



Sporad na Mara Offshore Wind Farm

Offshore Project

Environmental Impact Assessment Report

Appendix 17.1: Airspace Analysis and Radar Modelling, Volume 2c

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1 INTRODUCTION

1.1 OVERVIEW

- 1.1.1.1 This appendix provides detailed airspace analysis and radar modelling and outlines potential mitigation options for the offshore elements of the Spiorad na Mara Offshore Wind Farm (hereafter referred to as 'the Project') with respect to Military and Civil Aviation. This appendix accompanies **Chapter 17: Military and Civil Aviation, Volume 2a** of the Environmental Impact Assessment Report (EIAR).
- 1.1.1.2 This appendix should be read in conjunction with the project description provided in **Chapter 3: Offshore Project Description, Volume 1a** and the relevant parts of the following chapters and appendices **Chapter 17, Volume 2a**.

1.2 PROJECT BACKGROUND

- 1.2.1.1 Spiorad na Mara Limited (hereafter referred to as 'the Applicant') is proposing to develop the Project. The Project is an offshore wind farm (OWF) that will consist of up to 60 fixed-bottom wind turbine generators (WTGs).
- 1.2.1.2 The Project will include both offshore and onshore infrastructure. This Offshore EIAR supports the application for the offshore components of the Project as outlined in **Chapter 1: Introduction, Volume 1a**. The offshore components of the Project (here after referred to as 'the Offshore Project') includes all infrastructure and activities located seaward of Mean High Water Springs (MHWS) within the Array Area and Offshore Cable Area of Search (OCAS) (**Figure 1.2: Offshore Project Location, Volume 1b**). Further detailed information is provided in **Chapter 3, Volume 1a**.
- 1.2.1.3 The Offshore Project is situated off the northwest coast of Isle of Lewis/*Eilean Leòdhais* and the Array Area is located approximately 5-13 km offshore and is approximately 161 km² in size. It will comprise WTGs, foundations, Offshore Cables, Offshore Substation Platform (OSP) (if required), and Landfall. The Array Area combined with the OCAS is defined as the Offshore Project Boundary. The water depths across the Array Area range from 37-67 m with the southwest corner of the Array Area reaching 72 m. The proposed WTGs, OSP (if required), and fixed foundations will be located within a Turbine Area of approximately 140 km², within the Array Area. The Offshore Project Array Area and Turbine Area is depicted in **Plate 2-1, Annex A**.

1.3 PURPOSE OF THIS APPENDIX

- 1.3.1.1 This appendix describes the detailed airspace analysis and radar modelling undertaken for the Offshore Project. This includes:

- Assessing how the proposed wind farm infrastructure could affect airspace and radar operations, both Military and Civil Aviation;
- Identifying the types of airspace in the vicinity, their classification, and how they are used;
- Evaluating the potential impacts of WTGs on radar systems (Primary Surveillance Radar, Secondary Surveillance Radar, Met Office weather radars);
- Outlining possible mitigation measures, both operational and technical, to address any identified impacts;
- Providing technical data, methodology, and modelling results to support the assessment; and
- Ensuring that the findings are consistent with regulatory requirements and stakeholder feedback, including consultation with relevant authorities such as the Ministry of Defence, Civil Aviation Authority, and the Met Office.

2 EFFECTS OF WIND TURBINE GENERATOR ON RADAR

- 2.1.1.1 WTGs can impact aviation Primary Surveillance Radars (PSRs) as the characteristics of a moving WTG blade create a similar signature to aircraft on radars. Some PSRs under certain conditions may not be able 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).
- 2.1.1.2 Secondary Surveillance Radars (SSRs) are less affected by WTGs than PSRs, but turbine towers can cause physical blanking and diffracting effects and reflections can result in the SSR outputting false targets.
- 2.1.1.3 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 Turbine Area and the uses of that airspace (military and civil) are set out in this appendix.
- 2.1.1.4 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.
- 2.1.1.5 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.

2.2 TECHNICAL DATA

Wind Turbines

- 2.2.1.1 There will be between 44 and 60 WTGs within the Turbine Area and tip heights between 293.8 m AMSL to 338.4 m AMSL. Further detailed information on project parameters is provided in **Chapter 3, Volume 1a**.

3 AIRSPACE ANALYSIS

3.1 INTRODUCTION

- 3.1.1.1 This assessment is a review of potential impacts on aviation within the Turbine Area. 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.
- 3.1.1.2 The maximum tip height for WTGs within the Turbine Area will be 338.4 m (1,110.4 ft AMSL). For the purpose of the assessment of airspace and Instrument Flight Procedures (IFPs), a maximum tip height of 1,200 ft AMSL has been assumed for all WTGs, the equivalent of 338.4 m AMSL rounded up to the nearest 100 ft.
- 3.1.1.3 This assessment identifies areas of potential impact. The potential impacts are assessed in **Chapter 17, Volume 2a**.

3.2 SCOPE

- 3.2.1.1 The scope of this assessment includes the Turbine Area and the surrounding airspace relating to aviation, its use and potential impact. The types of airspace and limitations on its use are identified.

3.3 AIRSPACE CLASSIFICATION

- 3.3.1.1 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.
- 3.3.1.2 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.
- 3.3.1.3 There are 5 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.

3.3.1.4 Airspace within the vicinity of the Turbine Area is described in Section 3.5.

3.4 AIRCRAFT VERTICAL REFERENCE

3.4.1.1 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 1,013.2 hectopascals. With aircraft using a common vertical datum, safe separation can be achieved by either ATC or between pilots of different aircraft.

3.4.1.2 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.

3.4.1.3 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.

3.5 CURRENT AIRSPACE BASELINE

3.5.1.1 The Turbine 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 380 km to the south-southeast of the Turbine Area. Located approximately 178 km to the west of the Turbine Area is the Shanwick FIR boundary, regulated by the UK CAA.

3.5.1.2 NATS provides en route civil ATS within these FIRs and operates a network of radar facilities which provide en route information on airborne traffic for both civil and military ATC. The FIR boundaries are depicted in **Plate 3-1, Annex A**.

3.5.1.3 Immediately surrounding the Turbine Area is class G uncontrolled airspace. This airspace extends from sea level to FL195 (approximately 19,500 ft AMSL).

3.5.1.4 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 1 of 2 flight rules: VFR or Instrument Flight Rules (IFR). VFR flight is conducted with visual reference to the natural horizon, whereas IFR requires reference solely to aircraft instrumentation. Under both IFR

and VFR flight outside controlled airspace, the pilot is responsible for maintaining a safe distance from terrain, obstacles, and other aircraft.

- 3.5.1.5 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 008A, 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 controlled airspace is FL660 (approximately 66,000 ft AMSL).
- 3.5.1.6 Laterally, the nearest controlled airspace to the Turbine Area is the Moray Control Area (CTA) 9, located 34.1 km to the southwest as shown in **Plate 3-2, Annex A**. This airspace has vertical limits of FL55 to FL195 (approximately 5,500 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.
- 3.5.1.7 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.
- 3.5.1.8 The nearest ATS route to the Turbine Area is Y906, located approximately 36 km to the southwest of the Turbine Area as shown in **Plate 3-3, Annex A**. There are no upper ATS routes within the upper-class C airspace above the Turbine Area, which is designated as Free Route Airspace between FL255 and FL660 (approximately 25,500 ft and 66,000 ft AMSL respectively).

3.6 SPECIAL USE AIRSPACE

- 3.6.1.1 Laterally, the nearest military airspace to the Turbine Area is the Hebrides Danger Area EGD701F, located 10.1 km to the west. This airspace is not permanently active but is activated on request. This airspace has unlimited vertical limits extending from sea level. Activities within this danger area include target towing, unmanned aircraft system (Visual Line of Sight (VLOS)/Beyond Visual Line of Sight (BVLOS)), high energy manoeuvres, ordnance, munitions and explosives, parachuting, balloons, electronic, and optical hazards. This airspace accommodates the Hebrides Missile Range. EGD701F is shown in **Plate 3-4, Annex A**.
- 3.6.1.2 Located 41.2 km to the east of the Turbine Area is the Northern Danger Area (DA) Complex, 1 of 4 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. When activated, the nearest airspace within this complex, EGD712A, is active from FL245 to FL660 (approximately 24,500 ft to 66,000 ft AMSL respectively). Activities within this DA include high energy manoeuvres.

3.6.1.3 The UK is divided into 20 separate Low Flying Areas (LFAs). Low flying occurs in most parts of the UK at any height up to 2,000 ft above the surface. This activity is mostly concentrated between the altitudes of 250 ft and 500 ft. The entirety of the Turbine Area is located within LFA14 as shown by the pink line boundaries in **Plate 3-5, Annex A**. The Defence Infrastructure Organisation (DIO) must be consulted in all cases where a proposed wind development may affect military operations.

Low flying training may be undertaken at night. Most night-time flying by Ministry of Defence (MOD) aircraft is undertaken by crews equipped with Night Vision Goggles (NVGs), therefore Infrared (IR) lights that meet MOD requirements will be necessary for wind farms within Night-Time LFAs. The Turbine Area is located within the Night-Time LFA 1BW as shown in **Plate 3-6, Annex A**. The MOD have stated in their scoping response that the development be fitted with MOD accredited aviation safety lighting in accordance with the CAA, Air Navigation Order 2016.

3.7 HELICOPTER MAIN ROUTING INDICATORS

3.7.1.1 The Aberdeen Offshore Safety Area (OSA) is located 280 km to the east of the Turbine Area. This airspace has a vertical limit of sea level to FL100 (approximately 10,000 ft AMSL). This OSA contains a network of offshore routes over the North Sea that are flown by helicopters in support of the oil and gas installations. These routes are published on charts as Helicopter Man Routing Indicators (HMRI) and together alert other airspace users to the potential for frequent low-level helicopter traffic.

3.7.1.2 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 relevant Air Navigation Service Provider (ANSP).

3.7.1.3 The Turbine Area is located beyond the nearest route and 2 nm centreline buffer. The nearest route HMRI Yankee, is located 167 km to the east as shown in **Plate 3-7, Annex A**.

3.8 OFFSHORE HELIDECKS

3.8.1.1 To help achieve a safe operating environment, CAP 764 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 Turbine Area is the Captain WPPA, located 282 km to the east, outside the established 9 nm (16.7 km) consultation zone.

3.9 SEARCH AND RESCUE

- 3.9.1.1 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 (MCA).
- 3.9.1.2 The nearest SAR base is at Stornoway/*Steòrnabhag* Airport, located 29.6 km to the southeast of the Turbine Area as shown in **Plate 3-8, Annex A**. 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.
- 3.9.1.3 The MCA sets out its requirements for wind farms with regards to SAR in MGN 654 Annex 5 – Offshore Renewable Energy Installations: Requirements, guidance and operational considerations for SAR and Emergency Response.

4 RADAR LINE OF SIGHT ANALYSIS

4.1 TECHNICAL DATA

TERRAIN DATA

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

ANALYSIS TOOLS

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

- Advanced Topographic Development and Images (ATDI) HTZ Communications V2023.12.2 release 1498;
- Blue Marble Global Mapper v25.1 Geographic Information System (GIS).

MAPPING DATUM

4.1.1.3 UTM29 (ETRS89 datum) is used as a common working datum for geodetic references.

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

4.1.1.5 All heights stated in this analysis are AMSL (Newlyn datum) unless stated otherwise.

RADAR DATA

4.1.1.6 Antenna heights, models, and locations have been collected from the following data sources:

- Data held on file by Cyrrus from previous surveys;
- Ministry of Defence (MOD) Height Survey Data (Military AIP);
- Operational Programme for the Exchange of Weather Radar Information (OPERA);
- Ofcom Protected Radar List (August 2024);
- NATS Self-assessment maps.

4.2 WIND FARM PARAMETERS

4.2.1.1 The wind farm layout has been refined through the design evolution process to take onboard information from environmental assessments undertaken, engineering considerations, and stakeholder feedback. Through this, the location of WTGs has been refined to the Turbine Area to primarily provide additional set back from National Scenic Areas as shown in **Plate 4-1, Annex A** (see **Chapter 4: Consideration of Alternatives, Volume 1a**). WTGs with a maximum tip height of

338.4 m AMSL are considered within this Appendix, where RLoS exists between WTGs and a radar at this height, a second simulation is run using the lowest maximum tip height of 293.8 m AMSL.

4.3 METHODOLOGY

- 4.3.1.1 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.
- 4.3.1.2 Note that by using a DTM, no account is taken of possible further shielding of the WTGs 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 Turbine Area. Thus, the RLoS assessments are worst-case results.
- 4.3.1.3 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 338.4 m and 293.8 m AMSL.

4.4 MILITARY RADARS

- 4.4.1.1 The nearest military radar to the Turbine Area is the Thales STAR-NG PSR at the St Kilda/ *Hiort* tracking station, located 113 km to the southwest. RLoS analysis indicates WTGs with a maximum blade tip height of 338.4 m and 293.8 m AMSL will be within RLoS to St Kilda as shown in **Plate 4-2, Annex A**. The potential impact to St Kilda PSR has been scoped out from further assessment as the Turbine Area is located outside of the Hebrides Danger Area of which the radar is associated with, in addition to feedback received in the scoping response where, QinetiQ confirmed that they have no concerns regarding the Offshore Project.
- 4.4.1.2 The nearest radar equipped military airfield to the Turbine Area is Royal Air Force (RAF) Lossiemouth/*Inbhir Losaidh*, situated approximately 207 km to the east-southeast shown in **Plate 4-3, Annex A**. A Thales STAR-NG PSR is deployed at RAF Lossiemouth which operates at a range of 60 nm. At a distance of approximately 207 km (111.8 nm), the Turbine Area will be located outside range of the RAF Lossiemouth PSR. Within their scoping response, the MOD agreed with this assessment and is not considered further in this assessment.

- 4.4.1.3 The closest Air Defence radar to the Turbine Area is the Lockheed Martin TPS 77 radar at Remote Radar Head (RRH) Benbecula, located 85.5 km to the south-southwest. RLoS coverage of Benbecula/*Beinn na Faoghla* at 338.4 m AMSL and 293.8 m AMSL is shown in **Plate 4-4** and **Plate 4-5, Annex A**.
- 4.4.1.4 RLoS analysis indicates that WTGs with a maximum tip height of 338.4 m and 293.8 m AMSL within the western corner (15.04 km²) of the Turbine Area will be within RLoS to Benbecula. WTGs with a maximum tip height of 293.8 m AMSL will be within RLoS but within a slightly smaller area (13.2 km²).
- 4.4.1.5 Within their response to the Scoping Report the MOD highlight the impact of WTGs on Benbecula/*Beinn na Faoghla* and stated that the radar will require technical mitigations which would need to be provided by the Applicant and accepted by the MOD.

4.5 NATS EN ROUTE RADARS AND AGA

- 4.5.1.1 The nearest NATS PSR to the Turbine Area is Tiree, located 208 km to the south. RLoS coverage of for the maximum blade tip height of 338.4 m AMSL is shown in **Plate 4-6, Annex A**.
- 4.5.1.2 RLoS analysis indicates that WTGs with a maximum tip height of 338.4 m AMSL will not be within RLoS to the NATS Tiree En Route Radar.
- 4.5.1.3 WTGs have less of an impact on SSR than PSR systems when they are located more than 10 km away from the SSR facility (CAP 764). To protect their SSRs, NATS have established a safeguarded radius of 28 km around their SSR facilities. The nearest SSR facility to the Turbine Area is Sandwick/*Sanndabhaig*, located 29.2 km to the southeast. The Turbine Area is located outside of the 28 km safeguarded radius as shown in **Plate 4-7, Annex A**.
- 4.5.1.4 To protect their Air-Ground-Air (AGA) radio stations, NATS have established a 10 km safeguarded zone around each facility. The nearest NATS AGA radio station is located outside of this safeguarded radius, 14.3 km to the southeast of the Turbine Area as shown in **Plate 4-8, Annex A**. In their response to the Scoping Report, NATS highlighted concerns regarding their AGA radio station, Forsnaval, located on the northwestern side of the Isle of Lewis/*Eilean Leòdhais*. NATS theoretical modelling has indicated that the volume of impact to this radio station is limited and prevalent at lower altitudes. The modelling produced by NATS was completed using a maximum tip height of 380 m AMSL (based on project design information provided in the Scoping Report). This height has since been lowered to 338.4 m AMSL and the absence of WTGs within the southwest corner of the Turbine Area has increased the distance between the AGA radio station and the closest WTG. A reduced maximum tip height and rotor diameter combined with an increased distance from the AGA radio station will result in a reduced impact compared to the modelling conducted by NATS. NATS have been engaged and are currently considering the impact to their AGA communications.

4.6 MET OFFICE RADAR

- 4.6.1.1 The nearest Met Office radar to the Turbine Area is Druim A'Starraig, located 35.5 km to the southeast. The Met Office have established a safeguarded radius of 20 km around each of their radars. Although the Turbine Area is located outside of this area, RLoS coverage has been calculated to determine if WTGs with a maximum tip height of 293.8 m and 338.4 m AMSL will be visible to the radar as shown in **Plate 4-9, Annex A**.
- 4.6.1.2 RLoS analysis indicates that WTGs within the Turbine Area with maximum tip height of 293.8 m and 338.4 m AMSL will be within RLoS of Druim A'Starraig.
- 4.6.1.3 The Met Office have a new proposed radar site at Campar Mor, which may replace the current Druim A'Starraig radar. In their latest correspondence (19/9/2024), the Met Office provided the coordinates and antenna height of Campar Mor to be used in modelling. The proposed position of this radar is located 22 km to the east of the Turbine Area. Theoretical RLoS coverage of Campar Mor at 338.4 m and 293.8 m AMSL is shown in **Plate 4-10, Annex A**.
- 4.6.1.4 WTGs with a maximum tip height of 338.4 m and 293.8 m AMSL within the Turbine Area will be within RLoS of Campar Mor as shown in **Plate 4-10, Annex A**.
- 4.6.1.5 The RLoS coverage produced in **Plate 4-19, Annex A** and **Plate 4-10, Annex A** does not take into account the elevation angle of the radar beam.
- 4.6.1.6 During consultation with the Met Office, they stated they may be able to accept the impact provided the proposed WTGs are below the beam at an elevation scan of 1.0° which has a vertical range of 0.5° - 1.5°.
- 4.6.1.7 The elevation scans of the weather radars have been assessed by simulating a cross section path profile from each antenna to a WTG (with a tip height of 338.4 m AMSL) positioned at the closest point of the Turbine Area. These path profiles are illustrated in **Plate 4-11, Annex A**.
- 4.6.1.8 A 2-D path profile from Druim A'Starraig to the closest WTG is illustrated in **Plate 4-12, Annex A**. This path profile indicates WTGs with a maximum tip height of 338.4 m AMSL will be detectable at a maximum vertical angle of 0.27°. This shows that WTGs within the Turbine Area will be below the 1° elevation scan (0.5°-1.5°) and therefore acceptable to the Met Office.
- 4.6.1.9 A 2-D path profile from Campar Mor to the closest WTG is illustrated in **Plate 4-13, Annex A**. This path profile indicates WTGs with a maximum tip height of 338.4 m AMSL will be detectable at a maximum vertical angle of 0.27°. This shows that WTGs within the Turbine Area will be below the 1° elevation scan (0.5°-1.5°) and therefore acceptable to the Met Office.
- 4.6.1.10 For WTGs up to a maximum tip height of 338.4 m AMSL, all WTGs within the Turbine Area the 1° elevation scan for both Druim A'Starraig, and the proposed Campar Mor radar site.
- 4.6.1.11 Results of these assessments were presented to the Met Office in which they stated:

“Thanks for sending the draft modelling report, it looks very comprehensive. You have demonstrated that the wind turbines in the proposed windfarm are all below the 1.0 deg beam of the nearest weather radars, therefore I’m pleased to confirm that we would be able to manage any impacts and wouldn’t raise any objections to a planning application.”

4.6.1.12 The Met Office have agreed with the modelling outcome that any impact which may arise will be managed.

4.7 RADAR MITIGATION – AIR DEFENCE AND MILITARY RADARS

4.7.1.1 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.

4.7.1.2 The AD&OW Strategy and Implementation Plan (S&IP) was published in September 2021, setting out 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. The S&IP states that mitigation of the adverse impacts of wind farms on current AD systems will be a stepping stone towards a longer-term solution that will enable co-existence.

4.7.1.3 An important breakthrough noted in the S&IP has been the identification by MOD of at least one or more technical mitigations that could potentially support wind farm developments in the medium term. Further work has been undertaken by MOD Defence and Security Accelerator (DASA) during 2020-2024 to encourage development of novel solutions for the future.

4.7.1.4 In late summer 2023, the MOD launched Project NJORD, calling for potential AD solution providers to participate in pre-qualification trials. 6 suppliers were put onto contract in March 2024 (Contract award notice 2024/S 000-008124) for the “procurement of a framework of capabilities capable of mitigating the effects of windfarms to maintain the Recognised Air Picture (RAP) of Air Defence (AD) Radars within the UK”. The successful suppliers includes Lockheed Martin UK Limited and Thales UK Limited.

4.7.1.5 Updates as to progress on Project NJORD are not currently in the public domain, nor are the commercial terms for developers to support the deployment of newly identified mitigation solutions. However, the Secretary of State for DESNZ noted in a speech on 17 September 2024 that air defence mitigation delays and excessive costs have been potentially impacting deployment of offshore wind through the Contracts for Difference (CfD) Allocation Rounds. The Secretary of State

indicated that a solution to these mitigation issues had been identified jointly by DESNZ, MOD, and HM Treasury so that CfD bidders and subsequent energy consumers should not carry these costs and delays.

- 4.7.1.6 The Clean Power 2030 Action Plan and National Policy Statement (NPS) for Energy (EN) 1 (2025) revealed the full costs of the long-term radar mitigation solutions identified by Programme NJORD, including RRH Benbecula will be funded via an alternative route delivered by government, and the funding requirement is therefore removed from offshore wind developers.
- 4.7.1.7 It is important to note that the AD radar at RRH Benbecula is a Lockheed Martin TPS-77 which has wind farm tolerance capabilities, involving the activation of a Non-Auto Initiation Zone (NAIZ) in the lower beams of this 3D phased array. The application of a NAIZ requires modelling to be undertaken by the MOD's contractor, Serco, and evaluation of the operational impact of the application of the NAIZ by RAF personnel. While the MOD suspended applications of the NAIZ mitigation capability in 2018, it announced in June 2019 that it would resume consideration of TPS-77 modelling reports / mitigation proposals where the impact on operational capability was deemed to be acceptable.
- 4.7.1.8 The small area of the Turbine Area which is in RLoS of Benbecula and its proximity to land suggests that it is analogous to an onshore wind farm so that the TPS-77 NAIZ mitigation may be operationally acceptable to the MOD. Engagement with the MOD is ongoing with the aim to agree on a Radar Mitigation Scheme (RMS) as required.

4.8 GLOSSARY OF TERMS AND ABBREVIATIONS

A list of key terms and acronyms used in this Appendix are provided in **Table 4-1** and **Table 4-2**

4.8.1.1 Table 4-2.

Table 4-1 Acronyms and abbreviations

Term	Definition
AD&OW	Air Defence and Offshore Wind
AGA	Air-Ground-Air
AGL	Above Ground Level
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	Department for Business, Energy and Industrial Strategy
BVLOS	Beyond Visual Line of Sight
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
DIO	Defence Infrastructure Organisation
DTM	Digital Terrain Model
EIA	Environmental Impact Assessment
FIR	Flight Information Region
FL	Flight Level
EN	Energy
GIS	Geographic Information Systems
GNSS	Global Navigation Satellite System
HMRI	Helicopter Main Routing Indicator
IFP	Instrument Flight Procedure
IFR	Instrument Flight Rules
IR	Infrared
LFA	Low Flying Area
MLWS	Mean Low Water Springs
MOD	Ministry of Defence
nm	Nautical Mile
NPS	National Policy Statement
NVG	Night Vision Goggle

Term	Definition
OCAS	Offshore Cable Area of Search
OPERA	Operational Programme for the Exchange of Weather Radar Information (OPERA)
PSR	Primary Surveillance Radar
RAF	Royal Air Force
RLoS	Radar Line of Sight
RMS	Radar Mitigation Scheme
RRH	Remote Radar Head
S&IP	Strategy and Implementation Plan
SAR	Search and Rescue
SLVIA	Seascape, Landscape and Visual Impact Assessment
SSR	Secondary Surveillance Radar
SUA	Special Use Airspace
TMZ	Transponder Mandatory Zone
TRA	Temporary Reserved Area
UAV	Unmanned Air Vehicle
VFR	Visual Flight Rules
VLOS	Visual Line of Sight
WTG	Wind Turbine Generator

Table 4-2 Glossary

Term	Meaning
the Applicant	Sporad na Mara Limited (the Project owner)
Array Area	The offshore area within which the offshore wind turbine generators (WTGs), associated foundations, Offshore Cables, and Offshore Substation Platform (OSP) (if required), will be located. This area encompasses the Turbine Area that will contain all above water surface infrastructure (WTGs / OSP) and an additional area within which further below water infrastructure (foundations and cables) may also be located.
Array Cables	The offshore electrical and communication cables that connect infrastructure located within the Array Area, for: Scenario 1: Array Cables will used to connect Wind Turbine Generators (WTGs) to each other, and to connect WTGs to the OSP. Scenario 2: Array Cables will used to connect WTGs to each other.
Array Cables to Landfall	The offshore electrical and communication cables located in the Array Area and Offshore Cables Area of Search that connect the wind turbine generators (WTGs) directly to Landfall for Scenario 2.
Controlled Airspace	Defined airspace within which pilots must follow Air Traffic Control instructions. In the UK, Classes A, C, D and E are areas of controlled airspace.
Export Cable	The offshore electrical and communication cables located in the Array Area and Offshore Cables Area of Search that connect the Offshore Substation Platform (OSP) (if required) to Landfall for Scenario 1.

Embedded or 'Designed-in' Mitigation	Mitigation measures to avoid or reduce environmental effects that are directly incorporated into the preferred design for the Project. This can include standard practice in accordance with or without guidance. Embedded Mitigation is considered as part of the impact assessment, before effect significance is identified.
Flight Level (FL)	An aircraft altitude expressed in hundreds of feet at a standard sea level pressure datum of 1013.25 hectopascals.
Instrument Flight Rules (IFR)	IFR are rules which allow properly equipped aircraft to be flown under Instrument Meteorological Conditions (IMC).
Instrument Meteorological Conditions	IMC are meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling, less than the minima specified for Visual Meteorological Conditions (VMC).
Landfall	This consists of works from offshore Horizontal Directional Drill (HDD) exit pits to onshore at the Transition Joint Bays (TJB). The infrastructure and installation methods associated with the Landfall involves both onshore and offshore components.
Offshore Application	The application for a marine licence under the Marine (Scotland) Act 2010 (between 0 and 12nm) and a Section 36 consent under the Electricity Act 1989.
Offshore Cables	Electrical and communication cables located within the Array Area and Offshore Cable Area of Search. The Offshore Cables consist of Array Cables, Array Cables to Landfall, and Export Cables.
Offshore Cable Area of Search (OCAS)	The area within which the offshore cable infrastructure between the Array Area and Landfall up to Mean High Water Springs (MHWS) will be located.
Offshore Project	The offshore components of the Spiorad na Mara offshore wind farm (the Project) located seaward of Mean High Water Springs (MHWS).
Offshore Project Boundary	The 'red line boundary' encompassing the Offshore Project.
Offshore Substation Platform (OSP)	The optional offshore substation located within the Turbine Area. Includes the platform and associated components which allows the voltage to be increased to meet onward transmission requirements.
Onshore Application	The application for consent under the Town and Country Planning (Scotland) Act 1997 (as amended).
Onshore Transmission Works (OTW) / Onshore Project	The onshore components of the Spiorad na Mara offshore wind farm (the Project) located landward of Mean Low Water Springs (MLWS). The Applicant will seek consent for the OTW Project through a separate application and so does not form part of this application.
Project	The Spiorad na Mara offshore wind farm development. This term describes the whole development, including all offshore and onshore components.
Project Boundary	The 'red line boundary' encompassing all offshore and onshore components of the Project.
Primary Surveillance Radar (PSR)	A radar system that measures the bearing and distance of targets using the detected reflections of radio signals.
Scoping Opinion	A report presenting the written opinion of the Scottish Ministers, in consultation with Comhairle nan Eilean Siar (CnES) for the Onshore Project, as

	to the scope and level of detail of information to be provided in the Environmental Impact Assessment (EIA) for the Project.
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.
Visual Flight Rules (VFR)	VFR are the rules that govern the operation of aircraft in VMC, conditions in which flight solely by visual reference is possible.
Visual Meteorological Conditions	VMC are the meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling equal to or better than specified minima.
Turbine Area	A reduced area within the Array Area where above water surface infrastructure would be located i.e. wind turbine generators (WTG) or Offshore Substation Platform (OSP) (if required). This area has been developed and refined through stakeholder consultation and environmental assessment.
Wind Turbine Generator (WTG)	The wind turbines that generate electricity consisting of tubular towers and blades attached to a nacelle housing mechanical and electrical generating equipment.

4.9 REFERENCES

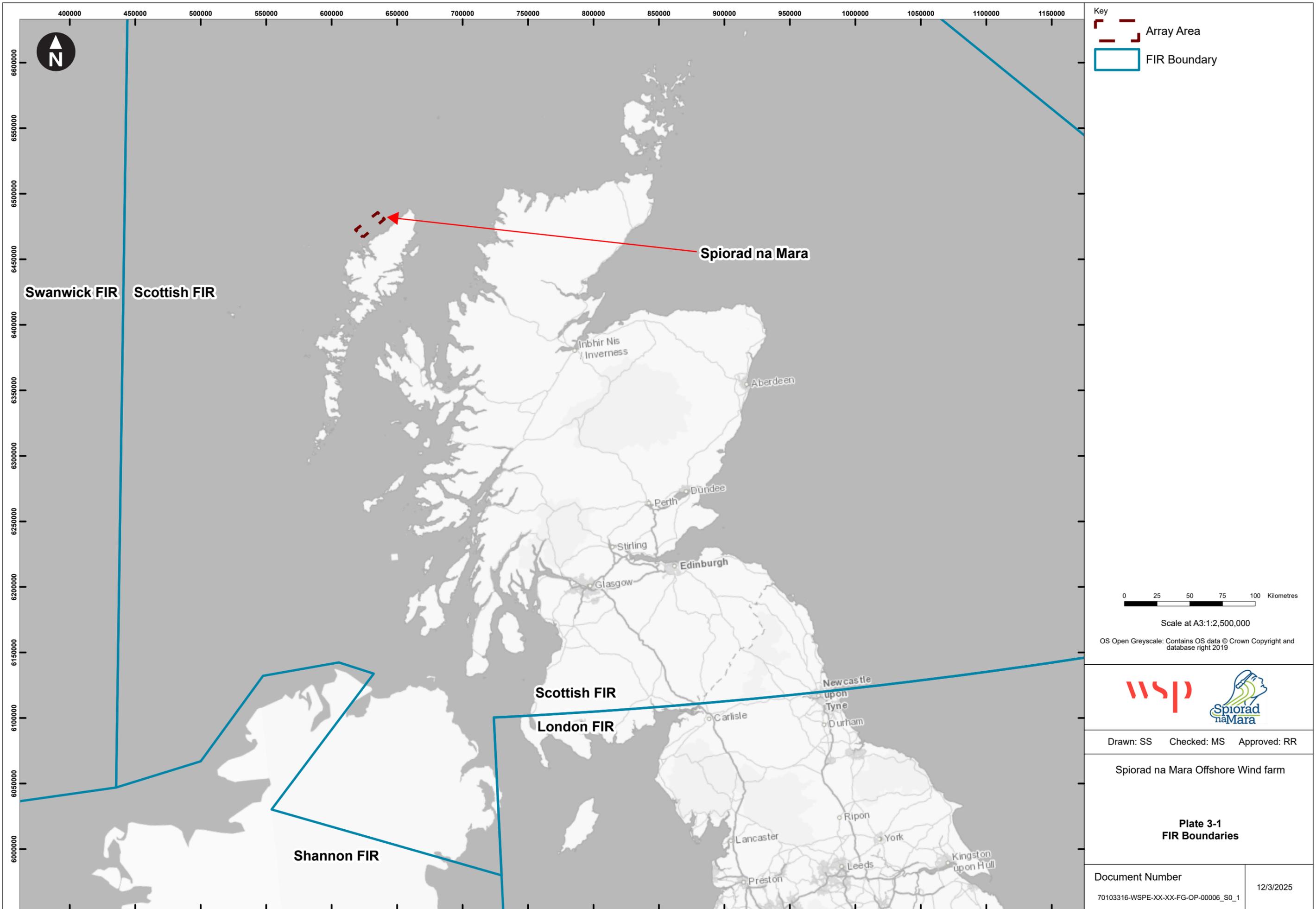
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ANNEX A

4.9.1.1 This annex contains Plates referenced throughout this appendix.

Plate 2-1 Spiorad na Mara Array Area

Plate 3-1 FIR Boundaries



Key
 Array Area
 FIR Boundary

0 25 50 75 100 Kilometres

Scale at A3:1:2,500,000

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Drawn: SS Checked: MS Approved: RR

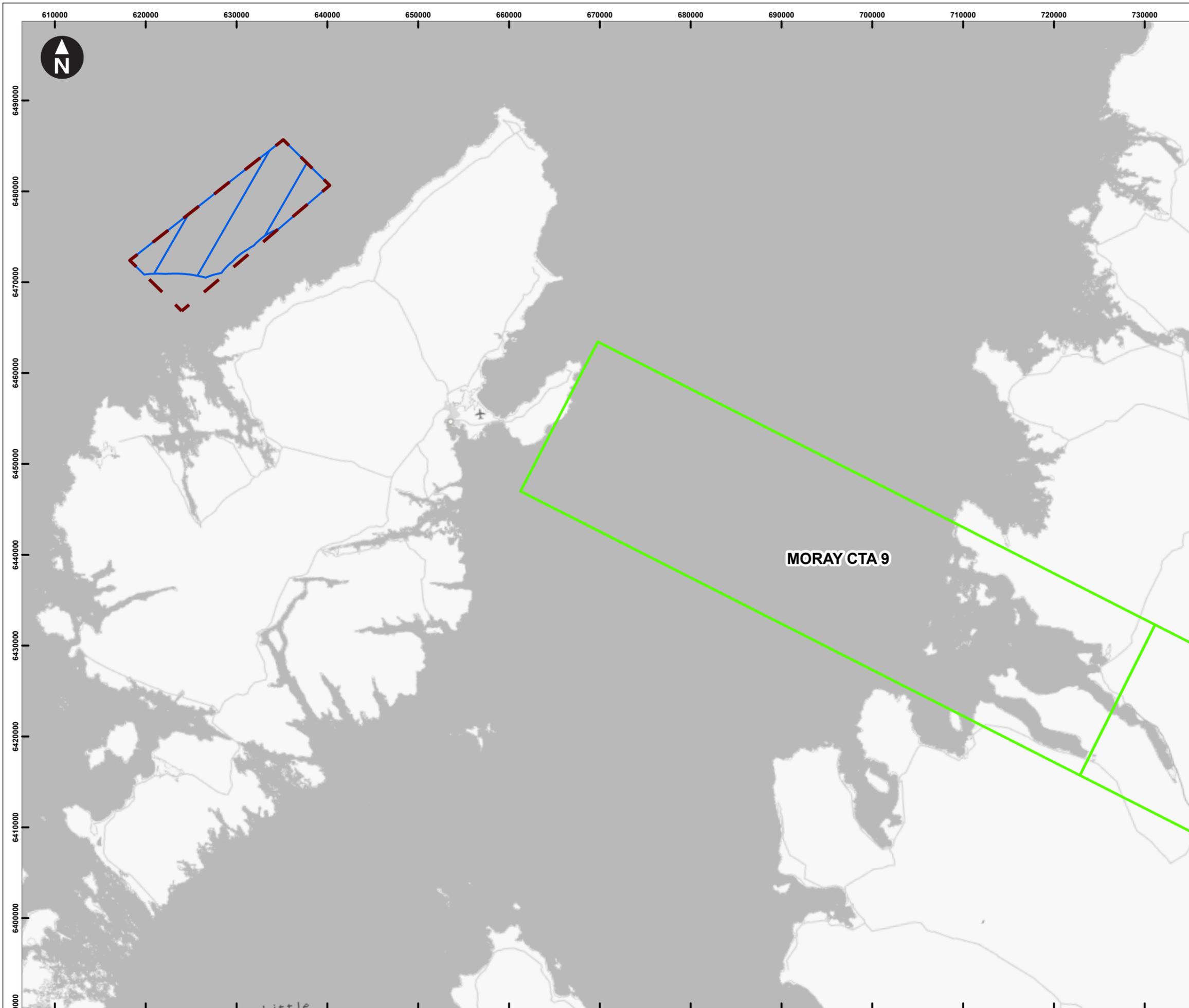
Spiorad na Mara Offshore Wind farm

**Plate 3-1
 FIR Boundaries**

Document Number
 70103316-WSPE-XX-XX-FG-OP-00006_S0_1

12/3/2025

Plate 3-2 Moray CTA 9 in Relation to the Sporad na Mara Turbine Area



Key

-  Array Area
-  Turbine Area
-  CTA



Scale at A3:1:400,000
 OS Open Greyscale: Contains OS data © Crown Copyright and database right 2019



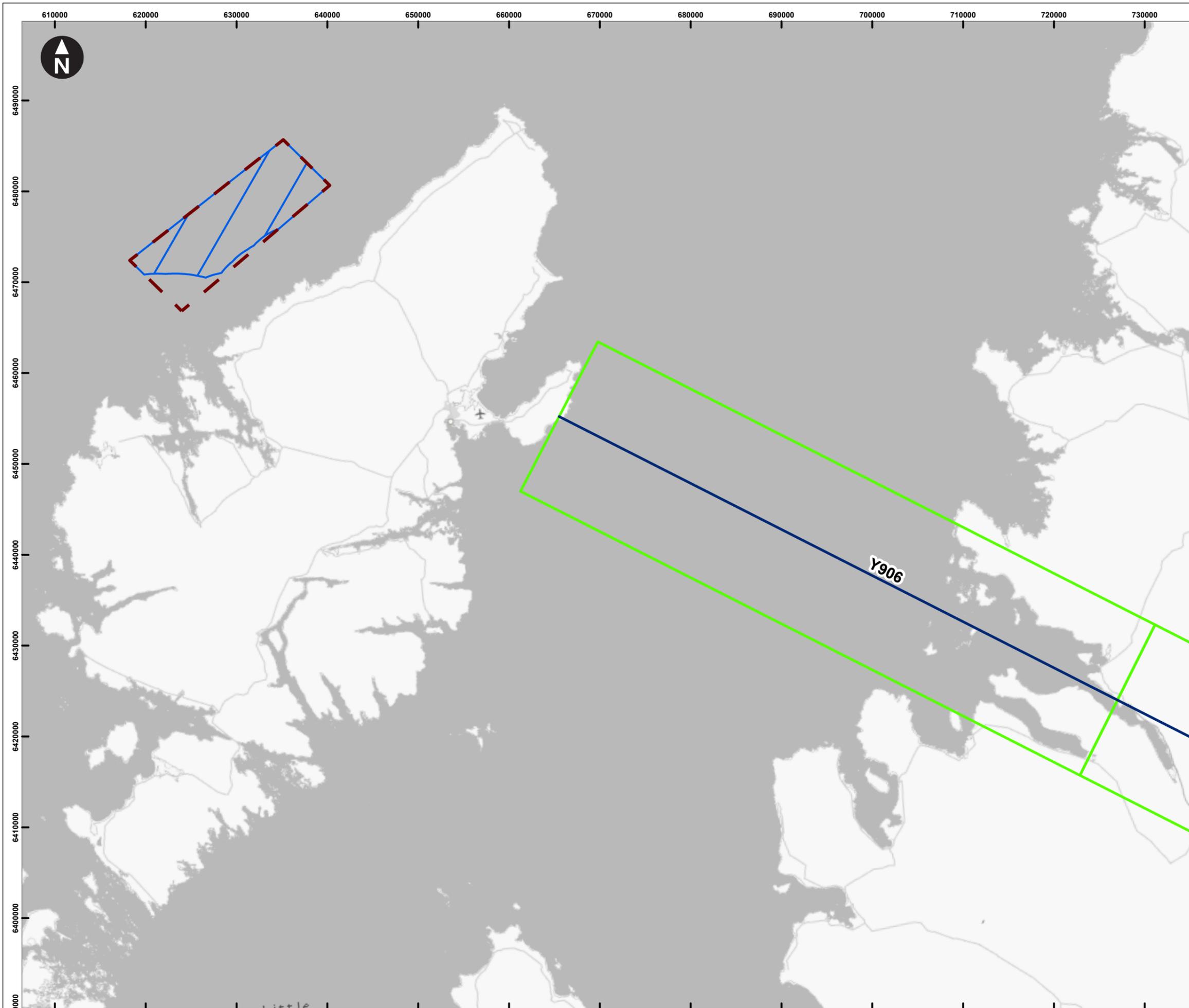
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Spiorad na Mara Offshore Wind farm

Plate 3-2
Moray CTA 9 in Relation to the
Spiorad na Mara Turbine Area

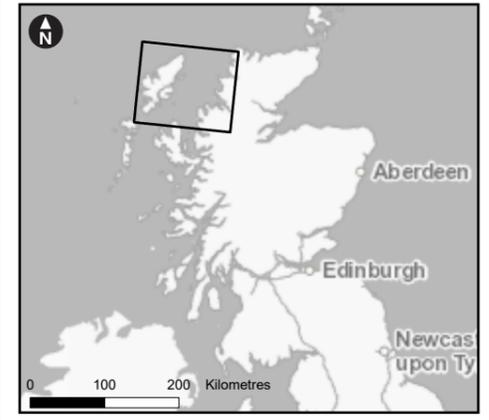
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Plate 3-3 ATS Route Y906



Key

-  Array Area
-  Turbine Area
-  CTA
-  ATS Route



Scale at A3:1:400,000
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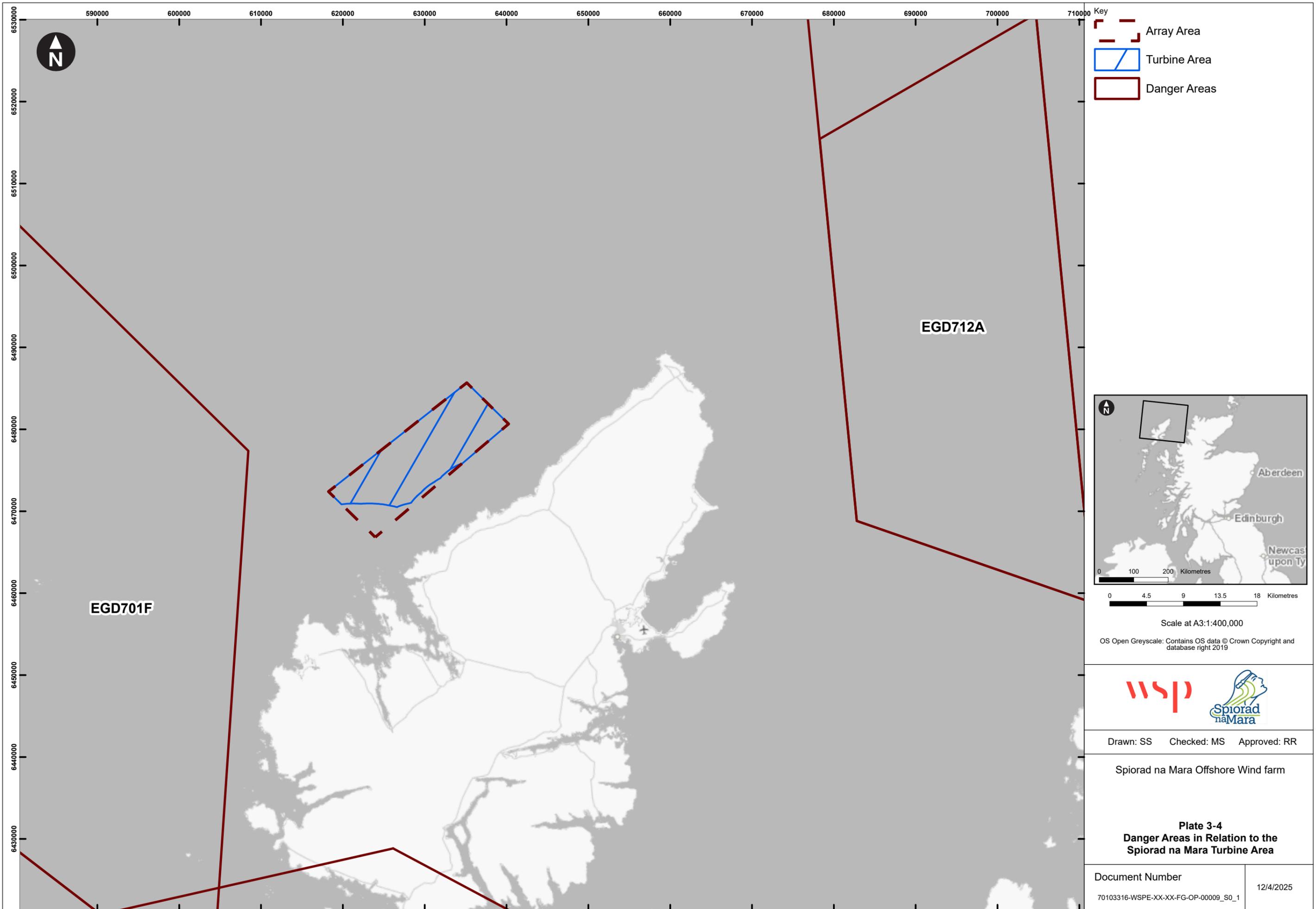

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Sporad na Mara Offshore Wind farm

**Plate 3-3
ATS Route Y906**

Document Number	12/4/2025
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Plate 3-4 Danger Areas in Relation to the Sporad na Mara Turbine Area



Key

-  Array Area
-  Turbine Area
-  Danger Areas



Scale at A3:1:400,000
 OS Open Greyscale: Contains OS data © Crown Copyright and database right 2019



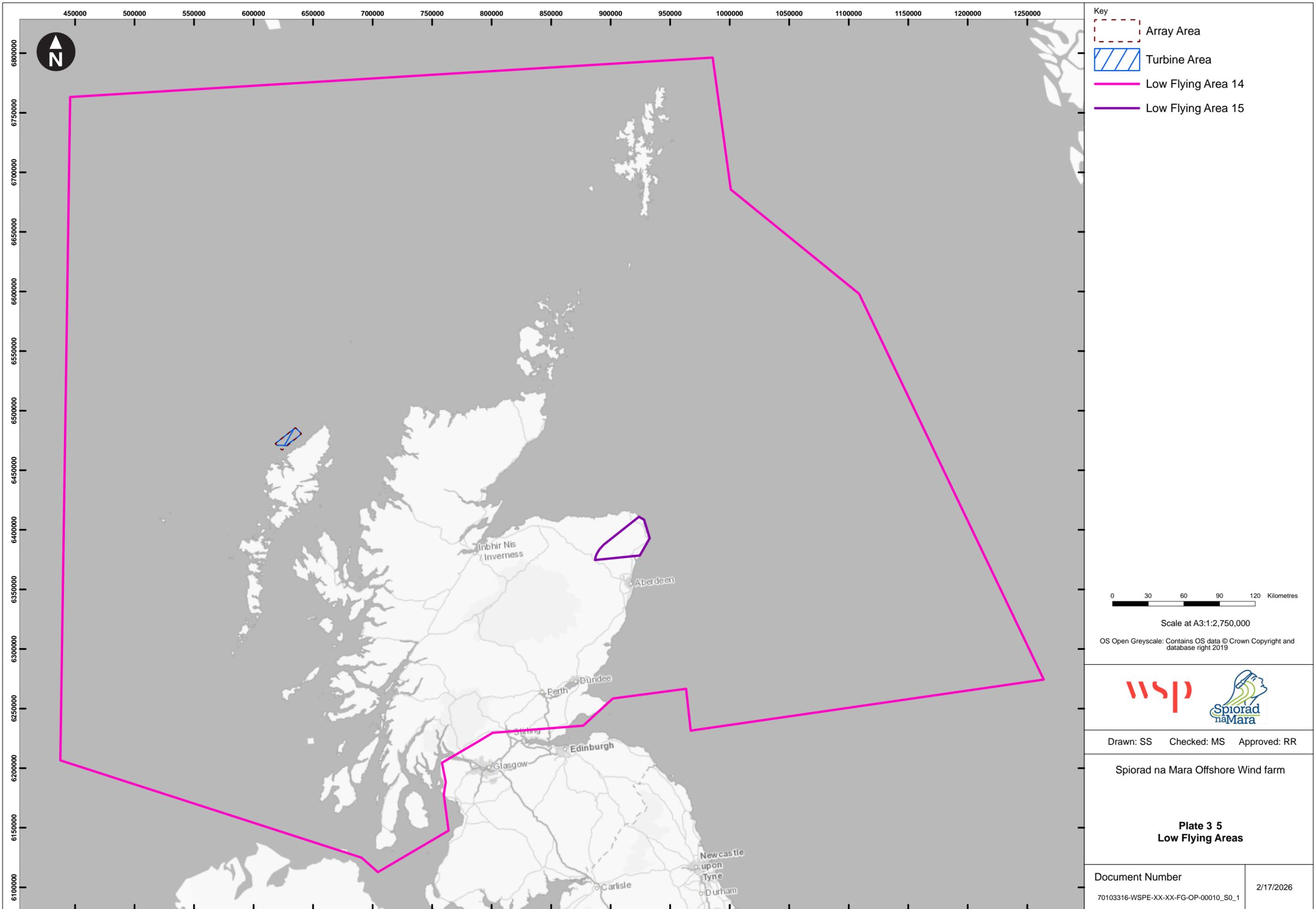
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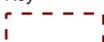
Spiorad na Mara Offshore Wind farm

Plate 3-4
Danger Areas in Relation to the
Spiorad na Mara Turbine Area

Document Number	12/4/2025
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Plate 3-5 Low Flying Areas



- Key
-  Array Area
 -  Turbine Area
 -  Low Flying Area 14
 -  Low Flying Area 15

0 30 60 90 120 Kilometres

Scale at A3:1:2,750,000

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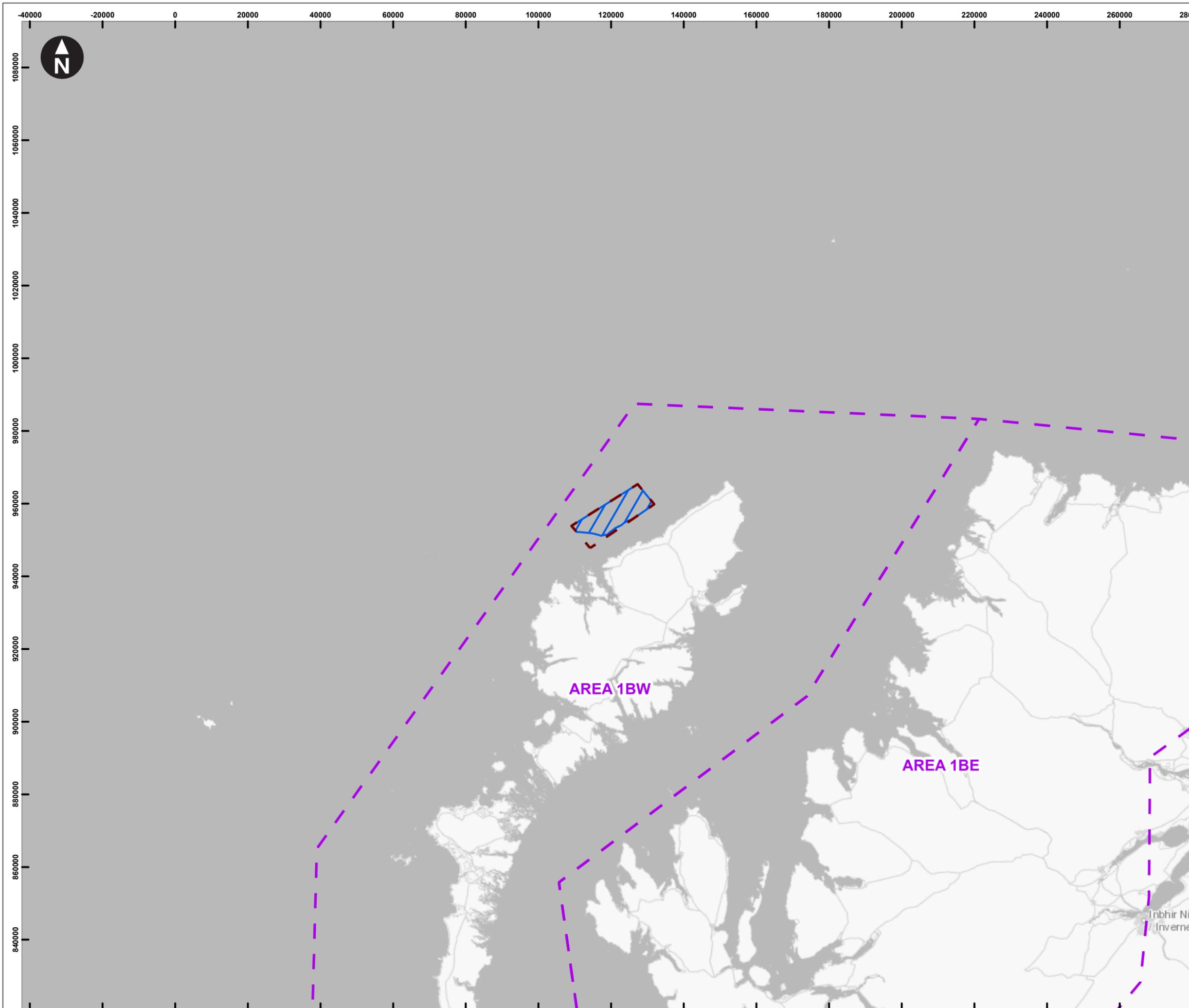
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Spiorad na Mara Offshore Wind farm

Plate 3 5
Low Flying Areas

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Plate 3-6 Night-Time Low Flying Areas



Key

-  Array Area
-  Turbine Area
-  Night-Time Low Flying Areas

The inset map shows a larger area with a north arrow and a scale bar from 0 to 40 Kilometres. It provides a regional context for the main map's location.

Scale at A3:1:1,000,000
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The logos for WSP (Wind Systems Planning) and Spiorad na Mara are displayed side-by-side.

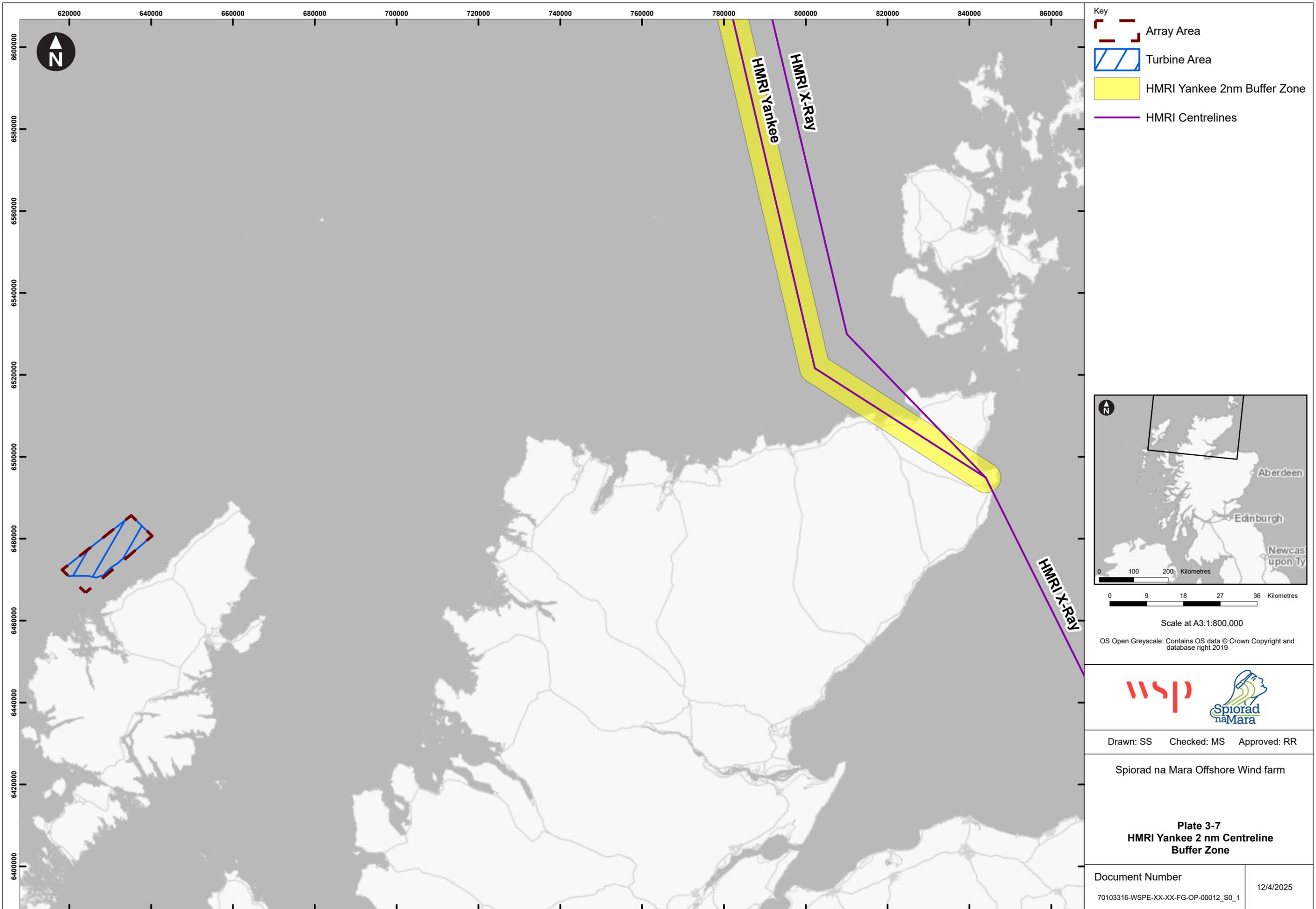
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Spiorad na Mara Offshore Wind farm

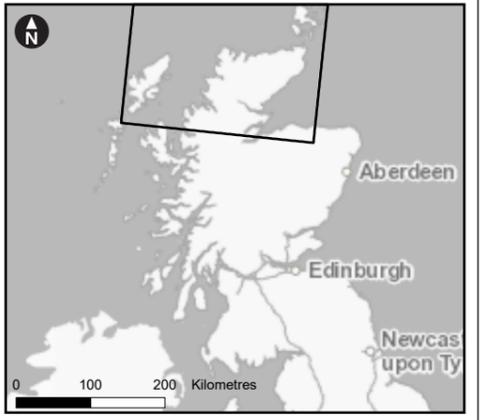
**Plate 3-6
 Night-Time Low Flying Areas**

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Plate 3-7 HMRI Yankee 2 nm Centreline Buffer Zone



- Key
- Array Area
 - Turbine Area
 - HMRI Yankee 2nm Buffer Zone
 - HMRI Centrelines



Scale at A3:1:800,000
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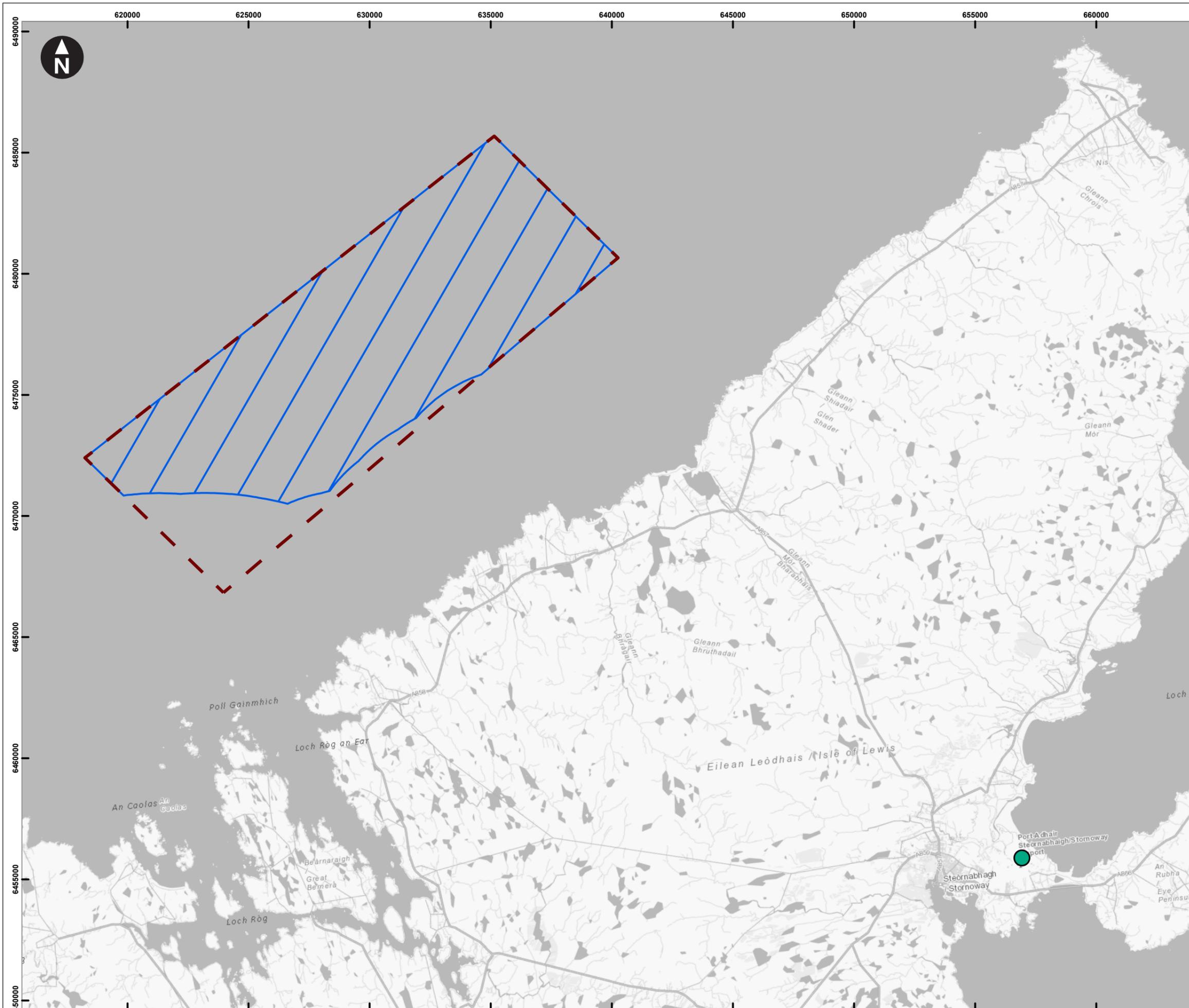
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Spiorad na Mara Offshore Wind farm

Plate 3-7
HMRI Yankee 2 nm Centreline
Buffer Zone

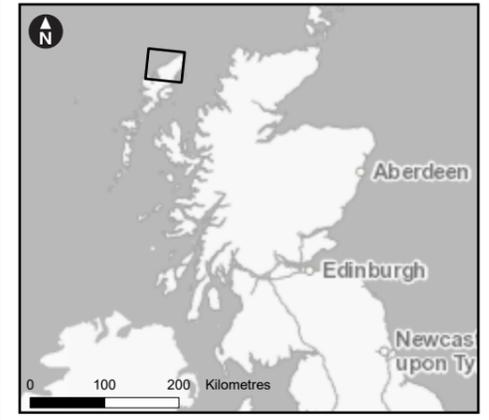
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Plate 3-8 Search and Rescue base near the Offshore Project



Key

-  Array Area
-  Turbine Area
-  Stornoway Airport SAR Base



0 1.5 3 4.5 6 Kilometres

Scale at A3:1:150,000

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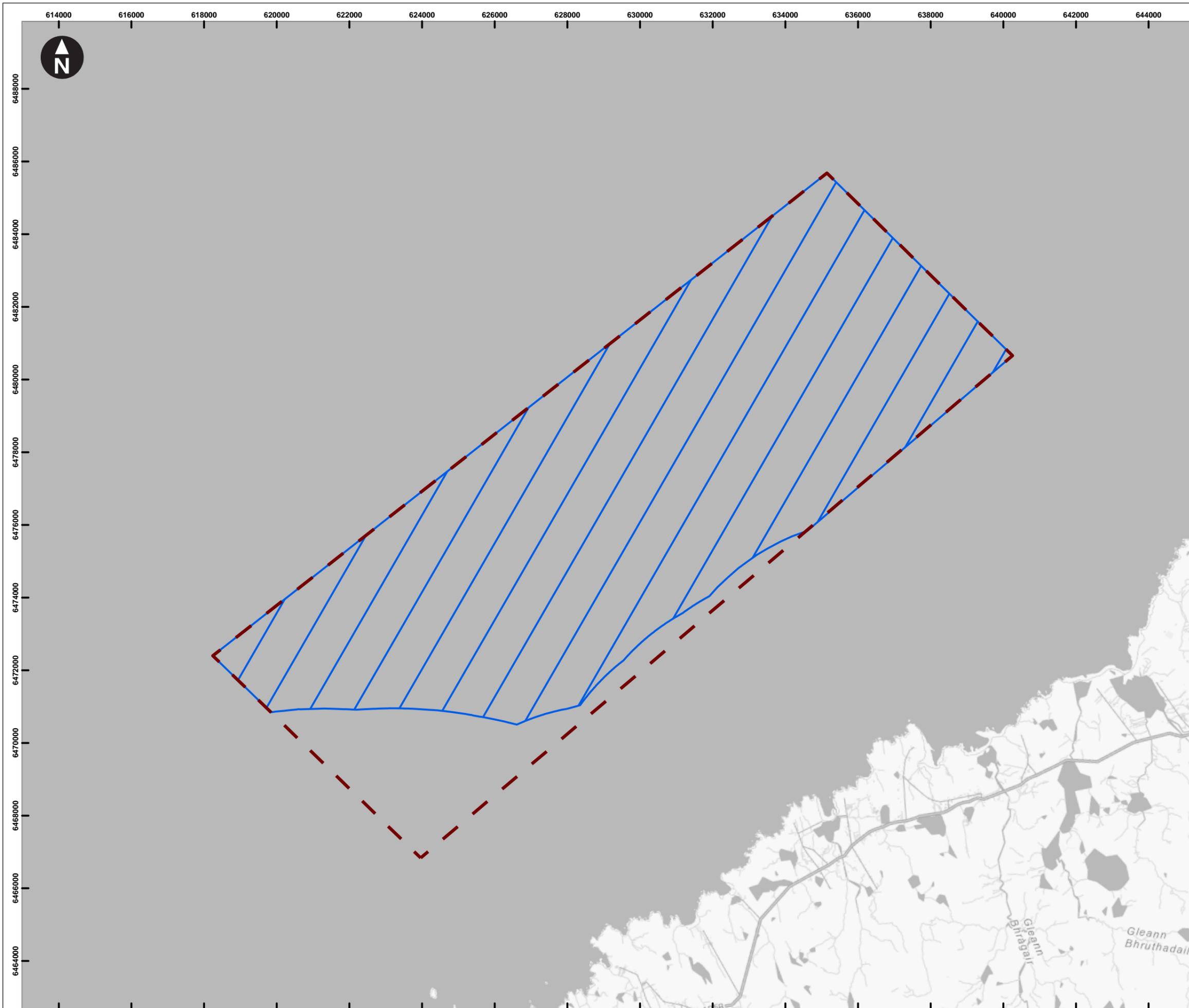
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Spiorad na Mara Offshore Wind farm

Plate 3-8
Search and Rescue base near the
Offshore Project

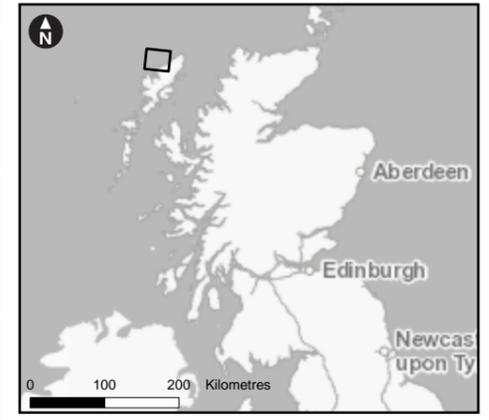
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Plate 4-1 Indicative Layout for largest WTG type (no. 44 WTG)



Key

-  Array Area
-  Turbine Area



0 1 2 3 4 Kilometres

Scale at A3:1:100,000

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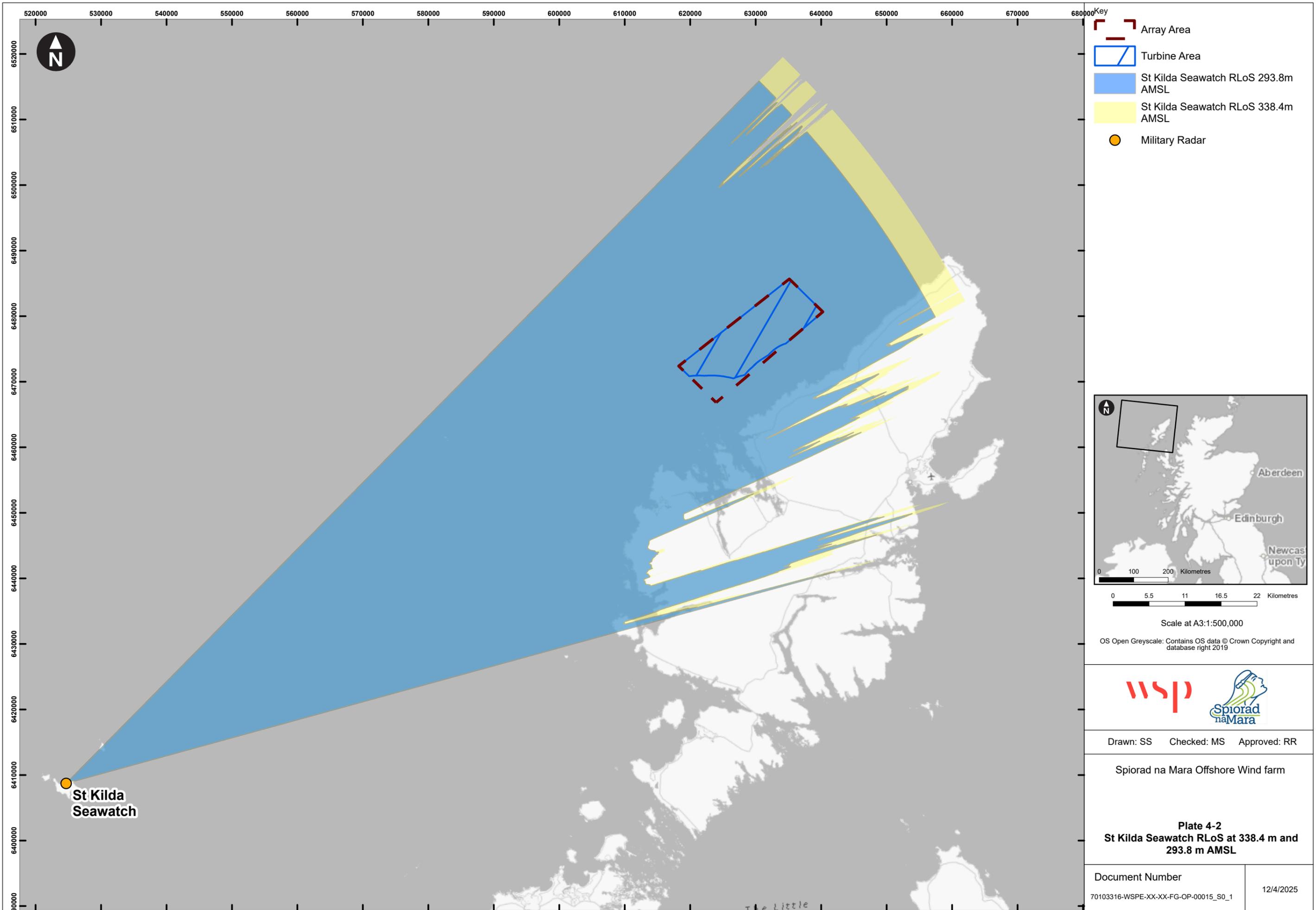
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Spiorad na Mara Offshore Wind farm

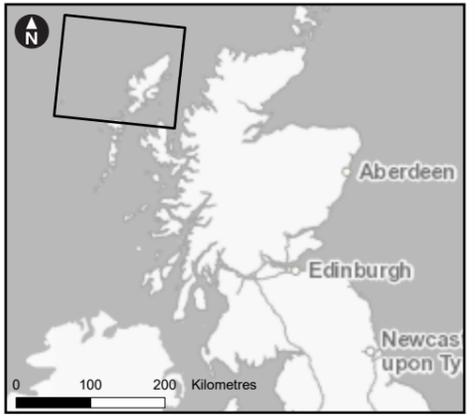
Plate 4 1
Indicative layout for largest WTG
type (no. 44 WTG)

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Plate 4-2 St Kilda Seawatch RLoS at 338.4 m and 293.8 m AMSL



- Key**
-  Array Area
 -  Turbine Area
 -  St Kilda Seawatch RLoS 293.8m AMSL
 -  St Kilda Seawatch RLoS 338.4m AMSL
 -  Military Radar



Scale at A3:1:500,000
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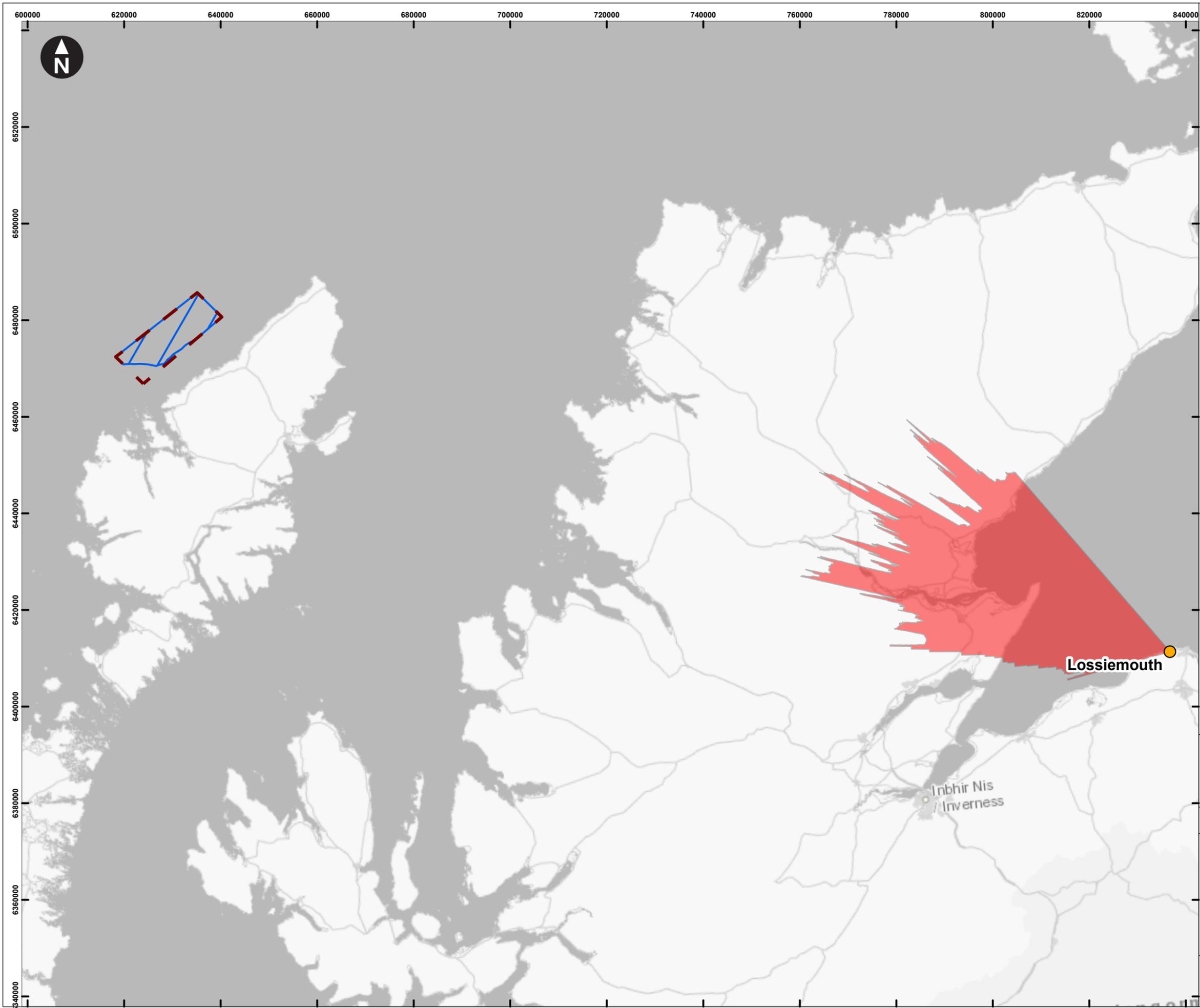
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Spiorad na Mara Offshore Wind farm

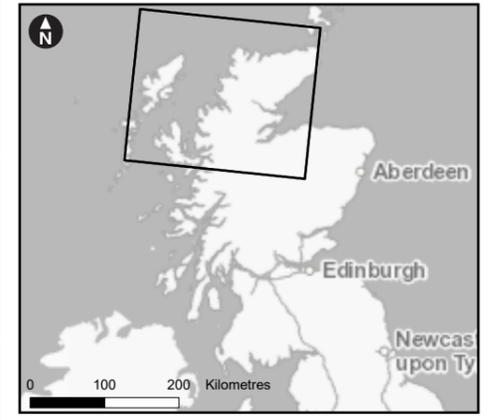
Plate 4-2
St Kilda Seawatch RLoS at 338.4 m and 293.8 m AMSL

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Plate 4-3 Lossiemouth RLoS at 338.4 m AMSL



- Key
-  Array Area
 -  Turbine Area
 -  Lossiemouth RLoS at 338.4m AMSL
 -  Military Airfield Radar



0 8.5 17 25.5 34 Kilometres

Scale at A3:1:750,000

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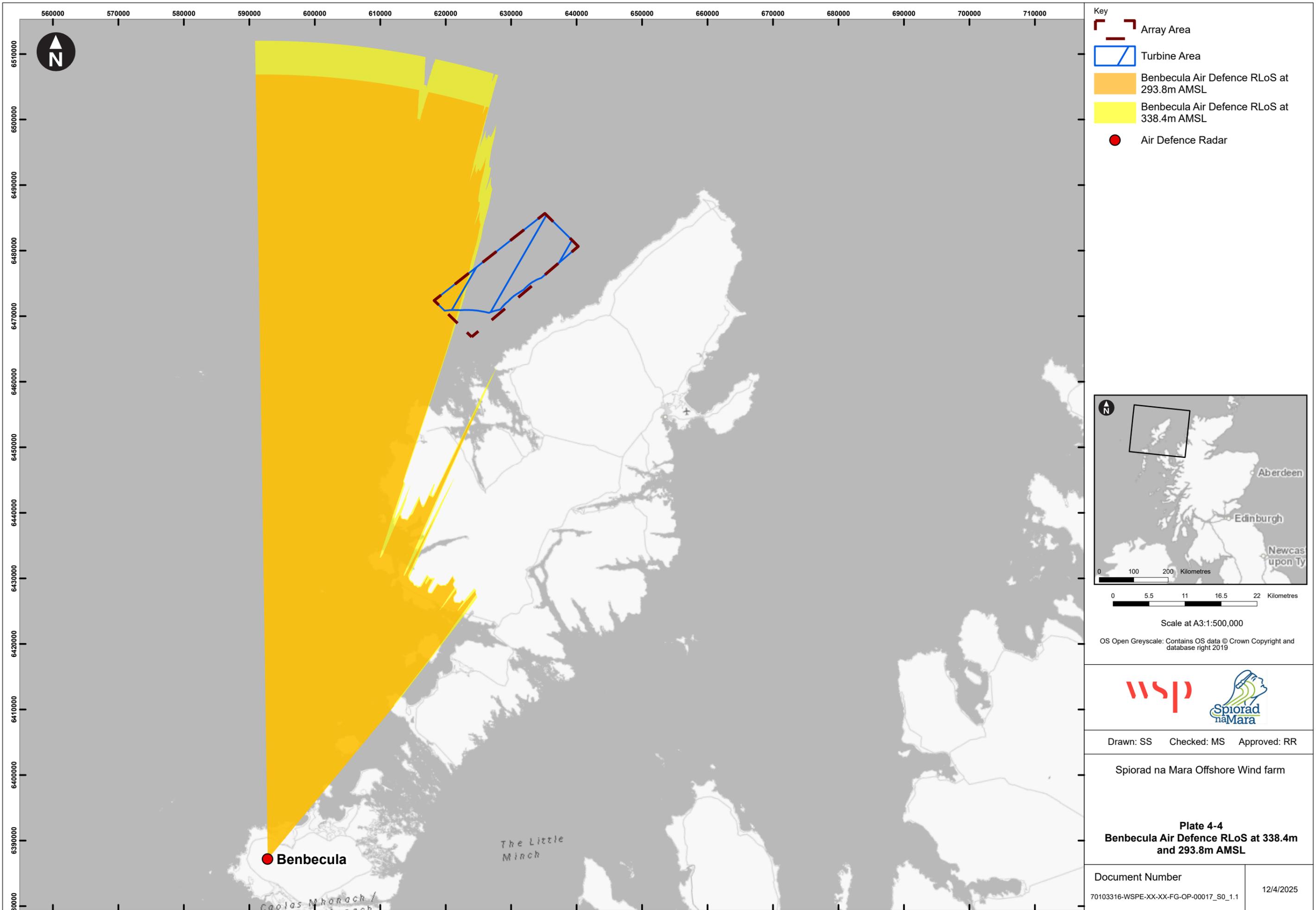
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Spiorad na Mara Offshore Wind farm

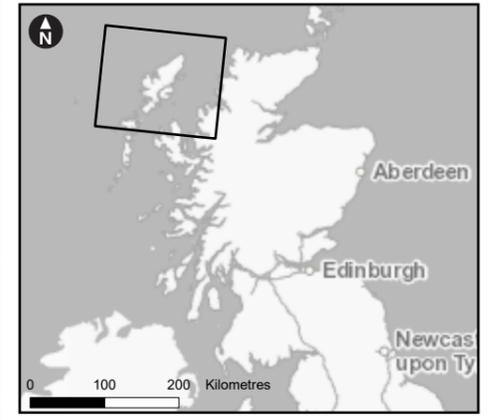
Plate 4-3
Lossiemouth RLoS at 338.4m AMSL

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Plate 4-4 Benbecula Air Defence RLoS at 338.4 m and 293.8 m AMSL



- Key
-  Array Area
 -  Turbine Area
 -  Benbecula Air Defence RLoS at 293.8m AMSL
 -  Benbecula Air Defence RLoS at 338.4m AMSL
 -  Air Defence Radar



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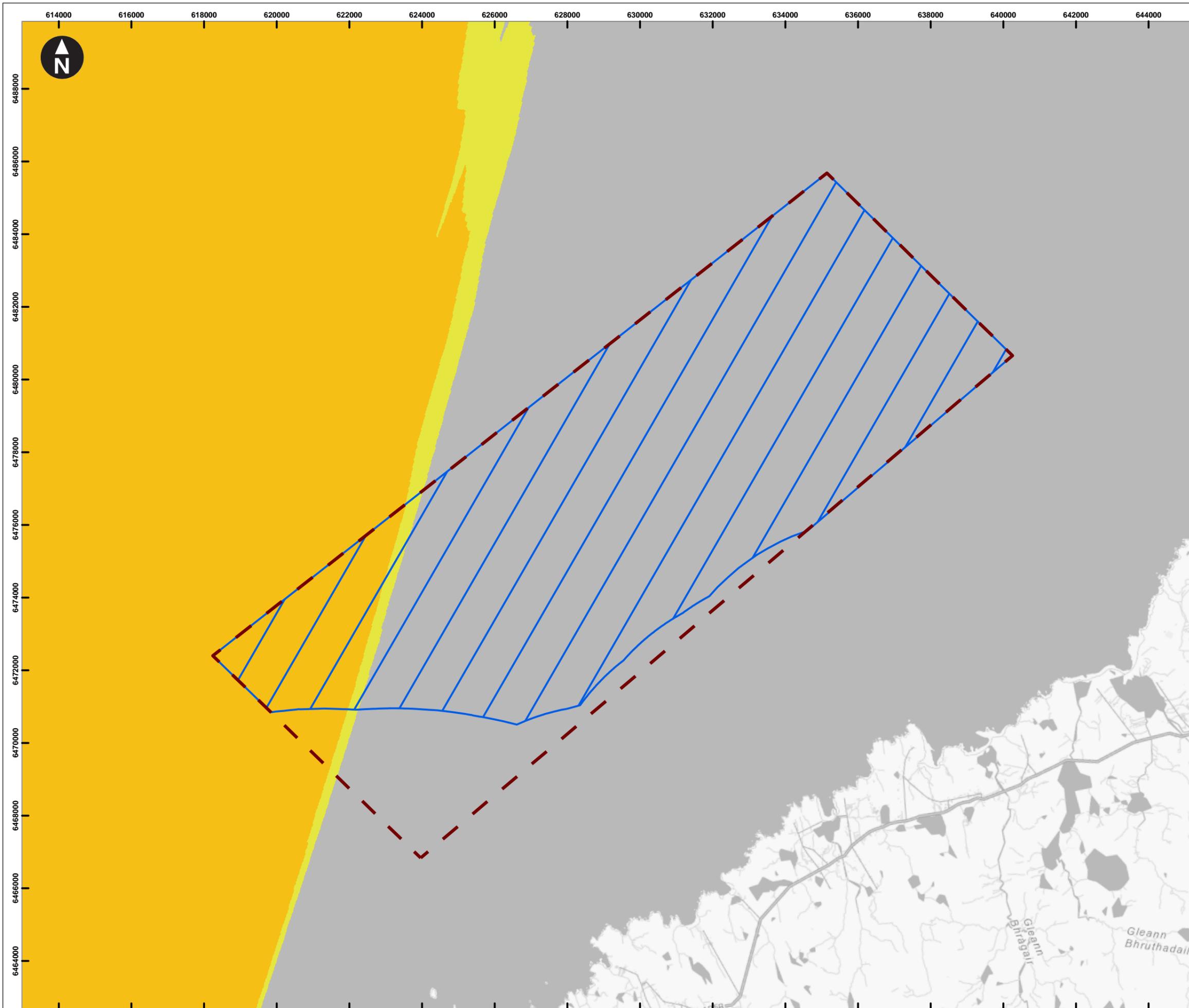
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Spiorad na Mara Offshore Wind farm

Plate 4-4
Benbecula Air Defence RLoS at 338.4m and 293.8m AMSL

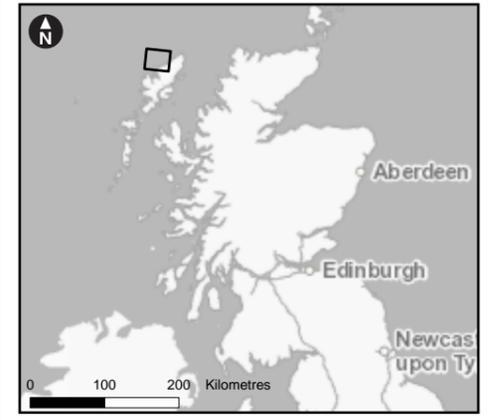
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Plate 4-5 Benbecula Air Defence RLoS at 338.4 m and 293.8 m AMSL – Zoomed



Key

-  Array Area
-  Turbine Area
-  Benbecula Air Defence RLoS at 293.8m AMSL
-  Benbecula Air Defence RLoS at 338.4m AMSL



Scale at A3:1:100,000
 OS Open Greyscale: Contains OS data © Crown Copyright and database right 2019



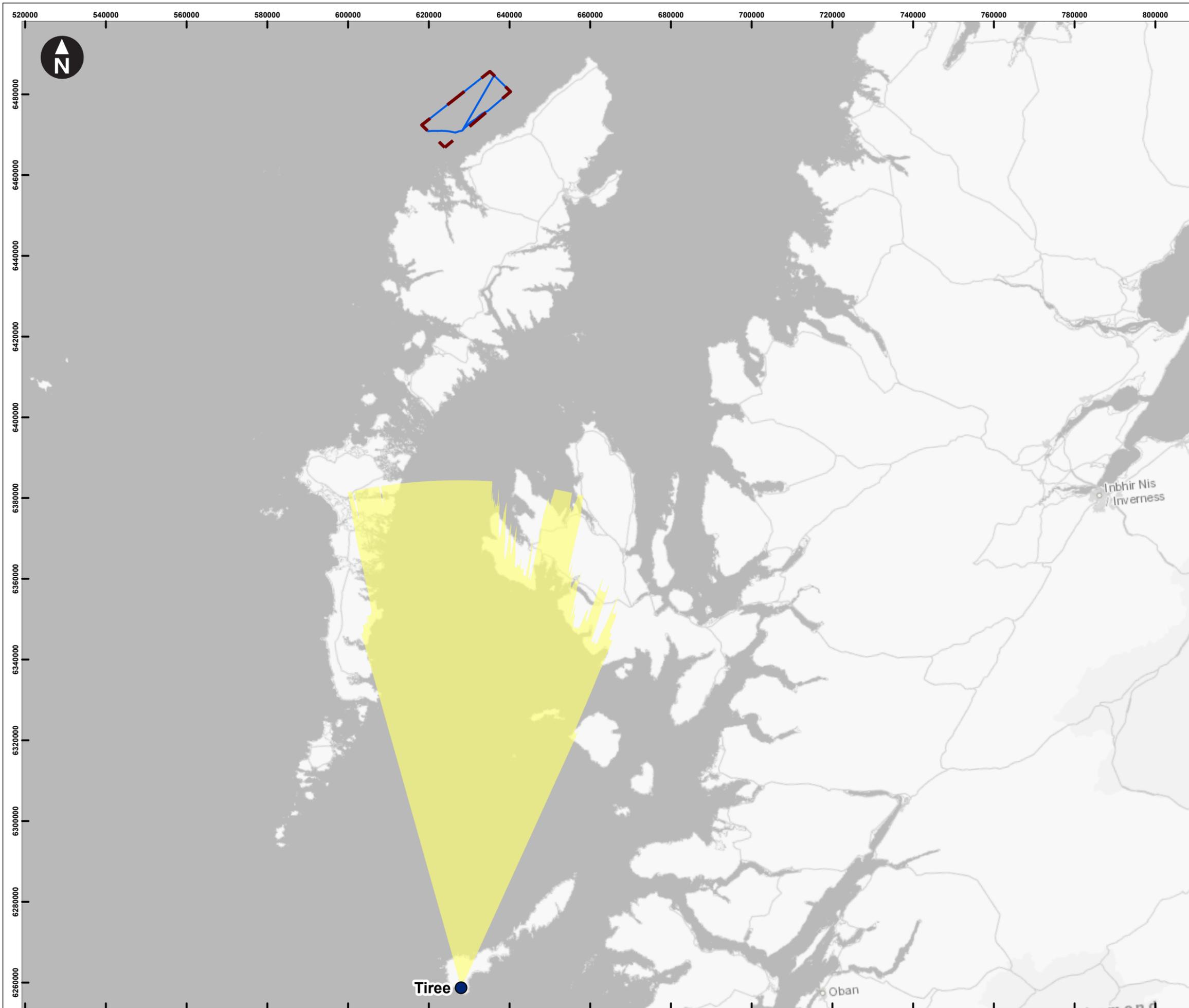
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Spiorad na Mara Offshore Wind farm

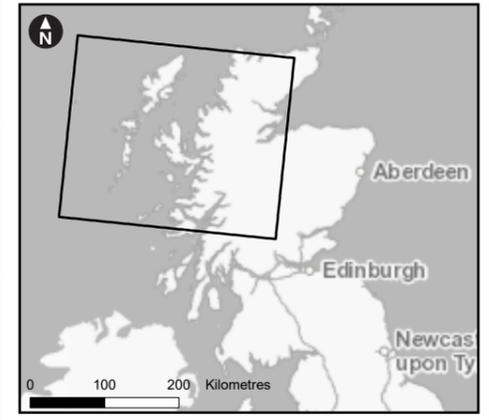
Plate 4 5
Benbecula Air Defence RLoS at 338.4m and 293.8m AMSL – Zoomed

Document Number	2/20/2026
70103316-WSPE-XX-XX-FG-OP-00018_S0_1	

Plate 4-6 Tiree RLoS at 338.4 m AMSL



- Key
-  Array Area
 -  Turbine Area
 -  Tiree RLoS 338.4m AMSL
 -  NATS En Route Radar



0 10 20 30 40 Kilometres

Scale at A3:1:900,000
 OS Open Greyscale: Contains OS data © Crown Copyright and database right 2019



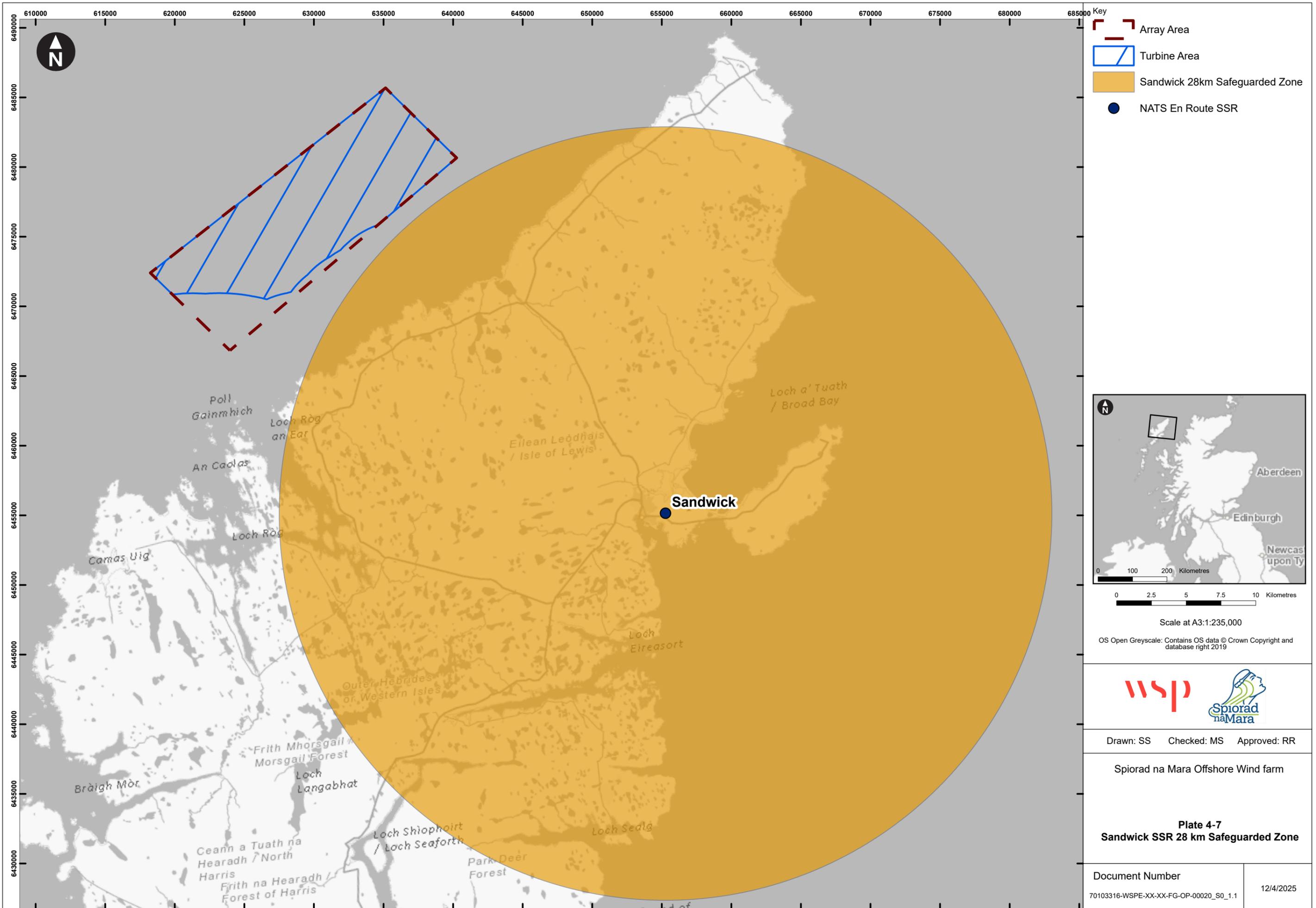
Drawn: SS Checked: MS Approved: RR

Spiorad na Mara Offshore Wind farm

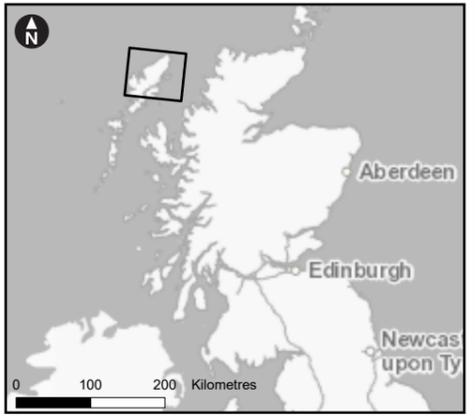
Plate 4-6
Tiree RLoS at 338.4m AMSL

Document Number	12/4/2025
70103316-WSPE-XX-XX-FG-OP-00019_S0_1.1	

Plate 4-7 Sandwich SSR 28 km Safeguarded Zone



- Key
-  Array Area
 -  Turbine Area
 -  Sandwich 28km Safeguarded Zone
 -  NATS En Route SSR



0 2.5 5 7.5 10 Kilometres

Scale at A3:1:235,000

OS Open Greyscale: Contains OS data © Crown Copyright and database right 2019

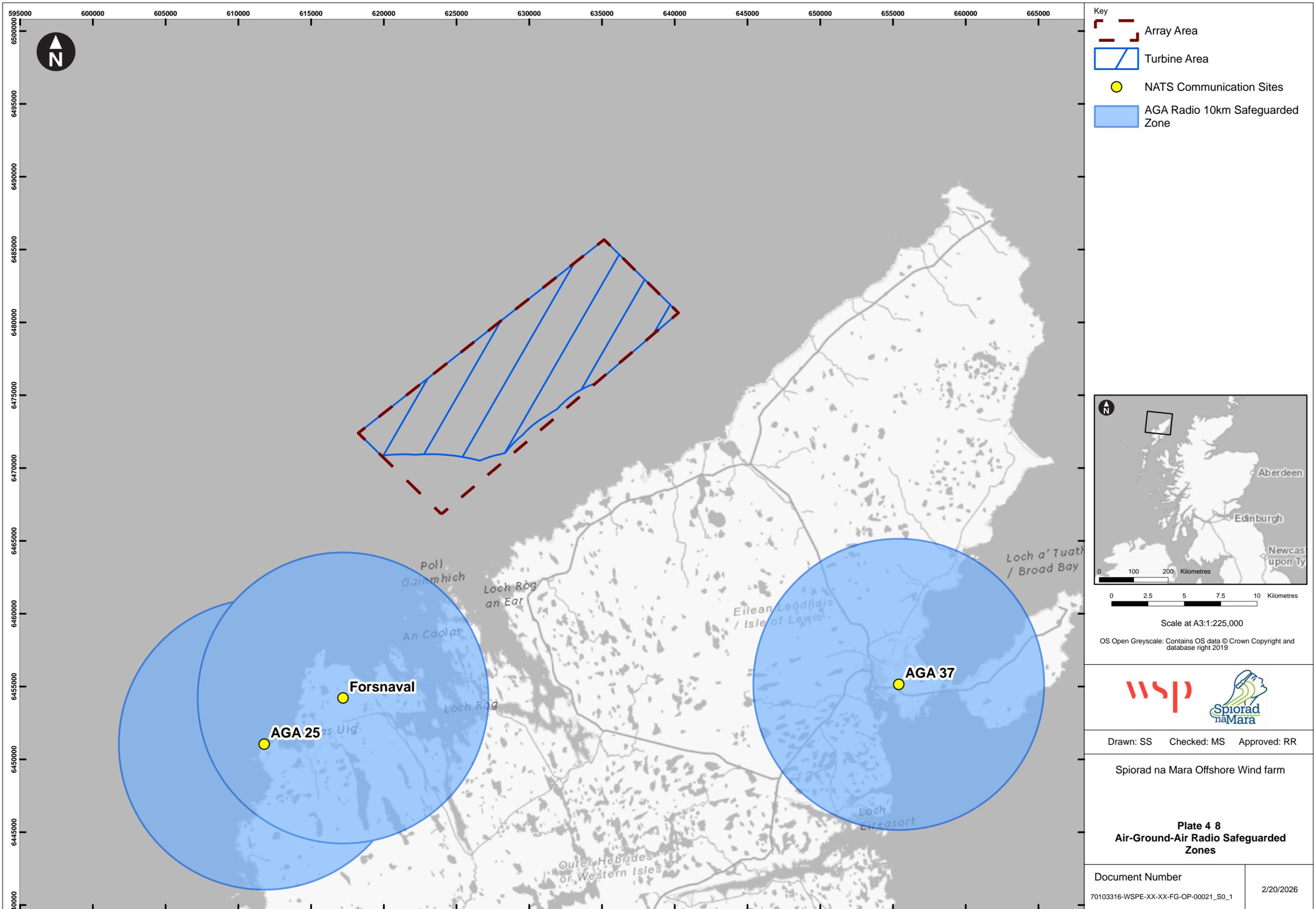


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Spiorad na Mara Offshore Wind farm

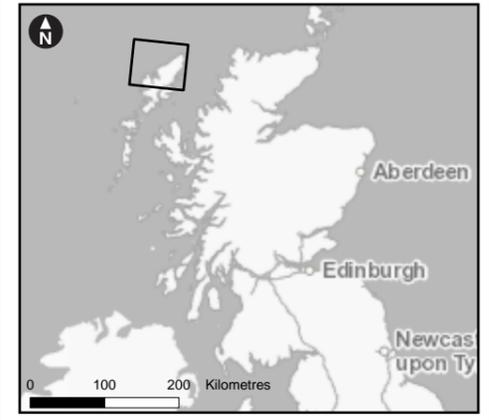
Plate 4-7
Sandwich SSR 28 km Safeguarded Zone

Plate 4-8 Air-Ground-Air Radio Safeguarded Zones



Key

-  Array Area
-  Turbine Area
-  NATS Communication Sites
-  AGA Radio 10km Safeguarded Zone



Scale at A3:1:225,000
 OS Open Greyscale: Contains OS data © Crown Copyright and database right 2019



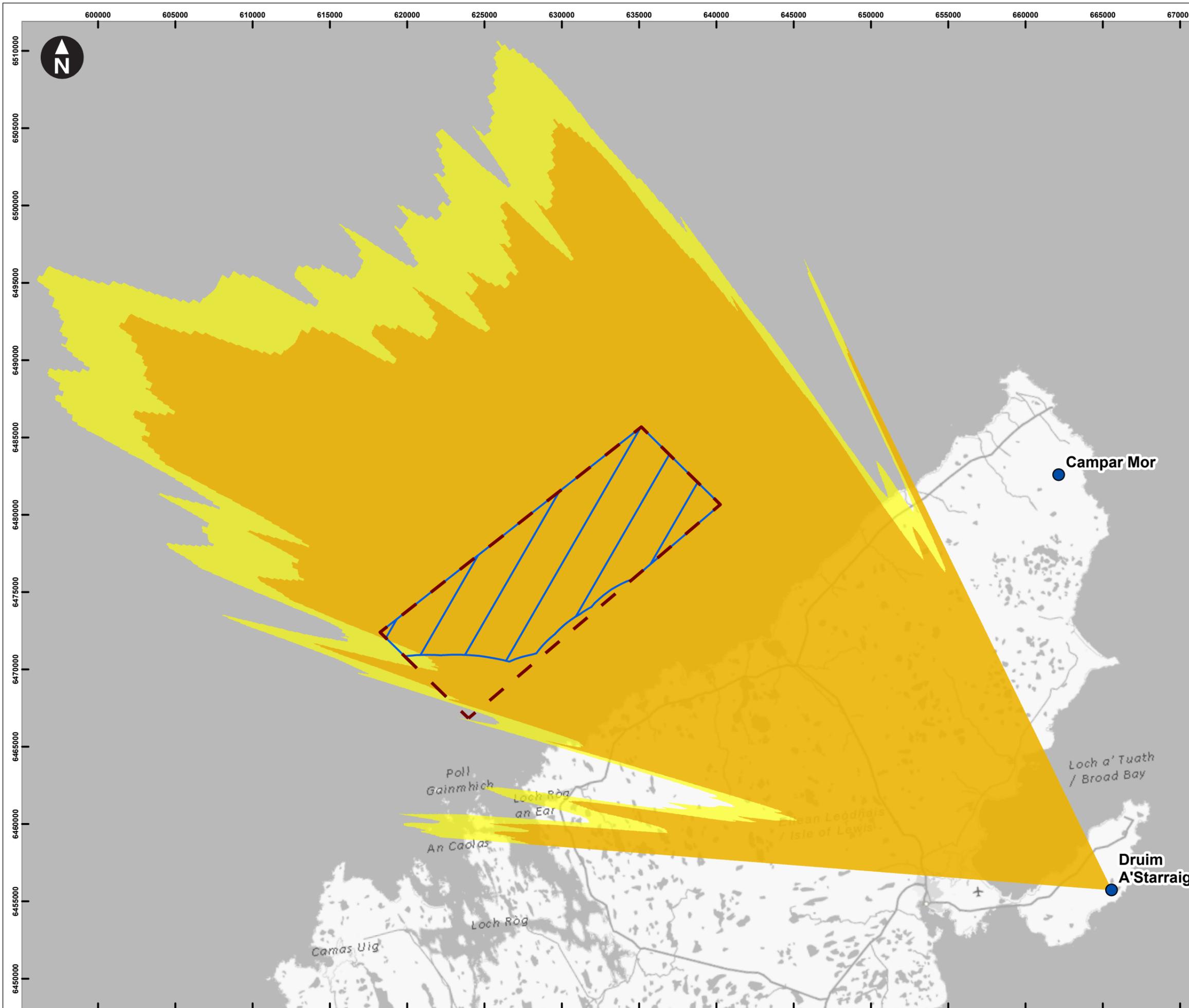
Drawn: SS Checked: MS Approved: RR

Spiorad na Mara Offshore Wind farm

Plate 4 8
Air-Ground-Air Radio Safeguarded Zones

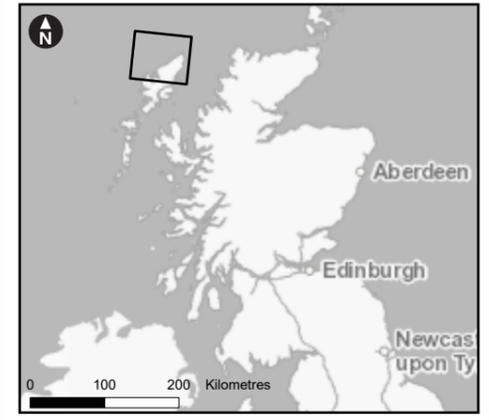
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70103316-WSPE-XX-XX-FG-OP-00021_S0_1	

Plate 4-9 Druim A'Starraig RLoS at 338.4 m and 293.8 m AMSL



Key

- Array Area
- Turbine Area
- Druim A'Starraig RLoS 293.8m AMSL
- Druim A'Starraig RLoS 338.4m AMSL
- Weather Radar



Scale at A3:1:235,000
 OS Open Greyscale: Contains OS data © Crown Copyright and database right 2019

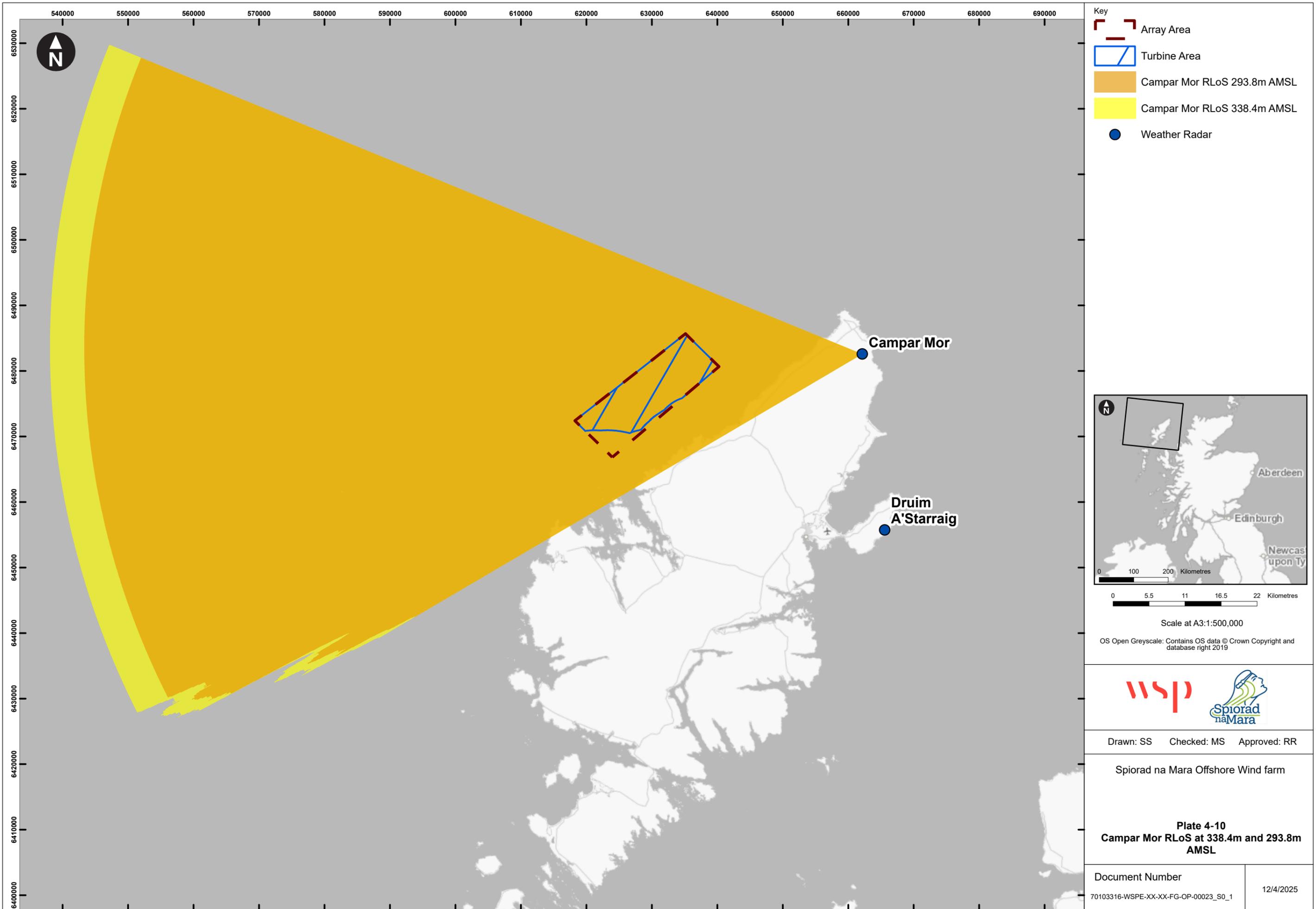
Drawn: SS Checked: MS Approved: RR

Spiorad na Mara Offshore Wind farm

Plate 4-9
Druim A'Starraig RLoS at 338.4m and 293.8m AMSL

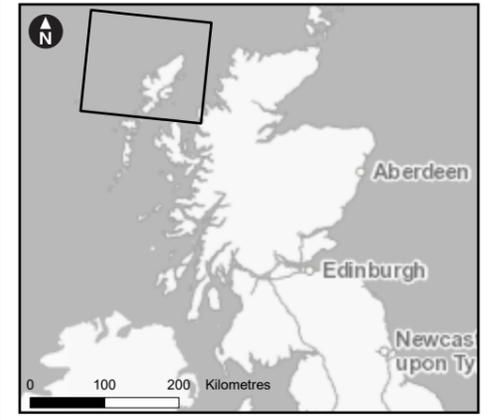
Document Number	12/4/2025
70103316-WSPE-XX-XX-FG-OP-00022_S0_1.1	

Plate 4-10 Campar Mor RLoS at 338.4 m and 293.8 m AMSL



Key

-  Array Area
-  Turbine Area
-  Campar Mor RLoS 293.8m AMSL
-  Campar Mor RLoS 338.4m AMSL
-  Weather Radar



0 100 200 Kilometres

0 5.5 11 16.5 22 Kilometres

Scale at A3:1:500,000

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Drawn: SS Checked: MS Approved: RR

Spiorad na Mara Offshore Wind farm

Plate 4-10
Campar Mor RLoS at 338.4m and 293.8m AMSL

Document Number	12/4/2025
70103316-WSPE-XX-XX-FG-OP-00023_S0_1	

Plate 4-11 Closest Distance Between Weather Radars and the Turbine Area

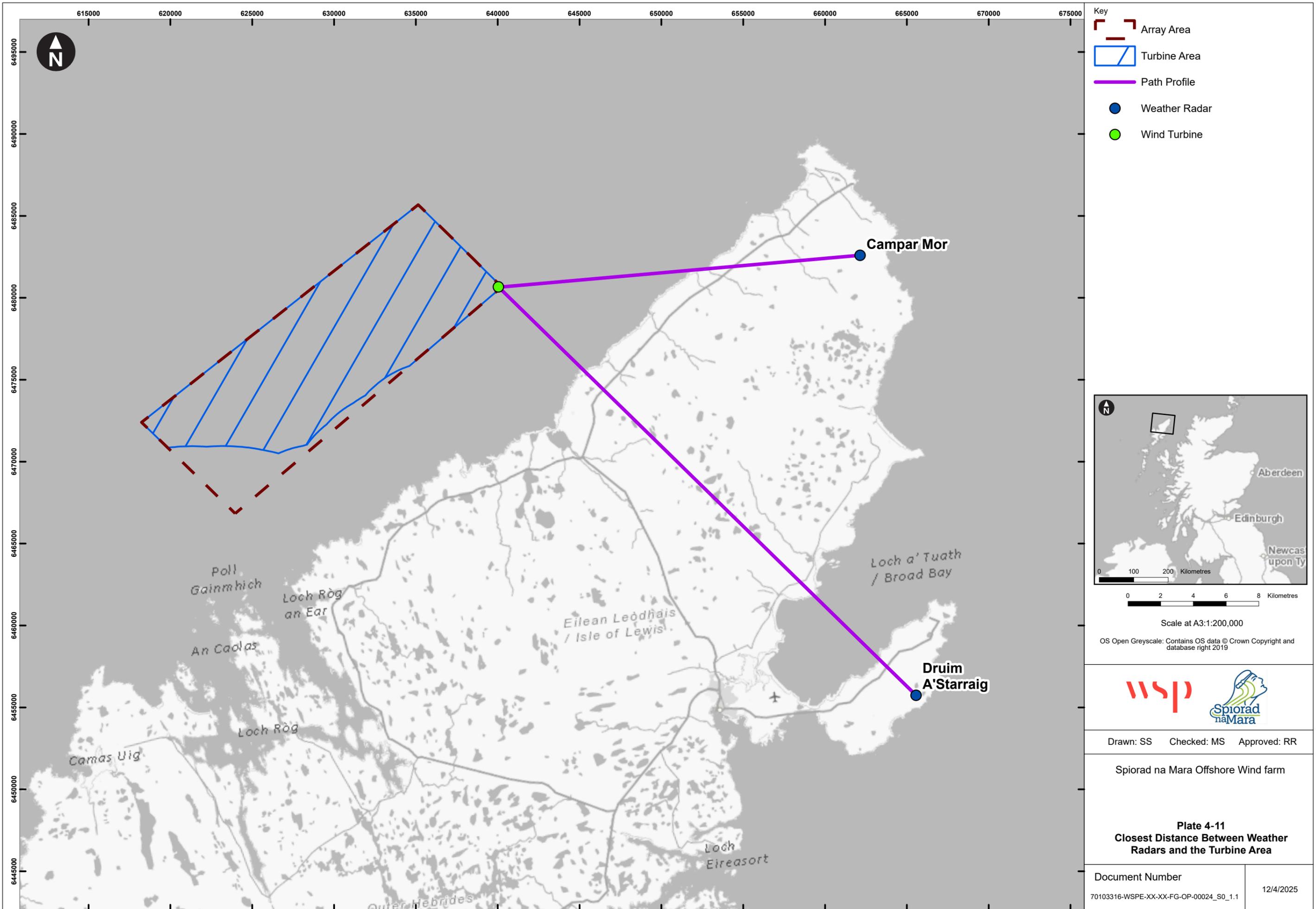


Plate 4-12 Druim A'Starraig to WTG Path Profile

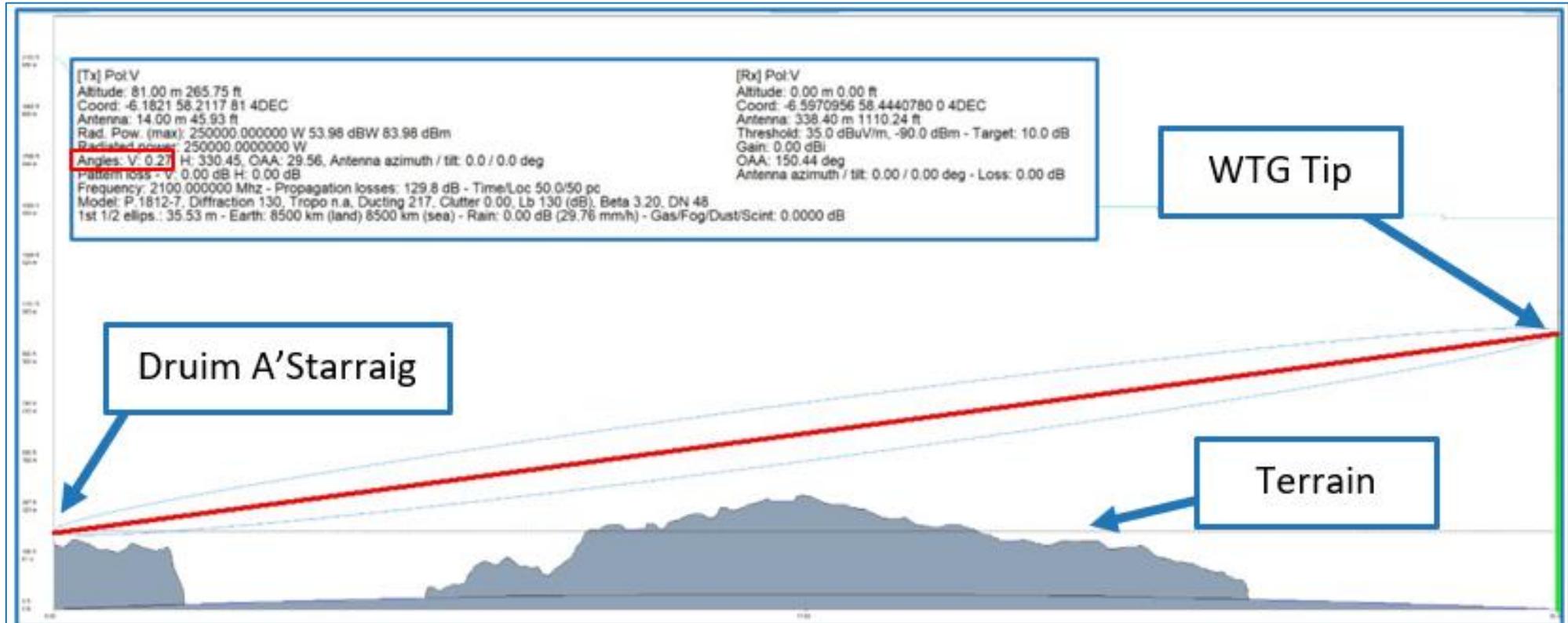


Plate 4-13 Campar Mor to WTG Path Profile

