ARCHAEOLOGICAL SERVICES WYAS

Land west of Doncaster Road
Thorpe Audlin
West Yorkshire

Geophysical Survey

Report no. 2363

July 2012

Client: West Yorkshire Archaeology Advisory Service

REGISTERED ORGANISATION IfA

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Thorpe Audlin
West Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering approximately 4 hectares, was carried out on agricultural land off Doncaster Road, to the north of Thorpe Audlin, at the request of the West Yorkshire Archaeology Advisory Service, in order to provide additional information about the extent and complexity of a cropmark site, believed to be a Roman fort. The survey has identified a series of linear anomalies describing a sub-square enclosure with internal partitioning suggestive of a Roman fort. Entrances have been located to the southern and eastern sides with a possible road providing access to the eastern entrance. The alignment and form of some of the internal features suggest that there may have been more than one phase of activity on this site. Anomalies to the east of the fort are possibly indicative of industrial activity with further features between the fort and the Roman road.

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Report Information

Client:	West Yorkshire Archaeology Advisory Service
Address:	Newstead Road, Wakefield, WF1 2DE
Report Type:	Geophysical survey
Location:	Doncaster Road, Thorpe Audlin
County:	West Yorkshire
Grid Reference:	SE 1655 4203
Period(s) of activity: represented	pre-historic?/Roman
Report Number:	2363
Project Number:	3659
Site Code:	WRP10
OASIS ID:	archaeol11-130476
Planning Application No.:	n/a
Museum Accession No.:	n/a
Date of fieldwork:	August 18th – September 2nd 2011
Date of report:	July 2012
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Authorisation for distribution: --

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1 Introduction

Archaeological Services WYAS was commissioned by Ian Sanderson, Principal Archaeologist of the West Yorkshire Archaeology Advisory Service (WYAAS), to undertake a geophysical (magnetometer) survey over a cropmarked site west of Doncaster Road, Thorpe Audlin, near Wakefield (see Fig. 1) which has been interpreted as a possible Roman fort. The survey was carried out between August 18th 2011 and September 2nd 2011.

Site location, topography and land-use

Thorpe Audlin is a small village, located approximately 2km to the south-west of Wentbridge and 4.5km south-east of Pontefract (see Fig. 1). The site is located to the north of the village, immediately south-west of the intersection of the River Went and Doncaster Road, the A639 (see Fig. 2). The survey area lies at about 22m above Ordnance Datum (aOD) in the east rising to 28m aOD in the west. It was fallow at the time of survey (see Plates).

Geology and soils

The underlying bedrock comprises Ackworth Rock – sandstone, which is overlain by alluvium in the north of the survey area (BGS 2012). The soils are classified in the Bardsey 1 and Conway associations. These soils are characterised as slowly permeable and seasonally waterlogged loams and deep stoneless fine silts and clays affected by ground water respectively (SSEW 1983).

2 Archaeological background

The site was first identified on air photographs as a large, nearly square cropmark enclosure measuring 135m by 130m situated 100m west of Roman Road 28b (Margary 1973). A more recent aerial photographic survey identified linear features within the main enclosure. The extent of the monument, which covers 1.75 hectares, suggests that it is a Roman fort (P. Wilson *pers comm*.), perhaps an auxiliary fort serving either the Roman fort and settlement at Castleford (*Lagentium*),10km to the north, or the Roman fort and settlement at Doncaster (*Danum*) 17km to the south-east. It has been suggested that it was located to defend the crossing of the River Went and the Roman Road (Roberts 2010).

The Monument Class Description (Carlton 1988) identifies a Roman fort as a rectangular enclosure covering between 0.8 hectares and 4 hectares, bounded by a single rampart. Most forts contain barrack blocks, stables and storehouses. Other features and structures may include pits, water tanks, wells, latrines and ovens; the two latter features being positioned against the inside of the ramparts. Other, less detectable and less definable, features may include postholes or groups of postholes.

The site was first investigated by fieldwalking carried out between 1977 and 1987 by the Pontefract and District Archaeological Society. This investigation located a number of tegulae and imbreces (roof tile), hypocaust box tiles, quern fragments, Dales ware and Samian pottery. A trial trench evaluation followed and located a section of an enclosure ditch nearly 10m wide and 2m deep which was recorded as cutting earlier features.

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 the possible Roman fort and any associated features.

In order to achieve these aims detailed (recorded) magnetometer survey was undertaken over the cropmark. Following consultation with WYAAS the survey area was subsequently expanded to more fully define the extent of archaeological activity. In total an area of approximately 4.2 hectares was surveyed. The results of the survey will help inform WYAAS.

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 (1:4000) site location plan showing the greyscale magnetometer data and cropmarks 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. Appendix 3 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

Ferrous Anomalies

Ferrous anomalies, either as individual 'spikes' or more extensive areas of magnetic disturbance, are typically caused by ferrous (magnetic) debris, either on the ground surface or mixed in with the plough-soil. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation, as ferrous debris is common on rural sites, often being present as a consequence of manuring or tipping/infilling. On this site there are relatively few iron spike anomalies which may signify that the land has probably not been manured frequently. The larger 'spike' anomalies, identified by the much larger black dots on the interpretation figure, correlate with the position of electricity poles and their support stays.

A very strong linear dipolar anomaly locates a ferrous pipe running north-east/south-west.

Archaeological Anomalies

The cropmark is clearly identifiable in the data set as a strong magnetic anomaly, **A**. The anomaly is caused by an infilled ditch defining a large, broadly square, enclosure approximately 135m by 130m. The eastern corner of the enclosure is not identified, any potential response being masked by the much stronger magnetic response of the pipe which cuts across this part of the site. The northern side of the enclosure is much less well defined; the magnetic response from the enclosure ditch perhaps being obscured by an increased depth of alluvium from the river immediately north of the survey area. A much weaker, discontinuous anomaly, **B**, located immediately adjacent to, and parallel with, the larger inner ditch, may be caused by a smaller, outer, ditch. Two obvious breaks in the response of the inner ditch, labelled **C** and **D**, may indicate entrances into the enclosure on the eastern and southern sides of the enclosure. On the southern side the possible outer ditch (**B**) appears to be positioned to defend this entrance whilst to the east a broad area of low magnetic response, approximately 9m wide, flanked by fragmented linear trends, **E**, may locate a possible road or trackway connecting the enclosure with the Roman road immediately to the east.

Within the enclosure a plethora of linear, curvilinear and discrete anomalies have been identified. Some of the linear ditch type anomalies, such as **F**, **G**, **H** and **I** are aligned north-west/south-east parallel with the orientation of the enclosure possibly signifying internal divisions within the enclosure. Others, such as **J**, are slightly oblique to the basic alignment of the enclosure and this anomaly also seems to continue to the west beyond the enclosure. Curvilinear anomalies **K** and **L** are also indicative of ditches. Although in some instances it appears that some of these anomalies intersect it is not possible to phase the site on the basis of the geophysical data. However, it is considered possible that the identified features are indicative of more than one phase of activity.

Throughout the enclosure discrete anomalies are identified (see below). These are too numerous to report individually, and some of them may have a geological origin. However, their location and context strongly suggests that the majority will have an archaeological origin. There is a particularly dense cluster of these anomalies in the north-eastern corner of the enclosure.

Immediately to the east of the enclosure another cluster of discrete anomalies, **M**, of increased magnetic enhancement has been identified. The strength of these anomalies relative to the soil filled features causing the majority of the anomalies suggests that this might be the site of industrial activity. The magnetic responses in this area are of higher magnitude and more variable than the rest of the site.

Possible remains of features external to the enclosure have been located in the south-eastern corner of the survey area, to the south of the pipe. A number of discontinuous and discrete anomalies, collectively labelled **N**, may be indicative of plough-damaged features almost certainly associated with the enclosure to the west or the Roman road to the east.

Discrete Areas of Magnetic Enhancement

Numerous isolated anomalies, characterised as discrete areas of magnetic enhancement, are present throughout the survey area. It is very difficult to give a confident interpretation for these types of responses but it is considered likely that all will be due to one of the two possible causes detailed below. The interpretations offered are based on the location of the anomaly (relative to other anomalies and landscape features) and the size and strength of each anomaly.

Geological anomalies

Most of the low magnitude discrete magnetic anomalies are located on the northern and eastern parts of the surveyed area. This part of the site is located on the flood plain of the nearby river and the anomalies recorded have been identified to reflect this. Although any of these anomalies could potentially be archaeological in origin a geological interpretation is thought more likely, being due to variations in the composition of the soils and sub-soils.

Archaeological features

Another possibility, particularly upon the higher ground above the flood plain, is that these anomalies are caused by archaeological features such as pits. This interpretation is given further credence by the proximity of probable archaeological features (see above).

5 Conclusions

The geophysical survey has confirmed the archaeological potential of this site, originally identified as a cropmark, locating a square enclosure measuring 135m by 130m. The internal divisions and numerous other discrete anomalies within the enclosed area suggests that the postulated interpretation of the feature as a Roman fort is likely. Two possible entranceways have been suggested on the southern and eastern sides with a possible road or trackway leading from the Roman road to the eastern entrance. The alignment of some of the linear features within the enclosure suggests that there may be more than one phase of activity at the site.

Between the fort and the Roman road an area of possible industrial activity has been identified together with several other features indicating further activity in this part of the site.

The geophysical survey has identified numerous anomalies of archaeological potential, several of which extend beyond the survey extents, particularly to the west. Further magnetometer survey to reveal the full extent of the archaeological activity between the fort and the road and in the wider landscape would greatly benefit the overall understanding of the site. In addition, targeted resistance survey within the interior of the fort may identify any surviving in situ structural remains.

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.

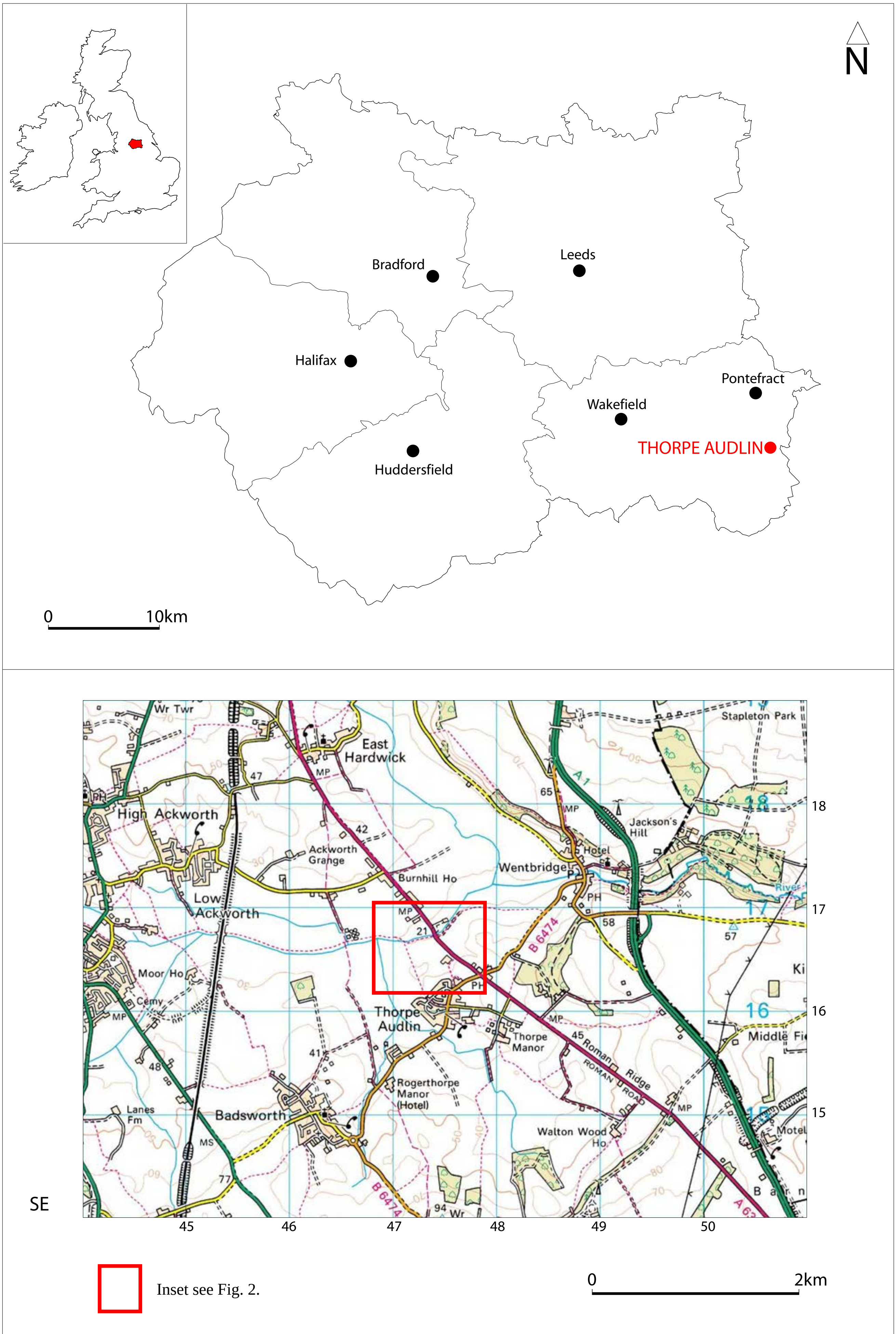

Fig. 1. Site location

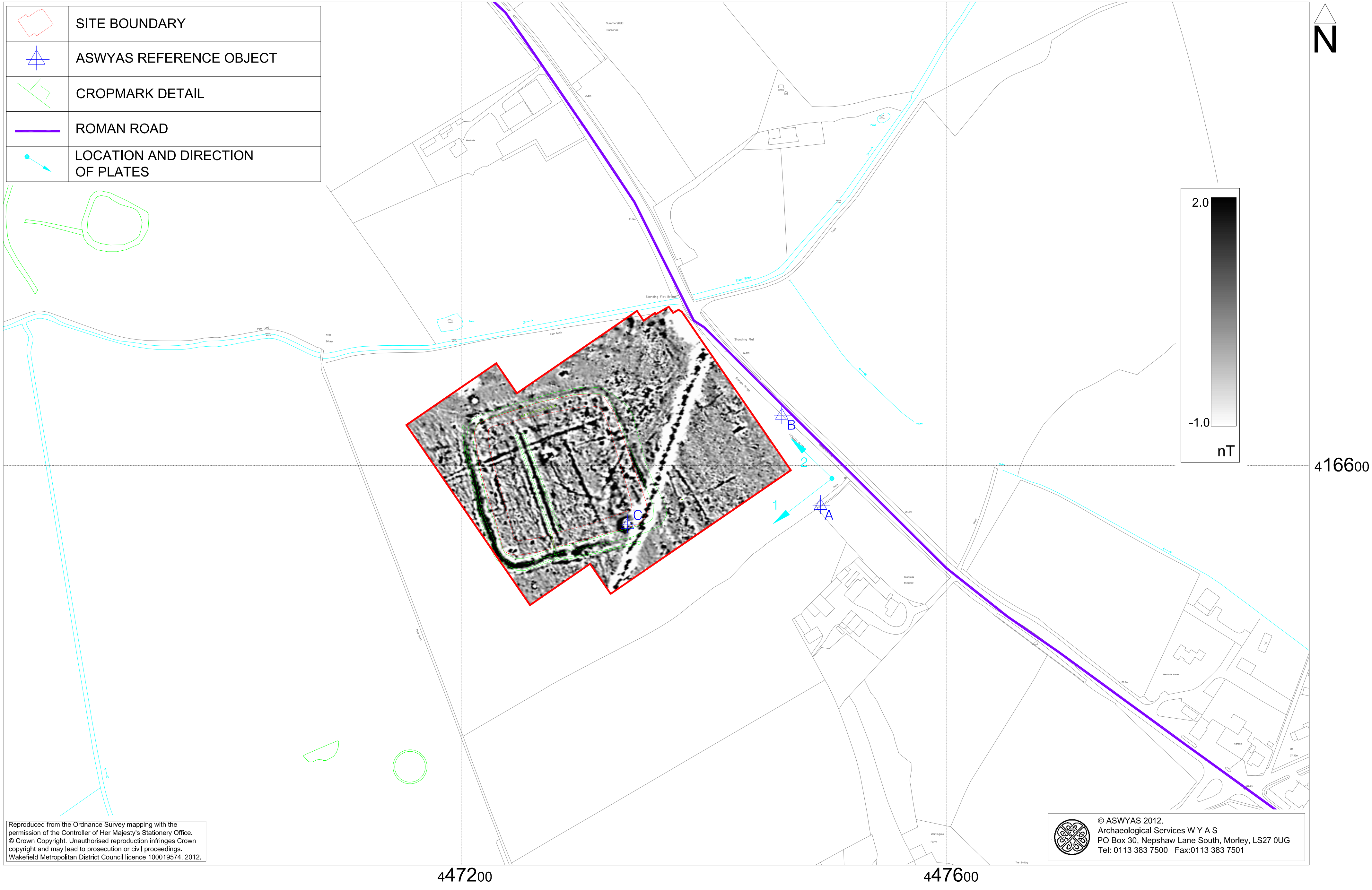

Fig. 2. Site location showing greyscale magnetometer data and cropmark detail (1:4000 @ A4)

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

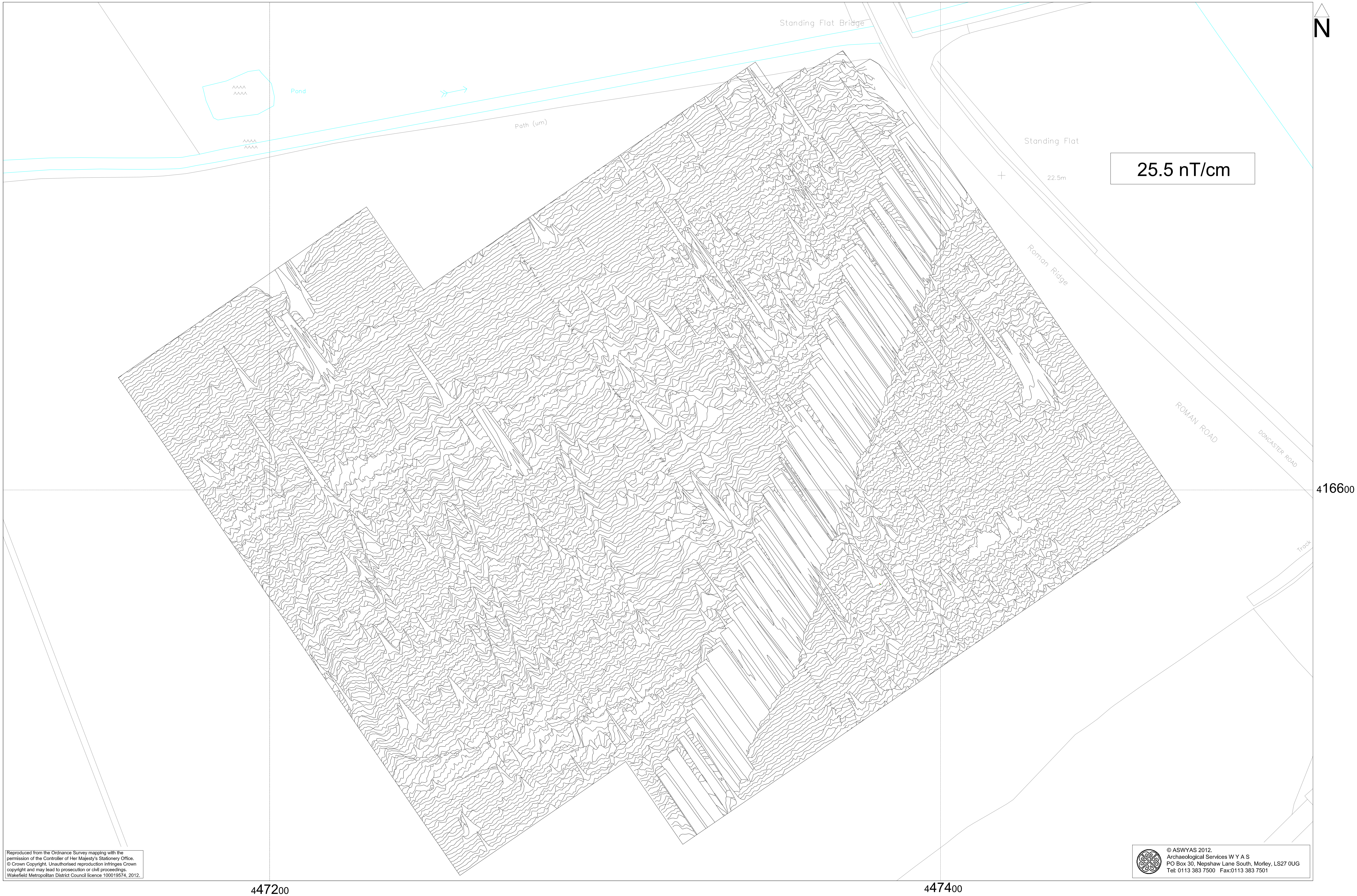

Fig. 4. XY trace plot of minimally processed magnetometer data (1:1000 @ A3)

0 25m

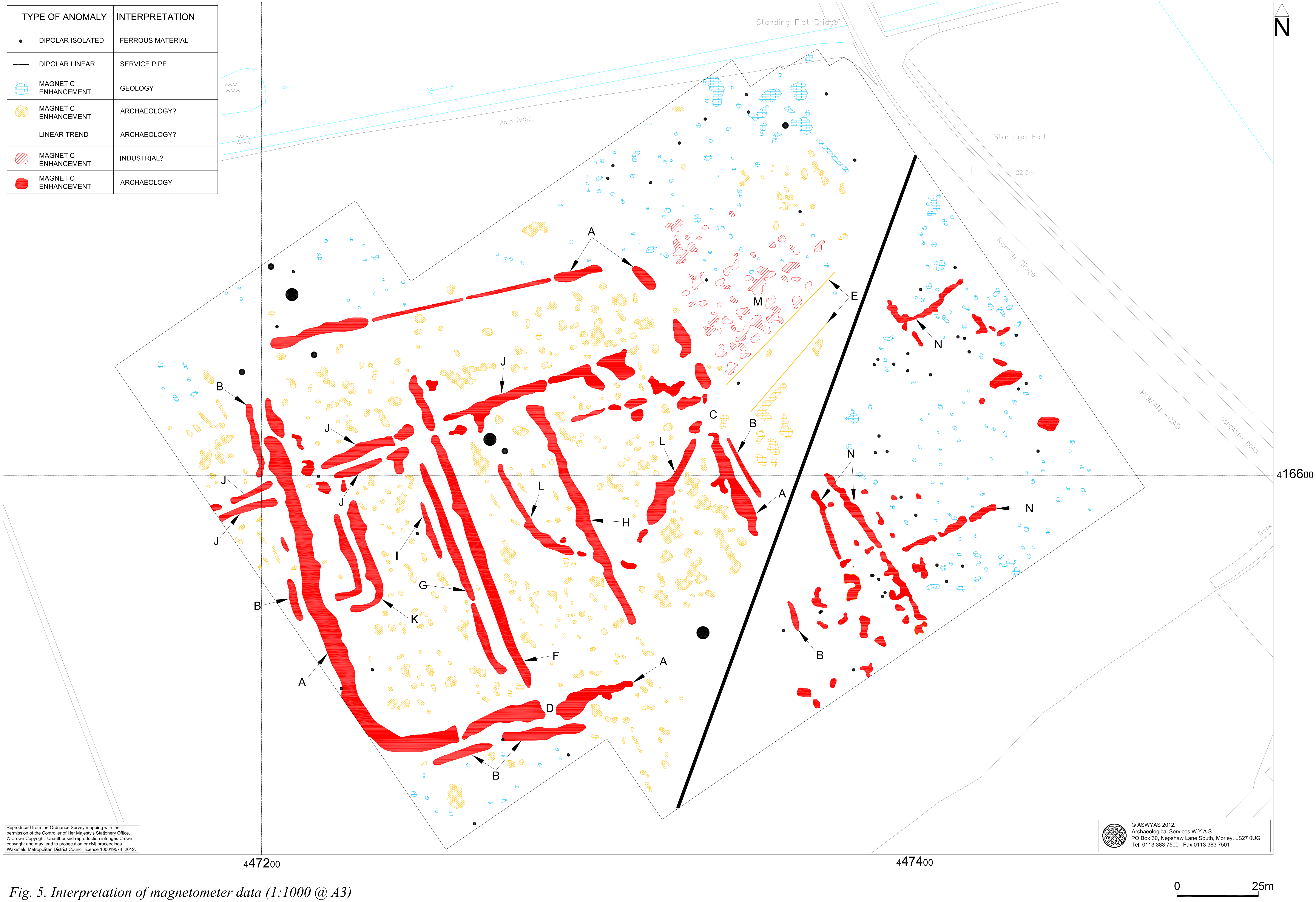

Fig. 5. Interpretation of magnetometer data (1:1000 @ A3)

Plate 1. General view of survey area, looking west

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

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 survey grid was laid out using a Geodimeter 600s total station theodolite and tied in to permanent landscape features and to temporary reference objects (survey marker pins) that were established and left in place following completion of the fieldwork for accurate geo-referencing. The locations of the temporary reference points are shown on Figure 2 and the Ordnance Survey grid co-ordinates tabulated below. The survey grids were then super-imposed onto a base map 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.

Station	Easting	Northing
A	447496.018	416566.920
B	447464.066	416641.197
C	447337.061	416551.208

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

Appendix 3: Geophysical archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (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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