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Stockendale Farm
Hunmanby
North Yorkshire

Geophysical Survey

June 2011

Report No. 2226

CLIENT
Myriad CEG Power Ltd

Stockendale Farm
Hunmanby
North Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering approximately 3 hectares was carried out to the south of Stockendale Farm, Hunmanby, at the site of two proposed wind turbines. Whilst the survey results are dominated by anomalies caused by near-surface geological variation, linear and discrete anomalies which may be of archaeological potential have also been identified. However, all anomalies are beyond the area that will be impacted by the development as currently proposed.

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Report Information

Client:	Myriad CEG Power Ltd.
Address:	Stockendale Farm, Hunmanby, North Yorkshire,
Report Type:	Geophysical survey
Location:	Hunmanby
County:	North Yorkshire
Grid Reference:	TA 071 773
Period(s) of activity: represented	Iron Age/Romano-British?
Report Number:	2226
Project Number:	3749
Site Code:	SFH11
Planning Application No.:	Pre-determination (Outline)
Museum Accession No.:	n/a
Date of fieldwork:	June 2011
Date of report:	June 2011
Project Management:	Sam Harrison BSc MSc AIfA
Fieldwork:	David Harrison BA MSc
	Alex Harrison BSc
Report:	Alistair Webb BA MIfA
Illustrations:	Alex Harrison
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Photography:	Alex Harrison
Research:	n/a

Authorisation for distribution: --

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1 Introduction

Archaeological Services WYAS was commissioned by Philip Mather of Myriad CEG Power Ltd to carry out a programme of non-intrusive geophysical (magnetometer) survey as part of pre-determination work to accompany a planning application for the proposed installation of two 11kw Gaia wind turbines at Stockendale Farm, North Yorkshire (see Fig. 1). The scheme of work was undertaken in accordance with the requirements of Planning Policy Statement 5. The survey was undertaken on June 2nd 2011.

Site location, topography and land-use

The site is located approximately 2km west of Hunmanby and 1km south of Stockendale Farm, centred at TA 071 773 (see Fig. 2), and is currently utilised as arable farmland. The survey comprised two separate areas totalling approximately 3 hectares. The main body of the survey (Area A) covered the proposed location of the two turbines and was under a maturing wheat crop (see Plate 1) whilst a much smaller adjoining area (Area B) covering the cable run was planted with potatoes (see Plate 2). The land was relatively flat at approximately 100m above Ordnance Datum.

Geology and soils

The solid geology comprises chalk of the Welton Chalk Formation which is overlain by superficial deposits of till and glaciofluvial drift. The soils are classified in the Hunstanton soil association which are characterised as deep, well-drained, loams.

2 Archaeological background

The proposed development site lies within a rich archaeological landscape with several archaeological monuments being known within the surrounding landscape. There are two scheduled monuments within a 1km radius of the proposed development. A round barrow (NY 818) lies 275m north of the site, whilst earthworks known as 'the camp' (NY 819) lie 715m to the south-west (see Fig. 1).

3 Aims, Methodology and Presentation

The general aim of the survey was to establish and clarify the potential for archaeological features as part of pre-determination evaluation works prior to the submission of a planning application for a small two turbine wind scheme. This information would then enable further, informed, decisions to be taken prior to the finalisation of the development proposals and in support of any planning application.

Specifically the aims were to provide information about the nature and possible interpretations of any magnetic anomalies identified during the survey and thereby determine the likely extent, presence or absence of any buried archaeological remains in and around the proposed locations of the turbines and cable routes.

Magnetometer survey

Bartington Grad601 magnetic gradiometers were used during the survey taking readings at 0.25m intervals on zig-zag traverses 1m apart within 30m by 30m grids so that 3600 readings were recorded in each grid. These readings were stored in the memory of the instrument and later downloaded to computer for processing and interpretation. Geoplot 3 (Geoscan Research) software was used to process and present the data. Further details are given in Appendix 1.

Reporting

A general site location plan, incorporating the Ordnance Survey map is shown in Figure 1. A large scale (1:1500) site location plan with processed greyscale magnetometer data and proposed turbine locations and cable routes is shown in Figure 2. The data are presented in greyscale and XY trace plot formats in Figure 3 and Figure 4 with an accompanying interpretation graphic included as Figure 5, all at a scale of 1:1000.

Further technical information on the equipment used, data processing and survey methodologies are given in Appendix 1 and Appendix 2. Appendix 3 describes the composition and location of the site archive.

The geophysical survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David *et al.* 2008) and by the IfA (Gaffney *et al.* 2002). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

The figures in this report have been produced following analysis of the data in 'raw' and processed formats and over a range of different display levels. All figures are presented to most suitably display and interpret the data from this site based on the experience and knowledge of Archaeological Services staff.

4 Results

The anomalies identified during the survey can be divided into four categories according to their interpreted origin.

Ferrous Anomalies

Ferrous anomalies either as individual 'spikes' or more extensive areas of magnetic disturbance are typically caused by ferrous (magnetic) material, either on the ground surface or in the ploughsoil. Little importance is normally given to such anomalies unless there is any supporting evidence for an archaeological interpretation, as modern ferrous objects or material are common on rural sites, often being present as a consequence of manuring or tipping/infilling. Throughout the site iron spike anomalies are common and there is no obvious pattern or clustering to their distribution to suggest anything other than random ferrous debris in the ploughsoil.

Geological Anomalies

The survey has identified numerous broad, low magnitude, magnetic fluctuations throughout Area A. These anomalies are interpreted as geological in origin being due to near-surface geological variation in the composition of the heterogeneous superficial till deposits.

Agricultural Anomalies

A series of parallel linear trend anomalies identified within Area B are caused by the mounded up rows of soil created for the potato crop.

Archaeological? Anomalies

Against this variable magnetic background anomalies of possible archaeological potential have been identified. In the north-eastern corner of the survey area, 75m due east of the proposed location of T1a, a small cluster of discrete anomalies, **A**, have been identified. These anomalies have been highlighted as they are of slightly greater magnetic strength than the geological anomalies. Twenty metres to the north of **A** are two other discrete anomalies, **B**. All these anomalies could be caused by archaeological features such as pits although a geological or modern origin cannot be discounted.

At the southern end of the main survey area a fragmentary linear anomaly, **C**, is clearly identified running east/west across the data just to the south of the proposed location of T2a. This may be caused by an infilled archaeological ditch. A curvilinear anomaly, **D**, and another cluster of discrete anomalies, **E**, both to the south of the linear ditch feature, are also considered to be of some archaeological potential.

5 Discussion and Conclusions

The survey has identified anomalies that could be caused by archaeological features such as ditches and pits. The presence of such features within a landscape of high archaeological potential should not be considered unexpected. However, the location of the turbines as currently proposed is not likely to result in any direct impact of these features, should they prove to be archaeological.

In conclusion the survey has identified features of some archaeological potential but the current proposals are unlikely to adversely affect these features.

The results and subsequent interpretation of data from geophysical surveys should not be treated as an absolute representation of the underlying archaeological and non-archaeological remains. Confirmation of the presence or absence of archaeological remains can only be achieved by direct investigation of sub-surface deposits.

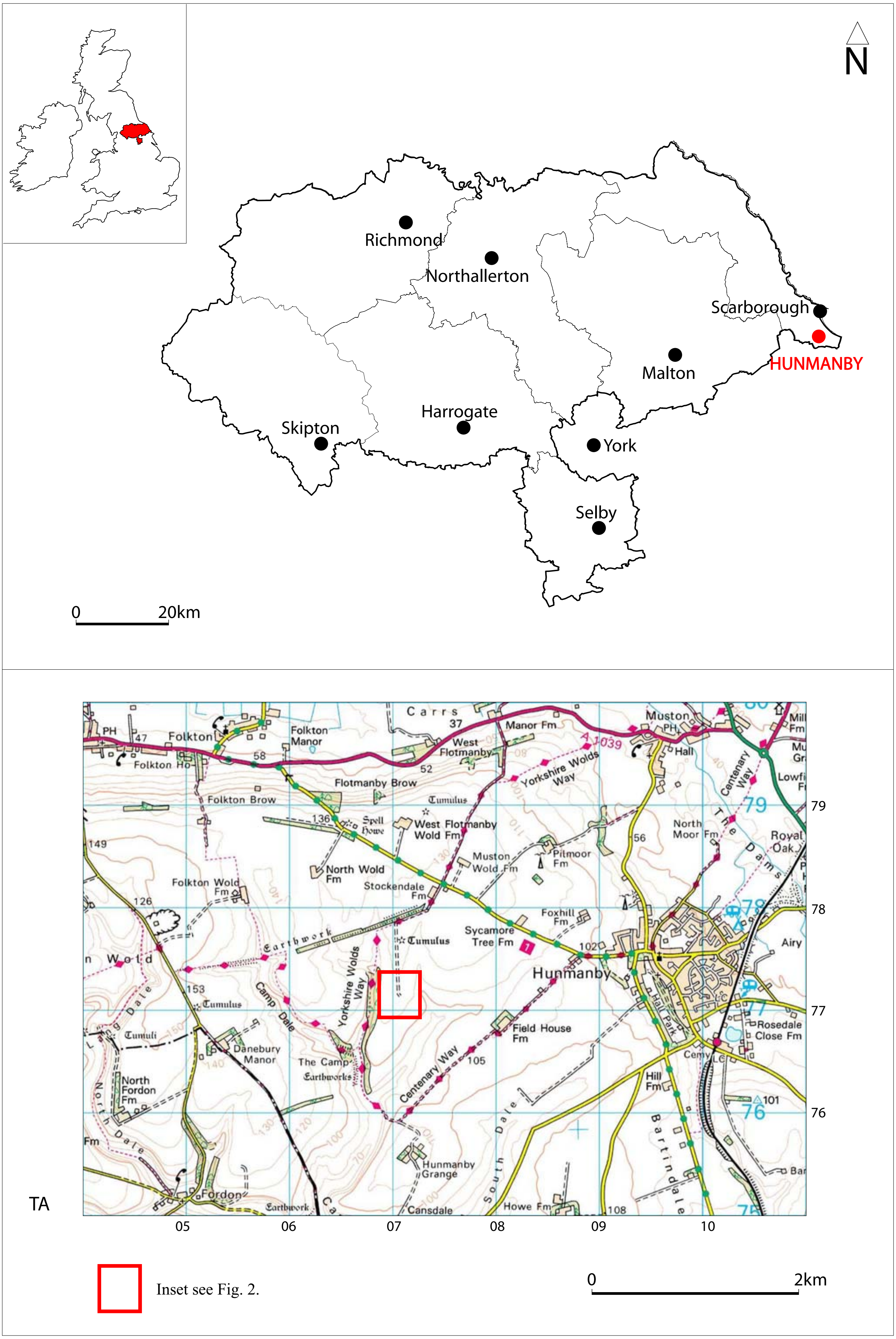

Fig. 1. Site location

Fig. 2. Site location showing greyscale magnetometer data (1:1500 @ A4)

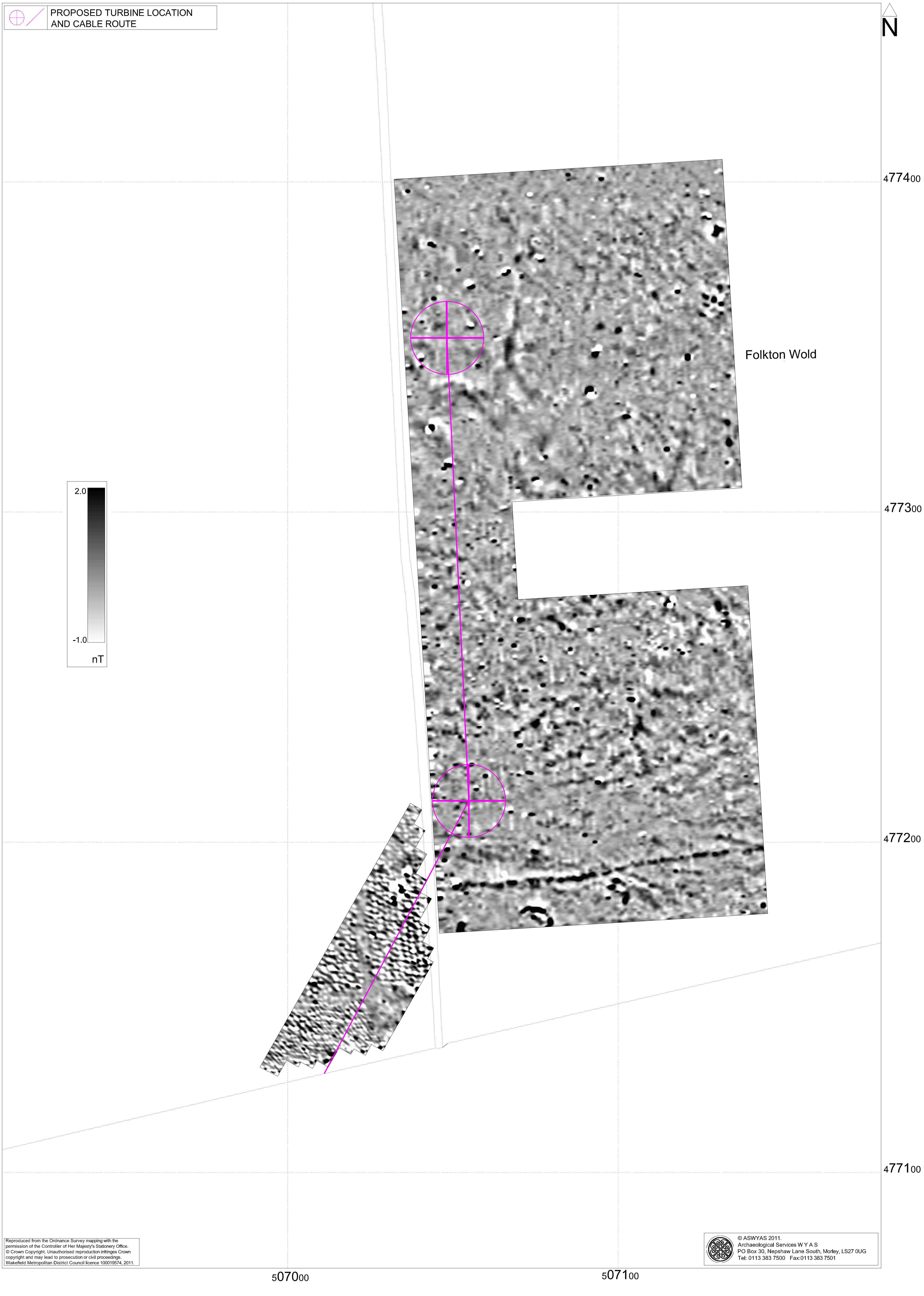

Fig. 3. Processed greyscale magnetometer data (1:1000 @ A3)

0 50m

Fig. 4. XY trace plot of minimally processed magnetometer data (1:1000 @ A3)

Fig. 5. Interpretation of magnetometer data (1:1000 @ A3)

Plate 1. General view of area A; looking north

Plate 2. General view of area B; looking north

Appendix 1: Magnetic survey - technical information

Magnetic Susceptibility and Soil Magnetism

Iron makes up about 6% of the Earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haemetite. These minerals have a weak, measurable magnetic property termed magnetic susceptibility. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil, areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

In general, it is the contrast between the magnetic susceptibility of deposits filling cut features, such as ditches or pits, and the magnetic susceptibility of topsoils, subsoils and rocks into which these features have been cut, which causes the most recognisable responses. This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features cut into the subsoil or geology, such as ditches, that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels. Discrete feature, such as pits, can also be detected. The magnetic susceptibility of a soil can also be enhanced by the application of heat and the fermentation and bacterial effects associated with rubbish decomposition. The area of enhancement is usually quite large, mainly due to the tendency of discard areas to extend beyond the limit of the occupation site itself, and spreading by the plough. An advantage of magnetic susceptibility over magnetometry is that a certain amount of occupational activity will cause the same proportional change in susceptibility, however weakly magnetic is the soil, and so does not depend on the magnetic contrast between the topsoil and deeper layers. Susceptibility survey is therefore able to detect areas of occupation even in the absence of cut features. On the other hand susceptibility survey is more vulnerable to the masking effects of layers of colluvium and alluvium as the technique, using the Bartington system, can generally only measure variation in the first 0.15m of ploughsoil.

Types of Magnetic Anomaly

In the majority of instances anomalies are termed 'positive'. This means that they have a positive magnetic value relative to the magnetic background on any given site. However some features can manifest themselves as 'negative' anomalies that, conversely, means that the response is negative relative to the mean magnetic background.

Where it is not possible to give a probable cause of an observed anomaly a '?' is appended.

It should be noted that anomalies interpreted as modern in origin might be caused by features that are present in the topsoil or upper layers of the subsoil. Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly.

The types of response mentioned above can be divided into five main categories that are used in the graphical interpretation of the magnetic data:

Isolated dipolar anomalies (iron spikes)

These responses are typically caused by ferrous material either on the surface or in the topsoil. They cause a rapid variation in the magnetic response giving a characteristic 'spiky' trace. Although ferrous archaeological artefacts could produce this type of response, unless there is supporting evidence for an archaeological interpretation, little emphasis is normally given to such anomalies, as modern ferrous objects are common on rural sites, often being present as a consequence of manuring.

Areas of magnetic disturbance

These responses can have several causes often being associated with burnt material, such as slag waste or brick rubble or other strongly magnetised/fired material. Ferrous structures such as pylons, mesh or barbed wire fencing and buried pipes can also cause the same disturbed response. A modern origin is usually assumed unless there is other supporting information.

Linear trend

This is usually a weak or broad linear anomaly of unknown cause or date. These anomalies are often caused by agricultural activity, either ploughing or land drains being a common cause.

Areas of magnetic enhancement/positive isolated anomalies

Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an XY trace plot) on two or three successive traverses. In neither instance is there the intense dipolar response characteristic exhibited by an area of magnetic disturbance or of an 'iron spike' anomaly (see above). These anomalies can be caused by infilled discrete archaeological features such as pits or post-holes or by kilns. They can also be caused by pedological variations or by natural infilled features on certain geologies. Ferrous material in the subsoil can also give a similar response. It can often therefore be very difficult to establish an anthropogenic origin without intrusive investigation or other supporting information.

Linear and curvilinear anomalies

Such anomalies have a variety of origins. They may be caused by agricultural practice (recent ploughing trends, earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by infilled archaeological ditches.

Methodology: Magnetic Susceptibility Survey

There are two methods of measuring the magnetic susceptibility of a soil sample. The first involves the measurement of a given volume of soil, which will include any air and moisture that lies within the sample, and is termed volume specific susceptibility. This method results in a bulk value that it not necessarily fully representative of the constituent components of the sample. For field surveys a Bartington MS2 meter with MS2D field loop is used due to its speed and simplicity. The second technique overcomes this potential problem by taking into account both the volume and mass of a sample and is termed mass specific susceptibility. However, mass specific readings cannot be taken in the field where the bulk properties of a soil are usually unknown and so volume specific readings must be taken. Whilst these values are not fully representative they do allow general comparisons across a site and give a broad indication of susceptibility changes. This is usually enough to assess the susceptibility of a site and evaluate whether enhancement has occurred.

Methodology: Gradiometer Survey

There are two main methods of using the fluxgate gradiometer for commercial evaluations. The first of these is referred to as ***magnetic scanning*** and requires the operator to visually identify anomalous responses on the instrument display panel whilst covering the site in widely spaced traverses, typically 10m apart. The instrument logger is not used and there is therefore no data collection. Once anomalous responses are identified they are marked in the field with bamboo canes and approximately located on a base plan. This method is usually employed as a means of selecting areas for detailed survey when only a percentage sample of the whole site is to be subject to detailed survey.

The disadvantages of magnetic scanning are that features that produce weak anomalies (less than 2nT) are unlikely to stand out from the magnetic background and so will be difficult to detect. The coarse sampling interval means that discrete features or linear features that are parallel or broadly oblique to the direction of traverse may not be detected. If linear features are suspected in a site then the traverse direction should be perpendicular (or as close as is possible within the physical constraints of the site) to the orientation of the suspected features. The possible drawbacks mentioned above mean that a ‘negative’ scanning result should be validated by sample detailed magnetic survey (see below).

The second method is referred to as ***detailed survey*** and employs the use of a sample trigger to automatically take readings at predetermined points, typically at 0.25m intervals, on zig-zag traverses 1m apart. These readings are stored in the memory of the instrument and are later dumped to computer for processing and interpretation. Detailed survey allows the visualisation of weaker anomalies that may not have been detected by magnetic scanning.

During this survey a Bartington Grad601 magnetic gradiometer was used taking readings on the 0.1nT range, at 0.25m intervals on zig-zag traverses 1m apart within 30m by 30m square grids. The instrument was checked for electronic and mechanical drift at a common point and calibrated as necessary. The drift from zero was not logged.

Data Processing and Presentation

The detailed gradiometer data has been presented in this report in XY trace and greyscale formats. In the former format the data shown is 'raw' with no processing other than grid biasing having been done. The data in the greyscale images has been interpolated and selectively filtered to remove the effects of drift in instrument calibration and other artificial data constructs and to maximise the clarity and interpretability of the archaeological anomalies.

An XY plot presents the data logged on each traverse as a single line with each successive traverse incremented on the Y-axis to produce a 'stacked' plot. A hidden line algorithm has been employed to block out lines behind major 'spikes' and the data has been clipped. The main advantage of this display option is that the full range of data can be viewed, dependent on the clip, so that the 'shape' of individual anomalies can be discerned and potentially archaeological anomalies differentiated from 'iron spikes'. Geoplot 3 software was used to create the XY trace plots.

Geoplot 3 software was used to interpolate the data so that 3600 readings were obtained for each 30m by 30m grid. The same program was used to produce the greyscale images. All greyscale plots are displayed using a linear incremental scale.

Appendix 2: Survey location information

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). The accuracy of this equipment is better then 0.01m. The locations of the temporary reference points left on site are shown on Figure 2 and the Ordnance Survey grid co-ordinates tabulated below. The internal accuracy of the survey grid relative to these markers is better than 0.05m. The survey grids were then superimposed onto a map base provided by the client as a 'best fit' to produce the displayed block locations. Overall there was a good correlation between the local survey and the digital map base and it is estimated that the average 'best fit' error is better than ±1.5m. However, it should be noted that Ordnance Survey co-ordinates for 1:2500 map data have an error of ±1.9m at 95% confidence. This potential error must be considered if co-ordinates are measured off for relocation purposes.

Station	**Easting**	**Northing**	**Elevation (aOD)**
A	507118.8130	477155.8550	114.39m
B	507050.9290	477140.5270	116.15m
C	507027.1100	477502.1510	121.98m

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.

Appendix 3: Geophysical archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Microsoft Word 2000), and graphics files (Adobe Illustrator CS2 and AutoCAD 2008) files.
- a full copy of the report

At present the archive is held by Archaeological Services WYAS although it is anticipated that it may eventually be lodged with the Archaeology Data Service (ADS). Brief details may also be forwarded for inclusion on the English Heritage Geophysical Survey Database after the contents of the report are deemed to be in the public domain (i.e. available for consultation in the relevant Historic Environment Record).

Bibliography

David, A., N. Linford, P. Linford and L. Martin, 2008. *Geophysical Survey in Archaeological Field Evaluation: Research and Professional Services Guidelines (2nd edition)* English Heritage

Gaffney, C., Gater, J. and Ovenden, S. 2002. *The Use of Geophysical Techniques in Archaeological Evaluations*. IFA Technical Paper No. 6