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**Little Morton Solar Development
Retford
Nottinghamshire**

Geophysical Survey

Report no. 2529

October 2013

Client: Hyder Consulting (UK) Ltd



Little Morton Solar Development

Retford

Nottinghamshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering 3.3 hectares, was carried out at Little Morton, part of a site for which a planning application has been submitted for a proposed 12 MW Solar PV Development. Cropmarks suggest that an Iron Age/Roman brickwork field system extends into the west of the survey area. However, no anomalies have been identified which correspond to the alignment of the cropmarks, and no other anomalies of archaeological potential have been identified. On the basis of the geophysical survey, the archaeological potential of the site is considered to be low.



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Report Information

Client:	Hyder Consulting (UK) Ltd
Address:	The Mill, Brimscombe Port, Stroud, Gloucestershire, GL5 2QG
Report Type:	Geophysical Survey
Location:	Little Morton, Retford
County:	Nottinghamshire
Grid Reference:	SK 671 791
Period(s) of activity:	n/a
Report Number:	2529
Project Number:	4135
Site Code:	LMN13
OASIS ID:	archaeol11- 163024
Planning Application No.:	n/a
Museum Accession No.:	n/a
Date of fieldwork:	October 2013
Date of report:	October 2013
Project Management:	Sam Harrison BSc MSc AIfA
Fieldwork:	Sam Harrison Thomas Fildes BA
Report:	David Harrison BA MSc MIfA
Illustrations:	David Harrison and Sam Harrison
Photography:	Sam Harrison
Research:	n/a

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PO Box 30, Nepshaw Lane South, Morley, Leeds
LS27 0UG
Telephone: 0113 383 7500.
Email: admin@aswyas.com

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1 Introduction

Archaeological Services WYAS (ASWYAS) were commissioned by Sarah Woodget of Hyder Consulting (UK) Ltd, on behalf of their client, Lightsource Renewable Energy Limited, to undertake a geophysical (magnetometer) survey of land at Little Morton, Retford, Nottinghamshire (see Fig. 1), prior to the determination of a planning application for a proposed 12 MW Solar PV Development. The work was undertaken in accordance with a Project Design (Harrison, 2013) supplied to and approved by the Client, with guidance contained within the National Planning Policy Framework (2012) and in line with current best practice (David *et al* 2008). The survey was carried out on October 14th 2013 in order to provide additional information on the archaeological potential of the site.

Site location, topography and land-use

The Proposed Development Area (PDA) comprises an irregular shaped parcel of land covering 27 hectares at Little Morton, 2km west of Retford and centred at SK 671 791 (see Fig. 1). It is bound to the east by Old London Road and to the north-west by Mansfield Road. Open farmland extends from the south of the PDA (see Fig. 2). Only the westernmost part of the PDA was targeted by geophysical survey, an area of 3.3 hectares. At the time of the survey the site was under pasture (see plates).

Topographically, the site is relatively flat at between 28m and 32m above Ordnance Datum (aOD).

Soils and geology

The underlying bedrock comprises Nottingham Castle Sandstone Formation - sandstone, pebbly (gravelly) (British Geological Survey 2013). No superficial deposits are recorded within the PDA although Mid Pleistocene till (diamicton, sand and gravel) is recorded to the immediate north of the site. The soils in this area are classified in the Cuckney 1 association, characterised as well-drained sands and coarse loams (Soil Survey of England and Wales 1983).

2 Archaeological Background

Baseline evidence collated as part of a Cultural Heritage Desk Based Assessment (Hyder 2013) suggests that the PDA lies within a landscape which has been occupied from the prehistoric period until the modern day. The majority of the assets identified within the study area are associated with 'brickwork' plan field systems which have been identified as linear cropmarks from the analysis of aerial photographs. The field system is broadly aligned east/west. Some of these cropmarks extend into the west of the PDA and are recorded within the Nottinghamshire Historic Environment Record (HER No. L4478). The assessment concluded that *'there is potential to impact Iron Age/Roman brickwork plan field systems of*

potentially local/regional significance’ but that there ‘is limited potential to impact upon archaeological remains, due to the nature of the proposed development’.

3 Aims, Methodology and Presentation

The main aim of the geophysical survey was to determine whether or not the archaeological resource extends into the western extent of the PDA and to provide sufficient information to enable an assessment to be made of the impact of potential sub-surface archaeological remains. To achieve this aim a magnetometer survey covering the western portion of the PDA was carried out, an area of 3.3 hectares.

The general objectives of the geophysical survey were:

- to provide information about the nature and possible interpretation of any magnetic anomalies identified;
- to therefore determine the presence/absence and extent of any buried archaeological features; and
- to prepare a report summarising the results of the survey.

Magnetometer survey

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). 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 1:50000 Ordnance Survey (OS) mapping, is shown in Figure 1. Figure 2 is a large scale (1:5000) location plan displaying the processed magnetic data. Detailed data plots (‘raw’ and processed) and full interpretative figures are presented at a scale of 1:1000 in Figures 3, 4 and 5.

Further technical information on the equipment used, data processing and survey methodologies is 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 Project Design (Harrison 2013) and 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 (see Figs 3, 4 and 5)

Numerous anomalies (areas of magnetic enhancement) have been identified throughout the survey area giving the data a 'speckled' appearance. Given the frequency and general consistency of these anomalies almost all are interpreted as being geological in origin, the areas of magnetic enhancement being due to magnetic variations within the sandstone geology.

A vague, low magnitude linear trend has been identified within the west of the survey area has been attributed an agricultural interpretation. The trend does not correspond to the east/west alignment of the recorded linear cropmarks and, whilst an archaeological origin cannot be completely dismissed, an agricultural interpretation is preferred - the linear nature of the trend, and orientation running parallel to Mansfield Road, being suggestive of ploughing.

Elsewhere, occasional ferrous 'spikes' have been identified which are due to the presence of magnetic material on the ground surface or in the plough soil, and three broad areas of magnetic disturbance along the northern perimeter of the site are due to the close proximity of pylons (see plate 2).

6 Conclusions

The magnetometer survey has not identified any anomalies of obvious archaeological potential and none corresponding to the linear cropmarks recorded within the Nottinghamshire HER (No. L4478). If, as the cropmarks suggest, soil-filled ditches associated with the brickwork field system do extend into the west of the PDA, it may be that there is insufficient contrast between the fill of the cut features and the surrounding soils for the ditches to be detected by the magnetometer. Alternatively, it may be that any trace of the ditches has been subsequently removed by later agricultural activity.

Therefore, on the basis of the geophysical survey, the potential for there being extensive archaeological activity within the west of the PDA is considered to be low. There remains, however, the possibility of soil-filled features which may not be detectable due to the soils and geology.

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.

Appendix 1: Magnetic survey - technical information

Magnetic Susceptibility and Soil Magnetism

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

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

Types of Magnetic Anomaly

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

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

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

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

Isolated dipolar anomalies (iron spikes)

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

Areas of magnetic disturbance

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

Linear trend

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

Areas of magnetic enhancement/positive isolated anomalies

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

Linear and curvilinear anomalies

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

Methodology: Magnetic Susceptibility Survey

There are two methods of measuring the magnetic susceptibility of a soil sample. The first involves the measurement of a given volume of soil, which will include any air and moisture that lies within the sample, and is termed volume specific susceptibility. This method results

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

Methodology: Gradiometer Survey

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

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

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

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

Data Processing and Presentation

The detailed gradiometer data has been presented in this report in XY trace and greyscale formats. In the former format the data shown is 'raw' with no processing other than grid biasing having been done. The data in the greyscale images has been interpolated and

selectively filtered to remove the effects of drift in instrument calibration and other artificial data constructs and to maximise the clarity and interpretability of the archaeological anomalies.

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

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

Appendix 2: Survey location information

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). The accuracy of this equipment is better than 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.

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 Nottinghamshire Historic Environment Record).

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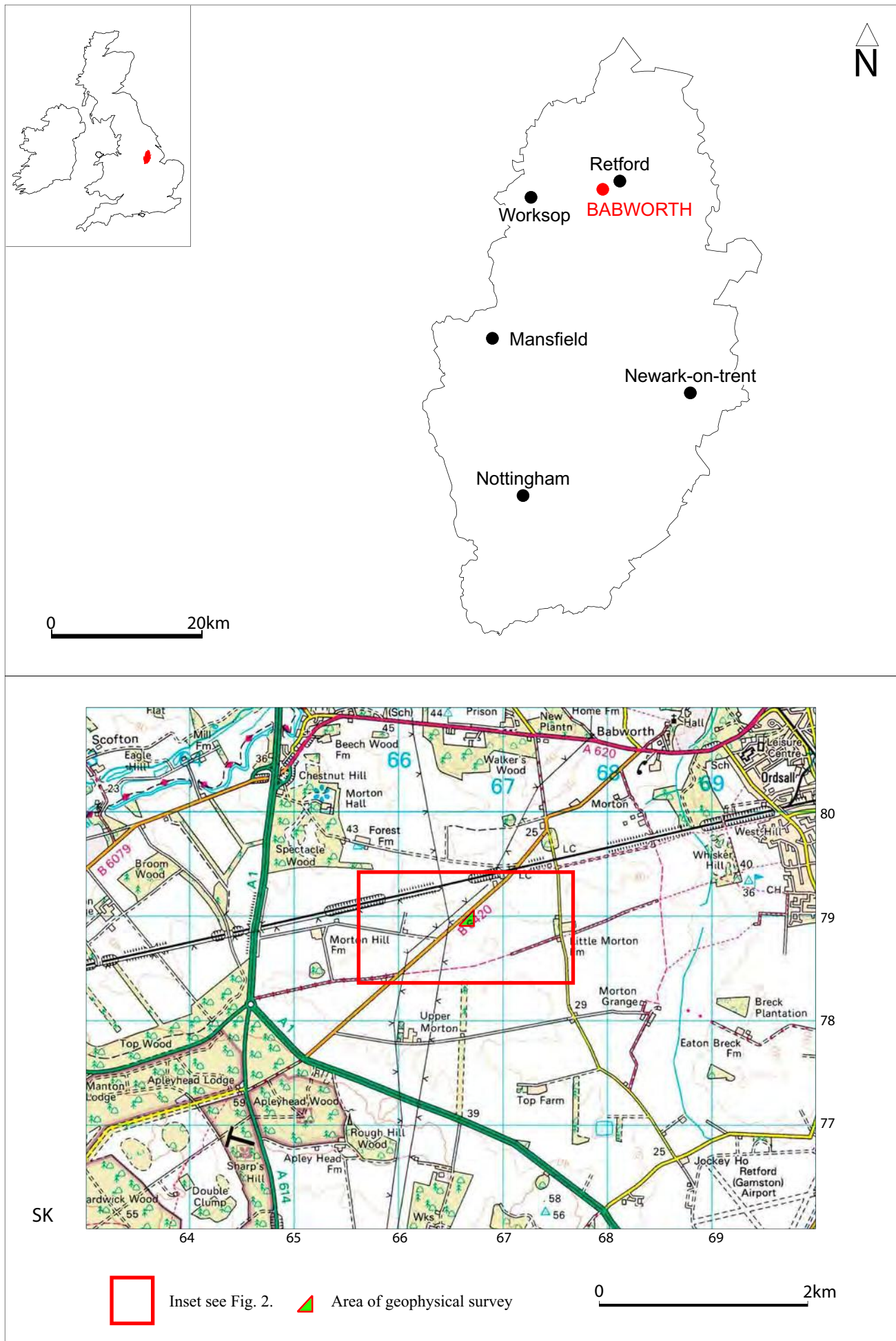


Fig. 1. Site location

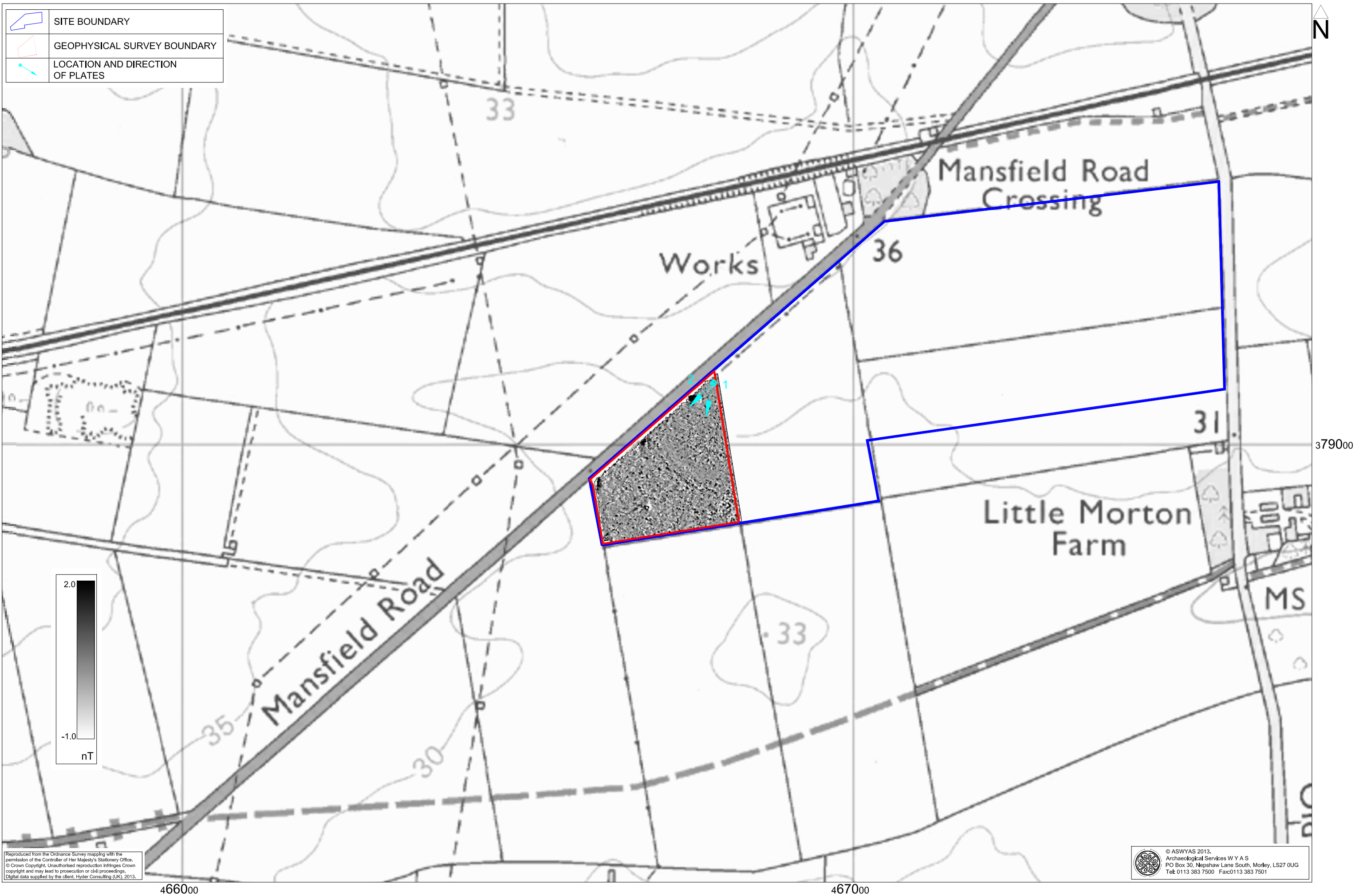


Fig. 2. Survey location showing greyscale magnetometer data (1:5000 @ A3)

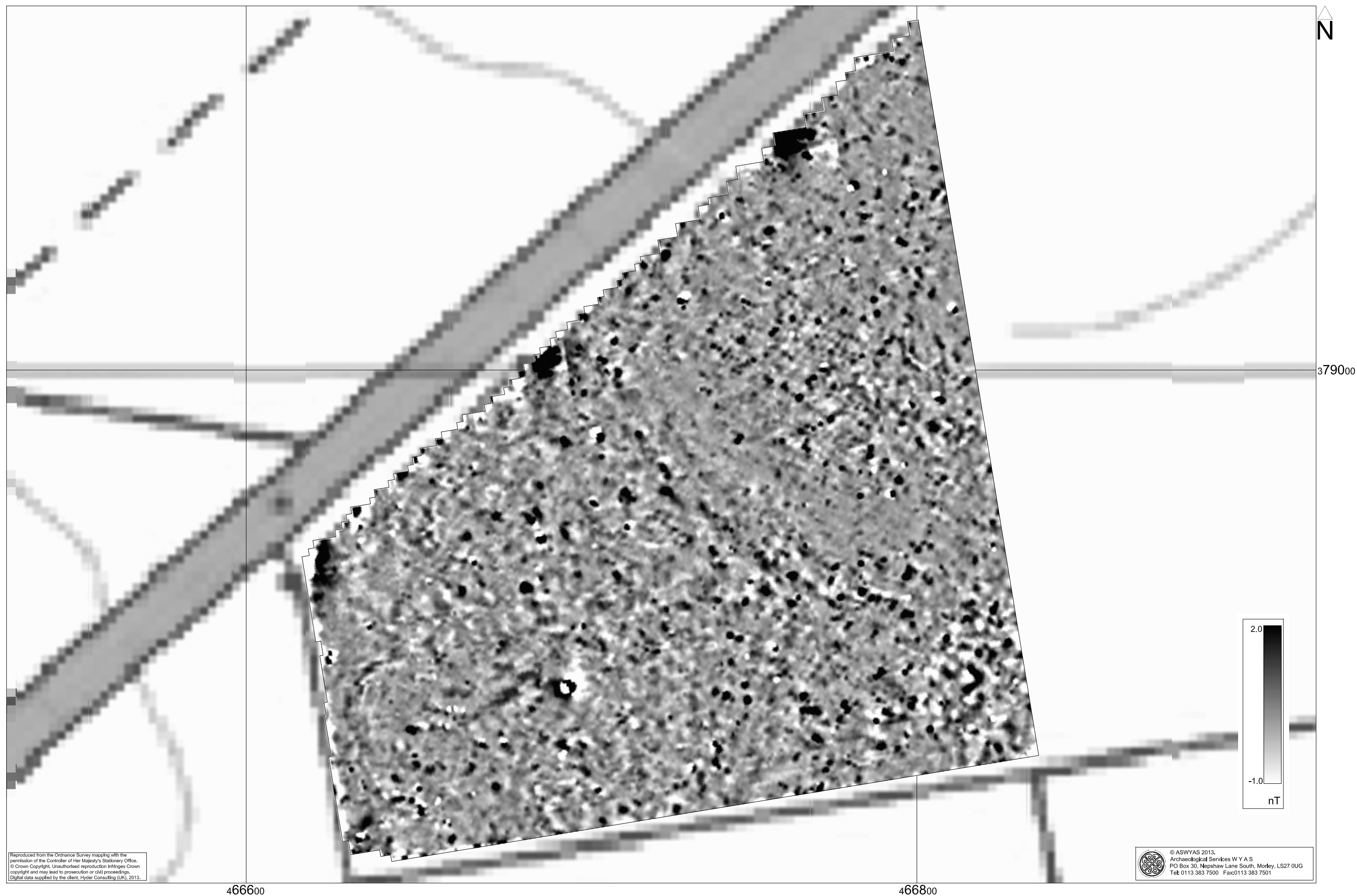


Fig. 3. Processed greyscale magnetometer data (1:1000 @ A3)

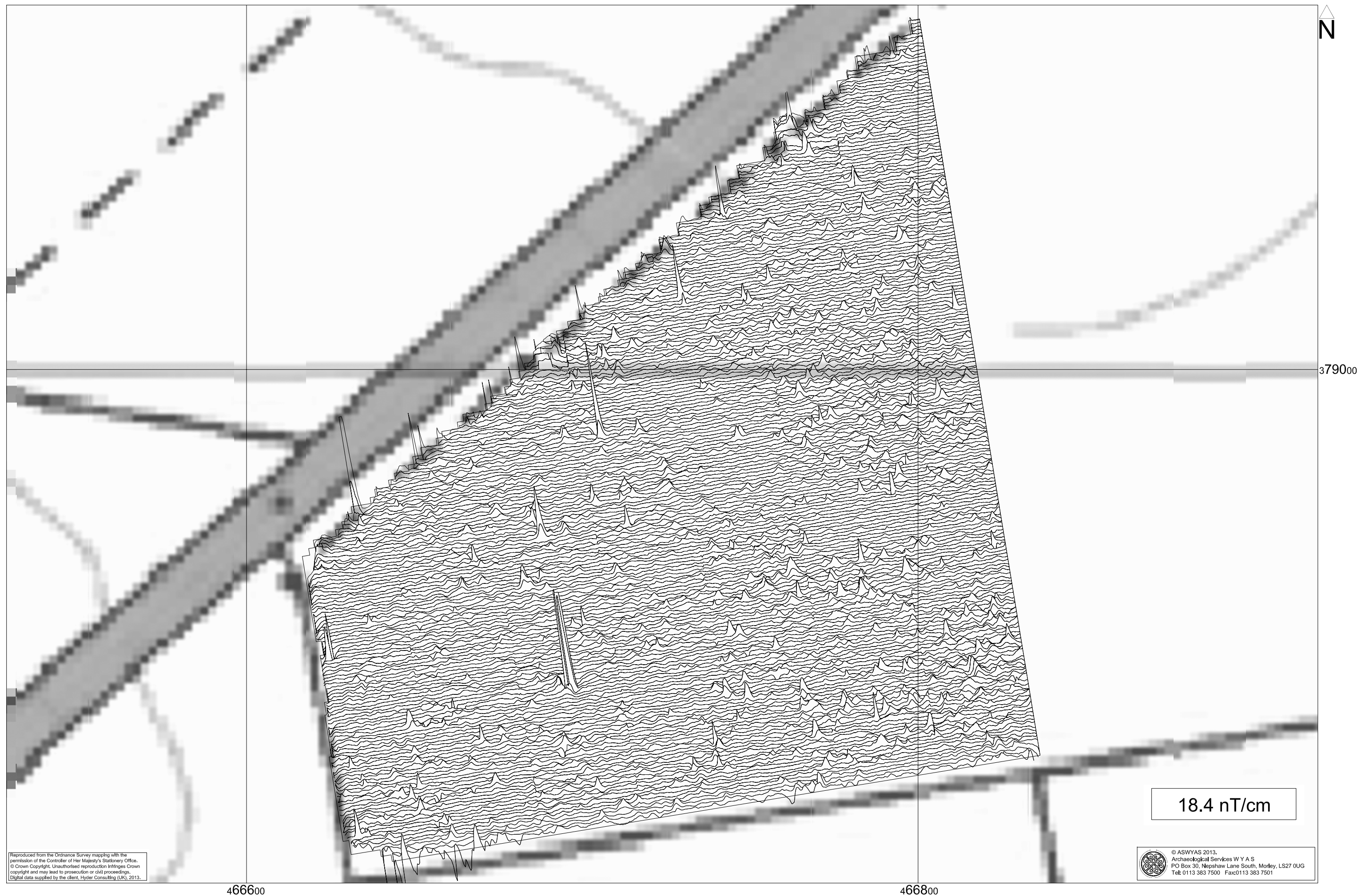


Fig. 4. XY trace plot of minimally processed magnetometer data (1:1000 @ A3)

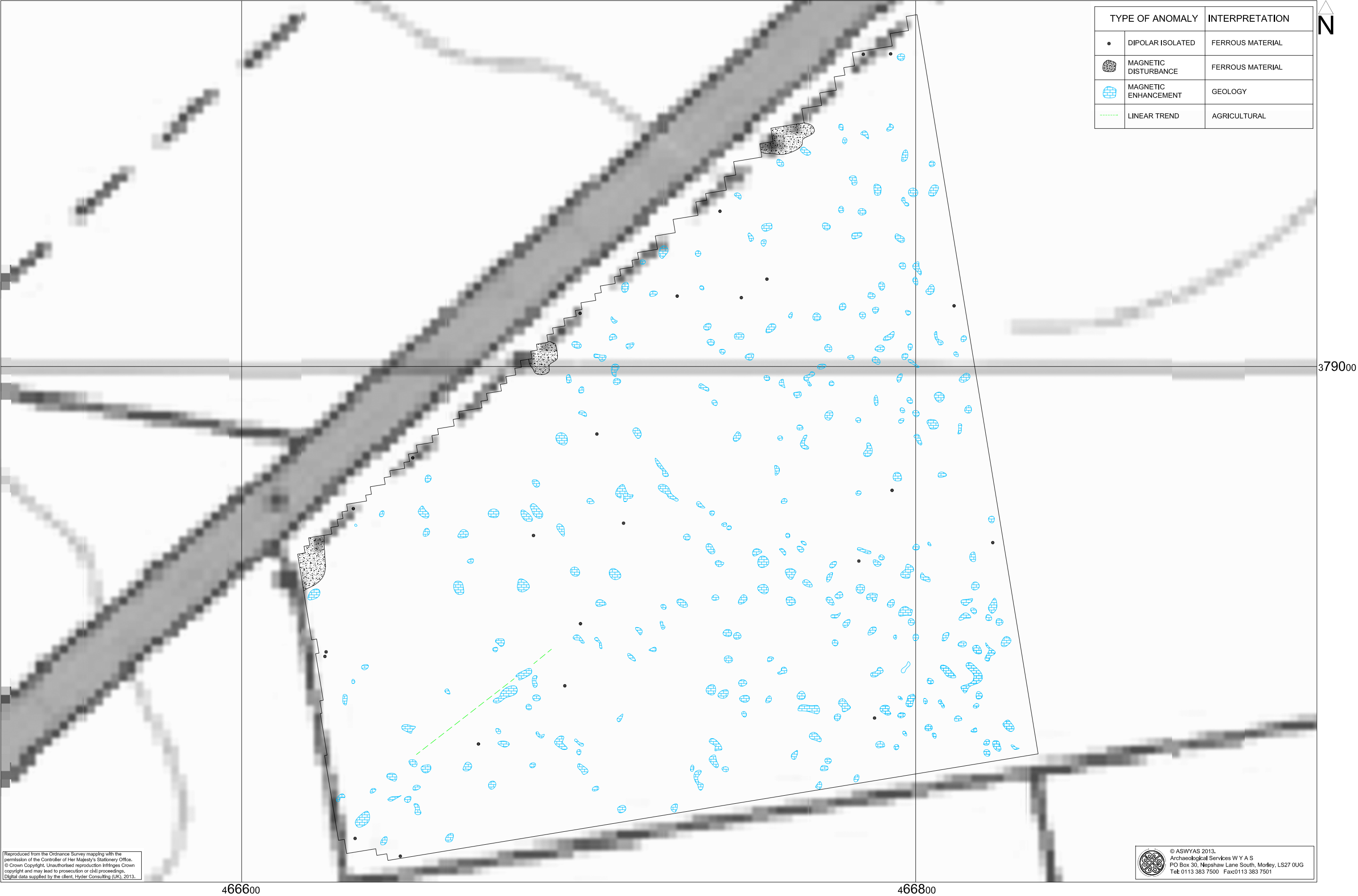


Fig. 5. Interpretation of magnetometer data (1:1000 @ A3)

0 20m



Plate 1. General view of survey area, looking south



Plate 2. General view of survey area, looking south-west