ARCHAEOLOGICAL SERVICES WYAS

Barnham Cross Water Treatment Works to Little Whelnetham Resevoir Suffolk

Geophysical Survey

Report no. 2455

March 2013

Client: NPS Archaeology

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Barnham Cross Water Treatment Works to Little Whelnetham Reservoir Suffolk

Geophysical Survey

Summary

A geophysical (magnetometer) survey was carried out at four locations along the proposed route of a new treated water main which will connect Barnham Cross Water Treatment Works to Little Whelnetham Reservoir. Three of the survey areas are devoid of any anomalies of archaeological potential. However, anomalies indicative of extensive archaeological activity have been identified in the area south of Ixworth. These anomalies are thought to locate features or activity associated with the adjacent Roman fort, a scheduled ancient monument, and Roman road.

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Report Information

Client:	NPS Property Consultants Ltd
Address:	NPS Archaeology, Scandic House, 85 Mountergate, Norwich, NR1 1PY
Report Type:	Geophysical Survey
Location:	Various locations between Fakenham Magna and Rushbrooke
County:	Suffolk
Grid Reference:	TL 900 778 to TL 898 614
Period(s) of activity represented:	Roman
Report Number:	2455
Project Number:	3960
Site Code:	TTB12
Planning Application No.:	n/a
Museum Accession No.:	n/a
OASIS ID:	archaeol11-146464
Date of fieldwork:	December 2012 – January 2013
Date of report:	March 2013
Project Management:	Sam Harrison BSc MSc AIfA
Geophysical survey team:	Marina Rose Chris Sykes James Lawton
Report:	Alistair Webb BA MIfA
Illustrations:	Sam Harrison
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Authorisation for distribution: --

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1 Introduction

Archaeological Services WYAS was commissioned by David Whitmore of NPS Archaeology, on behalf of their clients Anglian Water Services Ltd, to carry out a geophysical (magnetometer) survey at four locations along the proposed route of a treated water pipeline (see Fig. 1) that will connect Barnham Cross Water Treatment Works (TL 87008 81645) to Little Whelnetham Reservoir (TL 89618 60287). Although the northern end of the pipe corridor is in Norfolk the four areas selected for survey are all in Suffolk. The scheme of work was undertaken in accordance with the guidance contained in the National Planning Policy Framework (NPPF) and was carried out between December 10th and December 12th 2012 and was completed on January 2nd 2013.

Site location, topography and land-use

At each location a 30m wide transect was surveyed covering the maximum width of the pipe corridor including easements. Survey was carried out at four locations; Area 1 north-west of Fakenham Magna, Area 2 and Area 3 east and south of Ixworth and Area 4 east of Rushbrooke (see Fig. 2). All of the areas were under arable agricultural production (see plates) at the time of survey.

Soils and geology

The underlying bedrock geology comprises Lewes Nodular, Seaford, Newhaven and Culver Chalk formations along the northern half of the pipe corridor (Area 1, Area 2 and Area 3) overlain with superficial deposits of Lowestoft Formation Diamicton. At the southern end of the corridor at Rushbrooke (Area 4) the geology comprises Crag Group sands again overlain with Diamicton (British Geological Survey 2013).

In Area 1 the soils are deep, well-drained sandy and coarse loams of the Newport 3 soil association. In Area 2 and Area 3 the soils are shallow and well-drained calcareous coarse and sandy loams over chalk rubble of the Newmarket 2 association whilst in Area 4 the soils are classified in the Melford association being described as deep, well-drained fine loams (Soil Survey of England and Wales 1983).

2 Archaeological and Historical Background

A desk-based assessment (NPS Archaeology 2012) concluded that '*the route crosses a rural landscape close to areas of high archaeological potential*' and that '*there are remains of a number of archaeological remains from a range of periods recorded near*' to the pipe corridor. These include prehistoric features at Barnham, Euston, Fakenham Magna, Ixworth and Pakenham; Roman features at Fakenham Magna, Ixworth, Pakenham and Rougham and Saxon features at Fakenham Magna and Ixworth.

Of particular note are the Roman villa and triple ditched fort at Ixworth (a scheduled ancient monument) and a Roman road which the corridor follows at the southern end of the scheme.

3 Aims, Methodology and Presentation

The aim of the geophysical survey was to gather sufficient information to establish the presence/absence, character and extent of any archaeological remains within the specific areas to be impacted by the proposed pipeline, and to inform further strategies should they be necessary.

The specific objectives were to:

- 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 produce a comprehensive site archive and report.

Magnetometer survey

Bartington Grad601 instruments were used to take 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 technical information on the equipment used, data processing and survey methodologies are given in Appendix 1 and Appendix 2.

The survey methodology, reporting standards 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.

Reporting

A general site location plan, incorporating the 1:50000 Ordnance Survey mapping is shown in Figure 1. Figure 2 shows the locations of the four survey areas along the pipe corridor at a scale of 1:10000. The data and interpretation of each of the four areas are presented at a scale of 1:4000 in Figures 3 to 8 inclusive and at a scale of 1:1000 scale, including in X-Y trace plot format in Figures 9 to 35 inclusive.

4 Results and Discussion

The results are discussed by area.

Area 1 - Fakenham Magna (see Figs 3, 4 and 9 to 20 inclusive)

This section of the corridor extends for 1.2km on the southern side of, running parallel to and adjacent with, Thetford Road. Prehistoric, Roman, Saxon and Medieval remains have been recorded immediately to the north between the road and the River Black Bourn.

The data recorded in this area is dominated by linear trend anomalies, particularly in the central part (Sectors 2 and 3). These anomalies are due to cultivation rows/wheelings. Plate 1 clearly shows the amount of rutting in this part of the corridor.

At the southern end of this area in Sector 4 a cluster of discrete anomalies clearly stands out. Whilst these responses could be due to magnetic cobbles or gravels in the superficial deposits given the high archaeological potential of this area an archaeological origin cannot be dismissed.

Area 2 – Ixworth North (see Figs 5, 6 and 21, 22 and 23)

This section extends 240m running parallel with the A143 between Crown Lane at the northern end and Stow Lane at the southern end and is located approximately 300m west of a Roman villa site which was probably also the focus for occupation in the Saxon period.

Only linear cultivation trends, a few ferrous responses and a few discrete anomalies due to minor variations within the soils and superficial deposits have been identified in this survey area.

Area 3 – Ixworth South (see Figs 5, 6 and 24 to 29 inclusive)

Area 3 extends approximately 0.5km from the A143 in the north to Cutters Lane in the south. The projected line of a Roman road clips the northern corner of this survey area and a large triple ditched Roman fort (also a scheduled ancient monument) is located immediately to the west of the pipe corridor.

A plethora of anomalies are identified at the northern end of the survey area. These anomalies are a combination of fairly well defined linear anomalies and more amorphous discrete anomalies characterised as broad areas of enhanced magnetic response. Four intermittent, possibly conjoining, linear anomalies, **A**, **B**, **C** and **D** are clearly identified. These anomalies are indicative of soil filled ditches, probably forming a rectilinear enclosure and are almost certainly associated with the Roman fort located immediately to the west. A fifth linear anomaly, **E**, may form a sub-division within the enclosure.

The discrete anomalies are less easy to interpret. The level and proximity of known and significant archaeological remains (the fort to the west and the road to the north) suggests that all of these anomalies could be archaeological. However, these anomalies are also redolent of geological variation and the presence of Mickle Mere and the river Black Bourn just to the north of the survey area suggests that some at least of these anomalies may have a natural origin.

A line of discrete anomalies locates the line of a former field boundary.

Area 4 – Rushbrooke (see Figs 7, 8 and 30 to 35 inclusive)

Area 4 extends south from the junction of Elderstub Lane with Eastlowhill Road for 0.5km running parallel with, and immediately west of Eastlowhill Road, which follows the line of a Roman road.

Discrete anomalies interpreted as being due to pockets of magnetic material in the soils and superficial deposits.

A single anomaly, **F**, of unknown origin has been identified at the northern end of the survey area. In the absence of an explanation an archaeological origin cannot be dismissed, particularly given the proximity of the Roman road.

5 Conclusions

Despite the proximity of significant archaeological remains in close proximity to the four selected survey areas only in Area 3, south of Ixworth, have anomalies of obvious archaeological potential been identified. Further work in this section prior to the commencement of groundworks for the pipe may be required. In the other areas an archaeological watching brief may be more appropriate.

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.

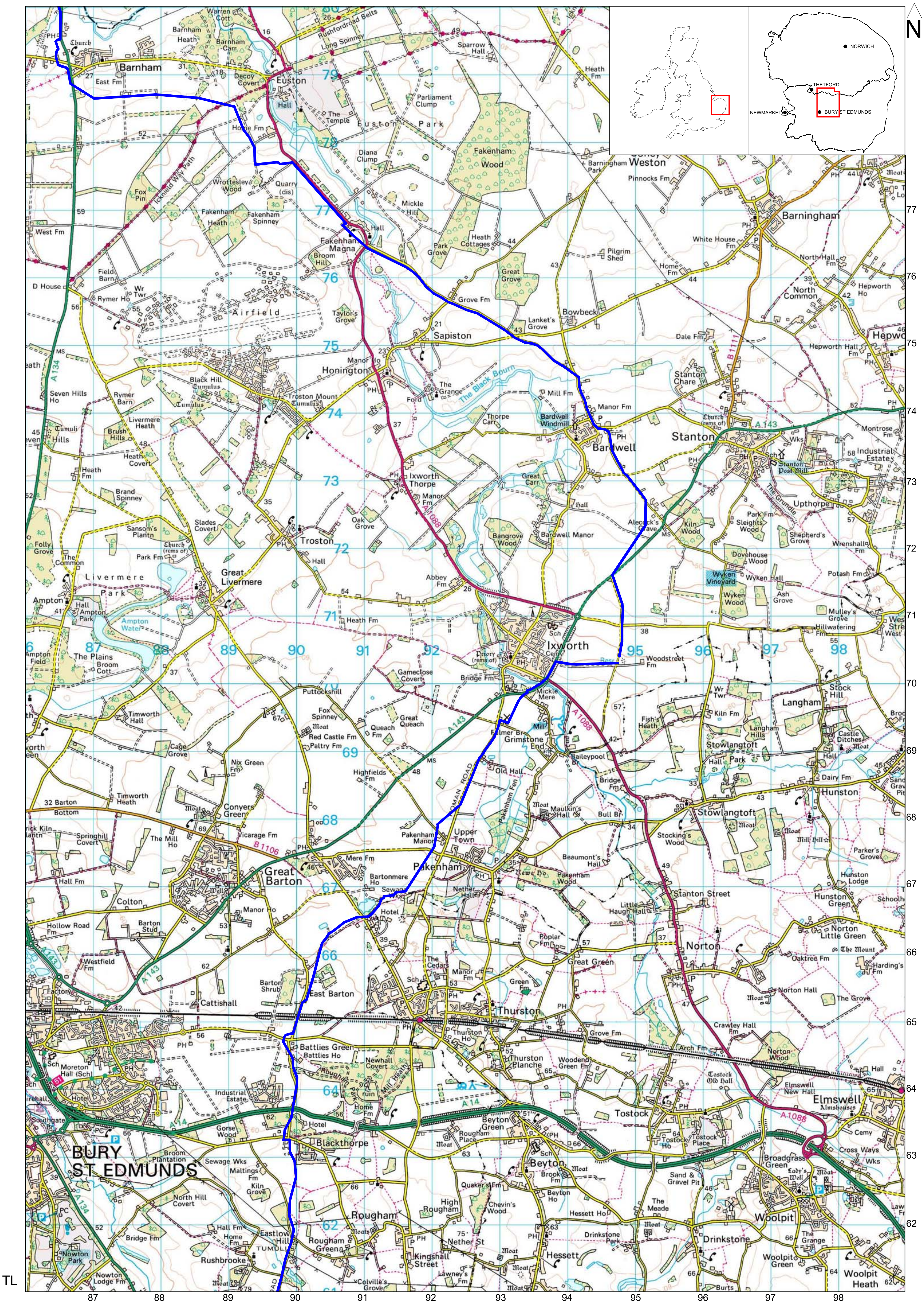

Fig. 1. Site location

Proposed pipeline

0 2km

Fig. 2. Pipe corridor showing areas of geophysical survey (1:10000 @ A3)

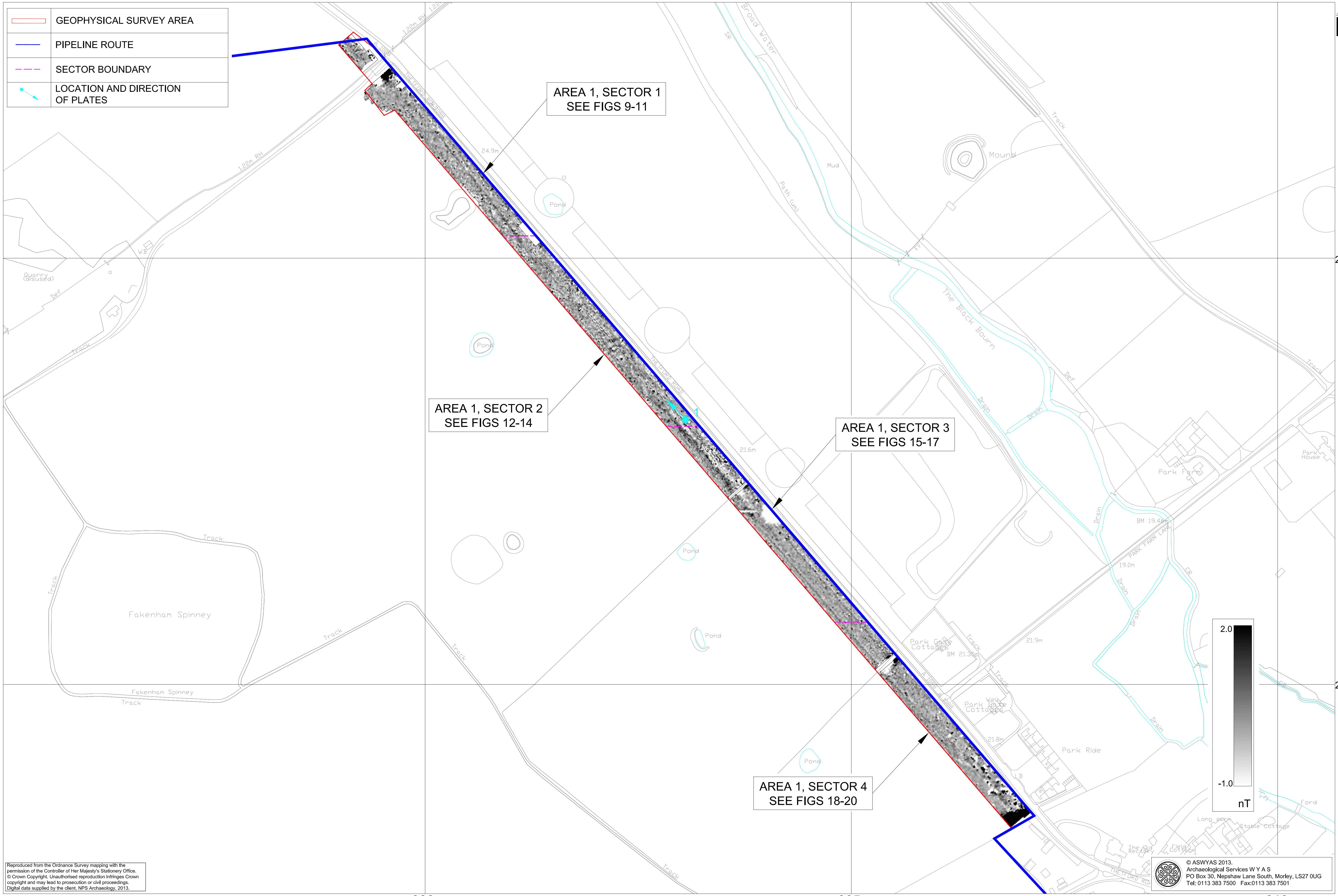

Fig. 3. Processed greyscale magnetometer data; Area 1, Fakenham Magna (1:4000 @ A3)

0 100m

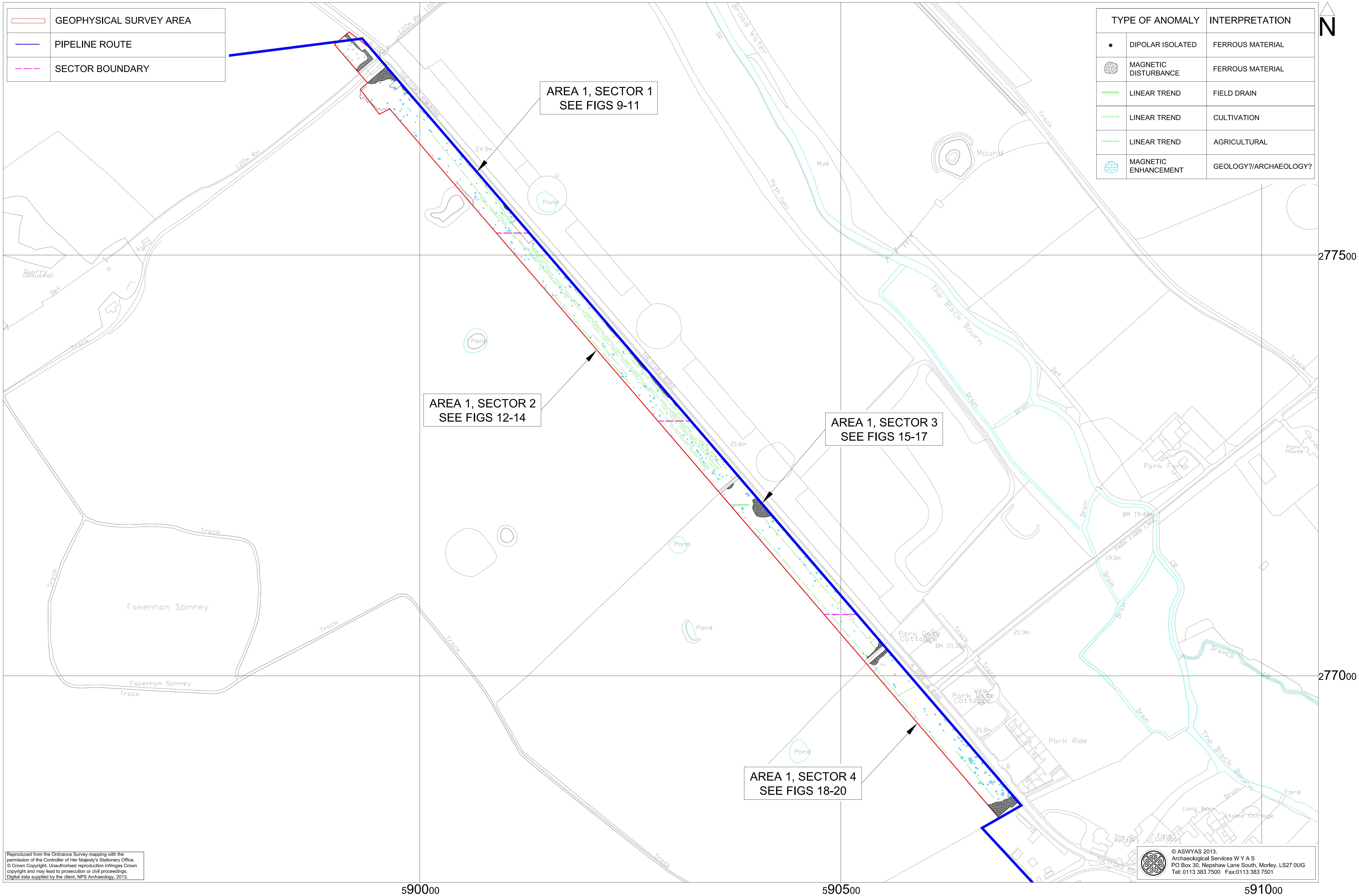

Fig. 4. Interpretation of magnetometer data; Area 1, Fakenham Magna (1:4000 @ A3)

0 100m

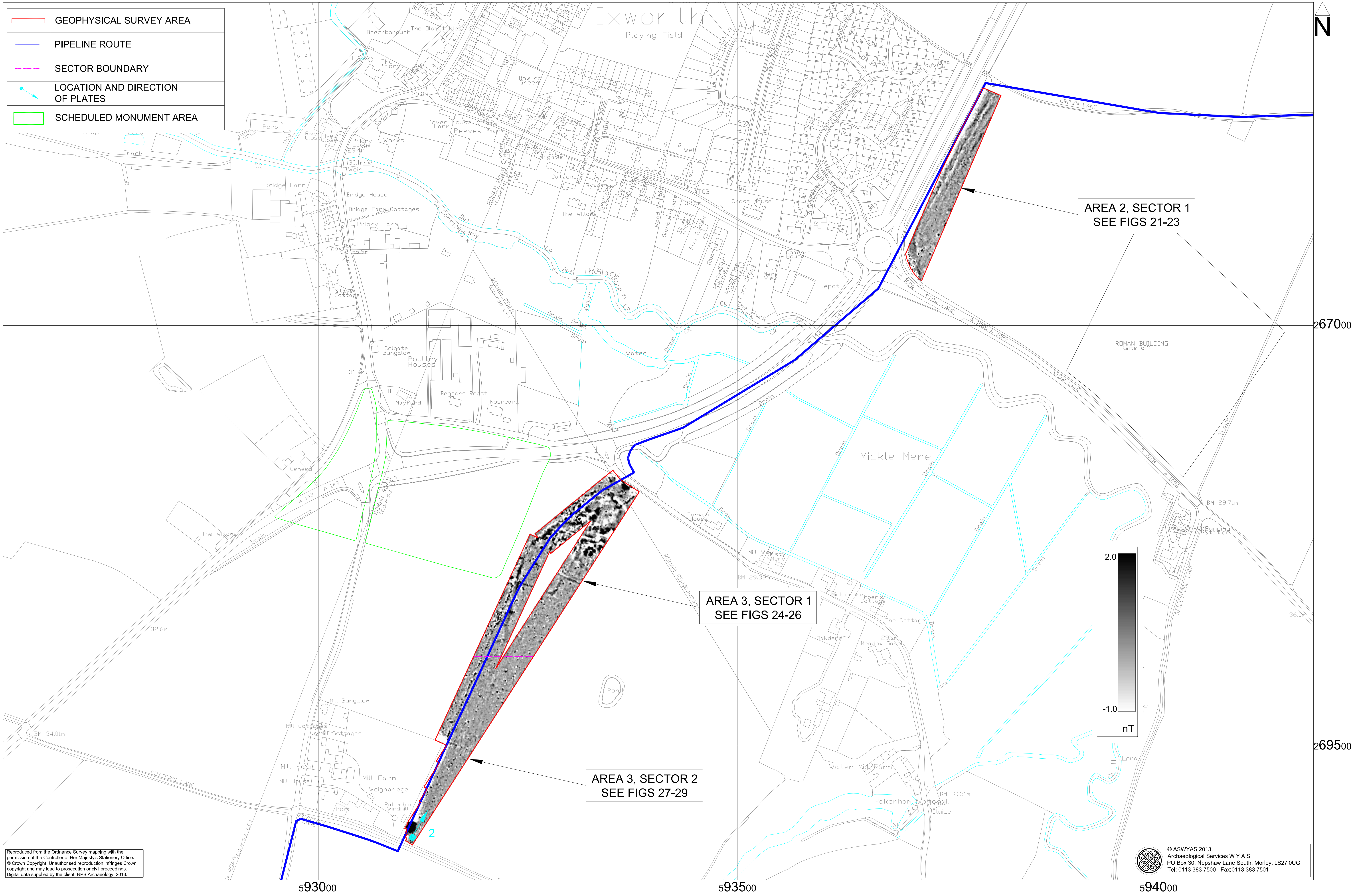

Fig. 5. Processed greyscale magnetometer data; Area 2 and Area 3, Ixworth (1:4000 @ A3)

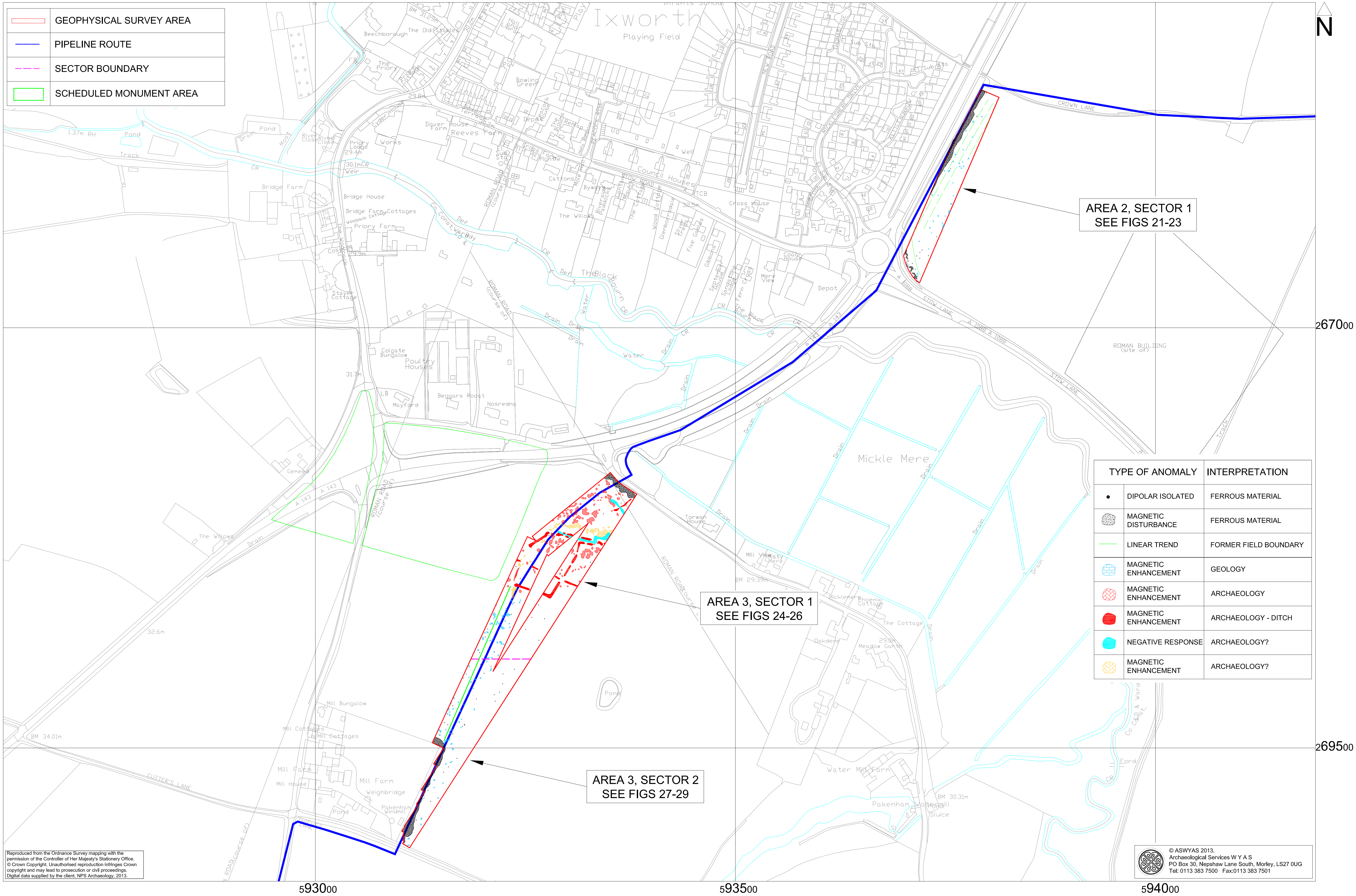

Fig. 6. Interpretation of magnetometer data; Area 2 and Area 3, Ixworth (1:4000 @ A3)

0 100m

Fig. 7. Processed greyscale magnetometer data; Area 4, Rushbrooke (1:4000 @ A3)

0 100m

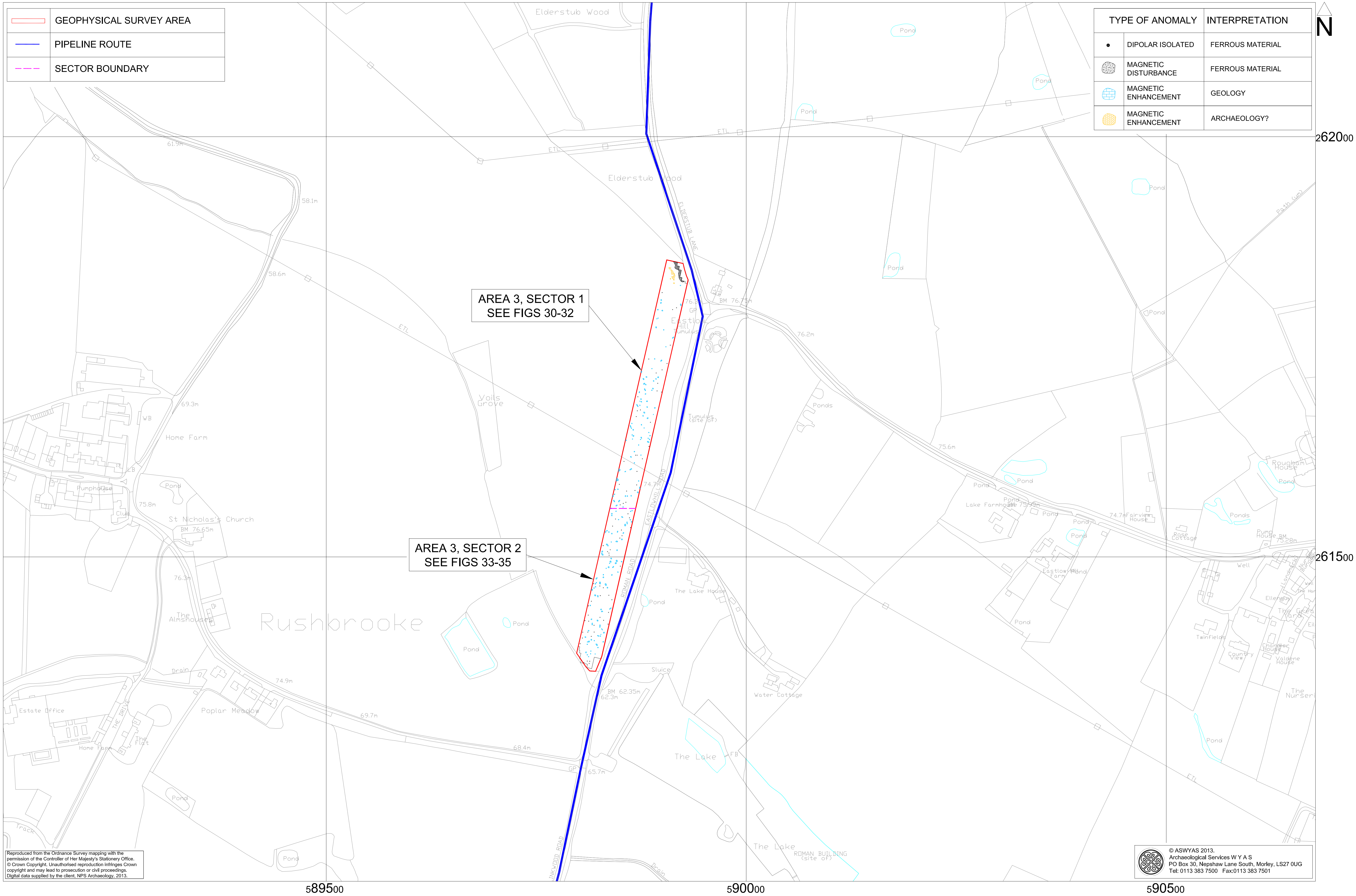

Fig. 8. Interpretation of magnetometer data; Area 4, Rushbrooke (1:4000 @ A3)

0 100m

Fig. 9. Processed greyscale magnetometer data; Area 1, Sector 1 (1:1000 @ A3)

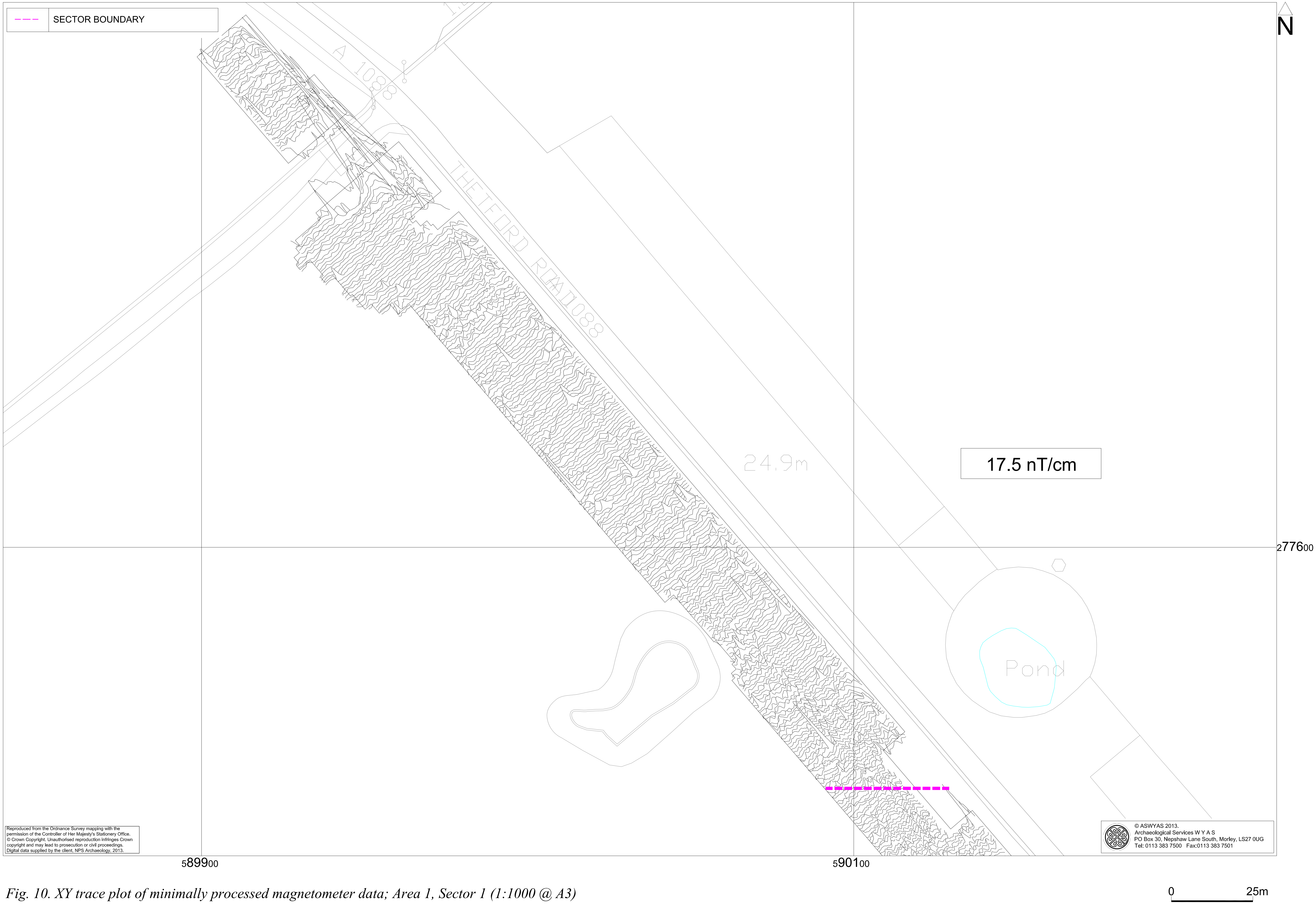

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Fig. 10. XY trace plot of minimally processed magnetometer data; Area 1, Sector 1 (1:1000 @ A3)

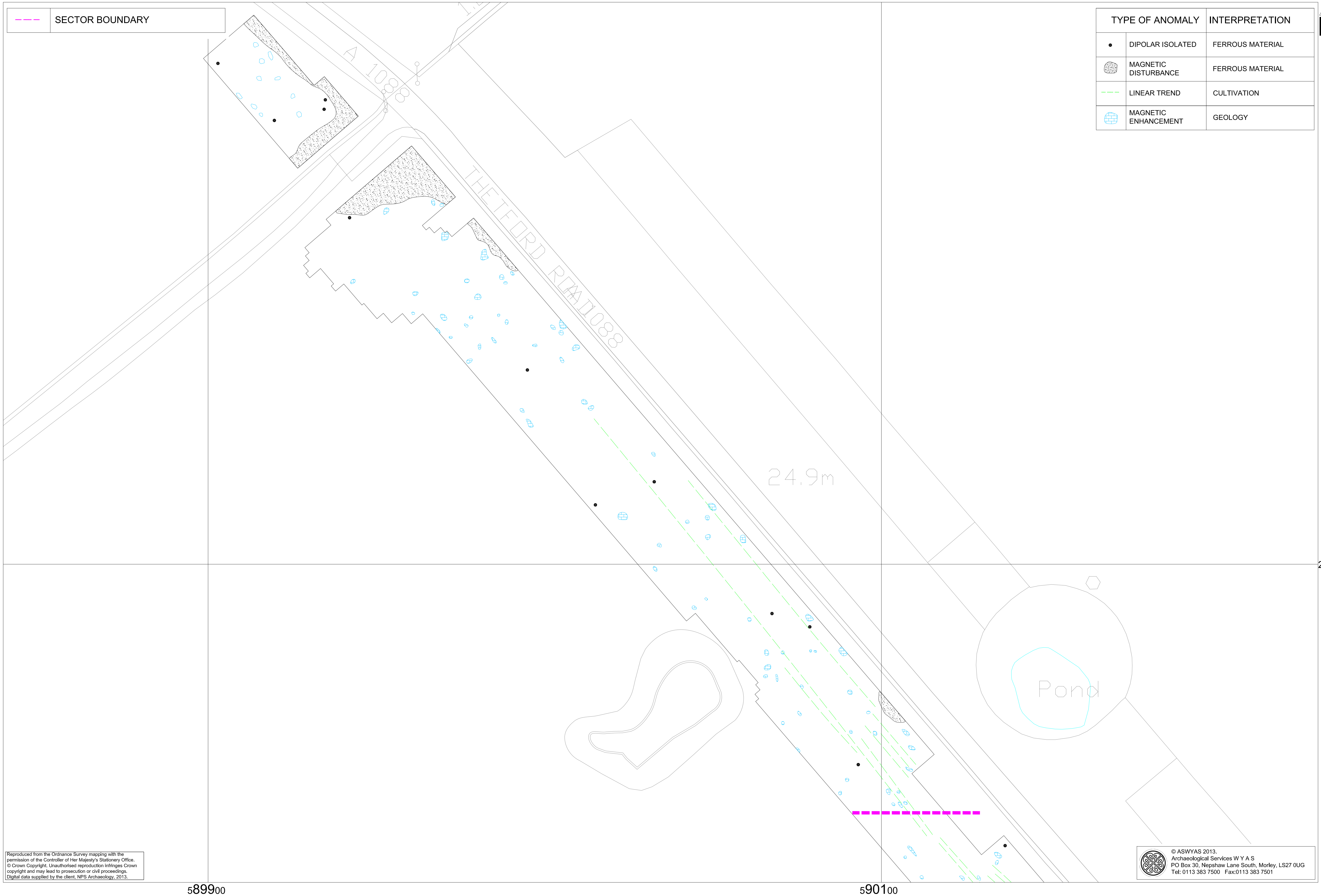

Fig. 11. Interpretation of magnetometer data; Area 1, Sector 1 (1:1000 @ A3)

0 25m

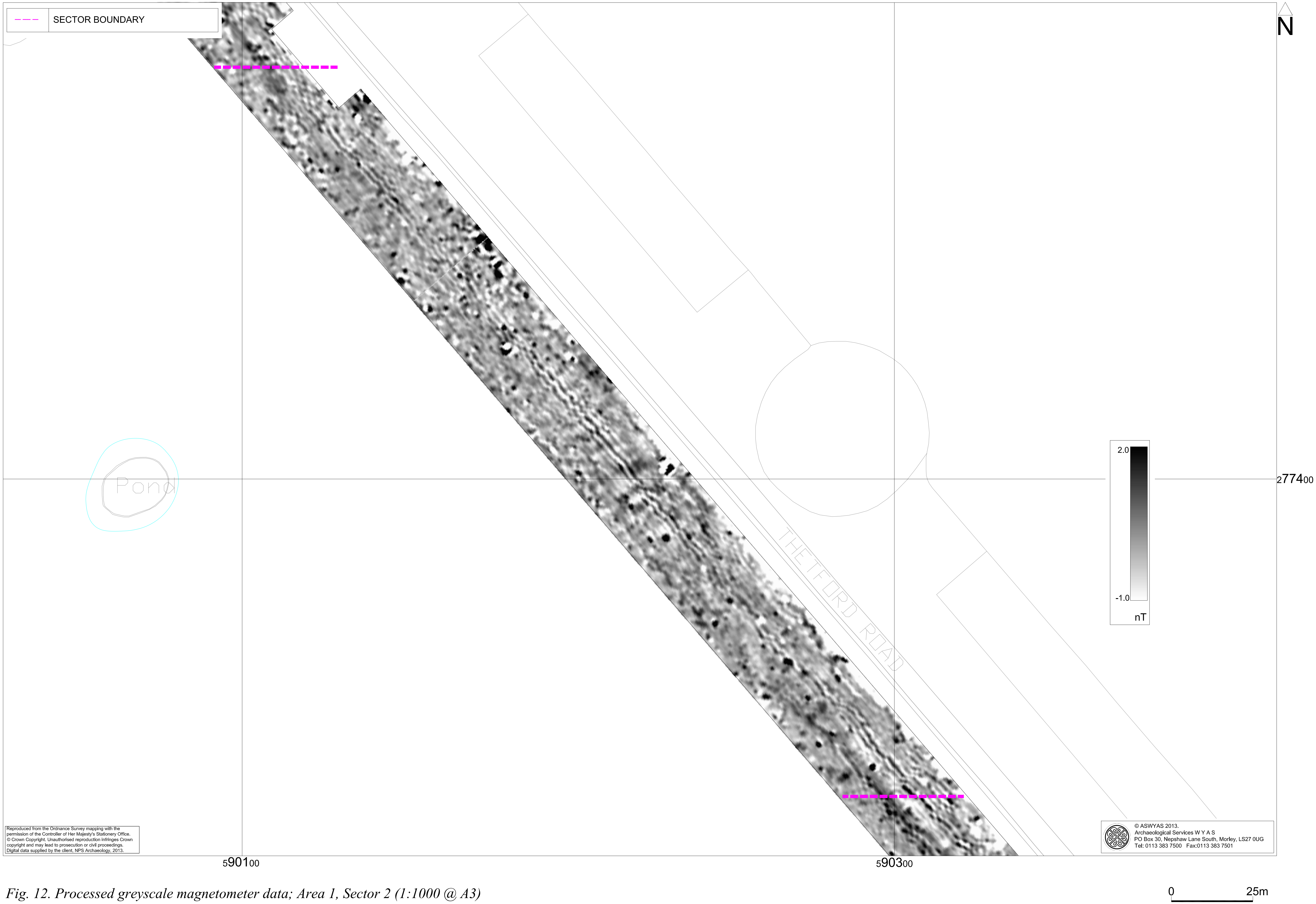

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Fig. 12. Processed greyscale magnetometer data; Area 1, Sector 2 (1:1000 @ A3)

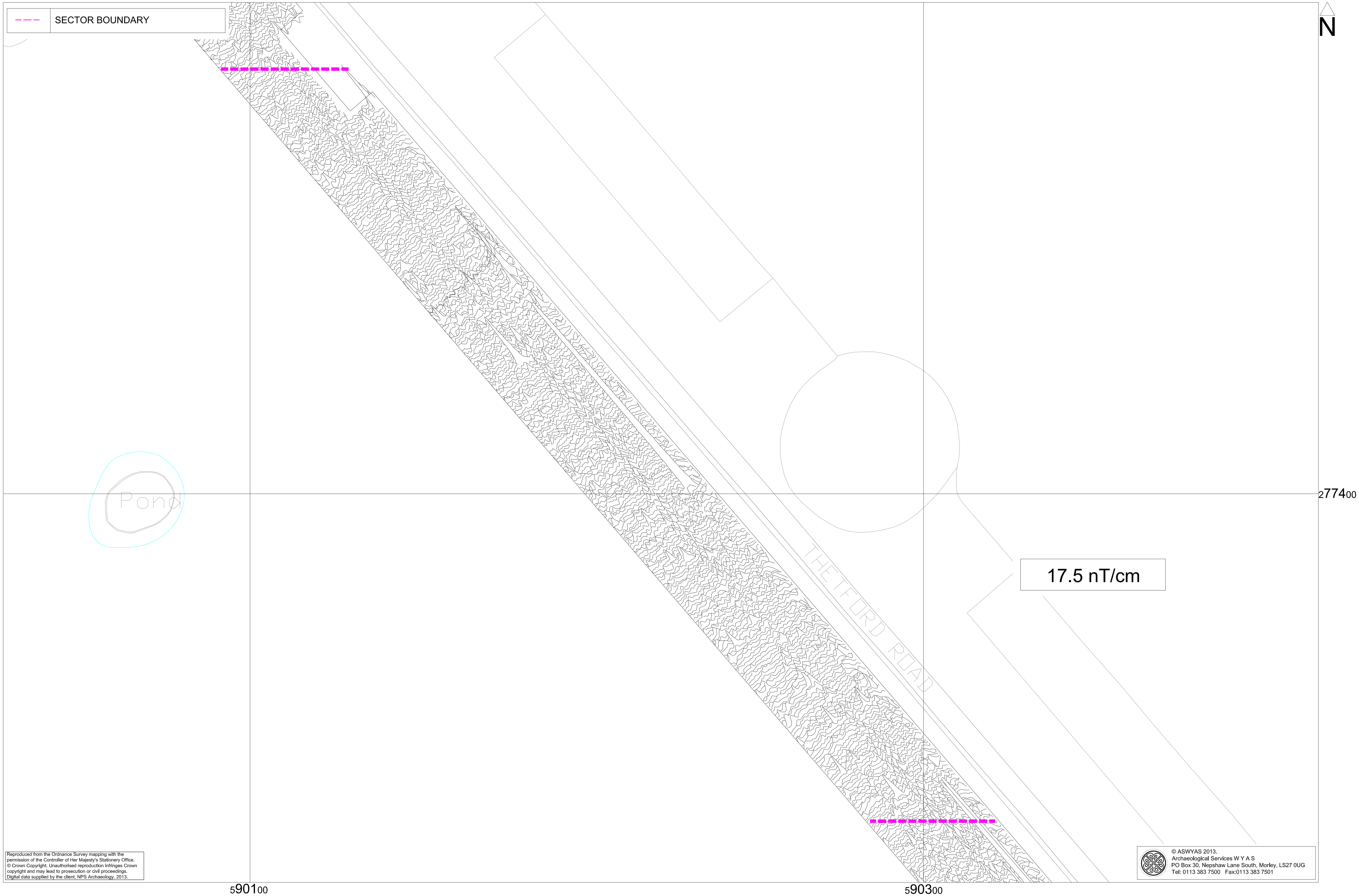

Fig. 13. XY trace plot of minimally processed magnetometer data; Area 1, Sector 2 (1:1000 @ A3)

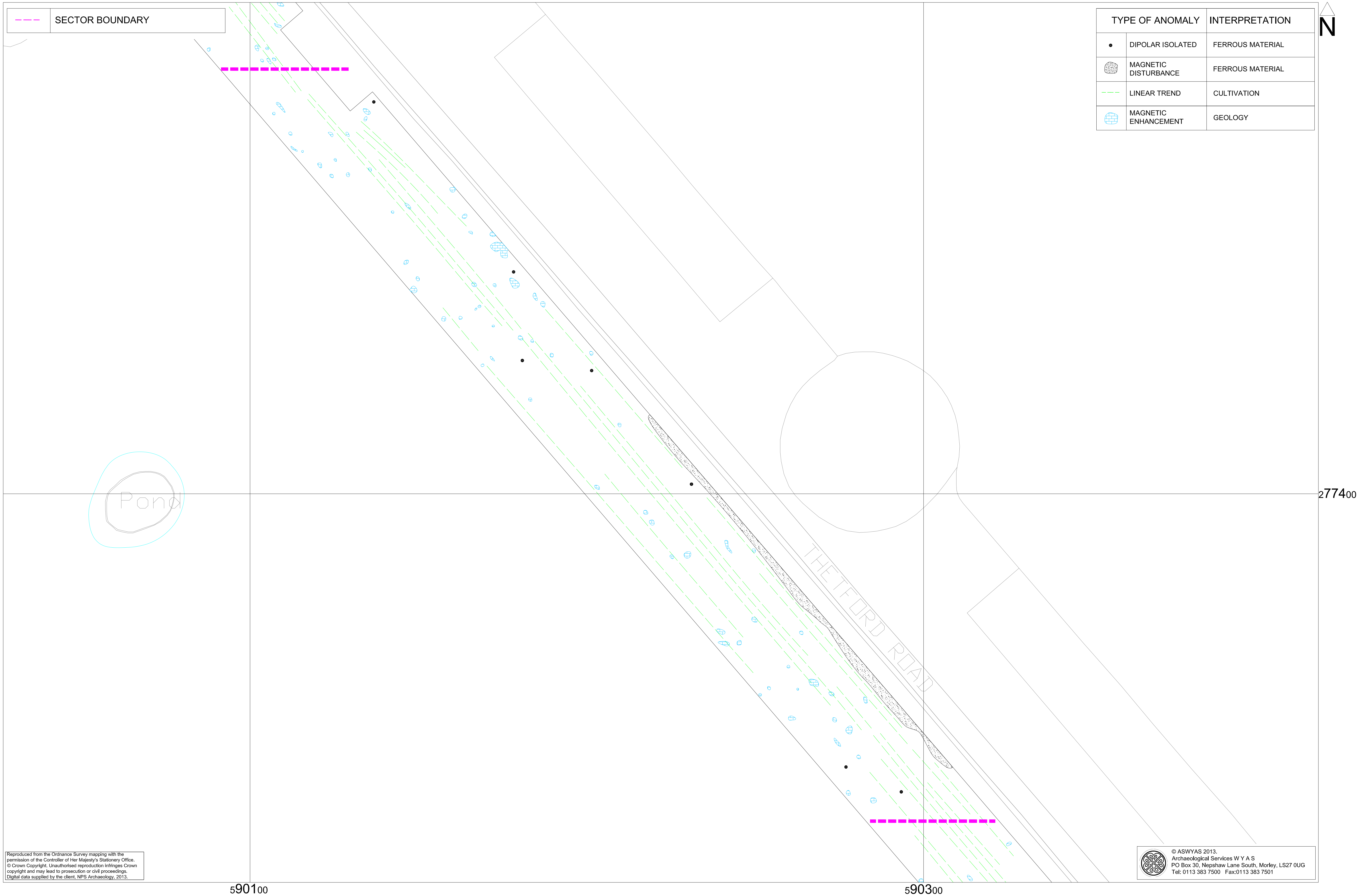

Fig. 14. Interpretation of magnetometer data; Area 1, Sector 2 (1:1000 @ A3)

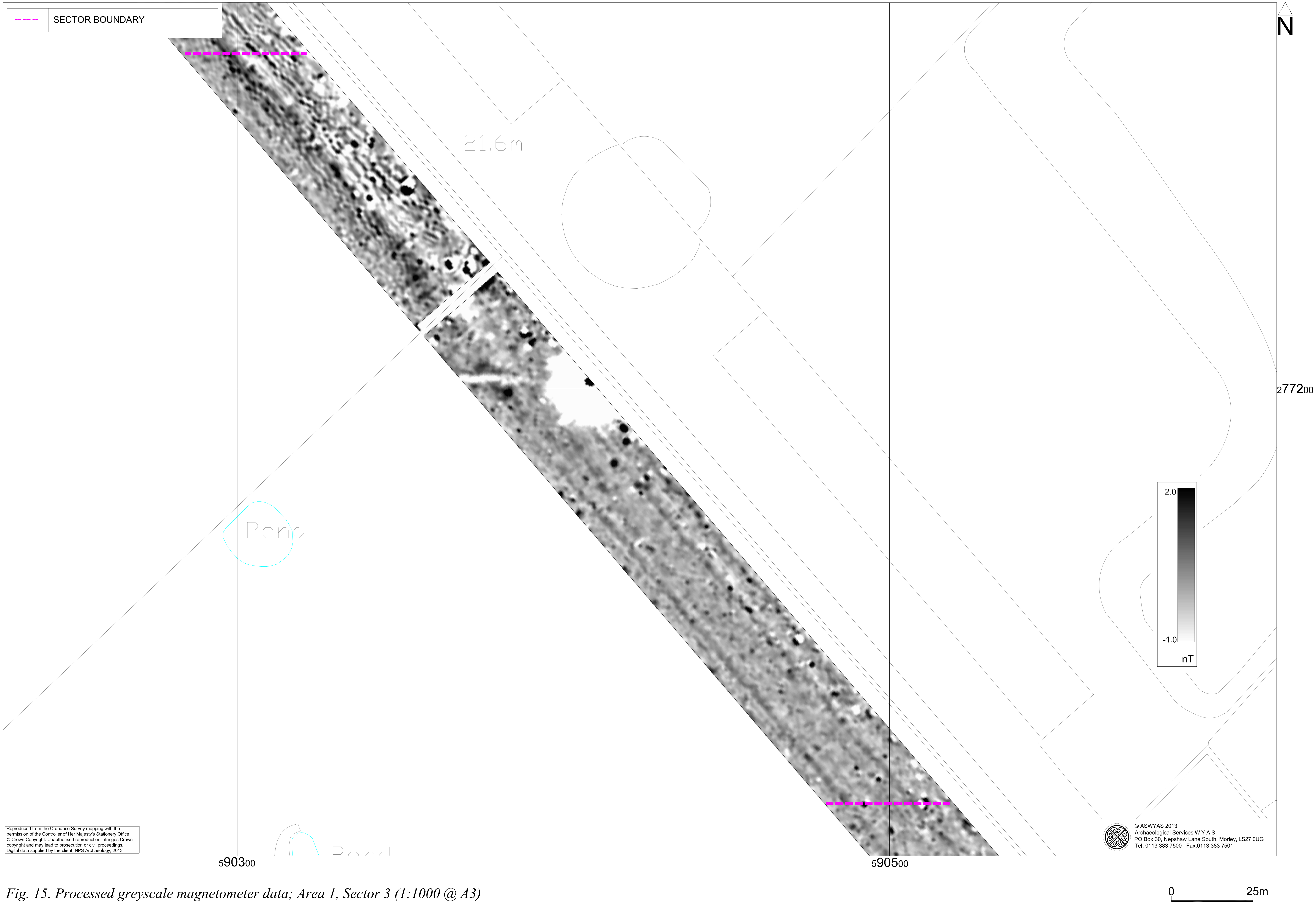

Fig. 15. Processed greyscale magnetometer data; Area 1, Sector 3 (1:1000 @ A3)

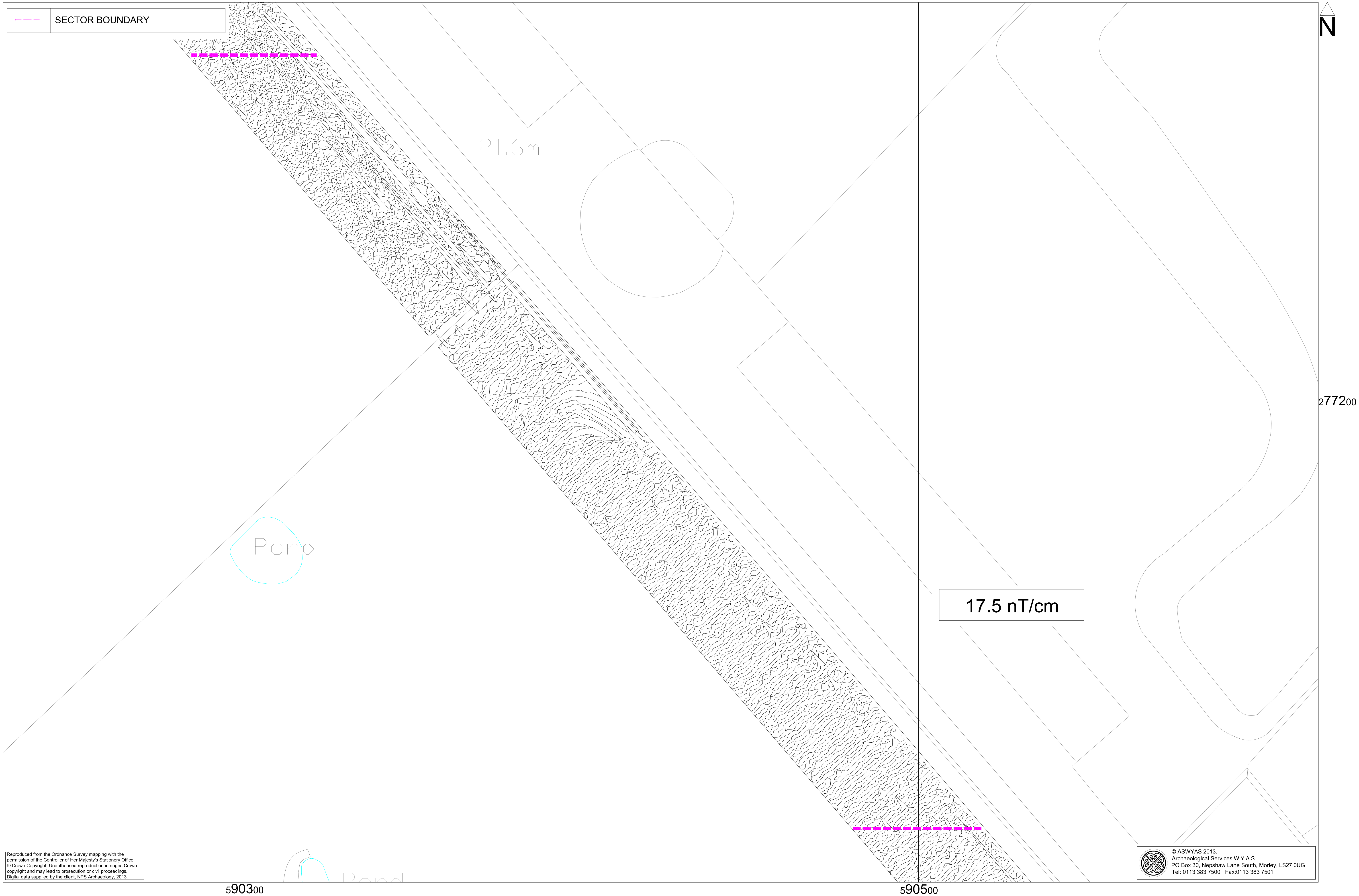

Fig. 16. XY trace plot of minimally processed magnetometer data; Area 1, Sector 3 (1:1000 @ A3)

0 25m

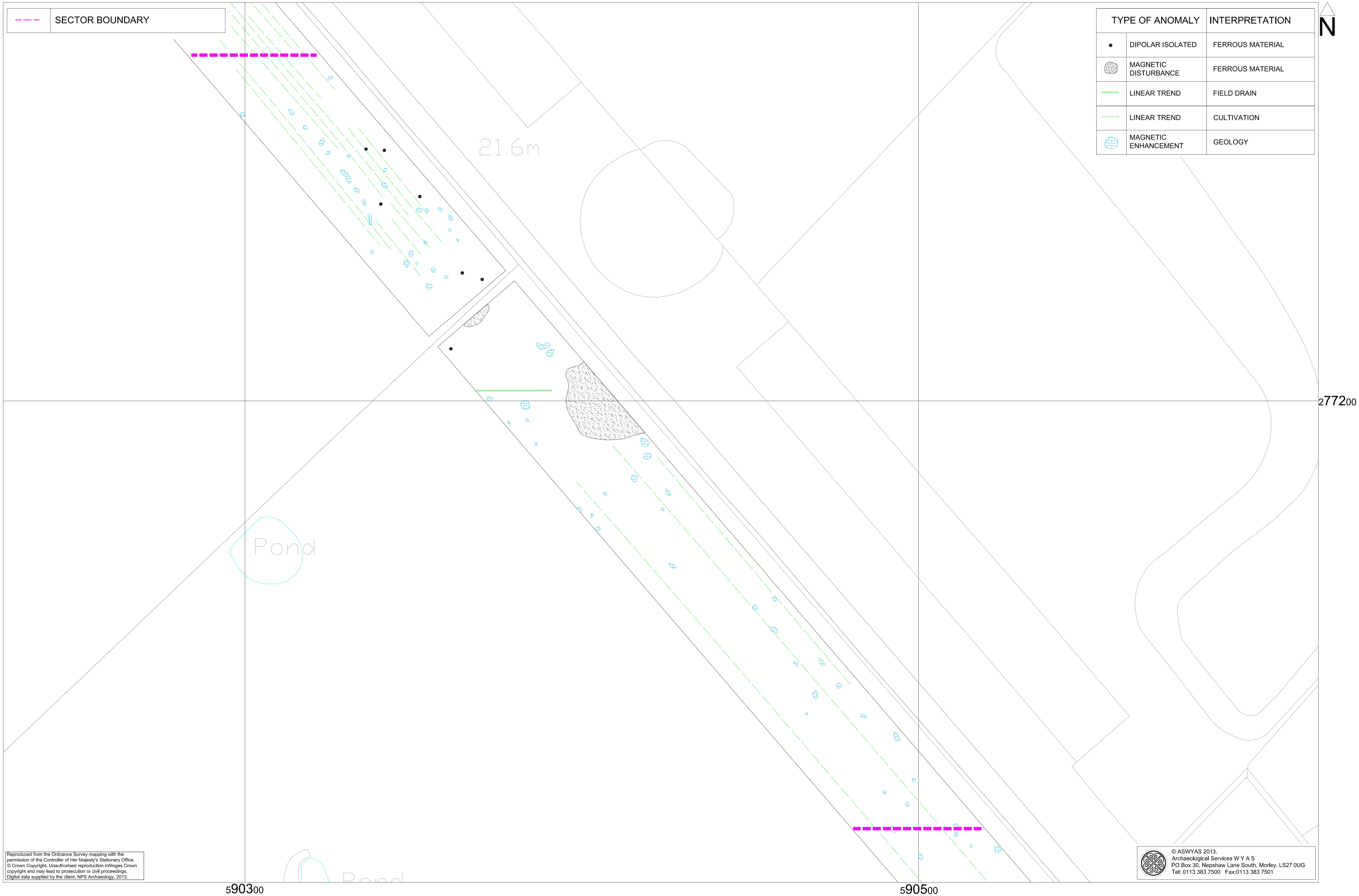

Fig. 17. Interpretation of magnetometer data; Area 1, Sector 3 (1:1000 @ A3)

0 25m

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Fig. 18. Processed greyscale magnetometer data; Area 1, Sector 4 (1:1000 @ A3)

0 25m

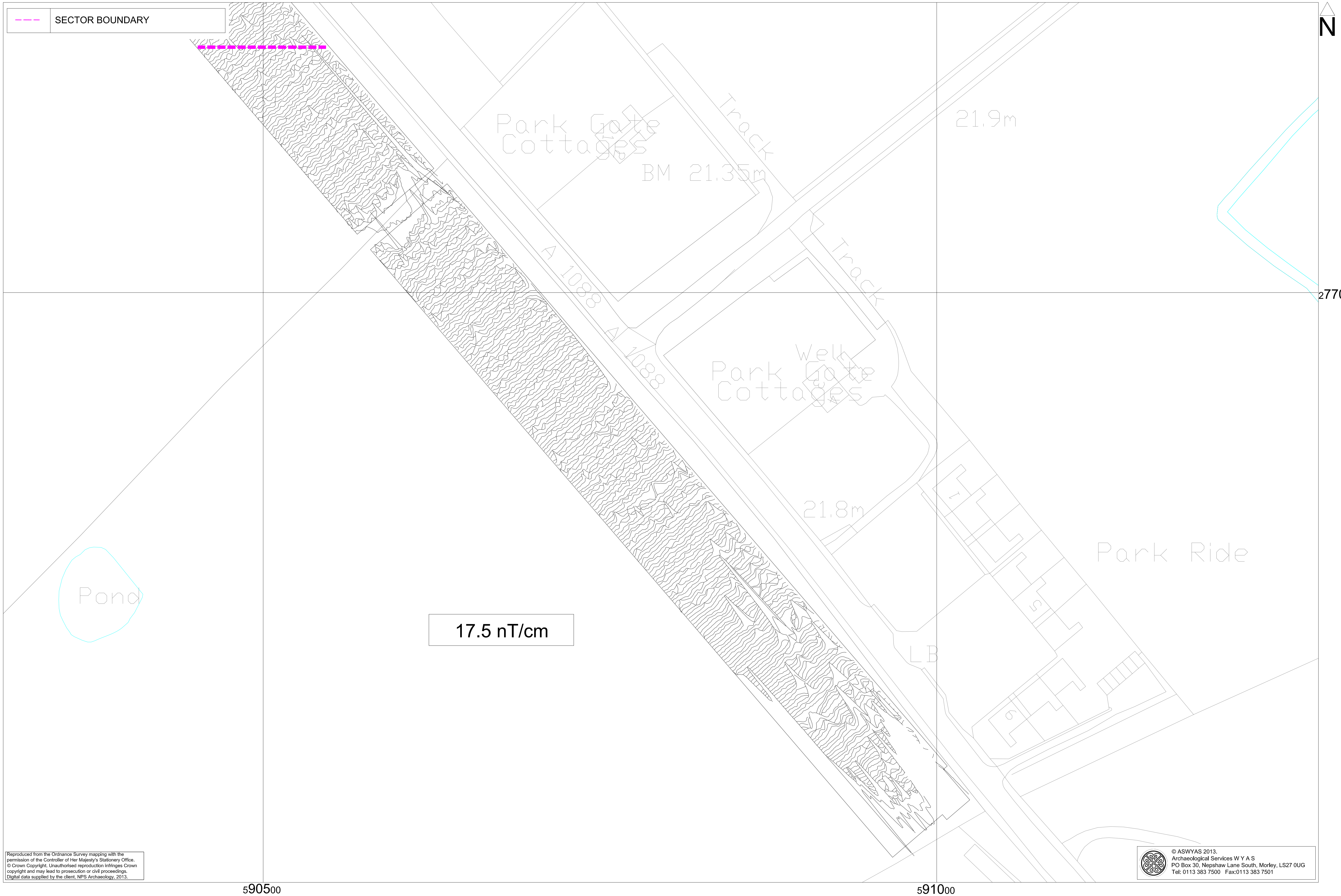

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Fig. 19. XY trace plot of minimally processed magnetometer data; Area 1, Sector 4 (1:1000 @ A3)

0 25m

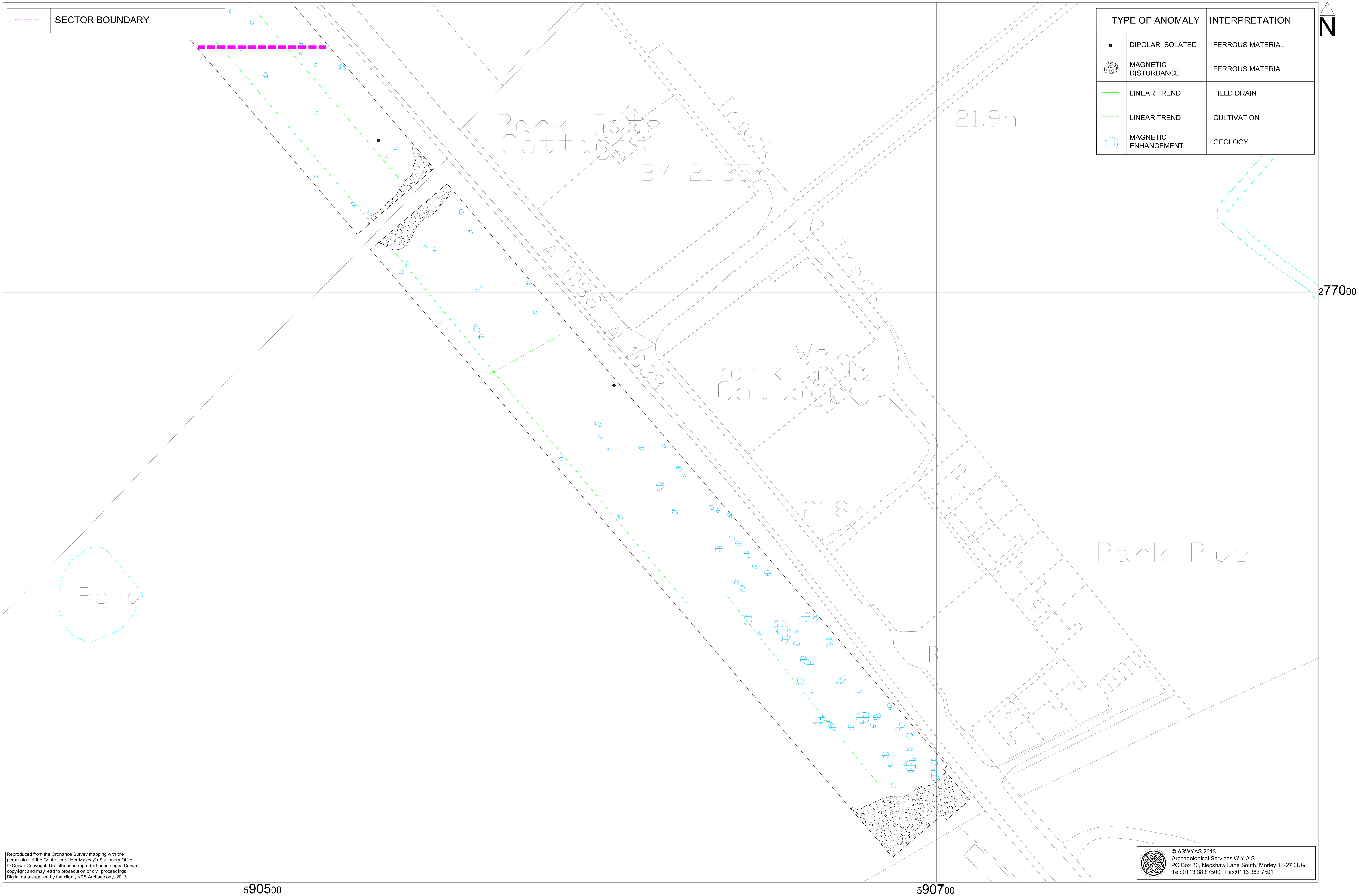

Fig. 20. Interpretation of magnetometer data; Area 1, Sector 4 (1:1000 @ A3)

0 25m

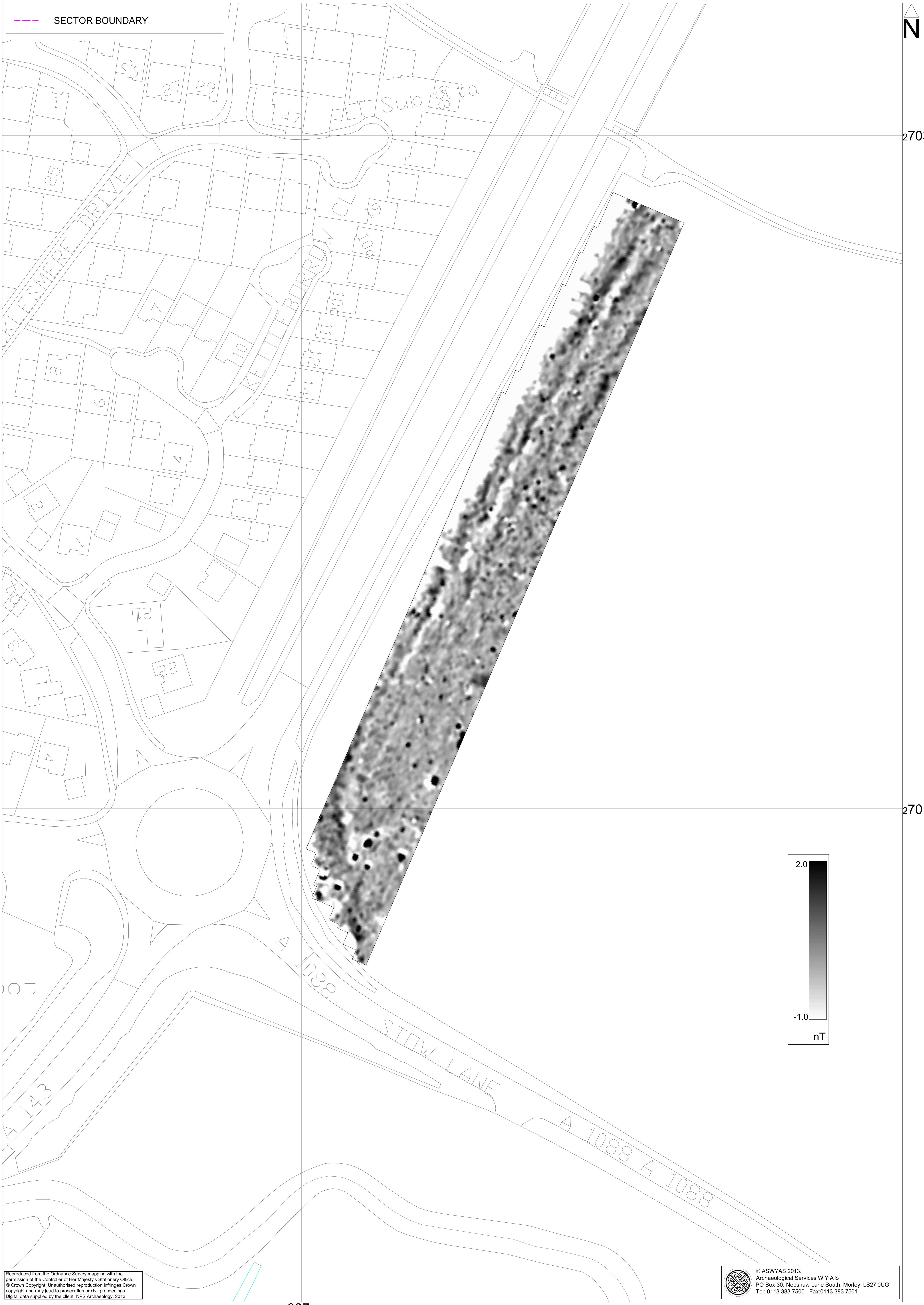

Fig. 21. Processed greyscale magnetometer data; Area 2, Sector 1 (1:1000 @ A3)

0 25m

Fig. 22. XY trace plot of minimally processed magnetometer data; Area 2, Sector 1 (1:1000 @ A3)

0 25m

Fig. 23. Interpretation of magnetometer data; Area 2, Sector 1 (1:1000 @ A3)

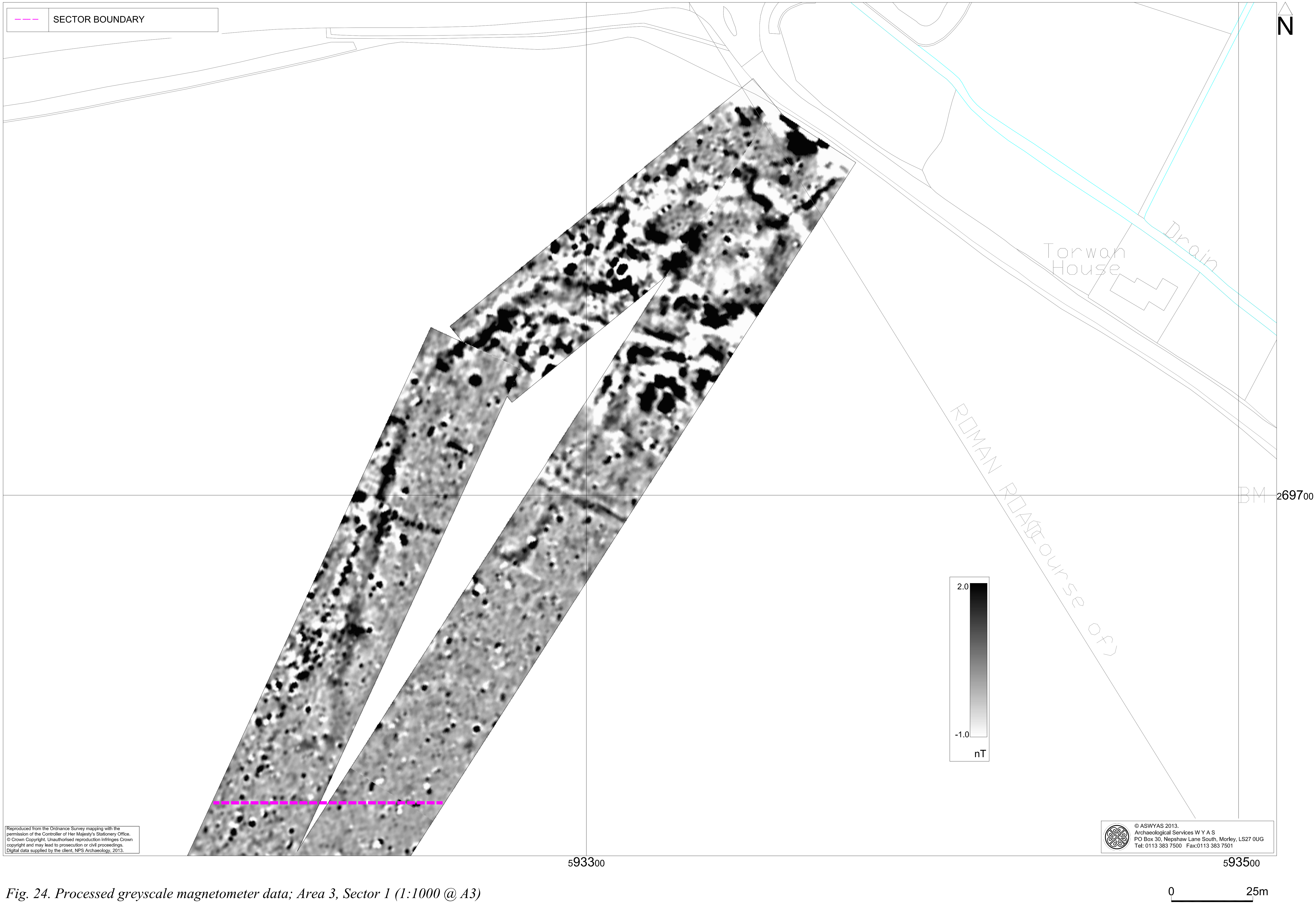

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Fig. 24. Processed greyscale magnetometer data; Area 3, Sector 1 (1:1000 @ A3)

Fig. 25. XY trace plot of minimally processed magnetometer data; Area 3, Sector 1 (1:1000 @ A3)

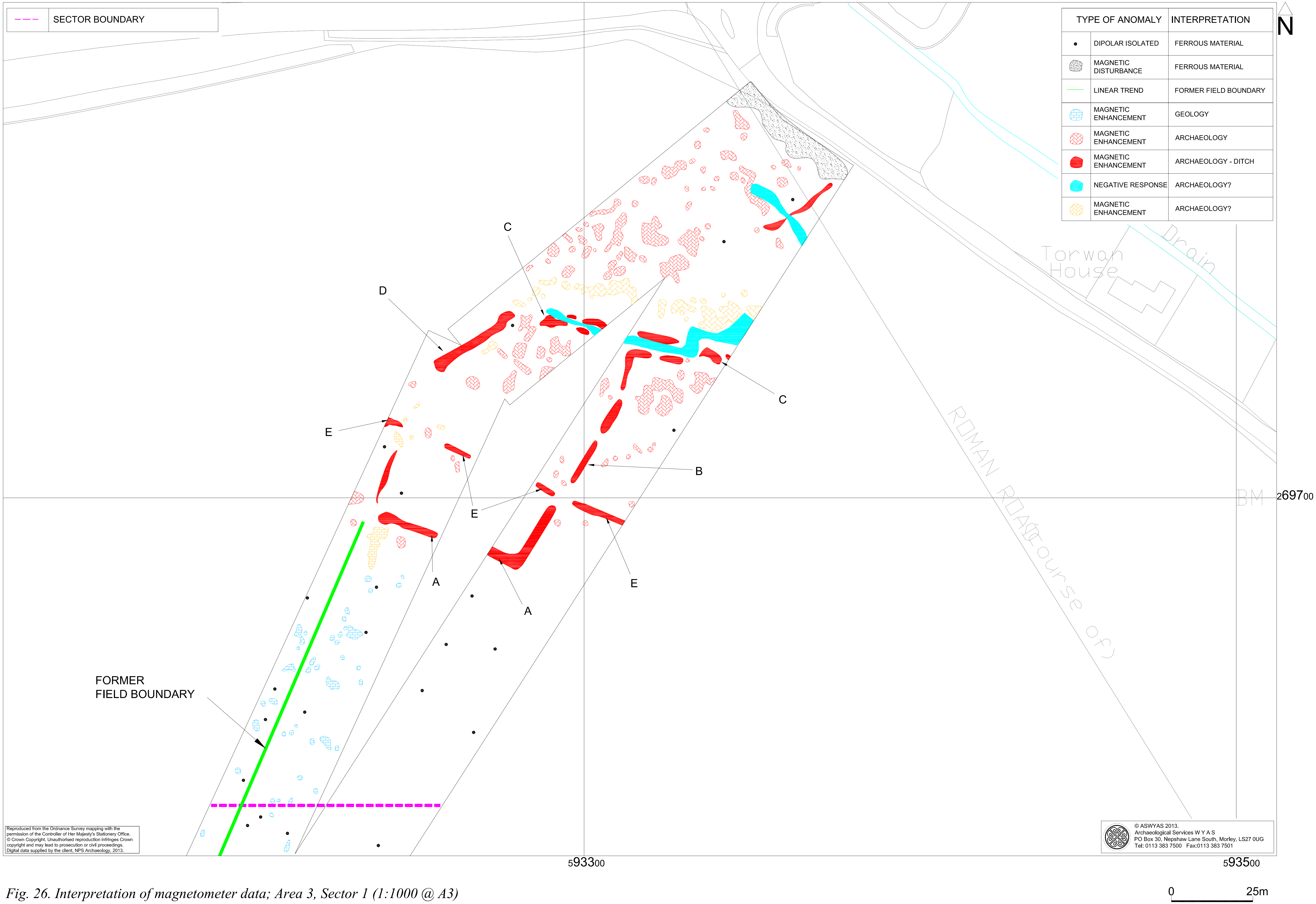

Fig. 26. Interpretation of magnetometer data; Area 3, Sector 1 (1:1000 @ A3)

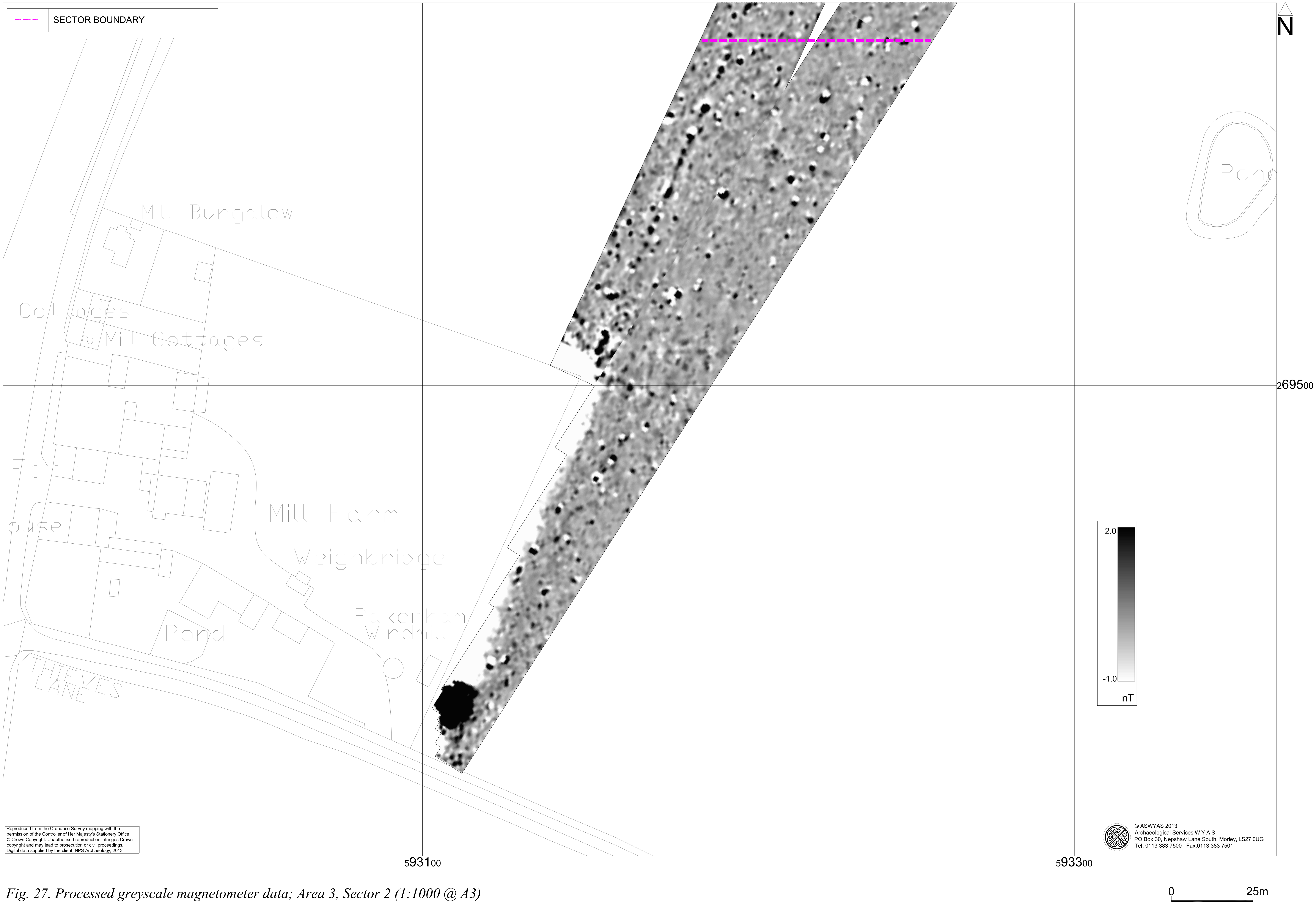

Fig. 27. Processed greyscale magnetometer data; Area 3, Sector 2 (1:1000 @ A3)

Fig. 28. XY trace plot of minimally processed magnetometer data; Area 3, Sector 2 (1:1000 @ A3)

0 25m

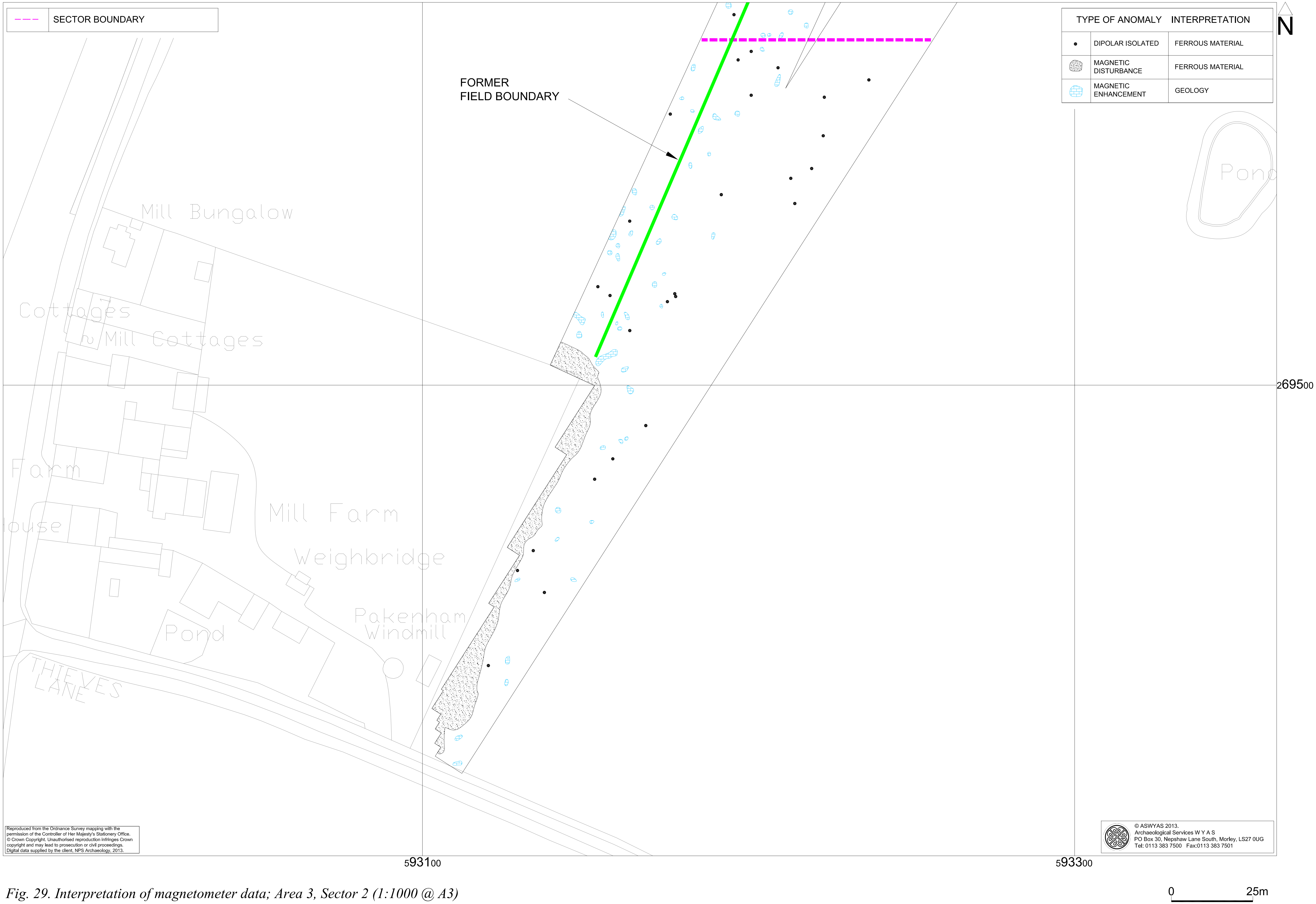

Fig. 29. Interpretation of magnetometer data; Area 3, Sector 2 (1:1000 @ A3)

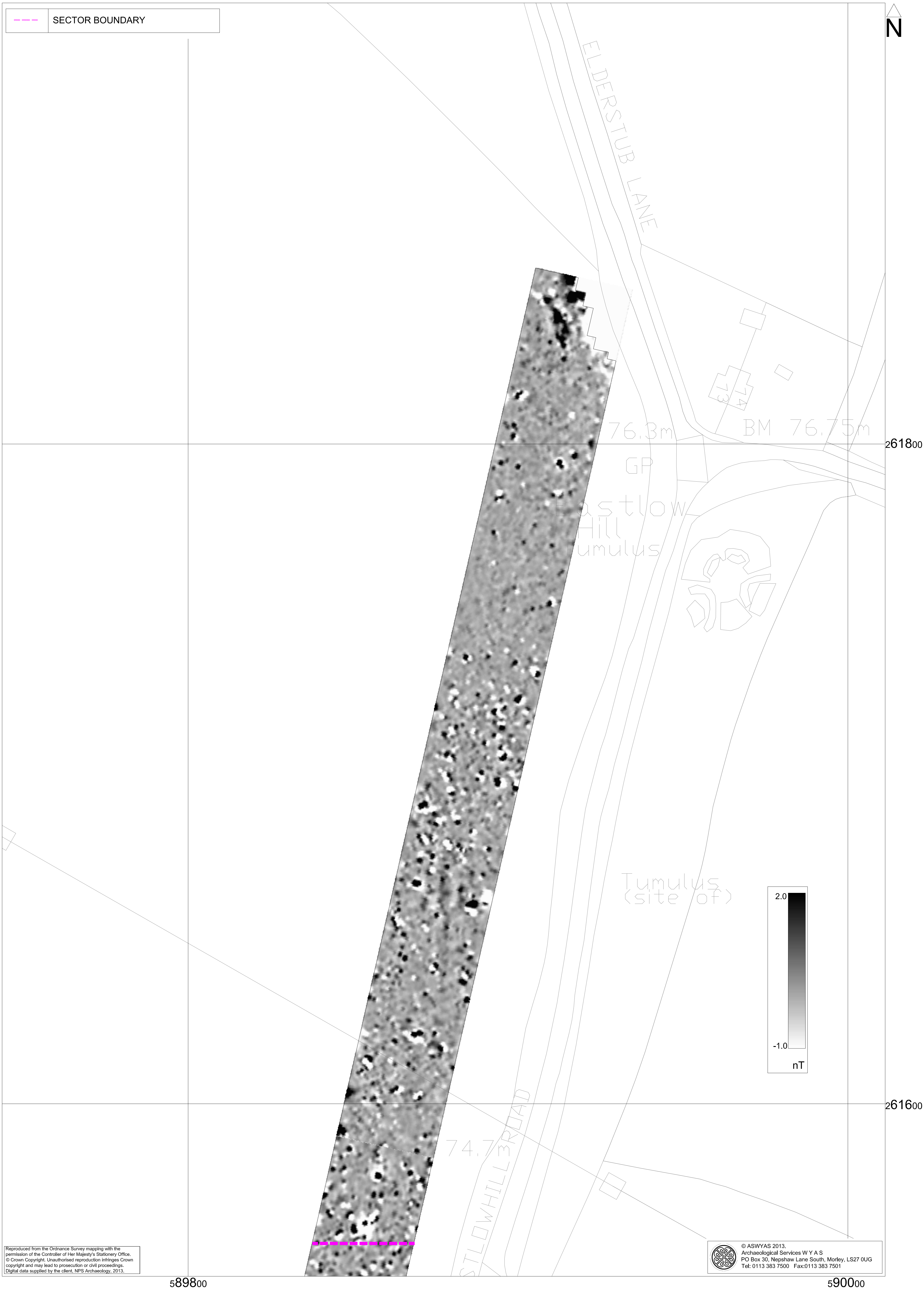

Fig. 30. Processed greyscale magnetometer data; Area 4, Sector 1 (1:1000 @ A3)

0 25m

Fig. 31. XY trace plot of minimally processed magnetometer data; Area 4, Sector 1 (1:1000 @ A3)

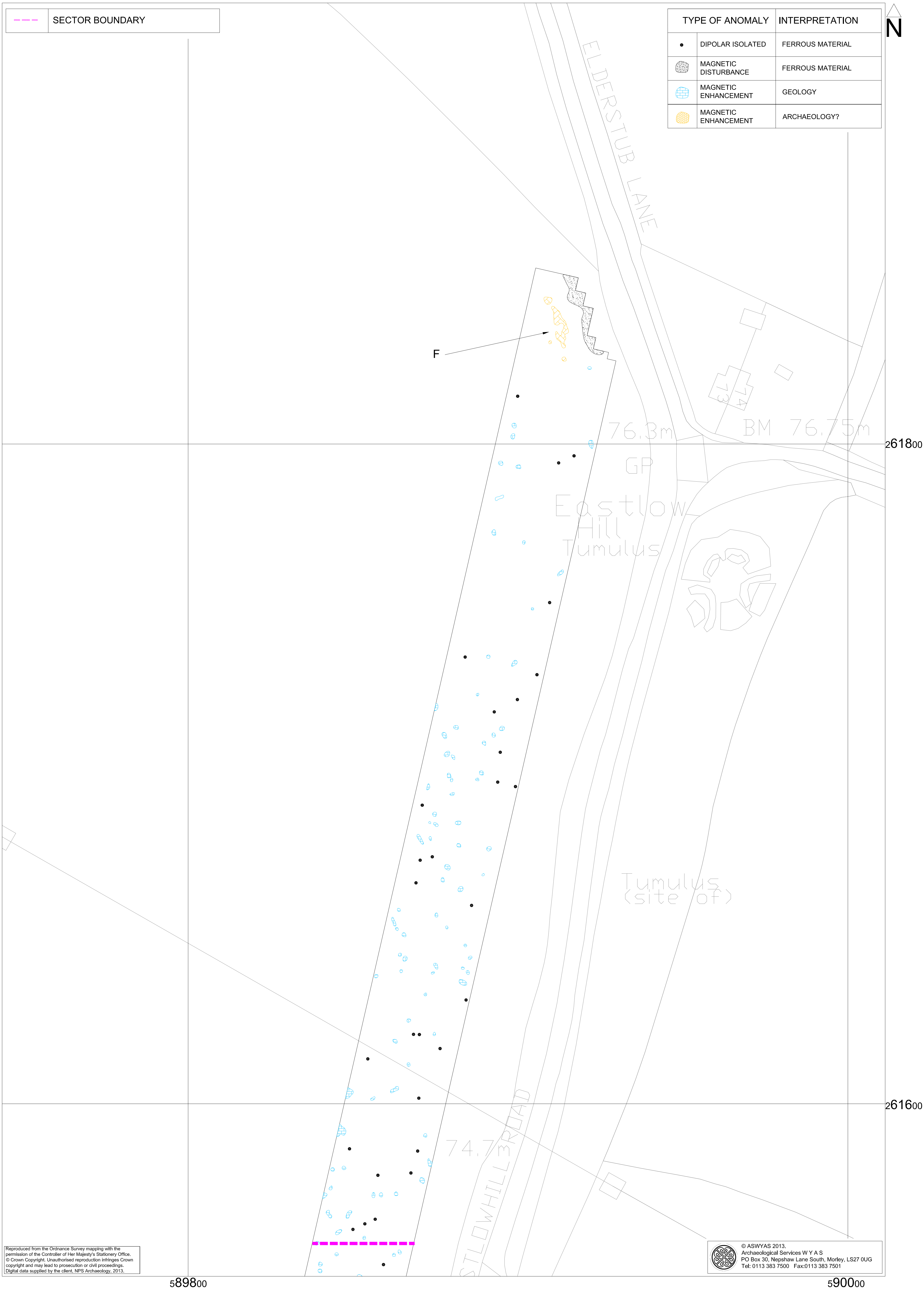

Fig. 32. Interpretation of magnetometer data; Area 4, Sector 1 (1:1000 @ A3)

0 25m

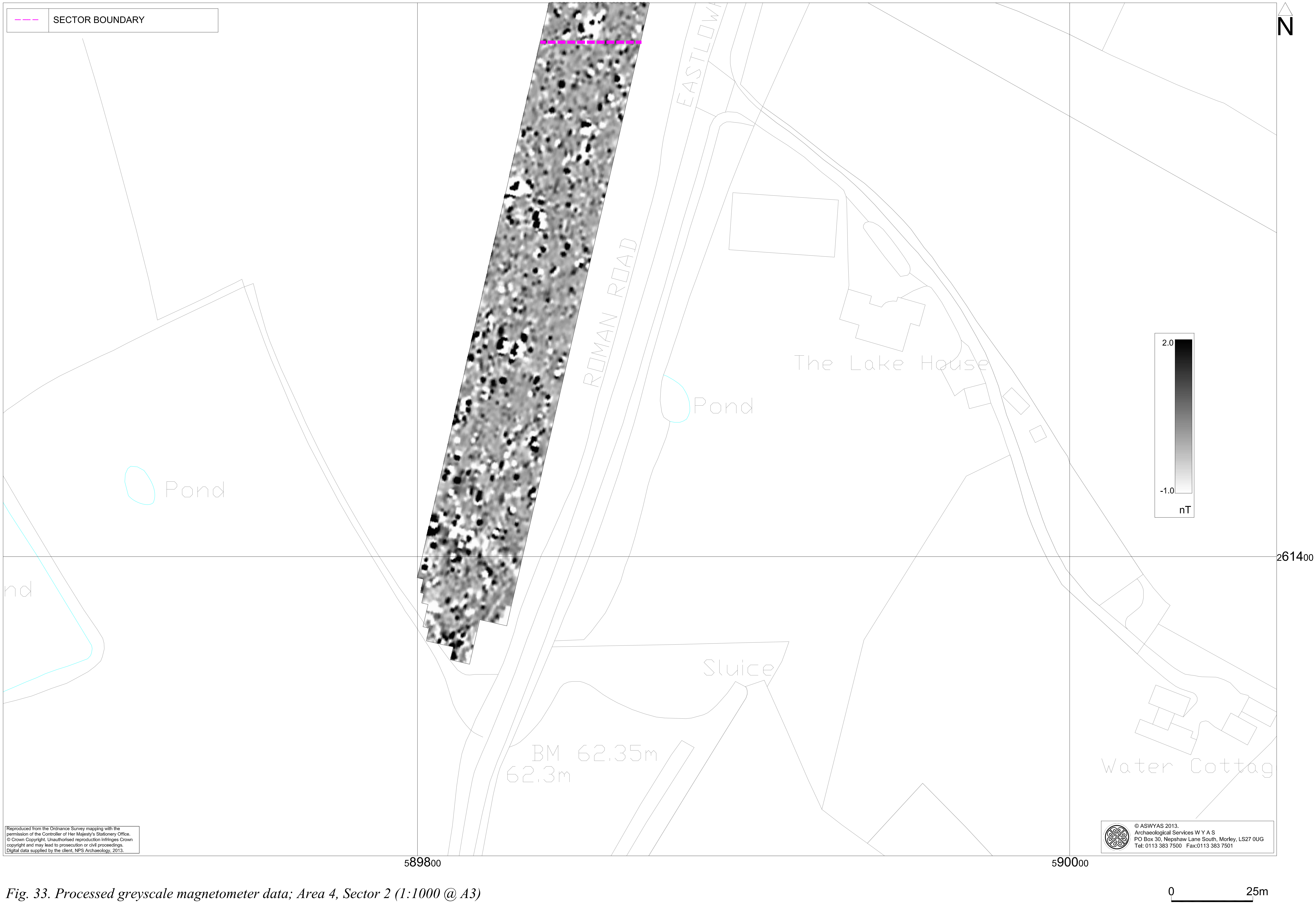

Fig. 33. Processed greyscale magnetometer data; Area 4, Sector 2 (1:1000 @ A3)

Fig. 34. XY trace plot of minimally processed magnetometer data; Area 4, Sector 2 (1:1000 @ A3)

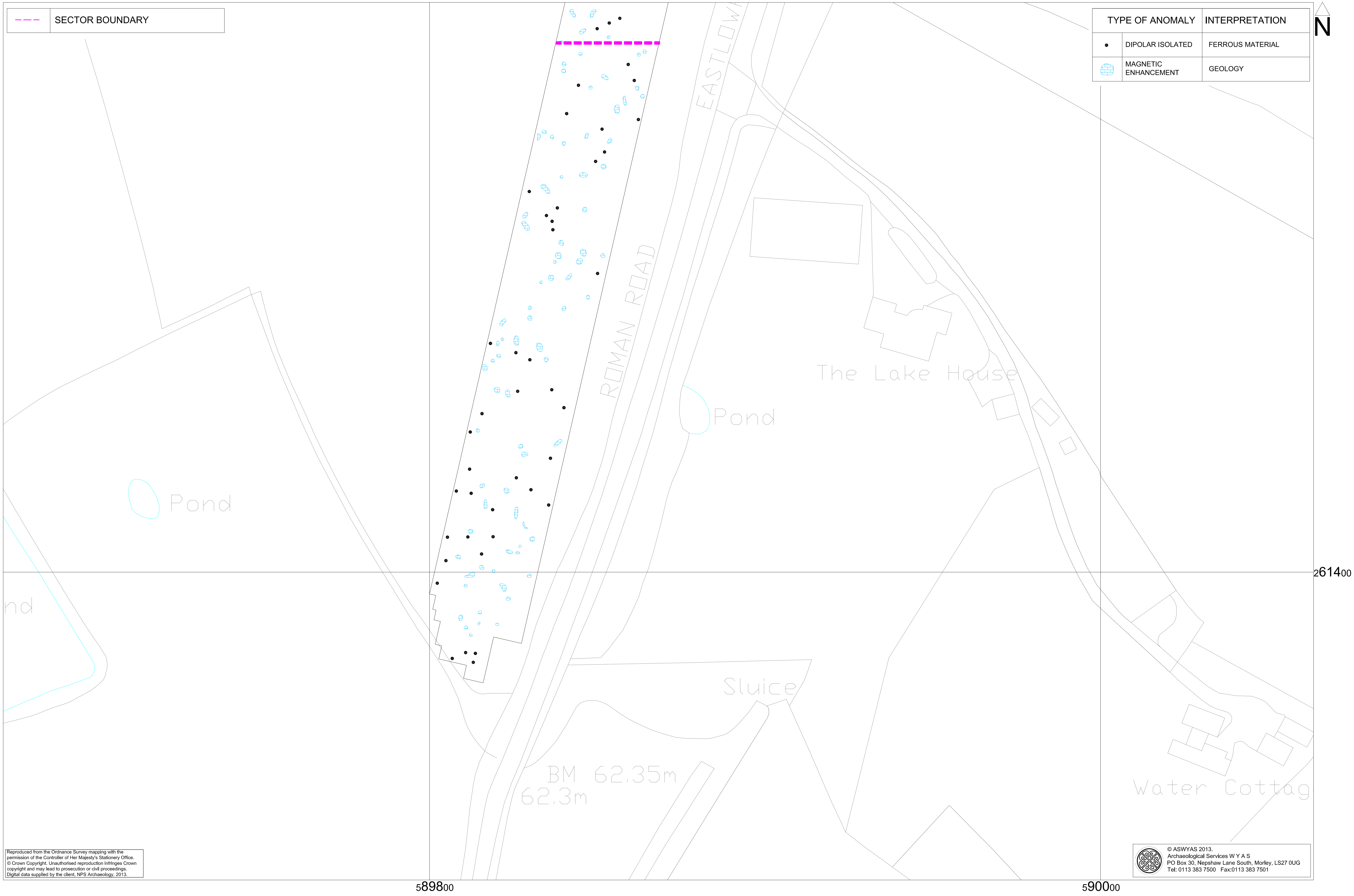

Fig. 35. Interpretation of magnetometer data; Area 4, Sector 2 (1:1000 @ A3)

Plate 1. General view of Area 1, Sector 2, looking north

Plate 2. General view of Area 3, looking north

Plate 3. General view of Area 4, looking south

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: 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 Suffolk Historic Environment Record).

Bibliography

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