Appendix 12.1: Aviation Impact Assessment

Hare Hill Windfarm Repowering and Extension

November 2025

CL-5865-RPT-002 V2.0

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Document Information

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1.0	Initial Issue	June 2025	Initial Issue
2.0	Turbine location updates	13 October 2025	2nd issue

Executive Summary

Cyrrus Limited has been engaged to provide guidance on aviation issues associated with the proposed Hare Hill Windfarm Repowering and Extension (the 'proposed Development'), at a site on the border between East Ayrshire and Dumfries and Galloway. The proposed Development is anticipated to comprise up to 23 wind turbines with maximum blade tip heights of between 150 m and 200 m.

Of the aviation stakeholders consulted at scoping, objections were noted from NATS (En Route) plc (NERL) and Prestwick Airport, concerns were raised by the Ministry of Defence (MOD) and observations made by Glasgow Airport.

NERL's objection is based on the predicted unacceptable impact of wind turbines on Lowther Hill, Great Dun Fell and Cumbernauld Primary Surveillance Radars (PSRs). Prestwick Airport identified issues including potential disruption to Instrument Flight Procedures (IFPs), potential for disruption to its Instrument Landing System facility, potential loss of ground to air communications, wind turbine generated clutter on its radar displays and cumulative impacts due to other windfarms in the vicinity. The MOD has concerns that wind turbines would create a physical obstruction to military low flying aircraft in the area. Glasgow Airport observed that the proposed Development would be within IFP safeguarding areas and could have an impact.

Modelling of PSRs at the closest radar equipped airports (Prestwick, Glasgow and Edinburgh) to the proposed Development shows that 21 of the 23 proposed turbines would be in Radar Line of Sight (RLoS) of Prestwick Terma PSR and likely to be detected by it. None of the proposed turbines would be in RLoS of the Glasgow or Edinburgh PSRs.

Modelling of the closest MOD PSRs to the proposed Development shows that none of proposed turbines would be in RLoS of these radars and would likely not be detected by them.

Modelling of NERL PSRs indicates that all the proposed turbines would be in RLoS of Lowther Hill PSR and Great Dun Fell PSR and likely to be detected. Modelling shows that, contrary to NERL's assessment, none of the 23 proposed turbines would be in RLoS of Cumbernauld PSR. The proposed Development would be within the safeguarded zone of Lowther Hill Secondary Surveillance Radar (SSR); however, NERL has not raised any concerns regarding potential SSR impacts.

There are no significant areas for concern specifically in relation to airspace or airspace users. The proposed Development would lie within a volume of uncontrolled airspace predominantly used by General Aviation and military aircraft. Above this airspace is controlled airspace where aircraft are under a Radar Control Service.

The proposed Development is in the vicinity of safeguarded obstacle protection surfaces associated with IFPs at Prestwick Airport and Glasgow Airport. The locations and tip heights of turbines within the final design layout have taken account of IFP constraints, but a full assessment must be undertaken by an Approved Procedure Design Organisation to ensure that IFPs at these airports would not be impacted by the proposed Development.

As noted by the MOD, the application boundary would fall inside Tactical Training Area 20T within which military aircraft may conduct tactical low flying training down to 100 ft above the ground. To alleviate MOD concerns, wind turbine obstructions would be fitted with MOD accredited aviation safety lighting in accordance with legal requirements.

Prestwick Terma PSR is a windfarm tolerant radar that can be optimised to filter out clutter generated by turbines. The processing capability of this radar should enable it to mitigate the impact of the proposed Development in addition to existing and future windfarms that are within RLoS.

An option for mitigating the impact on NERL's Lowther Hill and Great Dun Fell PSRs is to blank the area of clutter and use infill data from an alternative radar source. Cumbernauld PSR can provide sufficient low-level infill coverage over the proposed Development and is integrated into NERL's Multi-Radar Tracking infrastructure. The Glasgow Airport PSRs can also provide infill coverage, but their base of coverage may not be sufficient for NERL operational requirements.

Lowther Hill PSR has recently been upgraded and has the capability to filter out wind turbine clutter. Should optimisation to mitigate the proposed Development be feasible, then Lowther Hill PSR could be used as a source of infill data for Great dun Fell PSR.

Abbreviations

AD	Air Defence
agl	above ground level
AIP	Aeronautical Information Publication
AMA	Area Minimum Altitude
amsl	above mean sea level
ATC	Air Traffic Control
ATCSMAC	ATC Surveillance Minimum Altitude Chart
ATDI	Advanced Topographic Development and Images
ATS	Air Traffic Service
DTM	Digital Terrain Model
ENR	En Route
FL	Flight Level
GA	General Aviation
IAC	Instrument Approach Chart
IFP	Instrument Flight Procedure
ILS	Instrument Landing System
MOD	Ministry of Defence
MSA	Minimum Sector Altitude
NERL	NATS (En Route) plc
nm	nautical miles
Pd	Probability of detection
PSR	Primary Surveillance Radar
RLoS	Radar Line of Sight
SSR	Secondary Surveillance Radar
TMA	Terminal Control Area
TMZ	Transponder Mandatory Zone
TOPA	Technical and Operational Assessment

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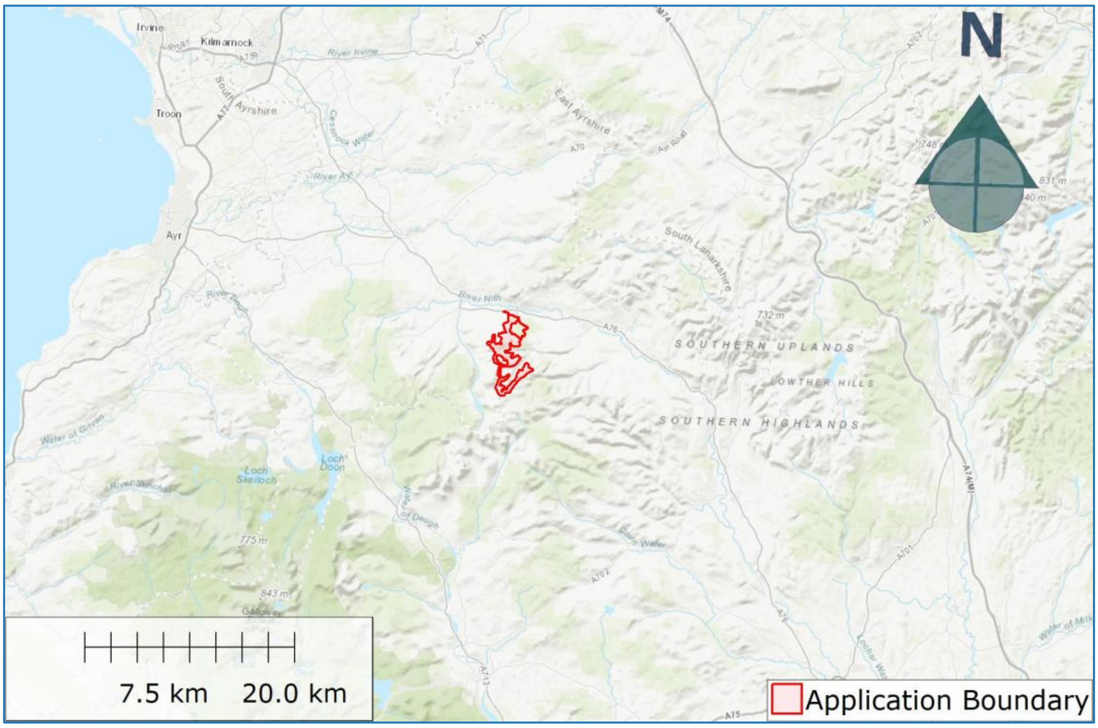
1. Introduction

1.1. Background

1.1.1. ScottishPower Renewables (UK) Limited (the 'Applicant') is proposing to develop Hare Hill Windfarm Repowering and Extension (the 'proposed Development') at a site located south east of New Cumnock in East Ayrshire. The Site (the area within the application boundary) straddles the border between East Ayrshire and Dumfries and Galloway, and the proposed Development is anticipated to comprise up to 23 wind turbines with maximum blade tip heights of between 150 m and 200 m above ground level (agl).

1.1.2. The location of the application boundary is indicated in Figure 1.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 1: Proposed Development application boundary

1.1.3. Cyrrus Limited has been engaged to provide guidance on aviation issues to support the Environmental Impact Assessment process for the proposed Development.

1.2. Effects of Wind Turbines on Aviation

1.2.1. Wind turbines are an issue for aviation Primary Surveillance Radars (PSRs) as the characteristics of a moving wind turbine blade are similar to that of an aircraft. The PSR is unable to differentiate between wanted aircraft targets and unwanted clutter targets introduced by the presence of turbines.

1.2.2. The significance of any radar impact depends on airspace usage in the vicinity of the windfarm site and the nature of the Air Traffic Service (ATS) provided in that airspace.

1.3. Scoping Responses

1.3.1. Following publication of the Scoping Report[1] responses were received from the following aviation stakeholders:

- Edinburgh Airport – 11 December 2023;
- Glasgow Airport – 8 January 2024;
- Highlands and Islands Airports Limited – 19 December 2023;
- Prestwick Airport – 12 December 2023;
- Ministry of Defence (MOD) – 12 January 2024; and
- NATS (En Route) plc (NERL) – 1 December 2023.

1.3.2. Edinburgh Airport confirmed that the proposed Development would lie outside its Aerodrome Safeguarding zone, and therefore it had no objection or comment.

1.3.3. Glasgow Airport observed that the proposed Development would lie outside its obstacle limitation surfaces and radar consultation area, but that it would be within the Instrument Flight Procedures (IFPs) safeguarding areas and could have an impact.

1.3.4. Highlands and Islands Airports Limited noted that the proposed Development would be out with its safeguarding criteria, and therefore had no objections.

1.3.5. Prestwick Airport stated that the proposed Development would be out with its controlled airspace but would lie on the Runway 30 extended centreline at a distance between 17 and 19.5 nautical miles (nm). Issues identified included potential disruption to IFPs, potential for disruption to the Runway 30 Instrument Landing System (ILS), potential loss of ground to air communications in the vicinity of the proposed Development and turbines visible to the Airport's PSR causing turbine clutter on radar displays. The Airport also raised concerns in respect of cumulative impact due to other proposed windfarms in the vicinity of the proposed Development.

1.3.6. The MOD noted that the proposed Development would lie within Tactical Training Area 20T, a military low flying area, and that turbines have the potential to create a physical obstruction to low flying. Aviation safety lighting would address this impact, together with sufficient data submitted to the MOD to ensure accurate charting of obstructions.

1.3.7. NERL indicated it objects to the proposal and provided a Technical and Operational Assessment (TOPA[2]) which predicted that all the proposed turbines are likely to cause false primary plots to be generated by Lowther Hill radar, and that five or more of the proposed turbines are likely to cause false primary plots to be generated by Great Dun Fell radar and Cumbernauld radar. This anticipated impact would be unacceptable to Prestwick Centre Air Traffic Control (ATC) operations.

1.4. Aviation Modelling Tasks

1.4.1. Note that the turbine layout has been revised since the Scoping Report was issued. The revised layout is modelled in this assessment.

[1] Hare Hill Repower Scoping Report, November 2023

[2] TOPA for Hare Hill Wind Farm Development, NATS ref: SG000AX, Issue 1, December 2023

1.4.2. The aviation modelling tasks identified are:

- Determine the radar visibility of the proposed Development to airport PSRs;
- Determine the radar visibility of the proposed Development to the MOD’s PSRs;
- Determine the radar visibility of the proposed Development to NERL’s PSRs; and
- Review the nature of the airspace in the vicinity of the proposed Development to determine any potential impact on aviation.

2. Data

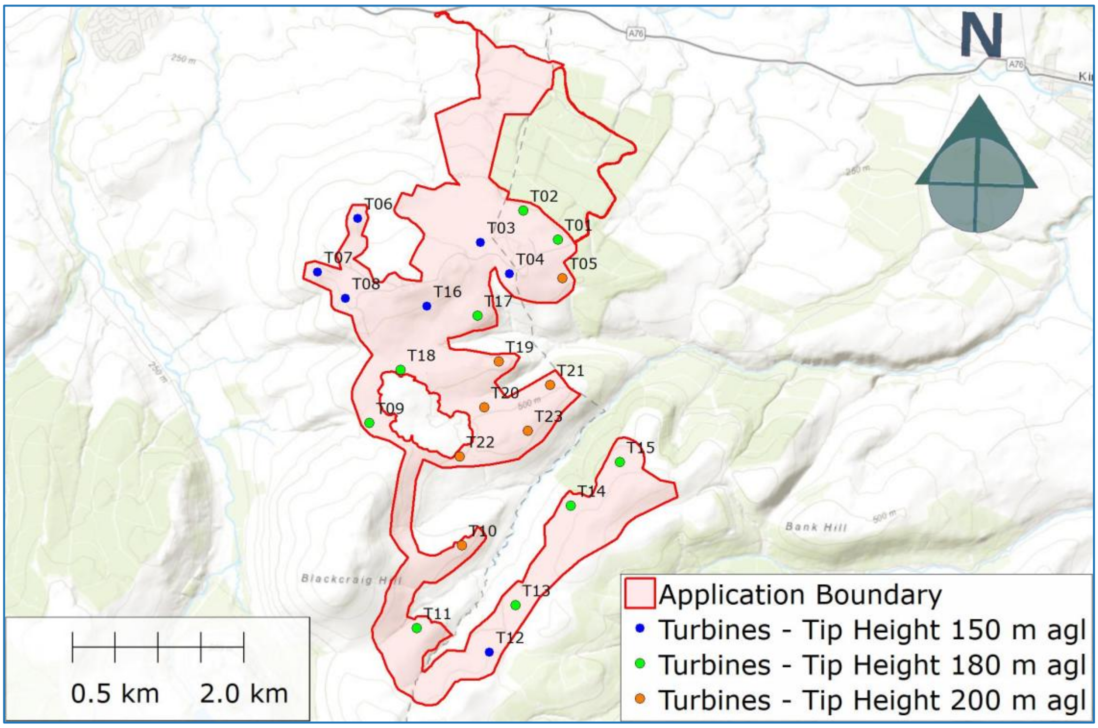
2.1. Proposed Development

2.1.1. The Ordnance Survey National Grid coordinates for this proposed turbine layout together with proposed turbine tip heights, as used in this assessment, are listed in Table 1.

Turbine	Easting (m)	Northing (m)	Tip Height agl (m)
T01	267299	610340	180
T02	266898	610678	180
T03	266400	610307	150
T04	266737	609943	150
T05	267351	609887	200
T06	264968	610589	150
T07	264499	609964	150
T08	264822	609655	150
T09	265107	608209	180
T10	266180	606783	200
T11	265656	605822	180
T12	266503	605539	150
T13	266806	606087	180
T14	267451	607244	180
T15	268025	607750	180
T16	265771	609567	150
T17	266368	609452	180
T18	265466	608824	180
T19	266613	608924	200
T20	266440	608389	200
T21	267212	608646	200
T22	266157	607818	200
T23	266952	608114	200

Table 1: Turbine coordinates and tip heights

2.1.2. The proposed turbine layout used for the modelling is shown in Figure 2.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 2: Turbine layout

2.2. Radar Data

2.2.1. Radar parameters used in this assessment have been taken from data held on file by Cyrrus.

2.3. Analysis Tools

2.3.1. The assessment utilises the following software packages:

- Advanced Topographic Development and Images (ATDI) HTZ communications version 2024.12 radio network analysis tool; and
- Global Mapper v26.0.3 Geographic Information System data processing utility.

2.4. Terrain Data

2.4.1. The following terrain data is used for the radar coverage modelling:

- 25 m ATDI Digital Terrain Model (DTM).

2.4.2. A 3D view of the turbines and the terrain model is shown in Figure 3.

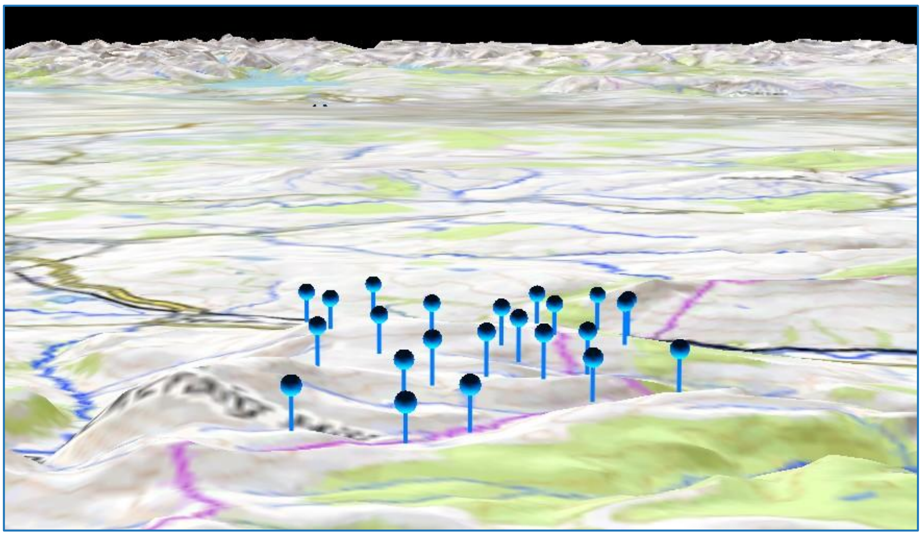


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Figure 3: 3D view of turbines and terrain from the south

3. Airport PSR Modelling

3.1. Radar Locations

3.1.1. The closest radar equipped civil airports to the proposed Development application boundary are Prestwick Airport, approximately 32 km to the north west, Glasgow Airport, approximately 57 km to the north, north west, and Edinburgh Airport, approximately 77 km to the north east.

3.1.2. The locations of the airports relative to the proposed Development are shown in Figure 4.

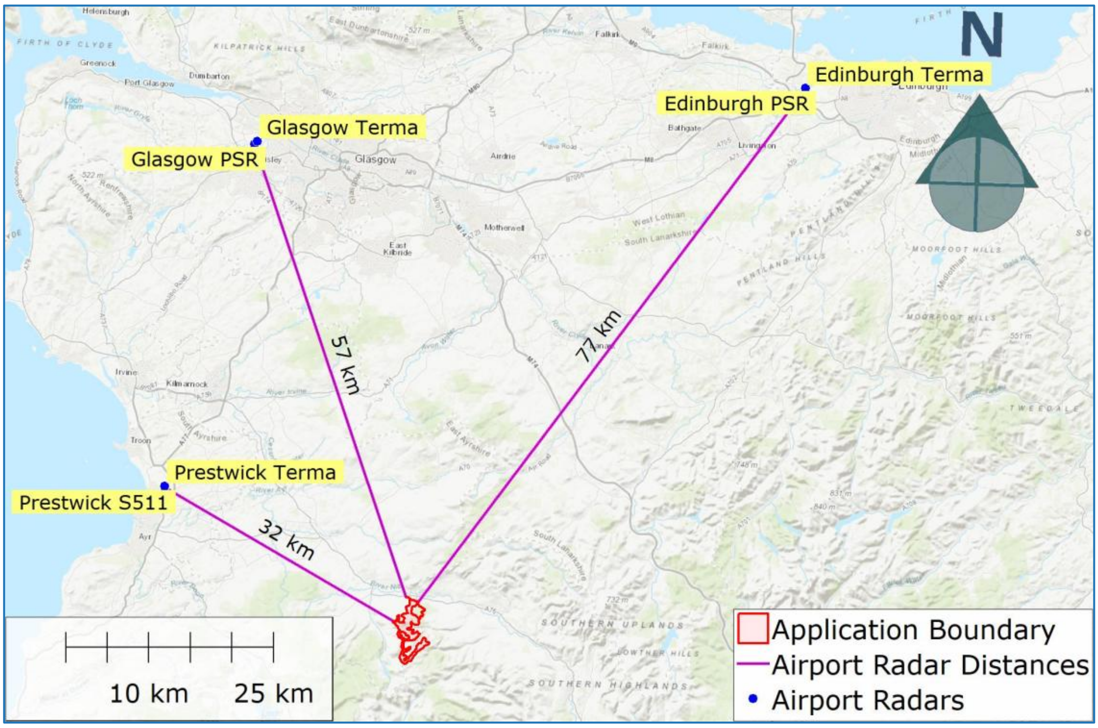

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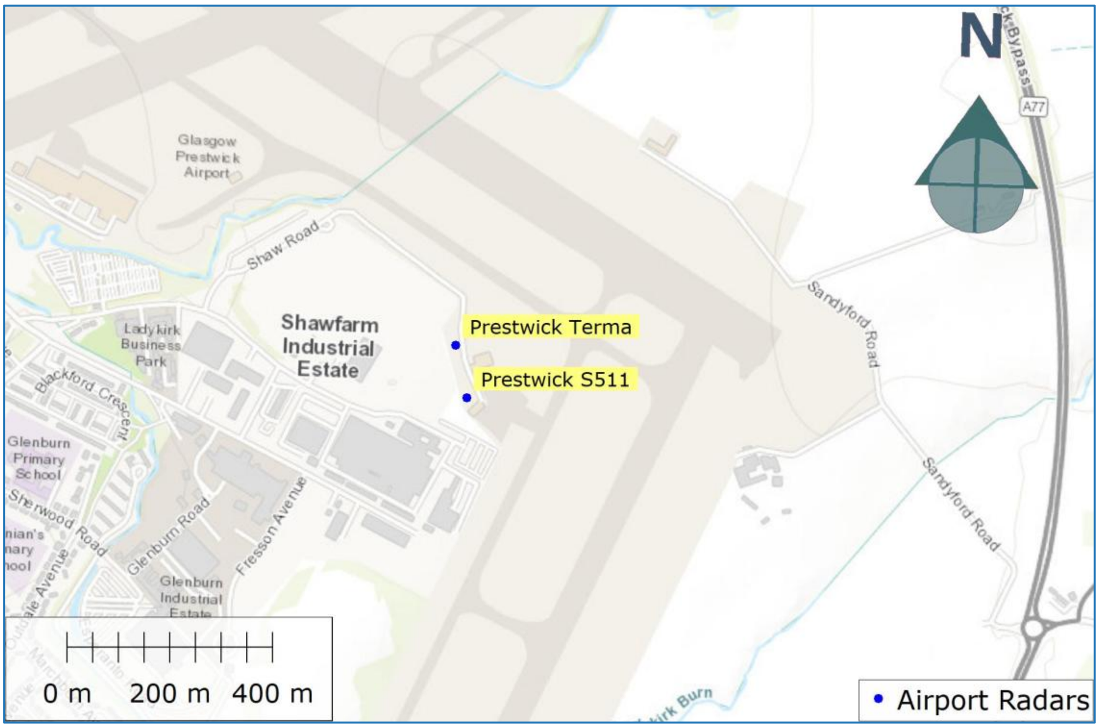
Figure 4: Locations of radar equipped civil airports and proposed Development

3.1.3. There are two PSR facilities at Prestwick Airport: a Marconi S511 radar used for planning purposes while a Terma Scanter 4002 radar is used for approach control. In addition, Prestwick is fed with Secondary Surveillance Radar (SSR) data from NERL's Lowther Hill radar. In the event of PSR failure, Prestwick is authorised to use SSR only.

3.1.4. The locations of the Prestwick PSRs are shown in Figure 5.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 5: Locations of Prestwick Terma and S511 PSRs

3.1.5. Both Glasgow Airport and Edinburgh Airport are equipped with NASR-10 PSRs together with Terma Scanter 4002 PSRs which are used to provide mitigation for wind turbines.

3.1.6. The locations of the Glasgow and Edinburgh PSRs are shown in Figure 6 and Figure 7 respectively.

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 6: Locations of Glasgow NASR-10 and Terma PSRs

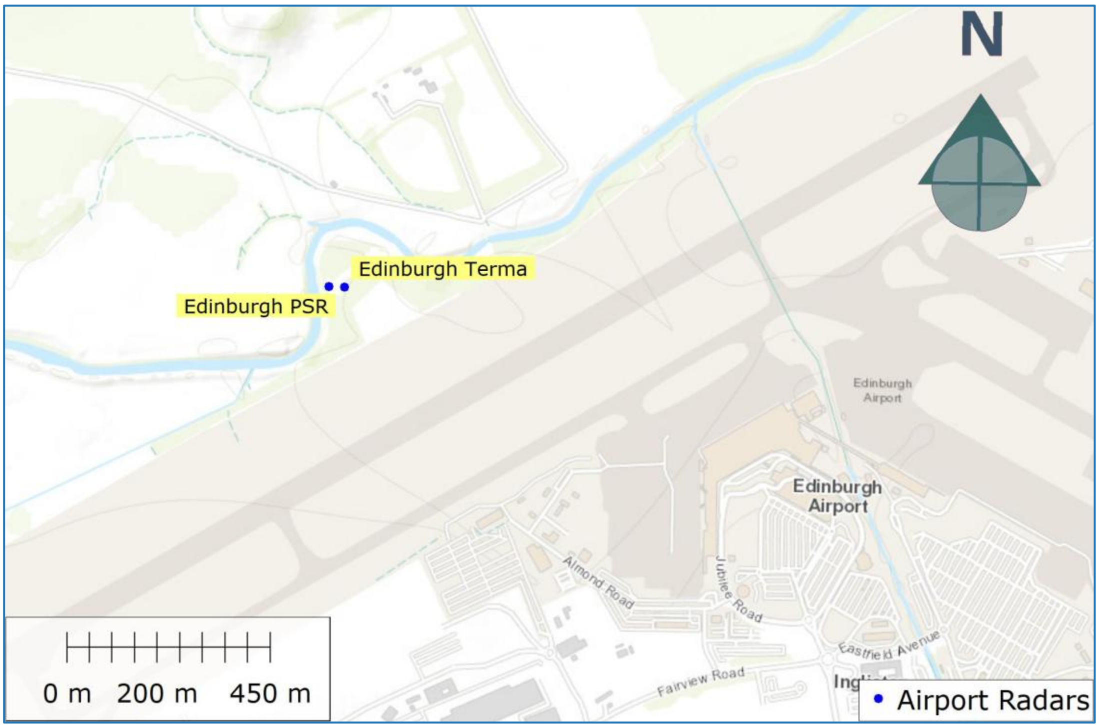


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Figure 7: Locations of Edinburgh NASR-10 and Terma PSRs

3.2. Radar Line of Sight

3.2.1. Radar Line of Sight (RLoS) is determined from a radar propagation model (ATDI HTZ communications) using 3D DTM data with 25 m horizontal resolution. Radar data is entered into the model and RLoS to the turbines from the radar is calculated.

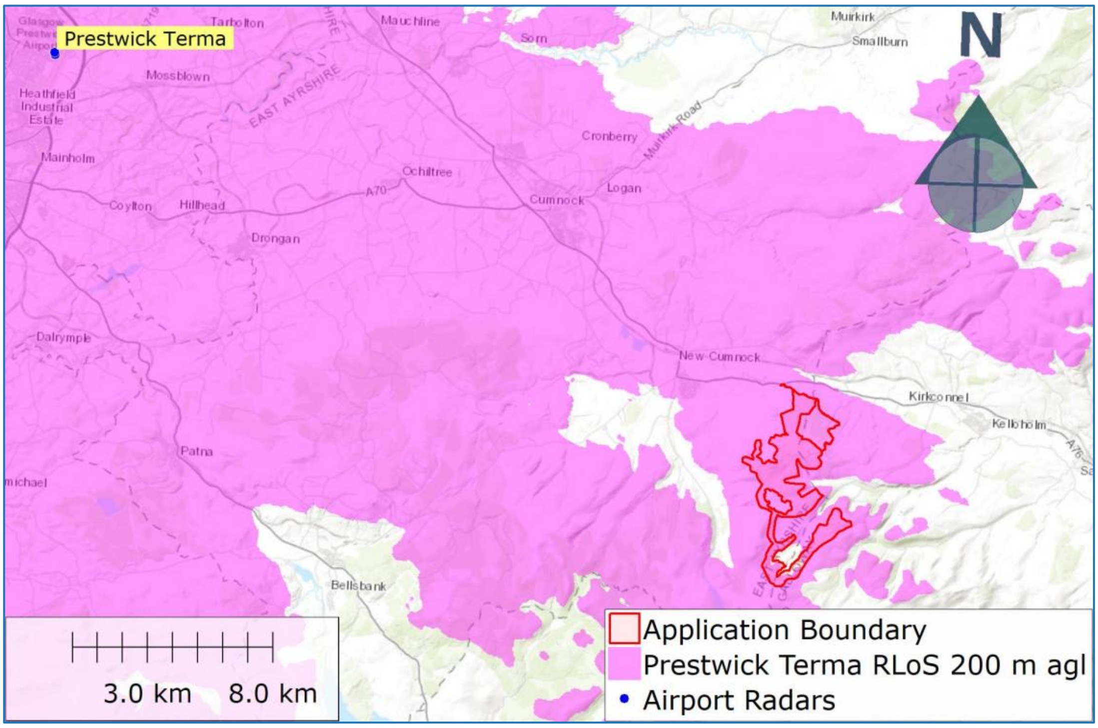
3.2.2. Note that by using a DTM no account is taken of possible further shielding of the turbines due to the presence of structures or vegetation that may lie between the radars and the turbines. Thus, the RLoS assessments are worst-case results.

3.2.3. For PSR, the principal sources of adverse windfarm effects are the turbine blades, so RLoS is calculated for the maximum tip heights of the turbines.

3.3. Prestwick PSRs

3.3.1. The S511 PSR was installed in 1990, and today is primarily used as a planning radar. The newly installed Terma PSR is effectively a replacement for this legacy radar but is limited to a range of approximately 40 nm (74 km), so the S511 may be used for traffic beyond this range. As the proposed turbines are within the range of the Terma PSR, modelling is focussed on this facility.

3.3.2. The magenta shading in Figure 8 illustrates the RLoS coverage from Prestwick Terma PSR to turbines with a blade tip height of 200 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 8: Prestwick Terma PSR RLoS to 200 m agl

3.3.3. The zoomed view of the proposed Development in Figure 9 shows that RLoS would exist between Prestwick Terma PSR and all seven turbines with a 200 m tip height (turbines T05, T10, T19, T20, T21, T22 and T23).

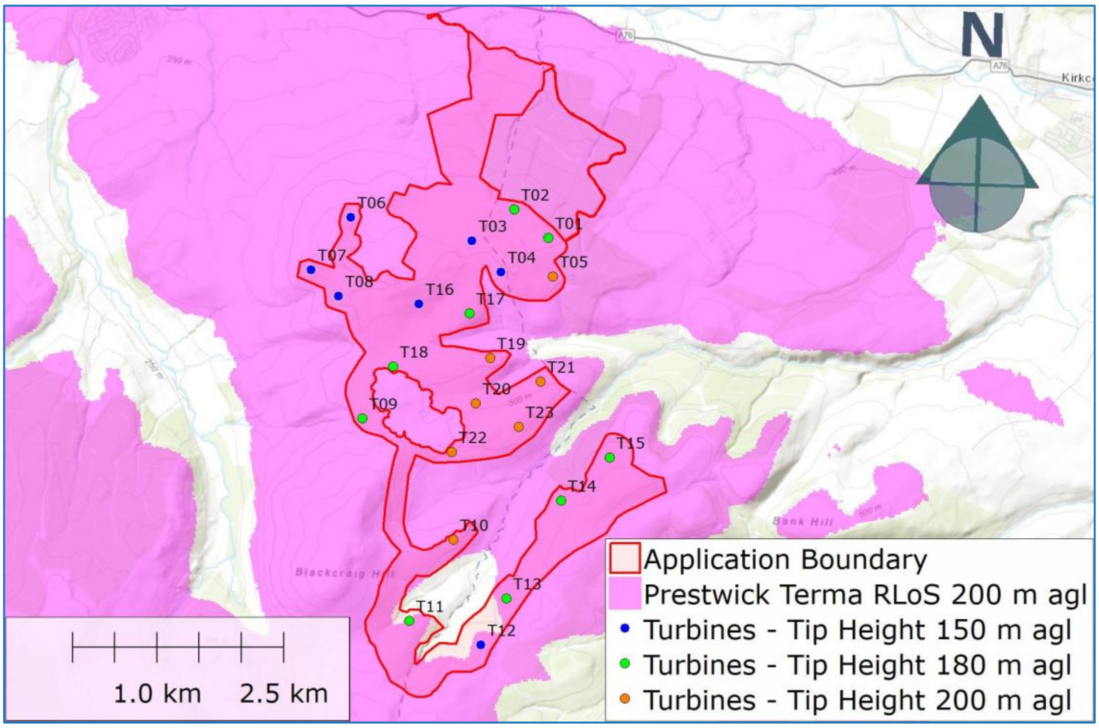


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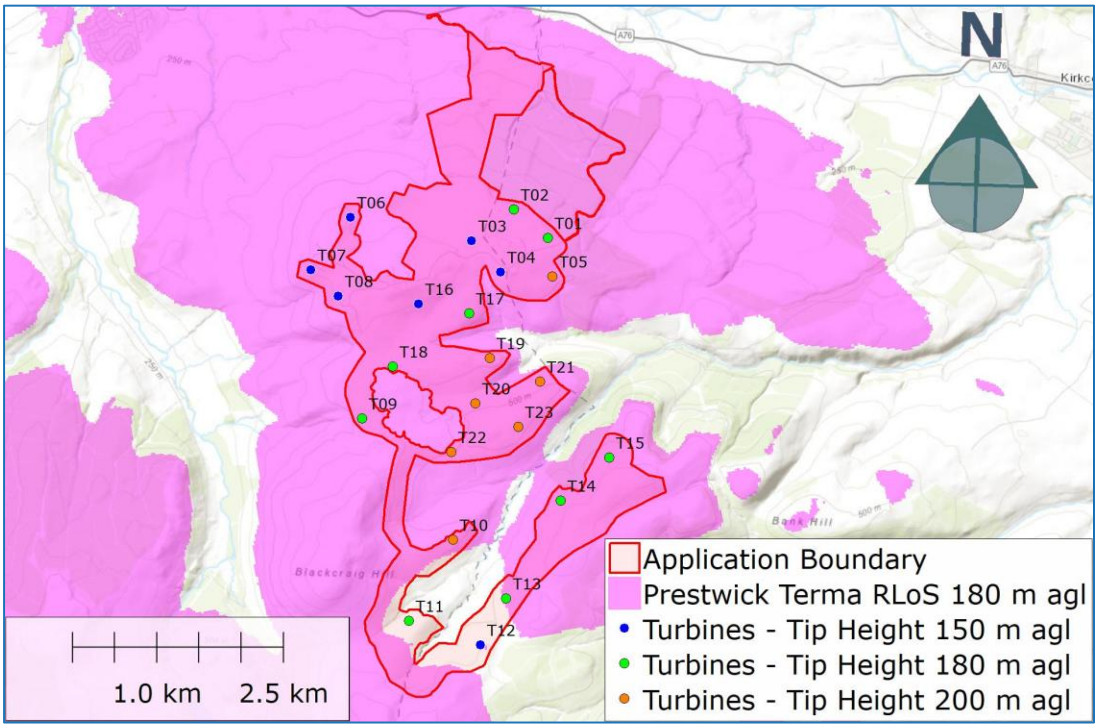
Figure 9: Prestwick Terma PSR RLoS to 200 m agl – zoomed

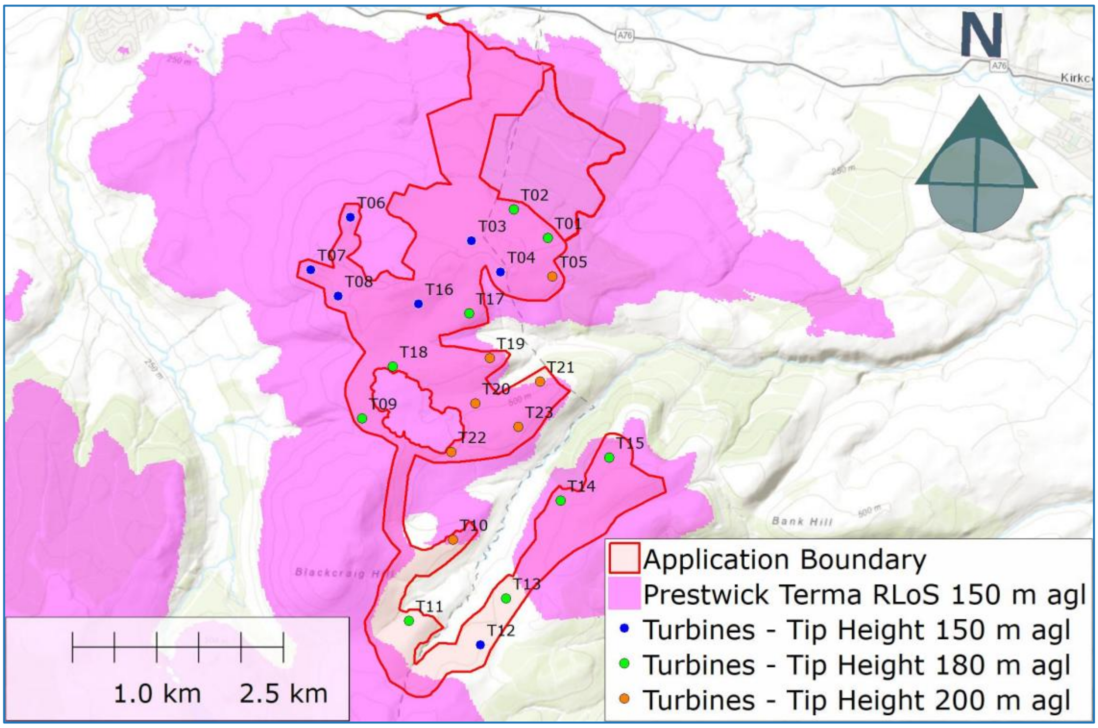
3.3.4. Figure 10 illustrates a zoomed view of the RLoS coverage from Prestwick Terma PSR to turbines with a blade tip height of 180 m agl. The magenta shading shows that RLoS would exist between Prestwick Terma PSR and eight of the nine turbines with a 180 m tip height (turbines T01, T02, T09, T13, T14, T15, T17 and T18).



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 10: Prestwick Terma PSR RLoS to 180 m agl – zoomed

3.3.5. Figure 11 illustrates a zoomed view of the RLoS coverage from Prestwick Terma PSR to turbines with a blade tip height of 150 m agl. The magenta shading shows that RLoS would exist between Prestwick Terma PSR and six of the seven turbines with a 150 m tip height (turbines T03, T04, T06, T7, T08 and T16).



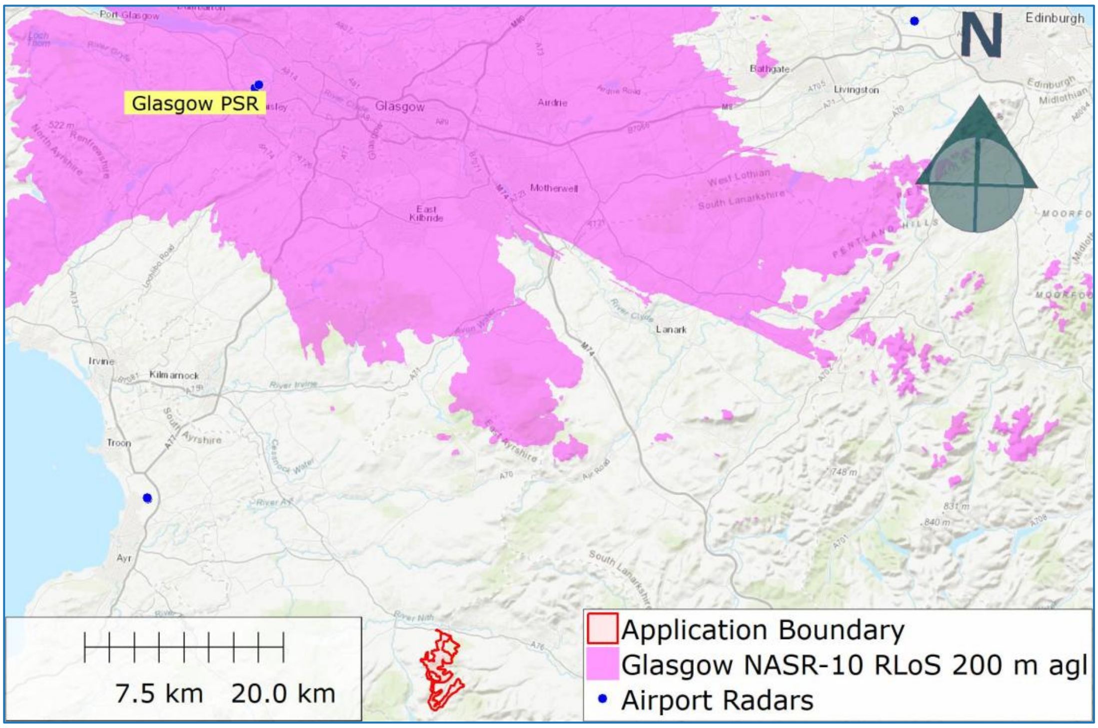
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 11: Prestwick Terma PSR RLoS to 150 m agl – zoomed

3.3.6. Overall, RLoS would exist between Prestwick Terma PSR and 21 of the 23 turbines. It can be assumed that Prestwick Terma PSR would detect at least 21 of the proposed Development turbines.

3.4. Glasgow PSRs

3.4.1. The magenta shading in Figure 12 illustrates the RLoS coverage from Glasgow NASR-10 PSR to turbines with a blade tip height of 200 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

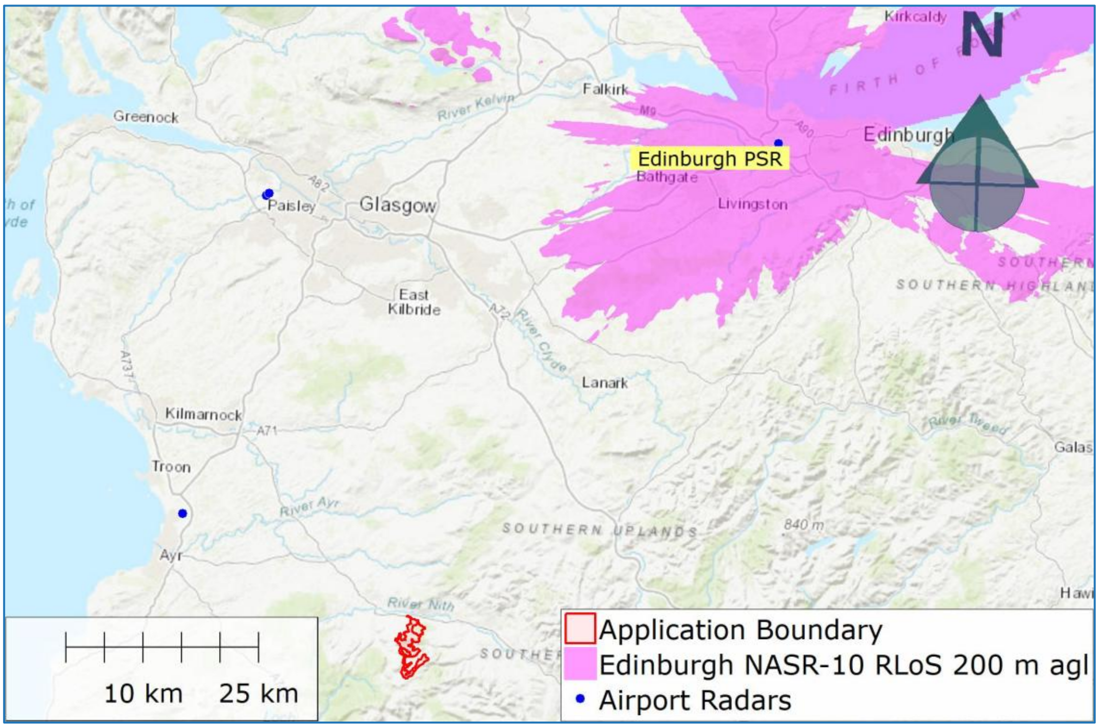
Figure 12: Glasgow NASR-10 PSR RLoS to 200 m agl

3.4.2. Figure 12 shows that RLoS would not exist between Glasgow NASR-10 PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that Glasgow NASR-10 PSR would not detect any of the proposed Development turbines.

3.4.3. Glasgow Terma PSR is sited in close proximity to Glasgow NASR-10 PSR and thus has very similar RLoS coverage performance. It can therefore be assumed that Glasgow Terma PSR would not detect any of the proposed Development turbines.

3.5. Edinburgh PSRs

3.5.1. The magenta shading in Figure 13 illustrates the RLoS coverage from Edinburgh NASR-10 PSR to turbines with a blade tip height of 200 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 13: Edinburgh NASR-10 PSR RLoS to 200 m agl

3.5.2. Figure 13 shows that RLoS would not exist between Edinburgh NASR-10 PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that Edinburgh NASR-10 PSR would not detect any of the proposed Development turbines.

3.5.3. The Terma PSR is limited to a range of approximately 40 nm or 74 km, so at a minimum distance of 77 km, the proposed Development turbines would lie beyond the expected operational coverage of Edinburgh Terma PSR.

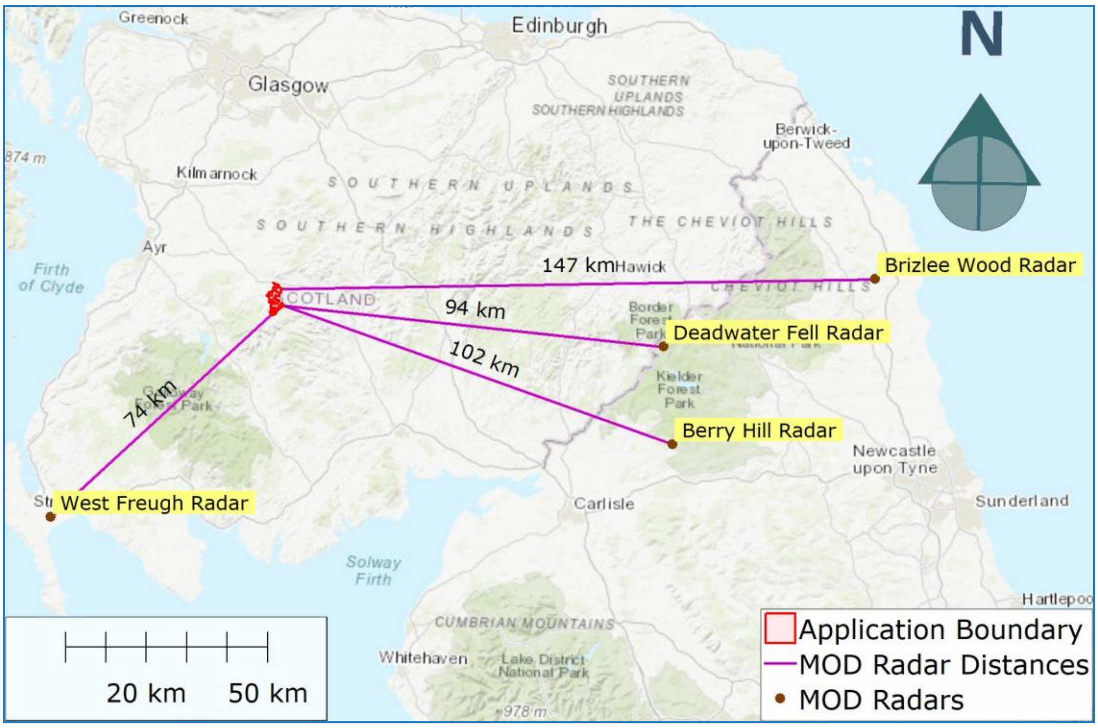
4. MOD PSR Modelling

4.1. Radar Locations

4.1.1. The closest MOD radars to the Site are the ATC PSR at MOD West Freugh, the ATC PSRs at Berry Hill and Deadwater Fell utilised by Royal Air Force Spadeadam, and the MOD Air Defence (AD) PSR at Brizlee Wood.

4.1.2. At its closest points, the proposed Development is approximately 74 km north east of West Freugh PSR, 94 km west, north west of Deadwater Fell PSR, 102 km west, north west of Berry Hill PSR and 147 km west of Brizlee Wood PSR.

4.1.3. The locations of the MOD PSRs relative to the proposed Development are shown in Figure 14.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 14: Locations of MOD radars and proposed Development

4.2. Radar Line of Sight

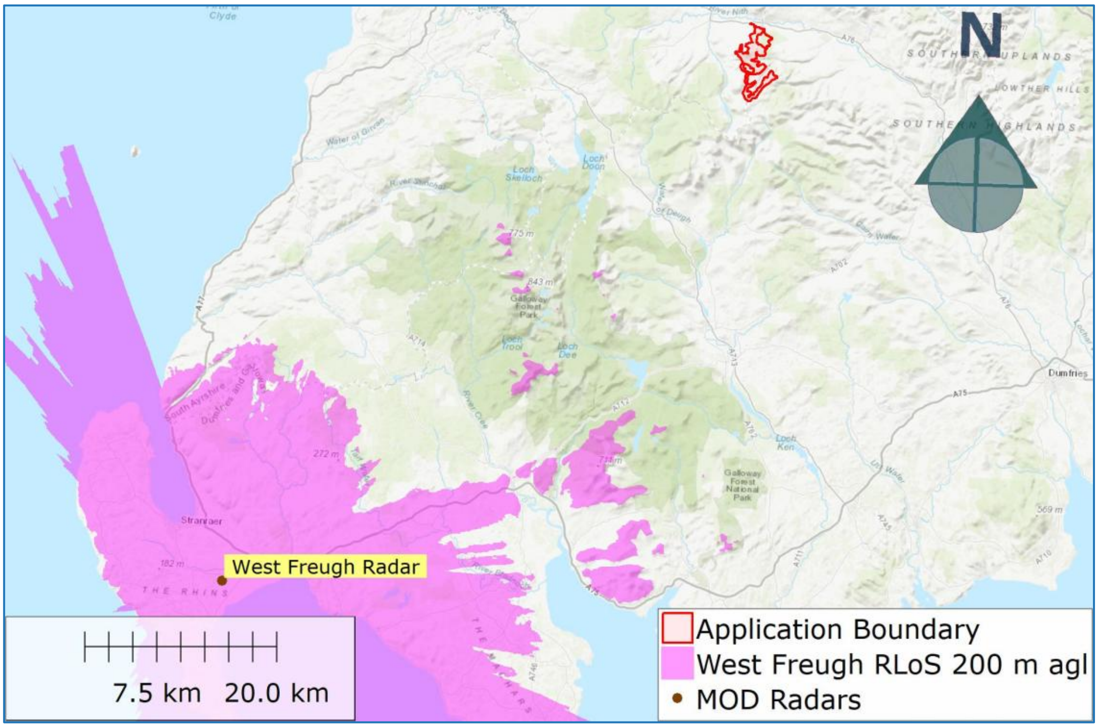
4.2.1. RLoS is determined from a radar propagation model (ATDI HTZ communications) using 3D DTM data with 25 m horizontal resolution. Radar data is entered into the model and RLoS to the turbines from the radar is calculated.

4.2.2. Note that by using a DTM no account is taken of possible further shielding of the turbines due to the presence of structures or vegetation that may lie between the radars and the turbines. Thus, the RLoS assessments are worst-case results.

4.2.3. For PSR, the principal sources of adverse windfarm effects are the turbine blades, so RLoS is calculated for the maximum tip heights of the turbines.

4.3. West Freugh PSR

4.3.1. The magenta shading in Figure 15 illustrates the RLoS coverage from Berry Hill PSR to turbines with a blade tip height of 200 m agl.



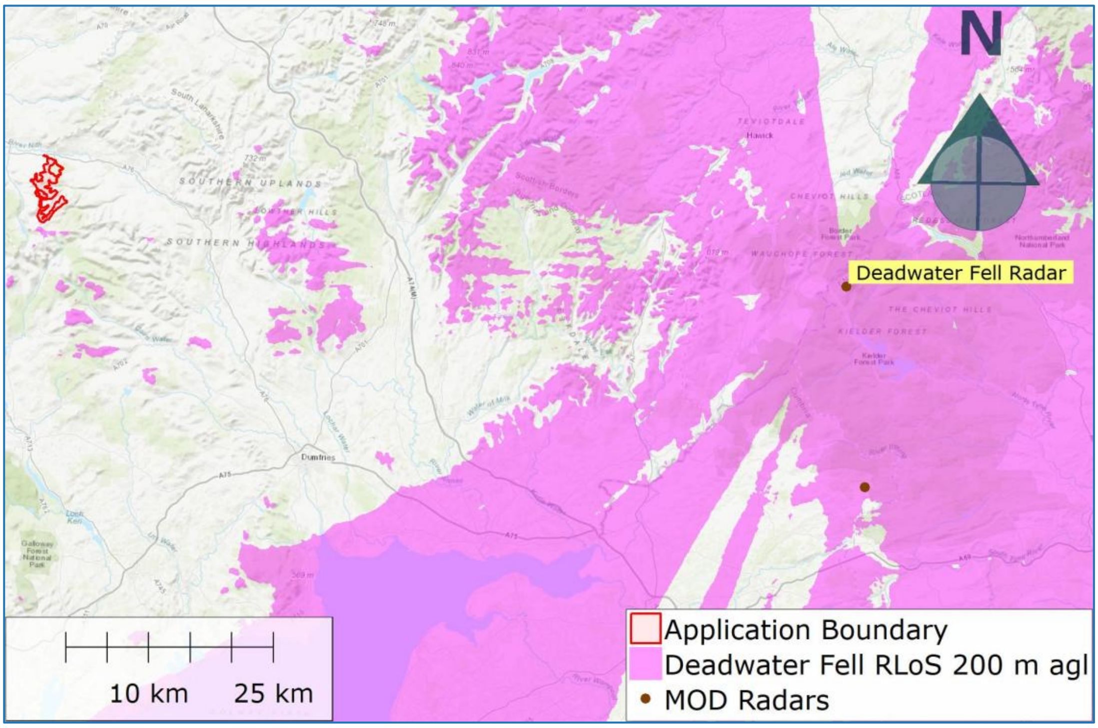
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 15: West Freugh PSR RLoS to 200 m agl

4.3.2. Figure 15 shows that RLoS would not exist between West Freugh PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that West Freugh PSR would not detect any of the proposed Development turbines.

4.4. Deadwater Fell PSR

4.4.1. The magenta shading in Figure 16 illustrates the RLoS coverage from Deadwater Fell PSR to turbines with a blade tip height of 200 m agl.



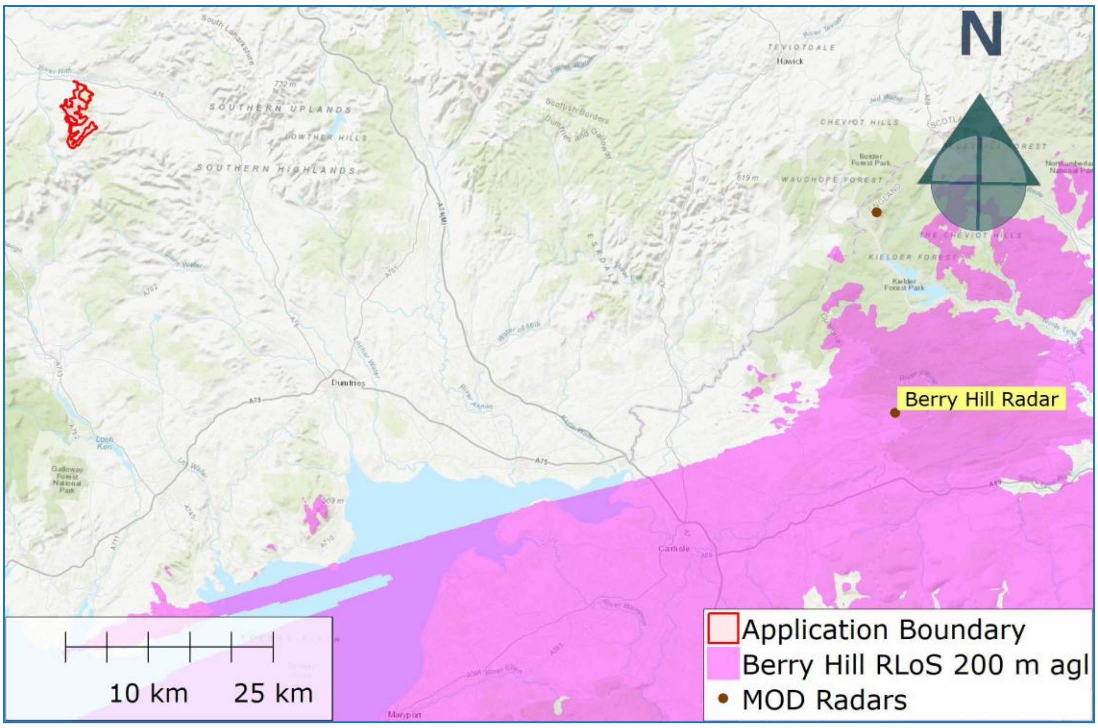
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 16: Deadwater Fell PSR RLoS to 200 m agl

4.4.2. Figure 16 shows that RLoS would not exist between Deadwater Fell PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that Deadwater Fell PSR would not detect any of the proposed Development turbines.

4.5. Berry Hill PSR

4.5.1. The magenta shading in Figure 17 illustrates the RLoS coverage from Berry Hill PSR to turbines with a blade tip height of 200 m agl.



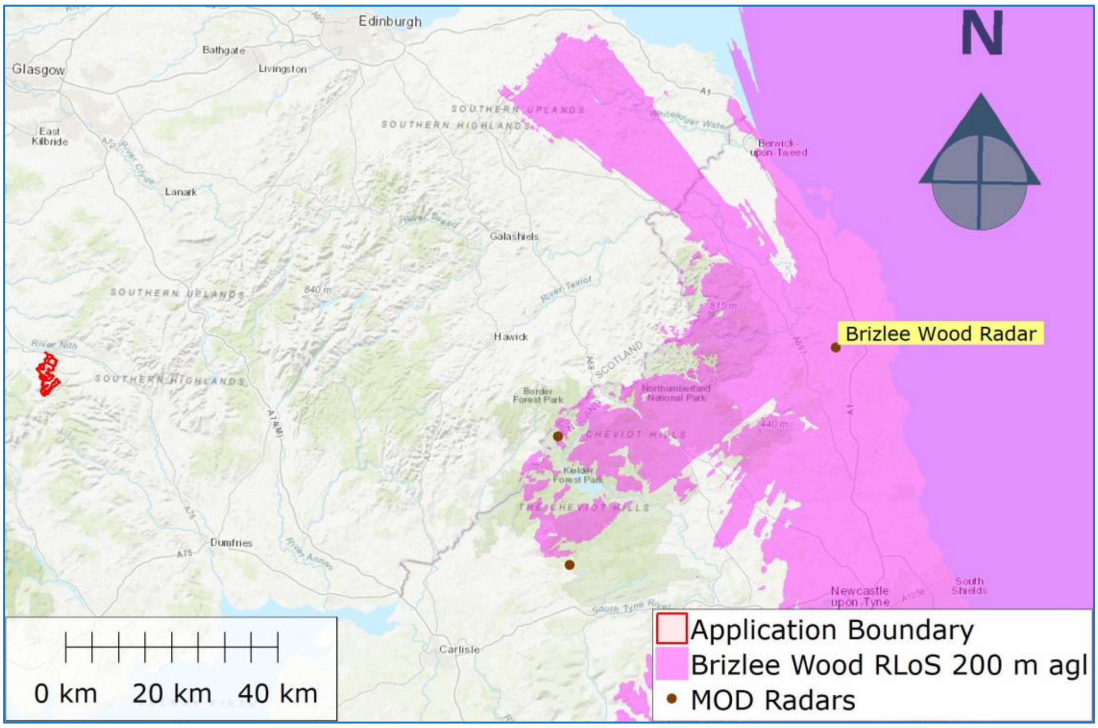
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 17: Berry Hill PSR RLoS to 200 m agl

4.5.2. Figure 17 shows that RLoS would not exist between Berry Hill PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that Berry Hill PSR would not detect any of the proposed Development turbines.

4.6. Brizlee Wood PSR

4.6.1. The magenta shading in Figure 18 illustrates the RLoS coverage from Brizlee Wood PSR to turbines with a blade tip height of 200 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 18: Brizlee Wood PSR RLoS to 200 m agl

4.6.2. Figure 18 shows that RLoS would not exist between Brizlee Wood PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that Brizlee Wood PSR would not detect any of the proposed Development turbines.

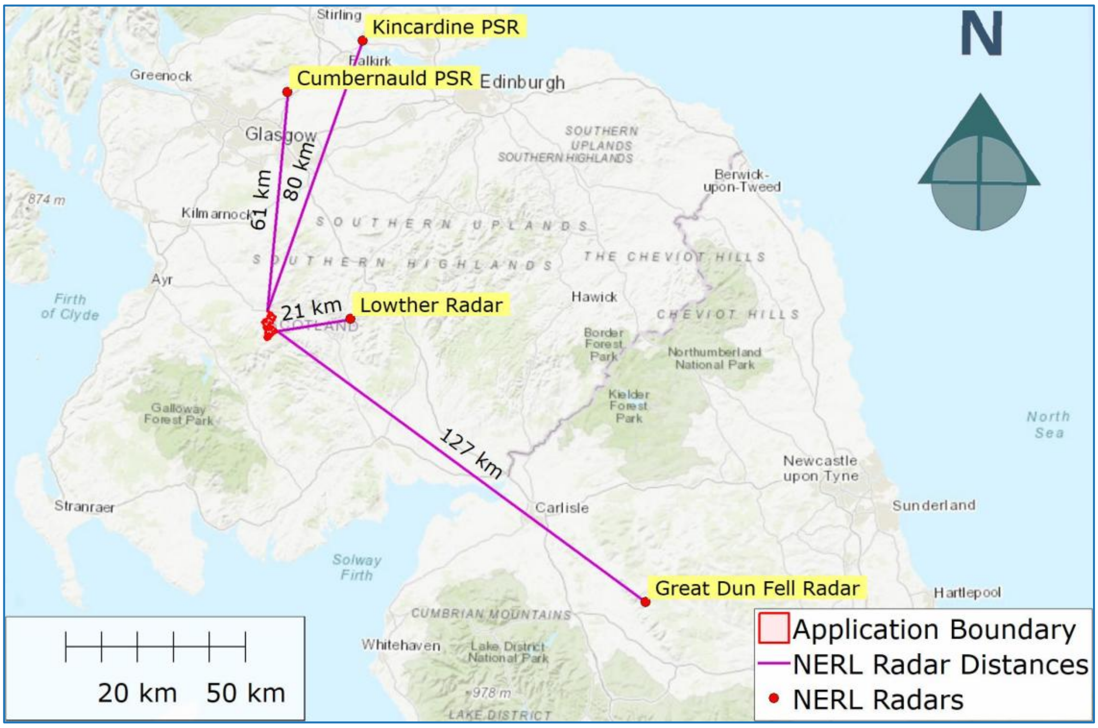
5. NERL PSR Modelling

5.1. Radar Locations

5.1.1. Four NERL PSRs have been identified that may be technically impacted by the proposed Development turbines: Lowther Hill, Great Dun Fell, Cumbernauld and Kincardine.

5.1.2. At its closest points, the proposed Development is approximately 20 km west of Lowther Hill PSR, 127 km north west of Great Dun Fell PSR, 61 km south of Cumbernauld PSR, and 80 km south, south west of Kincardine PSR.

5.1.3. The locations of NERL PSRs relative to the proposed Development are shown in Figure 19.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 19: Locations of NERL radars and proposed Development

5.2. Radar Line of Sight

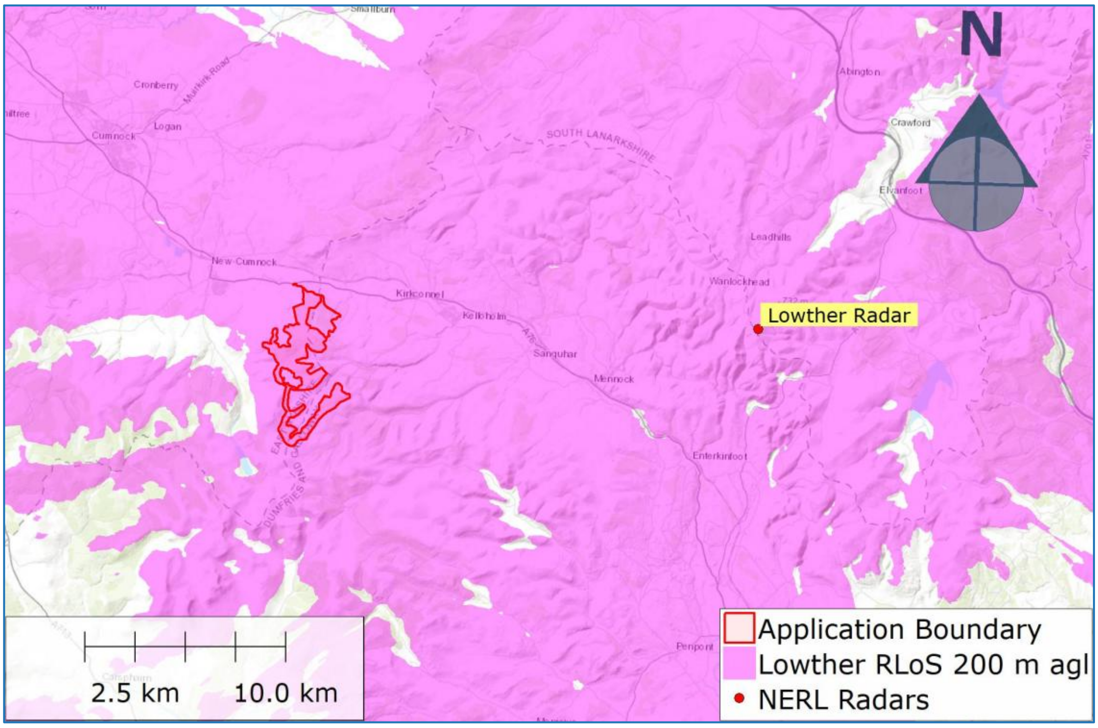
5.2.1. RLoS is determined from a radar propagation model (ATDI HTZ communications) using 3D DTM data with 25 m horizontal resolution. Radar data is entered into the model and RLoS to the turbines from the radar is calculated.

5.2.2. Note that by using a DTM no account is taken of possible further shielding of the turbines due to the presence of structures or vegetation that may lie between the radars and the turbines. Thus, the RLoS assessments are worst-case results.

5.2.3. For PSR, the principal sources of adverse windfarm effects are the turbine blades, so RLoS is calculated for the maximum tip heights of the turbines.

5.3. Lowther Hill PSR

5.3.1. The magenta shading in Figure 20 illustrates the RLoS coverage from Lowther Hill PSR to turbines with a blade tip height of 200 m agl.

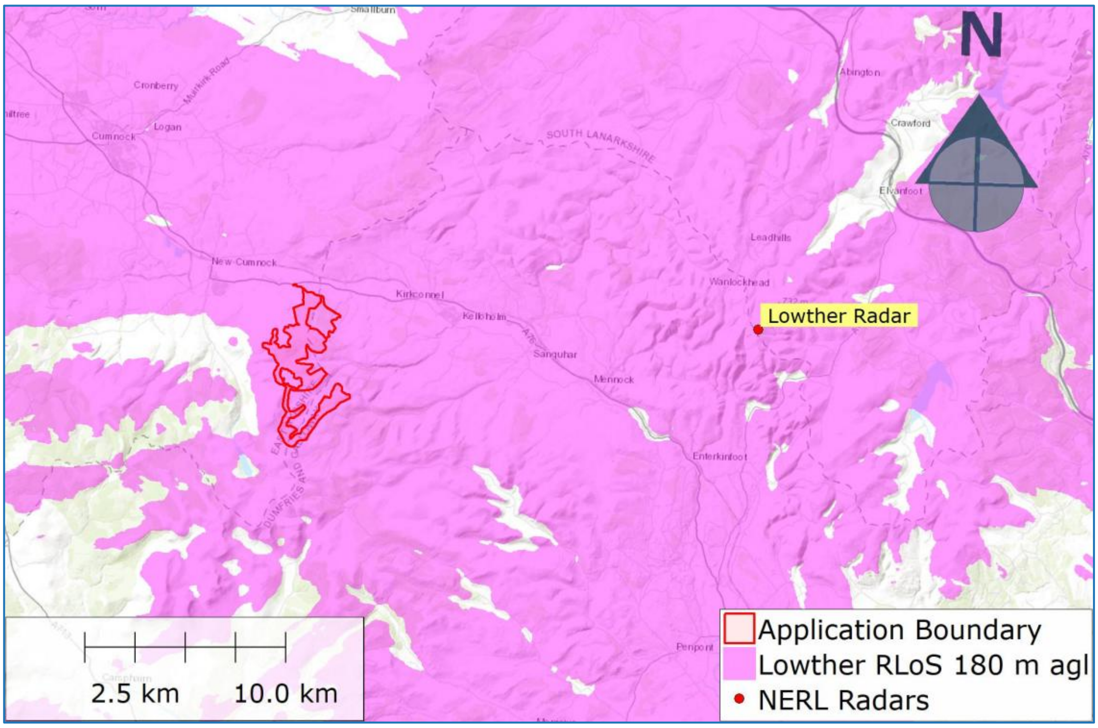


Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 20: Lowther Hill PSR RLoS to 200 m agl

5.3.2. Figure 20 shows that RLoS would exist between Lowther Hill PSR and any turbines with a 200 m tip height within the application boundary.

5.3.3. The magenta shading in Figure 21 illustrates the RLoS coverage from Lowther Hill PSR to turbines with a blade tip height of 180 m agl.

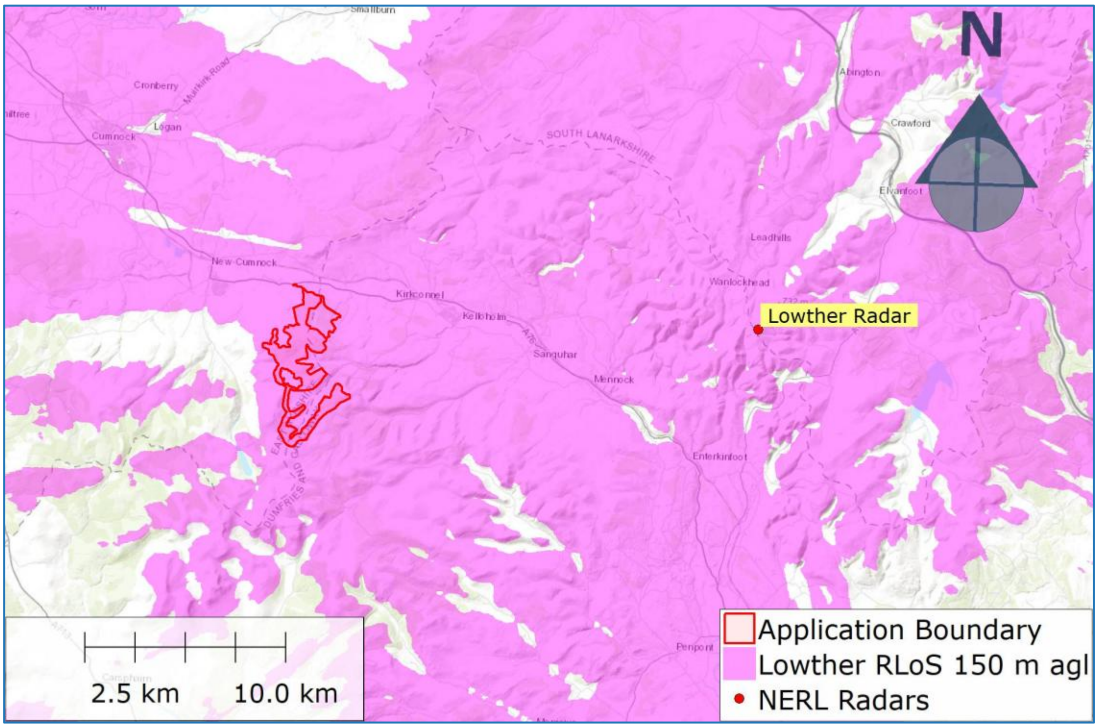


Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 21: Lowther Hill PSR RLoS to 180 m agl

5.3.4. Figure 21 shows that RLoS would exist between Lowther Hill PSR and any turbines with a 180 m tip height within the application boundary.

5.3.5. The magenta shading in Figure 22 illustrates the RLoS coverage from Lowther Hill PSR to turbines with a blade tip height of 150 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 22: Lowther Hill PSR RLoS to 150 m agl – zoomed

5.3.6. Figure 22 shows that RLoS would exist between Lowther Hill PSR and any turbines with a 150 m tip height within the application boundary.

5.3.7. Given that RLoS would exist between Lowther Hill PSR and any turbines with tip heights of between 150 m and 200 m agl within the application boundary, it can be assumed that Lowther Hill PSR would detect all of the proposed Development turbines.

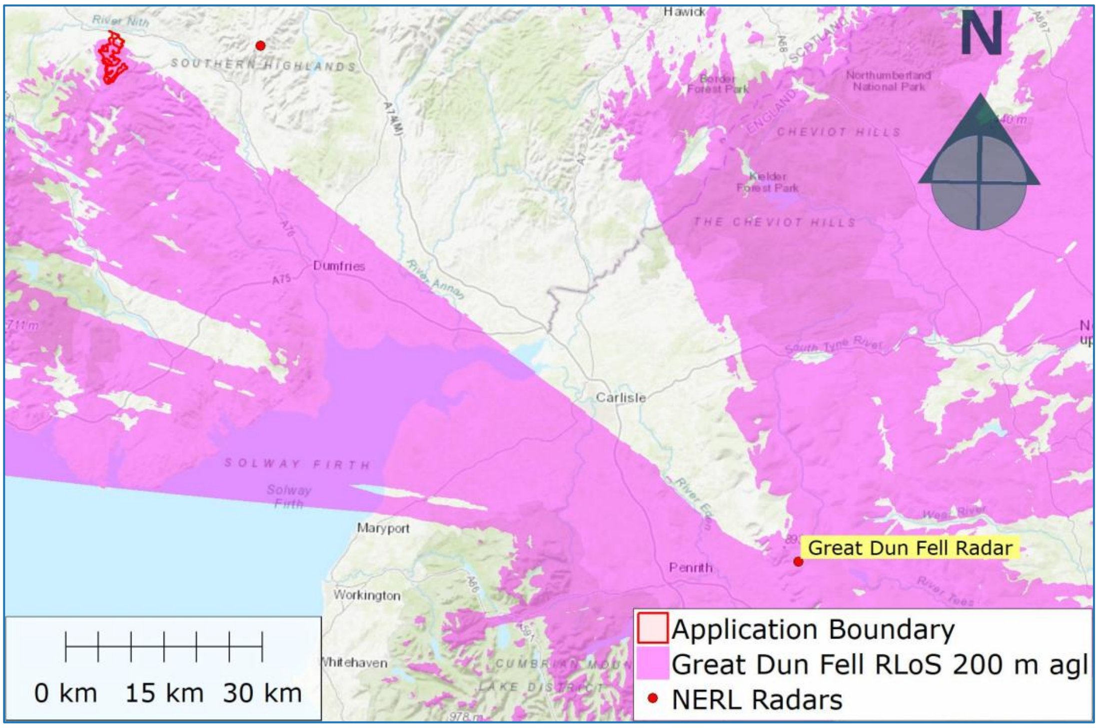
5.4. Lowther Hill SSR

5.4.1. The effects of wind turbines on SSR are considerably less than effects on PSRs. Turbine towers can physically blank and diffract SSR signals, but these effects are typically only considered when turbines are within 10 km of the facility. At greater ranges, SSR signals reflected from wind turbines can result in the radar generating a false target in a direction that is different to where the intended aircraft target is.

5.4.2. In order to protect their SSR facilities from the impact of windfarms, NERL establish a safeguarded zone of radius 15 nm (28 km) around them. The Site is within this range from Lowther Hill SSR; however, NERL has not raised any concerns regarding potential SSR impacts.

5.5. Great Dun Fell PSR

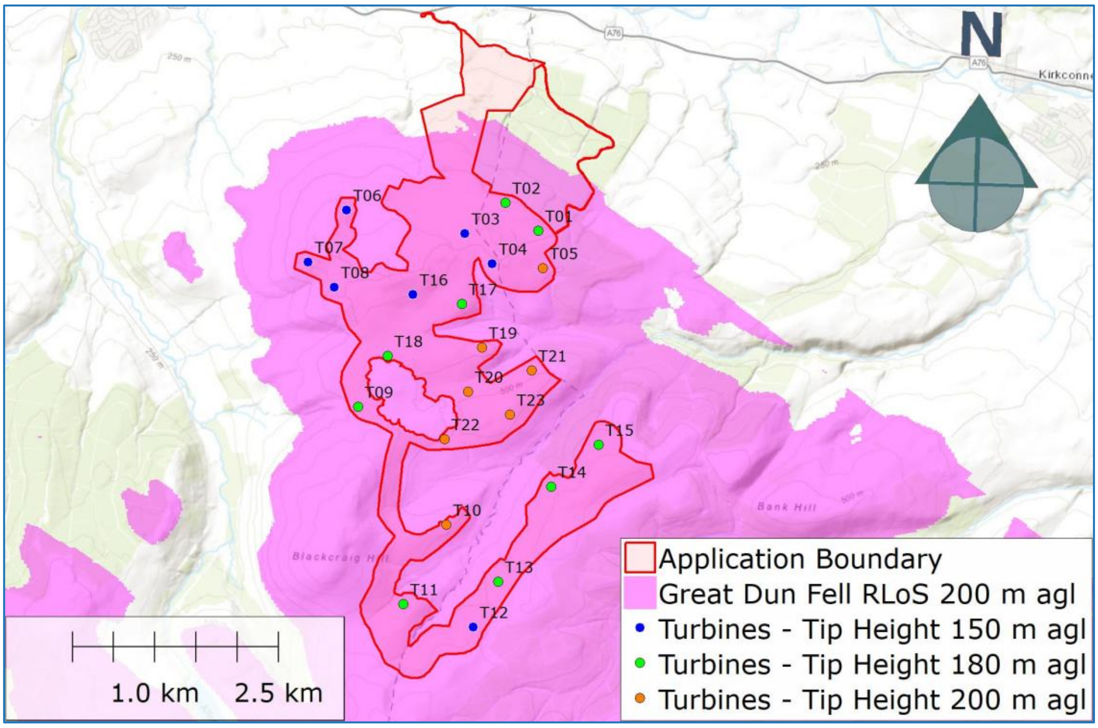
5.5.1. The magenta shading in Figure 23 illustrates the RLoS coverage from Great Dun Fell PSR to turbines with a blade tip height of 200 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 23: Great Dun Fell PSR RLoS to 200 m agl

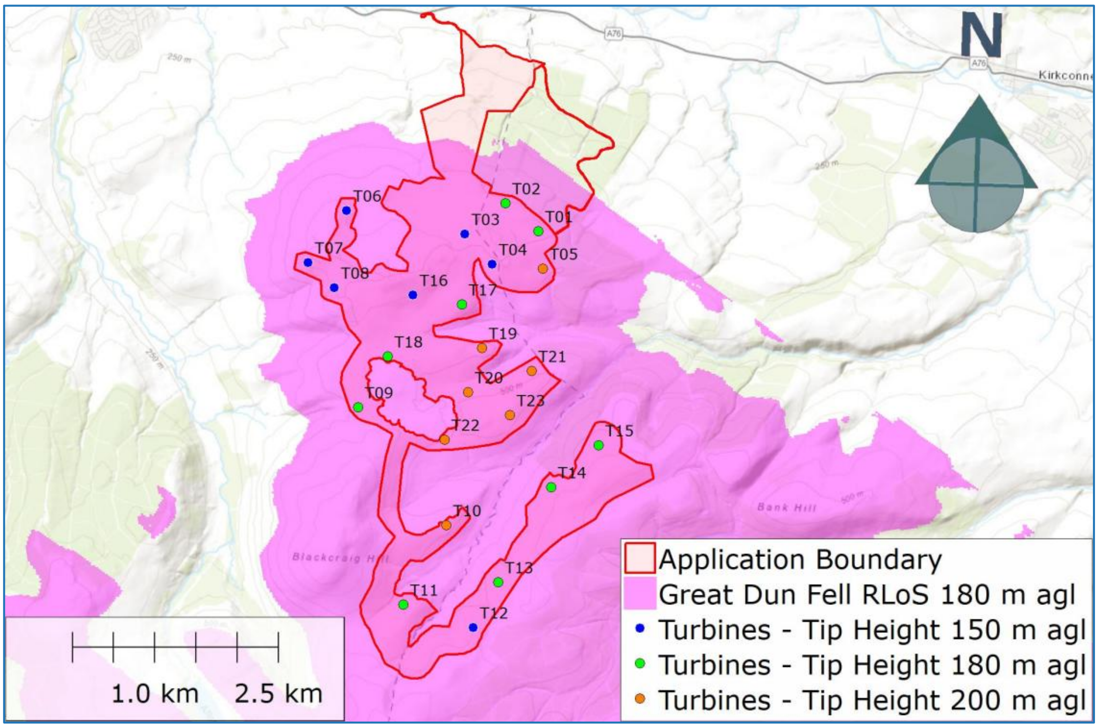
5.5.2. The zoomed view in Figure 24 shows that RLoS would exist between Great Dun Fell PSR and all seven turbines with a 200 m tip height (turbines T05, T10, T19, T20, T21, T22 and T23).



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 24: Great Dun Fell PSR RLoS to 200 m agl – zoomed

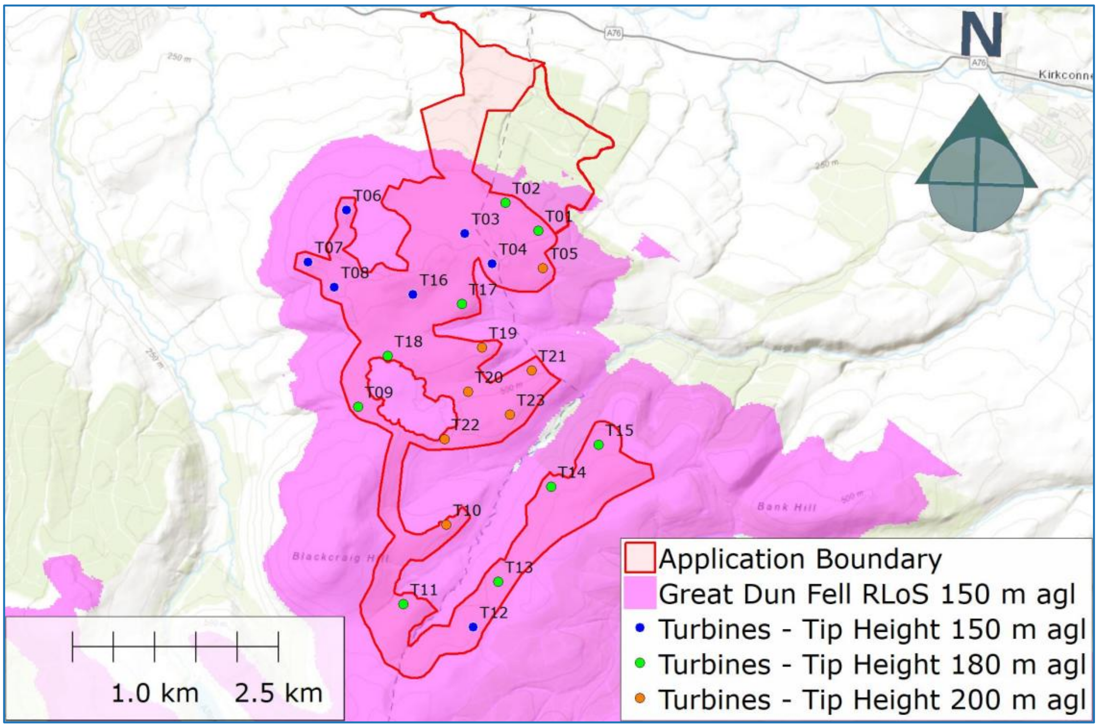
5.5.3. Figure 25 illustrates a zoomed view of the RLoS coverage from Great Dun Fell PSR to turbines with a blade tip height of 180 m agl. The magenta shading shows that RLoS would exist between Great Dun Fell PSR and all nine turbines with a 180 m tip height (turbines T01, T02, T09, T11, T13, T14, T15, T17 and T18).



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 25: Great Dun Fell PSR RLoS to 180 m agl – zoomed

5.5.4. Figure 26 illustrates a zoomed view of the RLoS coverage from Great Dun Fell PSR to turbines with a blade tip height of 150 m agl. The magenta shading shows that RLoS would exist between Great Dun Fell PSR and all seven turbines with a 150 m tip height (turbines T03, T04, T06, T07, T08, T12 and T16).



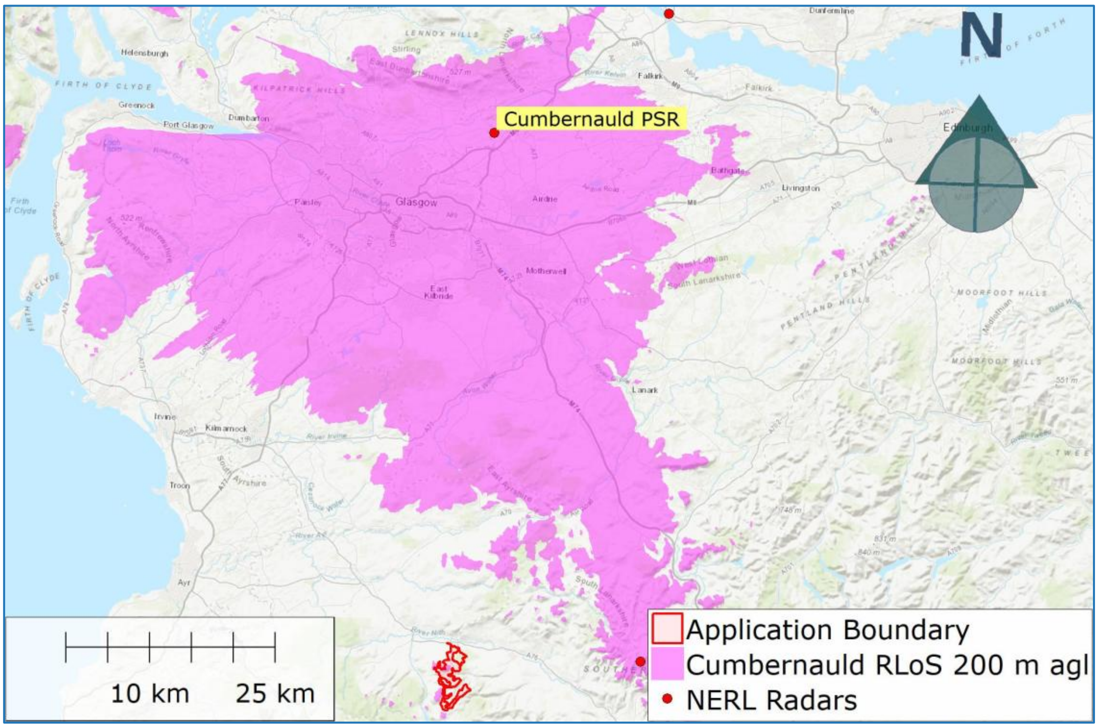
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 26: Great Dun Fell PSR RLoS to 150 m agl – zoomed

5.5.5. Given that RLoS would exist between Great Dun Fell PSR and all of the 23 turbines, it can be assumed that Great Dun Fell PSR would detect all of the proposed Development turbines.

5.6. Cumbernauld PSR

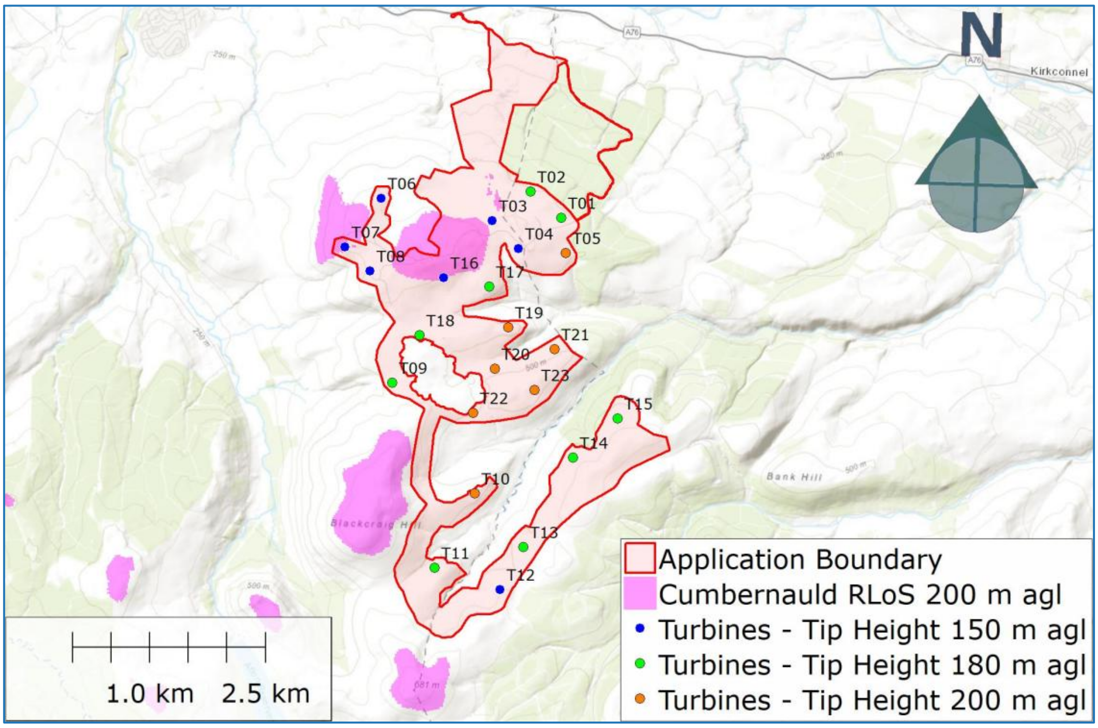
5.6.1. The magenta shading in Figure 27 illustrates the RLoS coverage from Cumbernauld PSR to turbines with a blade tip height of 200 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 27: Cumbernauld PSR RLoS to 200 m agl

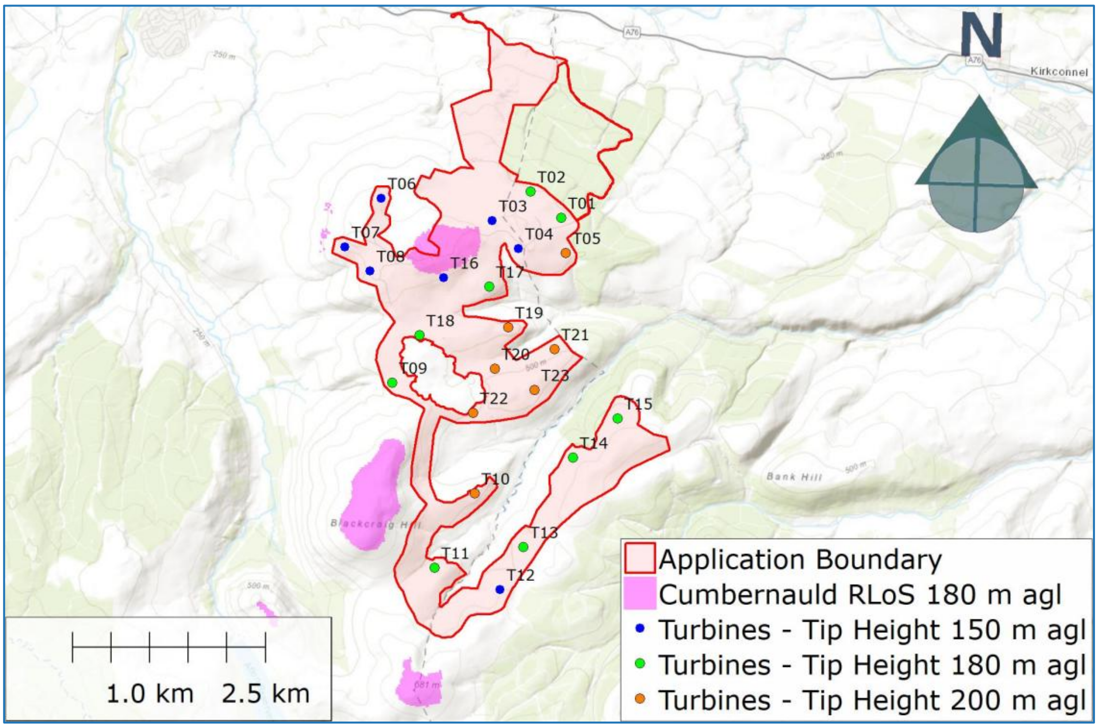
5.6.2. The zoomed view in Figure 28 shows that RLoS would not exist between Cumbernauld PSR and any of the seven turbines with a 200 m tip height.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 28: Cumbernauld PSR RLoS to 200 m agl – zoomed

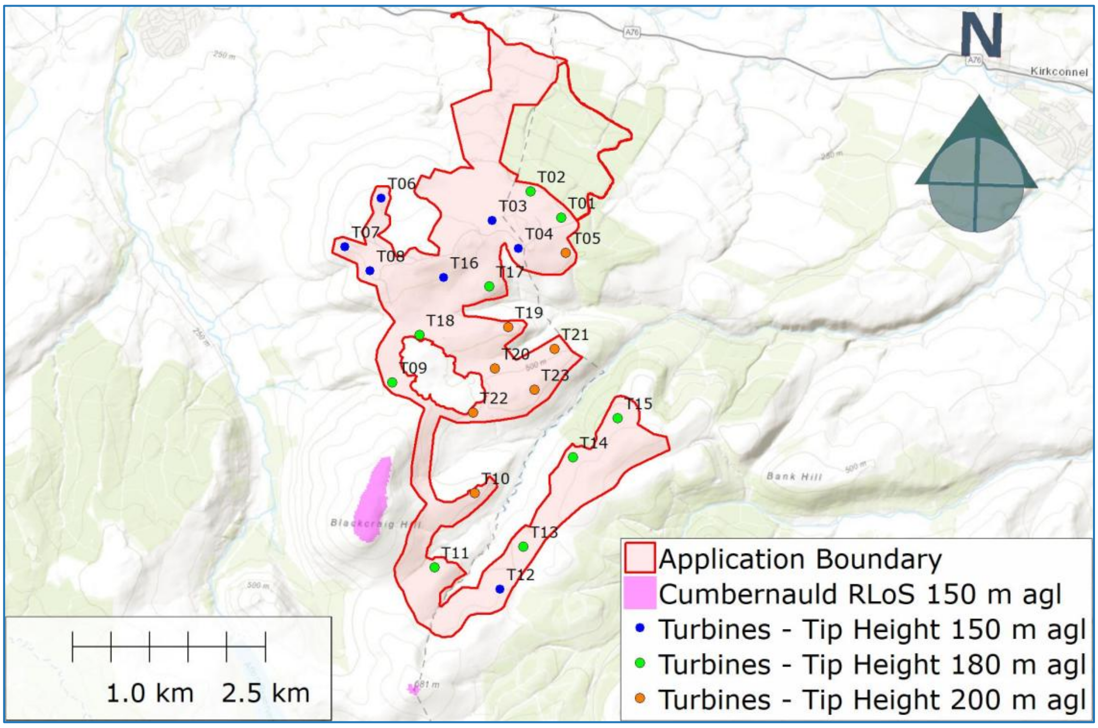
5.6.3. Figure 29 illustrates a zoomed view of the RLoS coverage from Cumbernauld PSR to turbines with a blade tip height of 180 m agl. The magenta shading shows that RLoS would not exist between Cumbernauld PSR and any of the nine turbines with a 180 m tip height.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 29: Cumbernauld RLoS to 180 m agl – zoomed

5.6.4. Figure 30 illustrates a zoomed view of the RLoS coverage from Cumbernauld PSR to turbines with a blade tip height of 150 m agl. The magenta shading shows that RLoS would not exist between Cumbernauld PSR and any of the seven turbines with a 150 m tip height.



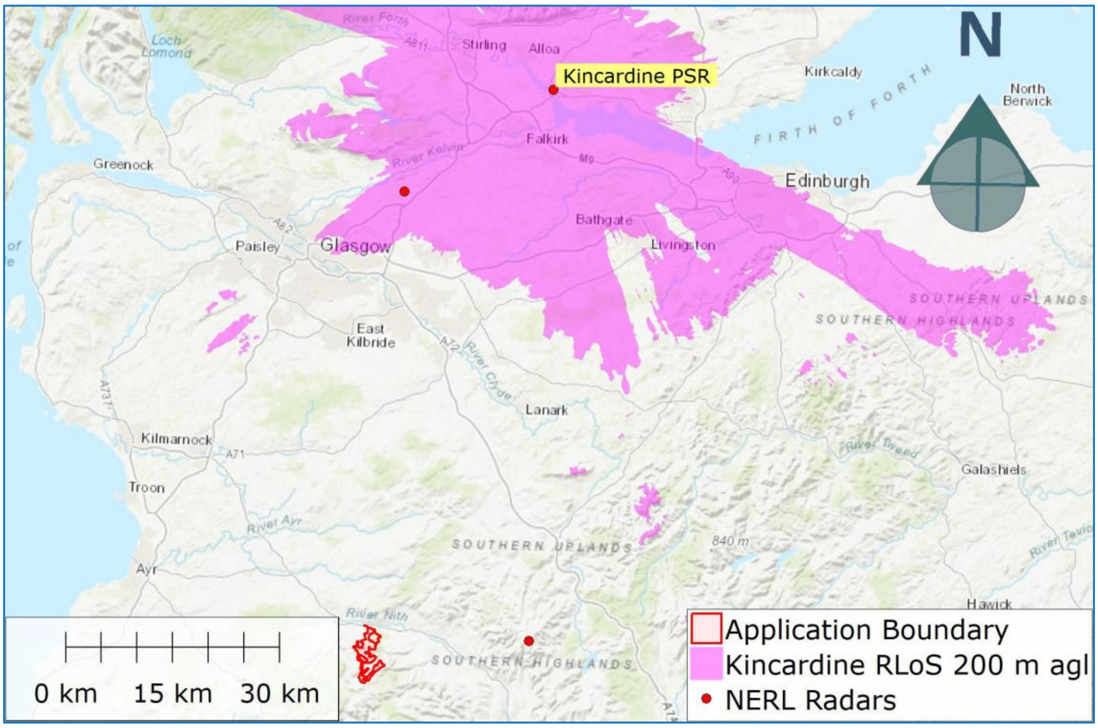
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 30: Cumbernauld PSR RLoS to 150 m agl – zoomed

5.6.5. Given that RLoS would not exist between Cumbernauld PSR and any of the 23 turbines, it can be assumed that Cumbernauld PSR would not detect any of the proposed Development turbines.

5.7. Kincardine PSR

5.7.1. The magenta shading in Figure 31 illustrates the RLoS coverage from Kincardine PSR to turbines with a blade tip height of 200 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 31: Kincardine PSR RLoS to 200 m agl

5.7.2. Figure 31 shows that RLoS would not exist between Kincardine PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that Kincardine PSR would not detect any of the proposed Development turbines.

6. Airspace Analysis

6.1. Overview

6.1.1. As already noted, the significance of any radar impact depends on airspace usage in the vicinity of the proposed Development and the nature of the ATS provided in that airspace.

6.1.2. The airspace surrounding the proposed Development is detailed in the UK Aeronautical Information Publication (AIP)[3]. The type (airspace classification), usage and dimensions are contained within various sections of the En Route (ENR) section of the AIP.

6.1.3. The airspace immediately above the proposed Development consists of two types of airspace. The first portion is classified as Class G and extends from ground level to 5,500 ft above mean sea level (amsl). Class G airspace is commonly referred to as 'uncontrolled airspace' and is predominantly used by General Aviation (GA) and military aircraft. In uncontrolled airspace the responsibility to see and avoid other traffic and obstacles rests with the pilots in command of civilian and military aircraft and any ATS provided is essentially advisory. Services within the area are provided in accordance with CAP 774[4].

6.1.4. Above the uncontrolled airspace is the Scottish Terminal Control Area (TMA) which is subdivided into TMAs 1 to 7 and is Class D controlled airspace. The proposed Development lies below TMA 2 which extends vertically from 5,500 ft amsl to Flight Level (FL) 195 (standard atmospheric pressure equivalent to 19,500 ft amsl). This airspace contains lower ATS routes and IFPs associated with Prestwick Airport, Glasgow Airport and Edinburgh Airport. IFPs are procedures published in the AIP used by aircraft that are departing, arriving and landing at airports. They are designed to achieve an acceptable level of safety in operations and keep aircraft clear of all known obstacles. Types of IFPs include Instrument Approach Procedures, Standard Instrument Departures and Standard (Instrument) Arrivals.

6.1.5. TMA 2 is managed by Scottish Control (NERL), based at NATS Prestwick Centre, and is declared a Transponder Mandatory Zone (TMZ) between 6,000ft amsl and FL 100 (standard atmospheric pressure equivalent to 10,000 ft amsl). Carriage and operation of an SSR transponder is mandatory within a TMZ. Control of the TMA airspace in the vicinity of Prestwick Airport from 5,500 ft to 6,000 ft amsl is delegated from NERL to Prestwick Airport to enable the airport to vector and sequence traffic. The proposed development is located east of Prestwick Airport's controlled airspace.

6.1.6. Aircraft within Class D airspace are under a Radar Control Service. Clearance from the controlling authority is required to enter the controlled airspace and ATC instructions are mandatory. It provides a 'known traffic environment' meaning that ATC is aware of all traffic operating within the designated airspace.

6.1.7. The airspace structure in the vicinity of the proposed Development is depicted in Figure 32, and lower ATS routes are shown in Figure 33.

[3] CAP 032: UK Aeronautical Information Publication, December 2024
[4] CAP 774: UK Flight Information Services, December 2021

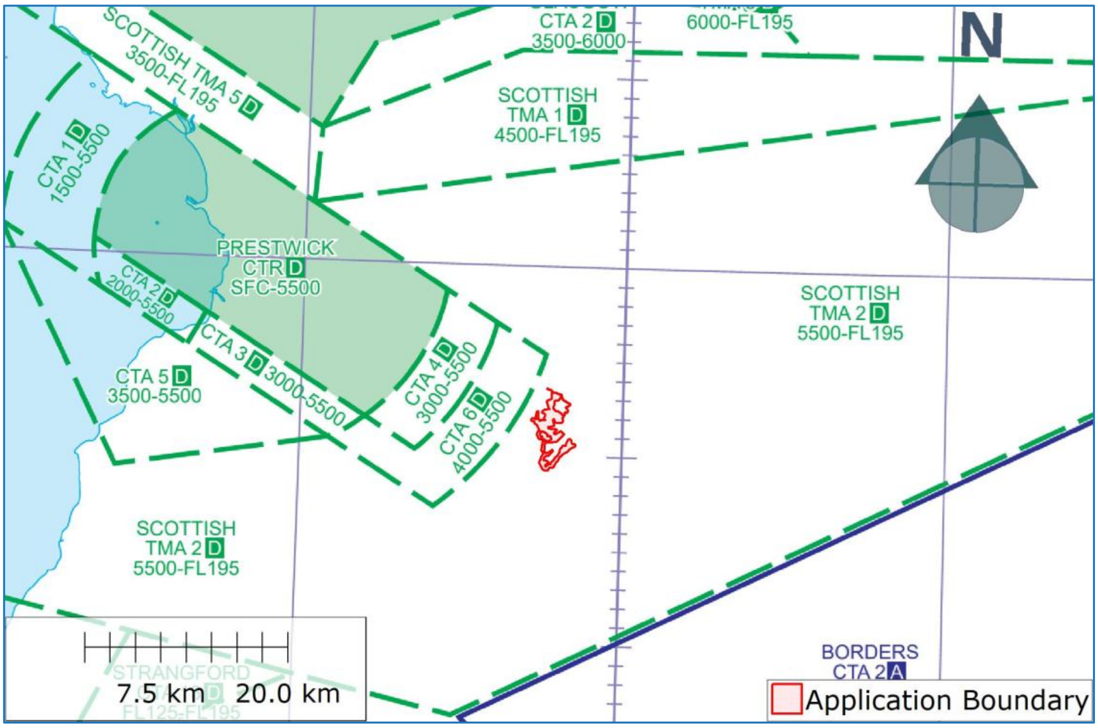


Figure 32: Airspace structure (extract from AIP chart ENR 6.7 (11 July 2024))

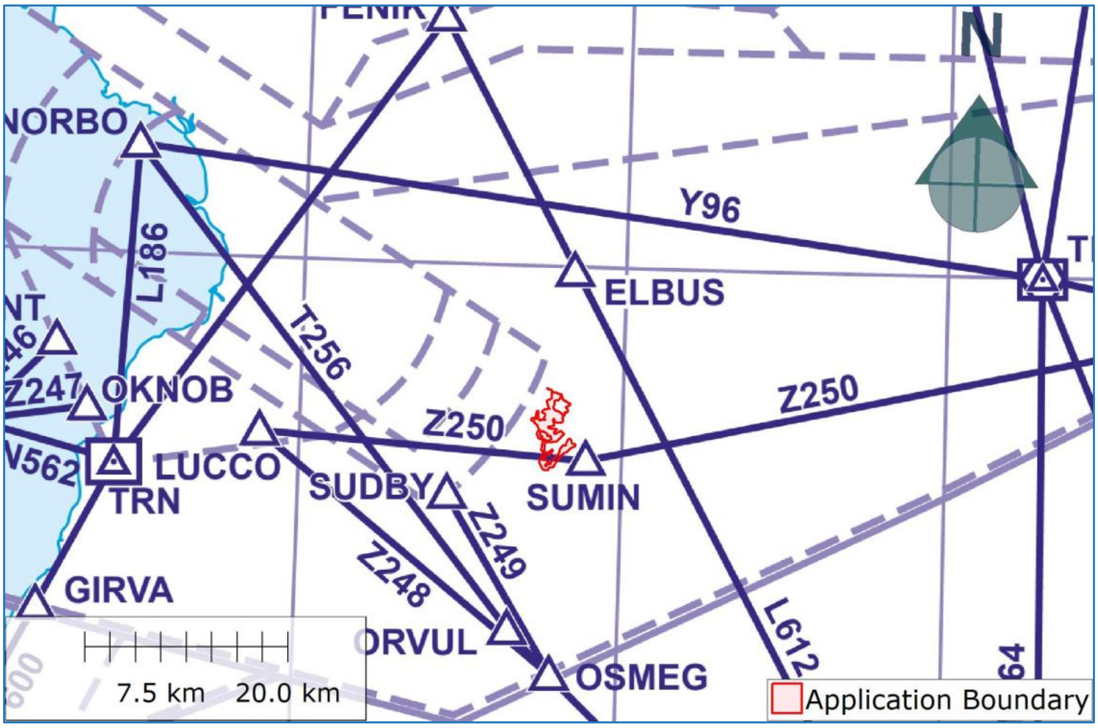


Figure 33: Lower ATS Routes (extract from AIP chart ENR 6-69 (23 May 2024))

6.1.8. The application boundary is approximately 2 km from the waypoint SUMIN, a Significant Point on lower ATS route Z250. The base level of Z250 to the west of SUMIN is 5,500 ft amsl and to the east is FL 125 (approximately 12,500 ft amsl). SUMIN is used as a Holding position for aircraft arriving at Prestwick Airport. Aircraft may need to hold overhead SUMIN at levels between 6,000 ft amsl and FL 90 (approximately 9,000 ft amsl).

6.2. Minimum Altitudes

6.2.1. Airports with IFPs, published on Instrument Approach Charts (IACs), have associated Minimum Sector Altitudes (MSAs). An MSA defines the minimum safe altitude an aircraft can descend to within a sector of radius 25 nm, approximately 46 km. These sectors provide vertical obstacle clearance protection of at least 1,000 ft to aircraft within that area. This allows pilots of aircraft flying under Instrument Flight Rules the reassurance of properly designated obstacle and terrain clearance protection whilst making an approach and landing at an airport in poor weather.

6.2.2. Airport IFPs published in the AIP show the associated MSA. For example, the ILS/DME/NDB(L) RWY 30 approach procedure at Prestwick Airport is shown in Figure 34. The 25 nm MSA, shown at the top of the chart, is divided into four sectors. The minimum safe altitude is 3,900 ft amsl in the south eastern sector, which extends across the proposed Development. Note that the MSA altitudes are marked as two digits representing hundreds, so 3,900 ft is shown as '39'.

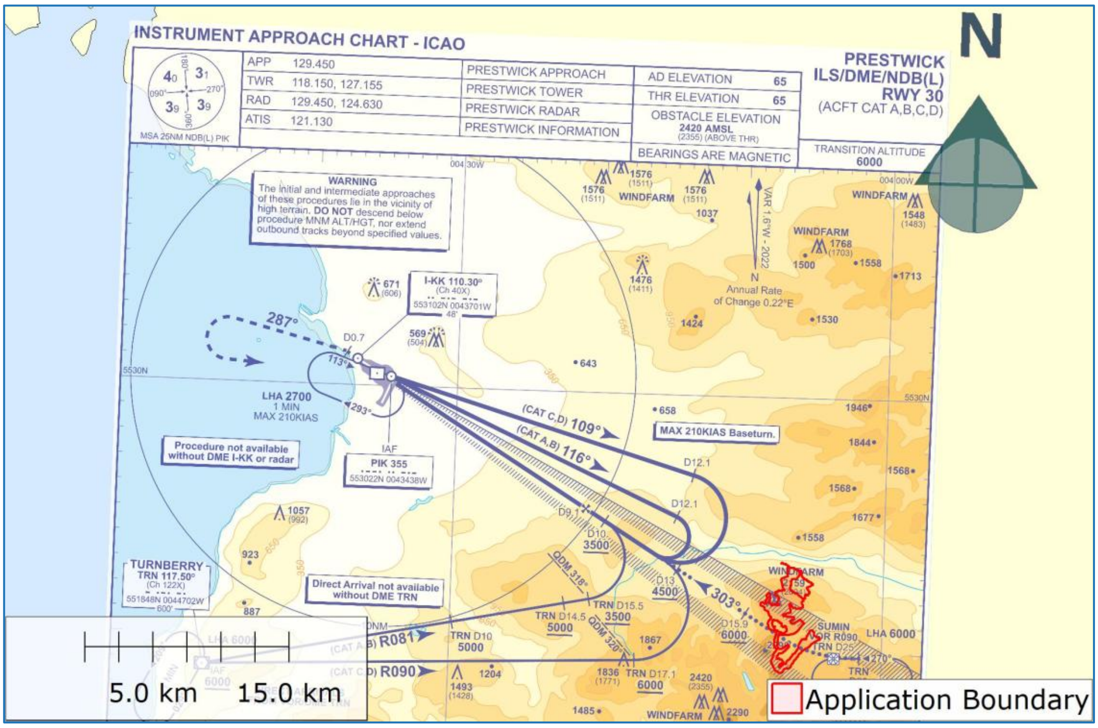


Figure 34: Prestwick ILS/DME/NDB(L) RWY 30 (Extract from AIP AD 2-EGPK-8-9 (16 May 2024))

6.2.3. The turbine with the highest elevation is T15 at 709.4m or 2,328 ft amsl, so the MSA would provide more than the minimum 1,000 ft obstacle clearance protection over the proposed Development.

6.2.4. Also published for Prestwick Airport in the AIP is an ATC Surveillance Minimum Altitude Chart (ATCSMAC), as shown in Figure 35. Within the ATCSMAC area the minimum initial altitude to be allocated by the approach surveillance controller in the southern sector is 3,000 ft amsl. When validating minimum altitudes against the highest known obstacles a buffer of 3 nm (5.6 km) is applied beyond the sector boundary. The closest turbine, T07, is approximately 5.7 km from the 3,000 ft amsl sector boundary and therefore beyond the obstacle buffer.

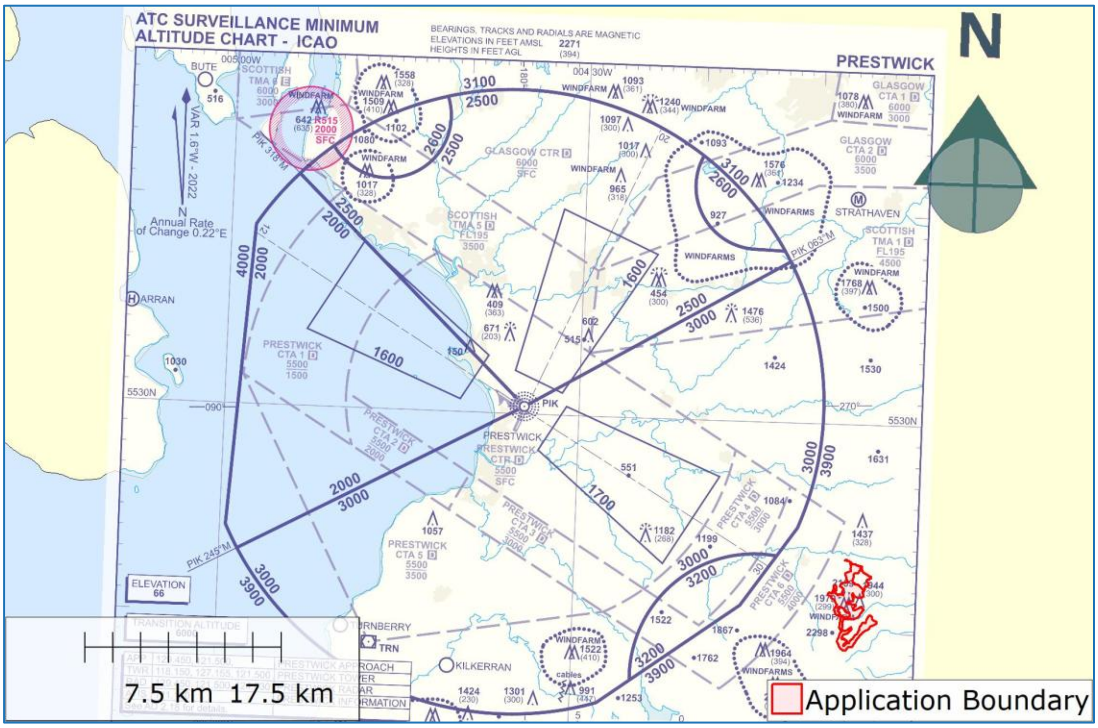


Figure 35: Prestwick ATCSMAC (Extract from AIP AD 2-EGPK-5-1 (16 May 2024))

6.2.5. The ATCSMAC for Glasgow Airport is shown in Figure 36.

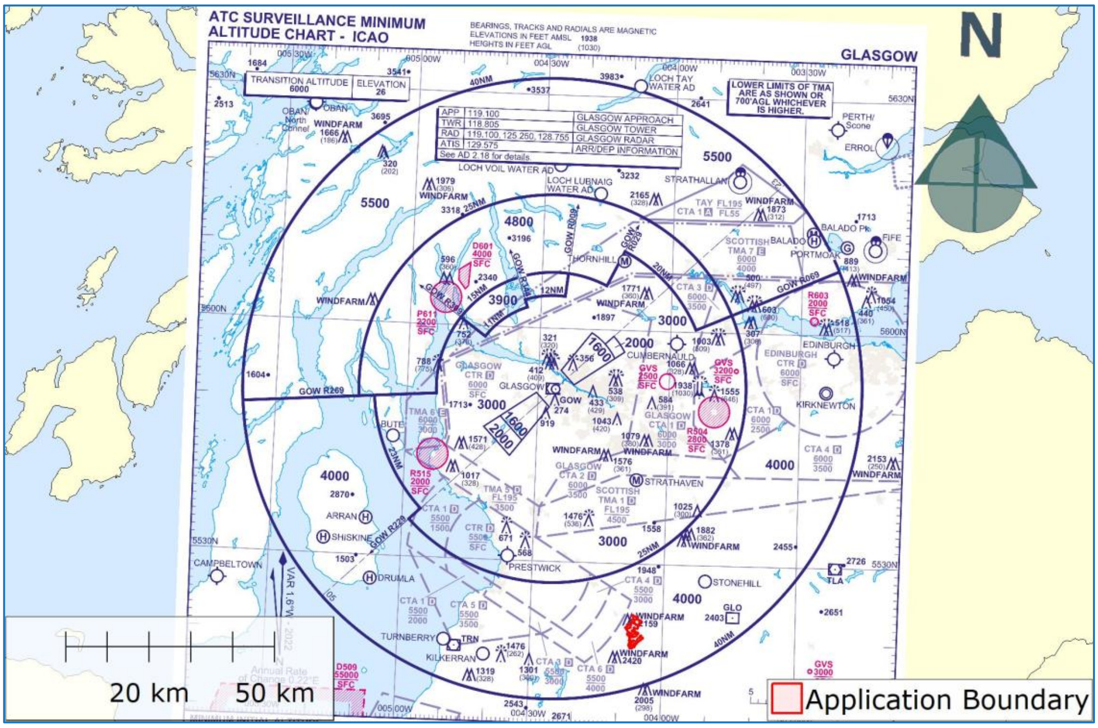


Figure 36: Glasgow ATCSMAC (Extract from AIP AD 2-EGPF-5-1 (24 Feb 2022))

6.2.6. The application boundary lies within the Glasgow Airport ATCSMAC, in a sector where the minimum altitude is 4,000 ft amsl. The turbine with the highest elevation is T15 at 709.4 m or 2,328 ft amsl, so the ATCSMAC sector minimum altitude would provide more than the minimum 1,000 ft obstacle clearance protection over the proposed Development.

6.2.7. All airport IFPs have numerous associated obstacle protection surfaces. The locations and tip heights of the turbines within the final design layout have taken account of these IFP constraints, but a full assessment must be undertaken by an Approved Procedure Design Organisation to ensure that the IFPs at Prestwick and Glasgow airports would not be impacted by the proposed Development.

6.2.8. A chart of Area Minimum Altitudes (AMAs) across the London and Scottish Flight Information Regions is published in the AIP, as shown in Figure 37.

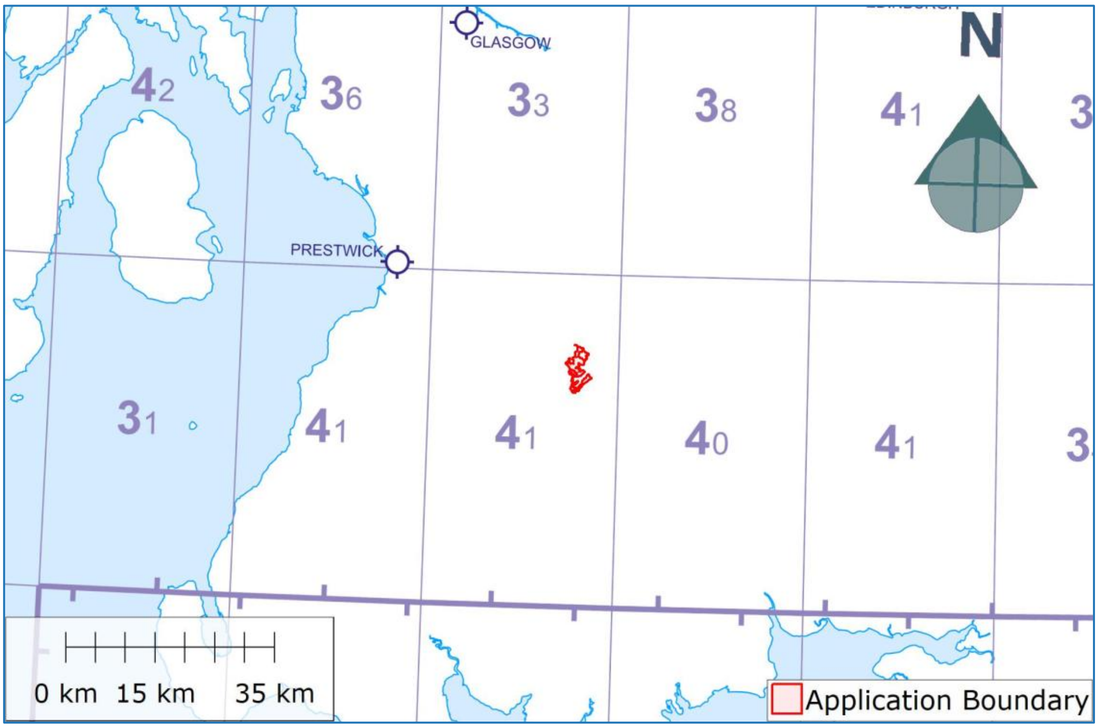


Figure 37: UK AMAs (Extract from AIP chart ENR 6-81 (8 August 2024))

6.2.9. An AMA provides a minimum obstacle clearance of 1,000 ft within a specified area in the same way as an MSA. The specified areas are formed by lines of latitude and longitude in half degree steps.

6.2.10. The proposed Development is within an AMA area of 4,100 ft amsl. With a maximum possible tip elevation of 2,328 ft amsl, the minimum 1,000 ft obstacle clearance protection would be maintained above the proposed Development.

6.3. Other Airspace Considerations

6.3.1. In addition to the commercial aircraft operating to and from the three major airports in the Scottish TMA, military and GA aircraft must be considered.

6.3.2. The nearest non-radar equipped licenced aerodrome to the proposed Development is Cumbernauld Airport, 66 km to the north, while the nearest minor aerodrome identified is the private airstrip at Benston Farm, 7 km to the north west. The closest known glider airfield is at Falgunzeon, 48 km south east of the proposed Development. Operations at these sites would not be impacted by the proposed Development.

6.3.3. The main risk posed by GA traffic transiting underneath controlled airspace is from infringements into controlled airspace. Traffic in uncontrolled airspace is not obliged to contact ATC and, in this area, does not have to be carrying a transponder. To a radar controller a transiting aircraft may display as a primary only contact. Clutter from the proposed Development would effectively mask any transit traffic that may prove to be a threat to traffic being provided with a radar control service.

6.3.4. As shown in Figure 38, the proposed Development would be within a military low flying area known as Tactical Training Area 20T (and within low flying Area 2B at night). Within Area 20T military aircraft may conduct tactical low flying training down to 100 ft agl. To alleviate MOD concerns, wind turbines would be fitted with MOD accredited aviation safety lighting in accordance with Air Navigation Order Article 222[5].

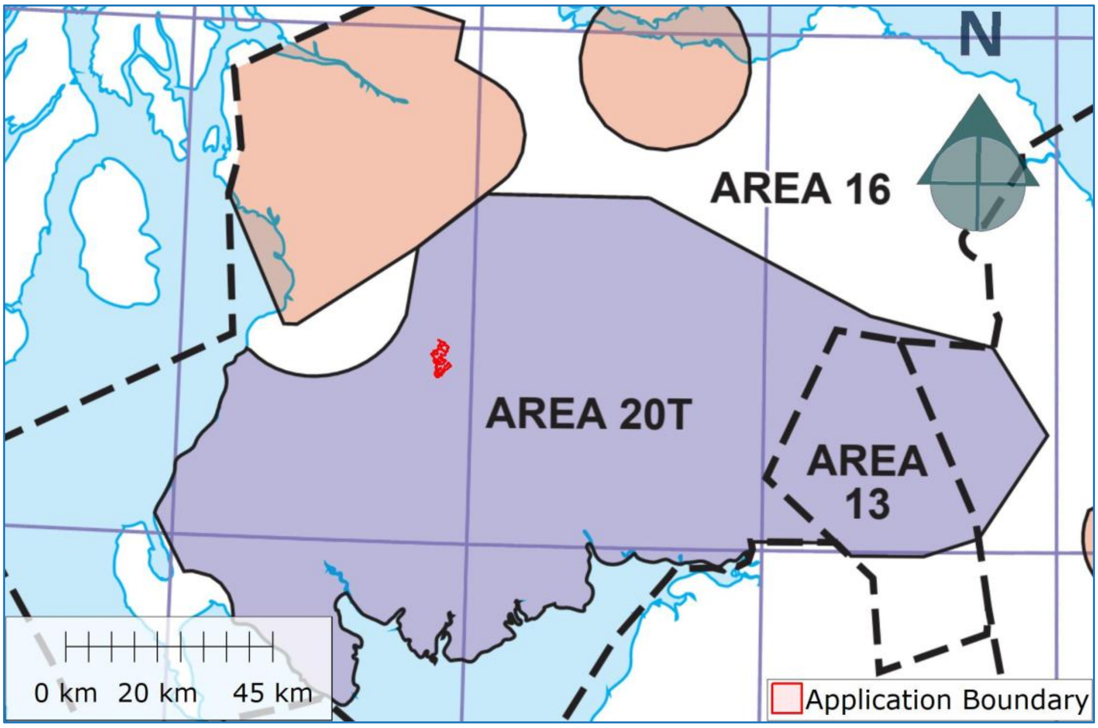


Figure 38: Low flying areas (extract from AIP chart ENR 6-20 (2 January 2020))

6.3.5. Volumes of controlled and restricted airspace can result in the channelling or funnelling of low level GA traffic around structures. In this instance there are no restrictive Danger Areas in the vicinity to create a funnelling effect as there is sufficient uncontrolled airspace above the proposed Development to allow for safe transit of this area under Visual Flight Rules subject to the applicable 'Rules of the Air' being complied with.

[5] Air Navigation Order 2016/765, April 2022

7. Radar Mitigation Options

7.1. Mitigation Requirement

7.1.1. Mitigation may be required where radar clutter generated by wind turbines has a detrimental impact on the ATS provided. RLoS modelling indicates that the NERL PSRs at Lowther Hill and Great Dun Fell, and the PSRs at Prestwick Airport, may be impacted by the proposed Development. Based on an earlier turbine design layout, NERL has determined an unacceptable impact on Lowther Hill PSR, Great Dun Fell PSR and Cumbernauld PSR. It is anticipated that NERL will not find an unacceptable impact on Cumbernauld PSR when assessing the final design layout of the proposed Development. Prestwick Airport has indicated that it would object to the proposed Development due to, inter alia, turbine generated clutter on its radar displays. To date, the MOD has not raised any concerns regarding impacts to radar facilities.

7.2. Prestwick Airport Mitigation

7.2.1. The newly installed Terma Scanter 4002 PSR at Prestwick Airport was introduced as a windfarm tolerant approach radar and is understood to have been funded through contributions from windfarm operators. Prestwick Terma PSR operates in the X frequency band (9 GHz), unlike the majority of PSRs providing approach services which operate in the S band (2.8 GHz). This means that the Terma antenna transmits a narrower beam with smaller range resolutions down to approximately 6 m as opposed to 50 m.

7.2.2. A white paper published in 2012, "Detection and Tracking of Aircraft over Wind Farms using SCANTER 4002 with Embedded Tracker 2", comprehensively presents the details and results of flight tests carried out over large offshore windfarms.

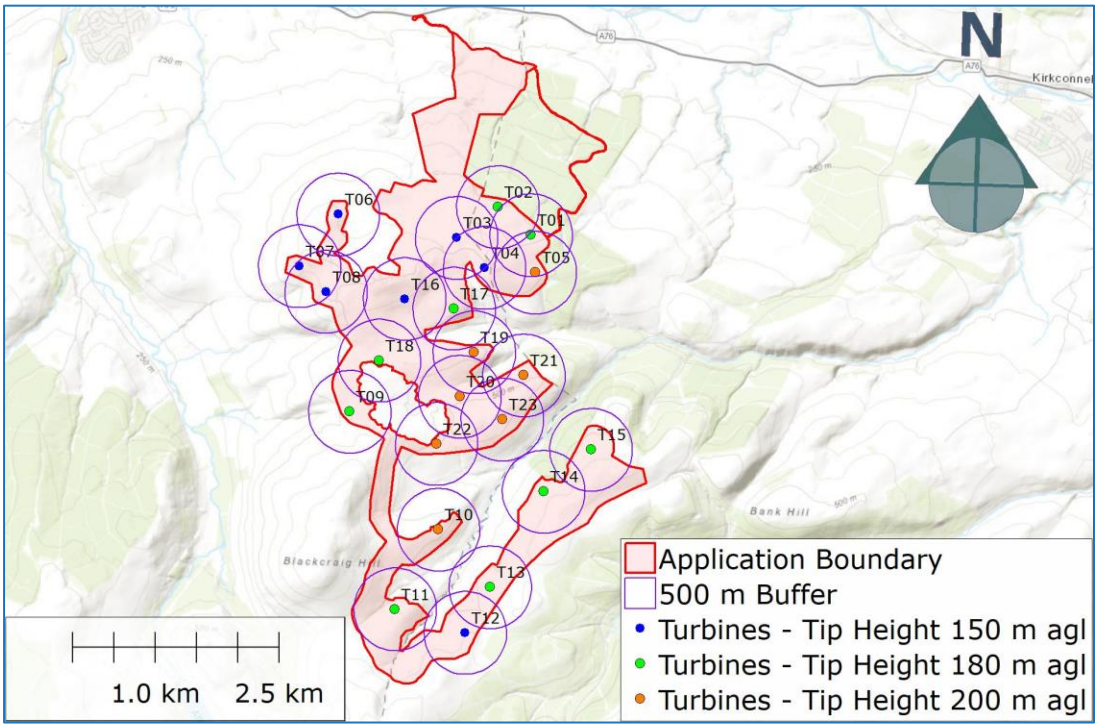
7.2.3. The document describes how, for windfarms with an inter-turbine spacing of 500 m or more, wind turbine clutter can be removed by allowing the turbine video to be extracted as plots to be used in the tracker and identified as static targets. Once established as static targets, they will have high association likelihood to new plots overlapping the track updated position and thereby help consume wind turbine plots and lower the risk of track seductions.

7.2.4. During the Clauchrie Public Local Inquiry, in response to questions regarding the Terma Scanter 4002[6], Terma stated that the 2012 white paper was based on the first generation 4002 radar and that the latest Terma Scanter 4002 differs in several ways. However, Terma did state that "*many of the principles described in the article are still valid and carried over in the latest design*."

7.2.5. Mitigation of turbines will impact the probability of detection (Pd) of aircraft within the windfarm area because it is not possible to distinguish an aircraft from a turbine in the radar cell directly over each wind turbine. It therefore follows that the inter-turbine spacing will affect the level of Pd impact. Although by itself it is not a guarantee of maintaining a satisfactory Pd, an inter-turbine spacing of more than 500 m should help to minimise the impact on Pd.

[6] Terma response to questions regarding Terma SCANTER 4002 radar (Clauchrie Windfarm Public Inquiry) email 18 June 2021

7.2.6. Circles of radius 500 m centred on each turbine within the application boundary are depicted in Figure 39. It can be seen that turbines T01 and T05 (456 m), T03 and T04 (496 m), and turbines T07 and T08 (447 m) are within 500 m of each other. All other turbines have an inter-turbine spacing that exceeds 500 m.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 39: 500 m inter-turbine spacing

7.2.7. When a new windfarm becomes operational within the Terma radar coverage area that is in RLoS and detected, then, if necessary, the Terma radar can be re-optimised to filter out any clutter generated by the turbines. Individual turbine positions must be manually added to the radar's internal map so that the plots originating from turbines are identified as static targets. Once optimised, Prestwick Terma PSR should then be capable of detecting the proposed turbines and maintaining internal tracks on them (which are not displayed to the controller) whilst simultaneously tracking air targets passing over the proposed Development. Once the proposed turbines have been optimised there should be no subsequent requirement for re-optimisation or mitigation unless the turbine sizes or locations are changed.

7.2.8. Prestwick Terma PSR, as part of its commissioning process, has already undergone one-off optimisation to mitigate several existing visible windfarms.

7.2.9. As reported in the 2012 white paper, the Terma Scanter 4002 PSR can reportedly maintain more than 1,000 concurrent internal tracks without a degradation to the display. It is reasonable to assume that the latest generation of the Scanter 4002 can maintain considerably more.

7.2.10. The potential number of turbines in the vicinity of Prestwick Airport is well within Prestwick Terma PSR's concurrent internal track capacity. In other words, the inherent processing capabilities of the Terma Scanter 4002 PSR should be able to mitigate the impact of the proposed turbines provided a Terma technician optimises Prestwick Terma PSR upon the erection of the proposed Development's turbines.

7.3. NERL Mitigation

7.3.1. A potential option for mitigating the impact on Lowther Hill and Great Dun Fell PSRs is to blank the area of clutter and use an infill radar feed that does not have RLoS of the proposed turbines but has adequate coverage over the proposed Development to satisfy ATC requirements.

7.3.2. The base of controlled airspace immediately above the proposed development is 5,500 ft amsl in the Scottish TMA. As has been stated, this airspace is under the control of NERL, based at Prestwick Centre; however, airspace in the vicinity of Prestwick Airport from 5,500 ft to 6,000 ft is delegated from NERL to Prestwick Airport to enable vectoring and sequencing of traffic. Most of the traffic passing over the proposed Development is likely to be inbound to Prestwick Airport, so it is likely that NERL only controls the airspace from 6,000 ft above the proposed Development.

7.3.3. Cyrrus understands that NERL units optimally require circa 2,000 ft of additional PSR coverage below the base of TMA controlled airspace to provide a safety buffer for controllers. The coverage buffer helps controllers to anticipate any incursions into the TMA from aircraft that are below controlled airspace. This means that PSRs must be capable of detecting airborne targets at a minimum altitude of either 3,500 ft or 4,000 ft over the proposed Development.

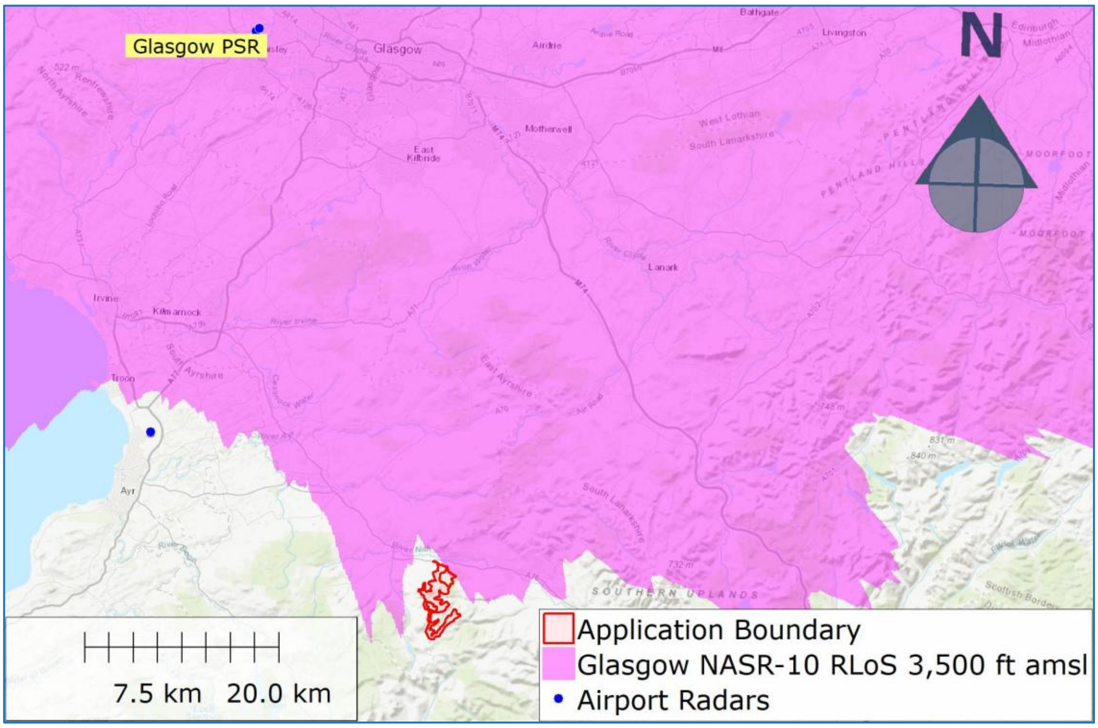
7.3.4. Surveillance coverage requirements in the enroute environment are summarised in the document CAP 670[7]. Section 3: SUR 01 states that below FL 100 (approximately 10,000 ft amsl) in areas of high traffic density and/or complexity, coverage shall be provided with at least a single layer of coverage by a non-cooperative surveillance technique, i.e. PSR, together with data from a suitable co-operative surveillance technique (e.g. SSR). Redundancy is only required for the co-operative surveillance provision, e.g. in the form of dual SSR, which suggests that a single layer of infill PSR coverage is sufficient to provide coverage over a blanked area.

7.3.5. Candidate radars for infill coverage over the proposed Development are Glasgow PSR and possibly Glasgow Terma PSR. Although NERL has determined an unacceptable impact on Cumbernauld PSR, modelling of the final design layout shows that RLoS would not exist between Cumbernauld PSR and any of the 23 turbines. Cumbernauld PSR is therefore also included as a possible infill radar.

7.4. NERL Potential Infill Radar – Glasgow PSRs

7.4.1. The magenta shading in Figure 40 illustrates RLoS coverage for Glasgow NASR-10 PSR at an altitude of 3,500 ft. It can be seen that Glasgow NASR-10 PSR cannot provide radar coverage at 3,500 ft amsl in the vicinity of the proposed Development.

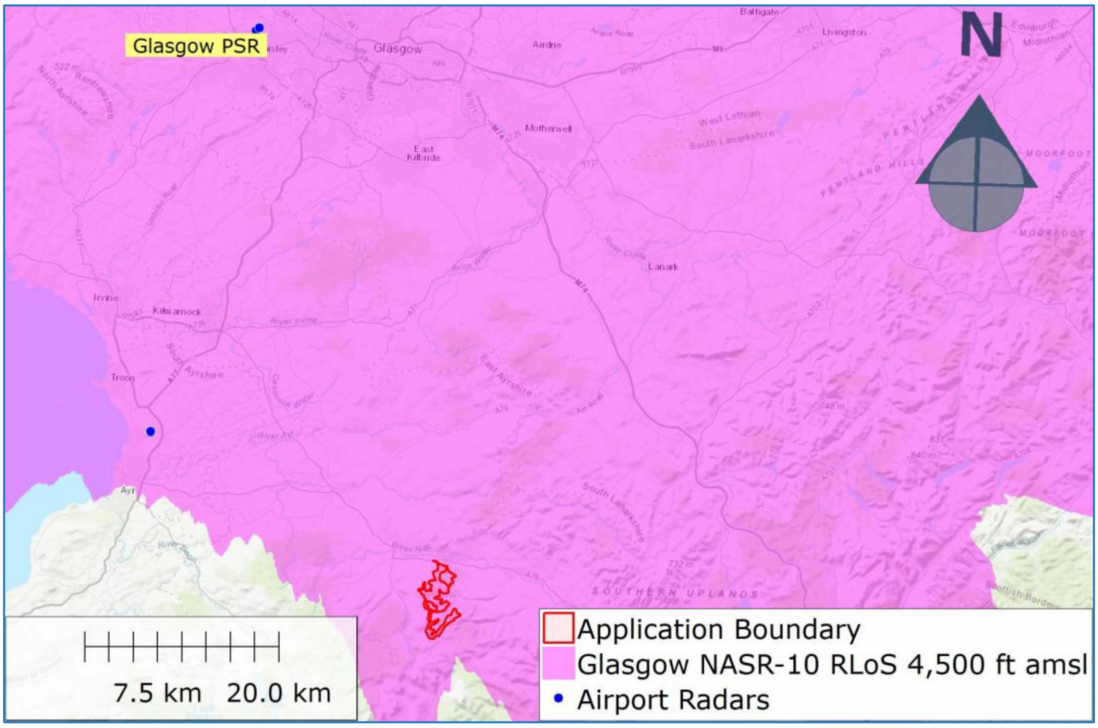
[7] CAP 670: Air Traffic Services Safety Requirements, June 2019



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 40: Glasgow NASR-10 PSR RLoS to 3,500 ft amsl

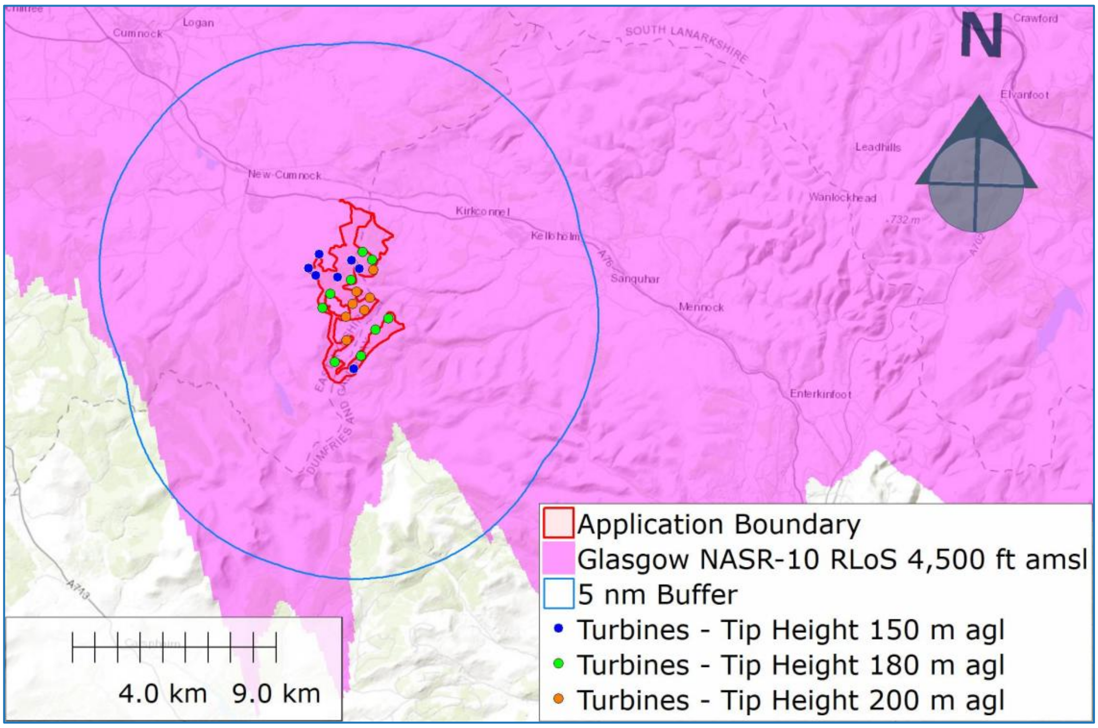
7.4.2. Glasgow NASR-10 PSR can provide radar coverage down to 4,500 ft amsl over the proposed Development, as shown in Figure 41.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 41: Glasgow NASR-10 PSR RLoS to 4,500 ft amsl

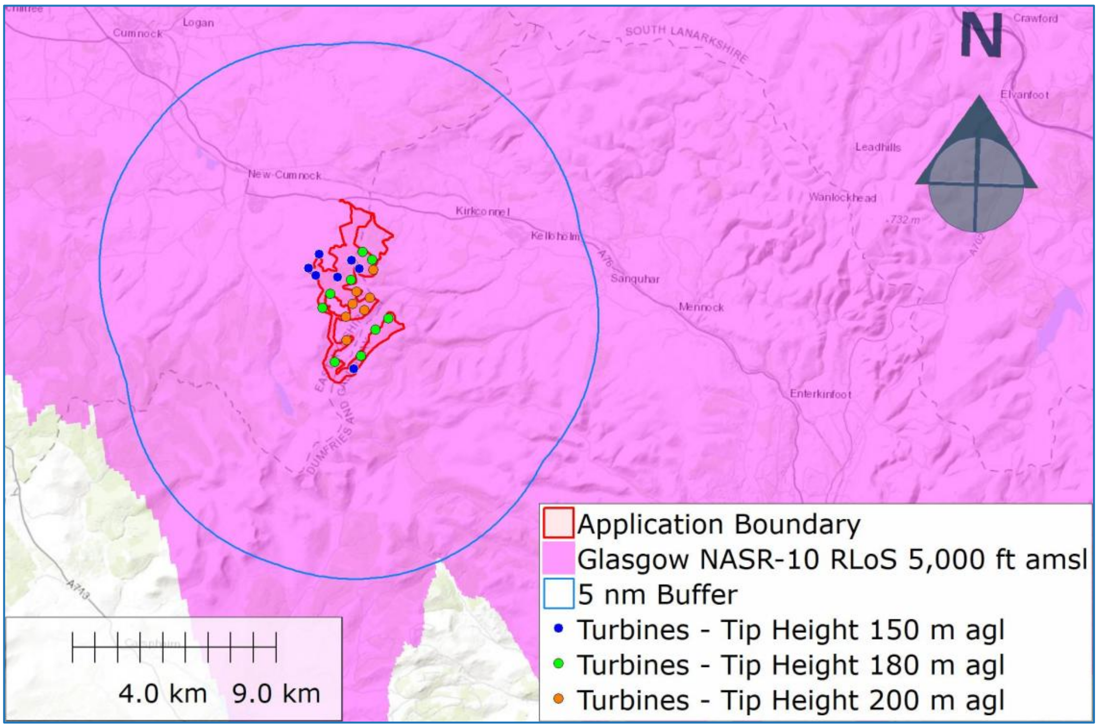
7.4.3. Historically there has been a NERL requirement that infill coverage is extended to include a 5 nm buffer on all the mitigated wind turbines. The zoomed view of Glasgow NASR-10 PSR's 4,500 ft amsl coverage in Figure 42 shows a 5 nm buffer around the final design layout turbine locations to illustrate where the infill coverage may be required to extend to, and shows that coverage at 4,500 ft amsl does not fully extend to 5 nm south of the proposed Development.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 42: Glasgow NASR-10 PSR RLoS to 4,500 ft amsl – zoomed

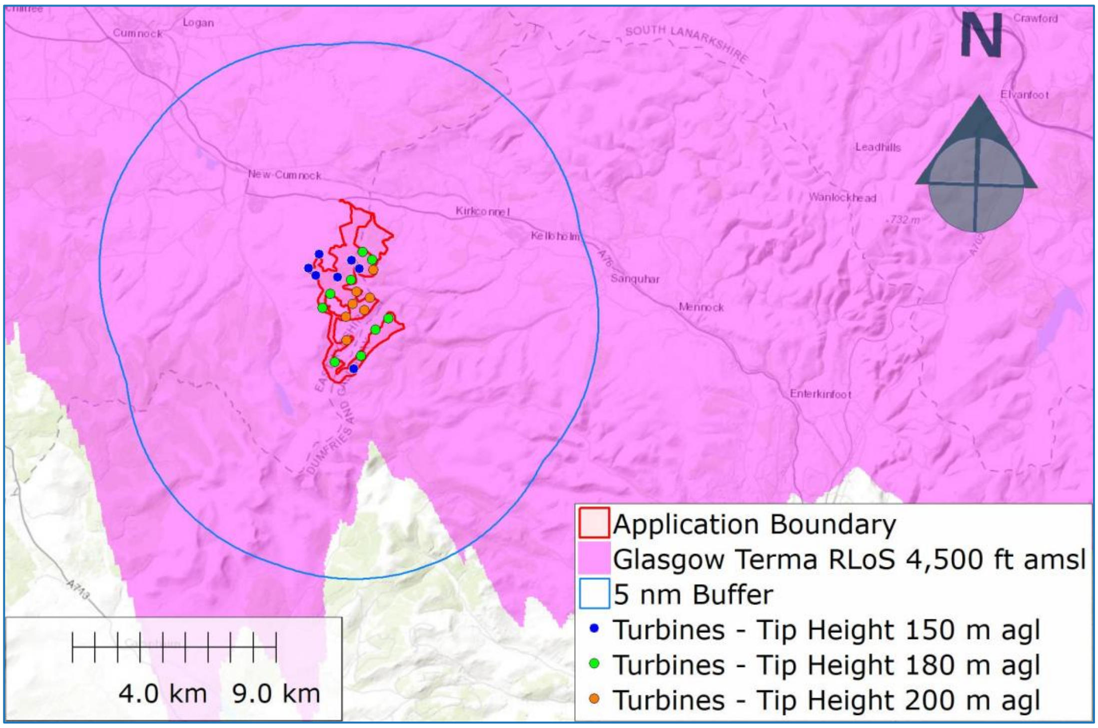
7.4.4. The zoomed view of Glasgow NASR-10 PSR's 5,000 ft amsl coverage in Figure 43 shows that the 5 nm buffer around the final design layout turbine locations is mostly achieved at this altitude.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

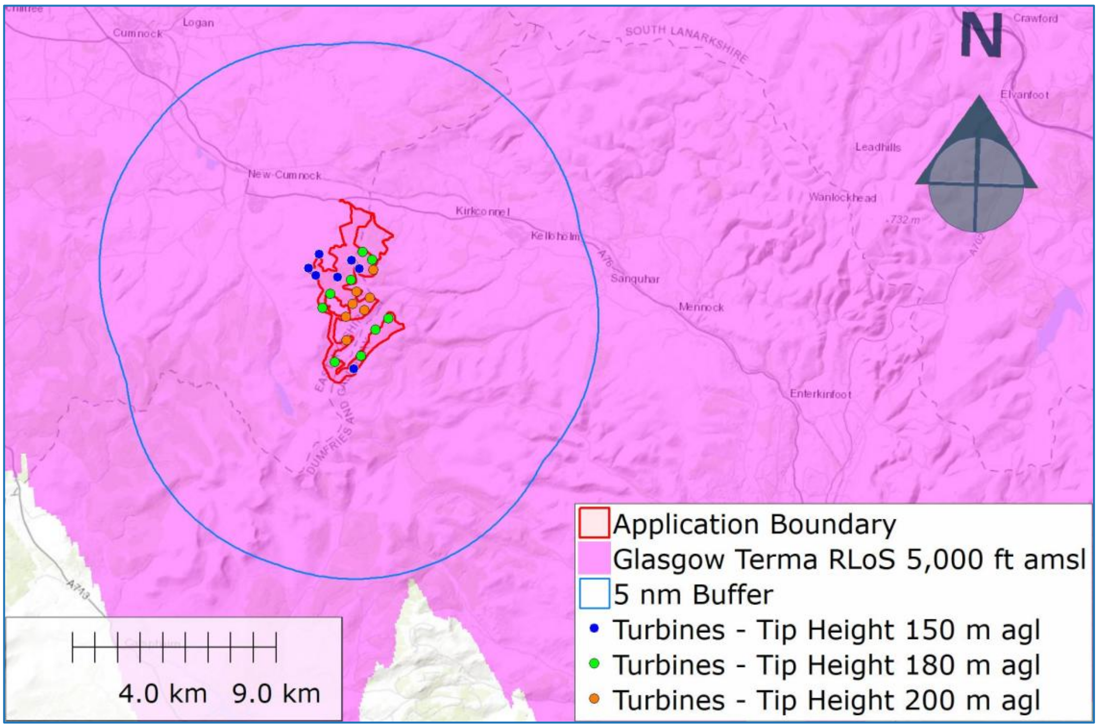
Figure 43: Glasgow NASR-10 PSR RLoS to 5,000 ft amsl – zoomed

7.4.5. Glasgow Terma PSR has very similar RLoS coverage to Glasgow NASR-10 PSR. The magenta shading in Figure 44 and Figure 45 shows Glasgow Terma PSR coverage at 4,500 ft amsl and 5,000 ft amsl respectively over the proposed Development.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 44: Glasgow Terma PSR RLoS to 4,500 ft amsl – zoomed



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

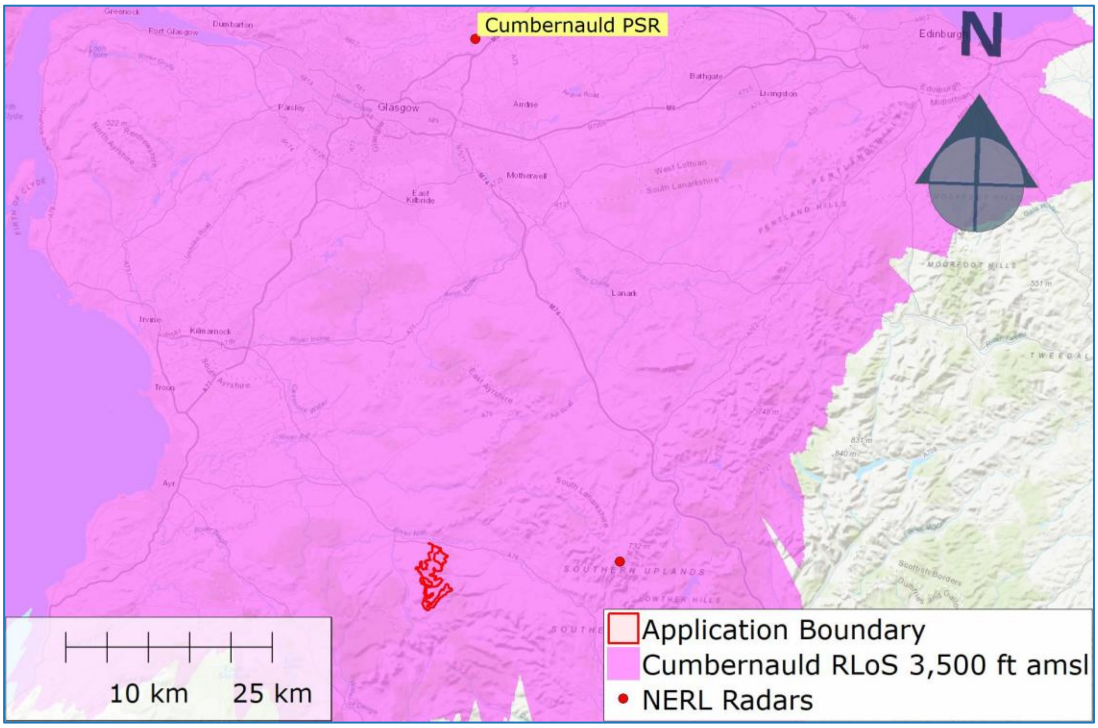
Figure 45: Glasgow Terma PSR RLoS to 5,000 ft amsl – zoomed

7.4.6. Notwithstanding the 5 nm buffer requirement, both Glasgow NASR-10 PSR and Glasgow Terma PSR can provide infill coverage at 4,500 ft amsl over the proposed Development. If the full 5 nm buffer is required then minimum infill coverage is 5,000 ft amsl. This would satisfy a NERL base of controlled airspace of 7,000 ft amsl.

7.4.7. The range of the proposed Development from Glasgow Terma PSR may be towards the limit of its maximum coverage performance when considering all possible weather conditions.

7.5. NERL Potential Infill Radar – Cumbernauld PSR

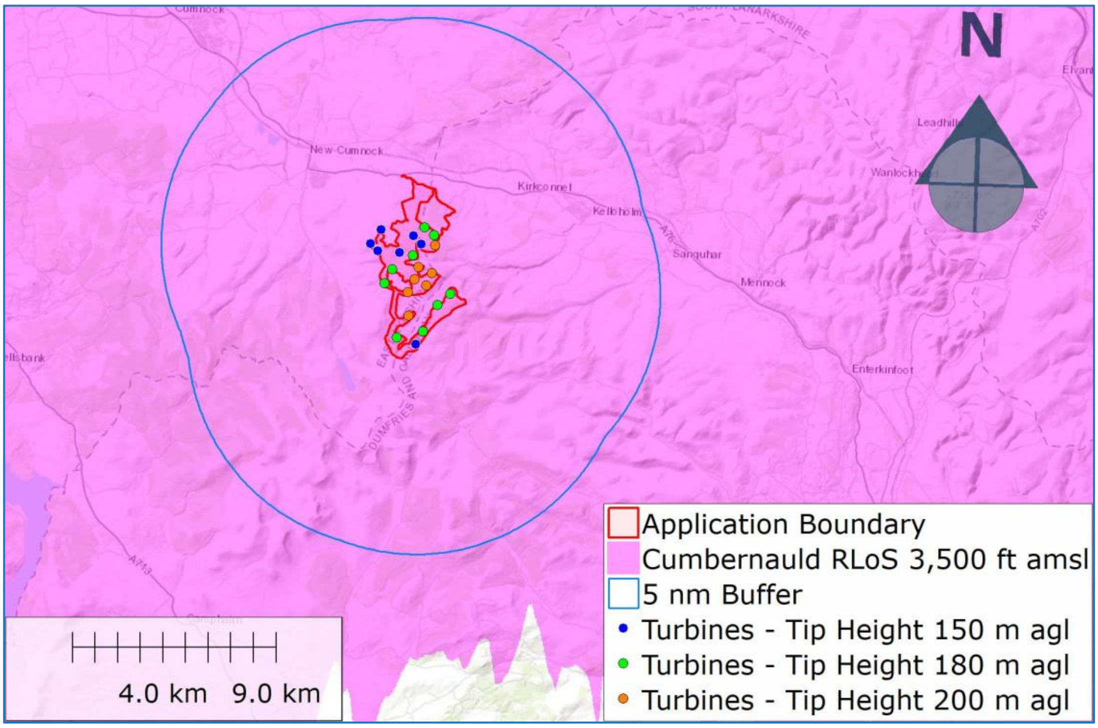
7.5.1. The magenta shading in Figure 46 illustrates RLoS coverage for Cumbernauld PSR at an altitude of 3,500 ft. It can be seen that Cumbernauld PSR can provide radar coverage down to 3,500 ft amsl in the vicinity of the proposed Development.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 46: Cumbernauld PSR RLoS to 3,500 ft amsl

7.5.2. The zoomed view of Cumbernauld PSR's 3,500 ft amsl coverage in Figure 47 shows a 5 nm buffer around the final design layout turbine locations to illustrate where the infill coverage may be required to extend to.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 47: Cumbernauld PSR RLoS to 3,500 ft amsl – zoomed

7.5.3. As can be seen, coverage at 3,500 ft amsl extends to beyond 5 nm south of the final design layout turbines. Cumbernauld PSR can provide a minimum of 3,500 ft amsl infill coverage over the proposed Development and is integrated into NERL's Multi-Radar Tracking infrastructure.

7.6. NERL Potential Infill Radar – Lowther Hill PSR

7.6.1. A new 3D PSR system has recently been deployed at Lowther Hill that has the capability to mitigate the impact of wind turbines by better filtering out the clutter the turbines generate. The new Lowther Hill PSR went online in September 2022 and, provided the radar can be successfully optimised to mitigate the proposed Development, it means that Lowther Hill PSR could also be available as a source of infill radar coverage for Great Dun Fell PSR.

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