ARCHAEOLOGICAL SERVICES WYAS

Land in Bramham Park
Leeds
West Yorkshire

Geophysical Survey

Report no. 2429

January 2013

Client: West Yorkshire Archaeology Advisory Service

REGISTERED IA ORGANISATION

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Leeds
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Summary

A magnetometer survey covering approximately 4.5 hectares was carried out in Bramham Park over an area of intense cropmarks interpreted as part of a system of fields/enclosures of probable late Prehistoric, Roman or early post-Roman date which may also include the location of a Roman villa. Apart from two small areas on the northern and southern edges of the survey area, where archaeological anomalies have been identified, the data is characterised by very strong linear anomalies which are thought to be caused by a system of field drains possibly recently installed to improve drainage in a part of the estate used for parking during events held in the park. Against this background it is impossible to identify any anomalies that might correlate with the cropmarks or any other underlying archaeological features. It is unclear what impact the installation of the drains may have had on any underlying archaeological features. However, a resistance survey covering part of the same area has identified low resistance anomalies indicative of ditches forming part of the cropmark system. On this basis it can be assumed that the drainage system may not have had too great a detrimental effect on the underlying archaeological resource. Unfortunately, the extent of the resource remains unquantified.

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Report Information

Client:	West Yorkshire Archaeology Advisory Service
Address:	Registry of Deeds, Newstead Road, Wakefield Road, West Yorkshire, WF1 2DE
Report Type:	Geophysical survey
Location:	Bramham Park, near Leeds
County:	West Yorkshire
Grid Reference:	SE 416 415
Period(s) of activity: represented	prehistoric/Romano-British?
Report Number:	2429
Project Number:	3933
Site Code:	BPL12
OASIS ID:	archaeol11-143095
Planning Application No.:	n/a
Museum Accession No.:	n/a
Date of fieldwork:	December 2012
Date of report:	January 2013
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Photography:	Chris Sykes
Research:	n/a

Authorisation for distribution: --

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1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by Ian Sanderson, Principal Archaeologist of the West Yorkshire Archaeology Advisory Service (WYAAS) to undertake a geophysical survey on a parcel of land within Bramham Park, a Grade 1 Registered Historic Park and Garden, West Yorkshire. The survey was carried out as part of WYAAS remit to record and understand the archaeological heritage of West Yorkshire. The survey concentrated on an area of intense cropmarks identified following interpretation and analysis of air photographs. The survey was carried out on December 13th and December 14th 2012.

Site location, topography and land-use

Bramham Park is situated approximately 2km south-west of the village of Bramham and 15km north-east of Leeds (see Fig. 1). The survey area comprised a broadly rectilinear block of short grazed permanent pasture, centred at SE 4165 4146 and covering a maximum area of 4.4 hectares, which is used for parking during events that are held in the park each year. The land is relatively flat at approximately 70m above Ordnance Datum.

Geology and soils

The bedrock geology comprises sedimentary Dolostone of the Cadeby Formation (formerly known as Magnesian Limestone) with no superficial deposits (British Geological Survey 2013). The soils in this area are classified in the Aberford association, characterised as shallow, locally brashy, well-drained calcareous fine loams over limestone (Soil Survey of England and Wales 1983).

2 Archaeological background

Analysis of air photographs has resulted in the identification of an extensive pattern of cropmarks within Bramham Park (see Fig. 2 and Fig. 3). These cropmarks, which extend across much of the landscape on Bramham Moor, are thought to date to the later Iron Age, Roman and early post-Roman periods and are thought to be indicative of enclosures, field systems, trackways and settlement activity. It has been suggested that the pattern of cropmarks in the park may locate the site of a Roman villa (Roberts 2011). Villa sites are rare in West Yorkshire with the only known site at Dalton Parlours, near Collingham.

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 over the known cropmarks and to therefore determine the presence/absence and extent of any buried archaeological features.

Specifically, the survey aimed to provide detailed information about the presence and extent of archaeological features within the designated survey area encompassing a dense area of cropmarks.

In order to achieve these aims detailed (recorded) magnetometer survey was undertaken centred on the cropmark features, an area of approximately 4.5 hectares. In addition resistance survey was also carried out over an area of approximately 0.5 hectares. The results of the survey will help inform the West Yorkshire Archaeology Advisory Service.

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.

Earth resistance survey

A Geoscan RM15 resistance meter was used during the earth resistance survey, with the instrument logging each reading automatically at 1m intervals on traverses 1m apart. The mobile probe spacing was 1m with the remote probes 15m apart and at least 15m away from the grid under survey. This mobile probe spacing gives an approximate depth penetration of up to 1m for most archaeological features. Further details are given in Appendix 2.

Reporting

A general site location plan, incorporating the Ordnance Survey map, is shown in Figure 1. Figure 2 is a large scale (1:2000) site location plan showing the survey areas and cropmark detail. Figure 3 shows the two data sets overlain by the cropmark detail. The processed and minimally processed data, together with an interpretation graphic, are presented in Figures 4 to 9 inclusive at scales of 1:1250 (magnetic data) and 1:1000 (resistance data).

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 and Discussion

Magnetometer Survey

The magnetic data is dominated by a series of very strong, parallel, linear trend anomalies. To the west of the track these anomalies are aligned north-west/south-east whilst to the east of the track they are aligned south-west/north-east. These anomalies extend across the whole of the survey area, with the exception of two very narrow linear strips to the northern and southern edges of the survey area (see Fig. 6) where the magnetic background is 'normal'. It is considered likely that these linear anomalies are caused by a system of land drains or a programme of sub-soiling instituted (probably fairly recently as the field was formerly under arable cultivation) to improve drainage in this part of the park which is now often used for car parking during the various events which are now held during the summer and early autumn each year. It is worth noting that the magnetic responses are much stronger than is usually observed from a system of drains. Against this background it is impossible to identify any, much weaker, anomalies caused by underlying archaeological features. Identification of any archaeological features is compounded by the fact that the cropmarks/archaeological features are aligned in exactly the same direction as the land drains (see Fig. 3).

In the two narrow strips not impacted by the drainage (see Fig. 6) two short linear anomalies, **A** and **B**, have been identified at the northern and southern ends of the survey area respectively. Although these anomalies do not correlate directly with the identified cropmarks they do align with, and are immediately adjacent to, known cropmarks and so they are consequently interpreted as ditches forming part of the system of enclosures/fields. Other discrete anomalies in these two areas have been interpreted as potentially archaeological due to the location but it is impossible to give a confident interpretation.

In the field to the east of the track four discrete rectilinear anomalies, **C**, **D**, **E** and **F**, are identified. These anomalies are caused by backfilled sewerage pits. These features are clearly visible on GoogleEarth images of the site.

Resistance Survey

Although the survey covered only a relatively small area clear high and low resistance anomalies have been identified. Low resistance linear and curvilinear anomalies **G**, **H**, **I** and **J**, clearly correspond with cropmarks and are interpreted as infilled ditches forming part of the system of enclosures/fields at the heart of the cropmark complex (see Fig. 3 - right). The ditches manifest as low resistance anomalies as the electric current will pass more readily through the moisture retentive fills. Adjacent areas of high resistance are also noted (not labelled) but it is unclear whether these locate specific features or, more likely, just reflect the relative contrast with the adjoining low resistance anomalies.

5 Conclusions

Unfortunately the installation of the system of land drains has resulted in such strong magnetic anomalies that it is completely impossible to identify any anomalies within the drained area that might be caused by any underlying archaeological features. Beyond the drained area two anomalies that are almost certainly archaeological in origin forming part of the system of enclosures/fields have been identified. The effects of the groundworks and installation of the drains on any surviving archaeological features is consequently unknown and cannot be established without direct investigation by trial trenching. However, the very good correlation between the low resistance anomalies and the cropmarks strongly suggests that the archaeological features are likely to survive although there may have been some degradation of the archaeological resource during the groundworks. Unfortunately any archaeological features in the area of the sewerage pits are likely to have been completely destroyed during the digging of these pits.

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.

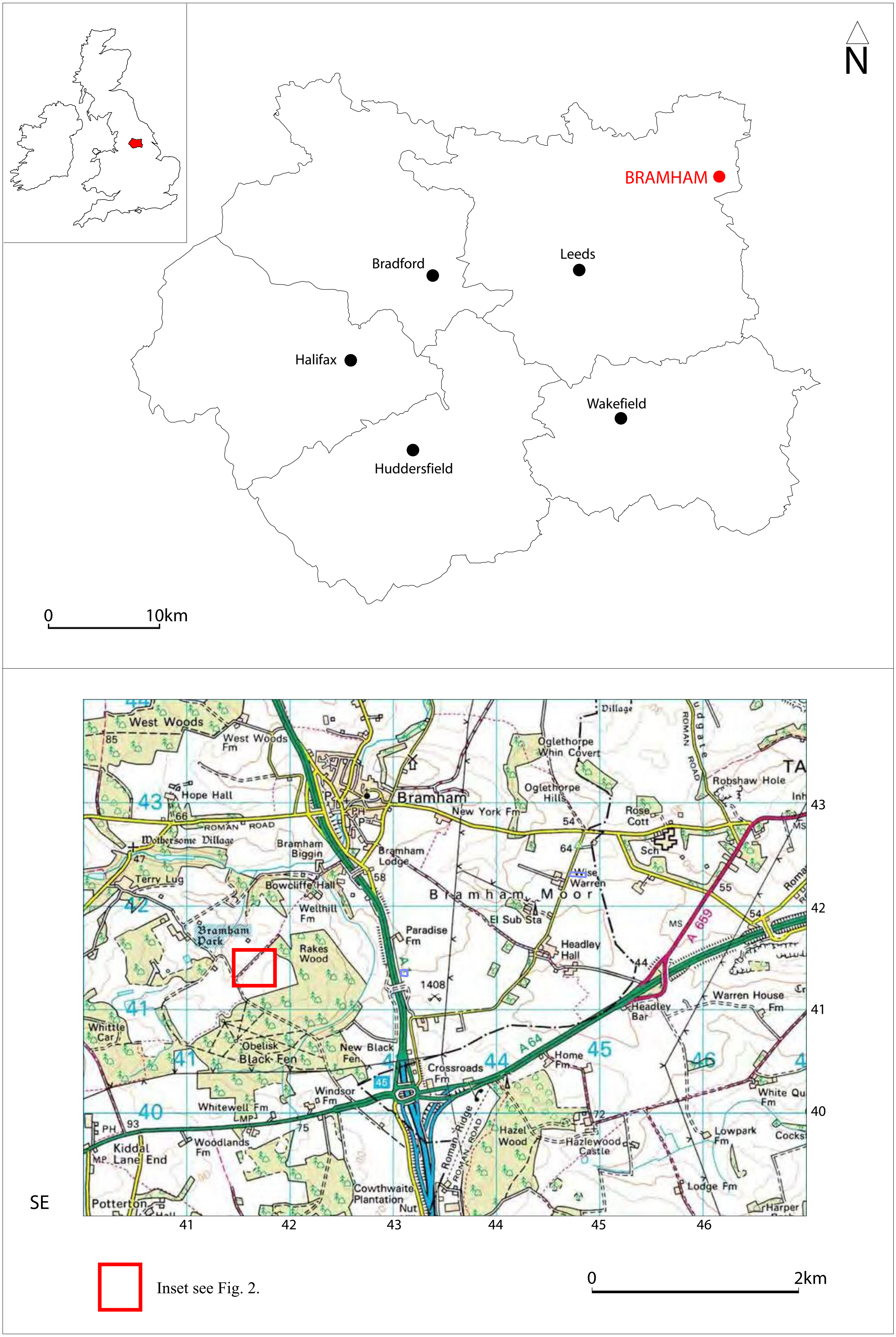

Fig. 1. Site location

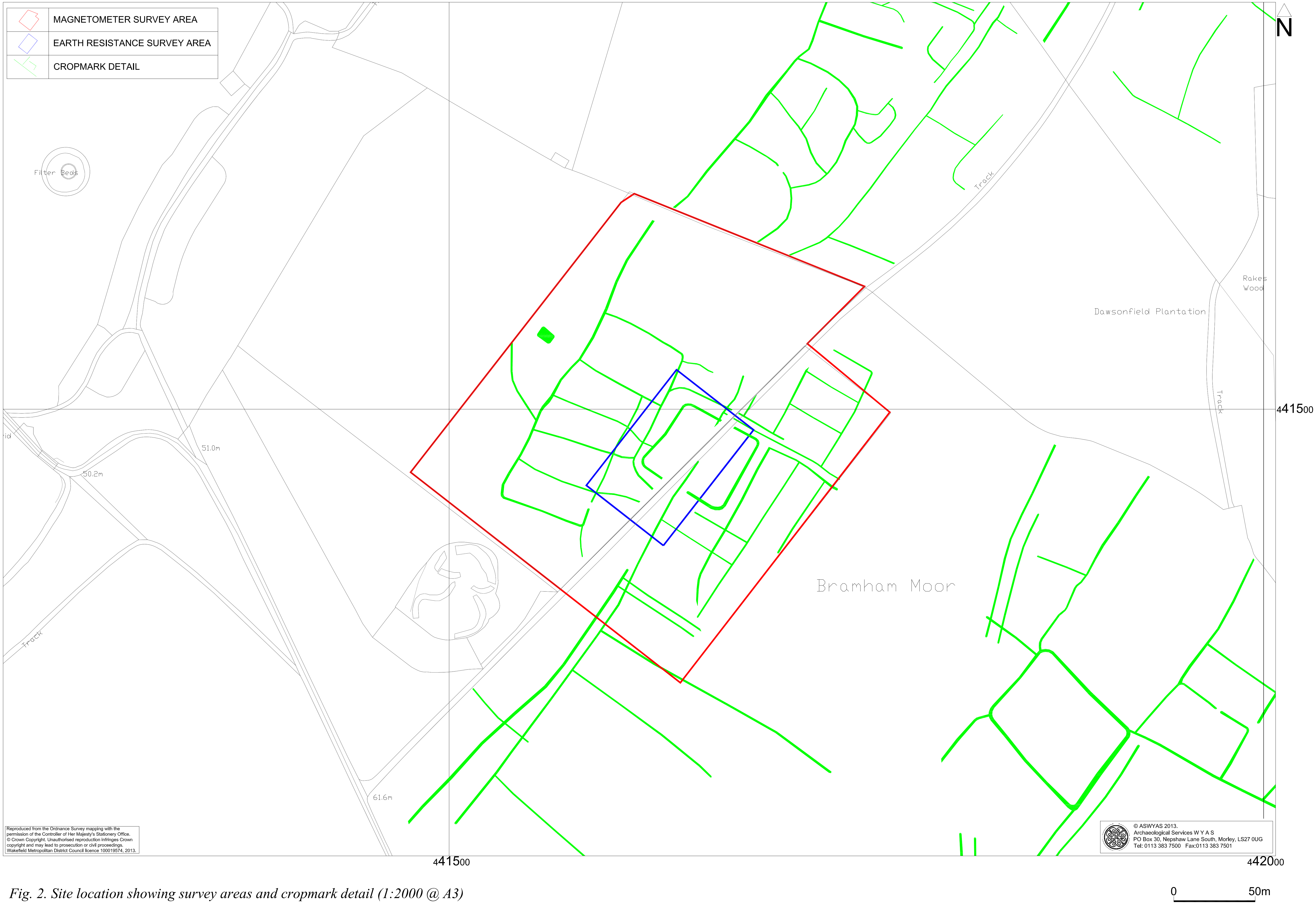

Fig. 2. Site location showing survey areas and cropmark detail (1:2000 @ A3)

Fig. 3. Processed magnetometer data (left) and processed earth resistance data (right) with cropmark detail (1:2000 @ A3)

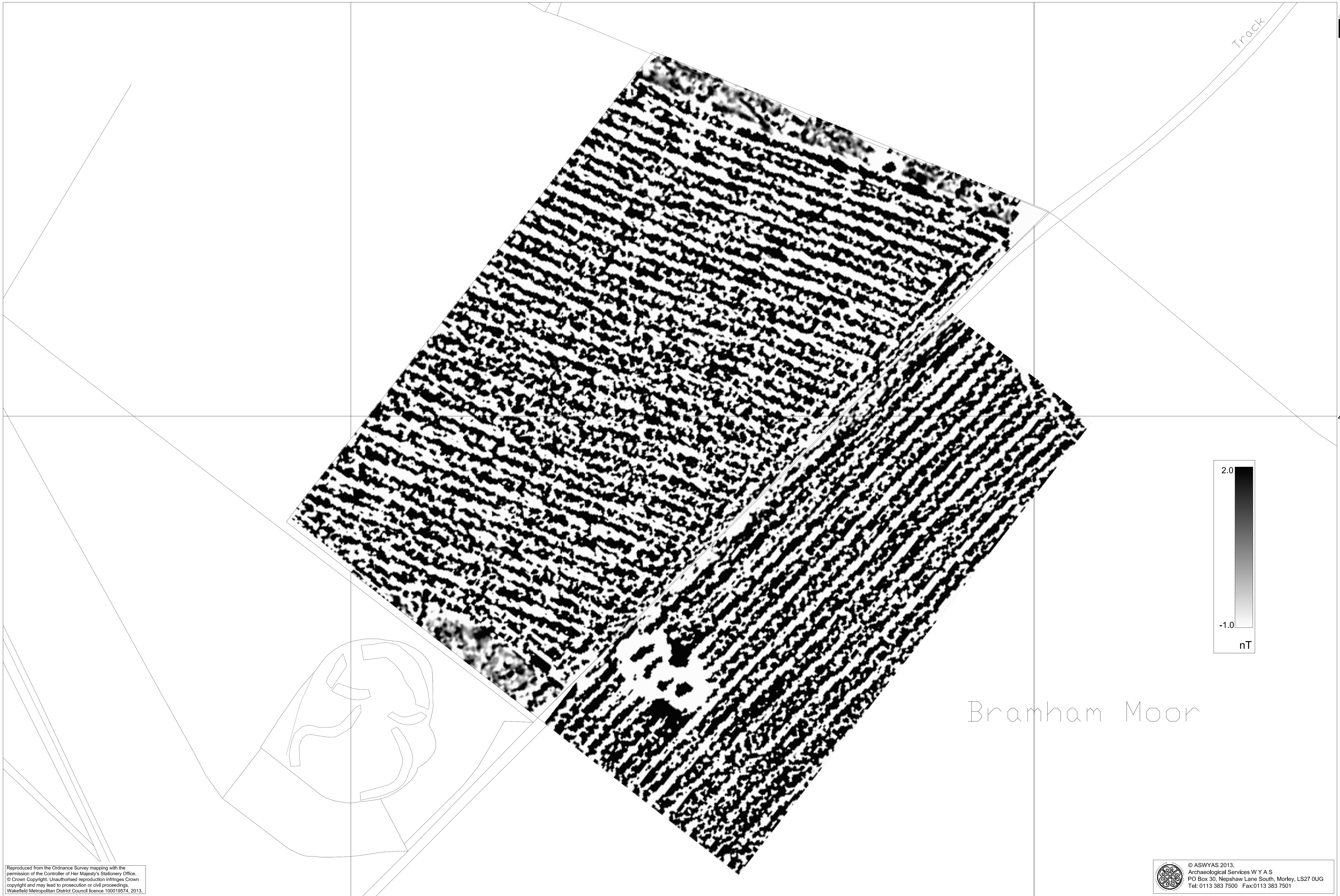

Fig. 4. Processed greyscale magnetometer data (1:1250 @ A3)

0 50m

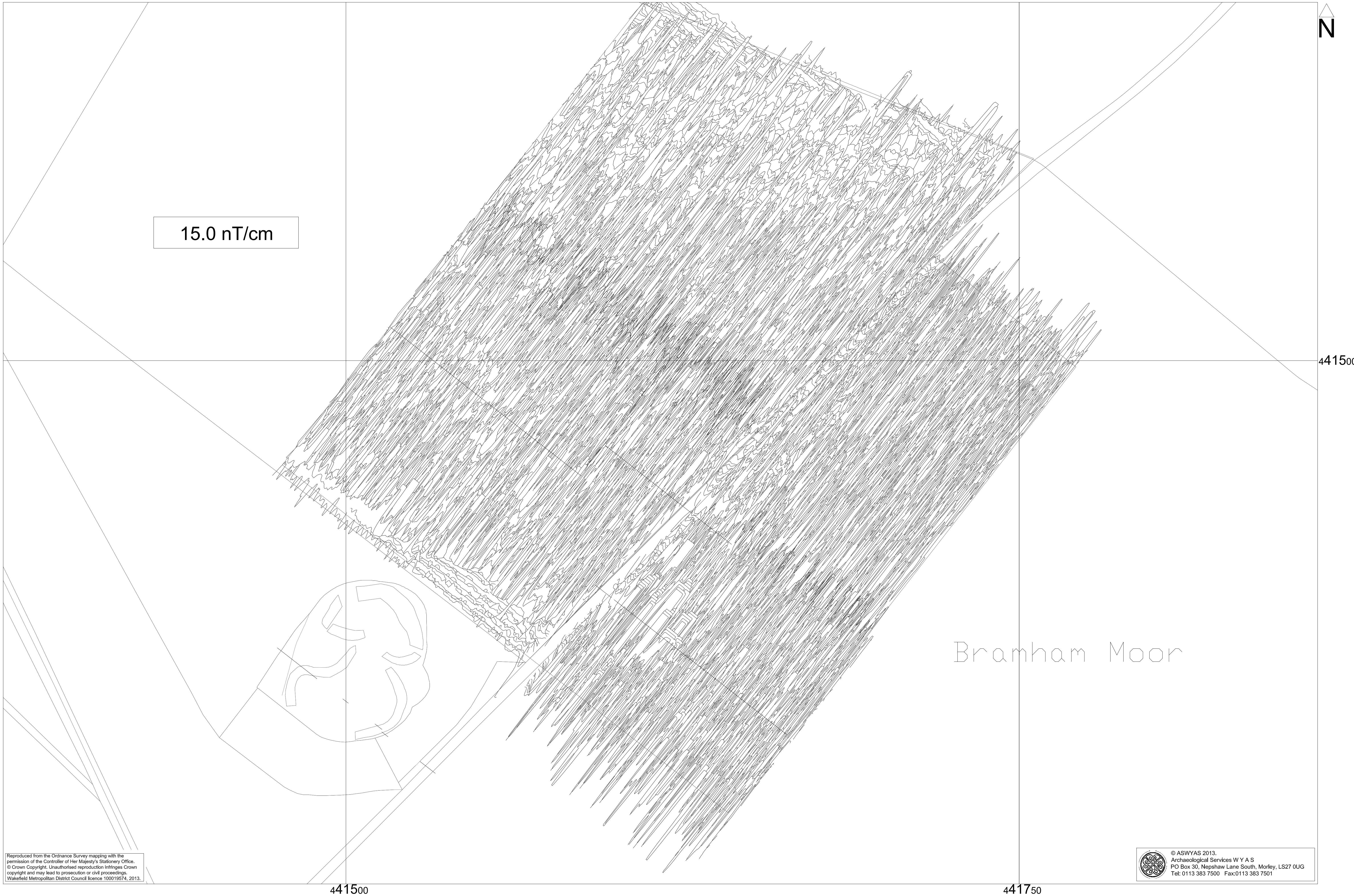

Fig. 5. XY traceplot of processed magnetometer data (1:1250 @ A3)

Fig. 6. Interpretation of magnetometer data (1:1250 @ A3)

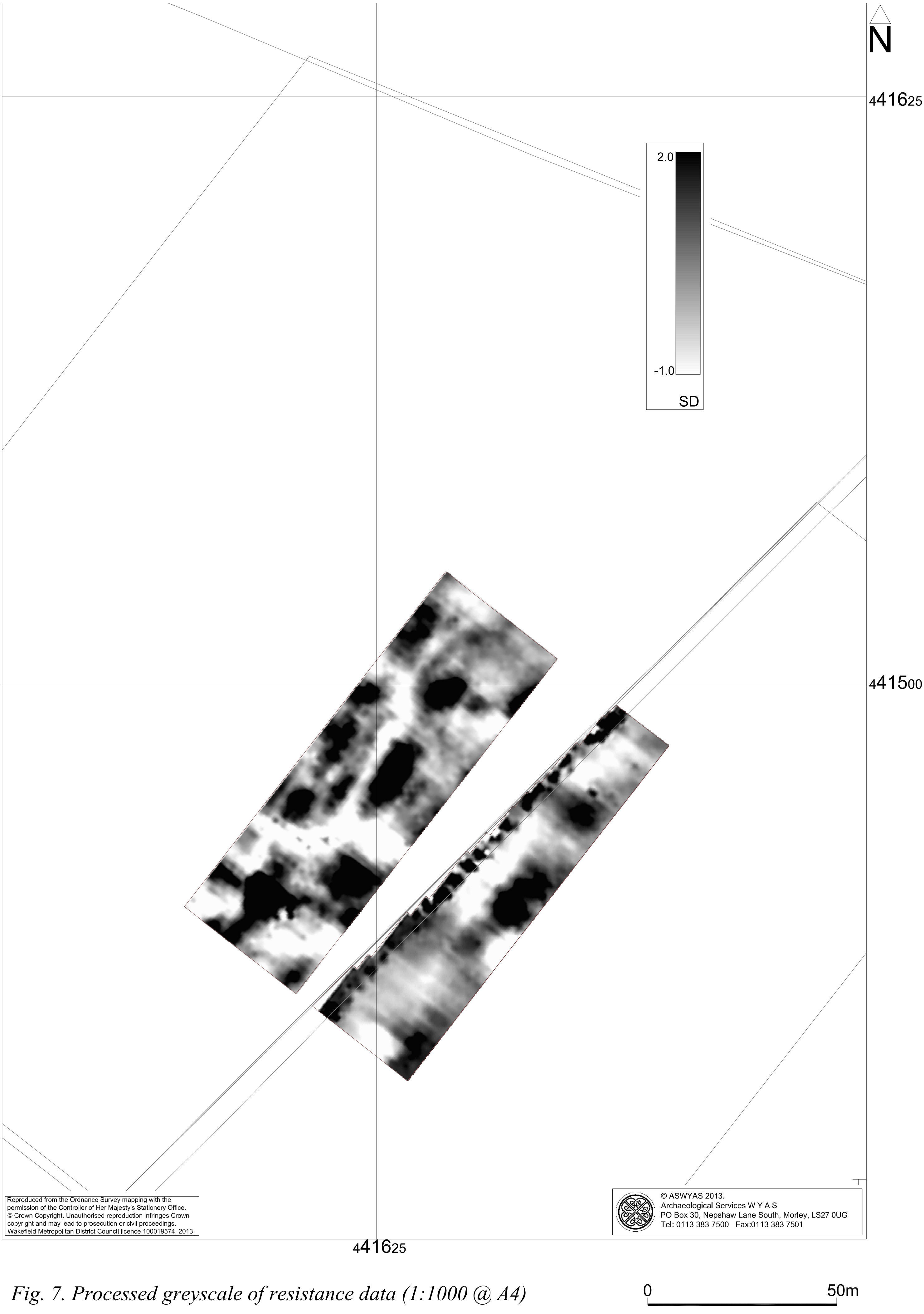

Fig. 7. Processed greyscale of resistance data (1:1000 @ A4)

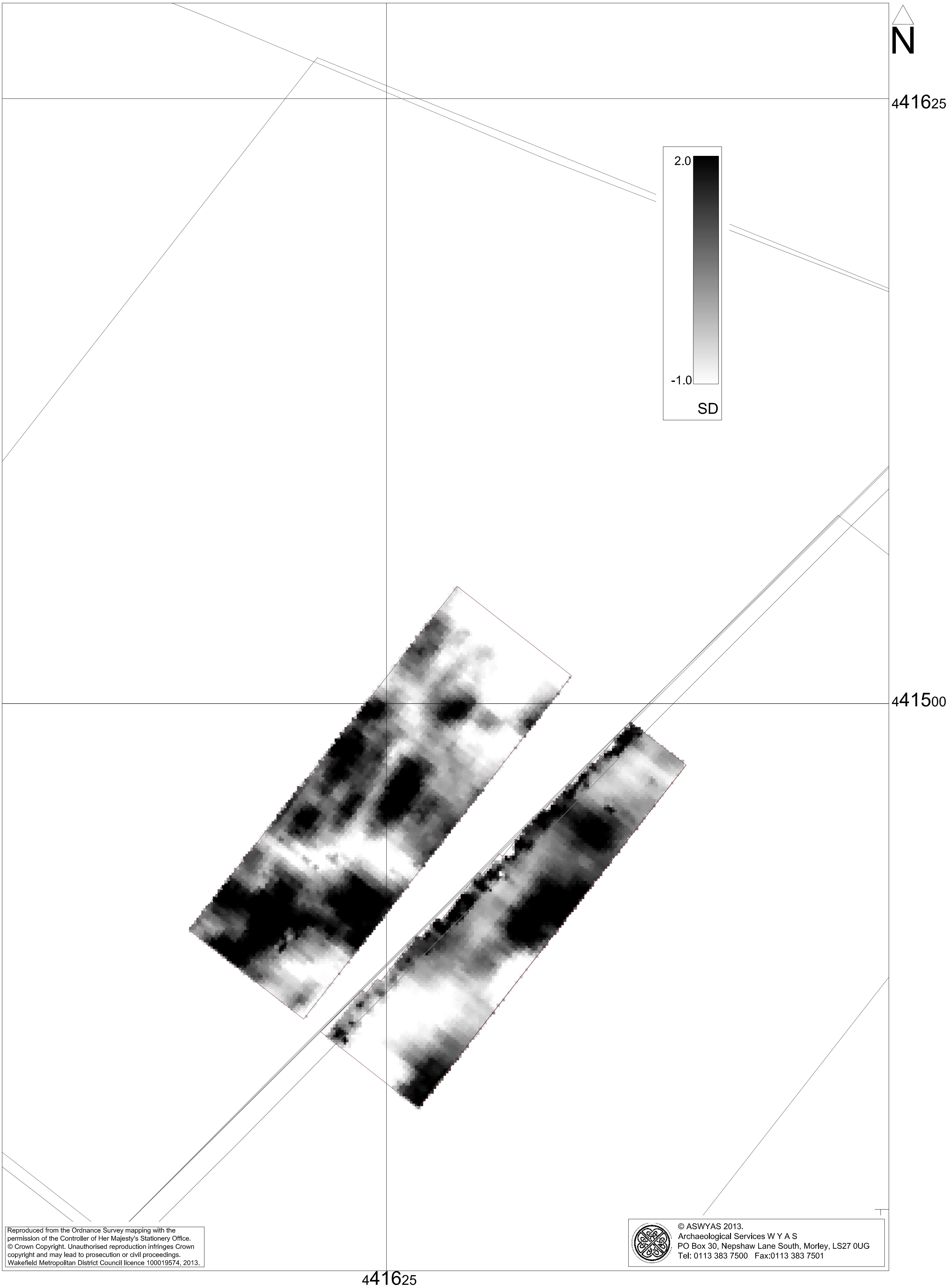

Fig. 8. Unprocessed greyscale of resistance data (1:1000 @ A4)

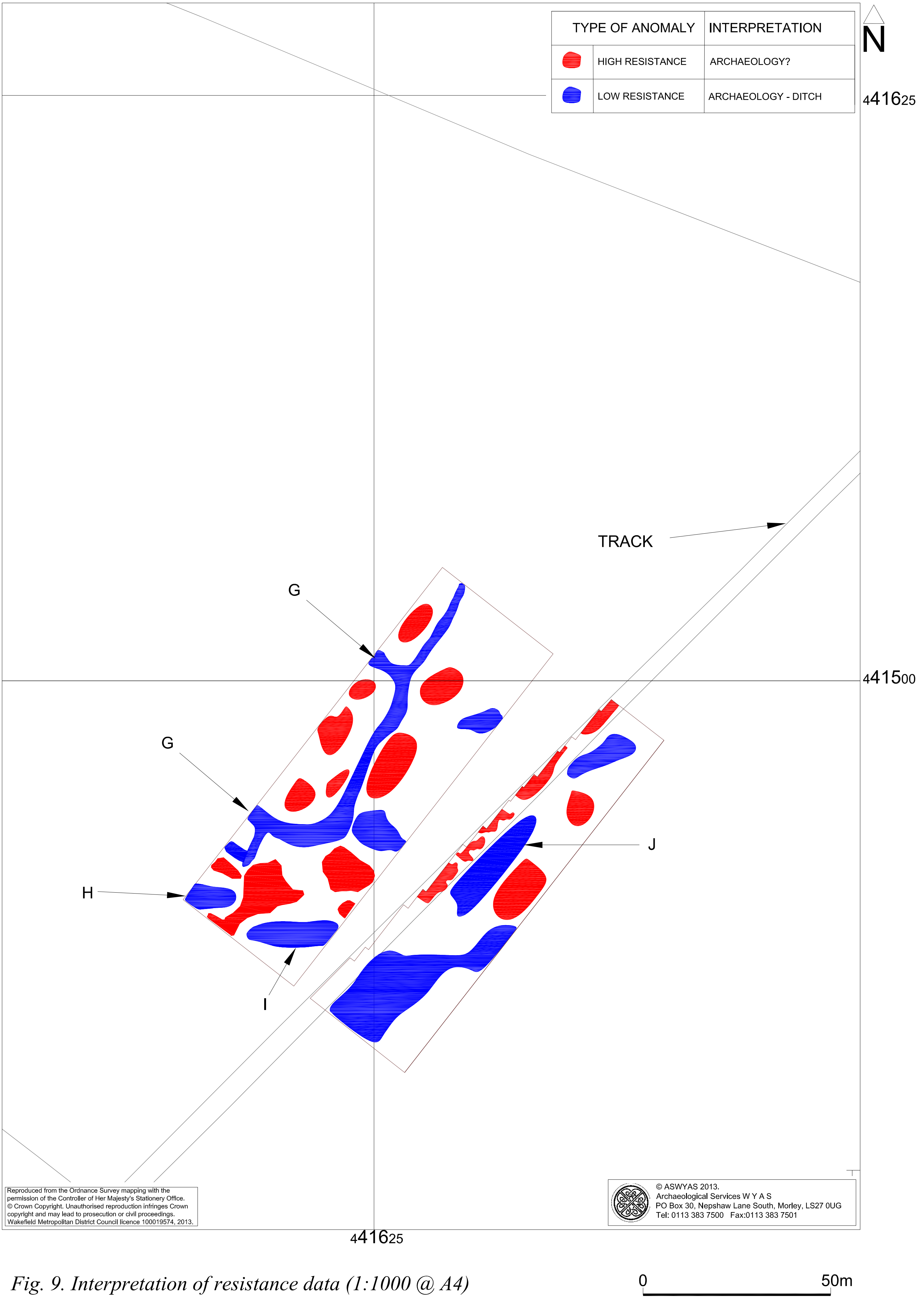

Fig. 9. Interpretation of resistance data (1:1000 @ A4)

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: Earth Resistance Survey - technical information

Soil Resistance

The electrical resistance of the upper soil horizons is predominantly dependant on the amount and distribution of water within the soil matrix. Buried archaeological features, such as walls or infilled ditches, by their differing capacity to retain moisture, will impact on the distribution of sub-surface moisture and hence affect electrical resistance. In this way there may be a measurable contrast between the resistance of archaeological features and that of the surrounding deposits. This contrast is needed in order for sub-surface features to be detected by a resistance survey.

The most striking contrast will usually occur between a solid structure, such as a wall, and water-retentive subsoil. This shows as a resistive high. A weak contrast can often be measured between the infill of a ditch feature and the subsoil. If the infill material is soil it is likely to be less compact and hence more water retentive than the subsoil and so the feature will show as a resistive low. If the infill is stone the feature may retain less water than the subsoil and so will show as a resistive high.

The method of measuring variations in ground resistance involves passing a small electric current (1mA) into the ground via a pair of electrodes (current electrodes) and then measuring changes in current flow (the potential gradient) using a second pair of electrodes (potential electrodes). In this way, if a structural feature, such as a wall, lies buried in a soil of uniform resistance much of the current will flow around the feature following the path of least resistance. This reduces the current density in the vicinity of the feature, which in turn increases the potential gradient. It is this potential gradient that is measured to determine the resistance. In this case, the gradient would be increased around the wall giving a positive or high resistance anomaly.

In contrast a feature such as an infilled ditch may have a moisture retentive fill that is comparatively less resistive to current flow. This will increase the current density and decrease the potential gradient over the feature giving a negative or low resistance anomaly.

Survey Methodology

The most widely used archaeological technique for earth resistance surveys uses a twin probe configuration. One current and one potential electrode (the remote or static probes) are fixed firmly in the ground a set distance away from the area being surveyed. The other current and potential electrodes (the mobile probes) are mounted on a frame and are moved from one survey point to the next. Each time the mobile probes make contact with the ground an electrical circuit is formed between the current electrodes and the potential gradient between the mobile and remote probes is measured and stored in the memory of the instrument.

A Geoscan RM15 resistance meter was used during this survey, with the instrument logging each reading automatically at 1m intervals on traverses 1m apart. The mobile probe spacing was 1m with the remote probes 15m apart and at least 15m away from the grid under survey. This mobile probe spacing of 1m gives an approximate depth of penetration of 1.5m for most archaeological features. Consequently a soil cover in excess of 1m may mask, or significantly attenuate, a geophysical response.

Data Processing and Presentation

All of the illustrations incorporating a digital map base were produced in AutoCAD 2008 (© Autodesk).

The resistance data is presented in this report in greyscale format with a linear gradation of values and was obtained by exporting a bitmap from the processing software (Geoplot v3.0; Geoscan Research) into AutoCAD 2008. The data has been processed and has also been interpolated by a value of 0.5 in both the X and Y axes using a sine wave (x)/x function to give a smoother, better defined plot.

Appendix 3: 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 survey grids were then super-imposed onto a base map provided by the client to produce the displayed block locations. However, it should be noted that Ordnance Survey positional accuracy for digital map data has an error of 0.5m for urban and floodplain areas, 1.0m for rural areas and 2.5m for mountain and moorland areas. This potential error must be considered if co-ordinates are measured off hard copies of the mapping rather than using the digital co-ordinates.

Appendix 4: 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 West Yorkshire Historic Environment Record).

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