Muir Mhòr Offshore Wind Farm

Environmental Impact Assessment Report

Volume 3, Appendix 16.1: Military and Civil Aviation Technical Report

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Airspace Analysis and Radar Modelling

Muir Mhòr Offshore Wind Farm

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Abbreviations

AARA	Air-to-Air Refuelling Area
ACP	Airspace Change Process
AD	Air Defence
AD&OW	Air Defence and Offshore Wind
AIP	Aeronautical Information Publication
amsl	Above Mean Sea Level
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATDI	Advanced Topographic Development and Images
ATS	Air Traffic Services
BEIS	Business, Energy, and Industrial Strategy
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CTA	Control Area
DA	Danger Area
DASA	Defence and Security Accelerator
DESNZ	Department for Energy Security and Net Zero
DTM	Digital Terrain Model
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
FIR	Flight Information Region
FL	Flight Level
GIS	Geographic Information Systems
GNSS	Global Navigation Satellite System
HMRI	Helicopter Main Routing Indicator
HTZ	Hertz
IFP	Instrument Flight Procedure
IFR	Instrument Flight Rules
JUV	Jack-Up Vessel
MGN	Marine Guidance Notice
MOD	Ministry of Defence
OLS	Obstacle Limitation Surface

OPERA	Operational Programme for the Exchange of Weather Radar Information
OSA	Offshore Safety Area
OSS	Offshore Substation
PSR	Primary Surveillance Radar
RLoS	Radar Line of Sight
S&IP	Strategy and Implementation Plan
SAR	Search and Rescue
SSR	Secondary Surveillance Radar
SUA	Special Use Airspace
TMZ	Transponder Mandatory Zone
TOPA	Technical and Operational Assessment
TRA	Temporary Reserved Area
UAV	Unmanned Air Vehicle
VFR	Visual Flight Rules
WTG	Wind Turbine Generator

Glossary

Term	Definition
Controlled Airspace	Defined airspace within which pilots must follow Air Traffic Control instructions implicitly. In the UK, classes A, C, D, and E are areas of controlled airspace.
Flight Information Region (FIR)	Airspace managed by a controlling authority with responsibility for ensuring air traffic services are provided to aircraft flying within it.
Primary Surveillance Radar (PSR)	A radar system that measures the bearing and distance of targets using the detected reflections of radio signals.
Proposed Development	The offshore Muir Mhòr Offshore Wind Farm project elements to which this Offshore EIA Report relates.
Project	Muir Mhòr Offshore Wind Farm – comprises the wind farm and all associated offshore and onshore components.
Secondary Surveillance Radar (SSR)	A radar system that transmits interrogation pulses and receives transmitted responses from suitably equipped targets.
Uncontrolled Airspace	Defined airspace in which Air Traffic Control does not exercise exclusive authority but may provide basic information services to aircraft in radio contact. In the UK, Class G is uncontrolled airspace.

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Contents

ABBREVIATIONS **2**

GLOSSARY **4**

REFERENCES **5**

CONTENTS **6**

1. INTRODUCTION **8**

1.1. Overview 8

1.2. Effects of Wind Turbine Generators on Aviation 8

1.3. Technical Data 9

1.3.1. Wind Turbines 9

2. AIRSPACE ANALYSIS **10**

2.1. Introduction 10

2.2. Scope 10

2.3. Airspace Classification 10

2.4. Aircraft Vertical Reference 11

2.5. Current Airspace Baseline 11

2.6. Special Use Airspace 14

2.7. Helicopter Main Routing Indicators 14

2.8. Offshore Helidecks 16

2.9. Search and Rescue 16

Wet Storage 17

3. RADAR LINE OF SIGHT ASSESSMENT **18**

3.1. Technical Data 18

3.1.1. Terrain Data 18

3.1.3. Analysis Tools 18

3.1.4. Mapping Datum 18

3.1.5. Radar Data 18

3.2. Methodology 18

3.3. MOD ATC Radars 19

3.4. NATS Radars 20

3.4.2. Allanshill 20

3.4.7. Perwinnes 21

3.5. Met Office Radar 22

3.6. MOD Air Defence Radars 24

3.7. Radar Mitigation – MOD Air Defence Radars 25
3.8. Radar Mitigation – NATS Radars 26
3.9. Radar Mitigation – Met Office Radars 27
3.10. Consultation on Mitigation 27

List of figures

Figure 1: Muir Mhòr Offshore Array Area and Offshore ECC 9
Figure 2: North Sea Area II 12
Figure 3: Moray CTA 2 and Lower ATS Route P600 13
Figure 4: Seagreen TMZ (Phase 1) 13
Figure 5: Special Use Airspace 14
Figure 6: HMRIs and 2nm Centreline Buffer Zones 15
Figure 7: Offshore Helidecks with 9 nm Radius 16
Figure 8: Lossiemouth RLoS at 340m amsl 19
Figure 9: Allanshill RLoS at 340m amsl 20
Figure 10: Allanshill RLoS at 266 m amsl 21
Figure 11: Perwinnes RLoS at 340m amsl 21
Figure 12: Perwinnes RLoS at 266 m amsl 22
Figure 13: Hill of Dudwick RLoS at 340 m amsl 23
Figure 14: Hill of Dudwick RLoS at 266 m amsl 23
Figure 15: Buchan RLoS at 340 m amsl 24
Figure 16: Buchan RLoS at 266 m amsl 25

List of tables

Table 1: Wind Turbine Design Parameters 9

1. Introduction

1.1. Overview

1.1.1. The Muir Mhòr Offshore Wind Farm (hereafter the Project) comprises an array area located in the North Sea approximately 63 km east of Peterhead, and an export cable corridor (ECC) with landfall near Peterhead. Onshore transmission infrastructure will facilitate connection of the Project to the National Grid.

1.1.2. This document is the technical appendix to Volume 2, Chapter 16: Military and Civil Aviation of the Environmental Impact Assessment Report (EIAR) for the offshore elements of the Project (hereafter the Proposed Development). It provides detailed airspace analysis and radar modelling and outlines potential mitigation options. Potential impacts as a result of onshore elements are covered within this technical appendix where relevant to military and civil aviation receptors.

1.1.3. The Proposed Development array area is approximately 200 km^2.

1.2. Effects of Wind Turbine Generators on Aviation

1.2.1. Wind Turbine Generators (WTGs) can be problematic for aviation Primary Surveillance Radars (PSRs) as the characteristics of a moving WTG blade are like an aircraft. Some PSR under certain conditions may be unable to differentiate between wanted aircraft targets and unwanted clutter targets introduced by environmental factors around them, including but not limited to the presence of WTGs that are within Radar Line of Sight (RLoS).

1.2.2. The Met Office have a network of radars throughout the UK which they use to monitor the weather. WTGs can block radar beams and the rotation of turbine blades can generate unwanted clutter and impact on Doppler data and wind field measurements.

1.2.3. Secondary Surveillance Radars (SSRs) are less affected by WTGs, but turbine towers can cause physical blanking and diffracting effects and reflections can result in the SSR outputting false targets.

1.2.4. Potential impacts on radars were identified at the Scoping stage.

1.2.5. The significance of any radar impact depends on the airspace usage and the nature of the Air Traffic Services (ATS) provided in that airspace. The classification of the airspace in the vicinity of the array area and the uses of that airspace (military and civil) are set out in this appendix.

1.2.6. Radar impacts may be mitigated by either operational or technical solutions or a combination of both. In either case, the efficacy and acceptability of any operational and/or technical mitigation options can only be determined through consultation with the radar operators and ATS providers.

1.3. Technical Data

1.3.1. Wind Turbines

1.3.1.1. The maximum number of WTGs considered within the array area is 67. The design parameters for the WTGs are shown in Table 1.

Parameter	Maximum Parameter	Minimum Parameter
Blade tip height above mean sea level (amsl)	340 m amsl	266 m amsl
Rotor diameter	300 m	236 m
Wind turbine spacing (centre to centre)	1,800 m (6x rotor diameter)	944 m (4x rotor diameter)
Number of wind turbines	67	32

Table 1: Wind Turbine Design Parameters

1.3.1.2. The Muir Mhòr offshore array area and offshore Export Cable Corridor (ECC) are shown in Figure 1.

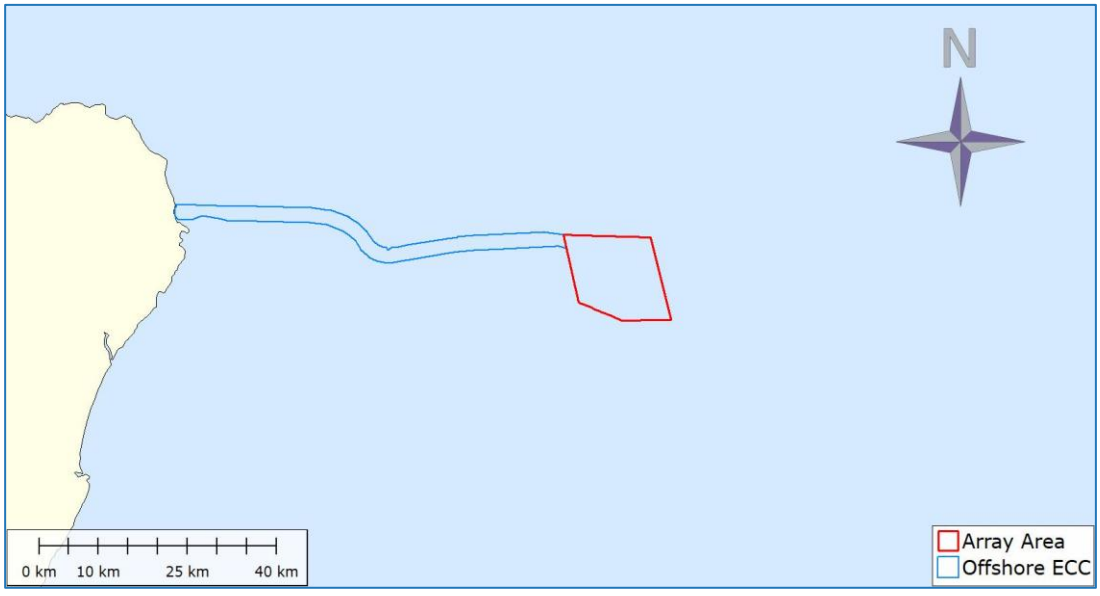

Figure 1: Muir Mhòr Offshore Array Area and Offshore ECC

2. Airspace Analysis

2.1. Introduction

2.1.1. This assessment is a review of potential impacts on aviation within the Proposed Development array area. The maximum tip height for WTGs within the Proposed Development array area will be 340 m amsl (1,115.49 ft). For the purposes of this assessment, a maximum tip height of 1,116 ft amsl has been assumed for all WTGs, the equivalent of 340 m rounded up to the nearest 1 ft.

2.1.2. All information has been referenced from the UK Aeronautical Information Publication (AIP), and the UK Military AIP, both available online from source, and is therefore the latest information available. Additional information has been sourced from UK Civil Aviation Authority (CAA) publications.

2.1.3. The assessment does not draw any conclusions but merely identifies areas of potential impact.

2.2. Scope

2.2.1. The scope of this assessment includes the array area and the surrounding airspace relating to aviation, its use and potential impact. The types of airspace and limitations on its use are identified.

2.3. Airspace Classification

2.3.1. In general, airspace can be characterised as either controlled or uncontrolled airspace. Aircraft in controlled airspace are being positively managed by Air Traffic Control (ATC) the entire time they are within that designated area. This type of airspace is generally used by airlines and corporate aviation. Aircraft in uncontrolled airspace are operating within a framework of rules but are not being controlled by ATC, although many pilots flying in this environment can choose to report their position, altitude, and intentions to ATC to benefit from enhanced situational awareness. Users of this airspace tend to be small personal aircraft engaged in training or private (social) flying.

2.3.2. In addition, Special Use Airspace (SUA) is designated for specific activities such that limitations on airspace access may be imposed on other non-participatory aircraft. An example of such airspace would be a Danger Area (DA) established for military flight training.

2.3.3. There are five classes of airspace in the UK, namely classes A, C, D, E and G. Classes A to E are controlled airspace whereas class G is uncontrolled airspace. Class A is the most strictly regulated controlled airspace whereby aircraft are positively controlled by ATC, compliance with ATC clearance is mandatory, and aircraft are flown and navigated solely with reference to aircraft instruments. Certain onboard equipment is also prerequisite. Flight in class G airspace is generally visual, meaning pilots fly and navigate with reference to the natural horizon and terrain features. Pilots are required to keep minimum separation distances from notified obstacles, including WTGs, and may only fly within the minimum weather and visibility criteria.

2.4. Aircraft Vertical Reference

2.4.1. An aircraft's vertical reference above the ground or sea can be either an altitude amsl or, above a designated altitude, a Flight Level (FL). An aircraft's altitude, expressed in feet, is based on the last known verified local barometric pressure while a FL, expressed in 100 ft increments, is based on a common international barometric pressure setting of 1013.2 hectopascals. With aircraft using a common vertical datum, safe separation can be achieved by either ATC or between pilots of different aircraft.

2.4.2. The airspace where vertical reference changes from altitude to FL and vice versa is known as the Transition Layer and consists of a (lower) Transition Altitude and (higher) Transition Level. In UK airspace the Transition Altitude is set at 3,000 ft amsl, except in certain specified airspace where it is higher.

2.4.3. The vertical limits of lower airspace are defined in terms of either altitudes or FLs, with airspace commonly having a lower limit expressed as an altitude and an upper limit expressed as a FL.

2.5. Current Airspace Baseline

2.5.1. The Proposed Development array area lies fully within the Scottish Flight Information Region (FIR), airspace regulated by the UK CAA. The boundary between the Scottish FIR and London FIR, also regulated by the UK CAA, is located approximately 261 km to the south of the Proposed Development array area. Located approximately 212 km to the northeast of the array area at its closest point is the boundary between the Scottish FIR and Polaris FIR, regulated by CAA Norway.

2.5.2. NATS (En Route) plc (NERL) provides en route civil ATS within the London and Scottish FIRs. NERL operates a network of radar facilities which provide en route information on airborne traffic for both civil and military ATC.

2.5.3. A portion of UK FIR airspace known as North Sea Area II is delegated to CAA Norway. Within this area, CAA Norway provide ATS to all aircraft from sea level to an altitude of FL85 (approximately 8,500 ft amsl). Procedures and communications within this area are as if the airspace was an integral part of the Polaris FIR. North Sea Area II is depicted in Figure 2, alongside the FIR boundaries, and lies approximately 163 km to the east of the Proposed Development array area.

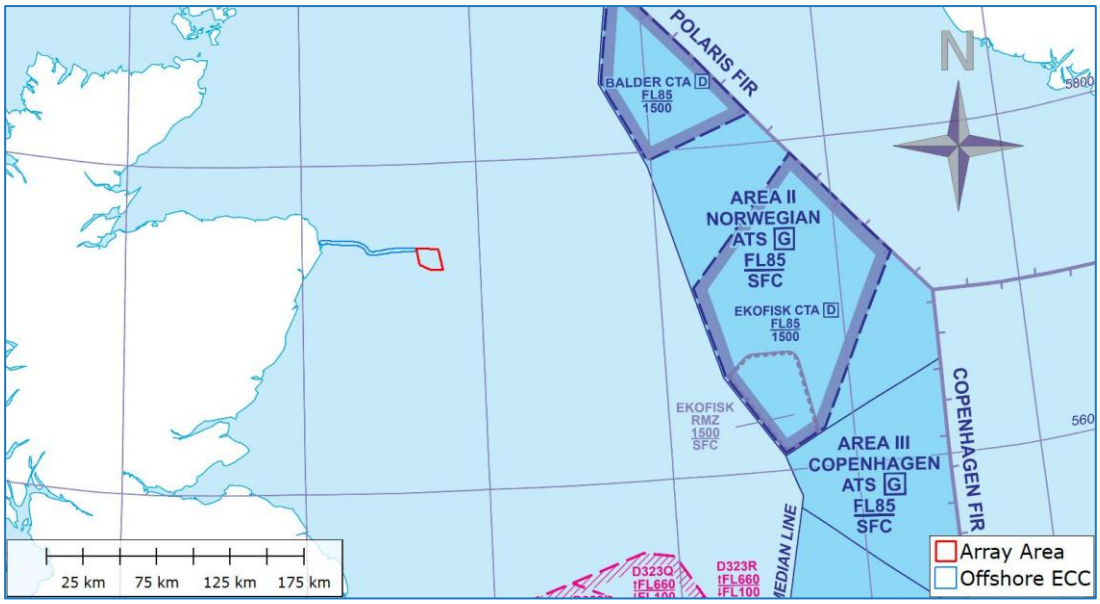

Figure 2: North Sea Area II

2.5.4. Immediately surrounding the Proposed Development array area is class G uncontrolled airspace. This airspace extends from sea level to FL195 (approximately 19,500 ft amsl).

2.5.5. This airspace is used by both civil and military aircraft, predominantly for low-level flight operations and generally by aircraft flying under Visual Flight Rules (VFR). Aircraft operate under one of two flight rules: VFR or Instrument Flight Rules (IFR). VFR flight is conducted with visual reference to the natural horizon while IFR flight requires reference solely to aircraft instrumentation. Under VFR flight the pilot is responsible for maintaining a safe distance from terrain, obstacles, and other aircraft.

2.5.6. Above FL195 (approximately 19,500 ft amsl) is class C controlled airspace in the form of a Temporary Reserved Area (TRA). This airspace, specifically TRA 007B, has an upper vertical limit of FL245 (approximately 24,500 ft amsl) and is available for use by both military and civil aircraft, though its main use is to accommodate VFR military flying activity. Above the TRA the upper limit of Class C airspace is FL 660, approximately 66,000 ft amsl.

2.5.7. Laterally, the nearest controlled airspace to the Proposed Development array area is the Moray Control Area (CTA) 2, located 9.5 km to the north as shown in Figure 3. This airspace has vertical limits of FL105 to FL195 (approximately 10,500 ft to 19,500 ft amsl respectively) and is Class E controlled airspace and a Transponder Mandatory Zone (TMZ). Within a TMZ, the carriage and operation of aircraft transponder equipment is mandatory. This enables such aircraft to be detected and tracked by SSR systems.

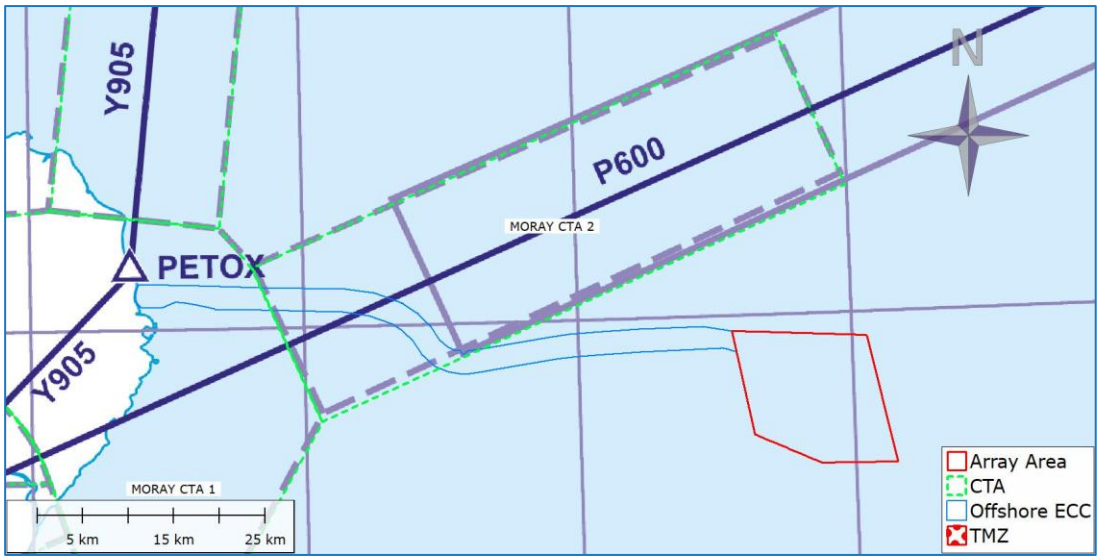

Figure 3: Moray CTA 2 and Lower ATS Route P600

2.5.8. Another TMZ is located 93 km to the southwest of the Proposed Development array area, the Seagreen TMZ (Phase 1) as shown in Figure 4. This airspace is defined from sea level to an upper limit of FL100 (approximately 10,000 ft amsl) and was established to mitigate the impact to PSR coverage of the Seagreen Offshore Wind Farm.

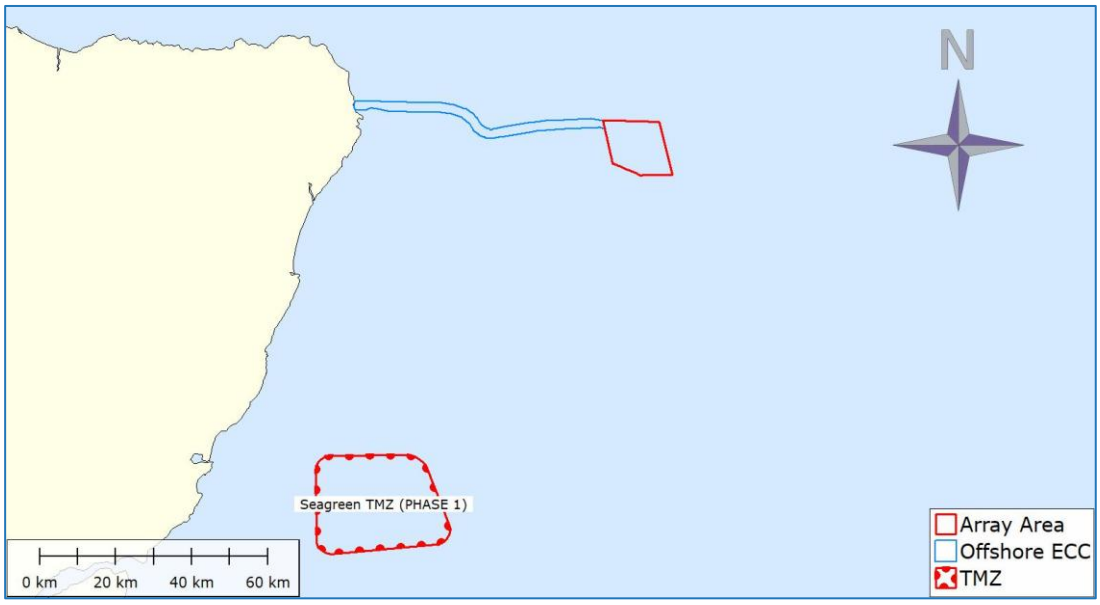

Figure 4: Seagreen TMZ (Phase 1)

2.5.9. ATS routes are airways along which aircraft fly navigating via ground-based electronic aids, or, increasingly, Global Navigation Satellite System (GNSS) waypoints. ATS routes are used where high levels of traffic move between areas. They may be standalone sections or embedded, either wholly or in part, within a segment of airspace.

2.5.10. The nearest lower ATS route is P600, located approximately 18 km to the north of the Proposed Development array area as shown in Figure 3. There are no upper ATS routes within the upper-class C airspace above the Proposed Development array area, which is

designated as Free Route Airspace between FL255 and FL660 (approximately 25,500 ft and 66,000 ft amsl respectively).

2.6. Special Use Airspace

2.6.1. The Proposed Development array area and offshore ECC lies beneath the Central Danger Area (DA) Complex, one of four DA complexes in UK airspace that provide segregated airspace for military training. These areas of airspace are not permanently active but are activated on request. Specifically, all the Proposed Development array area is located underneath DA EGD613A.

2.6.2. When activated, EGD613A has vertical limits from FL100 (approximately 10,000 ft amsl) up to FL660 (approximately 66,000 ft amsl). Activities within EGD613A include high energy manoeuvres, ordnance, munitions, and explosives. EGD613A is shown in Figure 5.

2.6.3. Also shown in Figure 5 are Area 2, Area 3 and Area 4 located to the northeast, east and north of the Proposed Development array area respectively. These areas are Air-to-Air Refuelling Areas (AARAs) within which fuel is transferred from tanker aircraft to receiver aircraft under a radar control service provided by military controllers based at Swanwick. Area 2 and Area 3 have vertical limits of FL100 to FL290 (approximately 10,000 ft to 29,000 ft amsl respectively). Area 4 is the closest AARA to the Proposed Development array area, located 27.7 km to the north northwest and has vertical limits of FL70 to FL240 (approximately 7,000 ft to 24,000 ft amsl respectively).

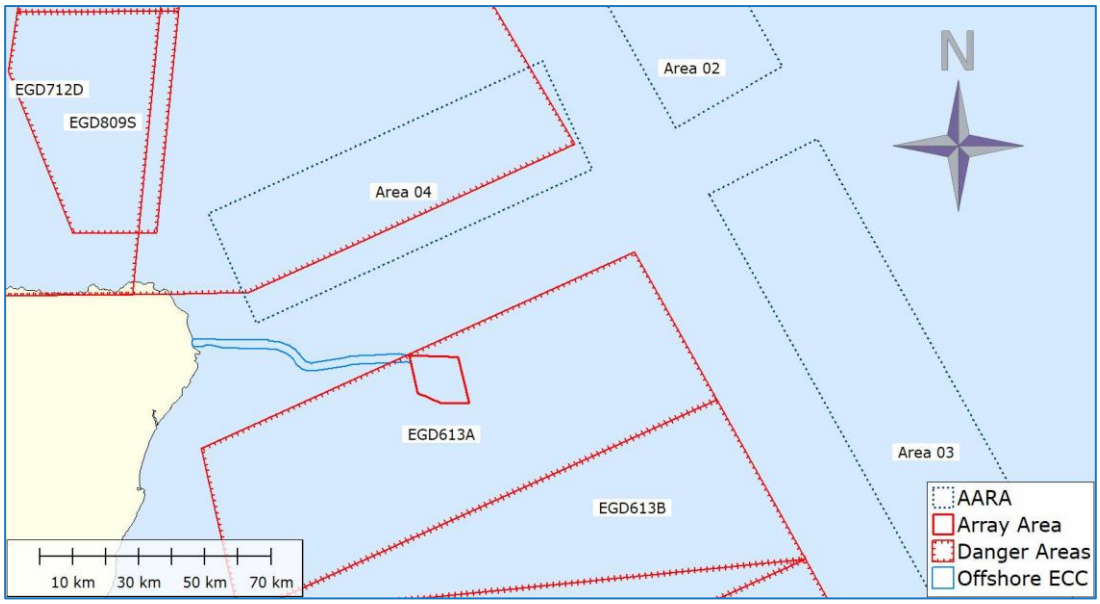

Figure 5: Special Use Airspace

2.7. Helicopter Main Routing Indicators

2.7.1. The Proposed Development array area and the offshore ECC are located within the Aberdeen Offshore Safety Area (OSA), which has a vertical limit of sea level to FL100 (approximately 10,000 ft amsl). The Aberdeen OSA contains a network of offshore routes over the North Sea that are flown by helicopters in support of oil and gas installations. These

routes are published on charts as Helicopter Main Routing Indicators (HMRIs) and, together with the OSA, alert other airspace users of the potential for frequent low-level helicopter traffic.

2.7.2. These routes have no lateral dimensions and assume the background airspace classification within which they lie. HMRIs within the Northern North Sea generally extend from 1,500 ft amsl to FL 85 (approximately 8,500 ft amsl), however where helicopter icing conditions or other flight safety considerations are present, they may force helicopters to operate below 1,500 ft amsl.

2.7.3. The CAA publication Civil Aviation Publication (CAP) 764 Policy and Guidelines on Wind Turbines (CAA, 2016) advises that planned obstacles within 2 nautical miles (nm) of an HMRI route centreline should be consulted upon with helicopter operators and the Air Navigation Service Provider (ANSP) (Aberdeen Air Traffic Service Unit).

2.7.4. Overlapping the Proposed Development array area are the centrelines for HMRIs 083, 086, and 089. In addition, the Proposed Development array area is within 2 nm of the centrelines for HMRIs 080 and 092. All overlapping HMRIs and 2 nm buffer zones are displayed in Figure 6.

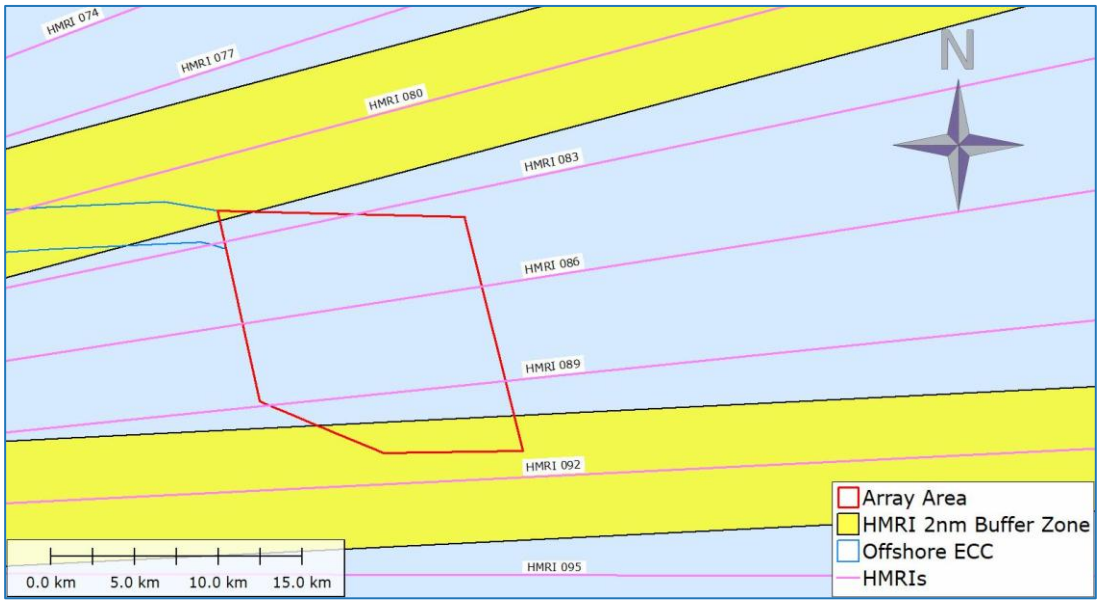

Figure 6: HMRIs and 2nm Centreline Buffer Zones

2.7.5. Helicopters operating under IFR must maintain at least 1,000 ft vertical clearance above the highest obstacles within 5 nm and would therefore need to transit the array area at a minimum of 2,200 ft amsl for the maximum WTG blade tip height of approximately 1,116 ft amsl. Helicopters flying under VFR must maintain a minimum of 500 ft separation from obstacles.

2.7.6. The ability of a helicopter to fly higher over WTGs depends on the icing level, and on days of low cloud base helicopters could be required to fly lower and extend their routings around the wind farm.

2.7.7. Aberdeen Offshore ATC, part of NATS, provides ATC services to helicopters operating in support of the North Sea oil and gas industry. As part of the Scoping Opinion Appendix I: Consultation Responses and Advice, NATS produced a Technical and Operational Assessment (TOPA). Within this TOPA, Aberdeen Offshore confirms that helicopter pilots typically require 1,000 ft vertical separation from en-route obstacles and may elect to operate at an altitude high enough to provide suitable obstacle clearance. However, this may not always be possible, and pilots may require a routing around the wind farm. In their scoping response, Aberdeen Offshore states that the development is likely to have a high operational impact and would therefore be unacceptable without further mitigation. Mitigation will be determined through consultation with NATS and North Sea helicopter operators.

2.8. Offshore Helidecks

2.8.1. To help achieve a safe operating environment, CAP 764 guidance establishes a 9 nm consultation zone for planned obstacles exists around offshore helicopter destinations. Within 9 nm, obstacles such as WTGs can potentially impact upon the feasibility of helicopters to safely fly low visibility or missed approach procedures at their associated helideck site. The nearest active offshore helideck to the Proposed Development array area is Buzzard, located approximately 39 km (21 nm) to the north northwest of the array area as shown in Figure 7.

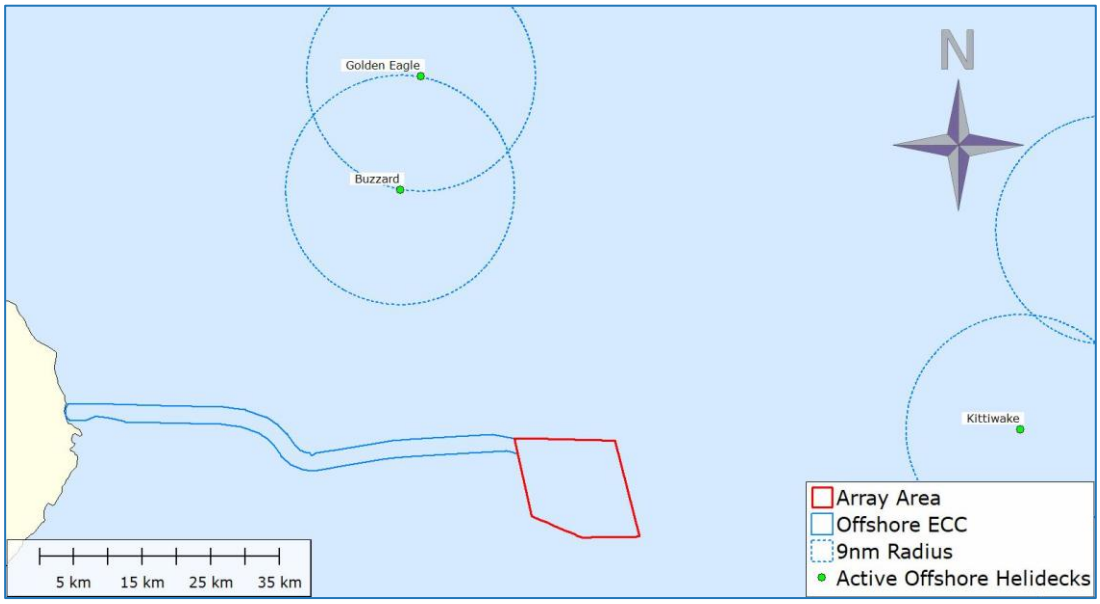

Figure 7: Offshore Helidecks with 9 nm Radius

2.8.2. The Proposed Development array area is anticipated to contain an Offshore Substation (OSS) featuring an offshore helideck. Helideck specifications will conform with CAP 437: Standards for offshore helicopter landing areas.

2.9. Search and Rescue

2.9.1. Search and Rescue (SAR) operations are a highly specialised undertaking involving not only aviation assets, but also small boats, ships, and shore-based personnel. SAR operations are

generally carried out in extremely challenging conditions and at all times of the day and night. There are 10 helicopter SAR bases around the UK with Bristow Group providing helicopters and aircrew on behalf of the Maritime and Coastguard Agency.

2.9.2. The nearest SAR base is at Inverness Airport, located approximately 200 km to the west of the Proposed Development array area. Its helicopters provide rescue services for both offshore and land-based incidents. The random nature of people, watercraft or aircraft in distress make it difficult to determine the routes taken by SAR aircraft. The Muir Mhòr Offshore Wind Farm will be designed in accordance with the guidance set out in Marie Guidance Notice (MGN) 654 as highlighted in embedded commitment C-21.

Wet Storage

2.9.3. The foundations of WTGs are likely to be assembled in a large construction port. Once assembly is completed, they will be 'wet stored' in a suitable sheltered area in the vicinity of the port facility. WTG integration is likely to take place via a large crane or a Jack-Up Vessel (JUV). The final stage is to tow-out the fully integrated unit to the Proposed Development array area. During the towing phase, the units will not be moving fast enough to generate PSR clutter.

2.9.4. The location of wet storage is at present, undetermined. Physical obstructions as a result of wet storage have the potential to impact military and civil airport's Instrument Flight Procedures (IFPs), Obstacle Limitation Surfaces (OLS), and communication and navigation aid facilities at airports.

2.9.5. The transport of WTGs from the wet storage location to the array area will be notified to enable promulgation to key aviation stakeholders. A wet storage plan will be developed and adhered to (embedded commitment C-40).

3. Radar Line of Sight Assessment

3.1. Technical Data

3.1.1. Terrain Data

3.1.2. RLoS modelling is undertaken using 3D 25 m resolution ATDI Digital Terrain Model (DTM) data.

3.1.3. Analysis Tools

3.1.3.1. The following software has been used to undertake the RLoS assessment:

- Advanced Topographic Development and Images (ATDI) Hertz (HTZ) Communications V2023.12.2 release 1498; and
- Blue Marble Global Mapper V21.1.1 Geographic Information System (GIS).

3.1.4. Mapping Datum

3.1.4.1. UTM30 (ETRS89 datum) is used as a common working datum for geodetic references.

3.1.4.2. Where necessary, mapping datum transformations are made using Global Mapper or Grid Inquest II Coordinate Transformation Program.

3.1.4.3. All heights stated in this document are amsl (Newlyn datum) unless stated otherwise.

3.1.5. Radar Data

3.1.5.1. Antenna heights, models and locations have been collected from the following sources:

- Data held on file by Cyrrus from previous surveys;
- MOD Height Survey Data (Military AIP);
- Operational Programme for the Exchange of Weather Radar Information (OPERA);
- Ofcom Protected Radar List (September 2023); and
- NATS Self-assessment maps.

3.2. Methodology

3.2.1. RLoS is determined by use of a radar propagation model ATDI HTZ Communications using 3D DTM data with 25 m horizontal resolution. The antenna locations and antenna heights are loaded into HTZ Communications. HTZ Communications uses the location, antenna height, DTM, and the Earth's curvature to produce a RLoS coverage for the desired receiver height. The coverage produced highlights the area within which the radar will be able to detect objects of the specified height (receiver height). Under certain atmospheric conditions, it is possible for radars to detect objects that are beyond the radar horizon, however the theoretical desk-based RLoS modelling provides a general indication of likely WTG visibility.

3.2.2. Note that by using a DTM, no account is taken of possible further shielding of the wind turbines due to the presence of structures or vegetation that may lie between the radar and the wind turbines. It is assumed that WTGs will occupy the furthest extents of the Proposed Development array area. Thus, the RLoS assessments are worst-case results.

3.2.3. For PSR, the principal source of adverse wind farm effects are the WTG blades, so RLoS is calculated for the maximum blade tip heights of the WTGs. If WTGs with the maximum blade tip height are within RLoS, the RLoS is calculated for the minimum blade tip height. Maximum and minimum blade tip heights used within these calculations are taken from the parameters in Table 1.

3.3. MOD ATC Radars

3.3.1. The nearest Military ATC radar to the Proposed Development array area is at Royal Air Force Lossiemouth, located 158 km to the west. RLoS coverage for a maximum blade tip height of 340 m amsl is shown in Figure 8.

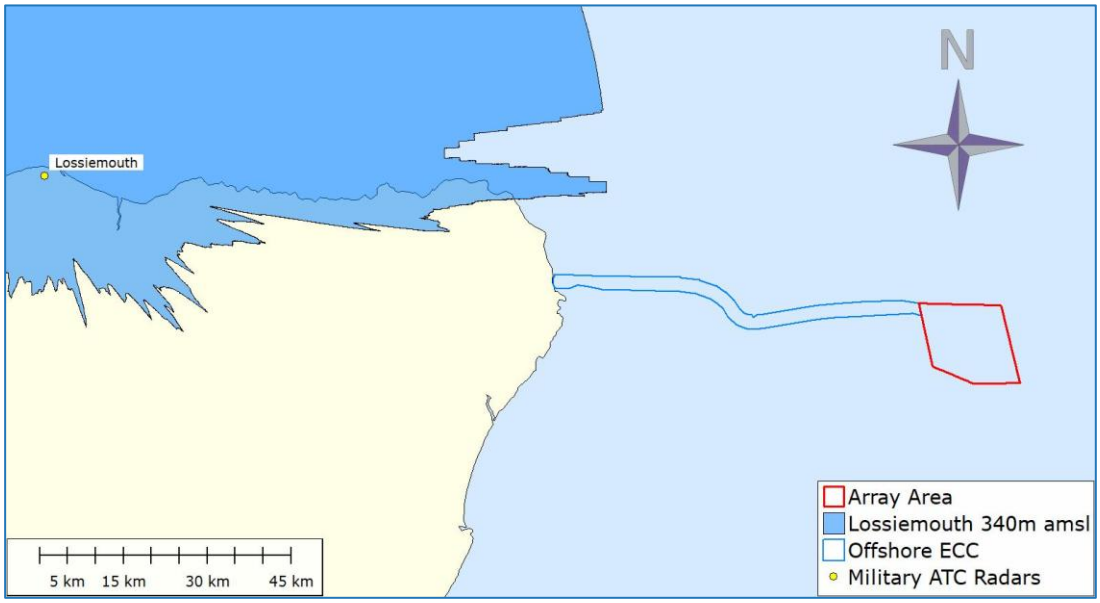

Figure 8: Lossiemouth RLoS at 340m amsl

3.3.2. With a maximum blade tip height of 340 m amsl, no WTGs within the Proposed Development array area will be within RLoS of Lossiemouth ATC PSR. As WTGs with a maximum tip height of 340 m will not be within RLoS, WTGs with a maximum tip height of 266 m will also not be within RLoS of Lossiemouth ATC PSR.

3.3.3. In the Scoping Opinion Appendix I: Consultation Responses and Advice, the MOD state they have “no concerns” for their MOD ATC radars based on their assessment of the Proposed Development array area using a blade tip height of 345 m amsl.

3.4. NATS Radars

3.4.1. The nearest NATS PSRs to the Proposed Development array area are Allanshill and Perwinnes, located 88.4 km to the west, and 89.3 km to the west southwest respectively as displayed in Figure 9 to Figure 12.

3.4.2. Allanshill

3.4.3. RLoS coverage for the maximum blade tip height of 340 m for Allanshill PSR is shown in Figure 9.

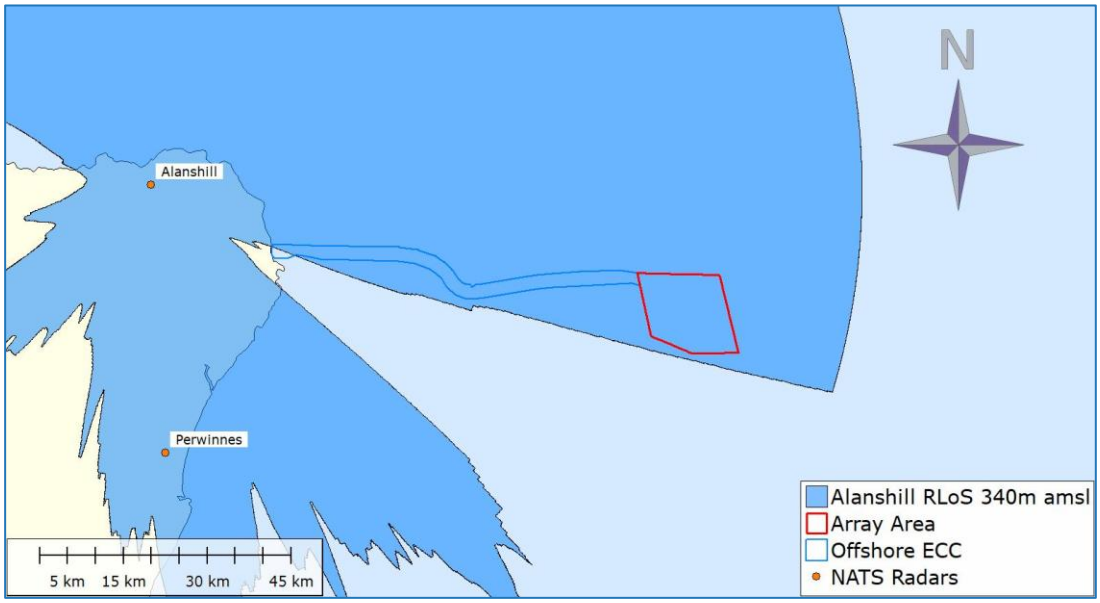

Figure 9: Allanshill RLoS at 340m amsl

3.4.4. With a maximum blade tip height of 340 m amsl, all WTGs within the Proposed Development array area will be within RLoS of Allanshill PSR. A second RLoS assessment using a maximum blade tip height of 266 m amsl is shown in Figure 10.

3.4.5. This coverage supports the NATS response in the Scoping Opinion Appendix I: Consultation Responses and Advice. For their response, NATS conducted a TOPA which included Allanshill radar. In the TOPA, NATS state that WTGs with a maximum tip height of 340 m will impact Allanshill radar. The users of Allanshill radar, Aberdeen Offshore and Prestwick Centre, deem this impact unacceptable without further mitigation.

Figure 10: Allanshill RLoS at 266 m amsl

3.4.6. With a maximum blade tip height of 266m amsl, all WTGs within the Proposed Development array area will be within RLoS of Allanshill PSR.

3.4.7. Perwinnes

3.4.8. RLoS coverage for a maximum blade tip height of 340 m amsl for Perwinnes PSR is shown in Figure 11.

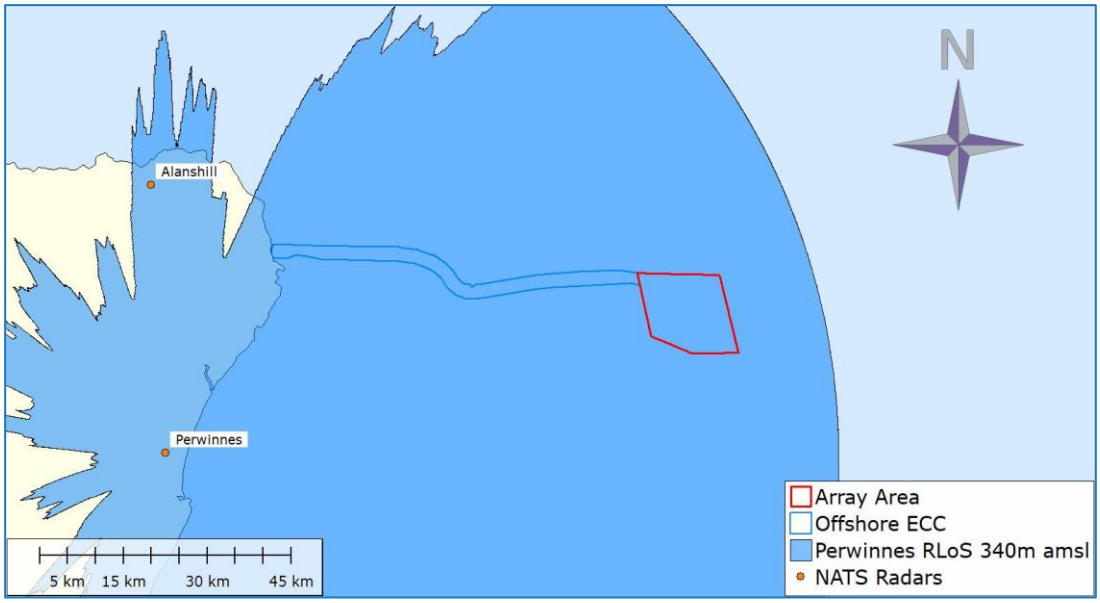

Figure 11: Perwinnes RLoS at 340m amsl

3.4.9. With a maximum blade tip height of 340 m amsl, all WTGs within the Proposed Development array area will be within RLoS of Perwinnes PSR. A second RLoS assessment using a maximum blade tip height of 266 m amsl is shown in Figure 12.

3.4.10. This coverage supports the NATS response in the Scoping Opinion Appendix I: Consultation Responses and Advice. For their response, NATS conducted a TOPA which included Perwinnes radar. In the TOPA, NATS state that WTGs with a maximum tip height of 340 m will impact Perwinnes radar. The users of Perwinnes radar, Aberdeen Offshore and Prestwick Centre, deem this impact unacceptable without further mitigation.

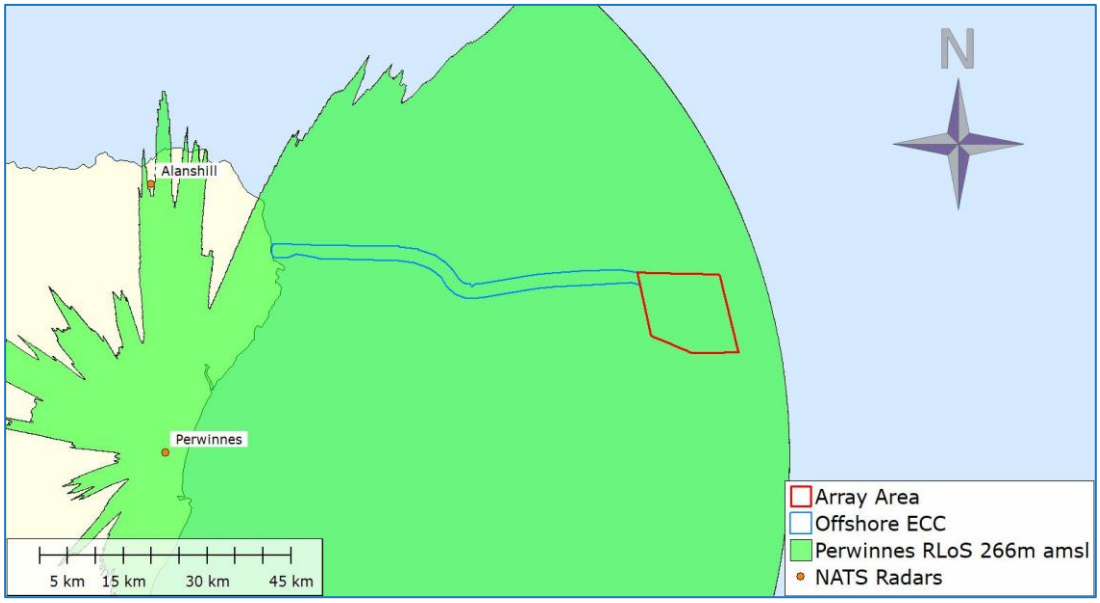

Figure 12: Perwinnes RLoS at 266 m amsl

3.4.11. With a maximum blade tip height of 266m amsl, all WTGs within the Proposed Development array area will be within RLoS of Perwinnes PSR.

3.5. Met Office Radar

3.5.1. The nearest Met Office radar to the Proposed Development array area is the Hill of Dudwick, located 79.5km to the west. Although the array area is located outside of the 20km safeguarded range for weather radar, RLoS coverage has been calculated to determine if WTGs will be visible to the radar.

3.5.2. RLoS coverage for a maximum blade tip height of 340m amsl for the Hill of Dudwick is shown in Figure 13.

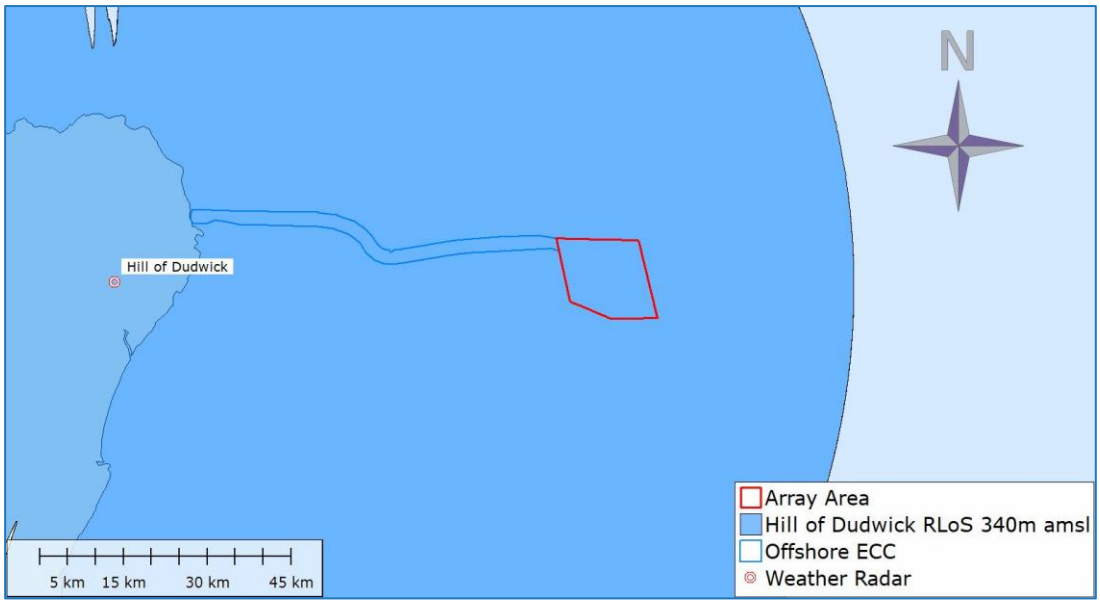

Figure 13: Hill of Dudwick RLoS at 340 m amsl

3.5.3. With a maximum blade tip height of 340 m amsl, all WTGs within the Proposed Development array area will be within RLoS of the Hill of Dudwick PSR. A second RLoS assessment for a maximum blade tip height of 266 m amsl is shown in Figure 14.

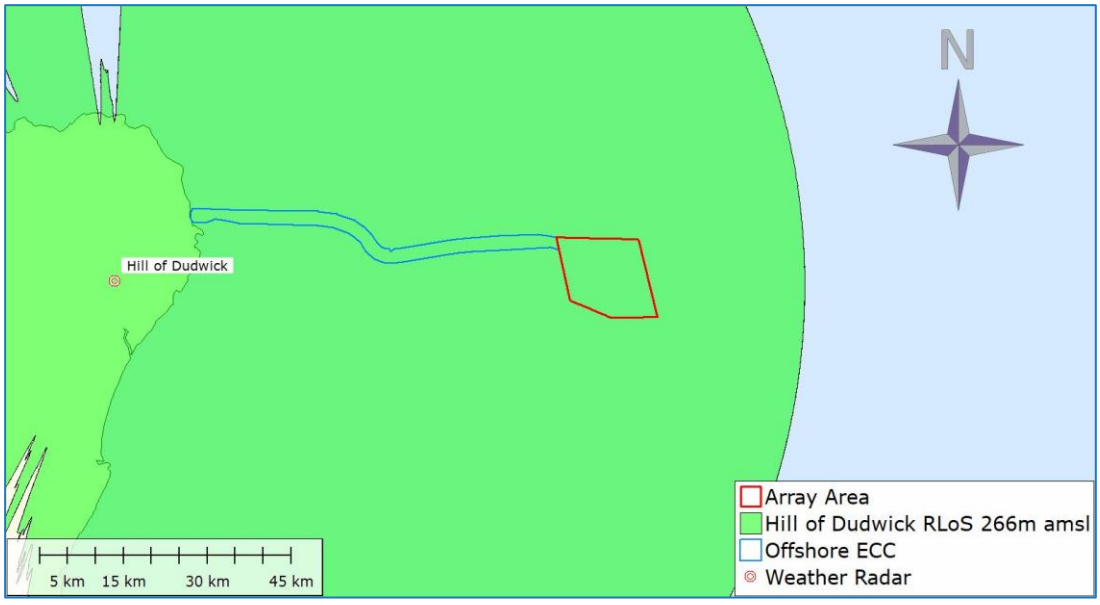

Figure 14: Hill of Dudwick RLoS at 266 m amsl

3.5.4. With a maximum blade tip height of 266 m amsl, all WTGs within the Proposed Development array area will be within RLoS of the Hill of Dudwick.

3.5.5. The Met Office confirmed during consultation that the base of the radar beam above the Proposed Development array area is approximately 550 m amsl. With WTGs with a maximum tip height of 340 m amsl, the Met Office confirmed they have no concerns about the Project.

3.6. MOD Air Defence Radars

3.6.1. The closest Air Defence (AD) radar to the Proposed Development array area is Buchan, located 65.8 km to the west. RLoS coverage for the maximum blade tip height of 340 m amsl is shown in Figure 15.

Figure 15: Buchan RLoS at 340 m amsl

3.6.2. With a maximum blade tip height of 340m amsl, all WTG within the Proposed Development array area will be within RLoS of Buchan AD radar. A second RLoS assessment using a maximum blade tip height of 266m amsl is shown in Figure 16.

3.6.3. This coverage is supported by the MOD response in the Scoping Opinion Appendix I: Responses and Advice. In their response, the MOD has undertaken assessment based on the 67 WTG positions with a tip height of 345 m and determined that the WTGs within the Proposed Development array area will be detectable to their Buchan AD radar. The MOD continue to state that the impact to Buchan AD will need to be addressed through a suitable technical mitigation solution.

3.6.4. Within their response the MOD also state that the safeguarding zone surrounding the AD radar at RAF Buchan extends over potential landfall locations of the ECC. The nearest potential landfall location of the ECC is 7.3 km north of RAF Buchan. Further engagement with the MOD will be undertaken to ensure there are no infringements of the safeguarding zone.

Figure 16: Buchan RLoS at 266 m amsl

3.6.5. With a maximum blade tip height of 266 m amsl, all WTG within the Muir Mhòr array will be within RLoS of Buchan AD radar.

3.7. Radar Mitigation – MOD Air Defence Radars

3.7.1. An Air Defence and Offshore Wind (AD&OW) Windfarm Mitigation Task Force was formed as a collaborative initiative between the MOD, what was the Department for Business, Energy and Industrial Strategy (BEIS) now the Department for Energy Security and Net Zero (DESNZ), the Offshore Wind Industry Council and The Crown Estate in August 2019. The aim of the Task Force is to enable the co-existence of UK Air Defence and offshore wind by identifying potential mitigations and supporting processes, allowing offshore wind to contribute towards meeting the UK Government's Net Zero target without degrading the nation's AD surveillance capability.

3.7.2. The AD&OW Strategy and Implementation Plan (S&IP) sets the direction for this collaboration by identifying, assessing and deploying solutions that will enable the co-existence of AD&OW operations such that neither is unduly nor excessively compromised. The S&IP may lead to significant changes to current AD PSR characteristics and capabilities that in turn affect the potential impact that the project may have.

3.7.3. In support of the S&IP, in March 2020 the MOD Defence and Security Accelerator (DASA) and BEIS launched an Innovation Challenge to reduce and remove the impact of wind farms on the UK's AD surveillance systems by seeking technological proposals in four areas:

- Alternatives to radar;
- Technologies applied to the wind turbine or installation;
- Technologies applied to the radar, its transmission or return; and
- Technological mitigations not covered by the above.

3.7.4. Phase 1 identified mitigations such as new radar signal processing methods or radar absorbing treatments applied to wind turbines and recommended a hybrid approach

involving changes to both radar and wind turbine design to solve the problem in the long term.

3.7.5. Phase 2 of the competition was launched in April 2021 seeking proposals to address four main subject areas:

- Reduction of clutter or the impact of clutter;
- Ensuring efficient detection and tracking time;
- Technologies to mitigate against larger turbine blades and wider turbine spacing development; and
- Alternate methods of surveillance.

3.7.6. Of twenty submitted proposals, contracts for seven proposals were awarded in September 2021 and completed by March 2023.

3.7.7. DASA and DESNZ launched Stream 1 of Windfarm Mitigation for UK Air Defence: Phase 3 in February 2023, building upon Phases 1 and 2 to advance innovative technologies in radar signal processing, wind turbine materials and alternative tracking approaches.

3.7.8. In August 2023, funding was awarded for two projects: a project developing passive air defence sensors to address clutter from wind turbine blades, and another project developing stealth materials for next-generation wind turbine blades. At the same time, Phase 3 Stream 2 was launched to find solutions for the modelling and testing of different mitigation technologies.

3.7.9. The ultimate aim of the S&IP is to have mitigations in place to support offshore wind developments from Q2 2025. The MOD through programme NJORD, is currently working on deploying mitigations as quickly as possible for current AD systems to enable the construction of large-scale offshore wind farms. Anticipated potential solutions as a result of NJORD may include replacing the current AD radar fleet, incorporating gap fill or supplementary radars, Unmanned Air Vehicles (UAVs), low orbit satellite technology and optical trackers. It is expected that Programme NJORD will provide such mitigation and will be available before the construction of the Proposed Development. Continuous consultation and coordination with the MOD is necessary. In their Scoping Opinion response, the MOD state it is the Developer's responsibility to provide a suitable technical mitigation solution.

3.8. Radar Mitigation – NATS Radars

3.8.1. NATS have identified potential effects of WTGs within the Proposed Development array area to the radars Allanshill and Perwinnes within a TOPA. The TOPA states that the development will cause false primary plots to be generated and that a reduction in the radar's probability of detection for real aircraft is anticipated for both radars.

3.8.2. A potential mitigation option against these effects could be to establish a TMZ around the Proposed Development array area with PSR blanking. Within a TMZ, it is mandatory for aircraft to carry and operate transponder equipment. This would enable the PSR blanking of the impacted radar coverage around the Proposed Development array area to negate the effects of WTGs, and ATC terminal controllers may provide ATS using only SSR.

3.8.3. This process will require an Airspace Change Process (ACP) to fully justify the requirement for a TMZ and so that the effect upon all airspace users is fully consulted and assessed.

3.8.4. During consultation between NATS and the developer, NATS revealed that they will be undergoing the replacement of the PSR systems at Allanshill and Perwinnes before 2030. It is not known whether this will result in one or two radars being bought, and where the location of these radars will be.

3.9. Radar Mitigation – Met Office Radars

3.9.1. Consultation with the Met Office confirmed that they have no concerns regarding the Muir Mhòr Offshore Wind Farm.

3.10. Consultation on Mitigation

3.10.1. Potential mitigation measures will be consulted upon with stakeholders throughout the application phase and as part of the EIA process and will also reflect appropriate measures that are being discussed at an industry level.

3.10.2. Considering the receptors affected by the Proposed Development, NATS and the MOD are the crucial consultees regarding radar mitigation. Aberdeen Offshore ATC and oil and gas helicopter operators will be an essential consultee regarding the affected HMRIs.

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