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Manor Farm
Bessacarr
Doncaster

Geophysical Survey

November 2010

Report No. 2145

CLIENT

MAP Archaeological Consultancy Ltd

Manor Farm
Bessacarr
South Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey covering approximately 0.5 hectares was carried out at the proposed location of a housing development near Manor Farm, Bessacarr, south-east of Doncaster. The survey was undertaken to determine the full extent of a probable area of Iron Age/Romano-British metal-working, partially defined by a previous geophysical survey and subsequently revealed by trial trenching. The current survey has clearly defined a broad area of intense magnetic disturbance, measuring approximately 25m by 30m, which is assumed to define the main area of metalworking. Less intense readings around the periphery of this disturbance probably define the limits of the industrial activity. Discrete low magnitude anomalies to the east and north are considered to have some archaeological potential given the activity in the immediate area.

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Report Information

Client:	MAP Archaeological Consultancy Ltd
Address:	Showfield Lane, Malton, North Yorkshire YO17 6BT
Report Type:	Geophysical Survey
Location:	Bessacarr
County:	South Yorkshire
Grid Reference:	SK 6165 9988
Period(s) of activity represented:	Iron Age/Romano-British?
Report Number:	2145
Project Number:	3667
Site Code:	MFB10
Planning Application No.:	n/a
Museum Accession No.:	n/a
Date of fieldwork:	November 2010
Date of report:	November 2010
Project Management:	Sam Harrison BSc MSc AIfA
Fieldwork:	Alex Harrison BSc
	David Harrison BA MSc
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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ISOQAR ISO 9001:2008
Cert. No. 125QM8003

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1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by Sophie Langford at MAP Archaeological Consultancy Ltd on behalf of their client, Persimmon Homes Yorkshire, to undertake a geophysical (magnetometer) survey on land at Manor Farm, Bessacarr, South Yorkshire (see Fig. 1) in advance of the determination of a planning application for a housing development. This survey extends an earlier magnetometer survey carried out by Stratascan (Smalley 2008) on behalf of Archaeological Research Services and encompasses an area recently evaluated through trial trenching (MAP Archaeological Consultancy, forthcoming).

Site location, topography and land use

The site is located approximately 5km south-east of Doncaster at Bessacarr, centred at SK 6165 9988 (see Fig. 2), and is situated within a large tract of derelict agricultural land that is bound to the south and east by the M18 motorway and by railway lines to the north and west (see Figs 1 and 2). The ground cover was predominantly short grass interspersed with occasional young trees and patches of light woodland (see plates). Patches of bare earth indicate the location of the recently completed scheme of trial trenching.

The site lies at approximately 5m above Ordnance Datum (aOD) with the land rising gradually to the north, south and west.

Geology and soils

The solid geology of the area comprises sandstone of the Nottingham Castle sandstone formation (BGS 1969). The soils in the area are classified in the Newport 1 association being characterised as deep, well-drained, sands and loams that can be affected by groundwater (SSEW 1983).

2 Archaeological background

A desk-based assessment undertaken as part of a previous phase of work (Archaeological Research Services 2008?) identified '*sites and spot finds from the prehistoric to the post-medieval period*' in the area around Manor Farm. Cropmarks indicative of possible infilled ditches forming fields, enclosures and trackways were also noted, particularly just to the immediate north-west of the area currently under evaluation.

A geophysical survey undertaken in 2008 subsequently identified '*a number of anomalies of a possible archaeological origin*' although there was little obvious correlation with the identified cropmarks; this survey did not extend into the area currently under evaluation. Large areas of magnetic disturbance were also noted, including to the immediate south of the current survey area. A programme of trial trenching (MAP Archaeological Consultancy Ltd forthcoming) following on from the 2008 survey has recently been completed. The results of this evaluation are not yet available but it is understood that several features of archaeological potential have been identified, including evidence of metal-working (see below).

3 Aims, Methodology and Presentation

The main aim of the survey was to determine the extent of features/metal-working activity identified during the trial trenching in an area that was not evaluated by the previous (2008) geophysical survey. The secondary aim was to clarify the potential for archaeological features within the defined survey area as a whole.

Specifically the survey sought to provide information about the nature and possible interpretations of any identified magnetic anomalies and thereby determine the likely extent, presence or absence of any buried archaeological remains in the defined survey area. These aims were to be achieved by undertaking detailed (recorded) magnetometer survey over a broadly rectangular area covering approximately 0.5 hectares located between Trench 63 in the north and Trench 26 to the south (see Fig. 2).

The survey area was set-out with a Trimble 5800 VRS differential GPS to the national grid. Temporary reference objects (wooden survey marker stakes) were established and left in place following completion of the fieldwork for accurate geo-referencing. The locations of the temporary reference objects are shown on Figure 2 and their Ordnance Survey co-ordinates tabulated in Appendix 2.

Magnetometer survey

Bartington Grad601 instruments were used to take readings at 0.25m intervals on zigzag 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. Detailed survey allows the visualisation of weaker anomalies that may not have been readily identifiable by magnetometer (magnetic) scanning.

Reporting

A general site location plan, incorporating the 1:50000 Ordnance Survey mapping is shown in Figure 1. Figure 2 is a more detailed site location showing the magnetometer data on the Ordnance Survey map base at a scale of 1:2500. The processed greyscale data, the ‘raw’ XY trace plot data and interpretation figures are presented at a scale of 1:500 in Figures 3 to 6 inclusive.

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 survey methodology, report and any recommendations comply with the Methodology and with guidelines outlined by English Heritage (David *et al* 2008) and by the IfA (Gaffney, Gater and Ovenden 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 and Discussion

A clearly defined area of intense magnetic disturbance has been identified to the south-western corner of the survey area. This area of disturbance extends north and south of T59, overlapping the northern edge of the 2008 survey. No detailed information on the findings from T59 have been provided but the results of the current geophysical survey certainly indicate the presence of intensely magnetic material, perhaps a spread of slag or iron waste, and potentially indicating that metal working was being carried out either here or in the immediate vicinity.

Around the periphery of the area of intense disturbance, and to the south-eastern corner of the survey area, less well defined areas of magnetic variation have been identified. The anomalies comprising these areas are probably associated with the activity/processes that resulted in the main area of disturbance and on this basis can also be deemed to be of archaeological potential.

To the north and east of the survey area several low magnitude anomalies, identified as small areas of magnetic enhancement, have been identified. These anomalies may be indicative of small pits but could also be due to geological variation or to modern ground disturbance. The more extensive low magnitude areas of magnetic enhancement are considered more likely to be geological in origin but an archaeological cause cannot be ruled out given the context.

Two trends can be seen in the data to the northern end of the survey area. The very weak low magnitude linear anomaly locates the backfilled T63. There is no obvious cause for the curvilinear trend immediately north-east of the trench.

5 Conclusions

An area of intense magnetic disturbance has been clearly defined fulfilling the primary aim of the survey. It would now seem clear that the magnitude of these responses is indicative of metal working either in situ or in the immediate vicinity. The responses may be due to the presence of slag or iron waste or to the remains of structures associated with the metal-working processes. Less well defined areas of magnetic variation around the presumed periphery of the industrial activity are also interpreted as being due to the processing of iron.

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.

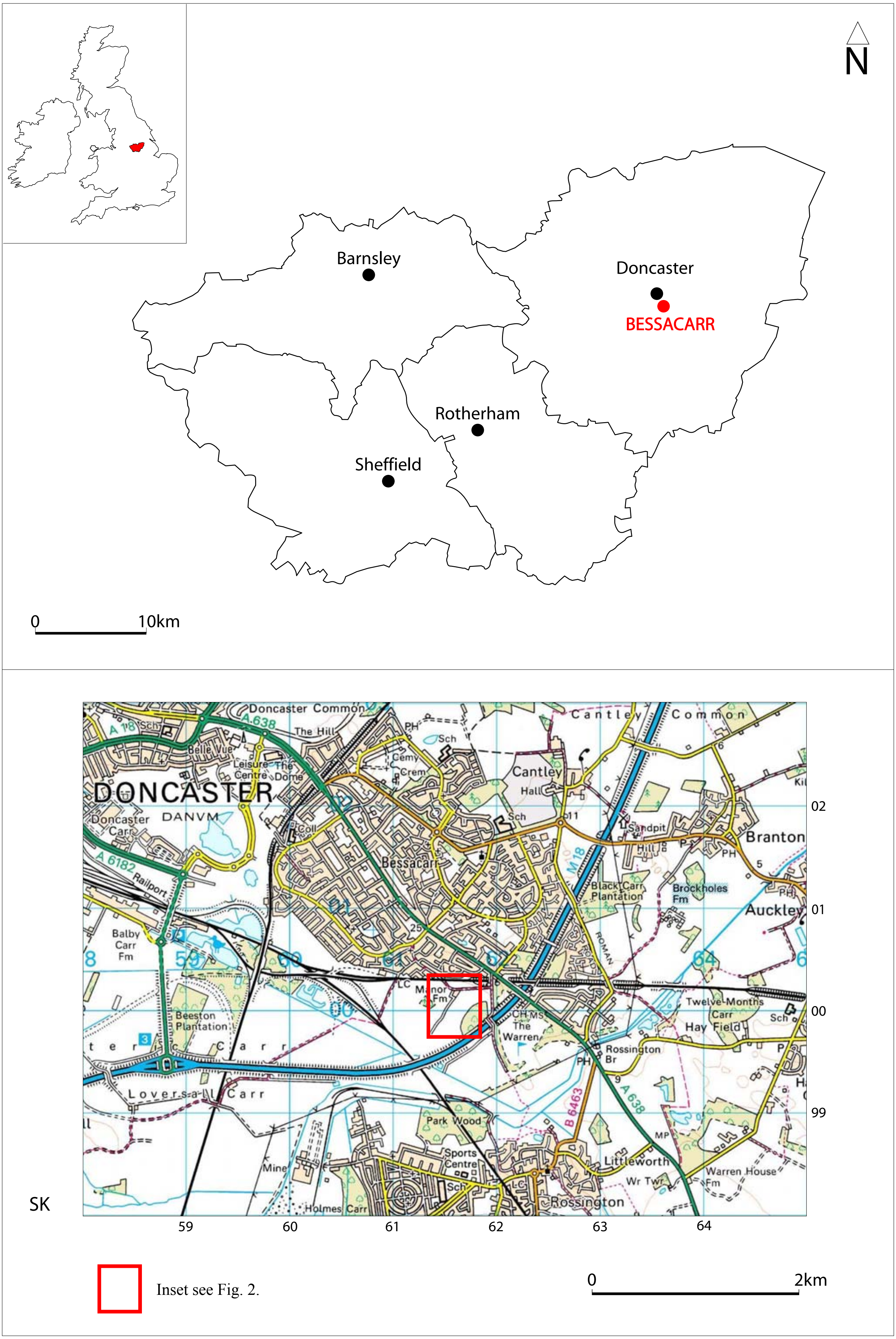

Fig. 1. Site location

Fig. 2. Site location showing greyscale magnetometer data (1:2500 @ A4)

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Fig. 3. Processed greyscale magnetometer data (1:500 @ A3)

Fig. 4. XY trace plot of unprocessed magnetometer data (1:500 @ A3)

Fig. 5. XY trace plot of unprocessed magnetometer data (1:500 @ A3)

Fig. 6. Interpretation of magnetometer data (1:500 @ A3)

Plate 1. General shot of survey area, looking south

Plate 2. General shot of survey area, 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 topsoil's, subsoil's 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 plough-soil.

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 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 zigzag 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 zigzag 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. 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	461670.5350	399986.0110	5.2600m
B	461604.2590	399930.3000	5.6720m
C	461603.8570	399864.4870	4.7220m

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 Sites and Monument Record Office).

Bibliography

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