Technical Appendix 2.2: Aviation Technical Appendix

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Wind Power Aviation Consultants Ltd

Aviation Technical Appendix for Appin Wind Farm V1.0

Our Reference: WPAC 022/25
Your Reference: Appin Wind Farm EIA

Authors: Commander John Taylor, RN (Ret)

Squadron Leader Mike Hale MBE MSc CFS RAF (Ret)

GIS, Radar Modelling and Mapping – Sam Taylor BA (Hons) MSc

Wind Power Aviation Consultants Ltd, Company No.: 6811887
e-mail: enquiries@wpac.co.uk Tel.: +44 (0)2380767345 Mob.: +44 (0)7949234440
www.wpac.co.uk

Scope

1. This report has been prepared by Wind Power Aviation Consultants Ltd on behalf of Appin Energy Park Ltd (hereinafter referred to as the 'Applicant'). This report is designed to be included in the Environmental Impact Assessment Report (EIAR) as a technical appendix and will inform the EIAR in relation to any aviation issues.

Introduction

2. Wind turbines have the potential to affect civil and military aviation infrastructure and activities. This report covers the methodology used to undertake the aviation safeguarding assessment, lists the aviation guidance and data sources used and describes the aviation baseline condition, consultation responses and potential mitigation needed. It assesses the potential for the Proposed Development to affect aviation communications, navigation and surveillance infrastructure in the vicinity of the site, and focusses on identifying where there could be an effect and if so, how this will be mitigated.

Legislation and Guidance

3. There are a number of aviation publications relevant to the interaction of wind turbines and aviation containing guidance and legislation, which cover the complete spectrum of aviation activity in the UK as shown below.

- Civil Aviation Authority (2020). Safeguarding of Aerodromes, Version 3, CAP738 CAA;
- Civil Aviation Authority (2010). Safe Operating Practices at Unlicensed Aerodromes, Ed 1, CAP 793 CAA;
- Civil Aviation Authority (2016) Policy and Guidance on Wind Turbines Version 6, CAP764 CAA;
- Civil Aviation Authority (2017). CAA Policy Statement: 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 CAA;
- Civil Aviation Authority (2023). Manual of Air Traffic Services, Part 1, Ed 11.0, CAP 493 CAA;
- Civil Aviation Authority (2021). UK Flight Information Services, Ed 4, CAP 774 CAA;
- Civil Aviation Authority (2019). ATS Safety Requirements, Version 3, CAP 670 CAA;
- Civil Aviation Authority (2022). Licensing of Aerodromes, Version 12, CAP 168 CAA;
- Civil Aviation Authority (2020). Parachuting, Ed 5, CAP660 CAA;
- Civil Aviation Authority (2022). Implementation of Safeguarding of Instrument Flight Procedures (IFPs) in the UK, Ed 2, Version 2, CAP 785B CAA;

- Civil Aviation Authority (2021) 'Guidance to crane users on aviation lighting and notification' CAP 1096 CAA and:
- Ministry of Defence (MoD) (2022). Military Aviation Authority Regulatory Article 2330 (Low Flying)

Scope of the Assessment

4. The layout of the Proposed Development has changed since the site was the subject of a scoping assessment and having taken into account any scoping responses it is still considered essential to re-examine any effects on aviation facilities and operations. The assessment of effects of the proposed turbines will be based upon the guidance laid down in CAA Publication CAP 764 *Policy and Guidelines on Wind Turbines* Version 6 Dated February 2016. Consultation criteria for aviation stakeholders is defined in Chapter 4. These distances inform the size of the study area and include:

- Airfield with a surveillance radar – 30 km;
- Non radar licensed aerodrome with a runway of more than 1,100 metres – 17 km;
- Non radar licensed aerodrome with a runway of less than 1,100 metres – 5 km;
- Licensed aerodromes where the turbines would lie within airspace coincidental with any published Instrument Flight Procedure (IFP);
- Unlicensed aerodromes with runways of more than 800 metres – 4 km;
- Unlicensed aerodromes with runways of less than 800 metres – 3 km;
- Gliding sites – 10km ; and
- Other aviation activity such as parachute sites and microlight sites within 3 km – in such instances developers are referred to appropriate organisations.

5. CAP 764 goes on to state that these distances are for guidance purposes only and do not represent ranges beyond which all wind turbine developments will be approved or within which they will always be objected to. These ranges are intended as a prompt for further discussion between developers and aviation stakeholders.

6. It is necessary to take into account the aviation and air defence activities of the Ministry of Defence (MOD) as safeguarded by the Defence Infrastructure Organisation (DIO).

7. It is also necessary to take into account the possible effects of wind turbines upon the National Air Traffic Services En Route Ltd (NERL) communications, navigation and surveillance (CNS) systems – a network of primary and secondary radars and navigation facilities around the country.

8. In addition to examining the technical impact of wind turbines on Air Traffic Control (ATC) facilities, it is also necessary to consider the physical safeguarding of ATC operations, using the criteria laid down in CAP 168 Licensing of Aerodromes, to determine whether a proposed development will

breach obstacle clearance criteria. In this case, there are no physical safeguarding issues associated with the Proposed Development.

Assessment Methodology

9. Radar modelling has been undertaken using specialist propagation prediction software (Rview Version 5). Developed over a number of years, it has been designed and refined specifically for the task. RView uses a comprehensive systems database which incorporates the safeguarding criteria for a wide range of radar and radio navigation systems. RView models terrain using the Ordnance Survey (OS) Terrain 50 digital terrain model, which has a post spacing of 50m and has a root mean square (RMS) error of 4m. The results are verified using the Shuttle Radar Topography Mission (SRTM) dataset, a separate smoothed digital terrain model with data spacing of 3 arc seconds. By using two separate and independently generated digital terrain models, anomalies are identified and consistent results assured. Rview models the refractive effects of the atmosphere on radio waves and the First Fresnel Zone. A feature of RView is that as well as performing calculations in the manner believed to be most appropriate, it also allows comparison with results from simpler models. For example, RView can perform calculations using the true Earth Radius at the midpoint between the radar and the wind turbine or the simplified 4/3 Earth Radius model. If needed, Rview is also capable of modelling a range of atmospheric refractive conditions. RView models the trajectory of radar signals at different elevations enabling modelling of both volume surveillance and pencil beam radars as well as the effects of angular sterilisation as applied, for example, in Met Office radars.

10. The following data sources were consulted to inform the assessment:

- UK Military Aeronautical Information Publication (MIL AIP);
- UK Aeronautical Information Publications (AIP);
- CAA 1:250,000 VFR and 1:500,000 Charts;
- UK Military Low Flying Charts; and
- WPAC in-house databases.

Assessing Significance

11. Assessing significance in an aviation context is highly controversial as there is no agreed definition of significance. This is due to the fact that whilst technical effects on communications, navigation and surveillance (CNS) systems are relatively simple to identify and evaluate, operational and flight safety effects can be subjective and are often challenged by third parties. It is enough in this context to identify any technical effects and then, taking into account the statements in CAP 764 regarding the status of aviation stakeholders, in general to accept the judgement of those stakeholders in assessing the significance of the effects. For example CAP 764 states: "*Where an ANSP determines that it is likely that a planned wind turbine development would result in any of the above effects on their CNS infrastructure, this may not, in itself, be sufficient reason to justify grounds for rejection of the planning application. The ANSP must determine whether the effect on the CNS infrastructure has a negative impact on the provision of the ATS. The developer should pay for an assessment of appropriate mitigating actions that could*

be taken by the ANSP and/or wind energy developer to deal with the negative impact. The position of an ANSP at inquiry would be significantly degraded if they had not considered all potentially appropriate mitigations."

12. Therefore, taking the above into account, it is not considered to be appropriate for the Applicant to be making an assessment of significance of an effect in relation to aviation interests. It is also often the case that different Air Navigation Service Providers (ANSP) can take a different view of the same scenario and may disagree with the assessment findings leading to the need for further post submission consultation to confirm the findings of the assessment and/or agree to the need for and extent of mitigation.

Turbine Details

Turbine	Easting	Northing	Indicative Hub Height	Tip Height	Indicative Disc Dia
1	271329	598727	119m	200m	162m
2	270343	598414	119m	200m	162m
3	270607	598414	119m	200m	162m
4	270920	598031	119m	200m	162m
5	271268	597665	119m	200m	162m
6	271751	597457	119m	200m	162m
7	272089	597035	119m	200m	162m
8	272534	596725	119m	200m	162m
9	272764	596380	119m	200m	162m

Table 1 Turbine Locations

Aviation Baseline Conditions

13. The site is located as shown in Figures 1 to 3. Figures 2 and 3 show the location in an aviation context with Figure 2 showing the airspace up to 5000ft and Figure 3 up to 19500 ft. The site is located 44 km to the south-east of Glasgow Prestwick Airport (GPA) and 72km to the south of Glasgow Airport. Figure 3 shows that the site is located under the Scottish Terminal Area (TMA), Class D regulated airspace with a base of 5500ft AMSL in this location. In military terms, the closest facilities are the dormant, but radar equipped airfield at West Freugh, over 72km to the south-west and the RAF Spadeadam Electronic Warfare Training Facility over 77km to the east.

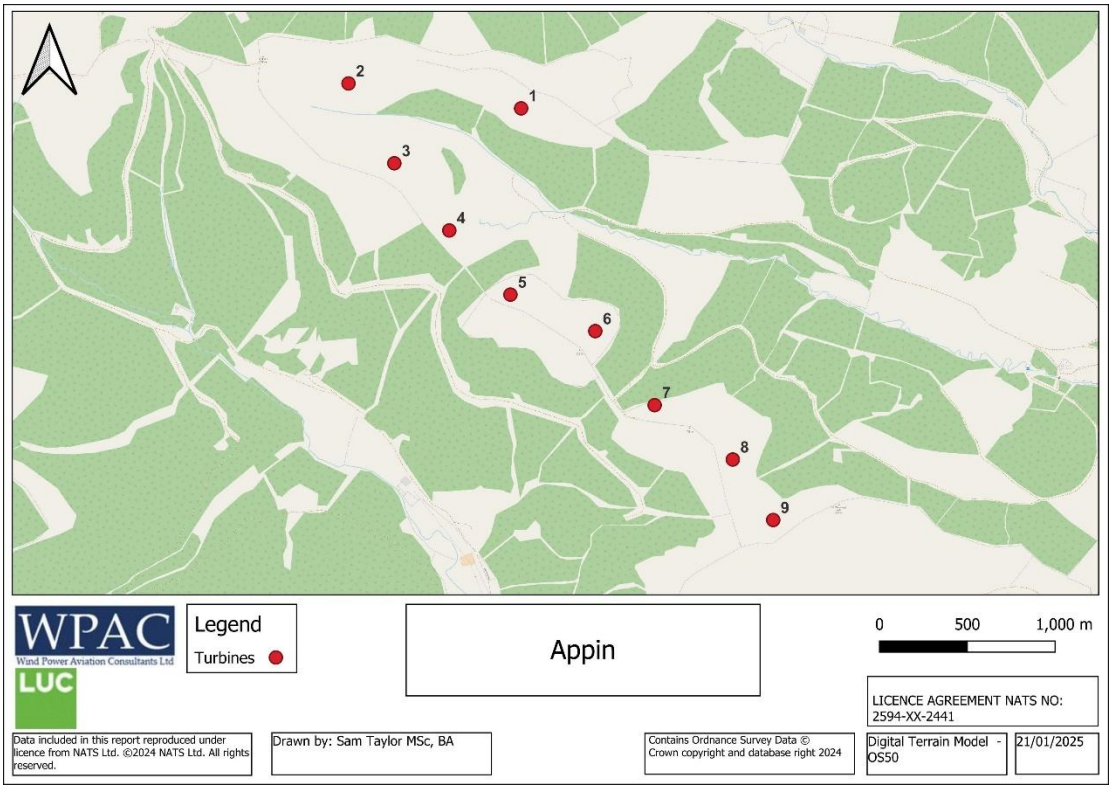

Figure 1

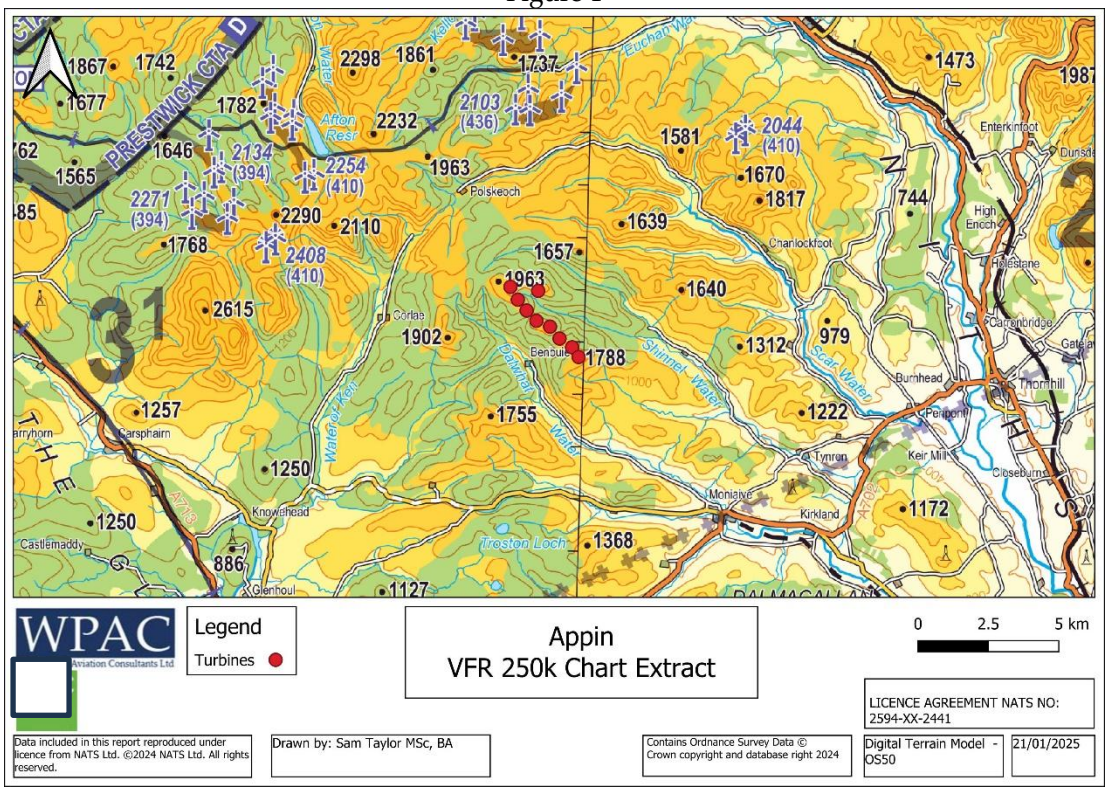

Figure 2

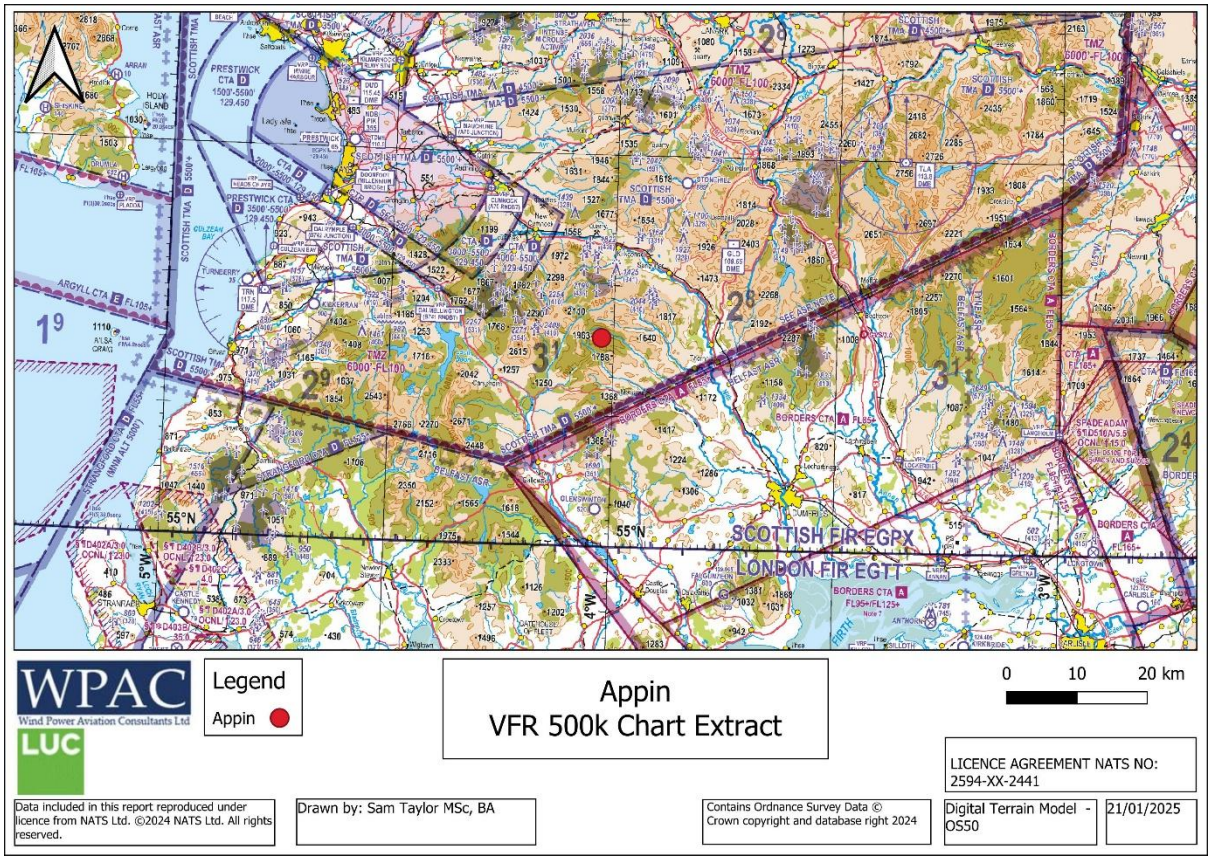

Figure 3

Military ATC Radars

14. **West Freugh** – the closest MOD ATC radar is at West Freugh. Radar modelling shows that radar line of sight is in excess of 300m AGL and there is no possibility of the radar being affected. Additionally the radar is only used to provide range safety in the vicinity of the Luce Bay Danger Areas. The Proposed Development will therefore have no effect on operations at West Freugh.

15. **RAF Spadeadam – Deadwater Fell Radar** - radar modelling for the Deadwater Fell radar at RAF Spadeadam shows that up to five turbines will be exposed to the radar as shown in Table 2, however, at a distance of over 90km, it is very unlikely that the MOD would consider turbine effects in this location to be an issue of concern.

16. MOD Scoping Response DIO10054723 dated 11 May 2022 confirms this assessment. In that case the MOD were responding to a proposal for a larger number of taller turbines and even then did not mention RAF Spadeadam radar as in issue of concern.

Turbine	Distance (km)	Radar Line of Sight (m AGL)
1	91.22	264.6
2	92.21	278
3	91.94	237.5
4	91.62	245.6
5	91.27	164.9
6	90.78	127.3
7	90.44	142.9
8	90.00	143.5
9	89.77	155

Table 2 RAF Spadeadam Thales Star 2000NG Radar Results

Military Air Defence Radars

17. The closest military air defence radar is located at Brizlee Wood, near Alnwick. Radar modelling shows that there is no possibility of the radar being affected by the Proposed Development.

Military Low Flying

18. The proposed development is within MOD Low Flying Area (LFA) 16; one of the busiest LFAs in the UK. In addition, the Appin turbines will be in the co-located Tactical Training Area (TTA) 20 where military fast jet aircraft operate down to 100ft (30m) day and night. However a close examination of the location of the turbines in relation to the MOD wind farm low flying interaction map show that the Proposed Development is within an area designated as 'Blue' by the MOD. The map at Figure 4 is not very accurate, however, a detailed assessment of the turbine locations conducted against the much more detailed MOD low flying charts not available in the public domain confirm the turbines as being in the 'Blue' area. A Blue area is defined as '*a low priority military low flying area less likely to raise concerns'.*

19. The MOD scoping response dated 11 May 2022 stated that '*in the interests of air safety the MOD would request that the development be fitted with MOD accredited aviation safety lighting in accordance with the requirements of the Air Navigation Order 2016.*' In fact the MOD will require MOD standard infra-red lighting suitable for aircrew operating using Night Vision Equipment (NVE). This issue is fully addressed in the Aviation Lighting and Mitigation Technical Appendix to the EIAR.

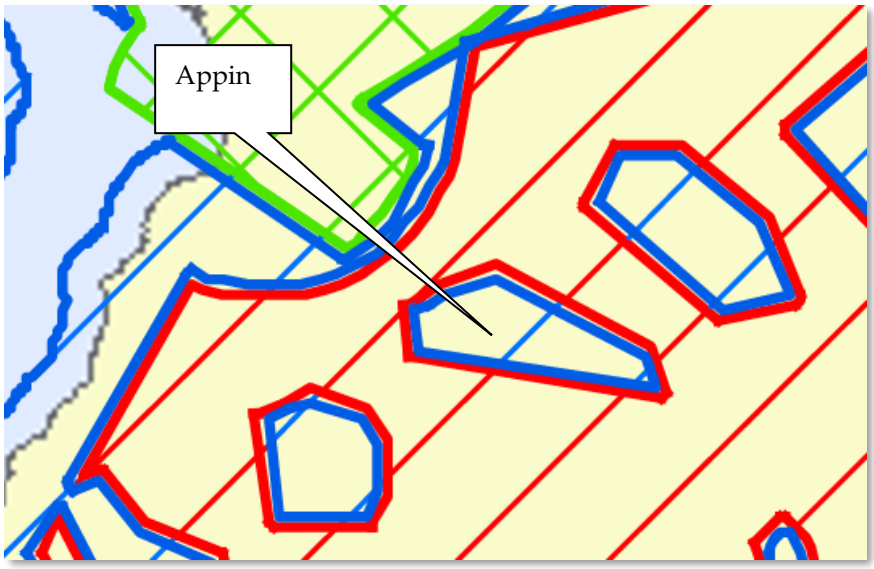

Figure 4 Low Flying Vs Windfarm Airspace Map

UK Met Office Radars

20. The Met Office safeguards its network of rainfall radars out to a distance of 20km. In this case the closest radar is at Holehead, over 100km to the north. There will be no effect on the Met Office radar network.

CAA Licensed Radar Equipped Airports

21. There are none within standard consultation distance, however, Glasgow Prestwick Airport (GPA) uniquely require to be consulted about any potential wind turbine developments within the entire coverage of their radars. Radar modelling results for both the old Primary Surveillance Radar (PSR) and the Terma Scanter 4002 windfarm mitigation radar are as shown in Tables 3 and 4 below.

Turbine	Distance (km)	Radar Line of Sight (m AGL)
1	43.97	187.8
2	43.10	165
3	43.60	195.6
4	44.09	298
5	44.59	253.9
6	45.10	244.8
7	45.62	288.8
8	46.17	272.1
9	46.56	287

Table 3 GPA PSR Radar Line of Sight Results

Turbine	Distance (km)	Radar Line of Sight (m AGL)
1	44.05	185.3
2	43.19	160.8
3	43.69	193.1
4	44.18	291.4
5	44.68	245
6	45.18	242.3
7	45.71	279
8	46.25	267
9	46.65	278.5

Table 4 GPA Terma Scanter Radar Line of Sight Results

22. The radar modelling results show that for both radars, there is marginal visibility of three turbines whilst the remaining six are screened by terrain. Turbines 1 and 3 are only marginally visible to the radar and at a distance of over 43km it is possible that they will have no effect on the radar. Only Turbine 2 has significant exposure likely to generate a single point of radar 'clutter' or unwanted radar returns. The results of radar modelling have been provided to GPA for comment and the Applicant has been in dialogue with GPA over an extended period of time in order to explore what, if any, mitigation will be required. The airport has yet to provide a substantive response in relation to the recently finalised turbine layout.

23. GPA responded to a scoping request on 26 April 2022 in response to a proposal for a much larger development using turbines with a tip height of 230m (now reduced to 200m). The response listed every possible issue that might arise including the following:

- ***Initial Operational Assessment*** – *the airport will be required to conduct further assessment work on these key Communications, Navigation and Surveillance Systems (CNS) which is provided for in the airport's safeguarding assessment process.* The Applicant has been in dialogue with GPA since then in order to resolve those issue which are relevant.

- ***Aviation Lighting*** – the airport make comment about aviation lighting requirements however, this is an issue for the CAA not the airport. In any case the Applicant has provided an Aviation Lighting and Mitigation Report as a technical appendix to the EIAR which includes CAA approval for a reduced aviation lighting scheme.

- ***Primary Surveillance Radar (PSR)*** The applicant has provided GPA with the results of detailed radar modelling as shown in Table 4 above. This demonstrates less impact than would have been the case with the layout being considered at scoping. It is clear that the effect on the PSR will be minimal. GPA are considering their position in relation to the radar impact. If necessary the Terma Radar will be able to provide sufficient radar coverage to mitigate any effect on the main PSR. The Applicant continues to engage with GPA in order to agree the best way to

resolve this issue in the context of planning decisions for other wind energy projects in the region.

- ***Instrument Flight Procedures*** – further discussions with GPA have resulted in a request for a Stage 1 IFP assessment, a simple assessment undertaken by or for the airport. The Applicant will be instructing such as assessment and continuing the dialogue with GPA in order to confirm that this is a non-issue in this location.

- ***Technical Safeguarding ILS and VHF radio equipment*** – It is clear that at a distance of over 40km, there is no possibility of the Proposed Development having an effect on the ILS and given the minimal exposure of only three turbines there is also no possible effect on VHF radio performance. It is understood that GPA will not be objecting in relation to these issues.

- ***Secondary Surveillance Radar (SSR)*** - GPA expressed concern regarding the effect of the Proposed Development on the performance of the SSR owned and operated by NATS at Lowther Hill. NATS are not concerned about the effect and the turbines are over 22km from the Lowther Hill SSR and therefore well beyond the 10km distance within which this would be assessed.

- ***Cumulative Impact*** – GPA raised concerns in relation to the cumulative impact of wind farm sites in the region. However, with the use of the Terma Scanter wind farm mitigation radar there is no cumulative effect as each wind farm will be mitigated using the capabilities of the radar.

24. The applicant continues to engage with GPA and it is anticipated that an agreed position relating to radar mitigation and safeguarding will be reached shortly

CAA Licensed Non-Radar Equipped Airports

25. There are no CAA licensed non-radar equipped airports within or close to consultation distance.

Unlicensed Aerodromes and Airstrips

26. There are no known unlicensed aerodromes or airstrips within the 3km consultation distance recommended in CAP 764 for unlicensed airstrips.

NATS En Route Ltd (NERL)

27. The closest NERL radar is at Lowther Hill. Radar modelling has been undertaken with the results shown in Table 5 below.

Turbine	Distance (km)	Radar Line of Sight (m AGL)
1	21.37	13.3
2	22.109	0
3	22.144	4.6
4	22.102	46.9
5	22.032	0
6	21.771	0
7	21.766	0
8	21.621	0
9	21.673	0

Table 5 NATS Lowther Hill Radar

28. The results confirm that every turbine will be in radar line of sight of the Lowther Hill radar. In their response to scoping, NATS stated under reference SG33091 dated April 2022 that the effect would be unacceptable and that they would object to the proposal.

29. The Applicant has had extensive discussions and meetings with NATS who have agreed that the Lowther Hill radar has suitable mitigation capabilities to overcome the unacceptable impact and confirmed via email dated 13/03/25 which stated: *'I have had the Frozen Co ordinates checked by Safeguarding who have advised that Signed Off Mitigation is available for Appin Wind Farm SG33091 in the form of an Indra Solution.'* The applicant will therefore be signing a mitigation contract with NATS which will enable them to withdraw their objection.

Potential Construction Effects

30. There are no technical effects on aviation interests during construction. The only aviation issues are those associated with the operation of large cranes which will be the subject of standard conditions for crane operations as laid down in CAA CAP1096 'Guidance to crane users on aviation lighting and notification'.

Potential Decommissioning Effects

31. There are no technical effects on aviation interests during decommissioning. The only aviation issues are those associated with the operation of large cranes which will be the subject of standard conditions for crane operations as laid down in CAA CAP1096 'Guidance to crane users on aviation lighting and notification.

Additional Mitigation and Enhancement

Aviation Lighting

32. Wind turbines with a tip height in excess of 150m are required to be illuminated with medium-intensity red aviation obstruction lights installed on the turbine hub in accordance with the Civil

Aviation Authority Policy Statement: *'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 Applicant provided a reduced lighting scheme that fulfils the requirements for flight safety whilst minimising environmental (visual) effects and gained approval from the CAA for the design (see Aviation Lighting Technical Appendix to the EIAR for details of the proposed mitigation). This sets out the arrangement of the aviation lights, together with an assessment of the intensity of the visible lights at selected viewpoints assessed in the LVIA (see: Landscape and Visual Impact Assessment) and provides an estimate of the percentage of time that the lights will be at full power and at 10% intensity based on historical Met Office records of visibility and cloud base in the region. As noted above, the Proposed Development will be fitted with MOD specification IR lighting to mitigate effects on military low flying. The implementation of the proposed lighting scheme (both visible and infrared) will be subject to a suspensive planning condition to the consent if granted.

Conclusion

33. The Proposed Development has been examined using the guidelines provided in CAP 764 and best practice developed over the past ten years or more. The report finds that in this case there are only likely to be two aviation issue to overcome, they are; the effect of the turbines on the NATS Lowther Hill radar and the effect on the radar at Glasgow Prestwick Airport. Discussions have already taken place between the Applicant and NATS who have identified a technical solution. In the case of GPA, discussions remain ongoing, however, if required, there is clearly a suitable mitigation available in the form of the utilization of the wind farm mitigation capabilities already available through the adaptation of the existing Terma Scanter 4002 radar installed and funded by wind farm developers specifically for this purpose. Both issues are therefore capable of being addressed through the use of suspensive planning conditions to protect aviation operations and flight safety. Aviation lighting will be required and this is fully addressed in the Aviation Lighting Technical Appendix.

Authors

Cdr John Taylor RN (Ret) – after a career in the Royal Navy specialising in Air Traffic Control (ATC), Airspace Management and Air Defence which culminated in leading both the ATC and Fighter Control Specialisations, John worked for Lockheed Martin UK for three years as a Principal Consultant and Business Area Manager responsible for Air Traffic Management Consultancy, including the provision of advice to wind farm developers. In 2008 he founded WPAC Ltd and since then he and his team have provided aviation advice in relation to over 2000 wind farm and wind turbine sites, given evidence at a number of planning inquiries and enabled many sites to overcome aviation objections where it was feasible to do so. He and his team have also provided advice to a number of Local Planning Authorities, Renewable UK and the Aviation Fund Management Board, including organising workshops and the provision of guidance documents. John also advises planners and developers in relation to physical and technical safeguarding of non-wind farm developments in the vicinity of aviation facilities.

Sqn Ldr Mike Hale RAF (Rtd) has over 45 years, piloting, instructing and examining experience on numerous military fast jet aircraft through to a range of civilian and military general aviation training aircraft and gliders. He has held many posts including Flying Instructor, Training Officer, Flight Commander, Squadron Commander and Principal Tornado AD Force Examiner. He has amassed over 10,000 flying hours of experience when operating at many locations around the world. In parallel to his flying duties, Mike held the post of Officer Commanding the MOD Low Flying Operations Squadron (OC LFOS). In this post he was both Low Level Airspace Manager for the MOD & Wind-Farm Subject Matter Expert for the Defence Infrastructure Organization (DIO). During that period, he assessed over 14,000 wind-farm pre-applications and 2000 full applications against low flying, weapons range, specialist airspace, local community and aerodrome safeguarding criteria. Mike also instigated two Qinetiq ground based Infra Red obstruction lighting trials. These were followed by instigating and managing the MOD Infra Red/Low Intensity (Henlow) flight trials and the CAA/MOD/Trinity-House/RUK off-shore IR/Morse (North Hoyle) flight trials. In conjunction, Mike organised numerous and various supporting trials including night vision equipment compatibility and detailed lighting beam overspill analysis (where light is emitted outside the required specification envelope). In 2012, he was awarded an MBE for generating a proactive and mutually successful working relationship between the Wind Power Industry and the MOD Air Staff.

Cdr John Taylor RN (Ret)
Managing Director
Wind Power Aviation Consultants Ltd
www.wpac.co.uk

Sqn Ldr Mike Hale MBE MSc CFS RAF (Retd)

Appendix A – Abbreviations and Definitions

ADSB……..……..Automatic Dependent Surveillance Broadcast
AGL.....Above Ground Level (Height)
AIAA……...Area of Intense Air Activity (MOD)
ANO.....Air Navigation Order
ANSP……..……..Air Navigation Service Provider
AMSL.....Above Mean Sea Level (Elevation)
ASG.....Aviation Steering Group
CAA.....Civil Aviation Authority
CAP.....Civil Aviation Publication (Refers to Specific Documents)
CNS…….Communications, Navigation and Surveillance Systems
cd.....Candela, a measure of light intensity
DIO.....Defence Infrastructure Organisation
HNTA.....Helicopter Night Training Area
IFP……..….Instrument Flight Procedure
In Flight Visibility.....The distance a pilot can see ahead to fly & navigate the aircraft
IR.....Infra-Red
Kts.....Knots: a measure of airspeed (10 kts = 12mph = 19 kph)
LED.....Light Emitting Diode
LFOS…….Low Flying Operations Squadron RAF
MOD.....Ministry of Defence
mW/sr.....milliWatts per steradian: electromagnetic energy output related to solid angle
NATS……..National Air Traffic Services Ltd
NERL…… ……..NATS En Route Ltd
Nm.....Nautical Mile
NVD .....Night Vision Devices - Aircraft Mounted
NVG.....Night Vision Goggles - Operator Worn
Radar Altimeter.....An altimeter that uses radar to accurately measure height above ground
QFE .....Setting on Altimeter that gives Height above Airfield
RoAR.....Rules of the Air Regulations
Rule 5.....The Low Flying Rule – part of RoAR
Rule 28.....VFR Rules Outside Controlled Airspace – part of the RoAR
ReUK.....Renewables UK – The UK Wind Industry Body
SAR Box.....Night Training Area for Search and Rescue Helicopter Units
SSA.....Sector Safety Altitude
SSR…… …….Secondary Surveillance Radar
TTA…….Tactical Training Area (MOD Low Flying)
UKAB.....United Kingdom Air Prox Board – Investigates Aircraft Near Misses
VFR.....Visual Flight Rules (Flight without ATC on a see-and-be-seen basis)
VMC.....Visual Meteorological Conditions (Weather suitable for VFR flight)