PAGERPOWER
Urban & Renewables

TA17.2
Aviation Risk Assessment

Torrance Farm Extension 2 Infinergy Ltd

February 2023





PLANNING SOLUTIONS FOR:

- Solar
- Telecoms
- Railways
- Defence
- Buildings
- Wind
- Airports
- Radar
- Mitigation

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ADMINISTRATION PAGE

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Issue	Date	Detail of Changes
1	April 2022	Initial issue
2	February 2023	Assessment of updated turbine positions

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KEY FINDINGS

Background

Pager Power has conducted an aviation risk assessment for a second proposed extension to the operational Torrance Farm Wind Park, located approximately 2.3 kilometres west northwest of Whitburn, West Lothian, to determine its impact upon aviation activity.

The Proposed Development

The proposed development has been assessed based on a wind turbine tip height of 200m above ground level (agl) and a rotor diameter of 170m.

Overall Conclusion

The primary risk to the proposed development is the objection sustained by Edinburgh Airport. Following undertaking its own assessment and reviewing the third-party assessment, it is concluded that the proposed development will not affect the Edinburgh radar due to terrain between the radar antenna and the wind turbine blades. Pager Power is willing to provide further evidence and assurances to Edinburgh Airport that the Primary Surveillance Radar (PSR) will not be affected.

Discussions with NATS to implement a technical mitigation prior to construction of the proposed development for the impacts upon the PSRs at Orchardton (Cumbernauld), Kincardine, and Lowther Hill are progressing.

An objection from Glasgow Airport is not predicted following consideration of the potential impacts upon their PSR in an operational context and their consultation response. They will provide their official position following submission of the planning application.

Visible aviation lighting will be required for all turbines, infrared lighting is also likely to be requested by the Ministry of Defence (MOD).

Assessment Results

Airports and Airport Radar

Technical impacts upon the PSRs at Orchardton (Cumbernauld) and Kincardine due to the high likelihood that the turbines will cause false returns to appear on the radar display. NATS has confirmed mitigation is required, and consultation regarding the implementation of a mitigation solution is ongoing.

Technical impacts upon the PSR at Glasgow Airport are predicted due to the high likelihood that the turbines will cause false returns to appear on the radar display. However, it is predicted that these impacts can be operationally accommodated given the distance from the radar and the sufficient vertical clearance between aircraft subject to a radar control service and the proposed development. Glasgow Airport has expressed they are not likely to have any concerns with the proposed development and will provide their official position following submission of the planning application

No impacts upon the PSR at Edinburgh Airport are predicted due to the proposed development having a highly unlikely likelihood of causing false returns upon the radar. Edinburgh Airport has undertaken an internal assessment and commissioned a third-party assessment, which concluded the turbines would cause false returns upon the radar.

Pager Power undertook its first assessment of wind turbines and the Edinburgh radar in 2004. That wind farm, Black Law, has now been built – with the wind turbines having a smaller impact in practice than Pager Power's prediction. Pager Power has reviewed the third-party assessment and has undertaken its own assessment and concluded that the proposed development will not affect the Edinburgh radar due to terrain between the radar antenna and the wind turbine blades.

NATS NERL – NATS En Route

The proposed development is predicted to have a significant technical impact upon the PSR at Lowther Hill due to the high likelihood that the turbines will cause false returns to appear on the radar display.

NATS has confirmed mitigation is required and has expressed they have a suitable solution which can be implemented for the proposed development. Consultation with NATS is progressing to implement a solution prior to the construction of the development.

Ministry of Defence

The proposed development is located within the 'blue' zone, which is a low priority military low flying zone where the MOD is less likely to raise concerns.

It is likely that the MOD will request the turbines be fitted with MOD accredited aviation lighting in accordance with the requirements of the Civil Aviation Authority, Air Navigation Order 2016.

Aviation Lighting

There is a statutory requirement to fit structures having a height of 150 metres or more with medium intensity (2000 Candela) aviation warning lights. This statutory requirement is set out within article 222 of The Air Navigation Order 2016 and Regulations – CAP 393.

In addition, there is a CAA Policy Statement entitled "Lighting of Onshore Wind Turbine Generators in the United Kingdom with a maximum blade tip height at or in excess of 150m Above Ground Level". Section 4.2 sets out the lighting requirements in more detail.

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LIST OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 55 countries within Europe, Africa, America, Asia and Australasia.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems. Over the years, the company has expanded into numerous fields including:

- Renewable energy projects.
- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 INTRODUCTION

1.1 Overview

Pager Power has conducted an aviation risk assessment for a second proposed extension to the operational Torrance Farm Wind Park, located approximately 2.3 kilometres west northwest of Whitburn, West Lothian, to determine its impact upon aviation activity. The proposed development has been assessed based on a wind turbine tip height of 200m above ground level (agl).

The report includes:

- Identification of relevant aviation infrastructure including:
    - Aerodromes (licensed, unlicensed and military);
    - Radar;
    - Radio navigation aids.
- Overview of relevant safeguarding assessment distances;
- Radio line of sight assessment for the relevant infrastructure, including:
    - Radar installations;
    - Radio navigation aids.
- Consideration of cumulative impacts;
- Overall risk and key issues.

The aim is to identify and assess the aviation risks associated with achieving planning permission and construction of the wind development.

2 PROPOSED DEVELOPMENT INFORMATION

2.1 Proposed Development Layout

The layout of the proposed development is shown in Figure 1 below.

Figure 1 *Proposed development layout*

2.2 Coordinate Data

The proposed turbine coordinates are shown in Table 1 below.

Turbine ID	Easting (British National Grid)	Northing (British National Grid)	Height
T1	290837	665528	Tip height is 200 metres above ground level. Hub height 115m above ground level.
T2	290293	665185	
T3	289627	665186	
T4	289217	664680	

Table 1 *Proposed turbine coordinates*

3 KEY AVIATION RISKS

3.1 Risk Assessment Results

Figure 2 below presents the aviation risk assessment chart.

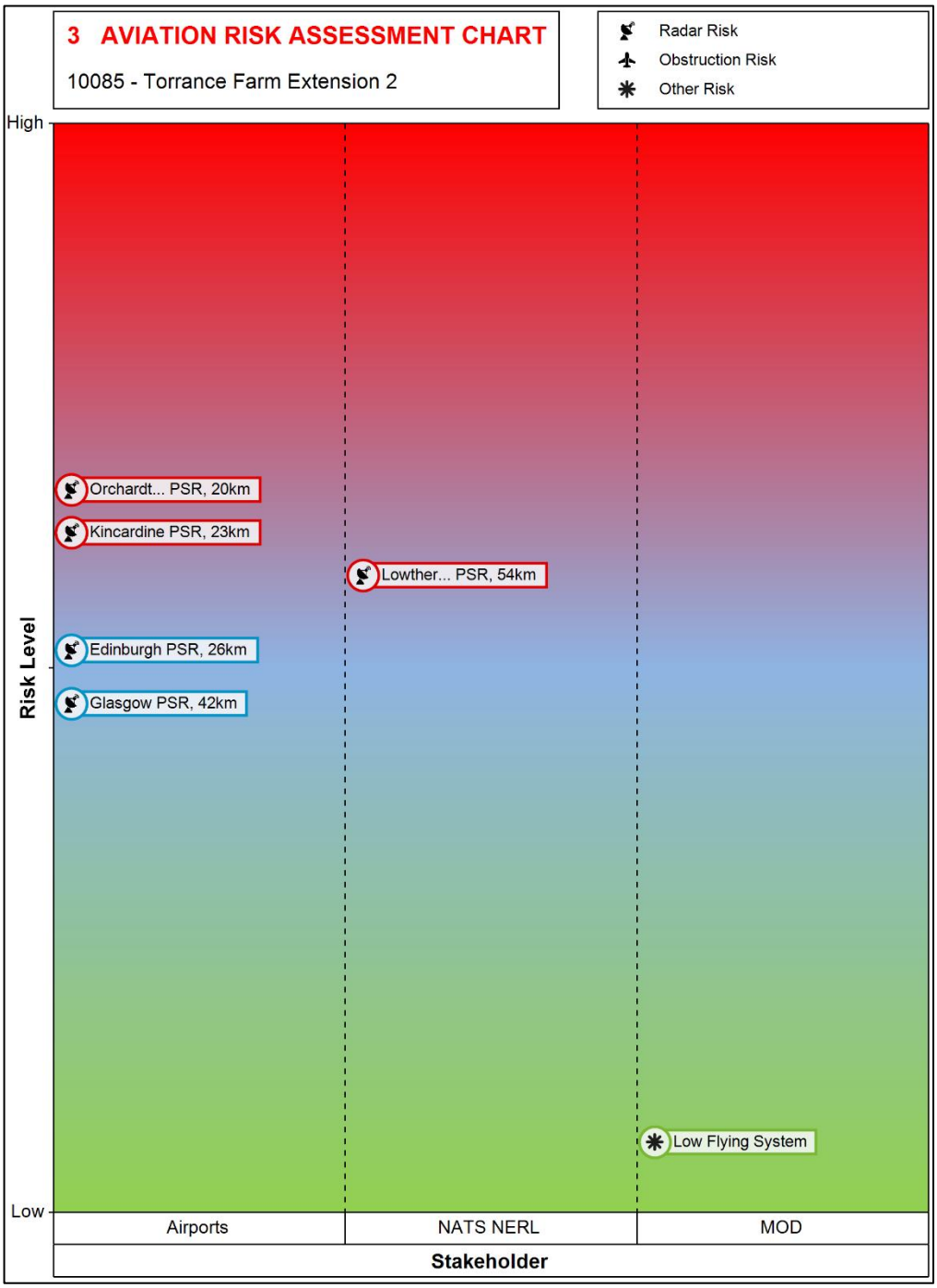


Figure 2 *Risk assessment chart*

3.2 Airports and Airport Radar

Aviation Risk	Distance	Risk Level
Orchardton (Cumbernauld) PSR[1]	19.9 km	High
Kincardine PSR	22.9 km	High
Edinburgh PSR	25.9 km	Medium
Glasgow PSR	42.0 km	Medium

Table 2 *Identified airport risks*

3.3 NATS NERL - NATS En Route

Aviation Risk	Distance	Risk Level
Lowther Hill PSR	54.0 km	High

Table 3 *Identified NATS NERL - NATS En Route risks*

3.4 MOD - Ministry of Defence

Aviation Risk	Distance	Risk Level
Low Flying System	/	Low

Table 4 *Identified MOD risks*

3.5 Civil Airfields

Aviation Risk	Distance	Risk Level
None	/	/

Table 5 *Identified civil airfield risks*

3.6 Met Office

Met Office Risk	Distance	Risk Level
None	/	/

Table 6 *Identified Met Office risks*

[1] Primary Surveillance Radar

4 RISK ASSESSMENT DISCUSSION

4.1 Overview

The following section presents the results and discussion of the aviation infrastructure identified by the risk assessment. The approach taken for the radar installations is as follows:

Technical Assessment

- Radar line of sight assessment for the proposed development at its maximum height (200m agl);
- A radar detectability assessment to determine the likelihood of false returns from the wind turbine appearing on the radar display;
- Consideration of the distance from the radar.

Cumulative Assessment

- Assessment of the predicted impact in the context of operational Torrance Farm and Torrance Farm Extension (where necessary).

Table 7 below presents the radar detection classifications.

Radar Detection	Comment
Highly Unlikely	Turbine hidden behind terrain.
Unlikely	Turbine within line-of-sight but not likely to cause false returns.
Possible	Turbine within line-of-sight and may cause false returns.
Likely	False returns predicted to appear on the radar display.
Highly Likely	

Table 7 *Radar detection classifications*

Additional information regarding the methodology or the additional line of sight charts can be provided upon request.

4.2 Airport and Airport Radar

4.2.1 Orchardton (Cumbernauld) PSR

The location of the proposed development relative to the PSR at Orchardton (Cumbernauld) is shown in Figure 3 below.

Figure 3 *Location of the proposed development relative to Orchardton (Cumbernauld) PSR*

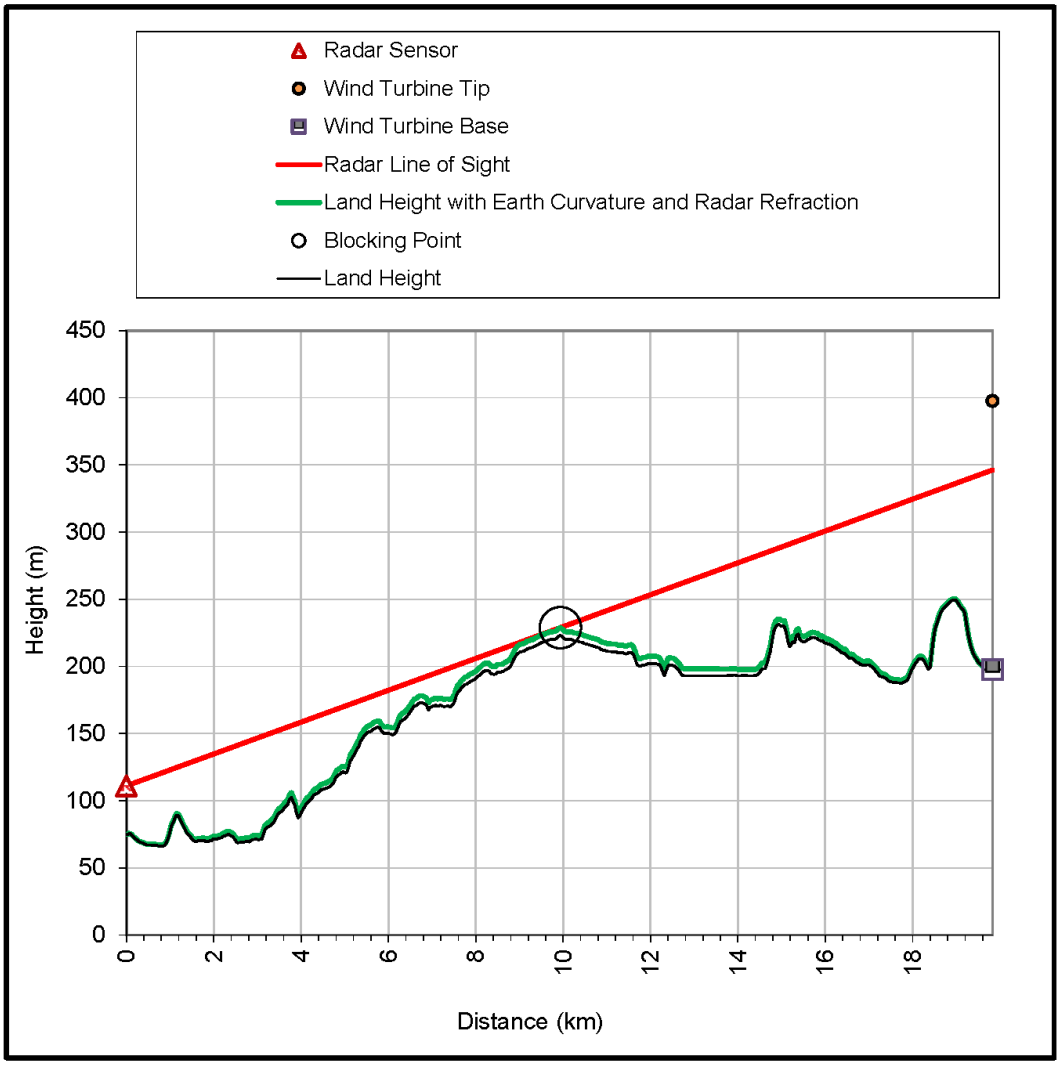
The radar line of sight analysis showed that all four proposed turbines would be visible to Orchardton (Cumbernauld) PSR, based on bare earth terrain. Figure 4 on the following page shows the line-of-sight chart to T4 for reference[2].

[2] The box labelled 'certainty' in the figure provides the distance (in metres) by which the wind turbine is within line of sight to the assessed radar (rounded to one decimal place).

Radar Line of Sight Calculation

Orchardton (Cumbernauld)

Torrance Farm Extension 2	
Turbine	T4
Result	VISIBLE
Certainty	51.4 metres



Turbine Height (m)	200
Hub Height (m)	115
Rotor Diameter (m)	170
Turbine Elevation (m)	197.5
Turbine Location	E289217 N664680
Distance to radar (km)	19.8
Blocking Point Location	E280418 N669201
Distance to BP (km)	9.9

Additional Analysis	
Angle (Radar to Tip)	0.761 degrees up
Maximum Tip Height	148.58 metres

Figure 4 *Radar line of sight chart for Orchardton (Cumbernauld) PSR – T4*

Table 8 below shows the turbine visibility and radar detection classifications for Orchardton (Cumbernauld) PSR.

Turbine	Turbine Visibility	Radar Detection
T1	24.0	Highly Likely
T2	29.7	Highly Likely
T3	50.2	Highly Likely
T4	51.4	Highly Likely

Table 8 *Radar detectability results for Orchardton (Cumbernauld) PSR*

4.2.2 Kincardine PSR

The location of the proposed development relative to the PSR at Kincardine is shown in Figure 5 below.

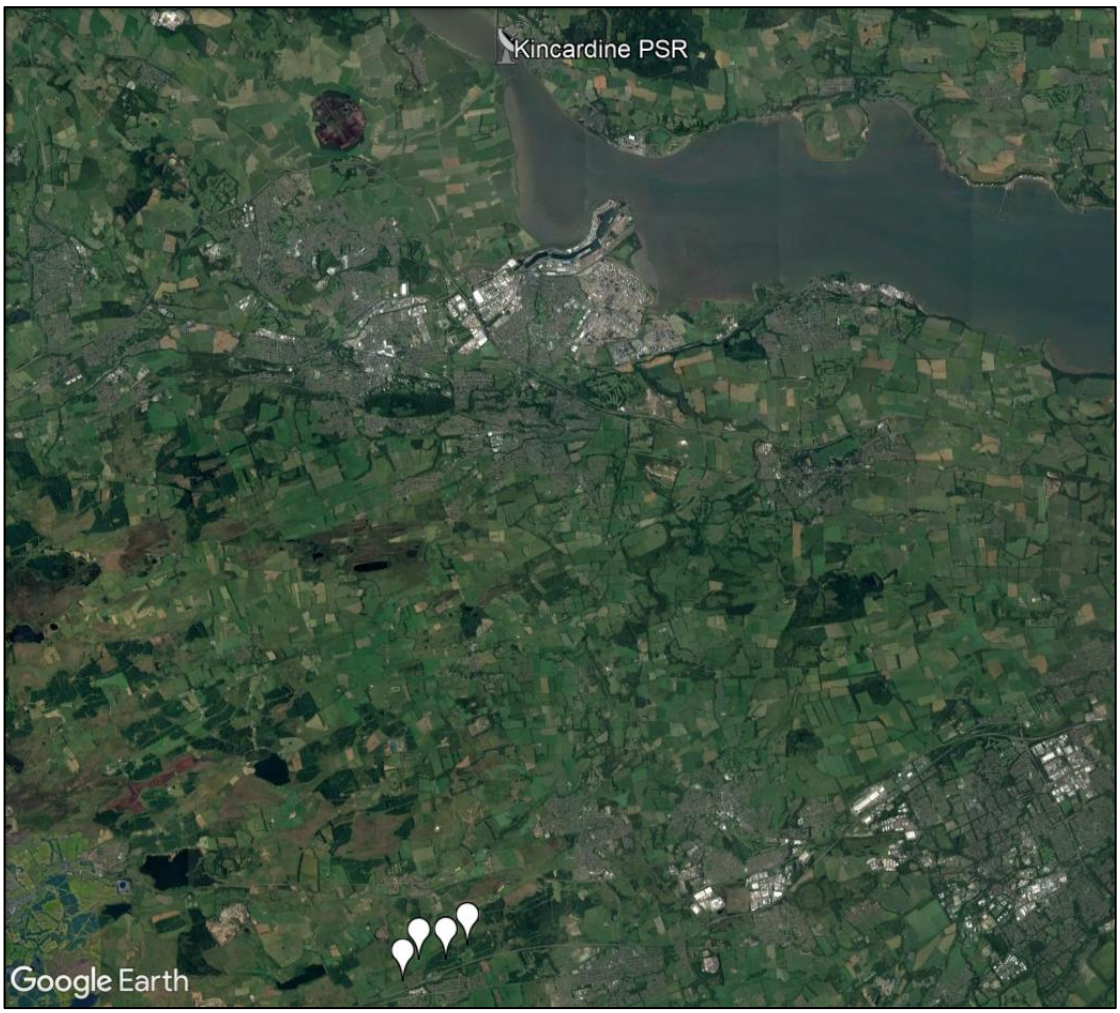


Figure 5 *Location of the proposed development relative to Kincardine PSR*

The radar line of sight analysis showed that all four proposed turbines would be visible to the Kincardine PSR, based on bare earth terrain. Figure 6 below shows the line-of-sight chart to T3 for reference.

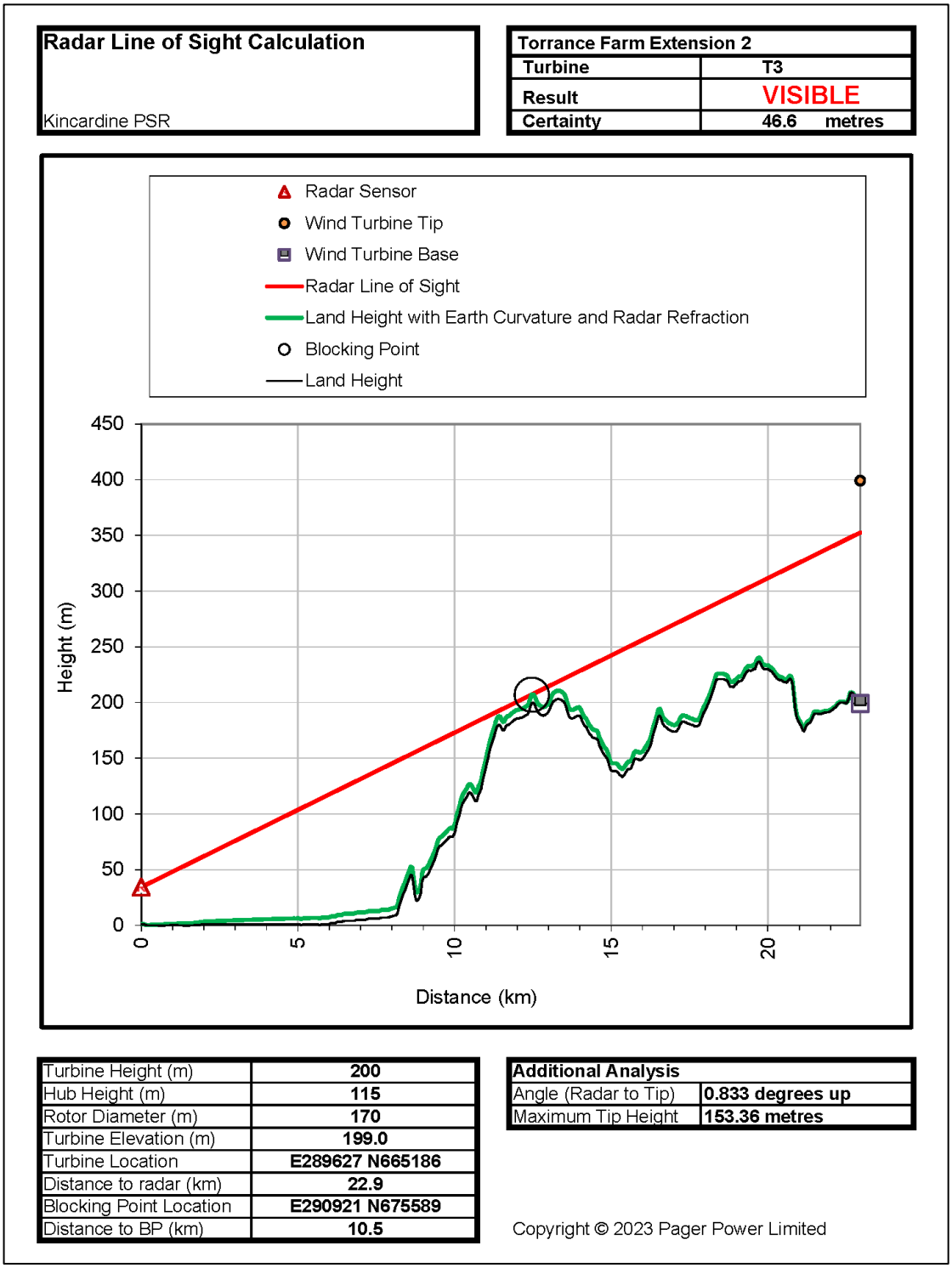


Figure 6 *Radar line of sight chart for Kincardine PSR – T3*

Table 9 below shows the turbine visibility and radar detection classifications for Kincardine PSR.

Turbine	Turbine Visibility	Radar Detection
1	36.3	Highly Likely
2	36.6	Highly Likely
3	46.6	Highly Likely
4	44.7	Highly Likely

Table 9 *Radar detectability results for Kincardine PSR*

4.2.3 Edinburgh PSR

The location of the proposed development relative to the PSR at Edinburgh Airport is shown in Figure 7 below.

Figure 7 *Location of the proposed development relative to Edinburgh PSR*

The radar line of sight analysis showed that T1 and T3 would be visible to Edinburgh PSR, based on bare earth terrain. Figure 8 on the following page shows the line-of-sight chart to T3 for reference.

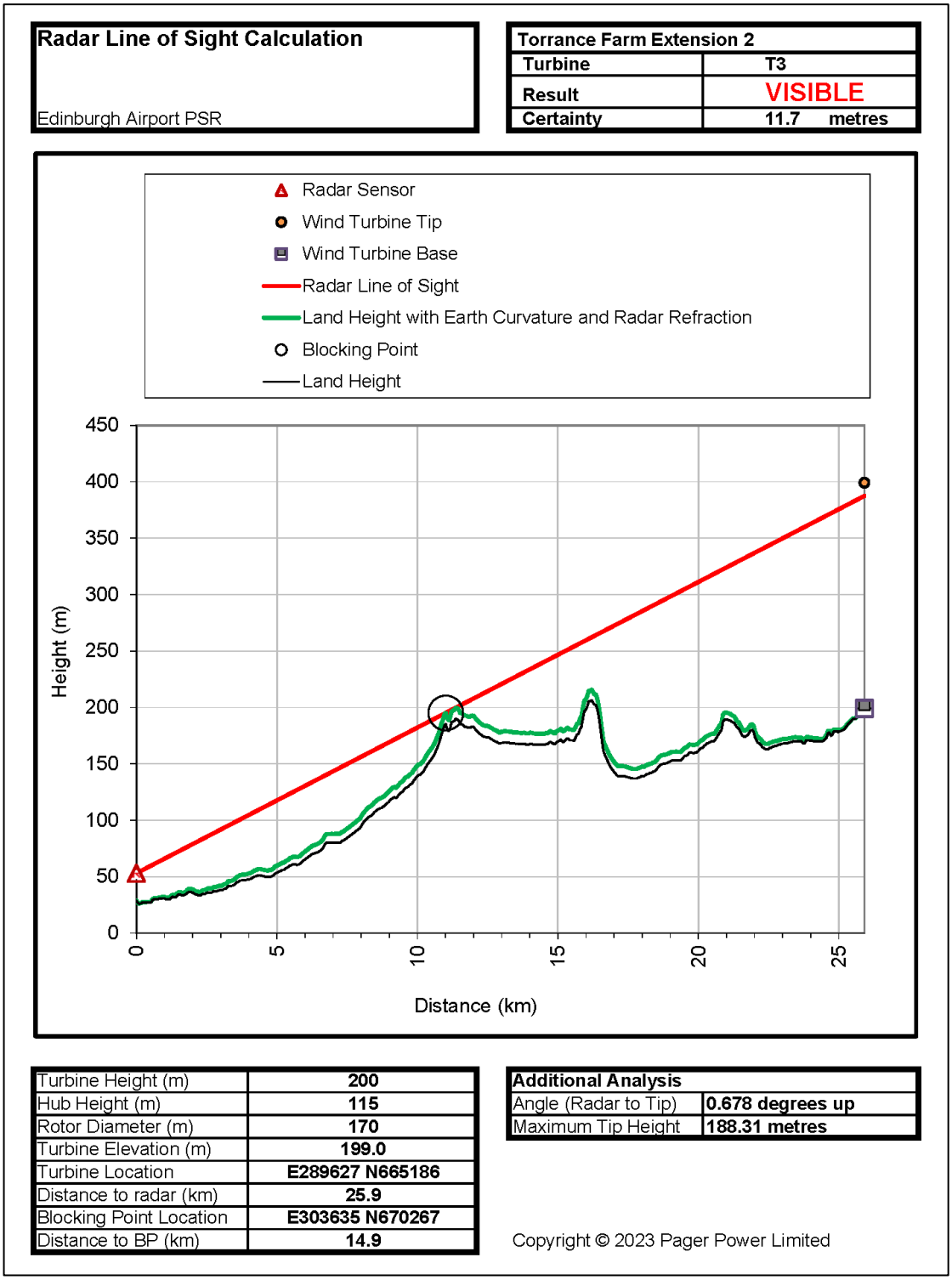


Figure 8 *Radar line of sight chart for Edinburgh PSR*

Table 10 below shows the turbine visibility and radar detection classifications for Edinburgh PSR.

Turbine	Turbine Visibility	Radar Detection
T1	4.2	Highly Unlikely
T2	-0.3	Highly Unlikely
T3	11.7	Highly Unlikely
T4	-12.7	Highly Unlikely

Table 10 *Radar detectability results for Edinburgh PSR*

4.2.4 Glasgow PSR

The location of the proposed development relative to the PSR at Glasgow Airport is shown in Figure 9 below.

Figure 9 *Location of the proposed development relative to Glasgow PSR*

The radar line of sight analysis showed that all four proposed turbines would be visible to Glasgow PSR. Figure 10 on the following page shows the line-of-sight chart to T3 for reference.

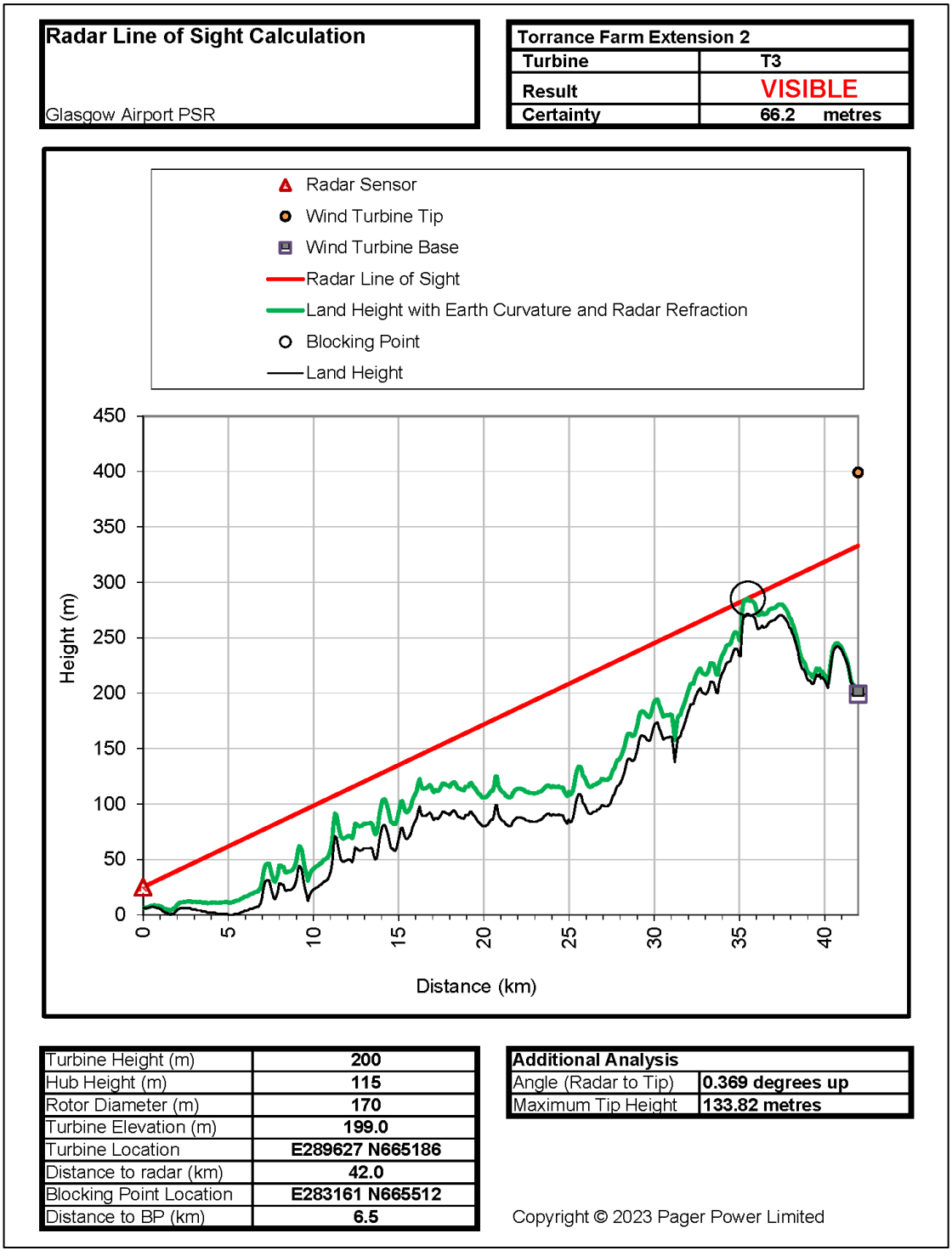


Figure 10 *Radar line of sight chart for Glasgow PSR – T3*

No meaningful obstructions were identified along the line-of-sight path that could significantly reduce the visibility of the turbines. No additional screening was therefore incorporated into the profile.

Table 11 below shows the turbine visibility and radar detection classifications for Glasgow PSR.

Turbine	Turbine Visibility	Radar Detection
T1	48.4	Highly Likely
T2	44.4	Highly Likely
T3	66.2	Highly Likely
T4	51.2	Highly Likely

Table 11 *Radar detectability results for Glasgow PSR*

4.2.5 Airport and Airport Radar Conclusions

Technical impacts upon the PSRs at Orchardton (Cumbernauld) and Kincardine due to the high likelihood that the turbines will cause false returns to appear on the radar display. NATS has confirmed mitigation is required, and consultation regarding the implementation of a mitigation solution is ongoing.

Technical impacts upon the PSR at Glasgow Airport are predicted due to the high likelihood that the turbines will cause false returns to appear on the radar display. However, it is predicted that these impacts can be operationally accommodated given the distance from the radar and the sufficient vertical clearance between aircraft subject to a radar control service and the proposed development. Glasgow Airport has expressed they are not likely to have any concerns with the proposed development and will provide their official position following submission of the planning application

No impacts upon the PSR at Edinburgh Airport are predicted due to the proposed development having a highly unlikely likelihood of causing false returns upon the radar. Edinburgh Airport has undertaken an internal assessment and commissioned a third-party assessment, which concluded the turbines would cause false returns upon the radar.

Pager Power undertook its first assessment of wind turbines and the Edinburgh radar in 2004. That wind farm, Black Law, has now been built – with the wind turbines having a smaller impact in practice than Pager Power's prediction. Pager Power has reviewed the third-party assessment and has undertaken its own assessment and concluded that the proposed development will not affect the Edinburgh radar due to terrain between the radar antenna and the wind turbine blades.

4.3 NATS NERL - NATS En Route

4.3.1 Lowther Hill PSR

The location of the proposed development relative to the PSR at Lowther Hill is shown in Figure 11 below.

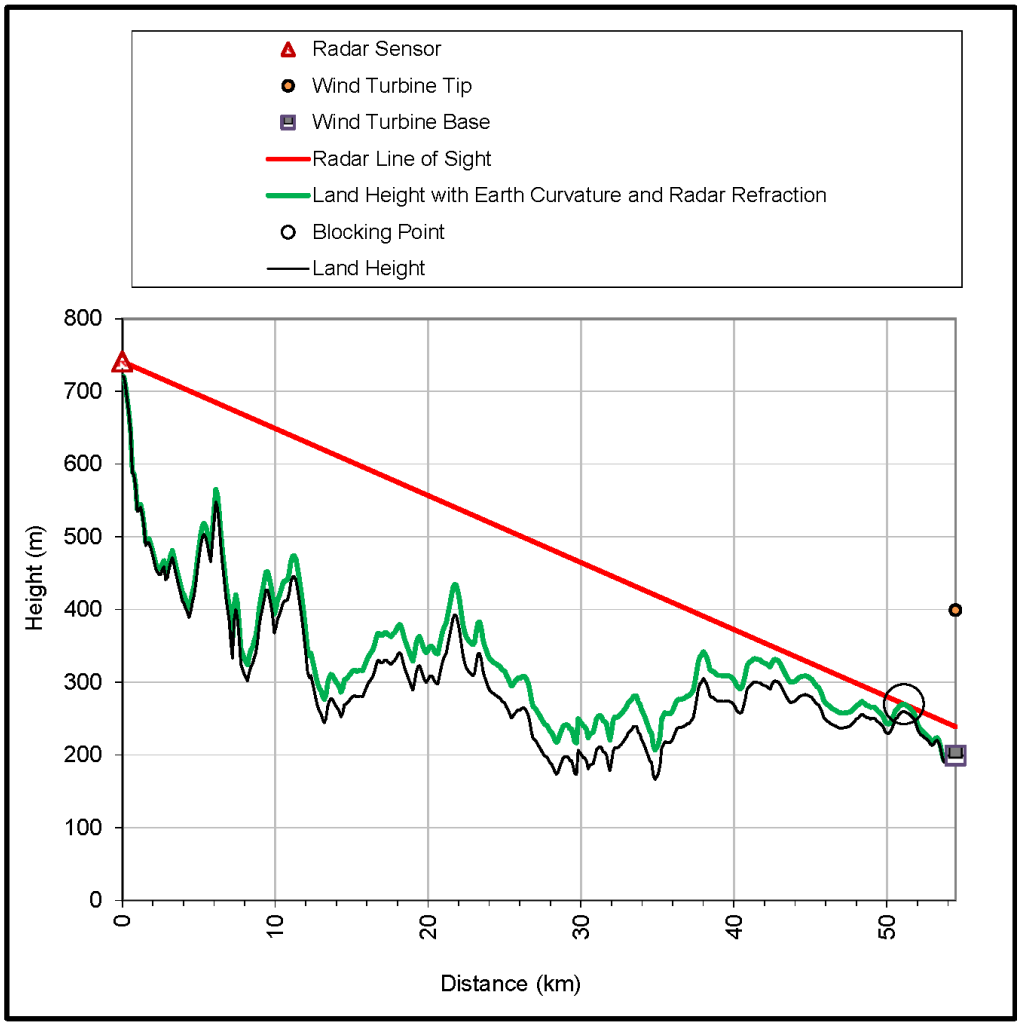
Figure 11 *Location of the proposed development relative to Lowther Hill PSR*

The radar line of sight analysis showed that all four proposed turbines would be visible to Lowther Hill PSR. Figure 12 below shows the line-of-sight chart to T3 for reference.

Radar Line of Sight Calculation

Lowther Hill PSR (NATS)

Torrance Farm Extension 2	
Turbine	T3
Result	VISIBLE
Certainty	160.2 metres



Turbine Height (m)	200
Hub Height (m)	115
Rotor Diameter (m)	170
Turbine Elevation (m)	199.0
Turbine Location	E289627 N665186
Distance to radar (km)	54.5
Blocking Point Location	E289589 N661801
Distance to BP (km)	3.4

Additional Analysis	
Angle (Radar to Tip)	0.543 degrees down
Maximum Tip Height	39.78 metres

See Appendix for further information

Figure 12 *Radar line of sight chart for Lowther Hill PSR – T3*

Table 12 below shows the turbine visibility and radar detection classifications for Lowther Hill PSR.

Turbine	Turbine Visibility	Radar Detection
T1	138.1	Highly Likely
T2	141.8	Highly Likely
T3	160.2	Highly Likely
T4	155.0	Highly Likely

Table 12 *Radar detectability results for Lowther Hill PSR*

4.3.2 NATS NERL - NATS En Route Conclusions

The proposed development is predicted to have a significant technical impact upon the PSR at Lowther Hill due to the high likelihood that the turbines will cause false returns to appear on the radar display.

NATS has confirmed mitigation is required, and consultation regarding the implementation of a mitigation solution is ongoing.

4.4 MOD - Ministry of Defence

4.4.1 Military Low Flying

Military low flying can take place throughout the UK. The MOD has published a map indicating areas within the UK where military low flying activities are the most likely to cause an objection. The map is colour coded as follows:

- Green – Area with no military low flying concerns;
- Blue – Low priority military low flying areas less likely to raise concerns;
- Amber – Regular military low flying area where mitigation may be necessary to resolve concerns;
- Red – High priority military low flying area likely to raise considerable and significant concerns.

The location of the wind turbines relative to the military low flying zones are shown in Figure 13 on the following page. The figure shows that all wind turbines are located within the 'blue' zone, which is a low priority military low flying zone where the MOD is less likely to raise concerns.

Nevertheless, it is likely that the MOD will request the turbines be fitted with MOD accredited aviation lighting in accordance with the requirements of the Civil Aviation Authority, Air Navigation Order 2016.

Figure 13 *Military low flying zones*

4.5 Aviation Lighting

There is a statutory requirement to fit structures having a height of 150 metres or more with medium intensity (2000 Candela) aviation warning lights. This statutory requirement is set out within article 222 of The Air Navigation Order 2016 and Regulations – CAP 393.

In addition, there is a CAA Policy Statement entitled "Lighting of Onshore Wind Turbine Generators in the United Kingdom with a maximum blade tip height at or in excess of 150m Above Ground Level". The policy sets out the following lighting requirements for onshore wind turbines that are 150 metres or more in height:

- Fitting of at least one, preferably two, 2000 Candela lights on top of the wind turbine nacelle. Note - where two lights are fitted only one need be lit;
- Fitting of three 32 Candela lights halfway up the wind turbine tower;
- The lights should switch on automatically when it is dark;
- Intensity of the 2000 Candela nacelle light may be reduced when there is good visibility.

4.6 Cumulative Impacts

It is common for safeguarding criteria to be constructed for individual developments. This simplifies the assessment process and can add clarity when determining acceptability. However, it is not always realistic to consider impacts of a development in isolation.

The proposed development is located directly west of the operational Torrance Farm and Torrance Farm Extension. The six operational turbines in the vicinity of the proposed development are shown in Figure 14 on the following page.

Figure 14 *Operational wind developments in the vicinity of proposed development*

4.6.1 Airport and Airport Radar

Based on previous radar line-of-sight analysis completed by Pager Power, Torrance Farm and Torrance Farm Extension are not predicted to be detectable by the PSRs at Orchardton (Cumbernauld), Kincardine, Edinburgh Airport, or Glasgow Airport.

No cumulative impacts upon airport radar are therefore predicted.

4.6.2 NATS NERL – NATS En Route

Following implementation of the technical mitigation solution, in agreement with NATS, no impacts from the proposed development upon Lowther Hill are predicted.

No cumulative impacts upon NATS En Route radar are therefore predicted.

4.6.3 Ministry of Defence

Torrance Farm and Torrance Farm Extension are also located within the same 'blue' low flying zone as the proposed development. It is therefore predicted the proposed development will be subject to the same MOD lighting requirements as the operational wind developments.

No cumulative effects are anticipated in the context of low flying constraints.

5 HIGH-LEVEL MITIGATION OVERVIEW

5.1 PSR Mitigation Options

The most relevant options for technical impacts upon PSR are presented below.

Option 1 – Layout Revisions

Changes to the wind farm layout can be made, such as:

- Utilising shorter turbines – shorter turbines are less visible, even though they may still be in LOS, and can be less illuminated by the main beam and the lower sidelobes.
- Aligning turbines on a radial relative to the radar – Such a configuration would reduce their footprint and therefore reducing the span of clutter.
- Utilising fewer turbines – Less turbines would mean fewer sources of clutter.

Option 2 – Radar Blanking

Radar blanking is a solution for unwanted radar returns. A zone is defined around the source of reflections, in this case the wind farm, within which radar returns are suppressed. The advantage of this solution is that the false returns are removed from the radar display. The drawback is that genuine returns from the blanked area are also suppressed. This means that an aircraft which overflies the wind development would not be detected within the blanked zone by the PSR.

The optimal blank will be the minimum size that encompasses the source of clutter without extending beyond this to maximise the level of coverage that is retained. It is important to consider that the function of the radar is understood to be detection of vessels in the sea – such that a small blank over land is likely to be operationally insignificant.

The dimensions of the blanked zone should be defined in terms of range (minimum and maximum) and bearing (minimum and maximum). These can be defined based on the position of the turbines themselves – without the need for bespoke modelling beyond this. Implementation should be coordinated with the radar operator / servicing team.

Option 3 – Radar In-Fill

Radar in-fill is a solution whereby:

- Radar blanking is applied for the impacted radar;
- Coverage from a second radar that has coverage over the wind farm site is imported to the affected radar's display system – resulting in seamless coverage.

It is necessary that the second radar has coverage to suitably low altitude but is not itself affected by the wind farm. This solution can in principle utilise an existing radar installation that meets the necessary requirements, or a custom-built radar installation.

The three typical ways which in-fill is applied are:

1. In-fill coverage is supplied by an existing conventional radar that meets the criteria set out above.

2. In-fill coverage is supplied by a new conventional radar that is sited to meet the criteria set out above.
3. In-fill coverage is provided by a 'local' in-fill radar that is sited at or near the wind farm location. These radar are specifically designed for the purposes of mitigating the impact of wind turbines on radar. As such, they offer some advantages including:
    a. They are generally less expensive to procure than conventional radar.
    b. They are able to distinguish between returns from wind turbines and other targets, meaning that siting them is less restrictive as it is not necessary to 'hide' the turbines from them.
    c. They can offer capabilities that are in some ways superior to conventional radar.

For in-fill radar coverage to be an effective solution, it is necessary to consider the existing system capabilities, such as ensuring that the radar display system can incorporate data from multiple feeds.

Option 4 – Replacement Wind Farm Tolerant Radar

Some specialised radar have increased capability to tolerate (reject) interreference from wind turbines. A radar which is less tolerant to wind farms can therefore be replaced with a specialised radar that is more tolerant to wind farms to eliminate any interference.

Changes to existing radar can also be implemented to increase their capability to tolerate (reject) interference. Upgrades can be physical, e.g. a larger radar antenna, or software based, e.g. processor upgrade or programming known reflector locations.

6 OVERALL CONCLUSION AND RECOMMENDATIONS

6.1 Assessment Results

6.1.1 Airports and Airport Radar

Technical impacts upon the PSRs at Orchardton (Cumbernauld) and Kincardine due to the high likelihood that the turbines will cause false returns to appear on the radar display. NATS has confirmed mitigation is required, and consultation regarding the implementation of a mitigation solution is ongoing.

Technical impacts upon the PSR at Glasgow Airport are predicted due to the high likelihood that the turbines will cause false returns to appear on the radar display. However, it is predicted that these impacts can be operationally accommodated given the distance from the radar and the sufficient vertical clearance between aircraft subject to a radar control service and the proposed development. Glasgow Airport has expressed they are not likely to have any concerns with the proposed development and will provide their official position following submission of the planning application

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6.1.2 NATS NERL – NATS En Route

The proposed development is predicted to have a significant technical impact upon the PSR at Lowther Hill due to the high likelihood that the turbines will cause false returns to appear on the radar display.

NATS has confirmed mitigation is required and has expressed they have a suitable solution which can be implemented for the proposed development. Consultation with NATS is progressing to implement a solution prior to the construction of the development.

6.1.3 Ministry of Defence

The proposed development is located within the 'blue' zone, which is a low priority military low flying zone where the MOD is less likely to raise concerns.

It is likely that the MOD will request the turbines be fitted with MOD accredited aviation lighting in accordance with the requirements of the Civil Aviation Authority, Air Navigation Order 2016.

6.1.4 Aviation Lighting

There is a statutory requirement to fit structures having a height of 150 metres or more with medium intensity (2000 Candela) aviation warning lights. This statutory requirement is set out within article 222 of The Air Navigation Order 2016 and Regulations – CAP 393.

In addition, there is a CAA Policy Statement entitled "Lighting of Onshore Wind Turbine Generators in the United Kingdom with a maximum blade tip height at or in excess of 150m Above Ground Level". Section 4.2 sets out the lighting requirements in more detail.

6.2 Overall Conclusion

The primary risk to the proposed development is the objection sustained by Edinburgh Airport. Following undertaking its own assessment and reviewing the third-party assessment, it is concluded that the proposed development will not affect the Edinburgh radar due to terrain between the radar antenna and the wind turbine blades. Pager Power is willing to provide further evidence and assurances to Edinburgh Airport that the PSR will not be affected.

Discussions with NATS to implement a technical mitigation prior to construction of the proposed development for the impacts upon the PSRs at Orchardton (Cumbernauld), Kincardine, and Lowther Hill are progressing.

An objection from Glasgow Airport is not predicted following consideration of the potential impacts upon their PSR in an operational context and their consultation response. They will provide their official position following submission of the planning application.

Visible aviation lighting will be required for all turbines, infrared lighting is also likely to be requested by the MOD.

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