White Cross Offshore Windfarm, Braunton, Devon

Gradiometer and Electromagnetic Survey Report

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Summary

A detailed gradiometer and electromagnetic survey was conducted over a linear scheme of land at White Cross Offshore Windfarm, Braunton, Devon (Northern Extent NGR: 245655 137581; Southern Extent NGR: 247718 131495). The project was commissioned by Royal Haskoning DHV, on behalf of Offshore Wind Ltd (OWL), a joint venture between Cobra Instalaciones Servicios, S. A., and Flotation Energy Ltd, with the aim of establishing the presence, or otherwise, and nature of detectable archaeological features in support of the onshore cable route of White Cross Offshore Wind Farm.

The site is located along a linear route, of which the centre is 2 km west of the village of Braunton and 9.3 km north-west of Barnstaple, in the county of Devon, covering a total area of 183 ha. The geophysical survey was undertaken between 26 September 2022 and 23 March 2023.

The survey has not identified any anomalies that can confidently be interpreted as archaeology. There are however several areas of possible archaeological activity.

Possible evidence of Second World War military activity can be seen across the north of the site and the dunes. In the north of the site there are several anomalies that appear to relate to former barrack blocks, with associated infrastructure, as shown on aerial photography from 1946. There is potential evidence of training activity within the dunes, with several areas of strong metallic responses identified. However, the majority of the anomalies only occur near the surface and may therefore be attributed to reinforcement used to inhibit anthropogenic erosion along pathways through the dunes.

Further possible archaeological activity is noted to the south, both immediately north and south of the Taw Estuary, which bisects the southern portion of the site. The possible archaeological features north of the estuary may be attributable to extraction activity. However, further information is not available, and these anomalies may be the by-product of military activity, modern agricultural practices, or variation in the geomorphology of the site.

The possible archaeological activity south of the estuary may be associated with archaeological ditch features, such as land or animal management boundaries. However, the majority of these features lie on an east – west orientation and may pertain to water management of the site, such as drainage ditches.

Extensive geomorphological activity is evident across a large percentage of the site. This is characterised by variation in the magnetic data along paleochannels, drainage basins, and marshland. The entirety of the site is situated within the UNESCO North Devon Biosphere Reserve and forms the edge of one of the largest dune systems in the British Isles which has resulted in these magnetic features being prevalent. There are areas within this that appear to have a more man-made form and may relate to former boundary features, but they are interpreted with a low level of confidence.

Areas of increased magnetic response are noted across the site. These are attributed to landscaping practices, either correlating with the golf course, trackways, or modern agricultural practices.

The remaining anomalies are thought to be modern. These include land drains, former field boundaries, modern trackways, and modern services.

Acknowledgements

Wessex Archaeology would like to thank Royal Haskoning DHV for commissioning the geophysical survey. The assistance of Conor Barron and George Stewart-Phillips is gratefully acknowledged in this regard.

The fieldwork was undertaken by Jake Bishop, Callum Jervis, Jo Instone-Brewer, and Ffion Lister. Brett Howard processed, interpreted the geophysical data, and prepared the illustrations. Brett Howard wrote the report. The geophysical work was quality controlled by Rok Plesnicar and managed on behalf of Wessex Archaeology by Tom Richardson.

White Cross Offshore Windfarm, Braunton, Devon

Gradiometer and Electromagnetic Survey Report

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by Royal Haskoning DHV, on behalf of Offshore Wind Ltd (OWL), a joint venture between Cobra Instalaciones Servicios, S. A., and Flotation Energy Ltd, to carry out a geophysical survey west of Braunton, Devon (southern extent NGR: 247718 131495; northern extent NGR: 245655 137581) (**Figure 1**). The survey forms part of an ongoing programme of archaeological works being undertaken in support of the onshore cable route for White Cross offshore windfarm.

1.2 Scope of document

1.2.1 This report presents a brief description of the methodology followed by the detailed survey results and the archaeological interpretation of the geophysical data.

1.3 The site

1.3.1 The site is located along a linear route, of which the centre is 2 km west of the village of Braunton and 9.3 km north-west of Barnstaple, in the county of Devon.

1.3.2 The survey comprises 183 ha of agricultural land currently utilised for pasture and crops, sand dunes, and a golf course. The site is bounded by Saunton Golf Club facilities to the north; Burrows Close Lane, Sandy Lane, east Yelland and further fields to the west, the Taw estuary to the south, and American road, Saunton Golf Club and the Taw estuary to the west.

1.3.3 The site is on a slight incline sloping towards the south and west from 20 m above Ordnance Datum (aOD) at the northern edge to 4 m aOD at the southern edge.

1.3.4 The solid geology of the northern and central extent of the site comprises Mudstone of the Pilton Mudstone Formation. The southern extent of the site comprises Mudstone and Siltstone of the Ashton Mudstone Member and Crackington, a further band of Mudstone of the Doddiscombe Formation and Codden Hill Chert Formation runs between the northern/central and southern extent of the site. Superficial deposits are mainly composed of clay, silt, and sand from tidal flat deposits across most of the survey area, except for small zones of blown sand on the westernmost edges, and clay, silt, sand, and gravel alluvial deposits in the southern fields (BGS 2022).

1.3.5 The soils underlying the north of the site are likely to consist of sand-pararendzinas of the 361 (Sandwich) association and brown earths of the 541w (Newnham) association. The central section of the site is likely to consist of humic-sandy gley soils of the 861a (Isleham 1) association. The soils underlying the south of the site are likely to consist of pelo-stagnogley soils of the 712e (Hallsworth 2) association (SSEW SE Sheet 5 1983). Soils derived from such geological parent material have been shown to produce magnetic contrasts acceptable for the detection of archaeological remains through magnetometer and electromagnetic survey.

2 ARCHAEOLOGICAL BACKGROUND

2.1 Introduction

2.1.1 An archaeological background was prepared in the Written Scheme of Investigation (WSI) by Royal Haskoning DHV (2022) for the White Cross Windfarm's onshore elements. This examined the potential for the survival of buried archaeological remains within the onshore development area, and a 1 km study area. The following background is not exhaustive but is summarised from aspects of the WSI and publicly available online resources including Devon and Dartmoor Historic Environment Record (HER), which are considered relevant to the interpretation of the geophysical survey data.

2.2 Summary of the archaeological resource

2.2.1 There are no designated heritage assets within the geophysical site boundary. However, there is 1 scheduled monument, 1 scheduled park and garden, 1 Grade I, 1 Grade II* listed building, and 37 Grade II listed buildings within the wider landscape study area.

Designated Assets

2.2.2 The scheduled monument of lynchets 34 m north-west of Saunton Sands Hotel (NHLE: 1424711) is situated 300 m north of the site. They are believed to be of medieval origin and are an example of well-preserved lynchets free from later agricultural damage.

2.2.3 The Grade I listed Church of St John the Baptist (NHLE1107600) is located 785 m to the south of the site. In its immediate surrounds are 11 Grade II listed entries for grave and headstones (NHLE: 1107601 – 3, NHLE: 1163562, NHLE: 1163583, NHLE: 1318173, NHLE: 1318187, NHLE: 1318191, NHLE: 1325307 – 8 & NHLE: 1325345), a lychgate (NHLE: 1163595), and a Sunday school room and storage shed (NHLE: 1325310).

2.2.4 The Grade II* listed Saunton Court (NHLE: 1107095) is a 15th century manor house 450 m to the north of the site. The early 20th century formal terraced garden attached to it is a Grade II listed park and garden (NHLE: 1000700). Just to the south of Saunton Court is The Chapel of St Anne with Lych Gate (NHLE: 1444584), a post-medieval Grade II listed building.

2.2.5 In a hamlet located 450 m to the north of the northern extent of the site is a collection of eight Grade II post-medieval agricultural buildings including farmhouses (NHLE: 1325554 & NHLE: 1107096), a cottage (NHLE: 1161840), houses and attached barn (NHLE: 1107111), barns (NHLE: 1325555 & NHLE: 1161245), general farm buildings (NHLE: 1107110), and a shippon (NHLE: 1107109).

2.2.6 Other Grade II post-medieval buildings in the wider study area consist of several in and around Instow Town located 750 m to the south of the southern extent of the site. These include a war memorial (NHLE: 1449685), windmill (NHLE: 1107604), Knill Cottage (NHLE: 1163463), and a former rectory (NHLE: 1163640). A cider mill (NHLE: 1325289) is located 770 m to the south-east of the southern extent of the site.

2.2.7 To the east of the central extents of the site are five Grade II post-medieval cattle shelters or linhays (NHLE: 1107116, NHLE: 1107119, NHLE: 1107117, NHLE: 1107118 & NHLE: 1310131) located 900 m, 890 m, 520 m, 310 m, and 175 m from the site boundary respectively. These are located on Braunton Marsh which was originally reclaimed in the medieval period and then more intensively drained after 1811 when 949 acres were drained.

2.2.8 There are three Grade II listed buildings related to water management in the wider area to the east of the southern area of the site (on the northern bank of the River Taw) including the Great Sluice (NHLE: 1310114) located 540 m to the east, and two stile and flanking walls (NHLE: 1310081 & NHLE: 1107120) 190 m and 405 m to the east respectively.

2.2.9 In the southern area of the site (on the northern bank of the River Taw) located 300 m to the east of the site boundary are eight WWII concrete replica landing craft structures (NHLE: 1463671). A cricket pavilion, scorebox, and a former pillbox (NHLE: 1163454) are located 430 m to the south-west of the southern extent of the site.

Non-Designated Assets

Mesolithic

2.2.10 A scatter of Mesolithic flint flakes was found 250 m west of the centre of the site, at Braunton Burrows (MDV12393). These comprised flint flakes, suggestive of encampment or other human activity in the area.

Bronze Age

2.2.11 A barbed and tanged Bronze Age arrowhead was found in the 1950s 1 km to the north of the northern extent of the site.

Medieval

2.2.12 A large area of early medieval open field agriculture on Braunton Marsh is located 280 m east of the northern sector of survey area (MDV199). The latter survives as one of three open field systems still operating in England (Harris 1985).

Post-medieval

2.2.13 The abandoned North Devon railway line (MDV18646), dating to 1855, crosses the southern zone of the survey area.

2.2.14 Within the survey area are located a post-medieval post alignment (MDV74019), a post-medieval stone building (MDV57286), an 18th century building (MDV131395), and a 19th century house (MDV77679).

2.2.15 Within the wider area are located various post-medieval features, the majority being associated with the surrounding villages, old quarries and sand pits and agricultural land of Braunton Marsh.

Modern

2.2.16 The whole survey area and its surroundings present WWII records related to the North Devon US Assault Training Centre (MDV73990). From September 1943 when the Assault Training Centre opened the North Devon Coast became an assault training centre for the US Army to prepare for the assault on northern France. Americans constructed a variety of fortifications and obstacles modelled on German coastal defences. The Assault Training Centre covered 11 separate areas from Morte Point in the north to Braunton Burrows in the south. The southern part of Braunton Burrows, near Crow Point, was used for training personnel in the loading, embarkation, and disembarkation of landing craft. Concrete replica landing craft structures were built to the north of Broad Sands Beach and 13 craft structures were built at Braunton Burrows. The training structures were abandoned, and a large number demolished in the late 20th century. Extensive crop marks associated with the North Devon US Assault Training Centre (MDV73990) have been recorded by the Historic England National Mapping Programme (NMP).

2.2.17 East Yelland Power Station, a coal-fired power station (MDV62888) is located 400 m north-east of the southern part of the survey area. It was built in the early 1950s and operative until 1974.

2.2.18 The National Record of the Historic Environment (NRHE) records 33 ‘Named Locations’ of aircraft and shipwrecks within the survey area. ‘Named locations’ do not indicate known identified remains, moreover, a general record of loss. As such, archaeological remains are not necessarily associated with these locations.

Unknown

2.2.19 An undated trackway runs north – south along the western boundary of the central area of the survey area and the eastern edge of Braunton Burrows. It crosses over the survey area further to the south and in the north. At points it runs along current rights of way, so may be an old footpath.

2.2.20 A former watercourse is in the centre of the site, depicted on the 1889 Ordnance Survey map, and an aerial photograph from 1999/2000.

2.2.21 An undated enclosure is located 1 km to the north of the northern extent of the site. It was identified from cropmarks in aerial photographs from 1973.

3 METHODOLOGY

3.1 Introduction

3.1.1 The geophysical survey was undertaken by Wessex Archaeology's in-house geophysics team between 26 September 2022 and 23 March 2023. Field conditions were variable, with vegetation and ground conditions proving to be challenging due to overgrowth, crop, or waterlogging. These conditions have meant a reduction in surveyable area of the site. An overall coverage of 86 ha was achieved with the gradiometer survey, and 15.6 ha of electromagnetic (EM) survey.

3.1.2 The methods and standards employed throughout the geophysical survey conform to that set out in the Written Scheme of Investigation (WSI) (Royal Haskoning DHV 2022), as well as to current best practice, and guidance outlined by the Chartered Institute for Archaeologists' (CIfA 2014) and European Archaeologiae Consilium (Schmidt *et al.* 2015).

3.2 Aims and objectives

3.2.1 The aims of the survey comprise the following:

- To determine, as far as is reasonably possible, the nature of the detectable archaeological resource within a specified area using appropriate methods and practices.
- Discount areas within the survey area that are found to have been subject to previous 'modern' disturbance, for example where the geophysical survey data indicate the presence of 'made' or previously heavily disturbed ground.
- To inform either the scope and nature of any further archaeological work that may be required; or the formation of a mitigation strategy (to offset the impact of the development on the archaeological resource); or a management strategy.

3.2.2 In order to achieve the above aims, the objectives of the geophysical survey are:

- To conduct a geophysical survey covering as much of the specified area as possible, allowing for on-site obstructions;
- Provide an interpretation of all recorded geophysical anomalies in order to inform the onshore project boundary refinement process, as well as the design of a programme of priority archaeological evaluation trial trenching, proposed to be undertaken pre-determination.
- Prepare a fully illustrated report on the results of the archaeological geophysical survey that is compliant with all relevant standards, guidance, and good practice

3.3 Fieldwork methodology (Gradiometer)

3.3.1 The cart-based gradiometer system used a Leica RTK GNSS instrument, which receives corrections from a network of reference stations operated by the Ordnance Survey (OS). Such instruments allow positions to be determined with a precision of 0.02 m in real-time and therefore exceeds European Archaeologiae Consilium recommendations (Schmidt *et al.* 2015).

3.3.2 The detailed gradiometer survey was undertaken using either: four Bartington Grad-01-1000L gradiometers spaced at 1 m intervals and mounted on a non-magnetic cart; or, four Sensys FGM650/3 gradiometers spaced at 1 m intervals and mounted on a non-magnetic cart. Data were collected with an effective sensitivity of 0.01 nT – 0.03 nT at a rate of 10 Hz – 100 Hz, producing intervals of 0.15 m or better along transects spaced 4 m apart.

3.4 Fieldwork methodology (EM)

3.4.1 The EM survey was conducted using a GF Instruments CMD Explorer. This is a multi-receiver EM conductivity instruments with pairs of coils (one as transmitter and the other as a receiver) at three inter-coil separations (1.48, 2.82 and 4.49 m). This provides measurements from several depths consecutively, up to approximately 6.7 m when collected in the horizontal coplanar (HCP) formation. It has measuring ranges of 1000 mS/m for the apparent conductivity and ± 80 ppt for the magnetic susceptibility.

3.4.2 The EM survey works by measuring the conductivity of different subsurface materials by transmitting electrical currents into the ground with a transmitter coil and measuring the secondary induced magnetic field with a separate tuned receiver coil. Readings are simultaneously recorded for the quadrature component (apparent conductivity) and the in-phase component (magnetic susceptibility). High conductivity values can be associated with clays and silts, whilst low conductivity values are likely to relate to deposits of sands and gravels, which have higher electrical resistance. If anomalies of both high magnetic susceptibility and high conductivity are coincident, then it is likely that the feature is metallic and therefore likely to be modern or artificial in origin.

3.4.3 The EM data was collected in transects at 5 m intervals with 2 readings taken per second throughout all survey areas using the zig-zag method. A SBAS GPS system was used in order to facilitate continuous measurement which is precise to ±0.3 m. The location of these areas was compared against survey data collected using a Leica RTK GNSS GPS instrument, which is precise to approximately 0.02 m, in order to ensure accurate correspondence between the datasets.

3.5 Data processing (Gradiometer)

3.5.1 Data from the survey were subjected to minimal correction processes. These comprise a ‘Destripe’ function (±5 nT thresholds), applied to correct for any variation between the sensors, and an interpolation used to grid the data and discard overlaps where transects have been collected too close together.

3.6 Data processing (EM)

3.6.1 The EM point data was gridded using ArcGIS in order to produce 2D depth slices of conductivity (mS/m) and magnetic susceptibility (ppt). This was undertaken for each nominal depth using the quadrature component (apparent conductivity), and in-phase component (magnetic susceptibility) data.

3.6.2 Data from the EM survey was not subject to any processes.

3.6.3 Further details of the geophysical and survey equipment, methods and processing are described in **Appendix 1, Appendix 2,** and **Appendix 3**.

4 GEOPHYSICAL SURVEY RESULTS AND INTERPRETATION

4.1 Introduction

4.1.1 The gradiometer survey has identified magnetic anomalies across the site pertaining to possible archaeology, along with former field boundaries, drainage, superficial geology, and modern disturbance. Results are presented as a series of greyscale plots and archaeological interpretations at a scale of 1:2000 (**Fig. 12** to **37**), with overview greyscale and interpretation plots at a scale of 1:10000 (**Fig. 2** to **11**). The data are displayed at -2 nT (white) to +3 nT (black) for the greyscale image.

4.1.2 The EM survey has identified anomalies of high magnetic conductivity and high magnetic susceptibility across the site, pertaining to possible archaeology and superficial geology. Results are presented as a series of colour scale plots, greyscale plots, and archaeological interpretations at a scale of 1:6000 (**Fig. 38** to **49**).

4.1.3 The interpretation of the datasets highlights the presence of potential archaeological anomalies, ferrous responses, burnt or fired objects, and magnetic trends. Full definitions of the interpretation terms used in this report are provided in **Appendix 4**.

4.1.4 Numerous ferrous anomalies are visible throughout the dataset. These are presumed to be modern in provenance and are not referred to, unless considered relevant to the archaeological interpretation.

4.1.5 It should be noted that small, weakly magnetised features may produce responses that are below the detection threshold of magnetometers. It may therefore be the case that more archaeological features may be present than have been identified through geophysical survey.

4.1.6 Gradiometer and EM survey may not detect all services present on site. This report and accompanying illustrations should not be used as the sole source for service locations and appropriate equipment (e.g., CAT and Genny) should be used to confirm the location of buried services before any trenches are opened on site.

4.2 Gradiometer survey results and interpretation

4.2.1 Multiple areas of increased magnetic response with linear or rectilinear anomalies have been identified across the northern portion of the site. A weak positive rectilinear anomaly, situated within an area of increased magnetic response, is evident towards the north of the site, at **4000** (**Fig. 13** and **15**). The rectilinear anomaly is 25 m north – south by 23 m east – west, with an anomaly width of 2 m. The wider irregularly shaped increased magnetic response anomaly covers an area of 50 m by 50 m. Two further amorphous areas, and one triangular linear area, of increased magnetic response, have been identified south of **4000**, at **4001**, **4002**, and **4003** (**Figure 15**). The anomaly at **4001** is 87 m at its widest extent, whereas **4002** is 83 m at its widest extent. The triangular linear anomaly at **4003** appears equilateral with each side 26 m long. These features are likely to relate to World War Two military activity. The site and surrounding area were utilised during the war by the US troops in preparation for the D-Day Normandy landings. There appears to have been a building at **4000**, with other infrastructure, such as tracks and recently removed temporary buildings, visible in aerial photography taken just after the war.

4.2.2 Several positive and negative discrete anomalies of similar relative dimension are noted towards the southern portion of the site, at **4004** to **4008** (**Figure 27**). The diameter of the anomalies range between 4 m and 19 m across, with further smaller discrete positive anomalies scattered in the immediate vicinity. These anomalies could represent archaeological activity in the form of extraction pits. Equally, however, these anomalies may be a product of geological or agricultural activity.

4.2.3 In the southern-most portion of the site, numerous positive linear anomalies are present, at **4009** to **4018** (**Fig. 31** and **33**). The linear anomalies at **4009** are on a different orientation to the other linear anomalies across the area. They are predominantly north – south rather than on the more prevalent east – west orientation. From north to south, the anomalies measure first 13 m, with a break of 4 m, followed by a continuation of a further 10 m, a turn 90 degrees to the west and the last continuation of 7 m. The anomalies are all between 1 – 2 m in width. An amorphous positive anomaly, 4 m in diameter, is also immediately adjacent to the eastern side of **4009**. These anomalies indicate archaeological activity, such as boundary ditches associated with agricultural practices. However, they could equally be more modern activity such as agriculture or drainage.

4.2.4 A concentration of these positive linear anomalies is apparent at **4010**, where they are situated within a wider area of an increased magnetic background (**Fig. 31** and **33**). The anomalies cover an area of 59 m east – west by 53 m north – south. The anomalies indicate archaeological activity in the form of ditches, possibly used for land or animal management. However, it is possible that the anomalies relate to natural features occurring within the marsh land and estuary.

4.2.5 The positive linear anomalies at **4011** to **4018** are predominantly on an east – west orientation (**Fig. 31** and **33**). The longest of these is at **4011** and **4012**, which most likely serve as a single feature. These anomalies combined are 143 m long and 2 – 3 m wide. Stronger examples of these linear anomalies are evident at **4015** – **4018**. The linear anomalies across this portion of the site indicate field boundaries or ditches for agricultural land management that may be archaeological. However, it is equally likely that they are modern boundaries or relate to drainage.

4.2.6 A collection of discrete positive anomalies is apparent east and west of **4009**, at **4019** and **4020** (**Fig. 31** and **33**). These anomalies are between 1 – 3 m in diameter and indicate possible archaeological activity, such as pits used for refuse or extraction. Equally, however, these anomalies may pertain to more modern agricultural processes, cattle movement, or variation in the underlying superficial geology.

4.2.7 Two further weakly positive linear anomalies have been identified in the centre of the site at **4021** (**Figure 23**) and **4022** (**Figure 25**). These have both been identified in areas of variable natural responses. While it is likely they are natural features, they do appear to have a more man-made form than the surrounding anomalies suggesting they are former boundary features of unknown date. The anomaly at **4019** is 115 m long north-west to south-east with a 37 m westerly projection. The anomaly at **4020** is 85 m north-east to south-west.

4.2.8 Numerous positive and dipolar linear anomalies are present across multiple areas of the site, at **4023** to **4029** (**Fig. 13**, **15**, **19**, **21**, **25**, **27**, **29**, **31**, and **33**). These anomalies correspond to former field boundaries noted on multiple historic maps and in post-World War Two aerial photography taken of the area.

4.2.9 Multiple areas of increased magnetic response are noted across the site, at **4030** to **4034** (**Fig. 11**, **19**, **21**, **29**, **31**, and **33**). The anomaly at **4030** (**Figure 11**) is 108 m by 44 m in area and corresponds with landscaping and a trackway associated with Saunton Golf Course. The anomalies at **4031** and **4032** (**Fig. 19** and **21**) are 40 m by 36 m and 81 m by 35 m in area respectively. These anomalies are likely a by-product of the crop cultivation and fertilisation. The anomaly at **4033** (**Figure 29**) is 60 m by 18 m and may be the product of ground disturbance, such as landscaping or a part of a former trackway. The anomaly at **4034** (**Fig. 31** and **33**) is 30 m by 16 m and is likely the result of animal activity, however, it

is equally possible that this is another naturally occurring phenomena within the geo-morphological processes of the marsh land and estuary.

4.2.10 A combination of weak and strong positive, and dipolar, anomalies are evident across the site, at **4035** to **4047** (**Fig. 13**, **21**, **25**, **27**, **29**, **31**, and **33**). These anomalies are associated with drainage and water management of the site. The weaker responses indicate simple ditches or plastic land drains, whereas the stronger indicate fired-clay or metallic drains.

4.2.11 Two linear areas of dipolar response are evident towards the southern portion of the site at **4048** and **4049** (**Fig. 29**, **31**, and **33**). These correspond to modern trackways or paths.

4.2.12 Several strong dipolar linear anomalies are evident across the site at **4050** to **4057** (**Fig. 11**, **21**, **29**, **31**, and **33**). These anomalies are interpreted as modern services.

4.2.13 Extensive geo-morphological activity is present across much of the site. The site forms a part of Braunton Burrows, which is at the core of the UNESCO North Devon Biosphere reserve. The dune system is one of the largest in the British Isles and is also an area of outstanding natural beauty. The magnetic response in many areas of the site displays paleo-channels, and other variations in the superficial geology, which forms a part of the wider dune system, marshes, and estuary.

4.3 EM survey results and interpretation

4.3.1 Anomalies of high magnetic conductivity and high magnetic susceptibility have been identified across the EM survey area, at **4100** to **4110** (**Fig. 35**, **37**, **39**, **41**, **43**, and **45**). The largest of these anomalies is at **4100**, which covers an area 63 m by 14 m, and at **4102** which is 78 m by 10 m. The anomalies at **4100**, **4103** and **4106** are evident in the magnetic conductivity results to a depth of 6.7 m, whereas **4100** alone is evident in the magnetic susceptibility results to a depth of 6.7 m. The deeper response of these anomalies suggests possible archaeology of a larger size, likely related to World War Two training equipment known throughout this area. The weaker anomalies, although possibly archaeological in nature and pertaining to further military activity, are likely associated with metal reinforcement present throughout the dunes to prevent further anthropogenic erosion.

4.3.2 Two very strong anomalies of high magnetic conductivity and high magnetic susceptibility are present at the western edge of the EM survey area, at **4111** and **4112** (**Fig. 35**, **37**, **39**, **41**, **43**, and **45**). The anomaly at **4111** covers an area of 100 m by 81 m, whereas **4112** covers an area of 87 m by 116 m. These anomalies correspond to the conditions created by the salinity of the beach and are therefore interpreted as superficial geology.

5 DISCUSSION

5.1.1 The survey has not identified any anomalies that can confidently be interpreted as archaeology. There are however several areas of possible archaeological activity.

5.1.2 Possible evidence of Second World War military activity can be seen across the north of the site and the dunes. In the north of the site there are several anomalies that appear to relate to former barrack blocks, with associated infrastructure, as shown on aerial photography from 1946. This activity would have been in support of the documented training efforts by the US military throughout the dunes system, in preparation for the D-Day landing offensive. There is potential evidence of this training activity within the dunes, with several areas of strong metallic responses identified. However, the majority of the anomalies only occur near the surface and may therefore be attributed to reinforcement used to inhibit anthropogenic erosion along pathways through the dunes.

5.1.3 Further possible archaeological activity is noted to the south, both immediately north and south of the Taw Estuary, which bisects the southern portion of the site. The possible archaeological features north of the estuary may be attributable to extraction activity. However, further information is not available, and these anomalies may be the by-product of military activity, modern agricultural practices, or variation in the geomorphology of the site.

5.1.4 The possible archaeological activity south of the estuary may be associated with archaeological ditch features, such as land or animal management boundaries. However, the majority of these features lie on an east – west orientation and may pertain to water management of the site, such as drainage ditches.

5.1.5 Numerous discrete positive anomalies are apparent in groups across the site. These may pertain to archaeological pits associated with extraction or refuse activity. However, they may equally be the by-product of agricultural activity or variation in geology.

5.1.6 Extensive geomorphological activity is evident across a large percentage of the site. This is characterised by variation in the magnetic data along paleochannels, drainage basins, and marshland. The entirety of the site is situated within the UNESCO North Devon Biosphere Reserve and forms the edge of one of the largest dune systems in the British Isles which has resulted in these magnetic features being prevalent. There are areas within this that appear to have a more man-made form and may relate to former boundary features, but they are interpreted with a low level of confidence.

5.1.7 Areas of increased magnetic response are noted across the site. These are attributed to landscaping practices, either correlating with the golf course, trackways, or modern agricultural practices.

5.1.8 The remaining anomalies are thought to be modern. These include land drains, former field boundaries, modern trackways, and modern services.

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APPENDICES

Appendix 1 Survey equipment and data processing (Bartington)

Survey methods and equipment

The magnetic data for this project were acquired using a Bartington 601-2 dual magnetic gradiometer system. This instrument has two sensor assemblies fixed horizontally 1 m apart allowing two traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 1 m separation and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

The gradiometers have an effective resolution of 0.03 nT over a ±100 nT range, and measurements from each sensor are logged at intervals of 0.25 m. All data are stored on an integrated data logger for subsequent post-processing and analysis.

Wessex Archaeology undertakes two types of magnetic surveys: scanning and detail. Both types depend upon the establishment of an accurate 20 m or 30 m site grid, which is achieved using a Leica Captivate RTK GNSS instrument and then extended using tapes. The Leica Viva system receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined with a precision of 0.02 m in real-time and therefore exceed the level of accuracy recommended by European Archaeologiae Consilium (Schmidt *et al.* 2015) for geophysical surveys.

Scanning surveys consist of recording data at 0.25 m intervals along transects spaced 10 m apart, acquiring a minimum of 80 data points per transect. Due to the relatively coarse transect interval, scanning surveys should only be expected to detect extended regions of archaeological anomalies, when there is a greater likelihood of distinguishing such responses from the background magnetic field.

The detailed surveys consist of 20 m x 20 m or 30 m x 30 m grids, and data are collected at 0.25 m intervals along traverses spaced 1m apart. These strategies give 1600 or 3600 measurements per 20 m or 30 m grid respectively and are the recommended methodologies for archaeological surveys of this type (Schmidt *et al.* 2015).

Data may be collected with a higher sample density where complex archaeological anomalies are encountered, to aid the detection and characterisation of small and ephemeral features. Data may be collected at up to 0.125 m intervals along traverses spaced up to 0.25 m apart, resulting in a maximum of 28800 readings per 30 m grid, exceeding that recommended by European Archaeologiae Consilium recommendations (Schmidt *et al.* 2015) for characterisation surveys.

Post-processing

The magnetic data collected during the detail survey are downloaded from the Bartington system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

As the scanning data are not as closely distributed as with detailed survey, they are georeferenced using the GPS information and interpolated to highlight similar anomalies in adjacent transects. Directional trends may be removed before interpolation to produce more easily understood images.

Typical data and image processing steps may include:

- Destripe – Applying a zero-mean traverse in order to remove differences caused by directional effects inherent in the magnetometer;
- Destagger – Shifting each traverse longitudinally by a number of readings. This corrects for operator errors and is used to enhance linear features;
- Despike – Filtering isolated data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings (generally only used for earth resistance data)

Typical displays of the data used during processing and analysis:

- Greyscale – Presents the data in plan view using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

Appendix 2 Survey equipment and data processing (Sensys)

Survey methods and equipment

The magnetic data for this project were acquired using a non-magnetic cart fitted with four SenSys FGM650/3 magnetic gradiometers. The instrument has four sensor assemblies fixed horizontally 1 m apart allowing four traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 0.6 m separation and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

The gradiometers have an effective resolution of ±8 µT over ±1000 nT range. All of the data are then relayed to a CS35 tablet, running the MONMX program, which is used to record the survey data from the array of FMG650/3 probes at a rate of 20 Hz. The program also receives measurements from a GPS system, which is fixed to the cart at a measured distance from the sensors, providing real time locational data for each data point.

The cart-based system relies upon accurate GPS location data which is collected using a Leica Captivate system with rover and base station. This receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined with a precision of 0.02m in real-time and therefore exceed the level of accuracy recommended by European Archaeologiae Consilium recommendations (Schmidt et al. 2015) for geophysical surveys.

Data may be collected with a higher sample density where complex archaeological anomalies are encountered, to aid the detection and characterisation of small and ephemeral features. Data may be collected at up to 0.01 m intervals along traverses spaced up to 0.25m apart.

Post-processing

The magnetic data collected during the survey is downloaded from the system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

Typical data and image processing steps may include:

- GPS DeStripe – Determines the median of each transect and then subtracts that value from each datapoint in the transect within the defined window. May be used to remove the striping effect seen within a survey caused by directional effects, drift, etc.
- Discard Overlaps - Intended to eliminate a track(s) that have been collected too close to one another. Without this, the results of the interpolation process can be distorted as it tries to accommodate very close points with potentially differing values.
- GPS Base Interpolation – Sets the X & Y interval of the interpolated data and the track radius (area around each datapoint that is included in the interpolated result).

Typical displays of the data used during processing and analysis:

- Greyscale – Presents the data in plan view using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

Appendix 3: Electromagnetic Survey Equipment and Data Processing

The electromagnetic data sets for the project were acquired using a Geonics EM31-MK2 low frequency electromagnetic instrument. Its total length is 4m while the distance between the transmitter coil and receiver coil is 3.66m. The operating frequency is 9.8kHz which sets it well within the Low Frequency Electromagnetic (LFEM or EM) instruments category which operate under 300kHz.

This is an active instrument that generates a low frequency electromagnetic field from the transmitter coil, the electromagnetic field generates eddy currents due to the effect of soil moisture, conductive features and earth materials present in the subsoil and these, in turn, generate another electromagnetic which is out of phase compared to the first one and is measured by the receiver coil.

The EM31-MK2, like other LFEM instruments, measures an in-phase component (or magnetic susceptibility) which represents the ratio between the primary and secondary magnetic fields in parts (ppt) and a quadrature (or apparent conductivity) component which represents an average of the conductivities of all components of the subsoil in the measured volume. The unit used for the quadrature component is mili-Siemens per metre (mS/m). The depth of investigation depends on the orientation of the two coils (transmitter and receiver). The horizontal magnetic dipole (HMD) deployment detects up to 3 metres deep while vertical magnetic dipole (VMD) has a depth of investigation up to 6 metres.

The measuring ranges are 10,100 and 1000 mS/m for apparent conductivity and ±20 ppt for magnetic susceptibility. The data was collected along 1m traverses with 2 readings per metre. The survey relies on GPS system (Trackmaker 31) to accurately locate each reading taken by the data logger (Juniper Archer). The sampling interval of 0.5x1m (reading/traverse) offers higher data density than the 'Evaluation' strategy recommended by European Archaeologiae Consilium (Schmidt *et al.* 2015) and is consistent with their 'Characterization' survey strategy of 0.5x1m.

Post-processing

The electromagnetic data collected during the detail survey are downloaded from the Geonics EM31-MK2 data logger for processing and analysis using specific software (DAT31W is used for processing the data, while analysis is done in ARC GIS and AutoCAD). This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

Typical data and image processing steps may include:

- Destripe – Applying a smooth function in order to remove differences caused by directional effects inherent in the magnetometer;
- Despike – Filtering isolated data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings (generally only used for earth resistance data

Typical displays of the data used during processing and analysis:

- Greyscale – Presents the data in plan using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

Appendix 4 Geophysical interpretation

The interpretation methodology used by Wessex Archaeology separates the anomalies into four main categories: archaeological, modern, agricultural, and uncertain origin/geological.

The archaeological category is used for features when the form, nature and pattern of the anomaly are indicative of archaeological material. Further sources of information such as aerial photographs may also have been incorporated in providing the final interpretation. This category is further sub-divided into three groups, implying a decreasing level of confidence:

- Archaeology – used when there is a clear geophysical response and anthropogenic pattern.
- Possible archaeology – used for features which give a response, but which form no discernible pattern or trend.

The modern category is used for anomalies that are presumed to be relatively modern in date:

- Ferrous – used for responses caused by ferrous material. These anomalies are likely to be of modern origin.
- Modern service – used for responses considered relating to cables and pipes; most are composed of ferrous/ceramic material although services made from non-magnetic material can sometimes be observed.

The agricultural category is used for the following:

- Former field boundaries – used for ditch sections that correspond to the position of boundaries marked on earlier mapping.
- Ridge and furrow – used for broad and diffuse linear anomalies that are considered to indicate areas of former ridge and furrow.
- Ploughing – used for well-defined narrow linear responses, usually aligned parallel to existing field boundaries.
- Drainage – used to define the course of ceramic field drains that are visible in the data as a series of repeating bipolar (black and white) responses.

The uncertain origin/geological category is used for features when the form, nature and pattern of the anomaly are not sufficient to warrant a classification as an archaeological feature. This category is further sub-divided into:

- Increased magnetic response – used for areas dominated by indistinct anomalies which may have some archaeological potential.
- Trend – used for low amplitude or indistinct linear anomalies.
- Superficial geology – used for diffuse edged spreads considered to relate to shallow geological deposits. They can be distinguished as areas of positive, negative, or broad bipolar (positive and negative) anomalies.

For the EMI survey several additional categories that relate to the character of the subsurface material are also provided;

- Higher / Lower Conductivity – Higher conductivity features are likely to be associated with clays and silts, whilst low conductivity values are likely to relate to deposits of sands and gravels, which have higher electrical resistance.
- Higher / Lower Magnetic Susceptibility - Volume specific areas magnetic susceptibility (dimensionless) relate to the extent that subsurface materials become magnetised in an applied magnetic field. Burnt/ fired material has an enhanced magnetic susceptibility, and areas of human activity with its accompanying rubbish / cultural material can also leave a permanent magnetic imprint on the soil. By contrast, natural material or bedrock geology has a lower magnetic susceptibility.
- If anomalies of both high magnetic susceptibility and high conductivity are coincident, then it is likely that the feature is metallic and therefore likely to be modern or artificial in origin.

Appendix 5 OASIS form

Project Details:

Project name		White Cross Offshore Windfarm, Braunton, Devon			
Type of project		Gradiometer and Electromagnetic induction survey			
Project description		*Gradiometer survey results* The presence of possible archaeological activity towards the north of the site, in the form of positive linear anomalies and areas of increased magnetic response, are likely attributable to military activity during the Second World War. That portion of the survey area is believed to have been utilised by the military for possible barrack blocks, with associated infrastructure, as shown on aerial photography from 1946. This activity would have been in support of the documented training efforts by the US military throughout the dunes system, in preparation for the D-Day landing offensive. Further possible archaeological activity is noted to the south, both immediately north and south of the Taw Estuary, which bisects the southern portion of the site. The possible archaeological features north of the estuary, may be attributable to extraction activity. However, further information is not available, and these anomalies may be the by-product of military activity, modern agricultural practices, or variation in the geo-morphology of the site. The possible archaeological activity south of the estuary, may be associated with archaeological ditch features, such as land or animal management boundaries. However, the majority of these features lie on an east-west orientation and may pertain to water management of the site, such as drainage ditches, or further variation in the geology. Numerous discrete positive anomalies are apparent in groups across the site. These may pertain to archaeological pits associated with extraction or refuse activity. However, they may equally be the by-product of agricultural activity or variation in geology. Areas of increased magnetic response were noted across the site. These areas have been attributed to landscaping practices, either correlating with the golf course or with trackways, and with potential green waste across agricultural land following crop rotation. Numerous linear anomalies were identified across the site. These have been attributed to land drains, former field boundaries, modern trackways, and modern services. Extensive geomorphological activity is evident across a large percentage of the site. This is characterised by variation in the magnetic data along paleochannels, drainage basins, and marsh land. The entirety of the site is situated within the UNESCO North Devon Biosphere Reserve and forms the edge of the second largest dune system in the world, which has resulted in these magnetic features being prevalent. *EM survey results* Several anomalies of high magnetic conductivity and high magnetic susceptibility were identified along the route through the dune system. Several anomalies are present to a depth of 6.7 m in the conductivity, with one apparent to 6.7 m in the susceptibility. These may correspond to archaeological features associated with the military activity known to have occurred in preparation for the D-Day landings. However, the majority of the anomalies only occur near the surface and may therefore be attributed to either modern detritus, or to the reinforcement used to inhibit anthropogenic erosion along pathways through the dunes. Two high magnetic conductivity and high magnetic susceptibility responses are evident at the western edge of the route through the dune system. These have been attributed to the salinity of the beach.			
Project dates		**Start:** 26-09-2022		**End:** 14-11-2022	
Previous work		Has there been any previous work on the site/area? WSI			
Future work		Is there any further work planned? Not known			
Project Code:	264500	**HER event no.**	N/A	**OASIS form ID:**	wessexar1-511561
		NMR no.	N/A		
		SM no.	N/A		
Planning Application Ref.		N/A			
Site Status		None			
Land use		Agricultural – crop and pasture			
Monument type		N/A	**Period**	N/A	

Project Location:

Site Address	Sandy Lane, Braunton,			**Postcode**	EX33 2NX
County	North Devon	**District**	Braunton	**Parish**	Instow
Study Area	133 ha	**Height OD**	4 m - 20 m aOD	**NGR**	Northern: 245655 137581 Southern: 247718 131495

Project Creators:

Name of Organisation	Wessex Archaeology		
Project brief originator	Royal Haskoning DHV	**Project design originator**	Client
Project Manager	Tom Richardson	**Project Supervisor**	Jake Bishop; Jo Instone-Brewer
Sponsor or funding body	Royal Haskoning DHV	**Type of Sponsor**	Private corporation

Project Archive and Bibliography:

Physical archive	N/A	**Digital Archive**	Geophysical survey and report	**Paper Archive**	N/A
Report title				**Date**	2022
Author	Wessex Archaeology	**Description**	Unpublished report	**Report ref.**	264500.03

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