WYAS Archaeological Services

Moorside Project

Sellafield

Cumbria

Geophysical Survey

Report no. 2807
May 2015

Client: NuGeneration Ltd.

Moorside Project
Sellafield
Cumbria

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering approximately 142 hectares, was carried out in fields to the south of Beckermet and north of Sellafield Nuclear Reprocessing site. This is in advance of the proposed development of the site. Anomalies indicative of recent and former agricultural practice were identified. The geology of the area has been recorded, especially where the topography of the land dramatically changes, and the topsoil thinner. This is clear to the west of the survey limits. To the south of the survey area, archaeological activity has been recorded. To the north, and the outlying parcels of land, no archaeological evidence has been detected. Therefore the archaeological potential of the site is medium around the area of Watch Hill, and low across the rest of the site.

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Services

Report Information

Client:	NuGeneration Ltd.
Address:	Unit 16, Ingwell Hall, Westlakes Science and Technology Park, Moor Row, Cumbria, CA24 3JZ
Report Type:	Geophysical Survey
Location:	Sellafield
County:	Cumbria
Grid Reference:	NY 020 042
Period(s) of activity:	multi-period
Report Number:	2807
Project Number:	4388
Site Code:	MOS15
OASIS ID:	archaeol11 - 226368
Planning Application No.:	-
Museum Accession No.:	n/a
Date of fieldwork:	March to May 2015
Date of report:	May 2015
Project Management:	David Harrison BA MSc
Fieldwork:	Alexander Schmidt BA
	David Harrison
	Christopher Sykes BA MSc
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Report:	Christopher Sykes
Illustrations:	Alexander Schmidt, Christopher Sykes, Ross Bishop
Photography:	Site staff
Research:	n/a

Authorisation for distribution: ----------

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1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by NuGeneration Ltd (the Client), to undertake a geophysical (magnetometer) survey on parcels of land designated for the Moorside Project. The work was undertaken in order to inform a planning application for the proposed development of the site and in accordance with the National Planning Policy Framework (DCLG 2012), in line with current best practice (CIfA 2014; David *et al.* 2008) and to a Project Design (Atkinson and Harrison 2015) approved by the Client. The survey was carried out on dates between March 27th and May 1st 2015.

Site location, topography and land-use

The area of investigation (AOI) consists of a number of fields used for a variety of agricultural purposes. Broadly, the AOI covers fields to the south of Beckermet village, and is bounded to the east by the main access road to the Sellafield Nuclear Reprocessing Plant, and to the west by a dismantled railway line, now used as a public footpath. The total size of the site is approximately 196 hectares and currently a mix of grazing pasture, arable, overgrown scrub land, plantation and areas prone to flooding. It is centred at NY 020 042.

The topography of the site generally slopes from the north-east at between 50-60m above Ordnance Datum (aOD) to 0m aOD in the south and western parts of the site. To the east of the disused railway land use in the AOI consists of improving pasture with some arable land. To the west of the AOI the land is low lying.

Soils and geology

The underlying bedrock comprises sandstone of the Calder and Bees Sandstone Formations in the north, and Sellafield Member sandstones to the south. The bedrock is overlain by superficial deposits. These are classified as sands and gravels, blown sand close to the coast and alluvium and till inland (British Geological Survey 2015). The soils in this area are classified in the Wick 1 association, characterised as deep, well-drained coarse loams and sandy soils, locally over gravel (Soil Survey of England and Wales 1983).

2 Archaeological Background

A Heritage Desk Based Study (NuGen 2014) has identified 48 archaeological sites within a 1km study area which incorporated the AOI and an area extending 1km in all directions from it. These sites include one Scheduled Monument (Old Church of St Bridget Cross Bases) and 47 undesignated heritage assets. These are summarised in the following table and described in the Heritage Desk Based Assessment from which the table is extracted.

3 Aims and Methodology

Magnetometer Survey

The aim of the geophysical survey as described in the Project Design (Atkinson and Harrison 2015) is to, as far as possible, identify the presence or absence, and extent and layout, of buried archaeological remains across the AOI, through the interpretation of magnetic anomalies identified following the processing of data gathered during the survey.

Magnetic survey methods rely on the ability of a variety of instruments to measure very small magnetic fields associated with buried archaeological remains. Features such as a ditch, pit or kiln can act like a small magnet, or series of magnets, that produce distortions (anomalies) in the Earth's magnetic field. By mapping these slight variations, detailed plans of sites can be obtained as buried features often produce reasonably characteristic anomaly shapes and strengths (Gaffney and Gater 2003). Further information on types of anomaly is provided as Appendix 1.

On this site Bartington Grad601 magnetic gradiometers were used. These instruments are calibrated to take readings at 0.25m intervals on zig-zag traverses 1m apart within a series of 30m by 30m grids resulting in 3600 readings per 30m grid square. The data are stored in the memory of the instrument before being downloaded to a lap-top computer each day in preparation for data processing and interpretation.

The survey grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model) providing an accuracy greater than 0.01m. The locations of the survey grid and anomalies are available as a DXF file. 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.

Data processing

The 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. 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'. The data in the greyscale images has been interpolated and selectively filtered, using Geoplot 3 (Geoscan Research) software 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.

Presentation

A general site location plan, incorporating the 1:50000 Ordnance Survey (OS) mapping, is shown in Figure 1. Figure 2 shows the extent of the survey areas together with the processed data at a scale of 1:12500. Figure 3 displays an overall interpretation of the site, at a scale of 1:12500. Detailed data plots ('raw' and processed) and interpretative figures are presented at a scale of 1:1250 in Figures 5 to 82 inclusive.

Further information on magnetic survey and characterisation and interpretation of anomaly types are given in Appendix 1. Appendix 2 describes the composition and location of the site archive and Appendix 3 reproduces the OASIS entry.

The survey methodology, report and any recommendations comply with the Project Design (Atkinson and Harrison 2015) and guidelines outlined by English Heritage (David *et al.* 2008) and by the Chartered Institute for Archaeologists (CIfA 2014). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

Disclaimers

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.

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.

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.

4 Results and Discussion (see Figures 5 to 82)

Ferrous, agricultural and geological anomalies are discussed first, with possible archaeology and archaeological anomalies discussed afterwards.

Ferrous anomalies

Ferrous responses, either as individual 'spike' anomalies or more extensive areas of magnetic disturbance, are typically caused by modern ferrous (magnetic) debris, either on the ground

surface or in the plough-soil, or are due to the proximity of magnetic material in field boundaries, buildings or other above ground features. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation, as ferrous debris or material is common on rural sites, often being present as a consequence of manuring or tipping/infilling. 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.

Agricultural anomalies

Throughout the AOI there is evidence of modern ploughing, former field boundaries and field drains. They are described in brief below.

Modern ploughing has been identified because of the regular, linear and close nature of the magnetic responses. This compares and contrasts with wider spaced and slightly stronger positively enhanced magnetic anomalies. These are considered to be indicative of post-medieval ridge and furrow. A clear example of this can be seen in Sector 2 (Fig 8-10) and Sector 22 (Figs 68-70).

Field drains can be identified by their thin, linear and dipolar magnetic signature. An area of intense activity can be seen in Sector 9 and 10 (Figs 29-34).

Some former field boundaries have been detected across the AOI, notably in Sector 12 (Figs 38-40) and 24 (Figs 74-76).

Geological anomalies

Throughout the site several small discrete anomalies are recorded. These anomalies are likely to be due to minor variation in the upper soil horizons or to recent localised ground disturbance. More prominent areas of geology have been detected along the western boundary of the AOI, near the dismantled railway, indicative of Calder Sandstone.

Such a large survey area has changes in geology and topography which have been recorded. These can be seen in places as broad and linear responses. They are especially prominent in areas where the topography changes dramatically and is more readily detected when the topsoil is at its thinnest. In parts of the site, there are notable changes in the magnetic responses detected by the instrumentation caused by changes in the geology (Sector 7; Figs 23-25, Sector 15; Figs 47-49), predominantly the areas to the west of the scheme where river deposits are present. Most notable geological anomalies can be found where the superficial glaciofluid deposits drain into the ‘valley’. These geological scars are possibly caused by Ice Age glaciers scouring the landscape as well as post-glacial meltwaters.

Possible archaeological anomalies

A small collection of magnetically enhanced responses in contrast to background levels **A** can be seen in Figs 41-43. They form a square type anomaly and could be a former structure, but its isolation means that geological material could have been brought to the surface. There are a collection of magnetically enhanced features present in the data that have been identified as archaeological anomalies Sector 13 (Figs 41-43) and has the appearance of a square feature (10m x 10m), consistent with a possible square barrow. An archaeological classification of the anomaly is based upon the strength of the magnetic responses, but also the regular linear nature of the anomaly. This appears to be the case with regards to this anomaly.

A linear magnetic response **B** (Sector 13, Figs 41-43) has been detected in the north east corner of a small field close to the NuGen compound. This projects south-east and appears to turn towards the east approximately halfway through the field. It has similar sinuous linear characteristics of a former field boundary. Furthermore, it appears to project southwards from an existing field boundary. Cartographic examination of historic mapping has not revealed any former boundary changes in this area. Its location and the area that it demarcates means that it has the potential to be a small square enclosure.

An area of concentrated material close to an identified site of flint working may have been detected. Anomaly **C** (Sector 17, Figs 53-55) is a collection of magnetically enhanced signatures in contrast to the surrounding environment. This may be an area of deposited flint associated with SMR 6447 and 6449 (Atkinson and Harrison 2015). However, because of the location of the response at the base of a slope it may be naturally deposited material.

Archaeological Anomalies

Two linear anomalies, collectively **D** (Sector 17; Figs 53-55) have been identified as possible archaeology. These anomalies correspond with the archaeological remains identified as Watch Hill mile fortlet (SMR 1492904/ 4797) (Atkinson and Harrison 2015). The location of these anomalies in such a prominent elevated position is a strong indicator that this was a Roman observation post. It measures approximately 30m x 60m. The weak magnetic response of these ditch remains is an indication that they are quite shallow as a result of the thin topsoil in this part of the site.

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.

5 Conclusions

The results of this survey have shown that there is some archaeological potential in the south-western corner of the AOI, close to Watch Hill. The survey results have re-enforced the existing evidence of archaeology within the site. The north of the AOI is archaeologically sterile and has detected current and former agricultural regimes. Survey of this type (magnetic gradiometer) has detected some archaeological anomalies, and the shallow soil filled features of agricultural practices, and also archaeological in origin, despite the combination of thin soils and interference from bedrock. Geological variation has been mapped across the AOI and some features which may be archaeological in nature have been chronicled. Is it concluded that further investigation would be required to determine the origin of these features. Therefore the archaeological potential of this site is medium with the area of Watch Hill, and low elsewhere.

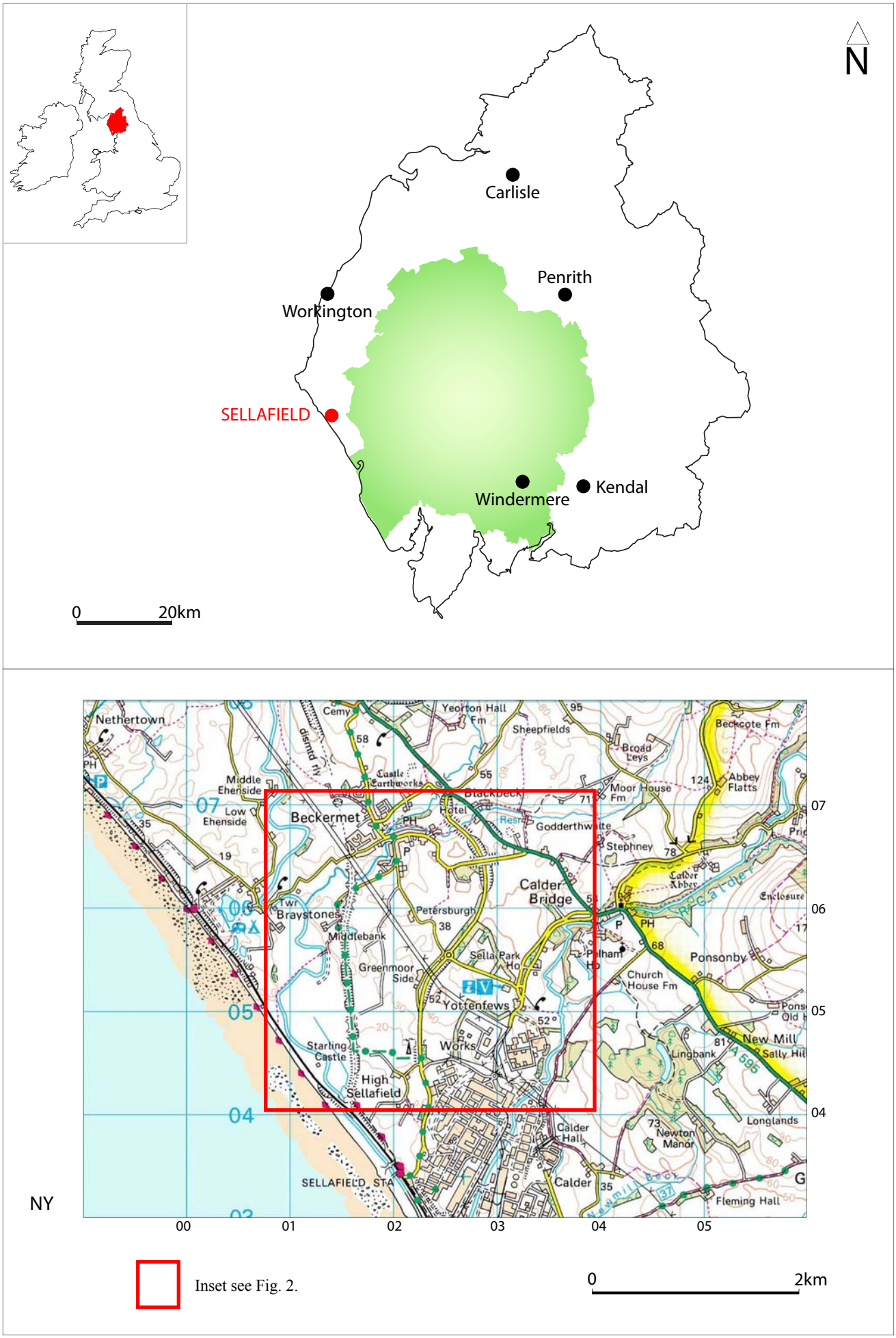

Fig. 1. Site location

PROPOSED DEVELOPMENT BOUNDARY

SECTOR 1 FIGS 5-7
SECTOR 2 FIGS 8-10
SECTOR 3 FIGS 11-13
SECTOR 4 FIGS 14-16
SECTOR 5 FIGS 17-19
SECTOR 6 FIGS 20-22
SECTOR 7 FIGS 23-25
SECTOR 8 FIGS 26-28
SECTOR 9 FIGS 29-31
SECTOR 10 FIGS 32-34
SECTOR 11 FIGS 35-37
SECTOR 12 FIGS 38-40
SECTOR 13 FIGS 41-43
SECTOR 14 FIGS 44-46
SECTOR 15 FIGS 47-49
SECTOR 16 FIGS 50-52
SECTOR 17 FIGS 53-55
SECTOR 18 FIGS 56-58
SECTOR 19 FIGS 59-61
SECTOR 20 FIGS 62-64
SECTOR 21 FIGS 65-67
SECTOR 22 FIGS 68-70
SECTOR 23 FIGS 71-73
SECTOR 24 FIGS 71-73
SECTOR 25 FIGS 74-76
SECTOR 26 FIGS 77-79

Beckermet
Petersburgh
Yottenfews
Calder Bridge
Ponsonby
Riverside
Broom Close
Holme
Middlebank
Home Farm
Lantern Moss Tarn
Sewage Works
Bog
Castle
Low Godderthwaite
High Godderthwaite
Nursery Houses
Stephney
Sparholme Wood
High Croft
Mill Farm
Bank Fold
Waste Wood
Town End
Pelham House
Sella Park House
Church/House Farm
Calder Abbey (rems of)
River Calder
Lady Wood
Gaterigg Bank
Ponsonby Tarn
Lingbank Plantation
Lingbank Moor
Newton Manor
Calder Hall
New Mill

N

3010000 3020000 3030000 3040000 3050000

2.0 -1.0 nT

0 200m

Fig. 2. Survey location showing greyscale magnetometer data and sector boundaries (1:12500 @ A3)

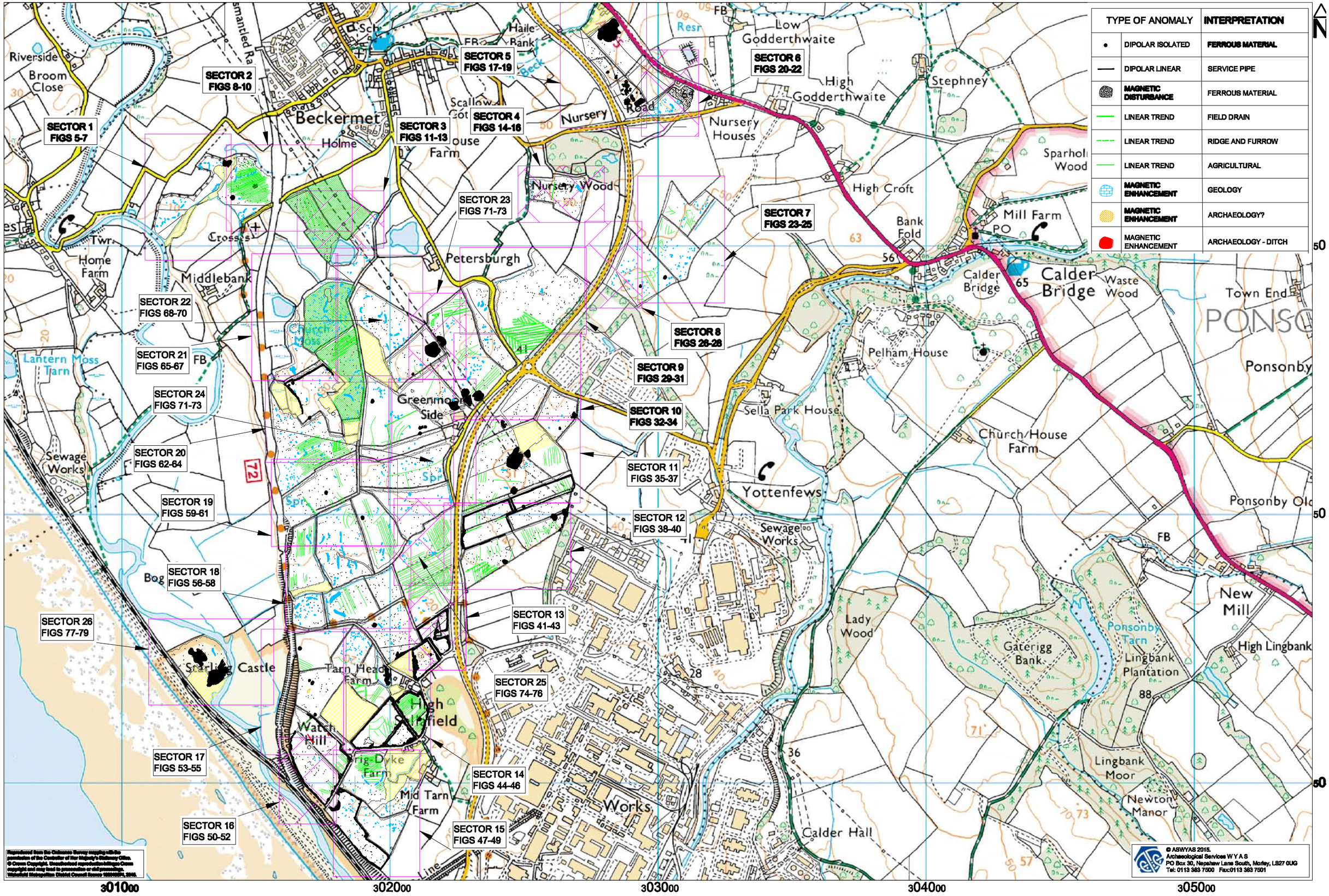

Fig. 3. Overall interpretation and sector boundaries (1:12500 @ A3)

CALDER SANDSTONE

ST BEES BEDROCK SANSTONE

1 LOCATION OF PLATES

N

Fig. 4. Location of plates and bedrock geology (1:12500 @ A3)

0 200m

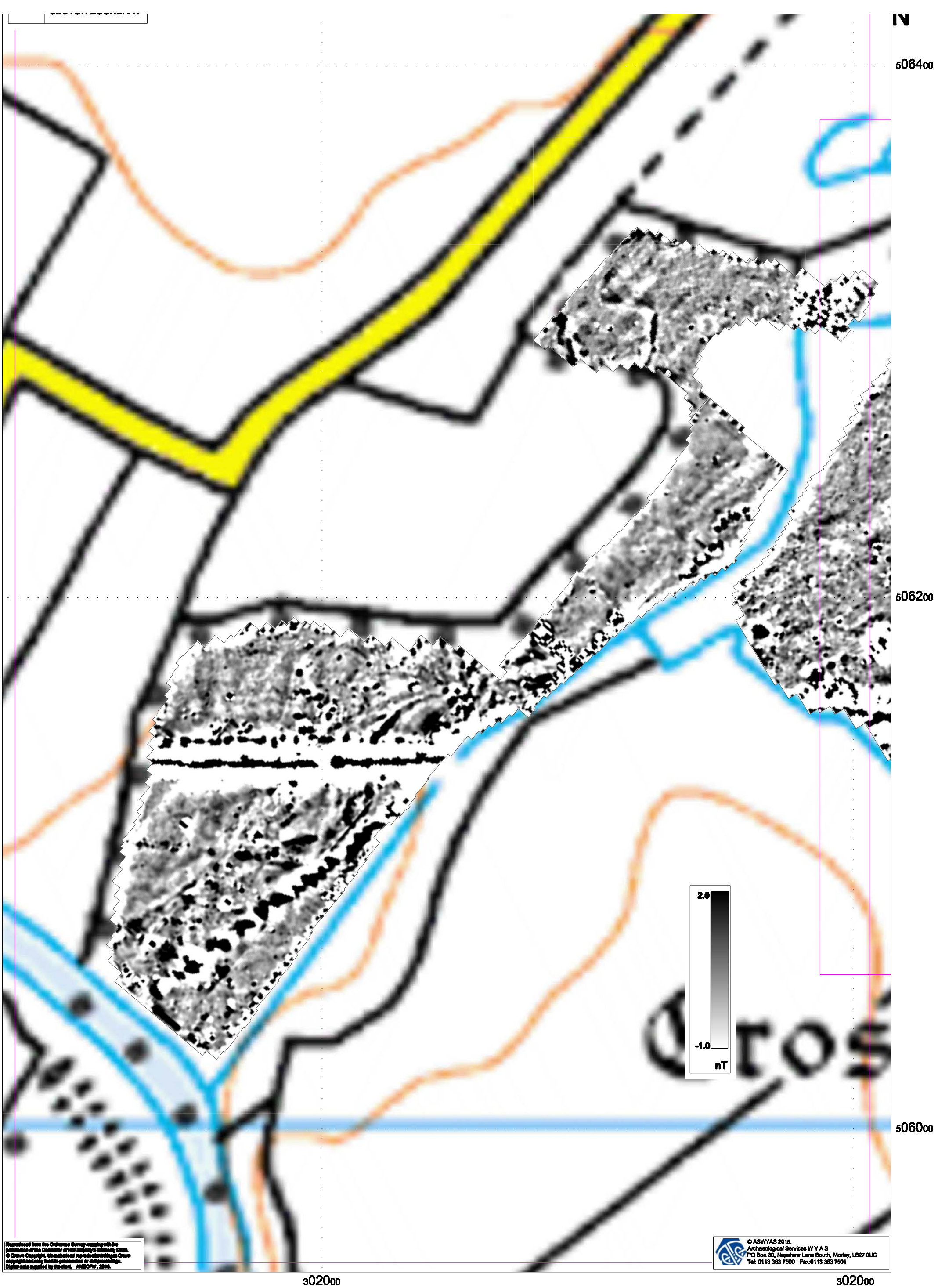

Fig. 5. Processed greyscale magnetometer data; Sector 1 (1:1250 @ A3)

N

5064 00

5062 00

5060 00

3020 00

3020 00

20.0 nT/cm

0 50m

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Fig. 6. XY trace plot of minimally processed magnetometer data; Sector 1 (1:1250 @ A3)

TYPE OF ANOMALY		INTERPRETATION
•	DIPOLAR ISOLATED	FERROUS MATERIAL
——	DIPOLAR LINEAR	SERVICE PIPE
	MAGNETIC DISTURBANCE	FERROUS MATERIAL
·····	LINEAR TREND	FIELD DRAIN
——	LINEAR TREND	AGRICULTURAL

N

5064 00

5062 00

5060 00

3020 00

3020 00

10

Cros

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0 50m

Fig. 7. Interpretation of magnetometer data; Sector 1 (1:1250 @ A3)

Fig. 8. Processed greyscale magnetometer data; Sector 2 (1:1250 @ A3)

SECTOR BOUNDARY

N

20.0 nT/cm

50

3014 00

3016 00

3018 00

0 30m

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Fig. 9. XY trace plot of minimally processed magnetometer data; Sector 2 (1:1250 @ A3)

TYPE OF ANOMALY		INTERPRETATION
•	DIPOLAR ISOLATED	FERROUS MATERIAL
—	DIPOLAR LINEAR	SERVICE PIPE
	MAGNETIC DISTURBANCE	FERROUS MATERIAL
—	LINEAR TREND	FIELD DRAIN
- - -	LINEAR TREND	RIDGE AND FURROW
—	LINEAR TREND	AGRICULTURAL
	MAGNETIC ENHANCEMENT	GEOLOGY

SECTOR BOUNDARY

N

50

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3014 00 3016 00 3018 00

0 30m

Fig. 10. Interpretation of magnetometer data; Sector 2 (1:1250 @ A3)

Fig. 11. Processed greyscale magnetometer data; Sector 3 (1:1250 @ A4)

Fig. 12. XY trace plot of minimally processed magnetometer data; Sector 3 (1:1250 @ A4)

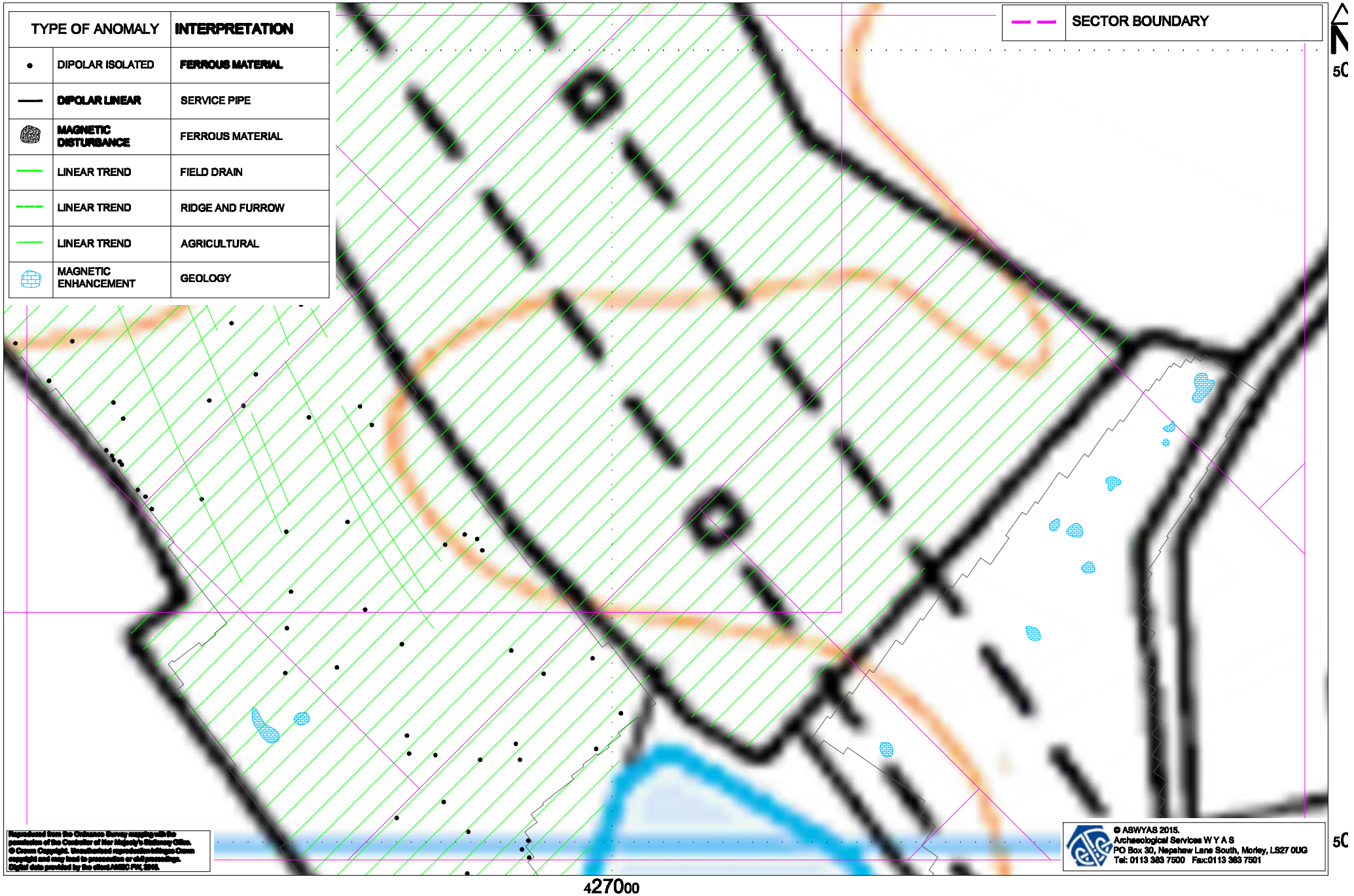

Fig. 13. Interpretation of magnetometer data; Sector 3 (1:1250 @ A4)

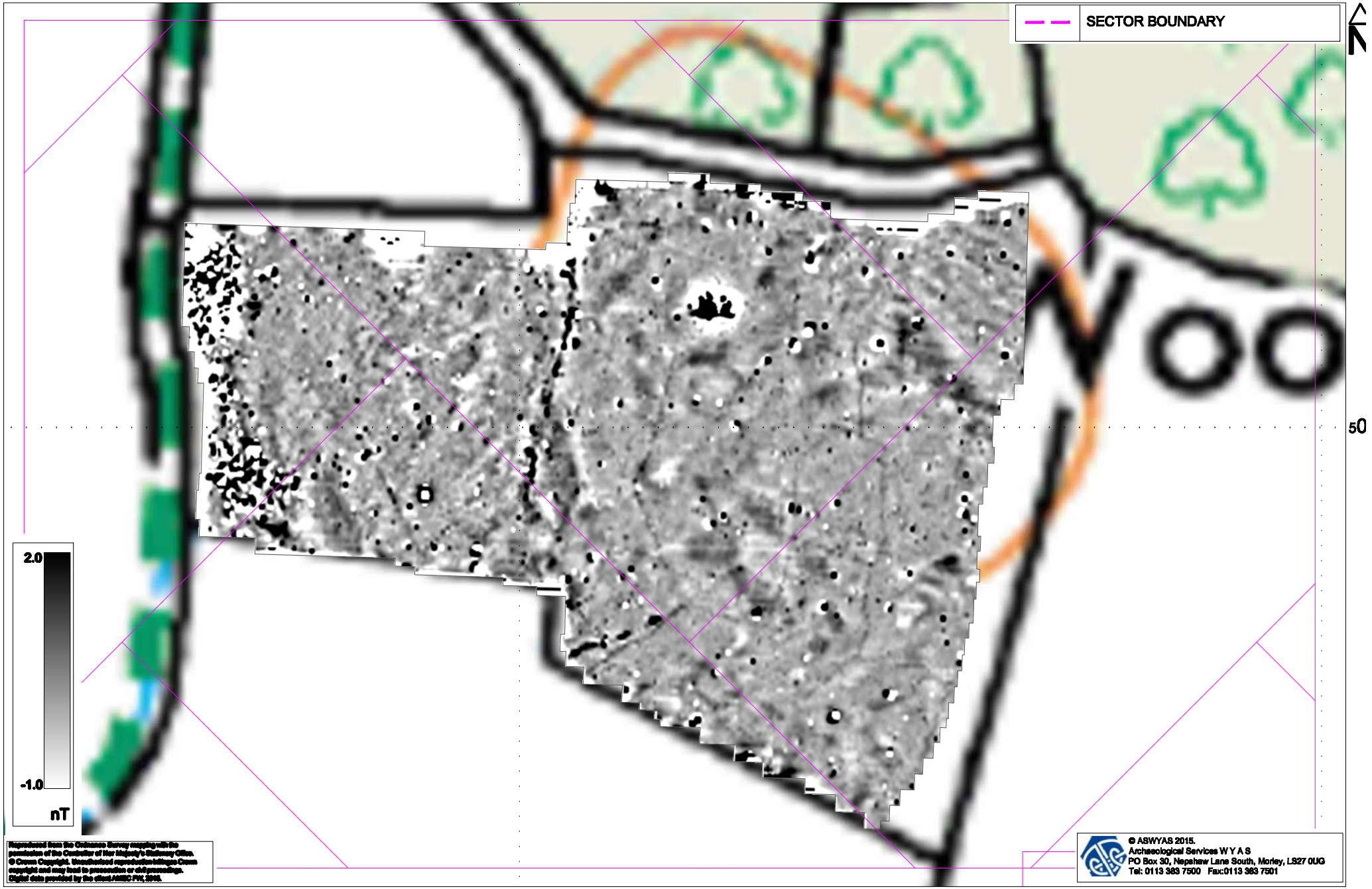

Fig. 14. Processed greyscale magnetometer data; Sector 4 (1:1250 @ A4)

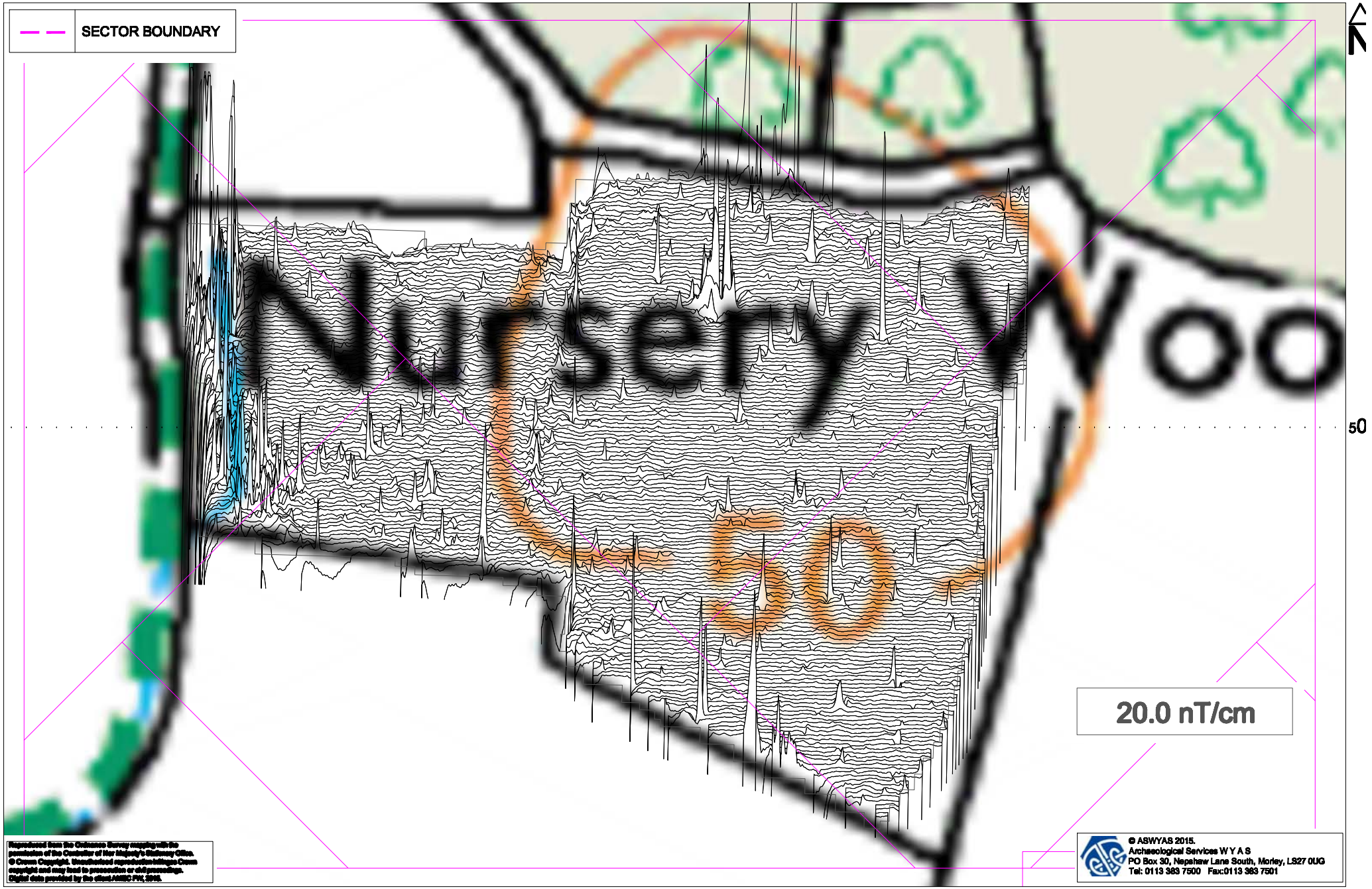

Fig. 15. XY trace plot of minimally processed magnetometer data; Sector 4 (1:1250 @ A4)

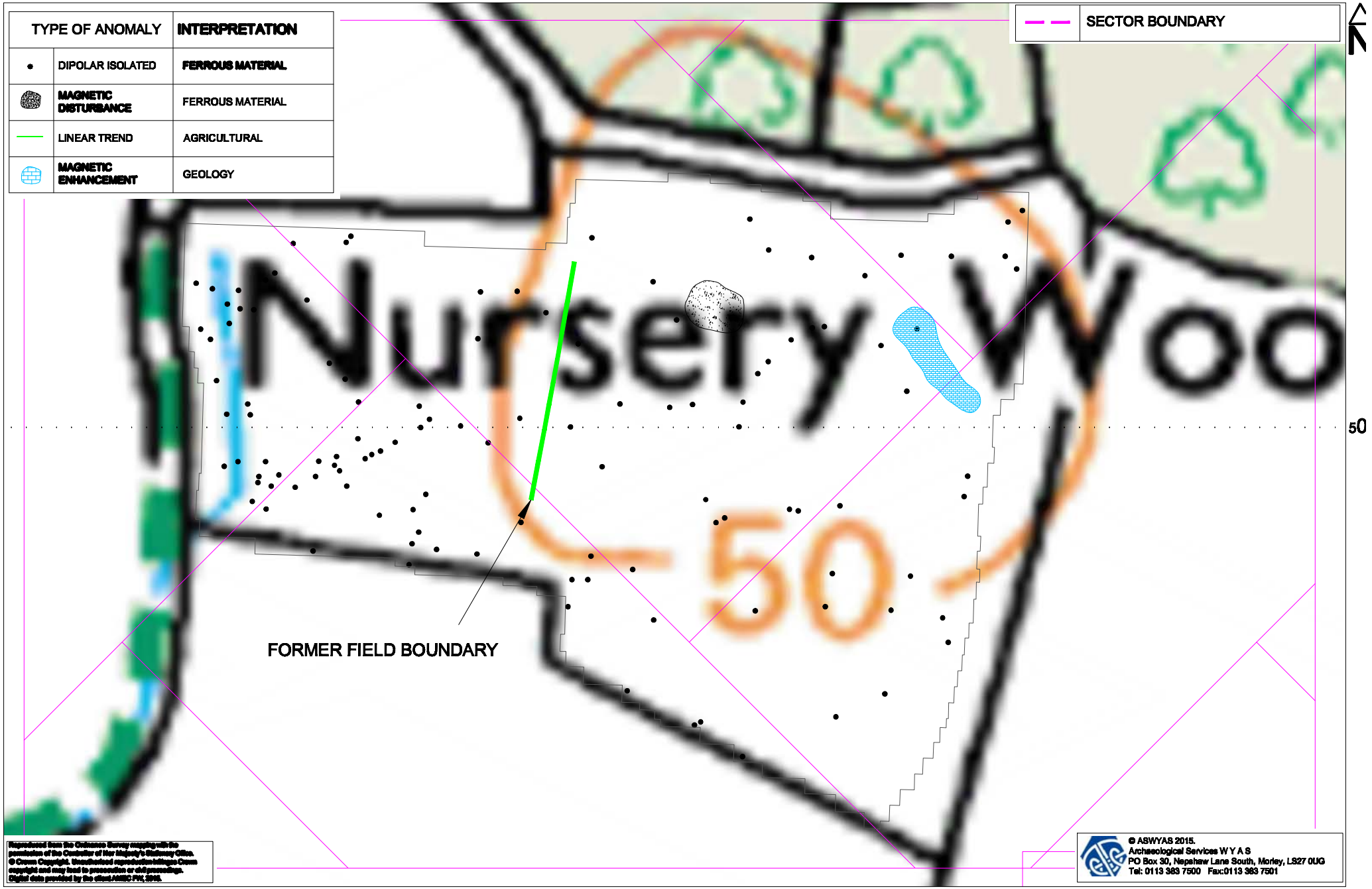

Fig. 16. Interpretation of magnetometer data; Sector 4 (1:1250 @ A4)

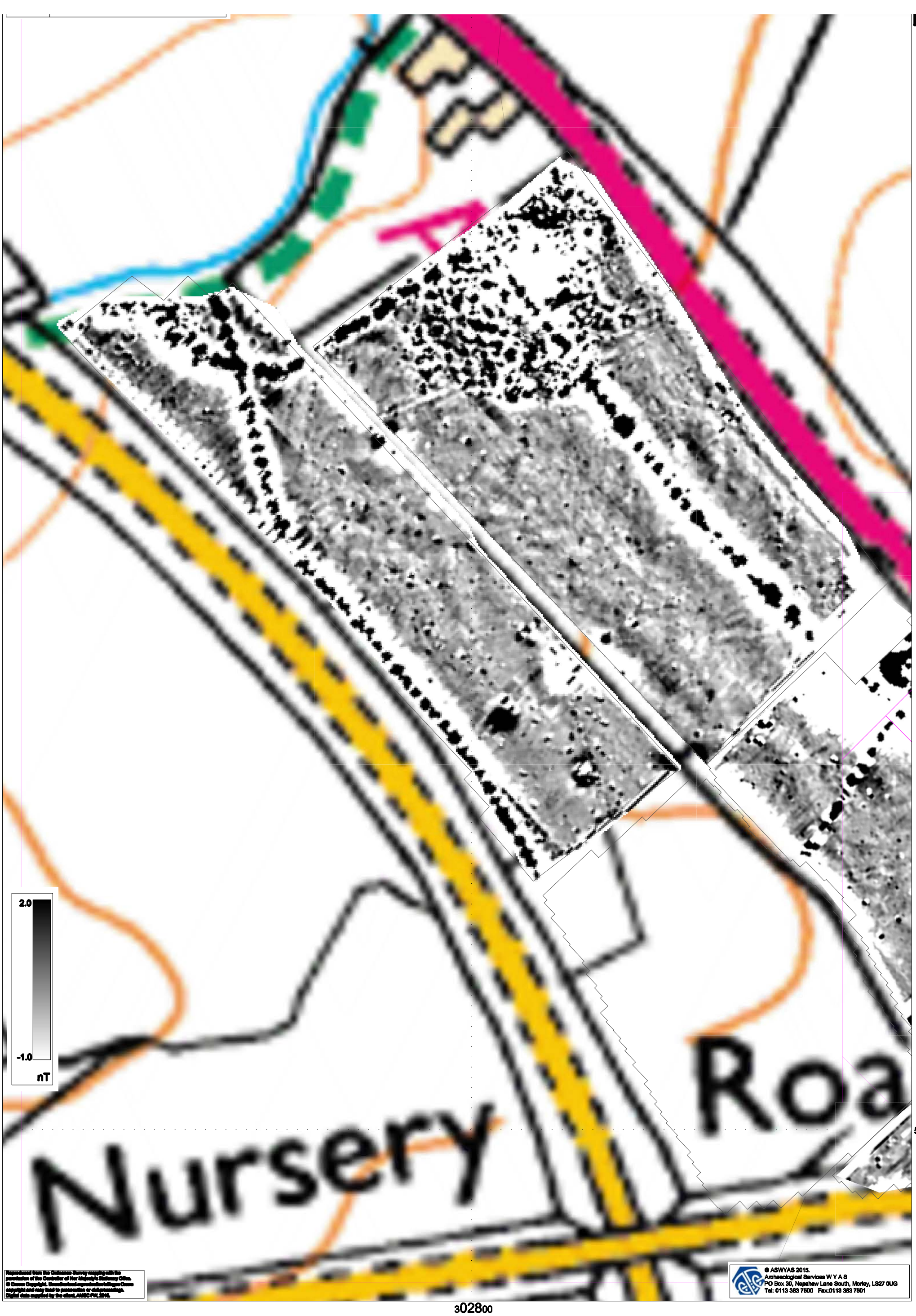

Fig. 17. Processed greyscale magnetometer data; Sector 5 (1:1250 @ A3)

Fig. 18. XY trace plot of minimally processed magnetometer data; Sector 5 (1:1250 @ A3)

•	DIPOLAR ISOLATED	FERROUS MATERIAL
—	DIPOLAR LINEAR	SERVICE PIPE
	MAGNETIC DISTURBANCE	FERROUS MATERIAL

N

Nursery

Roa

6

5065 00

3028 00

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Tel: 0113 383 7500 Fax:0113 383 7501

0 50m

Fig. 19. Interpretation of magnetometer data; Sector 5 (1:1250 @ A3)

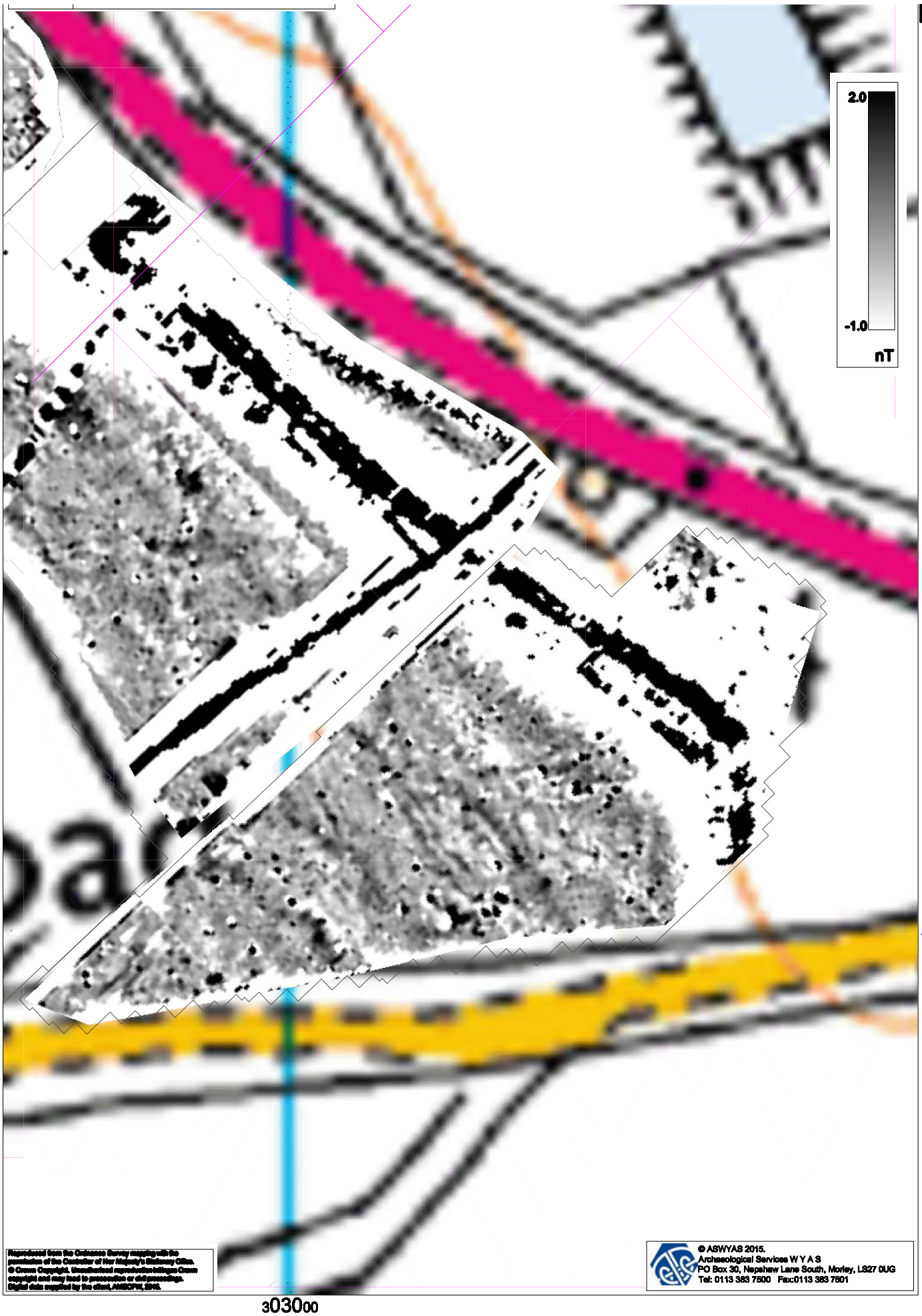

Fig. 20. Processed greyscale magnetometer data; Sector 6(1:1250 @ A4) 0 50m

Fig. 21. XY trace plot of minimally processed magnetometer data; Sector 6 (1:1250 @ A4)

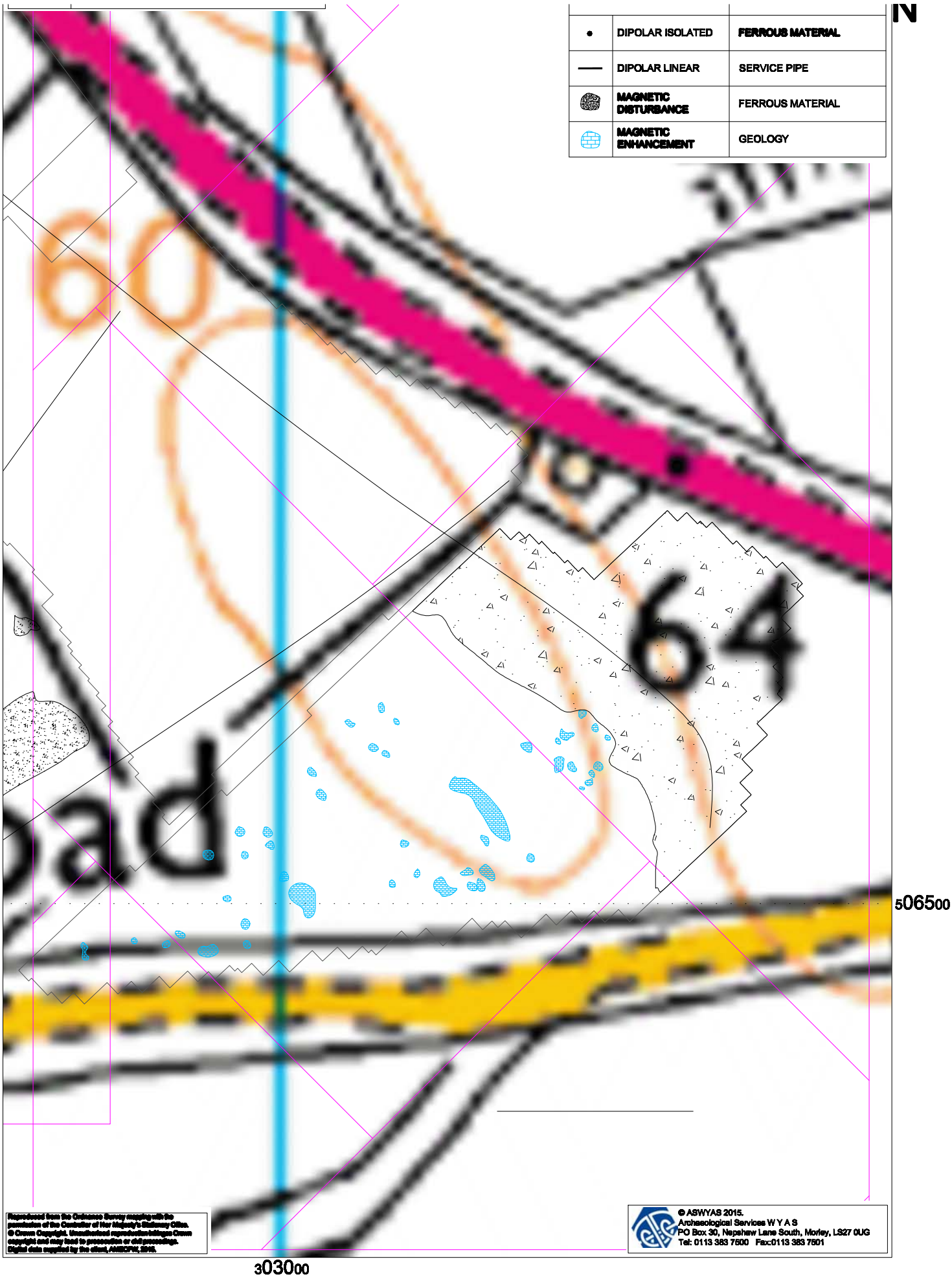

Fig. 22. Interpretation of magnetometer data; Sector 6 (1:1250 @ A4)

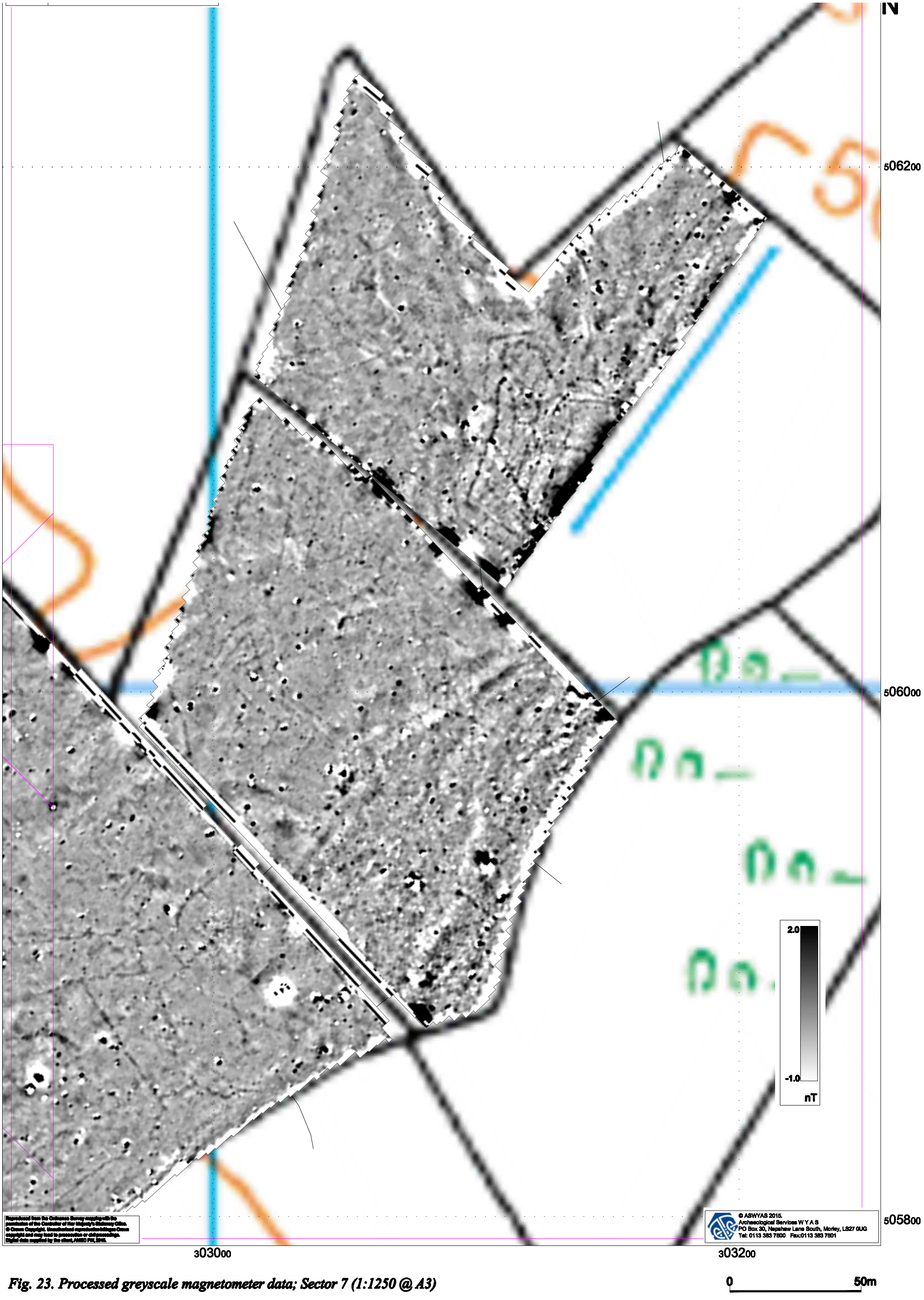

Fig. 23. Processed greyscale magnetometer data; Sector 7 (1:1250 @ A3)

N

5062 00

5060 00

5058 00

3030 00

3032 00

20.0 nT/cm

0 50m

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Fig. 24. XY trace plot of minimally processed magnetometer data; Sector 7 (1:1250 @ A3)

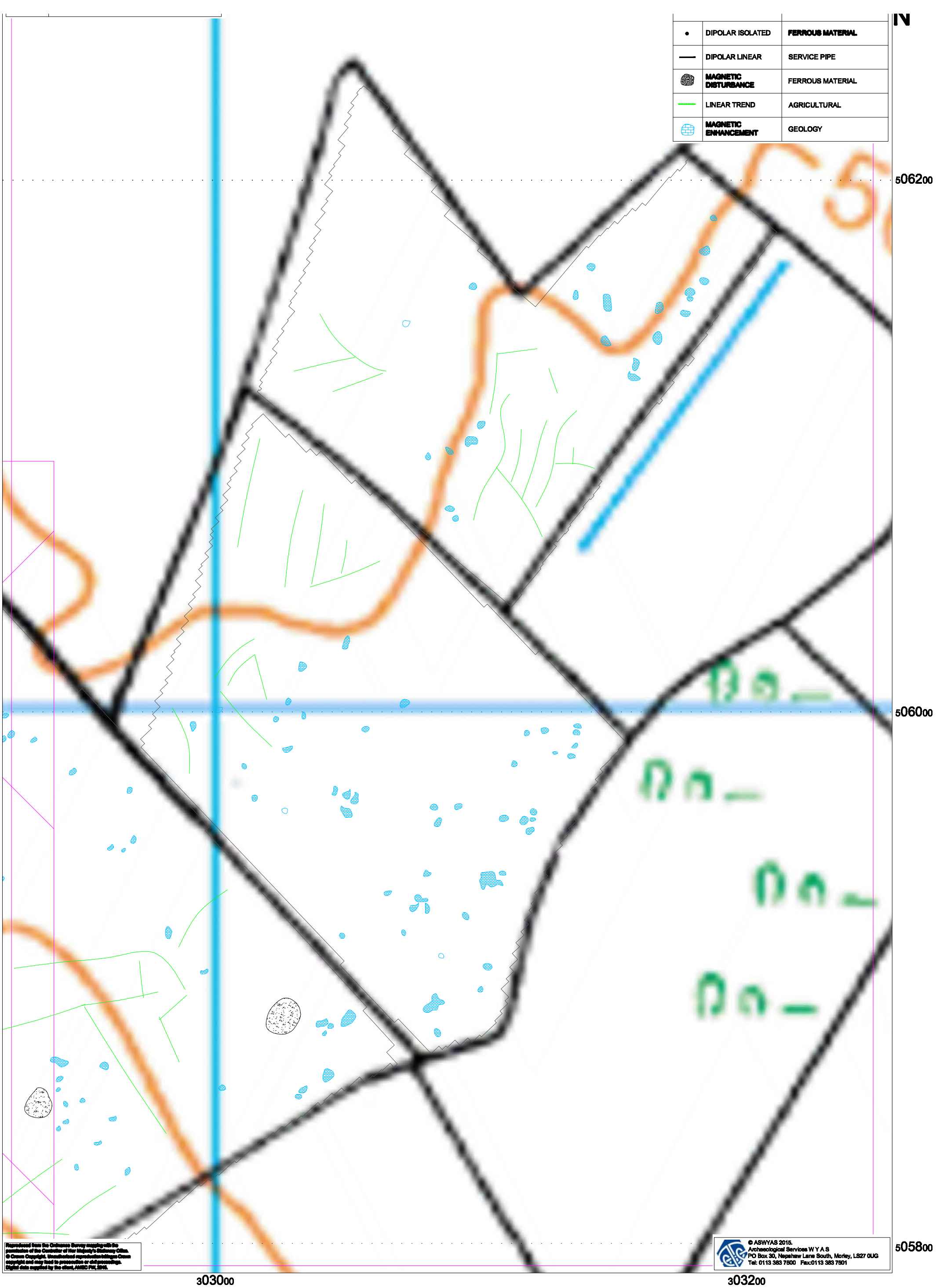

Fig. 25. Interpretation of magnetometer data; Sector 7 (1:1250 @ A3)

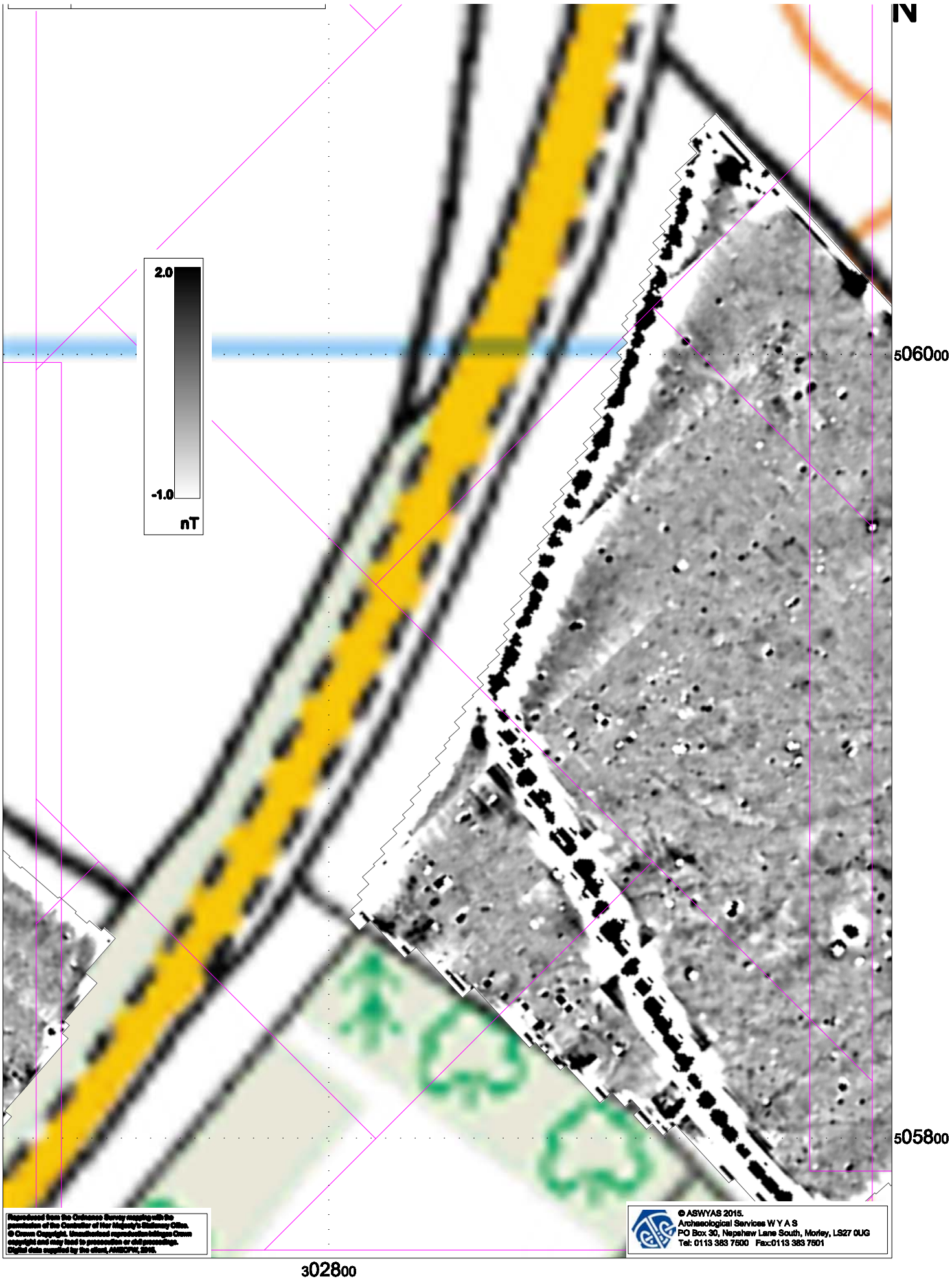

Fig. 26. Processed greyscale magnetometer data; Sector 8 (1:1250 @ A4)

Fig. 27. XY trace plot of minimally processed magnetometer data; Sector 8 (1:1250 @ A4)

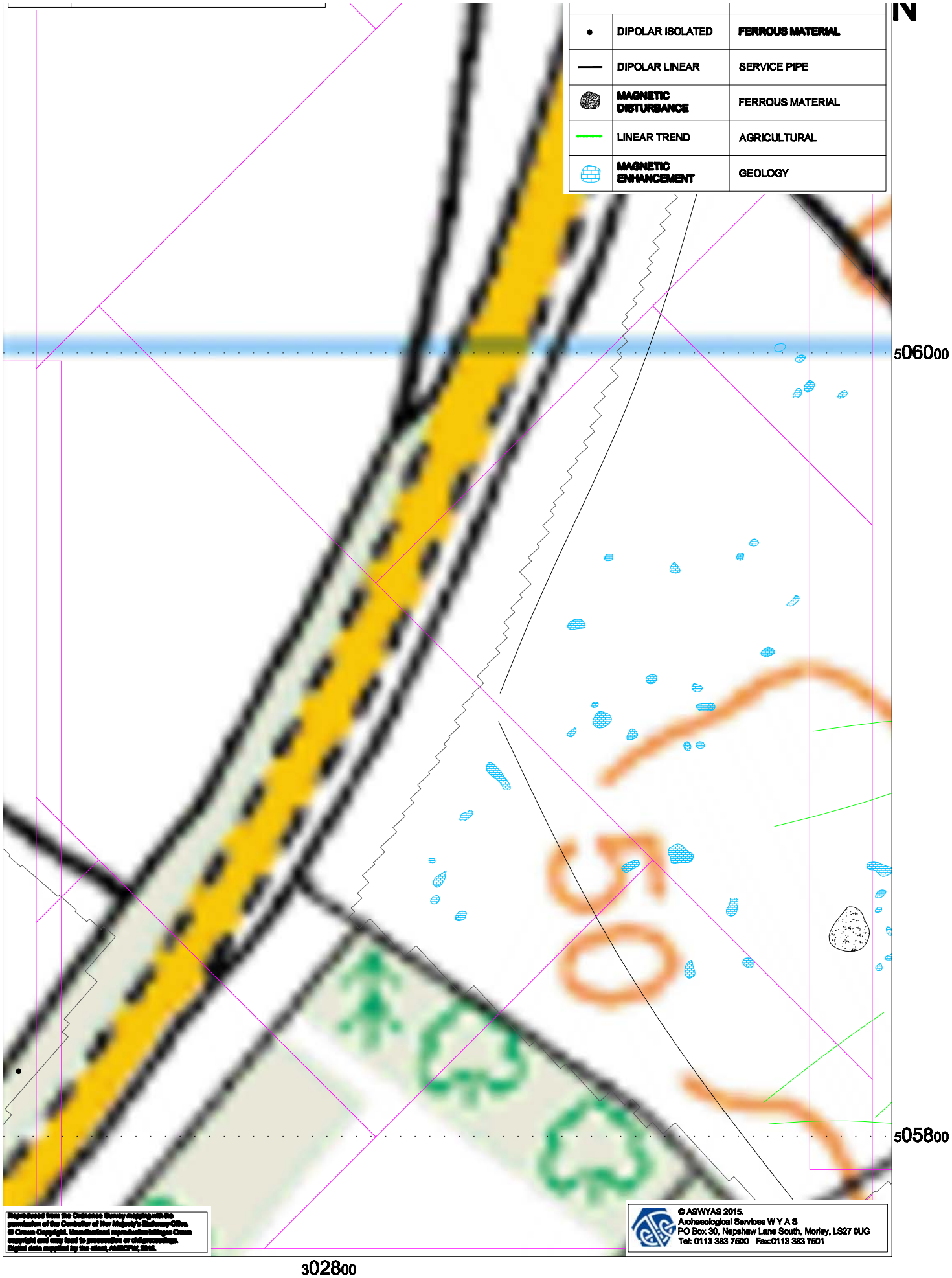

Fig. 28. Interpretation of magnetometer data; Sector 8 (1:1250 @ A4)

SECTOR BOUNDARY

N

etersburgh

3024 00

3026 00

50

2.0

-1.0

nT

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0 50m

Fig. 29. Processed greyscale magnetometer data; Sector 9 (1:1250 @ A3)

Fig. 30. XY trace plot of minimally processed magnetometer data; Sector 9 (1:1250 @ A3)

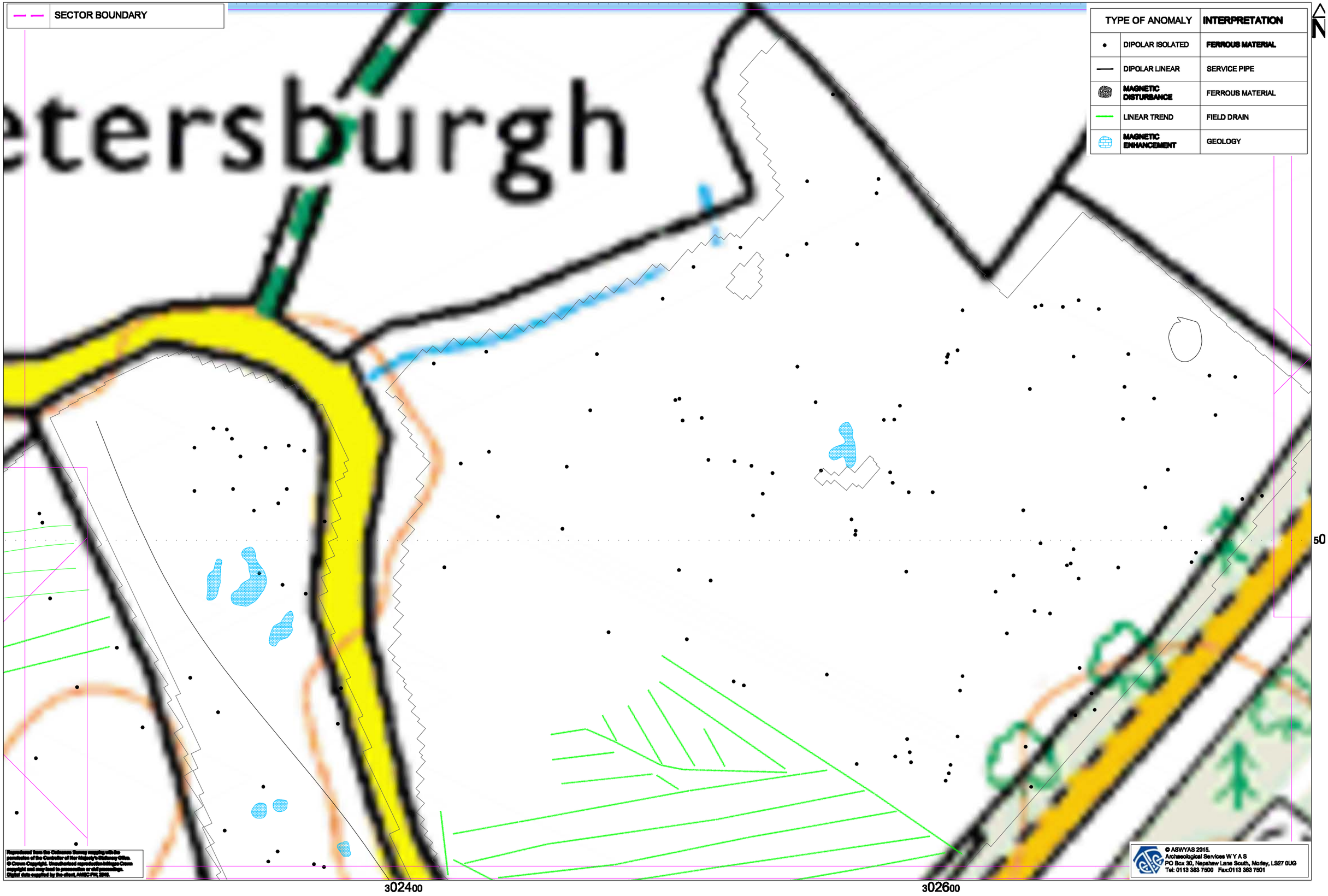

Fig. 31. Interpretation of magnetometer data; Sector 9 (1:1250 @ A3)

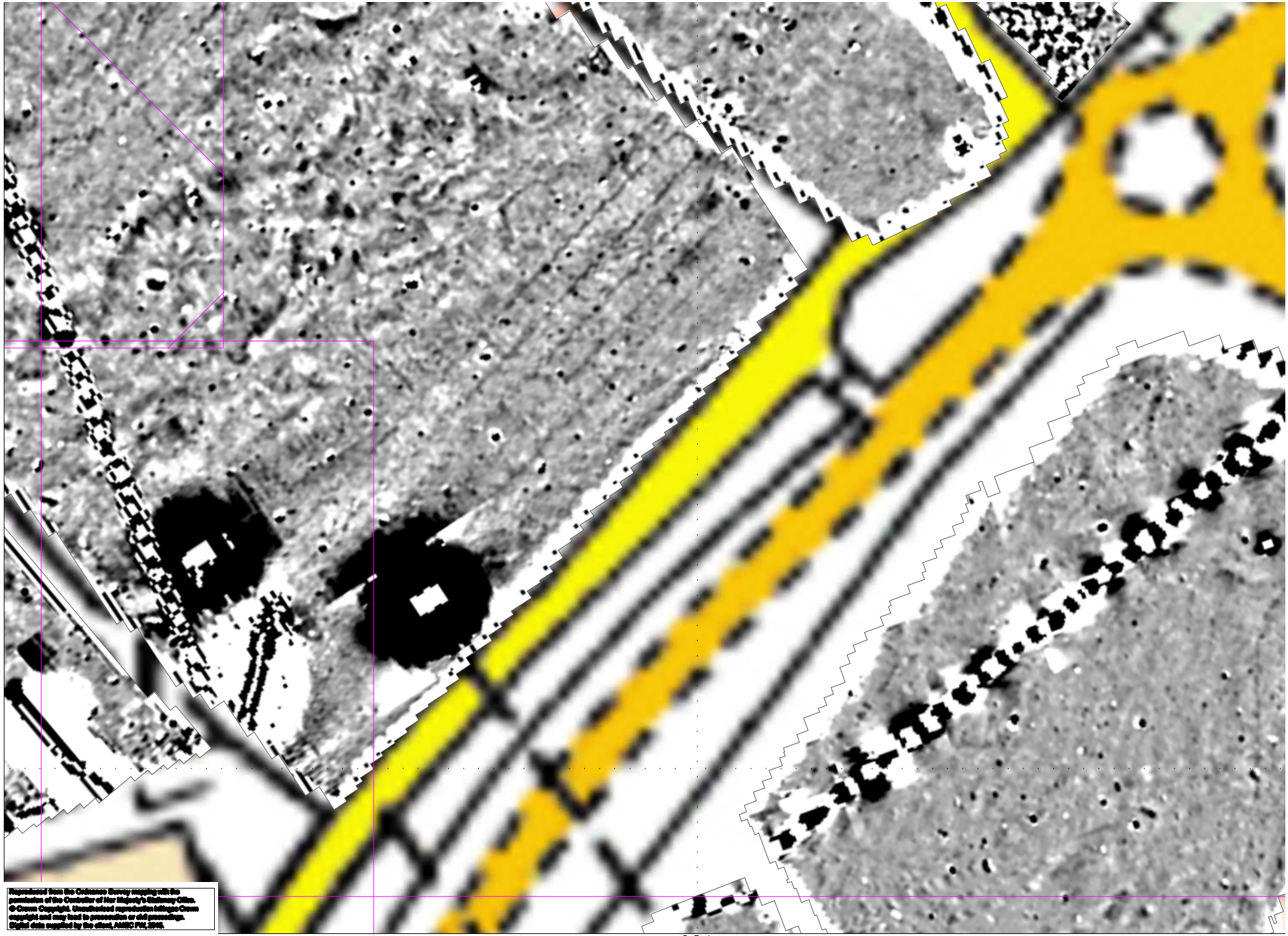

Fig. 32. Processed greyscale magnetometer data; Sector 10 (1:1250 @ A3)

SECTOR BOUNDARY

20.0 nT/cm

N

5 0

5 0

3024 00

3026 00

Archaeological Services W Y A S
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0 50m

Fig. 33. XY trace plot of minimally processed magnetometer data; Sector 10 (1:1250 @ A3)

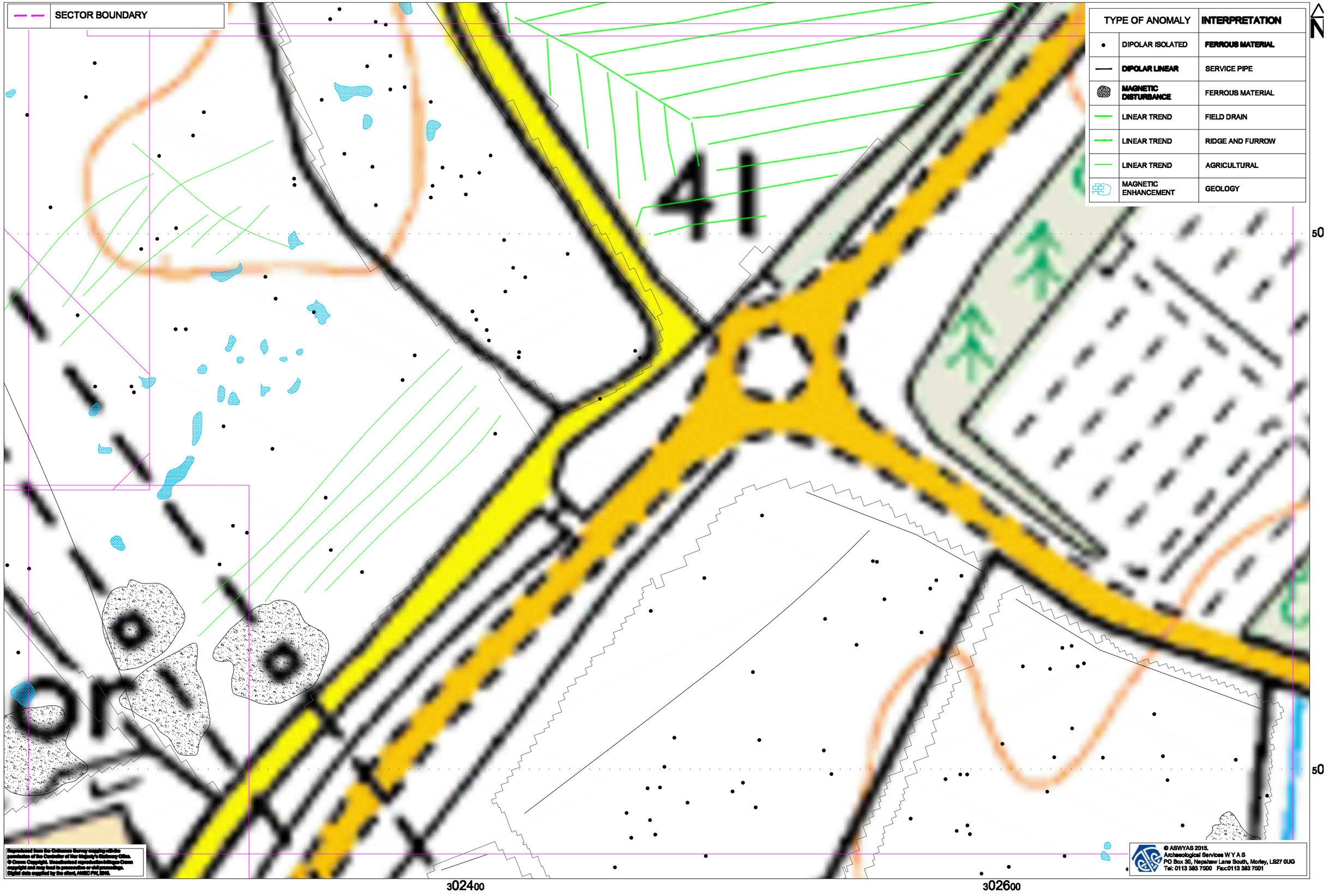

Fig. 34. Interpretation of magnetometer data; Sector 10 (1:1250 @ A3)

SECTOR BOUNDARY

N

2.0

-1.0

nT

5050

3024 00

3026 00

Archaeological Services W Y A S
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0 50m

Fig. 35. Processed greyscale magnetometer data; Sector 11 (1:1250 @ A3)

SECTOR BOUNDARY

20.0 nT/cm

N

50

3024 00

3026 00

0 50m

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Tel: 0113 383 7500 Fax:0113 383 7501

Fig. 36. XY trace plot of minimally processed magnetometer data; Sector 11 (1:1250 @ A3)

SECTOR BOUNDARY

TYPE OF ANOMALY		INTERPRETATION
•	DIPOLAR ISOLATED	FERROUS MATERIAL
——	DIPOLAR LINEAR	SERVICE PIPE
	MAGNETIC DISTURBANCE	FERROUS MATERIAL
——	LINEAR TREND	FIELD DRAIN
——	LINEAR TREND	AGRICULTURAL
	MAGNETIC ENHANCEMENT	GEOLOGY

N

50

51

302400

302600

0 50m

Fig. 37. Interpretation of magnetometer data; Sector 11 (1:1250 @ A3)

SECTOR BOUNDARY

N

5050

2.0

-1.0

nT

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Tel: 0113 383 7500 Fax:0113 383 7501

3022 00 3024 00 3026 00

Fig. 38. Processed greyscale magnetometer data; Sector 12 (1:1250 @ A3)

0 50m

SECTOR BOUNDARY

N

50

50

20.0 nT/cm

302200 302400 302600

0 50m

Fig. 39. XY trace plot of minimally processed magnetometer data; Sector 12 (1:1250 @ A3)

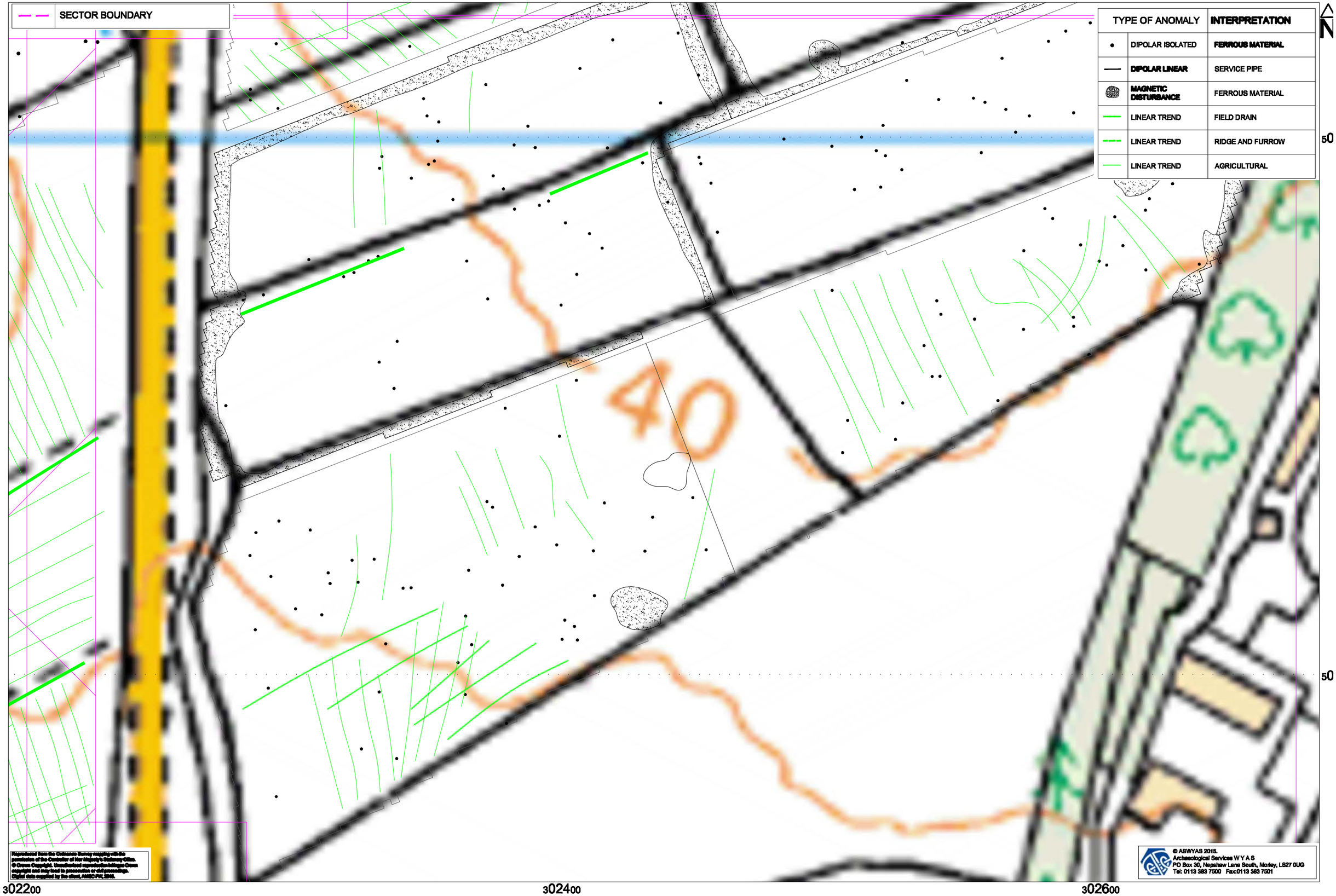

Fig. 40. Interpretation of magnetometer data; Sector 12 (1:1250 @ A3)

Fig. 41. Processed greyscale magnetometer data; Sector 13 (1:1250 @ A4)

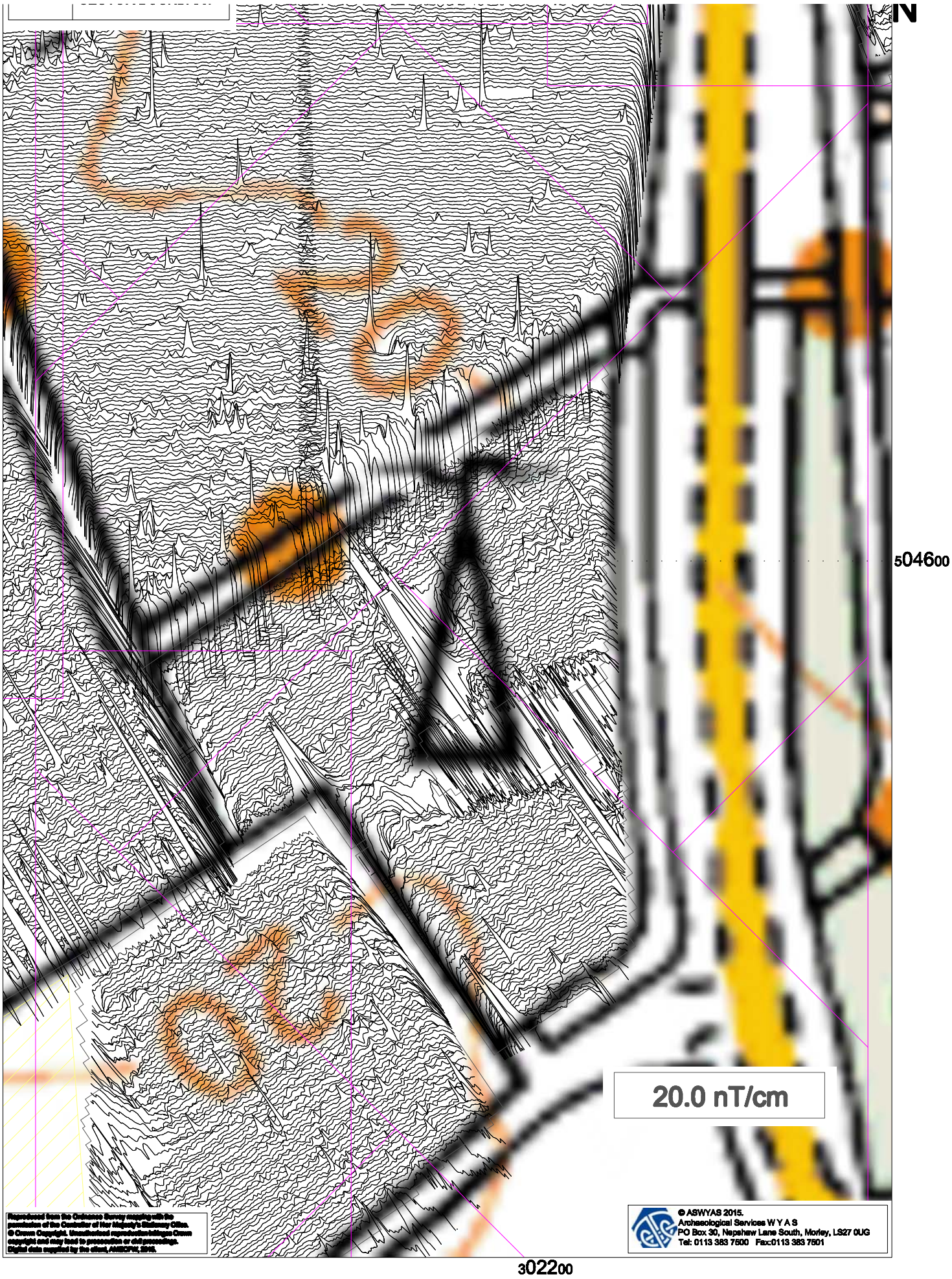

Fig. 42. XY trace plot of minimally processed magnetometer data; Sector 13 (1:1250 @ A4)

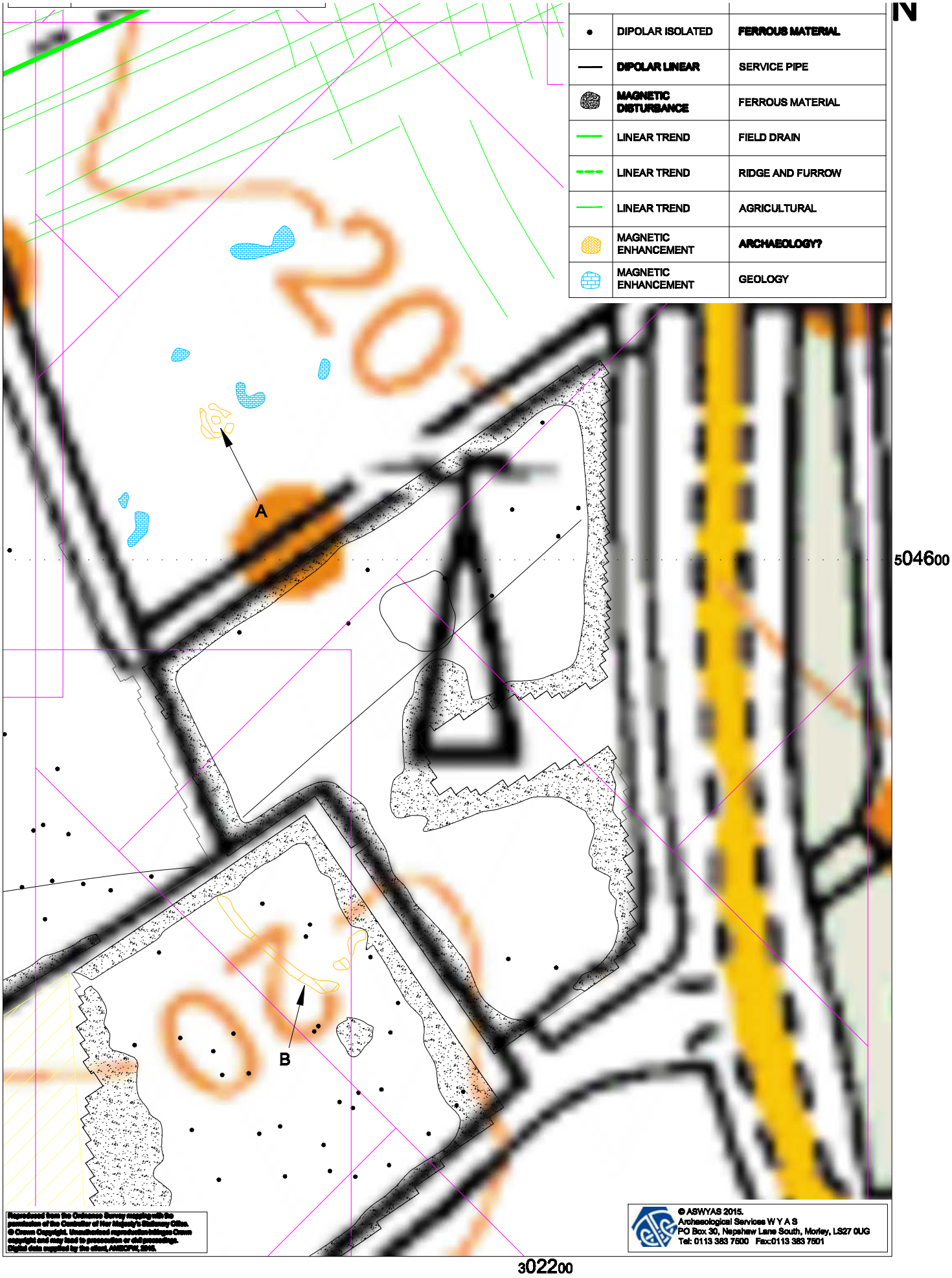

Fig. 43. Interpretation of magnetometer data; Sector 13 (1:1250 @ A4)

0 50m

N

5044 00

5042 00

3020 00

2.0

-1.0

nT

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

0 50m

Fig. 44. Processed greyscale magnetometer data; Sector 14 (1:1250 @ A3)

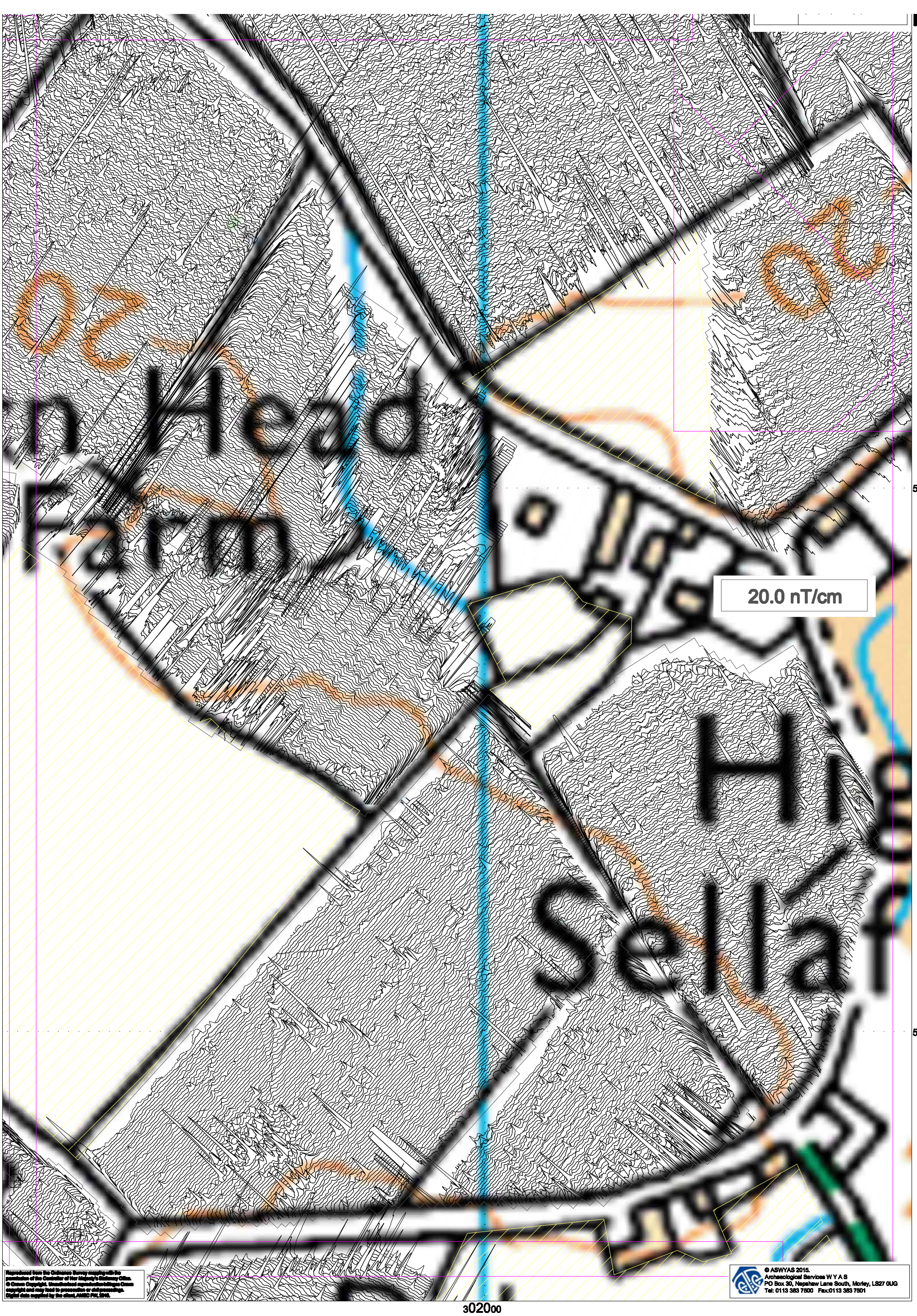

Fig. 43. XY trace plot of minimally processed magnetometer data; Sector 14 (1:1250 @ A3)

•	DIPOLAR ISOLATED	FERROUS MATERIAL
—	DIPOLAR LINEAR	SERVICE PIPE
	MAGNETIC DISTURBANCE	FERROUS MATERIAL
	LINEAR TREND	FIELD DRAIN
	LINEAR TREND	RIDGE AND FURROW
	LINEAR TREND	AGRICULTURAL
	MAGNETIC ENHANCEMENT	GEOLOGY

N

5044 00

5042 00

3020 00

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Tel: 0113 383 7500 Fax:0113 383 7501

Fig. 46. Interpretation of magnetometer data; Sector 14 (1:1250 @ A3)

0 50m

Fig. 47. Processed greyscale magnetometer data; Sector 15 (1:1250 @ A3)

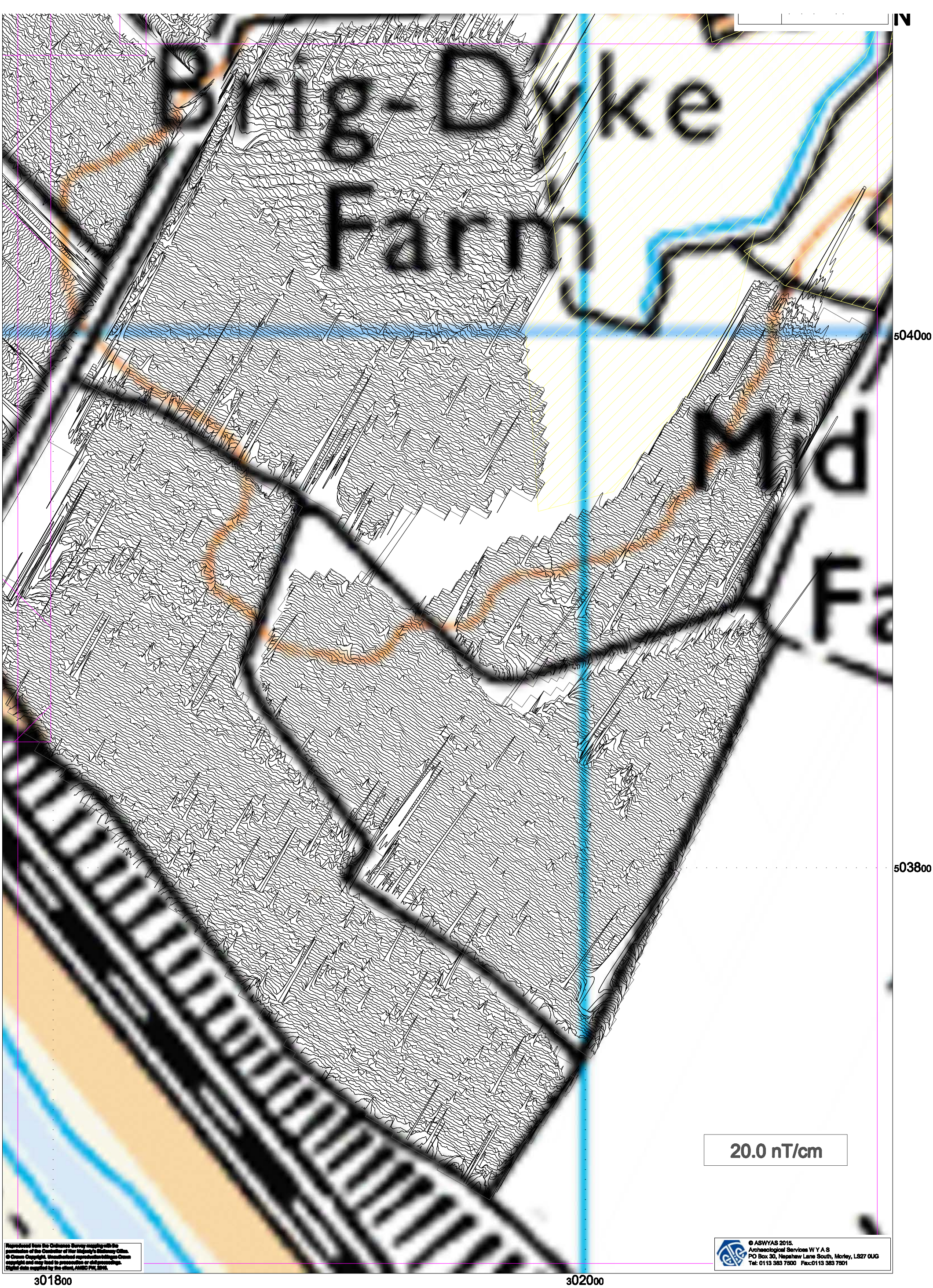

Fig. 48. XY trace plot of minimally processed magnetometer data; Sector 15 (1:1250 @ A3)

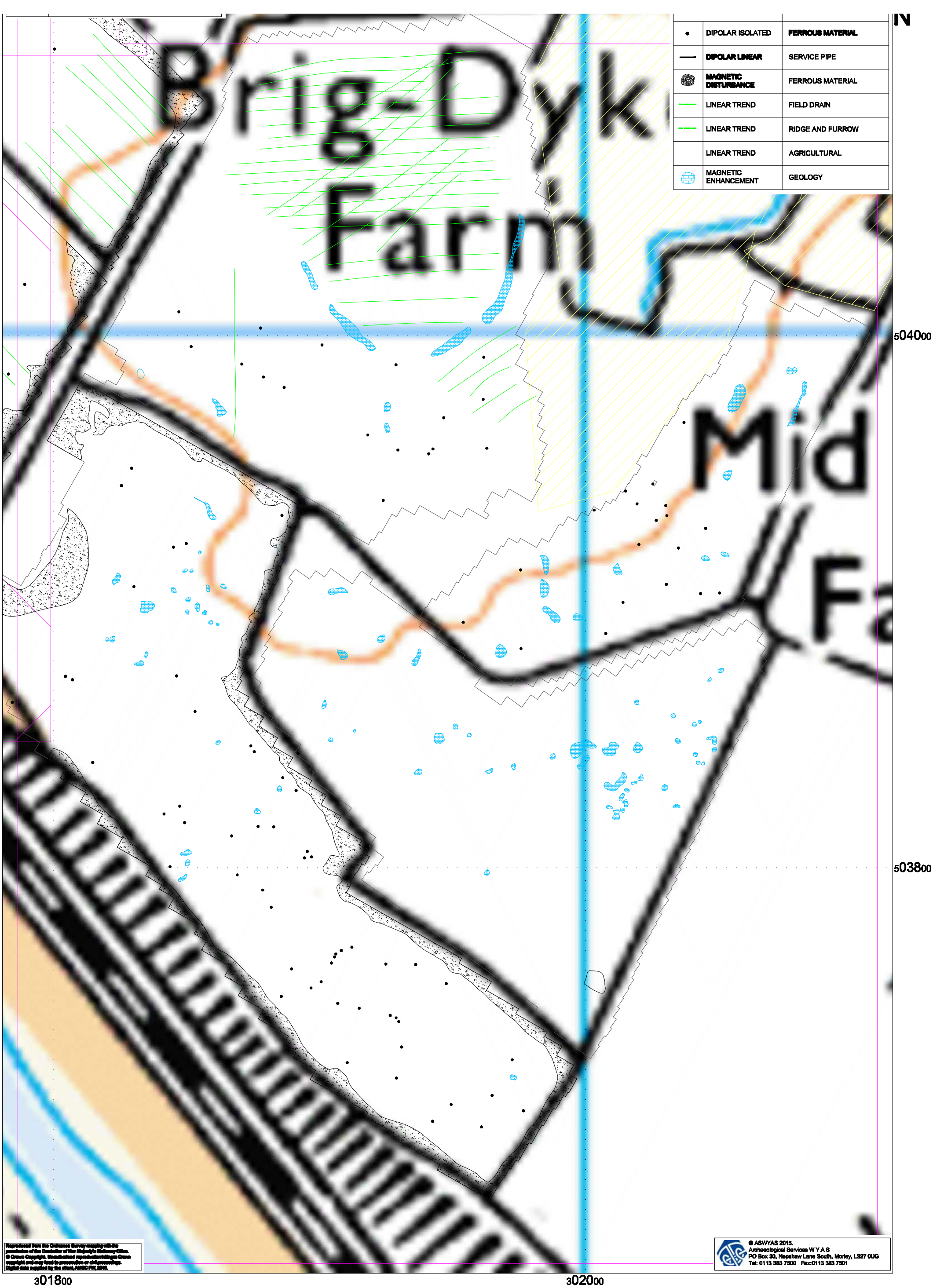

Fig. 49. Interpretation of magnetometer data; Sector 15 (1:12500 @ A3)

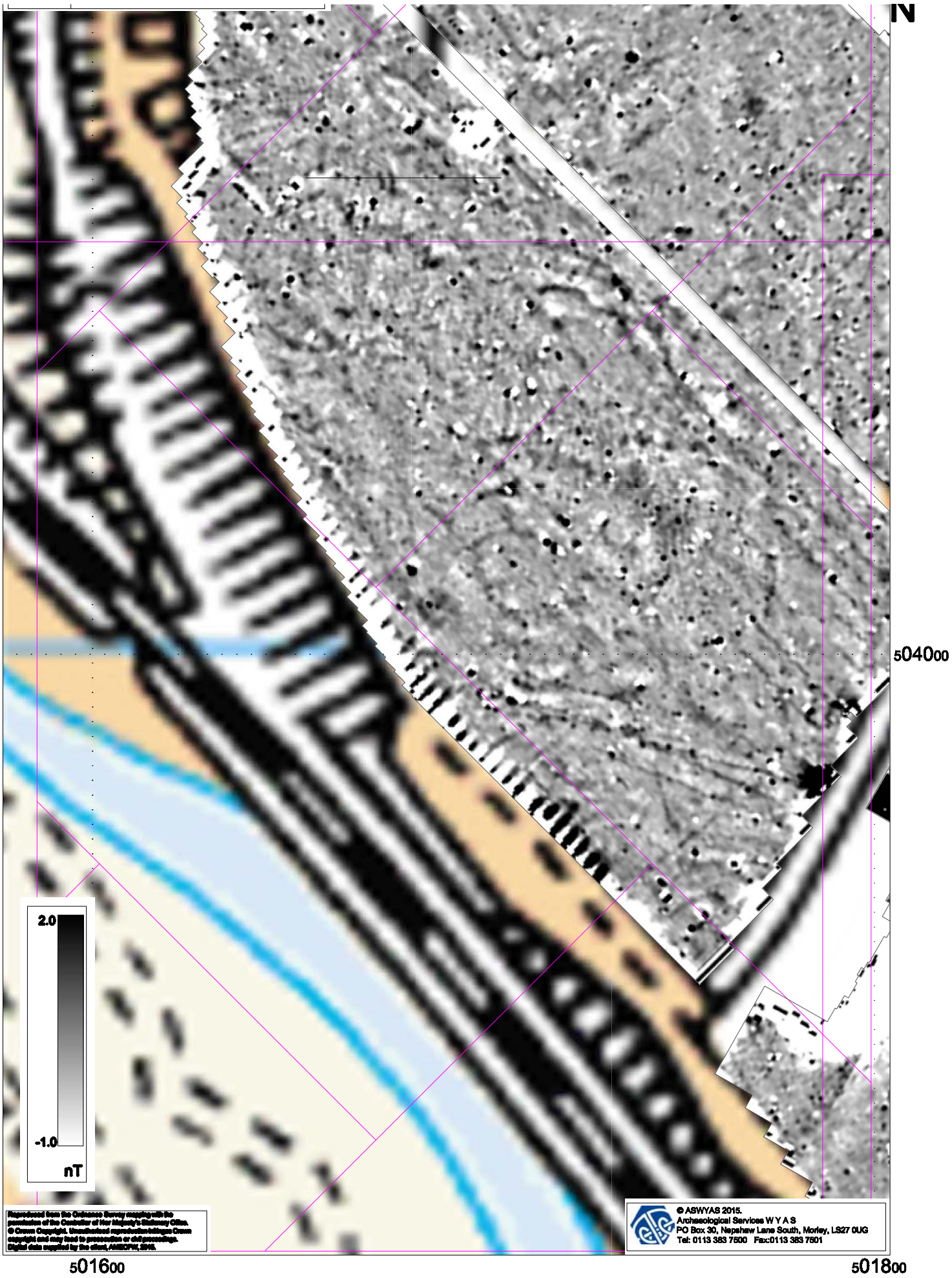

Fig. 50. Processed greyscale magnetometer data; Sector 16 (1:1250 @ A4)

Fig. 51. XY trace plot of minimally processed magnetometer data; Sector 16 (1:1250 @ A4)

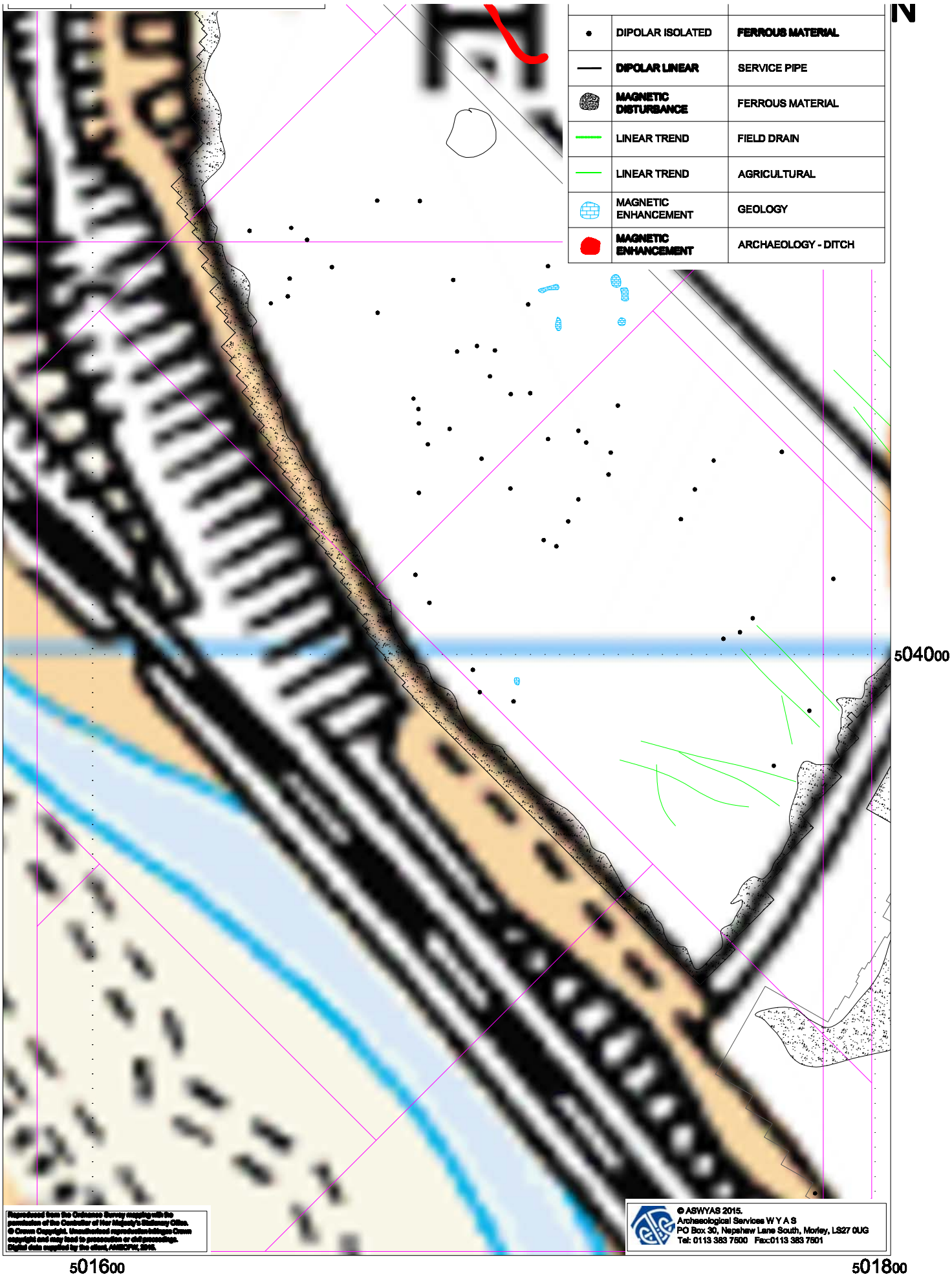

Fig. 52. Interpretation of magnetometer data; Sector 16 (1:1250 @ A4)

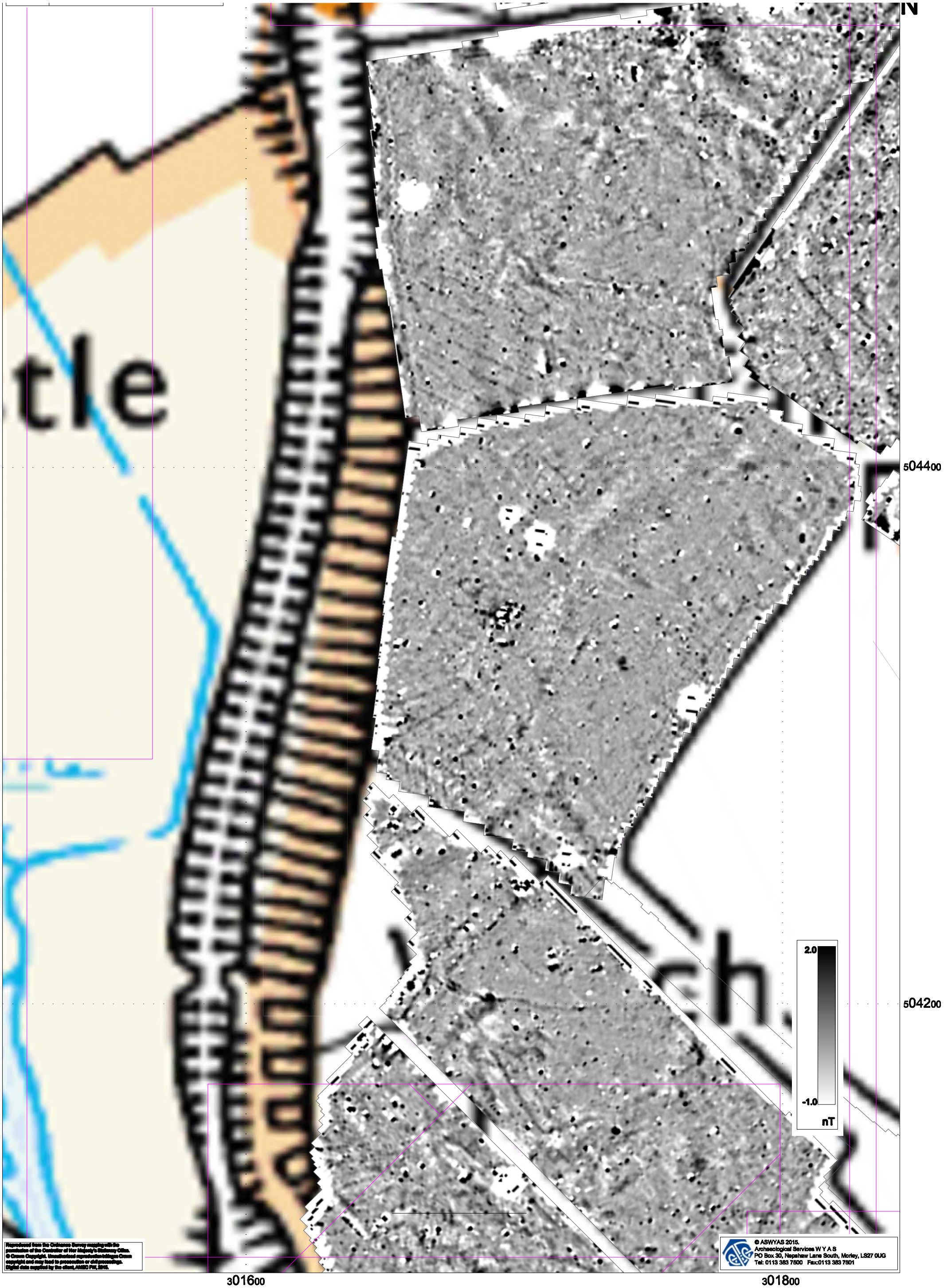

Fig. 53. Processed greyscale magnetometer data; Sector 17 (1:1250 @ A3)

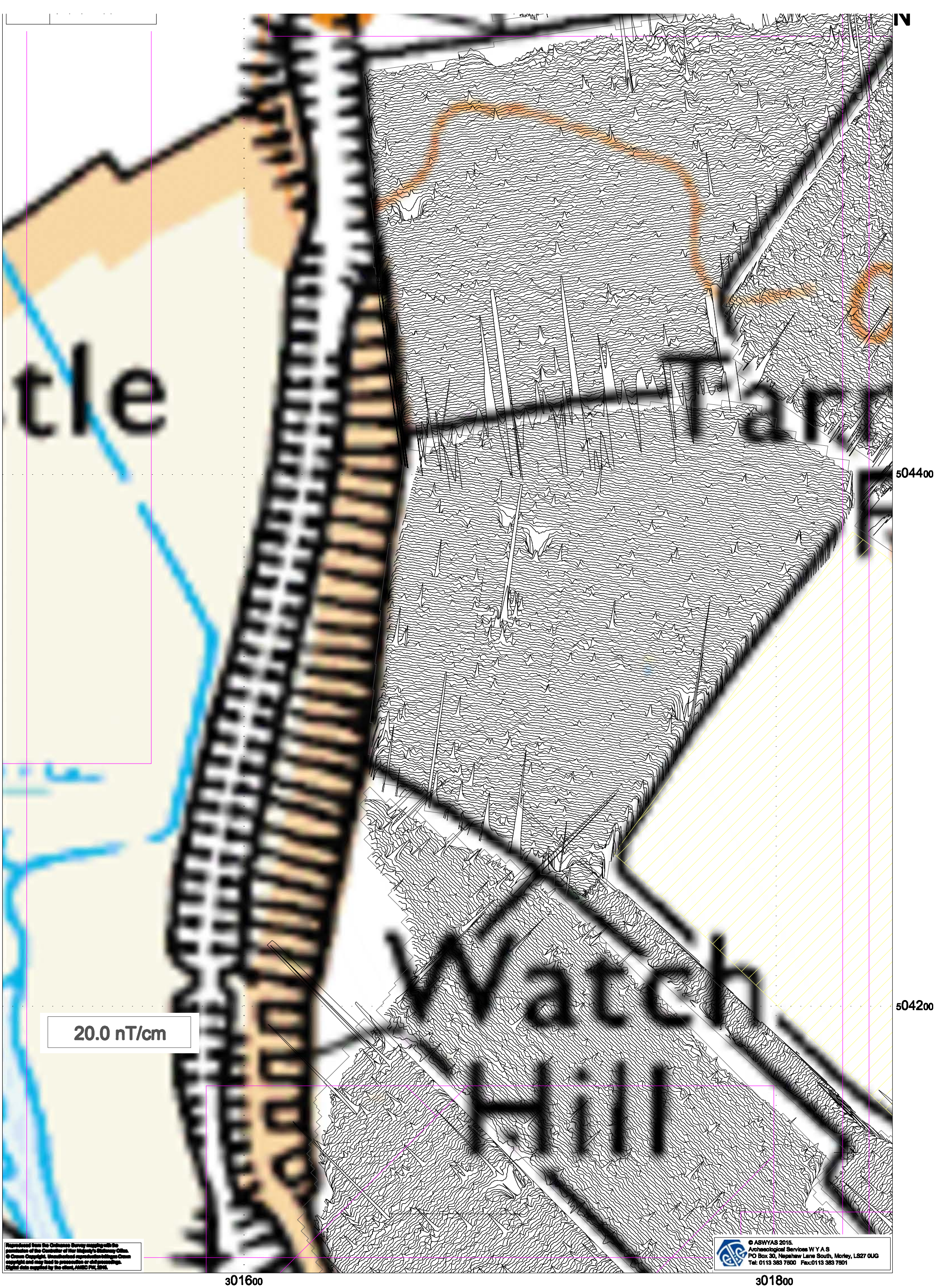

Fig. 54. XY trace plot of minimally processed magnetometer data; Sector 17 (1:1250 @ A3)

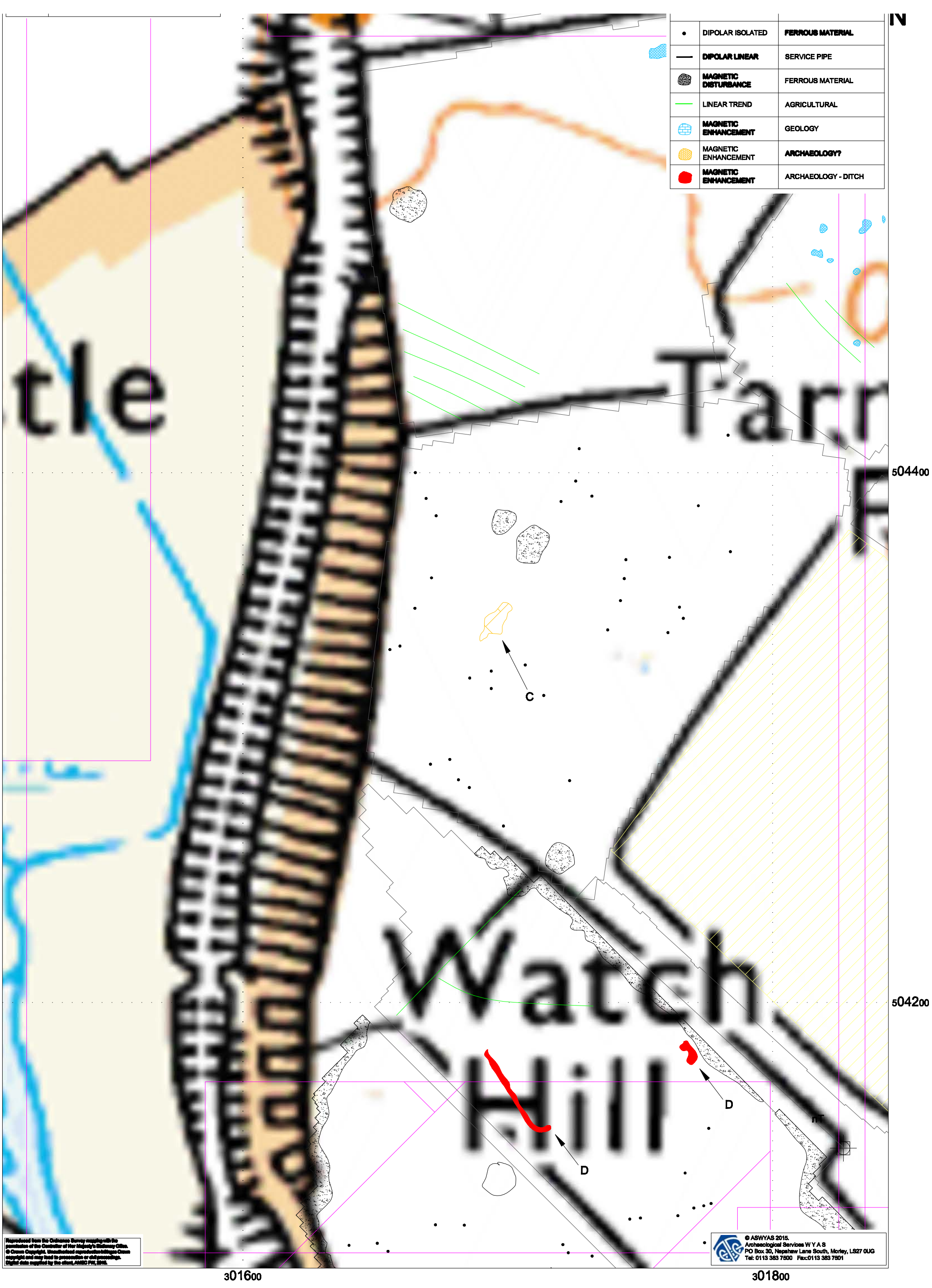

Fig. 55. Interpretation of magnetometer data; Sector 17 (1:1250 @ A3)

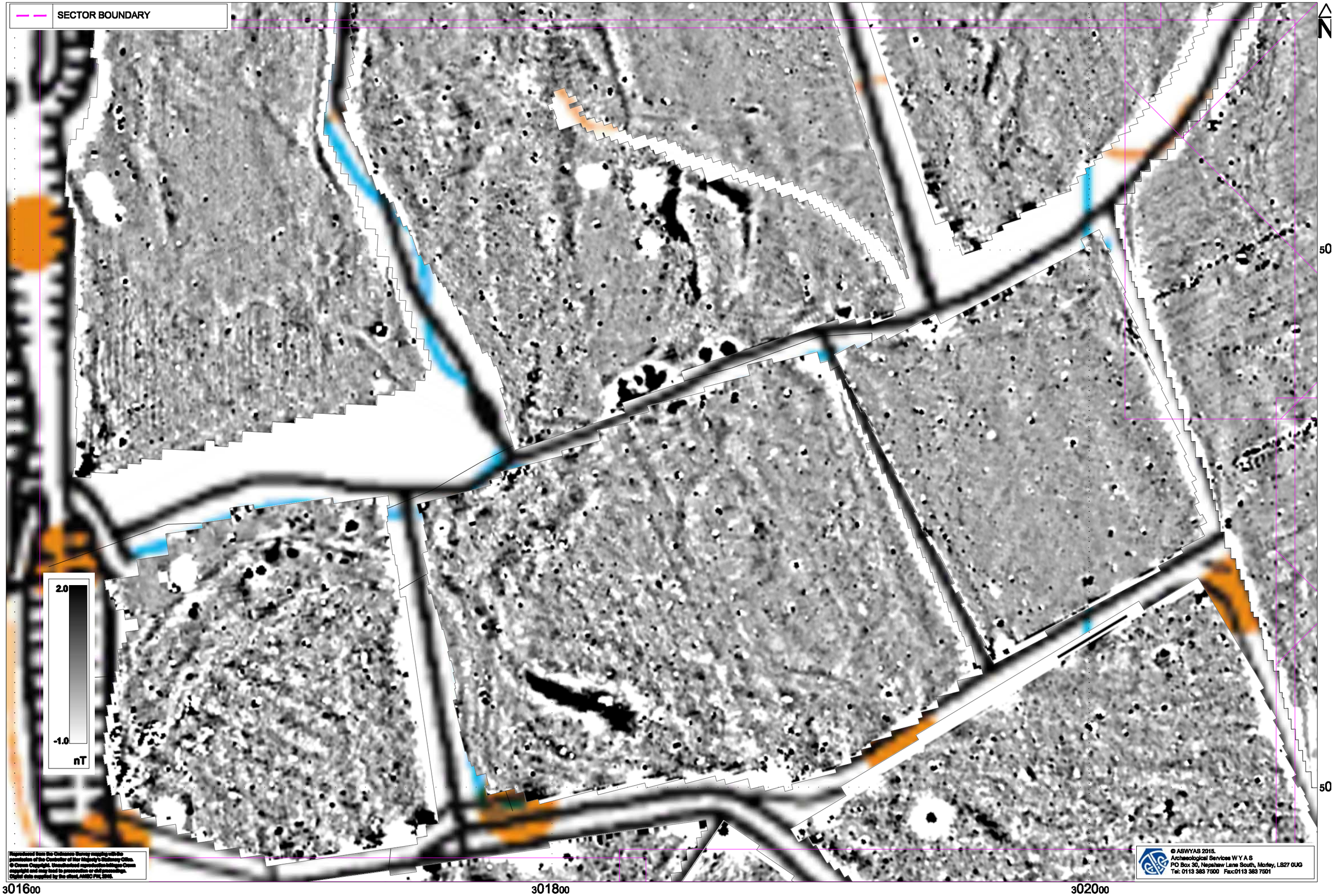

Fig. 56. Processed greyscale magnetometer data; Sector 18 (1:1250 @ A3)

SECTOR BOUNDARY

20.0 nT/cm

N

5050

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Tel: 0113 383 7500 Fax:0113 383 7501

3016000 3018000 3020000

0 50m

Fig. 57. XY trace plot of minimally processed magnetometer data; Sector 18 (1:1250 @ A3)

SECTOR BOUNDARY

TYPE OF ANOMALY		INTERPRETATION
•	DIPOLAR ISOLATED	FERROUS MATERIAL
	MAGNETIC DISTURBANCE	FERROUS MATERIAL
	LINEAR TREND	FIELD DRAIN
	LINEAR TREND	RIDGE AND FURROW
	LINEAR TREND	AGRICULTURAL

N

5050

5000

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

3016000 3018000 3020000

0 50m

Fig. 58. Interpretation of magnetometer data; Sector 18 (1:1250 @ A3)

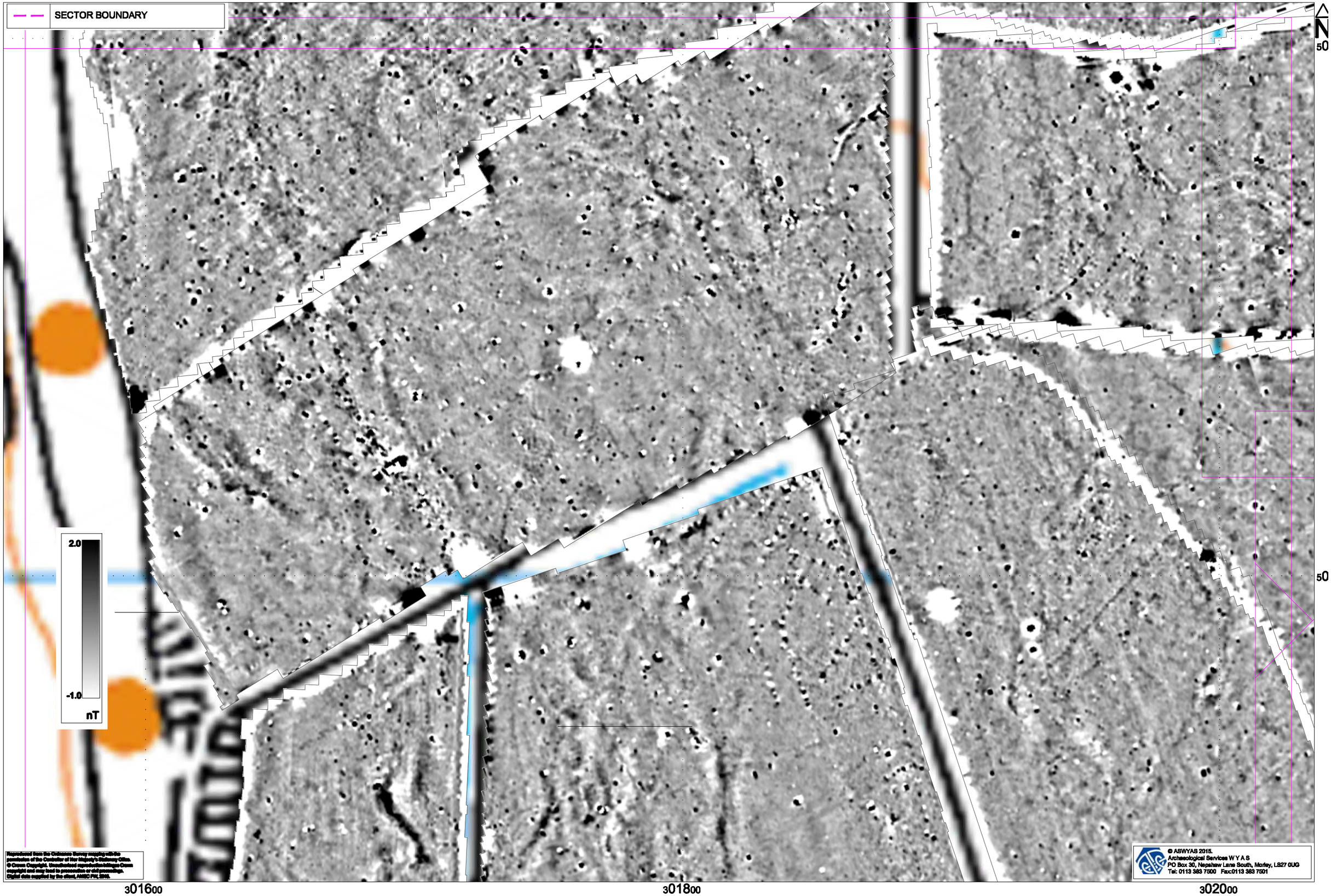

Fig. 59. Processed greyscale magnetometer data; Sector 19 (1:1250 @ A3)

SECTOR BOUNDARY

N

20.0 nT/cm

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Tel: 0113 383 7500 Fax:0113 383 7501

3016 00 3018 00 3020 00

5 0

0 50m

Fig. 60. XY trace plot of minimally processed magnetometer data; Sector 19 (1:1250 @ A3)

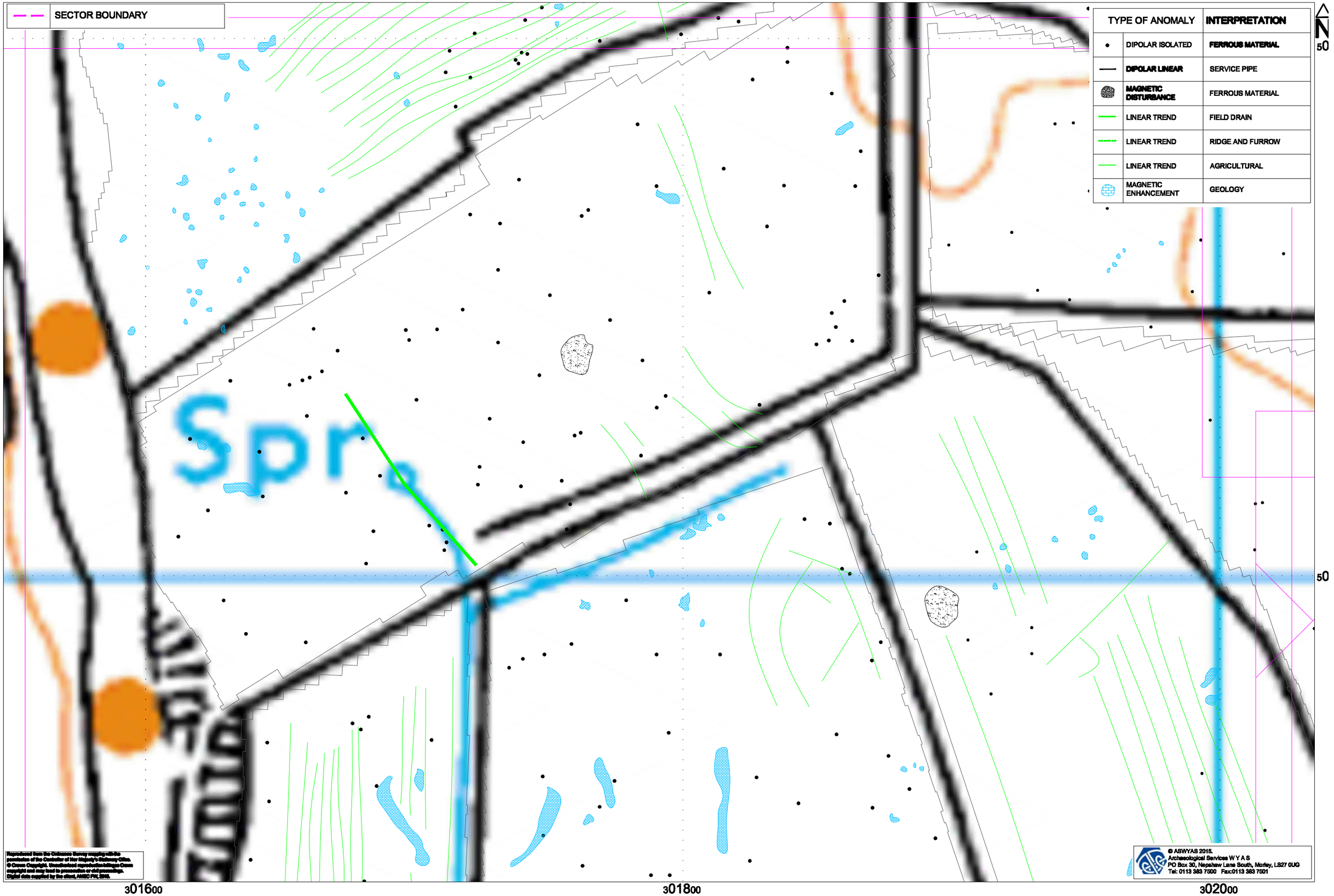

Fig. 61. Interpretation of magnetometer data; Sector 19 (1:1250 @ A3)

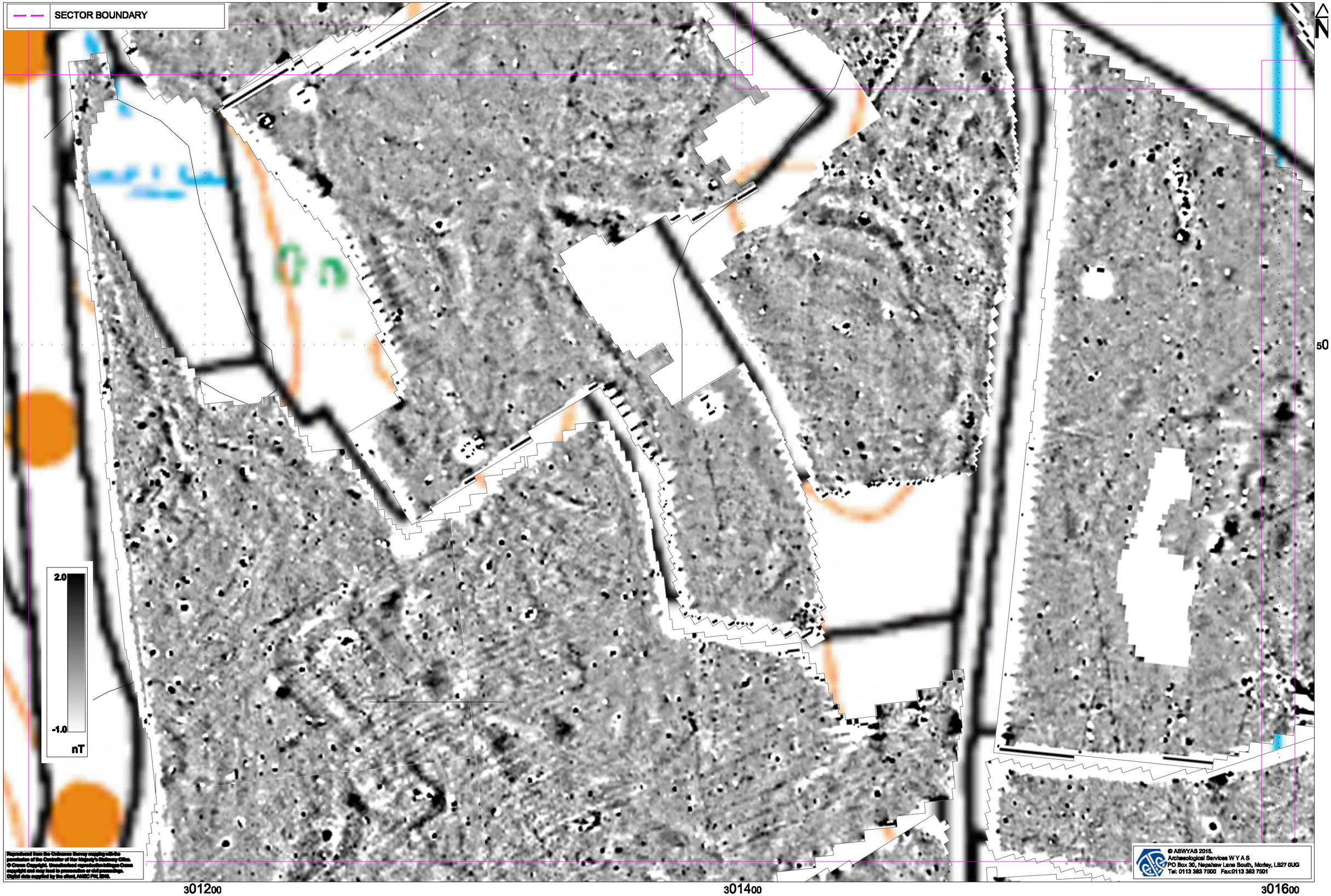

Fig. 62. Processed greyscale magnetometer data; Sector 20 (1:1250 @ A3)

SECTOR BOUNDARY

20.0 nT/cm

N

5050

3012000

3014000

3016000

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Tel: 0113 383 7500 Fax:0113 383 7501

0 50m

Fig. 63. XY trace plot of minimally processed magnetometer data; Sector 20 (1:1250 @ A3)

SECTOR BOUNDARY

TYPE OF ANOMALY		INTERPRETATION
•	DIPOLAR ISOLATED	FERROUS MATERIAL
	MAGNETIC DISTURBANCE	FERROUS MATERIAL
	LINEAR TREND	FIELD DRAIN
	LINEAR TREND	RIDGE AND FURROW
	LINEAR TREND	AGRICULTURAL
	MAGNETIC ENHANCEMENT	GEOLOGY

N

50

3012$_{00}$ 3014$_{00}$ 3016$_{00}$

0 50m

Fig. 64. Interpretation of magnetometer data; Sector 20 (1:1250 @ A3)

Fig. 65. Processed greyscale magnetometer data; Sector 21 (1:1250 @ A3)

N

5058 00

5056 00

20.0 nT/cm

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Tel: 0113 383 7500 Fax:0113 383 7501

3016 00

3018 00

0 50m

Fig. 66. XY trace plot of minimally processed magnetometer data; Sector 21 (1:1250 @ A3)

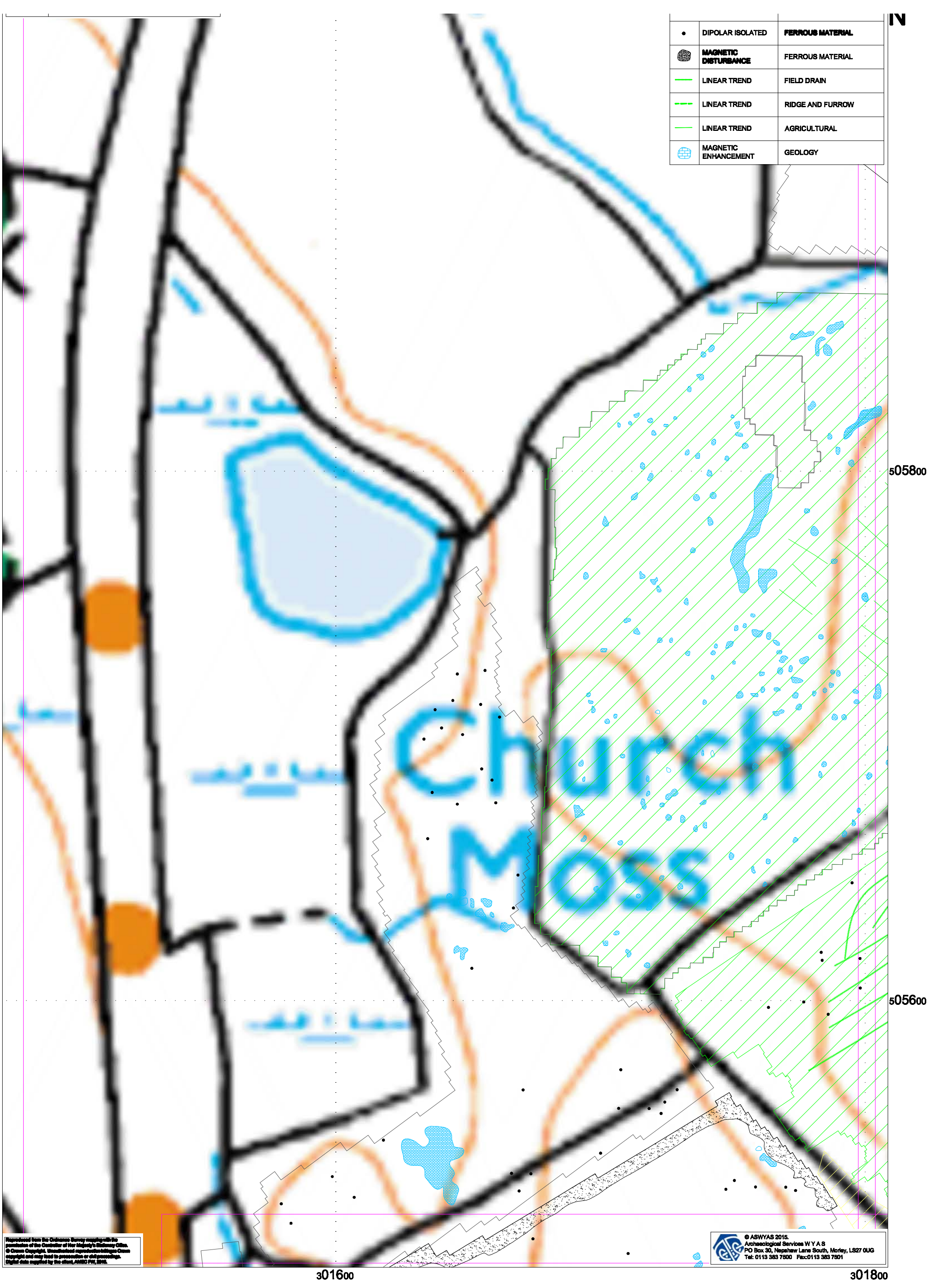

Fig. 67. Interpretation of magnetometer data; Sector 21 (1:1250 @ A3)

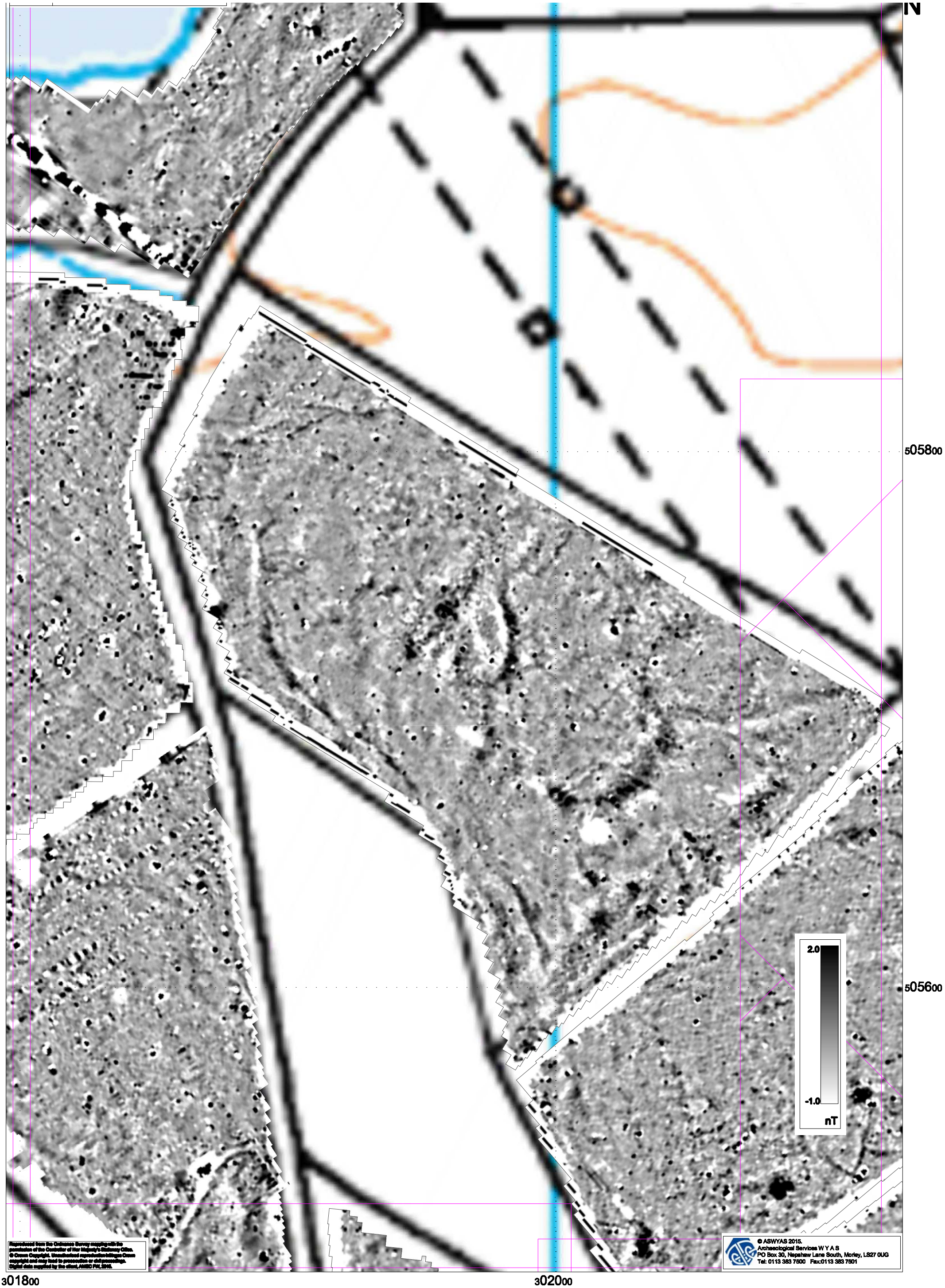

Fig. 68. Processed greyscale magnetometer data; Sector 22 (1:1250) @ A3)

Fig. 69. XY trace plot of minimally processed magnetometer data; Sector 22 (1:1250) @ A3)

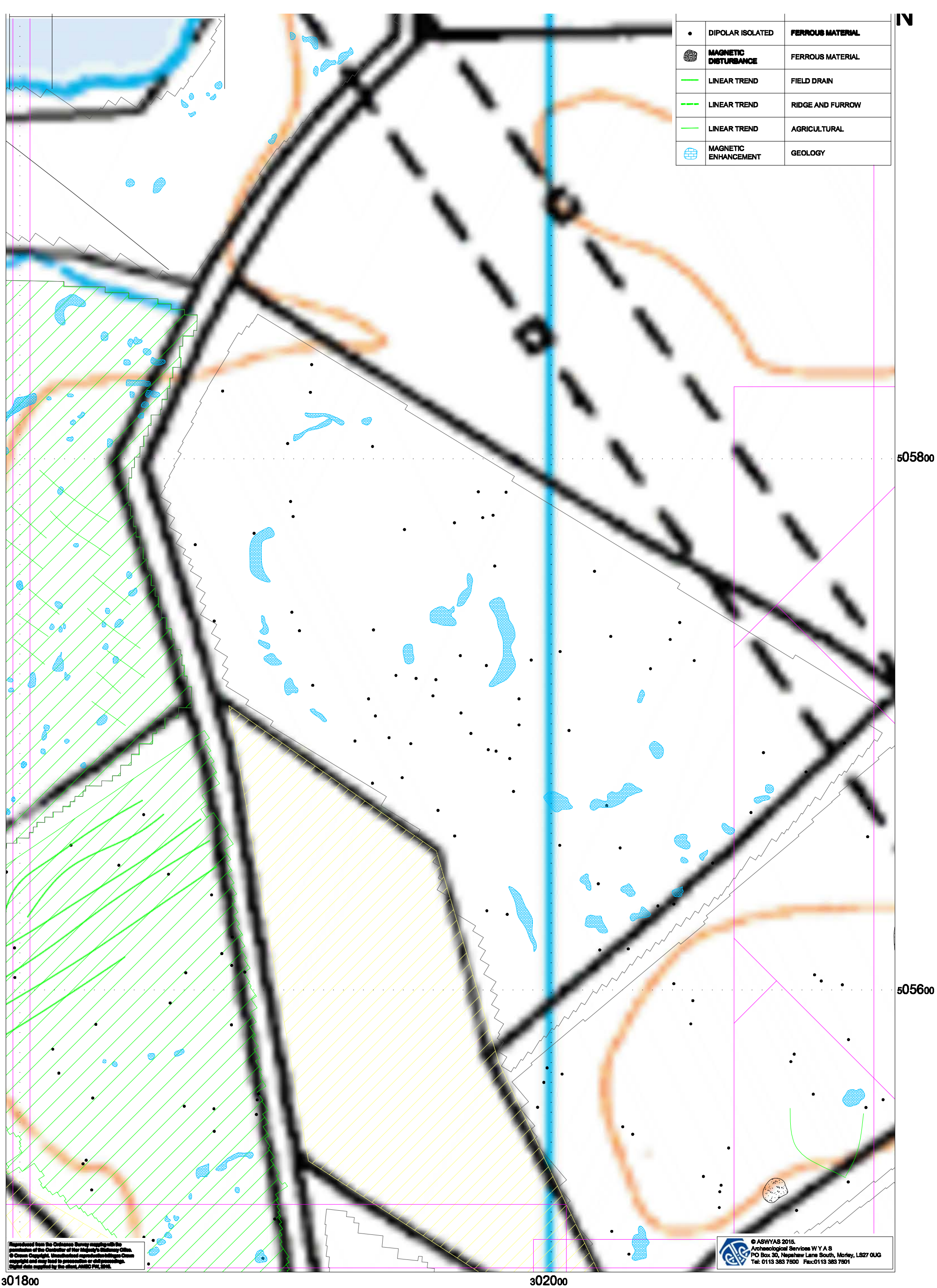

Fig. 70. Interpretation of magnetometer data; Sector 22 (1:1250) @ A3)

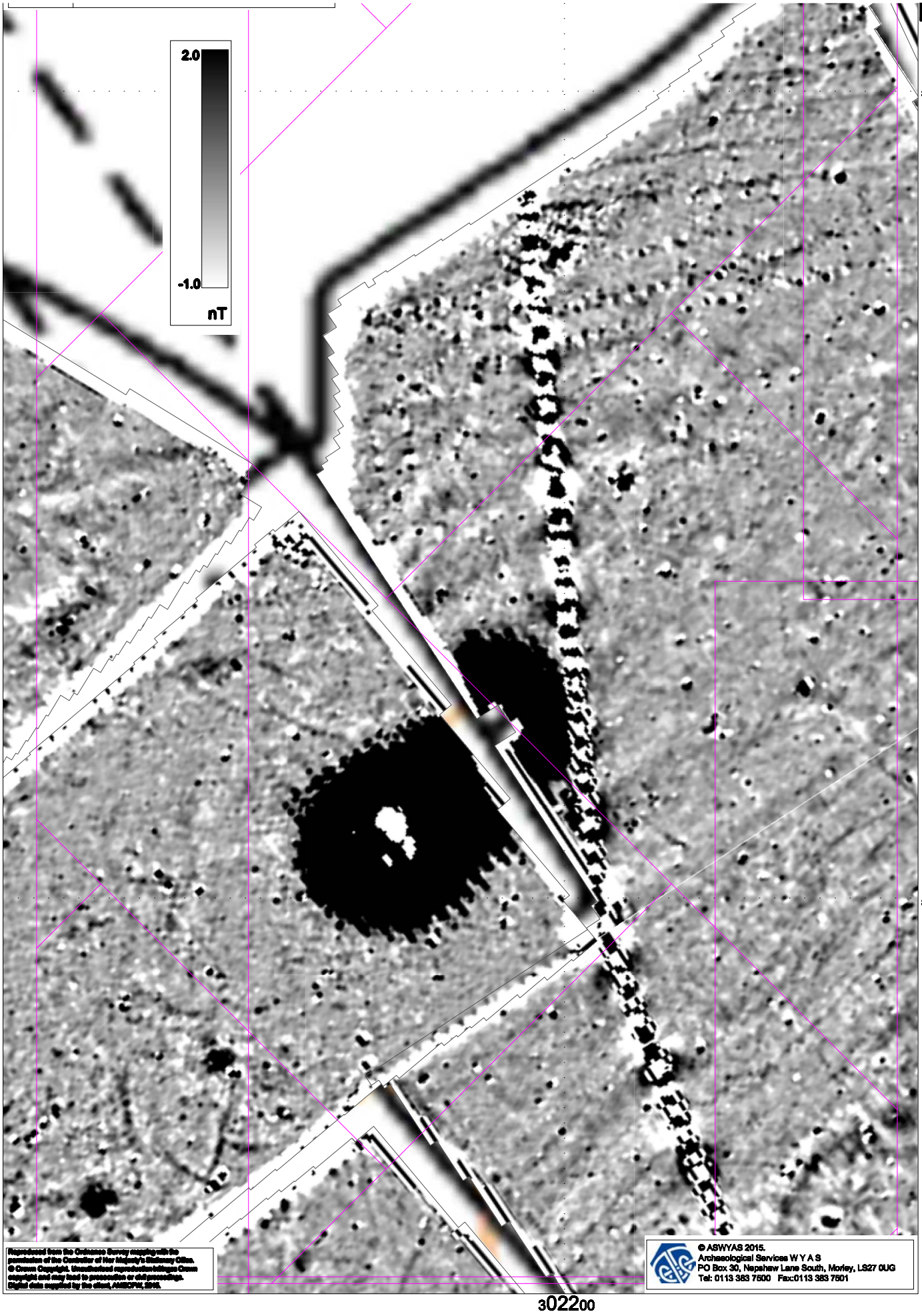

Fig. 71. Processed greyscale magnetometer data; Sector 23 (1:1250 @ A4) 0 50m

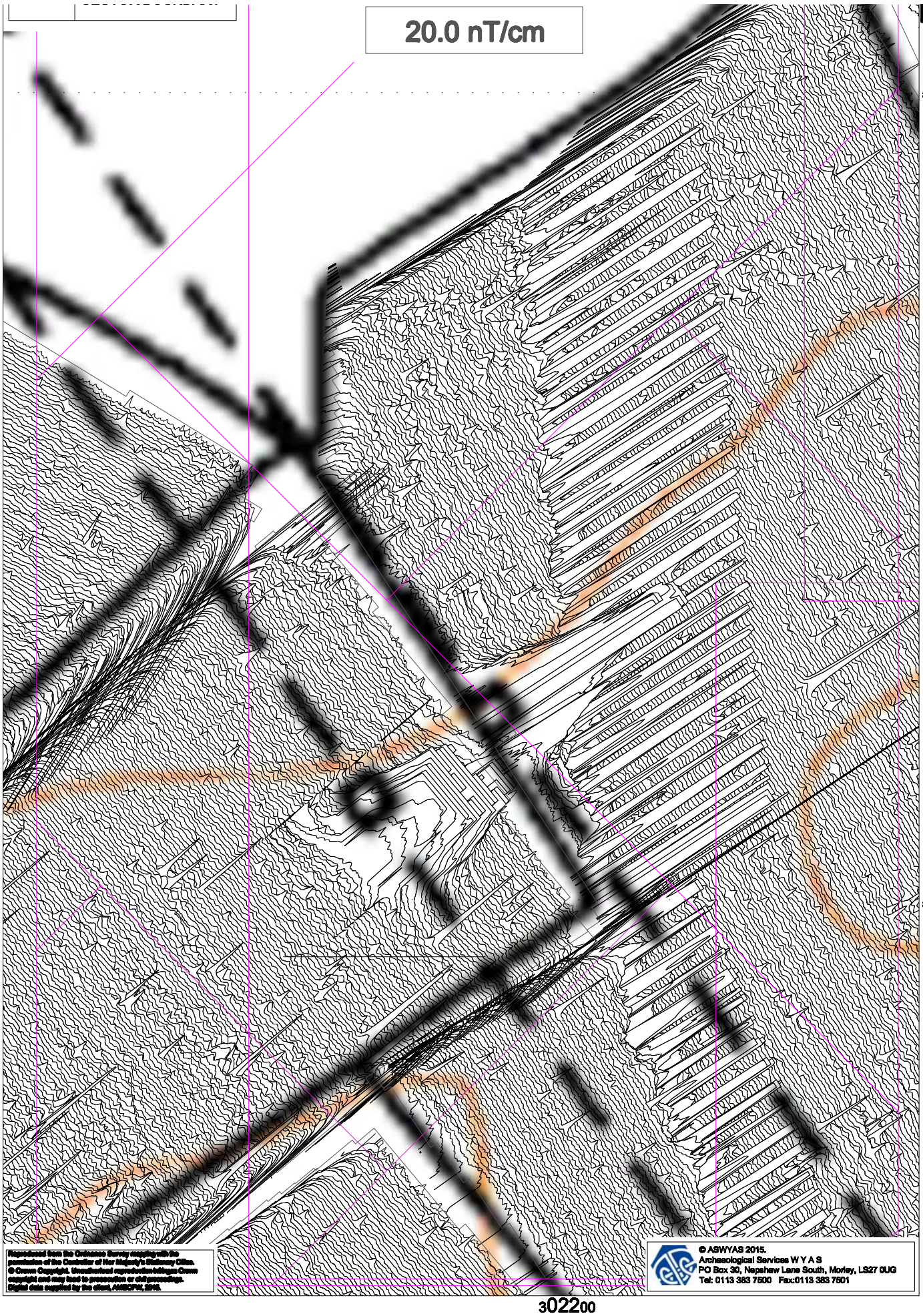

Fig. 72. XY trace plot of minimally processed magnetometer data; Sector 23 (1:1250 @ A4)

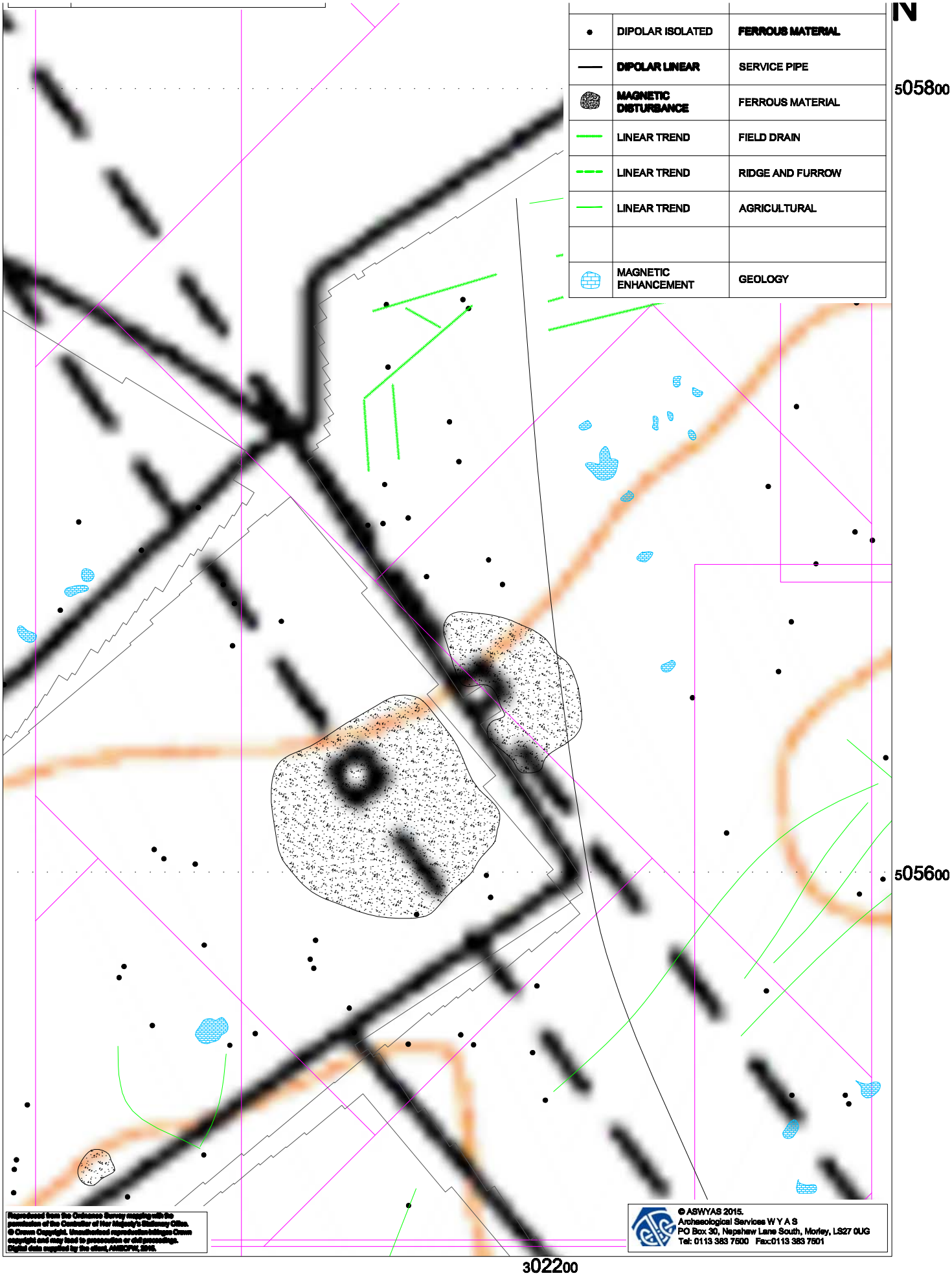

Fig. 73. Interpretation of magnetometer data; Sector 23 (1:1250 @ A4)

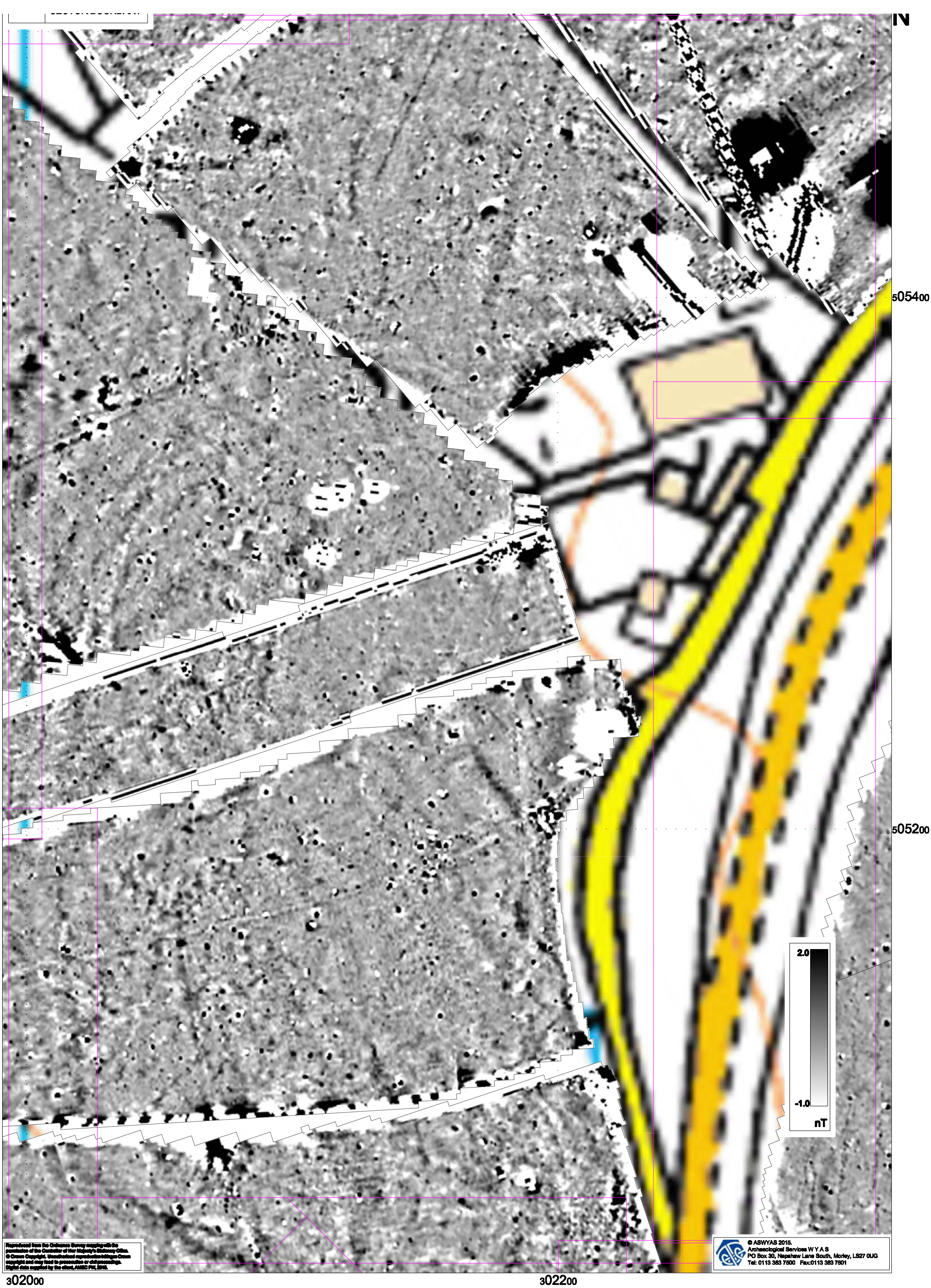

Fig. 74. Processed greyscale magnetometer data; Sector 24 (1:1250 @ A3)

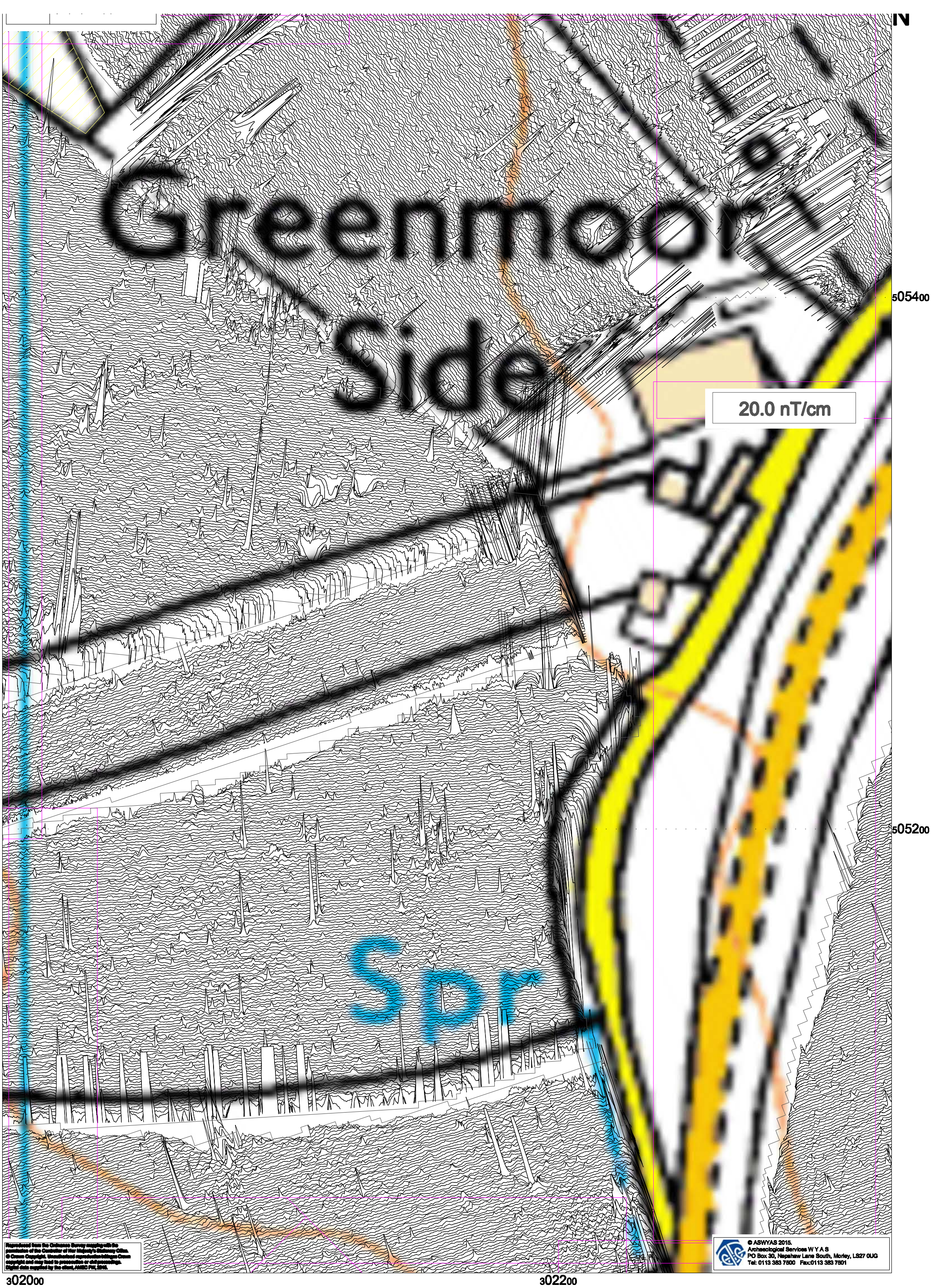

Fig. 75. XY trace plot of minimally processed magnetometer data; Sector 24 (1:1250 @ A3)

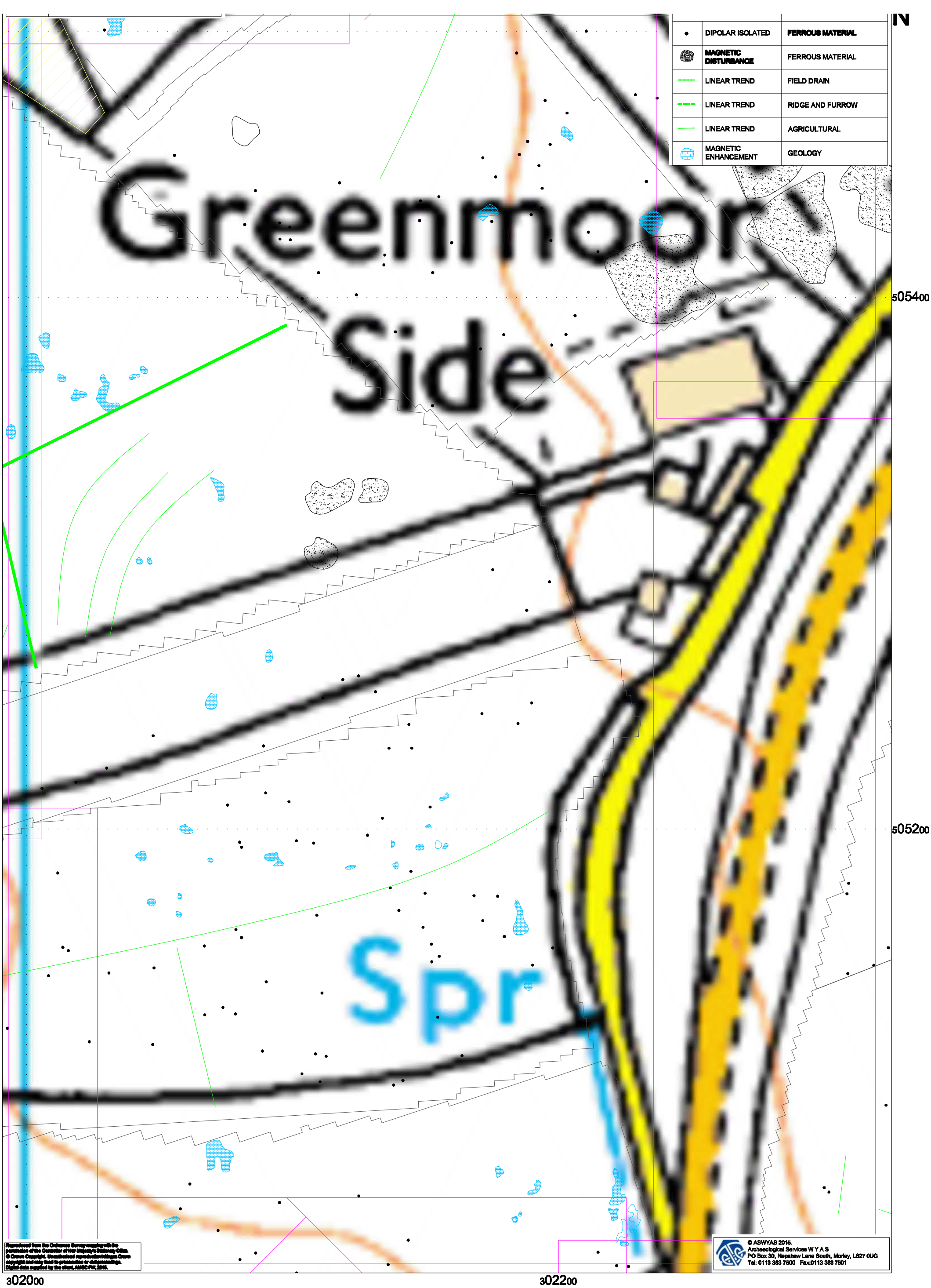

Fig. 76. Interpretation of magnetometer data; Sector 24 (1:12500 @ A3)

Fig. 77. Processed greyscale magnetometer data; Sector 25 (1:1250 @ A4)

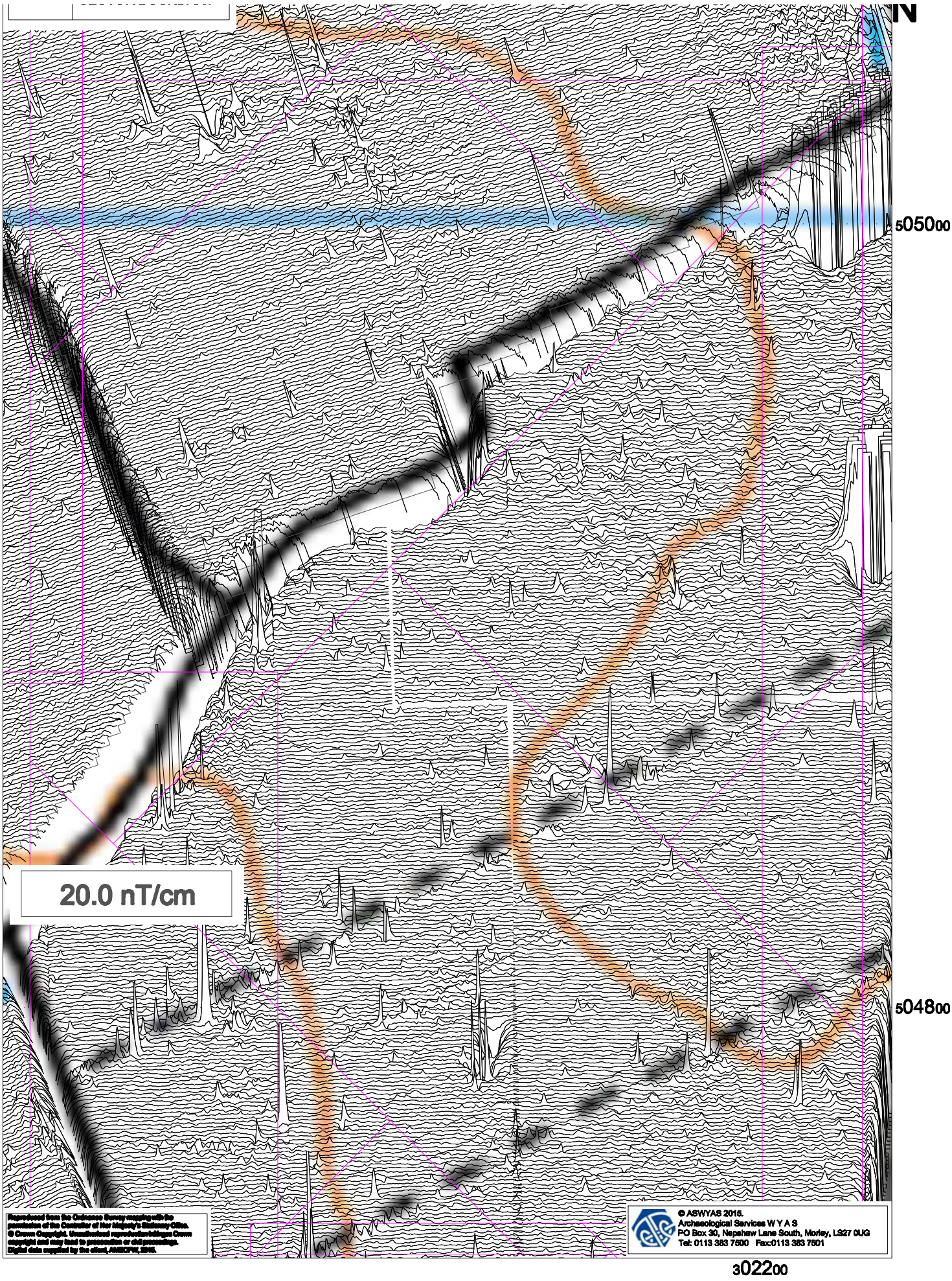

Fig. 78. XY trace plot of minimally processed magnetometer data; Sector 25 (1:1250 @ A4)

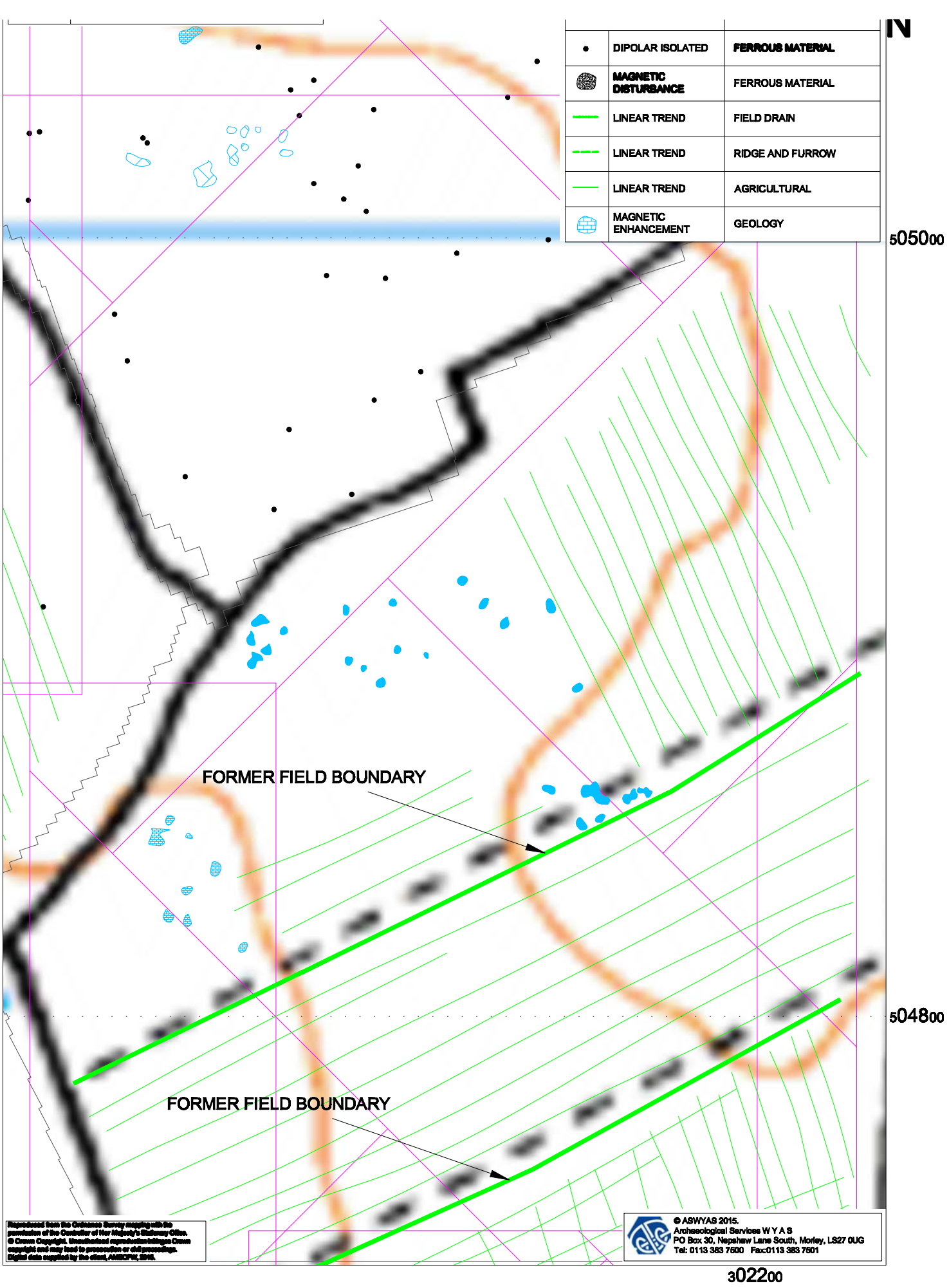

Fig. 79. Interpretation of magnetometer data; Sector 25 (1:1250 @ A4)

SECTOR BOUNDARY

N

Castle

2.0

-1.0

nT

50

Archaeological Services W Y A S
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Tel: 0113 383 7500 Fax:0113 383 7501

3012$_{00}$

3014$_{00}$

0 30m

Fig. 80. Processed greyscale magnetometer data; Sector 26 (1:1250 @ A3)

SECTOR BOUNDARY

N

Sarling

Castle

50

20.0 nT/cm

3012$_{00}$

3014$_{00}$

Fig. 81. XY trace plot of minimally processed magnetometer data; Sector 26 (1:1250 @ A3)

0 30m

Fig. 82. Interpretation of magnetometer data; Sector 26 (1:1250 @ A3)

Plate 1. General view of Area 1, looking west

Plate 2. General view of Area 5, looking north-west

Plate 3. General view of Area 14, looking south

Plate 4.General view of Area 3, looking north

Plate 5. General view of Area 31, looking north-east

Plate 6. General view of Area 63 and 64, looking north

Plate 7. General view of Area 48, looking west

Plate 8. General view of Area 17, looking north-west

Plate 9. General view of Area 38, looking south

Plate 10.General view of Area 7, looking south

Plate 11. General view of Area 13, looking west from Area 11

Plate 12. General view of Area 25 and 26, looking 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. Areas of human occupation or settlement can then be identified by measuring the magnetic susceptibility of the topsoil because 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.

Appendix 2: 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 Cambridgeshire Historic Environment Record).

Appendix 3: OASIS Form

OASIS DATA COLLECTION FORM: England

List of Projects | Manage Projects | Search Projects | New project | Change your details | HER coverage | Change country | Log out

Printable version

OASIS ID: archaeol11-226368

Project details

Project name	Project Moorside, Sellafield; Geophysical Survey
Short description of the project	A geophysical (magnetometer) survey, covering approximately 142 hectares, was carried out in fields to the south of Beckermet and north of Sellafield Nuclear Reprocessing site. This is in advance of the proposed development of the site. Anomalies indicative of recent and former agricultural practice were identified. The geology of the area has been recorded, especially where the topography of the land dramatically changes, and the topsoil thinner. This is clear to the west of the survey limits. To the south of the survey area, archaeological activity has been recorded. To the north, and the outlying parcels of land, no archaeological evidence has been detected. Therefore the archaeological potential of the site is medium around the area of Watch Hill, and low across the rest of the site.
Project dates	Start: 01-03-2015 End: 30-05-2015
Previous/future work	Not known / Yes
Any associated project reference codes	4403 - Contracting Unit No.
Type of project	Field evaluation
Current Land use	Grassland Heathland 4 - Regularly improved
Monument type	OBSERVATION POST Roman
Methods & techniques	"Geophysical Survey"
Development type	Service infrastructure (e.g. sewage works, reservoir, pumping station, etc.)
Development type	Nuclear Power Plant
Prompt	National Planning Policy Framework - NPPF
Position in the planning process	Not known / Not recorded
Solid geology (other)	Calder and Bees Sandstone Formation
Drift geology	SAND AND GRAVEL OF UNCERTAIN AGE OR ORIGIN
Techniques	Magnetometry

Project location

Country	England
Site location	CUMBRIA BARROW IN FURNESS BARROW IN FURNESS Moorside, Sellafield
Postcode	CA20 1PG
Study area	142 Hectares
Site coordinates	NY 020 042 54.423629348346 -3.510632091118 54 25 25 N 003 30 38 W Point

Project creators

Name of Organisation	Archaeological Services WYAS
Project brief originator	Self (i.e. landowner, developer, etc.)
Project design originator	Archaeological Services WYAS
Project director/manager	Harrison. D
Project supervisor	C. Sykes

Project archives

Physical Archive Exists?	No
Digital Archive recipient	Tullie House
Digital Contents	"Survey"
Digital Media available	"GIS","Geophysics","Images raster / digital photography","Survey"
Paper Archive recipient	Tullie House
Paper Contents	"Survey"
Paper Media available	"Report","Survey ","Unpublished Text"

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	Moorside Project, Sellafield, Cumbria; Geophysical Survey
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