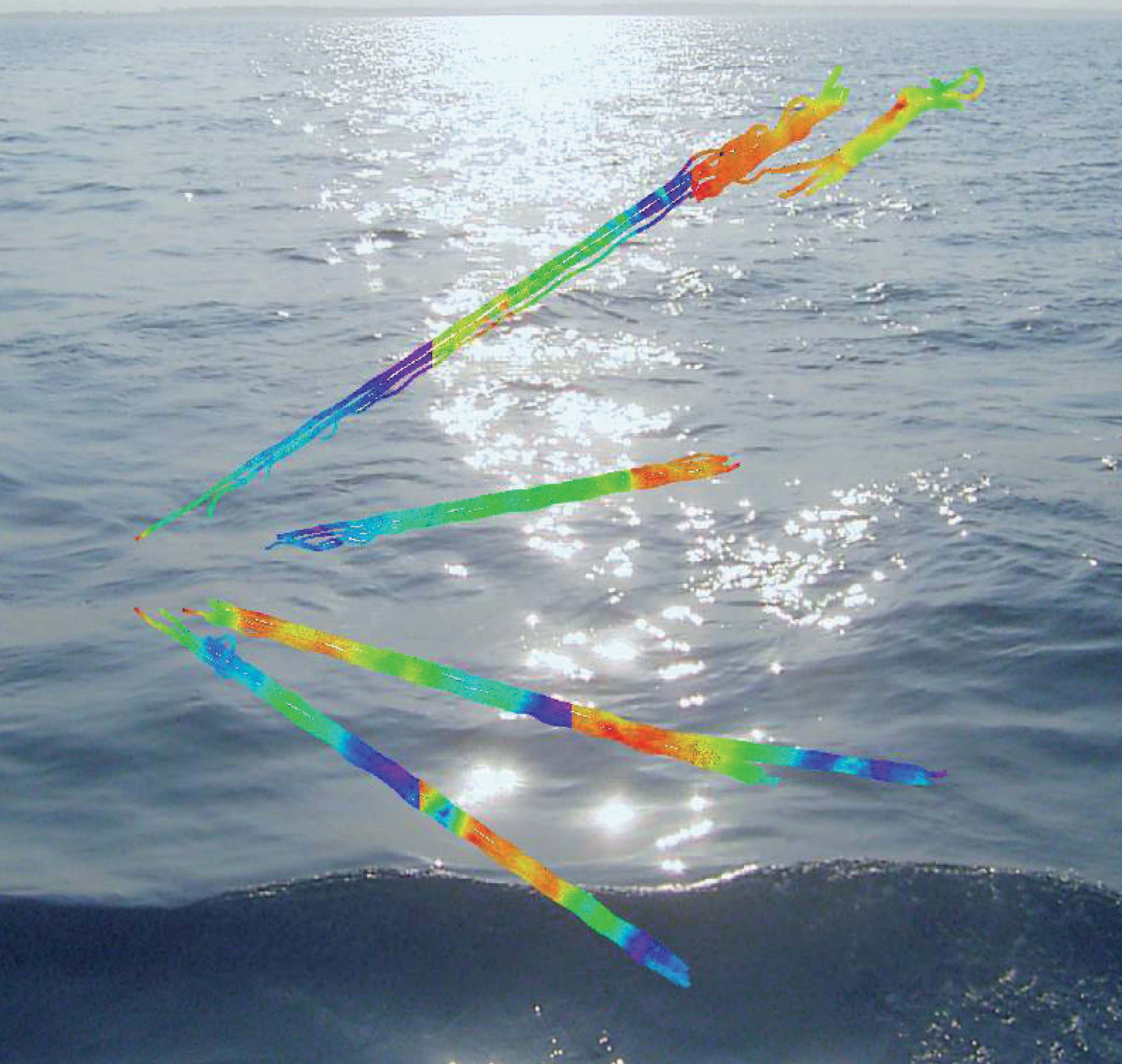
Wessex Archaeology

Lynn and Inner Dowsing Cable Routes

Archaeological Assessment of Geophysical Data



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July 2007

LYNN AND INNER DOWSING CABLE ROUTES

Archaeological Assessment of Geophysical Data

Prepared by:

Wessex Archaeology
Portway House
Old Sarum Park
Salisbury
SP4 6EB

Prepared for:

AMEC Wind Energy
Bridge End
Hexham
Northumberland
NE46 4NU

On behalf of:

Centrica Renewable Energy Limited

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Summary

Wessex Archaeology was commissioned by AMEC Wind Energy, on behalf of Centrica Renewable Energy Limited to undertake an archaeological evaluation of new geophysical data for a series of cable routes running from a common landfall on the Lincolnshire coast to the Lynn and Inner Dowsing Offshore Wind Farms.

There are eight cable routes in total. Six are export cables connecting the common landfall point on the Lincolnshire coast to the wind farms. A further two cables are inter-array cables within the Inner Dowsing wind farm. Centrica provided Wessex Archaeology with specific cable route coordinates, which Wessex Archaeology buffered by 150 metres for the purpose of delineating an area for archaeological assessment. This is referred in the report as the Geophysical Study Area. The buffer was designed to account for sites lying in close proximity to the positioning of the cables and any associated activities, which might be indirectly affected by them.

The evaluation of geophysical data entailed the processing and interpretation of sidescan sonar, sub-bottom profiler, magnetometer and bathymetric data acquired in January 2007 by Gardline Geosurvey Limited. The 2007 results were integrated with an earlier archaeological assessment of geophysical data undertaken by Wessex Archaeology in July 2002. The 2002 assessment had in turn integrated a complete study of casualty and wreck data from the National Monuments Record, UK Hydrographic Office and Receiver of Wreck (Wessex Archaeology 2002).

The 2007 archaeological assessment of geophysical data identified a total of 41 geophysical anomalies within the Geophysical Study Area: 25 from the sidescan sonar data and the remaining 16 from the magnetometer data. No bathymetric or sub-bottom profiler anomalies were recorded.

The majority of the 2007 anomalies (27) are associated with the two northernmost export cables and their associated inter-array cables to the Inner Dowsing wind farm (IDEXP01, IDEXP02, ID0514 and ID1524). No anomalies where identified on the southernmost export cable (IDEXP03) to the Inner Dowsing Wind Farm. Of the three export cables from the Lynn Wind Farm a total of 10 anomalies were identified along cable routes LEXP04 and LEXP05, and five anomalies along cable route LEXP06. In total, four anomalies were observed within 10m of any of the cable routes.

The archaeological assessment of the sub-bottom profiler did not identify any surfaces of significant archaeological interest and as such is considered of low potential for derived archaeological assemblages from the Palaeolithic and Mesolithic periods. Although, previous

work has indicated that sediments consistent with palaeochannels have been identified from boreholes in the area, no evidence was observed on the sub-bottom profiler data (Wessex Archaeology 2005, 2006, 2007).

It is noted that many of the geophysical anomalies identified in the 2007 geophysical data are small and generally isolated and it has not been possible from the data to fully characterise them. As a result, it is recommended that those anomalies situated within ten metres of the nearest cable route either require further investigation or the implementation of exclusion zones.

This report describes the methodologies used to process and interpret the geophysical data, presents the results of the assessment and details recommendations.

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Acknowledgements

This report was commissioned by AMEC Wind Energy, on behalf of Centrica Renewable Energy Limited. Data were provided by Gardline Geosurvey Limited, on behalf of the client. We are grateful to the staff of these organisations for their help and cooperation.

The geophysical interpretations and the archaeological assessment were undertaken by Cristina Serra and Louise Tizzard. Louise Tizzard compiled the report, and Kitty Brandon prepared the illustrations. John Gribble managed the project for Wessex Archaeology.

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1. INTRODUCTION

1.1. PROJECT BACKGROUND

1.1.1. Wessex Archaeology (WA) was commissioned by AMEC Wind Energy, on behalf of Centrica Renewable Energy Limited to undertake an archaeological evaluation of geophysical data for a series of cable routes running from a common landfall on the Lincolnshire coast to Lynn and Inner Dowsing Offshore Wind Farms.

1.1.2. This assessment was undertaken under the terms of the Archaeological Protocol which has been implemented for the Lynn and Inner Dowsing Wind Farms (WA 2006a).

1.1.3. The main development areas lie approximately five kilometres off Skegness on the Lincolnshire coast. They are linked to the coast by a series of cable routes that have a common landfall point on the coast before continuing inshore, connecting to the grid at Middlemarsh sub-station.

1.1.4. There are eight cable routes in total. Six are export cables connecting the wind farms to the common landfall point. A further two cables are inter-array cables within the Inner Dowsing Wind Farm. Details of the cable corridors are provided in **Table 1**.

Cable corridor	Windfarm	Cable Type	Comments
IDO514	Inner Dowsing	Inter-array cable	Associated with IDEXP01
ID1524	Inner Dowsing	Inter-array cable	Associated with IDEXP02
IDEXP01	Inner Dowsing	Export cable	
IDEXP02	Inner Dowsing	Export cable	
IDEXP03	Inner Dowsing	Export cable	
LEXP04	Lynn	Export cable	
LEXP05	Lynn	Export cable	
LEXP06	Lynn	Export cable	

Table 1. Details of the cable routes associated with the Lynn and Inner Dowsing Wind Farms.

1.1.5. **Table 2** lists the start and end point of the cable routes (WGS84, UTM zone 31). The locations of the cable routes are illustrated in **Figure 1**.

	Start of cable		End of cable	
Cable corridor	Easting	Northing	Easting	Northing
ID0514	328540	5896861	329433	5897390
ID1524	329414	5896853	330351	5897358
IDEXP01	322779	5893395	328540	5896861
IDEXP02	322779	5893395	329414	5896853
IDEXP03	322779	5893395	328403	5894199

LEXP04	322779	5893395	330049	5891562
LEXP05	322779	5893395	328749	5891562
LEXP06	322779	5893395	328101	5889837

Table 2. Start and end co-ordinates of the cable routes.

1.1.6. Previous reports undertaken by WA concerning the maritime (below mean sea level) section of the development have been referenced in this report and the data integrated where appropriate. The details of these reports are provided in **Table 3**.

Title	Description	Reference
Maritime Archaeological Assessment	**Technical archaeological desk-based assessment reporting on the proposed windfarms and associated cable routes.**	**WA (2002) Ref: 51145.02**
Stage 1 Borehole Assessment	**Archaeological assessment of borehole logs acquired in connection with the construction of the proposed windfarms**	**WA (2005) Ref: 59091.01**
Stage 2 Archaeological Recording of Cores	**Archaeological recording of vibrocores and borehole cores selected during the Stage 1 report**	**WA (2006) Ref: 59094.01**
Archaeological Protocol	**Archaeological protocol for the construction, use and de-commissioning phases of the offshore wind farms**	**WA (2006a) Ref: 59090.07**
Stage 3 Subsample Assessment	**Palaeoenvironmental sub-sampling of borehole BHID25**	**WA (2007) Ref: 59094.02**

Table 3. Details of previous WA reports on the offshore wind farms.

1.2. AIMS AND OBJECTIVES

1.2.1. The aim of this report is to provide an archaeological assessment of the new and existing geophysical data to further inform of potential impacts from the Lynn and Inner Dowsing cable route development.

1.2.2. The specific objectives of this report are:

- to provide an overview on the development of the historic environment within the Geophysical Study Area (GSA);
- to highlight known sites that may be impacted by the proposed laying of cables;
- to summarise the potential for the presence of hitherto unknown sites that may be impacted by the development;

1.2.3. This geophysical assessment consists of a baseline study, a statement of the known and potential archaeological remains within the cable route corridors, a review of existing geophysical data, a statement of likely impacts and suggestions for appropriate mitigation.

2. METHODOLOGY

2.1. APPROACH

2.1.1. The methodology of the assessment adopted reflects best practice in carrying out archaeological assessments included in the Historic Environment Guidance for the Offshore Renewable Energy Sector (COWRIE 2007), the *Code of Practice for Seabed Developers* produced by the Joint Nautical Archaeology Policy Committee (JNAPC 2006), and as set out by the Institute of Field Archaeologists (IFA) *Standard and Guidance for Archaeological Desk-based Assessment* (IFA 2001).

2.1.2. The geophysical interpretation of previous primary geophysical data undertaken in July 2002 (WA 2002), and the results of borehole assessments (WA 2005) and archaeological core recording (WA 2006) were integrated into this report.

2.1.3. Records of known maritime sites and anomalies were established during the 2002 assessment overlaid on a base map of the proposed development area in a Geographical Information System (GIS).

2.2. GEOPHYSICAL STUDY AREA

2.2.1. For the purposes of the archaeological assessment of the geophysical data a Geophysical Study Area (GSA) was created (**Figures 1** and **2**). The GSA encompasses a 150m buffer around each cable route. Geophysical data within the GSA was assessed for direct impacts along the route and indirect impacts of cable-laying operations on any sites of potential archaeological interest.

2.2.2. Full geophysical coverage of the GSA is not achieved in places along cable route IDEXP02 where the route has been re-designed and lies close to the southern extent of the acquired geophysical data. As such, to the south of this route there is little sidescan sonar coverage within the GSA.

2.2.3. There is a similar situation with route IDEXP01 where the route now lies on the northern edge of the geophysical data, limiting the coverage of the GSA to the north.

2.3. TECHNICAL SPECIFICATIONS

2.3.1. The geophysical data assessed for this report consisted of sidescan sonar, magnetometer, multibeam bathymetry and sub-bottom profiler data.

2.3.2. The geophysical survey was conducted by Gardline Geosurvey between 9th and 27th January 2007.

2.3.3. The 2007 survey dataset comprised a total of 301 line km. The nominal line spacing for the cable corridors was 75m. However, in places line spacing was as little as 20m. **Table 4** provides details of the number of lines acquired in each cable corridor.

Cable corridor	Number of survey lines
ID0514	8
ID1524	7
IDEXP01	8
IDEXP02	8

Cable corridor	Number of survey lines
IDEXP03	5
LEXP04	7
LEXP05	5
LEXP06	7

Table 4. Details of the number of survey lines associated with each corridor.

2.3.4. Gardline Geosurvey acquired the sidescan sonar data using a dual frequency Klein 3000 system. Data was collected at 445kHz with a 50m range for the IDEXP01 and IDEXP02 cable route corridors and 75m range setting for the remainder. Based on the sidescan sonar range and the line spacing, seabed coverage varied between 100 and 400%.

2.3.5. The sidescan sonar data was digitally recorded by an Octopus 760 system as xtf files and simultaneously printed onto thermal paper.

2.3.6. The position of the sidescan sonar towfish was ascertained using the layback method calculated from the length of cable between the towfish point on the stern of the vessel and the towfish, and the water depth. All layback changes were applied during post-processing in order to establish positioning of features observed on the data.

2.3.7. The sidescan sonar data were provided to WA for archaeological assessment in digital format.

2.3.8. Magnetometer data was acquired using a Geometrics 881 towed at a depth of 3-5m. Similar to the sidescan sonar data, the positioning of the data was ascertained using the layback method. The data was recorded in csv file format and provided to WA in digital format.

2.3.9. Bathymetric data was acquired using a dual frequency single-beam echosounder and a multibeam echosounder. The Simrad EA400 single-beam echosounder was used with a heave compensator and acquired data at frequencies of 38 and 200kHz.

2.3.10. The multibeam bathymetric data were acquired using a hull-mounted Simrad EM3002D operated at 300kHz. The data were then processed applying positional data and tidal corrections. The data were then gridded into a 0.5 x 0.5m Digital Terrain Model (DTM). The processed data were provided to WA as xyz gridded data files.

2.3.11. The sub-bottom surveys were undertaken using an Applied Acoustics surface-tow boomer with a towed external hydrophone. Seismic reflections were observed to a maximum of 6m below the seabed. The data were recorded on an Octopus 760 in SEG-Y (sgy) format. Data were provided to WA in digital format for archaeological assessment.

2.4. DATA QUALITY ASSESSMENT

2.4.1. Prior to any data processing the data were reviewed to ensure that the data were of sufficient quality for analysis and archaeological assessment.

2.4.2. The data were graded as good, average or variable. The criteria used to grade the data are detailed in **Table 5**.

Good	Data which are clear and unaffected by weather conditions or sea state. The dataset is suitable for the interpretation of standing and partially buried metal wrecks and their character and associated debris field. These data also provide the highest chance of identifying wooden wrecks and debris.
Average	Data which are affected by weather conditions and sea state to a slight or moderate degree. The dataset is suitable for the identification and partial interpretation of standing and partially buried metal wrecks, and the larger elements of their debris fields. Wooden wrecks may be visible in these data, but their identification as such is likely to be difficult.
Variable	This category contains datasets with the quality of individual lines ranging from good or average to below average. The dataset is suitable for the identification of standing and some partially buried metal wrecks. Detailed interpretation of the wrecks and debris field is likely to be problematic. Wooden wrecks are unlikely to be identified.

Table 5. Data quality rating criteria in considering suitability for assessing archaeological potential.

2.4.3. The sidescan sonar data was generally of average quality throughout, with the exception of data acquired in very shallow water. The data acquired in shallow water were subject to signal loss, however, the data were deemed adequate for archaeological interpretation purposes.

2.4.4. The magnetometer data were of variable quality throughout the survey. Certain lines were of poor quality due to the adverse weather conditions during the survey, direction of tow and proximity to the seabed. Generally the background noise level of approximately 5nT was observed, however, on certain lines this background noise level increased to up to 10nT. As such, it is not possible to identify small (5 – 10nT) magnetic anomalies, which would normally be recorded as part of the archaeological assessment.

2.4.5. The sub-bottom profiler data was generally of average quality, and was noisy in places due to the adverse weather conditions. However, seismic reflections were observed to 6m below the seabed, coinciding with the top of the bedrock layer and the data were assessed as adequate for interpretation for archaeological purposes.

2.4.6. The processed multibeam echosounder data provided to WA was of good quality with full coverage achieved. The data was gridded to a cell size of 0.5m which is of high enough resolution to discriminate small objects with height. However, the gridded data has been smoothed to provide a realistic impression of the seabed without losing real topographical features (Gardline 2007). Any small isolated objects are likely to be lost in this smoothing process.

2.5. Geophysical Data Processing and Anomaly Characterisation

2.5.1. WA staff archaeologically assessed the sidescan sonar data using Coda Geosurvey software. This allowed the data to be replayed with various gain settings in order to optimise the quality of the images. A mosaic was also created in order to assess the quality of the navigation information in the files.

2.5.2. The sidescan sonar data were interpreted for any objects of possible anthropogenic origin and the position and dimensions of such objects were recorded in a gazetteer.

2.5.3. The form, size and/or extent of an anomaly are a guide to its potential. A single small but prominent anomaly may be part of a much more extensive feature that is largely buried. Similarly, a scatter of minor anomalies may define the edges of a buried but intact feature, or it may be all that remains as a result of past impacts from, for example, dredging or fishing.

2.5.4. The magnetic data were processed to give an x,y,z file comprising of grid co-ordinates (x,y) and total magnetic field strength (z). Each line of data was then processed to remove the regional magnetic field and also any large diurnal variations, which may have masked small magnetic anomalies of interest to this survey. The data were then gridded to produce a contour map of the survey area and plotted with the magnetic field strength values represented by graded colour bands to show changes in the magnetic field strength.

2.5.5. The magnetic anomalies were then assessed and the position and, wherever possible, the magnitude of all anomalies with an amplitude of 5nT or more were recorded. Where the background noise level was in excess of 5nT, only anomalies with a magnitude greater than the background noise level were recorded in a gazetteer.

2.5.6. The shallow seismic data was studied in order to detect any in-filled palaeochannels, ravinement surfaces and peat/fine-grained sediment horizons that may have archaeological potential.

2.5.7. The shallow seismic data were processed by WA using Coda Geosurvey software. This software allows the data to be replayed with user selected filters and gain settings in order to optimise the appearance of the data for interpretation. The software then allows an interpretation to be applied to the data by identifying and selecting a sedimentary boundary that might be of archaeological interest. Any features of interest were recorded in a gazetteer.

2.5.8. The bathymetric data were gridded and made into a surface using IVS Fledermaus software. This data then provided a datum for the other geophysical datasets but was not of sufficient resolution for the identification of isolated anomalies, due to the smoothing of the data processing.

2.5.9. Once the gazetteers for the individual assessments were created, a combined gazetteer was produced listing all recorded anomalies in the GSA (**Appendix I**).

3. BASELINE ENVIRONMENTS

3.1. GEOLOGICAL BASELINE

3.1.1. Throughout the Pleistocene the area off the Lincolnshire coast has been severely affected by glacial events which have shaped the landscape. Over the last 700,000 years (a period encompassing the full extent of human habitation within the British Isles) sea level along the Lincolnshire coast has fluctuated considerably.

3.1.2. Generally, the geology of the area comprises pre-Tertiary rocks (Upper Cretaceous Chalk) underlying a thickness of Pleistocene glacial till, which in turn underlies Holocene marine sediments (Cameron *et al.* 1992).

3.1.3. During the latter part of the Cromerian Complex (during a glacioeustatic low sea level stand) the southern North Sea was predominantly occupied by a huge delta complex. One of the major rivers (the Yorkshire) was cut prior to the Cromerian Complex and existed where the River Humber is now situated.

3.1.4. The advance of the continental ice sheets during the Anglian Glaciation (Oxygen Isotope Stage (OIS) 12, 480,000 – 425,000 BP) completely re-modelled the landscape, with the older river course destroyed or buried and an entirely new landscape formed beneath the ice by glacial and fluvioglacial erosion and deposition. Following the Hoxnian interglacial (425,000 – 380,000 BP), during the Wolstonian Stage (OIS 6 or 8, 380,000 – 130,000 BP) the GSA was covered by ice. This had similar effects on the landscape as the Anglian Glaciation, again causing major landscape re-modelling.

3.1.5. During the Devensian (70,000 – 12,000 BP) there are considered to have been three major phases of glaciation in the North Sea Basin (Carr *et al.* 2006). The Ferder glacial episode in the Early Devensian (OIS 4), the Cape Shore glacial episode (OIS 3) during the Mid- to Late-Devensian and the Bolders Bank glacial episode in the Late-Devensian (OIS 2). Within the study area only the remnants of this third major ice sheet advance are represented in the form of the Bolders Bank Formation.

3.1.6. The Bolders Bank Formation is a sub-glacial till and exists as a large lobe that extends 50km offshore from northeast England before spreading out over a large area of the southern North Sea. This formation is generally between 6 and 25m thick (Cameron *et al.* 1992).

3.1.7. The surface of the Bolders Bank Formation is likely to have been modified by small channels and depressions created by meltwater and fluvioglacial processes as the ice sheet began to retreat. Within the channels carved out by the meltwater, sands and gravels would have been deposited. By the end of the Dimlington Stadial at around 13,000 BP (*c.* 13,400 cal BC) no ice would have remained over the GSA and a periglacial landscape would have prevailed (Coles 1998). Ellis describes the late glacial landscape of the Lincolnshire marshes as probably being “gently undulating with kettle holes and poorly drained hollows which rapidly became water filled” (Ellis 1993:20).

3.1.8. Evidence from the borehole assessment and subsequent core analysis (WA 2005; 2006; 2007) indicate glacial lacustrine deposits within the region. Although, no exact dates have been established it is likely that these sediments were deposited between the end of the Dimlington Stadial (13,000 BP (*c.* 13,400 cal BC)) and *c.*6700 BP (*c.* 5,600 cal BC).

3.1.9. By *c.*6,700 BP (*c.* 5,600 cal BC) the landscape would have been mixed woodland with the coastline being to the northeast, and the woodland stretching across the North Sea Basin to Denmark (Ellis 1993:20). General sea-level curves suggest that at 7,000 BP (*c.* 5,900 cal BC) the relative sea level of the Lincolnshire Marshes was nine metres below its current position (Shennan *et al.* 2000). Given the current water depth of the GSA of 2 – 13m LAT this would indicate that the GSA area would be mostly dry land with the seaward extents of the GSA in the intertidal zone. By 5,000 BP (*c.* 3,700 cal BC) the coastline would have been in a similar location to its present day position (Jelgersma 1979), although Shennan *et al* (2000) indicate that at the start of the Neolithic the sea level had risen to the point where it was approximately six metres below its present level. This places the GSA within the Neolithic inter-tidal and sub-tidal zone. By the start of the Bronze Age at *c.* 2,400 cal BC the GSA would have been completely inundated.

3.2. Archaeological Baseline

3.2.1. The dominant sediment type in the GSA is the Bolders Bank Formation. As this formation represents the erosion of a former landsurface there is little potential for pre-Devensian archaeological artefacts to remain *in situ*. However, derived artefacts transported by the ice sheet may remain.

3.2.2. A similar situation is observed onshore. During the monument record search conducted for the desk-based assessment report (Wessex Archaeology 2002) it was shown that evidence for Palaeolithic and/or Mesolithic activity within the coastal area of Lincolnshire was scarce with only one site known from this period. Lower Palaeolithic finds have been identified on the Wolds, inland of the landfall, notably at Salmonby and Kirmington. However, few of these finds relate to *in situ* material, and most of the Lower Palaeolithic finds within the area are thought to have been re-worked by the Wolstonian or Devensian glaciations and subsequently deposited within river gravels (May 1976).

3.2.3. The monument record search conducted for the 2002 WA report identified a temporary Mesolithic hunting encampment evidenced by a scatter of flint tools indicative of a hunter-gatherer population utilising a wide range of resources. During the Mesolithic the GSA would have been a coastal dry land site with potential for hunter-gather communities.

3.2.4. Numerous finds of Neolithic stone axes have been found on the coast and there is also archaeological evidence of activity throughout the Bronze and Iron Age (WA 2002). However, by the Neolithic it is likely that the GSA was gradually becoming inundated and was fully submerged at the start of the Bronze Age.

4. KNOWN WRECKS AND GEOPHYSICAL ANOMALIES

4.1. Overview

4.1.1. A full list of all known wrecks, from documentary sources, and geophysical anomalies identified in the 2007 geophysical assessment, within the GSA are listed in **Appendix I** and illustrated in **Figure 2**.

4.1.2. There are 41 geophysical anomalies within GSA. The sites were identified in the geophysical datasets outlined in **Table 6**.

Dataset	Number of sites identified
Sidescan sonar	**25**
Magnetometer	**16**
Bathymetric	**0**
Seismic	**0**
Total	**41**

Table 6. Means of anomaly identification.

4.1.3. Records of wrecks and obstructions within the GSA were collated using information provided by the UK Hydrographic Office (UKHO), the National Monument Record (NMR), and the Receiver of Wreck during the archaeological assessment undertaken by WA (2002).

4.1.4. The results from the 2002 assessment were imported into the 2007 GIS working space and were compared with the findings produced during the 2007 geophysical assessment. When imported into the GIS only one known record fell within the GSA. This is site **7000** (**Appendix I**, **Figures 2** and **3**), situated in the IDEXP01 corridor and is discussed in more detail in **Section 4.2**.

4.1.5. A total of 25 of the 41 anomalies were identified in the sidescan sonar data. Although identified, exact discrimination of the anomalies in terms of their origin is impossible to determine. These anomalies would require further visual investigation to confirm or deny their anthropogenic origin. Sixteen magnetic anomalies with a small to large sized amplitude for which there is no corresponding sidescan data were also identified. This is possibly because the site or material is buried beneath the seabed.

4.1.6. No anomalies were observed on the multibeam bathymetric data. Although the data was gridded to a high resolution, the anomalies observed on the sidescan sonar are small and less than 1m high. As such, the smoothing process used to create the DTM is likely to have been removed small objects from the dataset.

4.1.7. The shallow seismic data was studied in order to detect any in-filled palaeochannels, ravinement surfaces and peat/fine-grained sediment horizons that may have archaeological potential. During the Stage 1 borehole assessment phase (WA 2005; WA 2006) two boreholes (TB10-02 and TB10-10) were assessed as having archaeological potential. Borehole TB10-02, situated approximately 300m south of LEXP06 (**Figure 2**), contained peats and laminated silts and clays. TB10-10, situated within the GSA, 50m south of LEXP05 (**Figure 2**) contained organic silts and clays possibly associated with a palaeochannel. Borehole TB10-10 is situated 20m south of the nearest survey line. There was no evidence of a palaeochannel feature on the geophysical data in this area indicating the sediments are localised and not associated with a larger feature. No evidence of any peat or palaeochannels was observed in the assessment of the 2007 sub-bottom profiler data. As such, no features were recorded and the potential for *in situ* archaeological assemblages from the Palaeolithic is considered low.

4.1.8. Four anomalies identified on the sidescan sonar and one anomaly identified on the magnetometer data in the 2002 dataset are situated within the GSA coverage of the 2007 data. These anomalies are discussed in more detail in **Section 4.2** and **4.5**.

4.1.9. In the following sections the identified geophysical anomalies are discussed in terms of their proximity to each cable route corridor. Where The GSA for two cable routes merge, e.g. for routes LEXP04 and LEXP05, the routes have been discussed together. Also, the inter-array cables have been discussed along with their associated export cable.

4.2. Cable Routes IDEXP01, ID0514, IDEXP02 and ID1524

4.2.1. A total of 27 anomalies are located within the GSA for these four cable routes. One anomaly is an obstruction recorded by the UKHO (**7000**), 13 anomalies were identified from the magnetometer data (**7002**, **7003**, **7004**, **7009**, **7012** – **7014**, **7016**, **7019** – **7021**, **7025** and **7026**) and the remaining 13 (**7001**, **7005** – **7008**, **7010**, **7011**, **7015**, **7017**, **7018**, **7022** – **7024**) anomalies were identified from the sidescan sonar data.

4.2.2. Site **7000** is listed in the UKHO and NMR data, from 1969, as a DUKW (early amphibious vehicle from World War II) causing an obstruction, and is assumed to be a wartime loss. The recorded location is approximately 7.3km from the coastline. This feature was not identified in the 2007 sidescan sonar or bathymetric data. Although magnetic anomalies have been identified in the area (**7020** and **7021**) indicating possible buried ferrous bodies, it is not possible to establish a direct link between the magnetic anomalies and the recorded obstruction.

4.2.3. Of the anomalies identified on the sidescan sonar data, three exhibited height. Anomalies **7008** (1.5 x 0.6 x 0.4m) and **7023** (2.4 x 2.1 x 0.9m, **Figure 3**) are isolated anomalies, interpreted as possible debris; **7015** is a group of five closely spaced anomalies exhibiting a maximum height of 0.3m.

4.2.4. The remainder of the anomalies identified on the sidescan sonar are isolated dark reflectors of unknown origin, except for anomalies **7007** and **7022** that were identified as groups of small dark reflectors.

4.2.5. Of the 13 anomalies identified by the magnetometer, only three have magnetic amplitudes of less than 30nT (**7004**, **7009** and **7013**), the remainder all have large amplitudes. Based on the form of the magnetic signature and the fact that they do not coincide with sidescan anomalies, the features that have been recorded are anomalous to the background noise level and are indicative of buried ferrous objects within the vicinity. However, given the variable quality of the data it is considered possible that the amplitude values are over-inflated due to spikes in the data.

4.2.6. No direct link between any of the magnetic anomalies and the sidescan sonar anomalies can be made. The positioning of ferrous bodies is problematic due to the positioning of the fish and the inherent ambiguity of magnetic signature, particularly on lines orientated east - west. As such, the magnetic anomalies indicate that there may be ferrous bodies buried in the area, but their exact locations are not known.

4.2.7. Sidescan anomalies **7002** and **7006** are situated within 2m of the IDEXP02 cable route. These are relatively small isolated objects (5.7 x 1.6m and 2.2 x 0.8m, respectively) and exhibit no height. Although the features appear as dark reflectors on the sidescan sonar data, it is impossible to discern if they are anthropogenic or natural features. If anthropogenic in nature it is considered that they are of low archaeological potential.

4.2.8. Three anomalies that were identified on the 2002 sidescan sonar data are situated within the 2007 GSA (**Figure 2**). Two are situated to the south of IDEXP02 cable route: one on the very limit of the 2007 sidescan sonar coverage and the other outside the 2007 geophysical coverage but is within the GSA. Both of these anomalies are situated more than 25m from the proposed cable route. The third anomaly identified in 2002 is 30m north of the current ID1524 cable route. None of these anomalies are visible within the 2007 sidescan sonar dataset, however, and this may be due to sand movement since 2002.

4.3. Cable Route IDEXP03

4.3.1. No geophysical anomalies were identified within the GSA of the IDEXP03 cable route.

4.4. Cable Routes LEXP04 and LEXP05

4.4.1. Ten geophysical anomalies (**7027** – **7036**) were observed in the GSA of the LEXP04 and LEX05 cable routes.

4.4.2. Three anomalies (**7028**, **7035** and **7036**) were identified from magnetic data; the remainder were identified on the sidescan sonar data. The magnetic amplitude of the three anomalies was between 5 and 10nT. Anomalies **7035** and **7036** are isolated and have no corresponding anomaly on the sidescan sonar data. As such it is possible that these anomalies indicate buried ferrous objects. Although anomaly **7028** is situated only 110m southwest of sidescan sonar anomaly **7030**, no direct association can be made indicating that the two adjacent linear dark reflectors have a magnetic signature.

4.4.3. Of the anomalies observed on the sidescan sonar data three exhibit height (**7027**, **7033** and **7034**) and have been interpreted as dark reflectors, possibly debris. Anomaly **7029** exhibits some scouring around an angular object and anomalies **7031** and **7032** are identified as isolated linear dark reflectors.

4.4.4. Magnetic anomaly **7036** is situated within 1m of the cable route LEXP04. However, it should be noted that positioning of burial ferrous material is problematic due to the positioning of the fish and the inherent ambiguity of magnetic signature, particularly on lines orientated east to west. This magnetic anomaly was only identified on one line, however due to the background noise it is not possible to state with certainty that an anomaly was not present on the adjacent line. This anomaly has a low magnetic amplitude of 8nT, but nevertheless may indicate a buried ferrous body within the region of the anomaly.

4.5. Cable Route LEXP06

4.5.1. Five geophysical anomalies (**7037** – **7041**) were observed in the GSA of the LEXP06 cable route. All were identified from the sidescan data only and are isolated anomalies.

4.5.2. Anomalies **7037**, **7039** (**Figure 3**) and **7040** are observed standing proud of the seabed and are interpreted as possible debris. Anomaly **7038** is observed as a relatively large (9.0 x 3.6m) angular dark reflector and **7041**, which is situated approximately 5m north of the cable route, is identified as an isolated patch of dark reflectors.

4.5.3. Two anomalies identified on the 2002 geophysical data (one sidescan sonar and one magnetometer anomaly) are situated within the 2007 GSA of cable route LEXP06

(**Figure 2**). Neither is observed on the 2007 datasets. The anomaly identified on the sidescan sonar and interpreted as possible debris is situated on the very limit of the 2007 sidescan sonar coverage. There was no evidence in the 2007 magnetometer dataset that of an anomaly in this area. However, no 2007 survey lines ran directly over the position of the 2002 anomaly. Both anomalies are situated more than 100m from the proposed cable route.

5. MITIGATION

5.1. GEOPHYSICAL ANOMALIES

5.1.1. From a total of 41 sites identified in the geophysical data, four sites have been proposed for mitigation in the form of exclusion zones (**Figure 3**).

5.1.2. The anomalies identified in the 2007 geophysical data are small and generally isolated and it has not been possible from the data to fully characterise them. As a result, it is recommended that those anomalies situated within ten metres of the nearest cable route require either further investigation or the implementation of exclusion zones. The following exclusion zones are suggested:

WA ID	UTM Easting	UTM Northing	Description	LxBx H (m)	Location	Interpretation / Name	Exclusion Zone (m)
7000	329098	5897052	UKHO Obstruction	-	ID0514	DUKW Amphibious Vehicle	50
7002	325086	5894466	Object	5.7 x 1.6 x 0.0m	IDEXP02	Isolated angular dark reflector	15
7006	326009	5895042	Object	2.2 x 0.8 x 0.0m	IDEXP02	Dark reflector	10
7036	329587	5891629	Magnetic	-	LEXP04	Isolated magnetic anomaly with amplitude of 8nT	20
7041	326051	5891236	Object	3.8 x 6.7 x 0.0m	LEXP06	Patch of dark reflectors found in isolation	15

Table 7. Archaeological Exclusion Zones.

5.2. RECORDED SITES: MONITORING AND NEW SITE IDENTIFICATION

5.2.1. No clearly identifiable wreck sites have been found within the 2007 geophysical data. Although the named wreck of the DUKW (**7000**) was not identified in the 2007 geophysical data, it lies approximately 70m to the east of cable route IDEXP01 is already subject to a 50m exclusion zone in terms of the Archaeological Protocol (WA 2006a) (**Table 7**) (**Figure 3**).

5.2.2. In considering the potential for shipwrecks, it should be noted that such sites often occupy an extended area beyond the confines of any remaining hull, depending on the circumstances of loss and the effects of post-depositional processes. The extended area may contain significant elements of structure, artefacts and stratified deposits that are considered an integral part of the wreck site.

5.2.3. Furthermore, consideration must also be given to the potential for isolated finds that may be situated along the length of the cable routes. Finds of such sites and material will be handled under the terms of the Archaeological Protocol.

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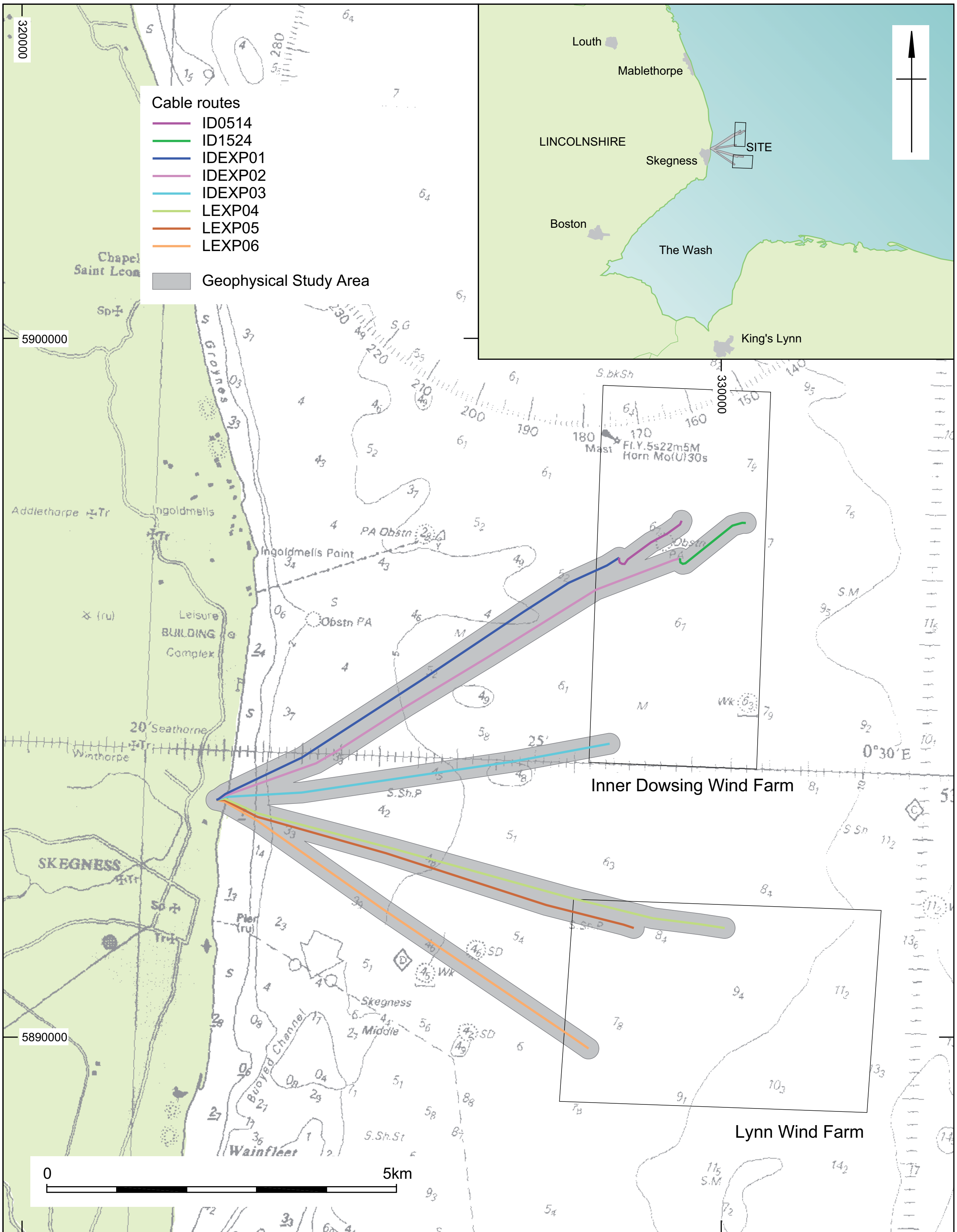
APPENDIX I: GAZETEER OF SITES OF ARCHAEOLOGICAL POTENTIAL

WA ID	Name / Classification	UTM Easting	UTM Northing	Description	Sources	External References
7000	Obstruction	329098	5897052	In 1969 the UKHO marked a DUKW as causing an obstruction. It is assumed to be a wartime loss. The obstruction was not seen in the 2007 geophysical data.	6042	UKHO 8607; NMR 913200
7001	Magnetic	324137	5893935	Isolated magnetic anomaly with a magnetic amplitude of 35nT	6028	
7002	Object	325086	5894466	Isolated angular dark reflector (5.7 x 1.6 x 0.0m)	6003	
7003	Magnetic	325145	5894770	Magnetic anomaly with a magnetic amplitude of 75nT	6029	
7004	Magnetic	325606	5894758	Isolated magnetic anomaly with a magnetic amplitude of 14nT	6033	
7005	Object	325998	5895100	Dark reflector (4.8 x 1.6 x 0.0m)	6004	
7006	Object	326009	5895042	Dark reflector (2.2 x 0.8 x 0.0m)	6005	
7007	Object	326665	5895529	Group of small dark reflectors (5.5 x 3.7 x 0.0m)	6023	
7008	Object with height	326643	5895487	Possible debris (1.5 x 0.6 x 0.4m)	6024	
7009	Magnetic	326688	5895738	Magnetic anomaly with amplitude of 8nT	6027	
7010	Object	326971	5895862	Angular dark reflector, possibly debris (8.2 x 6.6 x 0.0m)	6000	
7011	Object	327231	5895974	Angular dark reflector (6.6 x 12.3 x 0.0m)	6002	
7012	Magnetic	327272	5895846	Magnetic anomaly with amplitude of 47nT	6034	
7013	Magnetic	327726	5896389	Isolated magnetic anomaly with amplitude of 10nT	6030	
7014	Magnetic	328307	5896612	Magnetic anomaly with amplitude of 32nT	6031	
7015	Group of objects	328382	5896581	Group of five closely spaced objects, possibly debris (2.6 x 1.8; 2 x 1.4; 1.5 x 0.6 x 0.2; 1.4 x 0.4 x 0.3; 0.6 x 0.5 x 0.2). Magnetic anomaly (4006) 84m northwest of these objects, although no link established	6016	
7016	Magnetic	328677	5896617	Magnetic anomaly with amplitude of 580nT	6035	

WA ID	Name / Classification	UTM Easting	UTM Northing	Description	Sources	External References
7017	Object	328652	5896731	Angular isolated object (4.0 x 3.1 x 0.0m)	6015	
7018	Object	328655	5896882	Dark reflector (8.2 x 5.5 x 0.0m). Situated within 82m of magnetic anomaly 7019. No direct link established	6001	
7019	Magnetic	328731	5896847	Magnetic anomaly with amplitude of 53nT	6032	
7020	Magnetic	328808	5897023	Magnetic anomaly with amplitude of 229nT	6025	
7021	Magnetic	328873	5897120	Magnetic anomaly with amplitude of 299nT	6026	
7022	Group of objects	329010	5896908	Two angular dark reflectors (5.2 x 2.4; 6.6 x 2.4)	6017	
7023	Object with height	329558	5897382	Debris of unknown origin (2.4 x 2.1 x 0.9m)	6018	
7024	Object	329320	5896699	Angular dark reflector (6.3 x 3.3 x 0.0m)	6019	
7025	Magnetic	329435	5896805	Magnetic anomaly with amplitude of 125nT	6036	
7026	Magnetic	330234	5897293	Isolated magnetic anomaly with amplitude of 89nT	6037	
7027	Object with height	324471	5892753	Angular object, possible debris (3.6 x 3.3 x 0.3m)	6009	
7028	Magnetic	327184	5892035	Magnetic anomaly with a magnetic amplitude of 7nT	6038	
7029	Object	325221	5892700	Angular object with scour (3.6 x 1.6 x 0.0m)	6008	
7030	Group of objects	327288	5892084	Two adjacent linear dark reflectors 20m apart (3 x 0.7; 2.4 x 0.1). Close to magnetic anomaly 6038 (110m southwest), no direct link established	6007	
7031	Object	327476	5892039	Linear dark reflector observed in isolation (2.6 x 0.3 x 0.0m)	6006	
7032	Object	327944	5891907	Faint, curved and elongated dark reflector (7.5 x 2.1 x 0.0m)	6020	
7033	Object with height	328011	5891873	Possible debris (6.8 x 1.1 x 0.2m)	6021	
7034	Object with height	328005	5891902	Dark reflector, possible debris (2.6 x 0.5 x 0.3m)	6022	
7035	Magnetic	328378	5891681	Isolated magnetic anomaly with amplitude of 5nT	6039	
7036	Magnetic	329587	5891629	Isolated magnetic anomaly with amplitude of 8nT	6040	

WA ID	Name / Classification	UTM Easting	UTM Northing	Description	Sources	External References
7037	Object with height	324127	5892638	Possible debris (2.4 x 2.4 x 0.4m)	6014	
7038	Object	324933	5892007	Angular bright reflector (9.0 x 3.6 x 0.0m)	6013	
7039	Object with height	325171	5891859	Round object with shadow, possible debris (1.2 x 0.7 x 0.7m)	6012	
7040	Object with height	325959	5891224	Round object with shadow, possible debris (2.1 x 0.9 x 0.5m)	6011	
7041	Object	326051	5891236	Patch of dark reflectors found in isolation (3.8 x 6.7 x 0.0m)	6010	



Admiralty Chart 108 (dated 2000) Drawing projection: UTM WGS84 zone 31N	This product has been derived, in part, from Crown Copyright Material with the permission of the UK Hydrographic Office and the Controller of Her Majesty's Stationary Office (www.ukho.gov.uk) All rights reserved. (Wessex Archaeology Licence Number 820/020220/11) NOT TO BE USED FOR NAVIGATION WARNING: The UK Hydrographic Ofice has not verified the information within this product and does not accept liability for the accuracy of reproduction or any modifications made thereafter. Digital Map Data © (2007) XYZ Digital Map Company This material is for client report only © Wessex Archaeology. No unauthorised reproduction.

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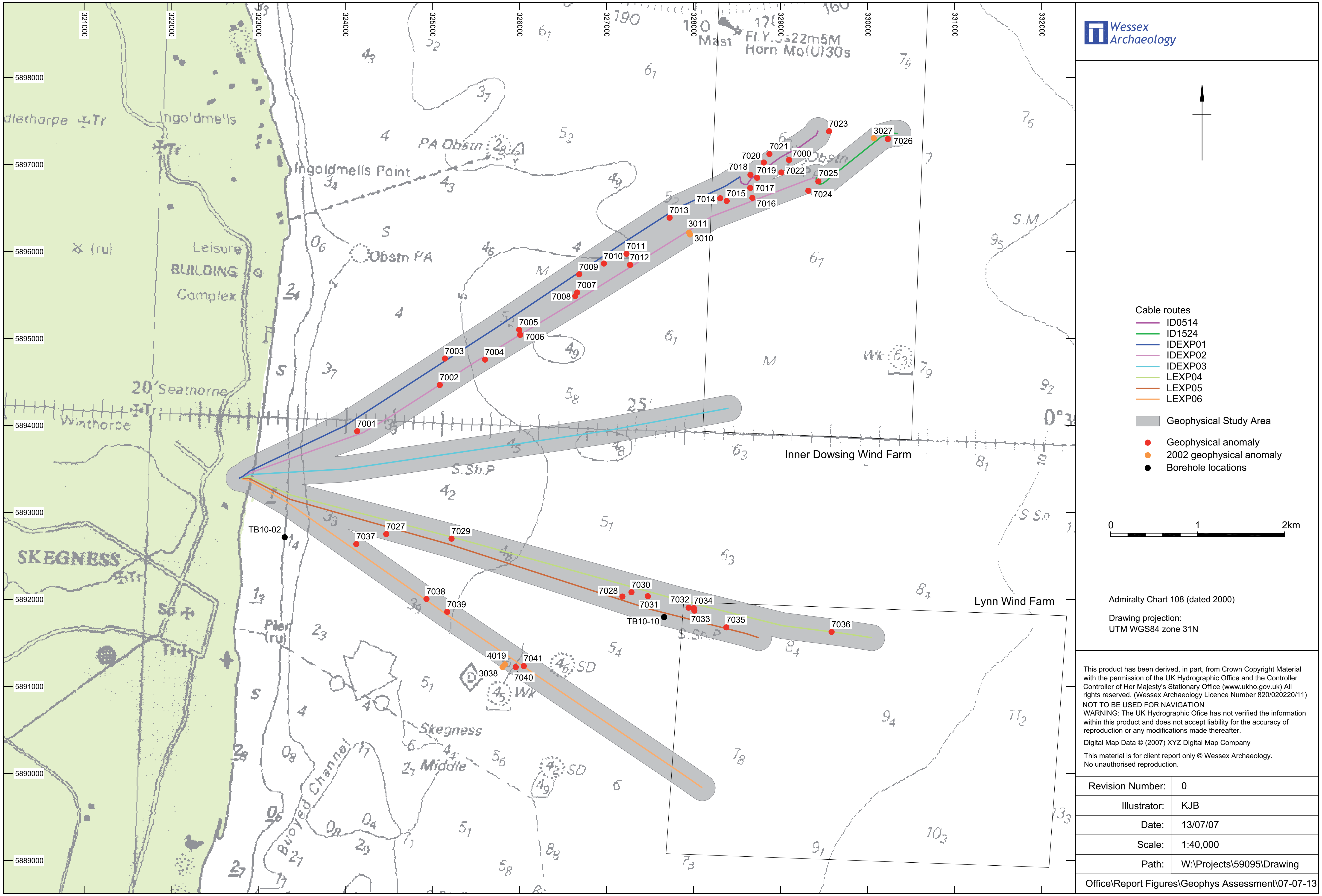
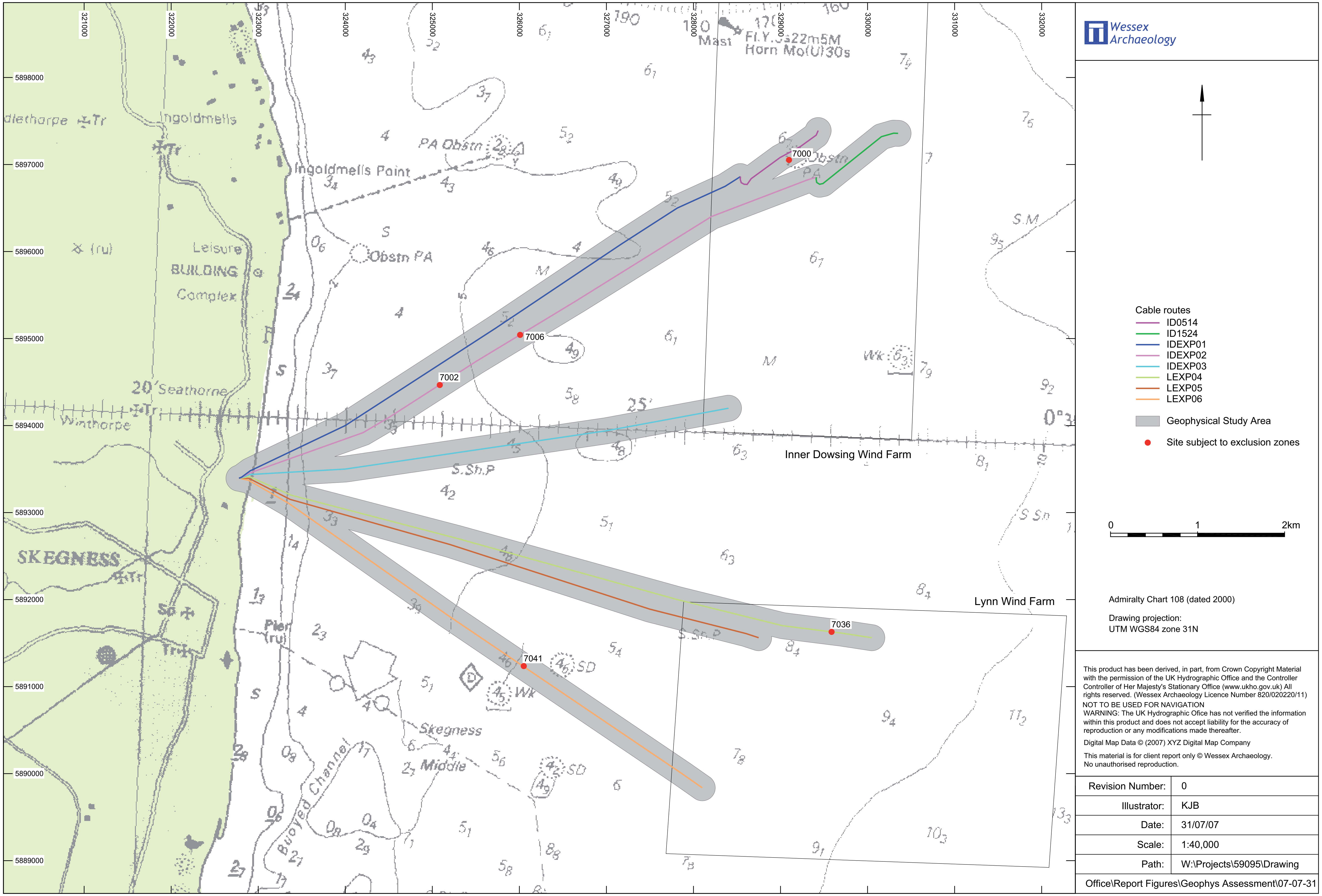
Location of the Lynn and Inner Dowsing export and inter-array cable routes Figure 1



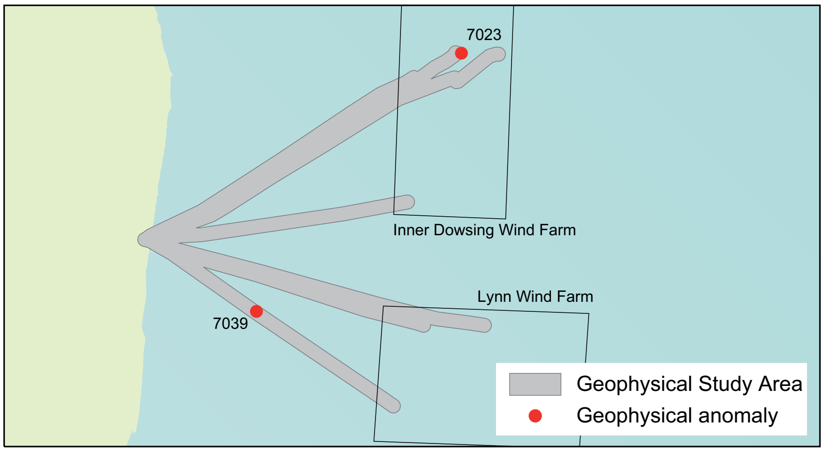
Geophysical anomalies within the Geophysical Study Area

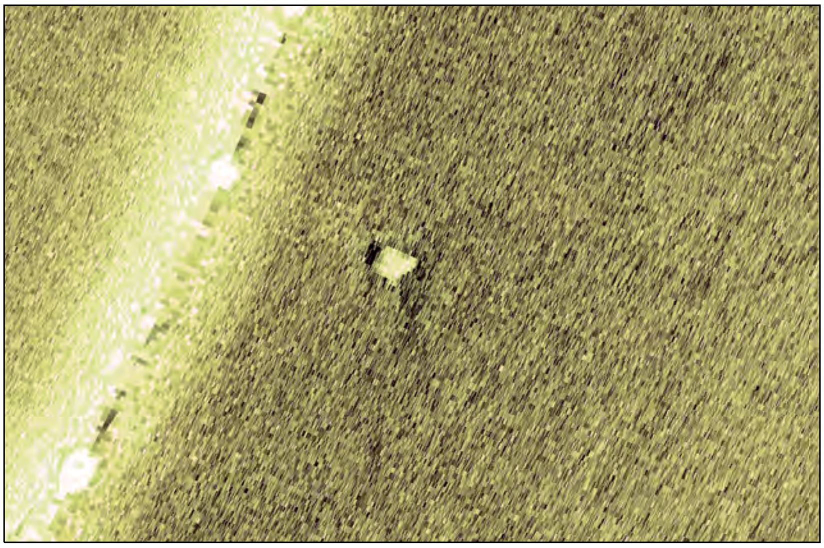
Figure 2



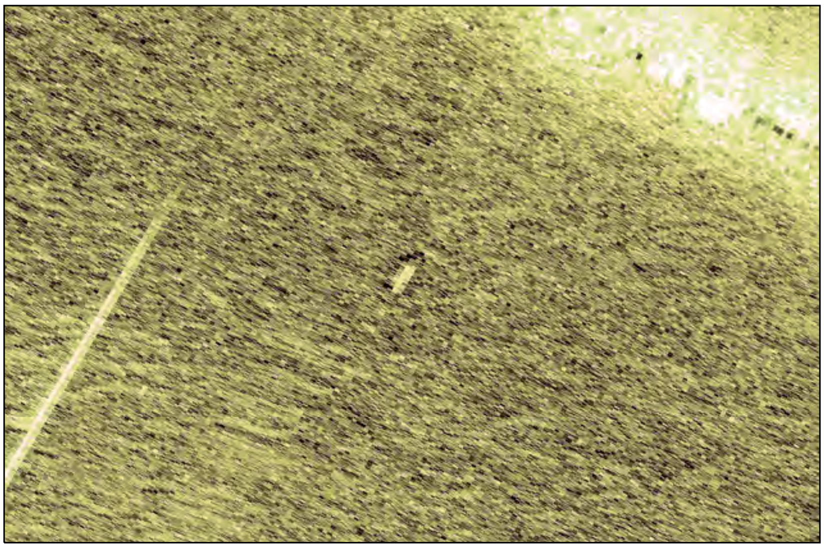
Sites subject to Archaeological Exclusion Zones

Figure 3





Feature 7023: Small object showing evidence of height, possibly debris (2.4m x 2.1m x 0.9m)



Feature 7039: Small object showing evidence of height, possibly debris (1.2m x 0.9m x 0.7m)

Drawing projection: UTM WGS84 zone 31N

0 10 20m

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Examples of sidescan sonar anomalies

Figure 4

WESSEX ARCHAEOLOGY LIMITED.
Head Office: Portway House, Old Sarum Park, Salisbury, Wiltshire SP4 6EB.
Tel: 01722 326867 Fax: 01722 337562 info@wessexarch.co.uk www.wessexarch.co.uk
London Office: Unit 113, The Chandlery, 50 Westminster Bridge Road, London SE1 7QY.
Tel: 020 7953 7494 Fax: 020 7953 7499 london-info@wessexarch.co.uk www.wessexarch.co.uk