ARCHAEOLOGICAL SERVICES WYAS

Land north of Dotterel Cottage
Weaverthorpe
North Yorkshire

Geophysical Survey

Report no. 2305

February 2012

Client: Hyder Consulting (UK) Ltd.

REGISTERED ORGANISATION IfA

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Weaverthorpe
North Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering approximately 1 hectare, was carried out on agricultural land to the north of Dotterel Cottage, Weaverthorpe, in advance of the determination of a planning application for the erection of a single wind turbine. No anomalies of probable archaeological potential have been identified although a cluster of low magnitude anomalies may indicate an area of plough-damaged archaeological remains. However, a geological or pedological interpretation is considered equally possible. Based on the surrounding landscape features and the geophysical survey the site is considered to have a low to moderate archaeological potential.

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Report Information

Client:	Hyder Consulting (UK) Limited
Address:	The Mill, Brimscome Port, Stroud, Gloucestershire, GL5 2QG
Report Type:	Geophysical survey
Location:	Dotterel Cottage
County:	North Yorkshire
Grid Reference:	SE 956 717
Period(s) of activity: represented	n/a
Report Number:	2305
Project Number:	3863
Site Code:	DOT12
Planning Application No.:	Pre-determination (Outline)
Museum Accession No.:	n/a
Date of fieldwork:	January 2012
Date of report:	February 2012
Project Management:	Sam Harrison BSc MSc AIfA
Fieldwork:	Christopher Sykes BA MSc Alex Harrison BSc
Report:	Sam Harrison and Christopher Sykes
Illustrations:	Sam Harrison and Christopher Sykes
Photography:	Christopher Sykes
Research:	n/a

Authorisation for distribution: ---

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1 Introduction

Archaeological Services WYAS was commissioned by Jenny Wylie of Hyder consulting (UK) Ltd, on behalf of her client All Wind (UK) Ltd, to carry out a programme of non-intrusive geophysical (magnetometer) survey as part of pre-determination work to accompany a planning application for a proposed wind turbine on land to the north of Dotterel Cottage (see Fig. 1). The scheme of work was undertaken in accordance with the requirements of Planning Policy Statement 5 and was carried out on January 25th 2012.

Site location, topography and land-use

The site lies to the north of Dotterel Cottage, approximately 1.2km north-west of Weaverthorpe (see Fig. 2), centred on SE 956 717. It is bounded by broken hedge boundaries and a trackway to the west and north.

The site is currently under arable cultivation (see Plates), and is located at 135m above Ordnance Datum (aOD), sloping to the south, and the east at the survey area extent.

Geology and soils

The geology comprises Welton and Burnham Chalk formations (BGS 2012) overlain by soils classified in the Andover 1 association. These soils are characterised as shallow and well draining silts (SSEW 1983).

2 Archaeological background

The following archaeological background is summarised from baseline information provided by the client. A more detailed and comprehensive assessment of the archaeological background will be contained within the Cultural Heritage Desk-based Assessment, currently in preparation (Wylie 2012).

The study area is located within the north central section of the Yorkshire Wolds. This area contains a large network of linear earthworks and trackways which began in the Bronze Age and remained in use, developing and changing through the Iron Age and Roman period. Also present in this area are Bronze Age defended enclosures delineated, or enclosed, by linear earthworks. Finds of animal bones at Grimthorpe and Thwing suggest that these early enclosures were associated with cattle rearing. These enclosed areas were extended and added to in the Iron Age (Stoertz 1997).

Along the access track, south of Dotterell Cottage, are more crop marks indicating both linear features and enclosures (see Fig. 2). It is likely that these features originated in the Prehistoric period but their use may have continued on into the Roman period. A possible barrow cemetery has been recorded 1km to the west of the survey area. The cemetery is made up of a group of six ring ditches visible as cropmarks.

A Prehistoric pit alignment also visible as cropmarks, is located 500m to the north of the survey area on an east/west alignment. The pit alignment is recorded as running for at least 2 kilometres. It is likely that the pit alignment formed a boundary in the Prehistoric period.

To the north-east of the survey area an earthwork signifies the site of a post-medieval cultivation terrace (see Fig. 2).

3 Aims, Methodology and Presentation

The general objective of the geophysical survey was to provide information about the nature and possible interpretation of any magnetic anomalies identified and to therefore determine the presence/absence and extent of any buried archaeological features. The results of the survey will help inform the planning application and determine what, if any, further archaeological work may be required in advance of, or during, the proposed development.

To achieve this aim a magnetometer survey covering 1 hectare, centred on the proposed location of the turbine, was carried out. The survey of a larger area than will be impacted by the proposed development allows the micro-siting of the turbine, without the need for further survey, should obvious archaeological features be identified at the preferred location.

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 (1:5000) site location plan showing the processed magnetometer data and cropmarks is shown in Figure 2. The data are presented in greyscale, XY trace plot and interpretation formats in Figures 3, 4 and 5 inclusive, 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 Institute for Archaeologists (IfA 2010). 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) debris, either on the ground surface or mixed in with the plough-soil. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation, as modern ferrous debris is 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 pieces of ferrous material in the plough-soil.

Geological Anomalies

Numerous discrete anomalies, identified as localised, low magnitude, magnetic anomalies are present throughout the survey area. These anomalies are interpreted as geological in origin being due to variations in the composition of the soils and sub-soils.

Agricultural Anomalies

Numerous parallel linear anomalies have been identified in the survey. These are considered to be too close together for ridge and furrow cultivation and are therefore interpreted as being caused by modern agricultural ploughing.

Possible Archaeological Anomalies

A cluster of localised, low magnitude, anomalies have been interpreted as possibly archaeological in origin. It is possible that these are the plough damaged remains of archaeological features or a large cluster of discrete features. However, a similar geological origin as above cannot be discounted. These anomalies have been identified as of archaeological potential due to their elevated enhancement, relative to those ascribed a geological origin.

5 Discussion and Conclusions

No anomalies of probable archaeological origin have been identified by the geophysical survey on this site. A cluster of localised anomalies of possible archaeological potential has been identified in the east of the survey area which may indicate plough-damaged archaeological remains. However, the fragmentary nature of these anomalies leaves interpretation tentative and a pedological interpretation is equally viable.

Although the survey is located in a landscape utilised for funerary activity between the Bronze Age through to the Iron Age or Romano-British periods, no evidence of definite archaeological activity has been identified. The cluster of possible archaeological anomalies may be indicative of prehistoric features, given that the surrounding landscape includes a number of barrows, linear alignments and a large pit alignment. On this basis of the geophysical survey the archaeological potential the site is considered to be low to moderate.

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.

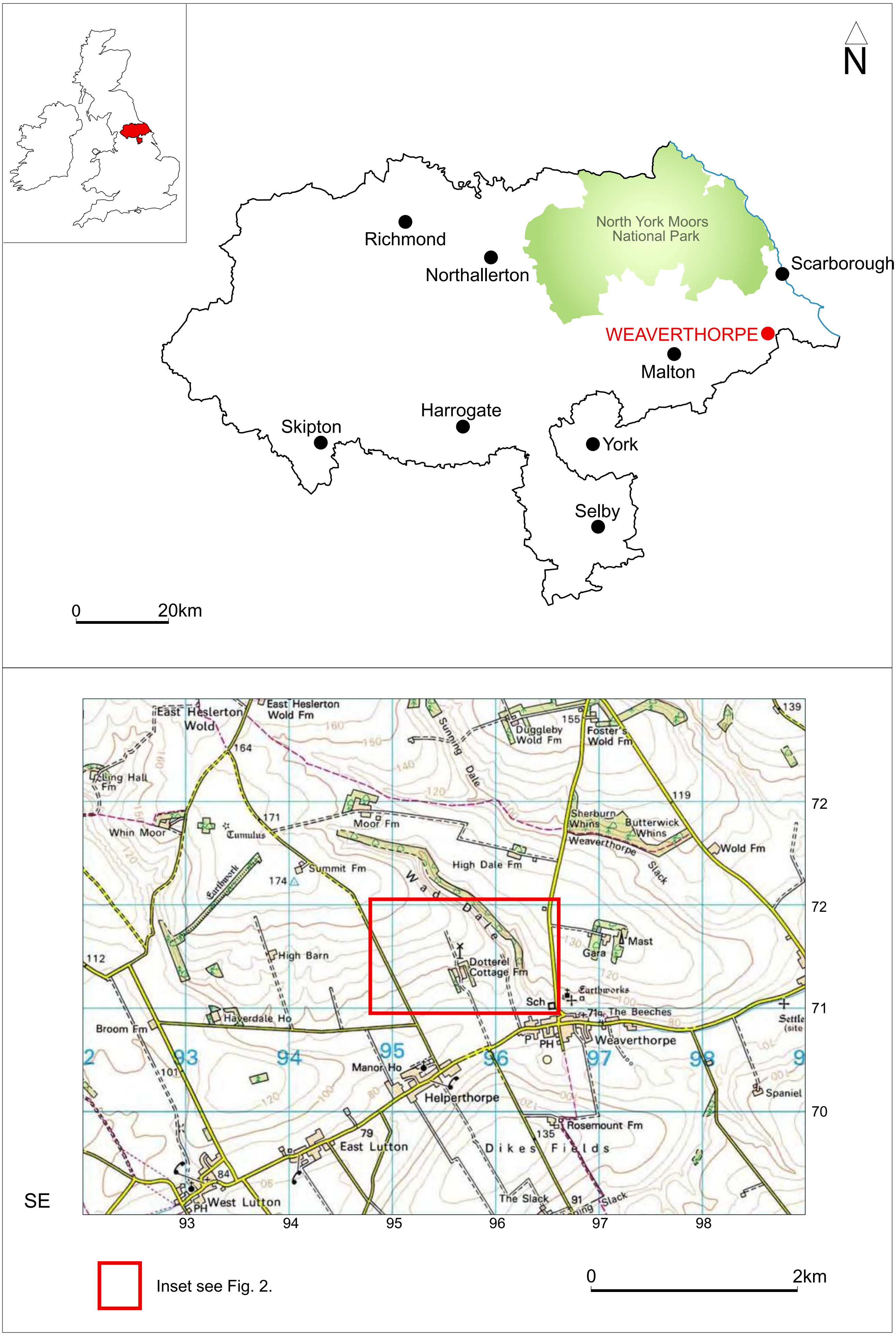

Fig. 1. Site location

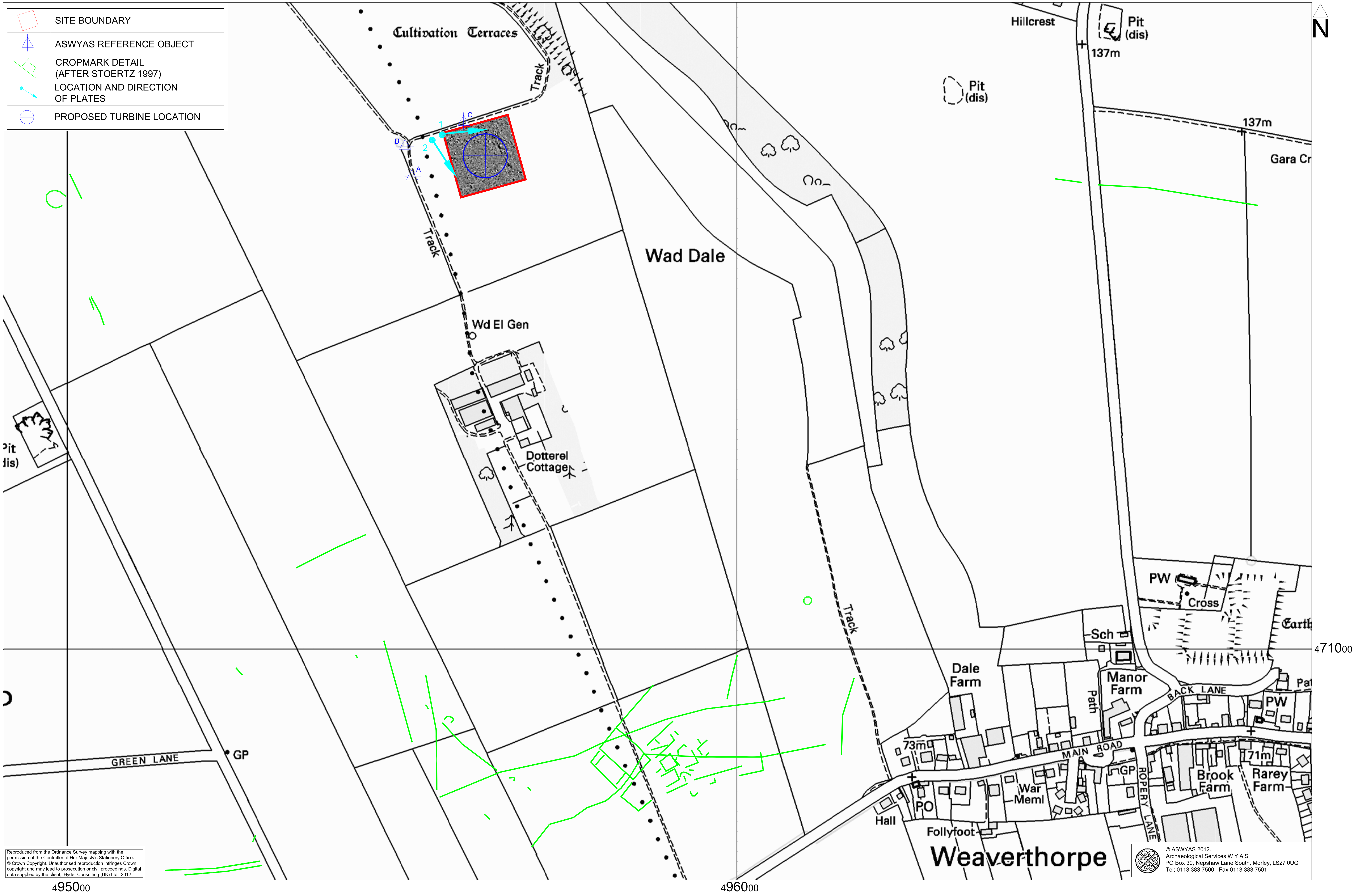

Fig. 2. Site location showing survey area and cropmark detail (after Stoertz 1997) (1:5000 @ A3)

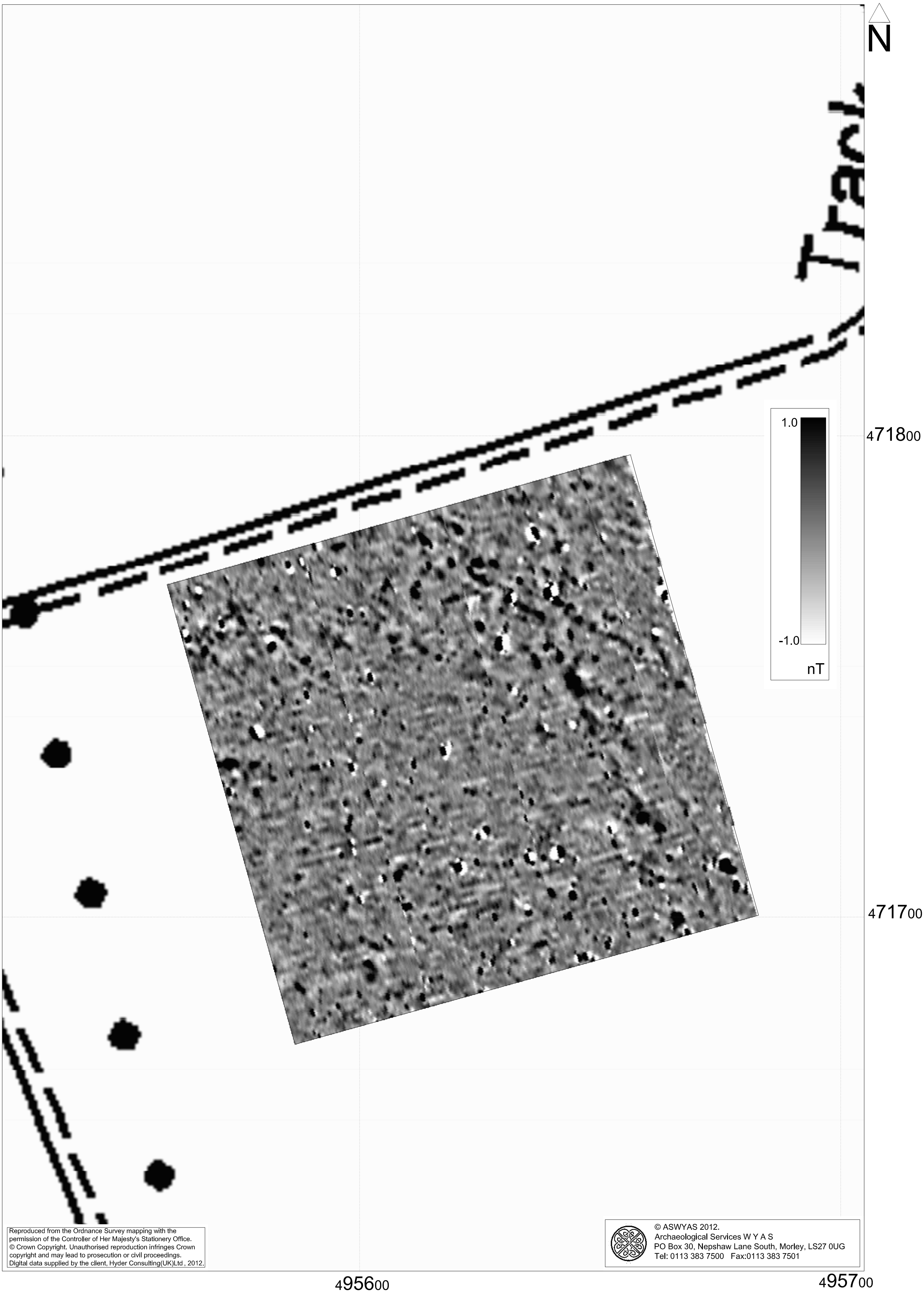

Fig. 3. Processed greyscale magnetometer data (1:1000 @ A4)

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Fig. 4. XY trace plot of minimally processed magnetometer data (1:1000 @ A4)

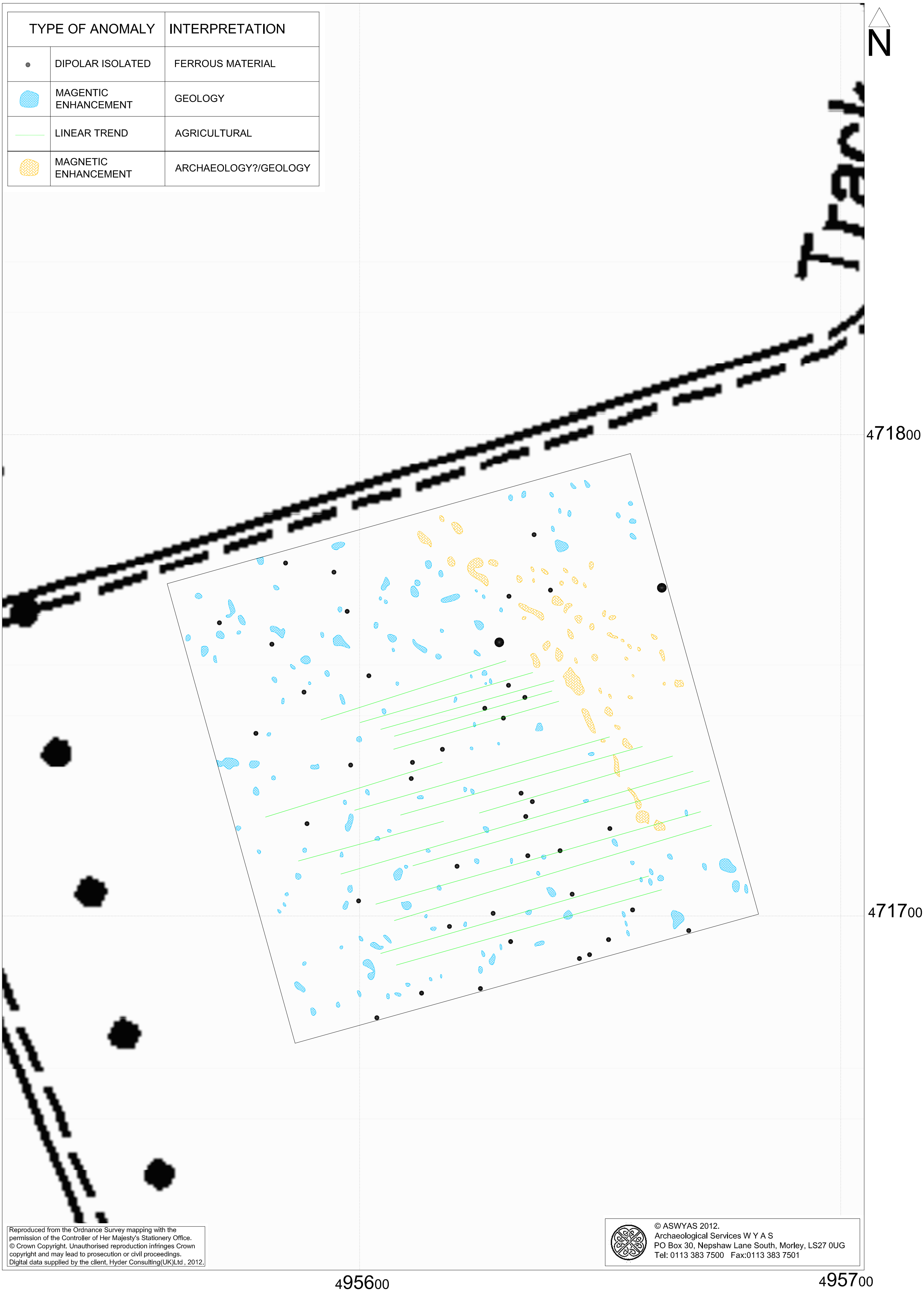

Fig. 5. Interpretation of magnetometer data (1:1000 @ A4)

Plate 1. General view of survey area, looking east

Plate 2. General view of survey area, looking south

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 Geodimeter 600s total station theodolite and tied in to the corners of buildings and other permanent landscape features and to temporary reference points (survey marker stakes) that were established and left in place following completion of the fieldwork for accurate geo-referencing. The locations of the temporary reference points 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**
A	495514.2695	471704.7222
B	495504.0869	471750.2517
C	495591.4324	471786.0677

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; and
- 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).

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