FEBRUARY 2016

AERONAUTICAL IMPACT ASSESSMENT

CROOKWELL 2 WIND FARM

Prepared for Crookwell Development Pty Ltd

AVIATION PROJECTS

AVIATION PROJECTS

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Revision History

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ACRONYMS

AAAA	Aerial Agriculture Association of Australia
AGL	above ground level
AIS	Aviation Impact Statement
ALA	aeroplane landing area
ALARP	as low as reasonably practicable
CAR	Civil Aviation Regulation(s) (1988)
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulation(s) (1998)
DA	development application
EIS	Environmental Impact Statement
ICAO	International Civil Aviation Organization
MOS	Manual of Standards
OLS	obstacle limitation surface
PANS-OPS	Procedures for Air Navigation Services - Aircraft Operations
RAAF AIS	Royal Australian Air Force Aeronautical Information Service
RFS	Rural Fire Service
VHF	very high frequency

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)

EXECUTIVE SUMMARY

Introduction

The Crookwell 2 Wind Farm [the Project] site is located on Crookwell Road, approximately 14 km south-east of Crookwell and 30 km north-west of Goulburn in NSW. The Project has approval to construct and operate up to 46 wind turbines with associated infrastructure. Crookwell Development Pty Ltd [the Proponent] is proposing to amend the Project's approved turbine envelope size, and utilise the latest turbine technology that is both higher in capacity and more efficient. The proposed new turbine envelope size will accommodate a tip height of up to 160 m, with hub heights up to 95 m and rotor diameter of up to 130 m. To reduce the potential impact from the larger turbine envelopes, the Proponent is proposing to reduce the number of turbines in the layout, with the amended Project to have up to 33 wind turbines.

The Proponent has engaged Aviation Projects to conduct an aeronautical impact assessment with respect to the proposed amendments.

Methodology

In undertaking this task, the following activities were conducted:

- the scope and deliverables were discussed with and agreed by the Proponent's Project Manager;
- a desktop review of supplied materials was conducted;
- relevant regulatory requirements and sources of information were reviewed;
- an Aviation Impact Statement was prepared;
- a qualitative risk assessment was prepared;
- a lighting design was prepared;
- stakeholders were consulted in writing and/or by telephone interview as applicable;
- a draft report was prepared, finalised and forwarded to Airservices Australia, Civil Aviation Safety Authority and Commonwealth Department of Defence for consideration; and
- a final report was delivered.

Conclusions

The following conclusions were made as a result of this assessment:

Consultation

An appropriate and justified level of consultation was undertaken with the following parties:

- Aerial Agricultural Association of Australia;
- Airservices Australia;
- Civil Aviation Safety Authority;
- Department of Defence;
- Fred Fahey Aerial Services;
- Goulburn Mulwaree Council;
- NSW Rural Fire Service;
- Royal Flying Doctor Service;
- Upper Lachlan Shire Council; and
- Yass Aerial service.

Aviation Impact Statement

The Aviation Impact Statement has made the following conclusions:

- In summary, the Aviation Impact Statement has determined that:

  1) *The blade tips of the highest obstacle in the wind farm project will be 1107m (3632ft) AHD and as such:*

     - Will not penetrate any OLS surfaces;
     - Will not penetrate any PAN-OPS surfaces;
     - Will not have an impact on nearby designated air routes.
     - Will not have an impact on prescribed airspace;
     - Is wholly contained within Class G airspace; and
     - Will not have an impact on existing local aviation activities.

  2) *The wind farm obstacles are located outside the clearance zones associated with aviation navigation aids and communication facilities.*

  3) *A preliminary assessment on the impact of the wind farm on ATC radar surveillance facilities has been made. There will be an impact on the RSR at Mt Bobbara. The PSR (primary surveillance radar) and SSR (Secondary surveillance radar) facility at Mt Majura may be affected.* ***Further liaison with Airservices Australia will be required to refine the impact analysis and if required, coordinate impact mitigation measures.***

4) *The wind farm is sufficiently distant from airfields to not have an impact on contingency procedures and engine inoperative flight paths.*

5) *Subject to resolution of PSR impact issues, the wind farm obstacles have been assessed as not having an impact on prescribed airspace. The development is therefore considered approvable in accordance with the relevant civil aviation regulations. This Aviation Impact Statement can be used as supporting documentation for an application to CASA.*

Airservices Australia was consulted with respect to the aviation impacts of the Project, which, in an email dated 14 December 2015, provided the following advice:

> *I refer to your request for Airservices assessment of the Crookwell 2 Wind Farm which is proposed for the NSW Southern Highlands.*
>
> ***Airspace Procedures***
>
> *With respect to procedures designed by Airservices in accordance with ICAO PANS-OPS and Document 9905, at a height of 1107m (3632ft) AHD the Crookwell 2 wind farm will not affect any sector or circling altitude, nor any instrument approach or departure procedure at Goulburn aerodrome.*
>
> *Note: procedures not designed by Airservices at Goulburn aerodrome were not considered in this assessment.*
>
> ***CNS Facilities***
>
> *This proposal for a wind farm as detailed in the AIS will not adversely impact the performance of any Airservices Precision/Non-Precision Nav Aids, Anemometers, HF/VHF/UHF Comms, A-SMGCS, Radar, PRM, ADS-B, WAM or Satellite/Links.*

Aircraft Operator Characteristics

- Based on input during consultation activities, the Project will result in a reduced net impact on aerial agricultural operations. Moreover, the impacts may be further alleviated by an effective and functional working relationship between the Proponent and aerial agricultural operators that are likely to operate in the vicinity of the Project.
- There is no significance in the impact of the Project on NSW Rural Fire Service (RFS) aerial firefighting operations. It would be beneficial to develop procedures to stop turbines blades from rotating before RFS begins aerial firefighting operations within the Project area.
- No significant impact is anticipated with the Project on Royal Flying Doctors Service operations as long as the obstacles are properly referenced on navigation charts.

Hazard lighting and marking

- The wind turbines in the Project are proposed to be up to 160 m AGL. With respect to MOS 139 7.1.5.1, the proposed towers must be reported to CASA if they will be higher than 110 m AGL. With respect to MOS 139 7.1.5.2, the wind turbines must be regarded as an obstacles if they are higher than 150 m AGL, unless CASA assesses otherwise.
- With respect to MOS 139 9.4.1.2 (b), the wind turbines will need to be lit if they are higher than 110 m AGL, unless an aeronautical study assesses they are of no operational significance.

- Aviation Projects has assessed 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 the Project.
- If lighting is required, the lighting design herein is subject to confirmation of the final turbine layout as any changes proposed could potentially affect which turbines should be lit in accordance with the 900 m interval consideration.
- CASA recommends that the wind farm is lit with steady red low intensity lighting at night as per Section 9.4 of the CASA Manual of Standards Part 139. Characteristics for low intensity area stated in subsection 9.4.6. CASA agrees that the turbines that should be lit are identified in the drawing '100405 Crookwell 2 Wind Farm Obstacle Lighting Design v0.1, (10 August 2015)'.
- A summary of design characteristics for obstacle lighting acceptable by CASA, if required, is provided below:
    - two steady red low intensity obstacle lights should be provided;
    - the light fixtures should be mounted sufficiently above the surface of the nacelle so that the lights are not obscured by the rotor hub, and at a horizontal separation to ensure an unobstructed view of at least one of the lights by a pilot approaching from any direction; and
    - the characteristics of the obstacle lights should be in accordance with the applicable standards in MOS 139.
- To ensure the ongoing availability of obstacle lights (if required), a monitoring, reporting and maintenance program will need to be established in accordance with the guidance in MOS 139 Section 9.4.10.
- With respect to marking of turbines, it is generally accepted that, as an alternative to white, an off-white or light grey colour will provide sufficient contrast with the surrounding environment to maintain an acceptable level of safety while lowering visual impact to the neighbouring residents.
- With respect to marking of wind monitoring towers, they will be lower than, and are likely to be within 400 m of, a turbine and are therefore not likely to require obstacle marking or lighting.
- Department of Defence was consulted with respect to the potential impacts of the Project on its aviation operations, which, in a letter dated 24 November 2015, advised it has no concerns with the Project subject to the following requests being met:
    - Provide Airservices Australia with "as constructed" details, by emailing the details to vod@airservicesaustralia.com;
    - The wind turbines should be lit in accordance with the requirements of MOS 139; and
    - If LED obstruction lighting is to be provided to the wind turbines, ensure the frequency range of the LED light emitted fall within the range of wavelengths 655 to 930 nanometres, thus being visible to persons using night vision devices.

Risk assessment

A summary of risks associated with the proposed Project, under the proposed treatment regime, is provided in Table E 1.

Table E 1 Summary of risk assessment

Risk Element	*Consequence*	*Likelihood*	*Risk*	*Actions Required*
Aircraft collision with a wind turbine	Catastrophic	Rare	6	Acceptable without obstacle lighting. Communicate details of wind farm to local and regional operators and make arrangements to publish details in ERSA for surrounding airports, before, during and following construction.
Aircraft collision with a 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 and make arrangements to publish details in ERSA for surrounding airports, following construction.
Harsh manoeuvring leads to CFIT	Catastrophic	Rare	6	Acceptable without obstacle lighting. Communicate details of wind farm to local and regional operators and make arrangements to publish details in ERSA for surrounding airports 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 and make arrangements to publish details in ERSA for surrounding airports 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 environmental impacts.

Recommendations

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

Notification and reporting

1. 'As constructed' details of wind turbine and wind monitoring tower coordinates and elevations should be provided to RAAF AIS, by emailing the details to vod@airservicesaustralia.com.

2. Any obstacles above 110 m AGL (including temporary construction equipment) should be reported to Airservices Australia NOTAM office until they are incorporated in published operational documents. With respect to crane operations during the construction of the Project, a notification to the NOTAM office may include, for example, the following details:

    - The planned operational timeframe and maximum height of the crane; and
    - Either the general area within which the crane will operate and/or the planned route with timelines that crane operations will follow.

Operating procedures

3. The Proponent should engage with local aerial agricultural operators and aerial firefighting operators in developing procedures for such aircraft operations in the vicinity of the Project. Procedures may include stopping the rotation of the wind turbine rotor blades prior to the commencement of the aircraft operations within relevant areas.

4. The Proponent should consult with the NSW Rural Fire Service when developing fire management procedures, making due consideration of the use of aerial firefighting techniques within the wind farm project area.

Marking of turbines

5. The rotor blades, nacelle and the supporting mast of the wind turbines should be painted white, off-white or a light grey colour.

Lighting of turbines

6. If obstacle lighting is required (for example, as a requirement of CASA), obstacle lighting should be installed on the following 24 turbines (without the 'F' as the identification prefix): 1, 4, 5, 9, 10, 11, 12, 17, 19, 21, 23, 24, 26, 27, 29, 31, 36, 37, 40, 43, 45, 47, 48 and 50.

7. If obstacle lighting is required (for example, as a requirement of CASA), the wind turbines should be lit with steady red low intensity lighting at night as per MOS 139 Section 9.4, while minimising visual impact. To ensure the ongoing availability of obstacle lights (if required), a monitoring, reporting and maintenance program should be established in accordance with the guidance in MOS 139 Section 9.4.10.

8. Department of Defence requested that if LED lighting is used for obstacle lighting, then emitted light should fall within the wavelength range of 655 to 930 nanometres for night vision devices compatibility.

9. The Proponent may consider other factors in its decision as to whether obstacle lights should be installed.

Marking of wind monitoring towers

10. Consideration should be given to marking the wind monitoring towers according to the requirements set out in MOS 139 Section 8.10 (as modified by the guidance in NASF Guideline D).

Triggers for review

11. 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

The Crookwell 2 Wind Farm [the Project] site is located on Crookwell Road, approximately 14 km south-east of Crookwell and 30 km north-west of Goulburn in NSW. The Project has approval to construct and operate up to 46 wind turbines with associated infrastructure. Crookwell Development Pty Ltd [the Proponent] is proposing to amend the Project's approved turbine envelope size, and utilise the latest turbine technology that is both higher in capacity and more efficient. The proposed new turbine envelope size will accommodate a tip height of up to 160 m, with hub heights up to 95 m and rotor diameter of up to 130 m. To reduce the potential impact from the larger turbine envelopes, the Proponent is proposing to reduce the number of turbines in the layout, with the amended Project to have up to 33 wind turbines.

The Proponent has engaged Aviation Projects to conduct an aeronautical impact assessment with respect to the changes to the proposed wind farm.

1.2. Purpose of task

This engagement is being undertaken to consider the impact of the proposed modifications to the wind turbines and overall layout.

1.3. Scope of work

The assessment will address aviation related aspects of the proposed modifications to the proposed wind turbines (application number DA 176–8–2004-i). This assessment will be in accordance with an email by the Proponent, dated 4 May 2015, which provided the following advice:

> *The modification will be done in accordance with section 75W of the Environmental Planning and Assessment Act 1979. Please note under this provision we only have to assess the impact from the latest approval (mod-1 in 2009) to the proposed (mod-2), not from the original application in 2005.*

The assessment will be undertaken in accordance with the guidance specified by Airservices Australia in the circular *Airservices Aviation Assessments for Wind Farm Development – 13 February 2014.*

The requirement for aviation obstacle lighting will be determined through preparation of a qualitative risk assessment.

1.4. Structure

This report is structured as follows:

- Introduction;
- Background;
- Stakeholder consultation;
- Aviation impact statement;
- Aerial agricultural aircraft operations;
- Hazard lighting and marking;
- Risk assessment;
- Conclusions; and
- Recommendations.

1.5. Stakeholders

Stakeholders consulted with and/or considered in this assessment included:

- Aerial Agricultural Association of Australia;
- Airservices Australia;
- Civil Aviation Safety Authority;
- Department of Defence;
- Fred Fahey Aerial Services;
- Goulburn Mulwaree Council;
- NSW Rural Fire Service;
- Royal Flying Doctor Service;
- Upper Lachlan Shire Council; and
- Yass Aerial Services.

1.6. Client material

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

- Email from Union Fenosa Wind Australia, with CASA's response attached, dated 19 February 2016;
- Union Fenosa Wind Australia Pty Ltd, 20040700 - C2WF, Original EIS - Chapter 17 - Hazards and Risks, received 13 July 2015;
- Union Fenosa Wind Australia Pty Ltd, 20040700 - C2WF, Original EIS - ExecSummary, received 13 July 2015;
- Union Fenosa Wind Australia Pty Ltd, 20090115 - C2WF, Mod-1 Application - Appendix G - Aeronautical Assessment (Ref 20090115-J0272), received 13 July 2015;
- Union Fenosa Wind Australia Pty Ltd, *20090116 - C2WF, Mod-1 Application - Chapter 9 – Aviation,* received 13 July 2015;
- Union Fenosa Wind Australia Pty Ltd, *20150624 - C2WF, Mod-2 Turbine Coordinates (AGD66-GDA94) v1*, received 13 July 2015;
- Union Fenosa Wind Australia Pty Ltd, *20150817 - C23WF, Site Map with revised turbine layout v4*, received 21 October 2015; and
- Union Fenosa Wind Australia Pty Ltd, *20150827 - UFWA, Wind Monitoring Towers Control Sheet v2*, received 27 August 2015.

1.7. References

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

- Aerial Agricultural Association of Australia, *National Windfarm Operating Protocols*, May 2014;
- Aerial Agricultural Association of Australia, *Powerlines Policy*, dated March 2011;
- Aerial Agricultural Association of Australia, *Windfarm Policy*, dated March 2011;
- Aeronautical Information Package; including AIP Book effective 12 November 2015, and En Route Supplement Australia dated 12 November 2015;
- Airservices Australia, letter: Airservices Aviation Assessments for Wind Farm Developments, dated 13 February 2014;
- AS/NZS ISO 31000:2009 *Risk management—Principles and guidelines*, Standards Australia;
- Australasian Fire and Emergency Service Authorities Council Ltd, *Wind Farms and Bushfire Operations POSITION*, version 2.0, 30 October 2014;
- Civil Aviation Safety Authority, Advisory Circular (AC) 139-8(0): Reporting of Tall Structures, dated April 2005;
- Civil Aviation Safety Authority, *Civil Aviation Regulations 1988 (CAR)*, as amended;

- Civil Aviation Safety Authority, *Civil Aviation Safety Regulations 1998* (CASR), compilation number: 66, registered 22 December 2015;
- Civil Aviation Safety Authority, *Manual of Standards Part 139 – Aerodromes*, version 1.12, dated 13 November 2014;
- Department of Infrastructure and Regional Development, *The National Airports Safeguarding Framework: Guideline D,* dated 15 July 2012;
- Department of Planning and Infrastructure, *NSW Planning Guidelines – Wind Farms (Draft)*, dated December 2011;
- Department of Planning and Environment, *NSW Wind Farms Map (PDF)*, dated 14 November 2013;
- Environment Protection and Heritage Council, *National Wind Farm Development Guidelines DRAFT*, dated July 2010;
- International Civil Aviation Organization, Doc 8168 *Procedures for Air Navigation Services—Aircraft Operations* (PANS-OPS);
- International Civil Aviation Organization, Standards and Recommended Practices, *Annex 14—Aerodromes*; and
- other references as noted.

2. BACKGROUND

2.1. History of approvals

The Project was originally approved by the Department of Planning (now the Department of Planning and Environment) on 10 June 2005. Details of the original proposal are as follows:

- 46 wind turbines;
- 67 m tower;
- 39 m blades;
- 80 m rotor diameter; and
- 107 m AGL at blade tip height.

Subsequent modifications were made to the original approval. The development application (DA) encompassing these modifications are collectively known as 'modification-1' (Mod-1). Mod-1 was approved on 29 June 2009. The details of Mod-1 are as follows:

- retaining the 46 turbines;
- an increase in hub height to up to 80 m;
- an increase in blade length to up to 47 m;
- an increase in the rotor diameter to up to 96 m; and
- an increase in blade tip height to up to 128 m.

The Proponent has proposed a DA encompassing further modifications to Mod-1, which is known as 'modification-2' (Mod-2). The details of Mod-2 are included in the current proposal for the project, which are as follows:

- a reduction in the number of approved turbines from 46 to up to 33;
- an increase of the hub height from 80 m to up to 95 m;
- an increase of the blade size from 47 m to up to 64 m;
- an increase of the rotor diameter from 96 m to up to 130 m; and
- an increase of the blade tip height from 128 m to up to 160 m.

2.2. Ambidji

Ambidji produced the report titled Aeronautical Impact and Obstacle Marking and Lighting Assessment, dated 15 January 2009, in support of Mod-1, which was subsequently approved. The report was inserted at Appendix G of the Environmental Impact Statement (EIS), which accompanied the DA.

The report addressed the following items:

- Consultations and consideration of local aviation activities;
- Analysis of obstacle limitation surfaces;
- Analysis of PANS-OPS surfaces;
- Contingency procedures – engine inoperative flight paths;
- Evaluation of obstacle marking and lighting; and
- Other issues, including:
    - Radar interference and shadowing;
    - Potential impact on airport navigation aids;
    - Future developments; and
    - Reporting of tall structures.

The conclusions made in the report are copied below:

> *This aeronautical assessment and evaluation of obstacle marking and lighting was conducted in accordance with the relevant aviation and aeronautical regulations and standards to consider the potential impacts of the proposed modifications to the Crookwell 2 Wind Farm on the safety of aircraft and airport operations.*
>
> *Aeronautical Impact Assessment*
>
> *The study has determined that the highest turbine in this proposed wind farm is 1073m (3520ft) AMSL and as such:*
>
> - *will not penetrate any OLS surfaces;*
> - *will not penetrate any PANS OPS surface;*
> - *will not have an impact on nearby designated air routes;*
> - *will not have an impact on local aviation activities;*
> - *will require notification to CASA under Reporting of Tall Structure requirements; and*
> - *will require consideration of obstacle marking and lighting requirements.*
>
> *The proposed Crookwell 2 Wind Farm site is:*
>
> - *located outside the clearance zones associated with Air Traffic Control radar facilities and aviation navigation aids; and*

- *sufficiently distant from airfields not to have an impact on contingency procedures and engine inoperative flight paths: [sic]*

A wind turbine at a maximum height of approximately 180m AGL could be located on the highest terrain within the boundary of the Crookwell 2 wind farm without penetrating the PANS OPS surfaces at Goulburn Airport.

As the height of the turbines exceed 110m AGL, it will be necessary to notify CASA in accordance with Advisory Circular AC 139-08(0) "Reporting of Tall Structures".

The proposed modifications to the Crookwell 2 Wind Farm have been assessed as not having an impact on prescribed airspace and are therefore considered approvable in accordance with the relevant regulations, subject to the consideration of the obstacle marking and lighting requirements and the notification to CASA of the wind farm being a "Tall Structure". This Aeronautical Study can be used as supporting documentation to an application to CASA using CASA Form 406 – Operational Assessment of Existing and Proposed Structures.

Obstacle Marking and Lighting Requirements

Obstacle marking of the wind turbines to increase daytime conspicuity is not considered necessary provided the turbines are of an appropriate colour that will not require painting or marking to increase conspicuity.

The Crookwell 2 wind farm modification involves an increase in turbine heights which will classify the wind turbines as "tall structures" and it is recommended that obstacle lighting be provided in accordance with CASA recommended guidelines.

The proposed obstacle lighting layout indicated in this study will meet the CASA objectives of:

- *defining the "general definition and extent of the objects" for each Group;*
- *the requirement for an "interval between obstacle lighted turbines not exceeding 900m" for each Group ; and*
- *marking the most prominent (highest for the terrain) turbine in each of the Groups.*

This evaluation of obstacle marking and lighting requirements can be used:

- *as supporting documentation to an application to CASA using CASA Form 406 – "Operational Assessment of Existing and Proposed Structures" and for the "Reporting of Tall Structures" in accordance with AC139-08(0); and*
- *for inclusion in a submission notifying the NSW Department of Planning of the requirement for obstacle lighting to identify the location of a potential hazard to aircraft operations.*

Alternative Solution to Obstacle Lighting

This evaluation submits that the circumstances prevailing in respect of the Crookwell 2 wind farm could justify consideration of alternative and more economic means of identifying the existence of the wind farm and the "Tall Structures". These circumstances include:

- *The aeronautical impact assessment has determined that there is no impact on prescribed airspace;*

- *The nearest airfield permanently equipped for night operations is approximately 30km to the south of the wind farm;*
- *There is no significant night flying activity in the area;*
- *There is considerable higher terrain in the immediate environs of the wind farm; and*
- *The absence of current CASA guideline material for the assessment of obstacle marking and lighting requirements for wind farms.*

As CASA has withdrawn the AC that provides guidelines for the marking and lighting of wind farms and given that Advisory Circulars provide guidelines which, (as indicated in the AC):

> *"... provides a means, but not necessarily the only means, of complying with the Regulations..."*

then, pending the review of the Advisory Circular, an alternative solution to indicate the existence and location of the "Tall Structure" in order to meet the relevant Regulations may be the declaration of the wind farm as a Danger Area.

Current CASA Safety Regulations apply to obstacles and structures within the vicinity (approximately 30km) of an aerodrome. Goulburn airfield is located approximately 30km south of the wind farm and is equipped for night operations. Although there are other airfields within a 30km radius, they are not equipped for night operations. An alternative solution to obstacle lighting of the wind farm is considered to be the declaration of A "Danger Area" to identify the existence and location of the wind farm. A Danger Area is defined in aeronautical information publications as:

> *"Airspace within which activities dangerous to the flight of aircraft may exist at specified times."*

In the case of wind farms, the specified times could be for continuous operation, or for night operations and in low visibility conditions only as CASA Advisory Circulars indicate that wind turbines are considered to be sufficiently conspicuous in daytime, provided the turbine is of a colour that enables it to be readily seen against the background. Danger Areas are identified in AIP's and included on relevant aeronautical charts, and it is the responsibility of pilots to be fully aware of such operational constraints. Supplementing the Danger Area with a reduced number of obstacle lights to identify the centre of the wind farm, (as is currently provided for Danger Areas associated with high rise plume exhausts), the highest terrain points and the wind farm extremities would significantly reduce the need for obstacle lighting of a significant number of the turbines while still meeting the requirement to identify the existence of a Tall Structure and potential hazard to aircraft operations.

The modifications proposed in Mod-2 will invalidate certain findings in the report produced by Ambidji. Therefore, there is an obligation to reanalyse these invalidated findings in order to satisfy planning requirements in support of the development application for the Project.

To address the invalidated findings as a result of Mod-2, the following tasks are required:

- Consultations and consideration of local aviation activities;
- An Aviation Impact Statement (AIS) in accordance with the Airservices Australia letter: *Airservices Aviation Assessments for Wind Farm Developments*, dated 13 February 2014;
- An assessment to determine obstacle lighting and marking requirements; and

- An obstacle lighting design, recommending which wind turbines should be provided with obstacle lighting if obstacle lighting was required.

2.3. Crookwell 2 Wind Farm [Mod-2]

The Project will comprise of up to 33 individual wind turbines. The proposed development is located in the Southern Highlands of NSW, on a 2088 hectare site located approximately 14 km south-east of Crookwell and 30 km north-west of Goulburn, in the vicinity of the existing Crookwell 1 Wind Farm.

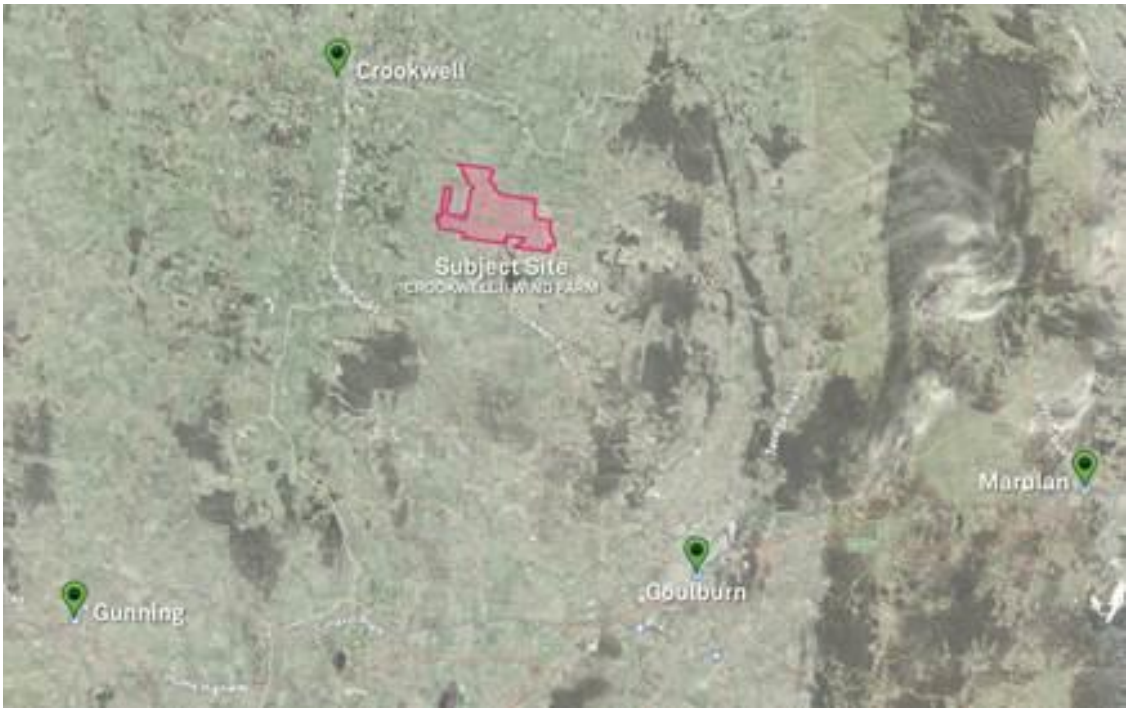

Figure 1 shows the general area of the Project.

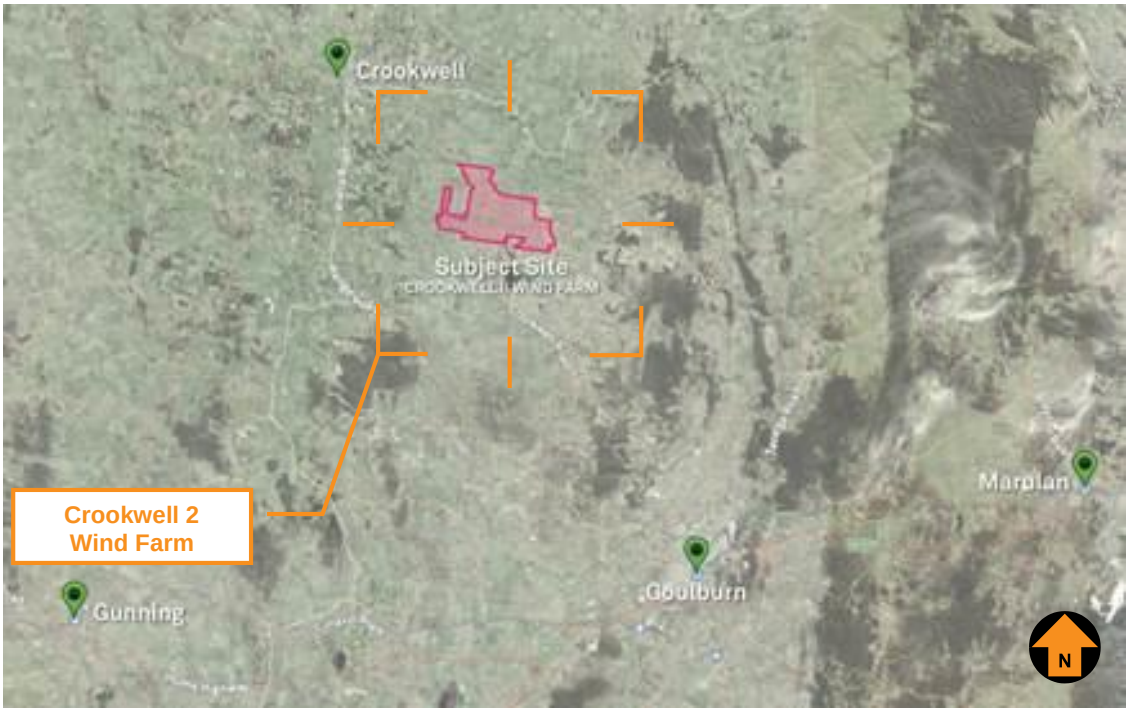

Figure 1 Crookwell 2 Wind Farm general area

The Project will also include ancillary structures, access tracks, temporary concrete batching plant(s) and electrical infrastructure that is required to connect the Project into the electrical network infrastructure.

2.4. Description of wind turbines

The proposed wind turbines will have a height of up to 160 m above ground level (AGL) (524.9 ft) to the top of the blade on a maximum ground elevation of 947 m AHD (3107.0 ft above mean sea level (AMSL)), having a maximum overall height of 1107 m AHD (3631.9 ft AMSL). The indicative wind farm layout, highlighting the turbine with the greatest elevation, issued by the Proponent on 5 August 2015, is shown in Table 1.

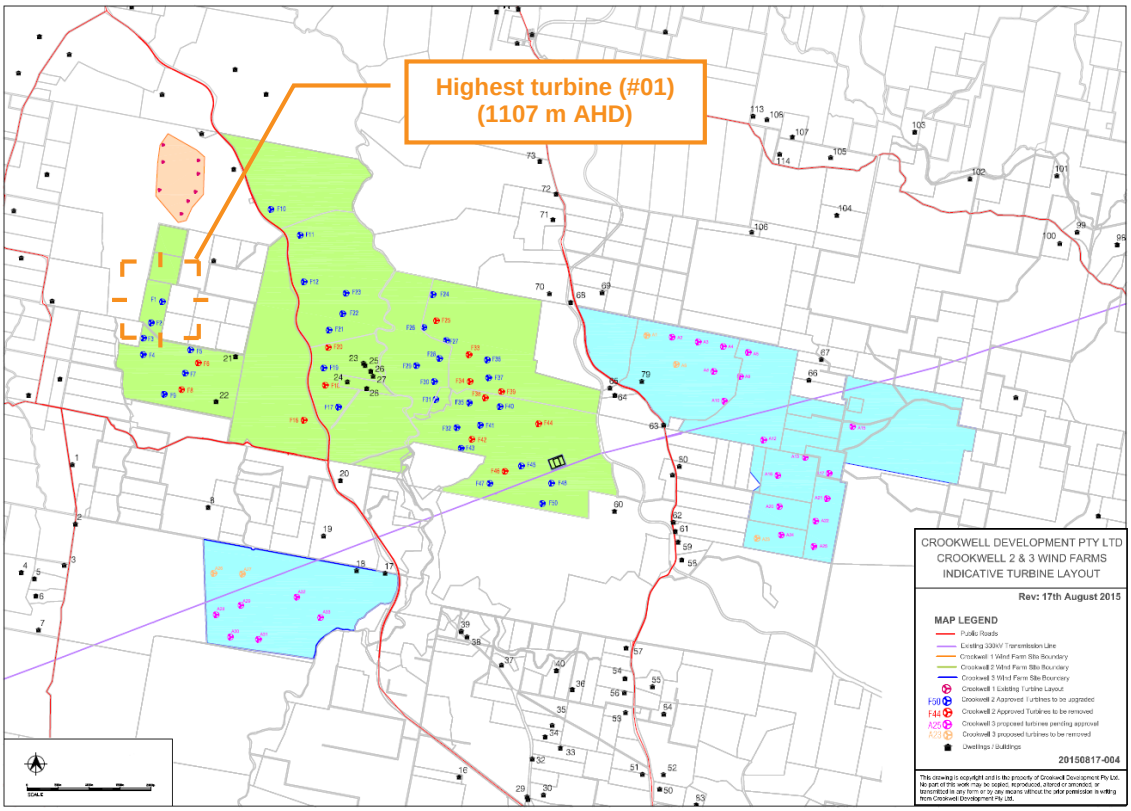

Figure 2 Crookwell 2 Wind Farm project site and proposed layout

The coordinates and ground elevations of the proposed wind turbines are listed at **Annexure 1**.

This assessment will be based on the Hybrid turbine parameters in accordance with advice provided in an email by the Proponent dated 4 May 2015, which states the following:

> *We are considering a range of turbine model options, however we like to assess it as a hybrid / generic turbine envelope that can capture all of the possible options.*

The proposed amendment will result in the following net change:

- Number of wind turbines decreased by 13; and
- Maximum blade tip height increased by 32 m.

2.5. Description of wind monitoring towers

Currently, two wind monitoring towers are installed within the project application area. The details of each tower, provided by the Proponent on 21 July 2015, are detailed in Table 1. The relevant details of the wind monitoring towers have been notified to Royal Australian Air Force Aeronautical Information Service (RAAF AIS) in an email sent on 4 September 2015.

Table 1 Wind monitoring towers description

Criteria	*Tower 1*	*Tower 2*
Name	CR4	CR5
Ground elevation at site	911 m (2989 ft)	873 m (2864 ft)
Height of tower AGL	60 m (197 ft)	80 m (262 ft)
Height of tower AHD	971 m (3186 ft)	953 m (3127 ft)
Markings existing/proposed	No markings	No markings
Design	Grey, tubular steel	Grey, lattice steel
Reported to RAAF AIS?	Yes	Yes

In an email from the Proponent dated 21 July 2015, the following advice was provided regarding the wind monitoring towers.

> *We anticipate up to 3 new wind monitoring towers in new locations, at hub height of up to 95 metres, steel lattice structure, (details to be decided and agreed with turbine manufacturer through final design process).*

It can be concluded that towers have a maximum height of 80 m AGL (at CR5) and 971 m AMSL (at CR4) and are not, nor are they required to be, obstacle marked or lit. It is expected that up to three new wind monitoring towers at hub heights of up to 95 m AGL will be installed. RAAF AIS has been notified of both towers.

2.6. Nearby aerodromes

There is one registered aerodrome located within 30 nm of the Project site, which is Goulburn Airport. There are no certified aerodromes located within 30 nm of the Project site. The AIS discusses the impacts on registered and certified aerodromes within 30 nm of the Project area. The AIS concluded that the operations at Goulburn Airport will not be impacted by the proposed wind farm. The aviation impacts of the Project on nearby registered and certified aerodromes are discussed in detail in the AIS provided at **Annexure 2.**

There is one uncertified/unregistered aerodrome identified that is located within 30 nm of the Project site, which is Crookwell Aerodrome. Crookwell Aerodrome is located approximately 4 nm (7.5 km) north west of the Project site boundary. The aerodrome does not have instrument procedures, does not have any OLS (obstacle

limitation surface) or PANS-OPS (Procedures for Air Navigation Services – Operations) surfaces. The aerodrome is sufficiently distant from the proposed wind farm that take-off and landing operations are not affected. It is limited to day operations only.

With respect to other nearby aerodromes, the following was noted in the aeronautical impact assessment produced by Ambidji, dated 15 January 2009, which was used in support of the approval of Mod-1.

> *Other private airstrips and landing grounds may be located within 30km of the boundary of the proposed wind farm, none of which require OLS and are not included in aeronautical charts for the region. Pilots operating at such private airstrips are responsible for ensuring that they are aware of the conditions on and surrounding these landing sites.*

It can by concluded that the Project will not adversely affect the operations of nearby aerodromes.

3. STAKEHOLDER CONSULTATION

The report by Ambidji, dated 15 January 2009, which was used to support the approval of Mod-1 included the consideration of stakeholder consultation. The report stated the following:

> *As the original proposal for Crookwell 2 had been the subject of discussions with the aviation industry during 2004/05, no further detailed discussions were conducted as part of this study. It will most likely be necessary to conduct consultations with CASA following completion of this study and the submission of an application to CASA for approval of the wind farm modifications. ...*

For the purposes of this aeronautical impact assessment in support of Mod-2, a comprehensive consultation process was undertaken to identify where the design of the development should be amended based on issues raised. The stakeholders consulted are listed below:

- Aerial Agricultural Association of Australia;
- Airservices Australia;
- Civil Aviation Safety Authority;
- Department of Defence;
- Fred Fahey Aerial Services;
- Goulburn Mulwaree Council;
- NSW Rural Fire Service;
- Royal Flying Doctor Service;
- Upper Lachlan Shire Council; and
- Yass Aerial service.

Details and results of the consultation activities are provided in Table 2 .

Table 2 Stakeholder consultation details

Agency/Contact	Activity/Date	Response/Date	Issues Raised During Consultation	Action Proposed
Aerial Agricultural Association of Australia Chief Executive Officer Phil Hurst	4 November 2015 Request for consideration sent via email phil@aerialag.com.au	Nil	Nil	Refer to discussion on Aerial Application and Hazard Marking and Lighting in section 6 of this report.
Fred Fahey Aerial Services Fred Fahey	30 July 2015 (02) 6342 9256 0428 637 253	No formal response to be provided.	He stated he was too busy to discuss the Project and declined the opportunity to have a follow up discussion.	Refer to discussion on Aerial Application and Hazard Marking and Lighting in section 6 of this report.
Royal Flying Doctor Service Mascot Senior Base Pilot Andrew Duma	Telecon 31 July 2015 02 8374 2400 0400 482 229 sbpsydney@rfdsse.org.au	NA	Mr Duma advised that the proposal should have no significant impact on operations as long as the obstacles are properly referenced on navigation charts.	Ensure obstacles are properly referenced on navigational charts.
Goulburn Mulwaree Council	Request for consideration sent on 4 November 2015 to council@goulburn.nsw.gov.au	Nil	Nil	Nil
Upper Lachlan Shire Council	Request for consideration sent on 4 November 2015 to council@upperlachlan.nsw.gov.au	Nil	Nil	Nil

Civil Aviation Safety Authority Dilip Mathew Manager Aerodromes	4 November 2015 Letter sent to Dilip Mathew seeking CASA's position in relation to the Project with specific reference to potential aviation impacts.	19 February 2016 Responding letter addressed to Mr Mike Young (Director Resource Assessments for Department of Planning and Environment.	CASA recommends the wind farm is lit with steady red low intensity lighting at night as per Section 9.4 of the CASA Manual of Standards Part 139. Characteristics for low intensity are stated in subsection 9.4.6. Refer to the discussion on Hazard Marking and Lighting in section 6 of this report. CASA agrees that the turbines that should be lit are those identified in the drawing *'100405 Crookwell 2 Wind Farm Obstacle Lighting Design v0.1 150810'.* CASA recommends that the proponent makes the notifications described in the NASF Guideline D.	Refer to discussion on Hazard Marking and Lighting. Refer to **Annexure 3** Refer to discussion on reporting of tall obstacles.

Airservices Australia Airport Developments	Request for consideration sent on 4 November 2015 to Airport.Developments@AirservicesAustralia.com	Email response received on 14 December 2015	**Airspace Procedures** With respect to procedures designed by Airservices in accordance with ICAO PANS-OPS and Document 9905, at a height of 1107m (3632ft) AHD the Crookwell 2 wind farm will not affect any sector or circling altitude, nor any instrument approach or departure procedure at Goulburn aerodrome. Note: procedures not designed by Airservices at Goulburn aerodrome were not considered in this assessment. **CNS Facilities** This proposal for a wind farm as detailed in the AIS will not adversely impact the performance of any Airservices Precision/Non-Precision Nav Aids, Anemometers, HF/VHF/UHF Comms, A-SMGCS, Radar, PRM, ADS-B, WAM or Satellite/Links.	Nil

Department of Defence Estate Planning ACT/NSW	Request for consideration sent on 4 November 2015 to lpsi.directorate@defence.gov.au	Letter response received on 24 November 2015	The Project will be outside any areas affected by the Defence (Areas Control) Regulations (DACR) or Obstruction Limitation Surfaces. However, there is an ongoing need to obtain and maintain accurate information about tall structures. The risk posed by a tall structure to aircraft safety can be minimised if information on the tall structure is conveyed to pilots so that they can fly at a safe margin above the structure. Airservices is responsible for recording the location and height of tall structures. The information is held in a central database and relates to the erection, extension or dismantling of tall structures the top of which is: a) 30 m or more AGL within 30 km of an aerodrome; or b) 45 m or more AGL elsewhere. The Project will meet the above definition of a tall structure. Defence has no concerns at this time with the Project subject to certain requests are met (refer to Actions Proposed column).	Defence requests the following: • Provide Airservices Australia with "as constructed" details, by emailing the details to vod@airservicesaustralia.com; • The wind turbines should be lit in accordance with the requirements of MOS 139; and • If LED obstruction lighting is to be provided to the wind turbines, ensure the frequency range of the LED light emitted fall within the range of wavelengths 655 to 930 nanometres, thus being visible to persons using night vision devices. Refer to Hazard Marking and Lighting in section 6 of this report.

NSW Rural Fire Service **A member of the aviation department who wished to remain anonymous.**	Telecon, 30 July 2015 and 16 December 2015 Request for consideration of potential impacts on aerial fighting of bushfires. 02 8741 5555	Nil	The member of the NSW Rural Fire Service (RFS) aviation department advised that the position of NSW RFS with respect to impacts of the Project on its aerial firefighting operations is in alignment with the position outlined in *Wind Farms and Bush Fires Operations*, version 2.0, dated 30 October 2014, published by Australasian Fire and Emergency Service Authorities Council (AFAC). The member also advised that the wind turbines are treated as just another obstacle by RFS air crew, which is of no significance to normal aircraft operations.	Refer to the position statement provided in the Wind Farms and Bush Fires Operations, version 2.0, dated 30 October 2014, published by Australasian Fire and Emergency Service Authorities Council (AFAC).

Yass Aerial Services Ted McIntosh	3 August 2015 (02) 6227 6007 Email: tedann1@hotmail.com	Nil	Conducts activities in to the area on an annual basis as required by agricultural industry. Wind turbines separated by 600 m seems to take a lot of the angst out of operating amongst wind farms for pilots. He would fly between them if they were 600 m apart. A South Australian wind farm at Yorke Peninsula has a policy that wind turbines are turned off when aerial agricultural operations are taking place in the vicinity of the turbines. Would expect wind farm to limit aerial agricultural activity in the affected area but would have to assess on an individual basis. Properties adjacent to the wind farms would need to be assessed on an individual basis. YAS conducts fire spotting activities for RFS but not fire-bombing activities. Refer to AAAA website.	Coordinate with wind farm management. Consider turning off certain wind turbines when aerial agricultural work is in progress.

4. AVIATION IMPACT STATEMENT

4.1. Scope of Aviation Impact Statement

IDS Australasia Pty Ltd was engaged by Aviation Projects to prepare an Aviation Impact Statement (AIS) in accordance with Airservices Australia guidance dated 13 February 2014.

4.2. Summary of Aviation Impact Statement

The Aviation Impact Statement has made the following conclusions:

> *In summary, the Aviation Impact Statement has determined that:*
>
> *1) The blade tips of the highest obstacle in the wind farm project will be 1107m (3632ft) AHD and as such:*
>
> - *Will not penetrate any OLS surfaces;*
> - *Will not penetrate any PAN-OPS surfaces;*
> - *Will not have an impact on nearby designated air routes.*
> - *Will not have an impact on prescribed airspace;*
> - *Is wholly contained within Class G airspace; and*
> - *Will not have an impact on existing local aviation activities.*
>
> *2) The wind farm obstacles are located outside the clearance zones associated with aviation navigation aids and communication facilities.*
>
> *3) A preliminary assessment on the impact of the wind farm on ATC radar surveillance facilities has been made. There will be an impact on the RSR at Mt Bobbara. The PSR (primary surveillance radar) and SSR (Secondary surveillance radar) facility at Mt Majura may be affected.* ***Further liaison with Airservices Australia will be required to refine the impact analysis and if required, coordinate impact mitigation measures.***
>
> *4) The wind farm is sufficiently distant from airfields to not have an impact on contingency procedures and engine inoperative flight paths.*
>
> *5) Subject to resolution of PSR impact issues, the wind farm obstacles have been assessed as not having an impact on prescribed airspace. The development is therefore considered approvable in accordance with the relevant civil aviation regulations. This Aviation Impact Statement can be used as supporting documentation for an application to CASA.*

A copy of the AIS is provided at **Annexure 2.**

In an email from Airport Developments (Airservices Australia), dated 14 December 2015, it was determined that there will be no aviation impacts on airspace procedures that have been designed by Airservices or communication, navigation and surveillance (CNS) facilities. An extract of the email is copied below:

I refer to your request for Airservices assessment of the Crookwell 2 Wind Farm which is proposed for the NSW Southern Highlands.

Airspace Procedures

With respect to procedures designed by Airservices in accordance with ICAO PANS-OPS and Document 9905, at a height of 1107m (3632ft) AHD the Crookwell 2 wind farm will not affect any sector or circling altitude, nor any instrument approach or departure procedure at Goulburn aerodrome.

Note: procedures not designed by Airservices at Goulburn aerodrome were not considered in this assessment.

CNS Facilities

This proposal for a wind farm as detailed in the AIS will not adversely impact the performance of any Airservices Precision/Non-Precision Nav Aids, Anemometers, HF/VHF/UHF Comms, A-SMGCS, Radar, PRM, ADS-B, WAM or Satellite/Links.

Based on the information provided by Airservices Australia and IDS Australasia, it can be concluded that the Project will not have an impact on airspace procedures or communication, navigation and surveillance (CNS) facilities.

5. AIRCRAFT OPERATOR CHARACTERISTICS

5.1. Aerial application

5.1.1. Aerial Agriculture Association of Australia

A request for consideration of the Project was emailed to the Chief Executive Officer, Mr Hurst, on 4 November 2015; however, no response was received at the time of finalising this report.

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

> *As a result of the overwhelming safety and economic impact of wind farms and supporting infrastructure on the sector, AAAA opposes all wind farm developments in areas of agricultural production or elevated bushfire risk.*
>
> *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.*

AAAA had developed National Windfarm Operating Protocols (adopted May 2014). These protocols note the following comments:

> *At the development stage, AAAA remains strongly opposed to all windfarms that are proposed to be built on agricultural land or land that is likely to be affected by bushfire. These areas are of critical safety importance to legitimate and legal low-level operations, such as those encountered during crop protection, pasture fertilisation or firebombing operations.*
>
> *However, AAAA realises that some wind farm proposals may be approved in areas where aerial application takes place. In those circumstances, AAAA has developed the following national operational protocols to support a consistent approach to aerial application where windfarms are in the operational vicinity.*

The protocols list considerations for developers during the design/build stage and also the operational stage, for pilots/aircraft operators during aircraft operations and discusses economic compensation. NASF Guideline D is included as Appendix 1, and AAAA Aerial Application Pilots Manual – excerpts on planning are provided as Appendix II.

5.1.2. Local aerial application operators

Local aerial application operators consulted during the consultation activities with a request for consideration on the impacts of the Project on aerial agricultural operations.

Mr McIntosh (Yass Aerial Services) provided input. He conducts activities in the area on an annual basis as required by agricultural industry. He also conducts fire spotting activities for RFS but not fire-bombing activities.

Mr McIntosh stated that wind turbines separated by 600 m seems to take a lot of the angst out of operating amongst wind farms for pilots and that he would fly between them if they were 600 m apart.

Mr McIntosh made reference to a South Australian wind farm at Yorke Peninsula, which has implemented a policy that wind turbines are turned off when aerial agricultural operations are taking place in the vicinity of the turbines. He has therefore suggested that the Proponent consider coordinating with aerial agricultural operators to turn off certain wind turbines when aerial agricultural work is in progress.

Mr McIntosh also directed Aviation Projects to the AAAA Windfarm Policy (refer to the discussion in subsection 5.1.1).

The issues raised in Mr McIntosh's advice generally aligns with the feedback received from consultation activities from previous aeronautical impact assessments of other wind farm developments. The general findings from these previous consultation activities applicable to the issues raised by Mr McIntosh were as follows:

- **The rotating blades of the wind turbines** – stopping the blade rotation of the wind turbines may allow aerial agricultural operations below tower height, subject to the density of with turbines. If wind turbine rotations were stopped during agricultural operations in the Project's vicinity, the impact on aerial agricultural operations due to this issue is likely to be alleviated.
- **Wind turbines density –** reducing the number of wind turbines, thereby reducing the number of turbines per unit area, would result in a net improvement with respect to impacts on aerial agricultural operations. As the Project will result in a reduced number of turbines within the same project area, the wind turbine density is reduced and therefore the impact due to this issue on aerial agricultural operations is reduced.

In addition to the abovementioned issues, other general findings from previous consultation activities which were issues not specifically mentioned by Mr McIntosh were the following:

- **The height margin between the rotor blade at its lowest point and the ground** – the greater clearance between the aerial agricultural operation heights (determined by ground level) and the lowest part of the wind turbine rotor diameter, the lesser the impact on aerial agricultural operations. As the Project will result in an increased height margin between the wind turbine blades and ground level, the impact on aerial agricultural operations due to this issue will be reduced.
- **Visibility of wind monitoring towers (WMT) –** WMTs are generally very difficult to see unless the pilot is aware of their location. The locations of the WMT in this Project area have been notified to RAAF AIS and are not proposed to be relocated.

5.2. Aerial firefighting

The NSW Rural Fire Service (RFS) was consulted with respect to understanding the impacts of the Project on firefighting operations. A member of the aviation department of RFS (who requested to remain anonymous) also advised that the position of RFS with respect to wind farms is consistent with the position statement provided in the Wind Farms and Bush Fires Operations, version 2.0, dated 30 October 2014, published by Australasian Fire and Emergency Service Authorities Council (AFAC).

An extract of the AFAC position statement is copied below:

> *Bushfire management issues are best treated at the planning stage of a wind farm project. This includes the impact of bushfires on the wind farm and the potential for fires to start within the development boundaries. Local planning controls are in place to regulate these issues with respect to any infrastructure development and some local planning controls refer specifically to wind farms.*
>
> *Wind monitoring towers associated with wind farm investigations and planning can be very much taller than the planned turbines and can be less visible. The location and height of monitoring towers should be noted during aerial firefighting operations.*
>
> *...*
>
> *Aerial fire fighting operations will treat the turbine towers similar to other tall obstacles. Pilots and Air Operations Managers will assess these risks as part of routine procedures. Risks due to wake turbulence and the moving blades should also be considered. Wind turbines are not expected to pose unacceptable risks.*
>
> *...*

The member also advised that RFS air crew treat wind turbines as just another obstacle and has no significance to normal aviation operations at RFS.

6. HAZARD LIGHTING AND MARKING

6.1. Civil Aviation Safety Authority

In considering the need for aviation hazard lighting, the applicable regulatory context was determined and direct consultation with the Civil Aviation Safety Authority (CASA) was undertaken.

CASA 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.

6.1.1. 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 to inform CASA. 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.

On 4 November 2015, a letter was addressed to Dilip Mathew (Manager Aerodromes of CASA), seeking CASA's position in relation to the proposed development, with specific reference to potential aviation impacts. On 19 February 2016, Mr Mathew responded in a letter to Mr Mike Young (Director Resources Assessments of the Department of Planning and Environment). An extract of the correspondence is copied below:

> ...
>
> *CASA has assessed the proposed Crookwell 2 Wind Farm based on the revised maximum height of 160m AGL.*
>
> *CASA recommends that the wind farm is lit with steady red low intensity lighting at night as per Section 9.4 of the CASA Manual of Standards Part 139. Characteristics for low intensity lights are stated in subsection 9.4.6. CASA agrees that the turbines that should be lit are those identified by the proponent in the drawing '100405 Crookwell 2 Wind Farm Obstacle Lighting Design v0.1 150810'.*
>
> *CASA recommends that the proponent makes the notifications described in the NASF Guideline D.*
>
> ...

CASA recommends that the Proponent makes the notifications described in the NASF Guideline D. Extracts of the paragraphs in the NASF Guideline D publication that are applicable to the Project are copied below:

> *21. 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.*

40. There is no requirement for CASA to be notified if a proposed wind turbine or wind monitoring tower is less than 150m in height and does not infringe the OLS of an aerodrome. However, they should still be reported for inclusion in the national database of tall structures maintained by the Royal Australian Air Force (RAAF). Information on reporting of tall structures may be found in an advisory circular issued by CASA 'AC 139-08(0) Reporting of Tall Structures'.

Mr Mathew did not provide any of CASA's analysis or conclusions of its assessment in order to provide an explanation for its recommendation to have the Project lit with steady red low intensity lighting.

6.1.2. Manual of Standards Part 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 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 MOS 139 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:

9.4.2.2 Low intensity obstacle lights are steady red lights and are to be used on non-extensive objects whose height above the surrounding ground is less than 45 m.

***Note:** A group of trees or buildings is regarded as an extensive object.*

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.

6.1.3. Advisory Circular 139-08(0)—Reporting of Tall Structures

In Advisory Circular (AC) 139-08(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.

The RAAF Aeronautical Information Service (AIS) has been assigned the task of maintaining a database of tall structures, the top measurement of which is:

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

b) 45 metres or more above ground level elsewhere.

The purpose of notifying RAAF AIS of these structures is to enable their details to be provided in aeronautical information databases and maps, charts and other sources of information used by pilots, so that the obstacles can be avoided.

As the proposed turbines will be located more than 30 km from an aerodrome but will be higher than 45 m AGL, they must be reported to RAAF AIS. This action should occur once the final layout is confirmed at the completion of the Environmental Assessment process and prior to construction.

Wind turbines in the Project are proposed to have a maximum height of 160 m AGL. With respect to MOS 139 7.1.5.1, the proposed turbines must be reported to CASA if they will be higher than 110 m AGL. With respect to MOS 139 7.1.5.2, the wind turbines must be regarded as an obstacle if they are higher than 150 m AGL, unless CASA assess otherwise.

With respect to MOS 139 9.4.1.2 (b), the wind turbines will need to be lit if they are higher than 110 m AGL, unless an aeronautical study assesses they are of no operational significance. Note that wind monitoring towers will be lower than the turbines and are not likely to likely to be shielded by the taller wind turbines.

6.2. 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.

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.

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

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

Where these SARPs are not met, a difference must be filed.

6.3. Turbine lighting design

In the event that obstacle lighting is required, a lighting design has been prepared on the basis of the requirements set out in ICAO Annex 14 Vol 1 Chapter 6 and MOS 139 Chapter 9.

Turbines proposed to be lit are, wherever possible, located on the perimeter of the wind farm at appropriate spacing and/or are significantly higher than surrounding turbines.

In addition, the lighting proposal has been based on:

- the specific configuration of the wind farm and its location in relation to surrounding facilities and features (including terrain);
- the relative elevation and proximity of each turbine in relation to others; and

- the position of turbines in relation to falling and rising terrain.

Due to the proposed configuration of the wind farm, however, not all lit turbines are within 900 m of each other—although the apparent intermediate distance (approaching from any direction) is minimised (and retained under approximately 1 nm) due to the location of intermediate lights set further back from turbines on the perimeter.

Given the minimum requirement for 5000 m visibility for flight under the visual flight rules, the lighting design should provide sufficient warning to pilots that they will be able to manoeuvre their aircraft to avoid the turbines.

If lighting is required, lights are recommended for the following 24 turbines (without the 'F' as the identification prefix): 1, 4, 5, 9, 10, 11, 12, 17, 19, 21, 23, 24, 26, 27, 29, 31, 36, 37, 40, 43, 45, 47, 48 and 50.

This lighting design is subject to confirmation of the final turbine layout as any changes proposed could potentially affect which turbines should be lit in accordance with the 900 m interval consideration.

A graphic representation of the lighting design which identifies those turbines proposed to be lit is provided in **Annexure 3**.

6.4. Light characteristics

If obstacle lighting is required, installed lights should be designed according to the criteria set out in the applicable regulatory material. Previously, the generally accepted lighting design characteristics includes two flashing red medium intensity obstacle lights which would have been recommended to be provided. However, for the Project, CASA has recommended steady red low intensity lighting.

A summary of design characteristics acceptable by CASA is provided below:

- two steady red low intensity obstacle lights should be provided;
- the light fixtures should be mounted sufficiently above the surface of the nacelle so that the lights are not obscured by the rotor hub, and at a horizontal separation to ensure an unobstructed view of at least one of the lights by a pilot approaching from any direction; and
- the characteristics of the obstacle lights should be in accordance with the applicable standards in MOS 139.

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

- MOS 139 section 9.4.6 outlines Characteristics of Low Intensity Obstacle Lights.

  9.4.6.1 Low intensity obstacle lights, for general applications, are to have the following characteristics:

  (a) fixed lights showing red;

  (b) a horizontal beam spread that results in 360° coverage around obstacle;

  (c) a peak intensity of 100 cd minimum;

  (d) a vertical beam spread (to 50% of peak intensity) of 10°;

(e) a vertical distribution with 100 cd minimum at +6° and +10° above the horizontal; and

(f) not less than 10 cd at all elevation angles between –3° and +90° above the horizontal.

Notes:

1. The intensity level is higher than ICAO standards because in Australia only obstacles assessed as significant to aircraft operations are required to be provided with obstacle lighting.

2. Currently the intensity requirement is normally met by a double-bodied light fitting which also provides a degree of redundancy.

3. Double-bodied light fittings should be orientated so that they show the maximum illuminated surface towards the predominant, or more critical, direction of aircraft approach.

4. For objects that do not infringe the obstacle limitation surfaces, and where CASA has not determined that obstacle lights are required, if the object owner wishes, of their own volition, to provide obstacle lights, it is sufficient for these low intensity obstacle lights to have the following intensity distribution: peak intensity 32 cd minimum, vertical beam spread of 10°, and 32 cd minimum at +6° and +10° elevation.

9.4.6.2 Low intensity obstacle lights, used to indicate taxiway obstacles or unserviceable areas of the movement area, are to have a peak intensity of 10 cd minimum.

MOS 139 section 9.4.7 outlines Characteristics of Medium Intensity Obstacle Lights.

9.4.7.1 Medium intensity obstacle lights are to be flashing or steady red lights or flashing white lights, visible in all directions in azimuth.

9.4.7.2 The frequency of flashes is to be between 20 and 60 flashes per minute.

9.4.7.3 The peak effective intensity is to be 2,000 ± 25% cd with a vertical distribution as follows:

(a) vertical beam spread is to be 3° minimum (beam spread is defined as the angle between two directions in a plane for which the intensity is equal to 50% of the lower tolerance value of the peak intensity);

(b) at -1° elevation, the intensity is to be 50% minimum and 75% maximum of lower tolerance value of the peak intensity; and

(c) at 0° elevation, the intensity is to be 100% minimum of the lower tolerance value of the peak intensity.

9.4.7.4 Where the flashing white light is used in lieu of obstacle marking during the day to indicate temporary obstacles in the vicinity of an aerodrome, in accordance with Paragraph 9.4.2.4(a), the peak effective intensity is to be increased to 20,000 ± 25% cd when the background luminance is 50 cd/m² or greater.

MOS 139 Section 9.4.10 sets out the requirements for ongoing availability of obstacle lights:

9.4.10.4 For obstacles located outside the obstacle limitation surface area of an aerodrome, the owners of the lights need to establish a program to monitor the lights and report light failures. The reporting point for obstacle light failure is normally the nearest CASA office. When an obstacle light is unserviceable, the matter needs to be reported immediately to the relevant CASA office so that a NOTAM warning pilots of the light outage can be initiated.

To ensure the ongoing availability of obstacle lights (if required), a monitoring, reporting and maintenance program will need to be established in accordance with this guidance.

6.5. Visual impact of night lighting

Generally accepted considerations regarding minimisation of visual impact are provided below for consideration in the 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.
- Where two lights are mounted on a nacelle, dynamic shielding or light extinction of one light at a time, for the period that a blade is passing in front of the light, is permissible, providing that at all times at least one light can be seen, without interruption, from every angle of azimuth.
- All obstacle lights on a wind farm should be synchronised so that they flash simultaneously.
- 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 conspicuity of the overall turbine.

6.6. Marking of turbines

ICAO Annex 14 Vol 1 Section 6.4.2 recommends that the rotor blades, nacelle and upper 2/3 of the supporting mast of the wind turbines should be painted white, unless otherwise indicated by an aeronautical study.

It is generally accepted that, as an alternative to white, an off-white or light grey colour will provide sufficient contrast with the surrounding environment to maintain an acceptable level of safety while lowering visual impact to the neighbouring residents.

6.7. Wind monitoring towers

There are two wind monitoring towers on the proposed wind farm site. CR4 is 60 m AGL and CR5 is 80 m AGL. Their locations, heights and other applicable details have been advised to RAAF AIS.

The wind monitoring towers are not marked or lit, and nor is there a requirement 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 30 m apart.*

NASF Guideline D suggests consideration of the following measures specific to the marking and lighting of wind monitoring towers:

- *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 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.*

6.8. Future regulatory requirements and guidance

The National Airports Safeguarding Advisory Group (NASAG), comprising of Commonwealth, State and Territory Government planning and transport officials, the Australian Government Department of Defence, the Civil Aviation Safety Authority (CASA), Airservices Australia and the Australian Local Government Association (ALGA), has developed the National Airports Safeguarding Framework (the Framework).

The National Airports Safeguarding Framework is a national land use planning framework that aims to:

- improve community amenity by minimising aircraft noise-sensitive developments near airports; and
- improve safety outcomes by ensuring aviation safety requirements are recognised in land use planning decisions through guidelines being adopted by jurisdictions on various safety-related issues.

Guideline D of the Framework deals with wind farm developments: *Managing the Risk to Aviation Safety of Wind Turbine Installations (Wind Farms) / Wind Monitoring Towers.*

The Framework and any future development or amendment of regulations or guidance could potentially affect the requirement for lighting and/or applicable design specifications.

Consideration of the need for obstacle lighting and the final layout and design specification is therefore subject to confirmation of applicable regulatory requirements and guidance. This consideration, in the form of an aeronautical study (a detailed and thorough risk assessment using internationally recognised standards) as previously described, should occur once the final layout is known and prior to installation of the lights during construction.

7. RISK ASSESSMENT

7.1. 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.

7.2. Likelihood

Likelihood is defined in AS/NZS ISO 31 000:2009 as the chance of something happening. Likelihood descriptors used in this report are as indicated in Table 3.

Table 3 Likelihood Descriptors

No	*Descriptor*	*Description*
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)

7.3. 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 4.

Table 4 Consequence Descriptors

No	Descriptor	People Safety	Property	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. 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.

7.4. Risk matrix

The risk matrix, which correlates likelihood and consequence to determine a level of risk, used in this report is shown in Table 5.

Table 5 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

7.5. Actions required

Actions required according to the derived level of risk are shown in Table 6.

Table 6 Actions Required

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.

7.6. 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 Regional Development 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. 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.

7.7. 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 a wind turbine

Discussion

An aircraft collision with a wind turbine would result in harm to people and damage to property.

There have been four reported occurrences worldwide of aircraft collisions with a component of a wind turbine structure since the year 2000. 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.

One example of a reported collision with a wind turbine occurred in France. The pilot decided to descend below the cloud base in the attempt to find the aerodrome. At the time of the collision, the pilot was attempting to find the runway as the ground was visible. In addition, the aircraft was in conditions of significantly reduced horizontal visibility in fog where the top of the turbine was obscured by cloud. The turbines became visible too late for avoidance manoeuvring and made contact with two turbines. The aircraft was damaged but landed safely.

Other examples of collisions occurred in VMC, where turbines would have been unobscured by weather, where it was reported that pilots were flying in the vicinity of wind farms for operations associated with testing wind farm impacts on the environment or where pilots were transiting near the wind farms en route to their destination.

If these recorded collisions were taken to be an exhaustive list of occurrences since 2000, it can be deduced that aircraft collisions with wind turbines occur very infrequently.

There is a relatively low rate of aircraft activity in the vicinity of the wind farm, with the exception of agricultural aviation operations.

There are no known aerial agriculture operations conducted at night in the vicinity of the wind farm.

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.

Consequence

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.

Consequence	Catastrophic

Untreated Likelihood

There have been four reports of aircraft collisions with wind turbines, which have resulted in a range of consequences, where aircraft occupants sustained minor injury in some cases and fatal injuries in others. Similarly, aircraft damage sustained ranged from minor to catastrophic. 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.

Untreated Likelihood	Rare

Current Treatments (without lighting)

- The Project is clear of the obstacle limitation surfaces 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 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 160 m (524.9 ft) at the top of the blade tip, so the rotor blade at its maximum height will be 7.6 m (24.9 ft) above aircraft flying at the minimum altitude of 152.4 m AGL (500 ft).
- 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 wind turbines.
- If cloud descends below the turbine hub (in this case 110 m (361 ft) for the highest proposed turbine model), 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 AGL (500 ft) (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 typically 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 160 m (524.9 ft) high at the blade tip. This is 50 m (164.0 ft) higher than the height below of 110 m (360.9 ft) which there would be no statutory requirement to report the turbines to CASA in any case.

Level of Risk

The level of risk associated with a Rare likelihood of a Catastrophic consequence is 6.

Current Level of Risk	6 - Manageable

Risk Decision

A risk level of 6 is classified as Manageable: Treatment action possibly required to achieve a risk as low as reasonably practical (ALARP) - conduct cost/benefit analysis. Relevant manager to consider for appropriate action.

Risk Decision	Accept, conduct cost benefit analysis

Proposed Treatments Given the current treatments and there being only four recorded occurrences of an aircraft colliding with a wind turbine since 2000 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. However, the following treatment which can be implemented at little cost will provide an additional margin of safety: • 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. • Arrangements should be made to publish details of the wind farm in ERSA for surrounding aerodromes, such as Canberra Airport, Goulburn Airport and Crookwell Aerodrome.
Residual Risk 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. 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 Crookwell 2 Wind Farm. However, the wind farm developer may consider other factors in its decision as to whether obstacle lighting should be installed.

Residual Risk	6 - Manageable

Risk ID:	2. Aircraft collision with a wind monitoring tower

Discussion

An aircraft collision with a wind monitoring tower would result in harm to people and damage to property.

CR4 is 60 m AGL on a base elevation of 911 m AHD (overall tower height of 971 m AHD). No markings exist on the tower.

CR5 is 80 m AGL on a base elevation of 873 m AHD (overall tower height of 953 m AHD). No markings exist on the tower.

Both towers' locations and other applicable have been advised to RAAF AIS.

It is anticipated that up to three wind monitoring towers at wind turbines hub heights of up to 95 m will be installed.

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.

There is a relatively low rate of aircraft activity in the vicinity of the wind farm.

There are no known aerial agriculture operations conducted at night in the vicinity of the wind farm.

For objects at a height of 110 m AGL or more and outside the OLS of an aerodrome, CASA must be notified. Obstacle lighting may be required unless CASA, in an aeronautical study, assesses it as being shielded by another lit object or that it is of no obstacle significance.

Consequence

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.

Consequence	Catastrophic

Untreated Likelihood

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.

Untreated Likelihood	Rare

Current Treatments (without lighting)

- The wind monitoring towers at the Project site are 60 m and 80 m high, and do not require lighting. Their locations and other applicable details have been advised to RAAF AIS.
- It is anticipated that up to three wind monitoring towers at wind turbines hub heights of up to 95 m AGL will be installed, which are higher than the existing towers.
- 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 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 after construction may be

at a maximum height of 95 m AGL (312 ft), so there will be at least 57.4 m (188 ft) vertical separation from an aircraft flying at this height.

- In the event that descending cloud forces an aircraft lower than 152.4 m AGL (500 ft), 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 the tower.
- 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) (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.

Level of Risk

The level of risk associated with a Rare likelihood of a Catastrophic consequence is 6.

Current Level of Risk	6 - Manageable

Risk Decision

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.

Risk Decision	Accept, conduct cost benefit analysis

Proposed Treatments

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:

- Details of the future wind monitoring towers when they are constructed should be advised to RAAF AIS.
- 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 (as modified by the guidance in NASF Guideline D); 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 30 m apart.
- Details of the wind farm wind monitoring towers should be communicated to local and regional aircraft operators and arrangements should be made to publish details in ERSA for surrounding aerodromes 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 Crookwell 2 Wind Farm.	
Residual Risk	6 - Manageable

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

Discussion

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.

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

There is a relatively low rate of aircraft activity in the vicinity of the wind farm.

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 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.

Untreated Likelihood	Rare

Current Treatments (without lighting)

- Aircraft are restricted to a minimum height of 152.4 m AGL (500 ft) 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 160 m (524.9 ft) at the top of the blade tip, so the rotor blade at its maximum height will be 7.6 m (24.9 ft) above aircraft flying at the minimum altitude of 152.4 m AGL (500 ft).
- 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 wind turbines.
- If cloud descends below the turbine hub (in this case 110 m (361 ft) for the highest proposed turbine model), 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 AGL (500 ft) (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 typically 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 160 m (524.9 ft) high at the blade tip. This is 50 m (164.0 ft) higher than the height below which there would be no statutory requirement to report the turbines to CASA in any case.

Level of Risk The level of risk associated with a Rare likelihood of a Catastrophic consequence is 6.	
Current Level of Risk	6 - Manageable
Risk Decision 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.	
Risk Decision	Accept, conduct cost benefit analysis
Proposed Treatments Given the current treatments and there has been one recorded example of a CFIT accident arising from harsh manoeuvring to avoid a wind turbine since 2000 (none in Australia), 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. However, the following treatment which can be implemented at little cost will provide an additional margin of safety: • 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. • Arrangements should be made to publish details of the wind farm in ERSA for surrounding aerodromes, such as Canberra Airport, Goulburn Airport and Crookwell Aerodrome.	
Residual Risk 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. 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 the Project. However, the proponent may consider other factors in its decision as to whether obstacle lighting should be installed.	
Residual Risk	6 - Manageable

Risk ID:	4. Effect on crew of limitations imposed by the wind farm

Discussion

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

There are no known aerial agriculture operations conducted at night in the vicinity of the wind farm.

There is a relatively low rate of aircraft activity in the vicinity of the wind farm.

Consequence

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.

Consequence	Minor

Untreated Likelihood

The likelihood of the imposition of operational limitations is Possible – might occur at some time in the future.

Untreated Likelihood	Possible

Current Treatments (without lighting)

- Aircraft are restricted to a minimum height of 152.4 m AGL (500 ft) 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 160 m (524.9 ft) at the top of the blade tip, so the rotor blade at its maximum height will be 7.6 m (24.3 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 wind turbines.
- 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 wind turbines.
- If cloud descends below the turbine hub (in this case 110 m (361 ft) for the highest proposed turbine model), 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 AGL (500 ft) (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 typically 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 160 m (524.9 ft) high at the blade tip. This is 50 m (164.0 ft) higher than the height below which there would be no statutory requirement to report the turbines to CASA in any case.	
Level of Risk The level of risk associated with a Possible likelihood of a Minor consequence is 5.	
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 Given the current treatments and the limited scale and scope of flying operations conducted within the vicinity of the Project, there is likely to be little additional safety benefit to be gained by installing obstacle lighting. However, the following treatment which can be implemented at little cost will provide an additional margin of safety: • 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. • Arrangements should be made to publish details of the wind farm in ERSA for surrounding aerodromes, such as Canberra Airport, Goulburn Airport and Crookwell Aerodrome.	
Residual Risk 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. 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 the Project. However, the proponent may consider other factors in its decision as to whether obstacle lighting should be installed.	
Residual Risk	5 - Manageable

Risk ID:	5. Effect of obstacle lighting on surrounding residents

Discussion

Installation and operation of obstacle lighting on wind turbines can have an effect on neighbours' visual amenity and enjoyment.

As the wind turbines are proposed to be higher than 150 m AGL (492 ft), albeit the wind farm is not located within the vicinity of an aerodrome, the turbines must be regarded as obstacles unless CASA assess otherwise. In general, objects outside an OLS and above 110 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 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 Likely - the event will probably occur in most circumstances (has occurred infrequently).

Untreated Likelihood	Likely

Current Treatments

As wind turbines are proposed to be higher than 150 m AGL (492 ft), albeit the wind farm is not located within the vicinity of an aerodrome, the turbines must be regarded as obstacles unless CASA assess otherwise. In general, objects outside an OLS and above 110 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.

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

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
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
Proposed Treatments Not installing obstacle lighting would completely remove the source of the visual impact on neighbours. If lighting is required, there are 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

7.8. Summary of risks

A summary of the level of risk associated with the approved Crookwell 2 Wind Farm, under the proposed treatment regime, is provided in Table 7.

Table 7 Summary of Risks

Risk Element	*Consequence*	*Likelihood*	*Risk*	*Actions Required*
Aircraft collision with a wind turbine	Catastrophic	Rare	6	Acceptable without obstacle lighting. Communicate details of wind farm to local and regional operators and make arrangements to publish details in ERSA for surrounding airports, before, during and following construction.
Aircraft collision with a 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 (as modified by the guidance in NASF Guideline D). Communicate details of wind monitoring towers to local and regional operators and make arrangements to publish details in ERSA for surrounding airports, following construction.
Harsh manoeuvring leads to CFIT	Catastrophic	Rare	6	Acceptable without obstacle lighting. Communicate details of wind farm to local and regional operators and make arrangements to publish details in ERSA for surrounding airports 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 and make arrangements to publish details in ERSA for surrounding airports 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 environmental impacts.

8. CONCLUSIONS

The following conclusions were made as a result of this assessment:

8.1. Consultation

An appropriate and justified level of consultation was undertaken with the following parties:

- Aerial Agricultural Association of Australia;
- Airservices Australia;
- Civil Aviation Safety Authority;
- Department of Defence;
- Fred Fahey Aerial Services;
- Goulburn Mulwaree Council;
- NSW Rural Fire Service;
- Royal Flying Doctor Service;
- Upper Lachlan Shire Council; and
- Yass Aerial service.

8.2. Aviation Impact Statement

The Aviation Impact Statement has made the following conclusions:

- In summary, the Aviation Impact Statement has determined that:

  6) *The blade tips of the highest obstacle in the wind farm project will be 1107m (3632ft) AHD and as such:*

     - Will not penetrate any OLS surfaces;
     - Will not penetrate any PAN-OPS surfaces;
     - Will not have an impact on nearby designated air routes.
     - Will not have an impact on prescribed airspace;
     - Is wholly contained within Class G airspace; and
     - Will not have an impact on existing local aviation activities.

  7) *The wind farm obstacles are located outside the clearance zones associated with aviation navigation aids and communication facilities.*

  8) *A preliminary assessment on the impact of the wind farm on ATC radar surveillance facilities has been made. There will be an impact on the RSR at Mt Bobbara. The PSR (primary surveillance*

radar) and SSR (Secondary surveillance radar) facility at Mt Majura may be affected. ***Further liaison with Airservices Australia will be required to refine the impact analysis and if required, coordinate impact mitigation measures.***

9) *The wind farm is sufficiently distant from airfields to not have an impact on contingency procedures and engine inoperative flight paths.*

10) *Subject to resolution of PSR impact issues, the wind farm obstacles have been assessed as not having an impact on prescribed airspace. The development is therefore considered approvable in accordance with the relevant civil aviation regulations. This Aviation Impact Statement can be used as supporting documentation for an application to CASA.*

Airservices Australia was consulted with respect to the aviation impacts of the Project, which, in an email dated 14 December 2015, provided the following advice:

> *I refer to your request for Airservices assessment of the Crookwell 2 Wind Farm which is proposed for the NSW Southern Highlands.*
>
> *Airspace Procedures*
>
> *With respect to procedures designed by Airservices in accordance with ICAO PANS-OPS and Document 9905, at a height of 1107m (3632ft) AHD the Crookwell 2 wind farm will not affect any sector or circling altitude, nor any instrument approach or departure procedure at Goulburn aerodrome.*
>
> *Note: procedures not designed by Airservices at Goulburn aerodrome were not considered in this assessment.*
>
> *CNS Facilities*
>
> *This proposal for a wind farm as detailed in the AIS will not adversely impact the performance of any Airservices Precision/Non-Precision Nav Aids, Anemometers, HF/VHF/UHF Comms, A-SMGCS, Radar, PRM, ADS-B, WAM or Satellite/Links.*

8.3. Aircraft Operator Characteristics

- Based on input during consultation activities, the Project will result in a reduced net impact on aerial agricultural operations. Moreover, the impacts may be further alleviated by an effective and functional working relationship between the Proponent and aerial agricultural operators that are likely to operate in the vicinity of the Project.
- There is no significance in the impact of the Project on NSW Rural Fire Service (RFS) aerial firefighting operations. It would be beneficial to develop procedures to stop turbines blades from rotating before RFS begins aerial firefighting operations within the Project area.
- No significant impact is anticipated with the Project on Royal Flying Doctors Service operations as long as the obstacles are properly referenced on navigation charts.

8.4. Hazard lighting and marking

- The wind turbines in the Project are proposed to be up to 160 m AGL. With respect to MOS 139 7.1.5.1, the proposed towers must be reported to CASA if they will be higher than 110 m AGL. With respect to MOS 139 7.1.5.2, the wind turbines must be regarded as an obstacles if they are higher than 150 m AGL, unless CASA assesses otherwise.
- With respect to MOS 139 9.4.1.2 (b), the wind turbines will need to be lit if they are higher than 110 m AGL, unless an aeronautical study assesses they are of no operational significance.
- Aviation Projects has assessed 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 the Project.
- If lighting is required, the lighting design herein is subject to confirmation of the final turbine layout as any changes proposed could potentially affect which turbines should be lit in accordance with the 900 m interval consideration.
- CASA recommends that the wind farm is lit with steady red low intensity lighting at night as per Section 9.4 of the CASA Manual of Standards Part 139. Characteristics for low intensity area stated in subsection 9.4.6. CASA agrees that the turbines that should be lit are identified in the drawing '100405 Crookwell 2 Wind Farm Obstacle Lighting Design v0.1, (10 August 2015)'.
- A summary of design characteristics for obstacle lighting acceptable by CASA, if required, is provided below:
    - two steady red low intensity obstacle lights should be provided;
    - the light fixtures should be mounted sufficiently above the surface of the nacelle so that the lights are not obscured by the rotor hub, and at a horizontal separation to ensure an unobstructed view of at least one of the lights by a pilot approaching from any direction; and
    - the characteristics of the obstacle lights should be in accordance with the applicable standards in MOS 139.
- To ensure the ongoing availability of obstacle lights (if required), a monitoring, reporting and maintenance program will need to be established in accordance with the guidance in MOS 139 Section 9.4.10.
- With respect to marking of turbines, it is generally accepted that, as an alternative to white, an off-white or light grey colour will provide sufficient contrast with the surrounding environment to maintain an acceptable level of safety while lowering visual impact to the neighbouring residents.
- With respect to marking of wind monitoring towers, they will be lower than, and are likely to be within 400 m of, a turbine and are therefore not likely to require obstacle marking or lighting.
- Department of Defence was consulted with respect to the potential impacts of the Project on its aviation operations, which, in a letter dated 24 November 2015, advised it has no concerns with the Project subject to the following requests being met:
    - Provide Airservices Australia with "as constructed" details, by emailing the details to vod@airservicesaustralia.com;

- The wind turbines should be lit in accordance with the requirements of MOS 139; and
- If LED obstruction lighting is to be provided to the wind turbines, ensure the frequency range of the LED light emitted fall within the range of wavelengths 655 to 930 nanometres, thus being visible to persons using night vision devices.

8.5. Risk assessment

A summary of risks associated with the proposed Project, under the proposed treatment regime, is provided in Table 8.

Table 8 Risk summary

Risk Element	*Consequence*	*Likelihood*	*Risk*	*Actions Required*
Aircraft collision with a wind turbine	Catastrophic	Rare	6	Acceptable without obstacle lighting. Communicate details of wind farm to local and regional operators and make arrangements to publish details in ERSA for surrounding airports, before, during and following construction.
Aircraft collision with a 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 and make arrangements to publish details in ERSA for surrounding airports, following construction.
Harsh manoeuvring leads to CFIT	Catastrophic	Rare	6	Acceptable without obstacle lighting. Communicate details of wind farm to local and regional operators and make arrangements to publish details in ERSA for surrounding airports 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 and make arrangements to publish details in ERSA for surrounding airports 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 environmental impacts.

9. RECOMMENDATIONS

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

Notification and reporting

1. 'As constructed' details of wind turbine and wind monitoring tower coordinates and elevations should be provided to RAAF AIS, by emailing the details to vod@airservicesaustralia.com.
2. Any obstacles above 110 m AGL (including temporary construction equipment) should be reported to Airservices Australia NOTAM office until they are incorporated in published operational documents. With respect to crane operations during the construction of the Project, a notification to the NOTAM office may include, for example, the following details:
    - The planned operational timeframe and maximum height of the crane; and
    - Either the general area within which the crane will operate and/or the planned route with timelines that crane operations will follow.

Operating procedures

3. The Proponent should engage with local aerial agricultural operators and aerial firefighting operators in developing procedures for such aircraft operations in the vicinity of the Project. Procedures may include stopping the rotation of the wind turbine rotor blades prior to the commencement of the aircraft operations within relevant areas.
4. The Proponent should consult with the NSW Rural Fire Service when developing fire management procedures, making due consideration of the use of aerial firefighting techniques within the wind farm project area.

Marking of turbines

5. The rotor blades, nacelle and the supporting mast of the wind turbines should be painted white, off-white or a light grey colour.

Lighting of turbines

6. If obstacle lighting is required (for example, as a requirement of CASA), obstacle lighting should be installed on the following 24 turbines (without the 'F' as the identification prefix): 1, 4, 5, 9, 10, 11, 12, 17, 19, 21, 23, 24, 26, 27, 29, 31, 36, 37, 40, 43, 45, 47, 48 and 50.
7. If obstacle lighting is required (for example, as a requirement of CASA), the wind turbines should be lit with steady red low intensity lighting at night as per MOS 139 Section 9.4, while minimising visual impact. To ensure the ongoing availability of obstacle lights (if required), a monitoring, reporting and maintenance program should be established in accordance with the guidance in MOS 139 Section 9.4.10.
8. Department of Defence requested that if LED lighting is used for obstacle lighting, then emitted light should fall within the wavelength range of 655 to 930 nanometres for night vision devices compatibility.
9. The Proponent may consider other factors in its decision as to whether obstacle lights should be installed.

Marking of wind monitoring towers

10. Consideration should be given to marking the wind monitoring towers according to the requirements set out in MOS 139 Section 8.10 (as modified by the guidance in NASF Guideline D).

Triggers for review

11. 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.

ANNEXURES

1. Turbine Coordinates and ground elevations
2. Aviation Impact Statement
3. Obstacle Lighting Design

ANNEXURE 1 – TURBINE COORDINATES AND GROUND ELEVATIONS

Crookwell 2 Wind Farm approved turbine coordinates (AGD66 converted to GDA 94 (Zone 55).

Turbine ID	UTM-X AGD66	UTM-Y AGD66	UTM-X GDA94	UTM-Y GDA94	Elevation (m ASL)	Site
F1	732987	6175425	733099	6175609	947	CW2
F2	732809	6175086	732921	6175270	911	CW2
F3	732672	6174845	732784	6175029	900	CW2
F4	732678	6174574	732790	6174758	888	CW2
F5	733442	6174650	733554	6174834	882	CW2
F7	733356	6174275	733468	6174459	871	CW2
F9	733018	6173935	733130	6174119	872	CW2
F10	734738	6176911	734850	6177095	912	CW2
F11	735210	6176495	735322	6176679	892	CW2
F12	735271	6175745	735383	6175929	895	CW2
F17	735826	6173730	735938	6173914	866	CW2
F19	735590	6174358	735702	6174542	892	CW2
F21	735675	6174968	735787	6175152	870	CW2
F22	735895	6175232	736007	6175416	879	CW2
F23	735948	6175561	736060	6175745	866	CW2
F24	737351	6175540	737463	6175724	893	CW2
F26	737161	6175004	737273	6175188	882	CW2
F27	737528	6174771	737640	6174955	871	CW2
F28	737456	6174511	737568	6174695	866	CW2
F29	737083	6174396	737195	6174580	861	CW2
F30	737373	6174140	737485	6174324	867	CW2
F31	737397	6173851	737509	6174035	857	CW2
F32	737735	6173398	737847	6173582	864	CW2
F35	737938	6173798	738050	6173982	871	CW2
F36	738227	6174488	738339	6174672	888	CW2

Turbine ID	UTM-X AGD66	UTM-Y AGD66	UTM-X GDA94	UTM-Y GDA94	Elevation (m ASL)	Site
F37	738247	6174200	738359	6174384	895	CW2
F40	738432	6173736	738544	6173920	884	CW2
F41	738115	6173438	738227	6173622	874	CW2
F43	737790	6173043	737901	6173227	868	CW2
F45	738775	6172781	738887	6172965	872	CW2
F47	738269	6172499	738381	6172683	859	CW2
F48	739261	6172503	739373	6172687	886	CW2
F50	739115	6172176	739227	6172360	877	CW2

ANNEXURE 2 – AVIATION IMPACT STATEMENT

IDS Australasia, Aviation Impact Statement, Crookwell 2 Wind Farm, New South Wales, Australia (Final), dated 4 November 2015.

AVIATION IMPACT STATEMENT
CROOKWELL 2 WIND FARM
NEW SOUTH WALES, AUSTRALIA

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KEYWORDS CROOKWELL 2, WIND FARM, AIS

SUMMARY This document contains the Aviation Impact Statement (AIS) considerations as detailed by Airservices Australia in relation to the Crookwell 2 Wind Farm, New South Wales, Australia.

CLASSIFICATION **COMMERCIAL IN CONFIDENCE**

PRODUCED BY IDS Australasia (IDSAU) Flight Procedure Design Organisation (FPDO)

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PREPARED FOR Aviation Projects Pty Ltd

DATE 4 November 2015

FINAL REPORT

Document Evolution		
Revision	Date	Reason of change
V1	04/08/2015	New Report
V1.1	17/09/2015	Amendment as per client request
V2	04/11/2015	Release of Final Report

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Notes

All elevations are with reference to the Australian Height Datum unless specified otherwise.

All positions are WGS84 coordinates unless specified otherwise.

1. Acronyms & Abbreviations

Acronym / Abbreviation	Description
AGL	Above Ground Level
AHD	Australian Height Datum
AIP	Aeronautical Information Publication
AIS	Aviation Impact Statement
AMSL	Above Mean Sea Level
ATC	Air Traffic Control
CASA	Civil Aviation Safety Authority (Australia)
ERC	Enroute Chart
ERSA	Enroute Supplement Australia
FIA	Flight Information Area
FIS	Flight Information Service
FPDAM	Flight Procedure Design & Airspace Management (software package)
GNSS	Global Navigation Satellite System
IAP	Instrument Approach Procedure
IFR	Instrument Flight Rules
LSALT	Lowest Safe Altitude
MOS	Manual of Standards
MSA	Minimum Sector Altitude
NDB	Non-directional Beacon
NOTAM	Notice to Airmen
OLS	Obstacle Limitation Surface
PANSOPS	Procedures for Air Navigation Services – Aircraft Operations
PSR	Primary Surveillance Radar
SSR	Secondary Surveillance Radar
VFR	Visual Flight Rules
WGS84	World Geodetic System 1984
WTG	Wind Turbine Generator

2. Executive Summary

IDS Australasia Pty Ltd has been engaged by Aviation Projects Pty Ltd to undertake an Aviation Impact Statement (AIS) for the proposed amendments to the approved Crookwell 2 Wind Farm (hereafter referred to as the "wind farm") located in southern New South Wales approximately 30km North West of Goulburn.

Crookwell Development Pty Ltd as the proponent for the wind farm, has an approval for the construction and operation of up to 46 horizontal axis wind turbine generators (WTGs) with an overall blade tip height of 128.0 m above ground level. Crookwell Development Pty Ltd is now proposing to reduce the turbine numbers to up to 33 WTGs and increase the maximum blade tip height to up to 160 M AGL (hereafter referred to collectively as 'obstacles').

This evaluation of the potential aviation impact has been undertaken with reference to applicable industry guidelines and relevant civil aviation safety regulations.

One registered airport with instrument approach procedures is within 30 NM of the wind farm. This is Goulburn Airport which is approximately 15.25 NM /28 km south east of the wind farm.

There is one uncertified/unregistered airfield located within 30 NM of the wind farm. Crookwell, which is located 4.5nm/8.5 km North West of the wind farm. This airfield does not have instrument procedures, and as such does not have any OLS (obstacle limitation surface) or PANS-OPS (Procedures for Air Navigation Services – Operations) surfaces. The airfield is sufficiently distant from the wind farm that take-off and landing operations are not affected. It is limited to day operations only and has no lighting facilities.

Other unregistered/uncertified private airstrips and landing grounds may be located within 30NM of the wind farm area, none of which have an OLS and are not noted in aeronautical charts or documents for the region. Pilots operating at such airstrips retain sole responsibility for ensuring that they are aware of the conditions on and surrounding these landing sites.

In summary, the Aviation Impact Statement has determined that:

1) The blade tips of the highest obstacle in the wind farm project will be 1107m (3632ft) AHD and as such:
    - Will not penetrate any OLS surfaces;
    - Will not penetrate any PAN-OPS surfaces;
    - Will not have an impact on nearby designated air routes.
    - Will not have an impact on prescribed airspace;
    - Is wholly contained within Class G airspace; and
    - Will not have an impact on existing local aviation activities.
2) The wind farm obstacles are located outside the clearance zones associated with aviation navigation aids and communication facilities.

3) A preliminary assessment on the impact of the wind farm on ATC radar surveillance facilities has been made. There will be an impact on the RSR at Mt Bobbara. The PSR (primary surveillance radar) and SSR (Secondary surveillance radar) facility at Mt Majura may be affected. **Further liaison with Airservices Australia will be required to refine the impact analysis and if required, coordinate impact mitigation measures.**

4) The wind farm is sufficiently distant from airfields to not have an impact on contingency procedures and engine inoperative flight paths.

5) Subject to resolution of PSR impact issues, the wind farm obstacles have been assessed as not having an impact on prescribed airspace. The development is therefore considered approvable in accordance with the relevant civil aviation regulations. This Aviation Impact Statement can be used as supporting documentation for an application to CASA.

3. Overview, Methodology & Reference Criteria

Crookwell Development Pty Ltd is seeking to amend the development permit for its approved Crookwell 2 Wind Farm, located approximately 30 km North West of Goulburn. The Crookwell 2 wind farm has approval for up to 46 horizontal axis wind turbine generators (WTGs) with an overall blade tip height of 128 m above ground level (AGL). Crookwell Development is now proposing to reduce the turbine numbers to up to 33 (WTGs)and increase the maximum planned blade tip height to up to 160 m AGL. (APPENDIX A, 0) effective 22/05/2015 and all assessments are based on this data. The highest terrain on which a WTG is proposed to be located has a maximum elevation of 947m AHD (WTG F1). This WTG has a maximum height of 160.0m AGL and would therefore be 1107m (3632ft) AHD at the rotor tip.

One registered aerodrome with published instrument approach and landing procedures exist within 30nm (55.56km) of the site. The following table identifies the aerodromes and associated distances to the site.

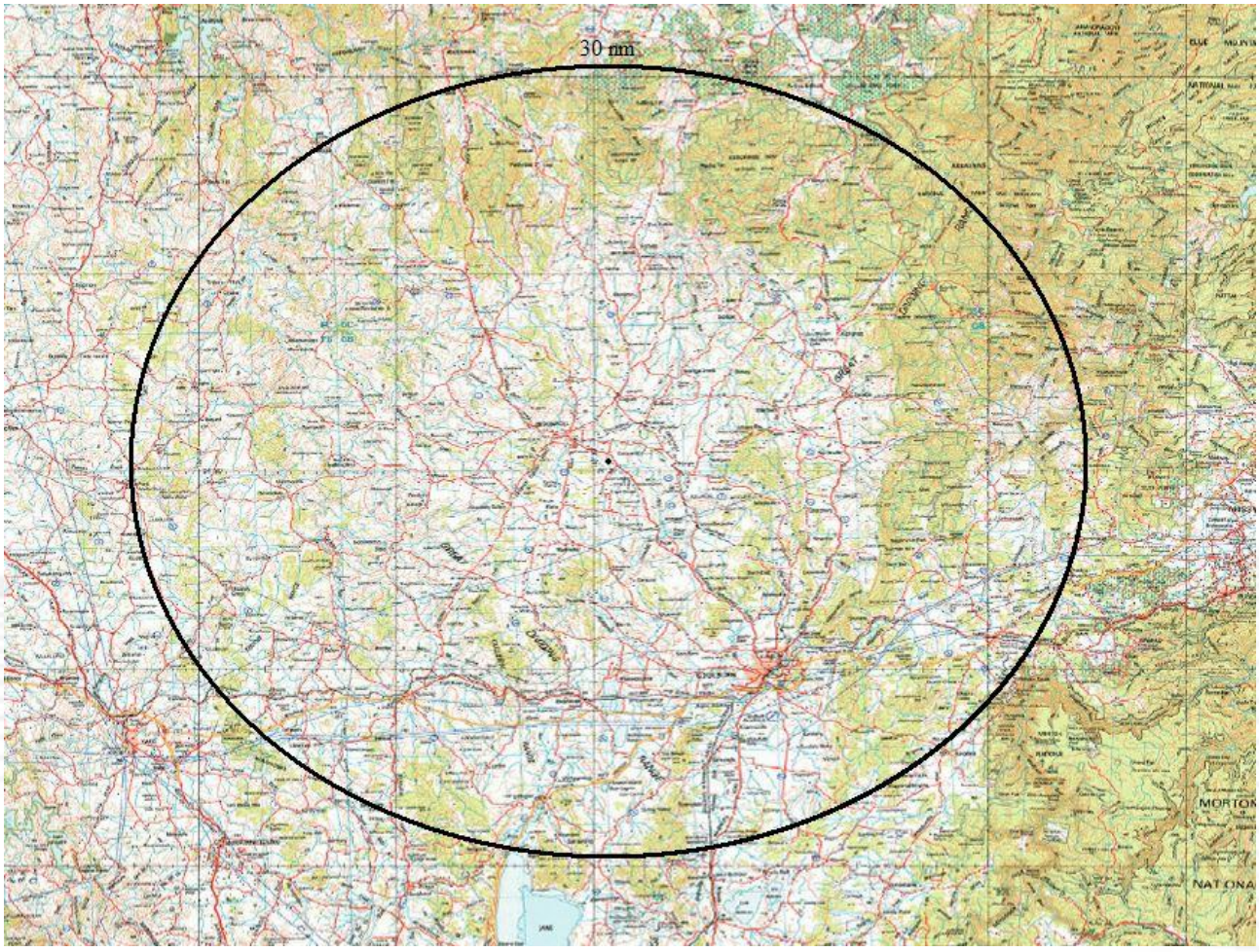

Figure 1 – Boundary of area considered for aviation impact statement (30 NM)

Aerodrome	Status	Distance to Closest WTG	IAPs Avail
Goulburn	Registered	15.95 NM (29.5 km)	Yes

Table 1: Aerodrome with published instrument procedures

The reference criteria on which impact assessments were made include the following:

- Civil Aviation Safety Regulations (CASR) 1988
    - Part 139 Manual of Standards (MOS) – Aerodromes, particularly:
        - Chapter 7: Obstacle Restriction and Limitation; and
        - Chapter 11: Standards for Other Aerodrome Facilities;
    - MOS Part 173 – Standards Applicable to Instrument Flight Procedure Design, particularly:
        - Section 1.1: General; and
        - Chapter 8: Design Standards;
- Civil Aviation Order 20.7.1B
- Civil Aviation Legislation Amendment (Part 175) 2014 (Effective 5 Mar 2015)
- ICAO Procedures for Air Navigation — Air Operations, Volume II - Construction of Visual and Instrument Flight Procedures, DOC 8168-OPS/611 Volume II
- ICAO Annex 14 Volume 1, Chapter 6 “Visual Aids for Denoting Obstacles”
- Airservices Australia publication “Airservices Aviation Assessments for Wind Farm Developments”
- EUROCONTROL Guidelines on how to Assess the Potential Impact of Wind Turbines on Surveillance Sensors

The methodology used in preparing the AIS has taken the following factors into consideration:

- Proximity of the proposed wind farm to controlled airspace (both terminal and enroute);
- Proximity of the proposed wind farm to PRD (prohibited, restricted and danger) classified airspace;
- Existing IFR (instrument flight rules) air routes were examined in relation to the proposed project development to determine the influence of any route lowest safe altitudes as published on various aeronautical charts and publications;
- Instrument approach procedures for aerodromes listed in Table 1 were examined in detail to determine whether the proposed wind farm obstacles would penetrate any PANSOPS surfaces. Any restriction on the instrument approach procedures would have to be examined by Airservices

Australia to determine if a change is possible to the procedures without imposing a restriction on aviation;

- Published instrument approach procedures only depict a "nominal" track, and not the airspace protection areas that exist around the nominal tracks for these procedures. Analysing the impact of the proposed wind farm on these procedures requires generating the three dimensional buffers (as defined by ICAO and CASA) around these tracks and assessing if any obstacles will penetrate the buffers. IDS certified procedure designers use the FPDAM (flight procedure design and airspace management) software tool to conduct these analyses.
- Annex 14 Obstacle Limitation Surfaces (OLS) were examined in detail to determine whether the proposed wind farm obstacles would penetrate any Annex 14 surfaces. Any restriction on the Annex 14 surfaces would have to be examined by the aerodrome operator and Airservices Australia to determine if a change is possible to the procedures without imposing a restriction on aviation;
- Civil Aviation Order 20.7.1B relates to the minimum requirements for clearance of obstacles by an aircraft that has suffered a failure of a critical engine during take-off. The contingency procedures analyse the minimum safe altitudes (and therefore relate to the maximum allowable obstacle height) required in such an event. The influence that the proposed project would have on contingency procedures was considered;
- A preliminary assessment of potential impacts on aviation navigation aids, communication facilities and ATC radar installations.

A summary was made of the findings and conclusion as to whether the proposal should be approved from an aeronautical impact and aviation safety aspect.

The obstacle marking and lighting requirements specified in CASA MOS139/ICAO Annex 14, Chapter 6 are not detailed as part of this report. The applicability of these requirements is contingent on subsequent determination by CASA as to whether or not the wind farm constitutes a "hazard to aviation".

4. Potential Impacts, Risk Analysis & Mitigation

4.1. Aircraft Operators

4.1.1. Airspace

In Australia, all airspace that is not promulgated as Class A, C, D, and E (or restricted) is Class G airspace.

Class G airspace is non-controlled airspace. Both VFR and IFR aircraft are permitted, and neither require ATC clearance to operate in class G airspace. Air Traffic Control directed separation is not provided, but IFR aircraft will receive information about other IFR aircraft operating in the vicinity.

The proposed wind farm is located in Class G airspace with an upper limit of 8500 feet. Above that level is Class C airspace.

There are no Danger/Restricted Areas in the vicinity of proposed wind farm site.

4.2. IFR (instrument flight rules) operations

4.2.1. Enroute Airways

Airways are used in IFR operations and consist of defined corridors that connect specific locations. Historically they allowed aircraft to easily navigate between successive ground-based navigational aids, but with the advent of more advanced navigation systems such as RNAV and GNSS/GPS, airways can be defined without being dependent on a ground based navigation facility. IFR airways have a published lowest safe altitude (LSALT) which guarantees a minimum clearance from ground obstacles.

Appendix C depicts IFR airways in close proximity to the proposed wind farm.

Table 2 (below) details the airways reviewed and the route lowest safe altitudes for each segment. The air routes were assessed with reference to Airservices Australia AIP enroute and terminal area charts effective 28th May 2015.

ROUTE NUMBER	Waypoint Names on Route	Published Route Lowest Safe
W817	YAS-KEDDY - BIK	4900/5700
W138	CB - GLB	4800
W423	CB – CULIN - BTH	4600/5600
Y59	CULIN – SY	N/A (High Level Route)

Table 2 - Route numbers, Waypoints & Published LSALT

5600ft is lowest of the LSALTs for the airways that overfly, or are in the vicinity of the proposed wind farm. A minimum obstacle clearance of 1000ft **below** the published LSALT must be maintained along each airway. The most critical, or "controlling" obstacle (WTG #1) is approximately 68 ft below the protection area surface which starts at an altitude of 4600 ft.

A "grid" LSALT is specified on IFR charts that provides a LSALT for operations away from defined airways. The grid LSALT in the vicinity of the proposed wind farm is 5700ft.

The wind farm obstacles do not infringe any grid LSALT or airway route segment protection areas. No other adjacent airway protection areas are penetrated by the proposed obstacles. High level routes are for aircraft at or above FL200 (20,000ft). The proposed amendment to the approved Crookwell 2 wind farm does not affect high level routes.

4.2.2. Instrument Procedures

The nearest airfield with PANSOPS surfaces is Goulburn aerodrome, located approximately 16 NM (29.5 km to the south east of the wind farm site. With the exception of minimum sector altitudes (MSA's), PANSOPS surfaces associated with instrument flight procedures at Canberra are assessed as requiring no further analysis due to their distance from the proposed site and containment within terminal class C airspace.

There are no PANSOPS surfaces for Goulburn or Canberra procedures penetrated by the obstacles located within the proposed Crookwell 2 wind farm. Minimum sector altitudes have been assessed and are unaffected by the proposed Crookwell 2 wind farm.

The following table details the published instrument flight procedures[1] assessed.

Aerodrome	Procedure Title	Detailed Assessment required	Rationale	Wind Farm Impact on Procedure
Goulburn	NDB-A	**NO**	Procedure is to the south of Goulburn aerodrome and is not impacted by the windfarm.	**Protection area not penetrated**
	RNAV-Z (GNSS) RWY 04	**NO**	The procedure and associated protection areas are not within proximity of the windfarm	**Protection area not penetrated**
	RNAV-Z (GNSS) RWY 22	**NO**	The procedure and protection areas not within proximity of wind farm	**Protection area not penetrated**
	GNSS ARRIVAL (Sector B)	**NO**	Wind farm below protection areas	**Protection area not penetrated**
	MSA	**NO**	Wind farm below protection areas	**Protection area not penetrated**
Canberra	All Procedures	NO	Procedures contained within Class C controlled airspace	**Protection area not penetrated**
	MSA	**NO**		**Protection area not penetrated**

Table 3 – Assessed procedures matrix

4.2.3. YSCB (Canberra)

Canberra airport is a certified aerodrome located 7 km to the east of Canberra city (ICAO CODE YSCB). It predominantly serves domestic, high capacity RPT (regular public transport) operations and the RAAF military No. 34 Squadron which conducts VIP transport operations from the airport.

The airport is equipped with two instrument approach capable runways. All runways have corresponding non-precision approaches, runway 35 is equipped with a precision ILS (instrument landing system).

4.2.4. 10 & 25 NM MSA (Minimum Sector Altitude)

The wind farm obstacles do not infringe any of the MSA protection areas as they are outside the buffer zones.

4.2.5. YGLB (Goulburn)

Goulburn airport is a registered airport located 7km south of Goulburn Township (ICAO CODE YGLB). It is presently not served by any RPT (regular public transport) operator. The airport is equipped with two runways, one of which has non-precision instrument approach capability.

4.2.6. 10 & 25 NM MSA (Minimum Sector Altitude)

The protection area associated with the YGLB 25 NM MSA was generated using FPDAM and its location assessed with reference to the wind farm obstacles. The MSA is divided into two sectors, with the sector to the west having a MSA of 4700ft overlaying the wind farm site. The sector to the east with a MSA of 4100ft and the 10 NM MSA of 4600ft do not overlay the wind farm site.

A minimum obstacle clearance of 1000ft below the published MSA must be maintained within each sector protection area. The most critical obstacle (WTG F1) is approximately 70 ft. below the protection area surface which starts at an altitude of 3700 ft.

The wind farm obstacles do not infringe any of the MSA protection areas.

4.2.7. NDB-A Procedure

The wind farm obstacles do not penetrate any of the protection areas for the NDB-A procedure as its procedure is to the south of Goulburn aerodrome.

4.2.8. RNAV-Z (GNSS) RWY04 Procedure

The wind farm obstacles do not penetrate any of the protection areas for the RNAV-Z (GNSS) RWY04 as the procedure is not in proximity to the wind farm.

4.2.9. GNSS Arrival (Sector B) Procedure

The protection area associated with the YGLB GNSS Arrival procedure was generated using FPDAM and the location was assessed with reference to the wind farm obstacles. It was determined that sector B of the GNSS arrival was in closest proximity to the wind farm. Although the procedure associated with this GNSS arrival overlays the wind farm, the wind farm obstacles do not penetrate any of the protection areas.

4.2.10. Engine Inoperative Flight Paths

The proposed Crookwell 2 wind farm project is considered to be sufficiently distant from nearby airfields to not have an impact on contingency procedures and engine inoperative flight paths.

5. Air Navigation Service Provider

Airservices Australia is the sole provider of civil air navigation services for Australia. They are responsible for the provision of aeronautical data, telecommunications, navigation services and aviation rescue and firefighting services. The impact of the wind farm on their relevant areas of responsibility are described below.

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6. Protection of air navigation facilities

6.1. Surveillance Radar

A radar facility is located at Mt Bobbara, positioned approximately 46.2 nm / 85.5 km west of the proposed project site. This is a Route Surveillance radar (RSR) and Airservices Australia advise that this is a SSR only facility.

Wind turbines can negatively impact on surveillance radars, particularly when in the line of sight of the radar facility and the turbine blades are rotating. Turbines can reflect radio frequency energy which may mask legitimate targets and as a result, display of false targets or generate "clutter".

CASA MOS 139 11.1.14.4 clearance requirements for radar sensor sites describe the required clearance area as follows: "No intrusion within 1 km of the radar into a height surface 5 m below the bottom of the antenna. No intrusion between the radar and the possible location of any desired targets, i.e. roughly speaking above 0.5 degrees elevation at any distance."

Some obstacles within the windfarm do penetrate the MOS139 protection area for either radar facility. Further assessment requirements specific to wind farms are mandated by Airservices Australia, with the methodology based on the document "EUROCONTROL Guidelines on how to assess the Potential Impact of Wind Turbines on Surveillance Sensors".

These guidelines adopt a model which categorises WTGs in a given zone depending on certain parameters. The zoning of a given WTG dictates the level of assessment required. The following figures detail the criteria that dictate the zoning of a given WTG.

Zone	Zone 1	Zone 2	Zone 3	Zone 4
Description	0 - 500 m	500 m - 15 km and in radar line of sight	Further than 15 km but within maximum instrumented range **and in** radar line of sight	Anywhere within maximum instrumented range but **not in** radar line of sight or outside the maximum instrumented range.
Assessment Requirements	**Safeguarding**	**Detailed assessment**	**Simple assessment**	**No assessment**

Figure 2 – PSR Recommended Ranges (Source: EUROCONTROL)

Zone	Zone 1	Zone 2	Zone 4
Description	0 - 500 m	500 m - 16 km but within maximum instrumented range **and in** radar line of sight	Further than 16 km **or not** in radar line of sight
Assessment Requirements	**Safeguarding**	**Detailed assessment**	**No assessment**

Figure 3 – SSR Recommended Ranges (Source: EUROCONTROL)

Radar line of sight analysis (LOS) was performed to ascertain the zoning of WTGs with respect to both the radar installations. This analysis was performed using Global Mapper v16 using the following parameters:

Facility	**Mt Bobbara RSR(SSR)**
Latitude (WGS84)	-34.6398
Longitude (WGS84)	148.589914
Antenna elevation (m AHD)	783.7
Receiver (Turbine) height AGL (m)	170.0+10 (10m added to compensate for DEM error bounds)
View Radius	100km
Earth Curvature Correction	Enabled
Atmospheric Correction Factor	1.333
DEM model	Geoscience Australia 1sec SRTM DEM

Facility	**Mt Majura PSR**
Latitude (WGS84)	-35.23760908
Longitude (WGS84)	149.1823342
Antenna elevation (m AHD)	901.705
Receiver (Turbine) height AGL (m)	170.0+10 (10m added to compensate for DEM error bounds)
View Radius	100km
Earth Curvature Correction	Enabled
Atmospheric Correction Factor	1.333
DEM model	Geoscience Australia 1sec SRTM DEM

NOTE: EUROCONTROL guidelines recommend safeguarding of the area for the radar far-field monitor (FFM). At time of writing, information regarding this sensor had not yet been received from Airservices Australia. The potential impact of the proposed wind farm on any FFM has not yet been established.

6.2. Mt Bobbara RSR (SSR) Facility

Mt. Bobbara is approximately 87 km from the wind farm and preliminary assessment indicates that LOS is present between the Mt Bobbara RSR (SSR) facility and some of the WTGs. EUROCONTROL guidelines advise that further assessment is required if LOS is present between the radar facility and WTG. Additionally the Mt Bobbara facility is SSR only and further than 16km from the wind farm. The WTGs in LOS to Mt Bobbara are F1, F2, F3, F4, F5, F7, F9, and F12. **Further liaison with Airservices Australia will be required to refine the impact analysis and if required, coordinate impact mitigation measures.**

6.3. Mt Majura PSR and SSR Facility

Mt Majura is approximately 81 KM from the closest WTG and Preliminary assessment indicates that LOS **is** present between the Mt Majura SSR facility and some of the WTGs. EUROCONTROL guidelines advise that WTGs further than 16km or not in LOS require no further assessment (SSR Zone 4). The wind farm is considered to have no impact on the Mt Majura SSR facility as the WTGs are all located beyond 16km from the facility. (Note: The LOS analysis depicted in APPENDIX C & D is at the PSR antenna elevation. There is no detectable difference between the LOS analyses for the SSR antenna which is 2.45m higher than the PSR antenna).

The actual number of WTGs with LOS may change subject to further detailed assessment. **Further liaison with Airservices Australia will be required to refine the impact analysis and if required, coordinate impact mitigation measures.**

6.4. Ground Based Navigation Aids

The potential impact on aviation navigation aids were assessed in accordance with CASR MOS Part 139. The wind farm site is located outside the clearance zones associated with the nearest aviation navigation aids.

The following table identifies aviation navigation aids and approximate distances to the boundary of the proposed project site.

Location	NAVAID Type	Range	Distance to Closest WTG	MOS 139 Reference
Goulburn	NDB (GLB)	40 NM	16.0 NM (29.6km)	11.1.13
Canberra	VOR (CB)	60 NM	47.4 NM (88.7km)	11.1.6
Canberra	DME (CB)	60 NM	47.4 NM (88.7km)	11.1.7.6
Canberra	NDB (CB)	40 NM	47.8 NM (89 km)	11.1.13
Canberra	ILS RWY 35 (ICB)	20 NM	46.8 NM (86.6 km)	11.1.8

Table 4 – Aviation Navigation Aids

6.5. Communication Facilities

The potential impact on communication facilities was assessed in accordance with CASR MOS Part 139 11.1.15.2. There will be no impact as the wind farm will not affect the line of sight path between aircraft and ground based communication facilities.

7. Aerodrome Operators

7.1. Annex 14 OLS (obstacle limitation surfaces)

Annex 14 OLS defines the airspace around aerodromes to be maintained free from obstacles so as to permit the intended aeroplane operations at the aerodromes to be conducted safely and to prevent the aerodromes from becoming unusable by the growth of obstacles around the aerodromes. This is achieved by establishing a series of obstacle limitation surfaces that define the limits to which objects may project into the airspace.

Annex 14 surfaces are applicable to aerodromes where instrument approach procedures are conducted.

The proposed site is located beyond the distance from both YSCB (Canberra) and YGLB (Goulburn) where Annex 14 surfaces apply. As the surfaces are not penetrated by the proposed WTGs no further analysis is required.

8. Conclusion

The assessments and reviews contained in this Aviation Impact Statement were conducted in accordance with the relevant aviation and aeronautical regulations and standards. In summary, the Aviation Impact Statement has determined that:

1) The highest obstacle in the wind farm project will be 1107m (3632ft) AHD and as such:
    - Will not penetrate any OLS surfaces;
    - Will not penetrate any PAN-OPS surfaces;
    - Will not have an impact on nearby designated air routes.
    - Will not have an impact on prescribed airspace;
    - Is wholly contained within Class G airspace; and
    - Will not have an impact on existing local aviation activities.
2) The wind farm obstacles are located outside the clearance zones associated with aviation navigation aids and communication facilities.
3) A preliminary assessment on the impact of the wind farm on ATC radar surveillance facilities has been made. There should be no impact on the SSR (secondary surveillance radar) facilities at Mt Majura and Mt Bobbara. The PSR (primary surveillance radar) facility at Mt Majura may be affected. **Further liaison with Airservices Australia will be required to refine the impact analysis and if required, coordinate impact mitigation measures.**
4) The wind farm is sufficiently distant from airfields to not have an impact on contingency procedures and engine inoperative flight paths.

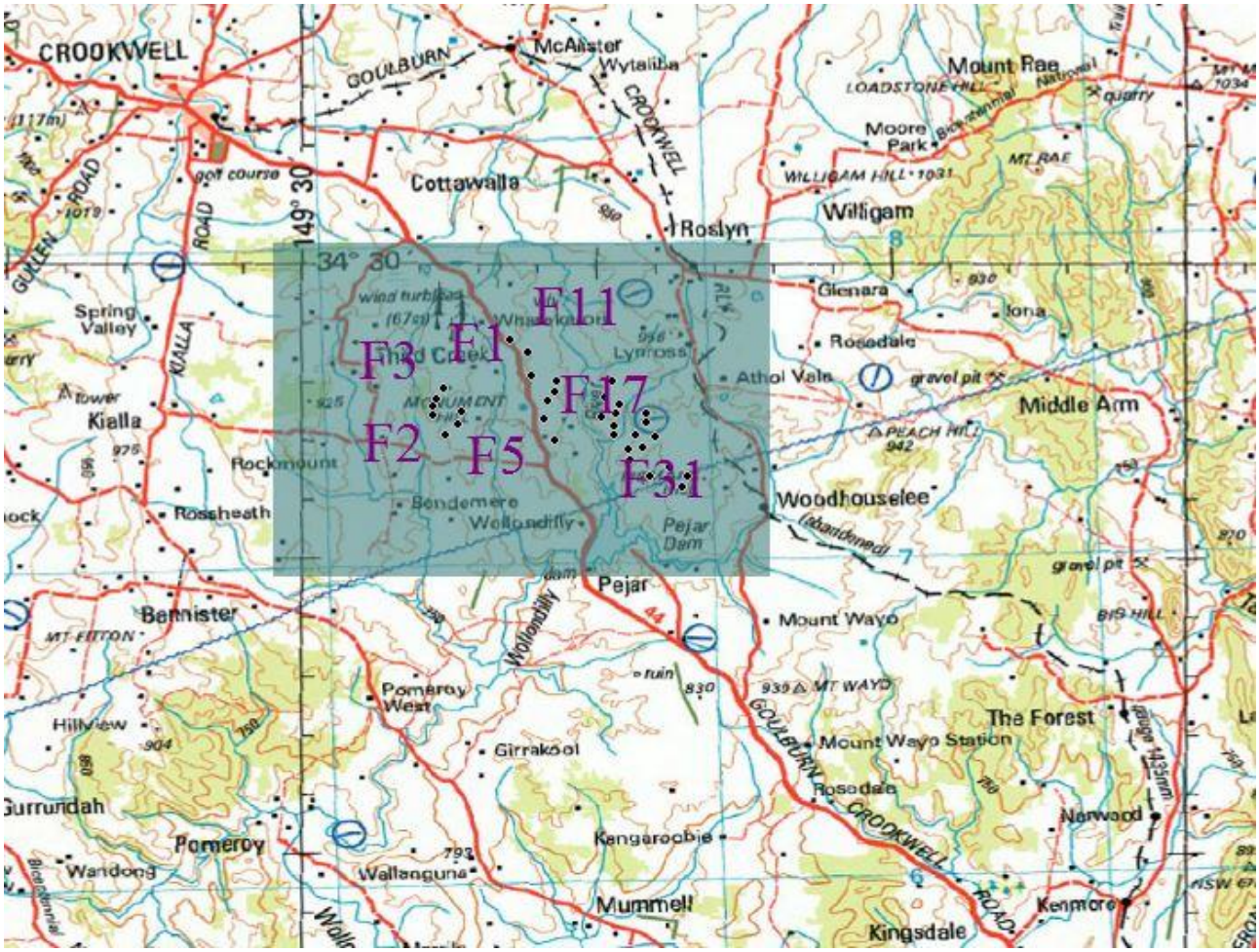
5) Subject to resolution of PSR impact issues, the proposed wind farm obstacles have been assessed as not having an impact on prescribed airspace. The development is therefore considered approvable in accordance with the relevant civil aviation regulations. This Aviation Impact Statement can be used as supporting documentation for an application to CASA.

APPENDIX A. Crookwell 2 Wind Farm – Proposed WTG Coordinates & Elevation

Turbine Model	Blade Length (m)	Rotor Diameter (m)	Hub Height (m)	Tip Height (m)
HYBRID	64	130	95	160

Name	Easting GDA94	Northing GDA55	Ground Elevation (m)
F1	733099	6175609	947
F2	732921	6175270	911
F3	732784	6165029	900
F4	723790	6174758	888
F5	733554	6174834	882
F7	733468	6174459	871
F9	733130	6174119	872
F10	734850	6177095	912
F11	735322	6176679	892
F12	733468	6174459	871
F17	735938	6173914	866
F19	735702	6174592	892
F21	735787	6175152	870
F23	736060	6175745	866
F24	737463	6175724	893
F26	737273	6175188	882
F27	737640	6174955	871
F28	737568	6174695	866
F29	737195	6174580	861
F30	737485	6174324	867
F31	737509	6174035	857
F32	737847	6173582	864
F35	738050	6173982	871
F36	738339	6174672	888
F37	738359	6174384	895
F40	738544	6173920	884
F41	738227	6173622	874
F43	737901	6173227	868
F45	738887	6172965	872
F47	738381	6172683	859
F48	739373	6172687	886
F50	739227	6172360	877

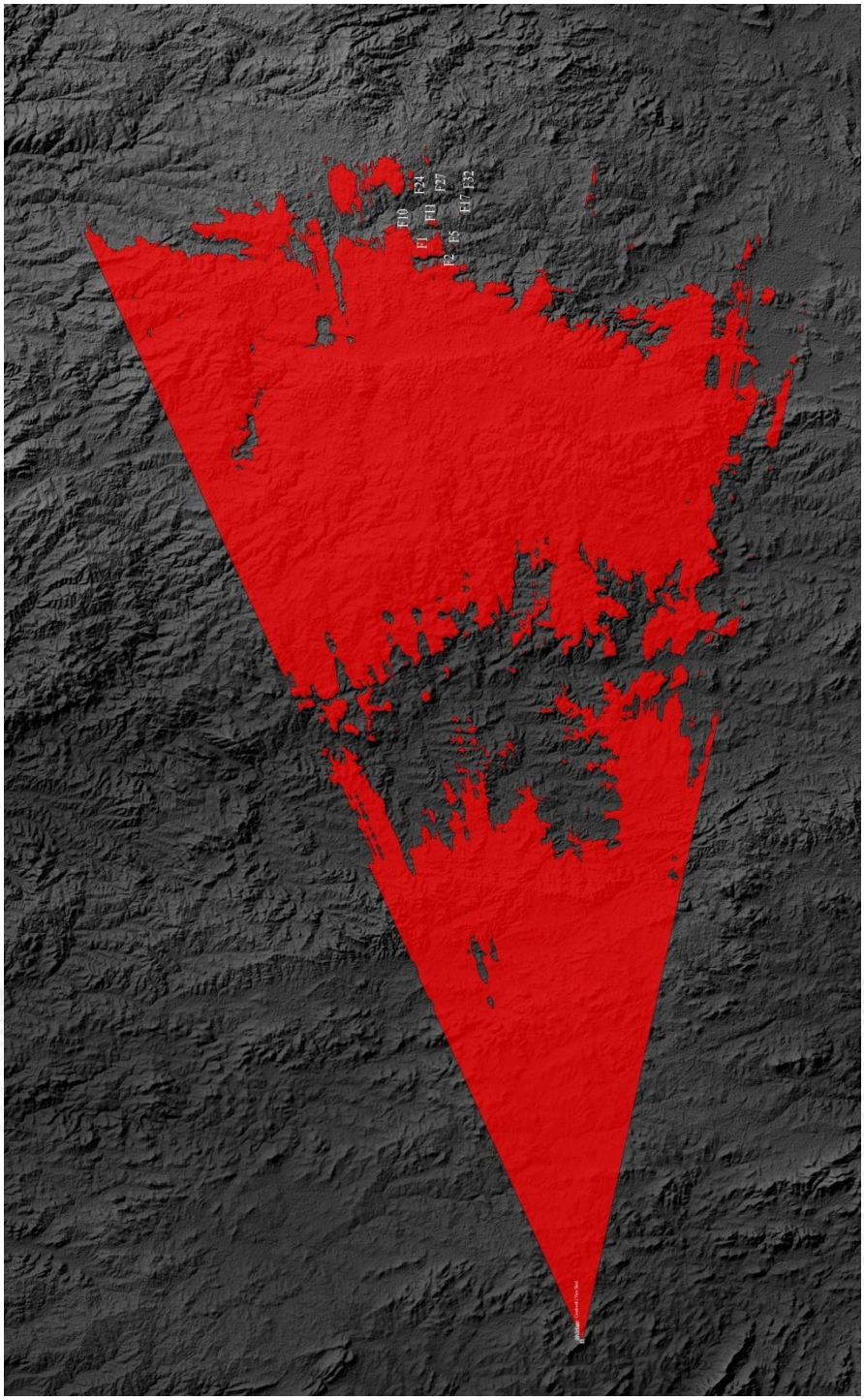
APPENDIX B - Site Map



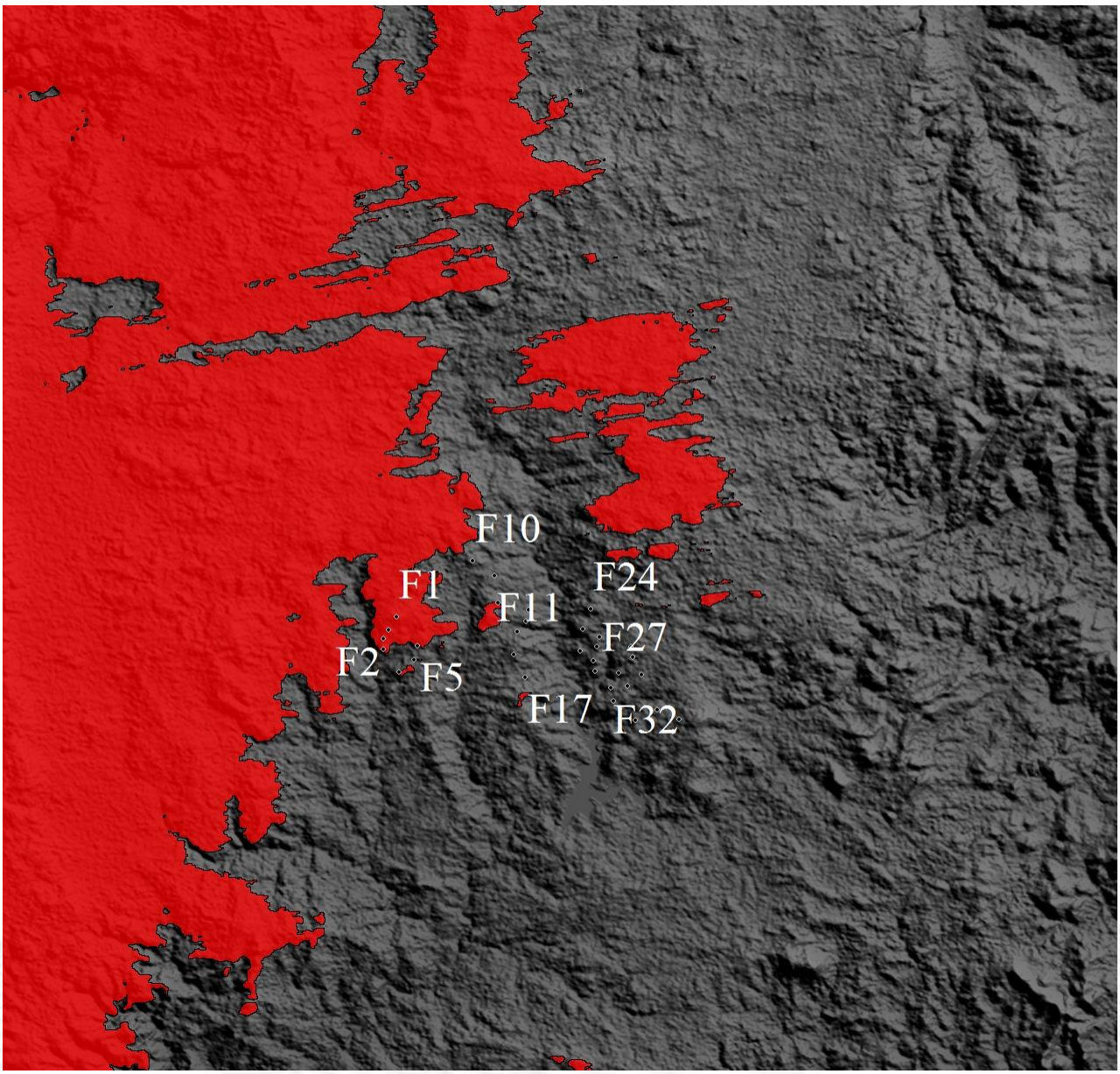
APPENDIX C - IFR airways in the proximity of the proposed wind farm

APPENDIX D - Analysis – Mt Bobbara route surveillance radar line of sight

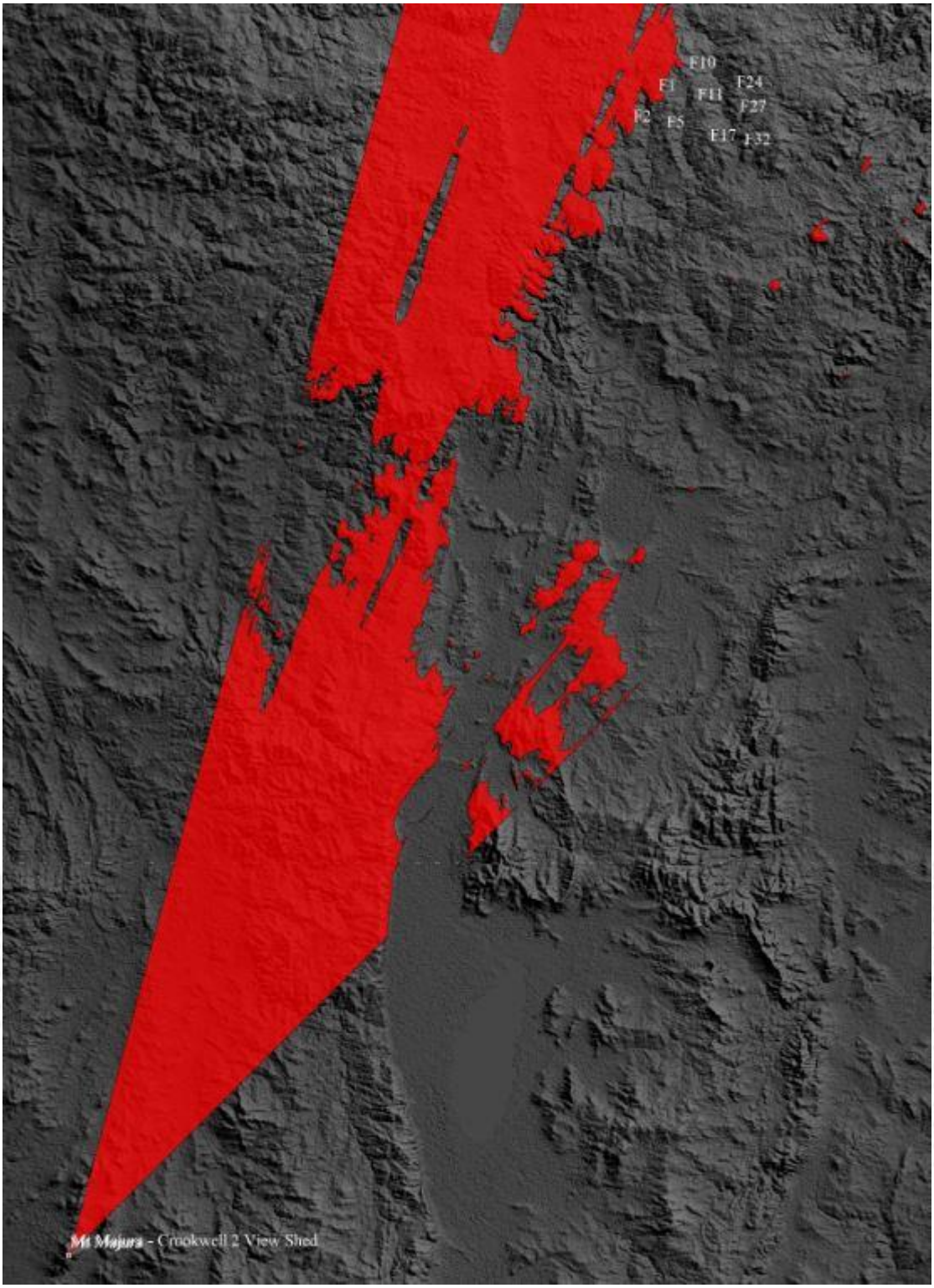
Note: Red shaded areas denote where radar line of sight exists.



APPENDIX E - Analysis – Mt Bobbara LOS Detail



APPENDIX F - Analysis - Mt Majura primary surveillance radar line-of-sight



APPENDIX G - Analysis - Mt Majura PSR and SSR line-of-sight detail

NOTE: Red shaded areas denote locations where radar line of sight exists at WTG max elevation (168.5m AGL)

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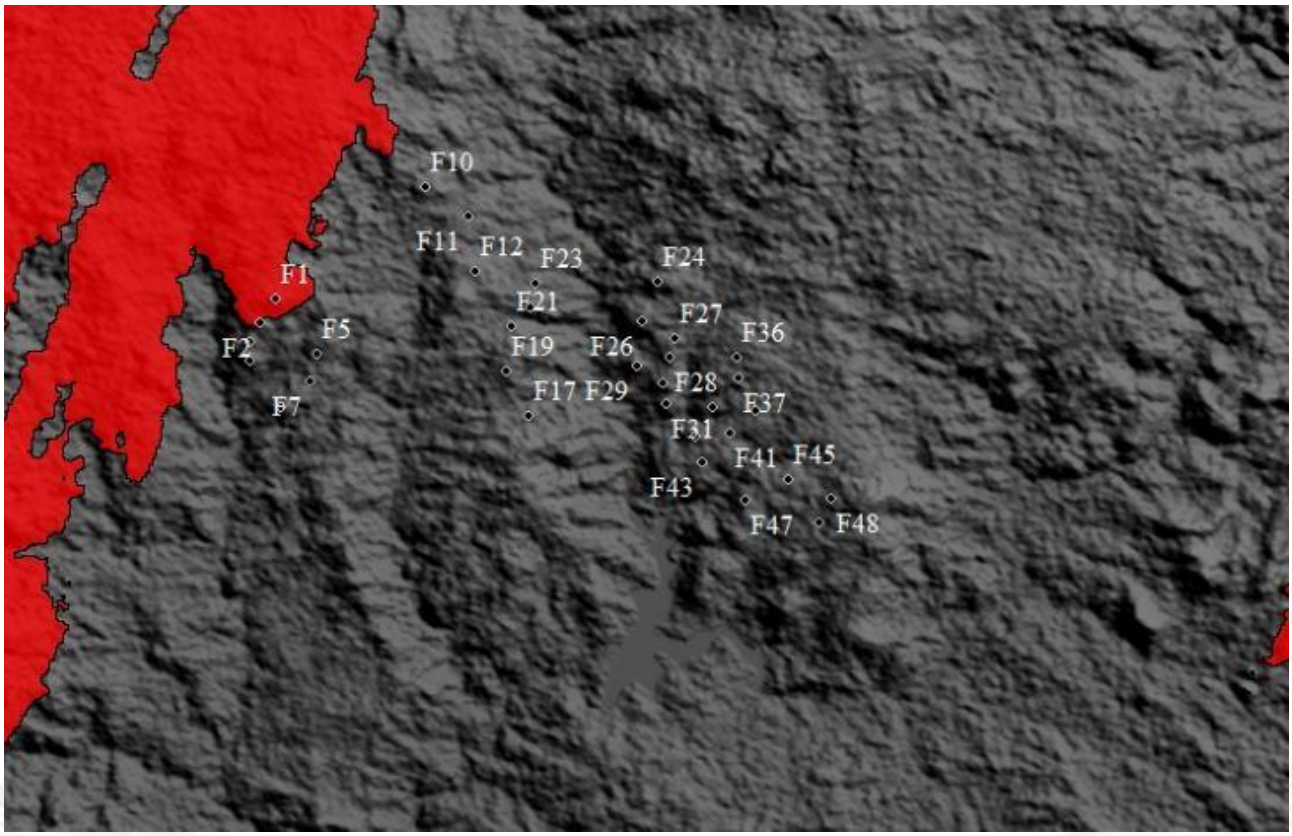


ANNEXURE 3 – OBSTACLE LIGHTING DESIGN

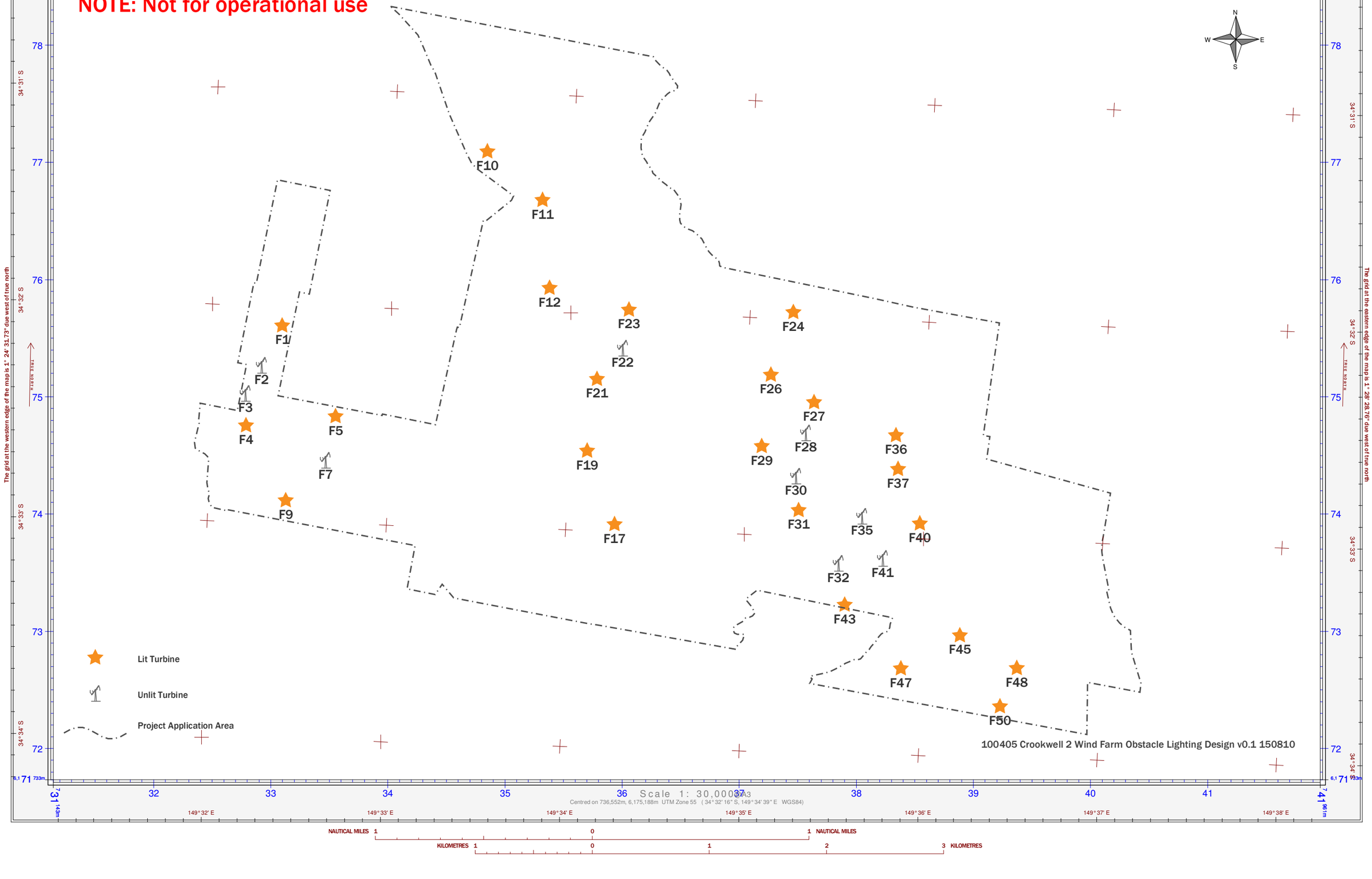
Aviation Projects, 100405-01 Crookwell 2 Wind Farm Obstacle Lighting Design v0.1, dated 10 August 2015.

AVIATION PROJECTS

10 August 2015

Crookwell 2 Wind Farm Obstacle Lighting Design

NOTE: Not for operational use



The grid at the western edge of the map is 1° 24' 31.73" due west of true north

The grid at the eastern edge of the map is 1° 28' 28.76" due west of true north

Scale 1: 30,000

Centred on 736,552m, 6,175,188m UTM Zone 55 (34° 32' 16" S, 149° 34' 39" E WGS84)

NAUTICAL MILES 1 0 1 NAUTICAL MILES

KILOMETRES 1 0 1 2 3 KILOMETRES

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