ARCHAEOLOGICAL SERVICES WYAS

Knottingley Power Project Gas Pipeline
Knottingley to Gateforth
West Yorkshire/ North Yorkshire

Geophysical Survey

Report no. 2426

January 2013

Client: Parsons Brinckerhoff

REGISTERED ORGANISATION IfA

Knottingley Power Project Gas Pipeline
Knottingley to Gateforth
West Yorkshire/North Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey was carried out at several locations along the route of a gas pipeline that will connect a proposed new gas power station on the outskirts of Knottingley with an existing pipeline to the north-east. The survey has successfully identified anomalies that correlate with cropmarks interpreted as indicative of archaeological activity. In addition other anomalies also interpreted as potentially archaeological have also been identified thereby clearly demonstrating that magnetometer survey has the potential to identify both previously known and unknown features of likely archaeological origin on the prevailing geology and soils. Consequently, it is likely that further geophysical survey will be required along the remainder of the corridor subject to access agreements and suitable ground conditions.

ARCHAEOLOGICAL
SERVICES
WYAS

Report Information

Client:	Parsons Brinckerhoff
Address:	Amber Court, William Armstrong Drive, Newcastle-upon-Tyne, NE4 7YQ
Report Type:	Geophysical Survey
Location:	Knottingley to Gateforth
County:	West Yorkshire/North Yorkshire
Grid Reference:	SE 518 247 – SE 560 280
Period(s) of activity represented:	prehistoric?/Romano-British
Report Number:	2426
Project Number:	3979
Site Code:	KGP12
Planning Application No.:	Pre-planning
Museum Accession No.:	Not assigned
OASIS ID:	archaeol11-141357
Date of fieldwork:	October 2012
Date of report:	January 2013
Project Management:	Alistair Webb BA MIfA
Geophysical survey team:	Sam Harrison BSc MSc AIfA
	David Harrison BA MSc MIfA
	James Lawton BSc MSc PIfA
	Chris Sykes BA MSc
Report:	Alistair Webb
Illustrations:	Sam Harrison
Photographs:	David Harrison and Chris Sykes

Authorisation for distribution: ---

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

Contents

List of Figures

List of Plates

1 Introduction

Archaeological Services WYAS was commissioned by Simon McCudden of Parsons Brinckerhoff, on behalf of their client Knottingley Power Ltd, to carry out a geophysical (magnetometer) survey at eight locations along the proposed route of a gas pipeline that will connect a new gas power station on the outskirts of Knottingley to an existing gas pipeline south-west of Thorpe Willoughby, near Gateforth (see Fig. 1). The position of the eight blocks were determined in order to assess whether the geophysical technique (magnetometry) had the potential to locate sub-surface archaeological features (previously identified as cropmarks) under the prevailing geological conditions. The number and location of the blocks were also partly determined by the prevailing ground conditions and access at the time of the survey. The results of the survey will form part of the Cultural Heritage chapter of an Environmental Statement in support of a forthcoming planning application.

Site location, topography and land-use

The pipe corridor extends on a south-west/north-east bearing from the proposed power station site to the east of Knottingley (SE 515 233), crossing the Aire and the Calder Navigation Canal and continuing for approximately 3.6km before turning to the north, crossing the River Aire and continuing for a further 3.6km to its terminus to the south-west of Thorpe Willoughby. With the exception of the first few metres (which are in West Yorkshire) the corridor is in North Yorkshire. The route covers primarily flat, low lying, agricultural land. The survey covered eight separate blocks which were either under stubble, abandoned crop or had been re-seeded following harvest.

Soils and geology

The underlying bedrock comprises Sherwood Sandstone and Roxby Formation Calcareous Mudstone overlain by glaciolacustrine deposits, alluvium and glaciofluval deposits (British Geological Survey 2012). The soils are classified in the Enbourne and Sessey associations, being described as deep, stoneless, fine loams and clays and fine and coarse loams, often stoneless, permeable soils affected by groundwater respectively (Soil Survey of England and Wales 1983).

2 Archaeological and Historical Background

No information on the archaeological potential of the corridor has been provided at the time of survey. However, there are cropmarks both within and immediately adjacent to the corridor that are likely to be indicative of archaeological activity.

3 Aims, Methodology and Presentation

The overall aim of the geophysical survey was to establish whether magnetometry was likely to be able to locate archaeological features on the prevailing soils and geology and therefore to clarify the nature of the archaeological resource at the pre-selected locations along the pipe corridor. This information would then be used to determine the extent of any further geophysical survey, if required, and to provide targets for a preliminary phase of trial trenching. The results of the evaluation (geophysical survey and trial trenching) will be included within the Cultural Heritage chapter of an Environmental Statement in support of a forthcoming planning application for the project, and will be used to determine what, if any, further archaeological work may be required should the application be granted.

Specifically the aim of the geophysical survey was to provide information about the nature and possible interpretation of any anomalies identified during the survey and thereby determine the presence or absence and likely extent of any buried archaeological remains. The objective of the survey was to survey a 60m wide strip, to cover the pipe easement, at eight pre-determined locations along the corridor. The surveys covered a combined area of approximately 6.5 hectares.

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), and are in compliance with the Specification (WYAAS 2012). 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 relative positions of the survey blocks along the pipe corridor at a scale of 1:20000. The data are presented in greyscale, X-Y trace plot and interpretation formats at a scale of 1:1000 in Figures 3 to 20 inclusive.

4 Results and Discussion

Magnetometer Survey (Figs 3 to 20 inclusive)

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

Ferrous anomalies

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

Linear bands of magnetic disturbance have been noted along the northern edges of Block 1 and Block 2 (see Fig. 5). This disturbance is likely to be due to ground disturbance or material used in the creation of the flood defence (Kemp Bank) which borders the survey areas immediately to the north.

A cluster of large 'spikes' is also identified in Block 3 (see Fig. 8). There are no above ground features to account for this disturbance. Also in Block 3 is a linear anomaly caused by surveying over an electric fence.

The massive area of disturbance at the northern end of Block 8 (see Fig. 20) is caused by the buried gas pipe into which the proposed new pipeline will connect.

Geological anomalies

Discrete anomalies, characterised as localised areas of magnetic enhancement, have been identified in several of the survey blocks. The lack of any apparent pattern suggests these anomalies have a geological origin, being due to localised variations in the underlying superficial deposits and/or soils.

Agricultural anomalies

Linear trend anomalies have also been identified in all of the survey blocks. These are all interpreted as having an agricultural origin being caused by either former field boundaries, drains or ploughing.

Linear anomalies locating former field boundaries have been identified in four of the eight survey blocks. In Block 2 (see Fig. 5) the faint linear anomaly, **A**, is aligned north/south at the western end of the survey block. Here the response is indicative of an infilled ditch. However, in Block 5 (see Fig. 9) the much stronger response, **B**, suggests (probably) a clay pipe laid in the bottom of the former boundary. The former boundary, **C**, located in Block 6 (see Fig. 14) is also indicative of a soil filled ditch whereas the much stronger anomaly, **D**, in Block 7 (see Fig. 17) is again likely to be filled with a strongly magnetic fill material. All these anomalies correspond with boundaries shown on the first edition Ordnance Survey map. The first edition mapping also confirms that linear anomaly **E** is caused by a drain.

Possible archaeological anomalies

Block 1 and Block 2 (see Figs 3, 4 and 5)

In the south-western quarter of this block a small sub-square anomaly, **F**, approximately 15m^2, and aligned on the ordinal points, has been identified. The varied magnetic background in this block, due to the uneven nature of the ploughed field, makes a confident interpretation difficult but this anomaly is possibly a small enclosure. Two very short linear anomalies, **G** and **H**, have also tentatively been identified in the western half of the survey area. Anomaly **G** is aligned east/west and **H** north/south. Although none of these anomalies has previously been identified as cropmarks a linear cropmark (ditch) feature, also aligned north/south, is located 30m to the west of this survey block (see Fig. 5).

In Block 2 50m to the east another linear anomaly, **I**, aligned north-west/south-east, has been interpreted as possibly archaeological. It does appear, however, to terminate at the former boundary, **A**. A non-archaeological (possibly agricultural) origin is also considered equally likely.

Block 3 (see Figs 6, 7 and 8)

Two short, parallel, ditch type anomalies, **J** and **K**, are located at the western edge of this block (see Fig. 8) aligned east/west. These anomalies do not correlate with any boundaries shown on the historic mapping and are therefore interpreted as potentially archaeological.

In the eastern half of this survey block another linear anomaly, **L**, does correspond with a cropmark and has been interpreted as of likely archaeological origin.

Block 4 and Block 5 (see Figs 9, 10 and 11)

In Block 4 two parallel linear anomalies, **M** and **N**, aligned north-west/south-east, and anomaly **O**, which intersects with **N** at right angles, clearly correspond with cropmarks. These anomalies are interpreted as archaeological ditches forming part of a former system of land division.

Another linear anomaly, **P**, in Block 5, is also aligned north-west/south-east. Whilst this anomaly does not correlate with a cropmark it is considered possible that this anomaly is another ditch forming part of the former system of land division identified in Block 4.

Block 6 (see Figs 12, 13 and 14)

Two parallel linear anomalies, R and S, are identified near the northern edge of the survey block (see Fig. 14), aligned south-west/north-east. These anomalies are interpreted as possibly archaeological in origin, perhaps indicating a trackway.

Block 7

No anomalies of archaeological potential have been identified in this block.

Block 8

No anomalies of archaeological potential have been identified in this block.

5 Conclusions

Anomalies caused by former field boundaries and drains and recent agricultural practice have been identified by the survey. In addition several linear anomalies that cannot be obviously categorised as non-archaeological have also been identified in six of the eight sample areas selected for survey. In some instances the anomalies correlate with cropmarks or are located close to or on the same alignment as cropmarks whilst others do not. These anomalies are considered to be of probable or possible archaeological potential and are probably indicative of infilled ditches forming part of a system of land division and enclosure.

Overall the sample survey has clearly demonstrated that magnetometry has the potential to locate sub-surface features, both previously known and unknown, on the prevailing soils and geology at the specific locations evaluated to date.

Disclaimer

The results and subsequent interpretation of data from geophysical surveys should not be treated as an absolute representation of the underlying archaeological and non-archaeological remains. Confirmation of the presence or absence of archaeological remains can only be achieved by direct investigation of sub-surface deposits.

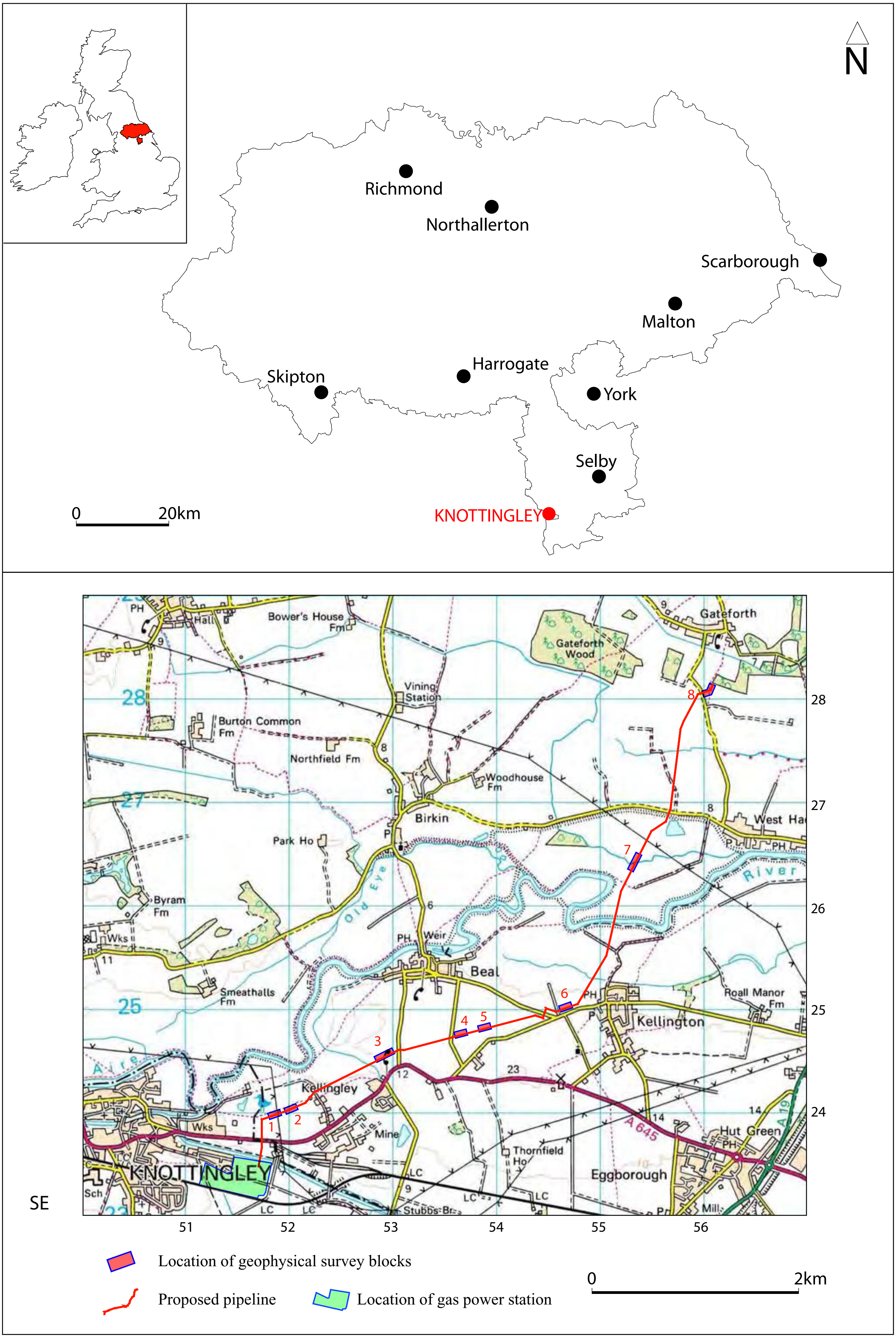


Fig. 1. Site location

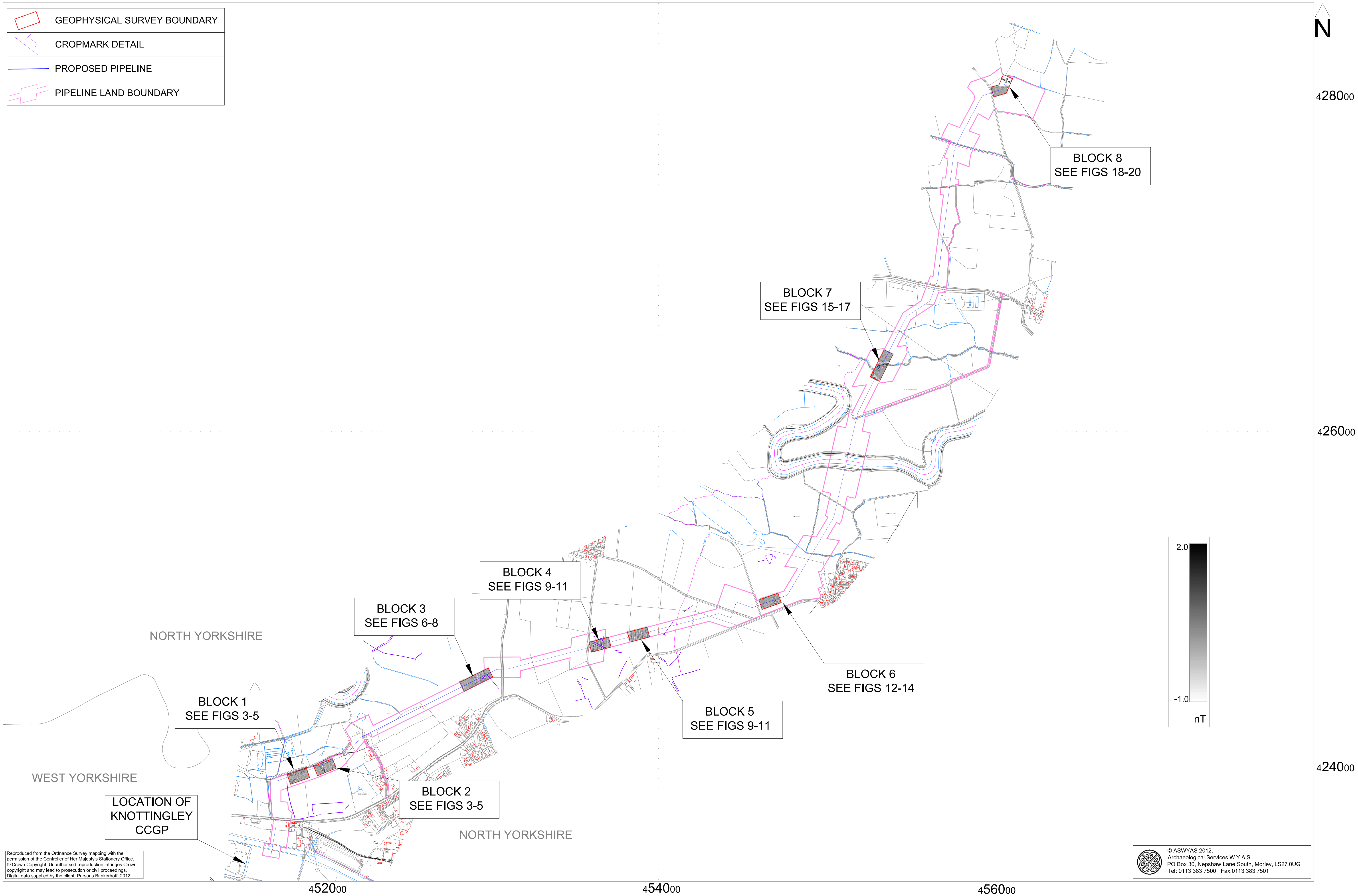


Fig. 2. Site location showing location of geophysical survey (1:20000 @ A3)

0 500m

Fig. 3. Processed greyscale magnetometer data; Block 1 and Block 2 (1:1000 @ A3)

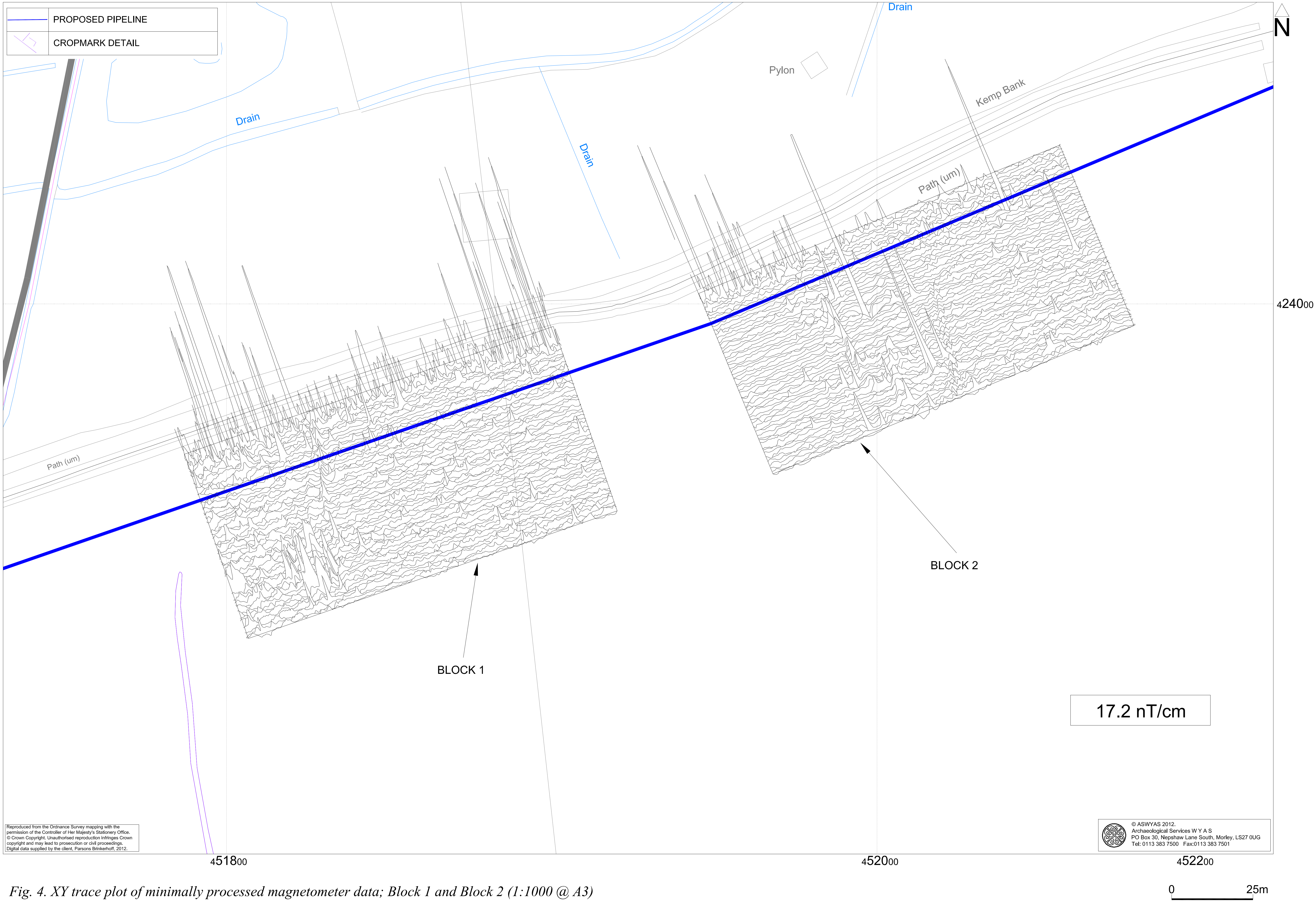


Fig. 4. XY trace plot of minimally processed magnetometer data; Block 1 and Block 2 (1:1000 @ A3)

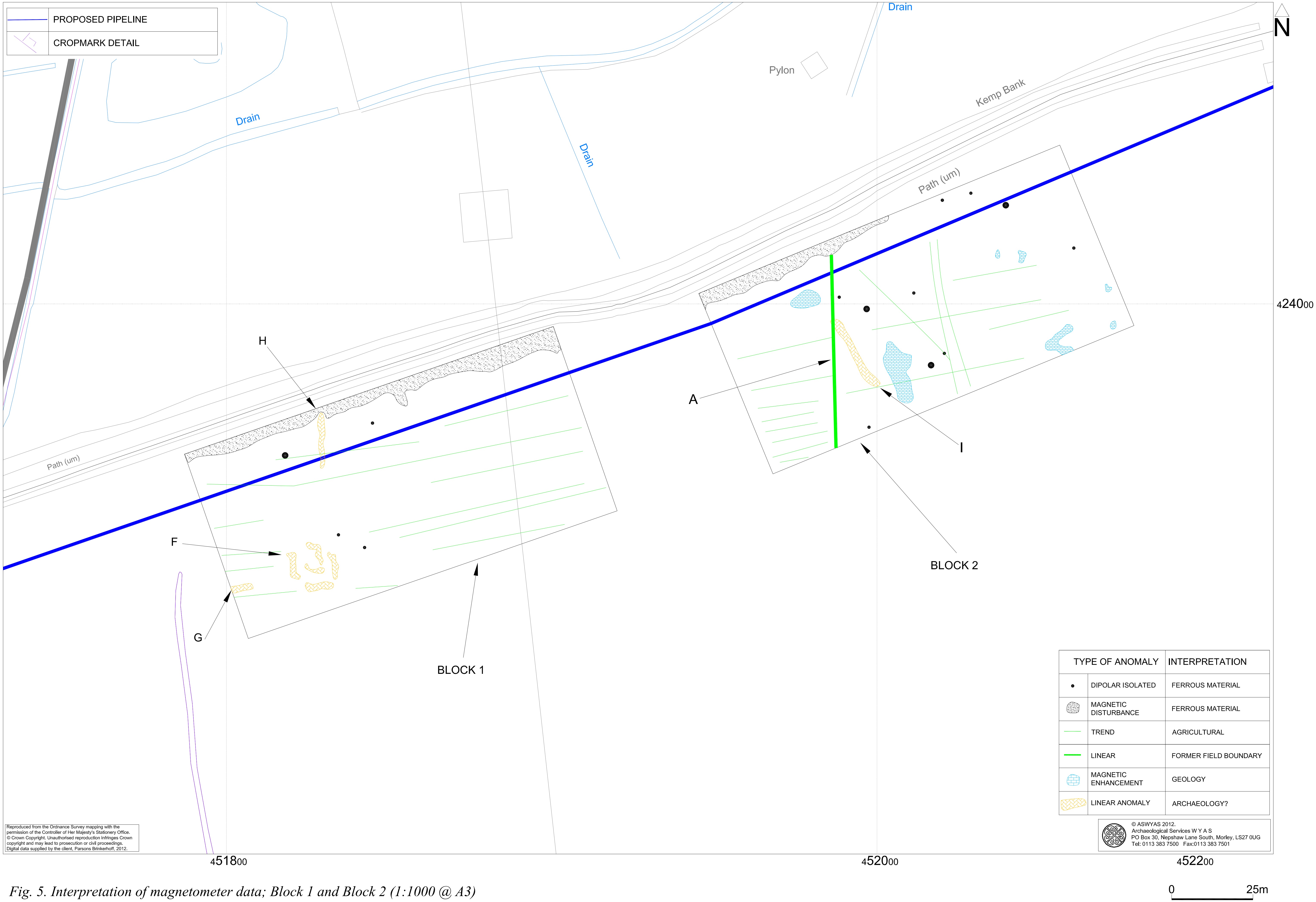


Fig. 5. Interpretation of magnetometer data; Block 1 and Block 2 (1:1000 @ A3)

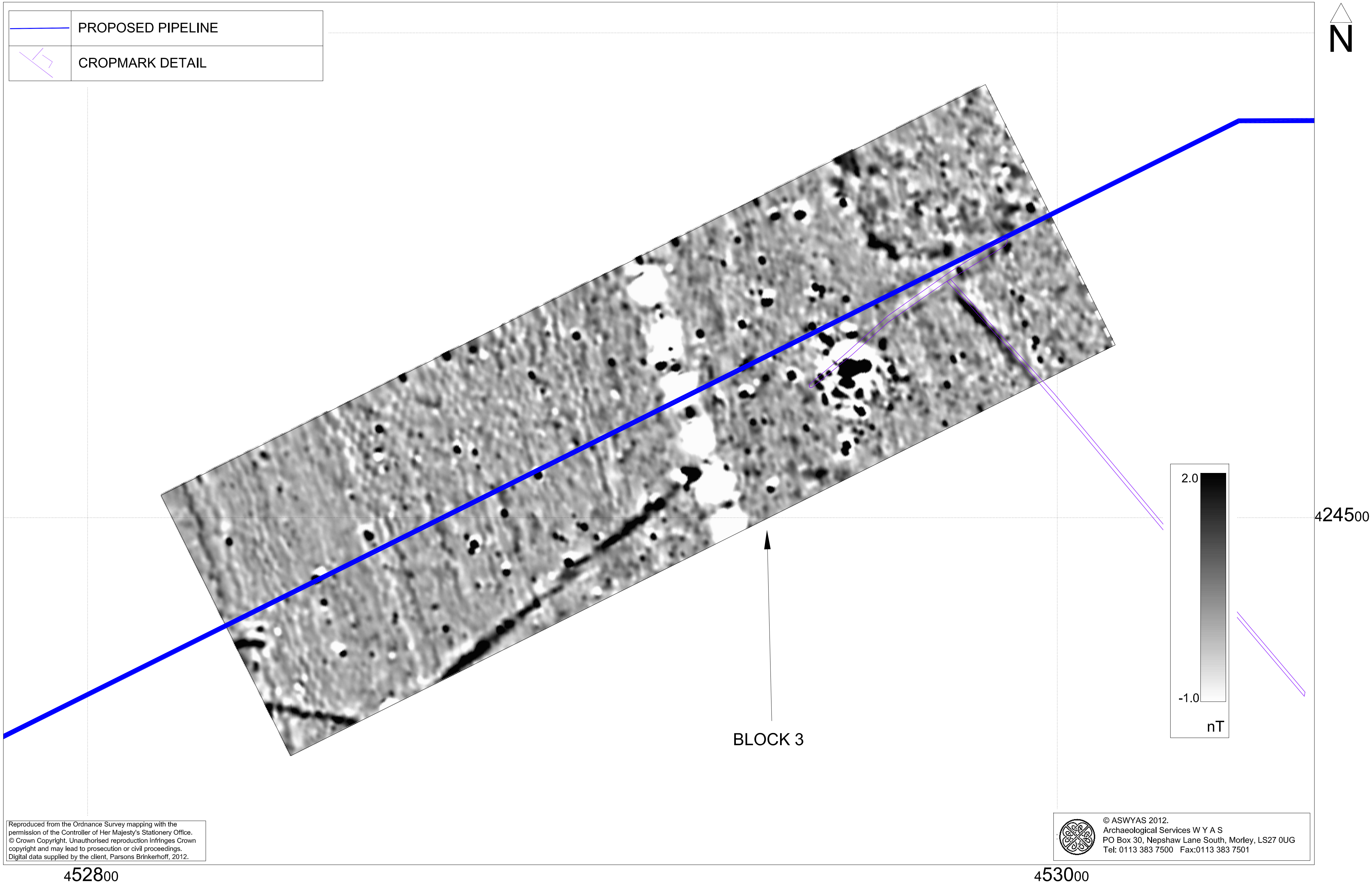


Fig. 6. Processed greyscale magnetometer data; Block 3 (1:1000 @ A4)

0 25m

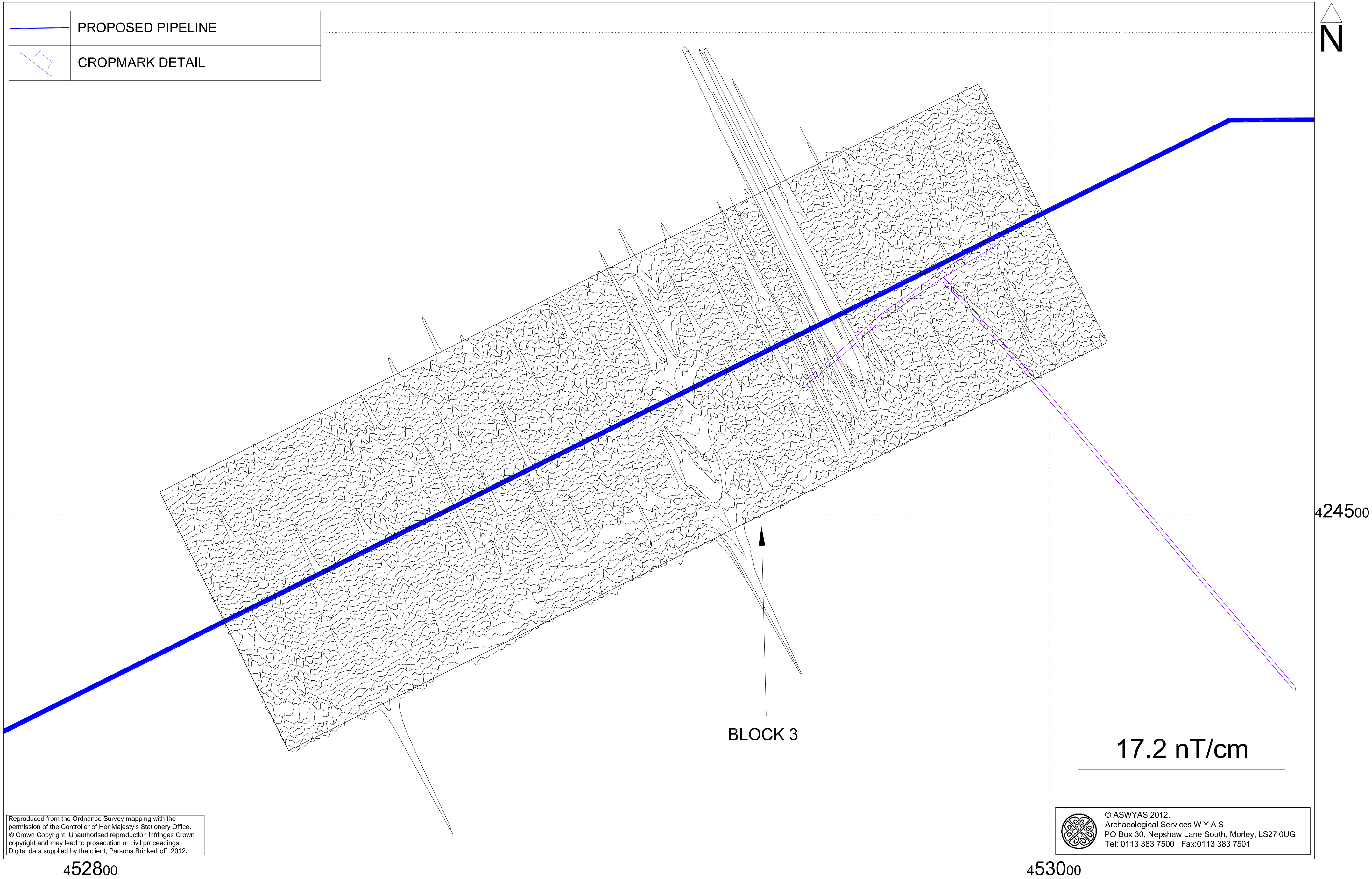


Fig. 7. XY trace plot of minimally processed magnetometer data; Block 3 (1:1000 @ A4)

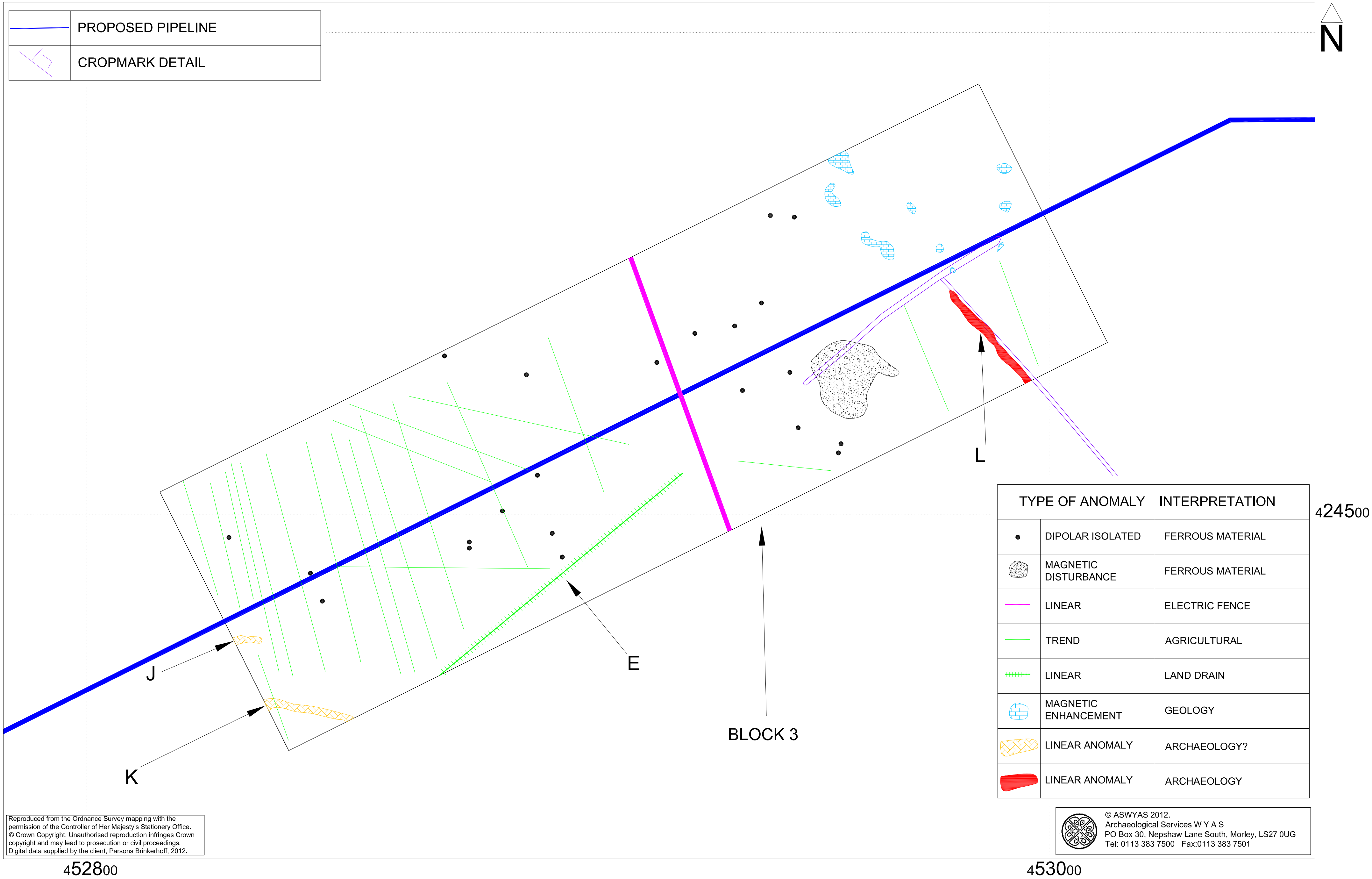


Fig. 8. Interpretation of magnetometer data; Block 3 (1:1000 @ A4)

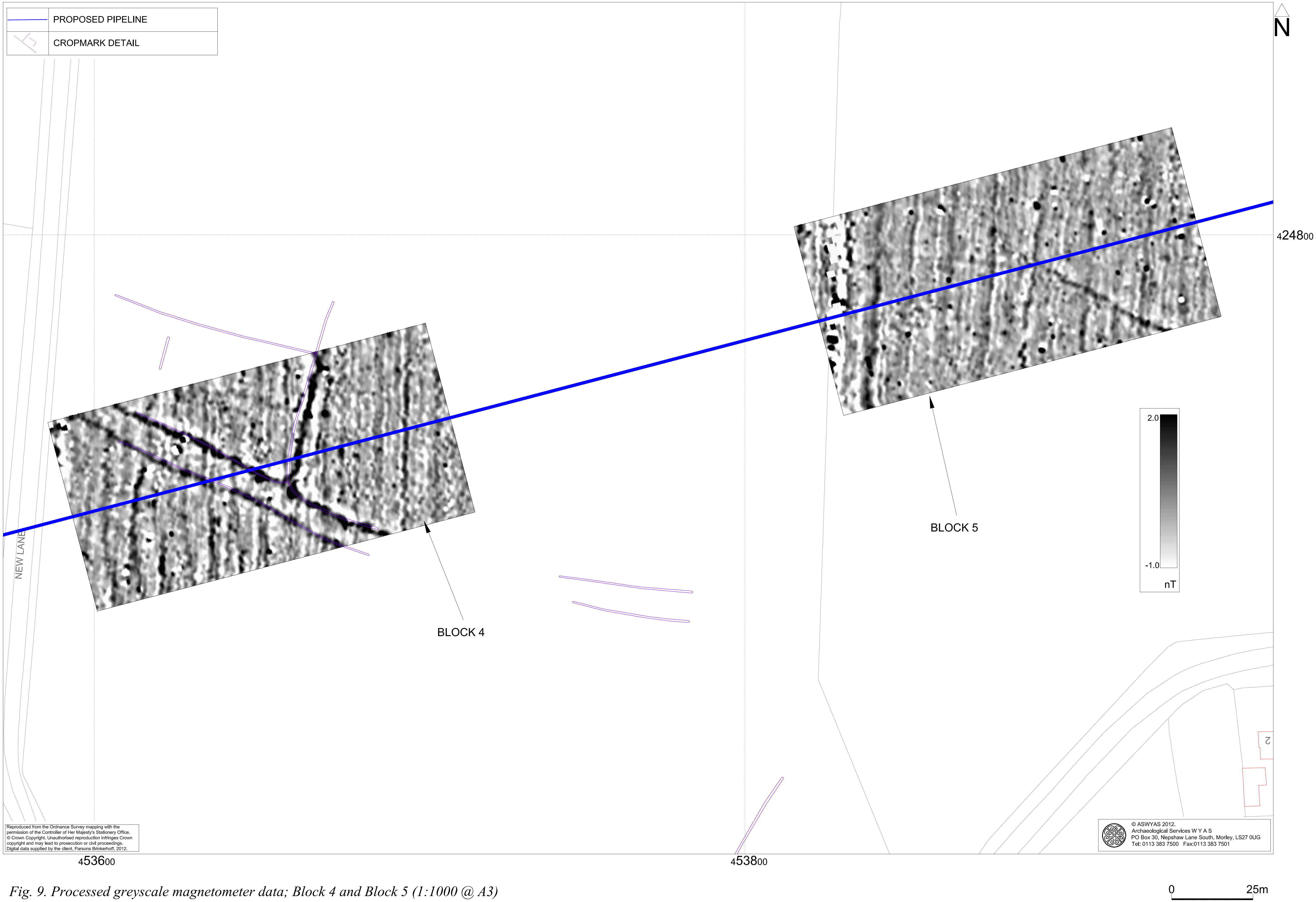
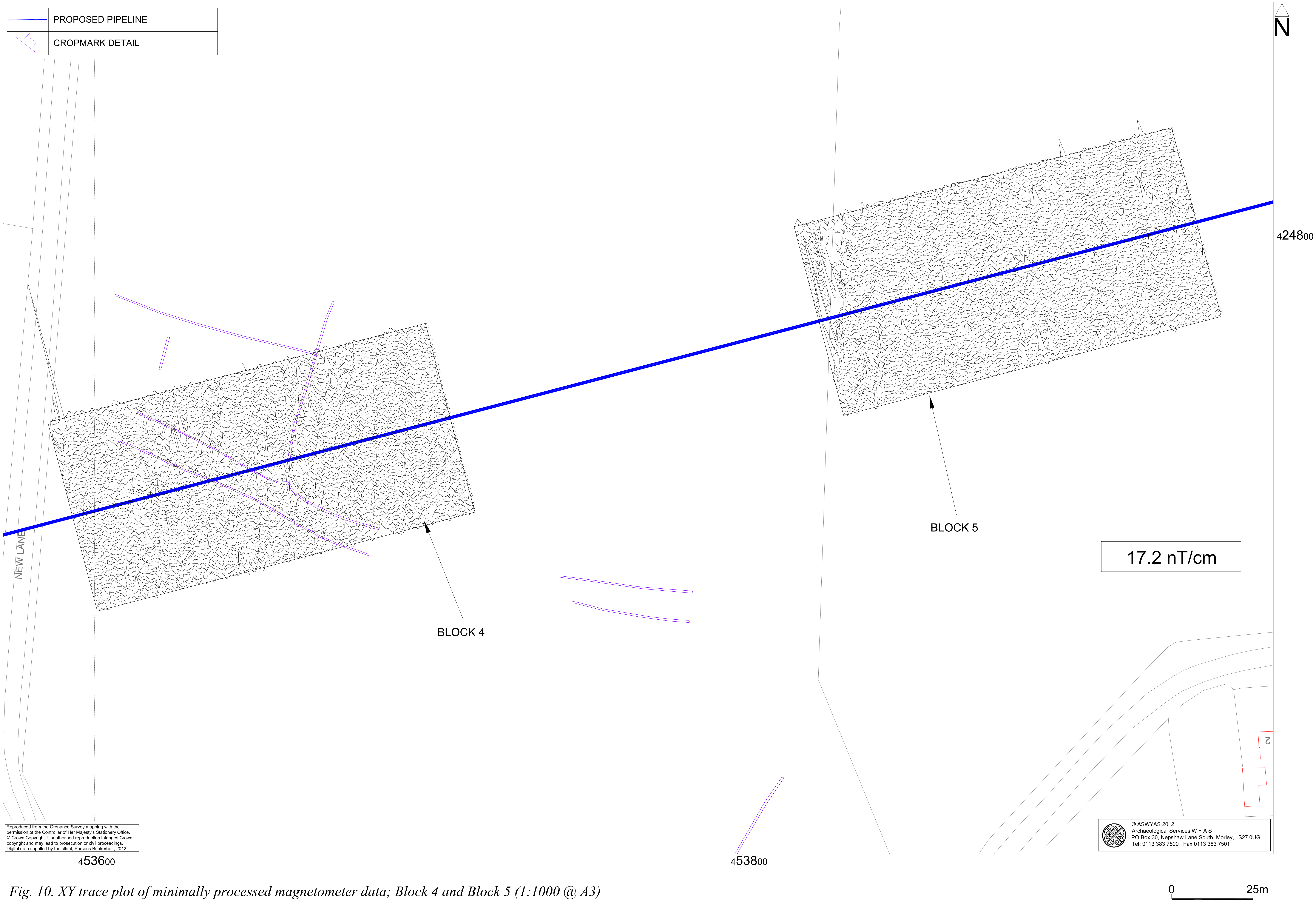


Fig. 9. Processed greyscale magnetometer data; Block 4 and Block 5 (1:1000 @ A3)



Archaeological Services W Y A S
PO Box 30, Nepshaw Lane South, Morley, LS27 0UG
Tel: 0113 383 7500 Fax:0113 383 7501

Fig. 10. XY trace plot of minimally processed magnetometer data; Block 4 and Block 5 (1:1000 @ A3)

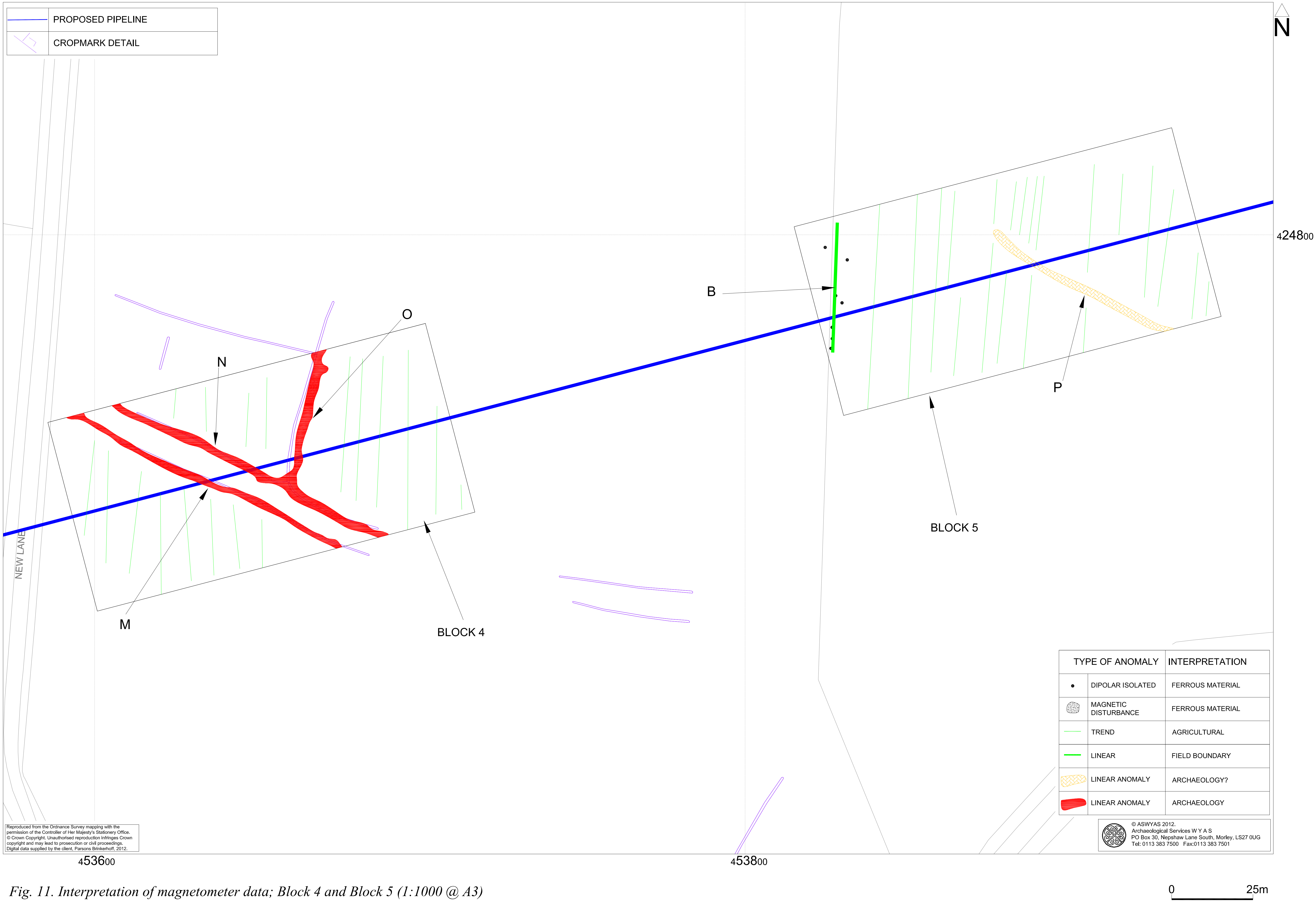


Fig. 11. Interpretation of magnetometer data; Block 4 and Block 5 (1:1000 @ A3)

Fig. 12. Processed greyscale magnetometer data; Block 6 (1:1000 @ A4)

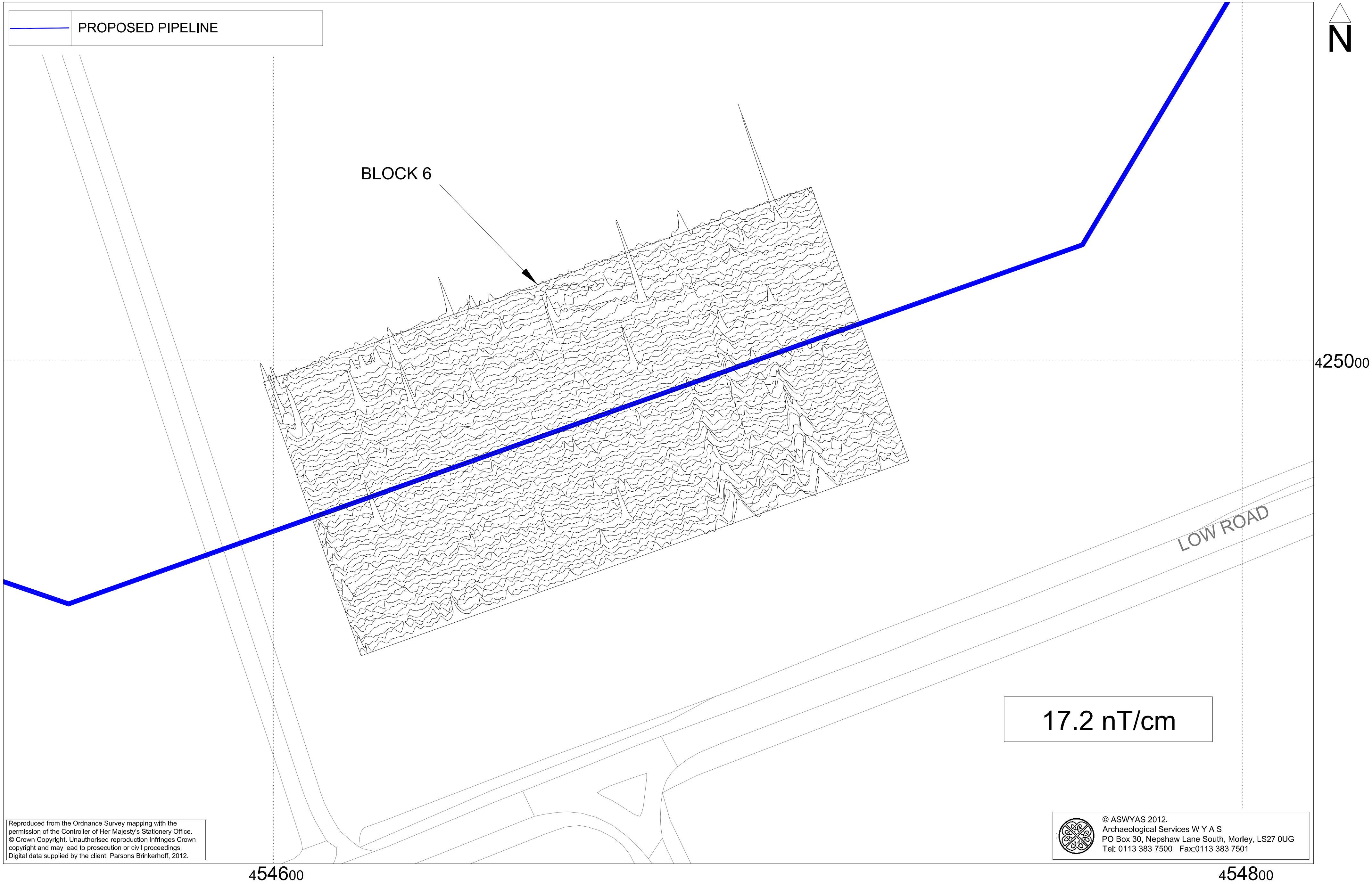


Fig. 13. XY trace plot of minimally processed magnetometer data; Block 6 (1:1000 @ A4)

0 25m

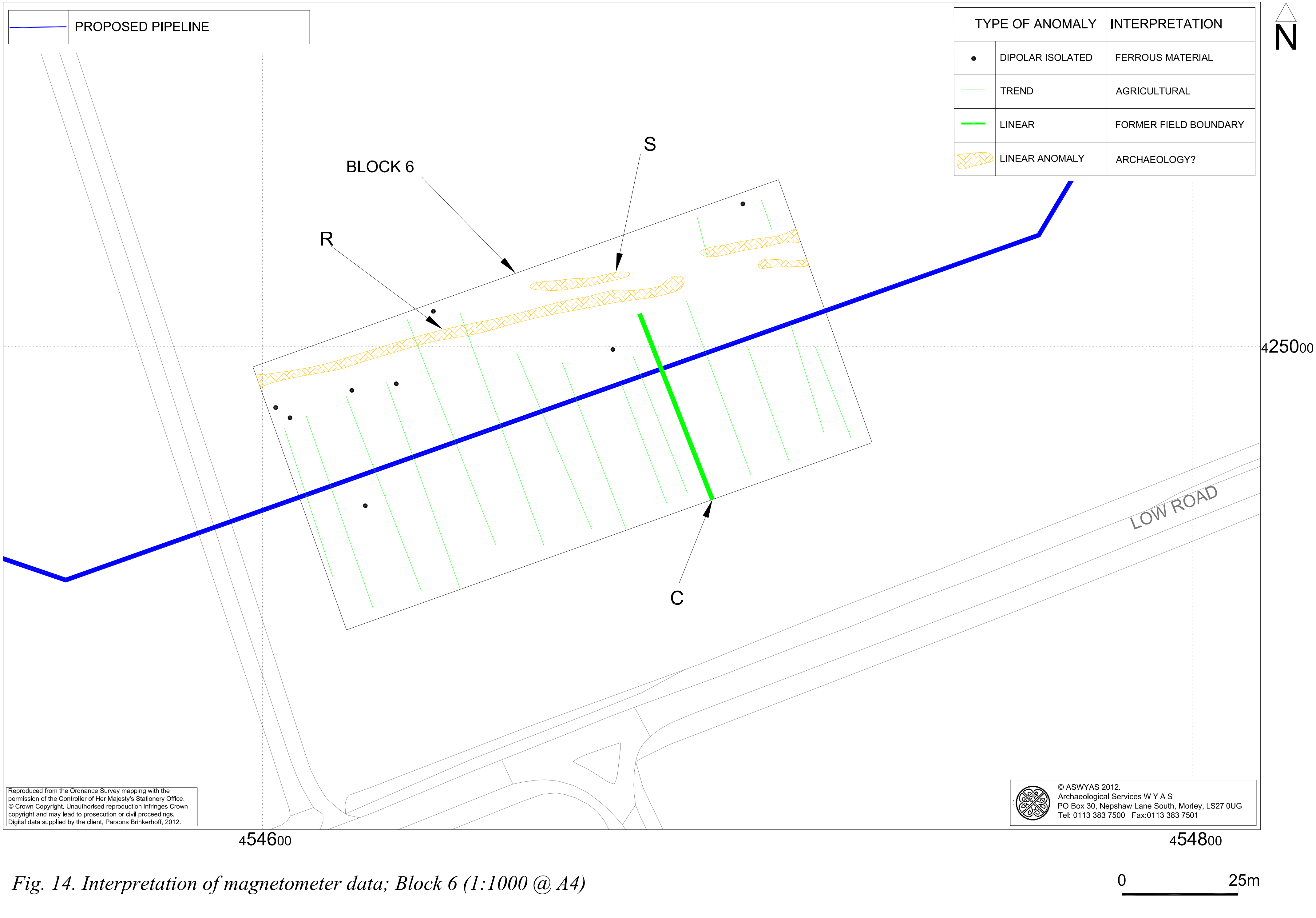


Fig. 14. Interpretation of magnetometer data; Block 6 (1:1000 @ A4)

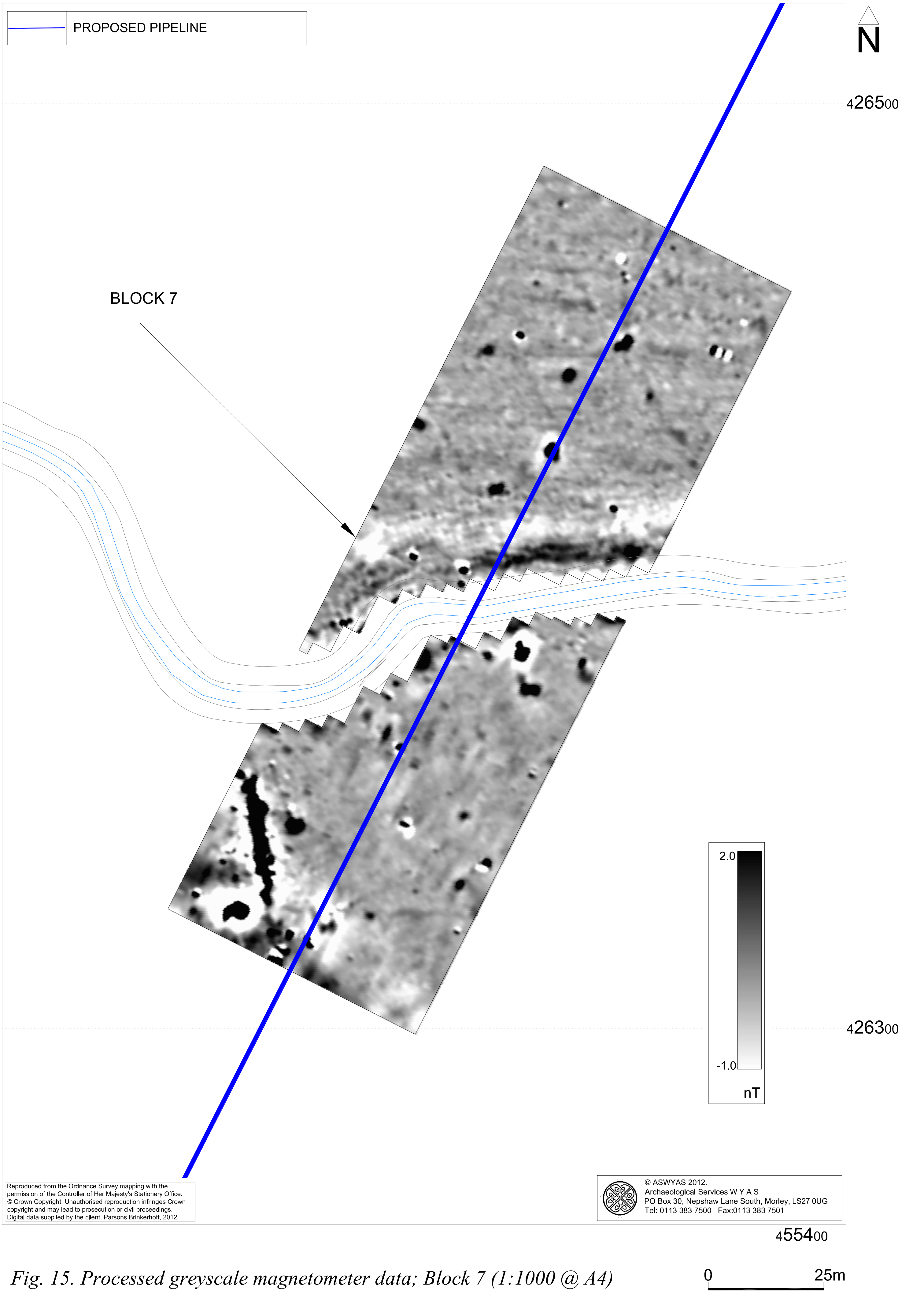


Fig. 15. Processed greyscale magnetometer data; Block 7 (1:1000 @ A4)

Archaeological Services W Y A S
PO Box 30, Nepshaw Lane South, Morley, LS27 0UG
Tel: 0113 383 7500 Fax:0113 383 7501

Fig. 16. XY trace plot of minimally processed magnetometer data; Block 7 (1:1000 @ A4)

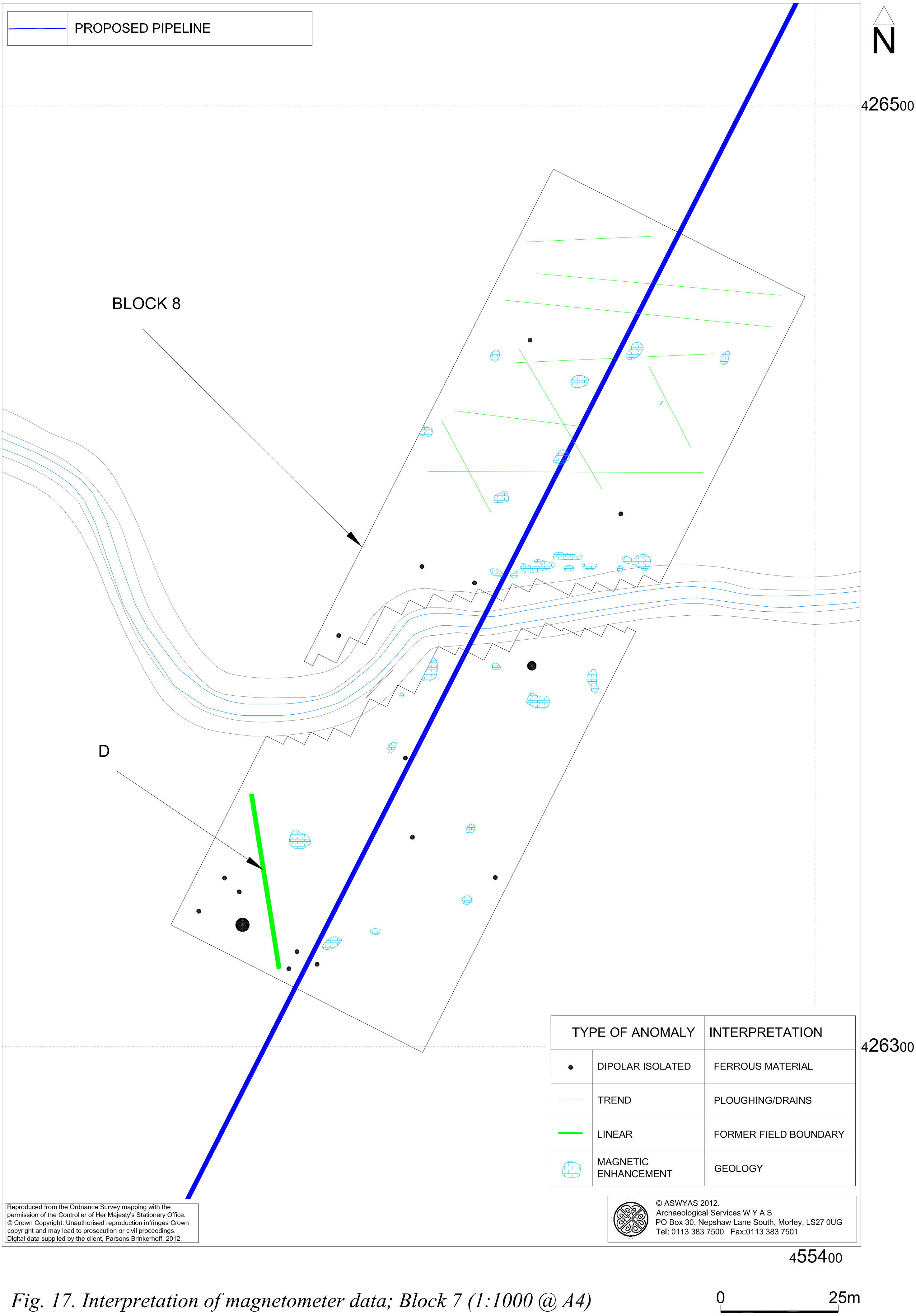


Fig. 17. Interpretation of magnetometer data; Block 7 (1:1000 @ A4)

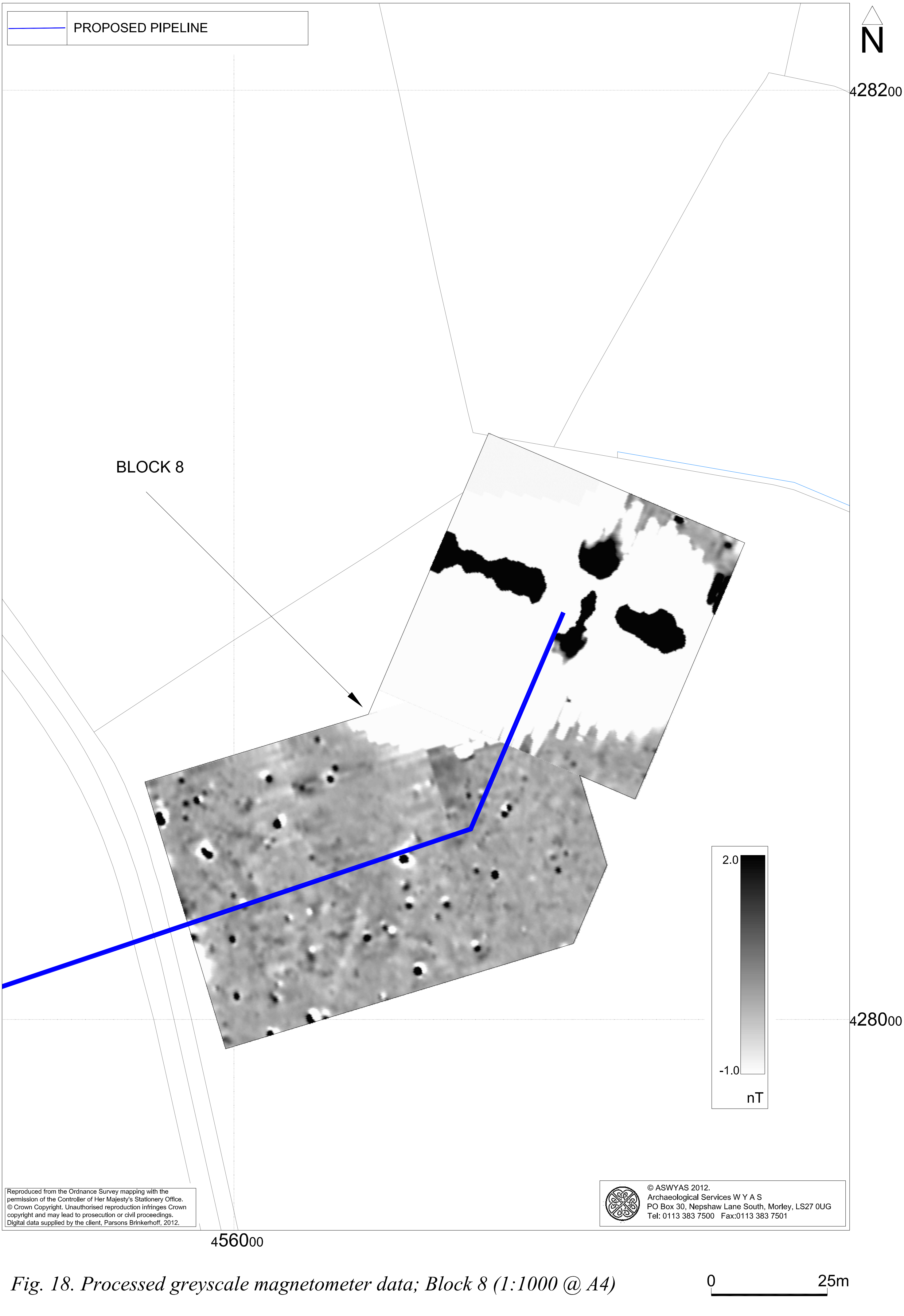
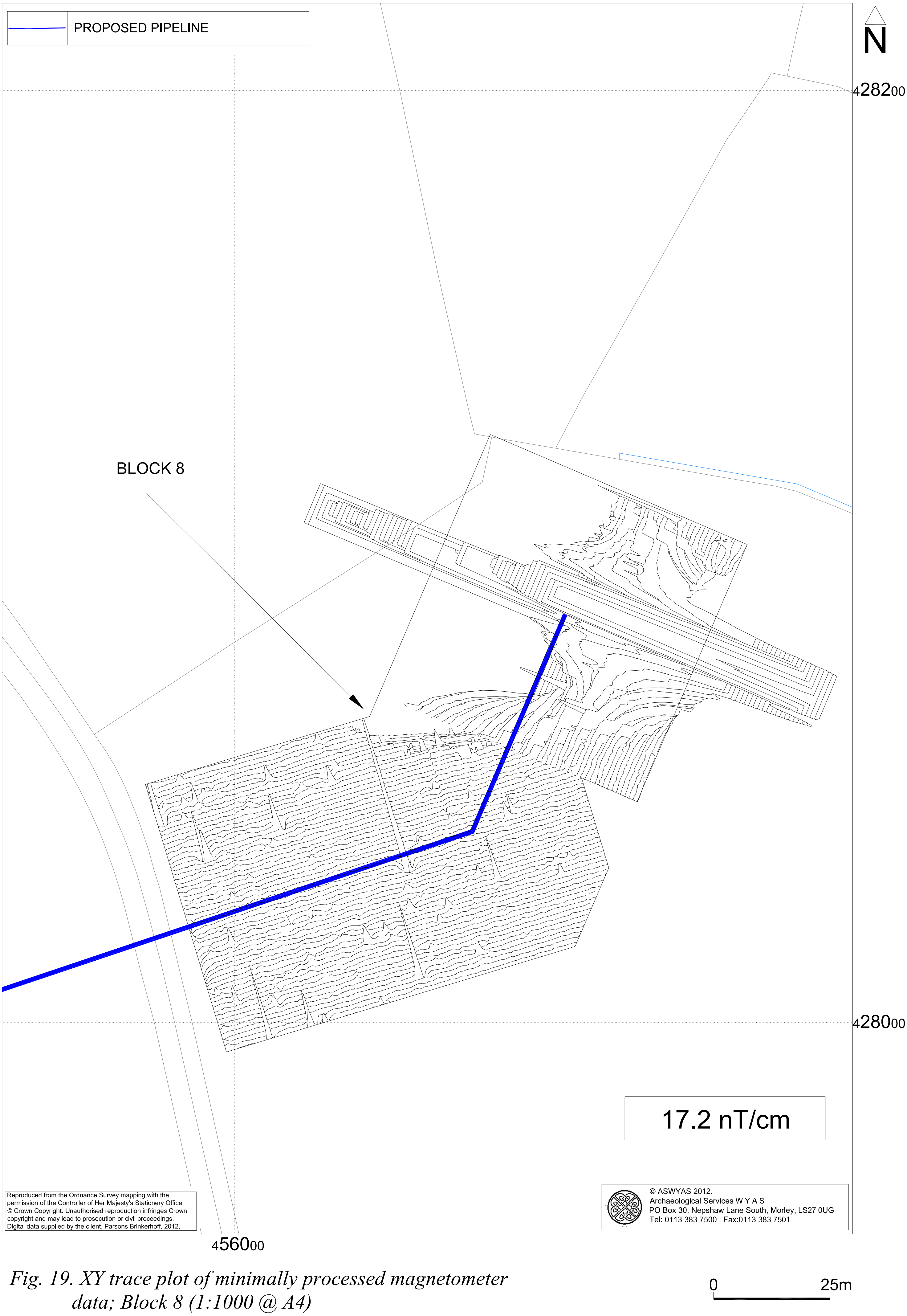


Fig. 18. Processed greyscale magnetometer data; Block 8 (1:1000 @ A4)



Archaeological Services W Y A S
PO Box 30, Nepshaw Lane South, Morley, LS27 0UG
Tel: 0113 383 7500 Fax:0113 383 7501

Fig. 19. XY trace plot of minimally processed magnetometer data; Block 8 (1:1000 @ A4)

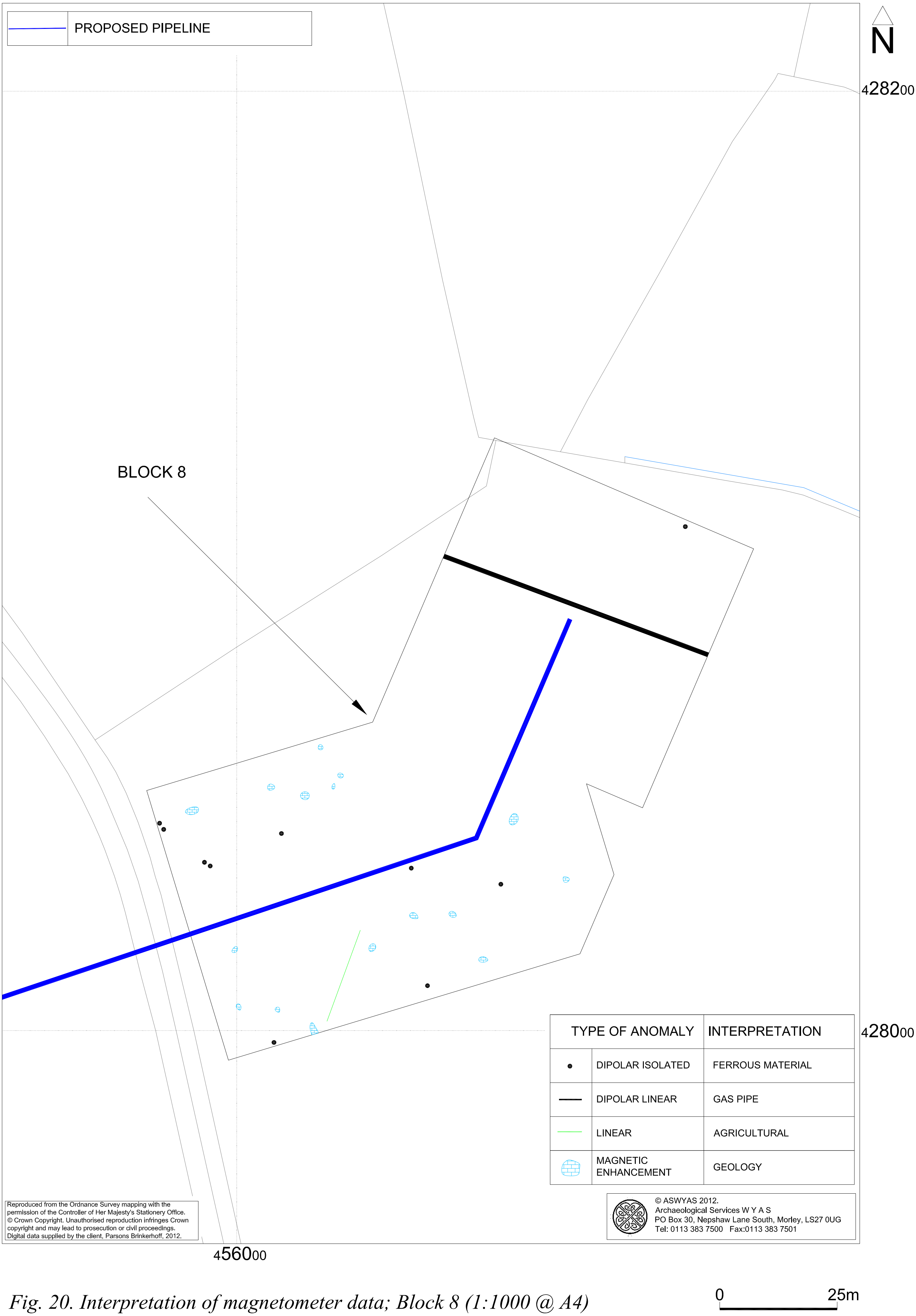


Fig. 20. Interpretation of magnetometer data; Block 8 (1:1000 @ A4)

Plate 1. General view of Block 1 and Block 2, looking north-east

Plate 2. General view of Block 3, looking south-east

Plate 3. General view of Block 4, looking north-east

Plate 4. General view of Block 5, looking north-west

Plate 5. General view of Block 7a, looking south-west

Plate 6. General view of Block 7b, looking south-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 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 appropriate Historic Environment Record).

Bibliography

British Geological Survey online http://www.bgs.ac.uk/opengeoscience/ (accessed 14/09/2012)

David, A., N. Linford, P. Linford and L. Martin, 2008. *Geophysical Survey in Archaeological Field Evaluation: Research and Professional Services Guidelines (2nd edition)* English Heritage

Institute for Archaeologists, 2010. *Standard and Guidance for archaeological geophysical survey*.

Soil Survey of England and Wales, 1983, Soils of Northern England Sheet 1