Archaeological Services WYAS

Land at White Horse Lane
Trowse
Norfolk

Geophysical Survey

Report no. 2402

October 2012

Client: NPS Archaeology

Registered Organisation IfA

Land at White Horse Lane
Trowse
Norfolk

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering approximately 4.5 hectares, was carried out at Trowse on the south-eastern edge of Norwich in advance of the proposed development of the site. Anomalies indicative of recent ploughing and geological variation have been identified. Other linear anomalies have been interpreted as being possibly archaeological in origin although a recent, post-medieval, cause is considered equally plausible. A large discrete anomaly may be due to an infilled gravel extraction pit. On the basis of the survey the archaeological potential of the site is considered to be moderate.

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Report Information

Client:	NPS Archaeology
Address:	Scandic House, 85 Mountergate, Norwich, NR1 1PY
Report Type:	Geophysical survey
Location:	Land at White Horse Lane, Trowse
County:	Norfolk
Grid Reference:	TG 246 065
Period(s) of activity: represented	post-medieval?
Report Number:	2402
Project Number:	3988
Site Code:	TIN12
OASIS ID:	archaeol11- 136798
Planning Application No.:	Pre-application
Museum Accession No.:	n/a
Date of fieldwork:	October 2012
Date of report:	October 2012
Project Management:	Sam Harrison BSc MSc AIfA
Fieldwork:	Louise Felding BA Mag. Art David Harrison BA MA MIfA James Lawton BSc MSc
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Photography:	David Harrison

Authorisation for distribution: --

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1 Introduction

Archaeological Services WYAS was commissioned by David Whitmore of NPS Archaeology to undertake a geophysical (magnetometer) survey in Trowse on the south-eastern periphery of Norwich (see Fig. 1), in advance of the submission of a planning application for a proposed development of the site. The scheme of work was undertaken in accordance with the guidance contained in the National Planning Policy Framework (NPPF) and was carried out on October 24th 2012.

Site location, topography and land-use

The proposed development area (PDA) is centred at TG 246 065 and is currently agricultural land (see Plate 1). It is bounded by White Horse Lane (and properties fronting onto it) to the north-west, the A146 to the south, allotments to the north-east and fields to the south-west (see Fig. 2) and comprised two separate fields covering approximately 5 hectares. The site is flat and is situated at approximately 30m above Ordnance Datum.

Geology and soils

The underlying bedrock geology comprises crag (sand and gravel) to the east with chalk to the west overlain by superficial deposits of Lowestoft Formation diamicton to the east and river terrace deposits to the west (BGS 2012). The soils are classified in the Burlingham 3 association being described as deep fine loams with slowly permeable subsoils (Soil Survey of England and Wales 1980).

2 Archaeological background

There are no known heritage assets within the proposed development area. However, an archaeological desk-based assessment of the site (Sillwood 2012) concluded that the ‘potential for heritage assets to be present ……. is high, especially those of prehistoric date’. This conclusion reflects the position of the site in the Yare valley, which is rich in prehistoric remains, with Arminghall Henge (see Fig. 2) approximately 600m from the PDA and numerous barrow cemeteries in the vicinity.

3 Aims, Methodology and Presentation

The general aim of the geophysical survey was to establish and clarify the nature of the archaeological resource within the PDA.

Specifically the survey sought to provide information about the nature and possible interpretation of any anomalies identified during the survey and thereby determine the presence or absence and likely extent of any buried archaeological remains.

The information from the geophysical survey will enable further evaluation and/or mitigation measures, if required, to be designed in advance of the proposed development.

In order to achieve these aims a detailed (recorded) magnetometer survey was carried out over the whole of the PDA, an area of approximately 4.6 hectares.

Magnetometer survey

Bartington Grad601 magnetic gradiometers were used during the survey taking readings at 0.25m intervals on zig-zag traverses 1m apart within 30m by 30m grids so that 3600 readings were recorded in each grid. These readings were stored in the memory of the instrument and later downloaded to computer for processing and interpretation. Geoplot 3 (Geoscan Research) software was used to process and present the data. Further details are given in Appendix 1.

Reporting

A general site location plan, incorporating the 1:50000 Ordnance Survey map is shown in Figure 1. A large scale (1:5000) site location plan showing the greyscale magnetometer data is shown in Figure 2. The data are presented in greyscale, XY trace plot and interpretation formats in Figures 3, 4 and 5 at a scale of 1:1000.

Further technical information on the equipment used, data processing and survey methodologies are given in Appendix 1 and Appendix 2. Trace plots of the 'raw' data and data repeatability plots are included in Appendix 3 and Appendix 4. Appendix 5 describes the composition and location of the site archive.

The geophysical survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David *et al.* 2008) and by the Institute for Archaeologists (IfA 2010). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

The figures in this report have been produced following analysis of the data in 'raw' and processed formats and over a range of different display levels. All figures are presented to most suitably display and interpret the data from this site based on the experience and knowledge of Archaeological Services staff.

4 Results and Discussion

For clarity, the interpretation of the results will be described according to the causes of the identified anomalies with those interpreted as having a non-archaeological origin first and possible archaeological anomalies last.

Ferrous anomalies

Isolated dipolar ('iron spike') anomalies have been identified throughout the survey area. These anomalies are typically caused by ferrous (magnetic) debris, either on the ground surface or in the topsoil horizon, which causes rapid variations in the magnetic readings giving a characteristic 'spiky' XY trace. Unless there is supporting evidence for an archaeological interpretation little importance is normally attributed to such anomalies, as modern ferrous objects are common on rural sites, often being present as a consequence of manuring or tipping/infilling. There is no obvious clustering to these anomalies that might suggest some potential significance and they are therefore interpreted as being due to random ferrous debris.

An extensive zone of magnetic disturbance around the north-eastern periphery of the PDA is due to the presence of track around the edge of the field.

A linear, dipolar anomaly, running parallel with White Horse Lane is caused by a ferrous service pipe.

Geological anomalies

Numerous small discrete anomalies, characterised as localised areas of magnetic enhancement, have been identified across the whole of the survey area. The widespread distribution and lack of any apparent pattern suggests these anomalies have a geological origin, being due to localised variations in the underlying superficial deposits and/or soils.

Broad, vague linear trends aligned north-west/south-east (aligned obliquely to the ploughing trends (see below) are also identified in the south-eastern half of the site. These are also interpreted as geological in origin and seem to correlate with the change in bedrock and superficial geologies in this part of the site (see above).

Agricultural anomalies

Numerous linear trend anomalies, aligned north-west/south-east, at right angles to White Horse Lane, are caused by modern ploughing.

Possible archaeological anomalies

Four linear anomalies, **A**, **B**, **C** and **D** have been identified. These anomalies are all slightly oblique to the current field layout, do not appear to correspond with any boundaries shown on the historic mapping and are of a much stronger magnitude than the ploughing and geological trends described above. For these reasons these anomalies are interpreted as having some archaeological potential although a more recent origin is also considered possible. In recognition of this interpretation some of the discrete anomalies, particularly those located between **B**, **C** and **D**, are also interpreted as being potentially archaeological.

A much larger discrete anomaly, **E**, is also highlighted. Again an archaeological origin is possible but a more likely origin is that it locates an infilled (gravel?) extraction pit – similar features are shown on early mapping.

5 Conclusions

Anomalies due to recent agricultural and modern activity have been identified by the magnetometer survey across all parts of the site. Although no anomalies of definite archaeological potential have been identified four linear anomalies which do not readily fall into any of the non-archaeological categories have been identified and these have consequently been ascribed a possible archaeological cause. However, a non-archaeological cause for any or all of these anomalies is considered equally plausible. On the basis of the survey the site is assessed as having a moderate archaeological potential.

Disclaimer

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.

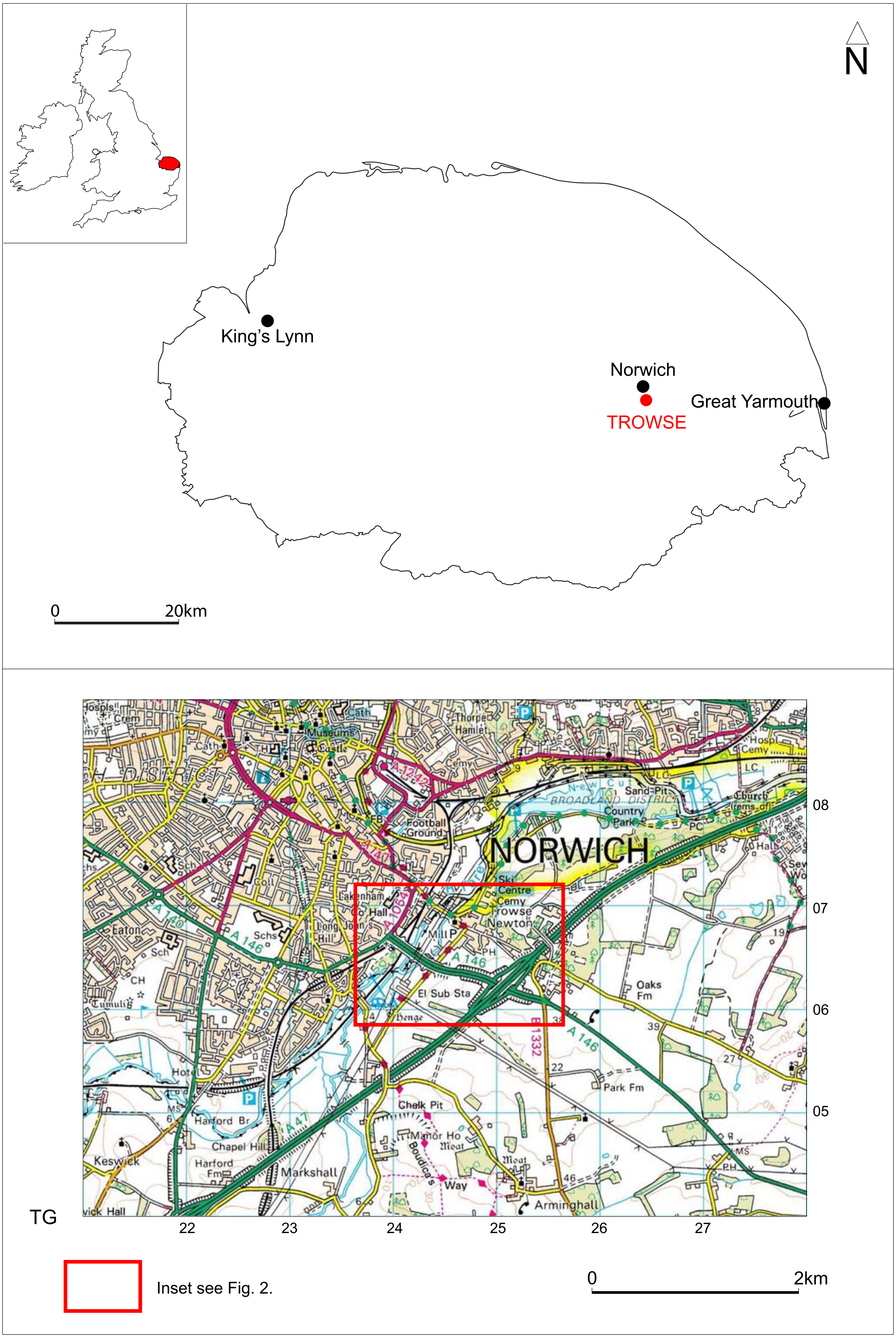

Fig. 1. Site location

Fig. 2. Site location showing greyscale magnetometer data (1:5000 @ A4)

0 100m

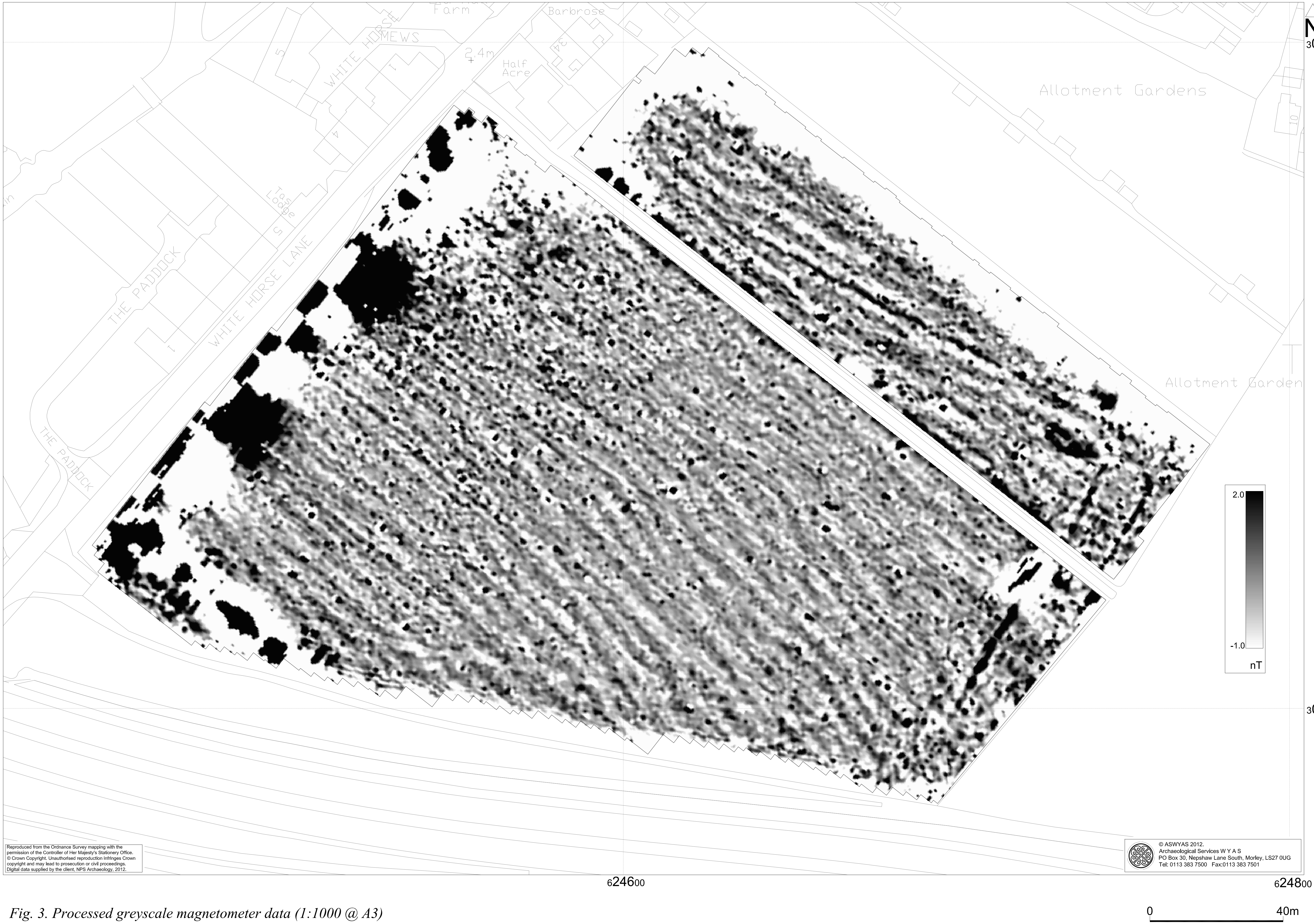

Fig. 3. Processed greyscale magnetometer data (1:1000 @ A3)

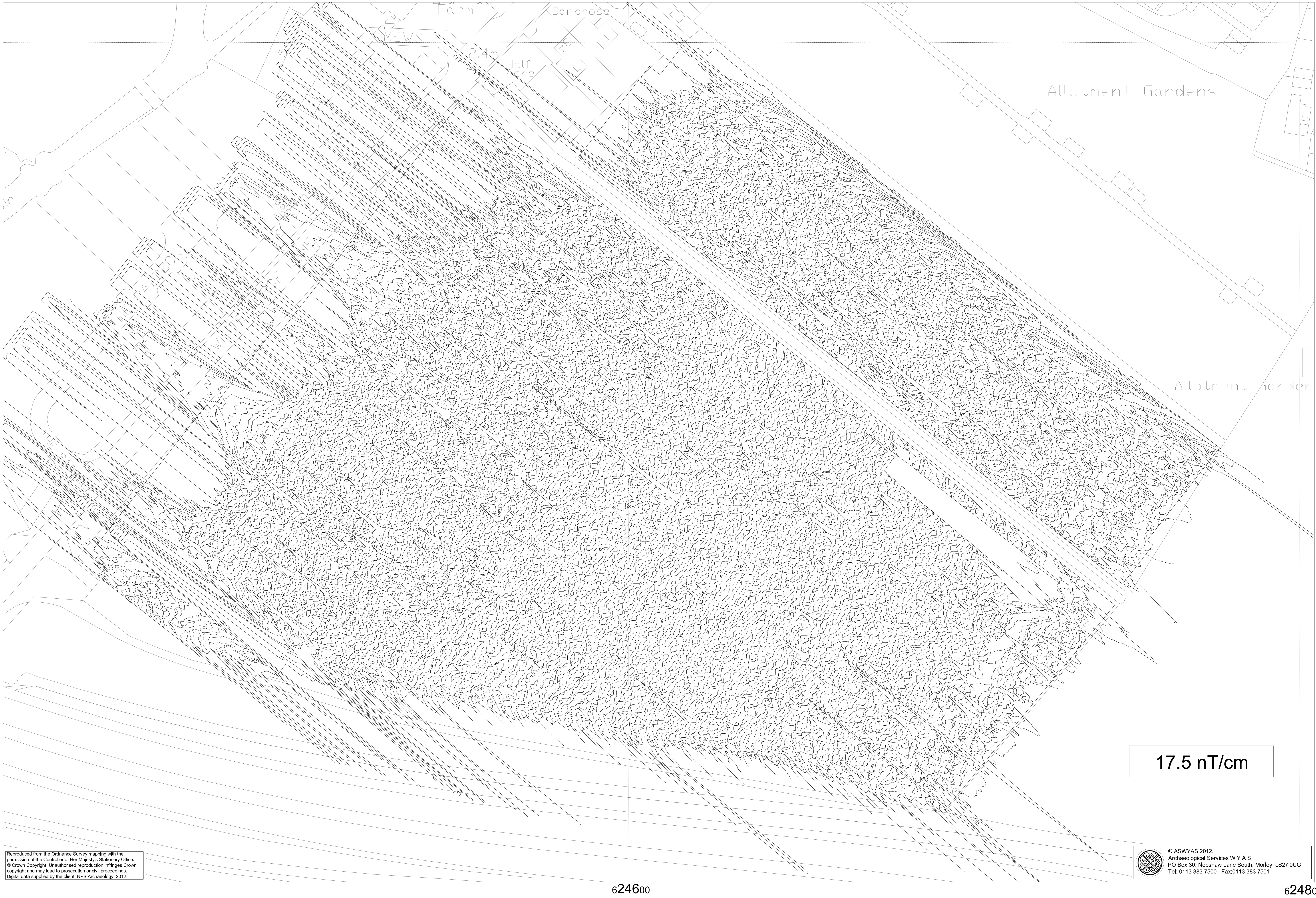

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Fig. 4. XY trace plot of minimally processed magnetometer data (1:1000 @ A3)

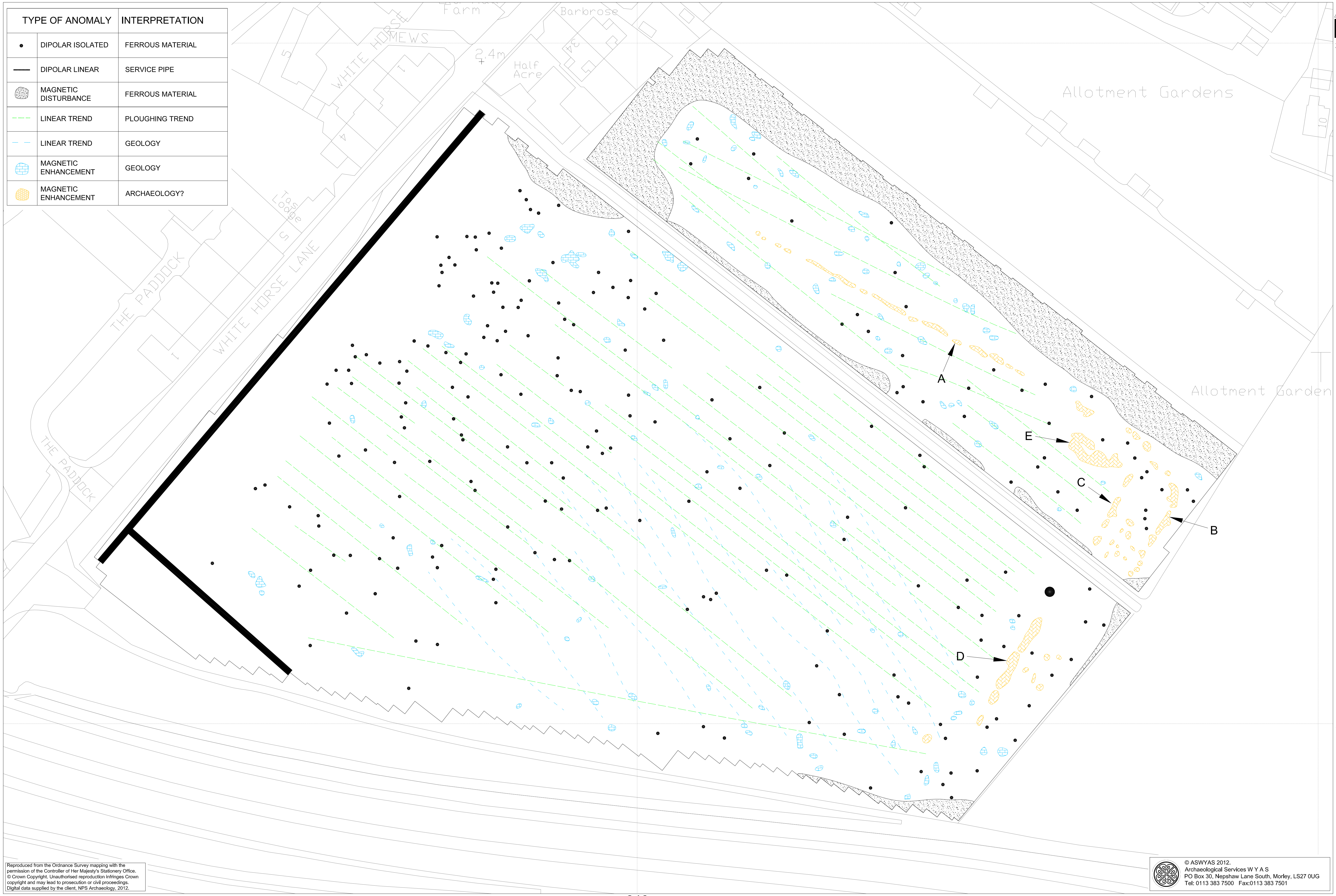


Fig. 5. Interpretation of magnetometer data (1:1000 @ A3)

Plate 1. General view of survey area, looking north-east

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.

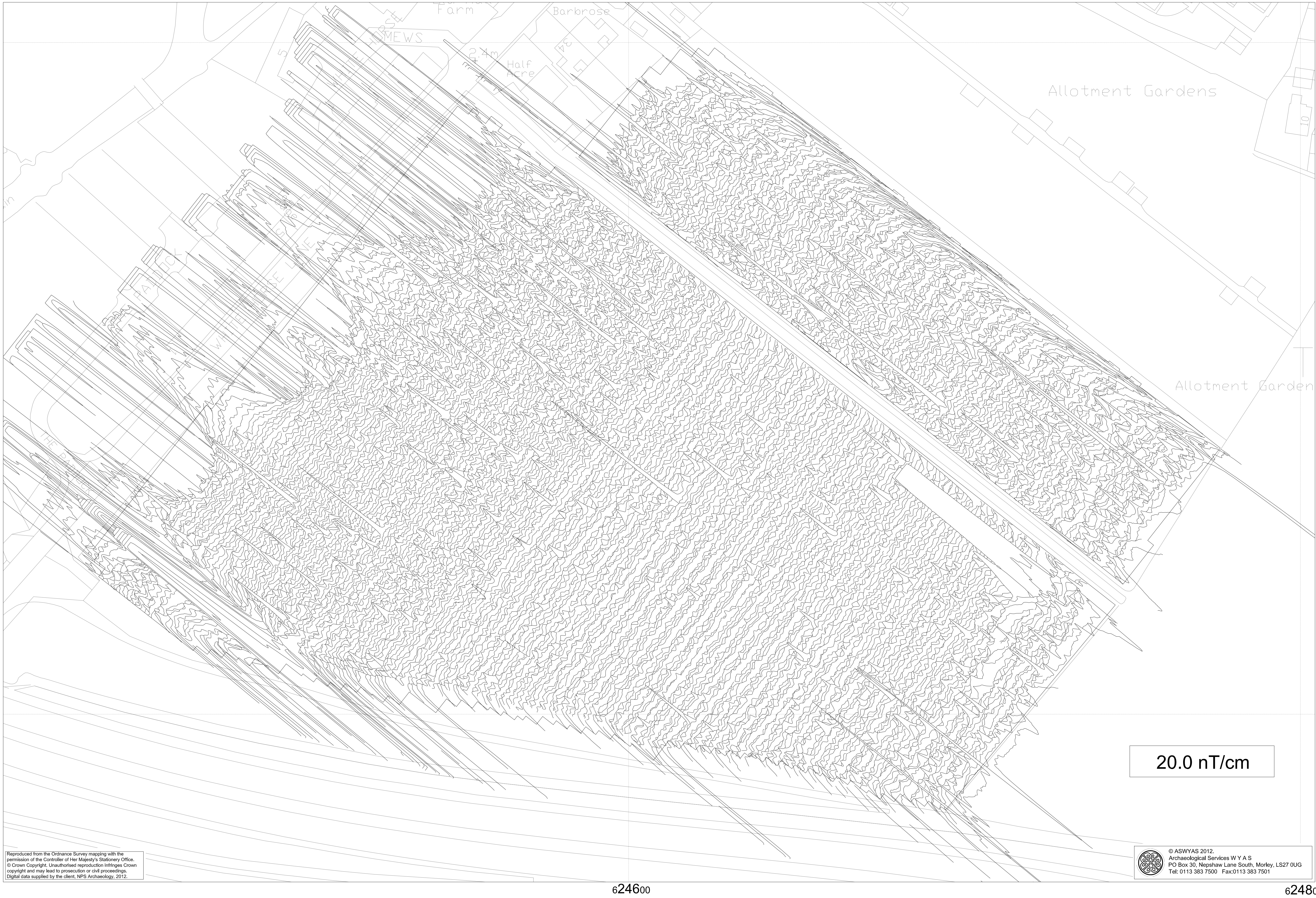
Geoplot 3 software was used to interpolate the data so that 3600 readings were obtained for each 30m by 30m grid. The same program was used to produce the greyscale images. All greyscale plots are displayed using a linear incremental scale.

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 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.

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: Raw XY trace plot data



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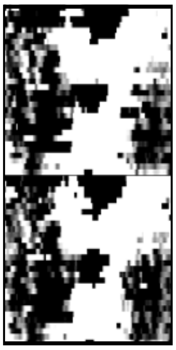
XY trace plot of raw magnetometer data (1:1000 @ A3)

Appendix 4: Data repeatability

Data Repeatability

JOB NUMBER	3988	SITE CODE	TIN12	JOB NAME	Land off White Horse Lane, Trowse



25/10/2012 Grid surveyed at 08:00 and 15:00

Appendix 5: 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 Norfolk Historic Environment Record).

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Soil Survey of England and Wales, 1980, Soils of Eastern England Sheet 3