and the significance of any element of the proposed action that may have a negative impact on population size, either through construction or operational phase of the project.

Clearing of roost trees will only occur in the construction zone (nominal 40m clearing width for most of the alignment except at culverts and bridge crossings). The immediate impact of the construction phase will be the physical removal of 195 trees assessed as being potential habitat trees (AECOM 2012a). The present study examined the majority of these trees, and other hollow bearing trees in the surrounding landscape and concluded that suitable roost trees rarely occurred in trees less than 10-12m in height. Of the 195 trees assessed by AECOM, only twenty five (25) of these were in the 10-15m height range. This includes twenty two (22) Popular gums (*Eucalyptus platyphylla*), a species most commonly associated with roosts of the Bare-rumped sheathtail bat (Schulz and Thomson 2007). The present study did not locate any bats within any of the tree hollows inspected, and while this may be partly due to limitations in burrow scope design, the findings are also consistent with previous research into tree hollow occupancy by this species, where a total of 150 tree cavities were searched, including 60 hollows inspected every two months, but failed to detect any colonies of Bare-rumped sheathtail bats (Murphy 2002). The recovery plan for this species notes that evidence suggests they occur at low densities in the region (Schulz and Thomson 2007). From this we can conclude that the Bare-rumped sheathtail bat may be expected to only utilise a small percentage of available suitable hollows in suitable habitat. Our calculations using site inspections, aerial photo interpretation and LiDAR data estimates that there are 11,050 available hollows in RE 11.3.35 / 11.3.25 in the remnant vegetation patch within and immediately contiguous with the proposed disturbance site, and that the removal of the hollows within the road alignment represent only 1.58% of the total hollows available in that particular community. In addition, we calculate that the remnant vegetation patch also contains an additional 6,320 hollows in Regional Ecosystem 11.3.30 and 19,203 hollows in RE11.3.12, so the estimated total hollows requiring removal represent only 1.24% and 3.63% respectively.

Considering the very small proportion of available roosts being removed, the general low abundance of Bare-rumped sheathtail bats in the landscape, their absence from any of the trees to be removed, and that mitigation measures will be employed to ensure no bats are harmed during the tree clearing process (see Table 7 of the referral), we conclude that the physical removal of the trees is not likely to lead to a long-term decrease in the size of the population, either during the clearing phase, or as a permanent alteration to their habitat.

Similarly, we believe that impacts associated with construction (e.g. dust, noise, artificial lighting etc.) will be restricted to such a limited and small area of available habitat, relative to the available habitat in the vicinity of the project, that this is unlikely to have a significant impact on the bats, particularly with consideration of the mitigation measures employed to reduce these impacts.

The operational phase of the project carries impacts generally associated with the use of the alignment as a major road corridor with high traffic levels, such as increased noise and light, increased risk of road mortality and potential disruption of breeding and/or behaviour by noise pollution and human/ vehicular disturbance.

The Bare-rumped sheathtail bat is known to be prone to disturbance, with the bats observed to have been flushed from a tree hollow simply by a person walking within 5m of a roost tree (Murphy 2002). As this was a one-off event it is difficult to determine whether or not the bats would always be this easily flushed, however it can be assumed that the bats would generally be prone to flushing from roost hollows during daylight hours as a significant portion of time during the night would be spent foraging rather than roosting.

We also note that a road-killed individual has been recorded on Magnetic Island off Townsville (Queensland Museum Specimen No. JM13938). However, the Magnetic Island 'probable road-killed individual' is described as an 'anomaly ' by Schulz and Thomson (2007), though it's unclear whether this refers to the geographic location or the fact it was a road kill. This bat species is generally considered to be a high flying species, feeding on insects above the canopy to a height of 80 metres, though sometimes swooping down to within 2m of the ground in pursuit of prey (Churchill 2008). Their fast and high flying behaviour makes them a difficult species to trap, and they have never been caught in harp traps (Schulz and Thomson 2007). This makes them an unlikely candidate for road kill except when swooping down in pursuit of prey. A recent survey in the Barratta floodplain south of Townsville found an abundance of highly probable Bare-rumped sheathtail calls, including emergence calls, from a stand of Poplar gums immediately on the edge of the Bruce Highway (RPS 2011). Although traffic volumes at this location would be significantly less than that anticipated for the proposed Ring Road, the implications of this is that:

- Bare-rumped sheathtail bats can occur in immediate proximity to a major thoroughfare;
- Impacts of light, noise and vibration from regular traffic do not appear to have a significant impact;
- Mortality from road kill does not appear to pose a significant threat to the species; and
- Bare-rumped sheathtail bats may become habituated to traffic disturbance.

Route lighting will not be required along the proposed road alignment, and this will reduce the likelihood of bats being attracted to insect gatherings around light sources and being subject to collisions with vehicles.

Repeated bird surveys have demonstrated that birds that are habituated to vehicle traffic are still easily disturbed by pedestrian traffic. Along the proposed Ring Road, public access will be restricted and discouraged by appropriate signage. Signage at targeted track closure locations has been found to be an effective deterrent.

On the basis of findings from previous studies and mitigation measures proposed, we conclude that the operational phase of the proposed ring road is unlikely to lead to a significant long-term decrease in the size of a population.

4.3 Reduce the Area of Occupancy of the Species

The proposed road has an estimated footprint of 40 ha, and traverses a large block of continuous remnant woodland approximately 3,138 ha in size. From **Table 6**, the proposed clearing will be removing an estimated 8.658 ha of suitable habitat, defined here as being open woodland communities with large hollow-bearing eucalypts. As a proportion of the optimal habitat immediately contiguous with the area being traversed (i.e. RE 11.3.35/ 11.3.25), it is estimated that 1.582% of suitable habitat will be removed. Although RE 11.3.12 is also considered suitable habitat due to the presence of scattered hollow-bearing *Eucalyptus platyphylla* and *Corymbia dallachiana*, the patchy distribution of these emergent trees means that not all areas traversed had similar habitat values, as measured by abundance of hollows. Of the 511 ha of this habitat in the broader contiguous vegetation, only 3.63% is included in the proposed clearing footprint.

Additionally, there is strong connectivity to other large remnant patches, both through strips of woodland and along riparian corridors, and the area of available habitat with connectivity to the proposed impact area is incalculable. The southern boundary of this patch of remnant vegetation is arbitrarily set as being Hervey Range Road; however, we do not consider this to be a barrier to movements by this bat species.

The area of remnant vegetation assessed in the present report was selected due to proximity of the proposed alignment and availability of LiDAR data, and we recognise the extensive connectivity of this patch to other areas of vegetation, including via riparian vegetation in an otherwise modified and cleared landscape.

This bat species is described as preferring ‘coastal eucalypt forests with high rainfall’ (Curtis *et al.* 2012), however, average rainfall is not defined. Using 200mm rainfall isohyets available from the Bureau of Meteorology, it is noted that records of Bare-rumped sheathtail bat around Townsville have been recorded in both the 1200mm and 2000mm average rainfall contours, and suitable habitat could therefore be defined as eucalypt woodland communities extending from north of the Burdekin River up the east coast to Taylors Beach near Ingham, and inland to include Hervey Range, an area of approximately 750,000 ha. Using the predictive Bioclim data provided by Schulz and Thomson (2007) and based entirely on climate and not on any other environmental or biological parameters, the proposed alignment is with an area of approximately 194,395 ha of predicted distribution centred on Townsville.

On the basis of the location of Bare-rumped sheathtail bats on the edge of the Bruce Highway (RPS 2011), we do not believe that the proposed road alignment will reduce the occupancy of the bat beyond the area physically removed, and that based on their tendency to forage at heights above the normal tree canopy, there is a high probability that the bats may continue to use the airspace above the road as foraging habitat.

Based on their demonstrated ability to persist next to a busy highway, the very small proportion of vegetation being removed, the large area of suitable habitat contiguous with the project area, the significant area of suitable habitat in the broader landscape and the assumption that the ring road project will not act as a barrier and fragment populations, we conclude that the proposed ring road project will not significantly reduce the area of occupancy of the species beyond the area of suitable habitat actually being cleared.

4.4 Fragment an Existing Population into two or More Populations

For the proposed project to fragment the existing population, it would need to assume that the proposed road corridor is likely to act as a barrier to movements.

Although a road kill of this species has been recorded from Magnetic Island (Schulz and Thomson 2007), there is no suggestion in the literature that road kill is considered a threatening process. Although woodland and tall open forests are their preferred habitat (Churchill 1998), they have also been recorded from grassy beach dunes with *Melaleuca* and *Acacia* (Churchill 1998) and in forest clearings (Schulz and Thomson 2007). Their presence on Magnetic Island implies that they are capable of flying over expanses of open water, and this ability to fly between land masses is supported by their extra-limital distribution which ranges from India in the west to Bougainville Island in the East.

Evidence therefore supports the theory that open treeless areas are not a barrier to movement, and it is reasonable then to expect that a high flying species capable of flying hundreds of kilometres over open ocean would not regard a 50m wide road corridor as a barrier to movement. The highest elevation of the proposed road will be a 6.5m high overpass at Kalynda Parade and Geaney Lane, which is significantly lower than the 12-15m woodland canopy that the bats normally forage above. No route lighting will be required beyond the need for lighting at intersections and merge areas, therefore, there will not be any artificial structures that might inhibit or prevent movement across the road.

We conclude that the proposed road alignment will not fragment an existing population into two or more populations.

4.5 Adversely Affect Habitat Critical to the Survival of a Species

There are no maps available that show habitat critical to the survival of the Bare-rumped sheathtail bat (Schulz and Thomson 2007). Impacts on roosting and foraging habitat described in the recovery plan as being critical to the survival of the species is discussed below. The recovery plan does not provide any information on commuting or temporal habitat usage.

4.5.1 Roosting Habitat

At the time of publication of the *National recovery plan for the bare-rumped sheathtail bat Saccolaimus saccolaimus nudicluniatus* (Schulz and Thomson 2007), the Bare-rumped sheathtail bat had only been recorded from Poplar gum *Eucalyptus platyphylla*, Darwin woollybutt *E. miniata* and Darwin stringybark *E. tetrodonta*, however, it has since also been located in Weeping tea tree *Melaleuca leucadendra* (Greg Ford pers. Comm.).

Assessment of vegetation across the site using a combination of Regional Ecosystem mapping, site inspections, aerial photo interpretation and LiDAR data analysis shows that *Eucalyptus platyphylla* occurs in specific zones across the broader landscape, primarily along watercourses and other low-lying areas. Woodland dominated by *E. platyphylla* is mapped across the broader landscape as Regional Ecosystem 11.3.35 (*Eucalyptus platyphylla, Corymbia clarksoniana* woodland on alluvial plains) and 11.3.25b (Riverine wetland or fringing riverine wetland. *Melaleuca leucadendra* and/or *M. fluviatilis, Nauclea orientalis* open forest). *E. platyphylla* woodland is intersected by the proposed alignment, and surveys by AECOM indicate that 58 individuals with hollows are within the proposed footprint (AECOM 2012a).

Existing Regional Ecosystem (RE) mapping overestimates its abundance in the landscape. Vegetation analysis (**Table 5**) showed a total of 304 ha occurs in the 3,138 ha of vegetation contiguous to the project area, with tree hollow density an average of 36.35/ ha. It is estimated that 11,050 suitable hollows are available in this contiguous area of remnant vegetation. Although the majority of these hollows are in *E. platyphylla*, this figure also includes Grey bloodwood (*Corymbia clarksoniana*) which frequently has hollows and occurs at an approximate average frequency of 9.87% of trees >12m with an average abundance of 1.7 hollows/tree. It should be noted that the Bare-rumped sheathtail bat has not previously been recorded using hollows in this tree species, however, it cannot be discounted that this is an artefact of sampling intensity.

In addition, *Corymbia dallachiana* is another smooth-barked gum with a high frequency of hollows in trees above 12m in height. Occurring primarily in low densities (5.7%) amongst ironbark communities (RE 11.3.30), this species provides an average density of 3.78 hollows/ ha, totalling 6,320 hollows across the entire site. It should be noted that the Bare-rumped sheathtail bat has not previously been recorded using hollows in this tree species, so this can be regarded as potential marginal roosting habitat only. Although *Melaleuca viridiflora* only very rarely produces hollows, it often occurs with *Eucalyptus platyphylla* and *Corymbia dallachiana* as sparse emergents in RE 11.3.12, proving an average of 37.58 hollows/ ha, totalling a significant 19,203 hollows across the entire site.

We conclude that in the 3,138 ha of vegetation contiguous and immediately adjacent to the project site, there is 304 ha of optimal habitat (RE 11.3.35/ 11.3.25) providing an estimated 11,050 hollows, with an additional 511 of suitable habitat in RE 11.3.12 providing an estimated 19,203 hollows and 1,672 ha of marginally suitable habitat (11.3.30), providing an estimated 6,320 hollows in *Corymbia dallachiana*.

We conclude that the proposed project will not have a significant adverse impact on roosting habitat critical to the survival of the bare-rumped sheathtail bat.

4.5.2 Foraging Habitat

The use of open woodland vegetation within the proposed road alignment for foraging by *S. saccolaimus* is considered highly probable, including the use of creeks as movement corridors and drinking at pools of water along these creeks.

Potential foraging habitat is based primarily on anecdotal information based on habitat around roosts or from shot specimens (Schulz and Thomson 2007). Recorded foraging habitat includes:

- Poplar gum woodland typical of the alluvial plains adjacent to the lower Burdekin and Haughton Rivers, with adjacent carbeen *Corymbia tessellaris* and ghost gum *E. papuana* (now *Corymbia dallachiana*);
- Darwin stringybark (*E. tetradonta*) woodland with Clarkson's bloodwood *Corymbia clarksoniana* and *C. tessellaris* subdominant. Adjacent to the roost was a narrow strip of gallery forest along a seasonally dry watercourse and less than one kilometre away were large patches of rainforest;
- Riverine vine forest with adjacent open forest/woodland; and
- Open Pandanus woodland fringing sedgelands (Schulz and Thomson 2007).

In these reported cases, it was not known if individuals foraged over some or all of the vegetation communities in the vicinity of the roost (Schulz and Thomson 2007). Additional surveys for Bare-rumped sheathtail bats undertaken by RPS have returned additional foraging information:

- 'Highly Probable' occurrence in 11.3.25b (Riverine wetland or fringing riverine wetland) and 11.3.35 (*Eucalyptus platyphylla, Corymbia clarksoniana* woodland on alluvial plains) (RPS 2011); and
- 'Highly likely' occurrence in RE 7.3.25 (*Melaleuca leucadendra* +/- vine forest species, open to closed forest, on alluvium fringing streams), RE 7.3.45 (*Corymbia clarksoniana* +/- *C. tessellaris* +/- *Eucalyptus drepanophylla* open forest to open woodland on alluvial plains), and RE 7.3.40 (*Eucalyptus tereticornis* medium to tall open forest on well drained alluvial plains of lowlands) (RPS 2012a).

The bare-rumped sheathtail bat has been suggested to forage over habitat edges such as the edge of rainforest and in forest clearings (Schulz and Thomson 2007).

From the literature, it is evident that the Bare-rumped sheathtail bat is known to utilise a broader range of vegetation types for foraging than they do for roosting. Although most available literature suggests a strong affinity with *Eucalyptus platyphylla* (e.g. Schulz and Thomson 2007, Churchill 2008), the acoustic monitoring location at Site 1 (farm dam) approximately 900m to the south west of the proposed alignment was surrounded by Regional Ecosystems 11.3.12 and 11.3.30. The highly probable detection of the Bare-rumped sheathtail bat at that site indicates that the bats do indeed forage in these other Regional Ecosystem types, and that all the remnant vegetation communities in the remnant patch should be considered as potential foraging habitat. Regional Ecosystem 11.3.12 is dominated by the low growing *Melaleuca viridiflora* which never contains suitable hollows, however, there is a scattered number of *Eucalyptus platyphylla* and *Corymbia dallachiana* which are hollow bearing. With an estimated 37.58 hollows per hectare, this vegetation community should also be regarded as suitable roosting and foraging habitat for the Bare-rumped sheathtail bat.

Table 5 shows that within the 3,138 ha of vegetation contiguous with the project area, there is 304 ha of optimal habitat (RE 11.3.35 / 11.3.25), 511 ha of suitable foraging habitat (RE11.3.12) and 1,672 ha of marginal foraging habitat (RE 11.3.30). The proposed project will remove 4.81 ha of RE 11.3.35/ 11.3.25b (1.582%) and 70.812 ha of the other Regional Ecosystems (3.63% of RE 11.3.12, 1.242 % of 11.3.30).

Considering these small percentages of total available habitat, we conclude that the proposed project will not have a significant adverse impact on habitat critical to the survival of the Bare-rumped sheathtail bat.

4.6 Disrupt the Breeding Cycle of a Population

Reproduction in the Bare-rumped sheathtail bat is known to vary between geographic regions, but in Queensland it is known that females give birth to a single young between late December and early January, and lactate during the wet season (Churchill 2008). To define the 'Wet Season', monthly mean average rainfall data available from the Bureau of Meteorology from 1940-2013 shows that Townsville receives its highest rainfall between December and March, with February being Townsville's wettest month. Wet weather may persist into April. Clearing for the alignment will take place in April 2014, by which time we anticipate that any young will be fully fledged and able to fly independently of its mother. Consequently, we do not believe that the proposed action will significantly disrupt the breeding cycle of the local population.

4.7 Modify, Destroy, Remove, Isolate or Decrease the Availability or Quality of Habitat to the Extent that the Species is likely to Decline

In previous sections, we have used abundances of tree hollows within and external to the proposed clearing footprint to demonstrate that the proposed action is unlikely to have a significant impact on potential roosting habitat. We have presented information to justify why a narrow road corridor is unlikely to act as a barrier to movement, and conclude that the proposed action is unlikely to fragment or isolate the population.

No information is available in the literature describing the home range or what area of foraging habitat is required to support a population of Bare-rumped sheathtail bat. From results obtained in the present study, and previous investigations into Bare-rumped sheathtail bats along the alignment (e.g. AECOM 2012a, RPS 2012b), indicate that individuals are foraging across a large area of the associated remnant vegetation in the area. As previously described, it is evident that the Bare-rumped sheathtail bat is known to utilise a broader range of vegetation types for foraging than they do for roosting. Although most available literature suggests a strong affinity with *Eucalyptus platyphylla* (e.g. Schulz and Thomson 2007, Churchill 2008), the acoustic monitoring location at Site 1 (farm dam) was surrounded by Regional Ecosystems 11.3.12 and 11.3.30. The highly probable detection of the Bare-rumped sheathtail bat at that site indicates that the bats do indeed forage in these other Regional Ecosystem types, and that all the remnant vegetation communities in the remnant patch should be considered as potential foraging habitat.

Within the 3,138 ha of vegetation contiguous with the project area, there is 304 ha of optimal habitat (RE 11.3.35 / 11.3.25b) and 2,183 ha of marginal foraging habitat (RE 11.3.12 and 11.3.30). The proposed project will remove 8.658 ha of RE 11.3.35 / 11.3.25b (2.848%) and 70.812 ha of the other Regional Ecosystems (3.244%). The area of available habitat within easy range is significantly larger than the 3,138 ha of contiguous vegetation, due to broad connectivity to open woodland areas to the south of Hervey Range Road, and the broad riparian connectivity along the Bohle River and other watercourses. The proposed action neither removes a significant proportion of available habitat or constrains the ability of the Bare-rumped sheathtail bat to access other potential roosting and foraging habitat.

Considering the broad area of suitable habitat across the broad connected landscape, their demonstrated low frequency of occupancy of tree hollows, ability to move and disperse over broad areas of unsuitable habitat, and ability to forage over cleared open areas, we conclude that the proposed action is unlikely to significantly modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

4.8 Result in Invasive Species that are Harmful to a Critically Endangered or Endangered Species becoming established in the Endangered or Critically Endangered Species' Habitat

Since *S. saccolaimus* is primarily known from hollows high in trees, it is relatively well protected from predation from introduced pest animals such as cats, foxes, wild dogs and cane toads. However, there are numerous new introduced plant species that may have the potential to negatively impact on their preferred roosts in hollow trees. Townsville is known to have approximately 245 introduced plant species with wild populations, with 12 new species having been detected over the 2011-2012 calendar years. The proposed road alignment is relatively weed free, with virtually no introduced grass species recorded. However, with a total of 43 introduced grass species in the Townsville area, there is a significant opportunity for invasion, particularly as a consequence of the inevitable disturbance that will be associated with road construction. Several of these grasses, particularly *Andropogon gayanus* (gamba grass), *Chloris gayana* (Rhodes grass), *Hyparrhenia rufa* (Thatch grass), *Pennisetum pedicellatum* (Kyasuma grass), *Sorghum halepense* (Johnson grass) and *Themeda quadrivalvis* (Grader grass), are large robust grasses that can significantly alter fuel loads.

Research from the Northern Territory showed that Gamba grass communities can generate anywhere from 11–15 tonnes/ ha to 30 tonnes/ ha dry fuel loads, compared to native grasses that generally produce 3-5 tonnes/ ha, and that this can increase late-season fire intensity up to 25 times (Csurhes & Hannan-Jones 2008). Like many weeds, Gamba grass spreads best in areas where natural vegetation has been disturbed, and where roadside slashing can spread seeds (Csurhes & Hannan-Jones 2008). Although roadsides can act as a conduit for movement and spread of weeds such as Gamba grass, it can and will invade into undisturbed environments, particularly along creeks (Csurhes & Hannan-Jones 2008). Under worst-case conditions, Gamba grass and its related fire regimes can halve tree canopy cover in five years, with tree recruitment reduced up to 75% (Csurhes & Hannan-Jones 2008).

Without mitigation measures, the spread and invasion of these large African grasses could pose a significant threat to the long-term persistence of *S. saccolaimus.* The Department of Transport and Main Roads (TMR) are committed to complying with the requirements of the *Land Protection (Pest and Stock Route Management) Act* 2002 to manage declared pests such as Gamba grass. This includes preventing weed seed spread, and optimising management of declared pests in the road reserve including eradication, local eradication and containment of infestations (Taylor 2010). Although this document is primarily aimed at the management of declared weeds, it does note that 'Priority weeds' includes those species declared under local government bylaws. Unfortunately, many of the weedy grass species that threaten these woodlands are not declared species, and Townsville has not declared any weed species under their bylaws.

It is noted that TMR propose to propagate and plant preferred forage grass species for the Black-throated finch (as per the BTF recovery plan) as part of the mitigation measures for the project. This intent to manage the road reserve for other threatened species will assist greatly in the management of potential weed species within the road reserve.

It is recommended that development of the overall 'Planning and Construction Environmental Management Plan' should therefore include management of weed and fire impacts in the road reserve and would include a range of prescribed mitigation measures including:

- Limiting unnecessary vegetation clearing and soil disturbance;
- Implementing a weed management plan for the site including a wash down area and weed control through both chemical, biological and mechanical means during construction phase;
- Implementing a pest management plan for the site including the control of feral pigs and cats;
- Implementing a fire management plan for the site;
- Implement a rehabilitation plan to commence as soon as construction in an area is complete to minimise the time bare ground is exposed;
- Post construction, ensuring habitat surrounding the TRR4 does not become degraded by human use (i.e.); and
- Recreational use, illegal dumping) by restricting access, education, installing fire breaks and maintaining

the weed and pest management plans.

It should be noted that the EPBC referral for TRR4 includes most of these items as components of the proposed Planning and Construction Environmental Management Plan.

In the past, it was common practice to use exotic pasture grasses for roadside rehabilitation and this can be cause of weed invasion. Roadside revegetation along TRR4 will involve the use of suitable local native provenance grasses (especially the dominant grass on site *Themeda triandra* – kangaroo grass) or sterile annual grasses such as *Echinochloa esculenta* - Japanese millet. Minimising bare ground and providing competition through revegetation will significantly reduce opportunities for grass weeds to establish, however, routine inspections may be required to ensure no infestations have occurred.

4.9 Introduce Disease that May Cause the Species to Decline

Although there are no records of Australian microbats being detected with Hendra virus, some species are known to be potentially impacted by a rabies-like virus known as Lyssavirus. The bat family Emballonuridae to which the Bare-rumped sheathtail bat (*S. saccolaimus*) belongs is known to be affected by rabies and Lyssavirus in America, Asia, Africa and Australia (Tidemann *et al.* 1997). Lyssavirus was first reported from the Townsville area in 1995 and is known to infect a closely related species, the yellow-bellied sheathtail bat (*Saccolaimus flaviventris*) (Tidemann *et al.* 1997). Infection is generally spread by bites or scratches from infected animals, though infection by rabies has been reported in cases where the aerosolized virus is in a confined space with little to no air movement (Tidemann *et al.* 1997). Incidence of the disease in microbats is relatively uncommon. Of 318 wild microbats tested for Lyssavirus, none tested positive for the disease, while nine individuals (2.8%) were antibody positive (Ewald & Durrheim 2008). So far, the only microbat that has been tested positive for Lyssavirus is *S. flaviventris*, however, four other microbats have tested positive to antibodies. On the basis of the close relationship between the two *Saccolaimus* species, and the noted susceptibility of *Saccolaimus flaviventris* and other members of the Emballonuridae family, it would be reasonable to presume that *S. saccolaimus* is susceptible to infection by Lyssavirus.

It has been speculated that large-scale vegetation clearing can contribute to changes in the distribution and spread of bat-borne diseases, by influencing the movements and ranges of bats dependant on that vegetation (Tidemann *et al.* 1997).

The proposed road development is unlikely to introduce either the Hendra or Lyssavirus diseases, since these are not thought to be carried by humans, soil or machinery. Removal of trees and the reduction in number of hollows may reduce roosting opportunities and lead to increased numbers of bats sharing roost positions in hollow trees, but considering that *S. saccolaimus* is a colonial roosting species in groups of 4-40 (Curtis *et al*. 2012), then the opportunities for cross-infection are already high and unlikely to be significantly increased through the proposed action.

4.10 Interfere with the Recovery of the Species

Schulz and Thomson (2007) also note that there are currently no conservation measures specifically aimed at *S. saccolaimus*, with the protection of suitable and potential habitat in conservation reserves being the only measure to reduce any potential decline.

While the loss of tree hollow availability due to land clearance has been listed as a primary threat by Schulz & Thompson (2007), additional potential impacts on *S. saccolaimus* include:

- Timber collection and the targeted removal of hollow-bearing and dead trees along road reserves, in parks and other urban situations;
- Competition for hollows by bees and feral birds such as the Common myna (*Acridotheres tristis*);

- Disease such as Australian bat lyssavirus; and
- The loss of climatic habitat such as tropical forests through climate change (Curtis *et al*. 2012).

The presence of *S. saccolaimus* has been confirmed immediately next to the Bruce Highway south of Townsville, proving the resilience and ability of this species to live and forage safely adjacent to a high volume of traffic. Therefore the impact of traffic movements along the proposed road is unlikely to have a significant impact on any of the significant impact criteria listed above. However, this known site is in a relatively high ecological intactness without the associated influence of increased human encroachment, and many of the potential impacts above cannot be discounted as having a potential influence.

The recommended mitigation measures listed in the initial referral for the Townsville Ring Road Referral (EPBC 2012/6562) should be adopted to minimise these impacts. Mitigation measures listed in the referral are detailed in the following section.

4.11 Proposed Mitigation Measures

4.11.1 Harming / Loss of Individuals

Should the Bare-rumped sheathtail bat (or Semon's leaf nosed bat) be confirmed during the proposed survey then a species management program (SMP) (inclusive of marking habitat trees for spotter catchers, avoid clearing fringing trees around the construction zone where possible, and using spotter catchers to remove bats) will be prepared. A preliminary species management program will include:

- Staged clearing works to allow bats to leave roosting sites;
- No vegetation clearing to occur at night (Note that this mitigation measure should be modified to ensure that all clearing of potential roost trees is undertaken at night to allow bats to shift to an alternative roost);
- Periodic impact noise to encourage bats to leave roosting sites – use of noise cannons is currently the preferred method;
- Additional methods to encourage bats to leave roosting sites is the intrusive method of tapping trees with hollows before clearing;
- Immunised spotter catcher will be on site for the entire clearing exercise to monitor clearing works and assist with clearing hollows as each tree is felled;
- Timing for clearing works will where practicable be outside the breeding season (tropical wet season) so young are not keeping adult bats in roosting sites; and
- Stockpiles will be placed away from concentrations of potential roost trees areas in the green zone that remains.

4.11.2 Minimisation of Clearance

The contractor's Construction EMP will have a strong focus and control over activities that will have an impact on movement, feeding and breeding behaviour of threatened micro bats (and BTF) during construction.

Clearing of roost trees will only occur in the construction zone (nominal 40m clearing width for most of the alignment except at culverts and bridge crossings); cleared logs/stags will be placed in remaining road reserve or adjoining habitat.

4.11.3 Disturbance

As far as practicable, clearing of roost trees will be avoided between December and April (to avoid disturbing microbat breeding activities). Habitat ecology for this bat is not well known, the presumption is that it breeds in the tropical wet season (Schulz & Thomson, 2007). TMR will require that the contractor undertakes regular machinery inspections on all vehicles to ensure compliance with relevant regulations in relation to noise. In particular, exhaust systems will be checked regularly for all construction and other vehicles entering site during construction. This measure is expected to reduce the potential level of noise during construction, although higher noise levels compared to ambient conditions will occur, from heavy machinery and safety reversing beeper operations. It is not known if micro bats would habituate to construction noises.

A fugitive dust program will be included in the construction contract to meet the following performance requirements:

- Zero loads uncovered;
- Dust suppression tools will be used on stockpiles for embankment fill (if stockpiled on site); and
- Water trucks will be used to suppress dust on haul road and generally in the construction zone.

Lighting of the northern and southern connections for safety reasons will be required. Route lighting elsewhere is not required. This is expected to reduce nuisance to bats. This measure is expected to be effective in reducing the likelihood of bats being attracted to insect gathering around light sources, however, limited construction works will occur at dusk or at night (some pavement and surfacing work may occur at night at the connections to existing roads).

It is recommended, however, that clearing of potential roost trees be undertaken at night, so that any resident microbats can easily escape and relocate to another suitable roost.

4.11.4 Education and Awareness Mitigation Measures

Provide findings and learning's to relevant academic and study bodies to expand knowledge base on *S. saccolaimus* and other threatened bat species if present from this area. Take opportunities where possible to raise awareness of threatened species management issues and outcomes on the TMR web site, to ensure learning's are available to other road projects. If *S. saccolaimus* is found then the results from the various ecological assessments about roost habitat conditions will be published.

General environmental management controls for the site as a whole will inform the Planning and Construction Environmental Management Plans for the project:

- Site inductions to be undertaken by all people working/ entering the site;
- Ensure signage is in place to protect habitat areas outside of the construction zone;
- Erect signage in areas to alert and educate the public on essential fauna/flora habitat post construction;
- Ensure toolbox talks incorporate the significance of threatened species and their habitat on site;
- Ensure the availability of information sheets for threatened species and their habitat;
- Clearing of vegetation should be staged and aim to limit impacts on bats and threatened bird species;
- Avoid night-time construction work if possible;
- A buffer zone around construction should be clearly delineated;
- Implement a Weed Management Plan for the site (this should include a wash down area and weed control through chemical, mechanical and other means);
- Implement a Pest Management Plan for the site (this should include the control of pigs and cats);

- Implement a Fire Management Plan for the site for the construction period;
- Ensure appropriate erosion control measures are in place;
- Ensure all rubbish (especially food articles) are removed from site regularly;
- Ensure speed limits are enforced on site during construction to reduce collisions with wildlife;
- Ensure vehicles on site comply with machinery requirements to avoid elevated noise pollution; and
- Ensure vehicles use only approved tracks within and around the construction site.

It is likely that the most significant impacts will be during construction phase and the direct impacts of removing potential habitat trees. It is recommended that a Species Management Plan (SMP) should be prepared, including approved mitigation measures.

We conclude that implementation of these mitigation measures should ensure that the proposed action will not significantly interfere with the recovery of the species.

5.0 Conclusion

A detailed assessment of the proposed project against the EPBC significant impact guidelines for a critically endangered species has concluded that there is unlikely to be any significant impact. Site inspections by AECOM (2012a) showed that the proposed project will be removing 134 potential roost trees. Although detailed assessment of tree hollows with a burrow scope did not find any evidence of the Bare-rumped sheathtail bat in any of these hollows, it should be noted that very little is known of preferred roost trees for this bat species, and it is unknown how many roost trees are likely to be utilised by the same animal or colony, and what their tolerance would be to having to relocate to new roost trees. The proposed project will reduce the potential occupancy of the species within the actual road corridor, however, it is not likely to fragment or lead to a long-term decrease in the size of the population. The proposed action is unlikely to significantly and adversely affect critical habitat or modify or decrease habitat to the point that the Bare-rumped sheathtail bat is likely to decline. We have proposed mitigation measures to avoid disrupting the breeding cycle, allowing a harmfully invasive species or disease to become established, and the project is not likely to interfere with the recovery of the species.

Although we believe that the removal of the 134 potential roost trees is below the level of significance, some form of offset may be appropriate considering the critically endangered status of this bat species. Revegetation would not be a suitable offset since the bat species is only known to utilise hollows in old growth trees, and while bat nest boxes may assist in alleviating short term loss of potential roost trees, this artificial habitat has a limited life span. Since this bat species is so poorly known, it is difficult to positively confirm its presence, assess potential impacts and to determine the nature of a suitable offset where a residual impact is determined to exist. Therefore, any improvement in our understanding of the detection and ecology of this species would have significant conservation benefits. An appropriate offset would be the funding of a post-graduate student to study the autecology of the Bare-rumped sheathtail bat, to enable and assist future projects in assessing and mitigating potential impacts.

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Appendix 1

Microbat Call Identification Report

Microbat Call Identification Report

Prepared for ("Client"):	RPS (Townsville)
Survey location/project name:	Townsville Ring Road
Survey dates:	17-26 December 2012
Client project reference:	PR114955-2
Job no.:	RPS-1301
Report date:	12 February 2013

Methods

Data receipt and processing

Bat calls were recorded over two weeks in December 2012, with a Song Meter SM2BAT detector (Wildlife Acoustics, Concord MA, USA) deployed from 17-20 December and an Anabat (Titley Scientific, Brisbane) deployed from 23-26 December.

Data recorded by the SM2BAT detector were saved as *.WAV* files (full-spectrum audio format), whereas the Anabat detection sessions produced standard Anabat sequence files (zero-crossing format).

Target species

All analyses were aimed at detecting and demonstrating the presence of a single threatened species (*Saccolaimus saccolaimus*), as advised by the client upon submission of the data.

Zero-crossing analysis

The .WAV files from the SM2BAT detectors were post processed with Wildlife Acoustics' *Kaleidoscope* (Version 0.1.4) software to extract detected calls as Anabat sequence files. All Anabat sequence files from both detectors were then analysed using *AnalookW* (Corben 2009), with call identification achieved manually in several steps.

1. All sequence files were scanned using a filter designed to find calls within the dominant harmonic range (18-28 kHz) of the target species.
2. Sonograms for all files that passed the filter were viewed in *AnalookW* and identified, if possible, by comparing them with north Queensland reference calls from the target species. Two distinct reference call types were considered: "emergence" calls made by bats exiting a tree roost; and "search" calls made by free-flying bats commuting or foraging in open space.
3. Where Anabat sequence files were identified as probably containing a threatened species, further analysis was undertaken on the full-spectrum equivalent files.

Full-spectrum analysis

Call sequence files that were identified as potentially containing *S. saccolaimus* calls during the zero-crossing analysis were viewed in full-spectrum mode using Wildlife Acoustics' *Song Scope* (Version 4.1.1) software. The main objective of the full-spectrum analysis was to investigate presence and patterns of harmonics in the calls, in particular the unusual "alternating triplet" call structure described by Coles *et al.* (2012).

A more complete scan of the full-spectrum data was also completed in *Song Scope* using call recognisers built from *S. saccolaimus* reference calls (search-phase only) that were collected by the author in Cairns in January 2012. The recogniser scan results were then compared with the manually identified calls from the zero-crossing analysis to further confirm the presence of this species.

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003), available on-line at http://www.ausbats.org.au/.

Results & Discussion

Zero-crossing analysis

Manual identification of zero-crossing data yielded a large number of calls potentially attributable to *Saccolaimus saccolaimus*. These calls were recorded by both detectors and across all nights of survey by each detector.

Full-spectrum analysis

Application of the *S. saccolaimus* call recogniser to the recorded data in *Song Scope* also yielded positive identification of the species for all nights recorded with the SM2BAT detector. There were, however, fewer calls attributed to the species using this method because of the relatively high "call quality" and "goodness of fit" limits applied to the scan results.

Call quality (i.e. the 'clarity' of the signal) is rated on a percentage scale and only calls with a "quality" ranking of >60% were accepted. The recogniser model used has a mean ± standard deviation "fit" of 82.54 ± 10.88% (when tested on "training data" of known *S. saccolaimus* calls). Consequently, only calls with a mean "fit" score of >70% were considered to be reliably attributable to *S. saccolaimus*.

Call spectrographs for those calls indicated as probable *S. saccolaimus*, when viewed in *Song Scope*, revealed no clear evidence of the "alternating triplet" pattern described by Coles *et al.* (2012). Indeed, only a few calls included evidence of the harmonics usually associated with this species in high-quality recordings. This is possibly a result of "sensitivity" settings on the SM2BAT detector during deployment (e.g. lower gain may have resulted in more of the low-energy harmonics being recorded).

Table 1. Summary of echolocation data analysed for the Townsville Ring Road surveys conducted on 17-26 December, 2012.

Detector:	**SM2BAT**				**Anabat**			
Date:	17/12	18/12	19/12	20/12	23/12	24/12	25/12	26/12
Total number of Anabat sequence files extracted	190	340	345	595	1117	915	772	1027
Number of filtered files possibly containing *S. saccolaimus* calls	27	41	40	11	18	19	9	11
No. of calls manually identified as "probable" *S. saccolaimus*	13	20	15	1	1	3	2	3
No. of *S. saccolaimus* calls reliably attributed by Song Scope	5	4	3	2	n/a	n/a	n/a	n/a

Conclusion

It is highly probable that *Saccolaimus saccolaimus* was present at all sites that were surveyed during this event.

However, further collections of reference calls and observational studies on the species' calling behaviour are required to provide a more solid basis upon which to reliably identify echolocation calls from surveys such as this one.

The following point made by Balance! Environmental in a previous bat call identification report for the Townsville Ring Road project (report to AECOM, dated 23/10/2012) must be reiterated. If further evidence is required for the presence of *S. saccolaimus* in the study area, it is recommended that active (hand-held) call detection be undertaken whilst visual observations are made using spotlights. This would allow the gathering of morphological and behavioural observations on the bats being detected (e.g. flight pattern, foraging behaviour, wing-shape and ventral fur colour), which could provide additional evidence towards species identity for the calls being recorded.

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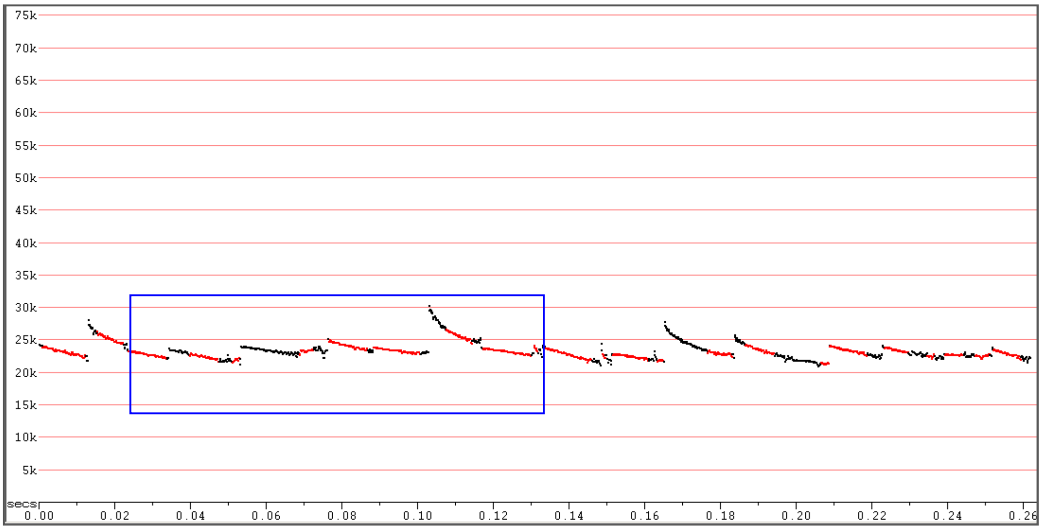

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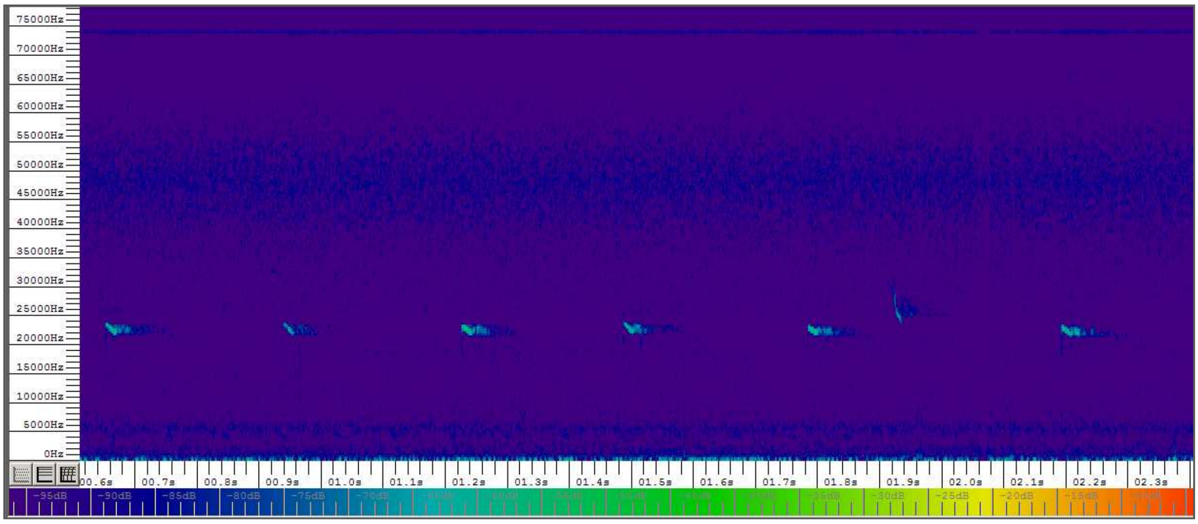

b

Figure 2 Representative calls, probably attributable to *Saccolaimus saccolaimus*, recorded during the Townsville ring-road survey, 17-26 December 2012.

a) *AnalookW* sonogram - 10msec per tick; time between pulses removed.

b) *Song Scope* sonogram of part of the same call (indicated by blue rectangle in a).

NB time expansion factor (x-axis) of (b) is approximately ¼ of that used in (a).

Appendix D

AECOM Field Surveys on New Design Areas

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Memorandum

To	Marjorie Cutting	Page	1
CC	David Derrick		
Subject	TRR4- Design Change: Additional Ecology Survey		
From	Kristina Ihme		
File/Ref No.	60285754:T363/13:KXI/DC	Date	24-Sep-2013

1.0 Background

The TRR4 project was submitted to the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) for decision on whether the project was a controlled action on 27 September 2012 under the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act). SEWPaC determined on 25 October 2012 that the Minister considered the TRR4 project was a controlled action, to be assessed by way of preliminary documentation, due to the proposed road's potential to impact on Black-throated Finch (BTF), Squatter Pigeon and the Bare-rumped Sheathtail Bat.

The following field surveys have been undertaken:

Black-throated Finch (Endangered)

- A late dry season field survey for BTF within Lot 1 SP232873, with field tasks including water source watching, targeted searches and habitat assessment.
- A wet season field survey using the same methodology as the previous survey for BTF.

Squatter Pigeon (Vulnerable)

- In both of the BTF surveys listed above, observations of location and activity of Squatter Pigeon were also obtained.

Bare-rumped Sheathtail Bat (Critically Endangered)

- Eight nights of passive acoustic monitoring sites not previously monitored in earlier field investigations for the referral.
- Burrow scope investigations of tree hollows with a 900 nest box camera.

Offset Investigations

- A range of offset locations have also been assessed or surveyed during 2013 to locate a suitable offset for the project.

Results from surveys have indicated that there are two 20 strong colonies of Black-throated Finch located adjacent to and south of the TRR4 road reserve, centred around two stock dams in the dry season, with breeding habitat extending up and over the TRR4 road reserve during the wet season (NRA, 2013). Twenty or more Squatter Pigeons have also been observed south of the TRR4 road reserve. Passive acoustic monitoring for microbats indicates that the Bare-rumped Sheathtail Bat is probably present in the broader area and thought to be foraging, but this species has not been observed roosting in suitable trees within the road alignment (RPS, 2013).

1.1 Objectives

A day of additional survey was undertaken after minor design changes were applied in August 2013 (Figure 1), with the aim to add information to existing ecological results, and check if existing results hold true within the changed alignment option.

The objective of the survey within the additional area for the alignment was to:

- Assess the presence of threatened flora and fauna species likely to occur;

- Assess the presence of suitable habitat for threatened flora and fauna;
- Assess the presence of declared pest fauna and weed species;
- Assess the site condition.

2.0 Methods

The survey was undertaken on the 21st of August, 2013. Survey methods were based on those used in previous environmental assessments and included three habitat assessments, tree hollow quadrats and walking the amended alignment in order to record any relevant environmental features as well as incidental species sightings.

At each survey point, floristic composition was recorded including weed species. In most circumstances, 500 m distances between points were covered on foot to survey for threatened flora. The site survey included vegetation assessments to ground truth RE mapping, threatened flora surveys and habitat assessments to determine the likelihood of threatened species based on the presence of suitable habitat. Habitat assessments were not analysed to their full extent in this memorandum, but will be used in the impact assessment for the preliminary documentation and are provided as a reference for the construction phase to identify areas where site-specific mitigation measures may be needed.

2.1 Habitat Assessments

The survey targeted EVNT species and pest species listed under state or local legislation that have previously been identified to be likely to occur within habitats present (AECOM, 2012).

Surveys involved:

- Incidental survey for birds, identified by sight and by calls
- Direct searches for mammals, reptiles and amphibians, and
- Searches for signs of fauna (tracks, scats, shed skins, diggings etc.).

Three detailed habitat assessments were carried out at Site 1-3. Detailed habitat assessments were based on Regional Ecosystems present and a site that had records of the Northern Spadefoot Toad (Site 1 – RE 11.3.30 (Northern Spadefoot Toad, Site 2- RE 11.3.30 and Site 3- RE 11.3.12) (Figure 1).

2.2 Tree Hollow Assessments

Based on regional ecosystems present, detailed tree hollow assessments were undertaken at Site 2 and 3 (Figure 2). The methodology followed the tree hollow abundance study undertaken by RPS in April 2013. Two 50 x 50 m plots were established in RE 11.3.30 and RE 11.3.12. Within these plots, the vegetation was described with regards to canopy tree species and average height, and the number of hollows recorded.

Given the aim of the study to primarily add information to existing ecological results, and check if results hold true within the changed alignment option, additional information regarding relative percentage abundances of different tree species in different vegetation communities was not determined. However, if needed results may be interpreted further using combined LiDAR and aerial photo interpretation.

3.0 Results

Targeted Species Comments: Site: 1

Bog Figwort:

- Not observed, but probably good habitat for this species. Indication of seasonal inundation and fact that species has been found nearby in similar habitat.

Northern Spadefoot Toad:

- Toad site ‘reference site’ (Francis, 2013). Depression/gilgai close by (photo 9411). Clearly a boggy area. Melaleuca prevalent.
    - Evidence of inundation/gilgai: Melaleuca and pugging prevalent.

Black-throated Finch:

- Native grasses present.

Squatter Pigeon:

- Possible. Sparse, open grassy ground storey

Grey Goshawk & Square-tailed Kite:

- No raptor nests observed.

Bare-rumped Sheathtail Bat:

- Few hollows observed.

Echidna:

- Likely. Lots of termite mounds with diggings at base.

Targeted Species Comments: Site: 2

Bog Figwort:

- Not observed, but potential habitat for this sp. given presence of Melaleuca viridiflora (indication of seasonal inundation), and fact that species has been found nearby in similar habitat.

Northern Spadefoot Toad:

- Less pugging than observed at Site 1, may indicated less inundation. However Melaleuca prevalent. Several depressions (that clearly fill with water) close by.
- Evidence of inundation/gilgai: Melaleuca and pugging prevalent.

Black-throated Finch:

- Native grasses present.

Squatter Pigeon:

- Possible. Sparse, low grassy ground storey.

Grey Goshawk & Square-tailed Kite:

- No raptor nests observed.

Bare-rumped Sheathtail Bat:

- One hollow (5 cm diam.) observed during tree hollow count (see Tables 4 & 5).

Echidna:

- Possible. Diggings observed at base of termite mounds.

Targeted Species Comments: Site: 3

Bog Figwort:

- Melaleuca (indicator of seasonal inundation) prevalent. Grass fairly sparse.

Northern Spadefoot Toad:

- Melaleuca (indicator of seasonal inundation) prevalent.

  Evidence of inundation/gilgai: No melon holes observed. Minor pugging. Melalleuca prevalent.

Black-throated Finch:

- *Aristida* sp. dominant.

Squatter Pigeon:

- Possible. Sparse, low grassy groundstorey.

Grey Goshawk & Square-tailed Kite:

- No raptor nests observed.

Bare-rumped Sheathtail Bat:

- Almost no hollows observed. Median diameter at breast height (DBH) for Melaleuca was less than 10 cm (probably 7 or 8 cm). A few emergent trees of other species were present. However, these had DBH<20 cm.

Echidna:

- Possible, but no diggings observed.

Habitat assessment information, tree hollow assessment results, an incidental species list and photographs from field inspection can be found in Tables 1-7 in Attachment A.

4.0 Discussion

The current study confirmed previously identified habitat types and reflects the most recent changes in design of the alignment. The study concluded that minor alignment amendments, should not alter the overall assessments of previous studies, potential EVNT species and their habitat present as well as predictions about impacts or mitigation measures.

4.1 Site Condition

General site condition of the surveyed area is even though currently grazed, overall good. The surveyed area had low levels of introduced species, good habitat features such as logs, termite mounts and signs of animals such as echidna and macropods. Declared weeds such as rubber vine (*Cryptostegia grandiflora**), lantana (*Lantana camara**), and chinee apple (*Ziziphus mauritiana**) were mostly detected close to the existing road (south of Site 1), but were rare to absent at Site 1-3.

4.2 Tree Hollows

Results of tree hollow assessment undertaken for TRR4 have shown to be particularly useful in separating out vegetation types that were unlikely to have many tree hollows (e.g. low growing broad-leaved paperbark communities) (RPS, 2013). In general, the tree hollow estimates taken during this assessment is consistent with RPS (2013) that state that tree hollows are generally rare in *E. crebra* and *M. leucadendra* woodlands (see Tables 4 and 5).

However even though not many tree hollows were observed within the quadrats surveyed, several mature trees (e.g. *E. platyphylla*) were detected along the alignment bearing hollows. While the quadrats taken generally represent the regional ecosystem vegetation characteristics of the area, they do not exclude the presence of tree hollows within the project footprint.

4.3 Threatened Species

In summary the potential for threatened species to occur within the new components of the alignment are:

- Bog Figwort *Rhamphicarpa australiensis*: Even though it was not observed during this dry season survey (annual plant), likely habitat exists throughout the survey alignment changes. The Bog Figwort occurs in a range of open Eucalypt and Melaleuca woodlands, usually in moist poorly drained areas, often growing in association with other small ephemeral wetland species (Calvert *et al*., 2005). It has been found to be commonly associated with *Melaleuca viridiflora* and an understorey dominated by numerous sedges and grasses.
- Northern Spadefoot Toad: Additional information about the potential location of this species close to Site 1 was available for this survey, which was not present when modelling toad habitat in the previous habitat characterisation (AECOM, 2013). An area close to Site 1, within the existing Shaw road corridor is thought to have habitat considered highly probable to be suitable for Northern Spadefoot Toad (pers. comm., David Francis). This area is a highly impacted and modified stretch of non-remnant vegetation next to Shaw's Road. Evidence of modification extends back to the World War II period when the area was used as the Bohle airfield, with this area in particular appearing to be where aircraft at the time were 'parked' near a hanger which was nearby. Large concrete drains which were built to drain the airstrip are also in the vicinity (Ray Holyoak, pers. comm.). Vegetation was characterised by non-declared weeds and almost no mid to top layer present. This area was characterised by grey silty/clay soil that must have been waterlogged during the wet season displaying a characteristically ploughed or undulating pattern, which made it challenging to walk on during the dry season.

- This area attributes to just one of three possible habitat features present (AECOM, 2013). Site 1 and 2 both had just one of the habitat characteristics present (soil type) and are both thought to be potential habitat for Northern Spadefoot Toad in areas that are waterlogged in the wet season (depressions/gilgai), with Site 3 having two of the modelled habitat features present (soil and vegetation type), but was thought from this site inspection to be less like the other two areas surveyed. It is considered likely that soil type characteristics is the only clear habitat determinant identified to date for Northern Spadefoot Toad (silty or sandy loam to 15cm, then heavy clay), rather than vegetation type. However it is possible that small scale relief in landform may play a part in habitat suitability, however no landform mapping at this scale is available to test this. To conclude, the majority of the study area is characterised by silty or sandy loam and it is theoretically possible that it is suitable habitat for the Northern Spadefoot Toad in areas that become waterlogged during the wet season (see Figure 6, AECOM, 2013). Survey during a heavy rainfall event would still be the primary method to determine if the toad is present.
- Black-throated Finch: BTF are known to occur within the study area. Habitat characterisation previously undertaken by NRA (NRA, 2013), show the study area at Sites 2 and 3 as being within the higher probability of supporting BTF populations. Site 1 is located very close to the existing Shaw Road, occurs outside of NRA's BTF habitat model and is unlikely to be suitable for BTF.
- Squatter Pigeon: Squatter Pigeon are known to occur in the study area. Habitat surveyed did match suitable Squatter Pigeon habitat previously identified.
- Square tailed Kite, no raptor nests were observed during the survey. The study area might be used for foraging and this activity has been recorded in the vicinity of the study.
- Bare-rumped Sheathtail Bat: Tree hollow assessment confirmed that habitat present is only very marginal (Sites 1 and 2) to marginally suitable (Site 3) for supporting Bare-rumped Sheathtail Bat, due to the lack of mature trees with hollows for roosting. Surveyed areas might be used temporarily for foraging only.
- Echidna: Signs of echidna (diggings, scratches on termite mounts) have been observed at all survey sites. It is likely that suitable habitat exists.

5.0 References

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Attachment A

Habitat Assessments

Table 1 Detailed Habitat Assessments- Site 1

Fauna Habitat Assessment							
Assess one hectare area (100m x 100m). Results should reflect the whole hectare.							
Job	60285754	**Site no**	1	**Waypoint no**		**Co-ordinates**	467845E / 7867334N ± 4 m
Location description		Townsville Ring Road 4 Amended Alignment					
Date	21/8/2013	**KP**		**Assessor(s)**	Kristina Ihme, Leonie Mynott		
Aspect	Flat. If anything, faces south	**Geology** [1]	Not recorded	**Soil colour** [2]	Pale grey brown	**Soil texture**[3]	Sandy CLAY
Elevation	Not recorded	**Land use**	Grazing, cattle				
Photographs		9392 – 9395 (N, E, S, W). 9396 (Ground). Others, to 9410					

Landform

Plains	*Hill, mountain, tableland*	*Dunes*	*Streams*	*Water*
Downs: open, rolling, ashy, pebbly	Slope or hill not specified	Fossil coastal dune, high dune	Permanent lake, river, stream, water course, levees and/or their banks	Freshwater lake, lagoon, spring
Alluvial plain or flat, flood plain	Cliff, steep rock, rocky ledge, rocky outcrop, scrap, crevice	Coastal dune: unspecified, beach dune, recent dune, low dune, coastal sandhill		
Inland clay pan, salt flat, salt pan			Seasonal or intermittent creek, gully, drainage line, ravine, gorge, outwash	Freshwater swamp, marsh, soak, seepage area
Coastal tidal flat or salt flat	Coastal rocky headland			
Unspecified, flat gentle slopes, undulating terrain	Top, crest of mountain or ridge	Inland dune, inland sandhill	Inland channel country, stream distributary system, intermittently flooded	Gilgai, melonhole, sinkhole
	Jump-up, mesa, tableland, plateau			Sea, saltwater swamp

Slope class

Class	Level	Very gentle	Gentle incline	Moderate	Steep	Very steep	Precipitous
Percentage	<1	1-3	3-10	10-32	32-56	56-99	100
Degree	0	1-2	3-6	7-18	19-29	30-45	>45

Relief class

Very high (>300m)	~	~	~	Rolling mountains	Steep mountains	Very steep mountains	Precipitous mountains
High (90-300m)	~	~	Undulating hills	Rolling hills	Steep hills	Very steep hills	Precipitous hills
Low (30-90m)	~	~	Undulating low hills	Rolling low hills	Steep low hills	Very steep low hills	Badlands
Very low (9-30m)	~	Gently undulating rises	Undulating rises	Rolling rises	Steep rises	Badlands	Badlands
Extremely low (<9m)	level plain	Gently undulating plain	Undulating plain	Rolling plain	Badlands	Badlands	Badlands

General vegetation description *Eucalyptus crebra* or *E. paedoglauca* and *Corymbia dallachiana* woodland. Forms an open-woodland to open forest in places. Has a grassy ground layer of *Heteropogon contortus*, *Bothriochloa bladhii*, *Themeda triandra*, *Sehima nervosum*, *Enneapogon* spp., with forbs such as *Indigofera* spp., *Glycine tabacina*, *Galactia tenuiflora* and *Tephrosia juncea* common. Occurs on older floodplain complexes on Cainozoic alluvial plains.

Vegetation community/RE 11.3.30 *Eucalyptus crebra, Corymbia dallachiana* woodland on alluvial plains

	Height (m)	**Projected cover**[5]	**% cover**		**Projected cover**[5]	**% cover**	**Trees/shrubs**	
Canopy	12	5-10	1	bare ground		<1	% with vines	<1
Midstorey	3-5	25-50	10-25	sheet rock		40	% affected by dieback	1-5
understorey	1	1-5	<1	fractured rock, scree, gravel		0	% with mistletoe	<1
ground cover	0.1 and 0.6	90-100	25-50	Leaf litter		20, 1 cm depth	% with heavy mistletoe infestation	0

Canopy dominant species	*Corymbia dallachiana, E. crebra, C. tessellaris*
Midstorey dominant species	*Melaleuca viridiflora, unknown species,* possibly *Petalostigma* spp.
Understorey dominant species	*M. viridiflora, Grevillea striata*
Ground cover dominant species	*Aristida* sp., *Themeda triandra, Stachytarpheta jamaicensis**

Tree size *(Choose three random points & measure the dbh of the three closest living trees)*

	Point 1		Point 2		Point 3		Comments
	Dbh	bark type	dbh	bark type	dbh	bark type	
tree 1	10-20	Smooth	<10	Flaky	20	Smooth	
tree 2	10	Flaky	10-20	Flaky	10	Flaky	
tree 3	<10	Flaky	<10	Flaky	5	Flaky	

No logs *(100m x 20m transect)*		**Dead trees** *(nearest 3 to centre of site)*				**No hollows** *(100m x 20m transect)*	
<20cm dbh			Distance (m)	dbh	decay stage [4]	<5cm	0
20-50cm dbh		Tree 1	12	10	No branches	5-15cm	0
50-100cm dbh		Tree 2	12	12	Major branches	>15cm	2
>100 cm dbh		Tree 3	5	10	No branches		

Termite mounds *(100m x 20m transect)*		**Disturbance**	**Erosion**
No	7	Pugging throughout	Vehicle track, minor
Height	20 cm – 1 m	Cattle tracks	

Weeds	
Species	*Stachytarpheta jamaicensis** (<1% projected cover). NB: Numerous grasses not in flower or seed at time of survey.
Life form	
Projected cover	

Condition *(general description)* Good

Fire			
% trees with fire scars	0	scar height	-
% site affected by fire	-	% canopy affected by fire	-
years since fire (<3, 3-10; >10)	-	% saplings killed by fire	-
other evidence	-		

Animal sign *(description, indication of abundance, source, etc)*	
Nests, shelters	-
Diggings	Diggings into bases of termite mounds, possibly echidna (photo 9407). Some broadly conical diggings dug vertically into ground (photo 9408)
Scats	Cattle dung (old and circa 1 month old). Macropod
Tracks	Cattle
Burrows	-
Tree scratches, feeding scars	-
Other sign	-

Connectivity *(describe)* Band of soil or vegetation continues east-west through this site.

Other significant features

Comments Relatively few weeds compared with nearby roadside area, which has considerable amounts of *Zizyphus mauritianus* (chinee apple)

1 alluvial, clay, sand, coarse sedimentary, fine sedimentary, igneous (coarse), volcanic (fine), metamorphic, limestone, laterite

2 whitish, yellow, orange, brown, red, black, grey, pale, dark, mottled (can be more than one)

3 clay, silt, loam, sand, gravel, stone, saline mud

4 decay stages

5 for the purposes of this assessment, projected cover is meant to represent the area that would be covered if a blanket was placed over the entire canopy of the strata, whereas % cover represents the area that would be in shadow at noon due to the plant matter of that strata

Fauna Habitat Assessment

Looking north

Looking east

Looking west

Looking south

	
Typical ground cover	*Diggings at base of termite mound*

Table 2 Detailed Habitat Assessments -Site 2

Fauna Habitat Assessment							
Assess one hectare area (100m x 100m). Results should reflect the whole hectare.							
Job	60285754	**Site no**	2	**Waypoint no**		**Co-ordinates**	467462E / 7867139N ± 4 m
Location description		Townsville Ring Road 4 Amended Alignment					
Date	21/8/2013	**KP**		**Assessor(s)**	Kristina Ihme, Leonie Mynott		
Aspect	Fairly flat. Facing slightly to south east	**Geology** [1]	Not recorded	**Soil colour** [2]	Pale grey brown	**Soil texture**[3]	Sandy CLAY
Elevation	Not recorded	**Land use**	Grazing, cattle				
Photographs		9413 – 9416 (N, E, S, W). 9417 (Ground).					

Landform				
Plains	*Hill, mountain, tableland*	*Dunes*	*Streams*	*Water*
Downs: open, rolling, ashy, pebbly	Slope or hill not specified	Fossil coastal dune, high dune	Permanent lake, river, stream, water course, levees and/or their banks	Freshwater lake, lagoon, spring
Alluvial plain or flat, flood plain	Cliff, steep rock, rocky ledge, rocky outcrop, scrap, crevice	Coastal dune: unspecified, beach dune, recent dune, low dune, coastal sandhill		
Inland clay pan, salt flat, salt pan			Seasonal or intermittent creek, gully, drainage line, ravine, gorge, outwash	Freshwater swamp, marsh, soak, seepage area
Coastal tidal flat or salt flat	Coastal rocky headland			
Unspecified, flat gentle slopes, undulating terrain	Top, crest of mountain or ridge	Inland dune, inland sandhill	Inland channel country, stream distributary system, intermittently flooded	Gilgai, melonhole, sinkhole
	Jump-up, mesa, tableland, plateau			Sea, saltwater swamp

Slope class							
Class	Level	Very gentle	Gentle incline	Moderate	Steep	Very steep	Precipitous
Percentage	<1	1-3	3-10	10-32	32-56	56-99	100
Degree	0	1-2	3-6	7-18	19-29	30-45	>45

Relief class							
Very high (>300m)	~	~	~	Rolling mountains	Steep mountains	Very steep mountains	Precipitous mountains
High (90-300m)	~	~	Undulating hills	Rolling hills	Steep hills	Very steep hills	Precipitous hills
Low (30-90m)	~	~	Undulating low hills	Rolling low hills	Steep low hills	Very steep low hills	Badlands
Very low (9-30m)	~	Gently undulating rises	Undulating rises	Rolling rises	Steep rises	Badlands	Badlands
Extremely low (<9m)	level plain	Gently undulating plain	Undulating plain	Rolling plain	Badlands	Badlands	Badlands

General vegetation description *Eucalyptus crebra* or *E. paedoglauca* and *Corymbia dallachiana* woodland. Forms an open-woodland to open forest in places. Has a grassy ground layer of *Heteropogon contortus*, *Bothriochloa bladhii*, *Themeda triandra*, *Sehima nervosum*, *Enneapogon* spp., with forbs such as *Indigofera* spp., *Glycine tabacina*, *Galactia tenuiflora* and *Tephrosia juncea* common. Occurs on older floodplain complexes on Cainozoic alluvial plains.

Vegetation community/RE 11.3.30 *Eucalyptus crebra, Corymbia dallachiana* woodland on alluvial plains

	Height (m)	**Projected cover**[5] **%**	**% cover**		**Projected cover**[5] **%**	**% cover**	**Trees/shrubs**	
canopy	10-12	10-25	5	bare ground		50	% with vines	0
midstorey	3-5	5-10	<5	sheet rock		0	% affected by dieback	10
understorey	1	<1	<1	fractured rock, scree, gravel		0	% with mistletoe	0
ground cover	0.1 and 0.5	75-90	25-50	Leaf litter		15, 1 cm depth	% with heavy mistletoe infestation	0

Canopy dominant species *Corymbia dallachiana, E. crebra, E. platyphylla*

Midstorey dominant species *Melaleuca viridiflora, Acacia* sp.

Understorey dominant species *M. viridiflora, Grevillea striata*

Ground cover dominant species *Themeda triandra, Heteropogon contortus,* other unidentified spp. *Aristida* sp., *Stachytarpheta jamaicensis* Stylosanthes hamata**

Tree size *(Choose three random points & measure the dbh of the three closest living trees)*							
	Point 1		Point 2		Point 3		Comments
	dbh	bark type	dbh	bark type	dbh	bark type	
tree 1	10	Smooth	<5	Rough	5	Flaky	
tree 2	10	Smooth	10-20	Rough	5	Smooth	
tree 3	10-20	Smooth	5	Flaky	10	Flaky	

No logs *(100m x 20m transect)*		**Dead trees** (*nearest 3 to centre of site)*				**No hollows** *(100m x 20m transect)*	
<20cm dbh	8		Distance (m)	dbh	decay stage [4]	<5cm	See other hollow
20-50cm dbh	0	Tree 1	7	5	Some thin branches	5-15cm	assessment
50-100cm dbh	0	Tree 2	12	8	Some thin branches	>15cm	
>100 cm dbh	0	Tree 3	7	12	Major branches		

Termite mounds *(100m x 20m transect)*		**Disturbance**	**Erosion**
No	3	Occasional pugging throughout	Vehicle tracks (2), where whole car-width is cleared to bare earth
Height	20 cm	Cattle tracks	

Weeds	
Species	*Stachytarpheta jamaicensis** (<1% projected cover). *Stylosanthes hamata**
Life form	
Projected cover	

Condition *(general description)* Good

Fire			
% trees with fire scars	0	scar height	-
% site affected by fire	-	% canopy affected by fire	-
years since fire (<3, 3-10; >10)	-	% saplings killed by fire	-
other evidence	-		

Animal sign *(description, indication of abundance, source, etc)*	
Nests, shelters	-
Diggings	Diggings into bases of termite mounds, possibly echidna.
Scats	Cattle dung, macropod
Tracks	Cattle
Burrows	Mounded ring of clay above earth, possible yabby or other crustacean
Tree scratches, feeding scars	-
Other sign	Low piles of grass seeds on ground, possibly ants
Comments	Compared with Site 1, this site has one unknown species (possibly *Petalostigma*?), less *Grevillea striata*, more acacias, relatively sparse midstorey, few termite mounds.

1 alluvial, clay, sand, coarse sedimentary, fine sedimentary, igneous (coarse), volcanic (fine), metamorphic, limestone, laterite

2 whitish, yellow, orange, brown, red, black, grey, pale, dark, mottled (can be more than one)

3 clay, silt, loam, sand, gravel, stone, saline mud

4 decay stages

5 for the purposes of this assessment, projected cover is meant to represent the area that would be covered if a blanket was placed over the entire canopy of the strata, whereas % cover represents the area that would be in shadow at noon due to the plant matter of that strata

Fauna Habitat Assessment **Site 2**

Looking north

Looking east

 *Looking west*	 *Looking south*
 *Typical ground cover*	

Table 3 **Detailed Habitat Assessment- Site 3**

Fauna Habitat Assessment							
Assess one hectare area (100m x 100m). Results should reflect the whole hectare.							
Job	60285754	**Site no**	**3**	**Waypoint no**		**Co-ordinates**	467462E / 7867139N ± 4 m
Location description		Townsville Ring Road 4 Amended Alignment					
Date	21/8/2013	**KP**		**Assessor(s)**	Kristina Ihme, Leonie Mynott		
Aspect	Various	**Geology** [1]	Not recorded	**Soil colour** [2]	Pale grey brown	**Soil texture**[3]	Sandy CLAY
Elevation	Not recorded	**Land use**	Grazing, cattle				
Photographs		9422 – 9425 (N, E, S, W). 9426 (Ground).					

Landform				
Plains	*Hill, mountain, tableland*	*Dunes*	*Streams*	*Water*
Downs: open, rolling, ashy, pebbly	Slope or hill not specified	Fossil coastal dune, high dune	Permanent lake, river, stream, water course, levees and/or their banks	Freshwater lake, lagoon, spring
Alluvial plain or flat, flood plain	Cliff, steep rock, rocky ledge, rocky outcrop, scrap, crevice	Coastal dune: unspecified, beach dune, recent dune, low dune, coastal sandhill		
Inland clay pan, salt flat, salt pan			Seasonal or intermittent creek, gully, drainage line, ravine, gorge, outwash	Freshwater swamp, marsh, soak, seepage area
Coastal tidal flat or salt flat	Coastal rocky headland			
Unspecified, flat gentle slopes, undulating terrain	Top, crest of mountain or ridge	Inland dune, inland sandhill	Inland channel country, stream distributary system, intermittently flooded	Gilgai, melonhole, sinkhole
	Jump-up, mesa, tableland, plateau			Sea, saltwater swamp

Slope class								
Class	Level	Very gentle	Gentle incline	Moderate	Steep	Very steep	Precipitous	
Percentage	<1	1-3	3-10	10-32	32-56	56-99	100	
Degree	0	1-2	3-6	7-18	19-29	30-45	>45	

Relief class							
Very high (>300m)	~	~	~	Rolling mountains	Steep mountains	Very steep mountains	Precipitous mountains
High (90-300m)	~	~	Undulating hills	Rolling hills	Steep hills	Very steep hills	Precipitous hills
Low (30-90m)	~	~	Undulating low hills	Rolling low hills	Steep low hills	Very steep low hills	Badlands
Very low (9-30m)	~	Gently undulating rises	Undulating rises	Rolling rises	Steep rises	Badlands	Badlands
Extremely low (<9m)	level plain	Gently undulating plain	Undulating plain	Rolling plain	Badlands	Badlands	Badlands

General vegetation description	*Melaleuca viridiflora* with occasional *M. argentea* +/- *M. dealbata* woodland to open-woodland. Occasional midstratum of *Grevillea pteridifolia* and *Acacia leptocarpa*. Ground layer of perennial grasses such as *Themeda triandra*, *Elionurus citreus*, *Ectrosia leporina*, *Eriachne rara*, *Eremochloa bimaculata*, *Thaumastochloa pubescens*, *Eragrostis brownii* and *Ischaemum australe*. Occurs on older alluvial plains on strongly duplex clay soils with restricted drainage.
Vegetation community/RE	11.3.12 *Melaleuca viridiflora* woodland on alluvial plains

	Height (m)	**Projected cover**[5] **%**	**% cover**		**Projected cover**[5] **%**	**% cover**	**Trees/shrubs**	
canopy	8-12	1-5	<1	bare ground		55	% with vines	0
midstorey	3-7	75-90	10-25	sheet rock		0	% affected by dieback	<5
understorey	1-2	<1	<1	fractured rock, scree, gravel		0	% with mistletoe	0
ground cover	0.1 and 0.5	50-75	10-25	Leaf litter		25, 1 cm depth	% with heavy mistletoe infestation	0

Canopy dominant species	*Eucalyptus crebra, Corymbia dallachiana*
Midstorey dominant species	*Melaleuca viridiflora.*, Unknown possibly *Petalostigma* spp., *Petalostigma pubescens*
Understorey dominant species	*M. viridiflora*
Ground cover dominant species	*Aristida* sp., *unidentified grass species (low growing tussock)*

Tree size *(Choose three random points & measure the dbh of the three closest living trees)*							
	Point 1		Point 2		Point 3		Comments
	dbh	bark type	Dbh	bark type	dbh	bark type	
tree 1	4	Flaky	7	Flaky	Not recorded		
tree 2	4	Flaky	5	Rough			
tree 3	2	Flaky	10	Flaky			

No logs *(100m x 20m transect)*		**Dead trees** *(nearest 3 to centre of site)*				**No hollows** *(100m x 20m transect)*	
<20cm dbh	12		Distance (m)	dbh	decay stage [4]	<5cm	See other hollow
20-50cm dbh	0	Tree 1	7	5	Some thin branches	5-15cm	assess-ment
50-100cm dbh	0	Tree 2	12	8	Some thin branches	>15cm	
>100 cm dbh	0	Tree 3	7	12	Major branches		

Termite mounds *(100m x 20m transect)*		Disturbance	Erosion
No	9	Grazing, cattle tracks	Vehicle track, where whole car-width is cleared to bare earth
Height	20 cm (median) – 1 m		Minor pugging in some areas

Weeds	
Species	*Stachytarpheta jamaicensis** (<1% projected cover). *Stylosanthes hamata**
Life form	
Projected cover	

Condition *(general description)* Good

Fire			
% trees with fire scars	0	scar height	-
% site affected by fire	-	% canopy affected by fire	-
years since fire (<3, 3-10; >10)	-	% saplings killed by fire	-
other evidence	-		

Animal sign *(description, indication of abundance, source, etc)*	
Nests, shelters	-
Diggings	Occasional broad (10 cm diam.) vertical digging
Scats	-
Tracks	Cattle
Burrows	Old burrows at base of fallen bloodwood
Tree scratches, feeding scars	-
Other sign	-

1 alluvial, clay, sand, coarse sedimentary, fine sedimentary, igneous (coarse), volcanic (fine), metamorphic, limestone, laterite

2 whitish, yellow, orange, brown, red, black, grey, pale, dark, mottled (can be more than one)

3 clay, silt, loam, sand, gravel, stone, saline mud

4 decay stages

5 for the purposes of this assessment, projected cover is meant to represent the area that would be covered if a blanket was placed over the entire canopy of the strata, whereas % cover represents the area that would be in shadow at noon due to the plant matter of that strata

Fauna Habitat Assessment **Site 3**


Looking north


Looking east


Looking west


Looking south

AECOM

 *Typical ground cover*	