windlab

Public Environment Report – Section 3: Potential Impacts and Mitigation Measures

Upper Burdekin Wind Farm

Report prepared for: Windlab

Document Classification: Windlab Only

2rog

Important Notice and Disclaimer

This report has been prepared by Windlab solely for the purpose of progressing the development of this project and makes no representations or warranties regarding merchantability, fitness for purpose or otherwise. Any third party relying on the report does so entirely at their own risk. Windlab and all persons associated with it exclude all liability in relation to any opinion, advice or information contained in this Report, including, without limitation, any liability which is consequential to the use of such option, advice or information to the full extent of the law, including without limitation consequences arising as a result of action or inaction taken by that person or any third parties pursuant to reliance on the report.

Key to Document Classification

Commercial in confidence:	Not be disclosed outside the Recipient's organisation.
Windlab only:	Not to be disclosed to non-Windlab staff.
Recipient's discretion:	Distribution for information at the discretion of the Recipient.
Public:	Available to the general public.

3. Potential Impacts and Mitigation Measures

Without the implementation of the proposed project environmental management plans, the Upper Burdekin Wind Farm (UBWF) has the potential to result in impacts to Matters of National Environmental Significance (MNES) during construction, operation and decommissioning. Impacts resulting from the project have been broadly grouped into the following categories:

- Ground level impacts – construction, operation and decommissioning
- Turbine level impacts – operation only.

Each potential impact is discussed in more detail below in Section 3.1 and Section 3.2.

The proponent is committed to avoiding, minimising and managing potential impacts to MNES known and likely to occur in the development footprint and wider project area. There are a number of measures that will be implemented over the life of the project, with many of these are not specific to a particular environmental value and provide site-wide benefits. Further discussion on the management of impacts, avoidance through design and mitigation measures is provided in Section 3.2 below.

The following sections are primarily focused on threatened and migratory species, which are the MNES present within the project area. The project also has the potential to impact the World and National Heritage values of the Wet Tropics World Heritage Area (WTWHA). UBWF is located outside, but within proximity to the WTWHA and therefore there will be no direct impacts within the WTWHA[1] (refer to Section 5: Impact Assessment - World and National Heritage Values). However, there is potential for indirect impacts, and these are the focus of a detailed impact assessment in Section 5 using relevant policy guidance.

3.1 Potential Impacts from Ground level Activities

If not appropriately managed, ground level activities of the project are likely to result in impacts to ecologically sensitive features of the environment primarily through vegetation clearance and works associated with the establishment of the wind farm infrastructure. Potential impacts to threatened species from ground level activities during construction, operation and decommissioning are listed below. These impacts may operate within and/or immediately adjacent to the development footprint.

- Vegetation clearance and associated habitat removal
- Fragmentation and edge effects including weed and pest incursion
- Impacts from excavation
- Habitat disturbance and degradation
- Fauna injury and/or mortality.

3.1.1 Vegetation clearance

The potential impact of vegetation clearance, including short-term impacts during vegetation removal, and long-term impacts of reduction in available habitat, fragmentation and edge effects have been well documented in scientific literature and are known and predictable.

[1] The project area will be accessed via Charters Towers and therefore no heavy vehicles will be required to traverse the Wet Tropics to access the site during construction.

The risks and nature of impacts potentially occurring during clearing are assessed within the Environmental Management Plan (EMP, Appendix A).

3.1.1.1 Habitat removal

Vegetation clearing occurring during construction to establish the project infrastructure will reduce vegetative cover and habitat for flora and fauna dependent on those ecosystems over the life of the wind farm. The development footprint includes the maximum area associated with the infrastructure elements and encompasses approximately 769 ha.

For the purposes of the current assessment, a conservative approach has been adopted, where it is assumed all vegetation will be removed within the development footprint. However, some areas within the development footprint may not need to be fully developed e.g., parts of the 50 m corridor for access tracks; 275kV transmission line clearance width where only vegetation above 1-2 m will be removed[2]. However, full clearing has been assumed for the purpose of this assessment to ensure the maximum potential effects have been evaluated. Actual clearing required will be further minimised, where possible, during detailed design.

Table 3-1 indicates the proposed extent of clearance of each broad habitat type in the development footprint.

The majority of the development footprint comprises linear infrastructure such as access tracks. Areas of broader disturbance will occur at wind turbine pads (approximately 2 ha at each pad, with a combined total of 160 ha) and at camp, batching plants, switching yards and substations.

Table 3-1: Extent of broad habitat types within development footprint (ha)

Broad Habitat Type	Broad Habitat (ha) in Development Footprint	Broad Habitat (ha) in the Survey Area
Floodplain	0.98	48.26
Open forest to woodlands on uploads	52.03	3983.07
Open forest with Allocauarina spp. Dominant or co-dominant in the canopy	0.76	124.21
Open woodlands on basalt plains	56.86	1357.52
Open woodlands on open forest on granite or Tertiary surfaces	540.35	19122.30
Riparian forest	4.86	620.77
Rock pavement	18.58	437.27
Simple or notophyll vine forest	0	2.61
Tussock grassland	0	3.83
Very open woodland on metamorphics and low hills	60.12	3337.26
Vine thicket	0	6.65
Woodland on lateritised surface	11.94	125.25
Melaleuca swamps	0	2.7

Land clearing (defined as the loss of native vegetation and species habitat), is listed as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). A reduction in vegetation cover can reduce the available shelter, nesting, breeding and foraging habitat for threatened fauna species. Fauna species with narrow habitat preferences may be impacted more than others and be subject to adverse impacts such as increased competition for limited resources, which can result in a reduction in local populations.

Research suggests certain amounts of vegetation/habitat can be lost over wide geographic scales before population level effects become critical. Both modelling and empirical studies support the view that when available habitat declines to approximately 10 to 30% of the landscape, species will be lost from the ecosystem (Andrén 1994; Radford et al. 2005). It should be noted that much of this work has focused on species groups (e.g., Radford et al. 2005 examined woodland birds in Victoria) and the specific thresholds for individual species may differ. For UBWF, 97% of vegetation across the approximately 30,000 ha project area will remain in place ensuring high levels of ongoing habitat availability for all species in both a local and regional context.

The impacts from different types of linear development that have been studied within Australia include roads, powerlines, recreational trails, forestry operations and seismic exploration. Understanding the outcomes of such clearing is relevant to UBWF, where the development footprint is largely linear and dispersed through an otherwise well vegetated landscape. Within the project area, the maximum width of linear clearing that will occur is a 60 m corridor, associated with the transmission line. The majority of other clearing comprises either <50 m in width for roads or <2 ha for turbine hardstand. All clearing within the development footprint will be locally small and dispersed throughout the project area across a mosaic of well vegetated areas. Some of the 50 m wide clearing for roads will be short-term for construction only and allowed to naturally regenerate beyond the 10 m required for access tracks.

Multiple studies focusing on the environmental effects of linear clearing have indicated the width of clearing and subsequent extent of development and impact mitigation measures are often the prevailing factors which determine the effects on individual species, communities, and the continuing functionality of the surrounding landscape.

Collectively, these studies suggest that:

- Species are likely to decline in isolated and small remnant patches. However, where connectivity and moderate or greater patch size is retained, as will occur at UBWF, species are more likely to persist over time (e.g., Youngentob et al. 2013)
- Retaining some structural complexity within and at the edges of cleared corridors (e.g., adjacent to access tracks at UBWF), particularly when they are adjacent to woodland and open forest environments, maintains or increases habitat diversity and can provide favourable conditions in these immediately adjacent areas (Clarke et al. 2006; Carthew et al. 2013)
- The make-up of the 'matrix' i.e., cleared areas in between vegetated patches is important. An Australian study into the importance of the matrix for arboreal mammals in Victoria (including the greater glider, (*Petauroides volans*)), concluded that a structurally complex matrix within a human-modified landscape was important for ongoing species persistence (Brady et al. 2011). At UBWF, the majority of the matrix will be comprised of vegetated and undisturbed habitat areas.

3.1.1.2 Fragmentation and edge effects

The project area is predominantly covered by remnant vegetation and contains large tracts of well-connected native vegetation. Consequently, there is potential for clearing occurring for the construction of the project to disrupt movement across the project area i.e., fragmentation of landscape habitat features, over the life of the wind farm. The relevance, extent and severity of impacts from fragmentation (e.g., weeds, fire, increased exposure to wind, barriers to movement of fauna) needs to be considered for each species (refer to Section 4: Impact Assessment - Threatened and Migratory Species).

There is unlikely to be significant barriers to movements from the project due to the narrow clearing widths (10 – 60 m)[3] and configuration of infrastructure in the surrounding landscape. Field surveys identified threatened species traversing existing access tracks and cleared areas within the project area. Barriers to movement of terrestrial fauna like linear fencing and busy roads will not result from the project.

Edge effects are the various consequences on plants and animals, which occur as a result of one type of habitat adjoining with another, usually a highly disturbed area (Williams et al. 2013). Edge effects can influence communities in numerous ways, but most significantly via:

- Acting as barriers to movement or dispersal (Weston et al. 2011);
- Providing vectors for the introduction of invasive species (weeds and pest fauna and associated degradation and availability of habitat, refer to Section 3.1.3.1) (Ramp et al. 2005; Clarke et al. 2006)
- Increasing the opportunities for interaction between ecological communities and human disturbance (e.g., increased traffic along roads) (Pickering & Hill 2007; Ben-Ami & Ramp 2013; Wolf & Croft 2014).

These mechanisms become significantly more pervasive in fragmented landscapes and when perimeter-to-area ratios of patches are high (i.e., there are long edge interfaces compared with the internal area of a patch) (Wintle et al. 2019).

The project is unlikely to result in an overall change in the edge-to-area ratio. There are existing farm tracks, some are within the alignment of proposed access tracks (refer to Figure 3-1) and the extent of clearing is minor in the context of the landscape and will not result in the creation of new, small patches of habitat. The linear nature of clearing introduces new pathways and an increased extent of the interface between cleared and vegetated areas, which will require careful management for weed and pest incursion throughout the operation of the wind farm.

[3] The 60m width is for the transmission easement, access tracks will be narrower.

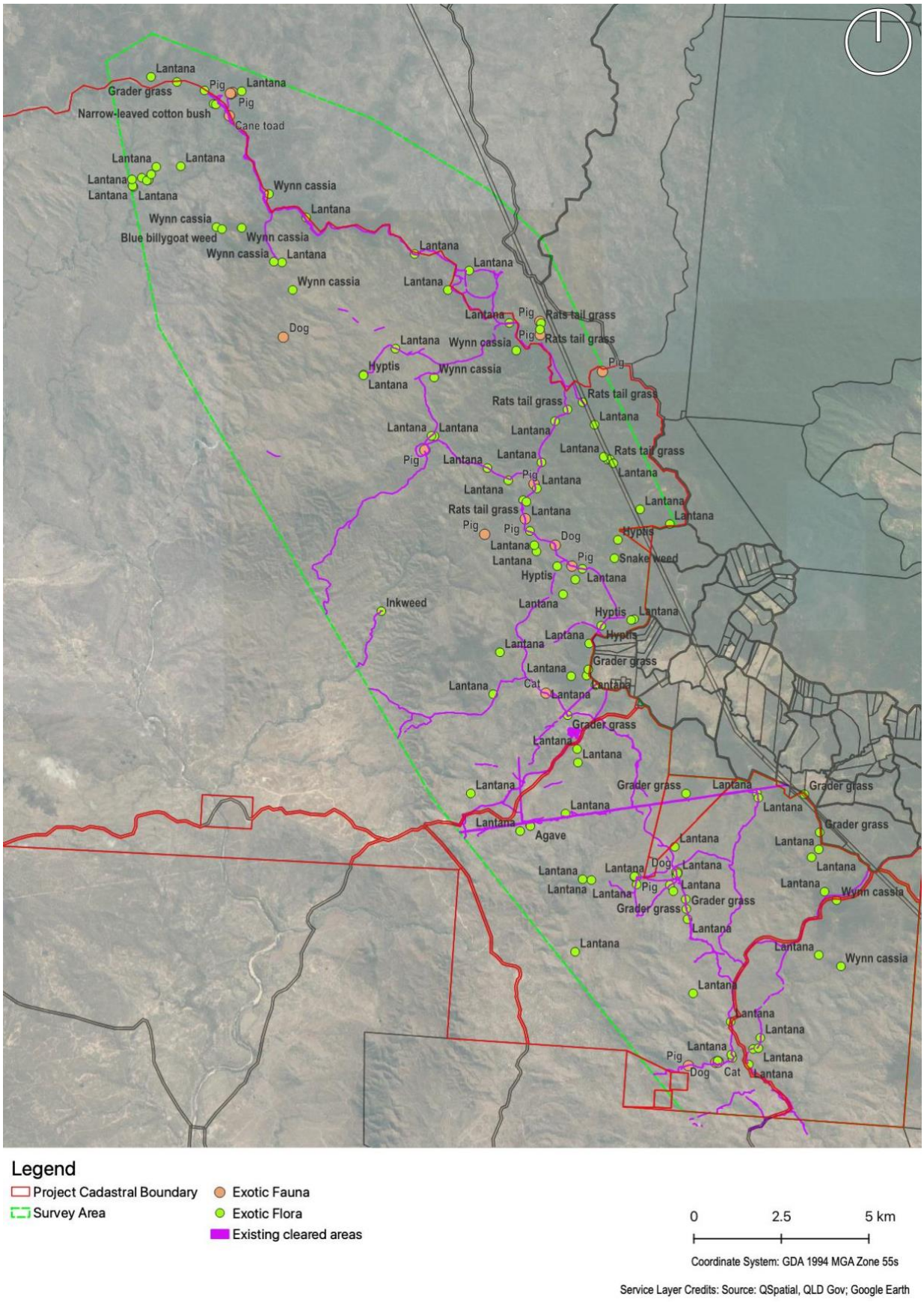

Figure 3-1: Existing tracks, clearings, weed and pest fauna sightings in project area

3.1.1.2.1 State Biodiversity Corridor

The project area intersects a State-wide Terrestrial corridor, identified through Queensland Biodiversity Planning Assessment as a significant corridor associated with the Wet Tropics – Einasleigh ecotone (Figure 3-2). The terrestrial corridor is approximately 10 – 15 km wide and runs in a north – south alignment, in a similar alignment to the development footprint. The terrestrial corridor continues beyond the project area to the north and south. A 200 m wide Riparian Bioregional Corridor associated with Michael Creek is also present within the project area (Figure 3-2)

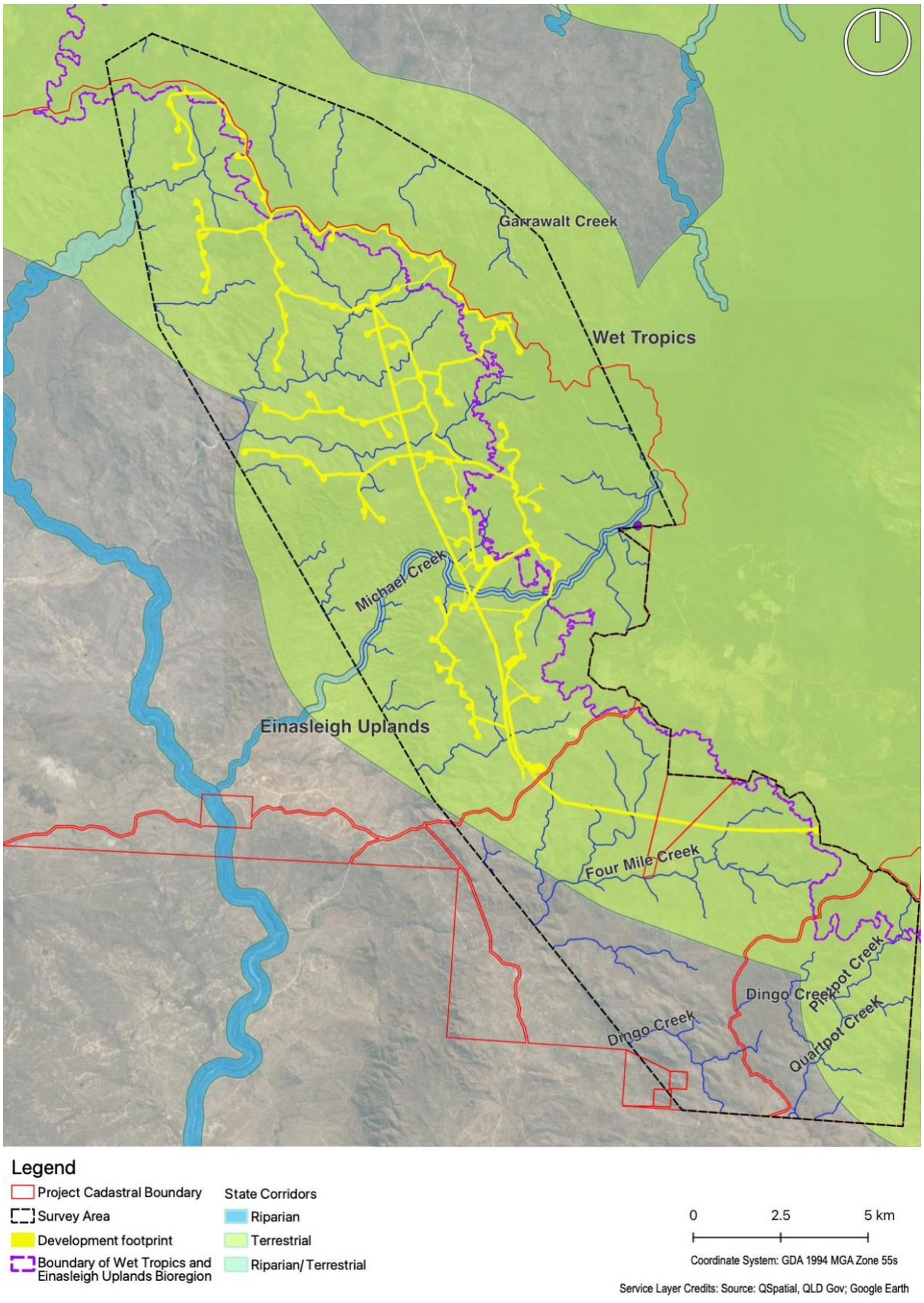

Figure 3-2: State biodiversity corridors

Micro-scale – this is the scale at which impacts occur within a patch, whilst the overall patch size and shape is maintained. It can be thought of as internal fragmentation. This type of fragmentation is likely to result from activities like creating 10 m and 50 m wide access tracks and the 60 m transmission line. Key considerations here include the total extent of habitat removed in the patch i.e., will more habitat be removed from within the patch than will be retained, thereby affecting ecological functionality and the ability of mitigation measures to effectively prevent issues such as weed incursion along cleared strips. Sometimes (e.g., 50 m wide construction access, allow to rehabilitate to 10 m wide) internal fragmentation will be temporary and if so, the resilience of communities to recover from short-term internal fragmentation should also be considered. Fragmentation occurring at this scale is unlikely to result in populations being fragmented into two or more populations.

Within the terrestrial corridors the project won't impact connectivity as the project area will retain significant connectivity within a large tract of remnant vegetation after construction and through the operational phase of the wind farm. The narrow linear nature of clearing is unlikely to be a significant impediment to the movement of threatened and migratory species within the project area. The majority of the development footprint is also located outside of the ecotone between the wetter broad habitat of open forest to woodland on uplands, and the drier open sclerophyll woodlands broad habitats. The proposed layout will result in the riparian corridor being traversed only once by an access road and once by the transmission easement. All other works are located outside the riparian corridor.

3.1.2 Impacts from excavation

Excavation is required to lay underground cabling and construct wind turbine hardstands. Impacts from excavation are therefore short-term, occurring only during the construction phase of the wind farm. The potential impacts from excavation are well understood and predictable and include removal or disturbance of habitat and may be most pronounced in areas where animals are roosting or denning (e.g., rocky sites). Additionally, fauna injury/mortality may occur if animals fall into open trenches or pits. Fauna injury or mortality may also occur as a result of strike from excavation equipment (discussed further in Section 3.1.4). There are good opportunities to avoid and reduce these impacts using good practice construction and operation controls as outlined in the EMP (Appendix A).

Dewatering will not be required to facilitate construction excavation works for the project.

3.1.3 Habitat disturbance and degradation

In addition to direct habitat removal, construction and operation of the wind farm has the potential to disturb and degrade habitats. Key drivers of such disturbance include:

- Weed and pest incursion
- Dust emissions
- Noise – construction and operational from turbines
- Light emissions
- Alterations to the hydrological regime
- Erosion
- Contamination from spills and leaks
- Vehicle movements
- Increased human presence
- Waste
- Increased risk of fire incursion

3.1.3.1 *Weed and pest fauna*

Vegetation clearing and other construction activities have the potential to introduce and / or disperse weeds and pests as per the following:

- Increased infestations of existing weed species in the project area
- Introduction of new weed species in the project area
- Providing vectors for the introduction and dispersal of pest fauna into the project area.

Weed incursion has the potential to impact MNES in the project area through the degradation and availability of flora and fauna habitat through detrimental changes in vegetation community structure and composition. The changes in vegetation structure and composition can also result in increased fuel loads and more frequent and intense fires. This may potentially provide favourable conditions for pest fauna to proliferate and facilitate movement of pest fauna into the project area. Changes in vegetation structure and condition can also result in increased risk of erosion, further degrading and reducing the availability of habitats.

Pest fauna are already present within the project area (refer to Figure 3-1), however vegetation clearing can also create new pathways that may facilitate movement of pest fauna into the project area. Pest fauna can degrade MNES habitat through spreading weed vegetation and grazing on native vegetation. Pest fauna may also directly destroy habitat through, for example, trampling and digging (eg, pigs). Predation by feral predators including cats and wild dogs have the potential to impact MNES fauna through negative pressure on species populations.

3.1.3.2 *Dust*

Dust emissions may be generated by construction activities including:

- Vegetation and soil clearing
- Construction of hardstand areas, including moving, dumping and shaping material
- Wheel-generated dust from unsealed access roads.

Impacts from excavation are therefore short-term, occurring only during the construction phase of the wind farm. The potential impacts from excavation are well understood and predictable and for the project are more likely to be localised and not impact the broader project area.

Excessive deposition of dust on leaves of plants can suppress growth and photosynthesis and result in reduced habitat quality for fauna. High levels of airborne dust particles can irritate the respiratory systems of fauna and potentially result in ingestion of dust-coated seeds and other foods. Excessive deposition of dust on open water bodies may also degrade water quality, and overall habitat quality for fauna.

3.1.3.3 *Noise*

Potential impacts from noise may occur both during construction and operation of the wind farm.

Noise levels greater than existing ambient noise levels are expected in the short-term during construction within the development footprint. Sources are likely to consist of noise in short, intense pulses from mobile plant equipment, and more prolonged noise, with consistent vibration, pitch and volume from generators and pumps, in addition to noise from vehicles. Construction noise impacts will be temporary, lasting for up to 36 months from the first mobilisation to site through to testing

and commissioning phase. Construction noise at any one point within the project area will be considerably shorter.

Operational noise from the wind turbines will be present whenever the rotors are spinning, which will occur at wind speeds greater than 3.0 ms^{-1} and will increase with wind speed until approximately 10 ms^{-1} where noise levels reach their maximum. Modelling of wind turbine noise has been undertaken with results showing maximum noise levels of 50 – 60 dBA being restricted to relatively small areas (100 – 200 m) from the base of each wind turbine (Figure 3-3).

Noise may impact terrestrial fauna in two general ways, either by masking (i.e., where noise affects communication between individuals of a species) or by eliciting a reaction, which may range from a mild alert response through to avoidance or abandonment of habitat. Noise thresholds for terrestrial fauna are not well understood, although Manci et al. (1988) suggest that sound levels above ~90 dB are likely to be adverse to mammals and are associated with a number of behaviours such as retreat from the sound source, freezing, or a strong startle response. Sound levels below 90 dB usually cause much less adverse behaviour. More recent studies on the impact of noise of fauna species in Australia indicate that birds are more likely to be affected and will move away from habitat areas, as opposed to mammal and reptile species (Lindenmayer et al. 2016). Studies in Europe have shown noise levels up to 60 dBA do not result in negative or adverse response in some terrestrial fauna (Helldin et al. 2012).

Studies by Zwart et al. (2016) have investigated potential links between wind turbine noise and altered territorial behaviour of the European robin (*Erithacus rubecula*). The study detected a negative response in robins when territorial intrusions were simulated in the presence of wind farm noise (i.e., birds were exposed to call playback of territorial songs). No negative response was detected in low noise conditions (i.e., no wind farm noise) nor were there effects detected when only turbine noise was present, without call playback simulating territorial intrusions. Zwart et al. (2016) suggest the results imply wind farm noise may have a detrimental impact on breeding success due to an over expenditure of time and energy. However, no link has been studied or established between the behavioural response elicited in the experiments and actual differences in breeding outcomes.

All but one threatened or migratory songbirds present or potentially present in the project area are non-breeding visitors and therefore the most relevant outcome of the Zwart et al. (2016) is the observation of no behavioural impacts in the presence of wind turbine noise. Black-faced Monarch does breed in Australia, however, is a wet forest specialist, breeding in rainforest which is present in two small patches (totalling 2.6 ha), and more than 2 km from turbines. As such, disruption of breeding behaviour from wind turbine noise is not considered a potential impact for these species.

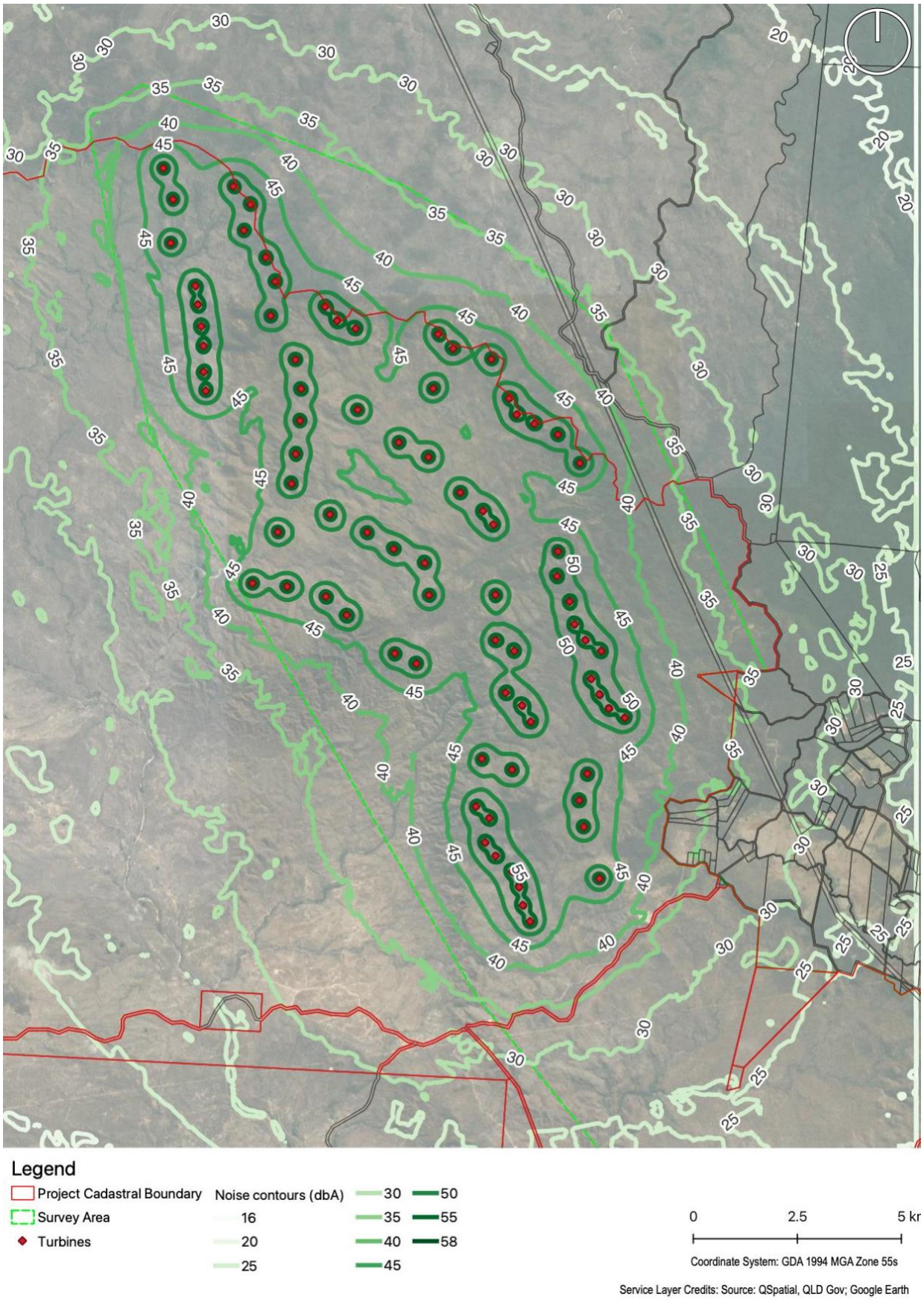

Figure 3-3: Turbine noise contours

3.1.3.4 Light

Any potential impacts of artificial lighting are expected to be localised and minor although will be present during both the construction and operational phase of the wind farm. No aviation lighting is proposed on the wind turbines, as the Civil Aviation Safety Authority considers the project unlikely to be a hazard to aviation safety. Site lighting will be kept to the minimum required for safety (including security). Lighting will be limited to site offices during construction and operation, and lighting for accommodation camp during construction only. Placement and orientation of lighting will be away from sensitive fauna habitats.

The potential impacts of artificial light on fauna are understood and predictable. These impacts can affect both nocturnal and diurnal animals by disrupting patterns, with quality of light (e.g., wavelength, colour), intensity and duration potentially evoking different responses. Impacts from increased light levels include disorientation from or attraction toward artificial sources of light; mortality from collisions with structures; and effects on light-sensitive cycles of species (e.g., breeding and migration for fauna and flowering in plants). An increase in artificial lighting can also increase the abundance and efficiency of predators. This could result in fauna avoiding some areas due to an increased perceived risk of predation and or become more vulnerable to being predated.

3.1.3.5 Changes to water surface hydrology and erosion

Works that may lead to changes in hydrology include clearing vegetation, excavation and filling during construction near and within waterway corridors. Impacts may be, for example, short-term from a lack of sediment control measures in place during construction, or long-term from altered flow quantity and direction occurring as a consequence of construction. The only works proposed within waterway corridors are water crossings for access roads which traverse riparian zones and the 275 kW transmission easement. The majority of other infrastructure are located outside of waterways.

Changes to hydrological regimes (e.g., through installation of infrastructure that comprise obstacles to surface flows or additional stormwater run-off) can potentially impact downstream receiving environments including run-off characteristics, intensity of flood flows and stability of waterways. Erosion destabilises vegetation communities resulting in habitat degradation Elevated levels of erosion and transport of sediments across the site may result in biodiversity losses to local and downstream environments. Scouring and/or waterlogging can also have deleterious impacts to local environments.

3.1.3.5.1 Reef 2050 Water Quality Improvement Plan 2017 - 2022

The five-year *Reef 2050 Water Quality Improvement Plan* (Reef 2050 WQIP) aligns and is part of the Australian and Queensland governments' *Reef 2050 Long-Term Sustainability Plan*. The Reef 2050 WQIP seeks to improve the quality of water flowing from the catchments adjacent to the Great Barrier Reef (Reef). The overarching outcome for which the Reef 2050 WQIP is aiming is '*Good water quality sustains the Outstanding Universal Value (OUV) of the Great Barrier Reef, builds resilience, improves ecosystem health and benefits communities.*' To achieve this, an overall target has been set for a 25% reduction in anthropogenic end-of-catchment fine sediment loads. The majority of the UBWF project footprint is located within the Burdekin catchment. The Burdekin catchment is currently the greatest source of fine sediment pollutant at 890 kilo tonnes, far ahead of the next major source, the Fitzroy catchment at 430 kilo tonnes (Reef 2050 WQIP). The target for the Burdekin is for the highest fine sediment load reduction of 30%.

There is a potential for unmanaged stormwater runoff during and after construction of UBWF to contribute to increased fine sediment pollutants downstream of the project site. However, given the distance from the Reef, and the highly vegetated nature of the project area and development footprint watercourse setbacks (excluding the construction of creek crossings), it is unlikely unmanaged stormwater run-off from the construction of UBWF would contribute in a meaningful way to Burdekin end-of-catchment fine sediment load. Further, the Reef 2050 WQIP identifies the vast majority of the 30% reduction is expected to come from the adoption of minimum standards in agricultural practice.

The Reef 2050 WQIP also acknowledges urban development and industrial activities are already regulated by local and State government legislation. With effective erosion and sediment control in place, as required by Queensland State legislation, it is highly unlikely the UBWF project will negatively impact the OUV of the Reef and will be consistent with the Reef 2050 WQIP Outcome, Objectives and Targets (refer Section 3.5.2.2 for detail).

3.1.3.6 Contamination from spills and leaks

Contamination from spills and leaks is primarily relevant during the construction phase of the project, however, may occur during maintenance activities during the operational phase.

Inappropriate disposal of liquid and solid wastes, including spills and leaks from transfers (fuel, chemicals) and inadequate storage could result in point-source contamination of surrounding land, including habitats of threatened and migratory species. Direct adverse impacts include toxic impacts on vegetation (resulting in degradation or loss), direct toxic impacts on fauna (from contact, inhalation or ingestion) or indirect impacts on threatened species from habitat loss. Direct adverse impacts on surface and groundwater quality are also possible.

Depending on the scenario the impact from spills and leaks could be either short or long-term depending on the magnitude of the spill and the effectiveness of the response. With effective controls, most spill and leaks will be minor and impacts temporary and reversible.

3.1.3.7 Vehicle movements

Potential impacts from vehicle movements will occur for the life of the project but are primarily relevant during the construction phase when numerous vehicles and heavy machinery is present on site. Impacts may also occur during the operational phase, although risks are substantially lower due to reduced vehicle numbers.

Potential impacts from vehicle movements are well understood and predictable. Vehicles may damage or destroy vegetation and fauna habitat whilst moving around the project area. This can be exacerbated if access roads are not an appropriate width and/or if vehicles deviate from established access roads. Vehicles and machinery may also kill or injury fauna on impact. Vehicles are also a key vector for the transmission of weeds and pathogens, which could result in longer term impacts of a greater extent of the project area.

3.1.3.8 Increased human presence

Potential impacts from increased human presence will occur for the life of the project but are primarily relevant during the construction phase when construction crews are on-site. Impacts may also occur during the operational phase, although risks are substantially lower due to reduced numbers of operational staff.

Increased activity by people within the development area and surrounds during construction has the potential for short-term impacts from the disturbance to disturb fauna, with fauna that roost or forage in adjacent areas being particularly vulnerable. Fauna may be disturbed by work activities, or other effects to human presence, for example increased food waste. Risks from domestic animals will be prevented, as staff cannot bring their pets to site. Impacts can include disruption to foraging and roosting efficiency or deterring animals from using particular areas that may have been used prior to the works beginning (resulting in the effective reduction in habitat availability).

Given the private land tenure and remote location of UBWF, interactions with people not associated with the wind farm are very unlikely.

3.1.3.9 Waste

Increased waste is primarily relevant during the construction phase of the project, however, may occur during maintenance activities during the operational phase. It is a requirement of the Environmental Management Plan that all wastes are disposed of appropriately in suitable facilities. Construction activities have the potential to result in the unintended deposition of construction waste through the temporary storage, handling and transport of waste. Waste can also be generated by construction personnel as general rubbish, food and human waste. Inappropriate management of waste can result in:

- The contamination of soils, water resources and vegetation
- Degradation or loss of vegetation and/or fauna habitat
- Injury to or loss of fauna, and attraction of pest species.

Waste generated during maintenance is expected to be low.

Substantial amounts of waste will be generated during decommissioning, as wind turbines and other infrastructure is dismantled at the end of the wind farm's operating life. Finding sustainable and best practice waste management options will be a priority of the decommissioning plan, including implementing the waste reduction hierarchy and seeking all reuse and recycling options as a priority to disposal.

3.1.3.10 Increased risk of fire incursion

Increased risk of fire incursion is more likely to be associated with construction. Construction activities have the potential to increase the risk of fire, causing injury or loss of human life, loss of flora and vegetation, fauna and habitat, and impacting surface water quality. Aspects of the project that could lead to increased fire incursion include:

- Introduction of ignition sources including vehicles and machinery and equipment such as generators
- Welding, grinding and other hot works
- Introduction or spread of weed species which can increase fuel load.

Depending on the extent, severity and frequency of increased fire incursion, impacts may be either short-term or long-term.

3.1.4 Fauna injury and/or mortality (ground level)

As highlighted above fauna injuries or mortality may result primarily from vegetation clearing, vehicle strike and trenching.

3.2 Potential Impacts from Turbine Operation

3.2.1 Turbine collision

Bird and bat species have the potential to be impacted through direct or near collision with turbine towers and blades, which can cause mortality and/or injury.

Overall, the extent to which birds and bats may be impacted by collisions with turbines is influenced by a number of factors including:

- Patterns of temporal and spatial habitat utilisation at a site including:
  - Flight paths, speeds and heights
  - Permanent versus transient presence
- Local population sizes
- Aggregational behaviour
- Ability to detect and avoid wind turbines
- Species specific risk levels e.g., raptors and common birds are most frequently affected
- Factors that attract birds and bats to vicinity of turbines including:
  - Increase in perching habitat e.g., on powerlines, turbine nacelle
  - Lighting that increases prey item (e.g., insect) abundance around turbines
  - Presence of carcasses at the base of turbines (food source for raptors).

A species-specific risk assessment has been undertaken, both to inform this impact assessment and to develop a Bird and Bat Management Plan to address collision risk in a targeted way. The risk assessment is presented below.

3.2.2 Barotrauma

Moving turbine blades result in changes in air pressure which can lead to mortality of microbats. Birds are considered less susceptible to air pressure changes than mammals which cannot detect rapid air pressure reductions (Baerwald et al. 2008). The potential impact to microbats within the project area from barotrauma are analogous with the risk of impacts from turbine collision with regards to microbat species flight height and occurrence in the project area. Therefore, the risk assessment presented for collision risk applies equally to barotrauma.

However, while barotrauma from wind turbines has been previously hypothesised by Baerwald et al. (2008) to be major contributor to bat mortality, recent studies by AWWI (2019) indicate that it does not appear to be an important source of bat mortality (Bennun et al. 2021). In addition, Bennun et al. (2021) highlights there is little empirical evidence of bat mortality from barotrauma.

3.2.3 Risk of Turbine Collision Assessment

The likelihood and consequence of turbine collision varies substantially across bird and bats species. Lumsden et al. (2019) have developed a framework for evaluating which species are likely to be affected by turbine collisions. The framework includes:

- Developing criteria that adequately reflect collision risks posed by wind turbines to various species
- Assessing each species against these criteria
- Developing a method to combine the rankings from these criteria into an ultimate score for each species

- Providing a method for evaluating these scores to enable a decision to be made on which species should be considered 'of concern'.

An adapted version of the framework (presented below) has been developed for the project to assess in detail which bird and bat species require further assessment for the risk of turbine collision. Species included in the assessment are MNES species that have been identified through desktop and field assessments as occurring or have potential to occur in the project area (refer to Section 2).

The criteria to determine overall collision risk includes considering both the likelihood and the consequences of collisions. Two criteria are used to address the likelihood of risk, flight height and species habitat preferences (Lumsden et al. 2019). Four criteria address the consequences (e.g., will collision mortalities affect species populations); whether the population was highly localised or concentrated in certain areas, the demographic capacity of the population to replace individuals lost due to turbine collisions, the size of the population, and the species conservation status (Lumsden et al. 2019). High, medium, and low rankings for each criterion have been developed based on the project. These are displayed in Table 3-2.

Table 3-2: Risk assessment criteria for the project (adapted from Lumsden et al. 2019)

Criteria	Ranking		
	Low	Moderate	High
Used to ascribe likelihood of risk			
Flight height	Rarely flies within rotor-swept area (RSA)[4]	Flight activity is concentrated below RSA, but species does fly at RSA[4] during some activities, or this aspect is uncertain / previous fatalities have been recorded	High proportion of flight activity is within RSA[4] and/or previous fatalities recorded and wind farms
Habitat availability	Species utilise habitats that are widely available across the landscape, including in areas where turbines are not present. Habitat in proximity to turbines is not considered critical to the survival of the species.	Species utilise habitats that are widely available across the landscape, including in areas where turbines are not present, but may rely on resources that are prevalent within proximity to turbines. Habitat in proximity to turbines is not considered critical to the survival of the species but does contain important resources.	Species is restricted to habitats that occur only within or immediately adjacent to turbines and/or relies on resources that are only present within proximity to turbines. Habitat in proximity to turbines is considered critical to the survival of the species.
Used to ascribe consequence of risk			
Geographic population and concentration	Species that are widely dispersed within areas of suitable habitat and the	Species that may be more widespread or have greater flexibility in the	Bat species that have major aggregations at a few caves, or species of

[4] Rotor swept area for the two options of UBWF turbine models is from 57.5 - 67 m (lower tip) to 222.5 - 230 m (upper tip) with a rotor swept area of 163 -165 m. Canopy clearance (distance between canopy and rotor swept height) is 27.5 m.

Criteria	Ranking		
	Low	Moderate	High
	habitat itself is relatively widely dispersed	range of suitable habitat availability, but their population is likely to be concentrated at sites where they do occur.	birds that have very restricted distributions or may be seasonally concentrated at very few small locations.
Demographic resilience	Species that form breeding territories and that have a reasonable proportion of the population as non-breeding 'floaters' that can rapidly replace breeding territorial adults if lost; species that may or may not form breeding territories and that are short-lived and have high fecundity; species that have capacity for long-range or widespread juvenile or sub-adult dispersal.	Species with life-history characteristics that sit between the low and high descriptions here.	Species that form breeding territories but where there is limited capacity for a lost breeding adult to be readily replaced; species that do not form breeding territories and that are long-lived and/or have low fecundity; species that may have short-distance juvenile or sub-adult dispersal capacity only.
Population size	project area does not contain an important population or ecologically significant proportion of the population. The local population is likely to represent a very small to small proportion of the total population size.	Project area does not contain an important population or ecologically significant proportion of the population. The local population is likely to represent a medium to large proportion of the total population size.	Project area does contain an important population or ecologically significant proportion of the population. The local population is likely to represent a very large proportion of the total population size.
Conservation Listing Status[5]	Species listed as near threatened or data deficient under the EPBC Act or NC Act	Species listed as vulnerable under the EPBC Act or NC Act	Species listed as critically endangered or endangered under the EPBC Act or NC Act

Once the overall risk levels for the likelihood and consequence of collision had been determined for each individual bird and bat species, the results were then placed into a risk matrix to determine the final and overall risk level (Table 3-3). Any species that had a final risk greater than negligible has had the risk of collision assessed further (refer to BBMP, Appendix B). The results for each individual species are presented in Table 3-4.

[5] Non-listed species and migratory species that do not have a threat status are not assigned a rank for this criterion

Table 3-3: Risk matrix for birds and bats

		Consequence of collisions		
		Low	**Moderate**	**High**
Likelihood of collisions	**Low**	Negligible risk	Negligible risk	Low risk
	Moderate	Negligible risk	Low risk	Moderate risk
	High	Low risk	Moderate risk	High risk

Table 3-4: Risk assessment results, ranking and justification

Species	Status	Assessment	Ranking	Justification
Spectacled flying-fox	Endangered	Likelihood – Moderate Consequence – High	Moderate risk	Flight height – Aircraft strike data indicate flight height is likely 150 m (Parsons *et al*. 2008). Recorded fatalities at wind farms. Likely flies at RSA. Habitat availability – Very small area of potential roosting habitat located away from turbines in rainforest pocket in the east of the project area. No roost camp observed and only low numbers of individuals – limited breeding habitat unlikely to be habitat critical to the survival of the species. Foraging habitat widely available across project area. Available foraging habitat has been assessed as not 'habitat critical' to the survival of the species, particularly given the proximity to substantial and widespread resources in the nearby WTWHA rainforests. Geographic population and concentration – Wet Tropics population is the main concentration of the species and is undergoing decline. Demographic resilience – Species aggregates in maternity camps and then disperses. Females produce one young per year. Population size – Species occurs as one connected population, with individuals moving considerable distances across the landscape, both during nightly foraging and seasonally for foraging and breeding. Individuals observed within the project area are part of this single population. Recorded in project area and within foraging distance of known camp. Unlikely to occupy project area year-round.
Grey-headed flying-fox	Vulnerable	Likelihood – Moderate Consequence – Moderate	Low risk	Flight height – unknown but has been struck by aircrafts before indicating it can reach RSA. Habitat availability – Winter and spring flowering myrtaceous and other plant species are present in the project area and are technically 'habitat critical to the survival of the species'. However, the habitat is unlikely to play more than a limited role in sustaining the species, and necessity of this habitat for foraging, roosting and dispersal is likely low however is widely available across project area and broader

Species	Status	Assessment	Ranking	Justification
				landscape, and is not within foraging distance of Nationally Important Camp and no individuals have been recorded. Geographic population and concentration - The Grey-headed flying-fox is considered to be a single, mobile population, with all significant camps located 100-1,000's km to the south of the project area. Demographic resilience – Species aggregates in maternity camps and then disperses. Females produce one young per year. Average life expectancy of 7 years and reach sexual maturity at ~ 3years. Population size – Project unlikely to support an important population, if present likely to be small proportion of population of grey-headed flying-foxes, given the lack of observations and distance to the camp in Ingham.
Greater large-eared horseshoe bat	Vulnerable	Likelihood – Low Consequence – Moderate	Negligible risk	Flight height – Usually flies within the lower half of the canopy (1-8 m) but has been observed at canopy height (around 25 m) (TSSC 2016a). This is outside of the RSA. Habitat availability – Foraging habitat is limited within the project area to watercourses and areas of denser vegetation, mainly within the east and north-east of the project area. This habitat is considered 'habitat critical' to the survival of the species. Geographic population and concentration – Occurs only in northern QLD. Small colonies, typically less than 10 individuals. The population is considered to be continuous, and the project area is not located at end of range. Demographic resilience – Sexual maturity and life expectancy of the species is uncertain but thought to be 1 year and 10 years respectively (TSSC 2016a). Population size – Recorded in the project area. Project area near the southern most record of the species, important population may be present.
Bare-rumped sheathtail bat	Vulnerable	Likelihood – High	Moderate risk	Flight height – Known to fly at altitude up to and above 400 m. Recorded in the project area.

Species	Status	Assessment	Ranking	Justification
		Consequence – Moderate		Habitat availability – Foraging habitat widely available across project area and region. The habitat has been assessed as not 'habitat critical' to the survival of the species. Geographic population and concentration – generally occurs in low densities and has been recorded from less than 25 localities. Project area is not at the end of the species range. Demographic resilience – Adaptable species tolerant of some level of disturbance (TSSC 2016b). Capable of dispersing long distances. Generation length is assumed to be 3-5 years, derived from a mean of age at sexual maturity (estimated at 1-2 years) and longevity (probably around 5-8 years), but no detailed information is available for this subspecies (TSSC 2016b). Population size – Not well known. Anecdotal evidence suggests that the species occurs in low densities (Schulz & Thomson 2007).
Red goshawk	Vulnerable	Likelihood – Moderate Consequence – High	Moderate risk	Flight height – Spends most of its time below the canopy but has been observed regularly flying just above the canopy. Recorded in the project area (overhead observation) once during baseline surveys, no additional sighting during BUS. No nests found. Habitat availability – Foraging habitat widely available across project area. Potential nesting habitat is also available along the higher order watercourses throughout the project area. The habitat has been assessed as 'habitat critical' to the survival of the species. Geographic population and concentration – Solitary and sparsely distributed across approximately 15% of coastal and sub-coastal Australia. Project area is not at the end of the species range. Demographic resilience – Large home range of up to 200 km^2, juvenile dispersal may be extensive. Population size – It is estimated 1,400 individuals exist in the wild, with 35-40 breeding pairs estimated to exist in North Queensland. An important population of red goshawk is likely to occur within the project area.

Species	Status	Assessment	Ranking	Justification
Masked owl	Vulnerable	Likelihood – Moderate Consequence – Moderate to high	Low to moderate risk	Flight height – May fly at RSA, but generally forages within and below the canopy. Previous fatalities have not been documented. Habitat availability – Foraging and breeding habitat occurs within the project area. Species has a large home range and can use a range of habitat types including open landscapes. Project area contain habitat critical to the survival of the species, however habitats within vicinity of turbines are unlikely to be specifically relied on, given the species home range is >1,000 ha. Geographic population and concentration – Distribution is poorly known however can use a range of habitat types. Large home range and low population density. Demographic resilience – Sedentary and territorial with nests 7-8 km apart. Form breeding pairs. Females lay 2-3 eggs each breeding season. Sexual maturity and life span not known. Population size – Recorded in the project area and part of an important population. Low number of records (i.e. 2 observations across multiple surveys) represents <0.1% of total population size (TSSC 2015)
White-throated needletail	Vulnerable Migratory	Likelihood – High Consequence – High	High risk	Flight height – The species can occur up to 1,000 m off the ground and there is evidence of collision with wind turbines and powerlines. Habitat availability – Foraging habitat widely available across project area. The habitat has been assessed as not 'habitat critical' to the survival of the species. Geographic population and concentration – Widespread in eastern and south-eastern Australia. Generally gregarious sometimes occurring in large flocks. Demographic resilience – Migratory bird which spends non-breeding season in Australia. Very high dispersal capability.

Species	Status	Assessment	Ranking	Justification
				Population size – Recorded in the project area during March 2022 surveys, in numbers[6] that meet the definition of an 'ecologically significant proportion of a population' (DoE 2015). Based on this observation, a high consequence rating based on population size has been adopted.
Fork-tailed swift	Migratory	Likelihood – High Consequence – Moderate	Moderate risk	Flight height – The species occurs to at least 300 m off the ground and potentially higher. Observed flying at heights of 300 m above ground during surveys. Habitat availability – Foraging habitat widely available across project area. The habitat has been assessed as not 'habitat critical' to the survival of the species. Geographic population and concentration – Widespread throughout Australia. Occurs in flocks which can be as large as 50 000+. Migratory bird which spends non-breeding season in Australia. Very high dispersal capability. Demographic resilience – Unknown. Population size – Recorded in the project area, however not in numbers that constitute an ecologically significant proportion of the population. Recent surveys recorded flocks of 85, 40, 13 individuals at different locations across the wind farm during the wet season survey period justifying a moderate consequence rating based on local population size.
Latham's snipe	Migratory	Likelihood – Moderate Consequence – Low	Low risk	Flight height – As a transcontinental migrant, it can fly within the RSA when on passage, though likely to spend most of the time below RSA if utilising the project area. Habitat availability – Species recorded adjacent to the project area and limited suitable wetland habitat is present. Species has previously been recorded near other Australian windfarms situated near wetland vegetation.

[6] The species was recorded during the BUS, White-throated Needletail surveys and as incidentals with counts ranging from one to 47 and with an average flock size of seven.

Species	Status	Assessment	Ranking	Justification
				Geographic population and concentration – Passage migrant through northern Australia and non-breeding visitor to south-eastern Australia. Demographic resilience – Unknown though banding data indicates that birds are capable of surviving for more than four years. The age of sexual maturity is unknown, but birds probably breed for the first time at one or two years of age (DCCEEW 2022a). Very high dispersal capability. Population size – Occurs as a single dispersed non-breeding population in Australia. Limited habitat available and species not recorded within project area. Unlikely to support an ecologically significant proportion of the population.
Oriental cuckoo	Migratory	Likelihood – Low Consequence – Low	Negligible risk	Flight height – Unlikely to fly in RSA, observed flying at heights below 30 m during surveys. Habitat availability – Utilises a range of vegetated habitats. Habitat is widely available within and outside the project area. Geographic population and concentration – Non-breeding migrant to northern and eastern Australia in small numbers. Tends to be solitary. Demographic resilience – Very high dispersal capability. Population size – Recorded within project area, likely a vagrant visitor. project area unlikely to support ecologically significant proportion.
Barn swallow	Migratory	Likelihood – Low Consequence – Low	Negligible risk	Flight height – Unlikely to fly at RSA. Species feeds by aerial pursuit (sallying) or gleaning or skimming insects from plants or water surface. They feed mainly low over the ground or water. Occasionally, birds are recorded feeding on clear ground, such as roads, paths and beaches, by walking around and picking at the surface (DCCEEW 2022b). Habitat availability – Utilises a range of open vegetated and open water habitats. Widely dispersed throughout this habitat. Potential habitat abundant throughout the broad landscape and limited within the project area.

Species	Status	Assessment	Ranking	Justification
				Geographic population and concentration – Non-breeding migrant to northern Australia in small numbers. Forages singly or in small groups. Demographic resilience – Migratory bird which spends non-breeding season in Australia. Very high dispersal capability. Population size – Not recorded, vagrant visitor at best. Project area does not support ecologically significant proportion.
Black-faced monarch	Migratory	Likelihood – Low Consequence – Low	Negligible risk	Flight height – Unlikely to fly in RSA. Feeds within or below the canopy. Habitat availability – Wet forest specialist. Habitat is widely available outside of the project area. Potential habitat within the project area is largely within priority avoidance areas, away from turbines. Geographic population and concentration – Widespread breeding migrant to eastern Australia. Estimated to occupy 260,000 km^2 when breeding. Movement pattern characterised by moving 'directly along the coast' (DCCEEW 2022c). Demographic resilience – High dispersal capability. Species appears to have a relatively high rate of fledging failure, with analyses of hatching and fledging success indicating that an average of 0.1 fledged young is yielded per nest per breeding event (DCCEEW 2022c). Population size – Not recorded, vagrant visitor at best. project area unlikely to support ecologically significant proportion.
Spectacled monarch	Migratory	Likelihood – Low Consequence – Low	Negligible risk	Flight height – Unlikely to fly in RSA. Forages at 5-15 m above ground. The species was recorded flying at heights less than 30 m above ground level. Habitat availability – Occupies a range of densely vegetated habitat types associated with riparian areas. This habitat is largely setback 300m away from turbines. Geographic population and concentration – Widespread throughout the north-east and east coast of Australia during breeding season.

Species	Status	Assessment	Ranking	Justification
				Demographic resilience – High dispersal capability. Population size – Recorded within project area. project area unlikely to support ecologically significant proportion.
Satin flycatcher	Migratory	Likelihood – Moderate Consequence – Low	Negligible risk	Flight height – May fly in RSA however was only recorded flying at heights less than 30 m above ground level during surveys. Feeds within canopy and sub-canopy (DCCEEW 2022d) and flight likely to generally be at or below canopy height. Habitat availability – Utilise a diversity of wooded habitat, particularly during migration. Habitat is limited within the project area, associated with the denser areas of open forest to woodlands and riparian zones, and largely located away from turbines. Geographic population and concentration – Widespread throughout coastal eastern Australia and along the Great Dividing Range. Demographic resilience – High dispersal capability Population size – Recorded within the project area. project area does not support ecologically significant proportion.
Rufous fantail	Migratory	Likelihood – Low Consequence – Low	Negligible risk	Flight height – Unlikely to fly in RSA. Recorded flying at heights less than 30 m above ground level during surveys. Forages mostly in the understorey. Habitat availability – Utilise a diversity of wooded habitat, particularly during migration. Habitat is limited within the project area, associated with the denser areas of open forest to woodlands and riparian zones, and largely located away from turbines. Geographic population and concentration – Widespread and common in eastern Australia. Forages singly or in pairs. Demographic resilience – Common and secure species. Population size – Recorded within the project area. Project area does not support ecologically significant proportion.

Species	Status	Assessment	Ranking	Justification
Eastern osprey	Migratory	Likelihood – Moderate Consequence – Low	Negligible risk	Flight height – Species may fly in RSA. The species was recorded in project area perched on a stag adjacent permanent water (Michael Creek) at a height of 20 m. Habitat availability – Due to habitat preferences, species is more likely to occur close to permanent water rather than elevated areas of the project area where wind turbines are proposed. Habitat for vagrant individuals. Geographic population and concentration – Widespread around the northern coast of Australia. Vagrant in southern coastal Australia. Project area is within the species distribution mapped as 'vagrant range' (DoE 2015). Demographic resilience – Breed in monogamous pairs. Adults are resident within territories, young birds may disperse more than 700 km from their natal territories. Population size – Only 1 individual recorded in project across numerous survey event. Considered to be moderately common in Australia, and most abundant in northern Australia (DAWE 2020). Australian population reported to have increased.

3.3 INTERACTIONS BETWEEN THE PROJECT AND EXTREME ENVIRONMENTAL EVENTS

Preparing for a low emissions future is a priority for the Australian and Queensland governments, both to meet the domestic policy agenda and to deliver on our international obligations. Significant progress towards decarbonisation can be made now, via investment in renewable energy projects such as UBWF. The key purpose of the global decarbonisation agenda is to slow and ideally reverse the impacts of climate change, including more frequent and extreme environmental events. At the macro-level, projects such as UBWF become a critical mitigation strategy in addressing the climate crisis. Importantly, UBWF is located in a region that has been identified as suitable for renewable energy development by the state government i.e., within the north Queensland Renewable Energy Zone.

Locally at UBWF relevant extreme environmental events may include bushfire, cyclone and drought. Given the topography of the project area, floods are considered to be a negligible risk. The potential interaction between UBWF and extreme environmental events may occur in two ways that are relevant to MNES:

1. The project increases the risk of an extreme event
2. The project exacerbates the impacts from an extreme event.

The former is only relevant for bushfire, whereby fire risk is increased during construction or operation of the wind farm. These risks are considered low and will be proactively managed via the implementation of the EMP.

The likelihood of UBWF exacerbating the impacts of extreme events is also considered to be low. The relative scale of impacts from the wind farm relative to the likely scale of impacts from wildfires, cyclone and droughts will be low, as the impacts of these extreme events manifest over regions. In contrast the impacts of the Proposal Action are small (in the order of hundreds of hectares) and occur in a dispersed fashion across an otherwise intact landscape. The suite of management measures to be implemented via the EMP are aimed at ensuring all project related impacts are managed according to industry best practice and thereby retaining landscape-scale resilience within the project area.

3.4 FACILITATED IMPACTS

A facilitated impact is an indirect impact of the project, that has been made possible or facilitated by the realisation of the project, including impacts that occur outside of the project area. For example, a road may be constructed to access or construct the project that becomes trafficked by users not associated with the project and leads to increased vehicle strike and fauna mortality.

There are not anticipated to be any facilitated impacts of the project. The UBWF will not become public property and access, aside from the landholder, will be restricted to the UBWF employees and contractors, which will abide by all protocols with regards to speed limits, weed management and hygiene protocols, and all other avoidance, minimise and mitigation measures outlined in Section 3.5.2. The switchyard to which the UBWF will connect to will be built despite the UBWF development, so is also not a facilitated impact.

Facilitated impacts to MNES outside the project area are also unlikely.

3.5 MEASURES TO AVOID AND REDUCE POTENTIAL IMPACTS

The proponent is committed to avoiding, minimising and managing potential impacts to MNES known and likely to occur in the development footprint and wider project area. There are a number of measures that will be implemented over the life of the project to avoid, reduce and manage impacts to biodiversity values. Many of these are not specific to a particular environmental value and provide site-wide benefits. Further discussion on the management of impacts, avoidance through design and mitigation measures is provided in the section below.

3.5.1 Avoidance through design

3.5.1.1 Constraints analysis in early design

Avoidance through design has been the primary guiding principle to reduce impacts on protected values. Field investigations undertaken during September 2019 established a baseline understanding of ecological values present (ELA 2020, Appendix E). From the baseline data collected, a preliminary constraints analysis was undertaken, with additional refinement via GIS analysis using high resolution aerial imagery and LiDAR data for the project area (refer to Section 2).

The results of the final ecological constraints analysis indicated that important ecological values were present across the majority of the project area, primarily due to a high diversity and abundance of threatened species. However, there were areas where avoidance could be prioritised and some areas where there were no or few constraints, and these presented the most desirable locations for placing infrastructure.

The constraints analysis developed an 'avoidance priority' dataset, which was used to inform design. Constrained areas were ranked and then mapped as either no-go zones or priority avoidance areas according to their ecological value for threatened species. The mapping identified areas where, from a biodiversity perspective, clearing should not proceed, be avoided as much as possible or undertaken only with mitigation strategies in place. The dataset included:

- No go areas – should be avoided as a priority, as these are the areas of highest environmental sensitivity. To further protect these areas, buffers have been provided around the no go areas, and clearing within the buffer zone should also be avoided as far as possible. Examples include:
    - Inhabited Sharman's rock-wallaby shelter habitat (highly stacked and complex rock piles, large extents of rocky areas / boulder piles and vine thickets for threatened species)
    - Major watercourses (potential red goshawk nesting habitat and important for connectivity)
- Priority avoidance areas – these areas also contain significant environmental values and should be avoided as a priority. However, some clearing may be required and where avoidance is not possible, clearing should be kept to a minimum. Examples include:
    - distinctive habitat features that provide high quality habitat for a range of threatened species (includes riparian forest, rock pavements, moist / wet vegetation communities of the Wet Tropics Bioregions, Melaleuca swamps and rainforest).
- Implement mitigation strategy areas – the remainder of the project area falls into this category, where there are still some environmental values that should be considered, but where mitigation is more feasible than avoidance. In these instances, the key mitigation measure will be to minimise clearing to only that required, whilst taking advantage of already disturbed areas.

These categories were used both to guide design and also in the development of the avoidance and mitigation commitments in the Environmental Management Plan (see below).

3.5.1.2 Further impact reduction during design

As discussed in Section 1.4.3.1, the layout of the project has been substantially reduced during the ongoing design phase. Fifty-four turbines have been removed from the proposal, reducing impact by over 200ha for some species (refer to Table 1-1 for details of the impact reduction for species). Where impact area has increased for species, this is a result of further refinement and increasing extent of habitat mapping.

3.5.2 Avoidance and mitigation

The project will implement the environmental mitigation hierarchy of avoid, minimise and mitigate impacts to relevant MNES during the detailed design phase of the project and will continue to implement this throughout the life of the project. These measures will be realised through implementing the Upper Burdekin Environmental Management Plan (EMP, Appendix A).

3.5.2.1 Management Plans

The proponent has developed a comprehensive avoidance and mitigation strategy, which will be delivered via the implementation of the EMP and associated management sub-plans (Appendix A). The EMP establishes suitable controls to eliminate or minimise the risks to the environment to a level that is low, negligible or reduced to as low as reasonably practicable. It provides the overview for the environmental management of the construction and operation phases of the UBWF.

The UBWF will be designed with an operational life of 30 years and will be designed fit for purpose. With refurbishment, the wind farm may have a much longer operational life. At the appropriate time, areas disturbed as part of the permanent footprint will be rehabilitated and the wind farm decommissioned consistent with the requirements of legislation, Australian Standards and industry practices at the time, and the land agreement requirements and regulatory authorities. A detailed decommissioning and rehabilitation plan will be prepared at this time to guide these activities.

The EMP is a standalone document that includes all the avoidance and mitigation measures that must be implemented to appropriately manage the potential ground-level impacts from the wind farm. It is based on a series of sub-plans that address specific elements of the environment and/or project impacts/risks. There are both measures that are not specific to individual species, but rather demonstrate good environmental practice in addressing potential impacts and species-specific requirements designed to provide additional protection for threatened species.

Potential impacts associated with turbine collision risk and barotrauma are addressed separately in the Bird and Bat Management Plan (BBMP, Appendix B).

The EMP also provides a framework for measuring environmental performance against legislative requirements and company policies and standards. To achieve these overarching objectives, the EMP specifically aims to:

- Inform UBWF staff and contractors of their environmental obligations
- Provide site-specific environmental control procedures
- Provide rational and practical environmental guidelines for the construction and operation of the UBWF, to ensure activities do not adversely affect environmental values and in particular threatened species

- Ensure that any potential environmental impacts arising from the construction and operation of the UBWF are managed in accordance with legislative requirements
- Develop environmental guidelines for conducting staff induction and training.

The EMP includes a number of management sub-plans providing specific management objectives, targets and management actions for the following matters:

- Fauna
- Vegetation
- Construction weed management
- Bushfire
- Soils and sediments
- Noise
- Air emissions
- Surface water
- Hazardous materials
- Waste
- Site reinstatement and rehabilitation
- Feral predators

All proposed avoidance and mitigation measures have been drafted to meet the S.M.A.R.T principle where appropriate:

- S – Specific
- M – Measurable
- A – Achievable
- R – Relevant
- T – Timebound.

3.5.2.2 Avoidance and mitigation measures - overview

This section provides an overview of the key controls included in the EMP (Appendix A).

Primary measures to avoid impacts to MNES include:

- Environmental constraints analysis used to inform preliminary project design
- Targeted siting strategies for avoiding impacts to habitat connectivity values of the project area for identified threatened species
- Locate infrastructure within cleared areas where possible
- Preferentially locate access tracks along routes of existing tracks (although upgrades and widening of these tracks will be necessary to facilitate the project)
- Locating watercourse crossings within the alignment of existing tracks and crossings as much as practicable.

Measures to minimise impacts to MNES areas include:

- Conduct micro-siting of project infrastructure
- Limit disturbance to the smallest extent practicable for undertaking the project, with rehabilitation implemented within areas not required for project operation
- Minimise clearing and construction within 1 km of watercourses

- Rehabilitate access tracks after the project has been constructed to operational widths as much as practicable
- Minimise clearing within watercourse buffers, where possible to less than 25 m lineal width, and implement crossing designs to reduce interference with existing aquatic or terrestrial habitats and connectivity
- Implement speed limits to reduce the likelihood of vehicle strike injuries or fatalities to wildlife, to limit impact to connectivity
- Limit construction works to daylight hours as much as possible to avoid impacts to nocturnal fauna behaviour
- Locate cabling underground as much as possible
- Turbines will not require night-time aviation lighting
- Site lighting will be kept to the minimum required for safety (incl. security). Placement and orientation of lighting will be away from sensitive fauna habitats
- Direction of lighting beams will be downwards, or shields/baffles used to minimise light spill into habitat area.

A project-specific stormwater management and erosion and sediment control plan (SMESC plan) will be developed in accordance with the relevant management objectives of the EMP surface water sub-plan and soils and sediment sub-plan. The SMESC plan will detail measures such as sediment basins, swale drains, culverts and good stormwater management practices during construction and operation, to avoid and minimise impacts from stormwater runoff, erosion and associated sedimentation.

The EMP objectives for soils and sediments include:

- Minimise change to soil profile from excavation activities
- Prevent occurrence of soil erosion during and following construction.

Table 7-25 of the EMP identifies a suite of management measures to be implemented pre-construction, during construction and post-construction to meet these objectives. Also outlined in the EMP is a monitoring program designed to ensure that construction of the project is consistent with the control measures, with triggers and corrective actions identified.

With standard erosion and sediment control in place, a requirement of development approval under Queensland State legislation, it is highly unlikely UBWF will contribute to end-of-catchment fine sediment loads and impact the achievement of the target for the Burdekin catchment under the Reef 2050 WQIP.

3.5.3 Rehabilitation

Rehabilitation will be required to revegetate areas cleared for construction purposes that are not required for operational use. Rehabilitation will focus on reducing the risk of promoting weed species and stabilising disturbed areas, thereby reducing the potential for erosion and sedimentation of surrounding environments.

The EMP includes a site-reinstatement and rehabilitation sub-plan to address management of activities associated with rehabilitation. A detailed rehabilitation plan will be produced consistent with the management objectives, targets and measurement criteria outlined in the site-reinstatement and rehabilitation sub-plan and will be the responsibility of the construction contractor, once appointed.

The rehabilitation of temporary disturbance areas is required under Queensland Government State Code 16 (refer to Section 1).

At the appropriate time, areas disturbed as part of the permanent footprint will be rehabilitated and the wind farm decommissioned consistent with the requirements of legislation, Australian Standards and industry practices at the time, and the land agreement requirements and regulatory authorities. A detailed decommissioning and rehabilitation plan will be prepared to guide these activities.

3.6 REFERENCES (PER – SECTION 3)

2rog Consulting, 2022. *Upper Burdekin Wind Farm Environmental Management Plan*. Produced on behalf of Windlab Pty Ltd.

American Wind Wildlife Institute (AWWI), 2019. *Wind turbine interactions with wildlife and their habitats: a summary of research results and priority questions*. Washington DC, USA: American Wind Wildlife Institute. American Wind Wildlife Institute [website]. Accessed 2022. https://rewi.org/wp-content/uploads/2019/05/Wind-Wildlife-Impacts-Summary-2019.pdf

Andren, H., 1994. Effects of Habitat Fragmentation on Birds and Mammals in Landscapes with Different Proportions of Suitable Habitat: A Review. *Oikos*. 71 (3): 355–366.

Baerwald, E. F., D'Amours, G. H., Klug, B. J. & Barclay, R. M. R., 2008. Barotrauma is a significant cause of bat fatalities at wind turbines, *Current Biology*. 18 (16): 695-696.

Ben-Ami, D. & Ramp, D., 2013. Impact of roadside habitat on swamp wallaby movement and fitness. *Wildlife research*, 40(6): 512.

Bennun, L., van Bochove, J., Ng, C., Fletcher, C., Wilson, D., Phair, N. & Carbone, G., 2021. *Mitigating biodiversity impacts associated with solar and wind energy development. Guidelines for project developers*. IUCN, Gland, Switzerland and The Biodiversity Consultancy, Cambridge, UK.

Brady, M. J., McAlpine, C. A., Possingham, H. P., Miller, C. J. & Baxter G. S., 2011. Matrix is important for mammals in landscapes with small amounts of native forest habitat. *Landscape ecology,* 26(5): 617–628.

Carthew, S. M., Jones, K. M. W. & Lawes, M., 2013. Responses of small vertebrates to linear clearings in a South Australian woodland. *Ecological research.* 28(6): 1003-1010.

Clarke, D. J., Pearce, K. A. & White, J. G., 2006. Powerline corridors: degraded ecosystems or wildlife havens? *Wildlife research*, 33(8): 615–626.

Department of Agriculture, Water and the Environment (DAWE), 2020. *Wildlife Conservation Plan for Seabirds.* Department of Agriculture, Water and the Environment, Canberra.

Department of the Environment (DoE), 2015. *Draft referral guideline for 14 birds listed as migratory species under the EPBC Act.* Commonwealth of Australia.

Department of Climate Change, Energy, the Environment and Water (DCCEEW), 2022a. *Species Profile and Threats Database - Gallinago hardwickii — Latham's Snipe, Japanese Snipe*. Accessed 18/10/2022. http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=863

Department of Climate Change, Energy, the Environment and Water (DCCEEW), 2022b. *Species Profile and Threats Database - Hirundo rustica — Barn Swallow.* Accessed 18/10/2022. https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=662

Department of Climate Change, Energy, the Environment and Water (DCCEEW), 2022c. *Species Profile and Threats Database - Monarcha melanopsis — Black-faced Monarch.* Accessed 18/10/2022. *https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=609*

Department of Climate Change, Energy, the Environment and Water (DCCEEW), 2022d. *Species Profile and Threats Database - Myiagra cyanoleuca — Satin Flycatcher.* Accessed 18/10/2022. https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=612

Eco Logical Australia (ELA), 2020. *Upper Burdekin Wind Farm – Ecological Assessment* (Version 1). Prepared for Windlab Developments Pty Ltd.

Helldin, J. O., Jung, J., Neumann, W., Olsson, M., Skarin, A. & Widemo, F., 2012 *The impact of wind power on terrestrial mammals. A synthesis*. The Swedish Environmental Protection Agency, Stockholm.

Lindenmayer, D. B., MacGregor, C., Wood, J., Westgate, M. J., Ikin, K., Foster, C., Ford, F. & Zentelis, R., 2016. Bombs, fire and biodiversity: Vertebrate fauna occurrence in areas subject to military training. *Biological Conservation*, 204(B): 276-283.

Lumsden, L. F., Moloney, P. & Smales, I., 2019. *Developing a science-based approach to defining key species of birds and bats of concern for wind farm developments in Victoria.* Arthur Rylah Institute for Environmental Research Technical Report Series No. 301. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Manci, K. M., Gladwin, D. N., Villella, R. & Cavendish, M. G., 1988. *Effects of aircraft noise and sonic booms on domestic animals and wildlife: a literature synthesis*. U.S. Fish and Wildlife Servive National Ecology Research Center, Ft. Collins, CO.

Parsons, J., Blair, D., Luly, J., & Robson, S., 2008. Flying-fox (Megachiroptera: Pteropodidae) flight altitudes determined via an unusual sampling method: Aircraft strikes in Australia. *Acta Chiropterologica*. 10: 377-379.

Pickering, C. M. & Hill, W., 2007. Impacts of recreation and tourism on plant biodiversity and vegetation in protected areas in Australia. *Journal of environmental management*, 85: 791–800.

Radford, J. Q., Bennett, A. F. & Cheers, G. J., 2005. Landscape-level thresholds of habitat cover for woodland-dependent birds. *Biological Conservation*, 124: 317–337.

Ramp, D., Wilson V. K. & Croft D. B., 2005. Assessing the impacts of roads in peri-urban reserves: road-based fatalities and road usage by wildlife in the Royal National Park, New South Wales, Australia. *Biological conservation*, 129: 348-359.

Schulz, M. & Thomson, B., 2007. *National recovery plan for the bare-rumped sheathtail bat* Saccolaimus saccolaimus nudicluniatus. Report to Department of the Environment and Heritage, Canberra. Queensland Parks and Wildlife Service, Brisbane.

State of Queensland [SoQ] 2018. *Reef 2050 Water Quality Improvement Plan 2017 – 2022*. Queensland Government.

Threatened Species Scientific Committee (TSSC), 2015. *Conservation Advice* Tyto novaehollandiae kimberli *masked owl (northern)*. Department of the Environment, Canberra.

Threatened Species Scientific Committee (TSSC), 2016a. *Conservation Advice* Rhinolophus robertsi *greater large-eared horseshoe bat*. Department of the Environment and Energy, Canberra.

Threatened Species Scientific Committee (TSSC) 2016b. *Conservation Advice* Saccolaimus saccolaimus nudicluniatus *bare-rumped sheathtail bat*. Department of the Environment and Energy, Canberra.

Weston, N., Goosem, M., Marsh, H., Cohen, M. & Wilson, R., 2011. Using canopy bridges to link habitat for arboreal mammals: successful trails in the Wet Tropics of Queensland. *Australian mammalogy*, 33(1): 93.

Williams, E. R., Adams-Hosking, C., McAlpine, C. & Seabrook, L., 2013. *The potential impacts of coal seam gas on biodiversity in Australia: Identification of knowledge gaps and research priorities*. Prepared for the University of Queensland – Centre for Coal Seam Gas. The Sustainable Minerals Institute, University of Queensland.

Wintle, B. A., Kujala, H., Whitehead, A. & Bekessy, S. A., 2019. Global synthesis of conservation studies reveals the importance of small habitat patches for biodiversity. *Proceedings of the National Academy of Sciences (PNAS)*, 116(3): 909–914.

Wolf, I. D. & Croft, D. B., 2014. Impacts of tourism hotspots on vegetation communities show a higher potential for self-propagation along roads than hiking trails. *Journal of environmental management*, 143: 173–185.

Youngentob, K. N., Wood, J. T. & Lindenmayer, D. B., 2013. The response of arboreal marsupials to landscape context over time: a large-scale fragmentation study revisited. *Journal of Biogeography*, 40: 2082-2093.

Zwart, M. C., Dunn, J. C., McGowan, P. J. K., & Whittingham, M. J., 2016. Wind farm noise suppresses territorial defence behaviour in a songbird. *Behavioural Ecology*, 27(1): 101-108.

About Windlab

Windlab is a global renewable energy development company. It was established to commercialise world leading atmospheric modelling and wind energy assessment technology, developed by Australia's premier scientific research institute, the CSIRO. Windlab owns and exclusively utilises this suite of industry best practice tools to identify and efficiently develop, finance, construct and operate high quality wind farms around the world, with considerably greater certainty and substantially less risk.

This technological advantage has enabled Windlab to amass a large portfolio of high quality wind farm development sites across North America, Australia, New Zealand and Southern Africa.

www.windlab.com