Appendix 27

Mount Emerald Wind Farm Aeronautical Assessment

Prepared by REHBEIN Airport Consulting

REHBEIN AIRPORT CONSULTING

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Mount Emerald Wind Farm Aeronautical Assessment

For Transfield Services (Australia) Pty Ltd

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1.0 EXECUTIVE SUMMARY

Transfield Services (Australia) Pty Ltd is proposing to locate up to 79 wind turbine generators at Mount Emerald near Atherton, Queensland. The site is located approximately 50 KM south west of Cairns Airport in the Tablelands Region and covers approximately 2,000 hectares. The turbine blade tips will be 129 m above ground level.

Civil Aviation Safety Regulation (CASR) 139.365 requires the proponent of a proposed structure *"…the top of which will be 110m or more above ground level…"* to notify the Civil Aviation Safety Authority (CASA) of their intention and to provide the proposed height and location of the building or structure. If the proposed obstacle, building or structure is deemed to be hazardous to aircraft operations CASA may direct the proponent to light or mark the hazard in accordance with the *Manual of Standards (*MOS Part 139 — *Aerodromes)*. CASA formerly provided guidance material on lighting of wind farms in Advisory Circular AC 139-18(0) *Obstacle Marking and Lighting of Wind Farms,* now withdrawn.

Following a recent risk review of man made objects located away from regulated aerodromes CASA is contemplating the development of a regulatory framework similar to that of the United States Federal Aviation Administration for marking and lighting of obstacles. The United States regulations define obstacles as buildings, objects and structures of 150m or more in height. In conjunction with rulemaking activity, CASA intends to review Advisory Circular 139-08(0) on reporting of tall structures and will consider reviewing the withdrawn Advisory Circular 139-18(0) on lighting of wind turbines to refer to lighting requirements for structures 150 metres or more above ground level. Updated guidance material is normally released with new regulations, following a process that may require two years to complete. However, guidance contained in AC 139-18(0) on lighting of wind turbines to fulfil duty of care obligations continues to be relevant.

This study considered in detail the likely impact of the location, height and blade rotation of the proposed wind turbines on the nearest aerodromes; air navigation and air traffic management services; transiting air routes; designated airspace such as Danger, Restricted or Prohibited areas; any other aviation activity; and electromagnetic interference (EMI) with airborne radio.

The proposed wind farm will not impact upon aircraft operations to and from Cairns Airport or Mareeba and Atherton Aerodromes. Nor will it interfere with airborne radio or navigation aid performance. Flights operating under the Visual Flight Rules (VFR) should not be affected by the proposed wind farm as these flights are required to be conducted at a minimum height of 500 ft above ground level outside populous areas and will be above the level of the turbines. The structures will be sufficiently conspicuous by day, and at night local en route lowest safe altitudes (LSALTs) will provide clearance required for flights under the Instrument Flight Rules (IFR) and night operations under the Visual Flight Rules (Night VFR).

Investigation undertaken by REHBEIN Airport Consulting suggests the impact, if any, of the proposed wind farm upon radar and radio performance in the region will not be of operational significance. However it would be prudent to confirm whether Airservices Australia has any concerns about the potential impact of the wind farm.

Low level flying operations such as agricultural aerial spreading and spraying operations or power transmission line inspections may be affected on the downwind side of the turbines over land on which the turbines are directly positioned, or over portions of some adjoining properties that are sited downwind from the turbines. This is due to wind shear, turbulence and downdrafts in the wake of the turbine rotors presenting a critical hazard to aircraft such as agricultural aircraft operating at low level and high weights during application of chemicals and seeding. However, agricultural spraying operations are normally conducted at very low levels and often require calm or very light wind conditions of less than 8 knots (15km/h). At these wind speeds it is reasonable to assume the wake can extend for a distance of 6 rotor diameters or 600m downwind of the nearest turbine based on the proposed rotor diameter of approximately 100m. Given the distances from wind turbines to cultivated areas of land on adjacent properties outside the wind farm boundary there should be minimal impact on agricultural aerial operations.

Apart from aerial agricultural operations over the wind farm the risk to civil aviation activities if any that this wind farm may pose is trivial. However, as with any reported tall structure that may pose a risk, regardless of its triviality, the position of the proposed wind farm should be shown on appropriate air navigation charts to assist pilots operating in the region. Additionally, hazard lighting in accordance with MOS 139, Chapter 9, Section 9.4 should be installed on sufficient turbines in the Mount Emerald Wind Farm to define the extremities of the site. The lighting should be operated in a manner consistent with a general duty of care towards aviation, such as during the period 1 hour before sunset to 1 hour after sunrise, and during conditions of reduced visibility caused by smoke, dust or haze. Implementation of such mitigation measures will ensure all the safeguards put in place by CASA to reduce the risk posed by tall structures, including wind turbines, to the safety of civil aircraft operations are satisfied.

2.0 INTRODUCTION

Transfield Services (Australia) Pty Ltd is proposing to locate wind generator towers at Mount Emerald near Atherton in Queensland and is seeking approval from the Queensland Government for their development. This assessment is intended to provide a sufficient level of detail to accompany a planning permit application.

The Mount Emerald Farm site is located approximately 50 KM south west of Cairns Airport in the Tablelands Region. The site location is shown in Appendix A. The nearest sizable towns are Atherton to the south east and Mareeba to the north with the country towns of Walkamin approximately 3 KM to the northeast and Tolga approximately 8 KM to the southeast.

The proposal is for a wind farm of 79 wind turbine generators (WTGs) with a maximum height of 129 metres above ground level, consisting of a mast 80 metres high and rotor blade length of 49 metres. The maximum height of the turbine blades will be approximately 3,869 ft AMSL.

As the proposed wind turbines will be greater than 110 metres in height, they must be reported to the Civil Aviation Safety Authority (CASA) for assessment of the risk the proposed structure may pose to civil aircraft operations. The Royal Australian Air Force (RAAF) also has an interest in assessing tall structures and it can be expected that CASA in its assessment will consider the impact upon military flying operations and if required, advice from the Australian Defence Force will be sought.

This aeronautical study has been carried out using the advice promulgated in CASA Advisory Circular AC 71-1(0), *Guidelines for Airspace Risk Management and Associated Aeronautical Study Methodology.*

3.0 LEGISLATIVE BACKGROUND

Under the provisions of the *Civil Aviation Act 1998,* the *Civil Aviation Regulations* (CAR) or the *Civil Aviation Safety Regulations* (CASR)*,* CASA is not empowered to approve or oppose the erection of structures on or near an aerodrome. If deemed necessary, CASA has limited power to order the removal of an object which is classified as an obstruction or hazardous to aircraft operations within 3,000m of an aerodrome (CAR 95).

CASR Part 139.E promulgates the requirements to be met in relation to obstacles and hazards. CASR 139.365 requires the proponent of a proposed structure *"…the top of which will be 110m or more above ground level…"* to notify CASA of their intention and to provide the proposed height and location of the building or structure.

In accordance with CASR 139.370 CASA may determine after conducting an aeronautical assessment that an obstacle, building or structure is, or will be hazardous to aircraft operations. If the proposed obstacle, building or structure is deemed to be hazardous to aircraft operations CASA may direct the proponent to light or mark the hazard in accordance with the *Manual of Standards (MOS) - Part 139 Aerodromes*. With respect to the lighting of wind farms CASA formerly provided guidance material in Advisory Circular AC 139-18(0) *Obstacle Marking and Lighting of Wind Farms,* subsequently withdrawn*.* Other means of providing lighting and / or marking can be proposed to CASA such as those detailed in advice from European agencies and the International Civil Aviation Organisation (ICAO).

Following a recent risk review of man made objects located away from regulated aerodromes, CASA is contemplating the development of a regulatory framework similar to that of the United States Federal Aviation Administration for marking and lighting of obstacles. The United States regulations define obstacles as buildings, objects and structures of 150m or more in height. In conjunction with rulemaking activity, CASA intends to review Advisory Circular 139-08(0) on reporting of tall structures and will consider reviewing the withdrawn Advisory Circular 139-18(0) on lighting of wind turbines to refer to lighting requirements for structures 150 metres or more above ground level. Guidance material is normally released with new regulations in a process that may require up to two years to complete. However, guidance contained in withdrawn AC 139-18(0) on lighting of wind turbines to fulfil duty of care obligations continues to be relevant.

CASA may determine that a particular activity is dangerous to aircraft operations and declare the area encompassing the activity a danger zone.

If a wind turbine is found to penetrate prescribed airspace surrounding an airport, it will be defined as an obstacle and shall be dealt with in accordance with the requirements set out in Chapters 7, 8 and 9 of the *Manual of Standards (MOS),* Part 139 – *Aerodromes*. If the aerodrome is used for night operations, lighting of the obstacle must be in accordance with the provisions of Chapter 9 of the MOS.

The legislative instruments protecting civil aircraft safety can be assumed to replicate the interests of the Australian Defence Force (ADF) aircraft operations and as such input from the ADF could be expected if the proposed activity has a potential impact on military flying operations. CASA may liaise with the RAAF Aeronautical Information Service (AIS) as that organisation maintains the tall structure database on behalf of the aviation community.

Likewise Airservices Australia, the provider of Air Traffic Control Services and Air Navigation Services has an interest in assessing proposed tall structures to ensure there is no impact upon the performance of ground based navigation aids and radar facilities.

4.0 METHODOLOGY

In carrying out the assessment REHBEIN Airport Consulting has considered the likely impact of the location, height and blade rotation of the proposed wind turbines on:

- The nearest aerodromes and:
  - the types of flying activities conducted there;
  - their airspace protection requirements established by the Obstacle Limitation Surfaces (OLS);
  - any existing aircraft instrument procedures published in the Aeronautical Information Publication – Departure and Approach Procedures (AIP-DAP); and
  - prescribed airspace;
- Air navigation and air traffic management services including:
  - radar; and
  - ground based navigation aids;
- Transiting air routes, including:
  - routes used by civil pilots operating under instrument flight rules (IFR);
  - routes used by civil pilots operating under visual flight rules (VFR); and
  - routes used by military aircraft;
- Designated Airspace such as Danger, Restricted or Prohibited areas;
- Any other aviation activity; and
- Electromagnetic interference (EMI) with airborne radio.

5.0 IDENTIFIED ISSUES

Each individual stakeholder will have differing concerns regarding a proposed development. Below is a breakdown of the stakeholder issues REHBEIN Airport Consulting has identified which are addressed in this aeronautical assessment.

5.1 CIVIL & MILITARY AIRCRAFT PILOTS

REHBEIN Airport Consulting has considered the effect of the proposed wind farm on aircraft transiting the region, arriving and departing from local aerodromes and on aircraft flying instrument approaches into Mangalore aerodrome. This consideration has addressed visual flight rules (VFR) and instrument flight rules (IFR) operations.

5.2 AIRPORT OPERATORS

REHBEIN Airport Consulting has assessed the aerodromes in close proximity to the proposed wind farm such as Mareeba Aerodrome and the Atherton ALA including the types of flying activities conducted at each.

5.3 AIRSERVICES AUSTRALIA

REHBEIN Airport Consulting has undertaken an assessment of the impact of the proposed wind farm on the performance on both ground based navigation aids and radar facilities.

5.4 OTHER AVIATION ACTIVITY

5.4.1 AERIAL APPLICATION

REHBEIN Airport Consulting has undertaken an assessment of the likely type of agricultural activities conducted in the area of the proposed wind farm and the impact of the turbines on aerial agricultural operations.

5.4.2 RECREATIONAL AVIATION

Given the proximity to Mareeba Aerodrome and Atherton ALA, consideration has been given to the effect of the proposed wind farm on recreational aviation and flying training in the region.

6.0 POTENTIAL RISKS TO AVIATION ACTIVITIES

As with any proposed obstacle, building or structure, wind turbines must be assessed for any potential hazard/risk to aircraft operations.

6.1 AIRSPACE AROUND AERODROMES

There are two key airspace surfaces which may be relevant dependent on the category of operations into the aerodrome.

6.1.1 OBSTACLE LIMITATION SURFACE (OLS)

The OLS is a set of imaginary surfaces associated with an aerodrome. They define the volume of airspace that should ideally be kept free from obstacles in order to minimise the danger to aircraft during an entirely visual approach or during the final visual segment of an instrument approach procedure. These surfaces are of a permanent nature and comprise the reference datum which defines an obstacle. Anything above the vertical limits of the OLS is regarded as an obstacle. Obstacles are reported so that CASA can determine if they are “hazardous” and therefore need to be marked and/or lit to ensure they are prominently identified.

Airspace requirements will depend on the nature and scale of activities at an aerodrome but could extend to a radius of 15 KM. The OLS also need to be considered in relation to both current and future aerodrome developments and activities.

Wind turbines may be acceptable in the areas covered by the OLS but will need to be assessed in relation to critical manoeuvres such as the approach to land and possible low level missed approaches, and a reduced power take-off following an engine failure.

6.1.2 PANS-OPS SURFACES

Airspace associated with aircraft instrument approach and departure procedures is defined by the PANS-OPS surfaces for an aerodrome. These surfaces are ascertained in accordance with the criteria in the International Civil Aviation Organisation (ICAO) *Procedures for Air Navigation Services – Aircraft Operations* (Doc 8168, PANS-OPS).

The PANS-OPS surfaces are intended to safeguard an aircraft from collision with obstacles when the pilot is flying by reference to instruments. The designer of an instrument procedure determines the lateral extent of areas needed for an aircraft to execute a particular manoeuvre. The designer then applies minimum obstacle clearance to structures, terrain and vegetation within that area to determine the lowest altitude at which the manoeuvre can be safely executed. As a result, PANS-OPS surfaces cannot be infringed in any circumstances.

These airspace requirements will depend on the nature and scale of activities at an aerodrome but could determine the acceptable obstacle heights to a radius of 10 - 20 KM from the aerodrome.

6.2 RADAR

Tall structures may interfere with electromagnetic transmissions. Steel towers and rotating turbine blades can cause reflection and/or deflection of radiated waves and cause interference with aviation communication, navigation and surveillance (CNS) systems established for air traffic management. The CNS system includes aerodrome based and enroute navigation aids (navaids) and radar used for air traffic control at an aerodrome and/or enroute surveillance.

Two types of radar are used for air traffic control (ATC) and surveillance – primary radar and secondary surveillance radar (SSR).

Primary radar works by radiating electromagnetic energy and detecting a return signal from reflecting objects. Comparison of the return signal with the original transmission provides information such as the direction and range of the target from the radar site. ATC radars are designed to filter returns from stationary objects to avoid moving targets, primarily aircraft, being obscured by radar clutter. Other than this means of differentiating between stationary and moving targets, primary radar cannot tell the type of object and has no means of determining the height of the object.

SSR emits radio frequency (RF) interrogation messages that trigger automatic responses from a “transponder” onboard an aircraft. The transponder reports aircraft identification and altitude.

The blades of a wind turbine may be detected if within the coverage and line of sight of primary radar. A grouping of blades will return intermittent reflections that create the impression of a moving target. Since the primary radar gives no height information, reflections from wind turbine blades may cause an air traffic controller to divert aircraft which may be in the vicinity of the wind farm within primary radar coverage regardless of their flight level.

The turning blades may also reflect or deflect the primary radar signals and prevent aircraft flying in their “shadow” from being detected. In this case the co-located SSR would also detect the aircraft but even then the reflection of SSR transmissions in some instances could cause the aircraft to be wrongly identified or its position to be inaccurately shown on ATC radar.

Weather radar can similarly be affected, and this too impacts on flight safety which relies on accurate forecasting of major weather events and wind shear at higher altitudes.

6.3 RADIO NAVIGATION AIDS

Ground based radio navigation aids could suffer from similar reflection and deflection effects as with radar. The effect of this may be that an aircraft is not tracking accurately towards the aid on the designated air route. This false tracking can cause the aircraft to deviate too far from the intended flight track and expose it to obstacles which infringe on the clearances defined in the design of the particular flight procedure in instrument conditions. Similarly, visually navigated

aircraft may track erroneously due to a conflict of navigation data available from maps and navigation aids.

Line of sight principles again apply but this type of facility will normally be protected by preventing new structures if they will extend above an elevation angle of 1º as seen from the site of the radio navigation aid.

This means that on level ground a 129 m high wind turbine could be safely located at around 7.5 KM from the site of the aid.

6.4 INSTRUMENT & VISUAL FLIGHT RULES

6.4.1 INSTRUMENT FLIGHT RULES (IFR)

Aircraft operating under IFR are navigated by reference to cockpit instruments which process data from aircraft systems, ground-based navaids or satellites. All regular public transport (RPT) jet aircraft operating into or between major Australian cities operate only in controlled airspace and under IFR.

In contrast, turboprop or piston engined regional RPT aircraft travelling to or from a regional city may operate route sectors outside controlled airspace (OCTA) and even under VFR.

Charter and business aircraft may operate in controlled airspace under IFR or VFR, or OCTA under VFR. General aviation training aircraft are most likely to operate under VFR. Military aircraft may operate anywhere and may be flying at very low levels.

Aircraft operating under IFR may do so either OCTA or within controlled airspace. If flying below 10,000 ft pilots must select, or will be assigned, cruising altitudes which are multiples of 1,000 ft – odd thousands if their track is 0 ºM - 179ºM and even thousands if their track is 180 ºM - 359ºM. IFR traffic must select or be assigned to a designated air route depicted on air navigation charts.

Since IFR pilots may be relying solely on cockpit instruments and have no outside visual reference, a lowest safe altitude (LSALT) is published for each air route. It is determined by adding 1,000 ft minimum vertical clearance to the highest terrain or known structure enroute.

It is conceivable that a new wind farm, if located on prominent terrain, may require an increase in LSALT for a particular air route.

6.5 VISUAL FLIGHT RULES (VFR)

Aircraft operating under VFR may do so only in visual meteorological conditions (VMC) defined as an average range of visibility of 5,000 m forward of the cockpit, horizontal cloud clearance of 1,500 m and vertical cloud clearance of 1,000 ft.

VFR traffic is most likely to operate OCTA but may fly in Class E controlled airspace without reference to ATC. VFR pilots may fly a designated air route in which case they must select

altitudes which are multiples of 500 ft - odd thousands plus 500 ft if their track is 0 - 179ºM and even thousands plus 500 ft if their track is 180 - 359ºM. This rule ensures there should be a minimum 500 ft separation between IFR and VFR traffic using the same air route.

The minimum statutory height for VFR flight is 500ft above ground level or clear of obstacles in non-populous areas. Night VFR pilots must fly at or above the LSALT for the route. Night VFR pilots must use either a published LSALT for the area or if on a dead reckoning (DR) track then a calculated LSALT taking into account obstacles and terrain within 10 NM of the nominated track.

VFR traffic in daylight hours is not confined to air routes and these aircraft may operate anywhere provided they do so in VMC and observe the same rules for selecting their cruising altitude.

In these conditions wind farms should be easily visible and have no impact on VFR flying activity.

6.6 MILITARY LOW FLYING

Military pilots must conduct low level flying training so that the skill becomes second nature. Low level flying exercises are carried out by military aircraft from a number of Defence aerodromes. Routes at or below 5,000 ft AGL used by military jet aircraft for low level, high speed navigation or terrain following exercises are designated as Military Low Jet Routes (MLJR).

Routes are planned to avoid controlled airspace, civil restricted areas and danger areas, civil aerodromes by at least 5 NM laterally and 4000 ft vertically, and CTAF airspace unless aircraft are equipped with the appropriate radio frequency.

Routes and duration of MLJR operations are advised by the Notice to Airmen (NOTAM) system. This policy means that MLJRs are more flexible and new installations such as wind farms would be considered by the Australian Defence Force (ADF) when planning low level flights.

6.7 DESIGNATED AIRSPACE

Special use airspace, extending to varying heights, is defined on air navigation charts and identified as P (Prohibited), R (Restricted) or D (Danger). For safety reasons flight into this airspace may be prohibited or restricted or the airspace may be designated as a danger area to warn pilots to take additional care.

Wind turbines will not be permitted within prohibited or restricted areas as these are usually set aside for military training, weapons firing or security sensitive structures.

Danger areas will usually relate to mining or quarrying sites, chimneys or stacks with high velocity or high temperature discharges, special aviation activities such as aerobatic training and the like. While pilots may elect to avoid these areas there is no restriction on entry.

Wind turbines may not be compatible with some activities conducted within a designated Danger Area but, more importantly, CASA may elect to designate a Danger Area around a wind farm in order to alert pilots to avoid low altitude flying.

6.8 OTHER AVIATION ACTIVITIES

Special use areas for hang-gliding, parachuting or radio controlled model aircraft flying are marked by symbols on air navigation charts. Although these do not usually justify the designation of a Danger Area the symbol serves to alert pilots to over-fly these sites at a safe height. Since a wind farm shares low level airspace it could seriously curtail these types of recreational activities. Wind farms are now being indicated on charts by a symbol in the same manner.

6.9 ELECTROMAGNETIC INTERFERENCE WITH AIRBORNE RADIO

Large scale power generation activities may cause electromagnetic interference (EMI) with on-board radio communication equipment in aircraft overflying and/or flying in the vicinity of the wind farm.

The available literature indicates that this effect may be considered negligible because of the standards which apply to wind turbine construction. Wind turbines have been installed world wide with very few instances of EMI being recorded.

7.0 AERONAUTICAL RISK ASSESSMENT

Having considered the potential risks to aviation activities as outlined in Section 6.0 as part of an overall analysis of the proposed wind farm, the following risk assessments are detailed.

7.1 AERODROMES

The proposed Mount Emerald Wind Farm is located approximately 7 NM (13 KM) northwest of the Atherton ALA, and 5 NM (10 KM) southwest of Mareeba Aerodrome.

Each aerodrome is serviced by a Common Traffic Advisory Frequency (CTAF). Pilots are encouraged to communicate with each other on the relevant CTAF when operating within 10 NM of the Atherton ALA or Mareeba Aerodrome.

Lower level controlled airspace in the area of the proposed wind farm is well above the planned heights for the wind turbines. Airspace in the Mount Emerald region is Class G and is not controlled (i.e. not subject to Air Traffic Control clearances / separation) below 6,500 ft between 22 and 36 NM by DME from Cairns. ATC may provide a Flight Information Service (FIS) in Class G airspace if resources allow. VFR aircraft operating in Class G airspace are not required to maintain radio contact below 5,000 ft or to operate with a serviceable transponder below 10,000ft.

7.1.1 ATHERTON ALA

Atherton ALA is located approximately 2 KM east of Atherton. The ALA is owned and operated by Tablelands Regional Council and consists of a single natural surface runway. Runway 15/33 is 1,160 m long and 30 m wide. The ALA caters for light general aviation activity only.

Since the greatest extent of the OLS for any ALA is 900m, the proposed height and location of the turbine structures will not infringe the OLS for Atherton ALA.

There are no published aircraft instrument procedures for Atherton ALA.

7.1.2 MAREEBA AERODROME

Mareeba Aerodrome is a certified aerodrome owned and operated by Tablelands Regional Council. The aerodrome is located approximately 7 KM south of Mareeba and has one sealed runway. Runway 10/28 is 1,505 m long and 30 m wide.

Mareeba currently caters to general aviation and helicopter aircraft activity with many serving the mining and agricultural industries and supplying remote communities. In addition, ultra light and manned balloon operations are conducted at the aerodrome. A draft Mareeba Airport Development Plan has been produced and a $13 million upgrade is planned to improve facilities and encourage increased usage as well as promote the aerodrome to pilot training schools.

The aerodrome is currently not equipped with any radio navigation aids however the Biboohra VHF omni-directional range (VOR) is located approximately 9 NM to the north of the aerodrome.

Mareeba Aerodrome is served by non-precision VOR–A and RNAV (GNSS) aircraft instrument procedures. The minimum descent altitude for the RNAV approach to Runway 10 is 2,390 ft and the missed approach procedure requires a climbing left turn onto (340°M), away from the wind farm site. The wind farm will not affect this procedure.

The minimum descent altitude for the VOR-A approach procedure is 3,160 ft and the missed approach procedure requires a climb on 170°M to 5,800 ft. The highest terrain to the south west of Walkamin in the vicinity of the proposed site is shown as 3,681 ft above mean sea level (AMSL) approximately 9 NM south of the missed approach point for the VOR-A procedure Assuming the standard missed approach gradient of 2.5% the worst case missed approach climb would put aircraft at approximately 4,380 ft AMSL over the wind farm site. As the blade zenith of the highest WTG will be 3,869 ft AMSL the VOR-A approach procedure will be unaffected by the proposed wind farm.

The runway at Mareeba Aerodrome is currently a Code 3 non-precision runway. The critical OLS in relation to the proposed wind farm are the approach and departure surfaces which extend out from the runway strip ends and diverge away from the runway centreline. For Mareeba Aerodrome these surfaces extend out 15 KM, which is the greatest extent for any aerodrome. As a result of the runway orientation there are no proposed wind turbines under the approach and departure surface and the proposed height and location of the turbine structures will not infringe the OLS.

7.2 PRESCRIBED AIRSPACE

Cairns Airport is approximately 25 NM (47 KM) north east of the proposed wind farm site. Cairns Airport is a Commonwealth leased airport and protected by prescribed airspace. Prescribed airspace consists of OLS and Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS) surfaces for the airport.

Since the greatest extent of the OLS for any aerodrome is 15 KM the proposed height and location of the turbine structures will not infringe the OLS for Cairns Airport.

The PANS-OPS surfaces for Cairns Airport lie within a 25 NM radius of the airport. The outer edge of the protection surface for the 25 NM Minimum Safe Altitude (MSA) of 6,500 ft AMSL is close to the wind farm site but the required minimum obstacle clearance will not be infringed. Other protection surfaces are distant from the wind farm site. Therefore the wind farm need not be considered in relation to prescribed airspace for Cairns Airport.

7.3 RADAR, COMMUNICATIONS, AND RADIO NAVIGATION AIDS

7.3.1 RADAR AND COMMUNICATIONS

The nearest radar is the Cairns SSR approximately 15 NM north of the proposed wind farm site on the Hann Tableland. The proposed wind farm is below the 0.5° protection surface for the radar outlined in the MOS Part 139 and should not affect its operation.

Primary radar and SSR facilities located adjacent to Cairns Airport are approximately 30 NM southeast of the proposed wind farm and therefore the wind farm will not affect the performance of radar, navigation, and communications facilities at the airport.

Additionally, the wind farm will not affect the Bellenden Kerr Communications Facilities.

It would nevertheless be prudent to confirm if Airservices Australia are concerned about possible impact on services in Class G airspace which may need to be evaluated by detailed investigation and/or modelling.

7.3.2 NAVAIDS

The Biboohra VHF omni-directional range (VOR) is located approximately 13 NM to the north of the proposed site and on that basis its intended operation will not be affected by the wind farm.

7.4 TRANSITING AIR ROUTES

7.4.1 IFR AIR ROUTES

The Atherton Tablelands Region area has spot heights of 3087, 3681 and 3156, and 3760 ft on the VNC. The maximum height of the turbine blades will be approximately 3869 ft AMSL. The only IFR air route passing over the site has a LSALT of 5700 ft and will not be physically affected by the proposed wind farm.

In regard to likely future marking and lighting requirements, the maximum recommended turbine blade zenith is 129 metres above ground level. This height is beneath the envisaged mandatory height of 150 metres AGL foreshadowed by CASA for future marking and lighting of tall structures away from aerodromes.

7.4.2 VFR AIR ROUTES

There are no published VFR routes in the vicinity of the proposed wind farm site. Aircraft approaching Cairns from the west will elect to track via the Mareeba Aerodrome and Atherton ALA approach points and avoid flying directly overhead the wind farm.

CASA has indicated in its Advisory Circular AC 139-18(0) Obstacle Marking and Lighting of Wind Turbines (see Section 5) that wind turbines are sufficiently conspicuous by day not to require painting in obstacle marking colours and/or patterns to alert VFR pilots.

As noted earlier, when flying a designated IFR route, night VFR traffic is required to fly at an appropriate cruising level above the published LSALT which, in this case, is at least 5700 ft. This height is beneath the envisaged mandatory height of 150 metres AGL foreshadowed by CASA for future marking and lighting of tall structures away from aerodromes.

The proposed wind turbines will have no impact on VFR flying activity.

7.4.3 MILITARY LOW FLYING OPERATIONS

The Department of Defence (DoD) should be informed of the wind farm proposal and any wind monitoring towers and other associated infrastructure of height. Early consultation is recommended before the planning permit application process. This will allow the Department time to undertake a formal assessment of the likely impact of the wind farm on military flying operations and on military aviation infrastructure including communications. To assess the proposal the following information will need to be provided to the DoD:

- Location map showing the wind farm land boundary, locations of WTGs and other infrastructure (i.e. wind monitoring masts, concrete batching plants, overhead wires etc.) and their orientation in relation to populated areas in the vicinity;
- WTG tower and blade dimensions; and
- WTG and associated infrastructure elevations.

The information can be forwarded to:

Brenin Presswell
Executive Officer, Land Use Planning
Estate Planning Branch - Infrastructure Division
Department of Defence
P: 02 6266 8138
F: 02 6266 8294
lpsi.directorate@defence.gov.au

RAAF Aeronautical Information Services (RAAF AIS) is informed of any structure taller than 30 m AGL prior to construction and again once construction is complete. This will enable monitoring masts, turbines, etc to be appropriately charted and help maintain safe flying. The RAAF AIS website at http://www.raafais.gov.au/ includes a form for submission of this data.

7.4.4 RESTRICTED AREAS

The proposed site is not near any restricted areas.

7.5 OTHER AVIATION ACTIVITY

7.5.1 AERIAL AGRICULTURAL OPERATIONS

It is assumed there is low or no requirement for aerial application of chemicals in the vicinity of the proposed wind farm as the proposed site is located on elevated undeveloped land. Nevertheless, it should be noted that low level flying operations such as agricultural aerial spreading and spraying operations or power transmission line inspections may be affected on the downwind side of the turbines over land on which the turbines are directly positioned, or over portions of some adjoining properties that are sited downwind from the turbines. This is due to wind shear, turbulence and downdrafts in the wake of the turbine rotors presenting a critical hazard to aircraft such as agricultural aircraft operating at low level and high weights during application of chemicals and seeding.

Studies suggest that a wake length equivalent to 6 times the rotor diameter is considered a minimum in wind conditions of 10-15 knots (18-28 km/h)[1]. When the wind turbines are operating in winds of 15 knots (28 km/h) or greater the wake from a single turbine is still prevalent at 10 blade diameters and can persist for up to 16 blade diameters downwind of the turbine. The majority of modern wind turbines reach their maximum output, and in theory, generate the strongest wake turbulence in wind speeds of approximately 47km/h. At this speed, and in combination with the wake produced by other turbines, the wake may exist up to 5km downstream from a large turbine cluster of several rows.

Agricultural aerial spreading and spraying operations are normally conducted at very low levels and often require calm or very light wind conditions of less than 8 knots (15km/h). At these wind speeds it is reasonable to assume the wake can extend for a distance of 6 rotor diameters or 600m downwind of the nearest turbine based on the proposed rotor diameter of approximately 100m. Given the distances from wind turbines to cultivated areas of land on adjacent properties outside the wind farm boundary there should be minimal impact on agricultural aerial operations during the periods of wind speeds at which these aircraft operate.

7.5.2 SPORT AVIATION

Symbols on navigation charts show that parachuting may occur around Mareeba.

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[1] L.J Vermeer, J.N. Sorenson, A Cresp, *Wind Turbine Wake Aerodynamics,* Progress in Airspace Sciences 39 (2003).

Hand M, Simms D, Finger L, Jager D, Coteril J, Schreck S, Larwood S *Unsteady aerodynamics experiments phase VI: Wind tunnel test configuration and available data campaigns.* Technical Report BREL/TP-500-29955, NREL (December 2001).

Wind Turbine Wakes – Control and Vortex Shedding by Davide Medici. Technical Reports from KTH Mechanics Royal Institute (2004)

These activities should not be adversely affected by the proposal as they are remote from the proposed wind farm site.

7.6 ELECTROMAGNETIC INTERFERENCE WITH AIRBORNE RADIO

Available literature indicates that this effect may be considered negligible because of the standards which apply to wind turbine construction. Wind turbines have been installed world wide with very few instances recorded of EMI affecting aircraft radio systems.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The proposed wind farm will not impact upon aircraft operations to and from Mareeba Aerodrome and the Atherton ALA. Nor will it interfere with airborne radio or navigation aid performance.

Analysis undertaken by REHBEIN Airport Consulting indicates that there will be no impact upon IFR traffic transiting the area. Traffic operating under the VFR should not be affected by the proposed wind farm as the structures will be sufficiently conspicuous by day, and en route LSALTs will provide adequate clearance from the turbines for Night VFR operations.

It would be prudent to confirm whether Airservices Australia has any concerns about the impact of the proposed wind farm upon radar and radio performance in the region although investigation undertaken by REHBEIN Airport Consulting suggests the impact, if any, will not be of operational significance. Early consultation is recommended in order to provide an opportunity for any objections to be addressed before the planning permit application process and to avoid delays during final planning. Apart from site plans and location of the proposed wind farm, Airservices Australia requires the following information to complete technical and operational assessments:

- Exact dimensions of proposed structures (turbine or wind monitoring mast).
- Maximum blade tip heights in AHD (Australian Height Datum) and above ground height for each turbine.
- The exact location including coordinates and datum for each turbine/wind monitoring mast extracted by survey:
  - Accurate Coordinates in latitude/longitude (Degrees, Minutes, Seconds)
  - Datum – WGS84 (or MGA94 can be received)
- A description of each structure to be built, including details of proposed external cladding materials, and proposed use (in this case, wind monitoring mast or wind turbine).
- Where possible, MicroStation .dgn files or AutoCAD .dwg files.

It is also advisable to provide an opportunity for the Department of Defence to comment formally during the planning permit application process as outlined in Section 7.4.3. Early consultation is recommended to provide an opportunity for any objections to be addressed before the planning permit application process begins.

A discussion with the Tablelands Regional Council is recommended to gain an understanding of their plans for development and expansion at Mareeba Aerodrome.

Low level flying operations such as agricultural aerial spreading and spraying operations or power transmission line inspections may be affected on the downwind side of the turbines over land on which the turbines are directly positioned, or over portions of some adjoining properties that are

sited downwind from the turbines. This is due to wind shear, turbulence and downdrafts in the wake of the turbine rotors presenting a critical hazard to aircraft such as agricultural aircraft operating at low level and high weights during application of chemicals and seeding. However, agricultural spraying operations are normally conducted at very low levels and often require calm or very light wind conditions of less than 8 knots (15km/h). At these wind speeds it is reasonable to assume the wake can extend for a distance of 6 rotor diameters or 600m downwind of the nearest turbine based on the proposed rotor diameter of approximately 100m. Given the distances from wind turbines to cultivated areas of land on adjacent properties outside the wind farm boundary there should be minimal impact on agricultural aerial operations during the periods of wind speeds at which these aircraft operate.

Aviation legislation does not require Transfield to consult with land owners in the vicinity of the proposed wind farm in regard to its likely impact on the conduct of aerial agricultural operations. However, Transfield may wish to initiate this consultation during early planning to determine the extent of reliance on agricultural aviation for seeding, spreading or weed control in the area and if any impact could be expected.

CASA currently allows fixed structures up to 110 m AGL without marking, lighting or advice to the aviation industry. These structures could be located anywhere and be any shape, size, colour or number. In this instance Transfield Services Pty Ltd proposes structures that are substantially higher at 129 metres above ground level, concentrated in a defined area, conspicuous because of their shape and colour and unlikely, on the basis of this preliminary investigation, to pose a hazard to aviation. In this case, apart from aerial agricultural operations over the wind farm the risk to civil aviation activities if any that this wind farm may pose is trivial.

However, as with any reported tall structure that may pose a risk, regardless of its triviality, the position of the proposed wind farm should be shown on appropriate air navigation charts to assist pilots operating in the region. Additionally, medium intensity hazard lighting in accordance with MOS 139, Chapter 9, Section 9.4 should be installed on sufficient turbines in the Mount Emerald Wind Farm to define the extremities of the site. Where clusters are widely separated this may entail lighting the turbine at the end of each cluster and one at or near the centre so clusters are well defined from the air. A detailed lighting plan should be submitted to CASA for comment. The lighting should be operated in a manner consistent with a general duty of care towards aviation, such as during the period 1 hour before sunset to 1 hour after sunrise, and during conditions of reduced visibility caused by smoke, dust or haze.

The foregoing recommendation concerning lighting is made pending rulemaking action by CASA concerning man-made objects located away from aerodromes. In regard to objects that are deemed to be obstacles outside the obstacle limitation surfaces of an aerodrome, CASA has foreshadowed an increase in the height of such objects from 110 metres to 150 metres above ground level. Objects 150 metres or more above ground level will require obstacle lighting unless an aeronautical study can show that an object will not be an obstacle. Objects not exceeding 150

metres in height may require some lighting to discharge duty of care obligations to aviation operators

Revisions to associated guidance material are likely to include reissue of CASA Advisory Circular AC139-18(0), *Obstacle Marking and Lighting of Wind Farms* updated to incorporate advice on providing obstacle lighting for structures 150 metres or more above ground level.

9.0 SOURCES OF INFORMATION

Aircraft Owners and Pilots Association, Airfields 2008/09

Airservices Australia, Aeronautical Information Publication – Departure and Approach Procedures, Amendment 127, 02 June 2011

Airservices Australia, Aeronautical Information Publication – Enroute Supplement Australia, 02 June 2011

Airservices Australia, Designated Airspace Handbook, 02 June 2011

Airservices Australia, Visual Terminal Chart – Cairns 02 June 2011

Airservices Australia, En Route Chart (ERC) Low – L4 Brisbane/Townsville, 02 June 2011

Airservices Australia, En Route Chart (ERC) High – L4 Brisbane/Townsville, 02 June 2011

Airservices Australia, World Aeronautical Chart (WAC) – Townsville (3219), 02 June 2011

Airservices Australia, Terminal Area Chart (TAC) – TAC-1 Cairns/Brisbane/Townsville, 02 June 2011

CASA Advisory Circular AC139-18(0) (Draft), 21 June 2004

CASA Manual of Standards, Part 139 – Aerodromes, Version 1.5 May 2010

CASA Visual Flight Rules Guide, 24 September 2010

Civil Aviation Safety Regulation 139

Defence (Areas Control) Regulations

Wind Energy, Defence and Civil Aviation Interests Working Group, (UK) Wind Energy and Aviation Interests - Interim Guidelines, 2002

10.0 ABBREVIATIONS

AC	Advisory Circular
AGL	Above Ground Level
AIP-DAP	Aeronautical Information Publication – Departure and Approach Procedures
AIP-ERSA	Aeronautical Information Publication – En route Supplement Australia
AIS	Aeronautical Information Service
AMSL	Above Mean Sea Level
R-AOS	Rehbein AOS Airport Consulting
ATC	Air Traffic Control
CAR	Civil Aviation Regulations
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulations
CTAF	Common Traffic Advisory Frequency
CTR	Control Zone
DoD	Department of Defence
EMI	Electromagnetic Interference
IFR	Instrument Flight Rules
LSALT	Lowest Safe Altitude
M	Magnetic
MLJR	Military Low Jet Routes
MOS	Manual of Standards
Navaids	Navigation aids
NDB	Non Directional Beacon
NM	Nautical Miles
NOTAM	Notice to Airmen
OCTA	Outside Controlled Airspace
OLS	Obstacle Limitation Surfaces
PANS-OPS	Procedures for Air Navigation Services – Aircraft Operations
RF	Radio Frequency
RIS	Radar / ADS-B Information Service
RPT	Regular Public Transport
RSR	Route Surveillance Radar

SSR	Secondary Surveillance Radar
TAR	Terminal Area Radar
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VNC	Visual Navigation Chart
VOR	VHF Omni Directional Radio Range

11.0 GLOSSARY OF TERMS

Advisory Circular (AC): Advisory documents issued by CASA suggesting preferred methods for complying with the CASR. The advice contained in the AC is meant to be read in conjunction with the CASR and Manual of Standards.

Aeronautical Information Publication (AIP): A publication issued by or with the authority of a State and containing aeronautical information of a lasting nature essential to air navigation. The AIP for Australia and its Territories is published under Section 8 of the *Air Services Act 1995.*

Aeronautical Information Service (AIS): A service provided by AA to collect, collate, edit and publish aeronautical information.

Air route: The navigable airspace between two points and the terrain beneath such airspace identified, to the extent necessary, for application of flight rules.

Air traffic control (ATC): A service established by Airservices Australia pursuant to section 8 of the *Air Services Act 1995*. ATC functions are chiefly to prevent collisions between aircraft (and on the manoeuvring area, between aircraft and obstructions), and to expedite and maintain an orderly flow of air traffic.

Civil Aviation Advisory Publication (CAAP): Advisory documents issued by CASA suggesting preferred methods for complying with the CAR and CASR. The advice contained in the CAAP is meant to be read in conjunction with the CAR, CASR and Manual of Standards.

Civil Aviation Regulations (CAR): Regulations made by the Governor-General under the *Civil Aviation Act 1988*.

Civil Aviation Safety Regulations (CASR): Regulations made by the Governor-General under the *Civil Aviation Act 1988*.

Common traffic advisory frequency (CTAF): A frequency for pilots to exchange traffic information while operating to or from an airport without an operating control tower, or within a designated area.

Controlled airspace: Airspace of defined dimensions within which ATC service is provided to controlled flights. A control area or control zone.

Danger area: An airspace of defined dimensions within which activities dangerous to the flight of aircraft may exist at specified times.

Departure and approach procedures (DAP): An aeronautical information publication (AIP-DAP) which contains aerodrome/landing charts, instrument approach and landing procedures, standard instrument departures, DME or GPS arrivals and noise abatement procedures.

En route Supplement Australia (ERSA): This AIP supplement (AIP-ERSA) is a joint military/civil publication containing the aerodrome and facility directory for military aerodromes and civil public aerodromes. ERSA contains aerodrome diagrams (ADDGM) and other information such as physical characteristics, visual ground aids, aeronautical lights, MBZ and CTAF boundaries.

General aviation (GA): All civil aviation operations other than RPT operations.

IFR operation: An operation conducted in accordance with the Instrument Flight Rules prescribed in Part XII of the Civil Aviation Regulations. These operations (landings and take-offs at an airport) are made in periods of inclement weather and poor visibility and under these conditions, positive control on approach and climb-out is maintained by the use of electronic navigational aids.

Instrument approach procedure: A series of pre-determined manoeuvres by reference to flight instruments with specified protection from obstacles from the initial approach fix, or where applicable, from the beginning of a defined arrival route, to a point from which a landing can be completed and thereafter, if a landing is not completed, to a position at which holding or en-route clearance criteria apply. The approved procedure to be followed by aircraft in letting down from cruising level and landing at an aerodrome.

Instrument flight rules (IFR): A set of rules, as outlined in Part XII of the CAR, governing the conduct of flight under instrument meteorological conditions (IMC). See also "IFR operation".

Instrument meteorological conditions (IMC): Meteorological conditions expressed in terms of visibility, distance from cloud and ceiling less than minima specified for visual meteorological conditions (VMC).

Lowest safe altitude (LSALT): The lowest altitude that will provide safe terrain clearance at a given place.

Nautical mile (NM): A length of 1 852 metres.

Navigation aid: A ground based or airborne facility or equipment relying primarily on the transmission/reception of radio or radar signals to provide information used to determine the location of an aircraft. Navaids are designed to be used either for en-route navigation or to assist in approach and landing in reduced visibility conditions.

Non-directional beacon (NDB): A ground radio station emitting continuous signals and providing an omni-directional radiating pattern which is used in conjunction with airborne ADF equipment to provide directional guidance to aircraft.

Notice To Airmen (NOTAM): A notice containing information 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. NOTAM are published under Section 8 of the *Air Services Act 1995*.

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 which extend above a defined surface intended to protect aircraft in flight. See also "obstacle limitation surfaces (OLS)".

Obstacle lights: Lights mounted on or adjacent to obstacles or potential hazards to aircraft moving on the ground or in the navigable airspace, for the purpose of indicating the obstructions or hazards by night.

Obstacle limitation surfaces (OLS): A series of planes associated with each runway of an airport, or the airport itself, which define the desirable limits to which objects may project into the airspace around the airport. Objects penetrating an OLS are defined as obstacles and may need to be marked and/or lit in accordance with CASA requirements.

PANS-OPS criteria: Specifications in ICAO *Procedures for Air Navigation Services —Aircraft Operations* (Doc 8168, PANS-OPS) for obstacle assessment or identification and allowances for minimum obstacle clearance used in the design of each stage of an instrument departure or approach procedure.

Primary radar: A radar system which uses reflected radio signals.

Prohibited area: An airspace of defined dimensions, above the land areas or territorial waters of a State, within which the flight of aircraft is prohibited.

Radar: A radio detection device which provides information on range, azimuth and/or elevation of objects.

Regular public transport (RPT): The transport of persons generally, or cargo for persons generally, for hire or reward in accordance with fixed schedules and to and from fixed terminals over specific routes.

Restricted area: airspace of defined dimensions, above the land areas or territorial waters of a State, within which the flight of aircraft is restricted in accordance with certain specified conditions.

Route: A way to be taken in flying from a departure to a destination airport, specified in terms of track and distance for each route segment.

Route surveillance radar (RSR): long range radar which is used for en route surveillance by ATC personnel.

Secondary surveillance radar (SSR): A system of secondary radar using ground transmitters/receivers (interrogators) and airborne transponders.

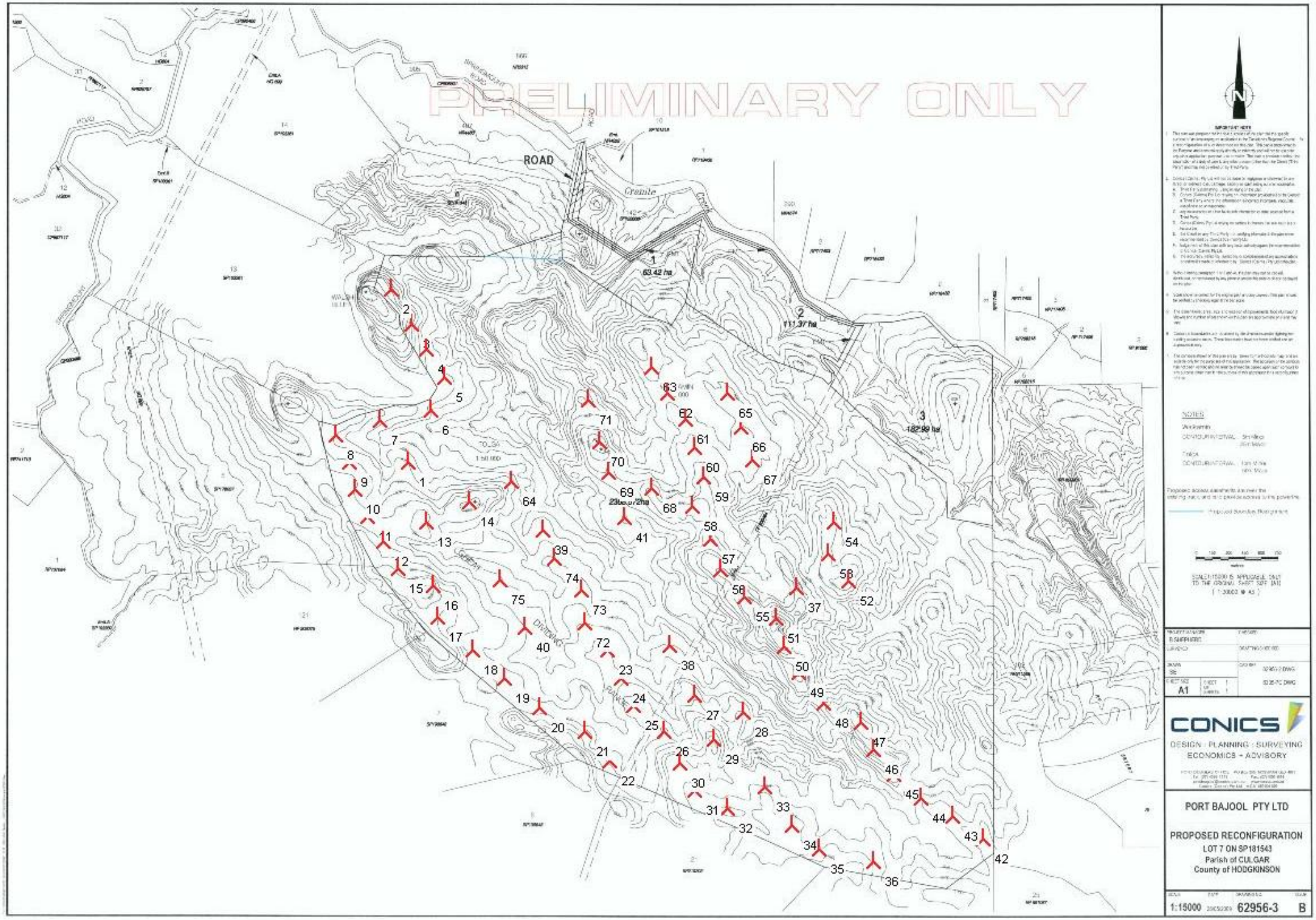
Terminal area radar (TAR): High definition radar used for air traffic control purposes in the terminal area.

VHF omni-directional radio range (VOR): A VHF radio navigation aid which provides a continuous indication of bearing from the selected VOR ground station. It provides 360 degree radial tracks to the beacon corresponding to the points of the magnetic compass and which may selected at one degree intervals by the pilot.

Visual flight rules (VFR): Rules of flight to permit operations on a see and be seen basis in visual meteorological conditions (VMC). These rules are prescribed in Part XII of the CAR.

APPENDIX A

SITE LAYOUT


PRELIMINARY ONLY
ROAD
Granite
1
63.42 ha
2
111.37 ha
3
182.99 ha
NOTES
PROJECT MANAGER
D.SHEPHERD
A1
CONICS
DESIGN · PLANNING · SURVEYING
ECONOMICS + ADVISORY
PORT BAJOOL PTY LTD
PROPOSED RECONFIGURATION
LOT 7 ON SP181543
Parish of CULGAR
County of HODGKINSON
1:15000
62956-3
B

REHBEIN Airport Consulting

APPENDIX B

WIND TURBINE SITE ELEVATIONS

WIND TURBINE SITE	EASTING	NORTHING	SITE ELEVATION AHD (m)	TURBINE ELEVATION AHD (m)
1	325809	8102197	817.8	946.8
2	325803	8103785	881.1	1010.1
3	325956	8103457	850.3	979.3
4	326073	8103207	803.7	932.7
5	326217	8102937	796.9	925.9
6	326064	8102645	787.7	916.7
7	325581	8102596	804.8	933.8
8	325167	8102500	822.8	951.8
9	325263	8102243	834.1	963.1
10	325299	8101986	839.7	968.7
11	325387	8101730	845	974.0
12	325507	8101485	856.1	985.1
13	325916	8101631	851.4	980.4
14	326327	8101782	854.7	983.7
15	325617	8101231	870	999.0
16	325929	8101048	892.7	1021.7
17	325934	8100748	871.7	1000.7
18	326232	8100427	850.2	979.2
19	326493	8100143	845.1	974.1
20	326789	8099837	847.8	976.8
21	327190	8099583	869.3	998.3
22	327386	8099294	860.4	989.4
23	327471	8100310	831.5	960.5
24	327570	8100046	837.2	966.2
25	327652	8099781	855	984.0
26	327915	8099518	858.8	987.8
27	328230	8099829	848.3	977.3
28	328656	8099631	851	980.0
29	328367	8099407	902.9	1031.9
30	328029	8099220	925.8	1054.8
31	328146	8098962	971	1100.0
32	328425	8098766	1011.6	1140.6
33	328786	8098927	974.3	1103.3
34	329002	8098559	1050.5	1179.5
35	329234	8098320	1012.8	1141.8
36	329717	8098155	999.6	1128.6
37	329260	8100722	860	989.0
38	328046	8100298	815.6	944.6
39	326981	8101460	789.7	918.7
40	326734	8100584	831.3	960.3
41	327737	8101507	810.7	939.7
42	330749	8098278	978.6	1107.6
43	330489	8098504	949	1078.0
44	330207	8098696	886.8	1015.8
45	329988	8098935	869.7	998.7

WIND TURBINE SITE	EASTING	NORTHING	SITE ELEVATION AHD (m)	TURBINE ELEVATION AHD (m)
46	329823	8099182	893.9	1022.9
47	329729	8099441	923	1052.0
48	329404	8099649	855.9	984.9
49	329203	8099946	902.3	1031.3
50	329091	8100198	926.1	1055.1
51	329040	8100460	932	1061.0
52	329738	8100745	842.7	971.7
53	329581	8101006	810	939.0
54	329659	8101299	814.6	943.6
55	328773	8100681	885.4	1014.4
56	328578	8100955	874.8	1003.8
57	328506	8101239	846.8	975.8
58	328368	8101559	840	969.0
59	328507	8101817	824.8	953.8
60	328450	8102087	818.2	947.2
61	328384	8102361	806.3	935.3
62	328250	8102610	799.4	928.4
63	328123	8102866	813.6	942.6
64	326730	8101936	812.6	941.6
65	328792	8102560	825	954.0
66	328891	8102237	812.2	941.2
67	328964	8101930	807.8	936.8
68	328019	8101756	835.5	964.5
69	327636	8101937	817.9	946.9
70	327578	8102225	841.7	970.7
71	327508	8102611	809.8	938.8
72	327279	8100581	821.7	950.7
73	327284	8100882	806.8	935.8
74	327063	8101191	801.4	930.4
75	326543	8101038	823.5	952.5