ARCHAEOLOGICAL SERVICES WYAS

Sheraton Windfarm
County Durham

Geophysical survey

Report no. 2277

December 2011

Client: AECOM

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Sheraton Windfarm
County Durham

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering approximately 10 hectares, was carried out at Sheraton, County Durham, in advance of the proposed construction of a five turbine windfarm. The survey covered areas of 1 hectare, centred on each turbine base, and a 20m wide corridor along the route of the access tracks and cable runs. Other areas of infrastructure were also covered. No anomalies of obvious archaeological potential have been identified with the majority of anomalies interpreted as of geological origin due to the presence of glacial till deposits, some of which form hummocks which are the proposed locations for the turbines. Despite the potential of the surrounding landscape the areas likely to be impacted by the proposed development appear to have a low potential based on the results of the geophysical survey.

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Report Information

Client:	AECOM
Address:	5th Floor, 2 City Walk, Leeds, LS11 9AR
Report Type:	Geophysical survey
Location:	Sheraton Windfarm, Sheraton
County:	County Durham
Grid Reference:	NZ 44451 36359
Period(s) of activity: represented	-
Report Number:	2277
Project Number:	3840
Site Code:	SHE11
OASIS ID	archaeol11-115674
Planning Application No.:	Pre-determination (Outline)
Museum Accession No.:	n/a
Date of fieldwork:	November 2011
Date of report:	December 2011
Project Management:	Alistair Webb BA MIfA
Fieldwork:	David Harrison BA MSc
	Alex Harrison BSc
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Report:	Alistair Webb
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Photography:	Alex Harrison / David Harrison
Research:	n/a

Authorisation for distribution: ---

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1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by James Lawton of AECOM to carry out a geophysical (magnetometer) survey as part of pre-determination work for a proposed windfarm at Sheraton, County Durham (see Fig. 1). The results of the survey will help assess the extent of the archaeological resource and thereby inform the final scheme layout. The scheme of work was undertaken in accordance with the requirements of Planning Policy Statement 5 and to a Written Scheme of Investigation (WSI) supplied by AECOM. The survey was carried out between November 21st and November 24th 2011.

Site location, topography and land-use

The proposed development area (PDA) occupies a large block of agricultural land situated east of the A19, and north-east of the village of Sheraton, County Durham, and is centred on NZ 44451 36359 (see Fig. 1). The survey comprised five 1 hectare blocks, centred on the proposed location of the five turbines, as well as areas of infrastructure including access tracks, cable runs, a control building, and areas of hard standing for cranes and construction compounds (see Fig. 2).

The turbine locations are generally located on raised sites within a undulating glacial landscape, at between 90m and 110m above Ordnance Datum (aOD). The survey area spanned twelve fields, each under arable production, containing young wheat and oil seed rape crops (see Plates).

Geology and soils

The underlying bedrock comprises Ford Formation Limestone and Roker Formation Dolostone overlain by glacial till and hummocky glacial deposits consisting of sands and gravels (BGS 2011). The soils in this area are classified in the Bishampton 1 association, characterised as deep fine loams with slowly permeable subsoils and slight seasonal waterlogging (SSEW 1983).

2 Archaeological background

A desk-based assessment of the area has highlighted archaeological and built heritage features both within and in proximity to the PDA. The assessment covered the proposed site and a 2km study area surrounding it. A total of 316 sites were identified within this area. A total of three sites dating to the prehistoric period lie within the development site itself. These comprise of the find spot of a Neolithic stone axe, worked flint find spots and an area of peat deposits containing pollen evidence for Iron Age/Romano-British cereal cultivation. In addition, a cropmark has been identified within the development site and a find spot of sherds of Roman pottery have been discovered to the east of the area. Place name evidence suggests early medieval activity within the environs of the PDA whilst medieval remains are frequent, including a number of ecclesiastical sites, agricultural evidence and settlement sites.

It is likely, therefore, that the proposed development would encounter archaeological deposits relating to the prehistoric, Romano-British, Anglo-Saxon, medieval and later periods.

3 Aims, Methodology and Presentation

The main aim of the geophysical survey is to provide sufficient information to enable an assessment to be made of the impact of the proposed development on any potential archaeological remains and for mitigation proposals, if appropriate, to be recommended.

To achieve this aim a magnetometer survey covering 1 hectare, centred on the proposed location of each turbine, was carried out. The survey of a larger area than will be impacted by the proposed development allows the micro-siting of the turbine without the need for further survey, should obvious archaeological features be identified at the preferred location. A corridor 20m in width was also surveyed along the proposed route of the access tracks, cable runs and construction compounds.

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

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 Ordnance Survey map, is shown in Figure 1. Figure 2 is a large scale (1:7500) site location plan showing the greyscale magnetometer data overlain by the proposed locations of the five wind turbines and associated infrastructure.

The processed and minimally processed data, together with interpretation graphics of the survey results are presented in Figures 3 to 35 inclusive, 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.

Archaeological Services WYAS is registered with the Online Access to the Index of archaeological investigations project (OASIS). The OASIS ID for this project is archaeol11-115674.

The geophysical survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David *et al.* 2008) and by the IfA (Gaffney *et al.* 2002). 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 (see Figs 3 – 35 inclusive)

Ferrous Anomalies

Ferrous anomalies, either as individual 'spikes' or more extensive areas of magnetic disturbance, are typically caused by ferrous (magnetic) material, either on the ground surface or in the plough-soil. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation, as modern ferrous debris or material is common on rural sites, often being present as a consequence of manuring or tipping/infilling. Throughout the majority of the site iron spike anomalies are common and there is no obvious pattern or clustering to their distribution to suggest anything other than a random background scatter of ferrous debris in the plough-soil.

Larger areas of disturbance are noted at several locations, primarily adjacent to buildings (for example adjacent to Hulam - see Figs 9 -11) or bordering tracks/roads or along and at the junction of boundaries. Again these areas of anomalous response are not considered to be of any archaeological potential being due to the proximity of buildings or fences or to the accumulation of ferrous debris along the edges of fields.

Linear dipolar anomalies have been noted crossing Access Tracks D and E (see Fig. 32 and Fig. 35). These anomalies are caused by a ferrous pipe.

Agricultural Anomalies

Linear trend anomalies have been identified on several different alignments across all parts of the site. These anomalies are caused by ploughing.

Geological Anomalies

Across all parts of the site numerous linear and discrete anomalies of varying magnitude have been identified. These are most prominent in the survey blocks centred on T2, T3 and T4 (see Fig. 2). There is a certain linearity to some of these anomalies, most noticeably in T4 (see Figs 24-26) but the magnitude of the response, the sheer number of anomalies and the absence of any obvious pattern all preclude an archaeological interpretation. Instead all these anomalies are interpreted as geological in origin being due to the undifferentiated till deposits and hummocks of glacial material which predominate in this area.

5 Discussion and Conclusions

Despite the potential for previously unknown archaeological remains within the site (as suggested by the DBA) no anomalies of clear archaeological potential have been identified by the geophysical survey on this site. Instead the data set is dominated by anomalies which are almost certainly due to the heterogeneous, unsorted, glacial till deposits which are present in the area and which account for the undulating nature of the landscape. Indeed some of these hummocks are where the turbines are to be sited. It is possible, however, that because of the magnitude and density of these geological anomalies that weaker responses caused by archaeological features or deposits, if present, may be ‘masked’.

It is always difficult making confident interpretations of data collected along narrow survey transects and of relatively small areas and the dispersed nature of the site adds to this problem. For this reason it cannot be stated categorically that there is no archaeological potential on this site. Nevertheless, it is considered highly likely that the overwhelming majority of anomalies identified on this site are due to geological variation, agricultural practice and modern activity. Therefore, on the basis of the geophysical survey, the site is assessed as having a low archaeological potential.

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.

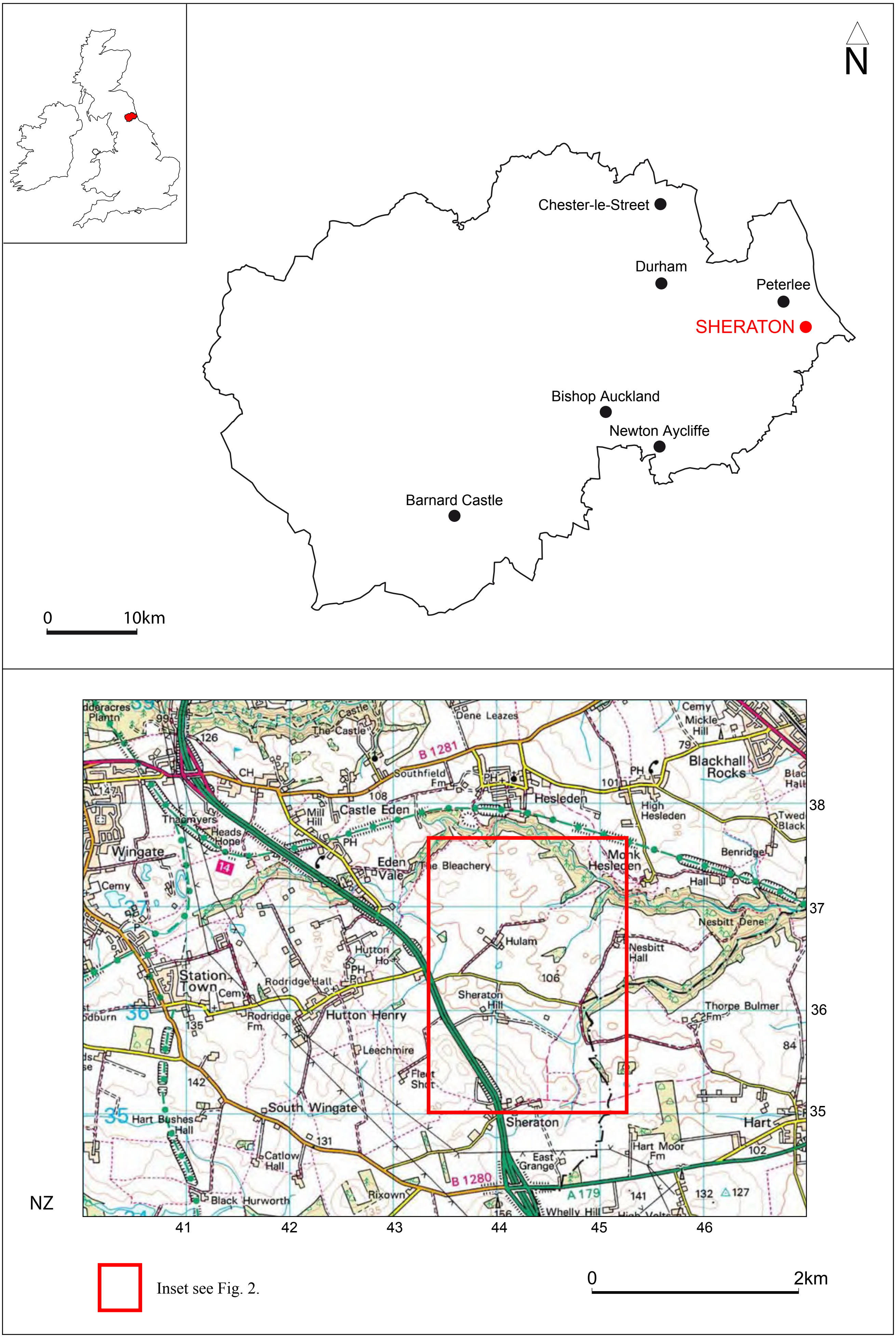

Fig. 1. Site location

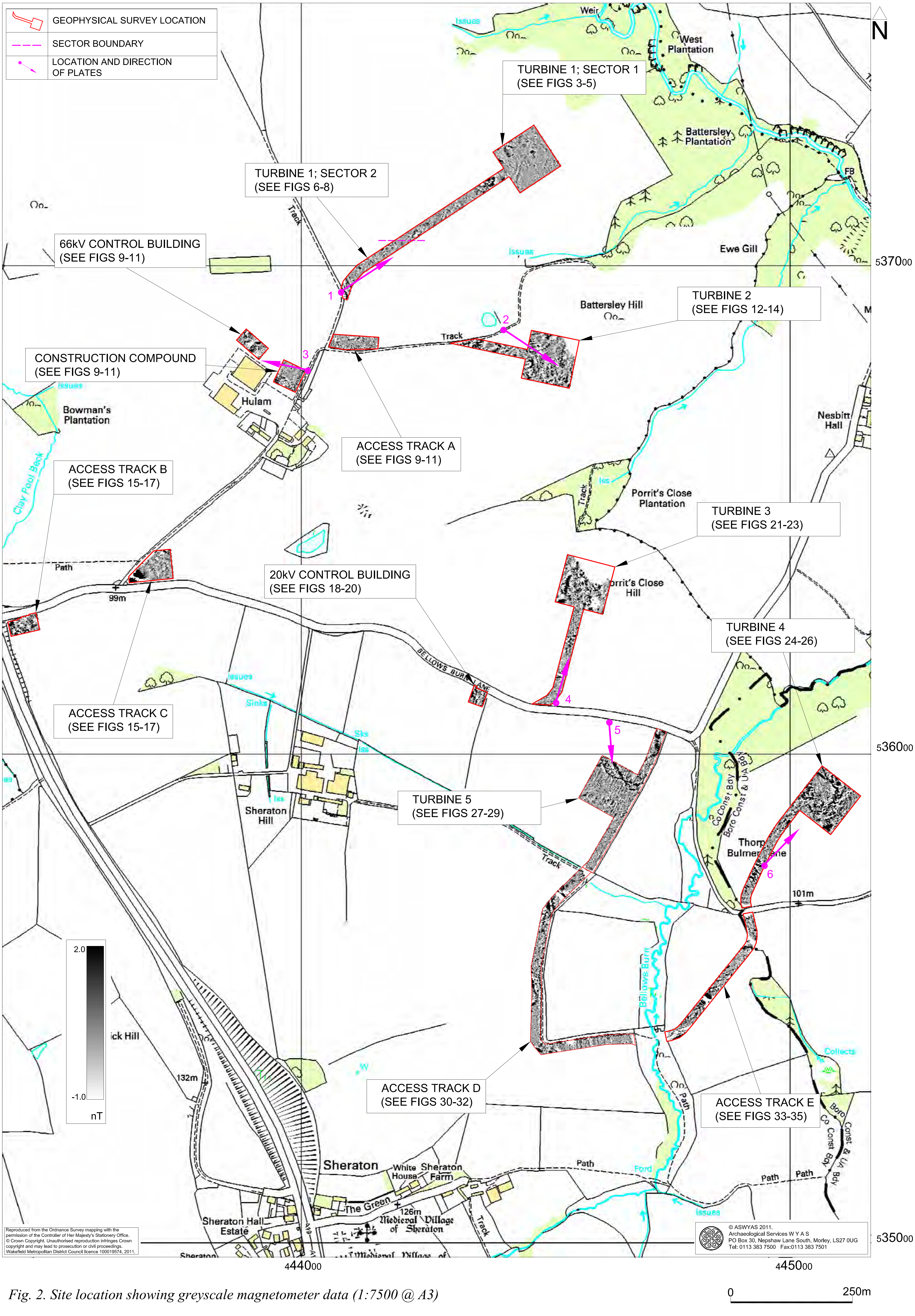

Fig. 2. Site location showing greyscale magnetometer data (1:7500 @ A3)

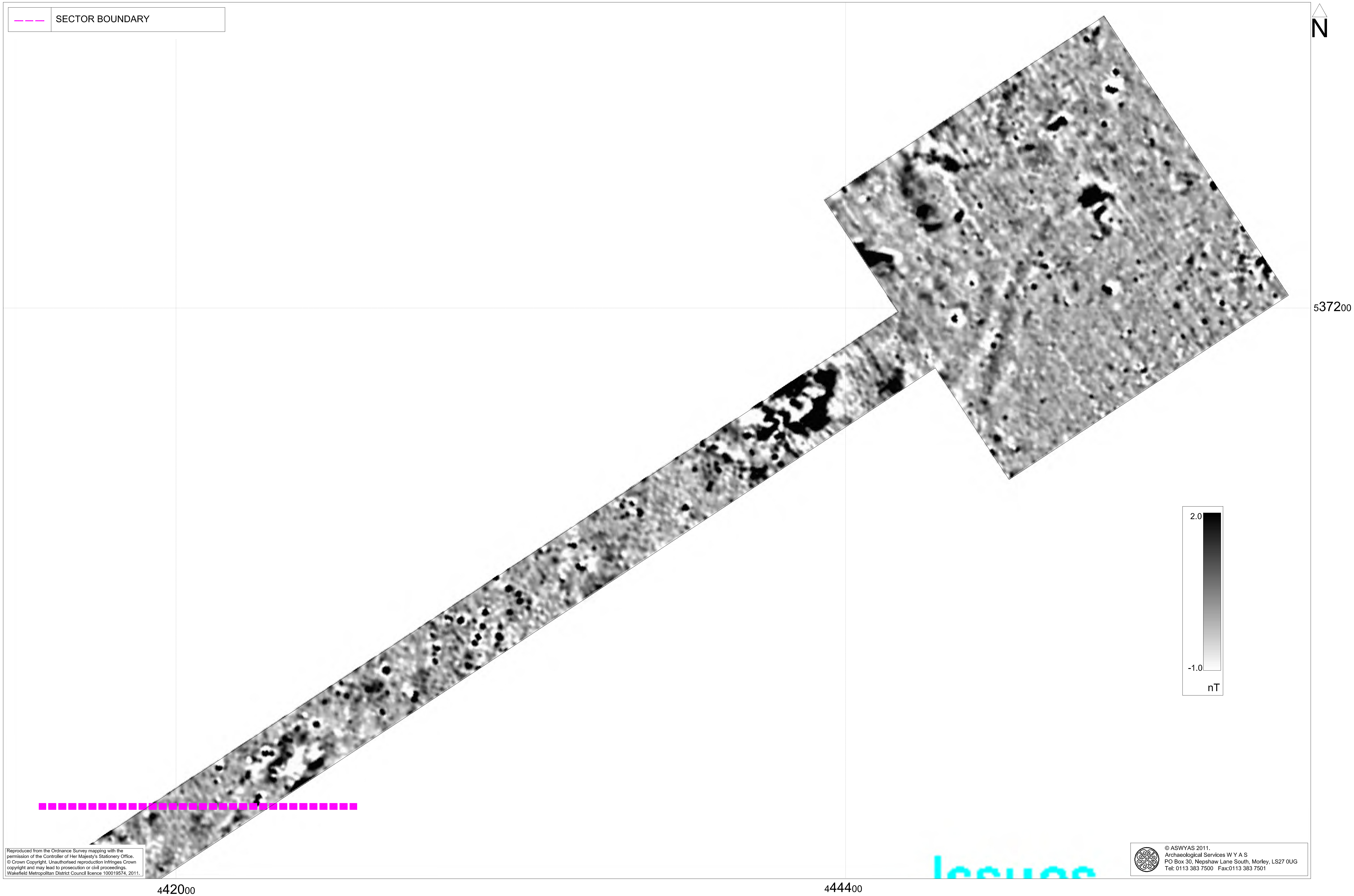

Fig. 3. Processed greyscale magnetometer data; Turbine 1, Sector 1 (1:1000 @ A3)

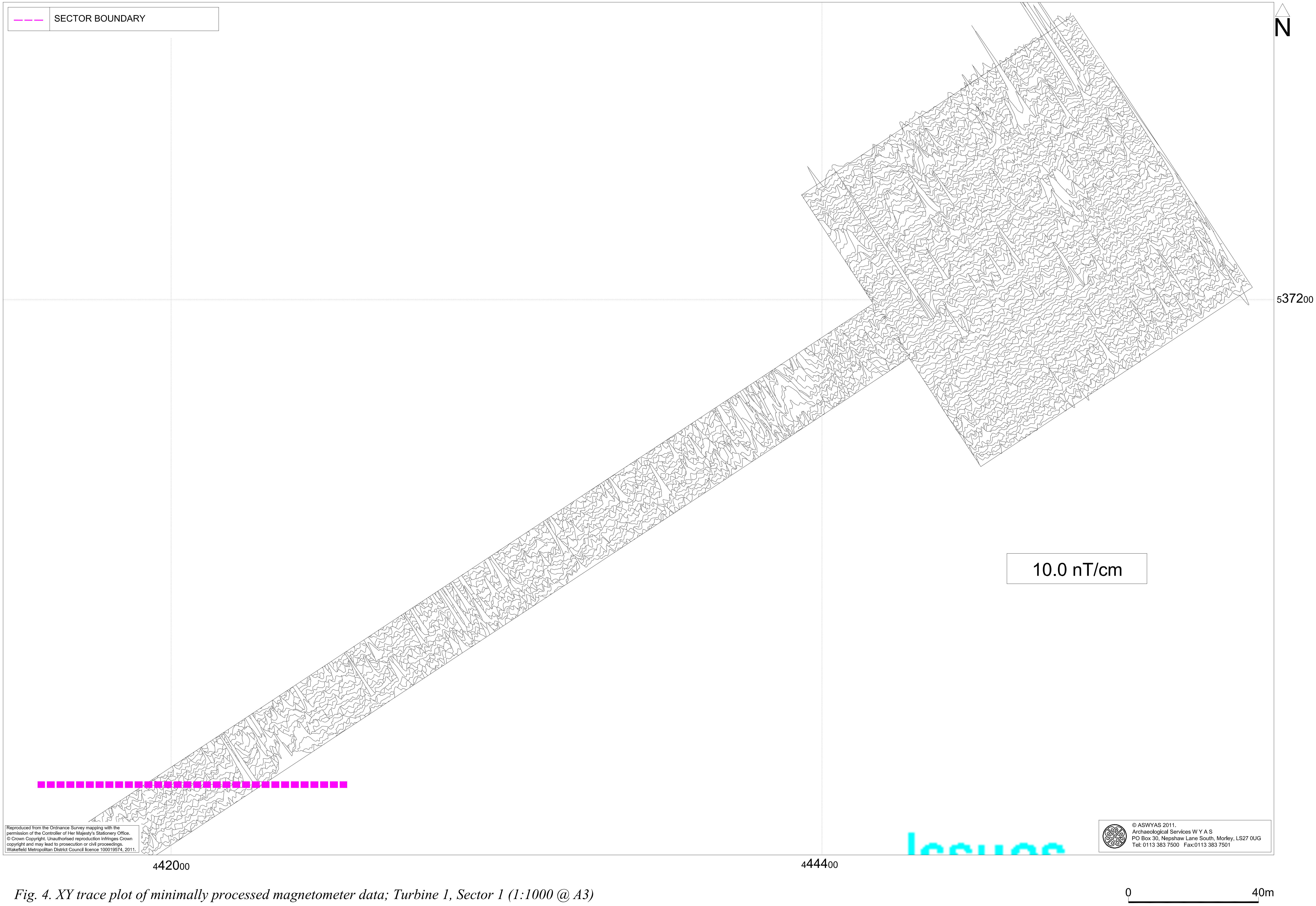

Fig. 4. XY trace plot of minimally processed magnetometer data; Turbine 1, Sector 1 (1:1000 @ A3)

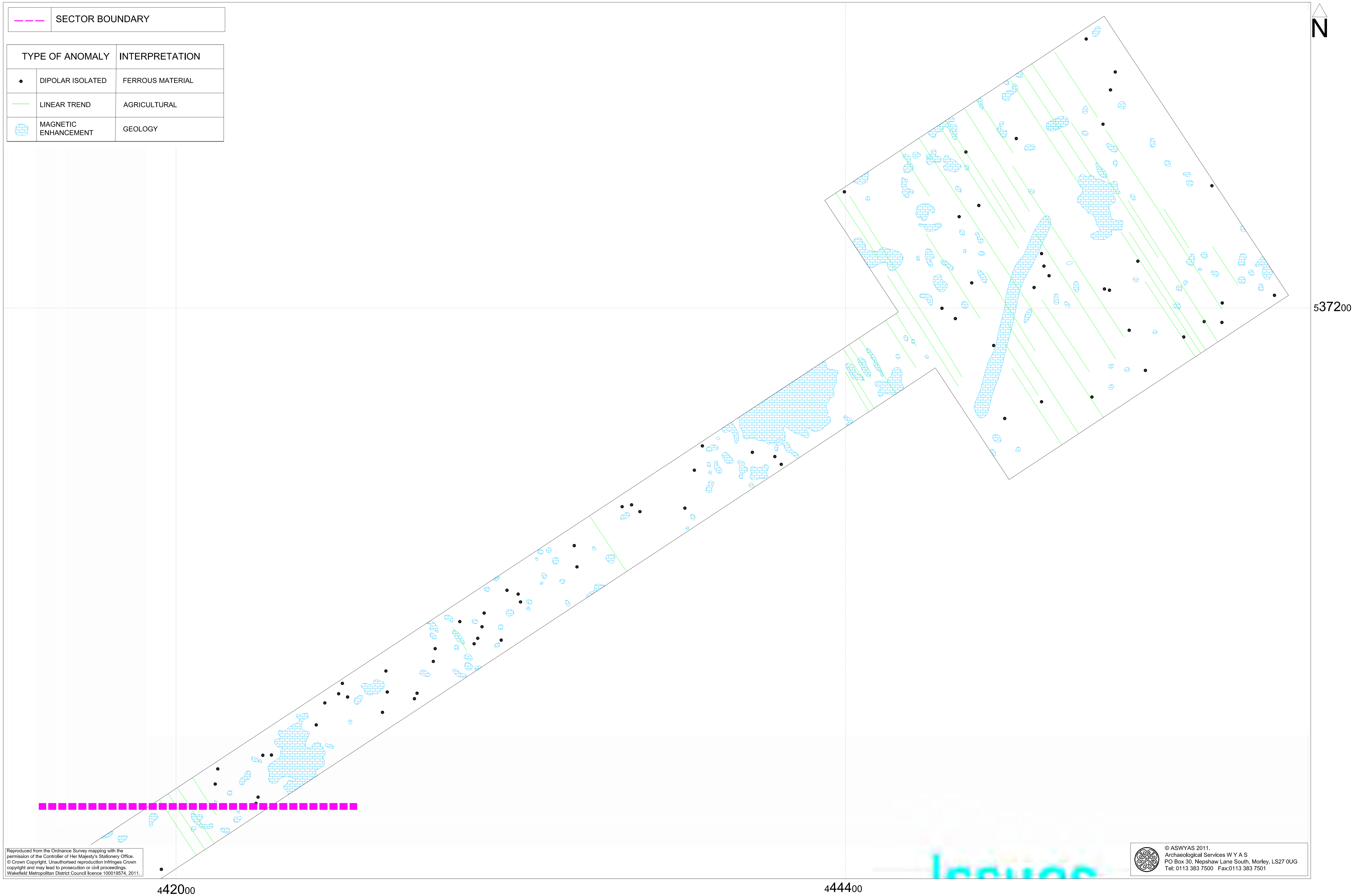

Fig. 5. XY trace plot of minimally processed magnetometer data; Turbine 1, Sector 1 (1:1000 @ A3)

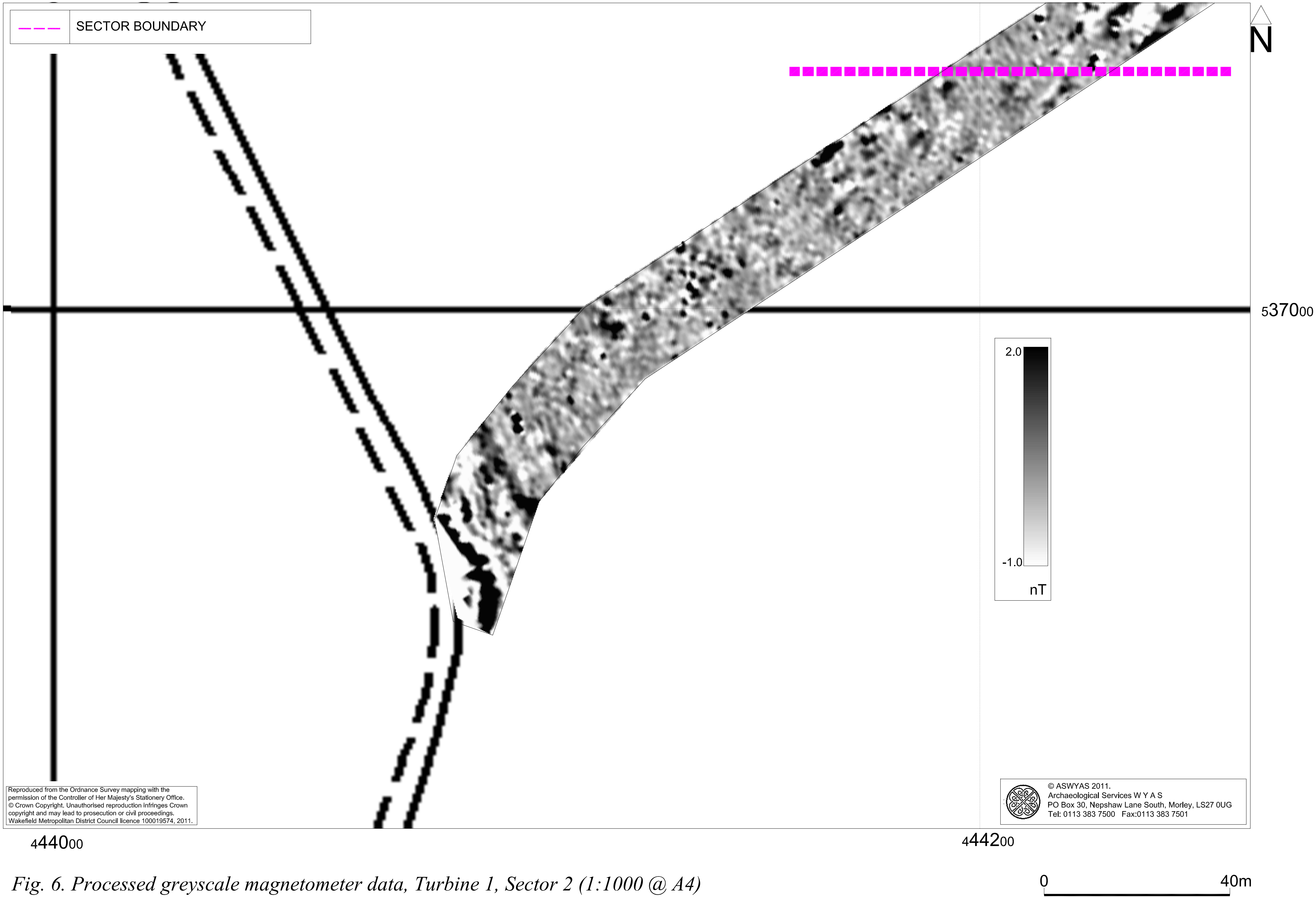

Fig. 6. Processed greyscale magnetometer data, Turbine 1, Sector 2 (1:1000 @ A4)

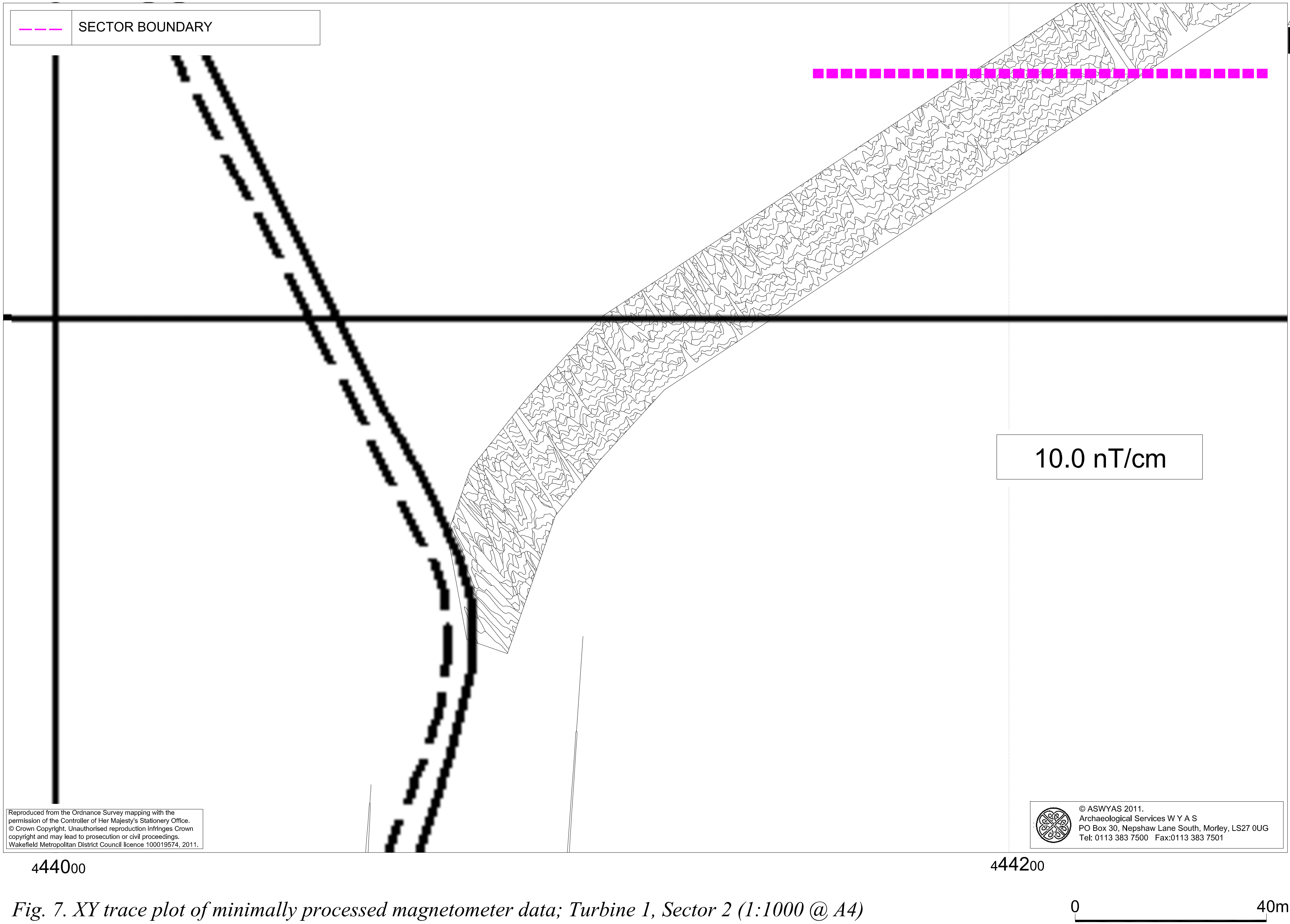

Fig. 7. XY trace plot of minimally processed magnetometer data; Turbine 1, Sector 2 (1:1000 @ A4)

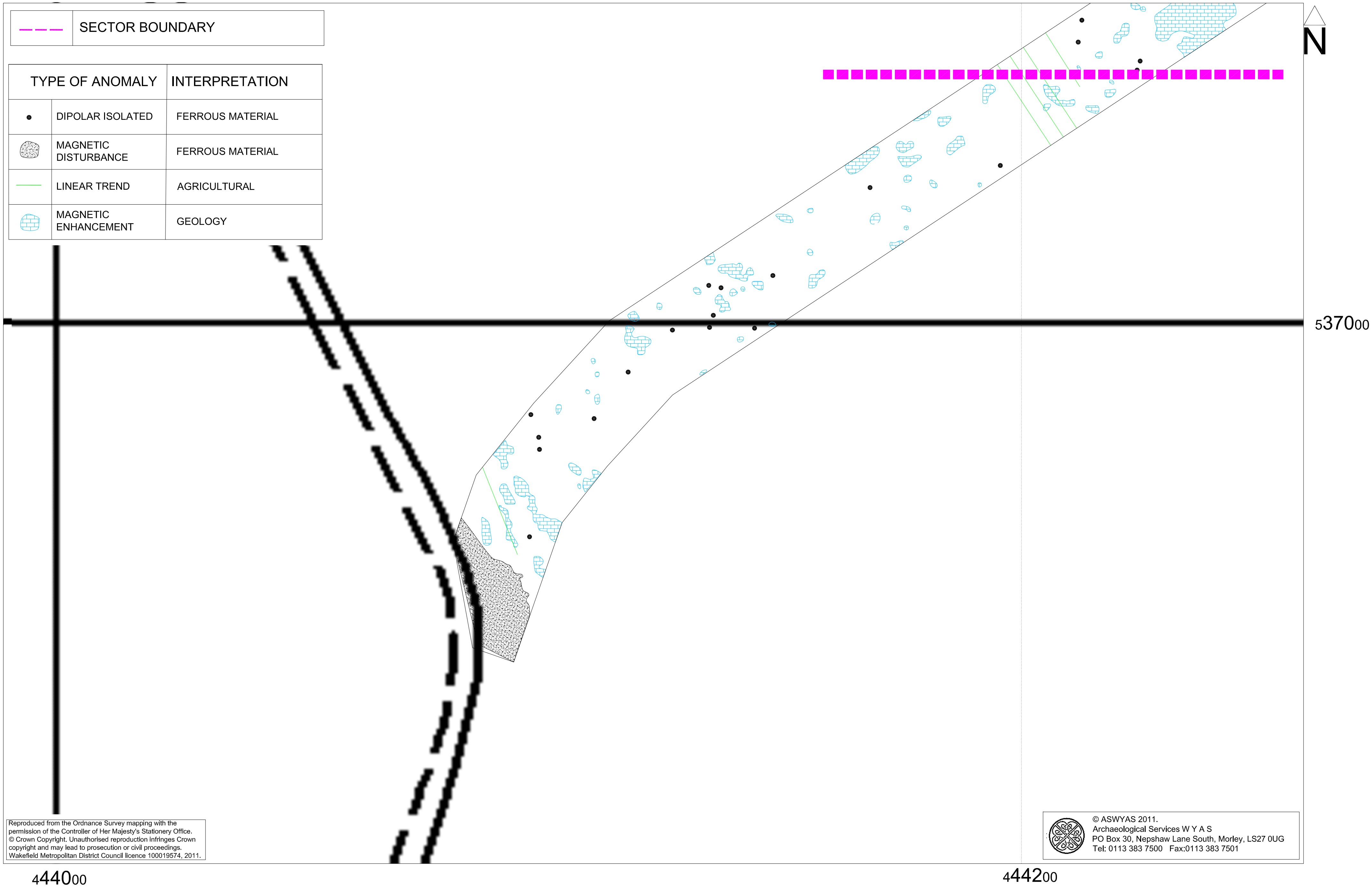

Fig. 8. XY trace plot of minimally processed magnetometer data; Turbine 1, Sector 2 (1:1000 @ A4)

0 40m

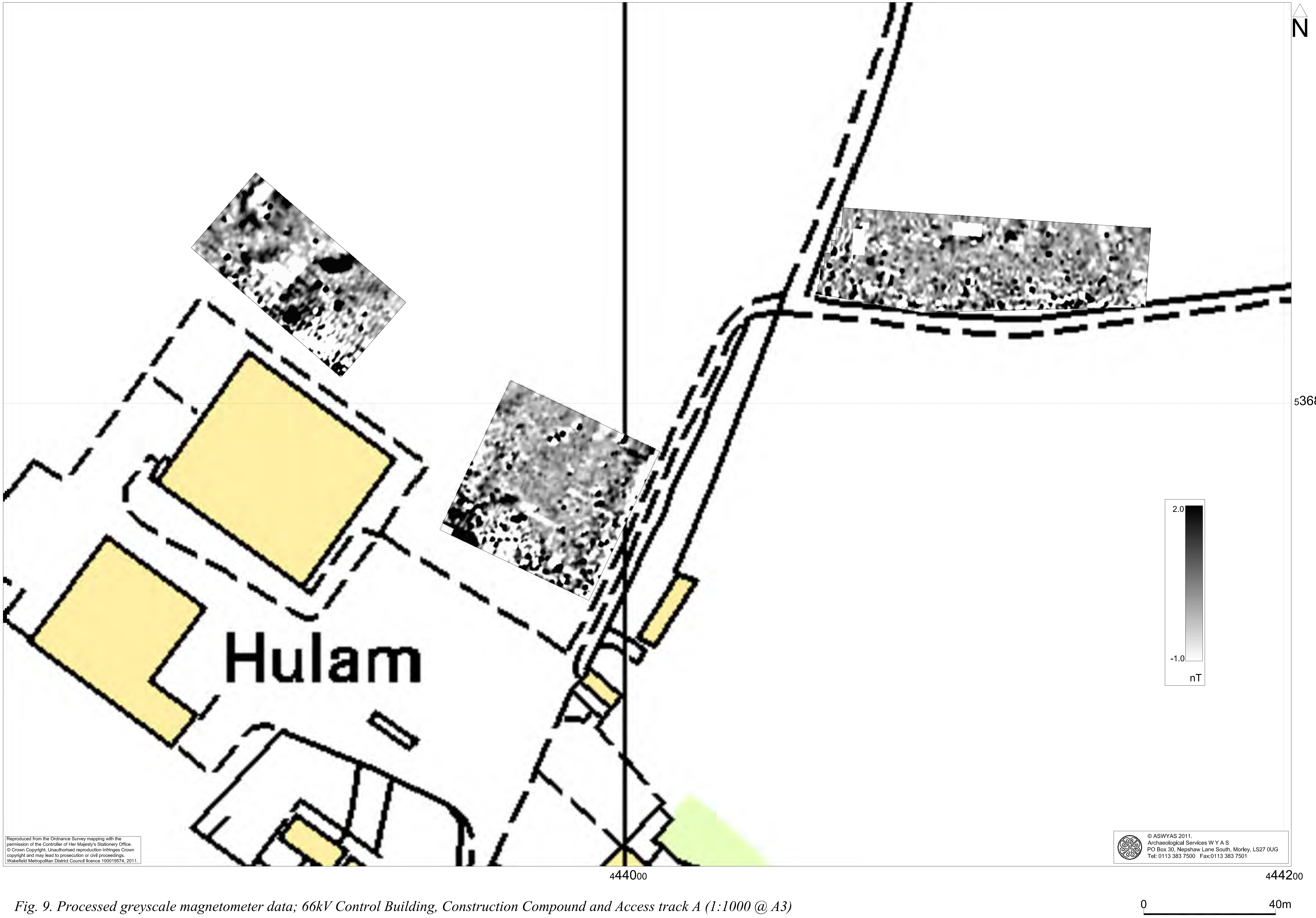

Fig. 9. Processed greyscale magnetometer data; 66kV Control Building, Construction Compound and Access track A (1:1000 @ A3)

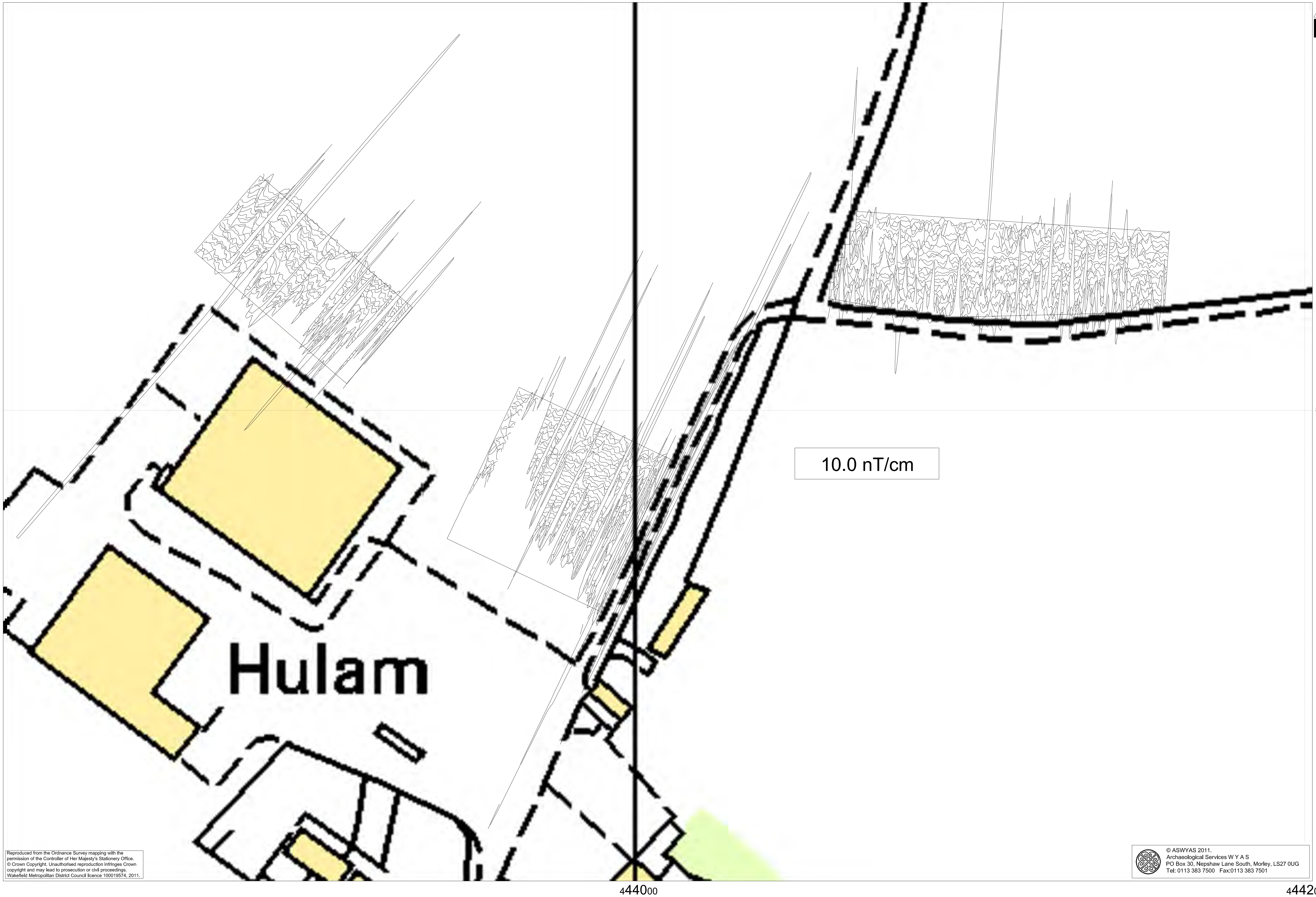

Fig. 10. XY trace plot of minimally processed magnetometer data; 66kV Control Building, Construction Compound and Access track A (1:1000 @ A3)

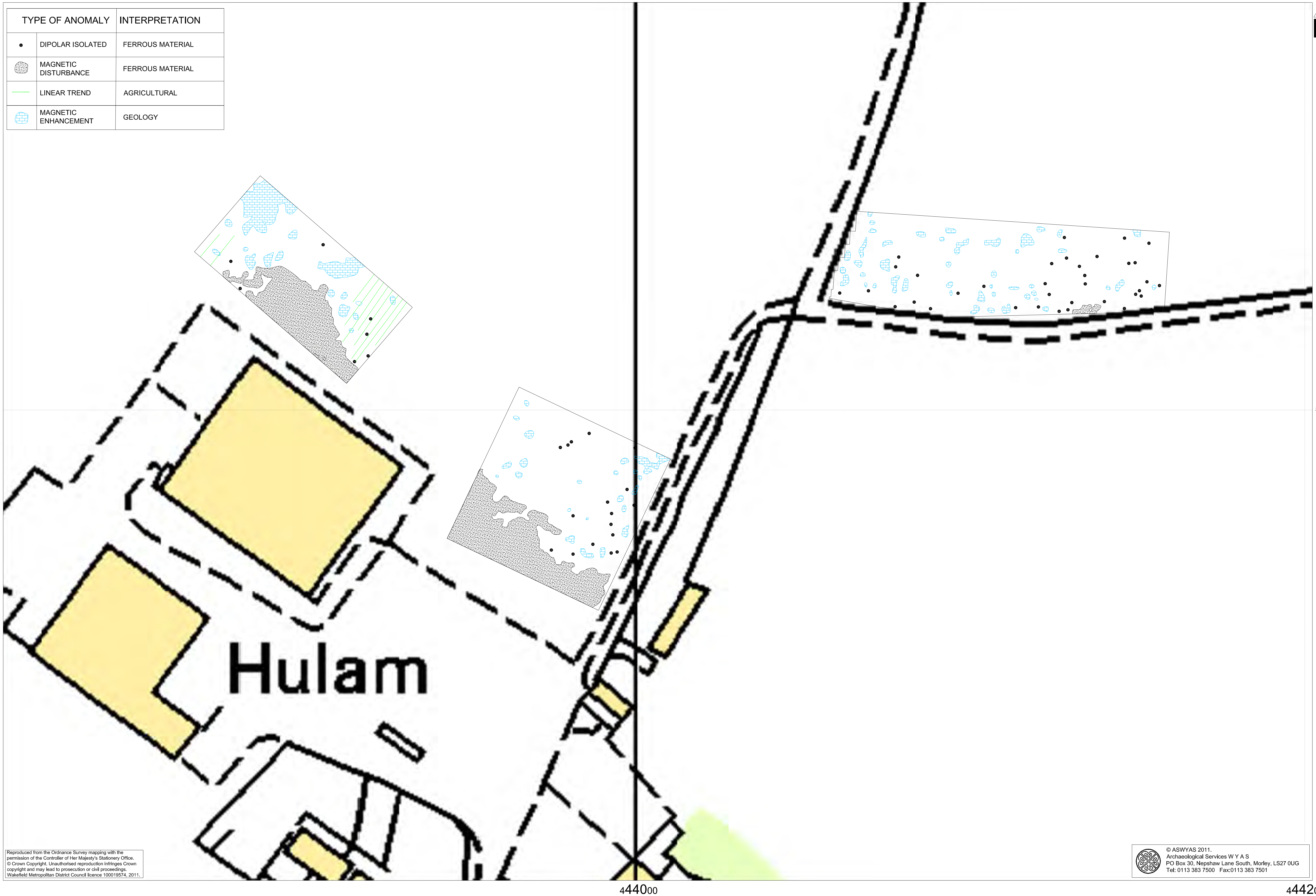

Fig. 11. XY trace plot of minimally processed magnetometer data; 66kV Control Building, Construction Compound and Access track A (1:1000 @ A3)

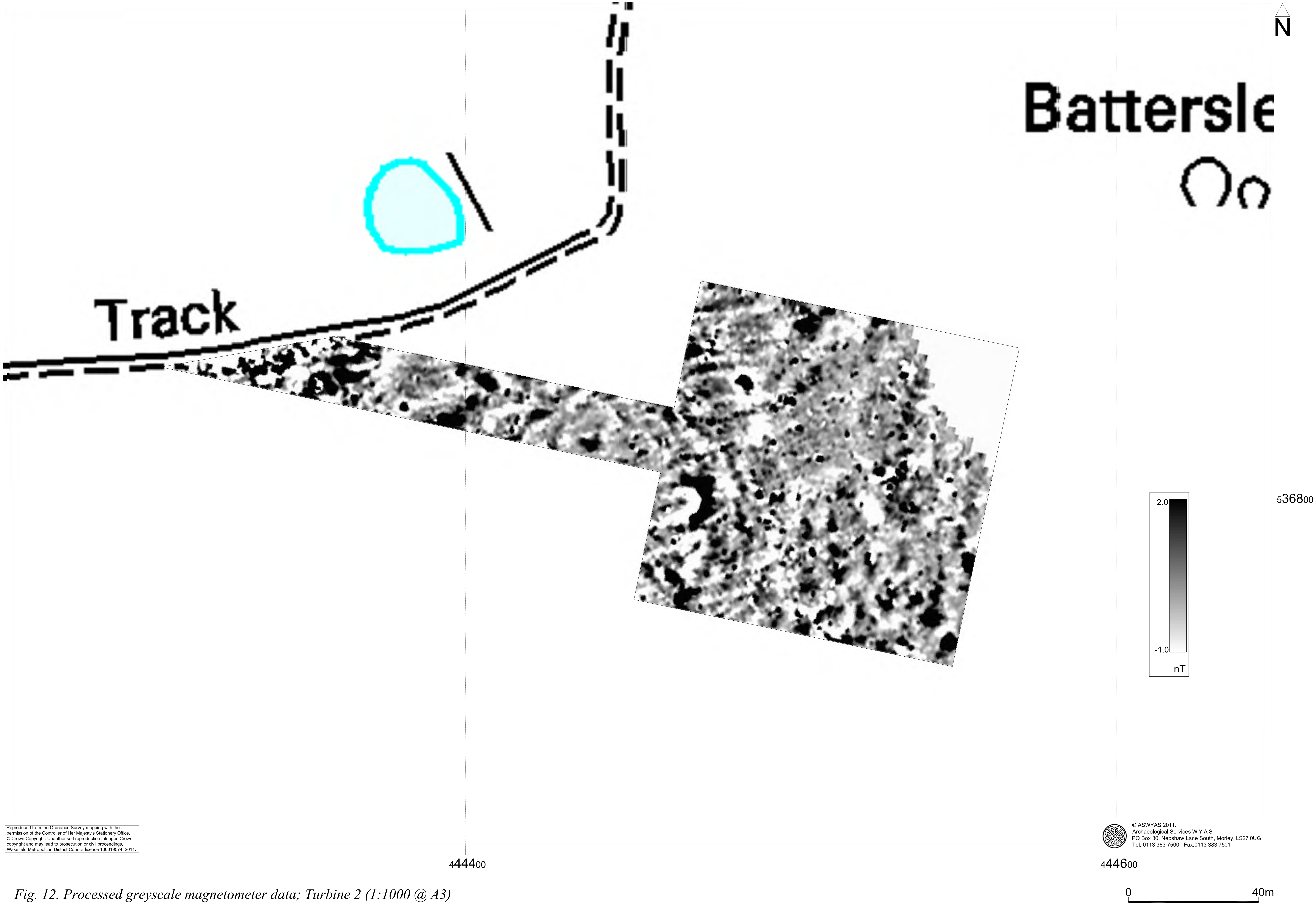

Fig. 12. Processed greyscale magnetometer data; Turbine 2 (1:1000 @ A3)

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

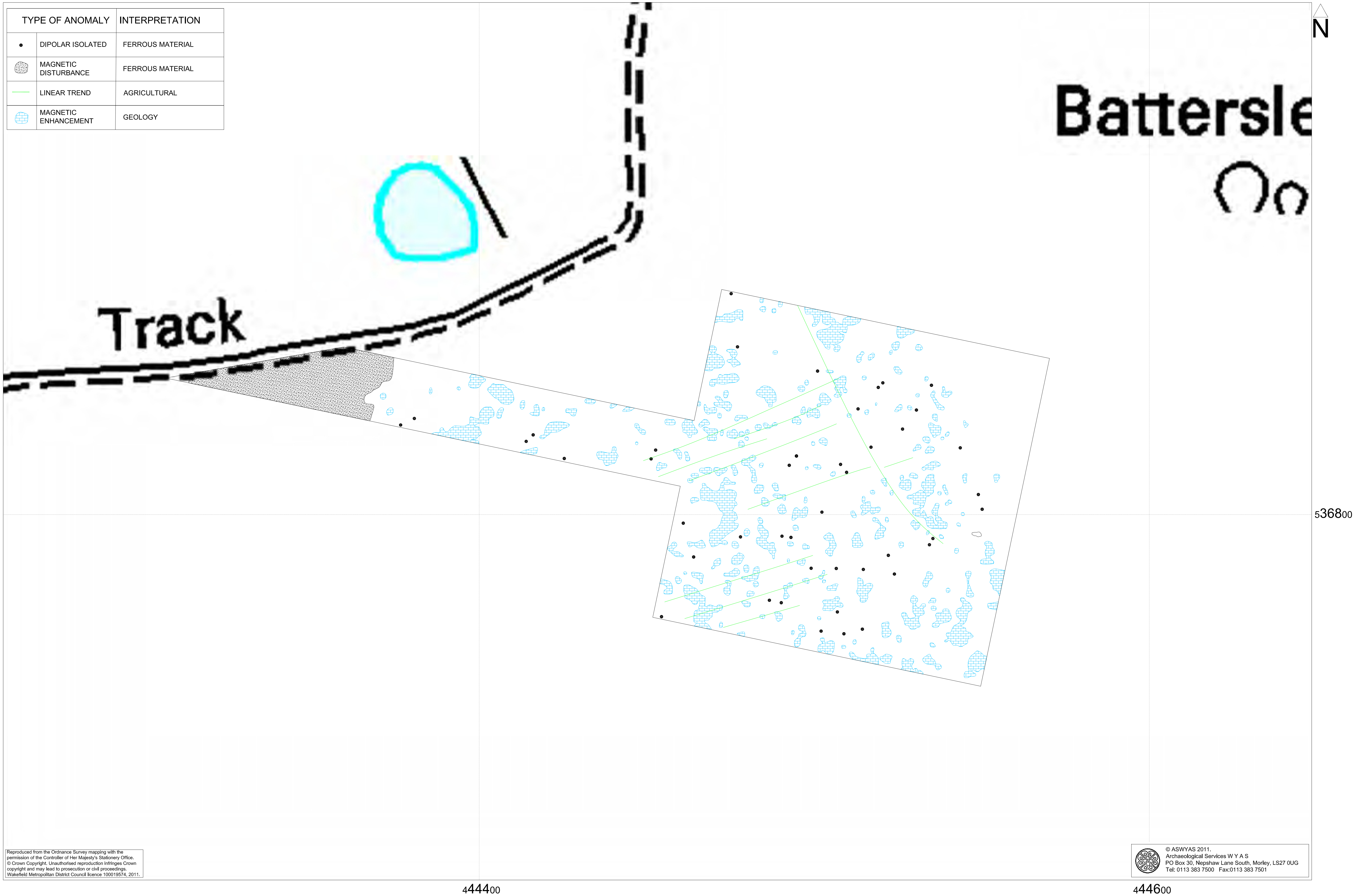

Fig. 14. Interpretation of magnetometer data; Turbine 2 (1:1000 @ A3)

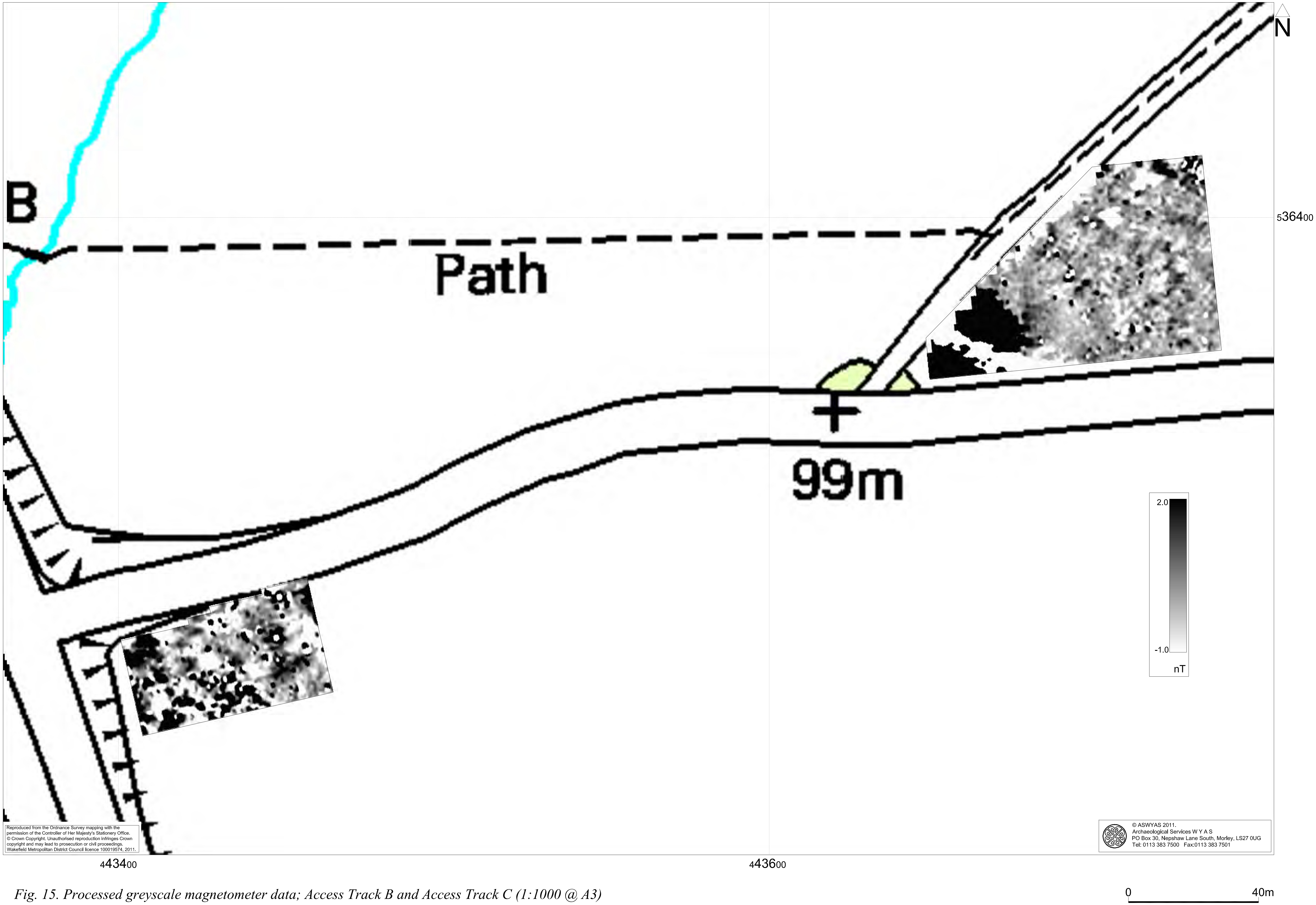

Fig. 15. Processed greyscale magnetometer data; Access Track B and Access Track C (1:1000 @ A3)

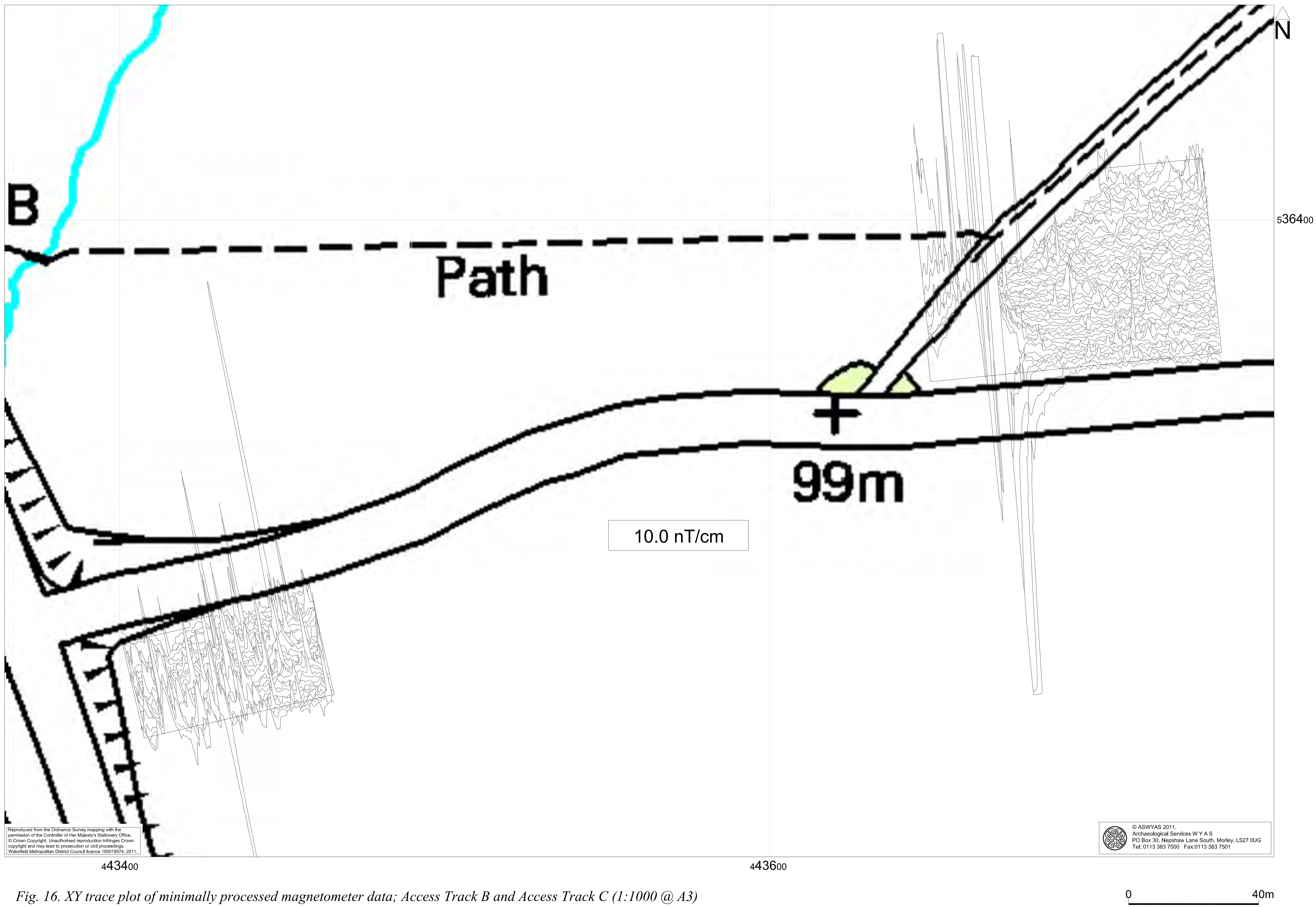

Fig. 16. XY trace plot of minimally processed magnetometer data; Access Track B and Access Track C (1:1000 @ A3)

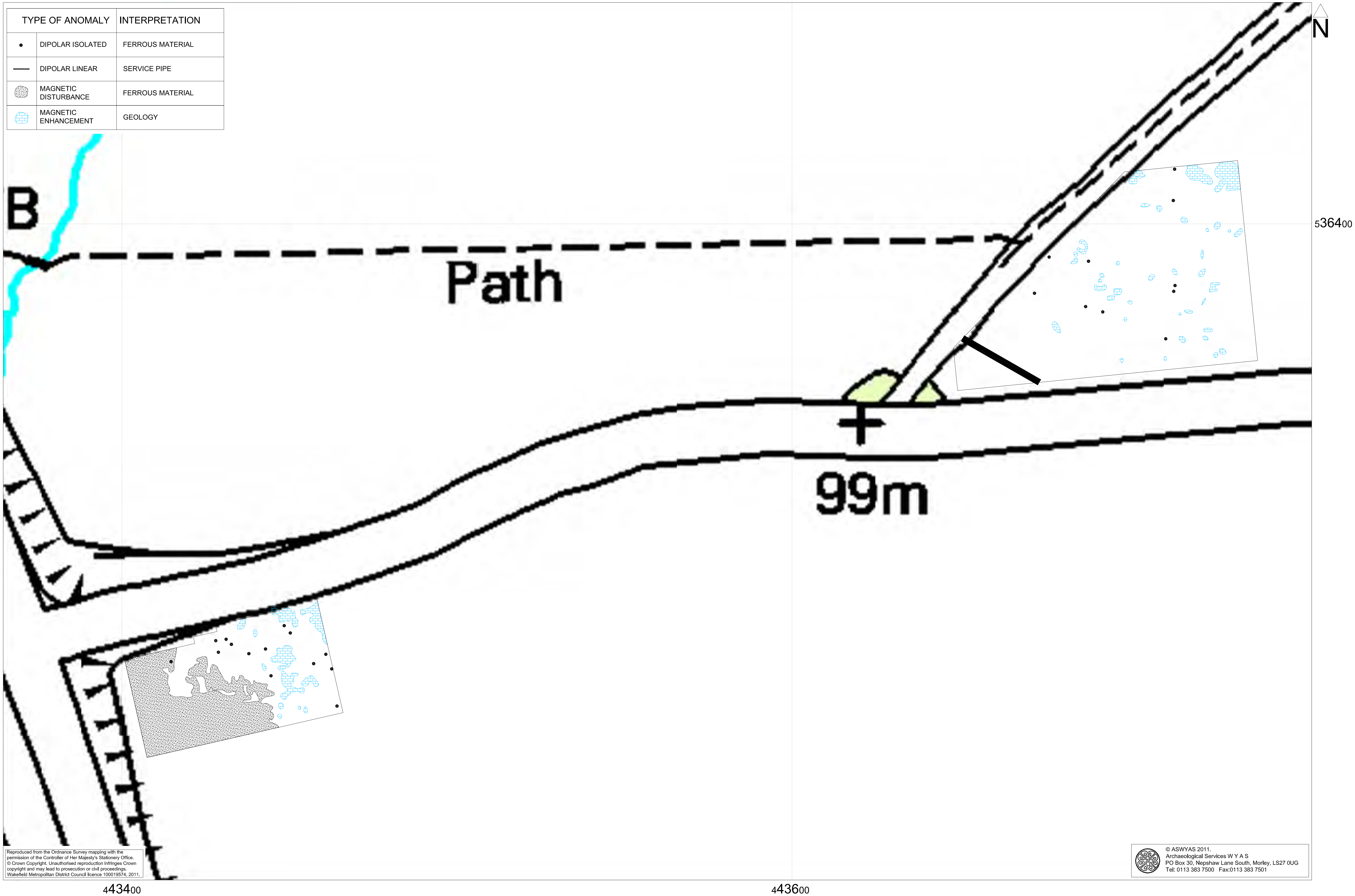

Fig. 17. Interpretation of magnetometer data; Access Track B and Access Track C (1:1000 @ A3)

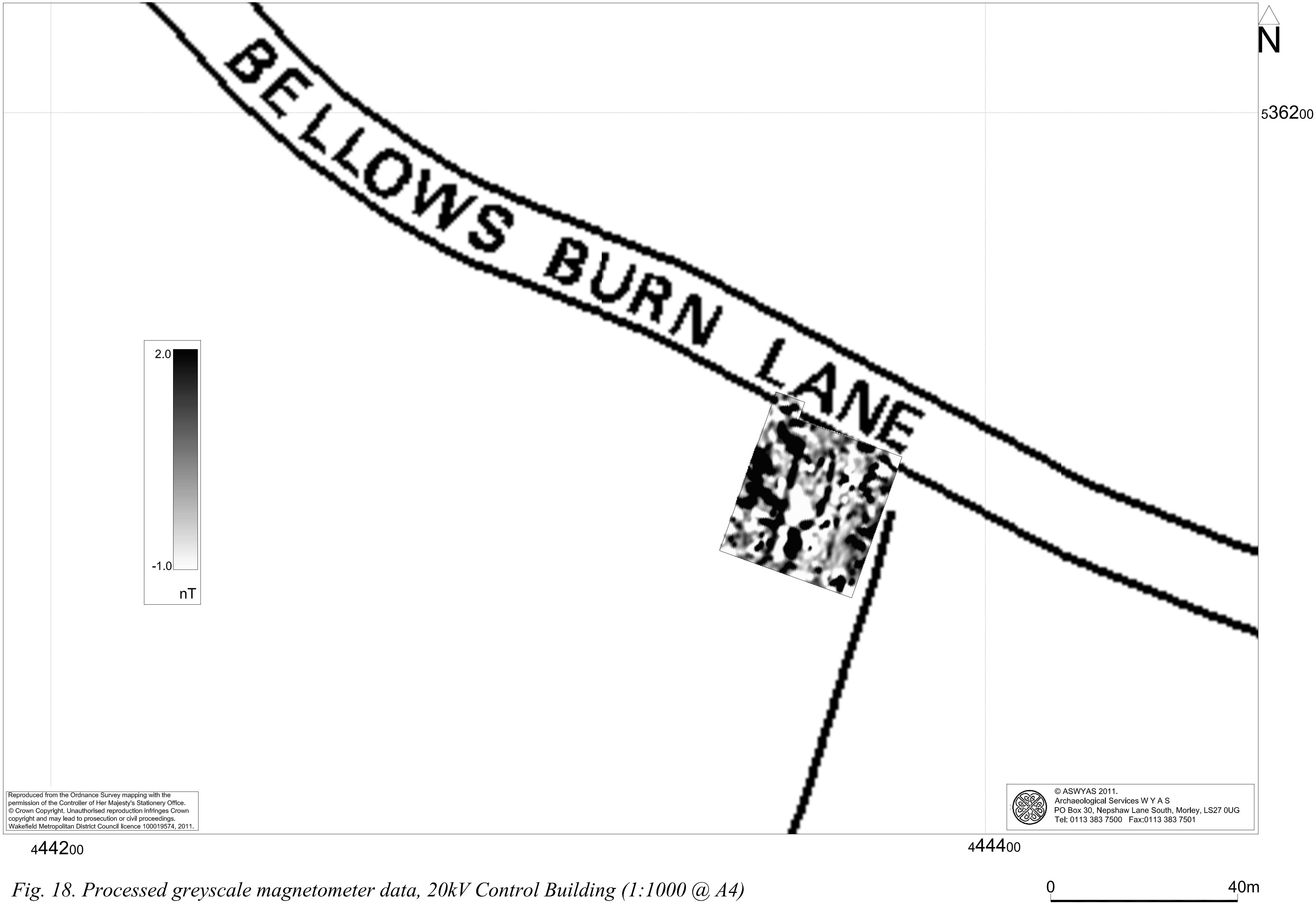

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Fig. 18. Processed greyscale magnetometer data, 20kV Control Building (1:1000 @ A4)

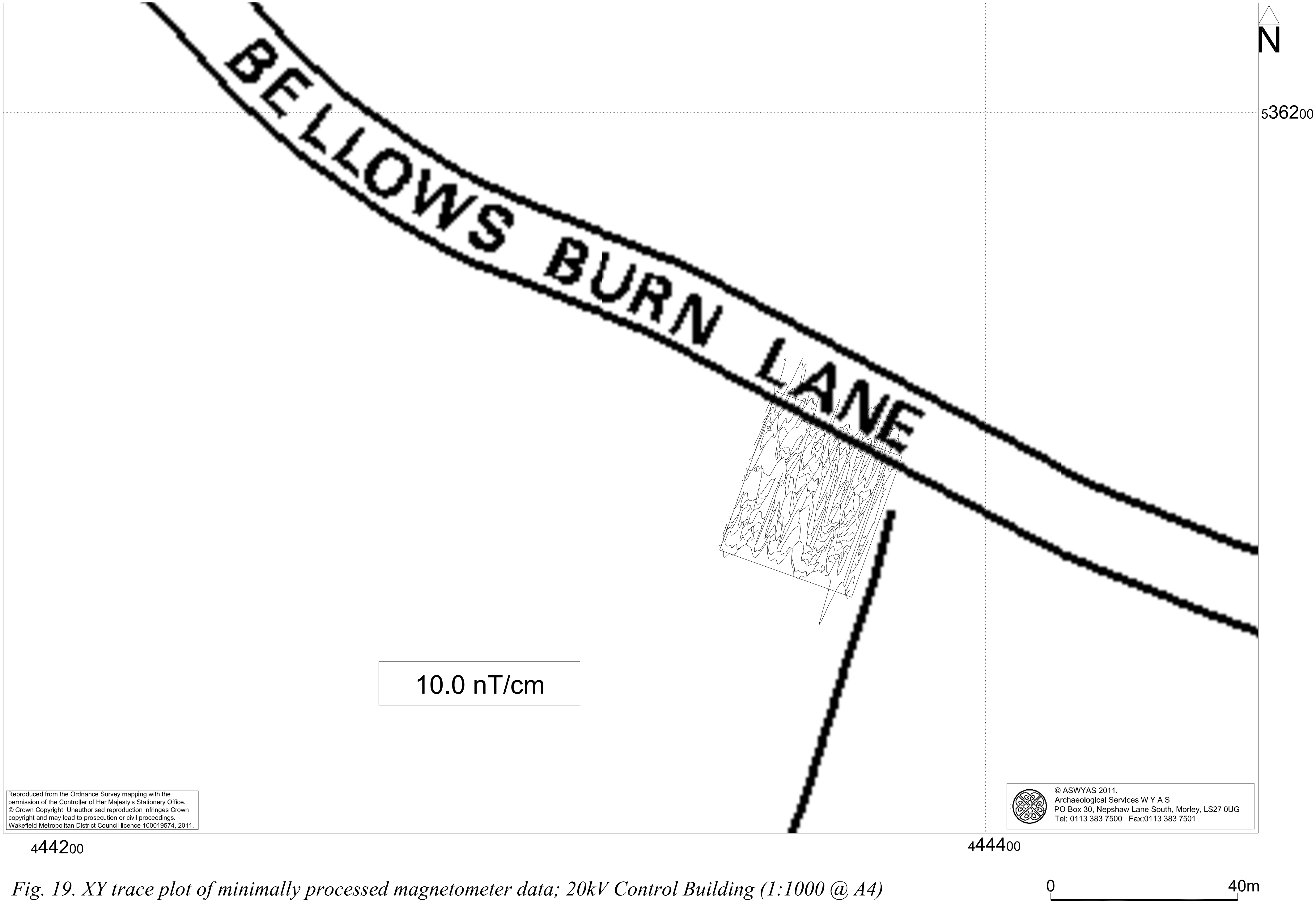

Fig. 19. XY trace plot of minimally processed magnetometer data; 20kV Control Building (1:1000 @ A4)

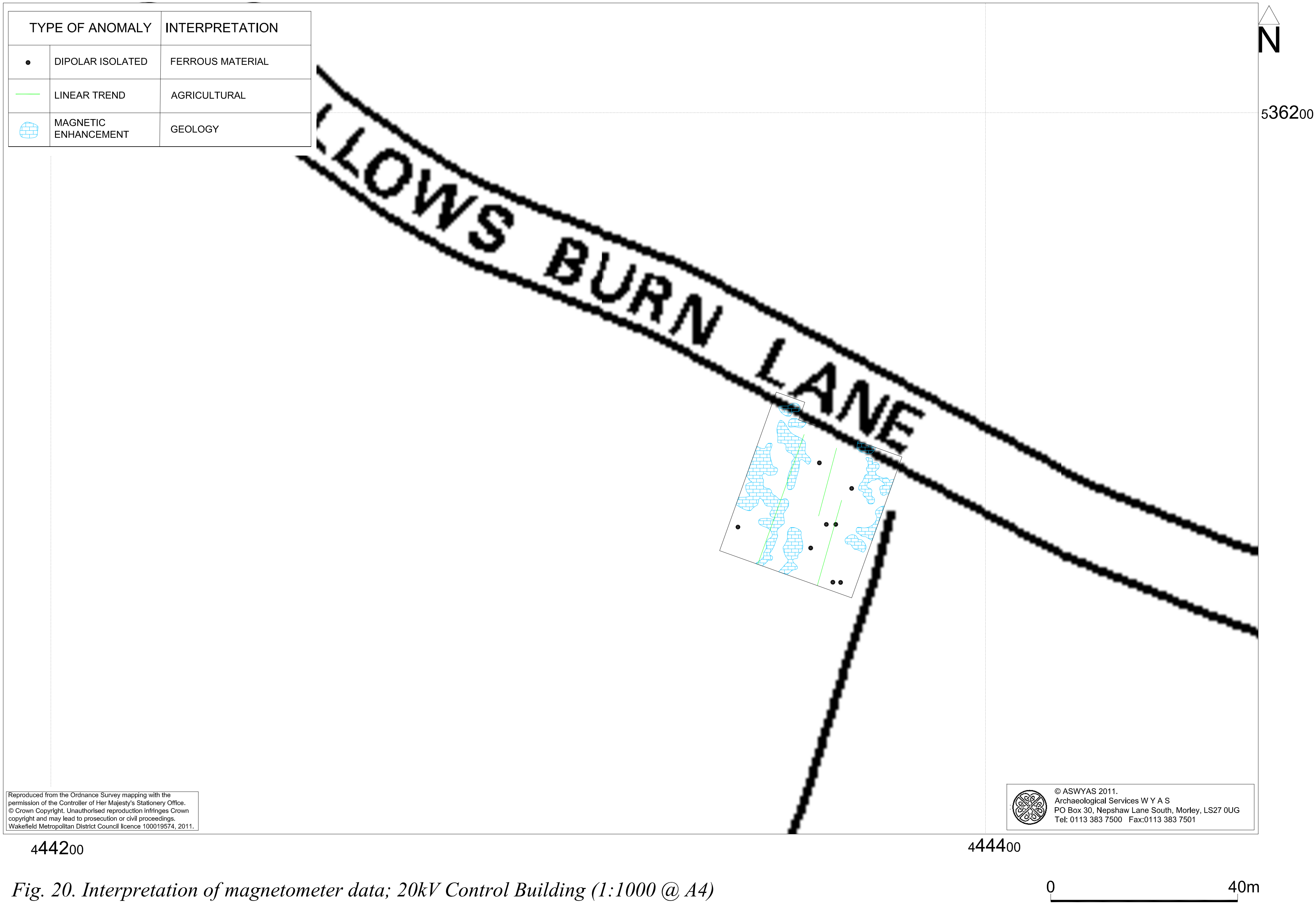

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Fig. 20. Interpretation of magnetometer data; 20kV Control Building (1:1000 @ A4)

Fig. 21. Processed greyscale magnetometer data; Turbine 3 (1:1000 @ A3)

0 40m

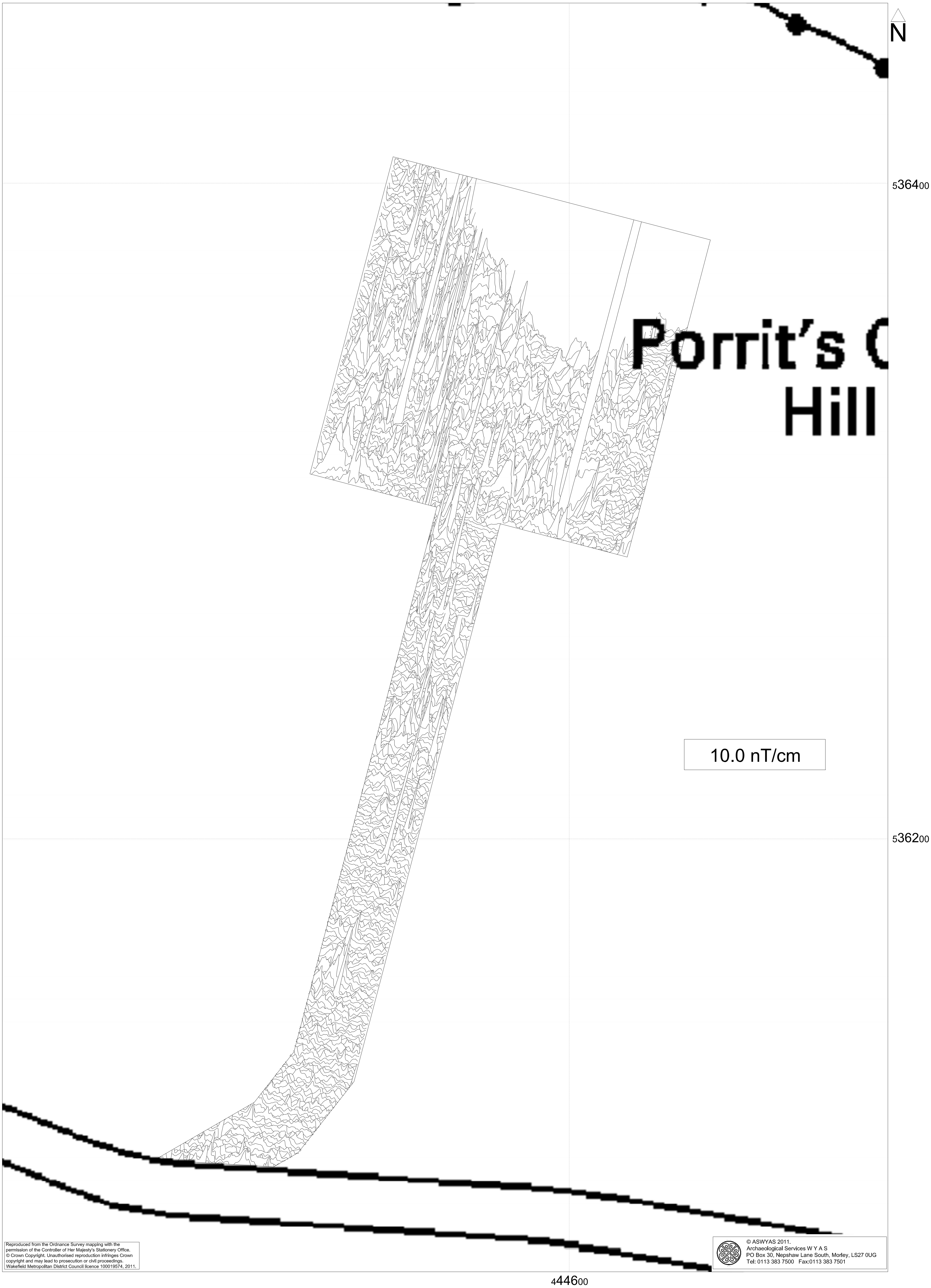

Fig. 22. XY trace plot of minimally processed magnetometer data; Turbine 3 (1:1000 @ A3)

0 40m

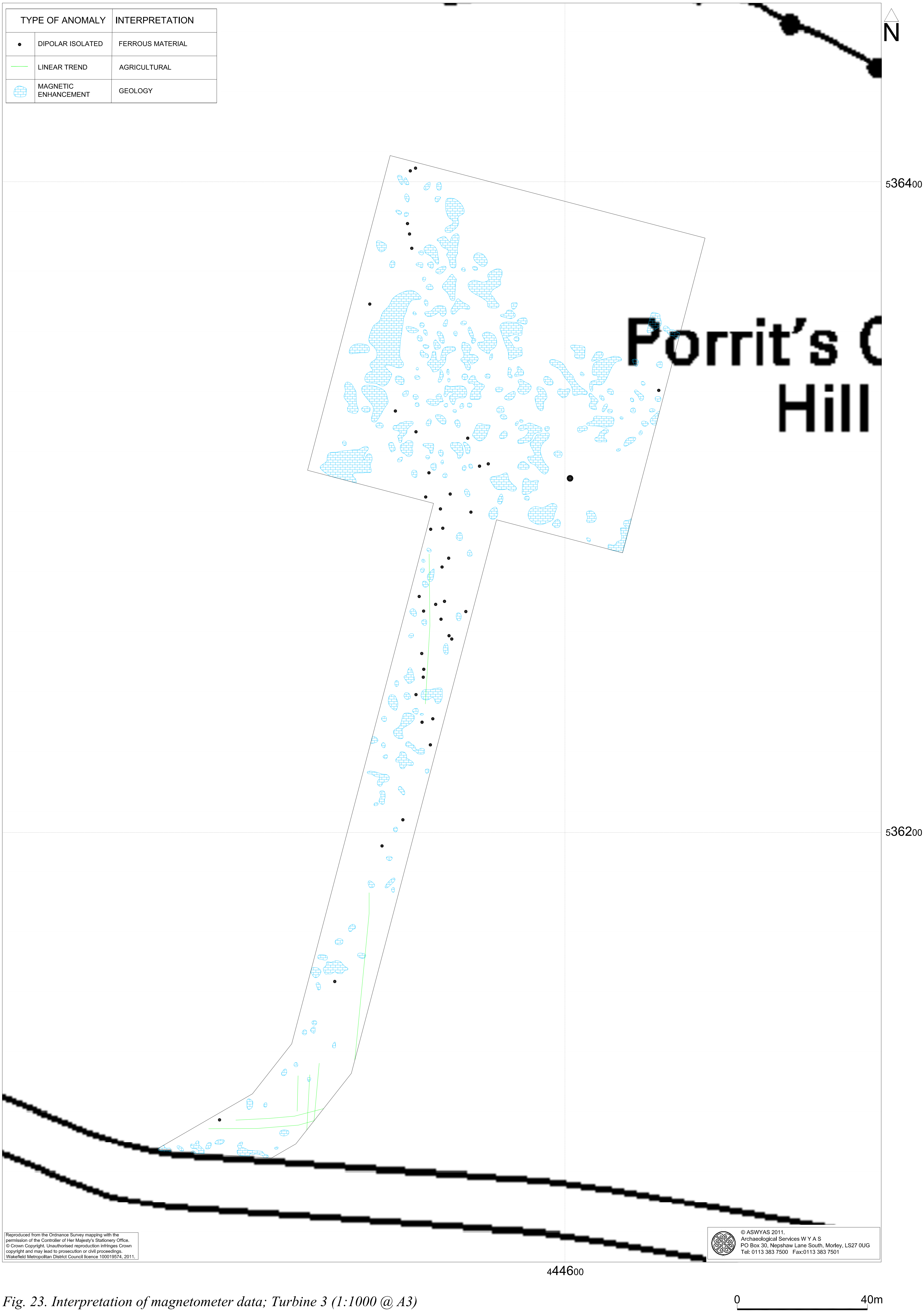

Fig. 23. Interpretation of magnetometer data; Turbine 3 (1:1000 @ A3)

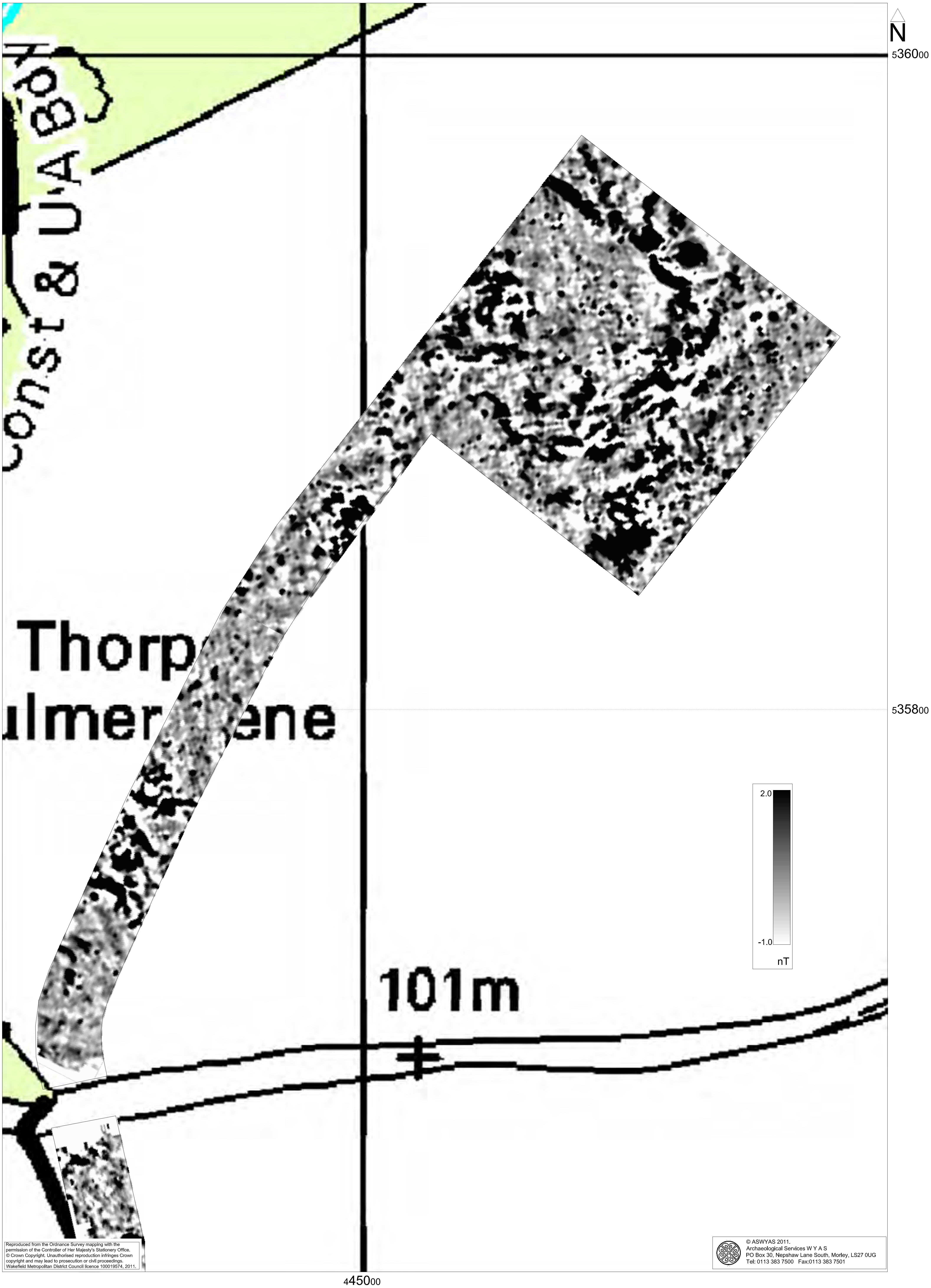

Fig. 24. Processed greyscale magnetometer data; Turbine 4 (1:1000 @ A3)

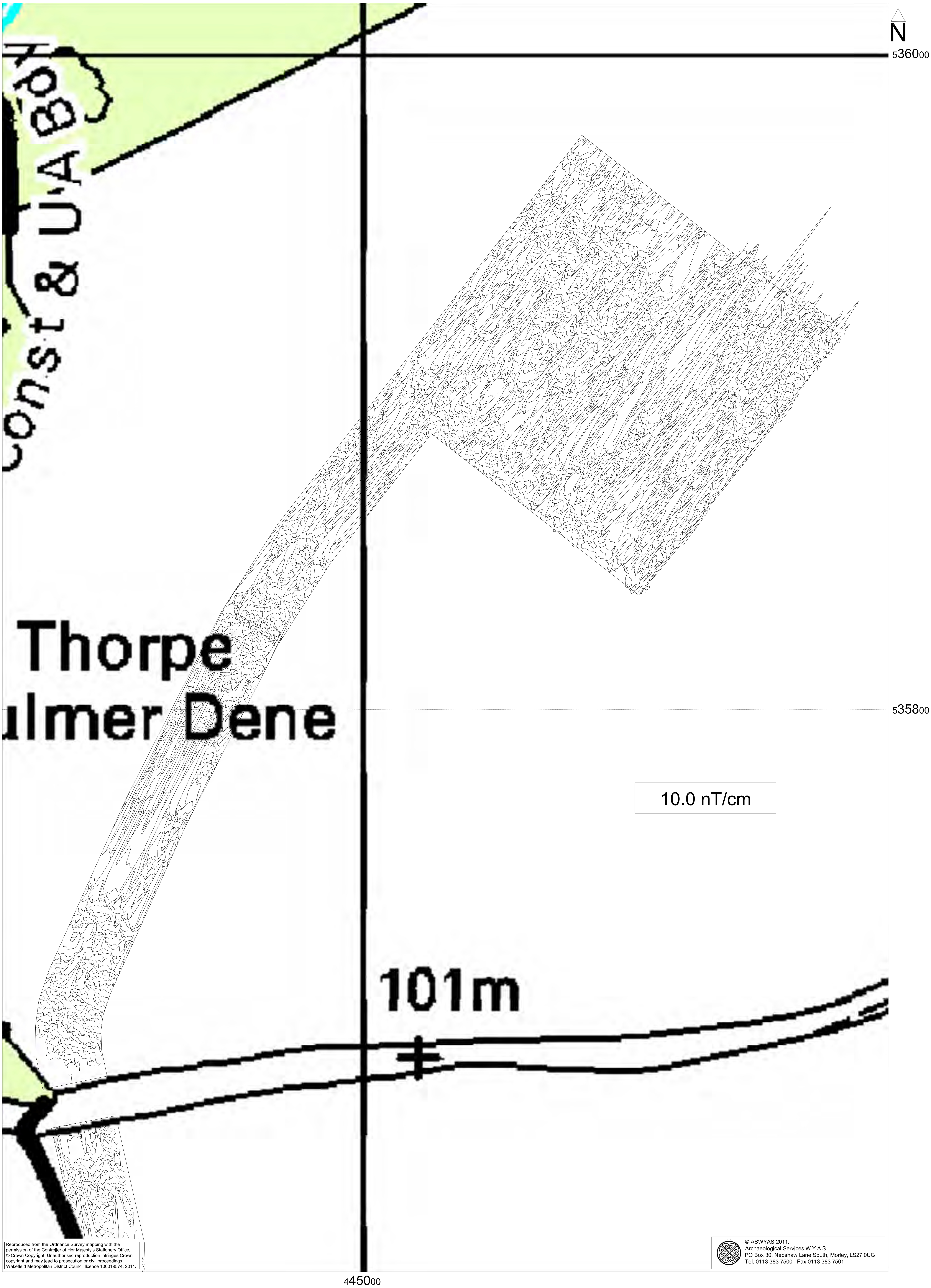

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Fig. 25. XY trace plot of minimally processed magnetometer data; Turbine 4 (1:1000 @ A3)

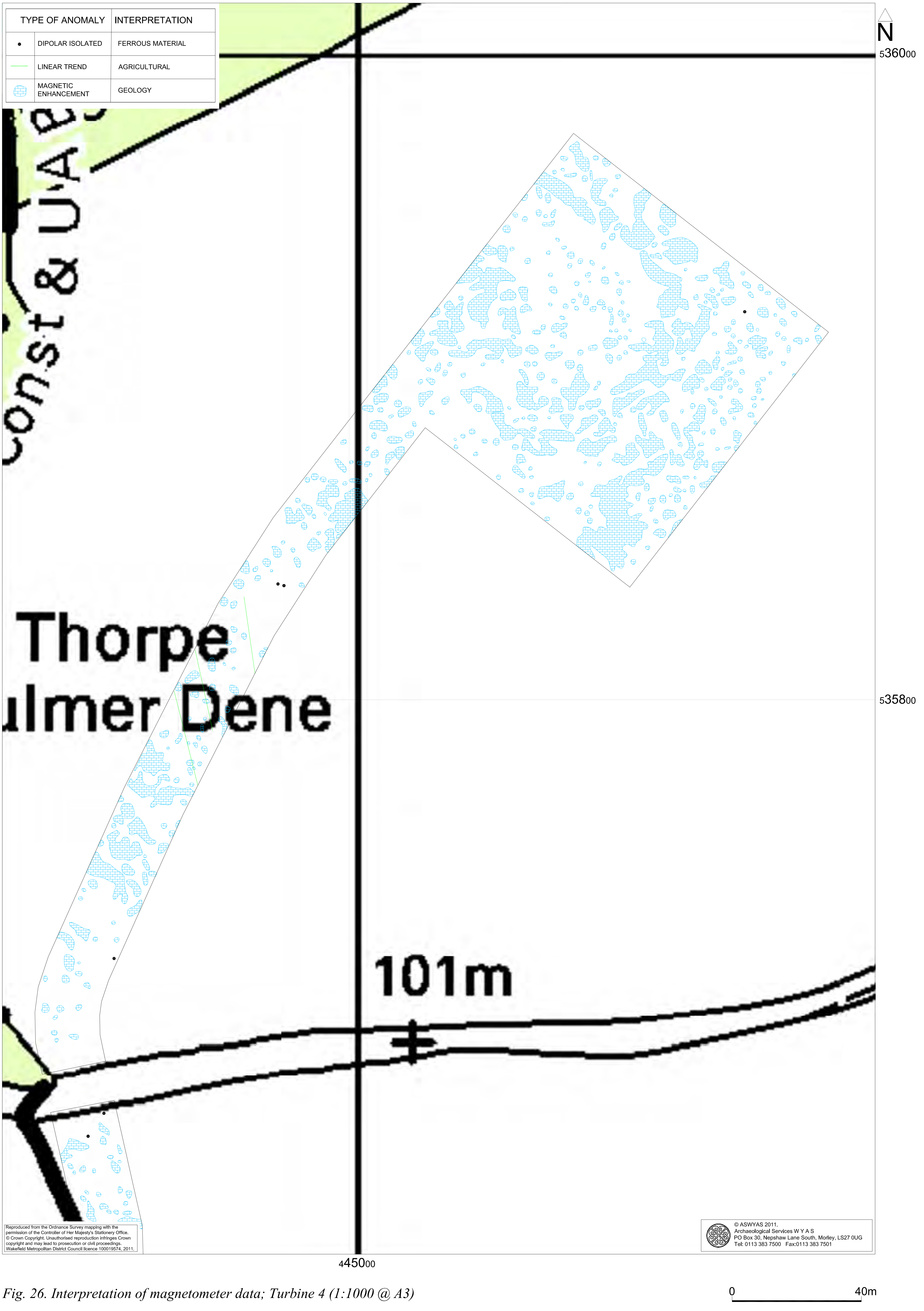

Fig. 26. Interpretation of magnetometer data; Turbine 4 (1:1000 @ A3)

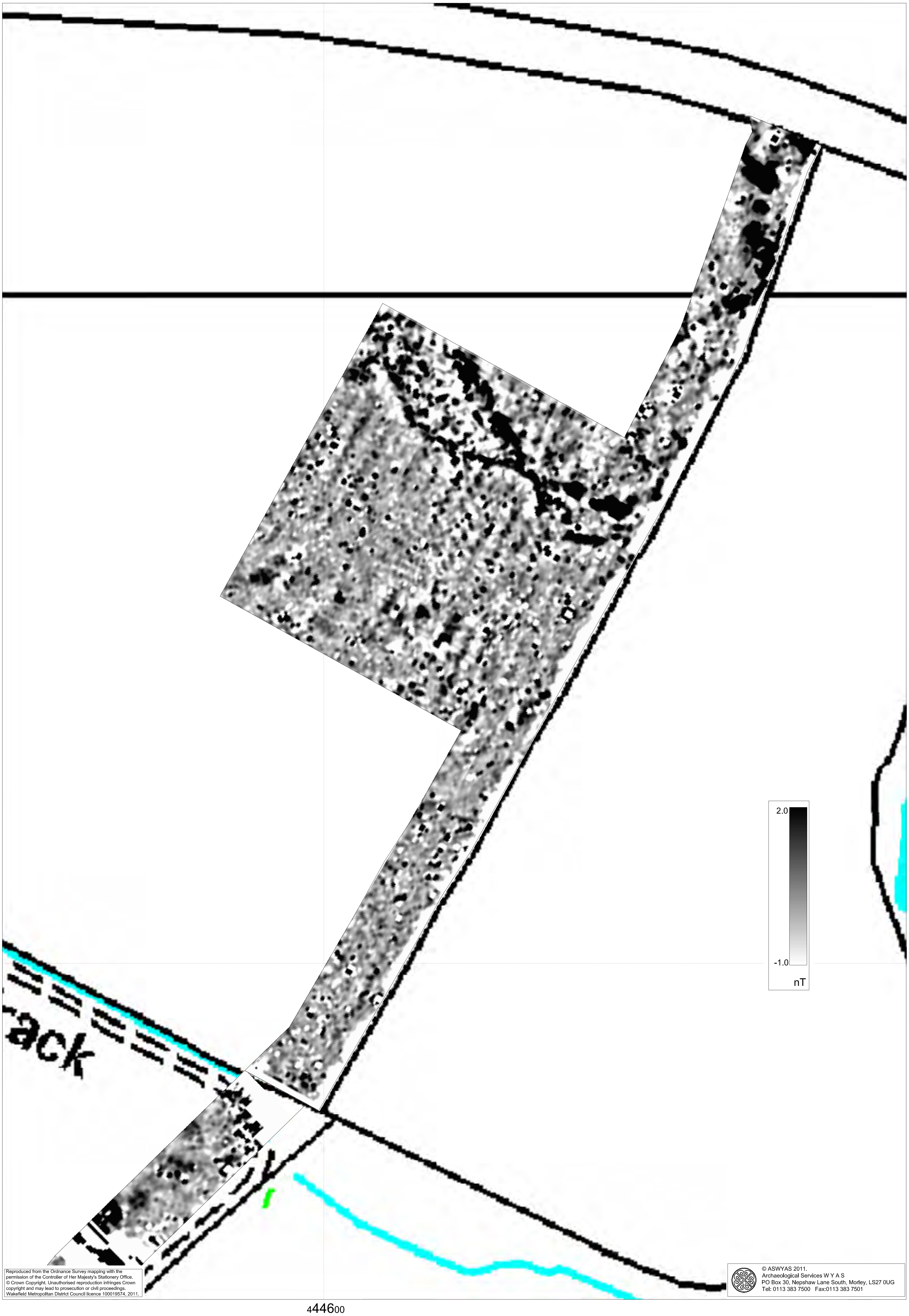

Fig. 27. Processed greyscale magnetometer data; Turbine 5 (1:1000 @ A3)

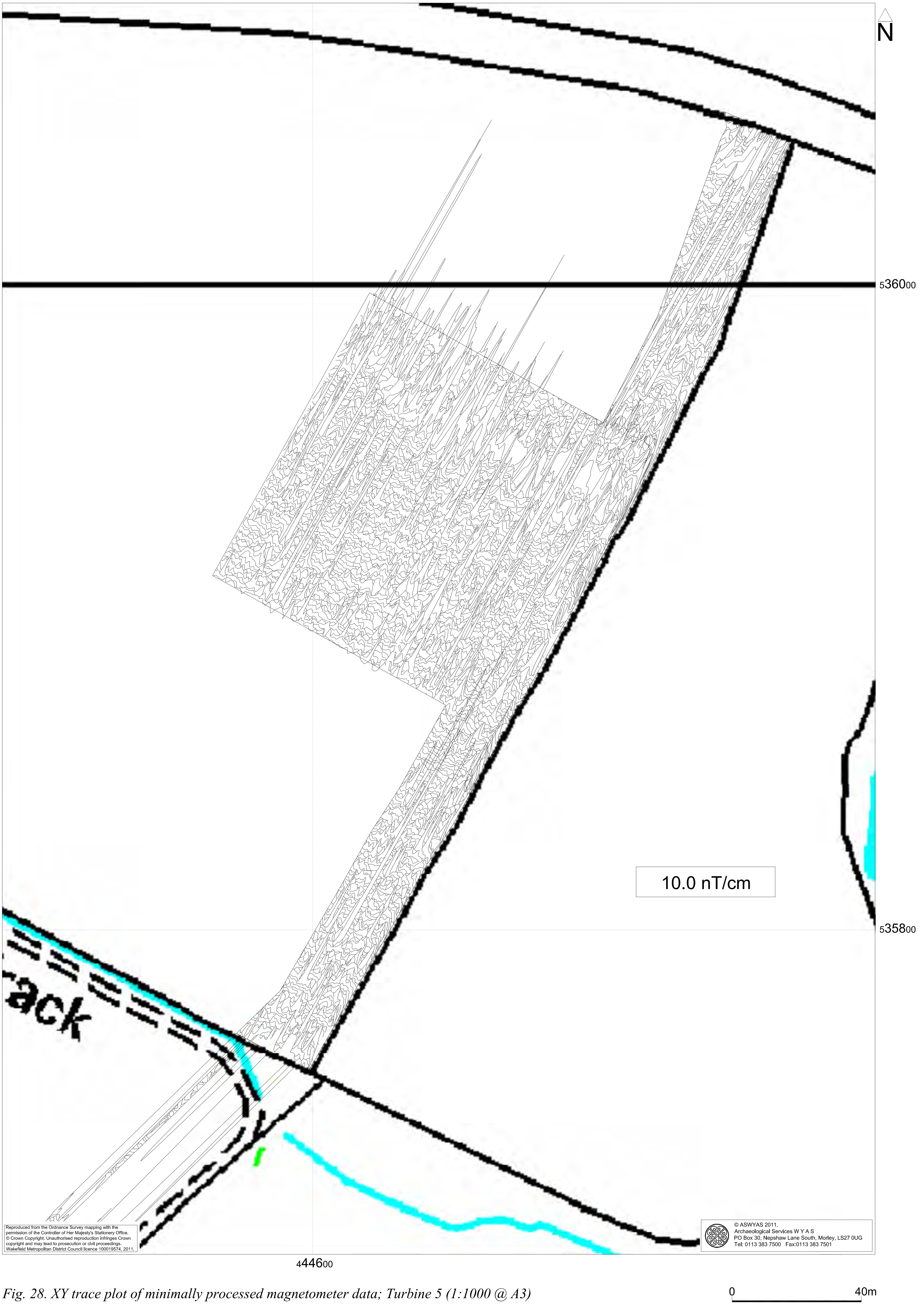

Fig. 28. XY trace plot of minimally processed magnetometer data; Turbine 5 (1:1000 @ A3)

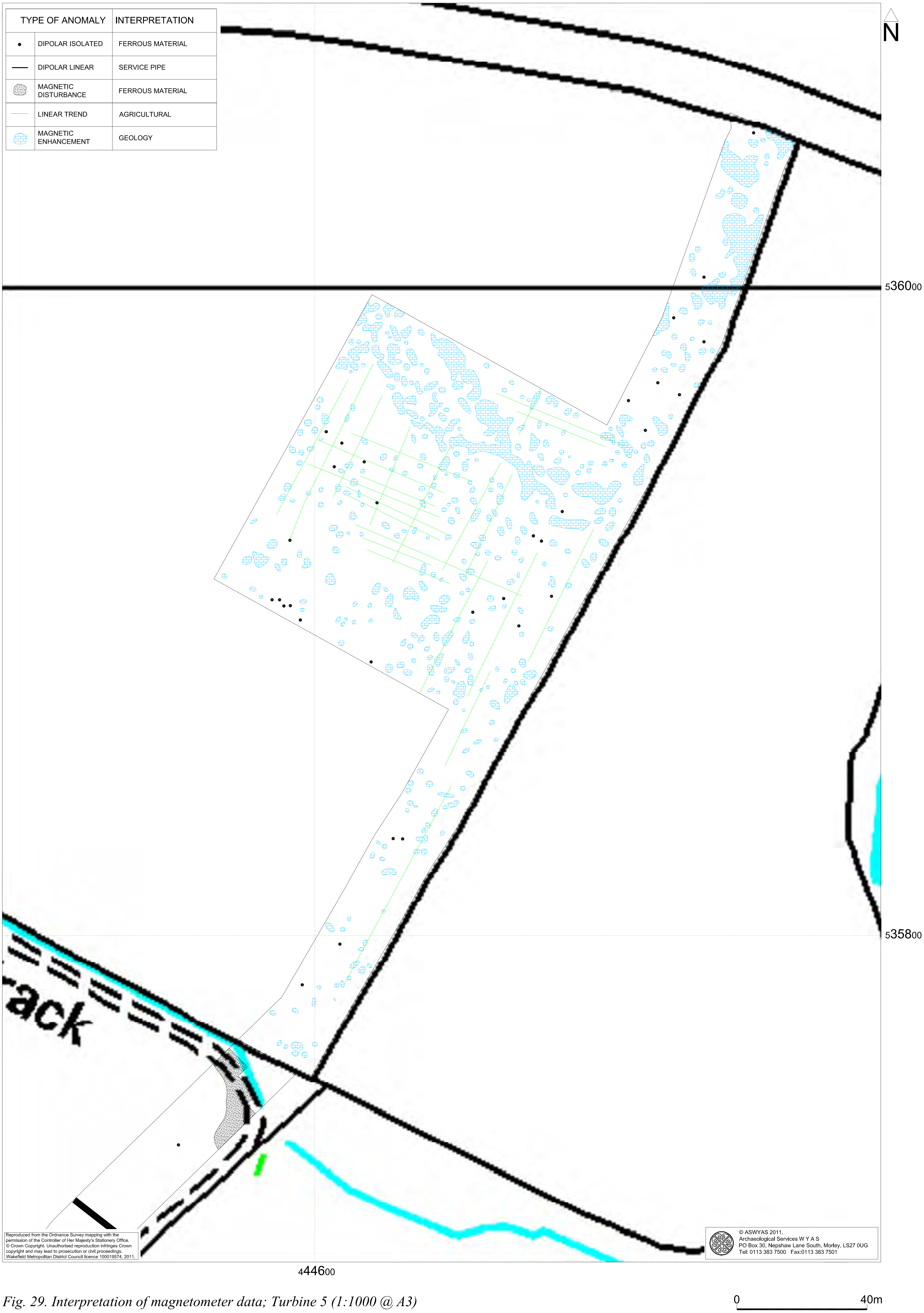

Fig. 29. Interpretation of magnetometer data; Turbine 5 (1:1000 @ A3)

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Fig. 30. Processed greyscale magnetometer data; Access Track D (1:1000 @ A3)

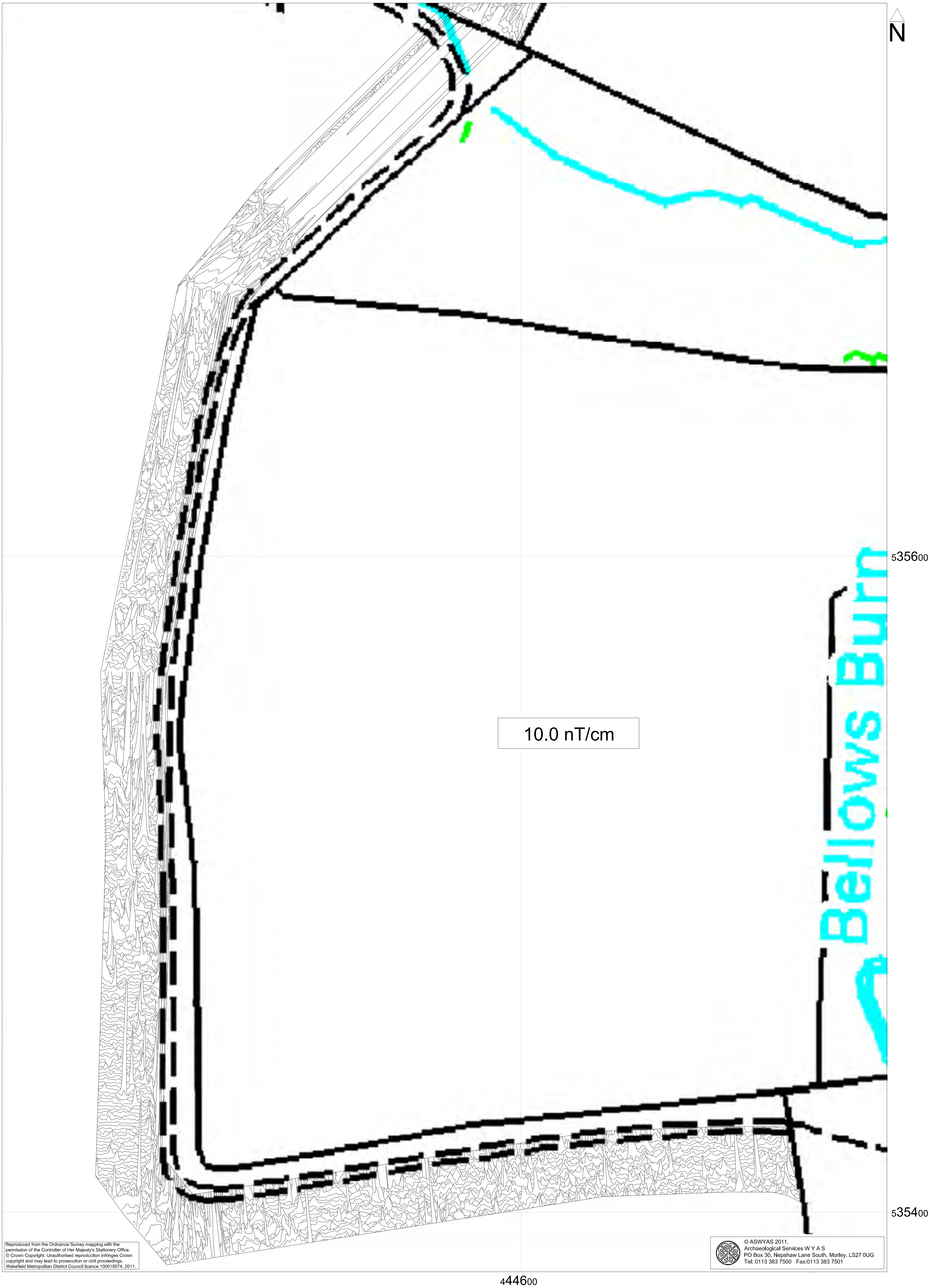

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Fig. 31. XY trace plot of minimally processed magnetometer data; Access Track D (1:1000 @ A3)

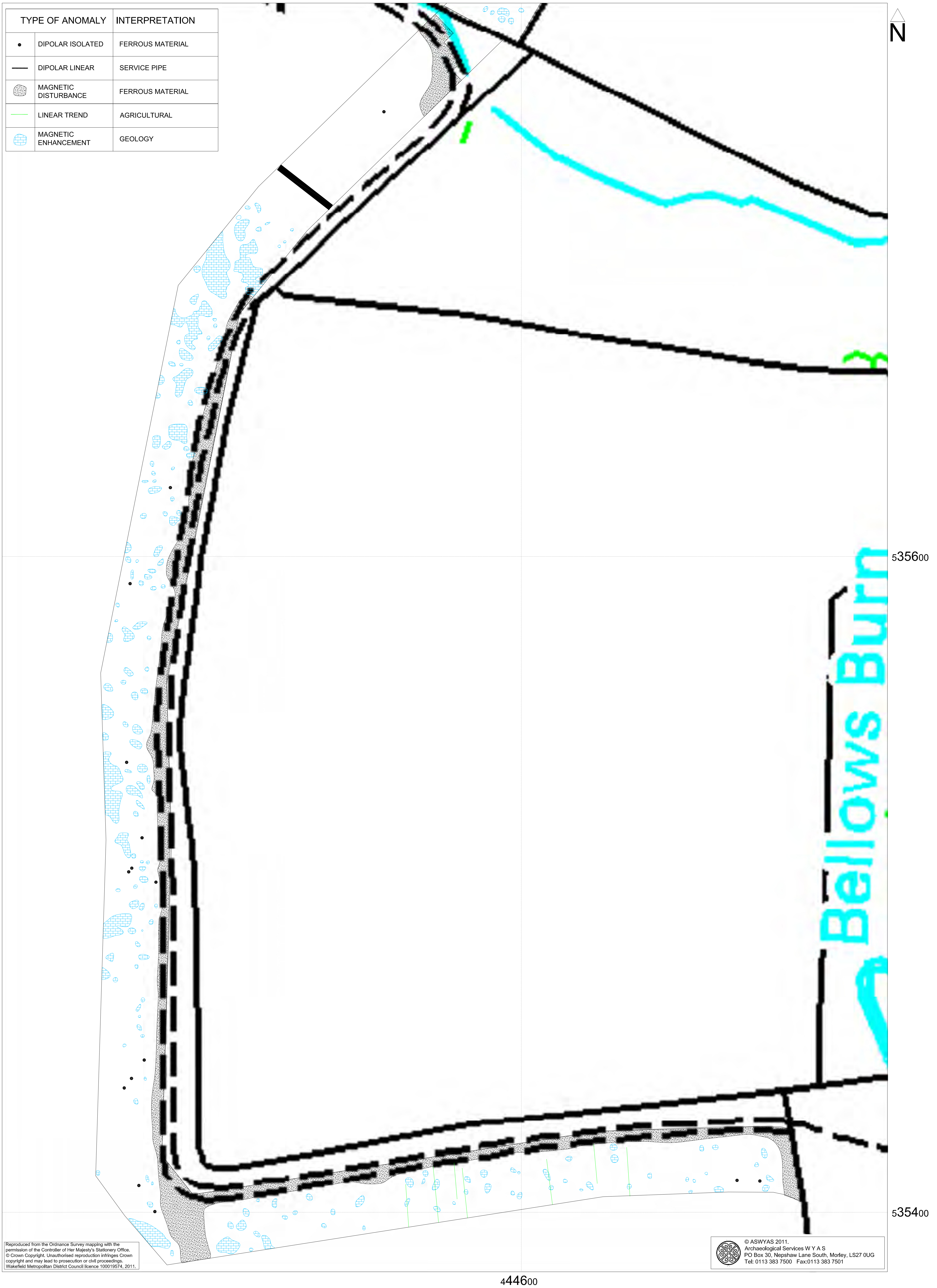

Fig. 32. Interpretation of magnetometer data; Access Track D (1:1000 @ A3)

0 40m

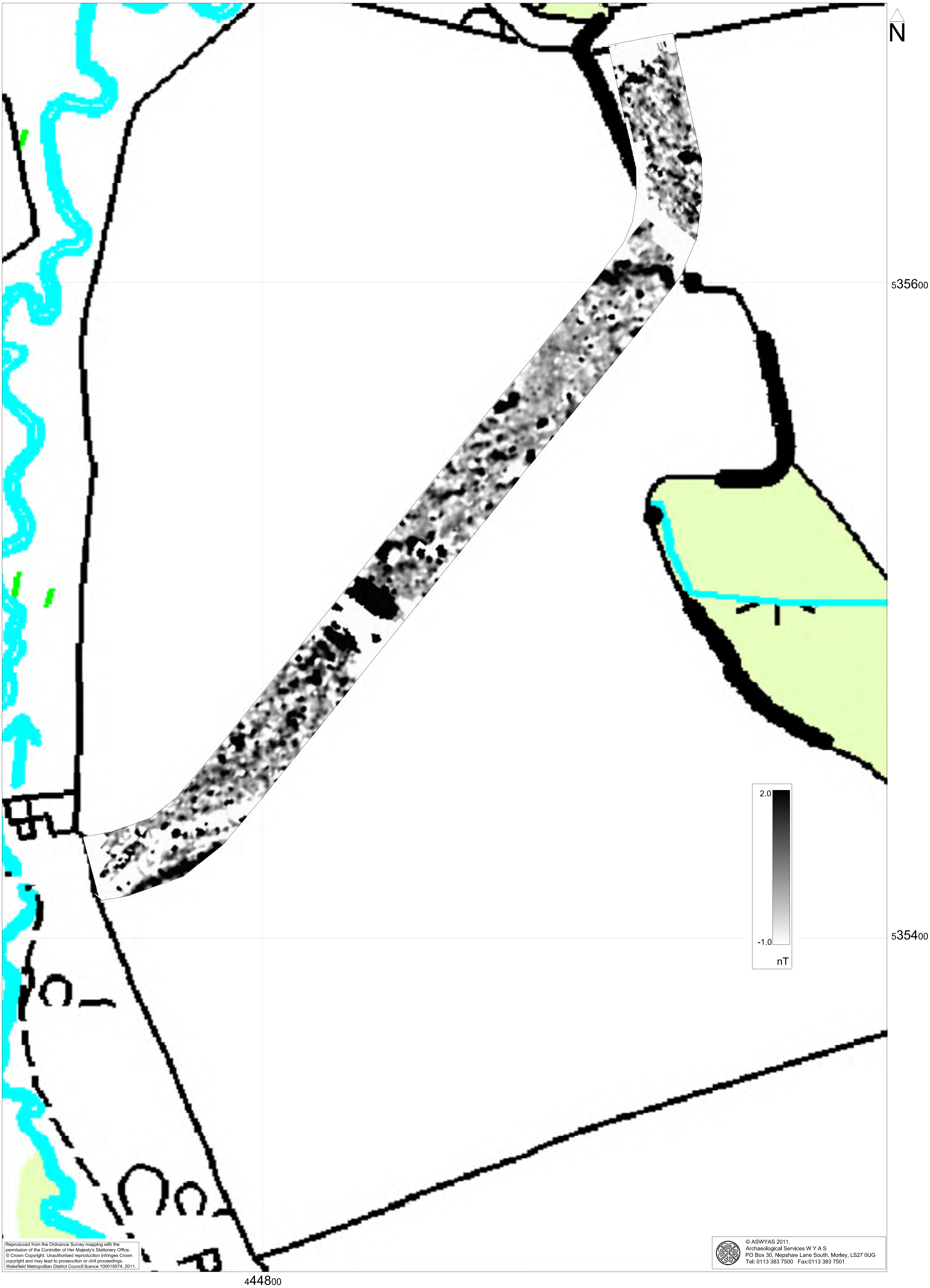

Fig. 33. Processed greyscale magnetometer data; Access Track E (1:1000 @ A3)

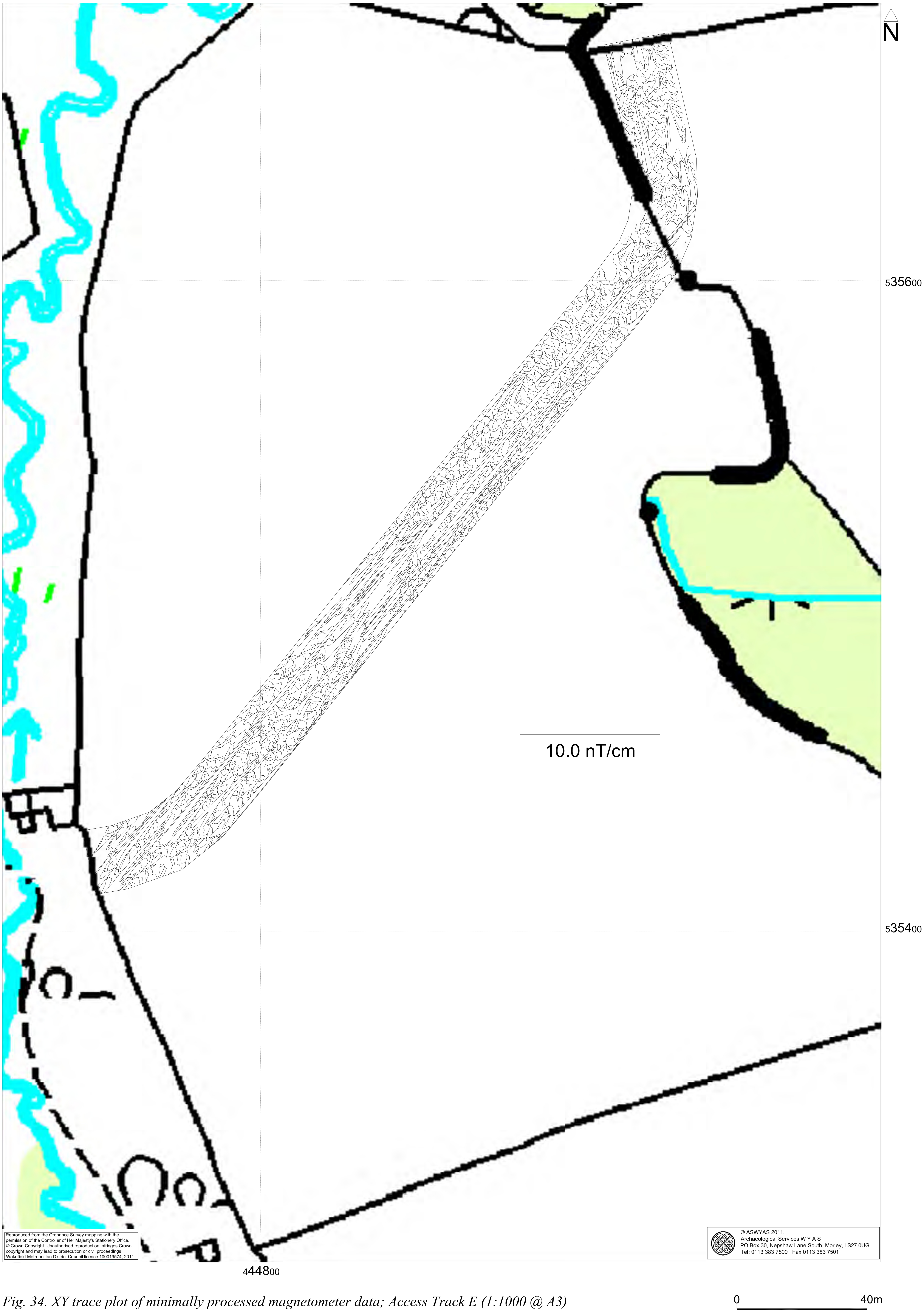

Fig. 34. XY trace plot of minimally processed magnetometer data; Access Track E (1:1000 @ A3)

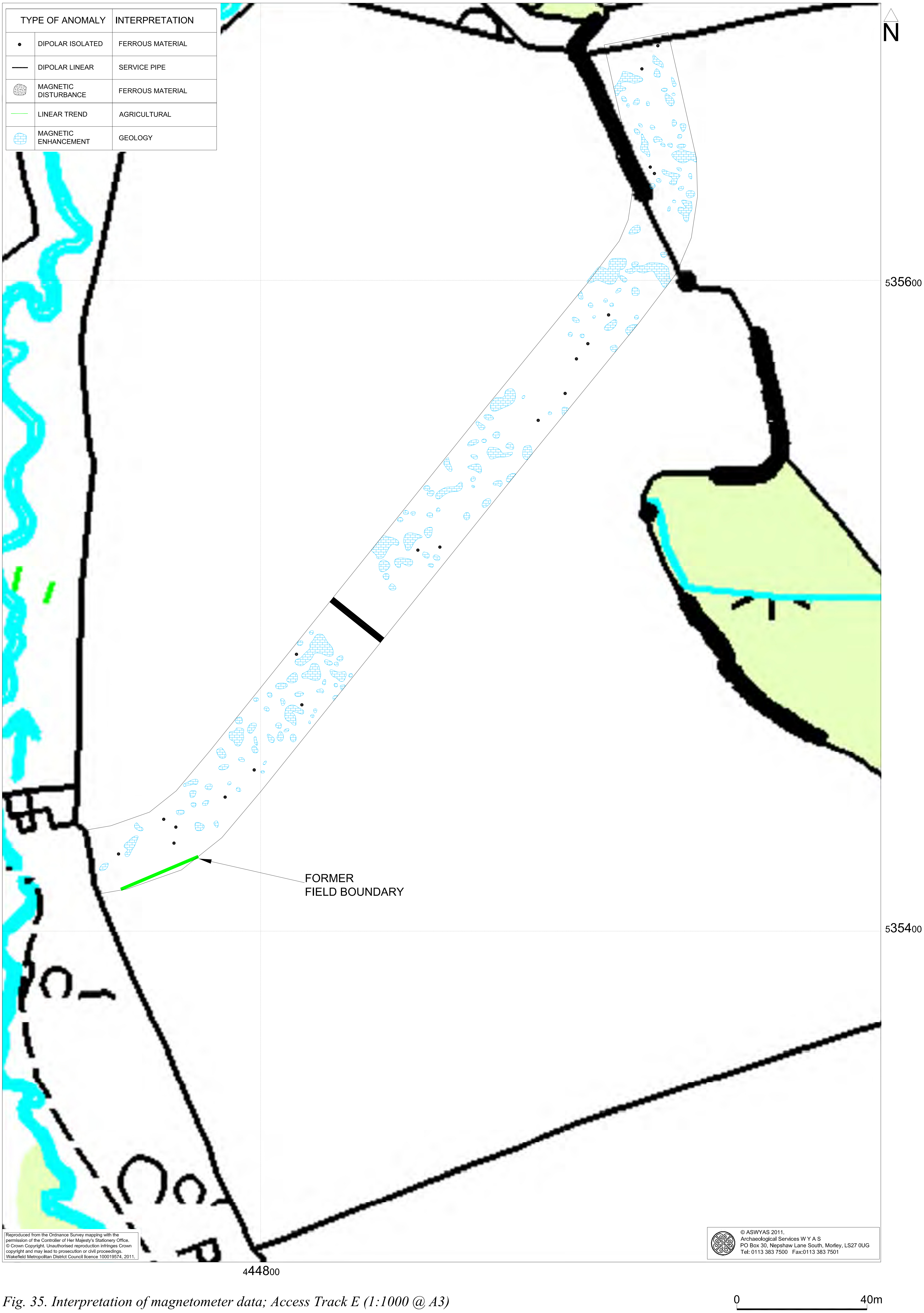

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Fig. 35. Interpretation of magnetometer data; Access Track E (1:1000 @ A3)

Plate 1. General view of Turbine 1; Sector 1 and Sector 2, looking north-east

Plate 2. General view of Turbine 2; looking east

Plate 3. General view of construction compound, looking west

Plate 4. General view of Turbine 3; looking north

Plate 5. General view of Turbine 5, looking south

Plate 6. General view of Turbine 4, 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

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 relevant Historic Environment Record).

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