October 2023

AVIATION IMPACT ASSESSMENT

# MORETON HILL WIND FARM

*Prepared for MHWF Nominees Pty Ltd*

AVIATION PROJECTS

## DOCUMENT CONTROL

| | |
|---|---|
| Document Title: | Moreton Hill Wind Farm – Aviation Impact Assessment |
| Reference: | 104405-01 |
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| Reviewed by: | K Tonkin |
| Released by: | P White |

## REVISION HISTORY

| Version | Description | Transmitted | Reviewed by | Date |
|---|---|---|---|---|
| 0.1 | First draft | 25 October 2023 | PL | 25 October 2023 |
| 1.0 | Final Report | 26 October 2023 | | |
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# ACRONYMS

| | |
|---|---|
| AAAA | Aerial Agricultural Association of Australia |
| AC | Advisory Circular |
| AFAC | Australasian Fire and Emergency Services Council |
| AGL | above ground level |
| AHD | Australian Height Datum |
| AIA | aviation impact assessment |
| AIP | Aeronautical Information Package |
| AIS | aviation impact statement |
| ALA | aircraft landing area |
| ALARP | as low as reasonably practicable |
| AMSL | above mean sea level |
| ARP | Aerodrome Reference Point |
| AS | Australian Standards |
| AsA | Airservices Australia |
| ATSB | Australian Transport Safety Bureau |
| BoM | Bureau of Meteorology |
| CAO | Civil Aviation Orders |
| CAR | Civil Aviation Regulation (1988) |
| CASA | Civil Aviation Safety Authority |
| CASR | Civil Aviation Safety Regulation (1998) |
| CFIT | controlled flight into terrain |
| CNS | communications, navigation and surveillance |
| DAH | Designated Airspace Handbook |
| EIS | environmental impact statement |
| ERC-H | en-route chart high |
| ERC-L | en-route chart low |
| ERSA | En Route Supplement Australia |
| GA | general aviation |
| ICAO | International Civil Aviation Organization |
| IFR | instrument flight rules |

| | |
|---|---|
| IMC | instrument meteorological conditions |
| LGA | local government area |
| LSALT | lowest safe altitude |
| MOC | minimum obstacle clearance |
| MOS | Manual of Standards |
| MSA | minimum sector altitude |
| NASAG | National Airports Safeguarding Advisory Group |
| NASF | National Airports Safeguarding Framework |
| NDB | non-directional (radio) beacon |
| OLS | obstacle limitation surface |
| PANS-OPS | Procedures for Air Navigation Services - Aircraft Operations |
| PSR | primary surveillance radar |
| RAAF | Royal Australian Air Force |
| RFDS | Royal Flying Doctor Service |
| RPT | regular public transport |
| RSR | route surveillance radar |
| SSR | secondary surveillance radar |
| VFR | visual flight rules |
| VFRG | visual flight rules guide |
| VMC | visual meteorological conditions |
| WMTs | wind monitoring towers |
| WTGs | wind turbine generators |

## UNITS OF MEASUREMENT

| | | |
|---|---|---|
| ft | feet | (1 ft = 0.3048 m) |
| km | kilometres | (1 km = 0.5399 nm) |
| m | metres | (1 m = 3.281 ft) |
| nm | nautical miles | (1 nm = 1.852 km) |

## DEFINITIONS

Definitions of key aviation terms are included in **Annexure 2**

# EXECUTIVE SUMMARY

**Introduction**

MHWF Nominees Pty Ltd (MHWF) is proposing to develop the Moreton Hill Wind Farm (the Project), located approximately 33 kilometres (km) southwest of Ballarat, Victoria.

MHWF has engaged Aviation Projects to prepare an Aviation Impact Assessment (AIA) to support the proposed development application and formally consult with aviation agencies.

This AIA assesses the potential aviation impacts, provides aviation safety advice in respect of relevant requirements of air safety regulations and procedures, and informs and documents consultation with relevant aviation agencies.

This AIA report includes an Aviation Impact Statement (AIS) and a qualitative risk assessment to determine the need for obstacle lighting.

**Aviation Impact Assessment**

Based on the Project layout with a maximum height of up to 638.2 m/2094 ft AHD, the Project:

- would not infringe the OLS at Ballarat Airport
- would not infringe the PANS-OPS surface related to the Ballarat Airport 25 nm MSA
- would not have an impact on the relevant Grid LSALT
- would require an increase in the LSALTs for two air routes (V126 and W571) to accommodate the Project
- would not affect the nearest ALA which is outside the area suggested by NASF Guideline D in which downwind turbulence from the wind farm could be experienced
- would not infringe standard aerodrome circuit operations at the closest ALA
- is wholly contained within Class G airspace
- is outside the clearance zones associated with civil aviation navigation aids and communication facilities.

**Obstacle lighting risk assessment**

Aviation Projects has undertaken a safety risk assessment of the Project and concludes that WTGs and temporary/permanent WMTs that are installed in close proximity to a WTG will not require obstacle lighting to maintain an acceptable level of safety to aircraft.

Temporary WMTs that are installed prior to WTG installation, and WMTs that are not in close proximity to a WTG, will require obstacle lighting to maintain an acceptable level of safety.

**Consultation**

An appropriate and justified level of consultation will be undertaken with relevant parties after acceptance of the final draft report and authorisation from MHWF.

Refer to Section 5 for details of the stakeholders consulted and a summary of the consultation.

**Summary of key recommendations**

A summary of the key recommendations of this AIA is set out below.

1. CASR 139.165 requires the owner of a structure (or proponents of a structure) that will be 100 m or more above ground level to inform CASA. This must be given in written notice and contain information on the proposal, the height and location(s) of the object(s) and the proposed timeframe for construction. This is to allow CASA to assess the effect of the structure on aircraft operations and determine whether or not the structure will be hazardous to aircraft operations.
   The proponent is required to report the WMT to CASA in accordance with CASR 139.165, as soon as practicable after forming the intention to construct or erect the proposed object or structure.
   The notification should be provided to CASA via email to Airspace.Protection@casa.gov.au .

2. 'As constructed' details of WMT coordinates and elevation should be provided to Airservices Australia, by submitting the form at this webpage: https://www.airservicesaustralia.com/wp-content/uploads/ATS-FORM-0085_Vertical_Obstruction_Data_Form.pdf to the following email address: vod@airservicesaustralia.com .
   Ideally this should only be done if potential impacts have been considered – through an aviation impact assessment or by sending the details to Airservices Australia in advance of the mast being erected, at this email address: airport.developments@airservicesaustralia.com .
   Details of the wind farm should be provided to local and regional aircraft operators prior to construction in order for them to consider the potential impact of the wind farm on their operations.

3. To facilitate the flight planning of aerial application operators, details of the Project, including the 'as constructed' location and height information of WTGs, WMTs and overhead transmission lines should be provided to landowners so that, when asked for hazard information on their property, the landowner may provide the aerial application pilot with all relevant information.

Operation

4. Whilst not a statutory requirement, the Proponent should consider engaging with any local aerial agricultural operators and aerial firefighting operators in developing procedures for such aircraft operations in the vicinity of the Project.

Marking of WTGs

5. The rotor blades, nacelle and the mast supporting the WTGs should be painted white, typical of most WTGs operational in Australia. No additional marking measures are required for WTGs.

Lighting of WTGs

6. Aviation Projects has assessed that the Project will not require obstacle lighting to maintain an acceptable level of safety to aircraft.

Marking of wind monitoring towers

7. Consideration should be given to marking the temporary and permanent WMTs according to the requirements set out in MOS 139 Section 8.10 (as modified by the guidance in NASF Guideline D). Specifically:

   a. marker balls or high visibility flags or high visibility sleeves should be placed on the outside guy wires

   b. paint markings should be applied in alternating contrasting bands of colour to at least the top 1/3 of the mast

c. ensuring the guy wire ground attachment points have contrasting colours to the surrounding ground/vegetation.

**Lighting of wind monitoring towers**

8. Consideration should be given to lighting temporary WMTs that are installed prior to WTG installation and WMTs that are not in close proximity to a WTG with medium intensity steady red obstacle lighting at the top of the WMT mast. Characteristics for medium-intensity obstacle lighting are contained in MOS 139, Section 9.33.

**Micrositing**

9. The potential micrositing of the WTGs and WMTs has been considered in the assessment with the estimate of the overall maximum height being based on the highest ground level within 100 m of the nominal WTG and WMT positions. Providing the micrositing is within 100 m of the WTGs and WMTs is likely to not result in a change in the maximum overall blade tip height of the Project. No further assessment is likely to be required from micrositing and the conclusions of this AIA would remain the same.

**Triggers for review**

10. Triggers for review of this risk assessment are provided for consideration:

    a. prior to construction to ensure the regulatory framework has not changed

    b. following any significant changes to the context in which the assessment was prepared, including the regulatory framework

    c. following any near miss, incident or accident associated with operations considered in this risk assessment.

# 1. INTRODUCTION

## 1.1. Situation

MHWF Nominees Pty Ltd (MHWF) is proposing to develop the Moreton Hill Wind Farm (the Project), located approximately 33 kilometres (km) southwest of Ballarat, Victoria.

MHWF has engaged Aviation Projects to prepare an Aviation Impact Assessment (AIA) to support the proposed development application and formally consult with aviation agencies.

This AIA assesses the potential aviation impacts, provides aviation safety advice in respect of relevant requirements of air safety regulations and procedures, and informs and documents consultation with relevant aviation agencies.

This AIA report includes an Aviation Impact Statement (AIS) and a qualitative risk assessment to determine the need for obstacle lighting.

## 1.2. Purpose and Scope

The purpose and scope of work is to prepare an AIA for consideration by Airservices Australia, CASA and Department of Defence and support the development application.

The assessment specifically responds to the:

- Victorian Government, Department of Environment, Land Water and Planning, *Development of Wind Energy Facilities in Victoria – Policy and Planning Guidelines* – November 2021
- Civil Aviation Safety Authority, *Civil Aviation Safety Regulations 1998* (CASR)
- Civil Aviation Safety Authority, Advisory Circular (AC) 139.E-05 v1.0 *Obstacles (including wind farms) outside the vicinity of a CASA certified aerodrome,* May 2021
- NASF Guideline D: *Managing the Risk to aviation safety of wind turbine installations (wind farms)/Wind Monitoring Towers*
- Aeronautical Impact Statement requirements as advised by Airservices Australia at https://www.airservicesaustralia.com/industry-info/airport-development-assessments/

Assistance will be provided in support of stakeholder consultation and engagement in preparing the assessment and negotiating acceptable mitigation to identified impacts.

### 1.3. Methodology

Aviation Projects conducted the task in accordance with the following methodology:

1. Confirm the scope and deliverables with the Proponent (or representative)
2. Review client material
3. Review relevant regulatory requirements and information sources
4. Prepare a draft AIA and supporting technical data that provides evidence and analysis for the planning application to demonstrate that appropriate risk mitigation strategies have been identified
5. Prepare an AIS for consideration by Airservices Australia
6. Prepare a qualitative risk assessment to determine need for obstacle lighting and marking
7. Identify risk mitigation strategies that provide an acceptable alternative to night lighting. The risk assessment was completed following the guidelines in *ISO 31000:2018 Risk Management – Guidelines*
8. Consult with relevant Certified Aerodrome Operators, Part 173 procedure designers (Airservices Australia) and aerodrome operators of the affected aerodrome/s to seek endorsement for possible changes to instrument flight procedures to accommodate the wind farm
9. Consult/engage with stakeholders to negotiate acceptable outcomes (if required)
10. Finalise the AIA report for client acceptance when responses received from stakeholders for client review and acceptance.

### 1.4. Aviation Impact Statement (AIS)

The AIS included in this report (see Section 6) includes the following specific requirements as advised by Airservices Australia:

Aerodromes:

- Specify all certified aerodromes that are located within 30 nm (55.6 km) of the project site
- Nominate all instrument flight procedures
- Nominate visual flight procedures and likely impacts
- Review the potential effect of the Project operations on the operational airspace of the aerodrome(s).

Air Routes:

- Nominate air routes which are located near/over the project site and review potential impacts of Project operations on aircraft using those air routes

Airspace:

- Nominate the airspace classification – A, B, C, D, E, G etc where the project site is located

Navigation/Radar:

- Nominate radar navigation systems with coverage overlapping the site.

## 1.5. Material reviewed

Material provided by the Proponent for preparation of this assessment include:

- 20230828 MHWF WTG Rev 1 for aviation.csv
- 20230829 MHWF Mest mast Rev 1.csv
- 20230829 MHWF Mest mast Rev 1.kml
- 20230829 MHWF WTGS Rev 1.kml.

# 2. BACKGROUND

## 2.1. Site overview

The Project site is located approximately 33 km (17.8 nm) southwest of Ballarat Airport and 7.3 km, in Victoria.

An overview of the Project site is provided in Figure 1 (source: MHWF, Google Earth).

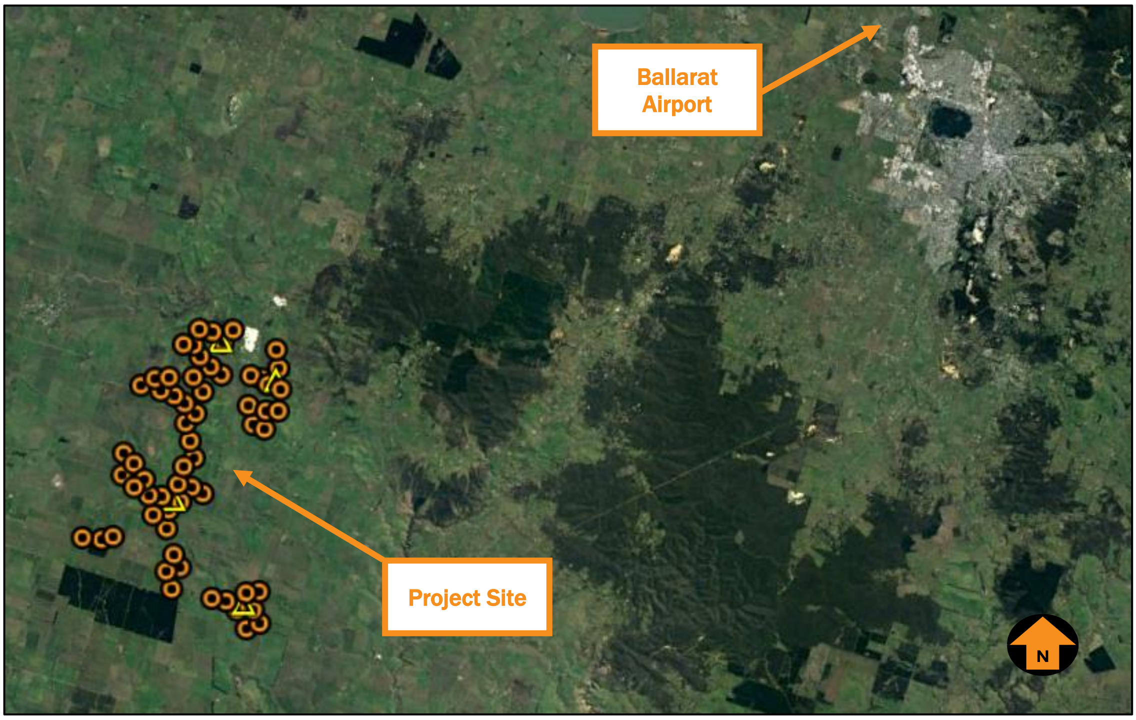


Figure 1 Project site location overview

## 2.2. Project Description

The Project involves the construction, operation, and maintenance of the Moreton Hill Wind Farm:

- Up to 62 Wind Turbine Generators (WTG) with:
  - three blade turbine rotor with a diameter of 172 m mounted to a rotor hub (hub height of 166 m) on a nacelle above a tubular steel tower, with a blade tip height (blade length plus hub height) of up to 252 m above ground level (AGL)
  - a gearbox and generator assembly housed in the nacelle; and
  - adjacent hardstands for use as crane pads, assembly and laydown areas
- Four (4) WMT with a maximum height of 160 m AGL at the locations indicated.

An overview of the Project site is provided in Figure 2 (source: MHWF, Google Earth). The highest WTG, #17 is highlighted in red.

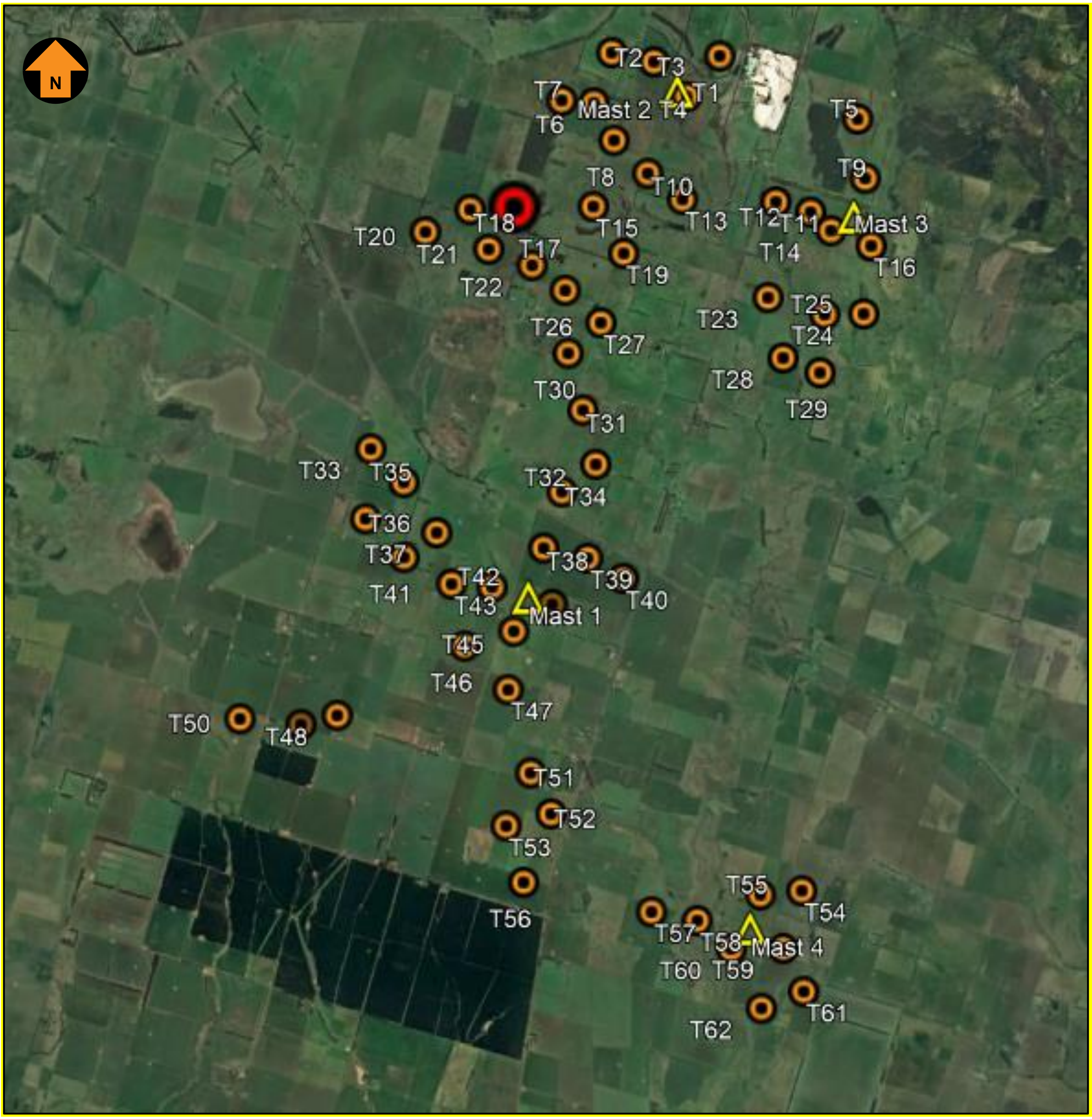


Figure 2 Project layout

# 3. EXTERNAL CONTEXT

### 3.1. Victorian Planning Context

The Victorian Government supports the development of the renewable energy sector as an important contributor to the sustainable delivery of Victoria's future energy needs.

The current Department of Transport and Planning (DTP), formerly DELWP, includes the protection of airports and their operations, especially in relation to:

- Aircraft noise
- Protected airspace
- Wildlife strikes
- Lighting distractions to pilots
- Wind turbines
- Building generated windshear/turbulence.

DTP has published a *"Policy and planning guidelines for development of wind energy facilities in Victoria"* dated November 2021 which includes "*Aircraft safety*".

Section 4.3.5 Aircraft Safety Issues

> *The height of wind energy turbines can be substantial, resulting in potential impacts upon nearby airfields and air safety navigation. Applicants should address aircraft safety issues by considering the proximity of the site to airports, aerodromes, or landing strips.*
>
> *Applicants should consult with the Civil Aviation Safety Authority (CASA) for wind energy facility proposals that:*
>
> - *are within 30 kilometres of a declared aerodrome or airfield*
> - *infringe the obstacle limitation surface around a declared aerodrome*
> - *include a building or structure the top of which will be 110 metres or more above natural ground level (height of a wind turbine is that reached by the tip of the turbine blade when vertical above ground level).*
>
> *Early engagement with aviation safety organisations like CASA is encouraged as aviation safety is a complex area of wind energy facility assessment.*
>
> *In addition to CASA consultation, the following is relevant for anemometers and other pre-permit infrastructure.*
>
> *The Aeronautical Information Service of the Royal Australian Air Force (RAAF AIS) maintains a database of tall structures in the country. The RAAF AIS should be notified of all tall structures meeting the following criteria:*
>
> - *30 metres or more above ground level for structures within 30km of an aerodrome; or*
> - *45 metres or more above ground level for structures located elsewhere.*
>
> *The contact details for the RAAF AIS are: Tel: (03) 9282 5750; ais.charting@defence.gov.au .*

*Operators of certified aerodromes are required to notify CASA if they become aware of any development or proposed construction near the aerodrome that is likely to create an obstacle to aviation, or if an object will infringe the Obstacle Limitation Surfaces (OLS) or Procedures for Air Navigation Services –Operations (PANS-OPS) surfaces of an aerodrome. Operators of registered aerodromes should advise CASA if the proposal will infringe the OLS; CASA will ask Airservices to determine if there is an impact on published flight procedures for the aerodrome.*

Section 5.1.5 Aircraft Safety

*The height of wind energy turbines can be substantial, resulting in potential impacts upon nearby airfields and air safety navigation. A responsible authority should consider the proximity of the site to airports, aerodromes or landing strips, and ensure that any aircraft safety issues are identified and addressed appropriately.*

*Although the Civil Aviation Safety Authority (CASA) is not a formal referral authority for wind energy facility permit applications, a responsible authority should nevertheless consult with CASA in relation to aircraft safety impacts of a wind energy facility proposal, particularly proposals that:*

- *are within 30 kilometres of a declared aerodrome or airfield;*
- *infringe the obstacle limitation surface around a declared aerodrome;*
- *include a building or structure the top of which will be 110 metres or more above natural ground level (height of a wind turbine is that reached by the tip of the turbine blade when vertical above ground level).*

*Other private airstrips may not be identified by consultation with CASA. These may be identified using aerial photographs, discussions with the relevant council, or consultation with local communities.*

*A responsible authority should ensure that the proponent has consulted appropriately with CASA in relation to aircraft safety and navigation issues. It is recommended that the proponent consults and receives approval from CASA prior to lodging their application for ease of process. Refer to Section*

*4.3.6 of these guidelines for more detail.*

*CASA may recommend appropriate safeguards to ensure aviation safety. These may include changes to turbine locations, turbine heights and/or the provision of aviation safety lighting. A responsible authority should ensure that any concerns raised by CASA are appropriately reflected in permit conditions.*

*Aviation safety lighting can have an impact on the amenity of the surrounding area. Responsible authorities may consider the following impact reduction measures (subject to CASA requirements and advice):*

- *reducing the number of wind turbines with obstacle lights;*
- *specifying an obstacle light that minimises light intensity at ground level;*
- *specifying an obstacle light that matches light intensity to meteorological visibility;*
- *mitigating light glare from obstacle lighting through measures such as baffling.*

### 3.2. National Airports Safeguarding Framework

The National Airports Safeguarding Advisory Group (NASAG) was established by Commonwealth Department of Infrastructure and Transport to develop a national land use planning framework called the National Airports Safeguarding Framework (NASF). The purpose of the NASF is to enhance the current and future safety, viability, and growth of aviation operations at Australian airports through:

- the implementation of best practice in relation to land use assessment and decision making in the vicinity of airports
- assurance of community safety and amenity near airports
- better understanding and recognition of aviation safety requirements and aircraft noise impacts in land use and related planning decisions
- the provision of greater certainty and clarity for developers and landowners
- improvements to regulatory certainty and efficiency
- the publication and dissemination of information on best practice in land use and related planning that supports the safe and efficient operation of airports.

NASF Guideline D: *Managing the Risk to Aviation Safety of Wind Turbine Installations (Wind Farms)/Wind Monitoring Towers*, provides guidance to State/Territory and local government decision makers, airport operators and developers of wind farms to jointly address the risk to civil aviation arising from the development, presence and use of wind farms and WMTs.

The methodology for preparing the risk assessment is contained in the NASF Guideline D *Managing the Risk of Wind Turbine Farms as Physical Obstacles to Air Navigation*.

The risk assessment will have regard to all potential aviation activities within the vicinity of the Project site including recreation, commercial, civil (including for agricultural purposes) and military operations.

The AIS of this report identifies high level risks, risk mitigation measures and development constraints that are likely to be applicable to the aviation risk assessment.

### 3.3. Aircraft operations at non-controlled aerodromes

There are several uncontrolled aerodromes in the vicinity of the Project Area. Advisory Circulars (ACs) provide advice and guidance from CASA to illustrate a means, but not necessarily the only means, of complying with the Regulations, or to explain certain regulatory requirements.

Advisory Circular (AC) 91-10 v1.1 *Operations in the vicinity of non-controlled aerodromes* provides guidance for pilots flying at or in the vicinity of non-controlled aerodromes, with respect to CASR 91.

A conventional circuit pattern and heights are provided in AC 91-10 v1.1. The standard circuit consists of a series of flight paths known as *legs* when departing, arrival or when conducting circuit practice. Illustrations of the standard aerodrome traffic circuit procedures provided in AC 91-10 v1.1. are shown in Figure 3 and Figure 4.

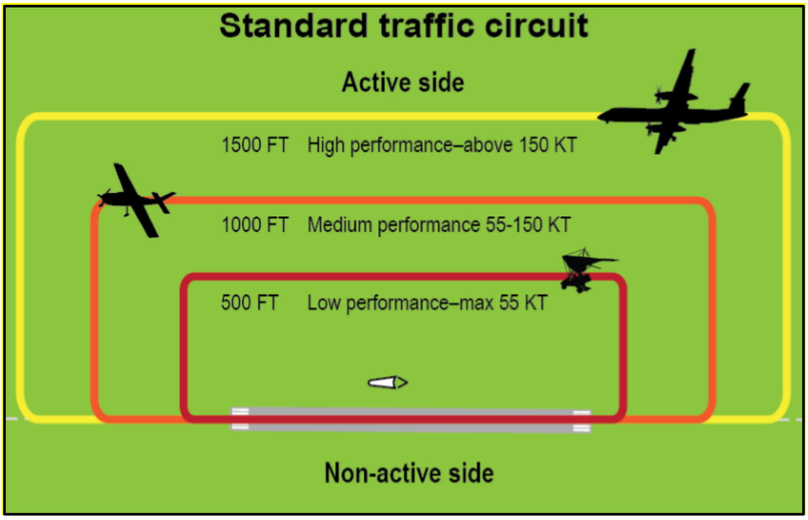


Figure 3 Lateral and vertical separation in the standard aerodrome traffic circuit

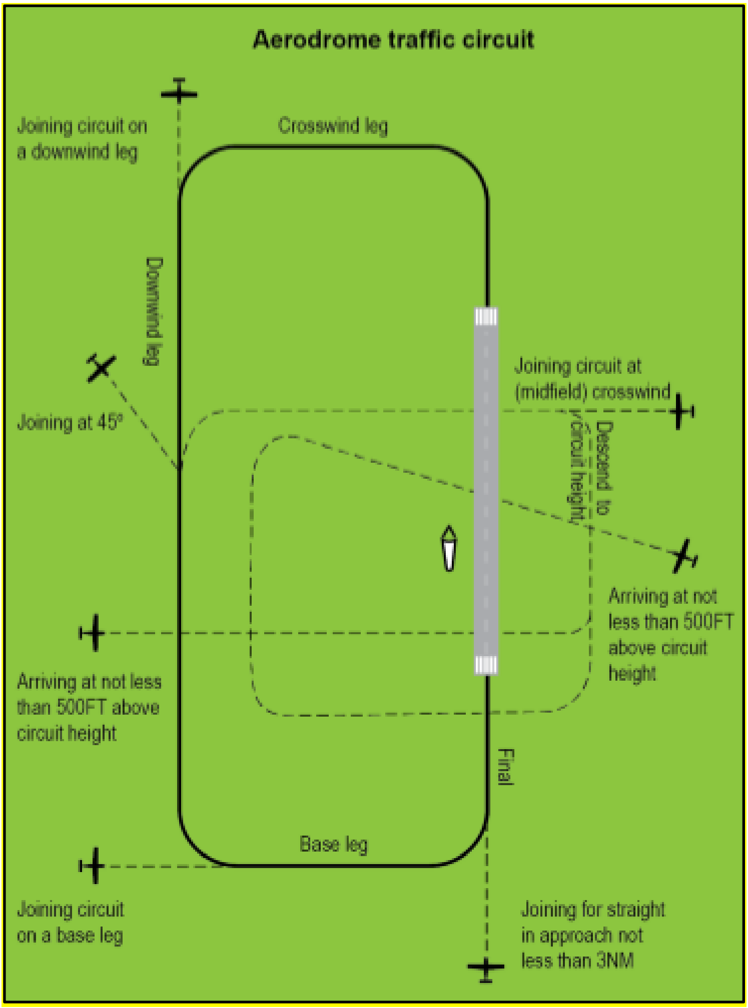


Figure 4 Aerodrome standard traffic circuit, showing arrival and joining procedures

AC 91-10 v1.1. paragraph 7.10 makes reference to a distance that is "normally" well outside the circuit area and where no traffic conflict exists, which is at least 3 nm (5556 m). The paragraph is copied below:

> *7.10 Departing the circuit area*
>
> *7.10.1 Aircraft should depart the aerodrome circuit area by extending one of the standard circuit legs or climbing to depart overhead. However, the aircraft should not execute a turn to fly against the circuit direction unless the aircraft is well outside the circuit area and no traffic conflict exists. This will normally be at least 3 NM from the departure end of the runway, but may be less for aircraft with high climb performance. In all cases, the distance should be based on the pilot's awareness of traffic and the ability of the aircraft to climb above and clear of the circuit area.*

## 3.4. Rules of flight

### 3.4.1. Flight under Day Visual Flight Rules (VFR)

According to Aeronautical Information Publication (AIP) the meteorological conditions required for visual flight in the applicable (Class G) airspace at or below 3000 ft AMSL or 1000 ft AGL whichever is the higher are: 5000 m visibility, clear of clouds and in sight of ground or water.

Civil Aviation Safety Regulation (1998) 91.267 (Minimum height rules—other areas) prescribes the minimum height for flight. Generally speaking, and unless otherwise approved, aircraft are restricted to a minimum height of 500 ft AGL above the highest point of the terrain and any object on it within a radius of 300 m in visual flight during the day when not in the vicinity of built-up areas, and 1000 ft AGL over built up areas (within a horizontal radius of 600 m of the point on the ground or water immediately below the aeroplane).

These height restrictions do not apply if through stress of weather or any other unavoidable cause it is essential that a lower height be maintained.

Flight below these height restrictions is also permitted in certain other circumstances.

### 3.4.2. Night VFR

With respect to flight under the VFR at night, Civil Aviation Safety Regulations (1998) 91.277 requires that the pilot in command of an aircraft flying VFR at night must not fly below the following heights (unless during take-off and landing operations, within 3 nm of an aerodrome, or with an air traffic control clearance):

a) *the published lowest safe altitude for the route or route segment (if any);*

b) *the minimum sector altitude published in the authorised aeronautical information for the flight (if any);*

c) *the lowest safe altitude for the route or route segment;*

d) *1,000 ft above the highest obstacle on the ground or water within 10 nautical miles ahead of, and to either side of, the aircraft at that point on the route or route segment;*

e) *the lowest altitude for the route or route segment calculated in accordance with a method prescribed by the Part 91 Manual of Standards for the purposes of this paragraph.*

### 3.4.3. Instrument Flight Rules (IFR) (Day or night)

According to CASR 91, flight under the instrument flight rules (IFR) requires an aircraft to be operated at a height clear of obstacles that is calculated according to an approved method. Obstacle lights on structures not within the vicinity of an aerodrome are effectively redundant to an aircraft being operated under the IFR due to the minimum obstacle clearance requirement for a flight path above the highest terrain or obstacles within the relevant flight path segment.

### 3.5. Aircraft operator characteristics

Flying training may be conducted under either the instrument flying rules (IFR) or the visual flight rules (VFR). Other general aviation operations under either IFR or VFR are also likely to be conducted at various aerodromes in the area.

Operations conducted under VFR are required to remain in visual meteorological conditions (VMC) (at least 5,000 m horizontal visibility at a similar height of the WTGs) and clear of the highest point of the terrain by 500 ft vertical distance and 300 m horizontal distance.

In Visual Meteorological Conditions (VMC), the WTGs will likely be sufficiently conspicuous to allow adequate time for pilots to avoid the obstacles. VFR operators will most likely avoid the Project Area once WTGs are erected.

Flight under day VFR is conducted above 500 ft (152.4 m) above the highest point of the terrain within a 300 m radius unless the operation is approved to operate below 500 ft AGL.

It is expected that the WTGs will be easily recognised by pilots conducting VFR operations within the vicinity of the Project to enable appropriate obstacle avoidance manoeuvring.

IFR and Night VFR (which are required to conform to IFR applicable altitude requirements) aircraft operations are addressed in Section 6.

### 3.6. Passenger transport operations

Scheduled and non-scheduled passenger carrying operations are generally operated under the IFR and are therefore protected by the PANS-OPS surfaces relevant to their flight path.

### 3.7. Private operations

Private operations are generally conducted under day or night VFR, with some IFR. Flight under day VFR is conducted above 500 ft AGL and usually at much higher altitudes for fuel efficiency, ease of navigation and passenger comfort.

### 3.8. Military operations

There may be some high-speed low-level military jet aircraft and helicopter operations conducted in the area. Military operations are conducted under separate but compatible regulations and standards, including obstacle separation requirements. Detailed low level route survey, pre-flight planning and specific authorisation for these flights provides pilots with detailed information about the area in which the flight is planned to operate.

### 3.9. Aerial application operations

Aerial application operations including such activities as fertiliser, pest and crop spraying are generally conducted under day VFR below 500 ft AGL: usually between 6.5 ft (2 m) and 100 ft (30.5 m) AGL.

Aerial application operations are conducted in the area.

Due to the nature of the operations conducted, aerial application pilots are subject to rigorous training and assessment requirements to obtain and maintain their licence to operate under these conditions.

The Aerial Application Association of Australia (AAAA) has a formal risk management program (which is recommended for use by its members) to assess the risks associated with their operations and implement applicable treatments to ensure an acceptable level of safety can be maintained.

The impact of the proposed WTGs on the safe and efficient aerial application of agricultural fertilisers and pesticides in the vicinity of the Project site was assessed.

### 3.10. Aerial Application Association of Australia (AAAA)

In previous consultation with the AAAA, Aviation Projects has been directed to the AAAA Windfarm Policy (dated March 2011) which states in part:

> *In other areas, AAAA is also opposed to wind farm developments unless the developer is able to clearly demonstrate they have:*
>
> *1. consulted honestly and in detail with local aerial application operators;*
>
> *2. sought and received an independent aerial application expert opinion on the safety and economic impacts of the proposed development;*
>
> *3. clearly and fairly identified that there will be no short or long term impact on the aerial application industry from either safety or economic perspectives;*
>
> *4. if there is an identified impact on local aerial application operators, provided a legally binding agreement for compensation over a fair period of years for loss of income to the aerial operators affected; and*
>
> *5. adequately marked any wind farm infrastructure and advised pilots of its presence.*

The AAAA's National Wind Farm Operating Protocols list considerations for developers during the design/build stage and the operational stage, for pilots/aircraft operators during aircraft operations and discusses economic compensation. NASF Guideline D is included in the Protocols document as Appendix 1, and AAAA Aerial Application Pilots Manual – excerpts on planning are provided as Appendix II.

This AIA has been prepared in consideration of the National Windfarm Operating Protocols.

### 3.11. Local aerial application operators

Local aerial application operators consulted in previous studies undertaken by Aviation Projects have stated that a wind farm would, in all likelihood, prevent aerial agricultural operations in that particular area, but that properties adjacent to the wind farm would have to be assessed on an individual basis.

Aerial application operators generally align their positions with the AAAA policies.

Based on previous studies for other wind farm projects undertaken by Aviation Projects, and the results of consultation with AAAA and local aerial application operators, it is reasonable to conclude that safe aerial application operations would be possible on properties within the Project site and on neighbouring properties, subject to final WTG locations and by implementing recommendations provided in this report at Section 11.

To facilitate the flight planning of aerial application operators, details of the Project, including location and height information of WTGs, wind WMTs and overhead powerlines should be provided to landowners so that, when asked for hazard information on their property, the landowner may provide the aerial application pilot with all relevant information.

The use of helicopters enables aerial application operations to be conducted in closer proximity to obstacles than would be possible with fixed wing aircraft due to their greater manoeuvrability.

### 3.12. Aeromedical services

Royal Flying Doctor Service (RFDS) and other emergency services operations are generally conducted under the IFR, except when arriving/departing a destination that is not serviced by instrument approach aids or procedures, in which case they would be operating under day or night VFR.

Most emergency aviation services organisations have formal risk management programs to assess the risks associated with their operations and implement applicable treatments to ensure an acceptable level of safety can be maintained.

For example, pilots and crew require specific training and approvals, additional equipment is installed in the aircraft, and special procedures are developed.

Refer to Section 5 for detailed responses from emergency service stakeholders.

### 3.13. Aerial firefighting

Aerial firefighting operations (firebombing in particular) are conducted under Day VFR, often below 500 ft AGL. Under certain conditions visibility may be reduced/limited by smoke/haze.

Aerial firefighting organisations have formal risk management programs to assess the risks associated with their operations and implement applicable treatments to ensure an acceptable level of safety can be maintained. For example, pilots require specific training and approvals, additional equipment is installed in the aircraft, and special procedures are developed.

The Australasian Fire and Emergency Services Council (AFAC) has developed a national position on wind farms, their development and operations in relation to bushfire prevention, preparedness, response and recovery, set out in the document titled *Wind Farms and Bushfire Operations*, version 3.0, dated 25 October 2018.

Of specific interest in this document is the section extracted verbatim from under the ‘Response’ heading, copied below:

> *Wind farm operators should be responsible for ensuring that the relevant emergency protocols and plans are properly executed in an emergency event. During an emergency, operators need to react quickly to ensure they can assist and intervene in accordance with their planned procedures.*
>
> *The developer or operator should ensure that:*
>
> - *liaison with the relevant fire and land management agencies is ongoing and effective*
> - *access is available to the wind farm site by emergency services response for on-ground firefighting operations*
> - *wind turbines are shut down immediately during emergency operations – where possible, blades should be stopped in the ‘Y’ or ‘rabbit ear’ position, as this positioning allows for the maximum airspace for aircraft to manoeuvre underneath the blades and removes one of the blades as a potential obstacle.*
>
> *Aerial personnel should assess risks posed by aerial obstacles, wake turbulence and moving blades in accordance with routine procedures.*

MHWF intends to consult with fire services (aerial and ground) before making any commitment to operational procedures.

# 4. INTERNAL CONTEXT

### 4.1. Wind farm site description

The Project involves the construction, operation, and maintenance of the Moreton Hill Wind Farm:

- Up to 62 Wind Turbine Generators (WTG) with:
    - three blade turbine rotor with a diameter of 172 m mounted to a rotor hub (hub height of 166 m) on a nacelle above a tubular steel tower, with a blade tip height (blade length plus hub height) of up to 252 m above ground level (AGL)
    - a gearbox and generator assembly housed in the nacelle; and
    - adjacent hardstands for use as crane pads, assembly and laydown areas
- Four (4) WMT with a maximum height of 160 m AGL at the locations indicated.

An overview of the Project site is provided in Figure 2 (source: MHWF, Google Earth). The highest WTG, #17 is highlighted in red.

The coordinates and ground elevations of the proposed WTGs and WMTs analysed are listed in Annexure 5.

The potential micrositing of the WTGs has been considered in the assessment with the estimate of the overall maximum height being based on the highest ground level within 100 m of the nominal WTG position.

'Micrositing' of WTGs means an alteration to the siting of a WTG by not more than 100 m and any consequential changes to access tracks and internal power cable routes.

The micrositing of the WTGs is not likely to result in a change in the maximum overall blade tip height of the Project. This AIA assumes that a maximum blade tip height of 252 m AGL is implemented at all WTG locations.

# 5. CONSULTATION

The following list of stakeholders were identified as requiring consultation:

- Airservices Australia
- Department of Defence
- Royal Flying Doctor Service
- Victorian Country Fire Authority
- Victorian Police Air Wing
- Ambulance Victoria
- Field Air Ballarat

Details and results of the consultation activities will be incorporated into Table 1 once received.

Table 1 Stakeholder consultation details (TBC)

| *Agency/Contact* | *Activity/Date* | *Response/ Date* | *Issues Raised During Consultation* | *Action Proposed* |
|---|---|---|---|---|
| Airservices Australia | | | | |
| Department of Defence | | | | |
| Royal Flying Doctor Service | | | | |
| VIC CFA | | | | |
| VIC Police Air Wing | | | | |
| Ambulance Victoria | | | | |
| Field Air Ballarat | | | | |

# 6. AVIATION IMPACT STATEMENT

## 6.1. Overview

The NASF Guideline D: *Managing the Risk to Aviation Safety of Wind Turbine Installations (Wind Farms)/Wind Monitoring Towers* provides information to proponents and planning authorities to help identify any potential safety risks posed by WTG and wind monitoring installations from an aviation perspective.

Potential safety risks include (but are not limited to) impacts on flight procedures and aviation communications, navigation, and surveillance (CNS) facilities which require assessment by Airservices Australia.

To facilitate these assessments all wind farm proposals submitted to Airservices Australia must include an Aviation Impact Statement (AIS).

This analysis considers the aeronautical impact of the WTGs on the following:

- The operation of nearby certified aerodromes
- The operation of nearby aircraft landing areas (uncertified aerodromes)
- Grid and air route LSALTS
- Airspace protection
- Aviation facilities
- Radar installations
- Local aircraft operations.

## 6.2. Nearby certified aerodromes

The area of 30 nm (56 km) from a certified airport's aerodrome reference point (ARP) is used to identify possible constraints from the Project.

There is one certified airport located within 30 nm of the Project site:

- Ballarat Airport (YBLT) located approximately 17.8 nm to the northeast of the Project's boundary

The locations of the certified airport are shown in Figure 5 (source: MHWF, OzRunways).

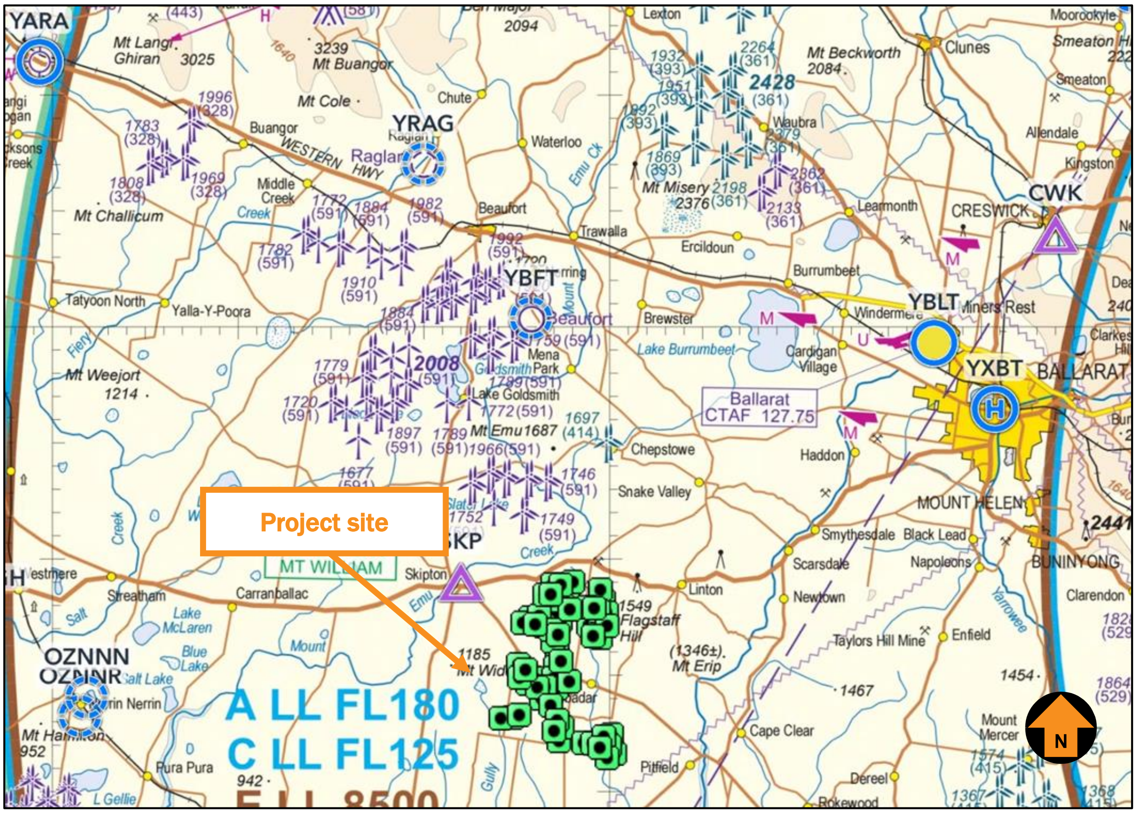


Figure 5 Ballarat Airport in relation to the Project site

### 6.3. Ballarat Airport

Ballarat Airport (YBLT) is a certified aerodrome, which is operated by the City of Ballarat council.

It is provided with instrument approach procedures that are published in the AIP.

#### 6.3.1. Instrument Approach Procedures

A check of Aeronautical Information Package (AIP) via the Airservices Australia website showed that YBLT is served by non-precision instrument flight procedures (source: AsA, effective 30 November 2023).

Table 2 identifies the aerodrome and procedure charts for YBLT, designed by Airservices Australia (AsA) as indicated.

Table 2 Ballarat Airport - aerodrome and procedure charts

| *Chart name* | *Effective date* |
|---|---|
| Aerodrome Chart | 30 November 2023 (Am 177) |
| RNP RWY 18 | 30 November 2023 (Am 177) |
| RNP RWY 36 | 30 November 2023 (Am 177) |

### 25 nm Minimum Safe Altitude

A minimum safe altitude (MSA) is applicable for each instrument approach procedure at YBLT.

The 25 nm MSA determines the altitude that all instrument approach procedures commence from and therefore the descent gradient applicable to each procedure.

An image of the MSA published for YBLT is shown in Figure 6 (source: AsA, 30 November 2023).

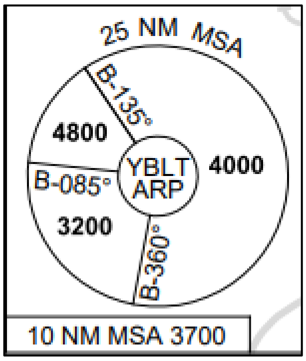


Figure 6 YBLT MSA diagram

International Civil Aviation Organisation (ICAO) and the CASR Part 173 Manual of Standards describes the design criteria applicable to instrument approach procedures, requires that a minimum obstacle clearance (MOC) of 984 ft above the highest obstacle within the protection area is applied.

Obstacles within the 10 nm MSA (within 15 nm of the reference point) and within the 25 nm MSA (within 30 nm of the reference point) define the lowest height at which an IFR aircraft can fly when within 10 nm and 25 nm when visual reference to the airport and local terrain has not been established.

The proposed Project is located within the 25 nm MSA area. The applicable MSA sector containing the Project has a minimum altitude of 3200 ft AMSL and a PANS-OPS surface elevation of 2216 ft AMSL (683.4 m AHD). (See Figure 7)

The maximum height of the WTGs is 2094 ft AMSL (638.2 m AHD).

This is lower than the PANS-OPS surface and therefore the project does not impact the 25 nm MSA minimum altitude.

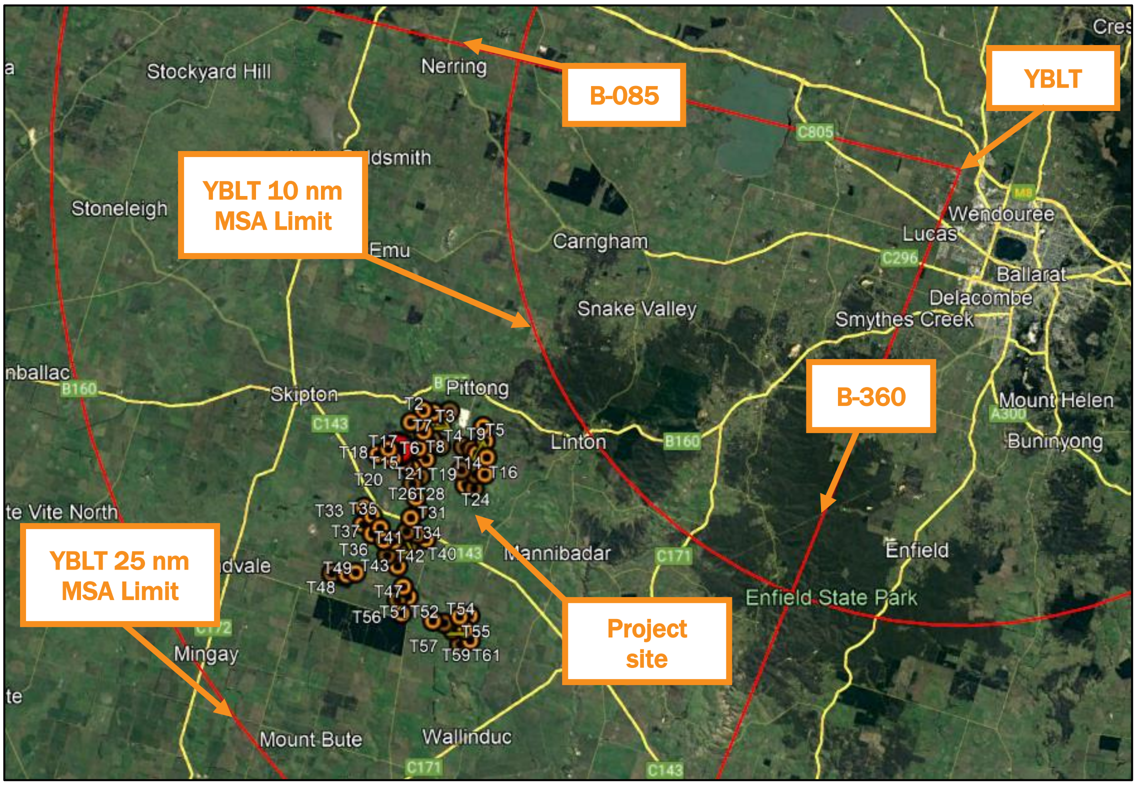


Figure 7 Location within the 25 nm MSA limits

#### Circling Areas

Ballarat Airport is capable of accepting aircraft operations up to Performance Category B aircraft such as twin engine aircraft similar to the RFDS Super King Air.

The maximum horizontal distance that the Category B circling area may extend for an aerodrome in Australia is 2.66 nm (4.9 km) from the threshold of each usable runway.

The entire project is located outside the horizontal extent of the IFR circling areas at Ballarat Airport.

The circling areas are not infringed.

#### Instrument Approach Procedures

All instrument approach procedures commence approximately 15 nm from the airport.

The instrument approach procedures flight paths are not located over any part of the proposed wind farm.

### 6.3.2. Summary

The Moreton Hill Wind Farm project will not infringe any PANS-OPS surface associated with instrument flight procedures at Ballarat Airport.

### 6.3.3. OLS

OLS are established for each runway. They are based on the runway code.

Ballarat Airport's Runway 05/23 and 18/36 are both code 3 non-precision instrument approach runways.

For a Code 3 non-precision instrument runway, the maximum lateral extent of some segments of the OLS is up to 15 km from a runway.

The Project site is located beyond the horizontal extent of the OLS. Therefore, the Project site will not impact the Ballarat Airport OLS.

### 6.4. Nearby aircraft landing areas (uncertified aerodromes)

An area of 3 nm (5.6 km) radius of an aircraft landing areas (ALA) is considered as the area in which aircraft are preparing to land or are getting airborne after take-off and intercepting their outbound track. It is used to assess potential impacts of proposed developments on aircraft operations at or within the vicinity of the ALA.

A search of Airservices Australia (AIP), Ozrunways Electronic Flight Bag software program and the Australian Government National Map website did not identify any ALA within 3nm from the Project site. The aeronautical data provided by OzRunways is approved under CASR Part 175.

The closest ALA is located at a property titled Banongill, east of the Vite Vite -Skipton Road, approximately 6.1 nm (11.25 km) west from the nearest WTG.

#### 6.4.1. Summary

There are no ALAs located within 3 nm of any WTG.

### 6.5. Potential wake turbulence impacts

National Airports Safeguarding Framework (NASF) Guideline D – *Managing the Risk to Aviation Safety of Wind Turbine Installations (Wind Farms)/Wind Monitoring Towers* provides guidance to State/Territory and local government decision makers, airport operators and developers of wind farms to jointly address the risk to civil aviation arising from the development, presence and use of wind farms and WMTs.

NASF Guideline D provides guidance regarding WTG wake turbulence which states:

> *Wind farm operators should be aware that wind turbines may create turbulence which is noticeable up to 16 rotor diameters from the turbine. In the case of one of the larger wind turbines with a diameter of 150 metres, turbulence may be present two kilometres downstream. At this time, the effect of this level of turbulence on aircraft in the vicinity is not known with certainty. However, wind farm operators should be conscious of their duty of care to communicate this risk to aviation operators in the vicinity of the wind farm…*

The configuration for the WTGs is :

- Hub height to a maximum of 166 m AGL
- Blade length to a maximum of 86 m, providing a rotor diameter of 172 m
- Tip height to a maximum of 252 m AGL.

Based on the 172 m rotor diameter the maximum extent of downwind wake turbulence referred to in the NASF guideline is 2752 m.

The wake turbulence at 2752 m from the WTGs would likely be at its weakest intensity after being dissipated by other turbulent impacts such as trees and general terrain, low level vertical turbulence created by rising air from warm objects heated by the sun and wind strength and direction variations. It is likely that wake turbulence from the WTGs at this distance would not create an increased adverse impact to aircraft operations in the circuit area of an ALA, above the existing turbulence created by normal atmospheric and mechanical turbulence experienced by pilots throughout Australia.

Aviation Projects, through research, considers that any adverse turbulence would most likely be confined to within 7 rotor diameters of a WTG. Aviation Projects applies a conservative area within 10 rotor diameters when assessing downwind turbulence from WTGs. It would be the maximum area where wake turbulence from WTGs would be felt by pilots operating in the circuit area of an aerodrome. This area would therefore have a maximum radius of 1720 m from a WTG.

The nearest ALA, at Banongill, is located 6.1 nm from the nearest WTG within the project area.

Aircraft operations there will not be impacted by downwind turbulence from the Moreton Hill Wind Farm.

### 6.6. Grid and Air routes LSALT

CASR Part 173 MOS requires that the published LSALT, for a particular airspace grid or air route, provides a minimum of 1000 ft clearance above the controlling (highest) obstacle within the relevant airspace grid or air route tolerances.

#### 6.6.1. Grid LSALT

The Project site located within a grid with LSALT of 4800 ft AMSL which provide clearance above obstacles with heights up to 3800 ft AMSL.

The highest WTGs, at a maximum height of 2094 ft AMSL does not infringe the Grid LSALT protection surface.

The Grid LSALT is not impacted by the Project.

Figure 8 shows the Grid LSALT and the numerous air routes. They are shown in Table 3.

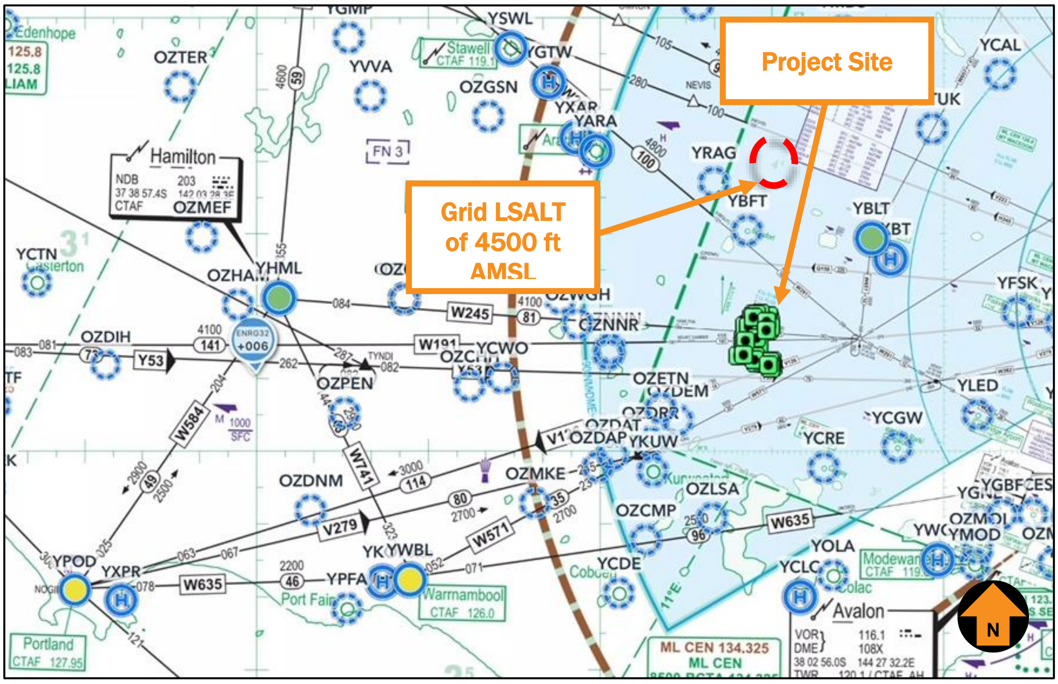


Figure 8 Grid LSALTs and Air Routes in proximity to the Project site

### 6.6.2. Air Route LSALTs

A protection area of approximately 7 nm laterally either side of an air route is used to assess the LSALT for the air route.

There are numerous air routes with a protection surface above the wind farm site the Project Site.

An impact analysis of the surrounding air routes is provided in Table 3.

Table 3 Air route impact analysis

| *Air route* | *Waypoint pair* | *Route LSALT (ft AMSL)* | *Obstacle Height Limit (ft AMSL)* | *Impact on airspace design* | *Potential solution* | *Impact on aircraft ops* |
|---|---|---|---|---|---|---|
| V126 | ESDIG - NOGIP | 3000 | 2000 | 94 ft infringement | Raise LSALT to 3100 ft AMSL | Minor |
| W191 | ESDIG – YHML | 4100 | 3100 | Nil | N/A | N/A |
| W245 | ESDIG – YMTG | 4100 | 3000 | Nil | N/A | N/A |
| W291 | ESDIG - UBGUT | 4800 | 3800 | Nil | N/A | N/A |
| W571 | ESDIG - LANUN | 3000 | 2000 | 94 ft infringement | Raise LSALT to 3100 ft AMSL | Minor |
| Y53 | TYNDI - WENDY | 4800 | 3800 | Nil | N/A | N/A |
| GRID | N/A | 4800 | 3800 | Nil | N/A | N/A |

The WTGs with a maximum elevation over 2000 ft AMSL infringe V126 and W571 necessitating an increase to their LSALT by 100 ft to accommodate the Project. The increase would cause a minor impact that would not be noticed by pilots.

## 6.7. Airspace Protection

The Project area is located outside of controlled airspace (wholly within Class G airspace) and are not located in any Prohibited, Restricted and Danger areas.

Therefore, the Project area will not have an impact on controlled or designated airspace.

## 6.8. Aviation facilities

The Project area is located sufficient distance away from nearby aviation navigation aids and facilities and will not have an impact on the aviation facilities.

## 6.9. ATC Radar installations

The closest ATC radar facility to the Project site is the Mt Macedon Secondary Surveillance Radar (SSR), which is located approximately 55 nm/101 km to the northeast of the Project.

The Project site is outside the radar assessment areas for the Mt Macedon radar and will not impact this facility.

### 6.10. AIS Summary

Based on the Project layout with a maximum height of up to 638.2 m/2094 ft AHD, the Project:

- would not infringe the OLS at Ballarat Airport
- would not infringe the PANS-OPS surface related to the Ballarat Airport 25 nm MSA
- would not have an impact on the relevant Grid LSALT
- would require an increase in the LSALTs for two air routes (V126 and W571) to accommodate the Project
- would not affect the nearest ALA is outside the area suggested by NASF Guideline D in which downwind turbulence from the wind farm could be experienced
- would not infringe standard aerodrome circuit operations at the closest ALA
- is wholly contained within Class G airspace
- is outside the clearance zones associated with civil aviation navigation aids and communication facilities.

The list of WTGs (obstacles), showing coordinates and elevation data that are applicable to this AIS, are provided in Annexure 5.

# 7. HAZARD LIGHTING AND MARKING

Based on the risk assessment set out in Section 9 it is concluded that aviation lighting is not required for WTGs and WMTs that are in close proximity to a WTG. Obstacle lighting is required for WMTs that are installed prior to WTG installation and WMTs that are not in close proximity to a WTG.

For completeness, relevant lighting standards and guidelines are summarised in **Annexure 3.**

Once the details of the wind farm, along with this report, are provided by the planning authority to CASA, CASA is likely to recommend obstacle lighting be fitted to sufficient obstacles to delineate the outline of the wind farm and the highest WTGs within it.

The Aviation Projects risk assessment for obstacle lighting should also be assessed by CASA.

## 7.1. Wind monitoring towers (WMTs)

Four (4) WMTs are planned to be installed at the Moreton Hill Wind Farm site. Each will have a maximum height of 160 m AGL.

This section describes the requirements for obstacle marking and/or lighting for WMTs.

Given that aerial operators might use the airspace within the Project site and that it is expected that WMTs will be constructed prior to WTGs, the WMTs may be free-standing and not surrounded by any other obstacles. Therefore, the proposed temporary and permanent WMTs should be marked and lit as per the content of NASF Guideline D.

In terms of obstacle marking and lighting requirements, relevant requirements set out in MOS 139 and NASF are provided below.

Consideration must be given to marking the WMTs according to the requirements set out in MOS 139 Chapter 8 Division 10 Obstacle Markings; specifically:

> *8.109 Obstacles and hazardous obstacles*
>
> *(1) The following objects or structures at an aerodrome are obstacles and must be marked in accordance with this Division unless CASA determines otherwise under subsections (3) and (5):*
>
>> *any fixed object or structure, whether temporary or permanent in nature, extending above the obstacle limitation surfaces. Note an ILS building is an example of a fixed object;*
>>
>> *any object or structure on or above the movement area that is removable and is not immediately removed.*
>
> *8.110 Marking of hazardous obstacles*
>
> *(5) long, narrow structures like masts, poles and towers which are hazardous obstacles must be marked in contrasting colour bands so that:*
>
>> *(a) the darker colour is at the top; and*
>>
>> *(b) the bands:*
>>
>>> *i. are, as far as physically possible, marked at right angles along the length of the long, narrow structure; and*
>>>
>>> *ii. have a length ("z" in Figure 8.110 (5)) that is, approximately, the lesser of:*

*(A) 1/7 of the height of the structure; or*

*(B) 30 m.*

*(7) Hazardous obstacles in the form of wires or cables must be marked using 3-dimensional coloured objects attached to the wire or cables. Note: Spheres and pyramids are examples of 3-dimensional objects.*

*(8) The objects mentioned in subsection (7) must:*

*(a) be approximately equivalent in size to a cube with 600 mm sides; and*

*(b) be spaced 30 m apart along the length of the wire or cable.*

NASF Guideline D suggests consideration of the following measures specific to the marking and lighting of WMTs:

- *the top 1/3 of wind monitoring towers to be painted in alternating contrasting bands of colour. Examples of effective measures can be found in the Manual of Standards for Part 139 of the Civil Aviation Safety Regulations 1998. In areas where aerial agriculture operations take place, marker balls or high visibility flags can be used to increase the visibility of the towers;*
- *marker balls or high visibility flags or high visibility sleeves placed on the outside guy wires;*
- *ensuring the guy wire ground attachment points have contrasting colours to the surrounding ground/vegetation;* ***or***
- *a flashing strobe light during daylight hours.*

It is our assessment that there will be an acceptable level of aviation safety risk associated with the potential for an aircraft collision with the Project permanent WMTs that are in close proximity to a WTG without obstacle lighting on the WMTs.

For temporary WMTs installed prior to WTG installation and WMTs that are not in close proximity to a WTG, there will be an acceptable level of aviation safety risk associated with the potential for an aircraft collision provided obstacle lighting is fitted with medium intensity lighting at the top of the mast to ensure visibility in low light and deteriorating atmospheric conditions.

Characteristics of medium-intensity lights are specified in MOS 139 Section 9.33:

1) *Medium-intensity obstacle lights must:*
   a) *be visible in all directions in azimuth; and*
   b) *if flashing — have a flash frequency of between 20 and 60 flashes per minute.*
2) *The peak effective intensity of medium-intensity obstacle lights must be 2 000 ☐ 25% cd with a vertical distribution as follows:*
   a) *for* **vertical beam spread** *— a minimum of 3 degrees;*
   b) *at -1 degree elevation — a minimum of 50% of the lower tolerance value of the peak intensity;*
   c) *at 0 degrees elevation — a minimum of 100% of the lower tolerance value of the peak intensity.*
3) *For subsection (2),* **vertical beam spread** *means the angle between 2 directions in a plane for which the intensity is equal to 50% of the lower tolerance value of the peak intensity.*

4) *If, instead of obstacle marking, a flashing white light is used during the day to indicate temporary obstacles in the vicinity of an aerodrome, the peak effective intensity of the light must be increased to 20 000 ± 25% cd when the background luminance is 50 cd/m² or greater.*

### 7.2. Overhead transmission line

There is no regulatory requirement to mark or light power poles or overhead transmission lines.

According to the AAAA *Powerlines Policy* dated March 2011:

> *Most agricultural land in Australia is crisscrossed with powerlines and aerial application companies and pilots put enormous effort into managing these hazards safely, generally using a risk identification, assessment and management process in line with Australian Standard AS4360/ISO 3[1]000.*
>
> *The agricultural pilot curriculum mandated by CASA includes training for the safe management of powerlines and AAAA has been active in providing ongoing professional development for application pilots that includes a focus on planning, risk management and a knowledge of human factors relevant to managing powerlines in a low-level aviation environment.*
>
> *AAAA runs a specific training course for aerial application pilots entitled 'Wire Risk Management' to address these issues.*

Overhead transmission lines and/or supporting poles that are located where they could adversely affect aerial application operations should be identified in consultation with local aerial application operators and marked in accordance with MOS 139 Chapter 8 Division 10 section 8.110 (7) and section 8.110 (8):

> *8.110 Marking of hazardous obstacles*
>
> *(7) Hazardous obstacles in the form of wires or cables must be marked using 3-dimensional coloured objects attached to the wire or cables. Note: Spheres and pyramids are examples of 3-dimensional objects.*
>
> *(8) The objects mentioned in subsection (7) must:*
> *(a) be approximately equivalent in size to a cube with 600 mm sides; and*
> *(b) be spaced 30 m apart along the length of the wire or cable.*

Following consultation with aerial operators, if a risk assessment is required, the Proponent should follow standards outlined in the AS 3891.2:2018 *Air navigation – Cables and their supporting structures – Marking and safety requirements Part 2: Low level aviation operations.*

# 8. ACCIDENT STATISTICS

This section establishes the external context to ensure that stakeholders and their objectives are considered when developing risk management criteria, and that externally generated threats and opportunities are properly taken into account.

## 8.1. General aviation operations

The general aviation (GA) activity group is considered by the Australian Transport Safety Bureau (ATSB) to be all flying activities that do not involve commercial air transport (activity group), which includes scheduled (RPT) and non-scheduled (charter) passenger and freight type. It may involve Australian civil (VH) registered aircraft, or aircraft registered outside of Australia. General aviation/recreational encompasses:

- Aerial work (activity type). Includes activity subtypes: agricultural mustering, agricultural spreading/spraying, other agricultural flying, photography, policing, firefighting, construction – sling loads, other construction, search and rescue, observation and patrol, power/pipeline surveying, other surveying, advertising, and other aerial work.
- Own business travel (activity type).
- Instructional flying (activity type). Includes activity subtypes: solo and dual flying training, and other instructional flying.
- Sport and pleasure flying (activity type). Includes activity subtypes: pleasure and personal transport, glider towing, aerobatics, community service flights, parachute dropping, and other sport and pleasure flying.
- Other general aviation flying (activity type). Includes activity subtypes: test flights, ferry flights and other flying.

## 8.2. ATSB occurrence taxonomy

The ATSB uses a taxonomy of occurrence sub-type. Of specific relevance to the subject assessment are terms associated with **terrain collision**. Definitions sourced from the ATSB website are provided below:

- **Collision with terrain**: Occurrences involving a collision between an airborne aircraft and the ground or water, where the flight crew were aware of the terrain prior to the collision.
- **Controlled flight into terrain (CFIT):** Occurrences where a serviceable aircraft, under flight crew control, is inadvertently flown into terrain, obstacles, or water without either sufficient or timely awareness by the flight crew to prevent the event.
- **Ground strike:** Occurrences where a part of the aircraft drags on, or strikes, the ground or water while the aircraft is in flight, or during take-off or landing.
- **Wirestrike:** Occurrences where an aircraft strikes a wire, such as a powerline, telephone wire, or guy wire, during normal operations.

## 8.3. National aviation occurrence statistics 2010-2019

The Australian Transport Safety Bureau (ATSB) recently published a summary of aviation occurrence statistics for the period 2010-2019 (AR-2020-014, Final - 29 April 2020).

According to the report, there were no fatalities in high or low capacity RPT operations during the period 2010-2019. In 2019, 220 aircraft were involved in accidents in Australia, and a further 154 aircraft involved in serious incidents (an incident with a high probability of becoming an accident). In 2019 there were 35 fatalities from 22 fatal accidents. There have been no fatalities in scheduled commercial air transport in Australia since 2005.

Of the 326 fatalities recorded in the 10-year period, almost two thirds (175 or 53.68%) occurred in the general aviation segment. On average, there were 1.51 fatalities per aircraft associated with a fatality in this segment. The fatalities to aircraft ratio ranges from 1.09 to 177:1. Whilst it can be inferred from the data that the majority of fatal accidents are single person fatalities, it is reasonable to assert that the worst credible effect of an aircraft accident in the general aviation category will be multiple fatalities.

A breakdown of aircraft and fatalities by general aviation sub-categories is provided in Table 4 (source: ATSB).

Table 4 Number of fatalities by General Aviation sub-category – 2010 to 2019

| *Sub-category* | *Aircraft assoc. with fatality* | *Fatalities* | *Fatalities to aircraft ratio* |
|---|---|---|---|
| Aerial work | 37 | 44 | 1.18:1 |
| Instructional flying | 11 | 19 | 1.72:1 |
| Own business travel | 3 | 5 | 1.6:1 |
| Sport and pleasure flying | 53 | 94 | 1.77:1 |
| Other general aviation flying | 11 | 12 | 1.09:1 |
| Totals | 115 | 174 | 1.51:1 |

Figure 9 refers to Fatal Accident Rate by operation type per million departures over the 6-year period (source: ATSB). Note the rates presented are not the full year range of the study (2010–2019). This was due to the availability of exposure data (departures and hours flown) which was only available between these years. According to the ATSB report, the number of fatal accidents per million departures for GA aircraft over the 6-year reporting period ranged between 6.6 in 2014 and 4.9 in 2019.

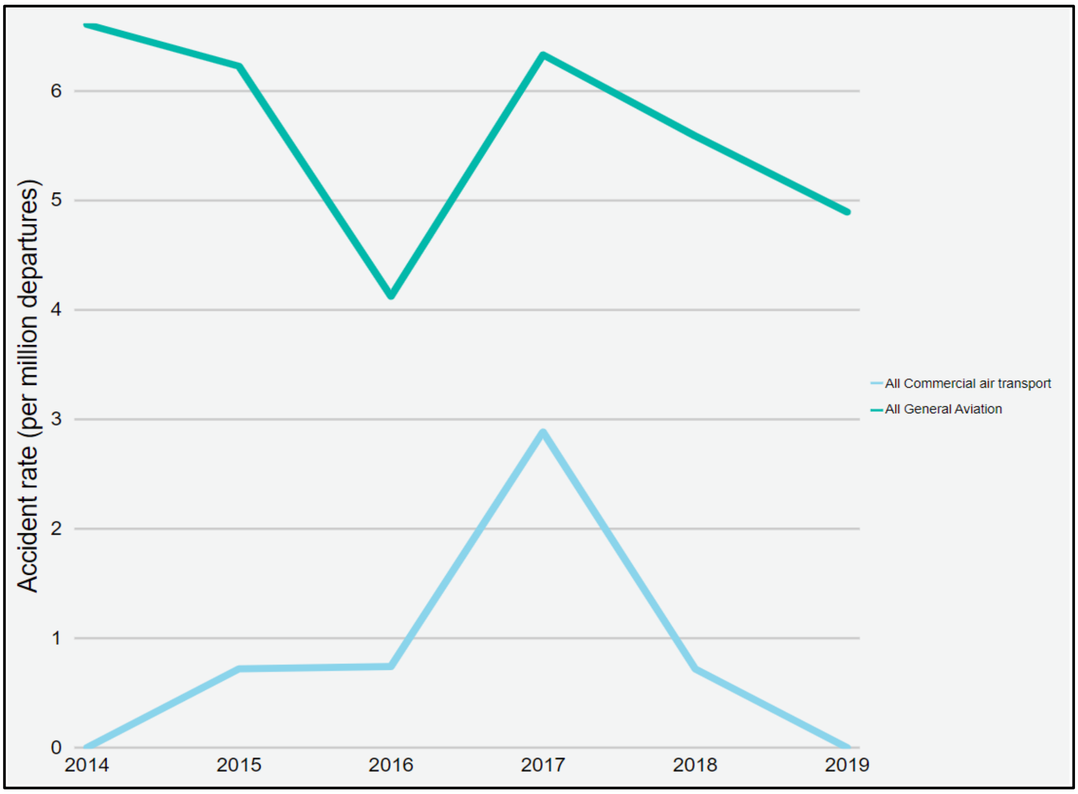


Figure 9 Fatal Accident Rate (per million departures) by Operation Type

In 2018, there were 9 fatal accidents and 9 fatalities involving GA aircraft, resulting in a rate of 5.6 fatal accidents per million departures and 7.7 fatal accidents per million hours flown.

In 2019, there were 1,760,000 landings, and 1,320,000 hours flown by VH-registered general aviation aircraft in Australia, with 8 fatal accidents and 17 fatalities. Based on these results, in 2019 there were 4.9 fatal accidents per million departures and 6.4 fatal accidents per million hours flown. A summary of fatal accidents from 2010-2019 by GA sub-category is provided in Table 5 (source: ATSB).

Table 5 Fatal accidents by GA sub-category – 2010 -2019

| Sub-category | Fatal accidents | Fatalities |
|---|---|---|
| Agricultural spreading/spraying | 13 | 13 |
| Agricultural mustering | 11 | 12 |
| Other agricultural | 1 | 1 |
| Survey and photographic | 5 | 10 |
| Search and rescue | 2 | 2 |
| Firefighting | 2 | 2 |
| Other aerial work | 3 | 4 |
| Instructional flying | 11 | 19 |

| *Sub-category* | *Fatal accidents* | *Fatalities* |
|---|---|---|
| Own business travel | 3 | 5 |
| Sport and pleasure flying | 53 | 94 |
| Other general aviation flying | 11 | 12 |
| Total | 115 | 174 |

Over the 10-year period, no aircraft collided with a WTG or with a WMT in Australia.

Of the 20,529 incidents, serious incidents and accidents in GA operations in the 10-year period, 1,404 (6.83%) were terrain collisions.

The underlying fatality rate for GA operations discussed above is considered tolerable within Australia's regulatory and social context.

### 8.4. Worldwide accidents involving wind farms

Worldwide since aviation accident statistics have been recorded, there have been a total of 4 aviation accidents involving a wind farm (i.e. where WTGs were erected). To provide some perspective on the likelihood of a VFR aircraft colliding with a WTG, a summary of the 4 accidents and the relevant factors applicable to this assessment is incorporated in this section.

Based on the statistics set out in the Global Wind Energy Council (GWEC) report 2016, there were 341,320 WTGs operating around the world at the end of 2016.

Based on the Australia's Clean Energy Council statistics there were 102 wind farms in Australia at the end of 2019. Aviation Projects has researched public sources of information, regarding aviation safety occurrences associated with wind farms. Occurrence information published by Australia, Canada, Europe (Belgium, Denmark, France, Germany, Norway, Sweden and The Netherlands), New Zealand, the United Kingdom and the United States of America was reviewed.

The 4 recorded aviation accidents involving a wind farm are summarised as follows:

- One accident, which resulted in 2 fatalities, occurred in Palm Springs in 2001. This accident involved a wind farm but was not caused by the wind farm. The cause of the accident was the inflight separation of the majority of the right canard and all of the right elevator resulting from a failure of the builder to balance the elevators per the kit manufacturer's instructions. The accident occurred above a wind farm, and the aircraft struck a WTG on its descent and therefore the cause of the accident was not attributable to the wind farm and not applicable to this AIA.
- Two accidents involving collision with a WTG were during the day, as follows:
    - One accident occurred in Melle, Germany in 2017 as the result of a collision with a WTG mounted on a steel lattice tower at a very low altitude during the day with good visibility and no cloud. The accident resulted in one fatality. If the tower was solid and painted white, as is standard on contemporary wind farms, then it more than likely would have been more visible than if it were to be equipped with an obstacle light which in all likelihood would not have been operating during daylight with good visibility conditions.
    - One accident occurred in Plouguin, France in 2008 when the pilot decided to descend below cloud in an attempt to find the destination aerodrome. The aircraft was flying in conditions of significantly reduced horizontal visibility in fog where the top of the WTGs were obscured

by cloud. The WTGs became visible too late for avoidance manoeuvring and the aircraft made contact with two WTGs. The aircraft was damaged but landed safely. No fatalities were recorded.

  - In both of the above cases, it is difficult to conclude that obstacle lighting would have prevented the accidents.

- One fatal accident, near Highmore, South Dakota in 2014 occurred at night in Instrument Meteorological Conditions (IMC).

There is one other accident mentioned in a database compiled by an anti-wind farm lobby group (wind-watch.org), which suggests a Cessna 182 collided with a WTG near Baraboo, Wisconsin, on 29 July 2000. The NTSB database records details of an accident involving a Cessna 182 that occurred on 28 July 2000 in the same area. For this particular accident, NTSB found that the probable cause of the accident was VFR flight into IMC encountered by the pilot and exceeding the design limits of the aircraft. A factor was flight to a destination alternate not performed by the pilot. No mention in the NTSB database is made of WTGs or a wind farm.

A summary of the 4 accidents is provided in Table 6.

Table 6 Summary of accidents involving collision with a WTG

| ID | Description | Date | Location | Fatalities | Flight rules | WTG height | Obstacle lighting | Cause of accident | Relevant to obstacle lighting at night |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Diamond DA320-A1<br>D-EJAR<br>Collided with a WTG approximately 20 m above the ground, during the day in good visibility. The mast was grey steel lattice, rather than white, although the blades were painted in white and red bands. | 02 Feb 2017 | Melle, Germany | 1 | Day VFR<br>No cloud and good visibility | Not specified | Not specified | Not specified | Not applicable |

| ID | Description | Date | Location | Fatalities | Flight rules | WTG height | Obstacle lighting | Cause of accident | Relevant to obstacle lighting at night |
|---|---|---|---|---|---|---|---|---|---|
| 2 | The Piper PA-32R-300, N8700E, was destroyed during an impact with the blades of a WTG, at night in IMC.<br>The wind farm was not marked on either sectional chart covering the accident location; however, the pilot was reportedly aware of the presence of the wind farm. | 27 Apr 2014 | 10 miles south of Highmore, South Dakota | 4 | Night IMC<br>Low cloud and rain | 420 ft AGL overall | Fitted but reportedly not operational on the WTG that was struck | The NTSB determined the probable cause(s) of this accident to be the pilot's decision to continue the flight into known deteriorating weather conditions at a low altitude and his subsequent failure to remain clear of an unlit WTG.<br>Contributing to the accident was the inoperative obstacle light on the WTG, which prevented the pilot from visually identifying the WTG. | An operational obstacle light may have prevented the accident. |

| ID | Description | Date | Location | Fatalities | Flight rules | WTG height | Obstacle lighting | Cause of accident | Relevant to obstacle lighting at night |
|---|---|---|---|---|---|---|---|---|---|
| 3 | Beechcraft B55<br>The pilot was attempting to remain in VMC by descending the aircraft through a break in the clouds. The pilot, distracted by trying to visually locate the aerodrome, flew into an area of known presence of WTGs.<br>After sighting the WTGs, he was unable to avoid them. The tip of the left wing struck the first WTG blade, followed by the tip of the right wing striking the blade of a second WTG.<br>The pilot was able to maintain control of the aircraft and landed safely. | 04 Apr 2008 | Plouguin, France | 0 | Day VFR<br>The weather in the area of the WTGs had deteriorated to an overcast of stratus cloud, with a base between 100 ft to 350 ft and tops of 500 ft. | 328 ft AGL hub height, 393 ft AGL overall | Not specified | This pilot reported having been distracted by a troubling personal matter which he had learned of before departing for the flight.<br>The wind farm was annotated on aeronautical charts. | Not applicable |

| ID | Description | Date | Location | Fatalities | Flight rules | WTG height | Obstacle lighting | Cause of accident | Relevant to obstacle lighting at night |
|---|---|---|---|---|---|---|---|---|---|
| 4 | VariEze N25063<br>The aircraft collided with a WTG following in-flight separation of the majority of the right canard and all of the right elevator. | 20 July 2001 | Palm Springs, USA | 2 | Day VFR | N/A | N/A | The failure of the builder to balance the elevators per the kit manufacturer's instructions. The cause of this accident is not attributable to the wind farm. | Not applicable |

# 9. RISK ASSESSMENT

A risk management framework is comprised of likelihood and consequence descriptors, a matrix used to derive a level of risk, and actions required of management according to the level of risk.

The risk assessment framework used by Aviation Projects and risk event description is provided in **Annexure 4.**

## 9.1. Risk Identification

The primary risk being assessed is that of aviation safety associated with the height and location of WTGs and WMTs proposed by the Project.

Based on an extensive review of accident statistics data (see summary in Section 8 above) five identified risk events associated with WTGs and WMTs relate to aviation safety or potential visual impact, and are listed as follows:

1. potential for an aircraft to collide with a WTG, controlled flight into terrain (CFIT) (related to aviation safety)
2. potential for an aircraft to collide with a WMT (CFIT) (related to aviation safety)
3. potential for a pilot to initiate abrupt manoeuvring in order to avoid colliding with a WTG or WMT resulting in loss of control of the aircraft resulting in collision with terrain (related to aviation safety)
4. potential for the hazards associated with the Project to invoke operational limitations or procedures on operating crew (related to aviation safety)
5. Potential effect of obstacle lighting on neighbours (related to potential visual impact).

It should be noted that according to guidance provided by the Commonwealth Department of Infrastructure, Transport, Regional Development and Communications, and in line with generally accepted practice, the risk to be assessed should primarily be associated with passenger transport services. Therefore, the risk being assessed herein is primarily associated with smaller aircraft likely to be flying under the VFR, and so the maximum number of passengers exposed to the nominated consequences is likely to be limited.

The five risk events identified here are assessed in detail in the following section.

## 9.2. Risk Analysis, Evaluation and Treatment

For the purpose of considering applicable consequences, the concept of worst credible effect has been used. Untreated risk is first evaluated, then, if the resulting level of risk is unacceptable, further treatments are identified to reduce the residual level of risk to an acceptable level.

A summary of the level of risk associated with the Project, under the proposed treatment regime, with specific consideration of the effect of obstacle lighting, is provided in Table 7 through to Table 11.

Table 7 Aircraft collision with wind turbine generator (WTG)

| Risk ID: | 1. Aircraft collision with wind turbine generator (WTG) (CFIT) |
|---|---|

**Discussion**

An aircraft collision with a WTG would result in harm to people and damage to property. Property could include the aircraft itself, as well as the WTG.

There have been 4 reported occurrences worldwide of aircraft collisions with a component of a WTG structure since the year 2000 as discussed in Section 1. These reports show a range of situations where pilots were conducting various flying operations at low level and in the vicinity of wind farms in both IMC and VMC. No reports of aircraft collisions with wind farms in Australia have been found.

In consideration of the circumstances that would lead to a collision with a WTG:

- GA VFR aircraft operators generally don't individually fly a significant number of hours in total, let alone in the area in question
- There is a very small chance that a pilot, suffering the stress of weather, will continue into poor weather conditions (contrary to the rules of flight) rather than divert away from it, is not aware of the wind farm, will not consider it or will not be able to accurately navigate around it.
- If the aircraft was flown through the wind farm, there is still a very small chance that it would hit a WTG.

Refer to the discussion of worldwide accidents in Section 8.

There are no known aerial application operations conducted at night in the vicinity of the Project site.

If a proposed object or structure is identified as likely to be an obstacle, details of the relevant proposal must be referred to CASA for CASA to determine, in writing:

(a) whether the object or structure will be a hazard to aircraft operations

(b) whether it requires an obstacle light that is essential for the safety of aircraft operations

The Project site is clear of the obstacle limitation surfaces (OLS) of any aerodrome.

**Consequence**

If an aircraft collided with a WTG, the worst credible effect would be multiple fatalities and damage beyond repair. This would be a Catastrophic consequence.

| | |
|---|---|
| **Consequence** | Catastrophic |

**Untreated Likelihood**

There have been 4 reports of aircraft collisions with WTGs worldwide, which have resulted in a range of consequences, where aircraft occupants sustained minor injury in some cases and fatal injuries in others (see Section 8). Similarly, aircraft damage sustained ranged from minor to catastrophic. One of these accidents resulted from structural failure of the aircraft before the collision with the WTG. Only two relevant accidents occurred during the day, and only one resulted in a single fatality. It is assessed that collision with a WTG resulting in multiple fatalities and damage beyond repair is unlikely to occur, but possible (has occurred rarely), which is classified as Possible.

| | |
|---|---|
| **Untreated Likelihood** | Possible |

**Current Treatments (without lighting)**

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| • The Project site is clear of the obstacle limitation surfaces (OLS) of any aerodrome.<br>• Aircraft are restricted to a minimum height of 500 ft (152.4 m) AGL above the highest point of the terrain and any object on it within a radius of 300 m in visual flight during the day when not in the vicinity of built-up areas. The proposed WTGs will be a maximum of 252 m (826.8 ft) AGL at the top of the blade tip. The rotor blade at its maximum height will be approximately 100.4 m (329.4 ft) above aircraft flying at the minimum altitude of 152.4 m AGL (500 ft).<br>• In the event that descending cloud forces an aircraft lower than 500 ft (152.4 m) AGL, the minimum visibility of 5,000 m required for visual flight during the day should provide adequate time for pilots to observe and manoeuvre their aircraft clear of WTGs.<br>• If cloud descends below the WTG hub (assumed to be approximately 200 m AGL), obstacle lighting would be obscured and therefore ineffective.<br>• At night, aircraft are restricted to a minimum height of 304.8 m (1,000 ft) above obstacles (including terrain) which are within 10 nm of the aircraft in visual flight at night and potentially even higher during instrument flight (day or night).<br>• Aircraft authorised to intentionally fly below 152.4 m (500 ft) AGL (day) or below safety height (night) are operated in accordance with procedures developed as an outcome of thorough risk management activities undertaken specifically for and prior to undertaking such authorised flights. Any obstacle including WTGs in the path of the authorised flight would be specifically risk assessed during that process.<br>• The WTGs are typically coloured white so they should be visible to pilots during the day.<br>• The 'as constructed' details of WTGs are required to be notified to Airservices Australia so that the location and height of all WTGs can be noted on aeronautical maps and charts.<br>• Because the Project WTGs are proposed to be above 100 m AGL, there is a statutory requirement to report the WTGs to CASA and notified to Airservices Australia prior to construction. |

| | |
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| ***Level of Risk***<br>The level of risk associated with a Possible likelihood of a Catastrophic consequence is 8 (Unacceptable). | |
| ***Current Level of Risk*** | 8 - Unacceptable |
| ***Risk Decision***<br>A risk level of 8 is classified as Unacceptable: Immediate action required by either treating or avoiding risk. Refer to executive management. | |
| ***Risk Decision*** | Unacceptable |
| ***Recommended Treatments***<br>The following treatments which can be implemented at little cost will provide an acceptable level of safety:<br>• Details of the Project should be communicated to local and regional aircraft operators (refer to Section 5) prior to construction to heighten their awareness of its location and so that they can plan their operations accordingly. Specifically: | |

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| ○ Engage with local aerial agricultural and aerial firefighting operators to develop procedures, which may include, for example, stopping the rotation of the WTG blades prior to the commencement of the subject aircraft operations within the Project site.<br>○ Arrangements should be made to publish details of the Project in ERSA for surrounding aerodromes, which would involve notification to Airservices Australia. |
| ***Residual Risk***<br>With the implementation of the Recommended Treatments listed above, the likelihood of an aircraft collision with a WTG resulting in multiple fatalities and damage beyond repair will be **Unlikely**, and the consequence remains **Catastrophic**, resulting in an overall risk level of **7 - Tolerable**.<br>It is considered that the significant cost of obstacle lighting (which is not a preventative control), may only slightly reduce the likelihood of a collision given that the pilot is already in a highly undesirable situation (and not in all situations – such as where the obstacle light may be obscured by cloud) and hence is not justified.<br>The level of risk with the implementation of the Recommended Treatments is considered **As Low As Reasonably Practicable (ALARP).**<br>**It is our assessment that there will be an acceptable level of aviation safety risk associated with the potential for an aircraft collision with a Project WTG without obstacle lighting on the WTGs.** |

| | |
|---|---|
| ***Residual Risk*** | 7 - Tolerable |

Table 8 Aircraft collision with wind monitoring tower (WMT)

| Risk ID: | 2. Aircraft collision with a wind monitoring tower (WMT) (CFIT) |
|---|---|
| ***Discussion***<br>An aircraft collision with a WMT would result in harm to people and damage to property.<br>There may be one WMT located within the project boundary.<br>The WMTs will be free standing at a maximum height of 160 m (525 ft) AGL.<br>The proposed masts will be marked in accordance with NASF Guideline D recommendations and CASA Part 139 MOS requirements.<br>The location of the proposed temporary and permanent WMT locations and other applicable details will be provided to Airservices Australia prior to construction.<br>There are a few instances of aircraft colliding with a WMT, but they were all during the day with good visibility. None were in Australia.<br>There is a relatively low rate of aircraft activity in the vicinity of the Project site.<br>There are no known aerial application operations conducted at night in the vicinity of the wind farm.<br>If a proposed object or structure is identified as likely to be an obstacle, details of the relevant proposal will be referred to CASA for CASA to determine, in writing:<br>• whether the object or structure will be a hazard to aircraft operations<br>• whether it requires an obstacle light that is essential for the safety of aircraft operations. | |
| ***Consequence***<br>If an aircraft collided with a WMT, the worst credible effect would be multiple fatalities and damage beyond repair. This would be a Catastrophic consequence. | |
| ***Consequence*** | Catastrophic |
| ***Untreated Likelihood***<br>There are a few occurrences of an aircraft colliding with a WMT, but all were during the day with good visibility when obstacle lighting would arguably be of no effect, and none were in Australia. It is assessed that collision with a WMT without obstacle lighting that would be effective in alerting the pilot to its presence is unlikely to occur, but possible (has occurred rarely), which is classified as Possible. | |
| ***Untreated Likelihood*** | Possible |
| ***Current Treatments***<br>• The mast locations will be advised to CASA and Airservices Australia prior to construction.<br>• Aircraft are restricted to a minimum height of 152.4 m (500 ft) AGL above the highest point of the terrain and any object on it within a radius of 300 m in visual flight during the day when not in the vicinity of built up areas. The highest permanent WMT may be at a maximum height of 160 m (525 ft), which will be 25 ft (7.7 m) above the minimum height of 500 ft AGL for an aircraft flying in this area.<br>• In the event that descending cloud forces an aircraft lower than 152.4 m (500 ft) AGL, the minimum visibility of 5,000 m required for visual flight during the day, the mast markings should provide adequate time for pilots to observe and manoeuvre their aircraft clear of the tower. | |

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| • At night, aircraft operating in visual flight are restricted to a minimum height of 304.8 m (1,000 ft) above obstacles within 10 nm of the aircraft.<br>• The WTGs and masts will be shown on aeronautical charts at the next publication cycle date available and NOTAMS prior to the publication date. This allows pilots to be aware of the existence of the wind farm at the pre-flight planning stage and during flight with reference to the aeronautical chart.<br>• Aircraft authorised to intentionally fly below 152.4 m (500 ft) (day) or below safety height (night) are operated in accordance with procedures developed as an outcome of thorough risk management activities.<br>• Since the masts will be higher than 100 m AGL, there is a statutory requirement to report them to CASA and Airservices Australia prior to construction. | |
| ***Level of Risk***<br>The level of risk associated with a Possible likelihood of a Catastrophic consequence is 8. | |
| ***Current Level of Risk*** | 8 - Unacceptable |
| ***Risk Decision***<br>A risk level of 8 is classified as Unacceptable: Immediate action required by either treating or avoiding risk. Refer to executive management. | |
| ***Risk Decision*** | Unacceptable |
| ***Recommended Treatments***<br>The following treatments which can be implemented at little cost will provide an acceptable level of safety:<br>• Details of any WMTs when they are constructed will be advised to Airservices Australia.<br>• Consideration could be given to marking any wind monitoring towers according to the requirements set in MOS 139 Chapter 8 Division 10 Obstacle Markings (as modified by the guidance in NASF Guideline D); specifically:<br>*8.110 (5) As illustrated in Figure 8.110 (5), long, narrow structures like masts, poles and towers which are hazardous obstacles must be marked in contrasting colour bands so that the darker colour is at the top; and the bands are, as far as physically possible, marked at right angles along the length of the long, narrow structure; and have a length ("z" in Figure 8.110 (5)) that is, approximately, the lesser of: 1/7 of the height of the structure; or 30 m.*<br>*8.110 (7) Hazardous obstacles in the form of wires or cables must be marked using 3-dimensional coloured objects attached to the wire or cables. Note: Spheres and pyramids are examples of 3-dimensional objects. (8) The objects mentioned in subsection (7) must: be approximately equivalent in size to a cube with 600 mm sides; and be spaced 30 m apart along the length of the wire or cable.*<br>• WMTs that are installed prior to WTG installation (Temporary WMTs) and WMTs that are not in close proximity to a WTG, should be fitted with a medium intensity steady red obstacle light at the top of the tower to ensure visibility in low light and deteriorated atmospheric conditions. Characteristics of medium-intensity lights are specified in MOS 139 Section 9.33:<br>*5) Medium-intensity obstacle lights must:* | |

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| c) *be visible in all directions in azimuth; and*<br><br>d) *if flashing — have a flash frequency of between 20 and 60 flashes per minute.*<br><br>6) *The peak effective intensity of medium-intensity obstacle lights must be 2 000 ☐ 25% cd with a vertical distribution as follows:*<br><br>d) *for* **vertical beam spread** *— a minimum of 3 degrees;*<br><br>e) *at -1 degree elevation — a minimum of 50% of the lower tolerance value of the peak intensity;*<br><br>f) *at 0 degrees elevation — a minimum of 100% of the lower tolerance value of the peak intensity.*<br><br>7) *For subsection (2),* **vertical beam spread** *means the angle between 2 directions in a plane for which the intensity is equal to 50% of the lower tolerance value of the peak intensity.*<br><br>8) *If, instead of obstacle marking, a flashing white light is used during the day to indicate temporary obstacles in the vicinity of an aerodrome, the peak effective intensity of the light must be increased to 20 000 ± 25% cd when the background luminance is 50 cd/m² or greater.*<br><br>• Ensure details of any additional WMTs at the Project site have been communicated to Airservices Australia, and local and regional aerodrome and aircraft operators before, during and following construction. |
| ***Residual Risk***<br><br>With the additional Recommended Treatments listed above, the likelihood of an aircraft collision with a WMT resulting in multiple fatalities and damage beyond repair will be **Unlikely**, and the consequence remains **Catastrophic**, resulting in an overall risk level of **7 – Tolerable**.<br><br>It is considered that the significant cost of obstacle lighting (which is not a preventative control), may only slightly reduce the likelihood of a collision given that the pilot is already in a highly undesirable situation (and not in all situations – such as where the obstacle light may be obscured by cloud) and hence is not justified.<br><br>Under these circumstances, the level of risk under the proposed treatment plan is considered **ALARP.**<br><br>**It is our assessment that there will be an acceptable level of aviation safety risk associated with the potential for an aircraft collision with the Project masts that are in close proximity to a WTG without obstacle lighting on the WMTs.**<br><br>**For masts installed prior to WTG installation and those that are not in close proximity to a WTG, there will be an acceptable level of aviation safety risk associated with the potential for an aircraft collision provided obstacle lighting is fitted to ensure visibility in low light and deteriorating atmospheric conditions.** |

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| ***Residual Risk*** | 7 - Tolerable |

Table 9 Harsh manoeuvring leading to controlled flight into terrain

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|---|---|
| *Risk ID:* | 3. Harsh manoeuvring leads to controlled flight into terrain (CFIT) |

***Discussion***

An aircraft colliding with terrain as a result of manoeuvring to avoid colliding with a WTG would result in harm to people and damage to property.

There are a few ground collision accidents resulting from manoeuvring to avoid wind farms, but none in Australia, and all were during the day.

The Project is clear of the OLS of any aerodrome.

Aircraft are restricted to a minimum height of 152.4 m (500 ft) above the highest point of the terrain and any object on it within a radius of 300 m in visual flight during the day when not in the vicinity of built up areas.

The proposed WTGs will be a maximum of 252 m (826.8 ft) AGL at the top of the blade tip. The rotor blade at its maximum height will be approximately 99.6 m (326.8 ft) above aircraft flying at the minimum altitude of 152.4 m (500 ft) AGL.

Nevertheless, the minimum visibility of 5000 m required for visual flight during the day should provide adequate time for pilots to observe and manoeuvre their aircraft clear of WTGs.

If cloud descends below the WTG hub, obstacle lighting would be obscured and therefore ineffective.

Aircraft are restricted to a minimum height of 304.8 m (1000 ft) above obstacles within 10 nm of the aircraft in visual flight at night and potentially even higher during instrument flight (day or night).

Aircraft authorised to intentionally fly below 152.4 m (500 ft) AGL (day) or below safety height (night) are operated in accordance with procedures developed as an outcome of thorough risk management activities.

***Assumed risk treatments***

- The WTGs are typically coloured white so they should be visible during the day.
- The 'as constructed' details of WTGs are required to be notified to Airservices Australia so that the location and height of WTGs can be noted on aeronautical maps and charts.
- Since the WTGs will be higher than 100 m AGL, there is a statutory requirement to report the WTG to CASA.

***Consequence***

If an aircraft collided with terrain, the worst credible effect would be multiple fatalities and damage beyond repair. This would be a Catastrophic consequence.

| | |
|---|---|
| *Consequence* | Catastrophic |

***Untreated Likelihood***

There are a few ground collision accidents resulting from manoeuvring to avoid WTGs, but none in Australia, and all were during the day (see Section 8). It is assessed that a ground collision accident following manoeuvring to avoid a WTG is unlikely to occur, but possible (has occurred rarely), which is classified as Possible.

| | |
|---|---|
| *Untreated Likelihood* | Possible |

***Current Treatments (without lighting)***

- The Project is clear of the OLS of any aerodrome.

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|---|
| <ul><li>Aircraft are restricted to a minimum height of 152.4 m (500 ft) above the highest point of the terrain and any object on it within a radius of 300 m in visual flight during the day when not in the vicinity of built-up areas.</li><li>WTGs will be a maximum of 252 m (826.8 ft) AGL at the top of the blade tip. The rotor blade at its maximum height will be approximately 99.6 m (326.8 ft) above aircraft flying at the minimum altitude of 152.4 m AGL (500 ft).</li><li>Nevertheless, the minimum visibility of 5000 m required for visual flight during the day should provide adequate time for pilots to observe and manoeuvre their aircraft clear of WTGs.</li><li>The WTGs and masts will be shown on aeronautical charts at the next publication cycle date available and NOTAMS prior to the publication date. This allows pilots to be aware of the existence of the wind farm at the pre-flight planning stage and during flight with reference to the aeronautical chart.</li><li>If cloud descends below the WTG hub, obstacle lighting would be obscured and therefore ineffective.</li><li>At night, aircraft operating in visual flight are restricted to a minimum height of 304.8 m (1,000 ft) above obstacles within 10 nm of the aircraft.</li><li>Aircraft authorised to intentionally fly below 152.4 m AGL (500 ft) (day) or below safety height (night) are operated in accordance with procedures developed as an outcome of thorough risk management activities.</li><li>The WTGs are typically coloured white, typical of most WTGs operational in Australia, so they should be visible during the day.</li><li>The 'as constructed' details of WTGs are required to be notified to Airservices Australia so that the location and height of wind farms can be noted on aeronautical maps and charts.</li><li>Since the WTGs will be higher than 100 m AGL, there is a statutory requirement to report the WTGs to CASA.</li></ul> |
| ***Level of Risk***<br>The level of risk associated with a Possible likelihood of a Catastrophic consequence is 8. |

| | |
|---|---|
| ***Current Level of Risk*** | 8 – Unacceptable |

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|---|
| ***Risk Decision***<br>A risk level of 8 is classified as Unacceptable: Immediate action required by either treating or avoiding risk. Refer to executive management. |

| | |
|---|---|
| ***Risk Decision*** | Unacceptable |

| |
|---|
| ***Recommended Treatments***<br>The following treatments which can be implemented at little cost will provide an acceptable level of safety:<ul><li>Ensure details of the Project WTGs have been communicated to Airservices Australia, and local and regional aerodrome and aircraft operators prior to construction.</li></ul> |

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| • Although there is no requirement to do so, the Proponent may consider engaging with local aerial agricultural and aerial firefighting operators to develop procedures for their safe operation within the Project site. |
| ***Residual Risk***<br>With the additional Recommended Treatments listed above, the likelihood of ground collision resulting from manoeuvring to avoid a WTG resulting in multiple fatalities and damage beyond repair will be **Unlikely**, and the consequence remains **Catastrophic**, resulting in an overall risk level of **7 – Tolerable.**<br>It is considered that the significant cost of obstacle lighting (which is not a preventative control), may only slightly reduce the likelihood of a collision given that the pilot is already in a highly undesirable situation (and not in all situations – such as where the obstacle light may be obscured by cloud) and hence is not justified.<br>In the circumstances, the level of risk under the proposed treatment plan is considered **ALARP.**<br>**It is assessed that there is an acceptable level of aviation safety risk associated with the potential for ground collision resulting from manoeuvring to avoid a Project WTG without obstacle lighting on the WTGs.** |

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| ***Residual Risk*** | 7 - Tolerable |

Table 10 Effect of the Project on operating crew

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|---|---|
| ***Risk ID:*** | 4. Effect of the Project on operating crew |

***Discussion***

Introduction or imposition of additional operating procedures or limitations can affect an aircraft's operating crew.

There are no known aerial application operations conducted at night in the vicinity of the Project site.

***Consequence***

The worst credible effect a wind farm could have on flight crew would be the imposition of operational limitations, and in some cases, the potential for use of emergency procedures. This would be a Minor consequence.

| | |
|---|---|
| ***Consequence*** | Minor |

***Untreated Likelihood***

The imposition of operational limitations is unlikely to occur, but possible (has occurred rarely), which is classified as Possible.

| | |
|---|---|
| ***Untreated Likelihood*** | Possible |

***Current Treatments***

- The Project is clear of the OLS of any aerodrome.
- Aircraft are restricted to a minimum height of 152.4 m (500 ft) above the highest point of the terrain and any object on it within a radius of 300 m in visual flight during the day when not in the vicinity of built-up areas.
- The WTGs and masts will be shown on aeronautical charts at the next publication cycle date available and NOTAMS prior to the publication date. This allows pilots to be aware of the existence of the wind farm at the pre-flight planning stage and during flight with reference to the aeronautical chart.
- WTGs will be a maximum of 252 m (826.8 ft) AGL at the top of the blade tip. The rotor blade at its maximum height will be approximately 99.6 m (326.8 ft) above aircraft flying at the minimum altitude of 152.4 m AGL (500 ft).
- In the event that descending cloud forces an aircraft lower than 500 ft (152.4 m) AGL, the minimum visibility of 5000 m required for visual flight during the day should provide adequate time for pilots to observe and manoeuvre their aircraft clear of WTGs.
- Nevertheless, the minimum visibility of 5000 m required for visual flight during the day should provide adequate time for pilots to observe and manoeuvre their aircraft clear of WTGs by the required margin.
- If cloud descends below the WTG hub, obstacle lighting would be obscured and therefore ineffective.
- At night, aircraft operating in visual flight are restricted to a minimum height of 304.8 m (1,000 ft) above obstacles within 10 nm of the aircraft.

| | |
|---|---|
| • Aircraft authorised to intentionally fly below 152.4 m AGL (500 ft) (day) or below safety height (night) are operated in accordance with procedures developed as an outcome of thorough risk management activities.<br>• The WTGs are typically coloured white so they should be visible during the day.<br>• The 'as constructed' details of WTGs are required to be notified to Airservices Australia so that the location and height of wind farms can be noted on aeronautical maps and charts.<br>• Since the WTGs will be higher than 100 m AGL, there is a statutory requirement to report the WTGs to CASA. | |
| ***Level of Risk***<br>The level of risk associated with a Possible likelihood of a Minor consequence is 5. | |
| ***Current Level of Risk*** | 5 - Tolerable |
| ***Risk Decision***<br>A risk level of 5 is classified as Tolerable: Treatment action possibly required to achieve ALARP - conduct cost/benefit analysis. Relevant manager to consider for appropriate action. | |
| ***Risk Decision*** | Accept, conduct cost benefit analysis |
| ***Recommended Treatments***<br>Given the current treatments and the limited scale and scope of flying operations conducted within the vicinity of the Project site, there is likely to be little additional safety benefits to be gained by installing obstacle lighting for WTGs and Permanent WMTs which are in close proximity to WTGs.<br>WMTs installed prior to WTG installation and those that are not in relatively close proximity to a WTG should be lit to ensure they are visible in low light and deteriorating atmospheric conditions. (see Risk ID: 2)<br>The following additional treatments will provide an additional margin of safety:<br>• Ensure details of the Project WTGs and masts have been communicated to Airservices Australia, and local and regional aerodrome and aircraft operators prior to construction.<br>• Although there is no requirement to do so, the Proponent may consider engaging with local aerial agricultural and aerial firefighting operators to develop procedures for such aircraft operations in the vicinity of the Project site. | |
| ***Residual Risk***<br>Notwithstanding the current level of risk is considered **Tolerable,** the additional Recommended Treatments listed above will enhance aviation safety. The likelihood remains **Possible**, and consequence remains **Minor**. In the circumstances, the risk level of 5 is considered **ALARP.**<br>**It is our assessment that there is an acceptable level of aviation safety risk associated with the potential for operational limitations to affect aircraft operating crew, without obstacle lighting on the Project WTGs and Permanent WMTs in close proximity to a WTG, and with obstacle lighting for temporary WMTs installed prior to WTG installation and WMTs that are not in close proximity to a WTG.** | |
| ***Residual Risk*** | 5 – Tolerable |

Table 11 Effect of obstacle lighting on neighbours

| | |
|---|---|
| *Risk ID:* | 5. Effect of obstacle lighting on neighbours |

***Discussion***

This scenario discusses the consequential impact of a decision to install obstacle lighting on the wind farm.

Installation and operation of obstacle lighting on WTGs or masts can have an effect on neighbours' visual amenity and enjoyment, specifically at night and in good visibility conditions.

If a proposed object or structure is identified as likely to be an obstacle, details of the relevant proposal must be referred to CASA for CASA to determine, in writing:

(a) whether the object or structure will be a hazard to aircraft operations

(b) whether it requires an obstacle light that is essential for the safety of aircraft operations.

In general, objects outside an OLS and above 100 m would require obstacle lighting unless CASA, in an aeronautical study, assesses it is shielded by another lit object or it is of no operational significance.

***Consequence***

The worst credible effect of obstacle lighting specifically at night in good visibility conditions would be:

- Moderate site impact, minimal local impact, important consideration at local or regional level, possible long-term cumulative effect. Not likely to be decision making issues. Design and mitigation measures may ameliorate some consequences.

This would be a Moderate consequence.

| | |
|---|---|
| ***Consequence*** | Moderate |

***Untreated Likelihood***

The likelihood of moderate site impact, minimal local impact is Almost certain - the event is likely to occur many times (has occurred frequently).

| | |
|---|---|
| ***Untreated Likelihood*** | Almost certain |

***Current Treatments***

If the WTGs or masts will be higher than 150 m (492 ft) AGL, they must be regarded as obstacles unless CASA assess otherwise. In general, objects outside an OLS and above 100 m would require obstacle lighting unless CASA, in an aeronautical study, assesses it is shielded by another lit object or it is of no operational significance.

***Level of Risk***

The level of risk associated with an Almost certain likelihood of a Moderate consequence is 8.

| | |
|---|---|
| ***Current Level of Risk*** | 8 - Unacceptable |

| | |
|---|---|
| ***Risk Decision***<br>A risk level of 8 is classified as Unacceptable: Immediate action required by either treating or avoiding risk. Refer to executive management. | |
| ***Risk Decision*** | Unacceptable |
| ***Recommended Treatments***<br>Not installing obstacle lighting would completely remove the source of the impact.<br>As per the above safety risk assessment, the provision of lighting for the WTGs and permanent masts is not necessary to provide an acceptable level of safety. For temporary WMTs installed prior to WTG installation and masts that are not in close proximity to a WTG, obstacle lighting is recommended to ensure visibility in low light and deteriorating atmospheric conditions.<br>If CASA or a planning authority decide that obstacle lighting is required there are impact reduction measures that can be implemented to reduce the impact of lighting on surrounding neighbours, including:<br>• reducing the number of WTGs with obstacle lights<br>• specifying an obstacle light that minimises light intensity at ground level<br>• specifying an obstacle light that matches light intensity to meteorological visibility<br>• mitigating light glare from obstacle lighting through measures such as baffling.<br>These measures are designed to optimise the benefit of the obstacle lights to pilots while minimising the visual impact to residents within and around the Project site.<br>Consideration may be given to activating the obstacle lighting via a pilot activated lighting system.<br>An option is to consider using Aircraft Detection Lighting Systems (referred in the United States Federal Aviation Administration Advisory Circular AC70/7460-1L CHG1 – *Obstruction Marking and Lighting*). Such a system would only activate the lights when an aircraft is detected in the near vicinity and deactivate the lighting once the aircraft has passed. This technology reduces the impact of night lighting on nearby communities and migratory birds and extends the life expectancy of obstruction lights. | |
| ***Residual Risk***<br>Not installing obstacle lights would clearly be an acceptable outcome to those potentially affected by visual impact.<br>If lighting is required, consideration of visual impact in the lighting design should enable installation of lighting that reduces the impact to neighbours.<br>The likelihood of a **Moderate** consequence remains **Likely**, with a resulting risk level of **7 – Tolerable**.<br>**It is our assessment that visual impact from obstacle lights can be negated if they are not installed.** If obstacle lights are to be installed, they can be designed so that there is an acceptable risk of visual impact to neighbours. | |
| ***Residual Risk*** | 7 - Tolerable |

# 10. CONCLUSIONS

The key conclusions of this AIA are summarised as follows:

### 10.1. Aviation Impact Statement

Based on the Project layout with a maximum height of up to 638.2 m/2094 ft AHD, the Project:

- would not infringe the OLS at Ballarat Airport
- would not infringe the PANS-OPS surface related to the Ballarat Airport 25 nm MSA
- would not have an impact on the relevant Grid LSALT
- would require an increase in the LSALTs for two air routes (V126 and W571) to accommodate the Project
- would not affect the nearest ALA which is outside the area suggested by NASF Guideline D in which downwind turbulence from the wind farm could be experienced
- would not infringe standard aerodrome circuit operations at the closest ALA
- would be wholly contained within Class G airspace
- would be outside the clearance zones associated with civil aviation navigation aids and communication facilities.

### 10.2. Aircraft operator characteristics

Aircraft will be required to navigate around the Project site where aircraft need to fly at 500 ft AGL.

WTGs are generally not a safety concern to aerial agricultural operators. WMTs remain the primary safety concern to aerial agricultural operators, who have expressed a general desire for these towers to be more visible.

### 10.3. Hazard marking and lighting

The following conclusions apply to hazard marking and lighting:

- With respect to CASR Part 139 Division 139.E.1 Notifying potential hazards 139.165, the proposed WTGs and WMTs must be reported to CASA.
- WTGs must be lit in accordance with Part 139 MOS 2019 Chapter 9 Division 4 9.30 and 9.31, unless an aeronautical study assesses they are of no operational significance, which this study reports.
- With respect to marking of WTGs, a white colour will provide sufficient contrast with the surrounding environment to maintain an acceptable level of safety while lowering visual impact to the neighbouring residents.
- Temporary and permanent WMTs should be marked according to the requirements set out in Manual of Standards (MOS) 139 Section 8.10 (as modified by the guidance in NASF Guideline D). Aviation marker balls and painting the top 1/3 of WMTs structures in red and white bands is considered to be an acceptable mitigation strategy.

- WTGs and permanent WMTs that are installed in close proximity (900 m) to a WTG will not require obstacle lighting to maintain an acceptable level of safety to aircraft
- WMTs that are installed prior to WTG installation, and WMTs that are not in close proximity to a WTG, will require obstacle lighting to maintain an acceptable level of safety. These WMTs should be lit with medium intensity steady red obstacle lighting at the top of the WMT mast. Characteristics of medium intensity obstacle lighting in MOS 139, Section 9.33.

### 10.4. Summary of risks

A summary of the level of residual risk associated with the Project with the Recommended Treatments implemented, is provided in Table 12.

Table 12 Summary of Residual Risks

| *Identified Risk* | *Consequence* | *Likelihood* | *Risk* | *Actions Required* |
|---|---|---|---|---|
| Aircraft collision with wind turbine generator (WTG) | Catastrophic | Unlikely | 7 | **Acceptable without obstacle lighting (ALARP).**<br>Communicate details of the Project WTGs to local and regional operators and make arrangements to publish details in ERSA for surrounding aerodromes before, during and following construction. |
| Aircraft collision with wind monitoring tower (WMT) | Catastrophic | Unlikely | 7 | **Acceptable without obstacle lighting (ALARP).**<br>Although there is no obligation to do so, consideration has been made for marking the WMTs according to the requirements set out in MOS 139 Chapter 8 Division 10 Obstacle Markings, specifically 8.110 (5), (7) and (8).<br>Communicate details of WMTs to local and regional operators and make arrangements to publish details in ERSA for surrounding aerodromes following construction. |
| Avoidance manoeuvring leads to ground collision | Catastrophic | Unlikely | 7 | **Acceptable without obstacle lighting (ALARP).**<br>Communicate details of the Project WTGs and WMTs to local and regional operators and make arrangements to publish details in ERSA for surrounding aerodromes before, during and following construction. |
| Effect on crew | Minor | Possible | 5 | **Acceptable without obstacle lighting (ALARP)**<br>Communicate details of the Project WTGs and WMTs to local and regional operators and make arrangements to publish details in ERSA for surrounding aerodromes before, during and following construction. |
| Visual impact from obstacle lights | Moderate | Likely | 7 | **Acceptable without obstacle lighting** (zero risk of visual impact from obstacle lighting).<br>If lights are installed, design to minimise impact. |

# 11. RECOMMENDATIONS

Recommended actions resulting from the conduct of this assessment are provided below.

Notification and reporting

1. CASR 139.165 requires the owner of a structure (or proponents of a structure) that will be 100 m or more above ground level to inform CASA. This must be given in written notice and contain information on the proposal, the height and location(s) of the object(s) and the proposed timeframe for construction. This is to allow CASA to assess the effect of the structure on aircraft operations and determine whether or not the structure will be hazardous to aircraft operations.
   The proponent is required to report the WMT to CASA in accordance with CASR 139.165, as soon as practicable after forming the intention to construct or erect the proposed object or structure.
   The notification should be provided to CASA via email to Airspace.Protection@casa.gov.au .

2. 'As constructed' details of WMT coordinates and elevation should be provided to Airservices Australia, by submitting the form at this webpage: https://www.airservicesaustralia.com/wp-content/uploads/ATS-FORM-0085_Vertical_Obstruction_Data_Form.pdf to the following email address: vod@airservicesaustralia.com .
   Ideally this should only be done if potential impacts have been considered – through an aviation impact assessment or by sending the details to Airservices Australia in advance of the mast being erected, at this email address: airport.developments@airservicesaustralia.com .
   Details of the wind farm should be provided to local and regional aircraft operators prior to construction in order for them to consider the potential impact of the wind farm on their operations.

3. To facilitate the flight planning of aerial application operators, details of the Project, including the 'as constructed' location and height information of WTGs, WMTs and overhead transmission lines should be provided to landowners so that, when asked for hazard information on their property, the landowner may provide the aerial application pilot with all relevant information.

Operation

4. Whilst not a statutory requirement, the Proponent should consider engaging with any local aerial agricultural operators and aerial firefighting operators in developing procedures for such aircraft operations in the vicinity of the Project.

Marking of WTGs

5. The rotor blades, nacelle and the mast supporting the WTGs should be painted white, typical of most WTGs operational in Australia. No additional marking measures are required for WTGs.

Lighting of WTGs

6. Aviation Projects has assessed that the Project will not require obstacle lighting to maintain an acceptable level of safety to aircraft.

Marking of wind monitoring towers

7. Consideration should be given to marking the temporary and permanent WMTs according to the requirements set out in MOS 139 Section 8.10 (as modified by the guidance in NASF Guideline D). Specifically:

   d. marker balls or high visibility flags or high visibility sleeves should be placed on the outside guy wires

   e. paint markings should be applied in alternating contrasting bands of colour to at least the top 1/3 of the mast

f. ensuring the guy wire ground attachment points have contrasting colours to the surrounding ground/vegetation.

Lighting of wind monitoring towers

8. Consideration should be given to lighting temporary WMTs that are installed prior to WTG installation and WMTs that are not in close proximity to a WTG with medium intensity steady red obstacle lighting at the top of the WMT mast. Characteristics for medium-intensity obstacle lighting are contained in MOS 139, Section 9.33.

Micrositing

9. The potential micrositing of the WTGs and WMTs has been considered in the assessment with the estimate of the overall maximum height being based on the highest ground level within 100 m of the nominal WTG and WMT positions. Providing the micrositing is within 100 m of the WTGs and WMTs is likely to not result in a change in the maximum overall blade tip height of the Project. No further assessment is likely to be required from micrositing and the conclusions of this AIA would remain the same.

Triggers for review

10. Triggers for review of this risk assessment are provided for consideration:

    d. prior to construction to ensure the regulatory framework has not changed

    e. following any significant changes to the context in which the assessment was prepared, including the regulatory framework

    f. following any near miss, incident or accident associated with operations considered in this risk assessment.

# ANNEXURES

1. References
2. Definitions
3. CASA regulatory requirements – Lighting and Marking
4. Risk Framework
5. WTG coordinates and heights

# ANNEXURE 1 – REFERENCES

References used or consulted in the preparation of this report include:


- Airservices Australia, Aeronautical Information Package; including AIP Book, Departure and Approach Procedures, Designated Handbook and En Route Supplement Australia dated 30 November 2023
- Civil Aviation Safety Authority
    - Civil Aviation Regulations 1988 (CAR)
    - Civil Aviation Safety Regulations 1998 (CASR)
    - Civil Aviation Safety Authority, Advisory Circular (AC) 91-10 v1.1: *Operations in the vicinity of non-controlled aerodromes*, dated November 2021
    - Manual of Standards Part 173 – Standards Applicable to Instrument Flight Procedure Design, version 1.5, dated March 2016
    - *CASR Part 139 (Aerodromes) Manual of Standards 2019*, dated 5 September 2019
    - Advisory Circular 139.E-01 v1.0—Reporting of Tall Structures , dated December 2021
    - Advisory Circular (AC) 139.E-05 v1.0 Obstacles (including wind farms) outside the vicinity of a CASA certified aerodrome
- Department of Infrastructure, Transport, Regional Development, Communications and the Arts, National Airport Safeguarding Framework, Guideline D *Managing the Risk to Aviation Safety of Wind Turbine Installations (Wind Farms)/ Wind Monitoring Towers*, dated July 2012
- International Civil Aviation Organization (ICAO) Doc 8168 Procedures for Air Navigation Services—Aircraft Operations (PANS-OPS)
- ICAO Standards and Recommended Practices, Annex 14—Aerodromes
- OzRunways, aeronautical navigation charts extracts, dated 17 April 2023
- Standards Australia, ISO 31000:2018 *Risk management – Guidelines*

# ANNEXURE 2 – DEFINITIONS

| *Term* | *Definition* |
|---|---|
| Aerial Agricultural Operator | Specialist pilot and/or company who are required to have a commercial pilot's licence, an agricultural rating and a chemical distributor's licence |
| Aerodrome | A defined area on land or water (including any buildings, installations, and equipment) intended to be used either wholly or in part for the arrival, departure, and surface movement of aircraft. |
| Aerodrome facilities | Physical things at an aerodrome which could include:<br>a. the physical characteristics of any movement area including runways, taxiways, taxilanes, shoulders, aprons, primary and secondary parking positions, runway strips and taxiway strips;<br>b. infrastructure, structures, equipment, earthing points, cables, lighting, signage, markings, visual approach slope indicators. |
| Aerodrome reference point (ARP) | The designated geographical location of an aerodrome. |
| Aeronautical Information Publication (AIP) | Details of regulations, procedures, and other information pertinent to the operation of aircraft |
| Aeronautical Information Publication En-route Supplement Australia (AIP ERSA) | Contains information vital for planning a flight and for the pilot in flight as well as pictorial presentations of all licensed aerodromes |
| Civil Aviation Safety Regulations 1998 (CASR) | Contain the mandatory requirements in relation to airworthiness, operational, licensing, enforcement. |
| Instrument meteorological conditions (IMC) | Meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling, less than the minimum specified for visual meteorological conditions. |
| Manual of Standards (MOS) | The means CASA uses in meeting its responsibilities under the Act for promulgating aviation safety standards |
| National Airports Safeguarding Framework (NASF) | The Framework has the objective of developing a consistent and effective national framework to safeguard both airports and communities from inappropriate on and off airport developments. |
| Obstacles | All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight. |

| *Term* | *Definition* |
|---|---|
| Runway | A defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft. |
| Safety Management System | A systematic approach to managing safety, including organisational structures, accountabilities, policies and procedures. |

# ANNEXURE 3 – CASA REGULATORY REQUIREMENTS – LIGHTING AND MARKING

In considering the need for aviation hazard lighting and marking, the applicable regulatory context was determined.

The Civil Aviation Safety Authority (CASA) regulates aviation activities in Australia. Applicable requirements include the Civil Aviation Regulations 1988 (CAR), Civil Aviation Safety Regulations 1998 (CASR) and associated Manual of Standards (MOS) and other guidance material. Relevant provisions are outlined in further detail in the following section.

**Civil Aviation Safety Regulations 1998, Part 139—Aerodromes**

CASR 139.165 requires the owner of a structure (or proponents of a structure) that will be 100 m or more above ground level to inform CASA. This must be given in written notice and contain information on the proposal, the height and location(s) of the object(s) and the proposed timeframe for construction. This is to allow CASA to assess the effect of the structure on aircraft operations and determine whether the structure will be hazardous to aircraft operations.

**Manual of Standards Part 139—Aerodromes**

Chapter 9 sets out the standards applicable to Visual Aids Provided by Aerodrome Lighting.

Section 9.30 provides guidance on Types of Obstacle Lighting and Their Use:

1. *The following types of obstacle lights must be used, in accordance with this MOS, to light hazardous obstacles:*
    a. *low-intensity;*
    b. *medium-intensity;*
    c. *high-intensity;*
    d. *a combination of low, medium or high-intensity.*
2. *Low-intensity obstacle lights:*
    a. *are steady red lights; and*
    b. *must be used on non-extensive objects or structures whose height above the surrounding ground is less than 45 m.*
3. *Medium-intensity obstacle lights must be:*
    a. *flashing white lights; or*
    b. *flashing red lights; or*
    c. *steady red lights.*

    *Note CASA recommends the use of flashing red medium-intensity obstacle lights.*

4. *Medium-intensity obstacle lights must be used if:*
    a. *the object or structure is an extensive one; or*

*b. the top of the object or structure is at least 45 m but not more than 150 m above the surrounding ground; or*

*c. CASA determines in writing that early warning to pilots of the presence of the object or structure is desirable in the interests of aviation safety.*

*Note For example, a group of trees or buildings is regarded as an extensive object.*

5. *For subsection (4), low-intensity and medium-intensity obstacle lights may be used in combination.*
6. *High-intensity obstacle lights:*
   a. *must be used on objects or structures whose height exceeds 150 m; and*
   b. *must be flashing white lights.*
7. *Despite paragraph (6) (b), a medium-intensity flashing red light may be used if necessary, to avoid an adverse environmental impact on the local community.*

Sections 9.31 (8) and (9) provide guidance on obstacle lighting specific to wind farms:

8. *Subject to subsection (9), for wind turbines in a wind farm, medium-intensity obstacle lights must:*
   a. *mark the highest point reached by the rotating blades; and*
   b. *be provided on a sufficient number of individual wind turbines to indicate the general definition and extent of the wind farm, but such that intervals between lit turbines do not exceed 900 m; and*
   c. *all be synchronised to flash simultaneously; and*
   d. *be seen from every angle in azimuth.*

   *Note: This is to prevent obstacle light shielding by the rotating blades of a wind turbine and may require more than 1 obstacle light to be fitted.*
9. *If it is physically impossible to light the rotating blades of a wind turbine:*
   a. *the obstacle lights must be placed on top of the generator housing; and*
   b. *a note must be published in the AIP-ERSA indicating that the obstacle lights are not at the highest position on the wind turbines.*
10. *If the top of an object or structure is more than 45 m above:*
    a. *the surrounding ground (ground level); or*
    b. *the top of the tallest nearby building (building level); then the top lights must be medium-intensity lights, and additional low-intensity lights must be:*
    c. *provided at lower levels to indicate the full height of the structure; and*
    d. *spaced as equally as possible between the top lights and the ground level or building level, but not so as to exceed 45 m between lights.*

### Advisory Circular 139.E-01 v1.0—Reporting of Tall Structures

In Advisory Circular (AC) 139.E-01 v1.0—Reporting of Tall Structures, CASA provides guidance to those authorities and persons involved in the planning, approval, erection, extension or dismantling of tall structures so that they may understand the vital nature of the information they provide.

Airservices Australia has been assigned the task of maintaining a database of tall structures. RAAF and Airservices Australia require information on structures which are:

a) 30 metres or more above ground level—within 30 kilometres of an aerodrome; or

b) 45 metres or more above ground level elsewhere for the RAAF, or

c) 30 m or more above ground level elsewhere for Airservices Australia.

The purpose of notifying Airservices Australia of these structures is to enable their details to be provided in aeronautical information databases and maps/charts etc used by pilots, so that the obstacles can be avoided.

The proposed WTGs must be reported to Airservices Australia. This action should occur once the final layout after micrositing is confirmed and prior to construction.

### International Civil Aviation Organisation

Australia, as a contracting State to the International Civil Aviation Organisation (ICAO) and signatory to the Chicago Convention on International Civil Aviation (the Convention), has an obligation to implement ICAO's standards and recommended practices (SARPs) as published in the various annexes to the Convention.

Annex 14 to the Convention — *Aerodromes, Volume 1,* Section 6.2.4 provides SARPs for the obstacle lighting and marking of WTGs, which is copied below:

> *6.2.4 Wind turbines*
>
> *6.2.4.1 A wind turbine shall be marked and/or lighted if it is determined to be an obstacle.*
>
> *Note 1. — Additional lighting or markings may be provided where in the opinion of the State such lighting or markings are deemed necessary.*
>
> *Note 2. — See 4.3.1 and 4.3.2*
>
> *Markings*
>
> *6.2.4.2 Recommendation. — The rotor blades, nacelle and upper 2/3 of the supporting mast of wind turbines should be painted white, unless otherwise indicated by an aeronautical study.*
>
> *Lighting*
>
> *6.2.4.3 Recommendation. — When lighting is deemed necessary, in the case of a wind farm, i.e. a group of two or more wind turbines, the wind farm should be regarded as an extensive object and the lights should be installed:*
>
> > *a) to identify the perimeter of the wind farm;*
> >
> > *b) respecting the maximum spacing, in accordance with 6.2.3.15, between the lights along the perimeter, unless a dedicated assessment shows that a greater spacing can be used;*
> >
> > *c) so that, where flashing lights are used, they flash simultaneously throughout the wind farm;*

*d) so that, within a wind farm, any wind turbines of significantly higher elevation are also identified wherever they are located; and*

*e) at locations prescribed in a), b) and d), respecting the following criteria:*

*i) for wind turbines of less than 150 m in overall height (hub height plus vertical blade height), medium-intensity lighting on the nacelle should be provided;*

*ii) for wind turbines from 150 m to 315 m in overall height, in addition to the medium-intensity light installed on the nacelle, a second light serving as an alternate should be provided in case of failure of the operating light. The lights should be installed to assure that the output of either light is not blocked by the other; and*

*iii) in addition, for wind turbines from 150 m to 315 m in overall height, an intermediate level at half the nacelle height of at least three low-intensity Type E lights, as specified in 6.2.1.3, should be provided. If an aeronautical study shows that low-intensity Type E lights are not suitable, low-intensity Type A or B lights may be used.*

*Note. — The above 6.2.4.3 e) does not address wind turbines of more than 315 m of overall height. For such wind turbines, additional marking and lighting may be required as determined by an aeronautical study.*

*6.2.4.4 Recommendation. — The obstacle lights should be installed on the nacelle in such a manner as to provide an unobstructed view for aircraft approaching from any direction.*

*6.2.4.5 Recommendation. — Where lighting is deemed necessary for a single wind turbine or short line of wind turbines, the installation should be in accordance with 6.2.4.3 e) or as determined by an aeronautical study.*

As referenced in Section 6.2.4.3(e)(iii), Section 6.2.1.3 is copied below:

*6.2.1.3 The number and arrangement of low-, medium- or high-intensity obstacle lights at each level to be marked shall be such that the object is indicated from every angle in azimuth. Where a light is shielded in any direction by another part of the object, or by an adjacent object, additional lights shall be provided on that adjacent object or the part of the object that is shielding the light, in such a way as to retain the general definition of the object to be lighted. If the shielded light does not contribute to the definition of the object to be lighted, it may be omitted.*

As referenced in Section 6.2.4.3(b), Section 6.2.3.15 is copied below:

*6.2.3.15 Where lights are applied to display the general definition of an extensive object or a group of closely spaced objects, and*

*a) low-intensity lights are used, they shall be spaced at longitudinal intervals not exceeding 45 m; and*

*b) medium-intensity lights are used, they shall be spaced at longitudinal intervals not exceeding 900 m.*

Section 4.3 Objects outside the OLS states the following:

*4.3.1 Recommendation.— Arrangements should be made to enable the appropriate authority to be consulted concerning proposed construction beyond the limits of the obstacle limitation surfaces that extend above a height established by that authority, in order to permit an aeronautical study of the effect of such construction on the operation of aeroplanes.*

*4.3.2 Recommendation. — In areas beyond the limits of the obstacle limitation surfaces, at least those objects which extend to a height of 150 m or more above ground elevation should be regarded as obstacles, unless a special aeronautical study indicates that they do not constitute a hazard to aeroplanes.*

*Note. — This study may have regard to the nature of operations concerned and may distinguish between day and night operations.*

ICAO Doc 9774 Manual on Certification *of Airports* defines an aeronautical study as:

*An aeronautical study is a study of an aeronautical problem to identify potential solutions and select a solution that is acceptable without degrading safety.*

**Light characteristics**

If obstacle lighting is required, installed lights should be designed according to the criteria set out in the applicable regulatory material and taking CASA's recommendations into consideration in the case that CASA has reviewed this risk assessment and provided recommendations.

The characteristics of the obstacle lights should be in accordance with the applicable standards in Part 139 MOS 2019.

The characteristics of low and medium intensity obstacle lights specified in Part 139 MOS 2019, Chapter 9, are provided below.

Part 139 MOS 2019 Chapter 9 Division 4 – Obstacle Lighting section 9.32 outlines Characteristics of Low Intensity Obstacle Lights.

1. *Low-intensity obstacle lights must have the following:*
   - a. *fixed lights showing red;*
   - b. *a horizontal beam spread that results in 360-degree coverage around the obstacle;*
   - c. *a minimum intensity of 100 candela (cd);*
   - d. *a vertical beam spread (to 50% of peak intensity) of 10 degrees;*
   - e. *a vertical distribution with 50 cd minimum at +6 degrees and +10 degrees above the horizontal;*
   - f. *not less than 10 cd at all elevation angles between –3 degrees and +90 degrees above the horizontal.*

   *Note: The intensity requirement in paragraph (c) may be met using a double-bodied light fitting. CASA recommends that double-bodied light fittings, if used, should be orientated so that they show the maximum illuminated surface towards the predominant, or more critical, direction of aircraft approach.*

2. *To indicate the following:*
   - a. *taxiway obstacles;*
   - b. *unserviceable areas of the movement area; low-intensity obstacle lights must have a peak intensity of at least 10 cd.*

Part 139 MOS 2019 Chapter 9 Division 4 – Obstacle Lighting section 9.33 outlines Characteristics of Medium Intensity Obstacle Lights.

1. *Medium-intensity obstacle lights must:*

    a. *be visible in all directions in azimuth; and*

    b. *if flashing — have a flash frequency of between 20 and 60 flashes per minute.*

2. *The peak effective intensity of medium-intensity obstacle lights must be 2 000 ☐ 25% cd with a vertical distribution as follows:*

    a. *for vertical beam spread — a minimum of 3 degrees;*

    b. *at -1-degree elevation — a minimum of 50% of the lower tolerance value of the peak intensity;*

    c. *at 0 degrees elevation — a minimum of 100% of the lower tolerance value of the peak intensity.*

3. *For subsection (2), vertical beam spread means the angle between 2 directions in a plane for which the intensity is equal to 50% of the lower tolerance value of the peak intensity.*

4. *If, instead of obstacle marking, a flashing white light is used during the day to indicate temporary obstacles in the vicinity of an aerodrome, the peak effective intensity of the light must be increased to 20 000 ± 25% cd when the background luminance is 50 cd/m² or greater.*

Visual impact of night lighting

Annex 14 Section 6.2.4 and Part 139 MOS 2019 Chapter 9 are specifically intended for WTGs and recommends that medium intensity lighting is installed.

Generally accepted considerations regarding minimisation of visual impact are provided below for consideration in this aeronautical study:

- To minimise the visual impact on the environment, some shielding of the obstacle lights is permitted, provided it does not compromise their operational effectiveness;
- Shielding may be provided to restrict the downward component of light to either, or both, of the following:
    - such that no more than 5% of the nominal intensity is emitted at or below 5 degrees below horizontal; and
    - such that no light is emitted at or below 10 degrees below horizontal;
- If a light would be shielded in any direction by an adjacent object or structure, the light so shielded may be omitted, provided that such additional lights are used as are necessary to retain the general definition of the object or structure.
- If flashing obstacle lighting is required, all obstacle lights on a wind farm should be synchronised so that they flash simultaneously; and
- A relatively small area on the back of each blade near the rotor hub may be treated with a different colour or surface treatment, to reduce reflection from the rotor blades of light from the obstacle lights, without compromising the daytime visibility of the overall WTG.

Marking of WTGs

ICAO Annex 14 Vol 1 Section 6.2.4.2 recommends that the rotor blades, nacelle and upper 2/3 of the supporting mast of the WTGs should be painted a shade of white, unless otherwise indicated by an aeronautical study.

It is generally accepted that a shade of white colour will provide sufficient contrast with the surrounding environment to maintain an acceptable level of safety while lowering visual impact to the neighbouring residents.

Wind monitoring towers

The details of the WMT were introduced in Section 4 of this report.

Consideration could be given to marking any WMTs according to the requirements set out in Part 139 MOS 2019 Chapter 8 Division 10 Obstacle Markings; specifically:

> *8.110 Marking of Hazardous Obstacles*
>
> *(5) As illustrated in Figure 8.110 (5), long, narrow structures like masts, poles and towers which are hazardous obstacles must be marked in contrasting colour bands so that the darker colour is at the top; and the bands are, as far as physically possible, marked at right angles along the length of the long, narrow structure; and have a length ("z" in Figure 8.110 (5)) that is, approximately, the lesser of: 1/7 of the height of the structure; or 30 m.*
>
> *(7) Hazardous obstacles in the form of wires or cables must be marked using 3-dimensional coloured objects attached to the wire or cables. Note: Spheres and pyramids are examples of 3-dimensional objects.*
>
> *(8) The objects mentioned in subsection (7) must:*
> *(a) be approximately equivalent in size to a cube with 600 mm sides; and*
> *(b) be spaced 30 m apart along the length of the wire or cable.*

NASF Guideline D suggests consideration of the following measures specific to the marking and lighting of WMTs:

- the top 1/3 of wind monitoring towers to painted in alternating contrasting bands of colour. Examples of effective measures can be found in the Manual of Standards for Part 139 of the Civil Aviation Safety Regulations 1998. In areas where aerial application operations take place, marker balls or high visibility flags can be used to increase the visibility of the towers
- marker balls or high visibility flags or high visibility sleeves placed on the outside guy wires
- ensuring the guy wire ground attachment points have contrasting colours to the surrounding ground/vegetation **or**
- a flashing strobe light during daylight hours.

Temporary WMTs installed prior to WTG installation and WMTs not in close proximity to a WTG should be lit with medium-intensity steady red obstacle lighting at the top of the WMT mast. Characteristics of medium-intensity obstacle lighting is contained in MOS 139, Section 9.33

# ANNEXURE 4 – RISK FRAMEWORK

A risk management framework is comprised of likelihood and consequence descriptors, a matrix used to derive a level of risk, and actions required of management according to the level of risk.

The risk assessment framework used by Aviation Projects has been developed in consideration of ISO 31000:2018 *Risk management—Guidelines* and the guidance provided by CASA in its Safety Management System (SMS) for Aviation guidance material, which is aligned with the guidance provided by the International Civil Aviation Organization (ICAO) in Doc 9589 *Safety Management Manual*, Third Edition, 2013. Doc 9589 is intended to provide States (including Australia) with guidance on the development and implementation of a State Safety Programme (SSP), in accordance with the International SARPs, and is therefore adopted as the primary reference for aviation safety risk management in the context of the subject assessment.

Section 2.1 of the ICAO Doc 9589 *The concept of safety* defines safety as follows [author's underlining]:

> *2.1.1 Within the context of aviation, safety is "the state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management."*

### Likelihood

Likelihood is defined in ISO 31000:2018 as the chance of something happening. Likelihood descriptors used in this report are as indicated in Table 1.

Table 1 Likelihood Descriptors

| No | Descriptor | Description |
|---|---|---|
| 1 | Rare | It is almost inconceivable that this event will occur |
| 2 | Unlikely | The event is very unlikely to occur (not known to have occurred) |
| 3 | Possible | The event is unlikely to occur, but possible (has occurred rarely) |
| 4 | Likely | The event is likely to occur sometimes (has occurred infrequently) |
| 5 | Almost certain | The event is likely to occur many times (has occurred frequently) |

### Consequence

Consequence is defined as the outcome of an event affecting objectives, which in this case is the safe and efficient operation of aircraft, and the visual amenity and enjoyment of local residents.

Consequence descriptors used in this report are as indicated in Table 2.

Table 2 Consequence Descriptors

| No | Descriptor | People Safety | Property/Equipment | Effect on Crew | Environment |
|---|---|---|---|---|---|
| 1 | Insignificant | Minor injury – first aid treatment | Superficial damage | Nuisance | No effects or effects below level of perception |
| 2 | Minor | Significant injury – outpatient treatment | Moderate repairable damage – property still performs intended functions | Operations limitation imposed.<br>Emergency procedures used. | Minimal site impact – easily controlled.<br>Effects raised as local issues, unlikely to influence decision making. May enhance design and mitigation measures. |
| 3 | Moderate | Serious injury - hospitalisation | Major repairable damage – property performs intended functions with some short-term rectifications | Significant reduction in safety margins. Reduced capability of aircraft/crew to cope with conditions. High workload/stress on crew. Critical incident stress on crew. | Moderate site impact, minimal local impact, and important consideration at local or regional level, possible long-term cumulative effect.<br>Not likely to be decision making issues. Design and mitigation measures may ameliorate some consequences. |
| 4 | Major | Permanent injury | Major damage rendering property ineffective in achieving design functions without major repairs | Large reduction in safety margins. Crew workload increased to point of performance decrement. Serious injury to small number of occupants. Intense critical incident stress. | High site impact, moderate local impact, important consideration at state level. Minor long-term cumulative effect.<br>Design and mitigation measures unlikely to remove all effects. |
| 5 | Catastrophic | Multiple Fatalities | Damaged beyond repair | Conditions preventing continued safe flight and landing.<br>Multiple deaths with loss of aircraft | Catastrophic site impact, high local impact, national importance. Serious long-term cumulative effect.<br>Mitigation measures unlikely to remove effects. |

### Risk matrix

The risk matrix, which correlates likelihood and consequence to determine a level of risk, used in this report is shown in Table 3.

Table 3 Risk Matrix

| | | CONSEQUENCE | | | | |
|---|---|---|---|---|---|---|
| | | INSIGNIFICANT 1 | MINOR 2 | MODERATE 3 | MAJOR 4 | CATASTROPHIC 5 |
| LIKELIHOOD | ALMOST CERTAIN 5 | 6 | 7 | 8 | 9 | 10 |
| | LIKELY 4 | 5 | 6 | 7 | 8 | 9 |
| | POSSIBLE 3 | 4 | 5 | 6 | 7 | 8 |
| | UNLIKELY 2 | 3 | 4 | 5 | 6 | 7 |
| | RARE 1 | 2 | 3 | 4 | 5 | 6 |

### Actions required

Actions required according to the derived level of risk are shown in Table 4.

Table 4 Actions Required

| | | |
|---|---|---|
| 8-10 | Unacceptable Risk | Immediate action required by either treating or avoiding risk. Refer to executive management. |
| 5-7 | Tolerable Risk | Treatment action possibly required to achieve As Low As Reasonably Practicable (ALARP) - conduct cost/benefit analysis. Relevant manager to consider for appropriate action. |
| 0-4/5 | Broadly Acceptable Risk | Managed by routine procedures and can be accepted with no action. |

# ANNEXURE 5 – PROJECT TURBINE AND WIND MONITORING TOWER COORDINATES AND HEIGHTS

| *Turbine Number* | *Longitude* | *Latitude* | *Terrain Elevation (m AHD)* | *Max Elevation (m AGL)* | *Max Elevation (m AHD)* | *Max Elevation (ft AHD)* |
|---|---|---|---|---|---|---|
| T1 | 717599 | 5826548 | 315.1 | 252 | 567.1 | 1860.4 |
| T2 | 715995 | 5826389 | 337.6 | 252 | 589.6 | 1934.4 |
| T3 | 716634 | 5826338 | 327.1 | 252 | 579.1 | 1900 |
| T4 | 717179 | 5825891 | 317.7 | 252 | 569.7 | 1869.2 |
| T5 | 719764 | 5825867 | 340.1 | 252 | 592.1 | 1942.5 |
| T6 | 715824 | 5825609 | 325.9 | 252 | 577.9 | 1896.1 |
| T7 | 715349 | 5825580 | 349.8 | 252 | 601.8 | 1974.5 |
| T8 | 716184 | 5825101 | 317.7 | 252 | 569.7 | 1869.2 |
| T9 | 719984 | 5825006 | 311.8 | 252 | 563.8 | 1849.9 |
| T10 | 716738 | 5824683 | 315.6 | 252 | 567.6 | 1862.3 |
| T11 | 718692 | 5824502 | 297.2 | 252 | 549.2 | 1801.7 |
| T12 | 719228 | 5824415 | 291.3 | 252 | 543.3 | 1782.5 |
| T13 | 717297 | 5824368 | 295.5 | 252 | 547.5 | 1796.2 |
| T14 | 719566 | 5824176 | 300.0 | 252 | 552.0 | 1810.9 |
| T15 | 715993 | 5824088 | 313.1 | 252 | 565.1 | 1854.1 |
| T16 | 720194 | 5824020 | 316.1 | 252 | 568.1 | 1863.7 |
| T17 | 714872 | 5823925 | 386.2 | 252 | 638.2 | 2094 |
| T18 | 714193 | 5823798 | 369.5 | 252 | 621.5 | **2039.1** |
| T19 | 716521 | 5823458 | 297.5 | 252 | 549.5 | 1802.7 |
| T20 | 713555 | 5823398 | 328.6 | 252 | 580.6 | 1904.7 |
| T21 | 714528 | 5823255 | 329.3 | 252 | 581.3 | 1907.1 |
| T22 | 715197 | 5823101 | 330.3 | 252 | 582.3 | 1910.5 |
| T23 | 718747 | 5823072 | 292.6 | 252 | 544.6 | 1786.7 |
| T24 | 720212 | 5822987 | 361.8 | 252 | 613.8 | **2013.9** |
| T25 | 719629 | 5822913 | 305.3 | 252 | 557.3 | 1828.3 |
| T26 | 715730 | 5822793 | 325.0 | 252 | 577.0 | 1893.1 |
| T27 | 716313 | 5822383 | 314.2 | 252 | 566.2 | 1857.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| T28 | 719082 | 5822204 | 279.6 | 252 | 531.6 | 1744 |
| T29 | 719661 | 5822049 | 286.9 | 252 | 538.9 | 1768 |
| T30 | 715881 | 5821873 | 309.4 | 252 | 561.4 | 1841.8 |
| T31 | 716203 | 5821056 | 285.9 | 252 | 537.9 | 1764.6 |
| T32 | 716491 | 5820278 | 286.7 | 252 | 538.7 | 1767.4 |
| T33 | 713108 | 5820100 | 306.1 | 252 | 558.1 | 1831 |
| T34 | 716037 | 5819810 | 296.1 | 252 | 548.1 | 1798.4 |
| T35 | 713668 | 5819661 | 317.1 | 252 | 569.1 | 1867 |
| T36 | 713166 | 5819053 | 312.4 | 252 | 564.4 | 1851.8 |
| T37 | 714258 | 5818973 | 323.2 | 252 | 575.2 | 1887.2 |
| T38 | 715865 | 5818943 | 300.7 | 252 | 552.7 | 1813.4 |
| T39 | 716535 | 5818874 | 295.4 | 252 | 547.4 | 1795.9 |
| T40 | 717102 | 5818638 | 290.6 | 252 | 542.6 | 1780.2 |
| T41 | 713813 | 5818549 | 318.3 | 252 | 570.3 | 1871.1 |
| T42 | 715166 | 5818272 | 298.3 | 252 | 550.3 | 1805.5 |
| T43 | 714562 | 5818242 | 306.0 | 252 | 558.0 | 1830.7 |
| T44 | 716093 | 5818125 | 295.5 | 252 | 547.5 | 1796.3 |
| T45 | 715566 | 5817656 | 288.9 | 252 | 540.9 | 1774.6 |
| T46 | 714863 | 5817347 | 297.5 | 252 | 549.5 | 1802.9 |
| T47 | 715585 | 5816777 | 285.5 | 252 | 537.5 | 1763.5 |
| T48 | 713081 | 5816085 | 284.7 | 252 | 536.7 | 1760.9 |
| T49 | 712549 | 5815883 | 279.1 | 252 | 531.1 | 1742.3 |
| T50 | 711621 | 5815856 | 270.9 | 252 | 522.9 | 1715.5 |
| T51 | 716069 | 5815581 | 279.0 | 252 | 531.0 | 1742.1 |
| T52 | 716448 | 5815010 | 278.4 | 252 | 530.4 | 1740 |
| T53 | 715799 | 5814748 | 279.9 | 252 | 531.9 | 1745.1 |
| T54 | 720331 | 5814322 | 269.3 | 252 | 521.3 | 1710.1 |
| T55 | 719719 | 5814184 | 268.0 | 252 | 520.0 | 1706 |
| T56 | 716160 | 5813941 | 275.3 | 252 | 527.3 | 1729.9 |
| T57 | 718115 | 5813727 | 259.1 | 252 | 511.1 | 1676.9 |
| T58 | 718815 | 5813680 | 258.3 | 252 | 510.3 | 1674.2 |
| T59 | 720157 | 5813426 | 264.5 | 252 | 516.5 | 1694.6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| T60 | 719378 | 5813322 | 259.8 | 252 | 511.8 | 1679.1 |
| T61 | 720540 | 5812821 | 253.3 | 252 | 505.3 | 1657.7 |
| T62 | 719934 | 5812487 | 246.5 | 252 | 498.5 | 1635.4 |
| | | | | | | |
| Mast 1 | 715703 | 5818149 | 296 | 160 | 456 | 1496.1 |
| Mast 2 | 717010.3 | 5825919 | 314 | 160 | 474 | 1555.1 |
| Mast 3 | 719862.4 | 5824384 | 316 | 160 | 476 | **1561.7** |
| Mast 4 | 719606 | 5813626 | 266 | 160 | 426 | 1397.6 |

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