Environmental Impact Statement

Uungula Wind Farm

Appendix O: Aeronautical Impact Assessment (Landrum and Brown Worldwide (Aust) Pty Ltd, 2020)

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CWP Renewables Pty Ltd
(02) 4013 4640

P.O. Box 1708 Newcasltle NSW 2300
cwprenewables.com

Aeronautical Impact Assessment

Uungula Wind Farm
NSW

Client

LB00345

Final V1
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Draft v001	Draft Updated report for submission to Client	PW	28 November 2019
Draft v002	Updated Draft with new 97 WTG layout	PW	10 February 2020
Draft v003	Updated draft considering client feedback	PW	19 February 2020
Final V1	Final Report	PW	21 February 2020

Contents

1 Introduction

1.1 The Development

CWP Renewables Pty Ltd, on behalf of Uungula Wind Farm Pty Ltd, has tasked Landrum & Brown Worldwide (Australia) Pty Ltd to prepare an Aeronautical Impact Assessment (AIA) for the proposed Uungula Wind Farm development located approximately 14km east of Wellington in central western NSW, consisting of up to 97 Wind Turbine Generators (WTG) with a maximum height from ground level to the tip of a WTG blade of 250 m AGL.

The location of each WTG is indicative only and may change. Final layout may vary within the boundary.

WTG blade tip elevations will vary between 734.831 m (2411 ft) AHD and 971.112 m (3186 ft) AHD.

The nearest certified aerodromes to the boundary of the proposed wind farm are Mudgee airport, located approximately 34 kms east and Dubbo airport located approximately 60 kms north west.

Wellington aerodrome, which is not certified, is located approximately 13 km from the boundary of the proposed wind farm. Wellington aerodrome is also known locally as Bodangora aerodrome.

Gulgong Aero Park is located approximately 36 km north east of the wind farm boundary.

Figure 1 shows the location of the Uungula Wind Farm in relation to Wellington, Gulgong, Mudgee and Dubbo.

They are the only locations with known aerodromes within 30 nm of the wind farm boundary.

1.2 Managing the Risk to Aviation Safety of Wind Farms

In order to comply with State and Commonwealth planning requirements, as well as those of the aviation authorities—the Civil Aviation Safety Authority (CASA) and Airservices Australia—this report provides an assessment of the Uungula Wind Farm development from an aviation safety perspective.

National Airports Safeguarding Framework Guideline D: *Managing the Risk to Aviation Safety of Wind Turbine Installations* provides guidance to address the risk to civil aviation activities near wind farms and acknowledges the importance of airports to national, state/local infrastructure networks and economies as well as their social value.

Wind farms can be hazardous to aviation activity due to the tall structures that could present a conflict with low flying aircraft. They can also interfere with the performance of ATC communications, navigation and surveillance equipment.

This report assesses the likely impact of the Uungula Wind Farm upon aviation activity in the area as well as the ATC facilities by examining the heights and locations of the turbines and their anticipated effect on aviation activity and airspace within 30 nm (55 km) of the development.

The NSW Department of Planning, Secretary's Environmental Assessment Requirements (SEARS) dated 11 November 2019 are also addressed in this report. (REF: SSD 6687)

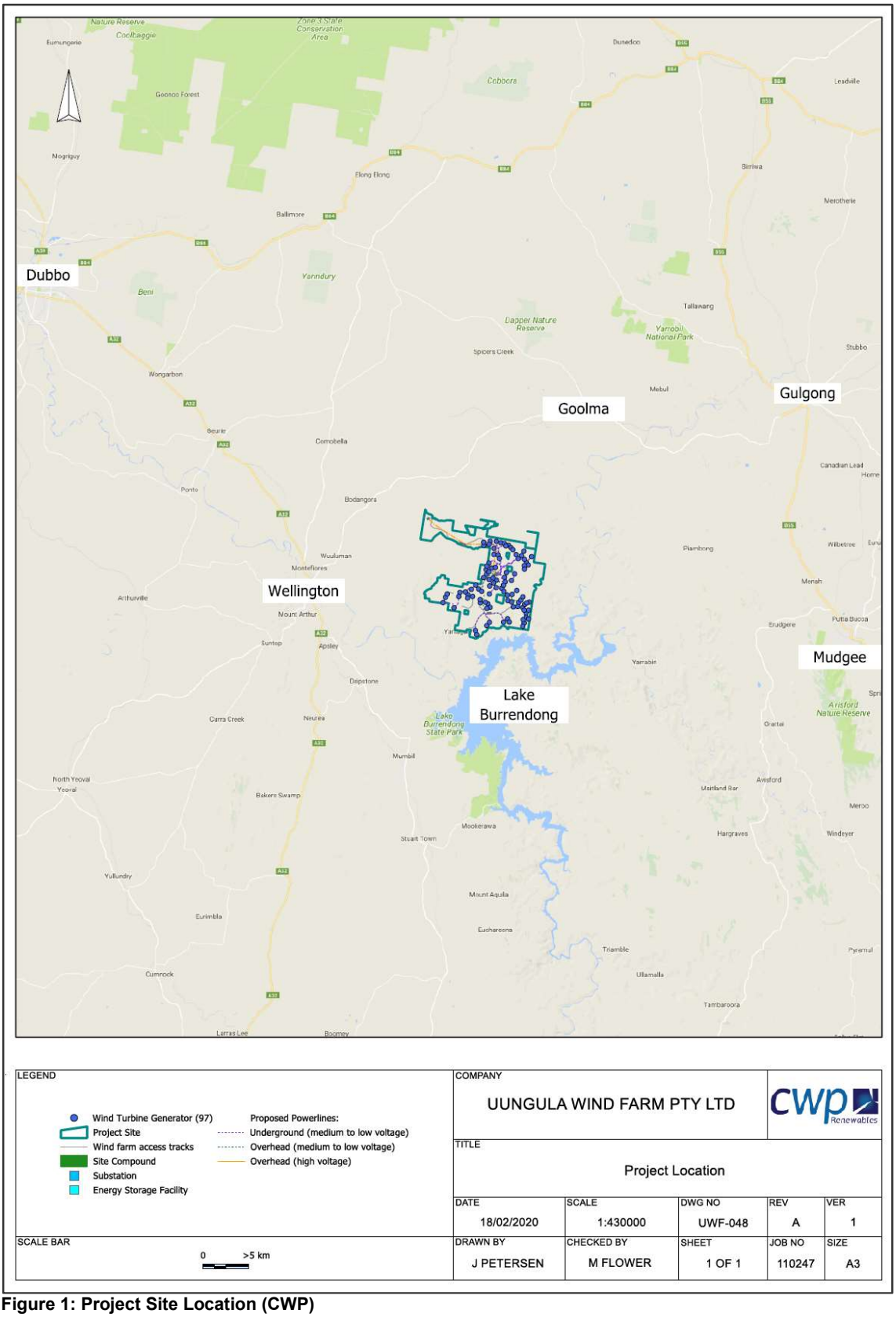

Figure 1: Project Site Location (CWP)

2 Airspace Protection

2.1 Overview

Protected airspace for an airport is the airspace above any part of either an Obstacle Limitation Surface (OLS), a PANS OPS (Procedures for Air Navigation Services – Aircraft Operations) surface.

The International Civil Aviation Organisation (ICAO) Annex 14 – *Aerodrome Design and Operations*, describes the minimum specifications for the OLS to be provided at aerodromes.

CASA prescribes the use of Annex 14 OLS and publishes any differences that Australia has initiated to cater for unique situations that may exist here.

The OLS are conceptual surfaces associated with an airport's runways that are designed to protect visual flight operations at the airport from unrestricted obstacle growth that may restrict take-off and landing performance.

For the airports considered in this report, the OLS extend to a maximum distance of 4 km from the airport.

PANS OPS surfaces are described in ICAO DOC 8168, *Procedures for Air Navigation – Aircraft Operations*. They are designed around instrument approach and departure flight paths with a prescribed minimum obstacle clearance from terrain and structures. They designate an obstacle-free flight path to enable safe and efficient aircraft operations in Instrument Meteorological Conditions (IMC), where the pilot is not guaranteed to be able to see the ground, water or obstacles on or near their flight path.

Airspace within the lateral navigation tolerances of an air route, have a vertical tolerance above terrain or obstacle to ensure safe flight operations during IFR flight on those routes. This then determines that Lowest Safe Altitude (LSALT) that an aircraft can fly on the particular route or within the applicable Grid shown on the aeronautical charts. The lateral tolerance for the air routes in the vicinity of the Uungula Wind Farm is 9.2 km (5 nm) and the vertical tolerance is 1000 ft (approximately 300 m).

Infringement by an infrastructure development or crane into protected airspace requires the approval of Airservices Australia, and CASA.

2.2 Obstacle Limitation Surfaces

Mudgee and Dubbo airports have OLS that extend to 4 km from the aerodrome.

Wellington and Gulgong aerodromes do not necessarily have any OLS in place, but in any case, would not extend beyond 2 km from it.

As the proposed wind farm is further away than 4 km from each aerodrome, their OLS are not infringed.

An examination of aeronautical charts does not show any other aerodromes within 5 kilometers of the boundary of the proposed wind farm.

The proposed Uungula Wind Farm does not infringe the OLS of any airport.

2.3 PANS OPS Surfaces

Mudgee and Dubbo airports are the nearest airports that have instrument flight procedures (IFP) published in the Australian Aeronautical Information Publication (AIP). They have PANS OPS protection surfaces extending to 55 km from the relevant point on the airport.

As the wind farm is located more than 55 km from the nearest point of Dubbo airport, the wind farm will not impact upon the PANS OPS surfaces for Dubbo.

The proposed wind farm is located within 55 km of Mudgee airport, an assessment of the impact of the WTGs was carried out to assess any potential impact.

The wind farm is located outside of the lateral PANS OPS protection surfaces for some of the IFPs and beneath and clear of the vertical limits for the others at Mudgee.

The lowest PANS OPS protection surface above any element of the wind farm is at an elevation of 1067 m (3800 ft) AHD. As the WTG blade tip elevations will range from 2366 ft to 3186 ft, this assessment

reveals that the proposed development of the Uungula Wind Farm does not infringe the PANS OPS surfaces for any airport in the vicinity.

Table 1 details the clearances.

Mudgee Instrument Flight Procedure Title	PANS OPS Protection Surface Elevation (m AHD)	Clearance of development at 971.112 m AHD (in metres)
25 nm MSA	1158	186.888
10 nm MSA	1067	95.888
GNSS ARR Sector A	1158	186.888
GNSS ARR Sector B	UWF located outside tolerance area	Laterally Clear
GNSS ARR Sector C	UWF located outside tolerance area	Laterally Clear
GNSS ARR Sector D	1158	186.888
NDB RWY 22	UWF located outside missed approach tolerance area	Laterally Clear
RNAV-Z (GNSS) RWY 04	1188	216.888
RNAV RWY 22	UWF located outside of missed approach tolerance area.	Laterally Clear

Table 1: Mudgee PANS OPS Assessment Details

Figure 2 shows that the PANS OPS protection area for the Left Initial Approach segment's secondary area of the RNAV-Z (GNSS) RWY 04 approach overlaps the boundary of the proposed wind farm slightly.

At this point the PANS OPS protection surface is almost equivalent to the procedure altitude.

The proposed Uungula Wind Farm does not infringe any PANS OPS surface.

Figure 2: Mudgee RNAV-Z (GNSS) RWY 04 Left Initial Approach Segment Protection Area

2.4 Air Routes

AIP Enroute Charts L3 and H1 were assessed in order to discover if any air routes exist within navigation tolerances of the wind farm. The navigation tolerance is 5 nm either side of the centerline of the air route.

Five Instrument Flight Rules (IFR) air routes exist within 5 nm of the Uungula Wind Farm.

Each air route has a published Lowest Safe Altitude (LSALT). The LSALT is the lowest altitude that an IFR aircraft can fly on that route, without visual reference to the ground or water.

The wind farm is also within a Grid LSALT area of 1523 m (5000 ft), as shown in green in Figure 3 just to the North West of Mudgee. The grid is based on a whole 1-degree longitude x 1-degree latitude square. The Grid LSALT provides pilots not flying on a published air route with a LSALT if they have chosen not to determine their own for the particular route being flown.

LSALT protection surfaces for these routes and the Grid LSALT with the relevant clearances above the WTGs are detailed in Table 2. UH226 is a high-level air route that is not shown in Figure 3.

The Uungula Wind Farm will not infringe the LSALT protection surface for any of the air routes or the Grid LSALT.

Air Route (LSALT)	Height of Protection Surface (m AHD)	Clearance of development at 971.112 m AHD (in metres)
V295 (1706 m)	1406	434.888
W717 (1432 m)	1132	160.888
W731 (1706 m)	1406	434.888
W785 (1310 m)	1010	38.888
UH226 (1676 m)	1376	404.888
Grid LSALT (1523 m)	1223	251.888

Table 2: Air Routes Clearances

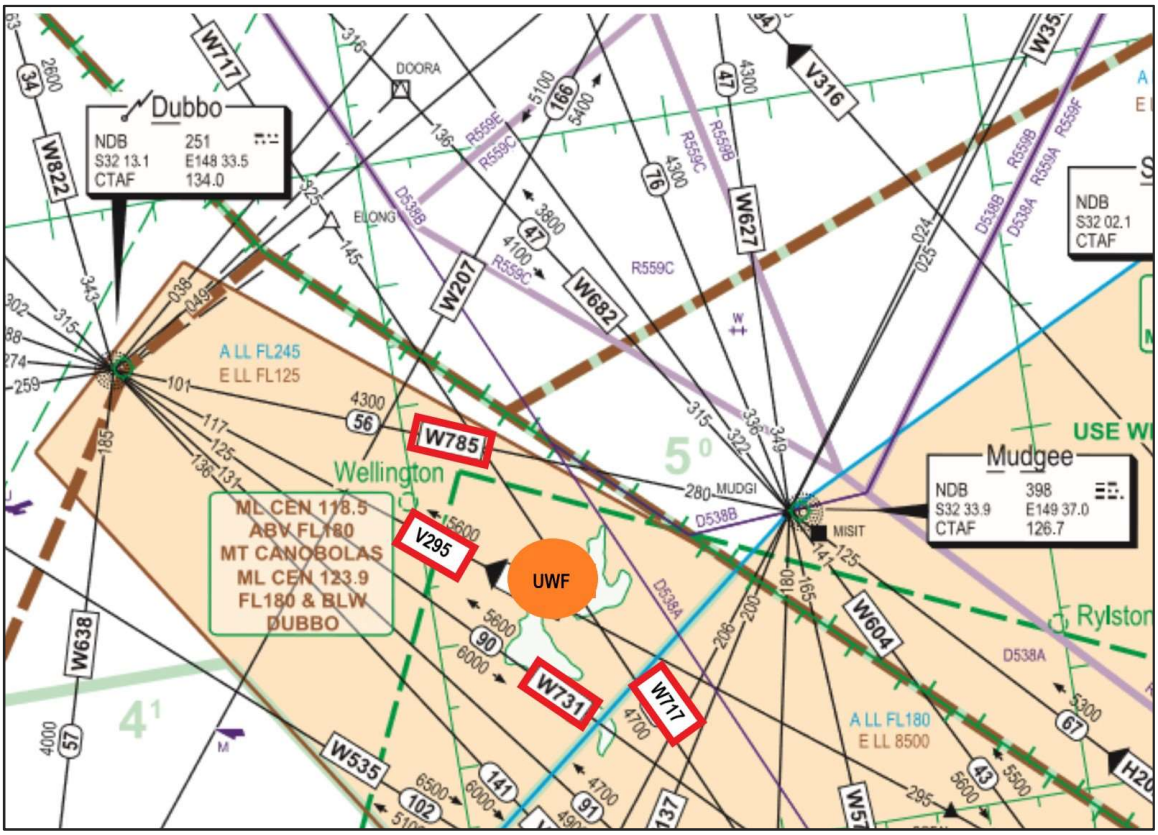

Figure 3: Air Routes and development site (AIP ERC L3 – 7 November 2019)

3 ATC Surveillance System and Navigation Aids

3.1 Overview

Wind farms have the potential to cause interference to ATC radar surveillance systems and to the accuracy of aeronautical navigation aids resulting in physical obstructions, the generation of 'radar clutter' and signal propagation.

Research has occurred around the world to determine the effect of WTGs on radar systems[1]. Primary radars (PSR) transmit a pulse of energy that is reflected to the radar receiver by an object that is within its line of sight. The closer a WTG is to a radar site, the greater the likelihood its reflected energy will be detected by the radar receiver. Secondary surveillance radar (SSR) systems differ from PSRs as rather than measuring the range and bearing of targets through detecting radar signals, an SSR transmits an interrogation requesting a dedicated response. Upon receiving an interrogation, the aircraft then transmits a coded reply which the SSR can use to ascertain the aircraft's position as well as decode other information contained within the response.

Wind turbine effects on SSR are traditionally less than those on PSRs but can be caused due to the physical blanking and diffracting effects of the turbine towers, depending on the size of the turbines and the wind farm. These effects are typically only a consideration when the turbines are located very close to the SSR, i.e. less than 10 km.

3.2 Surveillance Systems

The nearest ATC surveillance system is located at Bobbara Mountain in NSW, approximately 225 km south of the wind farm, beyond line of sight and located outside of the clearance zones associated with this facility.

Wind farms that are located near to other wind farms were considered to have an impact on ATC surveillance systems due to the cumulative effects of the many WTGs above those of an individual wind farm. Modern ATC surveillance systems such as ADS-B are not impacted to the same extent as Primary Radar systems. As the nearest surveillance radars are located more than 200 km from the boundary of the Uungula Wind Farm and therefore our assessment is that their signals will not be affected by the many WTGs in the area.

Another wind farm, Bodangora, comprising up to 33 turbines with a maximum height of up to 150 meters AGL, is located approximately 10.6 km north west of the Uungula Wind Farm.

Given the distance to the nearest ATC surveillance radar system more than 200 km away, there is unlikely to be any cumulative effects by the wind farms on ATC surveillance radar performance.

ADS-B will also mitigate any impacts that may occur.

3.3 Navigation Aids

The nearest aeronautical navigation aid is located at Mudgee Airport, 34km from the development. Clearance Zones for navigation aids are up to 3 km radius from the navigation aid.

The proposed wind farm is located outside the clearance zones associated with this and all other navigation aids.

Details of the wind farm should be provided to Airservices Australia to enable their engineers to confirm that the WTGs do not interfere with ATC communications, surveillance or navigations systems.

3.4 ATC Communications Systems

The nearest ATC communication system is located at Dubbo airport.

The wind farm will not have an impact upon this system due to the distance of this facility to the wind farm boundary.

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[1] UK CAA, *CAA Policy and Guidelines on Wind Turbines*. CAP764. Issue 6, February 2016.

4 Aviation Activity in the Vicinity of the Wind Farm

Table 3 shows the distances from the proposed wind farm to the airports and aerodromes within 55.56km (30 nm) of the Uungula Wind Farm boundary.

Figure 1, in Section 1, maps the development in relation to these airfields. Dubbo is included for reference only.

Airport	Direction and distance from site
Mudgee (Certified)	34 km east
Dubbo (Certified)	61 km north west
Wellington ALA (Uncertified)	14 km north west
Gulgong Aero Park (Uncertified)	38 km north east

Table 3: Airports within 30 nm of the Uungula Wind Farm

Of these airports, Dubbo and Mudgee are the only ones provided with instrument approach procedures.

Wellington and Gulgong aerodromes cater for Visual Flight Rules (VFR) operations. Considering the distance to the proposed development, the wind farm will not impact upon take-off and landing procedures at these airports. Local pilots will also be aware of the Bodangora Wind Farm which is in closer proximity to Wellington Aerodrome than Uungula wind farm will be.

There may be other privately-owned airstrips in the area that are not published in the Aeronautical Information Publication (AIP). The owners of these airstrips and the pilots that use them are responsible for ensuring that the condition of the airstrip and the surrounding terrain and obstacle environment are suitable for the safe operation of the aircraft using them.

Ongoing consultation by the developer will have created a community awareness of any impact the WTGs may have on these airstrips.

4.1 VFR operations

It is difficult to assess the level of aviation activity in the vicinity of the Uungula Wind Farm due to the lack of reporting requirements for VFR flights in this area and in fact most areas of Australia.

VFR flights, other than specially approved low-level operations, can occur down to a height of 500 ft (152 m) AGL.

Generally, VFR flights between airports operate at a comfortable altitude for their transit over the rugged terrain in the region, to their destinations for comfort and operational efficiency. They must always maintain visual reference to the ground or water so they should have ample opportunity to see any wind farm at a suitable distance to be able to avoid it if they need to.

VFR scenic and local flights might operate at lower altitudes in calm conditions than aircraft travelling between other aerodromes and operating at higher cruising altitudes, but the prominent wind turbines will be readily identifiable and avoidable and serve as a navigation feature. The existence of other wind farms in the region will have influenced pilot behavior due to an increased level of awareness of their presence.

Wellington aerodrome is equipped with runway and taxiway lighting. It is likely that night VFR flights are also conducted to/from Wellington Aerodrome. VFR flights at night are required to fly at altitudes similar to IFR flights to ensure separation from terrain during en-route operations. The proposed Uungula Wind Farm is more than 7 nm from the boundary of the wind farm is unlikely to impact upon take off, landing or circuit area flight operations.

Mechanical turbulence can be created because of wind on surrounding terrain. Most prudent pilots will avoid exposure either by remaining out of the area in windy conditions or flying above the mechanical turbulence.

Wellington ALA appears to be an active airfield with light aircraft operations occurring at irregular times.

Gulgong Aero Park appears to be a popular airfield that also incorporates some gliding activity.

There is also some ultralight activity in the region.

Glider flying training and cross-country soaring activity occurs around the Australia. Glider flights are conducted by day only and in good weather conditions using either thermal or mountain wave type updrafts to conduct cross-country flights away from the airfield. Gliding operations in mountainous areas requires careful consideration of the weather conditions for the entire period of the planned flight and constant awareness of available landing areas should the conditions change adversely. The glider flights will either be at an altitude well above the energy park or be landing in paddocks if they cannot get back to an airfield.

The WTGs are a prominent navigation feature that will enable pilots to avoid the wind farm if they need to land nearby.

4.2 Low level operations

Low level flight operations are considered to be those that require operations below 500 ft (152 m) AGL.

Pilots undertaking authorised low level operations such as crop dusting (aerial application of fertilisers), aerial firefighting, aerial cattle mustering, search and rescue, power line survey, gas pipe line monitoring and military low level flying in the area undergo specialised training and are required to take account of obstacles when planning and conducting their low level operations.

Depiction of the WTGs on aeronautical charts will provide information for pilots planning to operate in the vicinity of the Uungula Wind Farm. This will allow pilots to be aware of the wind farm's presence and to plan their flights in order to either avoid the location altogether or to consider any likely impact upon their proposed flight operations.

4.3 Aerial Agricultural Operations

Aerial agricultural operations in the vicinity of the wind farm occur approximately biennially.

Should the need for the aerial agricultural operation be required whilst the WTGs are active, pilots of these aircraft need to take into account the turbulence characteristics surrounding each WTG, including any cumulative effects of multiple WTGs operating together, their location in relation to the area(s) that require aerial application and would need to liaise with the land owner and the wind farm operator to assess the risk that the wind farm may have to a safe aerial agricultural operation.

Publication in appropriate aeronautical charts will also assist to inform operators.

4.4 IFR Operations

Pilots operating to the Instrument Flight Rules (IFR) in the area are required to maintain minimum altitudes published on aeronautical charts and instrument approach charts.

As shown in Section 2, the Uungula Wind Farm will not infringe any of the LSALTs for air routes in the area nor any PANS OPS protection surfaces for any aerodrome with published IFPs.

4.5 Contingency Procedures – Engine Inoperative Flight Paths

In the context of the aircraft and airport operations in the vicinity of the proposed development of the Uungula Wind Farm and the physical environment, it is considered to be sufficiently distant from nearby airports to have no impact on contingency procedures and engine inoperative flight paths in the area.

5 Obstacle Marking and Lighting

CASA is likely to impose a condition that the WTGs are painted in a colour that is visually conspicuous against the prevailing background, usually white. CASA then considers that WTGs are sufficiently conspicuous by day due to their shape, size and colour.

If CASA require obstacle lighting for Uungula Wind Farm, shielding of the lights to avoid distraction to residents may be installed, however the lights must remain visible above a horizontal plane.

CASA and the Commonwealth Department of Infrastructure, Transport, Regional Development and Cities are reviewing the requirements for lighting of wind farms.

A wind farm has been constructed at Bodangora, within 5 nm of Wellington Aerodrome as shown in Figure 5 later in this report. It does not have obstacle lighting.

As the proposed Uungula Wind Farm is located further from the Wellington Aerodrome than the Bodangora Wind Farm, it is unlikely that CASA will require it to be provided with obstacle lighting. However, CASA will determine the need for obstacle lighting based on each individual situation.

Discussion notes regarding the lighting of wind farms can be found in Appendix C.

As Uungula Wind Farm's WTG tip heights will exceed 110m AGL, formal notification to CASA and DoD is required in accordance with:

- CASA Advisory Circular AC 139-08(0) "Reporting of Tall Structures" to enable inclusion of the wind farm location and height of turbines in relevant aeronautical information publications; and
- CASA Form 406 – "Operational Assessment of Existing and Proposed Structures".

This aeronautical impact assessment and review of obstacle marking, and lighting requirements supports this formal notification requirement.

Formal notification of the intention to develop the Uungula Wind Farm should also be provided to local aviation organisations and relevant aviation stakeholders.

6 Turbulence

Turbulence caused by the turbine extends downwind behind the blades and the tower, which can extend to 2 km downwind of an individual WTG. The dissipation of the wake and the reduction of its intensity depend on the wind speed, convection, turbulence diffusion, the topography (obstacles, terrain, etc.) and other atmospheric conditions.

There is considerable research activity on modelling and studying the wake characteristics within wind developments, using computational fluid dynamics (CFD) techniques, wind tunnel tests and on-site LIDAR measurements[2].

The advice contained in the NASF Guideline D remains the current advice in Australia, noting that wind farm operators should be conscious of their duty of care to communicate with aviation operators within the vicinity of the wind farm.

In any wind condition the nearest aerodrome, Wellington aerodrome, is beyond 2 km from the boundary of the wind farm and therefore any turbulence caused by the WTG blades in unlikely to have an impact upon flight operations there.

7 Transmission Lines

High tension electric power transmission lines exist between Wellington Aerodrome and the proposed Uungula Wind Farm.

Pilots who regularly operate at Wellington Aerodrome would already consider these as an obstacle to avoid in their flight operations and plan them accordingly. Such procedures would also provide a safe margin for the proposed wind farm.

8 Cumulative Effect of Nearby Wind Farms

A wind farm has recently been constructed near Mt Bodangora, approximately 5 nm north east of Wellington Airport as shown on AIP Visual Navigation Chart Newcastle effective 7 November 2019, shown below in Figure 5. It does not have lighting installed.

[2] https://www.liverpool.ac.uk/flight-science/cfd/wake-encounter-aircraft/

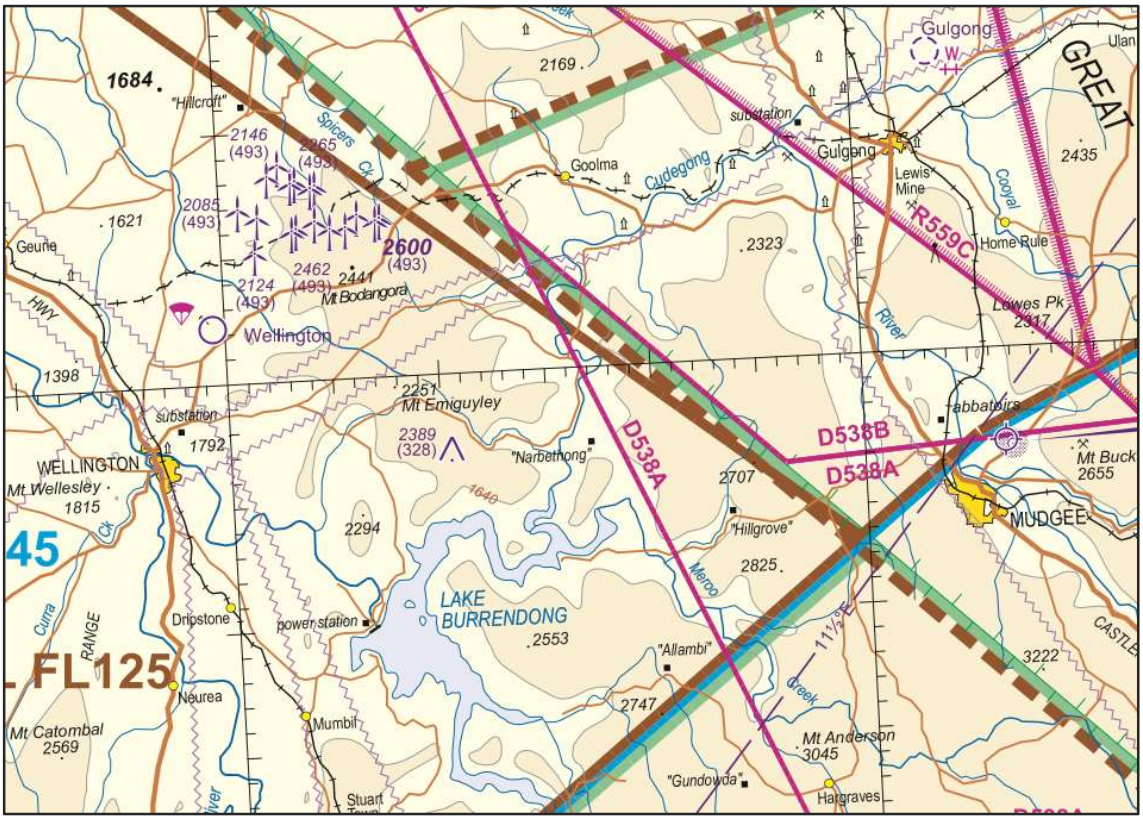


Figure 5: Bodangora Wind Farm in close proximity to Wellington Aerodrome (Airservices Australia VNC)

As the Uungula Wind Farm is proposed at a greater distance from the aerodrome, it will have less impact upon it.

9 National Aviation Safeguarding Framework D

The NASF provides guidance to State/Territory and local Government decision makers, airport operators and developers of wind farms to jointly address the risk to aviation activity from the presence and use of wind farms and wind monitoring towers.

THE NASF Guideline D suggests that a formal assessment of any risks to aviation safety posed by the proposed development should be commissioned following a preliminary assessment of potential issues.

Night flying activity at Wellington Aerodrome has been considered. At a distance of 7 nm from the wind farm boundary, the wind farm is outside of the recognised circuit area of the aerodrome and beyond the boundary of its OLS. The presence of the new Bodangora Wind Farm, within 5 nm of the aerodrome suggests that a wind farm located at 7 nm will not create any additional risk to the safety of flight operations.

Wellington Aerodrome provides services to air ambulance and Royal Flying Doctor Service aircraft. These aircraft operate to the IFR and it has been shown that the PANS OPS surfaces and the Air Route LSALTs are not impacted by the proposed wind farm.

Local night flying operations at Wellington Airport are similarly constrained to avoid obstacles that cannot be seen at night.

The proposed Uungula Wind Farm is unlikely to cause a hazard to flight safety that would require a formal risk assessment to be conducted.

The provision of obstacle lighting for the Uungula Wind Farm is not likely to be required as it is further away from Wellington Aerodrome than the Bodagora Wind Farm which is not required to have obstacle lighting installed.

10 Planning Secretary's Environmental Assessment Requirements (SEARS)

The SEARS require that an environmental impact assessment (EIS) must include a set list of assessments.

This AIA has considered the details of the SEARS related to aviation activity.

The Uungula Wind Farm will require assessment and approval from CASA, which will occur once the local planning authority provides the details, and this AIA to them.

All other SEARS requirements have been met.

11 Conclusion

The proposed Uungula Wind Farm development in central NSW between Mudgee and Dubbo, to a maximum height of 971.112 m AHD:

- is located within Class G airspace;
- will not infringe any OLS;
- will not infringe the PANS OPS surfaces of any airport;
- will not impact on contingency procedures;
- is located outside the clearance zones associated with all navigation aids, ATC surveillance and communications systems;
- the cumulative effect of this wind farm and that of neighbouring wind farms will not impact upon the ATC surveillance systems;
- will not infringe the LSALT protection surfaces for any air route;
- will not infringe the relevant Grid LSALT;
- will have little or no impact upon local flying activities including the aerial application of fertilisers by crop dusting aircraft outside the boundary of the wind farm;
- is unlikely to require the provision of obstacle lighting and
- will provide a significant visual navigation feature in the region.

This report must be referred to Airservices Australia for their assessment of any likely impact upon their ATC Surveillance, navigation and communications equipment as well as published air routes. Final built details of the wind farm will also be required to be provided to Airservices Australia for publication in aeronautical databases and on aeronautical charts.

Details of the wind farm must be provided to CASA by the local planning authority for assessment of the need for obstacle lighting.

The report should also be sent to Department of Defence for assessment of any potential low-level military flight training routes that may exist in the region.

Appendix A: Indicative Site Coordinates and Terrain Elevations

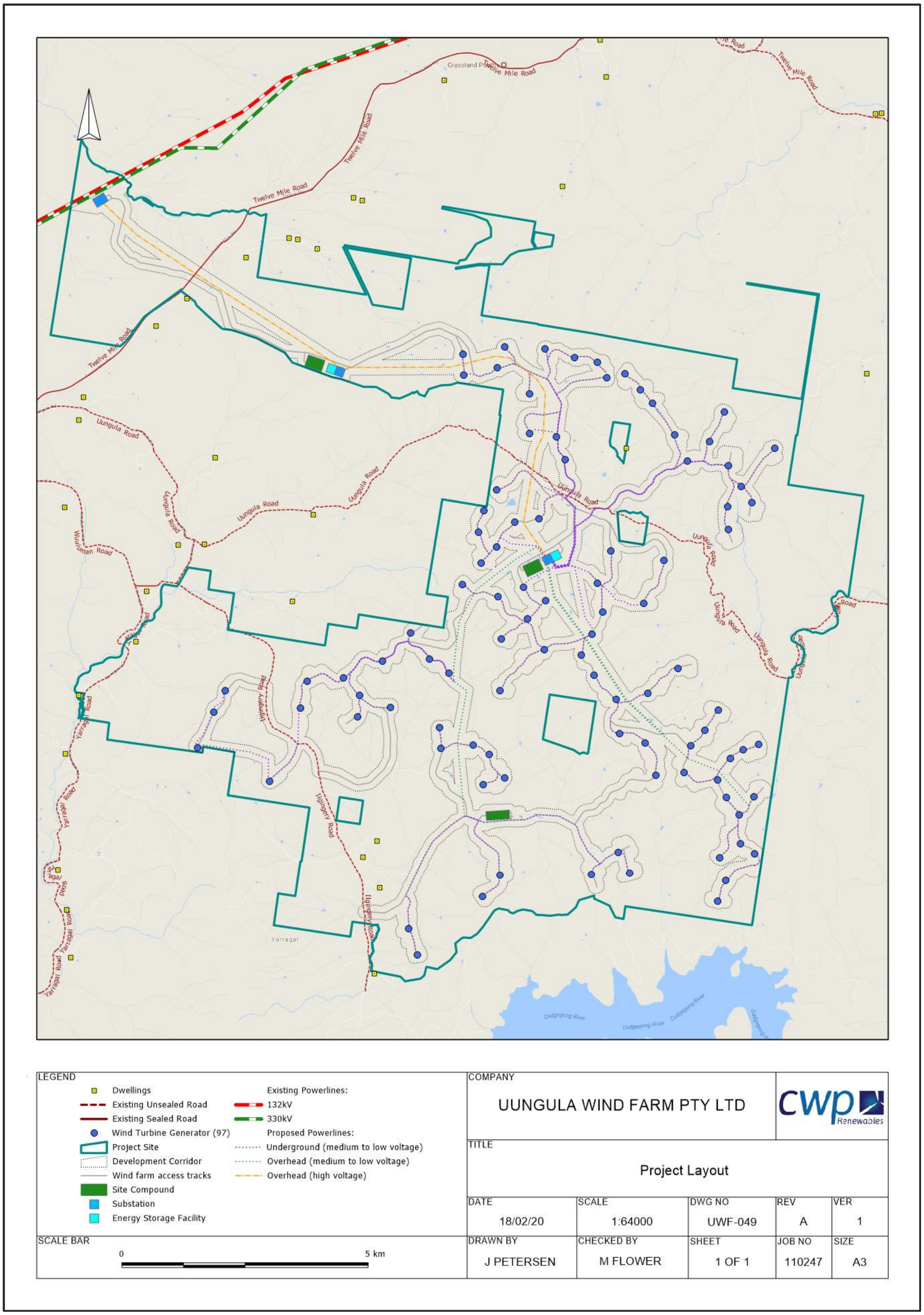
WTG ID	Longitude	Latitude	Site Elevation (m AHD)	Max WTG TIP Height (m AGL)	Max WTG TIP Elevation (m AHD)	Max WTG TIP Elevation (ft AHD)
1	149.1456	-32.5017	666.933	250	916.933	3008.31
2	149.1458	-32.5049	688.549	250	938.549	3079.229
3	149.1532	-32.5005	670.141	250	920.141	3018.835
4	149.1519	-32.5038	677.122	250	927.122	3041.739
5	149.1578	-32.5078	672.342	250	922.342	3026.057
6	149.1627	-32.5144	662.532	250	912.532	2993.871
7	149.1577	-32.5139	678.592	250	928.592	3046.562
8	149.1642	-32.5179	650.152	250	900.152	2953.255
9	149.1606	-32.5008	673.451	250	923.451	3029.695
10	149.166	-32.5022	678.176	250	928.176	3045.197
11	149.1701	-32.5029	672.823	250	922.823	3027.635
12	149.1719	-32.5053	678.675	250	928.675	3046.834
13	149.1752	-32.5047	678.37	250	928.37	3045.833
14	149.178	-32.5071	683.261	250	933.261	3061.88
15	149.1802	-32.5092	676.197	250	926.197	3038.704
16	149.1842	-32.5141	673.877	250	923.877	3031.093
17	149.1866	-32.5181	687.264	250	937.264	3075.013
18	149.1906	-32.5151	648.941	250	898.941	2949.282
19	149.1933	-32.5106	653.509	250	903.509	2964.268
20	149.194	-32.5188	672.471	250	922.471	3026.48
21	149.1964	-32.522	687.394	250	937.394	3075.44
22	149.2025	-32.5161	628.592	250	878.592	2882.52
23	149.1984	-32.5245	654.683	250	904.683	2968.12
24	149.1939	-32.5251	634.74	250	884.74	2902.69
25	149.194	-32.5286	628.508	250	878.508	2882.244
26	149.1517	-32.5226	683.03	250	933.03	3061.122
27	149.1494	-32.5257	665.778	250	915.778	3004.521
28	149.1484	-32.5291	672.055	250	922.055	3025.115
29	149.1551	-32.5275	661.931	250	911.931	2991.9
30	149.1595	-32.527	658.658	250	908.658	2981.162
31	149.1517	-32.5313	677.168	250	927.168	3041.89
32	149.1489	-32.5338	680.635	250	930.635	3053.265
33	149.1455	-32.5371	667.664	250	917.664	3010.709
34	149.152	-32.539	671.463	250	921.463	3023.173
35	149.1566	-32.5375	651.696	250	901.696	2958.32
36	149.1607	-32.5396	686.247	250	936.247	3071.677
37	149.1574	-32.5424	677.279	250	927.279	3042.254
38	149.1526	-32.5455	652.436	250	902.436	2960.748
39	149.1604	-32.5472	676.937	250	926.937	3041.132
40	149.1523	-32.5535	614.612	250	864.612	2836.654
41	149.1691	-32.5448	651.863	250	901.863	2958.868
42	149.1711	-32.5414	667.996	250	917.996	3011.798
43	149.1702	-32.5369	654.498	250	904.498	2967.513
44	149.1726	-32.532	630.949	250	880.949	2890.253
45	149.1786	-32.54	659.158	250	909.158	2982.802
46	149.1823	-32.5334	626.123	250	876.123	2874.419
47	149.1672	-32.548	651.234	250	901.234	2956.805
48	149.1695	-32.5511	676.512	250	926.512	3039.738

WTG ID	Longitude	Latitude	Site Elevation (m AHD)	Max WTG TIP Height (m AGL)	Max WTG TIP Elevation (m AHD)	Max WTG TIP Elevation (ft AHD)
49	149.1736	-32.5548	673.756	250	923.756	3030.696
50	149.1793	-32.5539	671.371	250	921.371	3022.871
51	149.1849	-32.55	652.464	250	902.464	2960.84
52	149.1742	-32.5601	642.978	250	892.978	2929.718
53	149.1788	-32.5615	650.642	250	900.642	2954.862
54	149.1808	-32.5665	678.555	250	928.555	3046.44
55	149.1872	-32.5619	666.083	250	916.083	3005.522
56	149.1898	-32.5596	639.908	250	889.908	2919.646
57	149.1922	-32.5564	622.175	250	872.175	2861.467
58	149.186	-32.5661	703.407	250	953.407	3127.976
59	149.1921	-32.5672	721.112	250	971.112	3186.063
60	149.1944	-32.5639	682.494	250	932.494	3059.364
61	149.1967	-32.5625	653.37	250	903.37	2963.812
62	149.1996	-32.5617	640.444	250	890.444	2921.404
63	149.1937	-32.5699	686.256	250	936.256	3071.706
64	149.196	-32.5726	692.617	250	942.617	3092.576
65	149.1987	-32.5698	655.561	250	905.561	2971.001
66	149.1962	-32.577	681.171	250	931.171	3055.023
67	149.1925	-32.5792	612.948	250	862.948	2831.194
68	149.1988	-32.5785	642.192	250	892.192	2927.139
69	149.1936	-32.5827	602.51	250	852.51	2796.949
70	149.1921	-32.5859	544.863	250	794.863	2607.818
83	149.176	-32.5816	574.283	250	824.283	2704.341
84	149.1739	-32.5784	587.042	250	837.042	2746.201
85	149.1691	-32.5818	577.611	250	827.611	2715.259
86	149.1492	-32.5852	617.885	250	867.885	2847.392
87	149.1524	-32.5819	563.974	250	813.974	2670.518
88	149.1357	-32.5901	487.882	250	737.882	2420.873
89	149.1373	-32.5942	529.358	250	779.358	2556.949
90	149.1493	-32.5679	561.154	250	811.154	2661.266
91	149.1532	-32.5669	567.238	250	817.238	2681.227
92	149.1504	-32.5633	592.959	250	842.959	2765.614
93	149.1475	-32.5618	573.266	250	823.266	2701.004
94	149.1416	-32.5624	571.759	250	821.759	2696.06
95	149.1413	-32.5591	563.336	250	813.336	2668.425
96	149.143	-32.5508	579.192	250	829.192	2720.446
97	149.1395	-32.5486	601.992	250	851.992	2795.249
98	149.1361	-32.5446	603.813	250	853.813	2801.224
99	149.1309	-32.5489	598.118	250	848.118	2782.539
100	149.1238	-32.5515	576.381	250	826.381	2711.224
101	149.1268	-32.5542	579.941	250	829.941	2722.904
102	149.1324	-32.556	550.485	250	800.485	2626.263
103	149.1264	-32.5575	552.426	250	802.426	2632.631
104	149.1172	-32.552	605.718	250	855.718	2807.474
105	149.1159	-32.5561	576.234	250	826.234	2710.742
106	149.1103	-32.5674	484.831	250	734.831	2410.863
107	149.1022	-32.5535	486.708	250	736.708	2417.021
108	149.1001	-32.5568	510.377	250	760.377	2494.675
109	149.0972	-32.5622	471.351	250	721.351	2366.637

Indicative WTG Coordinates and Terrain Elevations Source: CWP

Note: WTG 59 is the highest and WTG 106 is the lowest. There no WTGs with numbers between 71 and 82.

Appendix B: Wind Farm Layout



Uungula Wind Farm Layout (CWP)

Appendix C: Assessment Methodology

In preparing aeronautical impact assessments associated with airport safeguarding and protection, it is necessary to observe the requirements of the relevant aviation authorities including:

- The Department of Infrastructure, Regional Development and Cities (DIRDC);
- The Civil Aviation Safety Authority of Australia (CASA);
- Airservices Australia (ASA);
- Airport Operators; and
- Department of Defence where appropriate.

Relevant Acts and Regulations applicable to developments near airports and air traffic routes were referenced during this assessment.

The major relevant documents include:

- The Airports Act 1996, Airports (Protection of Airspace) Regulations 1996;
- Civil Aviation Safety Regulation (CASR) Part 139 Manual of Standards – Aerodromes;
- Aeronautical Information Publication (AIP);
- Airservices Australia's Airways Engineering Instruction – Navigation Aid Building Restricted Areas and Siting Guidance (BRA);
- International Civil Aviation Organisation (ICAO) DOC 8168 Procedures for Air Navigation – Aircraft Operations (PANS OPS); and
- NSW Planning & Environment – State Significant Development –Environmental Assessment Requirements (SEARS).

A Glossary of Aeronautical Terms and Abbreviations is shown at Appendix E.

Appendix D: Discussion Regarding Obstacle Lighting

The aeronautical requirements for marking and lighting of wind farms are currently undergoing review by the International Civil Aviation Organization (ICAO), the Department of Infrastructure, Regional Development and Cities (DIRDC) and CASA.

It is understood that ICAO will be issuing an amendment to ICAO Annex 14 (Aerodromes) that addresses, inter alia, wind farms.

DIRTDC recently issued a Discussion Paper “Safeguards for Airports and The Communities Around Them” that implies an amendment to the criteria for wind turbine heights from 110m to 152m AGL as being applicable to wind farms in the vicinity of aerodromes. In addition, CASA is currently reviewing its withdrawn Advisory Circular AC139-181 “Obstacle Marking and Lighting of Wind Farms”. The outcomes of these various reviews may result in:

- Revised criteria for wind farms; and
- Wind farms that are in remote locations, away from aerodromes, not requiring obstacle lighting, depending on the findings of a qualitative risk assessment to be undertaken by the proponent.

While the DIRDC Discussion Paper applies specifically to wind farms within the vicinity (generally accepted as 30km) of aerodromes, CASA is also currently reviewing the requirements for marking and lighting of obstacles and hazards remote from aerodromes. CASA has informally advised the wind farm industry that a qualitative risk assessment approach to the potential hazards, as presented by wind farms, may be considered.

CASA’s current position on obstacle lighting of wind farms that are remote from an aerodrome (which is the situation for Uungula Wind Farm) is summarised as:

- CASA cannot mandate obstacle lighting for wind farms that are not within the vicinity of an aerodrome, but they provide objective advice regarding aircraft operations and the need for lighting;
- provision of obstacle lighting is the responsibility of the relevant planning authority;
- any associated requirements placed on proponents by planning authorities, insurers or financiers are beyond CASA’s scope;
- a wind farm proponent may have a duty of care to the aviation industry and local operators in terms of ensuring obstacles are made conspicuous; and
- obstacle marking and lighting requirements as specified in the CASA Manual of Standards Part 139, Chapters 8 and 9 applies.

CASA Manual of Standards (MOS) 139, Chapter 9, Section 9.4 indicates that for structures more than 110m AGL, the proponent should expect that obstacle lighting will be required unless there are unusual circumstances. The turbines to be installed at Uungula Wind Farm will have a maximum height of 250 m AGL. However, there have been situations where CASA has acknowledged non-provision of obstacle lighting of wind farms in Australia where the turbine height exceeds 110m AGL. Such installations have been the subject of a hazard risk assessment that takes into account such factors as location of the wind farm with respect to nearby airfields and air routes, potential impact on navigable airspace, surrounding terrain, local aviation activity in the area, and environmental considerations.

As indicated above, Australian policy, standards and recommended practices for obstacle marking and lighting of wind farms are currently under review. A current proposal includes a change to the criterion height of 110m (361ft) to 152m (500ft) AGL for wind farms within the vicinity of a certified or registered aerodrome.

Appendix E: Glossary of Aeronautical Terms and Abbreviations

To facilitate the understanding of aviation terminology used in this report, the following is a glossary of terms and acronyms that are commonly used in aeronautical impact assessments and similar aeronautical studies.

Advisory Circulars (AC) are issued by CASA and are intended to provide recommendations and guidance to illustrate a means, but not necessarily the only means, of complying with the *Regulations*.

Aeronautical Information Publication (AIP) is a publication promulgated to provide operators with aeronautical information of a lasting character essential to air navigation. It contains details of regulations, procedures and other information pertinent to flying and operation of aircraft within the applicable country. AIP Australia is produced by Airservices Australia under contract to CASA.

Aeronautical study is a tool used to review aerodrome and airspace processes and procedures to ensure that safety criteria are appropriate.

Air routes exist between navigation aids or waypoints to facilitate the regular and safe flow of aircraft operating under the IFR.

Airservices Australia (ASA) is the Australian government-owned corporation Air Navigation Service Provider (ANSP) providing safe, secure, efficient and environmentally sound air traffic management and related airside services including telecommunications, aeronautical data, navigation services and aviation rescue and firefighting services to the aviation industry within the Australian flight information region.

Air Traffic Control (ATC) service is a service provided in controlled airspace for the purpose of preventing collisions between aircraft and between aircraft and obstructions on the manoeuvring area of controlled aerodromes whilst maintaining an expeditious and orderly flow of air traffic.

Altitude is the vertical distance of a level, a point or an object, considered as a point, measured from mean sea level.

Area navigation (RNAV) A method of navigation which permits aircraft operation on any desired flight path within the coverage of the station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these.

Circling approach An extension of an instrument approach procedure which provides for visual circling of the aerodrome prior to landing.

Civil Aviation Safety Authority (CASA) is the Australian government authority responsible under the *Civil Aviation Act 1988* for developing and promulgating appropriate, clear and concise aviation safety standards. As Australia is a signatory to the ICAO *Chicago Convention,* CASA adopts the standards and recommended practices established by ICAO, except where a difference has been notified.

Civil Aviation Safety Regulations (CASR) are promulgated by CASA and establish the regulatory framework *(Regulations)* within which all service providers must operate.

Civil Aviation Act 1988 (the Act) establishes the CASA with functions relating to civil aviation, in particular the safety of civil aviation and for related purposes.

Decision altitude (DA) or decision height (DH) A specified altitude or height in a 3D instrument approach operation at which a missed approach must be initiated if the required visual reference to continue the approach has not been established. *Note— Decision altitude (DA) is referenced to mean sea level and decision height (DH) is referenced to the threshold elevation.*

Elevation The vertical distance of a point or a level, on or affixed to the surface of the earth, measured from mean sea level.

Height The vertical distance of a level, a point or an object considered as a point, measured from a specified datum.

Instrument Flight Rules (IFR) are rules applicable to the conduct of flight under IMC. IFR are established to govern flight under conditions in which flight by outside visual reference is not available due to cloud cover or restricted visibility. IFR flight depends upon a qualified instrument rated pilot flying by reference to instruments located in the flight deck. Navigation is accomplished by reference to electronic signals. It is also referred to as, "a term used by pilots and controllers to indicate the type of flight plan an aircraft is flying," such as an IFR or VFR flight plan. IFR flights can and do regularly operate in VMC but remain an IFR flight for rule and ATC requirements. Regular Public Transport flights are required to file an IFR flight plan, irrespective of the weather conditions.

Instrument Meteorological Conditions (IMC) are meteorological conditions that are less than the minimum specified for visual meteorological conditions.

International Civil Aviation Organization (ICAO) is an agency of the United Nations which codifies the principles and techniques of international air navigation and fosters the planning and development of international air transport to ensure safe and orderly growth. The ICAO Council adopts standards and recommended practices concerning air navigation, its infrastructure, flight inspection, prevention of unlawful interference, and facilitation of border-crossing procedures for international civil aviation. In addition, the ICAO defines the protocols for air accident investigation followed by transport safety authorities in countries signatory to the Convention on International Civil Aviation, commonly known as the *Chicago Convention*. Australia is a signatory to the *Chicago Convention.*

Lowest Safe Altitude (LSALT) are published for each low level air route segment. Their purpose is to allow pilots of aircraft that suffer a system failure to descend to the LSALT to ensure terrain or obstacle clearance in IMC where the pilot cannot see the terrain or obstacles due to cloud or poor visibility conditions. It is an altitude that is at least 1,000 feet above any obstacle or terrain within a defined safety buffer region around a particular route that a pilot might fly.

Manual of Standards (MOS) comprises specifications (Standards) prescribed by CASA, of uniform application, determined to be necessary for the safety of air navigation in relation to a particular segment of the aviation regulations. For example, MOS 139 relates to CASR Part 139 – Aerodromes.

Minimum descent altitude (MDA) or minimum descent height (MDH) A specified altitude or height in a 2D instrument approach operation or circling approach operation below which descent must not be made without the required visual reference. Note: Minimum descent altitude (MDA) is referenced to mean sea level and minimum descent height (MDH) is referenced to the aerodrome elevation or to the threshold elevation if that is more than 2 m (7 ft) below the aerodrome elevation. A minimum descent height for a circling approach is referenced to the aerodrome elevation.

Minimum Obstacle Clearance (MOC) is the minimum distance above an obstacle or terrain that aircraft conducting instrument approach or departure procedures are not allowed to fly below in IMC. The MOC varies depending on the distance from the runway or in mountainous areas.

Notices to Airmen (NOTAMs) are notices issued by the NOTAM office containing information or instruction concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to persons concerned with flight operations.

Obstacles. All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight.

Obstacle assessment surface (OAS) is a defined surface intended for the purpose of determining those obstacles to be considered in the calculation of obstacle clearance altitude/height for a specific APV or precision approach procedure.

Obstacle Limitation Surfaces (OLS) are a series of planes associated with each runway at an aerodrome that defines the desirable limits to which objects may project into the airspace around the aerodrome so that aircraft operations may be conducted safely.

Prescribed airspace is an airspace specified in, or ascertained in accordance with, the Regulations, where it is in the interests of the safety, efficiency or regularity of existing or future air transport operations into or out of an airport for the airspace to be protected. The prescribed airspace for an airport is the airspace above any part of either an OLS or a PANS OPS surface for the airport and airspace declared in a declaration relating to the airport.

Procedures for Air Navigation Services - Aircraft Operations (PANS-OPS) is an ICAO term denominating rules for designing instrument approach and departure procedures. Such procedures are used to allow aircraft to land and take off under Instrument Meteorological Conditions (IMC) using the Instrument Flight Rules (IFR). ICAO document 8168-OPS/611 (volumes 1 and 2) outlines the principles for airspace protection and procedure design which all ICAO signatory states must adhere to. The regulatory material surrounding PANS-OPS may vary from country to country.

PANS OPS Surfaces. Similar to an Obstacle Limitation Surface, the PANS-OPS protection surfaces are imaginary surfaces in space, below the nominal flight path of the aircraft, which guarantee a certain minimum obstacle clearance above the ground or man-made obstacles. These surfaces may be used as a tool for local governments in assessing building development. Where buildings may (under certain circumstances) be permitted to penetrate the OLS, they cannot be permitted to penetrate any PANS-OPS surface, because the purpose of these surfaces is to guarantee pilots operating in IMC an obstacle free descent or climb path for a given approach, holding procedure or departure.

Regulations (Civil Aviation Safety Regulations)

Threshold (THR). The beginning of that portion of the runway usable for landing.

Visual Flight Rules (VFR) are rules applicable to the conduct of flights that are only permitted in VMC due to aircraft equipment and pilot qualifications. The visual flight rules allow a pilot to operate an aircraft in weather conditions that allow the pilot to navigate by visual reference to the ground or water by maintaining visual contact with the terrain and obstacle environment in order to be able to see and avoid other aircraft, terrain, obstacles or other hazards. Specifically, the weather must be equal to or better than basic VFR weather minima. If the weather is worse than VFR minima, IFR qualified pilots operating an IFR qualified aircraft are able to operate under the IFR.

Visual Meteorological Conditions (VMC) are meteorological conditions expressed in terms of visibility, distance from cloud and ceiling, equal or better than specified minima.

Visual Segment Surface (VSS) A PANS-OPS design segment of a straight-in instrument approach procedure, which needs to be monitored and kept clear of any penetrations by obstacles.

Abbreviations

Abbreviations used in this report, and the meanings assigned to them for the purposes of this report are detailed in the following table.

Abbreviation	Meaning
AC	Advisory Circular (document support CAR 1998)
ACFT	Aircraft
AD	Aerodrome
ADS-B	Automatic Dependent Surveillance - Broadcast
AHD	Australian Height Datum
AIP	Aeronautical Information Publication
Airports Act	Airports Act 1996, as amended
AIS	Aeronautical Information Service
ALT	Altitude
AMSL	Above Mean Sea Level
APARs	Airports (Protection of Airspace) Regulations, 1996 as amended
ARP	Aerodrome Reference Point
AsA	Airservices Australia
ATC	Air Traffic Control(ler)
ATM	Air Traffic Management
BARO-VNAV	Barometric Vertical Navigation
BRA	Building Restricted Area
CAO	Civil Aviation Order
CAR	Civil Aviation Regulation
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulation
Cat	Category
DAP	Departure and Approach Procedures (charts published by AsA)
DER	Departure End of (the) Runway
DME	Distance Measuring Equipment
Doc nn	ICAO Document Number nn
DIT	Department of Infrastructure and Transport. (Formerly Dept. of Infrastructure, Transport, Regional Development and Local Government and Department of Transport and Regional Services (DoTARS))
DOTARS	See DIT above
ELEV	Elevation (above mean sea level)
ENE	East North East
ERSA	Enroute Supplement Australia
FAF	Final Approach Fix

Abbreviation	Meaning
FAP	Final Approach Point
FAS	Final Approach Surface of a BARO-VNAV approach
ft	feet
GBAS	Ground Based Augmentation System (satellite precision landing system)
GNSS	Global Navigation Satellite System
GP	Glide Path
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organisation
IHS	Inner Horizontal Surface, an Obstacle Limitation Surface
ILS	Instrument Landing System
ISA	International Standard Atmosphere
km	kilometres
kt	Knot (one nautical mile per hour)
LAT	Latitude
LLZ	Localizer
LONG	Longitude
LNAV	Lateral Navigation criteria
m	metres
MAPt	Missed Approach Point
MDA	Minimum Descent Altitude
MGA94	Map Grid Australia 1994
MOC	Minimum Obstacle Clearance
MOS	Manual of Standards, published by CASA
MSA	Minimum Sector Altitude
MVA	Minimum Vector Altitude
NASAG	National Airports Safeguarding Advisory Group
NDB	Non Directional Beacon
NE	North East
NM	Nautical Mile (= 1.852 km)
nnDME	Distance from the DME (in nautical miles)
NNE	North East
NOTAM	NOtice to AirMen
OAS	Obstacle Assessment Surface
OCA	Obstacle Clearance Altitude
OCH	Obstacle Clearance Height
OHS	Outer Horizontal Surface
OIS	Obstacle Identification Surface

Abbreviation	Meaning
OLS	Obstacle Limitation Surface
PANS OPS	Procedures for Air Navigation Services – Aircraft Operations, ICAO Doc 8168
PBN	Performance Based Navigation
PRM	Precision Runway Monitor
QNH	An altimeter setting relative to height above mean sea level
REF	Reference
RL	Relative Level
RNAV	aRea NAVigation
RNP	Required Navigation Performance
RPA	Rules and Practices for Aerodromes — replaced by the MOS Part 139 — Aerodromes
RPT	Regular Public Transport
RTCC	Radar Terrain Clearance Chart
RWY	Runway
SFC	Surface
SID	Standard Instrument Departure
SOC	Start Of Climb
STAR	STandard ARrival
SGHAT	Solar Glare Hazard Analysis Tool
TAR	Terminal Approach Radar
TAS	True Air Speed
THR	Threshold (Runway)
TNA	Turn Altitude
TODA	Take-Off Distance Available
VNAV	Vertical Navigation criteria
V_n	aircraft critical Velocity reference
VOR	Very high frequency Omni directional Range
WAC	World Aeronautical Chart