



**OBSTACLE LIGHTING REQUIREMENTS
HAWKESDALE WIND FARM**

Prepared for Hawkesdale Development Pty Ltd

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ACRONYMS

AGL	above ground level
AIP	Aeronautical Information Package
ALARP	as low as reasonably practicable
AMSL	above mean sea level
CAR	Civil Aviation Regulation (1988)
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulation (1998)
CFIT	controlled flight into terrain
ERSA	En Route Supplement Australia
HDPL	Hawkesdale Development Pty Ltd
HWF	Hawkesdale Wind Farm
ICAO	International Civil Aviation Organization
IFR	instrument flight rules
IMC	instrument meteorological conditions
MOS	Manual of Standards
MSA	minimum sector altitude
OLS	obstacle limitation surface
PANS-OPS	Procedures for Air Navigation Services - Aircraft Operations
PPA	Planning Permit Application
RPT	regular public transport
VFR	visual flight rules
VMC	visual meteorological conditions

UNITS OF MEASUREMENT

ft	feet	(1ft = 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)

EXECUTIVE SUMMARY

Introduction

Hawkesdale Development Pty Ltd (HDPL) a wholly owned subsidiary of Union Fenosa Wind Australia Pty Ltd (UFWA) seeks to develop a wind farm known as Hawkesdale Wind Farm (HWF) approximately 2 km south of Hawkesdale in Victoria. The wind farm is proposed to comprise not more than 31 wind turbines with a planned maximum blade tip height of 126.3 m (414 ft) above ground level (AGL).

The approved HWF has conditions relating to obstacle lighting, and the regulatory framework with respect to obstacle lighting of wind farms in force at the time of the original application and subsequent planning permit approval in 2008 has changed.

In light of these changes, and a desire to reduce the anxiety of the community associated with potential visual impacts arising from operation of the obstacle lights at night, HDPL seeks an independent assessment of the requirement for obstacle lighting.

Context

The following aspects were considered in the external context:

- Department of Planning;
- Environment Protection and Heritage Council;
- Civil Aviation Safety Authority;
- International Civil Aviation Organization;
- Warrnambool Aerodrome;
- Airspace and air routes;
- Rules of flight;
- Aircraft operator characteristics; and
- Visibility of turbines and obstacle lighting during the day.

The following aspects were considered in the internal context:

- Wind farm description;
- Wind turbine description;
- Conclusions of PPA Section 18 - Aviation Safety Assessment; and
- Comparative analysis of lighting on nearby wind farms.

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.

Consequence is defined as the outcome of an event affecting objectives, which in this case are the safe and efficient operation of aircraft within the vicinity of the wind farm, and the visual amenity and enjoyment of surrounding residents.

The following risk events were assessed:

- aircraft collision with a wind turbine;
- aircraft collision with a wind monitoring tower;
- harsh manoeuvring to avoid a wind turbine leading to controlled flight into terrain;
- the effect on crew of limitations imposed by the wind farm; and
- the visual impact from obstacle lights on surrounding residents.

A summary of the level of risk associated with Hawkesdale Wind Farm under the proposed treatment regime, with specific consideration of the effect of obstacle lighting, is provided in the table below.

<i>Risk Element</i>	<i>Consequence</i>	<i>Likelihood</i>	<i>Risk</i>	<i>Actions Required</i>
Aircraft collision with wind turbine	Catastrophic	Rare	6	Acceptable without obstacle lighting. Communicate details of wind farm to local and regional operators before, during and following construction.
Aircraft collision with monitoring tower	Catastrophic	Rare	6	Acceptable without obstacle lighting. Although there is no obligation to do so, consider marking the wind monitoring towers according to the requirements set out in MOS 139 Section 8.10 Obstacle Markings, specifically 8.10.2.6 and 8.10.2.8. Communicate details of wind farm wind monitoring towers to local and regional operators following construction.
Harsh manoeuvring leads to CFIT	Catastrophic	Rare	6	Acceptable without obstacle lighting. Communicate details of wind farm to local and regional operators before, during and following construction.
Effect on crew	Minor	Possible	5	Acceptable without obstacle lighting. Communicate details of wind farm to local and regional operators before, during and following construction.
Visual impact from obstacle lights	Moderate	Possible	6	Acceptable without obstacle lighting (zero risk of visual impact from obstacle lighting). If lights are installed, design to minimise impact and in accordance with Planning Permit Conditions.

Conclusions

As a result of the foregoing risk assessment, the following conclusions are drawn:

- There is no regulatory requirement for lighting of obstacles lower than 150 m (492 ft) AGL that are not within the vicinity of an aerodrome.
- There is a relatively low rate of aircraft activity in the vicinity of the wind farm site.
- There are no known aerial agriculture operations conducted at night in the vicinity of the wind farm site.
- The wind farm will be clear of the obstacle limitation surfaces at Warrnambool aerodrome.

- The existing wind monitoring towers at HWF are 60 m (197 ft) and 40 m (131 ft) high, and do not require lighting. Their location and other applicable details have been advised to RAAF AIS.
- Removal or retention of these wind monitoring towers is subject to final micro-siting of the wind turbines (in accordance with any Planning Permit Conditions).
- A hub height wind monitoring tower may be erected for turbine power curve verification. The location of this tower is yet to be determined, but it will be positioned within rather than on the perimeter of a cluster of turbines.
- None of the wind farms in relatively close proximity to HWF with turbines greater than 110 m (361 ft) and less than 150 m (492 ft) AGL blade tip height are planned to have obstacle lighting. Waubra is the only operational wind farm with obstacle lighting, but the operator has submitted a request to the Department of Planning to have these lights turned off.
- Wind Farm Developments has advised that it has decided not to light the turbines of Woolsthorpe Wind Farm.
- The risk of an aircraft collision with a wind turbine, without obstacle lighting on the turbines, of Hawkesdale Wind Farm is considered acceptable. However, HDPL may consider other factors in its decision as to whether obstacle lighting should be installed.
- The risk of an aircraft collision with the wind monitoring towers, without obstacle lighting on the turbines, of Hawkesdale Wind Farm is considered acceptable. However, HDPL may consider other factors in its decision as to whether obstacle lighting should be installed.
- The risk of harsh aircraft manoeuvring to avoid collision with a wind turbine leading to controlled flight into terrain, without obstacle lighting on the turbines of Hawkesdale Wind Farm, is considered acceptable.
- The risk of Hawkesdale Wind Farm imposing operational limitations on aircraft operating crew, without obstacle lighting on the turbines, is considered acceptable. However, HDPL may consider other factors in its decision as to whether obstacle lighting should be installed.
- Visual impact from obstacle lights can be negated if they are not installed, but if obstacle lights are to be installed, they must meet Planning Permit Conditions 8 and 9 and can be designed so that there is an acceptable risk of visual impact to neighbours.
- The following risk treatments may provide an additional margin of safety:
 - Details of the wind farm, including wind monitoring towers, should be communicated to local and regional aircraft operators prior to, during and following construction to heighten their awareness of its location and so that they can plan their operations accordingly.
 - Although there is no obligation to do so, consideration could be given to marking the wind monitoring towers according to the requirements set out in MOS 139 Section 8.10 Obstacle Markings; specifically:
 - 8.10.2.6 Masts, poles and towers must be marked in contrasting bands with the darker colour at the top, as shown in Figure 8.10-3. The bands must be perpendicular to the longest dimension and have a width approximately 1/7 of the longest dimension or 30 m, whichever is less.
 - 8.10.2.8 Wires or cable obstacles must be marked using three-dimensional coloured objects such as spheres and pyramids, etc; of a size equivalent to a cube with 600 mm sides, spaced 30m apart.

Recommendations

As a result of the foregoing risk assessment, the following recommendations are made:

1. With respect to Conditions 8 and 9 of Planning Permit 20060221, it is assessed that Hawkesdale Wind Farm will not require obstacle lighting to maintain an acceptable level of safety to aircraft.
2. Hawkesdale Development Pty Ltd may consider other factors in its decision as to whether obstacle lighting should be installed.
3. The following additional risk treatments should be implemented:
 - a. Details of the wind farm, including wind monitoring towers, should be communicated to local and regional aircraft operators prior to, during and following construction to heighten their awareness of its location and so that they can plan their operations accordingly; and
 - b. Although there is no obligation to do so, consideration could be given to marking the wind monitoring towers according to the requirements set out in MOS 139 Section 8.10 Obstacle Markings; specifically:
 - 8.10.2.6 Masts, poles and towers must be marked in contrasting bands with the darker colour at the top, as shown in Figure 8.10-3. The bands must be perpendicular to the longest dimension and have a width approximately 1/7 of the longest dimension or 30 m, whichever is less.
 - 8.10.2.8 Wires or cable obstacles must be marked using three-dimensional coloured objects such as spheres and pyramids, etc; of a size equivalent to a cube with 600 mm sides, spaced 30m apart.
4. 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; and
 - c. following any near miss, incident or accident associated with operations considered in this risk assessment.

1. INTRODUCTION

1.1. Situation

Hawkesdale Development Pty Ltd (HDPL) a wholly owned subsidiary of Union Fenosa Wind Australia Pty Ltd (UFWA) seeks to develop a wind farm known as Hawkesdale Wind Farm (HWF) approximately 2 km south east of Hawkesdale in Victoria. The wind farm is proposed to comprise not more than 31 wind turbines with a planned maximum blade tip height of 126.3 m (414 ft) above ground level (AGL).

HWF is one of a number of wind farms at various stages of planning, approval, construction or operation in the region.

The approved HWF has conditions relating to obstacle lighting, and the regulatory framework with respect to obstacle lighting of wind farms in force at the time of the original application and subsequent planning permit approval in 2008 has changed.

In light of these changes, and a desire to reduce the anxiety of the community associated with potential visual impacts arising from operation of the obstacle lights at night, HDPL seeks an independent assessment of the requirement for obstacle lighting.

1.2. Background

The Hawkesdale Wind Farm development was originally proposed by Gamesa Energy Australia in 2006 under Planning Permit Application 20060221.

On 12 August 2008 the Victorian Minister for Planning issued Planning Permit No 20060221 for the proposed construction and operation of a wind farm consisting of up to 31 turbines and associated infrastructure, as described in the Hawkesdale Wind Farm Application for Planning Permit dated September 2006 and modified in accordance with the Planning Permit.

1.3. Purpose of task

The purpose of this engagement is to consider the need for obstacle lighting at HWF so that HDPL can make an informed decision about whether or not to install obstacle lighting, in due consideration of regulatory requirements, acceptable levels of aviation safety and community concerns about the visual impact of obstacle lighting.

1.4. Scope

The scope of the task is to consider whether obstacle lighting of the wind turbines of the approved Hawkesdale Wind Farm will be required to maintain an acceptable level of aviation safety. The risk assessment is to be conducted using the methodology outlined in AS/NZS ISO 31000:2009 *Risk Management – Principles and guidelines*.

1.5. Limitations of scope

The scope of the task is limited as follows:

- A detailed study of the effect of HWF on Warrnambool aerodrome's Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS) surfaces has not been undertaken by Aviation Projects.

1.6. Report structure

This report is structured around the following areas of consideration:

- external context;
- internal context;
- risk criteria;
- risk identification;
- risk analysis, evaluation and treatment;
- conclusions; and
- recommendations.

1.7. Methodology

In undertaking this task, the following activities were undertaken:

- current approvals, permits and associated planning material were reviewed to identify obstacle lighting issues;
- the current regulatory context was reviewed;
- a site visit was conducted on 31 July 2011;
- a comparative analysis of the obstacle lighting situation for other nearby wind farms was conducted;
- online resources were investigated for aircraft accidents/incidents associated with wind farms. These resources included Australian Transport Safety Bureau (ATSB) Aviation safety investigation and reports database, National Transport Safety Bureau (USA) accident database, Transportation Safety Board of Canada aviation reports database and German Federal Bureau of Aircraft Accidents Investigation database, as well as a compilation of accidents associated with wind farms compiled and published by Caithness Windfarm Information Forum;
- current aviation activities within the vicinity of the wind farm were investigated;
- applicable stakeholders, including CASA were consulted; and
- the levels of risk associated with aviation activities conducted within the vicinity of the wind farm site were assessed, including a review of current and planned treatments, and consideration of the effect that turbines with or without obstacle lighting will have on the overall level of risk to aviation safety.

1.8. Stakeholders

Stakeholders considered and/or consulted in the preparation of this report include:

- aircraft operators;
- Civil Aviation Safety Authority;
- Union Fenosa Wind Australia Pty Ltd and Hawkesdale Development Pty Ltd; and
- local residents.

1.9. Material provided

Material provided by HDPL for preparation of this assessment included:

- Letter from CASA dated 17 August 2006;
- Hawkesdale Planning Permit Application Section 18 – *Aircraft Safety Assessment*, dated 19 September 2006;
- Hawkesdale Permit No 20060221 dated 12 August 2008;
- The Ambidji Group Pty Ltd, *Hawkesdale Wind Farm Evaluation of Lighting Requirements*, dated 30 January 2008; and
- Letter from Department of Planning and Community Development, *Hawkesdale and Ryan Corner Wind Farm Projects Amendment to Turbine Specifications*, dated 12 August 2010.

1.10. References

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

- Aeronautical Information Package; including AIP Book effective 2 June 2011, and En Route Supplement Australia dated 2 June 2011;
- Civil Aviation Safety Authority, *Civil Aviation Regulations 1988 (CAR)*, as amended;
- Civil Aviation Safety Authority, *Civil Aviation Safety Regulations 1998 (CASR)*, First Edition January 2003 as amended;
- Civil Aviation Safety Authority, *Manual of Standards Part 139 – Aerodromes*, version 1.5 dated May 2010;
- Civil Aviation Safety Authority, email from Mr Byron Sullivan re Obstacle marking and lighting of wind farms – status update, 15 July 2011;
- Environment Protection and Heritage Council, *National Wind Farm Development Guidelines DRAFT*, July 2010;
- International Civil Aviation Organization (ICAO) Doc 8168 *Procedures for Air Navigation Services—Aircraft Operations (PANS-OPS)*;
- ICAO Standards and Recommended Practices, *Annex 14—Aerodromes*;

- Victoria Department of Planning and Community Development, *Policy and planning guidelines for development of wind energy facilities in Victoria*, dated August 2011; and
- other references as noted.

2. EXTERNAL CONTEXT

2.1. Department of Planning

The proposed development was the subject of Planning Permit Application 20060221, lodged in 2006 with the Victorian Department of Planning (now called Department of Planning and Community Development).

The Civil Aviation Safety Authority (CASA) was consulted (in August 2006, October 2007 and again in March 2008) and provided its view on the potential impact of the turbines on aviation safety. The responses are discussed in further detail in the next section.

The Ambidji Group Pty Ltd was then engaged to prepare a report entitled Hawkesdale Wind Farm Evaluation of Lighting Requirements (dated 30 January 2008), in which the original lighting design proposed in the Planning Permit Application (PPA) was revised and an alternative lighting design option was proposed.

On 12 August 2008 the Victorian Minister for Planning issued Planning Permit No 20060221 for the proposed construction and operation of a wind farm consisting of up to 31 turbines and associated infrastructure, as described in the Hawkesdale Wind Farm Application for Planning Permit dated September 2006 and modified in accordance with the Planning Permit.

Conditions 8 and 9 address lighting.

8. Except in the case of an emergency, no external lighting of infrastructure associated with the wind energy facility, other than low level security lighting may be installed or operated without the further written consent of the Minister for Planning.

9. Any obstacle lighting for aviation safety should be generally in accordance with the 'Alternative Obstacle Lighting Proposal' plan Revision 3 dated 30/01/08 prepared by the Ambidji Group and must be to the satisfaction of the Minister for Planning. In finalising any lighting plan:

- a) The applicant must consult with CASA;*
- b) Advice must be sought from a suitably qualified wildlife ecologist to ensure the light flashing period minimises any impact on bats or night flying birds.*
- c) The turbines to be lit must be selected in consultation with the owners of the adjacent Woolsthorpe Wind Farm with the objective of minimising the total number of lit turbines in the area;*
- d) Where turbines are to be lit, individual lighting installations must be in accordance with the CASA Advisory Circular 139-18(0) and the CASA Manual of Standards, particularly Chapter 9; and*
- e) The impact minimisation features to be incorporated in any installation must include, but are not limited to:*
 - (i) Treatment of the rear of the blade to avoid reflection of aviation lights;*
 - (ii) Shielding of the lights on top and bottom such that the maximum intensity of light is limited to a beam of 3 degrees, with only 0.5 degrees of this beam width below the horizon; and*

(iii) All lights on the wind farm synchronised to flash in unison.

2.2. Environment Protection and Heritage Council

The Environment Protection and Heritage Council (EPHC) has produced Draft National Wind Farm Development Guidelines, dated July 2010, to complement existing planning and development processes. The Guidelines are intended to be best practice and not mandatory. The twelve month evaluation period has just concluded, but no revision or final version of the Guidelines was available at the time of writing.

Guidance notes provided under section 3.7 Aircraft safety state as follows:

The physical intrusion of towers and blades into the airspace used by aircraft is addressed by the Civil Aviation Safety Authority (CASA) guidelines, which are currently under review. The CASA guidelines, once finalised, may indicate that night lighting should be installed on some or all turbines within the wind farm. This, in turn, may pose a visual impact that will need to be considered in the landscape assessment and in the birds and bats assessment.

2.3. Civil Aviation Safety Authority

The Civil Aviation Safety Authority regulates aviation activities in Australia. Applicable requirements include the Civil Aviation Regulations 1988 (CAR), Civil Aviation Safety Regulations 1998 (CASR) and associated Manuals of Standards (MOS) and other guidance material.

2.3.1. Civil Aviation Safety Regulations 1998, Part 139--Aerodromes

In areas remote from an aerodrome, CASR 139.365 requires the owner of a structure (or proponents of a structure) that will be 110 m or more above ground level (AGL) to inform CASA. This is to allow CASA, under CASR 139.370, to assess the effect of the structure on aircraft operations and determine whether or not the structure will be a hazardous object because of its location, height, or lack of marking or lighting.

After an initial enquiry by Gamesa Energy Australia in March 2006 and subsequently providing further explanatory information in July 2006, Mr Kim Jones, CASA's Manager, Airways and Aerodromes wrote on 17 August 2006:

Ref: Proposed Hawkesdale and Ryan Corner Windfarms, Victoria

Thank you for your letter dated 25 July, and data regarding relative heights of your proposed wind turbines and surrounding terrain. Having reviewed this data, CASA will not require that the turbines be lit.

Mr Jones, on behalf of CASA, wrote again on 3 April 2007:

Ref: Proposed Hawkesdale and Ryan Corner Windfarms, Victoria

I refer to my letter of 17 August 2006 in which I advised you that CASA will not require the proposed turbines at the above sites to be lit. On further representation from the industry and deliberation of the eight aerodromes and airstrips located close to the proposed sites, CASA believes that there are and will be significant aircraft traffic traversing the area. The number of tall turbine structures does pose a significant hazard. Without the obstacle lights, the hazard posed by these tall structures to

pilots operating at night or in marginal visibility conditions cannot be minimised. I need to withdraw my earlier advice, and regret any inconvenience caused.

Mr Jones did not explain why the number of tall turbine structures pose a significant hazard, and the conclusion about not being able to minimise the hazard to aircraft operating at night or in marginal visibility conditions is without justification.

On 4 March 2008 Mr Jones, on behalf of CASA, wrote to the Chairman of Planning Panels Victoria:

Hawkesdale Wind Farm – Planning permit application No. 20060221

We reiterate our comments sent to Gamesa Energy Australia, and copied to you, dated 3 April 2007. At that time we advised that due to the height of the turbines, and the extent and location of the proposed Hawkesdale Wind Farm, CASA would require the provision of obstacle lighting and marking in order to reduce the hazard to aviation.

2.3.2. Manual of Standards 139--Aerodromes

Chapter 7 of MOS 139 sets out the standards applicable to Obstacle Restriction and Limitation. Section 7.1.5 deals with objects outside the obstacle limitation surfaces (OLS):

7.1.5 Objects Outside the OLS

7.1.5.1 Under CASR Part 139 any object which extends to a height of 110 m or more above local ground level must be notified to CASA.

Note: For instrument runways, obstacle monitoring includes the PANS-OPS surface which extends beyond the OLS of the aerodrome. See paragraph 7.1.1.

7.1.5.2 Any object that extends to a height of 150 m or more above local ground level must be regarded as an obstacle unless it is assessed by CASA to be otherwise.

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

Section 9.4.1 provides some general guidance on obstacle lighting:

9.4.1.2 In general, an object in the following situations would require to be provided with obstacle lighting unless CASA, in an aeronautical study, assesses it as being shielded by another lit object or that it is of no operational significance:

(b) outside the obstacle limitation surfaces of an aerodrome, if the object is or will be more than 110 m above ground level.

Section 9.4.2 provides guidance on Types of Obstacle Lighting and Their Use:

9.4.2.3 Medium intensity obstacle lights are to be used either alone or in combination with low intensity lights, where:

(a) the object is an extensive one;

(b) the top of the object is 45 m or more above the surrounding ground; or

(c) CASA determines that early warning to pilots of the presence of the object is desirable.

9.4.2.5 High intensity obstacle lights are flashing white lights used on obstacles that are in excess of 150 m in height.

While the turbines will be located outside the obstacle limitation surfaces of an aerodrome but will be more than 110 m AGL and in any case are not approved to exceed 126.3 m (414 ft) AGL, CASA indicated the turbines pose a hazard to aviation. The risk assessment prepared for this report concludes that there will be an acceptable level of aviation safety without obstacle lighting and therefore there will be no requirement for obstacle lighting under the provisions of MOS 139 Chapter 9.

2.3.3. Advisory Circular 139-18(0) *Marking and lighting of wind farms*

CASA previously provided guidance on the marking and lighting of wind farms in Advisory Circular (AC) 139-18(0) *Obstacle Marking and Lighting of Wind Farms*, dated July 2007. This document was withdrawn from publication in 2008, after the Planning Permit was issued.

No replacement guidance has been developed or published by CASA since the withdrawal of AC 139-18(0).

It can be concluded that there is no regulatory obligation to conform to the guidance provided in AC 139-18(0), since it has been withdrawn from publication.

2.3.4. Current CASA guidance

To ascertain the current status of CASA guidance regarding obstacle marking and lighting of wind farms, Mr Byron Sullivan, CASA's Aerodrome Engineer (Aerodrome Lighting) was consulted via email on 15 July 2011. The relevant section of his response is provided below:

For tall structures not in the vicinity of an aerodrome.

For objects not in the vicinity of an aerodrome, CASA has no specific authority to require action for the marking and lighting of tall structures. If the owner of the structure decides to mark and/or light it as part of their duty of care to not pose a hazard to aviation, then the marking and lighting should be in accordance with the standards published in MOS Part 139.

Our previous Advisory Circular AC 139-18(0) was withdrawn following a legal challenge that it gave the impression that CASA did have regulatory authority over tall structures not in the vicinity of an aerodrome.

The subject of expanding CASA's regulatory authority to cover tall structures not in the vicinity of an aerodrome, has not yet been decided, as far as I know.

On the basis of this guidance, it can be concluded that there is no regulatory obligation to install obstacle lighting on the wind turbines of HWF.

2.4. International Civil Aviation Organization

As a contracting state to the International Civil Aviation Organization (ICAO) and signatory to the Chicago Convention on International Civil Aviation, Australia has an obligation to implement ICAO's standards and recommended practices (SARPs) as published in the various annexes to the Convention. Where these SARPs are not met, a difference must be filed.

Annex 14 to the Convention – Aerodromes, Volume 1 documents SARPs applicable to wind turbines. Section 6.4 of Annex 14 provides as follows:

6.4 Wind turbines

6.4.1 A wind turbine shall be marked and/or lighted if it is determined to be an obstacle.

Note.— See 4.3.1 and 4.3.2.

Markings

6.4.2 **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

6.4.3 **Recommendation.**— *When lighting is deemed necessary, medium-intensity obstacle lights should be used. In the case of a wind farm, i.e. a group of two or more wind turbines, it 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 6.3.14 [900 m], 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; and*

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

6.4.4 **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.*

Sections 4.3.1 and 4.3.2 of Annex 14 state as follows:

4.3 Objects outside the obstacle limitation surfaces

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.*

In accordance with section 4.3.1, because the turbines are proposed to reach a height of greater than 110 m AGL, CASA (the appropriate authority) was consulted. CASA assessed the turbines as posing a hazard to aircraft operations.

Section 4.3.2 does not apply, because the maximum permitted blade tip height is 126.3 m AGL (changed from 121.5 m through the secondary consent provisions).

The following risk assessment concludes that there will be an acceptable level of aviation safety without obstacle lighting and therefore there will be no requirement for obstacle lighting under the provisions of ICAO Annex 14 section 6.4.1.

2.5. Warrnambool Aerodrome

Warrnambool Aerodrome is a Registered aerodrome, main runway 13/31 - 1372 m long, secondary runway 04/22 - 1069 m long, bearing 145 degrees magnetic at 11 nm from HWF.

Aircraft operations conducted at the aerodrome include regular public transport, general aviation, training, private, air ambulance (helicopter) and charter.

Instrument procedures in use include a GPS arrival (circling), NDB-A (circling) and RNAV (GNSS) straight-in approach to runway 31. All instrument procedures are located clear of HWF.

HWF is located within 15 nm of the aerodrome but should not impact on the 25 nm minimum sector altitude (MSA) which is 2700 ft above mean sea level (AMSL).

Runway 13/31 is published as a code 3 runway (instrument non-precision). According to MOS 139 Chapter 7, the critical obstacle limitation surfaces are as follows:

- Inner horizontal surface 4000 m radius – no impact from HWF; and
- Approach and take-off surface total length – 15 000 m – no impact from HWF.

Warrnambool City Council was consulted during preparation of the PPA and advised that the development of HWF would have no impact on Warrnambool aerodrome.

A site overview showing the location of Warrnambool aerodrome with respect to HWF, taken from Section 18 of the PPA, is provided in Figure 1.

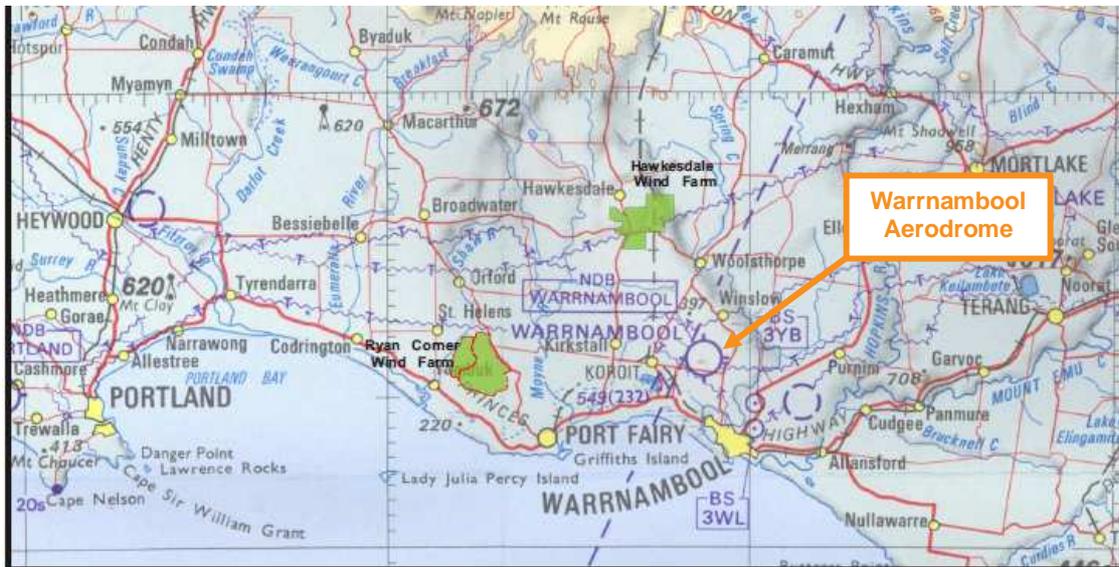


Figure 1 Warrnambool aerodrome

2.6. Airspace and air routes

HWF is located outside controlled airspace.

The air routes within the vicinity of HWF, taken from En Route Chart L2 are shown in Figure 2.

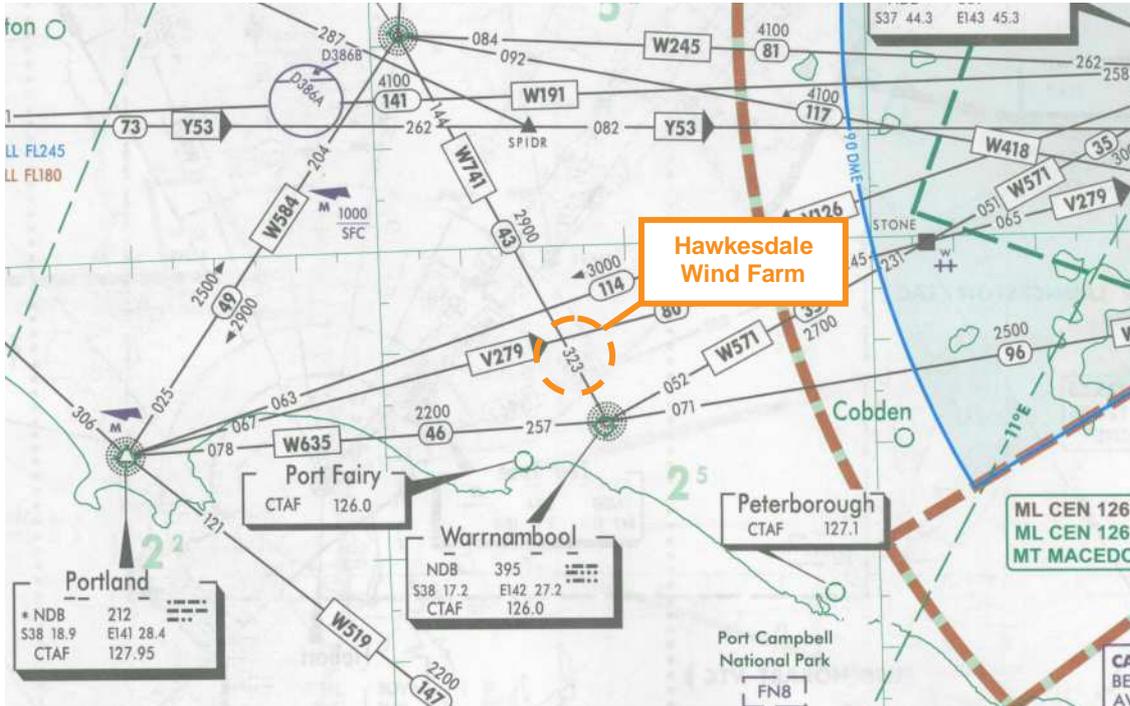


Figure 2 Air routes within the vicinity of HWF

2.7. Rules of flight

2.7.1. 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 Regulation 157 Low flying prescribes the minimum height for flight. Generally speaking 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 600 m (or 300 m for helicopters) in visual flight during the day when not in the vicinity of built up areas, and 1000 ft AGL over built up areas.

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.

2.7.2. Night VFR

With respect to flight under the VFR at night, Civil Aviation Regulations (1988) 174B states as follows:

The pilot in command of an aircraft must not fly the aircraft at night under the V.F.R. at a height of less than 1 000 feet above the highest obstacle located within 10 miles of the aircraft in flight if it is not necessary for take-off or landing.

2.7.3. IFR (Day or night)

According to CAR 178, 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.

2.8. Aircraft operator characteristics

2.8.1. Passenger transport operations

Regular public transport (RPT) and passenger carrying charter operations are generally operated under the IFR.

2.8.2. 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.

2.8.3. Aerial agriculture operations

Aerial agricultural operations including such activities as fertiliser, pest and crop spraying are generally conducted under day VFR below 500 ft AGL. Crop spraying can be conducted at night, although Todd Miller of Western Aerial based at Derrinallum stated that he had no knowledge of night aerial agricultural operations being conducted in the area. He did mention, however, that occasionally, due to inadvertent delays, an aircraft might conduct part of its flight home at the end of the day after evening civil twilight and therefore technically under night VFR.

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

The Aerial Agricultural Association of Australia (AAAA) has a formal risk management program which is recommended for use by its members.

2.8.4. Aerial fire fighting

Aerial fire fighting operations (fire bombing in particular) are conducted in Day VFR, sometimes below 500 ft AGL. Under certain conditions visibility may be reduced/limited by smoke/haze.

Most aerial fire fighting 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.

2.8.5. Emergency services/air ambulance/RFDS

Air ambulance 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.

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.

2.9. Visibility of turbines and obstacle lighting during the day

As a means of enhancing comprehension of the effectiveness of obstacle lighting during conditions of reduced visibility and low cloud in the day, the following photo, taken at Oaklands Hill Wind Farm in Victoria, is provided.

The photo was taken from the side of the road at the entrance to the site. A communications mast can be seen on the horizon in the left middle distance. There is also another mast just to the right of the green sign on the horizon in the right middle distance which is almost completely obscured by cloud. The masts are approximately 500 m from the camera, and it is obvious that any obstacle lighting on top of the masts would not be visible to an aircraft in these circumstances.

If the required visibility was available, it is argued that the towers would be visible in any case, and so lighting would not be required.



Figure 3 Communications masts at Oaklands Hill Wind Farm

3. INTERNAL CONTEXT

3.1. Wind farm description

Hawkesdale Wind Farm is planned to comprise a maximum of 31 wind turbines on a site located approximately 2 km south east of Hawkesdale.

The wind farm site is situated in an area comprised mainly of farming properties on gently rolling terrain.

The planned wind farm location, extracted from the original letter to CASA dated 28 March 2006, is shown in Figure 4.

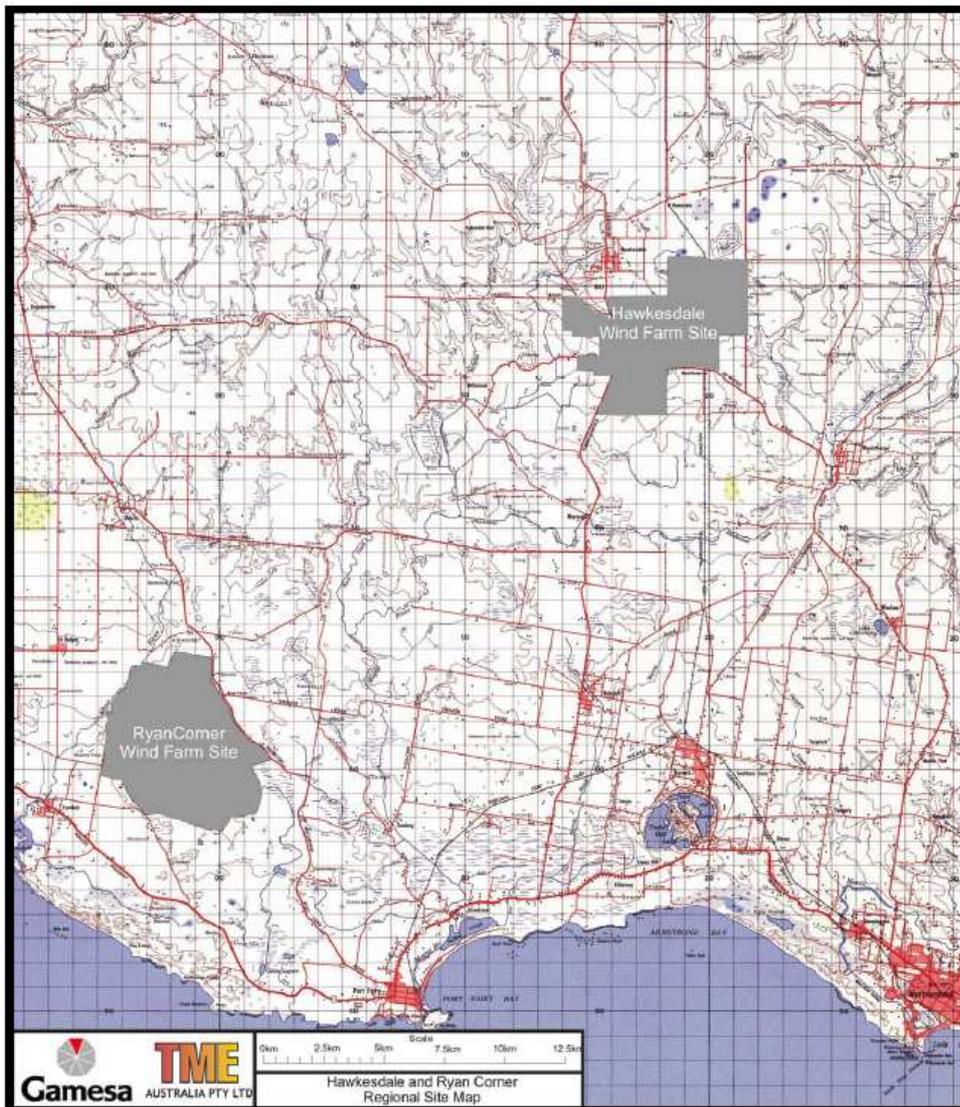


Figure 4 Site Map

A preliminary turbine layout, sourced from the original letter to CASA dated 28 March 2006, is shown in Figure 5.

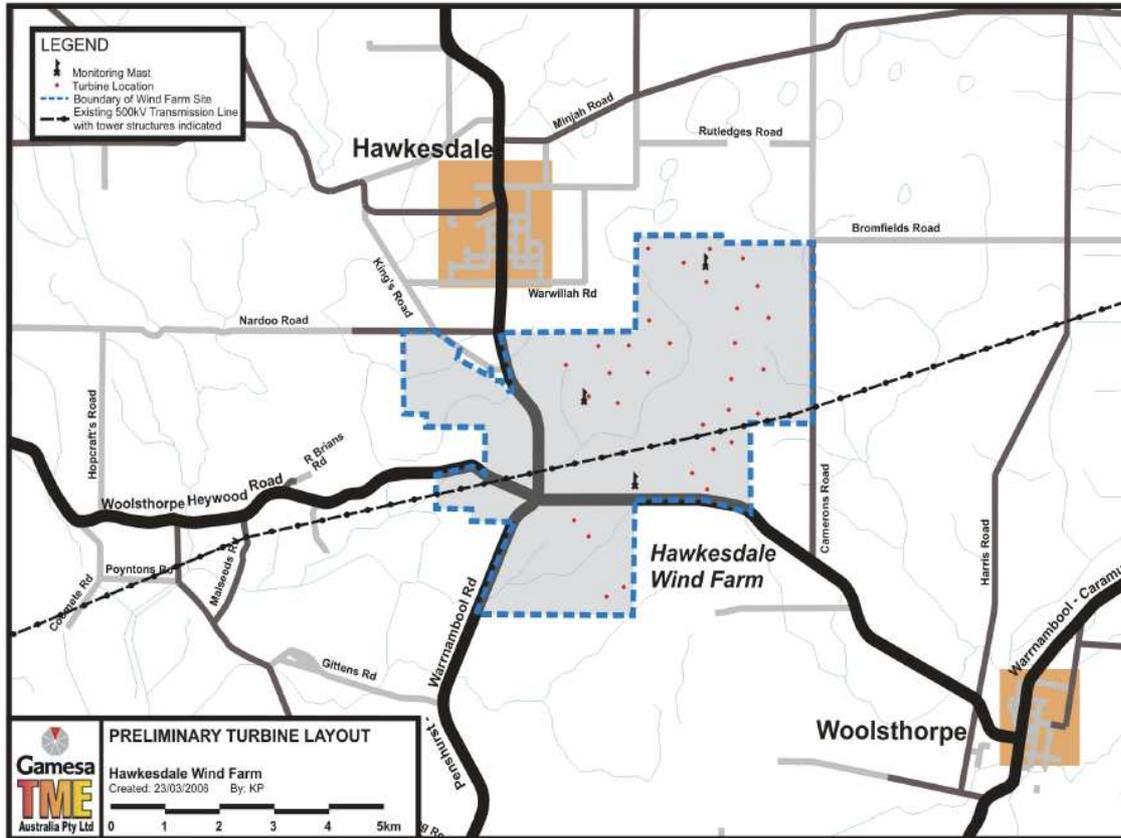


Figure 5 Preliminary Turbine Layout

A photo taken from just south of Hawkesdale on the Warrnambool Rd looking east is shown in Figure 6. A wind monitoring tower can be seen just to the left of centre in the middle distance.



Figure 6 View of site from just south of Hawkesdale looking east

3.2. Wind turbine description

HDPL advises that the wind turbines to be installed at HWF will be up to 126.3 m (414 ft) to the top of the blade tip, with an 80 m tower. A maximum height of 126.3 m (414 ft) above natural ground level is recorded in the secondary consent provisions.

The Planning Permit also specifies that the wind turbines, nacelles and rotor blades must pale grey, off white or other colour that blends with the landscape, and must be of a non-reflective finish.

3.3. Conclusions of PPA Section 18 - Aviation Safety Assessment

Section 18 - Aviation Safety Assessment of the PPA noted the following key results from the initial assessment and consultation:

- *the Project does not impact any OLS or PANS-OPS surfaces at any of the airports in the vicinity;*
- *the Project does not impact any other flying (commercial or recreational) activities in the area;*
- *the details of the Project should be marked on the World Aeronautical Chart and other navigation documentation, as with any other potential hazard; and*
- *there are very limited night-time flying activities in the area, and where they occur, they should be maintaining a height much greater than the height of the turbines (except for helicopter activities, but these are subject to operational procedures to ensure safe landing at night, when descending below the height of the turbines).*

3.4. Comparative analysis of lighting on nearby wind farms

Publicly available information and telephone conversations with applicable developers and/or operators revealed that none of the wind farms in relatively close proximity to HWF with turbines greater than 110 m (360.9 ft) and less than 150 m (492.2 ft) AGL blade tip height are planned to have obstacle lighting. Waubra is the only operational wind farm with obstacle lighting, but the operator has submitted a request to the Department of Planning and Community Development to have these lights turned off.

Wind Farm Developments has advised in written correspondence that it has decided not to light the turbines of Woolsthorpe Wind Farm.

The status of obstacle lighting on the wind farms near HWF is detailed in Table 1.

Table 1 Obstacle lighting on nearby wind farms

<i>Wind Farm Name</i>	<i>Status</i>	<i>Maximum turbine height</i>	<i>Obstacle Lighting</i>
Berrybank	Approved	131 m (430 ft) (max)	No obstacle lighting (permit condition).
Challicum Hills	Operational	100 m (328 ft)	No obstacle lighting.
Codrington	Operational	86 m (282 ft)	No obstacle lighting.
Macarthur	Approved	140 m (459 ft)	Yet to be determined.
Morton's Lane	Approved	112 m (368 ft) (max)	Yet to be determined.
Oaklands Hill	Constructed	124 m (407 ft)	No obstacle lighting.
Ryan Corner	Approved	126.3 m (414 ft) (max)	Yet to be determined.
Salt Creek	Approved	150 m (492 ft) (max)	Yet to be determined.
Waubra	Operational	119.8 m (393 ft)	Lights installed but operator seeking to have these lights turned off.
Woolsthorpe	Approved	135 m (443 ft) (max)	Proponent advises no obstacle lighting to be installed.
Yambuk	Operational	106 m (348 ft)	No obstacle lighting.

4. RISK CRITERIA

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.

4.1. Likelihood

Likelihood is defined in AS/NZS ISO 3100:2009 as the chance of something happening. Likelihood descriptors used in this report are as indicated in the table below.

Table 2 Likelihood Descriptors

<i>No</i>	<i>Descriptor</i>	<i>Description</i>
1	Rare	The event may occur only in exceptional circumstances
2	Unlikely	The event could occur at some time (not known to have occurred)
3	Possible	The event might occur at some time in the future
4	Likely	The event will probably occur in most circumstances (has occurred infrequently)
5	Almost certain	The event is expected to occur in most circumstances (has occurred frequently)

4.2. 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 the table below.

Table 3 Consequence Descriptors

<i>No</i>	<i>Descriptor</i>	<i>People Safety</i>	<i>Property</i>	<i>Effect on Crew</i>	<i>Environment</i>
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. Emergency procedures used.	Minimal site impact – easily controlled. 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. Not likely to be decision making issues. Design and mitigation measures may ameliorate some consequences.
4	Major	Fatal or 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 or fatal 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. Design and mitigation measures unlikely to remove all effects.
5	Catastrophic	Multiple Fatalities	Damaged beyond repair	Conditions preventing continued safe flight and landing. Multiple deaths with loss of aircraft	Catastrophic site impact, high local impact, national importance. Serious long term cumulative effect. Mitigation measures unlikely to remove effects.

4.3. Risk matrix

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

		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

Table 4 Risk Matrix

4.4. Actions required

Actions required according to the derived level of risk are shown in the table below.

9-10	Unacceptable Risk -	Immediate action required by either treating or avoiding risk. Refer to executive management.
7-8	Manageable Risk -	Treatment action is required to manage risk to an acceptable level. Refer to operational management.
5-6	Manageable 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	Acceptable Risk -	Managed by routine procedures, and can be accepted with no action.

Table 5 Actions Required

5. RISK IDENTIFICATION

The primary risk being assessed is that of aviation safety. In this case, risk is considered to be manifested by the wind farm in the following ways:

- there is potential for an aircraft to collide with a wind turbine;
- there is potential for an aircraft to collide with a wind monitoring tower;
- there is potential for a pilot to initiate harsh manoeuvring in order to avoid colliding with a wind turbine or monitoring tower resulting in controlled flight into terrain (CFIT); and
- there is potential for the hazards associated with the wind farm to invoke operational limitations or procedures on operating crew.

It should be noted that according to guidance provided by the Commonwealth Department of Infrastructure and Transport and in line with generally accepted practice, the risk to be assessed should primarily be associated with passenger transport operations conducted by major RPT airlines. As these operations are not conducted within the vicinity of the wind farm, the risk is associated with smaller aircraft likely to be flying under the VFR, and so the maximum number of passengers is likely to be limited.

The secondary risk being assessed is the visual impact that obstacle lights (if fitted) will have on the surrounding residents.

6. 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 level of risk to an acceptable level.

Each of the five risk events are considered in separate tables in the following pages.

Risk ID:	1. Aircraft collision with wind turbine	
Discussion		
<p>An aircraft collision with a wind turbine would result in harm to people and damage to property.</p> <p>There is only one recorded event of an aircraft colliding with a wind turbine anywhere in the world (France). This occurred during the day in conditions of low cloud (cloud base estimated to be between 50 m (164 ft) and 100m (328 ft)) and significantly reduced visibility (estimated to be between 400 m and 800 m) in fog where the turbine height was 120 m (393 ft) AGL. The aircraft was damaged but landed safely.</p> <p>There is a relatively low rate of aircraft activity in the vicinity of the wind farm.</p> <p>There are no known aerial agriculture operations conducted at night in the vicinity of the wind farm.</p> <p>There is no regulatory requirement for lighting of obstacles lower than 150 m (492 ft) AGL that are not within the vicinity of an aerodrome.</p>		
Consequence		
<p>If an aircraft collided with a wind turbine, the worst credible effect would be multiple fatalities and damage beyond repair. This would be a Catastrophic consequence.</p>		
Consequence		Catastrophic
Untreated Likelihood		
<p>There is one known occurrence of an aircraft colliding with a wind turbine, although the occupants were uninjured. It is assessed that collision with a wind turbine resulting in multiple fatalities and damage beyond repair would only occur in exceptional circumstances, which is classified as Rare.</p>		
Untreated Likelihood		Rare
Current Treatments (without lighting)		
<ul style="list-style-type: none"> • HWF is clear of the obstacle limitation surfaces of any aerodrome. • 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 600 m (or 300 m for helicopters) in visual flight during the day when not in the vicinity of built up areas. The proposed turbines will be a maximum of 126.3 m (414 ft) at the top of the blade tip, so there will be at least 85.6 ft (26.1 m) vertical separation from an aircraft flying at this height (500 ft). • In the event that descending cloud forces an aircraft lower than 500 ft (152.4 m) AGL, the minimum visibility of 5000m required for visual flight during the day should provide adequate time for pilots to observe and manoeuvre their aircraft clear of wind turbines. • If cloud descends below the top of the turbine nacelle (in this case 80 m = 262 ft), obstacle lighting would be obscured and therefore ineffective. • Aircraft are restricted to a minimum height of 1000 ft (304.8 m) 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 500 ft (152.4 m) AGL (day) or below safety height (night) are operated in accordance with procedures developed as an outcome of thorough risk management 		

<p>activities.</p> <ul style="list-style-type: none"> • The wind turbines are to be coloured pale grey or off white so they should be visible during the day. • The as constructed details of wind turbines are required to be notified to RAAF AIS so that the location and height of wind farms can be noted on aeronautical maps and charts. • The turbines are proposed to be a maximum of 126.3 m (414 ft) high at the blade tip. This is 16.3 m (53.4 ft) higher than the height below which there would be no statutory requirement to report the turbines in any case. 	
<p>Level of Risk</p> <p>The level of risk associated with a Rare likelihood of a Catastrophic consequence is 6.</p>	
Current Level of Risk	6 - Manageable
<p>Risk Decision</p> <p>A risk level of 6 is classified as Manageable: Treatment action possibly required to achieve ALARP - conduct cost/benefit analysis. Relevant manager to consider for appropriate action.</p>	
Risk Decision	Accept, conduct cost benefit analysis
<p>Proposed Treatments</p> <p>Given the current treatments and there being only one recorded occurrence of an aircraft colliding with a wind turbine (in meteorological conditions in which the effect of obstacle lighting would have been negligible), the likelihood of this outcome is so low that there is likely to be little additional safety benefit to be gained by installing obstacle lighting.</p> <p>However, the following treatment which can be implemented at little cost will provide an additional margin of safety:</p> <ul style="list-style-type: none"> • Details of the wind farm should be communicated to local and regional aircraft operators prior to, during and following construction to heighten their awareness of its location and so that they can plan their operations accordingly. 	
<p>Residual Risk</p> <p>With or without further treatment, the likelihood of an aircraft collision with a wind turbine resulting in multiple fatalities and damage beyond repair remains Rare, and the consequence remains Catastrophic, resulting in an overall risk level of 6. In the circumstances, this level of risk is considered acceptable.</p> <p>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 wind turbine, without obstacle lighting on the turbines of Hawkesdale Wind Farm. However, HDPL may consider other factors in its decision as to whether obstacle lighting should be installed.</p>	
Residual Risk	6 - Manageable

Risk ID:	2. Aircraft collision with wind monitoring tower
<p>Discussion</p> <p>An aircraft collision with a wind monitoring tower would result in harm to people and damage to property. HDPL advises there are three wind monitoring towers in HWF – one 60 m (197 ft) and two 40 m (131 ft) high. They are not marked or lit, nor are they required to be. Their location and other applicable details have been advised to RAAF AIS.</p> <p>Removal or retention of these wind monitoring towers is subject to final micro-siting of the wind turbines (in accordance with any Planning Permit Conditions).</p> <p>HDPL also advises that it is considering erection of a hub height wind monitoring tower for turbine power curve verification. The location of this tower is yet to be determined, but it will be positioned within rather than on the perimeter of a cluster of turbines.</p> <p>There are a few instances of aircraft colliding with a wind monitoring tower, but they were all during the day with good visibility, and none was in Australia.</p> <p>There is a relatively low rate of aircraft activity in the vicinity of the wind farm.</p> <p>There are no known aerial agriculture operations conducted at night in the vicinity of the wind farm.</p> <p>There is no regulatory requirement for lighting of obstacles lower than 150 m (492 ft) AGL that are not within the vicinity of an aerodrome.</p>	
<p>Consequence</p> <p>If an aircraft collided with a wind monitoring tower, the worst credible effect would be multiple fatalities and damage beyond repair. This would be a Catastrophic consequence.</p>	
<p>Consequence Catastrophic</p>	
<p>Untreated Likelihood</p> <p>There are a few occurrences of an aircraft colliding with a wind monitoring tower, but all were during the day with good visibility when obstacle lighting would arguably be of no effect, and none was in Australia. In the circumstances, it is assessed that collision with a wind monitoring tower without obstacle lighting that would be effective in alerting the pilot to its presence may only occur in exceptional circumstances, which is classified as Rare.</p>	
<p>Untreated Likelihood Rare</p>	
<p>Current Treatments (without lighting)</p> <ul style="list-style-type: none"> • The wind monitoring towers at HWF are 60 m (197 ft) and 40 m (131 ft) high, and do not require lighting. Their location and other applicable details have been advised to RAAF AIS. • Removal or retention of these wind monitoring towers is subject to final micro-siting of the wind turbines (in accordance with any Planning Permit Conditions). • A hub height wind monitoring tower may be erected for turbine power curve verification. The location of this tower is yet to be determined, but it will be positioned within rather than on the perimeter of a 	

<p>cluster of turbines.</p> <ul style="list-style-type: none"> • 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 600 m (or 300 m for helicopters) in visual flight during the day when not in the vicinity of built up areas. The highest wind monitoring tower is 263 ft (80 m) high, so there is at least 237 ft (72.4 m) vertical separation from an aircraft flying at this height. • In the event that descending cloud forces an aircraft lower than 500 ft (152.4 m) AGL, the minimum visibility of 5000m required for visual flight during the day should provide adequate time for pilots to observe and manoeuvre their aircraft clear of the tower. • Aircraft are restricted to a minimum height of 1000 ft (304.8 m) 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 500 ft (152.4 m) (day) or below safety height (night) are operated in accordance with procedures developed as an outcome of thorough risk management activities. • The towers are constructed from grey steel. 	
<p>Level of Risk</p> <p>The level of risk associated with a Rare likelihood of a Catastrophic consequence is 6.</p>	
Current Level of Risk	6 - Manageable
<p>Risk Decision</p> <p>A risk level of 6 is classified as Manageable: Treatment action possibly required to achieve ALARP - conduct cost/benefit analysis. Relevant manager to consider for appropriate action.</p>	
Risk Decision	Accept, conduct cost benefit analysis
<p>Proposed Treatments</p> <p>Within the current regulatory regime, the level of risk to aviation safety associated with the wind monitoring towers is considered acceptable without further treatment. However, the following treatments which can be implemented at a relatively low additional cost will provide an additional margin of safety:</p> <ul style="list-style-type: none"> • Although there is no obligation to do so, consideration could be given to marking the wind monitoring towers according to the requirements set out in MOS 139 Section 8.10 Obstacle Markings; specifically: <ul style="list-style-type: none"> 8.10.2.6 Masts, poles and towers must be marked in contrasting bands with the darker colour at the top, as shown in Figure 8.10-3. The bands must be perpendicular to the longest dimension and have a width approximately 1/7 of the longest dimension or 30 m, whichever is less. 8.10.2.8 Wires or cable obstacles must be marked using three-dimensional coloured objects such as spheres and pyramids, etc; of a size equivalent to a cube with 600 mm sides, spaced 30 m apart. • Details of the wind farm wind monitoring towers should be communicated to local and regional aircraft operators following construction to heighten awareness of their location. • It should also be noted that when the wind farm is constructed, the wind monitoring towers will be surrounded by wind turbines which are significantly more visible, and pilots should therefore be deterred from flying near the wind monitoring tower which will further reduce the likelihood of a collision. 	

Residual Risk

Notwithstanding the current level of aviation safety risk is considered acceptable, the additional treatment, which will eventuate as a result of constructing the wind farm, will enhance aviation safety. In the circumstances, the risk level of 6 is considered acceptable.

It is our assessment that there is an acceptable level of aviation safety risk associated with the potential for collision with the wind monitoring towers, without obstacle lighting on the turbines of Hawkesdale Wind Farm.

	Residual Risk 6 - Manageable
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Risk ID:	3. Harsh manoeuvring leads to controlled flight into terrain (CFIT)	
Discussion		
<p>An aircraft colliding with terrain as a result of harsh manoeuvring to avoid colliding with a wind turbine would result in harm to people and damage to property.</p> <p>There are a few CFIT accidents resulting from manoeuvring to avoid wind farms, but none in Australia, and all were during the day.</p> <p>There is a relatively low rate of aircraft activity in the vicinity of the wind farm.</p>		
Consequence		
<p>If an aircraft collided with terrain, the worst credible effect would be multiple fatalities and damage beyond repair. This would be a Catastrophic consequence.</p>		
		Consequence
		Catastrophic
Untreated Likelihood		
<p>There are a few CFIT accidents resulting from manoeuvring to avoid wind farms, but none in Australia, and all were during the day. It is assessed that a CFIT accident following harsh manoeuvring to avoid a wind turbine may only occur in exceptional circumstances, which is classified as Rare.</p>		
		Untreated Likelihood
		Rare
Current Treatments (without lighting)		
<ul style="list-style-type: none"> • 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 600 m (or 300 m for helicopters) in visual flight during the day when not in the vicinity of built up areas. The proposed turbines will be a maximum of 126.3 m (414 ft) at the top of the blade tip, so there will be at least 26.1 m (85.6 ft) vertical separation from an aircraft flying at this height. • 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 wind turbines. • If cloud descends below the top of the turbine nacelle (in this case 80 m = 262 ft), obstacle lighting would be obscured and therefore ineffective. • Aircraft are restricted to a minimum height of 1000 ft (304.8 m) 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 500 ft (152.4 m) (day) or below safety height (night) are operated in accordance with procedures developed as an outcome of thorough risk management activities. • The wind turbines are to be coloured pale grey or off white so they should be visible during the day. • The as constructed details of wind turbines are required to be notified to RAAF AIS so that the location and height of wind farms can be noted on aeronautical maps and charts. 		

<p>Level of Risk</p> <p>The level of risk associated with a Rare likelihood of a Catastrophic consequence is 6.</p>	
Current Level of Risk	6 - Manageable
<p>Risk Decision</p> <p>A risk level of 6 is classified as Manageable: Treatment action possibly required to achieve ALARP - conduct cost/benefit analysis. Relevant manager to consider for appropriate action.</p>	
Risk Decision	Accept, conduct cost benefit analysis
<p>Proposed Treatments</p> <p>Given the current treatments and there being no recorded example in Australia of a CFIT accident arising from harsh manoeuvring to avoid a wind turbine, the likelihood of this outcome is so low that there is likely to be little additional safety benefit to be gained by installing obstacle lighting.</p> <p>However, the following treatment which can be implemented at little cost will provide an additional margin of safety:</p> <ul style="list-style-type: none"> • Details of the wind farm should be communicated to local and regional aircraft operators prior to, during and following construction to heighten their awareness of its location and so that they can plan their operations accordingly. 	
<p>Residual Risk</p> <p>Notwithstanding the current level of risk is considered acceptable, the additional recommended treatment will enhance aviation safety. In the circumstances, the risk level of 6 is considered acceptable.</p> <p>It is our assessment that there is an acceptable level of aviation safety risk associated with the potential for CFIT resulting from harsh manoeuvring to avoid a wind turbine, without obstacle lighting on the turbines of Hawkesdale Wind Farm.</p> <p>However, HDPL may consider other factors in its decision as to whether obstacle lighting should be installed.</p>	
Residual Risk	6 - Manageable

Risk ID:	4. Effect of the wind farm on operating crew
Discussion	
<p>Introduction or imposition of additional operating procedures or limitations can affect an aircraft's operating crew.</p> <p>There are no known aerial agriculture operations conducted at night in the vicinity of the wind farm.</p> <p>There is a relatively low rate of aircraft activity in the vicinity of the wind farm.</p>	
Consequence	
<p>The worst credible effect a wind farm could have on flight crew would be the imposition of operational limitations. This would be a Minor consequence.</p>	
Consequence	Minor
Untreated Likelihood	
<p>The likelihood of the imposition of operational limitations is Possible – might occur at some time in the future.</p>	
Untreated Likelihood	Possible
Current Treatments (without lighting)	
<ul style="list-style-type: none"> • Aircraft are restricted to a minimum height of 500 ft (152.4 m) AGL in visual flight during the day when not in the vicinity of built up areas. The proposed turbines will be a maximum of 126.3 m (414 ft) at the top of the blade tip, so there is at least 26.1 m (85.6 ft) vertical separation from an aircraft flying at this height. • 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 wind turbines. • If cloud descends below the top of the turbine nacelle (in this case 80 m = 262 ft), obstacle lighting would be obscured and therefore ineffective. • Aircraft are restricted to a minimum height of 1000 ft (304.8 m) 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 500 ft (152.4 m) (day) or below safety height (night) are operated in accordance with procedures developed as an outcome of thorough risk management activities. • The wind turbines are to be coloured pale grey or off white so they should be visible during the day. • The as constructed details of wind turbines are required to be notified to RAAF AIS so that the location and height of wind farms can be noted on aeronautical maps and charts e.g. (World Aeronautical Chart, CFA fire maps). 	
Level of Risk	
<p>The level of risk associated with a Possible likelihood of a Minor consequence is 5.</p>	

Current Level of Risk		5 - Manageable
Risk Decision		
A risk level of 5 is classified as Manageable: 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
Proposed Treatments		
<p>Given the current treatments and the limited scale and scope of flying operations conducted within the vicinity of HWF, there is likely to be little additional safety benefit to be gained by installing obstacle lighting.</p> <p>However, the following treatment which can be implemented at little cost will provide an additional margin of safety:</p> <ul style="list-style-type: none"> • Details of the wind farm should be communicated to local and regional aircraft operators prior to, during and following construction to heighten their awareness of its location and so that they can plan their operations accordingly. 		
Residual Risk		
<p>Notwithstanding the current level of risk is considered acceptable, the additional recommended treatment will enhance aviation safety. In the circumstances, the risk level of 5 is considered acceptable.</p> <p>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 turbines of Hawkesdale Wind Farm.</p> <p>However, HDPL may consider other factors in its decision as to whether obstacle lighting should be installed.</p>		
Residual Risk		5 - Manageable

Risk ID:	5. Effect of obstacle lighting on neighbours
Discussion	
<p>Installation and operation of obstacle lighting on wind turbines can have an effect on neighbours' visual amenity and enjoyment.</p> <p>There is no regulatory requirement for lighting of obstacles lower than 150 m (492 ft) AGL that are not within the vicinity of an aerodrome.</p> <p>None of the wind farms in relatively close proximity to HWF with turbines greater than 110 m and less than 150 m AGL blade tip height are planned to have obstacle lighting. Waubra is the only operational wind farm with obstacle lighting, but the operator has submitted a request to the Department of Planning to have this lighting turned off.</p> <p>Wind Farm Developments has advised that it has decided not to light the turbines of Woolsthorpe Wind Farm.</p>	
Consequence	
<p>The worst credible effect of obstacle lighting would be:</p> <p>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.</p>	
Consequence	Moderate
Untreated Likelihood	
<p>The likelihood of moderate site impact, minimal local impact is Likely - the event will probably occur in most circumstances (has occurred infrequently).</p>	
Untreated Likelihood	Likely
Current Treatments	
<p>There is no regulatory requirement to install obstacle lighting on the wind turbines of HWF.</p> <p>Not installing obstacle lighting would completely remove the source of the impact.</p> <p>The Planning Permit specifies the following requirements:</p> <p style="margin-left: 40px;">8. Except in the case of an emergency, no external lighting of infrastructure associated with the wind energy facility, other than low level security lighting may be installed or operated without the further written consent of the Minister for Planning.</p> <p style="margin-left: 40px;">9. Any obstacle lighting for aviation safety should be generally in accordance with the 'Alternative Obstacle Lighting Proposal' plan Revision 3 dated 30/01/08 prepared by the Ambidji Group and must be to the satisfaction of the Minister for Planning. In finalising any lighting plan:</p> <p style="margin-left: 80px;">a) The applicant must consult with CASA;</p>	

- b) Advice must be sought from a suitably qualified wildlife ecologist to ensure the light flashing period minimises any impact on bats or night flying birds.
- c) The turbines to be lit must be selected in consultation with the owners of the adjacent Woolsthorpe Wind Farm with the objective of minimising the total number of lit turbines in the area;
- d) Where turbines are to be lit, individual lighting installations must be in accordance with the CASA Advisory Circular 139-18(0) and the CASA Manual of Standards, particularly Chapter 9; and
- e) The impact minimisation features to be incorporated in any installation must include, but are not limited to:
 - (i) Treatment of the rear of the blade to avoid reflection of aviation lights;
 - (ii) Shielding of the lights on top and bottom such that the maximum intensity of light is limited to a beam of 3 degrees, with only 0.5 degrees of this beam width below the horizon; and
 - (iii) All lights on the wind farm synchronised to flash in unison.

If lighting is required, there are impact reduction measures that can be implemented to reduce the impact of lighting on surrounding neighbours, including:

- 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; and
- mitigating light glare from obstacle lighting through measures such as baffling.

Level of Risk

The level of risk associated with a Likely likelihood of a Moderate consequence is 7.

Current Level of Risk	7 - Manageable
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Risk Decision

A risk level of 7 is classified as Manageable: Treatment action is required to manage the risk to an acceptable level. Refer to operational management.

Risk Decision	Reject – Treatment action required
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Proposed Treatments

Not installing obstacle lighting would completely remove the source of the impact.

If lighting is required, there are Planning Permit Conditions and impact reduction measures that can be implemented to reduce the impact of lighting on surrounding neighbours. These measures are designed to optimise the benefit of the obstacle lights to pilots while minimising the visual impact to those on the ground.

Residual Risk

Not installing obstacle lights would clearly be an acceptable outcome to those affected by visual impact.

Consideration of visual impact in the lighting design should enable installation of lighting that produces an acceptable impact to neighbours, which reduces the likelihood of a Moderate consequence to Possible – the event might occur at some time in the future, resulting in a risk level of 6 – Manageable.

It is our assessment that visual impact from obstacle lights can be negated if they are not installed, but 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 6 - Manageable
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6.1. Summary of risks

A summary of the level of risk associated with the approved Hawkesdale Wind Farm, under the proposed treatment regime, is provided in the table below.

Table 6 Summary of Risks

<i>Risk Element</i>	<i>Consequence</i>	<i>Likelihood</i>	<i>Risk</i>	<i>Actions Required</i>
Aircraft collision with wind turbine	Catastrophic	Rare	6	Acceptable without obstacle lighting. Communicate details of wind farm to local and regional operators before, during and following construction.
Aircraft collision with monitoring tower	Catastrophic	Rare	6	Acceptable without obstacle lighting. Although there is no obligation to do so, consider marking the wind monitoring towers according to the requirements set out in MOS 139 Section 8.10 Obstacle Markings, specifically 8.10.2.6 and 8.10.2.8. Communicate details of wind farm wind monitoring towers to local and regional operators following construction.
Harsh manoeuvring leads to CFIT	Catastrophic	Rare	6	Acceptable without obstacle lighting. Communicate details of wind farm to local and regional operators before, during and following construction.
Effect on crew	Minor	Possible	5	Acceptable without obstacle lighting. Communicate details of wind farm to local and regional operators before, during and following construction.
Visual impact from obstacle lights	Moderate	Possible	6	Acceptable without obstacle lighting (zero risk of visual impact from obstacle lighting). If lights are installed, design to minimise impact and in accordance with Planning Permit Conditions.

7. CONCLUSIONS

7.1. Department of Planning

On 12 August 2008 the Minister for Planning issued Planning Permit No 20060221 for the proposed construction and operation of a wind farm consisting of up to 31 turbines and associated infrastructure, as described in the Hawkesdale Wind Farm Planning Permit Application dated October 2006 and modified in accordance with the Planning Permit.

Conditions 8 and 9 refer specifically to lighting.

7.2. Civil Aviation Safety Authority

CASA advised in 2007 that the number of tall turbine structures does pose a significant hazard, and that without obstacle lights, the hazard posed by these tall structures to pilots operating at night or in marginal visibility conditions cannot be minimised. There was no explanation why the number of tall turbine structures pose a significant hazard, and the conclusion about not being able to minimise the hazard to aircraft operating at night or in marginal visibility conditions is without justification.

While the turbines will be located outside the obstacle limitation surfaces of an aerodrome but will be more than 110 m (361 ft) AGL and in any case are not approved to exceed 126.3 m (414 ft) AGL, CASA indicated the turbines pose a hazard to aviation. The risk assessment prepared for this report concludes that there will be an acceptable level of aviation safety without obstacle lighting and therefore there will be no requirement for obstacle lighting under the provisions of MOS 139 Chapter 9.

CASA advised in July 2011 that for objects not in the vicinity of an aerodrome, CASA has no specific authority to require action for the marking and lighting of tall structures. If the owner of the structure decides to mark and/or light it as part of their duty of care to not pose a hazard to aviation, then the marking and lighting should be in accordance with the standards published in MOS Part 139.

On the basis of this guidance, it can be concluded that there is no regulatory obligation to install obstacle lighting on the wind turbines of HWF.

7.3. International Civil Aviation Organization

With respect to ICAO Annex 14 section 6.4.1, the risk assessment prepared for this report concludes that there will be an acceptable level of aviation safety without obstacle lighting and therefore there will be no requirement for obstacle lighting

7.4. Comparative analysis of nearby wind farms

None of the wind farms in relatively close proximity to HWF with turbines greater than 110 m and less than 150 m AGL blade tip height have obstacle lighting. Waubra is the only operational wind farm with obstacle lighting, but the operator has submitted a request to the Department of Planning to have these lights turned off.

Wind Farm Developments has advised that it has decided not to light the turbines of Woolsthorpe Wind Farm.

7.5. Risk assessment

As a result of the foregoing risk assessment, the following conclusions are drawn:

- There is no regulatory requirement for lighting of obstacles lower than 150 m (492 ft) AGL that are not within the vicinity of an aerodrome.
- There is a relatively low rate of aircraft activity in the vicinity of the wind farm site.
- There are no known aerial agriculture operations conducted at night in the vicinity of the wind farm site.
- The wind farm will be clear of the obstacle limitation surfaces at Warrnambool aerodrome.
- The wind existing wind monitoring towers at HWF are 60 m (197 ft) and 40 m (131 ft) high, and do not require lighting. Their location and other applicable details have been advised to RAAF AIS.
- Removal or retention of these wind monitoring towers is subject to final micro-siting of the wind turbines (in accordance with any Planning Permit Conditions).
- A hub height wind monitoring tower may be erected for turbine power curve verification. The location of this tower is yet to be determined, but it will be positioned within rather than on the perimeter of a cluster of turbines.
- None of the wind farms in relatively close proximity to HWF with turbines greater than 110 m (361 ft) and less than 150 m (492 ft) AGL blade tip height are planned to have obstacle lighting. Waubra is the only operational wind farm with obstacle lighting, but the operator has submitted a request to the Department of Planning to have these lights turned off.
- Wind Farm Developments has advised that it has decided not to light the turbines of Woolsthorpe Wind Farm.
- The risk of an aircraft collision with a wind turbine, without obstacle lighting on the turbines, of Hawkesdale Wind Farm is considered acceptable. However, HDPL may consider other factors in its decision as to whether obstacle lighting should be installed.
- The risk of an aircraft collision with the wind monitoring towers, without obstacle lighting on the turbines, of Hawkesdale Wind Farm is considered acceptable. However, HDPL may consider other factors in its decision as to whether obstacle lighting should be installed.
- The risk of harsh aircraft manoeuvring to avoid collision with a wind turbine leading to controlled flight into terrain, without obstacle lighting on the turbines of Hawkesdale Wind Farm, is considered acceptable.
- The risk of Hawkesdale Wind Farm imposing operational limitations on aircraft operating crew, without obstacle lighting on the turbines, is considered acceptable. However, HDPL may consider other factors in its decision as to whether obstacle lighting should be installed.
- Visual impact from obstacle lights can be negated if they are not installed, but if obstacle lights are to be installed, they must meet Planning Permit Conditions 8 and 9 and can be designed so that there is an acceptable risk of visual impact to neighbours.
- The following risk treatments may provide an additional margin of safety:

- Details of the wind farm, including wind monitoring towers should be communicated to local and regional aircraft operators prior to, during and following construction to heighten their awareness of its location and so that they can plan their operations accordingly.
- Although there is no obligation to do so, consideration could be given to marking the wind monitoring towers according to the requirements set out in MOS 139 Section 8.10 Obstacle Markings; specifically:
 - 8.10.2.6 Masts, poles and towers must be marked in contrasting bands with the darker colour at the top, as shown in Figure 8.10-3. The bands must be perpendicular to the longest dimension and have a width approximately 1/7 of the longest dimension or 30 m, whichever is less.
 - 8.10.2.8 Wires or cable obstacles must be marked using three-dimensional coloured objects such as spheres and pyramids, etc; of a size equivalent to a cube with 600 mm sides, spaced 30m apart.

8. RECOMMENDATIONS

As a result of the foregoing risk assessment, the following recommendations are made:

1. With respect to Conditions 8 and 9 of Planning Permit 20060221, it is assessed that Hawkesdale Wind Farm will not require obstacle lighting to maintain an acceptable level of safety to aircraft.
2. Hawkesdale Development Pty Ltd may consider other factors in its decision as to whether obstacle lighting should be installed.
3. The following additional risk treatments should be implemented:
 - a. Details of the wind farm, including wind monitoring towers, should be communicated to local and regional aircraft operators prior to, during and following construction to heighten their awareness of its location and so that they can plan their operations accordingly; and
 - b. Although there is no obligation to do so, consideration could be given to marking the wind monitoring towers according to the requirements set out in MOS 139 Section 8.10 Obstacle Markings; specifically:
 - 8.10.2.6 Masts, poles and towers must be marked in contrasting bands with the darker colour at the top, as shown in Figure 8.10-3. The bands must be perpendicular to the longest dimension and have a width approximately $\frac{1}{7}$ of the longest dimension or 30 m, whichever is less.
 - 8.10.2.8 Wires or cable obstacles must be marked using three-dimensional coloured objects such as spheres and pyramids, etc; of a size equivalent to a cube with 600 mm sides, spaced 30m apart.
4. 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; and
 - c. following any near miss, incident or accident associated with operations considered in this risk assessment.

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