Bird and Bat Risk Assessment

SILVERTON WIND FARM

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1 INTRODUCTION

1.1 BACKGROUND

Project Approval for the Silverton Wind Farm was granted to Silverton Wind Farm Developments Proprietary Limited (SWDPL) on 24 May 2009. The approved project included the construction and operation of 282 wind turbines, and associated infrastructure including a 24km transmission line from the site to Broken Hill (NSW Government Department of Planning 2009).

A Modification Report (the third for this project) is being prepared to consider changes to the approved project including:

- Changed capacity, height and number of turbines; increasing the capacity and height while decreasing the overall turbine number.

Since the initial project approval, wind turbine technology has advanced to increase energy production which has resulted in larger wind turbines. A number of turbine designs are being considered; these are larger than those described for the approved project (refer to Table 1-1). In summary, the turbine parameters would be modified as follows:

- Increase capacity of turbines utilised up to 5 Mega Watt (MW).
- Increase maximum rotor diameter to approximately 140 metres.
- Increase the maximum turbine tip height approximately 180 metres.
- Reduce the minimum turbine tip height (ground clearance) down to 29.5 metres.
- Decrease number of Stage 1 turbines to 172.
- Removal of Stage 2 turbines and associated infrastructure.

Table 1-1 Specifications of the turbines under consideration for Silverton Wind Farm.

Of particular relevance to this assessment are rotor size (blade length) and ground clearance. Parameters summarised in the text above are highlighted in bold.

	Acciona	GE	Goldwind	Senvion	Siemens	Vestas
WTG model	AW125-3150	GE 3.43-130	GW136/3200	3.4-114 NES	SWT-3.6-130	V126-3.6
Size (MW)	3.15	3.43	3.2	3.4	3.6	3.6
Rotor size (m)	125	130	**136**	114	130	126
Hub height (m)	92	110	100	119	115	117
Maximum tip height (m)	154.5	175	168	176	**180**	180
Ground clearance (m)	**29.5**	45	32	62	50	54

These proposed changes to the wind turbines will result in an increased rotor area and reduced ground clearance in comparison to the original approval. This document provides a revised assessment of collision risks, specific to these parameters.

1.2 APPROACH OF THIS ASSESSMENT

This report provides a comprehensive revision of risks to bird and bats arising from the modified Silverton Wind Farm. The original assessments were reviewed and updated with reference to newer literature and guidance documents. This has involved:

i Review of the Biodiversity Assessment (BA) and the BA Addendum (NGH Environmental 2008a, 2008b). These provide the original assessment of bird and bat impacts as well as site context.

ii Review of recent / current assessments and literature.

iii Review of threatened species sightings in the locality using Atlas of Living Australia (ALA 2016).

iv Updated risk assessment for Silverton Wind Farm based on changes to turbine parameters and siting and considering points ii and iii.

It is structured as follows:

Section 2 – wind farm risks to birds and bats: general.

Section 3 – site-specific risks of the Silverton Wind Farm.

Section 4 - updated risk assessment for relevant species.

Section 5 – conclusion and recommendations.

1.2.1 Guidance documents and peer reviewed literature

Since the 2008 and 2009 assessments, the planning and assessment guidelines for wind farms have continued to develop. This document reviews the initial assessments with reference to the following guidelines (new guidelines in **bold**):

- AusWEA *Wind Farms and Birds: Interim Standards for Risk Assessment* (Brett Lane & Associates 2005)
- Auswind *Best Practice Guidelines for the implementation of Wind Energy Projects in Australia* (AusWEA 2006)
- **Environment Protection and Heritage Council *National Wind Farm Development Guidelines –Draft* (EPHC 2010)**
- **NSW Planning Guidelines: Wind Farms (DPI 2011)**
- Australian Standards for Risk Assessment (AS/NZS ISO 31000:2009). Risk Management Principles and Guidelines.

Since the 2008 and 2009 assessments, additional literature has become available and this is referenced when cited, within this document. A full reference list is provided in Section 6.

1.2.2 Expert consultation

Two zoologists were consulted on 25 May 2016:

- Ian Smales, of Biosis Pty Ltd, who was the principal author of the bird and bat section of the *National Wind Farm Development Guidelines* (EPHC 2010).
- Jacqui Coughlan PHD Ornithology, who is the consultant expert on a number of wind farm monitoring programs in NSW.

These experts provided advice as to key considerations for the lower rotor swept area during the risk assessment process, options for management of risks as well as information based on their experience. Their ideas are incorporated into the text of this document, and attributions made where appropriate.

2 GENERAL SYNOPSIS OF WIND FARM OPERATION IMPACTS UPON BIRDS AND BATS

2.1 COLLISION AND ALIENATION IMPACTS

Operational wind turbines present a risk to a range of birds and bats. The main risk is mortality through collision with moving turbine blades (blade-strike), although alienation (behavioural avoidance of suitable habitat near infrastructure) is also an important issue.

2.1.1 Collision impacts

Fatality and injury may be caused by collision with the moving blades, or by being swept down by the wake behind a blade (Winkelman 1994) or for microbats, via barotrauma. Barotrauma is a *"traumatic [usually fatal] respiratory tract injury caused as a result of a sudden air pressure differential that may occur near moving wind turbine rotors"* (EPHC 2010 p136). In this report, barotrauma and blade-strike are referred to collectively as 'collision' impacts. Key factors when considering the potential rates of collision at a wind farm include the proposed configuration in relation to habitat (such as good quality forest) and topographical features (such as steep slopes providing updraughts).

Birds and bats flying within or close to the rotor swept area (RSA) are at risk of collision impacts. This is the area of air space defined by the rotation of the turbine blade. As well as direct collision with infrastructure, the rotating blades produce a wake with turbulence, eddies and blade-tip vortices; the wake is principally behind the turbine (Sandersee 2009). The extent of the wake is influenced by factors including blade design and landscape location. The wake extends behind the turbines at least three blade-diameters (Holland 2008), attenuating with distance. The lateral extent of the wake appears to be less than a blade length (Maalouf et al. 2009), but this is not well studied. In summary, the wind turbine primarily presents a collision risk to birds and bats that fly within RSA height. An additional risk occurs for species that are affected by the wake. Therefore, the ground clearance of the RSA relative to the flying height of bird species is a key consideration.

The earliest large-scale wind farms, such as Altamont Pass in California, experienced high levels of avian collision mortality, mainly of migrating raptors. Turbine design and wind farm layouts have since progressed. While bird and bat fatalities continue to be recorded at modern wind farms, these are at substantially lower rates (EPHC 2010).

2.1.2 Alienation impacts

Operational wind turbines may cause changes in bird and bat behaviour. Where such behaviour includes avoiding nesting or foraging resources or diverging around the broad area where turbines are located, this is termed an 'alienation' or 'barrier' effect. The turbines, in these instances, act to 'sterilise' otherwise suitable areas of habitat or movement pathways. Alienation may affect local sedentary birds in their daily traverses for foraging, roosting and breeding sites or may cause migratory birds to shift migratory flyways. Birds and bats may be forced to change their flight behaviour to avoid collisions with turbines, subsequently impacting on their breeding and foraging success (Drewitt and Langston 2006). Alienation of hunting habitat for raptors such as Wedge-tailed Eagle may be of particular concern (Smales

2006) for local populations. The distance over which disturbance effects can extend from a wind farm varies considerably. A distance of 600 m is often reported as the zone of disturbance around turbines, however this ranges from 80 m (for a grassland songbird), to 800 m (for waterfowl) and 4 km (for seabirds) (Sharp 2010). Barrier effects have been demonstrated at offshore wind farms in Europe, however there is little evidence at onshore farms (EPHC 2010, Hull 2013).

For both collision and alienation impacts, many species appear to habituate to the presence of turbines, after an initial acclimation period, reducing the effect of these impacts (Auswind 2006, Hull 2013, De Lucas et al. 2008).

2.2 SITE FACTORS

Siting and configuration of turbines is the primary factor influencing alienation impacts; inappropriate layout (such as lines of turbines between important habitat features) can create a barrier effect, resulting in habitat loss or fragmentation (Brett Lane & Associates 2009). Turbines are generally placed to maximise wind values and to minimise turbulence from topographic features and other turbines. In practice, this means there are usually large and variable spaces between turbines (Smales 2006). Rows of turbines throughout the project area could in effect act as multiple barriers to the movement of birds and bats.

Within the turbine design layout there is potential for some turbines to result in higher collision risk to bird and bat species. These higher risk turbines are defined in areas where bird and bat collisions are considered more likely to occur due to proximity to:

- Steep topography: gully heads, ridge lines, deep valleys and escarpments. These areas can concentrate migrating birds along relatively narrow pathways. They also provide updraughts utilised by swifts, swallows, martins, gulls and raptors.
- Wetlands: marsh, pond, lake, stream, and/or river. Higher concentrations of birds and bats would be encountered near water sources. Water bodies may also provide staging areas for migrating waterbirds.
- Dense vegetation areas: woodland, forest, tree lines, tree clusters.
- Habitat resources such as hollow-bearing trees, caves. Narrow flight corridors usually occur near cave entrances or through gaps between habitat patches.

(Thelander 2004, Kunz *et al.* 2007, Hull 2011).

2.3 BIRDS

Generally speaking, birds at risk of collision are those that frequent the rotor sweep area (Hull 2013). Not all species of bird are at equal risk of collision with turbines. Generally, the identified groups at higher risk are (Kingsley and Whittam 2003, Kunz *et al.* 2007, Hull 2013):

- Raptors: Soaring birds use landform features such as elevation, ridges and slopes to cruise and take ascendance. Further, they are generally higher order species, meaning they are less abundant and therefore more susceptible to population level impacts.

- Passerines: Passerines have been among the most frequently reported fatalities at wind farms in Europe, America and Australia. Breeding birds in the vicinity of wind farms may be at greater collision risk if displaying aerial courtship. Migrating and nomadic passerines typically fly at altitudes of 150m or higher.

- Waterbirds: waterbird (i.e. grebes, cormorants, ducks, waders, cranes, rails, crakes, gulls, shorebirds) fatalities have been reported worldwide at wind farms close to staging, breeding and wintering areas.

In addition, wind farm sites may be frequented by scavenger species (e.g. crows, raptors), attracted by crops, livestock or carrion, resulting of collisions with turbines.

However, publically available carcass monitoring data from Australian wind farms, which is restricted to several facilities in Tasmania, have found *no single foraging or taxonomic guild* to predominate amongst mortalities. Species colliding with wind farms include *carnivores, scavengers, nectivores and ground- and aerial-feeders* (Woehler and Belbin undated). In Victoria, the species most often discovered in mortality surveys are, in descending order, Australian Magpie, Brown Falcon and Nankeen Kestrel (Smales pers. comm. May 2016).

Australian carcass monitoring results reviewed by Hull (2013) suggest that approximately 20 percent of the bird assemblage present at the wind farm are involved in collisions; common species were found to be at most risk of colliding with turbines rather than rare or threatened species, based on their higher abundance. However De Lucas et al. (2008) found no clear relationship between species abundance and species mortality (overseas study).

2.4 BATS

Bats, specifically microbats, are the second largest group of vertebrates to be impacted by collision impacts at wind farms worldwide (Cryan and Brown 2007, Kunz et al. 2007). In terms of blade-strike, Australian species that appear to be most at risk are those that forage above canopy height (i.e. in open airspace) and move through their environment at high speeds, such as the White-striped Freetail Bat. These species are more likely to travel at blade-sweep height. Collisions result either where the individual fails to detect the moving blades or is unable to manoeuvre around them.

Another group of microbats that appears to be at high risk from wind farms, based on international studies, are those that migrate (Baerwald & Barclay 2009). Migrating bats are thought to travel high in the air column on ‘auto-pilot’. That is they appear to rely less on echolocation when migrating, instead navigating using alternative spatial senses or orographic features such as mountain ranges (Baerwald & Barclay 2009, Popa-Lisseanu & Voight 2009). Consequently migrating bats may fail to detect wind turbines.

Based on the above, two groups of Australian bats can be identified as higher risk from blade-strike impacts:

- Non-migrating, high-flying microbats (e.g. White-striped Freetail Bat)
- Migrating, high-flying microbats, particularly those of conservation concern (e.g. threatened) (e.g. Eastern Bentwing Bat)

These factors are considered in the project specific risk assessment, provided in Section 3 and 4.

3 RISK REVIEW: SILVERTON WIND FARM

3.1 RISKS ASSOCIATED WITH HABITAT RESOURCES

Details relating to habitat in the locality and in the study area are provided in the Biodiversity Assessments for this project (NGH Environmental 2008a and b). The information below summarises key points specific to the bird and bat risk factors discussed in Section 2.

3.1.1 Vegetation, shelter and breeding resources

The bird and bat habitats in the study area consist of open areas of gibber and patchy mostly low growing vegetation communities like mulga and bluebush. There are also open woodlands on the upper slopes and ridges including Porcupine Grass - Red Mallee - Gum Coolibah woodland and Black Oak Woodland. Specific to the indicative turbine layout being considered in Modification Report 3, the layout is concentrated in low growing vegetation types that are not dense, minimising risks to species that primarily inhabit forest, woodland or use vegetation for navigation.

Table 3-1 shows the maximum vegetation height of vegetation communities where turbines are to be located. Surveys at the wind farm were undertaken in 2008 during a period of prolonged drought (the 'Millennium Drought', Wells 2015, BOM 2016). Drought conditions are likely to have affected the condition of vegetation communities surveyed. Most woodland canopies were in poor condition and did not reach maximum growth height. However, it is reasonable to assume some recovery of these vegetation communities in the wet conditions since the surveys.

The tree species within the open treed communities in the study area grow to between 10 and 30 metres height. Red Mallee *Eucalyptus socialis* rarely grow taller than 10 metres (CSIRO 2002), Black Oak (aka Belah) *Casuarina pauper* grow to 15 metres (Boland *et al.* 2006), Gum Coolibah *Eucalyptus intertexta* grow to 30 metres (Australian Museum undated), although in the arid zone this tree may be more common to 20 metres (Windmill Outback Nursery 2011). There are no turbines proposed within forest or woodland areas, although a number border a large patch of Porcupine Grass – Red Mallee – Gum Coolabah hummock grassland, and scattered patches of Mulga/Red Mallee shrubland in the southern section of the wind farm.

Table 3-1 Vegetation communities and maximum canopy height where turbines are to be located, Silverton Wind Farm

Vegetation community	Growth height of canopy species	Maximum vegetation height (m)	Indicative site photograph
Porcupine Grass – Red Mallee- Gum Coolibah Hummock Grassland / Low Sparse Woodland	Gum Coolibah– up to 30 metres Red Mallee– up to 15 metres	20 [1]	
Black Oak Woodland	Black Oak grows to 15 metres	15	
Mulga-Dead Finish on Stony Hills	Belah grows to 15 metres Mulga *Acacia aneura* grows to 10 metres	15	
Bluebush shrubland	Less than 2 metres	2	
Undescribed Community 1: Mulga / Red Mallee shrubland	Red Mallee– up to 15 metres Mulga - to 10 metres	15	
Prickly Wattle	4-5 meters in this area, up to 7 meters	7	

Even small trees were found to support raptor nests on site. In some instances, Wedge-tailed Eagles nests were found as low as 1.5m above ground level (NGH Environmental 2008a). Wedge-tail Eagle nests were observed near Mount Robe and near Lakes Knob in the south of the Stage 1a area, north of Umberumberka Dam.

[1] Gum Coolibah unlikely to reach maximum height on site.

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Mining has been historically undertaken in the wind farm area. Several disused mining shafts were observed. A small number of caves and overhangs were observed in the rocky and gorge areas. These sites can provide habitat refuge for microbats (and birds). The lack of nearby water reduces the likelihood that bats regularly use these areas. Proximity to shafts and mines is not expected to be a risk factor for birds and bats at the Silverton Wind Farm.

The wind farm is not known to be located near regionally important vegetation, shelter sites or breeding resources although there are resources, such as nest trees, in the turbine area.

3.1.2 Waterways and wetlands

There are a number of substantial ephemeral creeks in the study area, some flanked with large hollow-bearing trees. The large ephemeral creeks, such as Mundi Mundi Creek, are likely to provide free water and moist seeps for some time following larger rainfall events. High bird diversity was recorded in drainage lines in the study area.

No permanent wetlands occur in the wind farm area. Outside of the wind farm, Umberumberka Dam is a large open water body approximately one kilometre from the closest turbines (B015, B021, A013). The habitat characteristics of Umberumberka Dam make it unlikely to be suitable as an important wetlands habitat (refer to BA for habitat assessment details). Few waterbird species were recorded during bird surveys of the dam.

In summary, the wind farm is not located near regionally important waterways and wetlands. Turbines are located on ridge lines and not near drainage lines, therefore this is not a risk factor for birds and bats at Silverton Wind Farm. Proximity to Umberumberka Dam is not expected to be a risk factor for birds and bats at the Silverton Wind Farm.

3.1.3 Migration corridors

The biodiversity assessments for the wind farm site included anabat and harp trapping for bats and bird surveys however, for such a large site, subject to large seasonal variations, it cannot be said that daily movement or seasonal migration corridors for birds and bats in the study area are well understood. Based on the survey data and regional data, it can be stated that the wind farm is not located between significant habitat areas, does not include unique habitat elements and therefore is unlikely to affect important movement pathways.

As most woodland bird species, including nomadic honeyeaters, were observed to fly low (not greatly exceeding canopy height) between habitat patches rather than flying high in the open (NGH Environmental 2012), it was previously concluded that the infrastructure does not present high collision risks for these species.

Opportunistic bird movements observed on site suggested movement corridors are concentrated along riparian areas, particularly for nomadic honeyeaters dependent upon mistletoe, such as Painted Honeyeater. The indicative turbine layout can be seen to avoid these areas and as such is not likely to present a collision risk for species using the riparian resources or using these areas to navigate.

3.2 TURBINE PARAMETER RISKS

The turbines under consideration at the Silverton Wind Farm, as proposed by the Modification Report 3, are given in Table 1-1. In summary:

- The wind turbine tip height of approximately 180 metres
- The rotor diameter of approximately 140 metres.
- The minimum ground clearance (tip to ground distance) under consideration is 29.5 meters.

These figures belong to different turbine models, that is, the proposal is not for a turbine with the above parameters. Rather, the highest risk parameters of each turbine under consideration have been grouped to present a 'worst case scenario'. To understand the effects of increasing the rotor diameter and placing the rotor swept area (RSA) closer to the ground, this section considers bird and bat risks with reference to these two factors specifically.

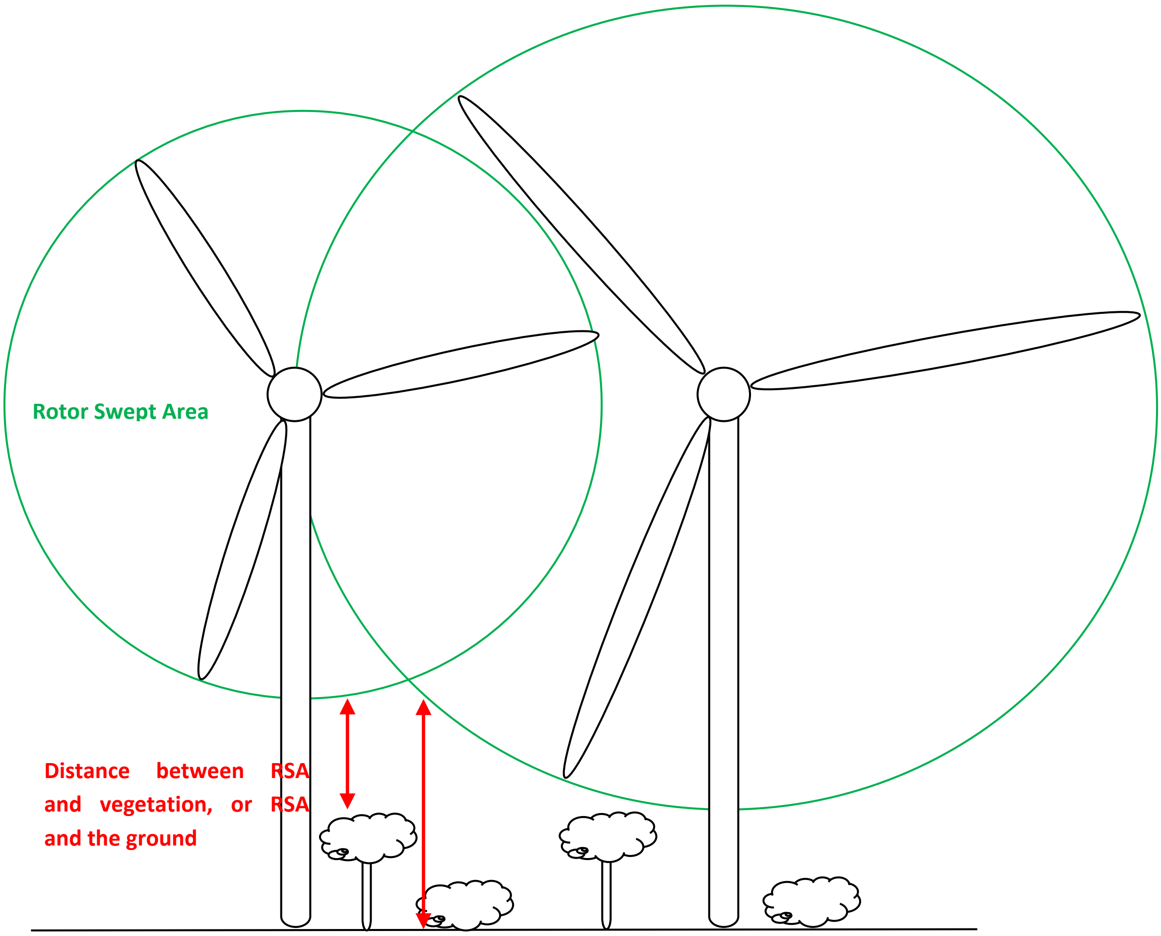

Figure 3-1 Key comparisons are size and height of the rotor swept area, and clearance between RSA and the ground, or top of vegetation. (Figure not to scale).

3.2.1 Total rotor swept area

The rotor swept area (RSA) is the area through which the rotor blades of the turbine spin. The RSA for each turbine is calculated simply as:

$$A = \pi r^2$$

The total rotor swept area for the wind farm is calculated by multiplying the swept area for one turbine by the number of turbines at the facility. A smaller total rotor swept area presents a lower overall collision risk (I. Smales pers. comm. May 2016). This is the basis for collision risk modelling. Table 3-2 shows that despite an increase in rotor diameter, the fewer turbines proposed in the modified project would result in a decrease in the total rotor swept area for the Silverton Wind Farm. Thus, the overall collision risk to all birds and bats across the entire wind farm facility would be lower:

- Reduced collision risk area of 32, 185 m^2

Table 3-2 Comparison of total rotor swept area for the approved and modified project at Silverton Wind Farm

	Rotor diameter (m)	RSA (m^2)	Number of turbines	Total RSA (m^2)
Approval	110	9,499	282	2,678,577
Modification 3	140	15,386	172	2,646,392

3.2.2 RSA height

The flying heights of bird species vary considerably (Sharp 2010). While flight-height data collected in south-eastern Australia indicates that many bird taxa rarely fly above 25 metres (EPHC 2010), this is influenced by site and species specific factors. Most birds and bats fly within or just above vegetation canopy height (NGH Environmental unpubl. data). The upper height of the RSA was sufficiently considered in the BA and BA Addendum, and the increase in height would not affect additional bird or bat species.

However, the RSA would be closer to the ground (by approximately five metres) than previously assessed and additional bird and bat species may encounter the turbines at this lower height. The greatest risk from turbines bordering treed vegetation would be to birds and bats flying between habitat patches.

Table 3-2 shows the maximum vegetation height for vegetation communities growing on the slopes and ridges in the wind farm area. It also shows that the modified project would reduce the distance between the vegetation canopy and turbines (the 'vegetation clearance'). An increased collision risk to birds and bats may occur where clearance is less than 10 metres, on the basis that:

- Most woodland birds fly within or slightly above canopy height, including when moving between patches.
- The wake within the immediate vicinity of the turbine, particularly the blade-tip vortex, would contribute to bird and bat mortality (either by destabilising the animal and increasing the chance of collision, or by shunting the animal to the ground).
- The blade-tip vortex would extend laterally beyond the blade tips in the vicinity of the turbine.

The modified project would increase collision risk where turbines border the Porcupine Grass – Red Mallee- Gum Coolibah Hummock Grassland / Low Sparse Woodland vegetation. Twenty-four turbines border this community as identified in Table 3-3.

Table 3-3 Maximum height levels of vegetation on slopes and ridges where turbines are proposed and comparison of RSA clearance and risk for the original assessment (NGH Environmental 2008a and b) and the Modification Report 3.

Vegetation community	Maximum vegetation height (m) *	Minimum clearance between canopy and turbines		Turbines this applies to: **
		Original assessment: 34 m	Modification 3: 29.5 m	
Porcupine Grass – Red Mallee- Gum Coolibah Hummock Grassland / Low Sparse Woodland	20	14	9.5	24
Black Oak Woodland	15	19	14.5	0
Mulga-Dead Finish on Stony Hills	15	19	14.5	172
Undescribed Community 1: Mulga / Red Mallee shrubland	15	19	14.5	7
Bluebush shrubland	2	~ 32	~ 27	1
Prickly wattle shrubland	7	~ 27	~ 22	6

** It is noted that in arid and ridge top locations, lesser heights would be more common.*

*** Total exceeds 172 turbines, due to application of 100m buffer to turbines to determine intersected vegetation communities.*

3.3 TURBINE LAYOUT RISKS

3.3.1 Spatial arrangement of turbines

Considering collision / alienation effects to birds and bats, there are no generally prescribed separation distances for turbines that can be said to effectively reduce these impacts. It logical to assume however, that greater distances between turbines would make turbines easier to avoid. The exception to this rule would be irregularly spaced 'outliers' which may have increased collision risk in the landscape, not being as easily discernible at a distance as a group of turbines. Hence two aspects are important:

- Spacing.
- Regularity / grouping.

The original layout has spacing of approximately 500 metres between turbines. The Modification Report 3 indicative layout is less regular, but has greater distances between turbines (particularly in the northern section of the wind farm). As such, generally the new layout would pose a lower collision and alienation risk than the original layout. However, as a number of proposed turbines will not be developed, there are

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now eight outlier turbines that present a collision risk to birds and bats that was not present in the original assessment (P147, P113, P082, P080, A001, A066, B027, B021). In any layout revision, new outliers (ie turbines now located at the end of a row) will appear. These should be monitored more frequently during operation.

4 SPECIES RISK ASSESSMENT

4.1 RISK METHODOLOGY

The original assessment involved a qualitative risk assessment for birds and bats, combining evaluation of likelihood and consequence to produce a risk category of low, moderate or high risk for selected species (AusWind 2006). This qualitative risk assessment was reviewed and updated. The updated assessment includes descriptions of likelihood and consequence factors. Likelihood incorporates biological, behavioural and environmental risk factors. Consequence includes the significance of habitat loss and collision in terms of habitat rarity and importance, population impacts, recovery potential and species conservation status. A distinction is made between the significance of impacts to individual birds at the site and impacts to the wider population, in keeping with significant impact guidelines for protected species. The assessment draws on the Interim Standards for Risk Assessment relating to birds and wind farms (Brett Lane and Associates 2005) and the Australian Standards for Risk Assessment (AS/NZS 4360) and Environmental Risk Management (HB203:2000) (Table 4-1).

It should be noted that the original assessment provided a risk rating for individuals and populations separately. However, this is now embedded within the consequence descriptors themselves (Table 4-2); therefore only a single risk rating is given for the species per threat.

Table 4-1 Risk matrix with three risk levels: Low, Moderate and High, assigned based on the likelihood

Likelihood	**Consequence**			
	Insignificant	**Minor**	**Moderate**	**Significant**
Rare	Low	Low	Moderate	High
Unlikely	Low	Low	Moderate	High
Possible	Low	Moderate	High	High
Probable	Moderate	High	High	High

Table 4-2 Descriptions of likelihood and consequence ratings.

Likelihood	Description	Consequence	Description
Rare	An impact may occur only in unusual circumstances	**Insignificant**	Impact on species not detectable in the short term
Unlikely	An impact might occur at some time	**Minor**	Impact may cause non-significant changes to local abundance of species
Possible	An impact could occur during most circumstances	**Moderate**	Impacts may cause significant changes to local abundance of species
Probable	An impact is expected to occur in most circumstances	**Significant**	Impacts may be significant at a population scale

4.1.1 Assessment limitations / assumptions

- Section 2.3 lists raptors, passerines, waterbirds and microbats that are high risk groups for collision with wind turbines. For reasons discussed in Section 3.1, waterbirds are not an important 'at risk' bird group for the Silverton Wind Farm. Raptors, passerines and microbats are discussed in the discussion below (Section 4.2.1).
- The original assessment (2008) was undertaken slightly differently, with an overall risk level determined for individuals and for populations. As already noted, the revised risk assessment matrix already incorporates population considerations, therefore there is not a separate risk result for individuals. Further, the revised risk assessment considers risk of alienation and collision separately. These were lumped together for the overall risk levels in the 2008 assessment.
- As there were reasons beyond just changes to the layout and turbine design that would affect the risk assessment results (e.g. changes to conservation status of species), collision risk was re-assessed for the original RSA ground clearance (34 metres) as well as for the new ground clearance (29.5 metres).

Additional limitations of this risk assessment include:

- Lack of site-specific bird utilisation data for the Silverton Wind Farm site, necessitating extrapolation from other parts of Australia and reliance on assumptions.
- Lack of ecological information for a number of species, particularly with regard to how nomadic movements are undertaken (e.g. whether the species travels by vegetation hopping, or by long distance flying).

4.2 SPECIES-SPECIFIC RISK ASSESSMENT RESULTS

Species that were subject to risk assessment were those that:

- Were evaluated in the 2008 assessment.

- Area known to occur in the area and whose conservation status has been elevated to threatened since the 2008 assessment.
- Were suggested by recent literature to be at increased risk than previously assumed in the 2008 assessment (may apply to some common species).

Risk assessment was undertaken for an additional 12 species compared to the 2008 assessment. The rationale for identification of species for risk assessment is provided in Appendix A.

Table 4-3 shows the results of risk assessment. In summary, the revision has resulted in a number of species being upgraded to a higher risk level. This is not attributable to the revised turbine parameters or the Modification Report 3 indicative layout; the updated species specific collision risk is equal for the original proposal and the modified project. Rather, increased risks are due to the following factors:

- The conservation status of several species have been elevated since the original assessment, which has increased the 'consequence' rating for the species.
- New information from bird and bat monitoring at Australian wind farms has been sourced which shows, particularly for microbats and large raptors, avoidance rates appear to be lower than originally assumed (refer to Section 4.2.1 for discussion).

In summary, comparing the findings of the original BA and this assessment:

- The risk levels of five species were elevated:
  - Brown Falcon - likelihood upgraded: new information indicates species is vulnerable to wind turbine collisions.
  - Nankeen Kestrel - likelihood upgraded: new information indicates species is vulnerable to wind turbine collisions.
  - Spotted Harrier – consequence upgraded: species now listed as threatened.
  - White-throated Needletail - likelihood upgraded: new information indicates species is vulnerable to wind turbine collisions.
  - Yellow-bellied Sheathtail Bat - likelihood upgraded: new information indicates species may be vulnerable to wind turbine collisions.
- The risk levels of two species remain the same:
  - Inland Forest Bat.
  - Little Pied Bat.
- The risk levels of two species were reduced:
  - Pink Cockatoo – likelihood downgraded: new information indicates the species is unlikely to be vulnerable to wind turbine collisions.
  - Diamond Firetail – likelihood downgraded: new information indicates the species is unlikely to be vulnerable to wind turbine collisions.

Table 4-3 Summary of risk assessment results for bird and bat species (additional species highlighted in grey, high risk ratings in red)

Species	Conservation status	Risk to populations	Collision risk	
		2008 assessment	Updated assessment (2016)	
		Original layout	Original layout	New RSA (29.5 m)
Wedge-tailed Eagle		Moderate-high	High	High
Little Eagle	Vulnerable NSW	n/a	High	High
Black Kite		n/a	High	High

Species	Conservation status	Risk to populations	Collision risk	
		2008 assessment	Updated assessment (2016)	
		Original layout	Original layout	New RSA (29.5 m)
Brown Falcon		Moderate	High	High
Nankeen Kestrel		Low	Moderate	Moderate
Collared Sparrowhawk		n/a	Low	Low
Spotted Harrier	Vulnerable NSW	Low	High	High
Black-breasted Buzzard	Vulnerable NSW	n/a	High	High
Square-tailed Kite	Vulnerable NSW	n/a	High	High
Grey Falcon	Endangered NSW	n/a	Moderate	Moderate
White-throated Needletail	Migratory - national	Low	Moderate	Moderate
Yellow-bellied Sheathtail Bat	Vulnerable NSW	Low-moderate	High	High
Inland Forest Bat	Vulnerable NSW	Low-moderate	Moderate	Moderate
Little Pied Bat	Vulnerable NSW	Low-moderate	Moderate	Moderate
White-striped Freetail Bat		n/a	High	High
Gould's Wattled Bat		n/a	High	High
Pink Cockatoo	Vulnerable NSW	Moderate	Low	Low
Diamond Firetail	Vulnerable NSW	Moderate	Low	Low
Pied Honeyeater	Vulnerable NSW	n/a	Moderate	Moderate
Painted Honeyeater	Vulnerable NSW	n/a	Moderate	Moderate
Rainbow Bee-eater	Migratory - national	n/a	Low	Low
White-fronted Chat	Vulnerable NSW	n/a	Low	Low

4.2.1 Discussion

Threatened raptors

The threatened raptors considered herein occur at low densities within the landscape and ongoing mortalities would be required to constitute a local population scale impact. The significance of mortalities to the local population would depend on other factors, such as the importance of onsite and offsite habitat. For example, if the site harbours a source population, from which individuals regularly disperse to surrounding more marginal areas, the significance of mortalities (and therefore the risk on a local population impact) would be greater. The ridge system and associated drainage lines of the Barrier Ranges provide resources which are rare on the surrounding plains (woodland and timbered water courses). Recommendations are given to manage high risk species in Section 5.2.

Non-threatened passerines

Experience at existing wind farms in eastern Australia has shown that common and introduced (denoted by asterisk) passerine species such as Australasian Pipit, Eurasian Skylark*, currawongs and magpies regularly suffer collision mortality. Risk assessments have not been undertaken for such species as the populations are considered secure and sufficiently robust to withstand low rates of morality. However, recommendations are given in Section 5.2 to manage unexpected mortality results.

White-throated Needletail *Hirundapus caudacutus* are a species of interest. They are a nationally protected migratory species and are disproportionately represented in available Australian carcass monitoring data (NGH Environmental 2012, Hull 2013, Tarburton 2015). White-throated Needletail has been affected at wind farms around eastern Australia, with one Bird Monitoring Report recording that *"no other non-raptor species had more than four mortality events over the 3 year period"* (Roaring 40s Renewable Energy 2010). The species may also be in decline and BirdLife Australia's Research and Conservation Committee has recently (2013) changed the conservation status of the White-throated Needletail to Vulnerable in Victoria (a non-statutory listing) (Tarburton 2015, SEWPAC 2016).

Microbats

As already discussed, fast flying species appear to have flight characteristics that make them vulnerable to collision. White-striped Freetail Bats are one of the most commonly recorded species in carcass monitoring at Australian windfarms (NGH Environmental 2012, NGH Environmental unpubl. data) The species was recorded during surveys at the wind farm site; otherwise there is only one other record of the species in the Broken Hill area (ALA 2016). Gould's Wattled Bats are also frequently colliding with turbines in Australia (NGH Environmental unpubl. data, Hull 2013).

Yellow-bellied Sheathtail Bat, Inland Forest Bat and Little Pied Bat are colonial and have fast flying and wide ranging movements. This suggests primarily that the density of the species onsite and therefore the probability of a collision would be greater than for solitary, sparsely distributed species. Recommendations are given to manage high risk species in Section 5.2.

5 CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

This risk assessment has analysed the likely risks to birds and bats as a result of the proposed changes in turbine parameters (height increase, ground clearance decrease) and number. Proximity to vegetation communities (based on the indicative layout) and clearance between canopy height and rotor swept area have been considered. Additional species to those initially assessed have been assessed where warranted. The findings are summarised below in term of risk factors:

- **Closer to vegetation canopy and therefore foraging height**: The 29.5 metre RSA ground clearance presents a higher risk to birds and bats where turbines occur close to the Porcupine Grass – Red Mallee- Gum Coolibah Hummock Grassland / Low Sparse Woodland community (24 turbines).
- **Smaller proportion of the site defined as RSA:** The total rotor swept area for the approved wind farm and for the modified project were compared, as the physical volume of space occupied by the wind turbines provides an indication of potential overall collision risk to birds and bats. The modified project occupies a smaller proportion of airspace and therefore poses a lower overall risk than the original proposal.
- **Turbine configuration:** The potential for alienation and barrier effects was identified as a low to moderate risk. However, eight 'outlier' turbines that may present an increased collision risk to birds and bats were identified (P147, P113, P082, P080, A001, A066, B027, B021). While the overall number of turbines and collision risk area is reduced, outliers will always present an increased collision risk, being less discernible than more closely clustered turbines.
- **Species specific risks:** the modified project does not present a greater species specific risk than the original proposal. However, other factors influenced assessment outcomes and nine additional bird and bat species were identified as 'high risk' species, on the basis of conservation status changes and new information:
    - Little Eagle.
    - Black Kite.
    - Brown Falcon.
    - Spotted Harrier.
    - Black-breasted Buzzard.
    - Square-tailed Kite.
    - Yellow-bellied Sheathtail Bat.
    - White-striped Freetail Bat.
    - Gould's Wattled Bat.

5.2 RECOMMENDATIONS

The key mitigation measure that forms a commitment of the project is to:

> *…design and implement an adaptive management monitoring program to document bird and bat mortalities, remove carcasses and assess the effectiveness of controls.*

The commitment includes the provision that:

> … *if the results of assessment demonstrate that further mitigation is required, further turbine ridge habitat modification and enhancement of off-site habitats would be undertaken*.

This measure is still considered appropriate to managing the operational impact of the wind farm on birds and bats. However, given the risks identified in this assessment, additional mitigation is considered warranted with regard to turbine placement. Mitigation strategies are discussed below.

5.2.1 Landscape position

This assessment has identified some higher risk sites not previously noted in the original assessments. It is recommended that:

- The final layout should avoid where practical irregularly spaced 'outliers' which may have increased collision risk in the landscape. For the indicative layout, these have been identified as: P147, P113, P082, P080, A001, A066, B027, B021.
- Higher risk sites (such as potential outliers) should initially be monitored more frequently in the adaptive management monitoring program and follow up management actions taken as required, in accordance with an adaptive management monitoring program.

It is noted that management such as turbine shut downs would be expensive and initial re-siting of turbines is likely to provide a better long term result for the project.

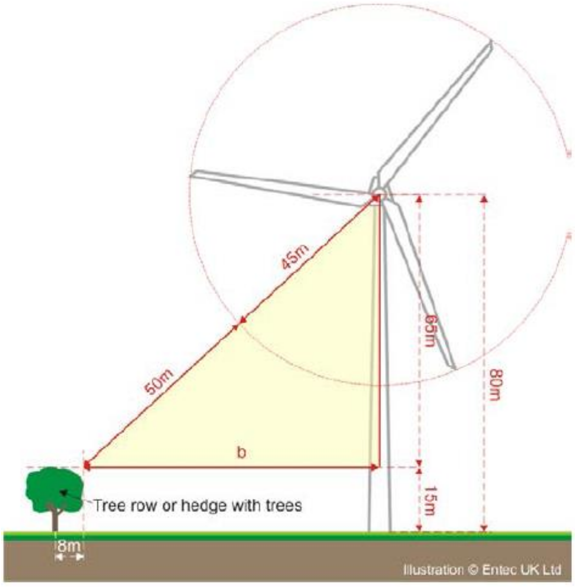
5.2.2 Proximity to vegetation communities

For turbines adjacent to treed vegetation (Porcupine Grass – Red Mallee – Gum Coolabah hummock grassland, Mulga/Red Mallee shrubland and other woodland communities), it is recommended to:

- Apply a minimum buffer distance between turbines and treed vegetation.

Buffers are a generally accepted means to reduce risks to birds and bats (EPHC 2010). New England Technical Information Note TIN05 (2014) offers some guidance specific to tree height which may be appropriate to the site.

$$b = \sqrt{(50 + bl)^2 - (hh - fh)^2}$$



where: bl = blade length, hh = hub height , fh = feature height (all in metres). For the example above, b = 69.3 m.

5.2.3 Species-specific risks

This assessment has identified some higher risk species not previously noted in the original assessments. It is recommended that:

- Higher risk species should initially be monitored more frequently in the adaptive management monitoring program and follow up management actions taken as required, in accordance with the plan.

5.3 CONCLUSION

In conclusion, this risk assessment has found that the project poses a lower overall risk of collision with birds and bats, due to the reduced total rotor swept area, when compared to the original assessment and Project Approval. Even though the Modification 3 turbines will be larger, the reduced number of turbines offsets the total rotor swept area. An overall reduction of 32, 185 m^2 is achieved under the Modification 3.

However, this assessment now identifies that there may be an increased collision risk to birds and bats in specific locations (proximity to woodland vegetation communities and ‘outlier’ turbines) than previously identified.

Species-specific collision risks would not be increased as a result of turbine design changes. Pre-emptive (turbine siting) in combination with reactive (monitoring during operation) mitigation measures are included to address the increased risks. The mitigated risk, assuming the effective implementation of these measures, is assessed as equal to or less than the original (approved) project.

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APPENDIX A SPECIES RISK ASSESSMENT

IDENTIFYING SPECIES FOR RISK ASSESSMENT

The species for which risk assessment was undertaken for the original layout were reviewed. The original assessment considered threatened species that occurred in the project area. Several species that occur in the project area were not assessed, but have since been listed as threatened. These species were included in this risk assessment.

Listed species

The original risk assessments undertaken for threatened species Pink Cockatoo *Cacatua leadbeateri* (Vulnerable NSW) and Diamond Firetail *Emblema guttata* (Vulnerable NSW) were updated. New species were identified for risk assessment based on: occurrence in the project area; listing as threatened or migratory if a nomadic or irruptive passerine species (as per 'at risk' species discussed in Section 2.3):

- Rainbow Bee-eater *Merops ornatus* (Migratory – national)
- White-fronted Chat *Epthianura albifrons* (Vulnerable NSW)
- Painted Honeyeater *Grantiella picta* (Vulnerable NSW; nomadic, irruptive)
- Pied Honeyeater *Certhionyx variegates* (Vulnerable NSW; nomadic, irruptive)

Raptors

The flight heights and behaviour of raptor species typically places them at risk of potential collision with turbines. Mortality of top order predators has greater potential for population scale effect than lower order species. A number of raptor species were recorded at the wind farm site during surveys:

- Wedge-tailed Eagle *Aquila audax*
- Little Eagle *Hieraaetus morphnoides* (Vulnerable in NSW)
- Black Kite *Milvus migrans*
- Brown Falcon *Falco berigora*
- Nankeen Kestrel *Falco cenchroides*
- Collared Sparrowhawk *Accipiter cirrocephalus*

Several additional conservation significant species occur in the locality, with habitat in the wind farm area:

- Spotted Harrier *Circus assimilis* (Vulnerable in NSW)
- Black-breasted Buzzard *Hamirostra melanosternon* (Vulnerable in NSW)
- Square-tailed Kite *Lophoictinia isura* (Vulnerable in NSW)
- Grey Falcon *Falco hypoleucos* (Endangered in NSW)

Updated risk assessments for these species follow below. Species have been grouped where attributes and conservation status are sufficiently similar.

Discussion

Wedge-tailed Eagle

The Wedge-tailed Eagle was recorded within the project area. Although Wedge-tailed Eagle (*Aquila audax*) does not have a rating under legislation, it is recognised as an at risk and flagship raptor species in relation to wind farm developments. Wedge-tailed Eagles exhibit a lower collision avoidance rate than other species of birds. Reasons for this including size, manoeuvrability and hunting style. The higher risk seems attributable in part to flight behaviour and the use of territories. If turbines are placed within the core territory of an individual Wedge-tailed Eagle, for example, then the likelihood of a collision is greatly increased for this individual due to the high proportion of flights made within the rotor-swept area by the species and their regular use of updraughts in certain landscape positions (often coinciding with turbine placements). Hull & Muir (2013) state the: *"the response by eagles to wind farms is highly variable, and likely to be species or site-specific."*

Microbats

Bats forage around woodland vegetation, in open space and over open water, dependent on the species foraging strategies. Many bat species use an 'edge-space' aerial foraging strategy focussed on vegetated habitat and water bodies, and are expected to stay within close proximity to these features (Churchill 2008). Linear features such as roads, drains and ridges have been recorded to have high bat activity (often associated with vegetation or water) and bats have been observed to navigate and forage along the length of these features (Churchill 2008). Bat-strike interactions are likely during the operation of proposed wind turbines in the project area.

Risk assessments were undertaken for four species based on mortality results from other wind farms, the bats' conservation rating, presence in the wind farm area, and flight height and characteristics:

- Yellow-bellied Sheathtail Bat *Saccolaimus flaviventrus* (Vulnerable in NSW)
- Inland Forest Bat *Vespadelus baverstocki* (Vulnerable in NSW)
- Little Pied Bat *Chalinolobus picatus* (Vulnerable in NSW)
- White-striped Freetail Bat *Austronomus australis*
- Gould's Wattled Bat *Chalinolobus gouldii*

White-striped Freetail-bat and Gould's Wattled Bat

Although the White-striped Freetail-bat does not have a rating under legislation, it is recognised as an at risk bat species in relation to wind farm developments due to their foraging and flight behaviour. The White-striped Freetail Bat is a relatively large microbat that pursues prey in open air above canopy height (around 50 m above ground – within RSA) at high speed (up to 60 km per hour). Due to speed and wing structure, they are not a highly manoeuvrable bat (Churchill 2008). Observations show that the species is a relatively straight path flier and appear to have limited ability to turn (McKenzie et al 2002). The echolocation call design of the White-striped Freetail Bat, which provides individuals with information to navigate through their environment, is a slow low frequency pulse which provides a low resolution picture (Herr 1998). Its echolocation call design is used for target detection of prey rather than navigating cluttered environments, hence the species' utilisation of open habitat (Rhodes 2006). The characteristics of its echolocation calls as well as flight and wing design mean White-striped Freetail Bat have a poor ability to detect and avoid obstacles (such as rotors) during pursuit flight. While White-striped Freetail Bats occupy a wide range of habitats including woodland, forest, agricultural land and grasslands (Churchill 2008), habitat preferences are correlated with open areas in canopy gaps and along the edge of vegetation and it is more active on upper slopes (Lloyd *et al.* 2006).

White-striped Freetail Bats are one of the most commonly recorded species in carcass monitoring at Australian windfarms (NGH Environmental 2012), NGH Environmental unpubl. data) The species was recorded during surveys at the wind farm site; otherwise there is only one other record of the species in the Broken Hill area (ALA 2016).

Like the White-striped Freetail Bat, the Gould's Wattled Bat does not have a rating under legislation, but it is a relatively large microbat and a fast, high flier with restricted manoeuvrability (Herr 1998). The Gould's Wattled Bat also have an echolocation call design which provides a low resolution image of its environment ideally suited to fast flying in open areas (Herr 1998) meaning this bat too has a poor ability to detect and avoid obstacles while pursuing prey, particularly mobile ones such as rotors. This species hunts most in the sub-canopy and along flyways, particularly on upper slopes (Lloyd *et al.* 2006), so turbines located between closely linked patches of bush or within patches are likely to present the highest risk to Gould's Wattled Bat. Gould's Wattled Bat are frequently colliding with turbines in Australia (NGH Environmental unpubl. data, Hull 2013).

Threatened bats

Several calls within the project area were attributed to Yellow-bellied Sheathtail. Although this species occurs across much of Australia, it is never found in large numbers. The species migrates from northern Australia into south-eastern Australia during the summer months (Churchill 2008), but as it flies predominately above the tree canopy, it is rarely trapped or detected via AnaBat. The flight height of this species make it potentially vulnerable to collision.

The Little Pied Bat was recorded at Umberumberka Dam in the 2007 surveys and may seek refuge within rocky outcrops close to turbine sites. Inland Forest Bat is recorded regionally (e.g. Menindee and Bimbowrie over the border in SA), but not in the Broken Hill / Silverton district. However, given that so few surveys are undertaken in area, the precautionary principle has been applied and the species is assumed to have potential to occur in the study area.

All three species are known to be colonial and have fast flying and wide ranging movements. This suggests primarily that the density of the species onsite and therefore the probability of a collision would be greater than for solitary, sparsely distributed species. As already discussed, fast flying species appear to have flight characteristics that make them vulnerable to collision

APPENDIX B SPECIES RISK ASSESSMENT

This risk assessment is based on those presented in NGH Environmental 2008a and 2008b. It provides a review of the original assessment (RSA ground clearance 34 m) based on the new information given above as well as an assessment of the new proposal (RSA ground clearance 29.5 m), in order to isolate changes to risk results based just on turbine parameters and numbers.

The risk matrix and descriptors given in Section 4 are reproduced here for ease of use.

Likelihood	Consequence			
	Insignificant	**Minor**	**Moderate**	**Significant**
Rare	Low	Low	Moderate	High
Unlikely	Low	Low	Moderate	High
Possible	Low	Moderate	High	High
Probable	Moderate	High	High	High

Likelihood	Description	Consequence	Description
Rare	An impact may occur only in unusual circumstances	**Insignificant**	Impact on species not detectable in the short term
Unlikely	An impact might occur at some time	**Minor**	Impact may cause non-significant changes to local abundance of species
Possible	An impact could occur during most circumstances	**Moderate**	Impacts may cause significant changes to local abundance of species
Probable	An impact is expected to occur in most circumstances	**Significant**	Impacts may be significant at a population scale

Wedge-tailed Eagle	
Risk factors	Observed at site, including nesting Utilises updrafts around the range when foraging (at blade height) Large-bodied, low manoeuvrability Large home range Male diving displays Prey source present at turbine sites (goats and rabbits) Low reproductive rate
Discussion	Observed singly and in a pairs soaring over the range and taking flight from within the turbine envelope. Rabbits and goats are local food sources. Rabbit warrens are present on the plains and goat nurseries on rocky outcrops. Important resources are concentrated within the range and adjacent area (habitat of moderate to high importance). Similar habitat is present in other parts of the range although, the proposal would cover an

	extensive area of preferred habitat. Sedentary, so reduction of habitat area through barrier effect would impact individuals. Wedge-tailed Eagles continue to be observed utilising habitat, foraging and breeding at wind farm sites. Wedge-tailed Eagles have a considerably lower avoidance rate than many other species, at between 90% and 95% (Smales 2009, MacMahon 2010). Although mortalities are generally low in number, this species is consistently recorded in carcass monitoring at wind farms in Australia (NGH Environmental 2012).	
Alienation / barrier effects	Likelihood: Unlikely Consequence: Minor - moderate	**Risk: Moderate**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Probable Consequence: Minor	**Risk: High**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Probable Consequence: Minor	**Risk: High**

Little Eagle		
Risk factors	Observed at site Utilises updrafts around the range when foraging (at blade height) Large-bodied, low manoeuvrability Large home range Low reproductive rate Threatened species	
Discussion	While Little Eagles have not been recorded in the Australian carcass search literature cited herein, it is a medium sized raptor with similar soaring and prospecting foraging behaviour (Aumann 2001) as the Wedge-tailed Eagle and may be similarly at risk from turbines in certain landscape positions. As for Wedge-tailed Eagles, juvenile Little Eagles with turbines near nests would be most at risk. Observed in the study area and there are many records of the species in the ALA. Rabbits are local food sources. Rabbit warrens are present on the plains Important resources are concentrated within the range and adjacent area (habitat of moderate to high importance). Similar habitat is present in other parts of the range although, the proposal would cover an extensive area of preferred habitat. Sedentary, so reduction of habitat area through barrier effect would impact individuals.	
Alienation / barrier effects	Likelihood: Unlikely Consequence: Moderate	**Risk: Moderate**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Probable Consequence: Moderate	**Risk: High**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Probable Consequence: Moderate	**Risk: High**

Black Kite, Brown Falcon

Risk factors	Observed at site Performs tumbling and diving flight displays Soars on thermals Potential to flock	
Discussion	Observed in the study area. Brown Falcons are been found regularly in carcass searches at Victorian wind farms (Biosis Research 2002, Smales pers.comm).	
Alienation / barrier effects	Likelihood: Unlikely Consequence: Minor	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Probable Consequence: Minor	**Risk: High**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Probable Consequence: Minor	**Risk: High**

Nankeen Kestrel		
Risk factors	Observed at site Forages, hovering, in open country at blade height Family parties play in air currents	
Discussion	Observed foraging on the plains and around the ranges of the proposal. Has been known to collide with aircraft when hunting at airports, but have a relatively rapid reproductive rate (URS 2004). One of the most commonly encountered species in mortality surveys in Victoria (Smales pers.comm). Very common species; occurs in reasonably high densities.	
Alienation / barrier effects	Likelihood: Rare Consequence: Insignificant	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Probable Consequence: Insignificant	**Risk: Moderate**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Probable Consequence: Insignificant	**Risk: Moderate**

Collared Sparrowhawk		
Risk factors	Observed at site Perch and pounce and fast pursuit of prey	
Discussion	Small highly manoeuvrable species that hunts prey within or near the canopy. Has a relatively rapid reproductive rate.	
Alienation / barrier effects	Likelihood: Rare Consequence: Insignificant	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground	Likelihood: Possible Consequence: Insignificant	**Risk: Low**

clearance		
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Unlikely Consequence: Insignificant	**Risk: Low**

Spotted Harrier		
Risk factors	Soars and glides in open country at blade height Low reproductive rate Threatened species	
Discussion	Observed in the study area and there are many records of the species in the ALA. Nomadic or migratory. Soars high and forages by low quartering over open country. Food sources, including rabbits, occur in wind farm area (NSW Scientific Committee 2011).	
Alienation / barrier effects	Likelihood: Unlikely Consequence: Minor	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Possible Consequence: Moderate	**Risk: High**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Possible Consequence: Moderate	**Risk: High**

Black-breasted Buzzard, Square-tailed Kite		
Risk factors	Utilises updrafts around the range when foraging (at blade height) Large-bodied, low manoeuvrability Large home range Low reproductive rate Threatened species	
Discussion	Wide-ranging, sparsely distributed species. There are several records in the locality; mostly observed in wooded habitats and riparian areas. Observed in the study area and there are many records of the species in the ALA. Rabbits are local food sources.	
Alienation / barrier effects	Likelihood: Unlikely Consequence: Insignificant	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Possible Consequence: Moderate	**Risk: High**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Possible Consequence: Moderate	**Risk: High**

Grey Falcon

Risk factors	Performs tumbling and diving flight displays Soaring Threatened species (endangered)	
Discussion	There are many records in the locality although species sparsely distributed. Forages using high-speed chase, quartering and high soaring usually over vegetated (including grassland) and riparian areas (Debus 2012). Main prey items are ground-feeding granivores (NSW Scientific Committee (2010). Prey sources present in the wind farm area.	
Alienation / barrier effects	Likelihood: Unlikely Consequence: Insignificant	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Rare Consequence: Moderate	**Risk: Moderate**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Unlikely Consequence: Moderate	**Risk: Moderate**

White-throated Needletail		
Risk factors	Migratory High-flying, fast flying Vertical flight and diving displays May form large flocks	
Discussion	Species was not recorded during surveys, but suitable habitat exists and as a common species, is likely to occur when conditions suit. The species is a seasonal migrant present in Australia outside of breeding season, and may occur in large flocks foraging aerially at heights of up to 1,000 m above the ground (SEWPAC 2016). Utilises updraughts. Fast and high-flying species such as this appear to be less able to avoid obstacles while foraging. White-throated Needletail breeds overseas, reducing the possibility of the wind farm becoming a population sink. Given the huge area of occupancy of this species, collisions would be unlikely to affect an ecologically significant proportion of the population.	
Alienation / barrier effects	Likelihood: Rare Consequence: Minor	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Probable Consequence: Insignificant	**Risk: Moderate**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Probable Consequence: Insignificant	**Risk: Moderate**

Pink Cockatoo	
Risk factors	Rapid flight at turbine height Flocking Declining species

Pink Cockatoo		
Discussion	Feeds mostly on the ground, on the seeds of native and exotic melons, saltbush, wattles and cypress pines. Normally found in pairs or small groups, though flocks of hundreds may be found where food is abundant (DECC 2007). Observed on site flying with the turbine envelope at blade height. A manoeuvrable flyer. Key habitat is not located within the development envelope. Cockatoos do not feature among regular carcass finds at wind farms (NGH Environmental unpubl. data).	
Alienation / barrier effects	Likelihood: Rare Consequence: Minor	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Rare Consequence: Minor	**Risk: Low**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Rare Consequence: Minor	**Risk: Low**

Diamond Firetail		
Risk factors	Seasonal flock aggregations Declining	
Discussion	Sedentary. Feeds predominantly on the ground on grass seeds, in groups from 5 to 150 individuals (Schodde & Tidemann 2007), nesting in pairs or communally in shrubs and small trees. May form large flocks during winter and autumn. Diamond Firetails are considered to have poor dispersal abilities and are likely to be less common away from tree cover. Recorded in study area.	
Alienation / barrier effects	Likelihood: Rare Consequence: Minor	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Rare Consequence: Minor	**Risk: Low**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Rare Consequence: Minor	**Risk: Low**

Pied Honeyeater, Painted Honeyeater		
Risk factors	Nomadic and irruptive Threatened species	
Discussion	Movement corridors likely to be along drainage lines as this is where mistletoes where recorded in the study area. But may occur in woodland on slopes, particularly while travelling. Tend to hop between tree-tops when migrating. Recorded in study area.	
Alienation / barrier effects	Likelihood: Rare Consequence: Minor	**Risk: Low**

Pied Honeyeater, Painted Honeyeater		
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Rare Consequence: Moderate	**Risk: Moderate**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Rare Consequence: Moderate	**Risk: Moderate**

Rainbow Bee-eater		
Risk factors	Migratory	
Discussion	When migrating may occur in large flocks. Forages by pursuing and catching flying insects, or by aerial sweeping. Considered secure and common in Australia. (SEWPAC 2016). Recorded in study area.	
Alienation / barrier effects	Likelihood: Rare Consequence: Minor	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Rare Consequence: Minor	**Risk: Low**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Rare Consequence: Minor	**Risk: Low**

White-fronted Chat		
Risk factors	Threatened	
Discussion	Usually gregarious, forages on or near the ground. Usually sedentary but may be partially nomadic in the region. Found in damp habitats, therefore unlikely to occur near turbines which are located on dry rocky slopes and ridges (OEH 2016)	
Alienation / barrier effects	Likelihood: Rare Consequence: Minor	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Rare Consequence: Minor	**Risk: Low**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Rare Consequence: Minor	**Risk: Low**

Yellow-bellied Sheathtail Bat	
Risk factors	High-flying, fast flying Migratory

Discussion	Yellow-bellied Sheathtail Bat was recorded during surveys and is known to occur in region. Fast and high-flying species such as this appear to be less able to avoid obstacles while foraging.	
Alienation / barrier effects	Likelihood: Rare Consequence: Minor	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Possible Consequence: Moderate	**Risk: High**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Possible Consequence: Moderate	**Risk: High**

Inland Forest Bat		
Risk factors	Threatened species Colonial	
Discussion	Little information is available for this species. There are ALA records for this species in the region, e.g. Menindee and Bimbowrie (over the border in SA), although but not in the Broken Hill / Silverton district. However, given that so few surveys are undertaken in area, the precautionary principle should be applied and their presence should be assumed. Other forest bats fly within the canopy, and their echolocation calls reflect flight in a cluttered environment: steep, fast calls. The call of the Inland Forest Bat is more like the Little Pied Bat (Pennay *et al.* 2004), suggesting the species flies in more open habitat, perhaps above vegetation.	
Alienation / barrier effects	Likelihood: Rare Consequence: Minor	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Rare Consequence: Moderate	**Risk: Moderate**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Rare Consequence: Moderate	**Risk: Moderate**

Little Pied Bat		
Risk factors	Threatened species Occurs in study area	
Discussion	Little is known about Little Pied Bat, however, it appears that the species prefers to forage within the canopy or understorey of vegetation communities. The physiology and the short pulse rate of the bat suggest it is a relatively slow flying and manoeuvrable species (Churchill 2008, Pennay *et al.* 2004).	
Alienation / barrier effects	Likelihood: Rare Consequence: Minor	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground	Likelihood: Unlikely	**Risk: Moderate**

clearance	Consequence: Moderate	
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Unlikely Consequence: Moderate	**Risk: Moderate**

White-striped Freetail Bat		
Risk factors	High-flying, fast flying	
Discussion	White-striped Freetail Bat was recorded in study area. Fast and high-flying species such as this appear to be less able to avoid obstacles while foraging. White-striped Freetail Bats are one of the most commonly recorded species in carcass monitoring at Australian windfarms (NGH Environmental 2012, NGH Environmental unpubl. data)	
Alienation / barrier effects	Likelihood: Rare Consequence: Insignificant	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Probable Consequence: Minor	**Risk: High**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Probable Consequence: Minor	**Risk: High**

Gould's Wattled Bat		
Risk factors	High-flying, fast flying	
Discussion	Gould's Wattled Bat was recorded in study area. Fast and high-flying species such as this appear to be less able to avoid obstacles while foraging. Gould's Wattled Bats are disproportionately represented in available Australian carcass monitoring data (NGH Environmental 2012, Hull 2013)	
Alienation / barrier effects	Likelihood: Rare Consequence: Insignificant	**Risk: Low**
Collision / barotrauma Original RSA: 34 m ground clearance	Likelihood: Probable Consequence: Minor	**Risk: High**
Collision / barotrauma Modified RSA: 29.5 m ground clearance	Likelihood: Probable Consequence: Minor	**Risk: High**

APPENDIX C VEGETATION MAP

The indicative layout is shown over existing vegetation mapping for the site in the Modification Report Appendix A.2 Map set.