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SERVICES
WYAS

Whitby Park and Ride
Whitby
North Yorkshire

Geophysical Survey

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Report No. 1615

CLIENT
Golder Associates (UK) Ltd

Whitby Park and Ride

Whitby

North Yorkshire

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Contents

Summary

A geophysical (magnetometer) survey covering 4 2 hectares was carried out on land off the A 171 near Newholm, Whitby, where it is proposed to locate a Park and Ride facility Linear anomalies indicative of ridge and furrow ploughing and trends indicative of more recent ploughing have been identified Numerous anomalies interpreted as being due to variations in the drift geology have also been located A degree of linearity exhibited by a series of discrete anomalies could be indicative of an anthropogenic cause but overall, on the basis of the magnetometer survey, the site is considered to have a low archaeological potential

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Archaeological Services WYAS
PO Box 30, Nepshaw Lane South, Morley, Leeds LS27 0UG

1. Introduction and Archaeological Background

1 1 Archaeological Services WYAS was commissioned by Paul Wheelhouse of Colder Associates (UK) to undertake a geophysical (magnetometer) survey at the proposed site of a Park and Ride facility, south-east of Newholm to the west of Whitby (see Fig 1)

1 2 The proposed site, centred at NZ 4872 5100, comprises a triangular block of agricultural land, approximately 4 2ha in extent, at the intersection of Barkers Lane to the north, the A 171 Guisborough Road to the south and the B 1460 to the east Another pasture field to the west bounds the remainder of the site (see Fig 2) The whole area is within the North York Moors National Park

1 3 At the time of the fieldwork (between November 20th and 21st 2006) the field was under rough pasture No problems were encountered during the survey

1 4 Topographically, the site lies between 90m and 100m Above Ordnance Datum (AOD) being situated on ground that rises up to the moorland plateau west of the site The site geology comprises Long Nab Member Mudstone and sandstone (Scalby Formation) overlain by reddish (glacial) till drift deposits The soils are fine loamy over clayey soils with slowly permeable sub soils and slight seasonal waterlogging and are classified in the Flint association

1 5 The archaeological potential of the site was assessed in the Cultural Heritage chapter of an Environmental Impact Assessment scoping study (Golder Associates 2006) The assessment concluded "*the area does have some potential for pre-medieval archaeological sites, in particular prehistoric settlements and field systems*" Although no archaeological sites were identified within the proposal area, cropmarks which are possibly indicative of prehistoric field systems have been recorded less than 0 5km from the site, to the south of Cross Butts Farm (Sites 6 and 7 - see Fig 2) The westernmost site (6) possibly contained a ring ditch or burial mound First edition Ordnance Survey mapping of 1853 (Sheet no 32) shows the site divided in two by a north-south aligned field boundary

2. Methodology and Presentation

2 1 Based on the identified archaeological potential of the site it was proposed (in the EIA) that a magnetometer survey should be carried out as a first stage mitigation measure, the general aim of the survey would be to obtain information that would contribute to a greater understanding of the archaeological potential of the site

2 2 As the site was relatively small (4 2ha) it was proposed that detailed (recorded) magnetometer survey would be carried out over the whole of the area likely to be affected by the proposed scheme

2 3 Detailed survey employs the use of a sample trigger to automatically take readings at predetermined points, typically at 0 25m intervals, on traverses 1m apart These readings are stored in the memory of the instrument and are later downloaded to computer for processing and interpretation Further details are given in Appendix 1 Detailed survey allows the visualisation of weaker anomalies that may not have been readily identifiable by magnetic scanning

2 4 A Bartington Grad601 magnetic gradiometer was used during the survey with readings being taken at 0 25m intervals on zig-zag traverses 1m apart within 20m by 20m grids The readings were stored in the memory of the instrument and later downloaded to computer for processing and interpretation using Geoplot 3 software

2 5 The survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David 1995) and by the IFA (Gaffney, Gater and Ovenden 2002) All figures reproduced from Ordnance Survey mapping are done so with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright)

2 6 A general site location plan, incorporating the 1 50000 Ordnance Survey mapping, is shown in Figure 1 Figure 2 shows the processed magnetometer data superimposed onto a map base at a scale of 1 4000 The processed (greyscale) and unprocessed (XY trace plot) data, together with accompanying interpretation diagram, are presented in Figures 3, 4 and 5 at a scale of 1 1000

2 7 Technical information on the equipment used, data processing and magnetic survey methodology is given in Appendix 1 Appendix 2 details the survey location information and Appendix 3 describes the composition and location of the site archive

3. *Results*

3 1 Several dipolar discrete anomalies are present across the site These anomalies are indicative of ferrous objects or other magnetic material in the topsoil/subsoil and, although archaeological artefacts may cause them, they are more often caused by modern cultural debris that has been introduced into the topsoil often as a consequence of manuring or public access Areas of magnetic disturbance at the site limits are caused by barbed wire in the hedge to the north of the site and by the proximity of a road sign in the case of the area of magnetic disturbance at the eastern site apex

3 2 Several parallel linear trend anomalies have been identified in the data The slightly curvilinear, S-shaped, striations indicative of ridge and furrow ploughing are clearly visible in the western half of the site, running north to south parallel with the former field boundary shown on the first edition Ordnance Survey mapping (see Fig 5) These anomalies are due to the magnetic contrasts between infilled furrows and former ridges

3 3 Other less visible linear trends have been noted aligned north-east to south-west, parallel with Guisborough Road These trends reflect the direction of recent ploughing

3 4 A large number of irregular anomalies comprising discrete areas of enhanced magnetic response have been identified across all parts of the site, with a particular concentration in a band across the centre of the site aligned east-west and another cluster towards the eastern corner The erratic and essentially random nature of these anomalies would seem to point to a geological rather than an archaeological origin, although in some places the anomalies do seem to have a more anthropogenic appearance, one such linear arrangement of anomalies has been tentatively interpreted as potentially archaeological However, a geological origin is considered equally likely

4. Discussion and Conclusions

4.1 Evidence for ridge and furrow ploughing has been identified in the western half of the site. The limits of this former agricultural practice are defined by a north/south aligned field boundary shown on first edition mapping.

4.2 Strong geological responses have been identified throughout the site. It is thought that these anomalies are due to magnetic variations in the material comprising the till drift deposits.

4.3 Although a single (discontinuous) anomaly has been identified as potentially archaeological, on the basis of the magnetometer survey, the archaeological potential of the site is considered to be low.

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.

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.

Bibliography

David, A , 1995 *Geophysical Survey in Archaeological Field Evaluation Research and Professional Services Guidelines* No 1 English Heritage

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

Golder Associates (UK) Limited, 2006 *Report on: Environmental Impact Assessment, Scoping Study, Whitby Park & Ride Facility, North Yorkshire*

Acknowledgements

Project Management

A Webb BA MIFA

Fieldwork

J Gidman BSc

K Munster BSc

Report

J Gidman

Graphics

J Gidman

K Munster

Figures

Appendices

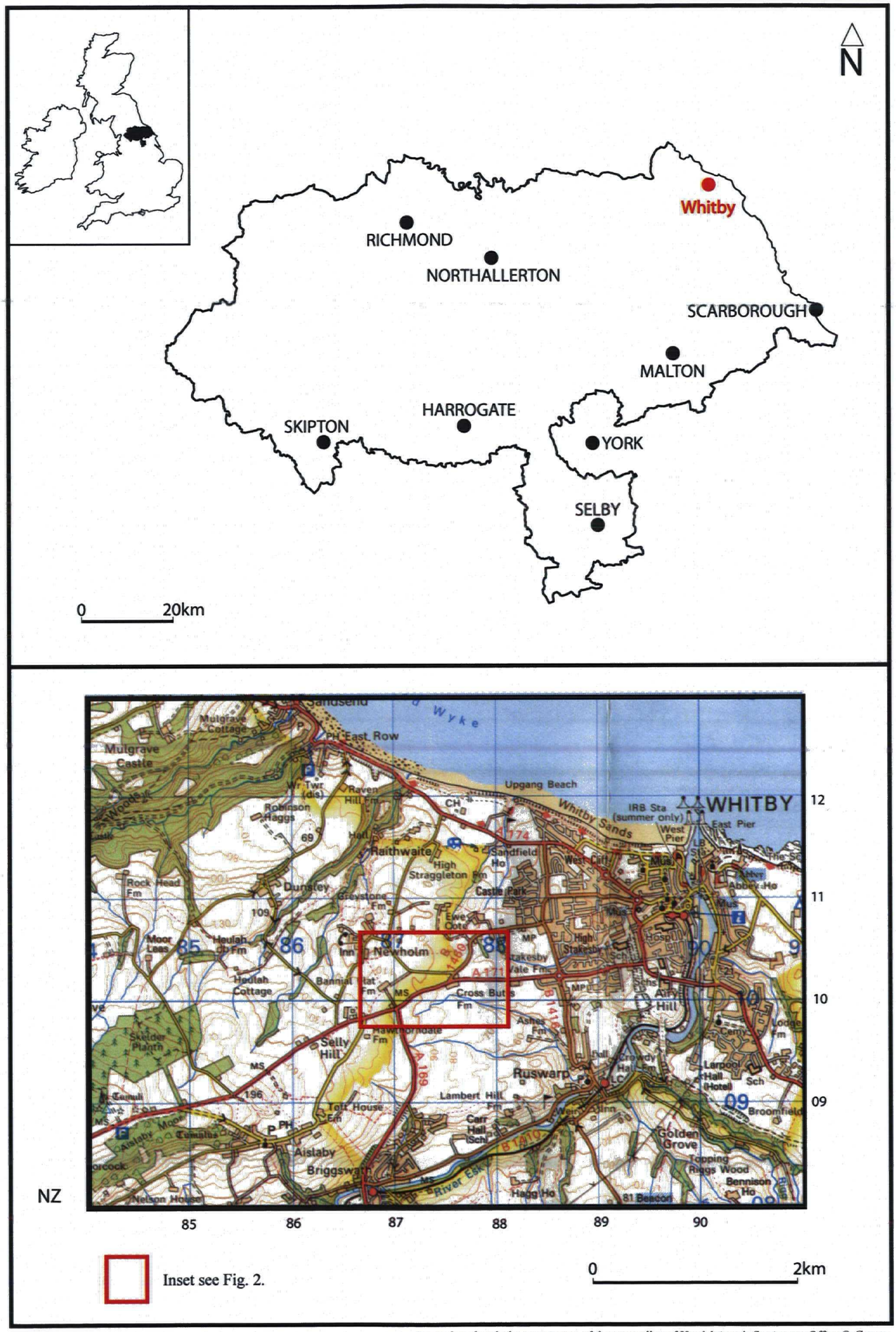

Fig. 1. Site location

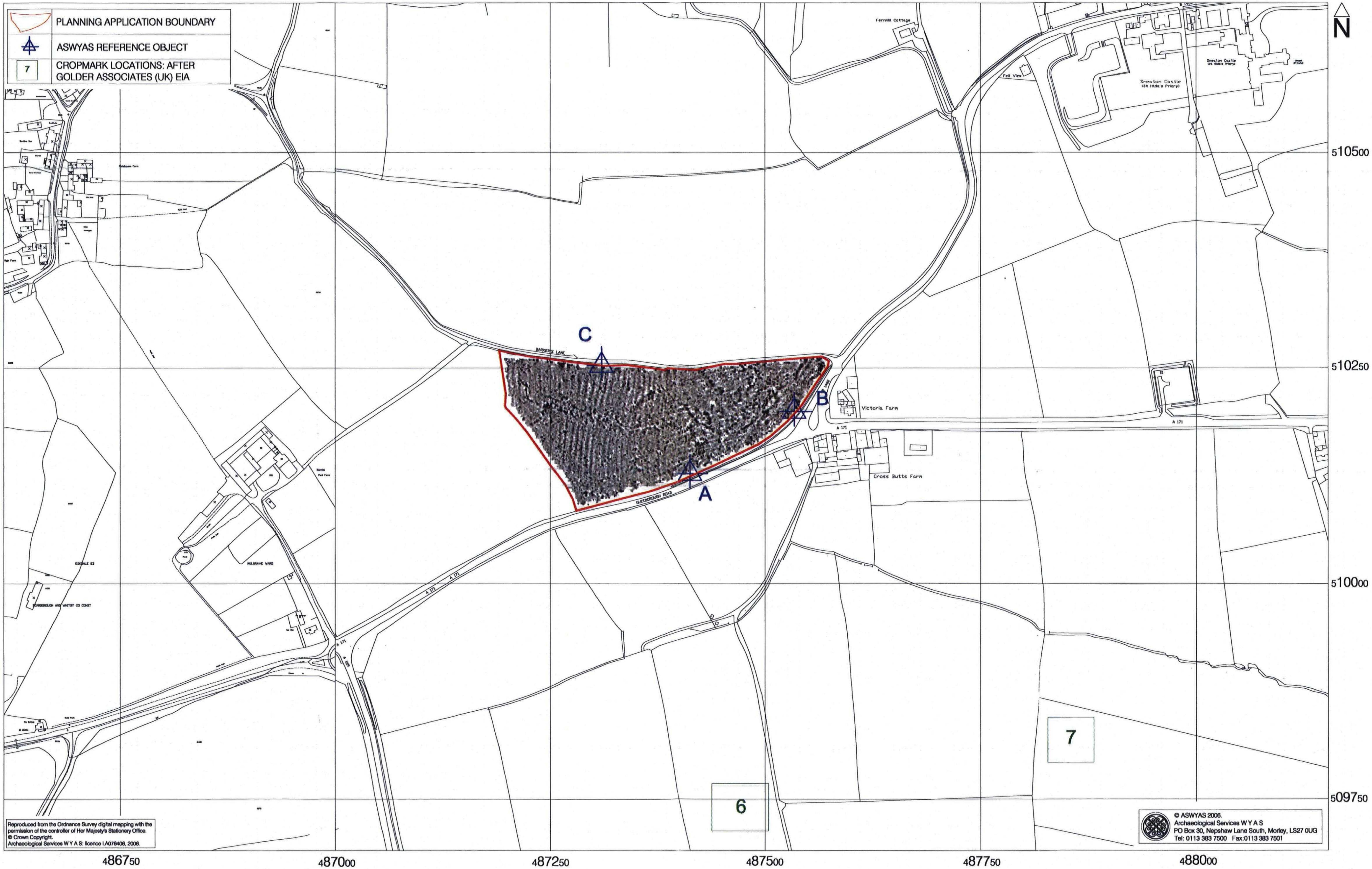

Fig. 2. Site location showing greyscale magnetometer data (1:4000 @ A3)

0 200m

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

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

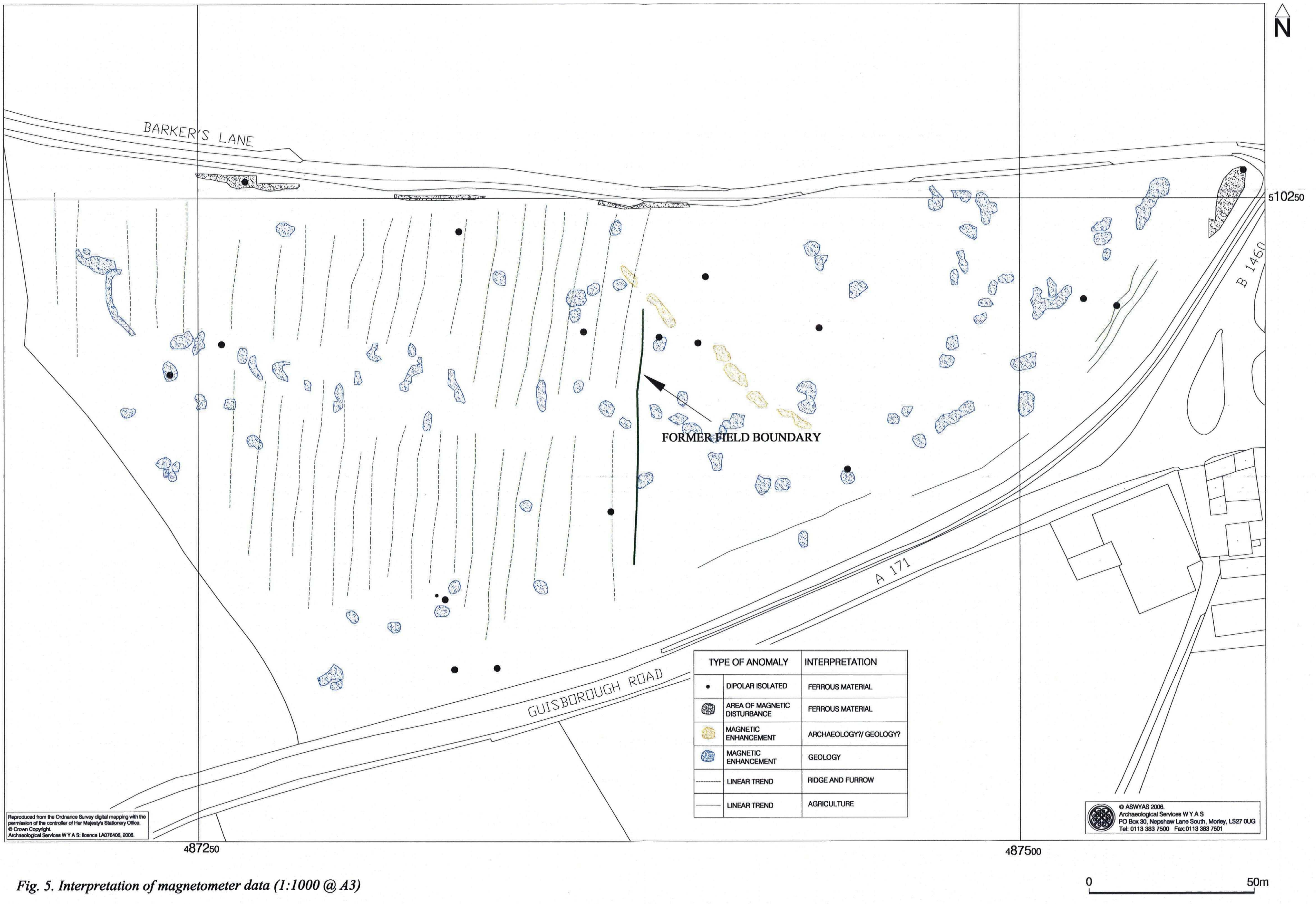

Fig. 5. Interpretation of magnetometer data (1:1000 @ A3)

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. Less magnetic material such as masonry or plastic service pipes that intrude into the topsoil may give a negative magnetic response relative to the background level.

The magnetic susceptibility of a soil can also be enhanced by the application of heat. This effect can lead to the detection of features such as hearths, kilns or areas of burning.

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. Such negative anomalies are often very faint and are commonly caused by modern, non-ferrous, features such as plastic water pipes. Infilled natural features may also appear as negative anomalies on some geological substrates.

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. An agricultural origin, either ploughing or land drains is 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. 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 undertaking an agreed 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 0.5m or 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 20m by 20m 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 1600 readings were obtained for each 20m by 20m 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	487413.0130	510127.2864
B	487534.0030	510199.2736
C	487309.6629	510252.4718

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party or for the removal of any of the survey reference points.

Appendix 3

Geophysical Archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Word 2000), and graphics files (Adobe Illustrator, CorelDraw6 and AutoCAD 2000) 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 will 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 Sites and Monument Record Office).