ARCHAEOLOGICAL SERVICES WYAS

Yorkshire and Humber Carbon Capture Scheme (CCS)
Cross Country Pipeline
Camblesforth to Tollingham
East Yorkshire

Geophysical Survey

Report no. 2600

March 2014

Client: AECOM

REGISTERED ORGANISATION IfA

Yorkshire and Humber Carbon Capture Scheme (CCS) Cross Country Pipeline

Camblesforth to Tollingham

East Yorkshire Section

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering approximately 88 hectares, was carried out along the preferred route of the Camblesforth to Tollingham (East Yorkshire) section of the Yorkshire and Humber Carbon Capture Scheme (CCS) Cross Country Pipeline. A proposed Block Valve site, close to Tollingham, was also surveyed. Anomalies locating the site of a Romano-British pottery kiln have been identified at Throlam Farm and a possible trackway and circular enclosure have been identified near Brind. Despite the high archaeological potential at Welhambridge only three isolated anomalies have been ascribed a potential archaeological origin. The survey has also identified the western extent of the former World War II airfield, RAF Holme-on-Spalding-Moor. On the basis of the geophysical survey, the archaeological potential of this section of the pipeline is assessed as being low to moderate, with an area of high archaeological potential at Throlam Farm.

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Report Information

Client:	AECOM
Address:	5th Floor, 2 City Walk, Leeds, LS11 9AR
Report Type:	Geophysical Survey
Location:	Camblesforth to Tollingham
County:	East Yorkshire
Grid Reference:	SE 6693 2714 to SE 8222 3598
Period(s) of activity:	Romano-British
Report Number:	2600
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Site Code:	DVC12
OASIS ID	archaeol11-177082
Planning Application No.:	
Date of fieldwork:	November 2012 – May 2013
Date of report:	March 2014
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1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by AECOM, on behalf of their client, National Grid, to undertake a programme of geophysical (magnetometer) survey along the proposed route of the Yorkshire and Humber Carbon Capture Scheme (CCS) Cross Country Pipeline and its associated infrastructure. The proposed route runs from Drax Power Station, in North Yorkshire, to the east coast near Barmston, in East Yorkshire (see Fig. 1), a distance of 74 kilometres. The route is divided into four sections – Camblesforth to Tollingham, Tollingham to Dalton, Dalton to Skerne and Skerne to Barmston. The Camblesforth to Tollingham section crosses the county boundary between North and East Yorkshire and therefore, to allow for ease of reporting and administration purposes, this section is further subdivided into North Yorkshire and East Yorkshire sections.

This report relates to the Camblesforth to Tollingham (East Yorkshire) section, which runs from the River Ouse in a north-easterly direction until it reaches the next section near Tollingham, to the south of Holme-on-Spalding-Moor. It includes the proposed site of a Block Valve at Tollingham (see Fig. 2). During the course of the survey the route of the pipeline corridor and location and extent of infrastructure was revised. Waterlogging and access issues also restricted access in certain areas. The scheme boundary shown on all figures represents the current proposals; previous boundaries are not displayed. Any apparent ‘gaps’ in the survey or areas surveyed ‘outside’ the displayed corridor are due to the reasons outlined above. The scheme of work was undertaken in accordance with guidance contained with the National Planning Policy Framework (2012) and to a Written Scheme of Investigation (WSI), produced by AECOM and approved by North Yorkshire County Council and Humber Archaeology Partnership. The geophysical survey was carried out between November 27th 2012 and May 21st 2013.

Site location, land-use and topography

The Camblesforth to Tollingham (East Yorkshire) section starts from the River Ouse, also the county boundary, at SE 6693 2714. It runs in a north-easterly direction, skirting around Asselby and Howden until it reaches the next section at Tollingham, SE 8222 3598. The route incorporates the proposed site of a Block Valve at Tollingham, centred at SE 8213 3578 (see Fig. 2). The route crosses mixed arable farmland and is flat with the topography varying little between 4m above Ordnance Datum (aOD) at the River Ouse and 6m aOD at Tollingham. Survey was not possible within some areas of the survey corridor due to waterlogging, excessive crop growth and refused access. These areas are depicted on Figures 2 to 77 inclusive.

Geology and soils

The underlying bedrock within the south-western part of the section comprises sandstone of the Sherwood Sandstone Group which is overlain by a mixture of alluvium and glaciofluvial deposits including sands, gravels, clays and silts. This extends from the River Ouse to a geological boundary close to the B1228 road which runs north from Howden. Here, the underlying bedrock becomes Mercia mudstone overlain by superficial deposits of silty clays which are recorded in the Thorganby clay member and the Hemingborough glaciolacustrine formation. Continuing eastwards, superficial deposits of alluvium, peat and silty peaty clays are encountered at Welhambridge, where the route crosses the River Foulness. From here, as the topography begins to rise slightly towards Tollingham, clayey sand of the Bielby sand member is recorded (British Geological Survey 2013). The soils to the west of the geological boundary described above comprise a mixture of deep stoneless fine and coarse silts - marine alluvium of the Romney soil association and deep, well-drained coarse loams and sands – glaciofluvial drift of the Newport 1 soil association. East of the geological boundary, seasonally waterlogged clays and fine loams of the Foggathorpe 2 soil association extend to the River Foulness, and fine and coarse loams of the Sessay soil association are found between the river and Tollingham. At Tollingham, sandy soils of the Holme Moor soil association are recorded. (Soil Survey of England and Wales 1983).

2 Archaeological Background

The following archaeological background is summarised from draft baseline information provided by the client. A more detailed and comprehensive assessment of the archaeological background will be contained within the Environmental Impact Assessment (EIA), currently in preparation. Preliminary data from the EIA does, however, indicate more than 257 archaeological records within the Camblesforth to Tollingham search area (as entered on the North Yorkshire Historic Environment Record, Humber Archaeological Partnership Sites and Monuments Record, and the National Monuments Record). An additional six assets were identified during a review of aerial photographs, while thirty sites or find spots were recorded during an archaeological walkover survey undertaken by the client. More than half of the records relate to post-medieval activity but with a significant number (45) relating to prehistoric activity and 60 assets have been recorded as being of Roman date.

Assets dating to the pre-Iron Age period are scarce within the Camblesforth to Tollingham section. One of the few assets identified is the find spot of a Neolithic polished stone axe (CT7) which is recorded 180m north-west of the survey corridor close to the River Ouse at Middle Marsh (see Figs 3, 4 and 5). Elsewhere, a number of flints were recovered during the archaeological walkover survey (CT277, CT279 – CT284 and CT288 - see Figs 12 to 17 inclusive and 21 to 26 inclusive), and a cropmark site (CT191), identified by aerial photographs as a double-ditched feature of possible prehistoric origin, is located close to the pipeline corridor at Brind Common (see Figs 15, 16 and 17). It has been suggested that the scarcity of prehistoric assets in the Humberhead levels may be due to the post-medieval practice of warping (AECOM 2013). This practice improved the fertility of the land by allowing river water to flood onto agricultural land, depositing layers of alluvial silts (warp) and sediments, before allowing the water to drain away. Warping is known to have been applied in this area, where the high tide of the River Ouse and River Derwent made the practicalities of the process relatively simple.

The most numerous and extensive remains within the Camblesforth to Tollingham (East Yorkshire) Section appear to originate in the Iron Age and Romano-British period with a major concentration of settlement and industrial activities identified in the Welhambridge area at the eastern end of the section (AECOM, 2013). Several settlement sites have been identified as cropmarks through aerial photography, three of which fall in close proximity to the pipeline corridor in the Welhambridge/Tollingham area (CT127 – see Figs 24, 25 and 26, CT237 and CT238). In addition, approximately 17 possible Romano-British smelting sites have been recorded within the wider study area, several of which lie within the immediate vicinity of the pipeline corridor (CT116, CT118, CT120, CT124 and CT130 – see Figs 24, 25 and 26). An extensive Roman pottery production site is recorded at Throlam with at least three kilns recorded (CT141, CT143 and CT275 – see Figs 27, 28 and 29.

Early medieval heritage assets are scarce within the Camblesforth to Tollingham (East Yorkshire) Section and whilst medieval assets are numerous, few fall within close proximity of the pipeline corridor. However, a possible ringwork and associated bailey (CT64) is recorded as a cropmark 160m east of the corridor at Newsholme (see Figs 6, 7 and 8).

Several post-medieval heritage assets fall within or close to the pipeline corridor. Of particular relevance here is the extensive farmstead complex at Prickett Hill, near Brind, CT270 (see Figs 12, 13 and 14), visible as extant earthworks on aerial photographs, and the site of RAF Holme-on-Spalding-Moor, a former World War II airfield, at the proposed Block Valve site, at Tollingham (CT144 and CT271 – see Figs 27, 28 and 29).

Therefore, on the basis of the current evidence base, the application area is considered to have a moderate archaeological potential with areas of high archaeological potential in the vicinity of Welhambridge and at the eastern end of the section at Throlam.

3 Aims, Methodology and Presentation

The main aim of the geophysical survey was 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 the whole of the pipeline corridor was carried out, a total of 88 hectares.

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

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). 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 and showing the four overall sections, is shown in Figure 1 at a scale of 1:250000. Figure 2 is a large scale (1:50000) overview of the Camblesforth to Tollingham section showing the extent of the pipeline corridor and its associated infrastructure. At this scale the corridor has been divided into nine blocks. Figures 3 to 29 inclusive show the processed greyscale magnetometer data, the first edition Ordnance Survey mapping (1852 – 1855) and the overview interpretation of the data along the route at a scale of 1:5000. Detailed data plots ('raw' and processed) and full interpretative figures are presented at a scale of 1:2000 in Figures 30 to 77 inclusive with the route split into seventeen sectors. The survey area numbers were assigned prior to the fieldwork to aid communications with the client. Archaeological identifier numbers, depicted on the same figures correspond to those in the draft baseline information provided by the client.

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 archaeol11-177082.

The geophysical survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David *et al.* 2008) and by the Institute for Archaeologists (IfA 2013). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

The figures in this report have been produced following analysis of the data in 'raw' and processed formats and over a range of different display levels. All figures are presented to most suitably display and interpret the data from this site based on the experience and knowledge of Archaeological Services staff.

4 Results and Discussion (see Figs 3 to 77 inclusive)

Magnetometer Survey

The anomalies identified by the survey fall into a number of different types and categories according to their origin and these are discussed below and cross-referenced to specific examples and locations along the proposed pipeline route.

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. Ferrous debris or material is common on rural sites, often being present as a consequence of manuring or tipping/infilling. Throughout the route 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.

Clusters of ferrous anomalies coalescing into larger areas of magnetic disturbance have been identified at a number of locations, predominantly adjacent to roads, trackways, pylons, buildings, boundaries or drains. Examples include the trackways in Area 208 and Area 204, manifesting in the data as linear bands of magnetic disturbance (see Figs 33, 34 and 35), and the area adjacent to a chicken shed in Area 184 (see Figs 51, 52 and 53). These clusters are not considered to be of archaeological significance.

High-magnitude dipolar linear anomalies have been identified traversing Area 209 and Area 208 (see Figs 33, 34 and 35) and Area 197, Area 194 and Area 192 (see Figs 42, 43 and 44). These anomalies delineate the routes of service pipes. The north-east/south-west aligned linear anomaly within Area 163 (see Figs 63 to 68 inclusive) locates a culvert.

The data within Area 168 is characterised by a mass of individual 'iron spike' anomalies which results in the data having a speckled appearance (see Figs 57, 58 and 59). These anomalies are caused by the practice of spreading a mulch of organic waste across these fields. The anomalies are either due to ferrous material incorporated within the organic waste or possibly to the concentration of magnetic minerals caused by bacteria during the decomposition process. It would not be possible to identify any anomalies of archaeological origin, if present, against this magnetic background.

Modern Anomalies

Several anomalies have been identified which correspond to agricultural features depicted on early Ordnance Survey mapping. For this reason, these anomalies have been ascribed a modern interpretation, and whilst they may be of local historical interest, they are not thought to be of any archaeological significance. Several broad areas of magnetic disturbance have been identified to the north of the post-medieval farmstead at Prickett Hill in Area 188a (CT270 - see Figs 45, 46 and 47). The areas are interpreted as being modern in origin and correspond to the site of ponds, **A** and **B**, and woodland which are depicted on the first edition Ordnance Survey map (see Fig. 13). Further localised areas of magnetic disturbance, **C**, are thought to relate to demolition material associated with the farm and its outbuildings. At Brind Common, a linear band of anomalies, **D**, corresponds to a rectangular feature depicted on the first edition Ordnance Survey map (see Fig. 16).

An amorphous area of magnetic disturbance, **E**, within Area 159 (see Figs 72, 73 and 74) has been interpreted as being modern in origin. The anomaly corresponds to the corner of a field, now removed (see Fig. 28), and is likely to be due to a buried gate or trough. Further east, within Area 157 (see Figs 75, 76 and 77), a concentration of discrete low magnitude anomalies, **F**, corresponds with a structure, perhaps a barn, depicted on the first edition Ordnance Survey map (see Fig. 28).

An abundance of high magnitude ferrous and modern anomalies have been identified throughout the proposed Block Valve Site at Tollingham, (Area 156 - see Figs 75, 76 and 77). Ordnance Survey mapping of 1972 indicates that this site corresponds with the western extent of RAF Holme-on-Spalding-Moor, a former World War II airfield, containing buildings and roads/trackways (Old-Maps 2013). Although the land has been remediated and returned to agricultural production, there is obviously still a significant quantity of magnetic material, such as concrete and brick, incorporated into the soil horizons.

Broad magnetic anomalies, **G**, **H**, **I** and **J**, correspond to former buildings depicted on the Ordnance Survey mapping and these anomalies are likely to be due to demolition material and *in situ* building remains. Fragmentary linear anomalies, **K**, **L** and **M**, correspond to former roads. Several large individual ferrous ‘spikes’, **N**, are clearly visible across the proposed Block Valve Site. The exact origin of these spikes is unclear. It is possible that they are due to footings for supporting airfield apparatus. However, the possibility that these anomalies may be due to military ordnance cannot be dismissed (see below).

Data reviewed from the Airfield Information Exchange (AIE 2013) suggests that this part of RAF Holme-on-Spalding-Moor may have been used for bomb storage. It is possible that some of these ferrous responses could be caused by small arms munitions or larger ordnance. No assurance can be given, or should be inferred, from the fact that none of these ferrous *responses has been ascribed a military origin. It is not possible for the technique and methodology used during this survey to discriminate the cause of individual ferrous responses nor indicate the depth at which the objects causing such a response may be buried.*

Agricultural Anomalies

Faint parallel linear trend anomalies have been identified in most sections of the survey corridor. The most numerous trend anomalies are caused by ploughing. The close spacing between these anomalies are typical of modern ploughing. One area containing broader and slightly curving trend anomalies has been identified in Area 207 (see Figs 33, 34 and 35), and is interpreted as being due to the medieval and post-medieval practice of ridge and furrow ploughing. In this case the anomalies are caused by the magnetic contrast between the infilled furrows and former ridges.

Over the last 150 years the size of the fields has been increased by the removal of many of the boundaries shown on the first edition Ordnance Survey map; these boundaries are indicated on the 1:5000 overview figures (see Figs 4, 7, 10, 13, 16, 19, 22, 25 and 28). Of the 52 former field boundaries within the pipeline corridor, only 18 have been identified in the geophysical survey, generally as weakly magnetised linear trends. Such trends are exemplified by the north/south aligned linear trend within Area 204 (see Figs 39, 40 and 41) and the faint linear trend, orientated north-west/south-east in Area 157 (see Figs75, 76 and 77). The exact reasons why the majority of the former field boundaries have not been detected by the geophysical survey are uncertain. Some may have been removed by later agricultural activity whereas others may be masked by the post-medieval practice of warping such as the former boundary in Area 214 (see Fig. 4). Other boundaries are masked by later trackways and service pipes such as the former field boundary within Area 209 (see Fig. 4). However, it is likely, given the mixed superficial deposits of silt, peat and alluvium, that there exists a low magnetic contrast between cut features, such as the soil-filled former boundary ditches, and the surrounding soils and alluvium deposits. Therefore, it is possible that low magnitude, discrete archaeological anomalies, may remain undetected. This interpretation is given further credence given the frequent occurrence of field drains, manifesting as widely spaced linear trend anomalies, throughout the Camblesforth to Tollingham (East Yorkshire) section. This frequency would tend to suggest that the land is susceptible to seasonal waterlogging. It is considered likely, therefore, that there will be numerous other drains that the survey has not identified.

Geological Anomalies

A relatively uniform magnetic background has been identified across the majority of the Camblesforth to Tollingham (East Yorkshire) section, and therefore few anomalies have been ascribed a geological origin. Three areas of clear geological variation are visible in the data, each manifesting as a dense concentration of high magnitude amorphous anomalies - Areas 214 – 210 (see Figs 30 to 35 inclusive), Area 194 and Area 195 (see Figs 39 to 44 inclusive) and Area 164 (see Figs 63, 64 and 65). The anomalies are interpreted as being due to areas of alluvium and magnetically enhanced silts being deposited over lower-lying areas following episodes of flooding. It is worth considering here that the magnetometer detects anomalies up to a depth of approximately 1m and that the continuous build up of alluvial deposits may result in discrete anomalies of archaeological potential remaining beyond detection. Within Area 199 another cluster of anomalies have been ascribed a geological origin (see Figs 36, 37 and 38). These anomalies are largely contained within the existing field boundary and are likely to be due to the sandy superficial deposits being disturbed by a deeper ploughing regime.

Elsewhere, occasional discrete anomalies of varying magnitude have been identified which have been assigned a geological interpretation. These are thought to be due to natural variations in the composition and depth of soil.

Unknown Anomalies

Within Area 182 a high magnitude anomaly, **O**, and a cluster of discrete anomalies, **P**, have been identified (see Figs 51, 52 and 53). The origin of these anomalies is unclear. Whilst they are located close to the corner of a former field depicted on the first edition Ordnance Survey map (see Fig. 16), and therefore may relate to modern agricultural activity, an archaeological origin cannot be discounted. A possible archaeological site has been identified 134m to the west (Site 1 - see below) and therefore these anomalies may be of interest.

Possible Archaeological Anomalies

Site 1 (see Figs 51, 52 and 53)

Within Area 183 a site of archaeological potential has been identified centred at SE 7465 3135. The site consists of a possible trackway, **Q**, visible as two faint parallel trends, and a possible circular enclosure, **R**, 15m in diameter and manifesting as a fragmented circular anomaly. Interpretation of the site is tentative as the possible trackway is not visible in the data within either of the adjacent fields, and the possible enclosure is located close to a field boundary, a modern track and a broad area of modern magnetic disturbance. Nevertheless, the form and magnitude of the anomalies are suggestive of archaeological origins and are therefore worthy of further investigation.

Welhambridge Area

Three anomalies of possible archaeological potential have been identified at Welhambridge in close proximity to possible enclosures, a trackway and a roundhouse (CT127) visible as cropmarks on aerial photographs, and to a Romano-British iron smelting site (CT130). None are of clear archaeological potential but, given the local archaeological context, an archaeological interpretation is ascribed. A high magnitude cross-shaped anomaly, **S**, is clearly visible within Area 162a (see Figs 68, 68 and 69), centred at SE 8012 3436. The anomaly is aligned parallel with, and at right angles to, existing and historical field boundaries and may therefore be agricultural in origin. However, the high magnitude of the anomaly is suggestive of burning and it is possible that industrial activity is represented here. Linear anomalies **T** and **U** are isolated and weakly defined and may indicate agricultural features such as field drains. However, an archaeological origin is considered possible.

Archaeological Anomalies

Site 2 (see Figs 75, 76 and 77)

One site of obvious archaeological potential has been identified at Throlam, centred at SE 8210 4355. The site corresponds to AECOM Archaeology Identifier Number CT143 (Throlam Farm Romano-British pottery kilns) and to a dense concentration of greyware pottery which was observed during the course of the survey. The site is centred upon a cluster of high magnitude anomalies, **V**, which are suggestive of intense episodes of burning. The exact location of the kiln(s) itself is not decipherable within the cluster of anomalies. Anomalies indicating possible ditches and ancillary features, **W**, have been identified to the north of the kiln site, and to the west, numerous discrete areas of magnetic enhancement are thought to relate to plough-damaged material, including pottery.

5 Conclusions

As well as the ubiquitous anomalies caused by ploughing trends, drains, ferrous scatters and former field boundaries the geophysical survey has identified two separate sites of archaeological potential within the pipeline corridor (Site 1 and Site 2). Relatively few other anomalies of archaeological potential have been identified throughout the length of the corridor. Tentatively, anomalies of archaeological potential have been identified at Welhambridge, although this interpretation is given more credence from the archaeological potential of the surrounding landscape than from the clarity of the identified anomalies.

Elsewhere, several anomalies have been identified as being modern in origin including the post-medieval farmstead at Prickett Hill, and the multitude of anomalies at the site of RAF Holme-on-Spalding-Moor.

The majority of the former field boundaries depicted on first edition mapping have not been detected by the survey, suggesting a low magnetic contrast between the cut features and the surrounding soils and alluvium deposits. This raises the possibility that low magnitude anomalies of archaeological potential may remain beyond the detection of the magnetometer. However, on the basis of the geophysical survey, the archaeological potential within the Camblesforth to Tollingham (East Yorkshire) section is assessed as being low to moderate, with an area of high archaeological potential at Throlam Farm.

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

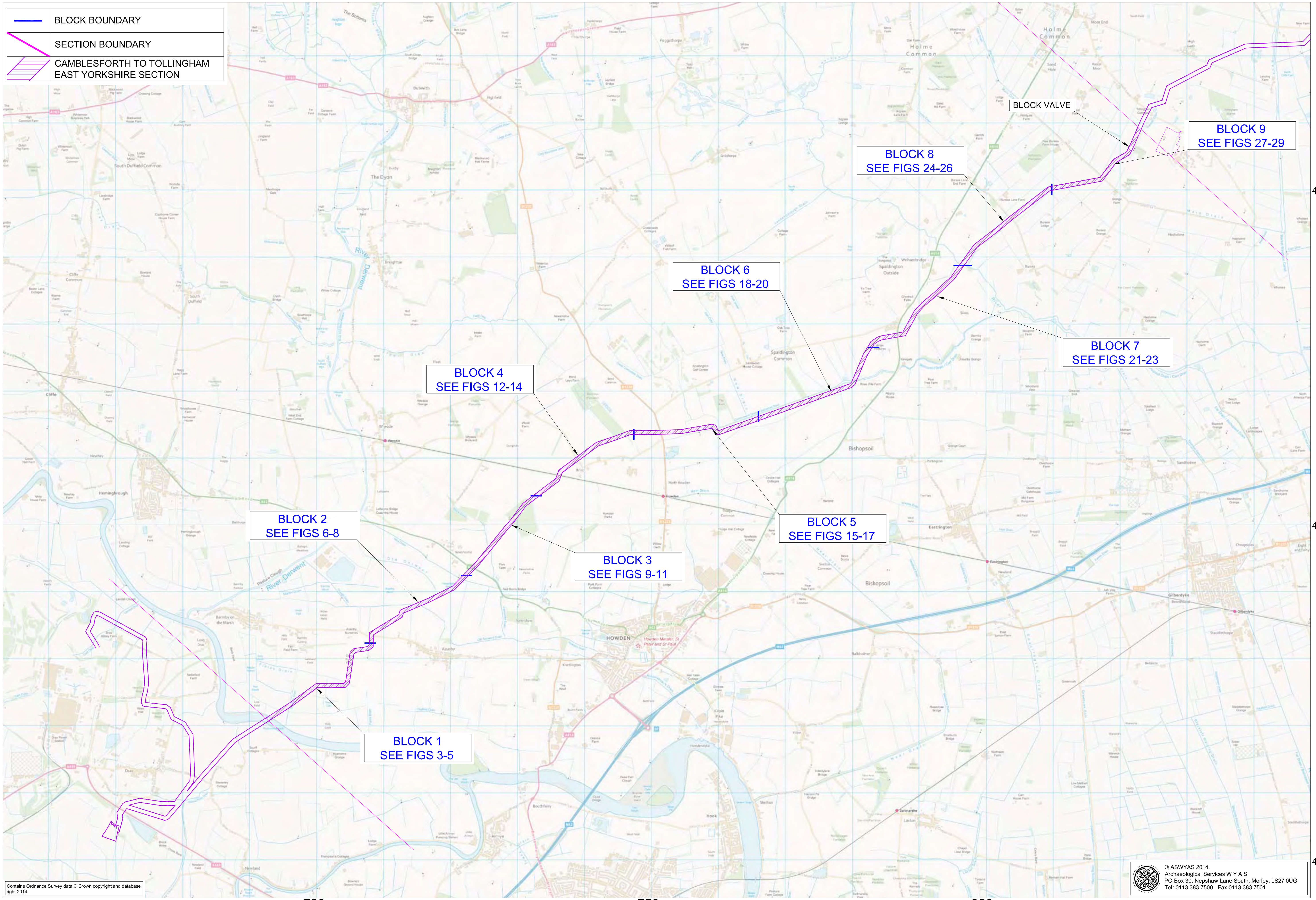

Fig. 2. Overview of survey location showing blocks (1:50000 @ A3)

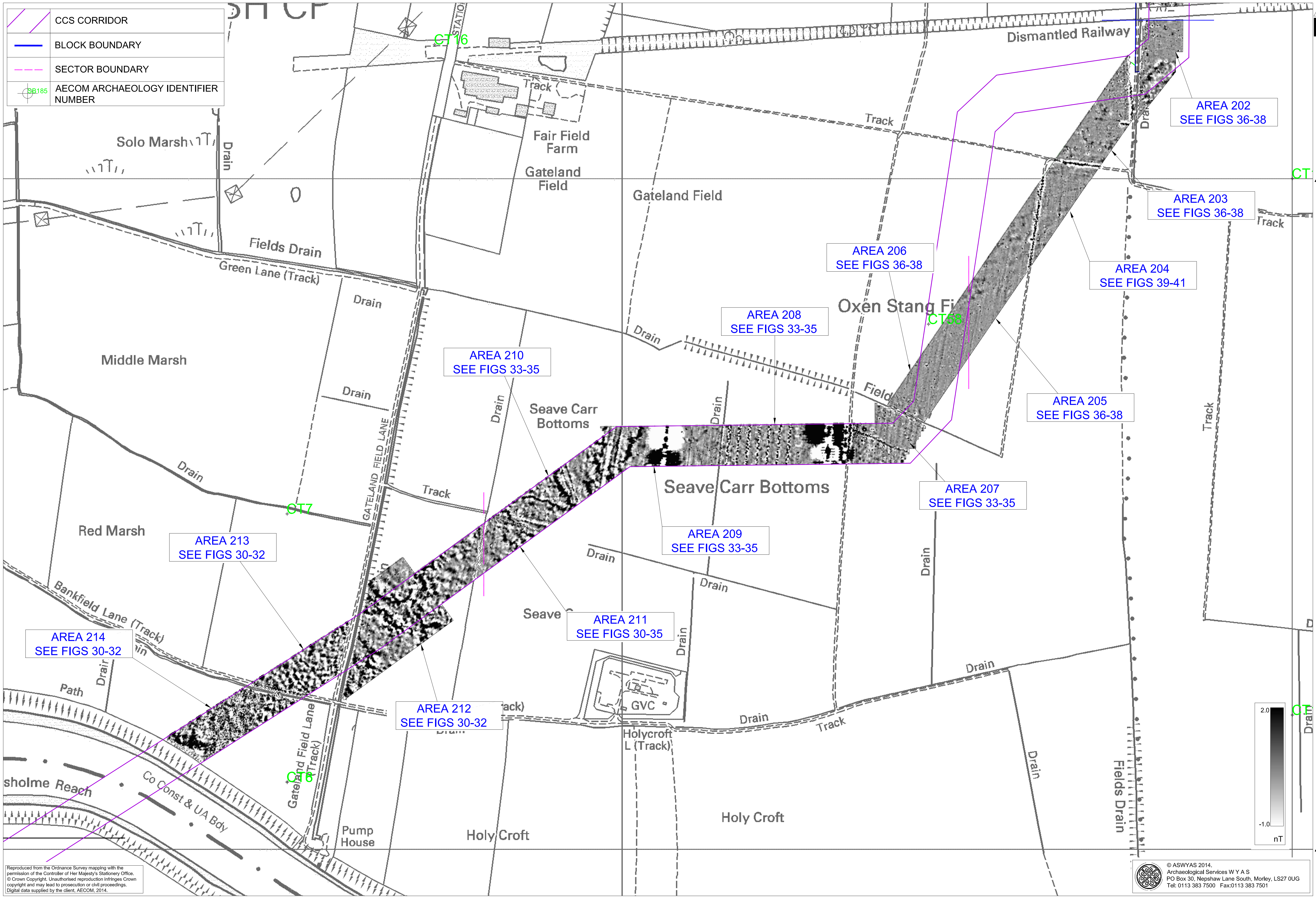

Fig. 3. Processed greyscale magnetometer data; Block 1 (1:5000 @ A3)

0 100m

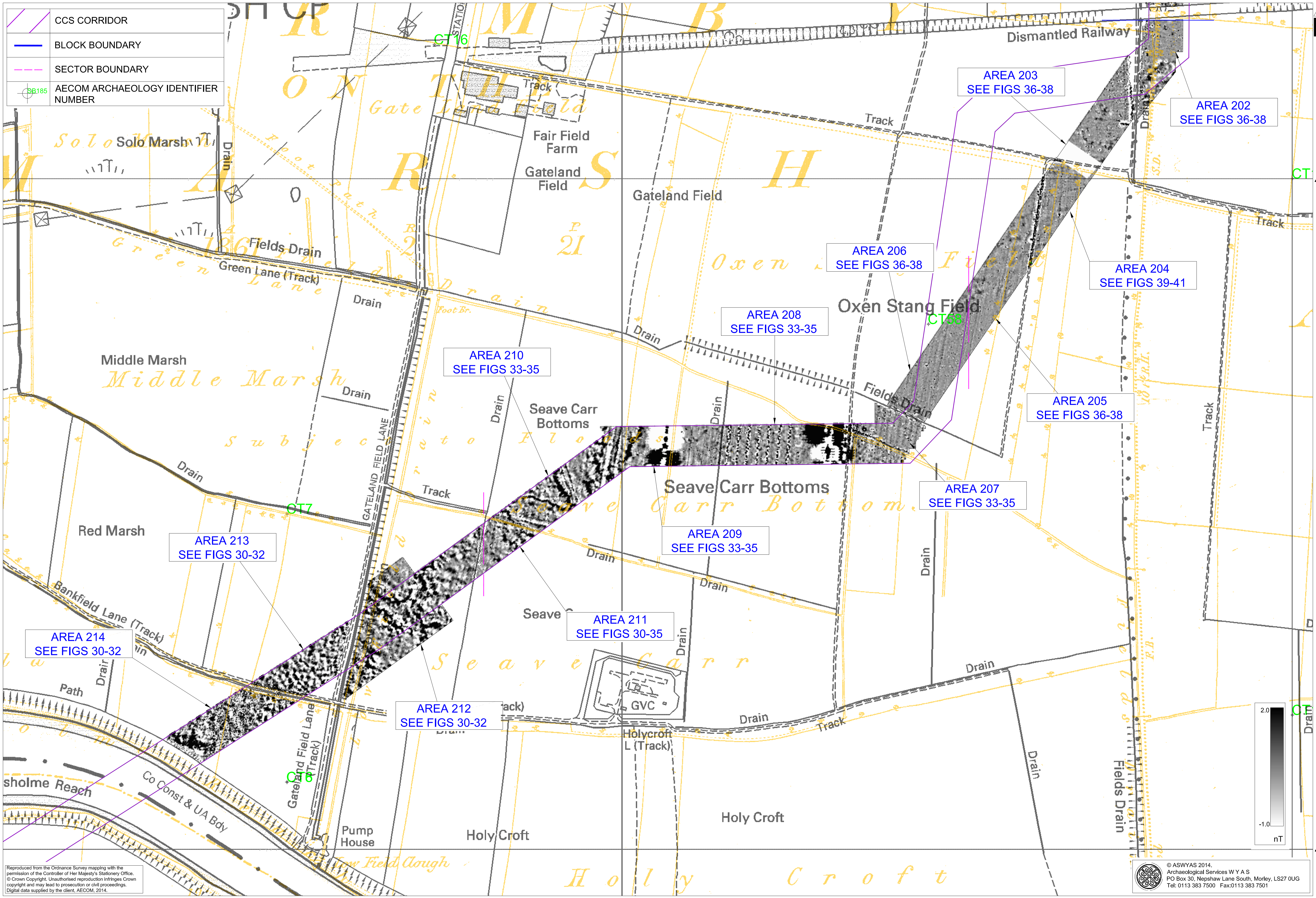

Fig. 4. Processed greyscale magnetometer data and first edition Ordnance Survey mapping; Block 1 (1:5000 @ A3)

0 100m

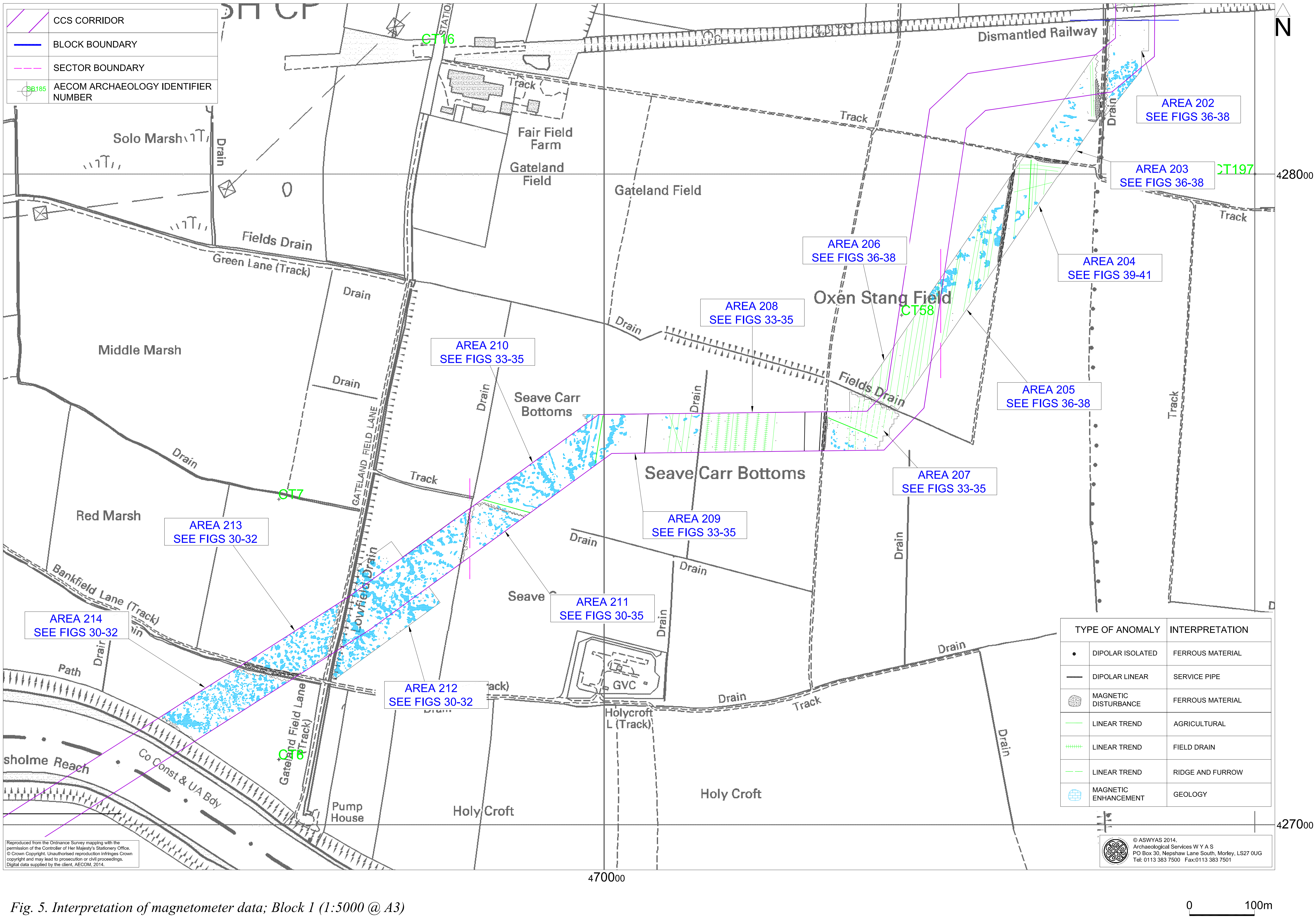

Fig. 5. Interpretation of magnetometer data; Block 1 (1:5000 @ A3)

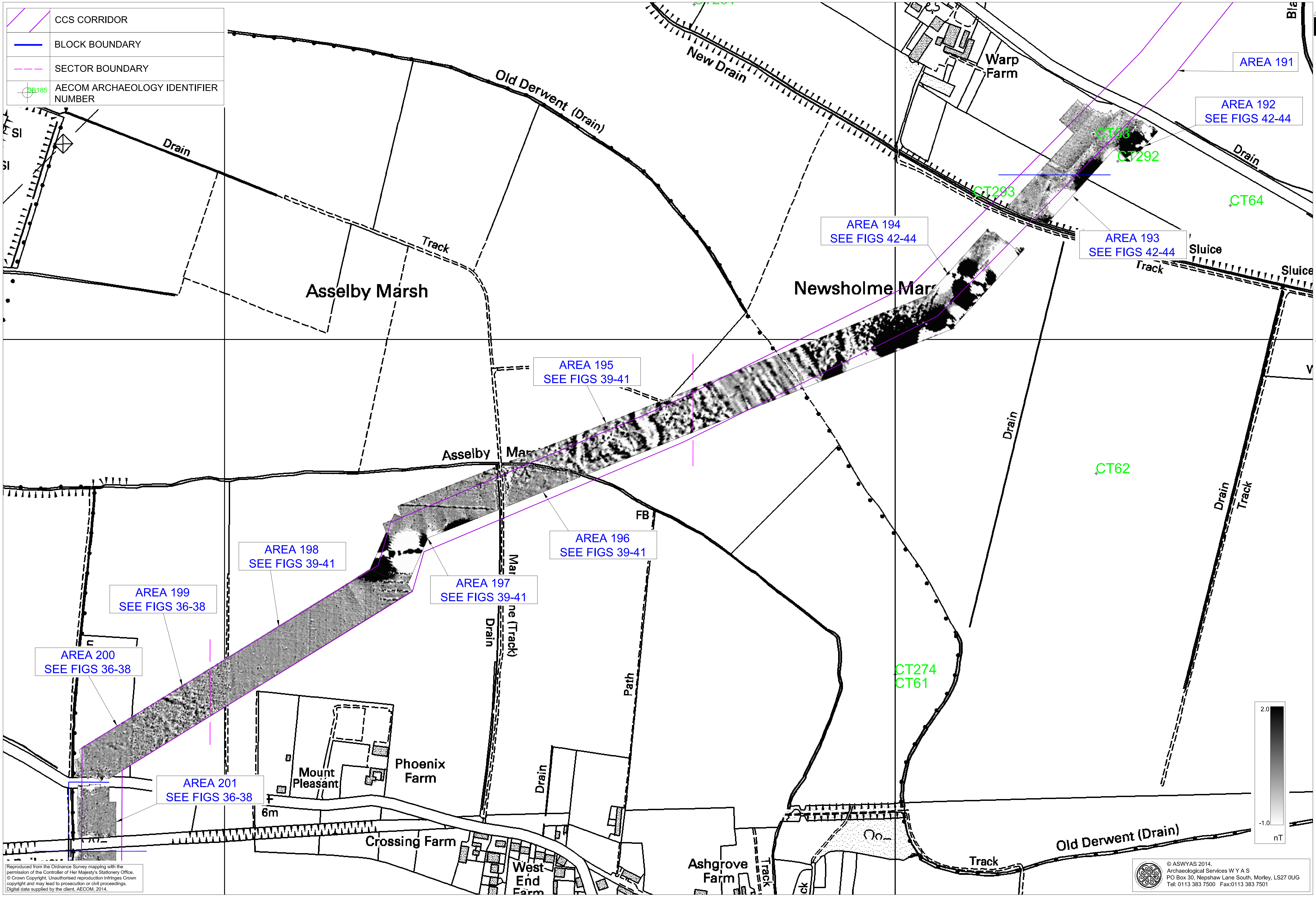

Fig. 6. Processed greyscale magnetometer data; Block 2 (1:5000 @ A3)

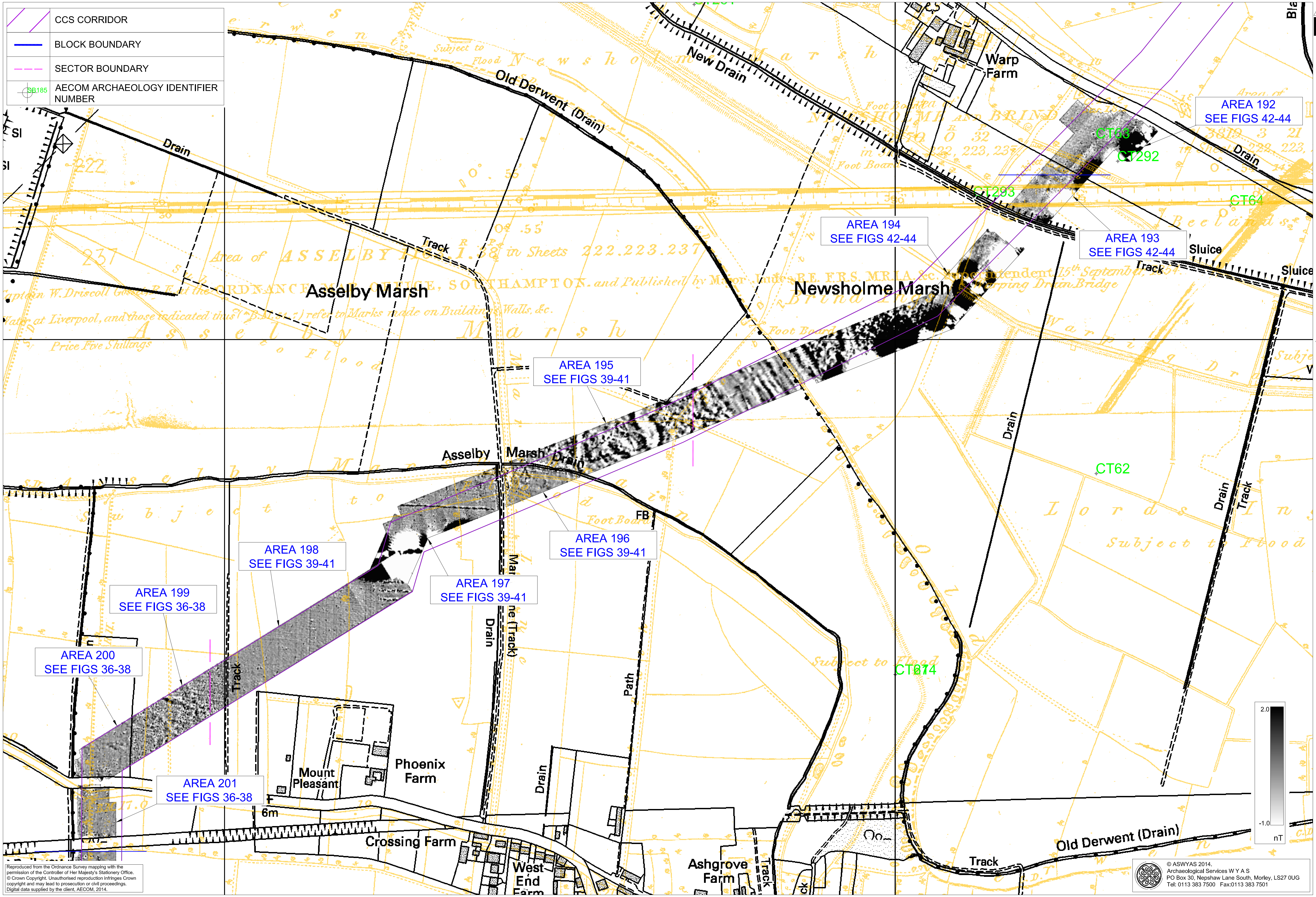

Fig. 7. Processed greyscale magnetometer data and first edition Ordnance Survey mapping; Block 2 (1:5000 @ A3)

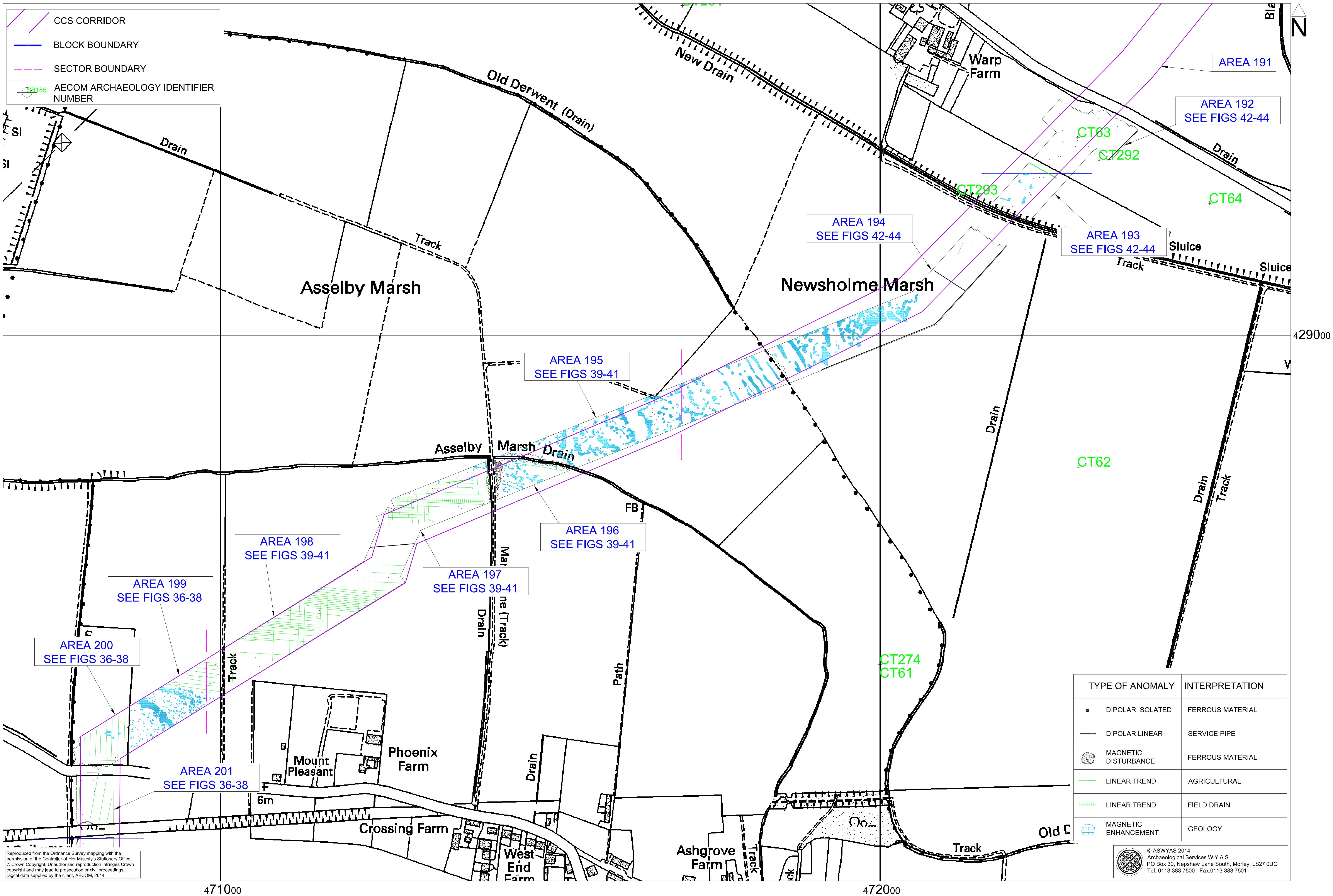

Fig. 8. Interpretation of magnetometer data; Block 2 (1:5000 @ A3)

0 100m

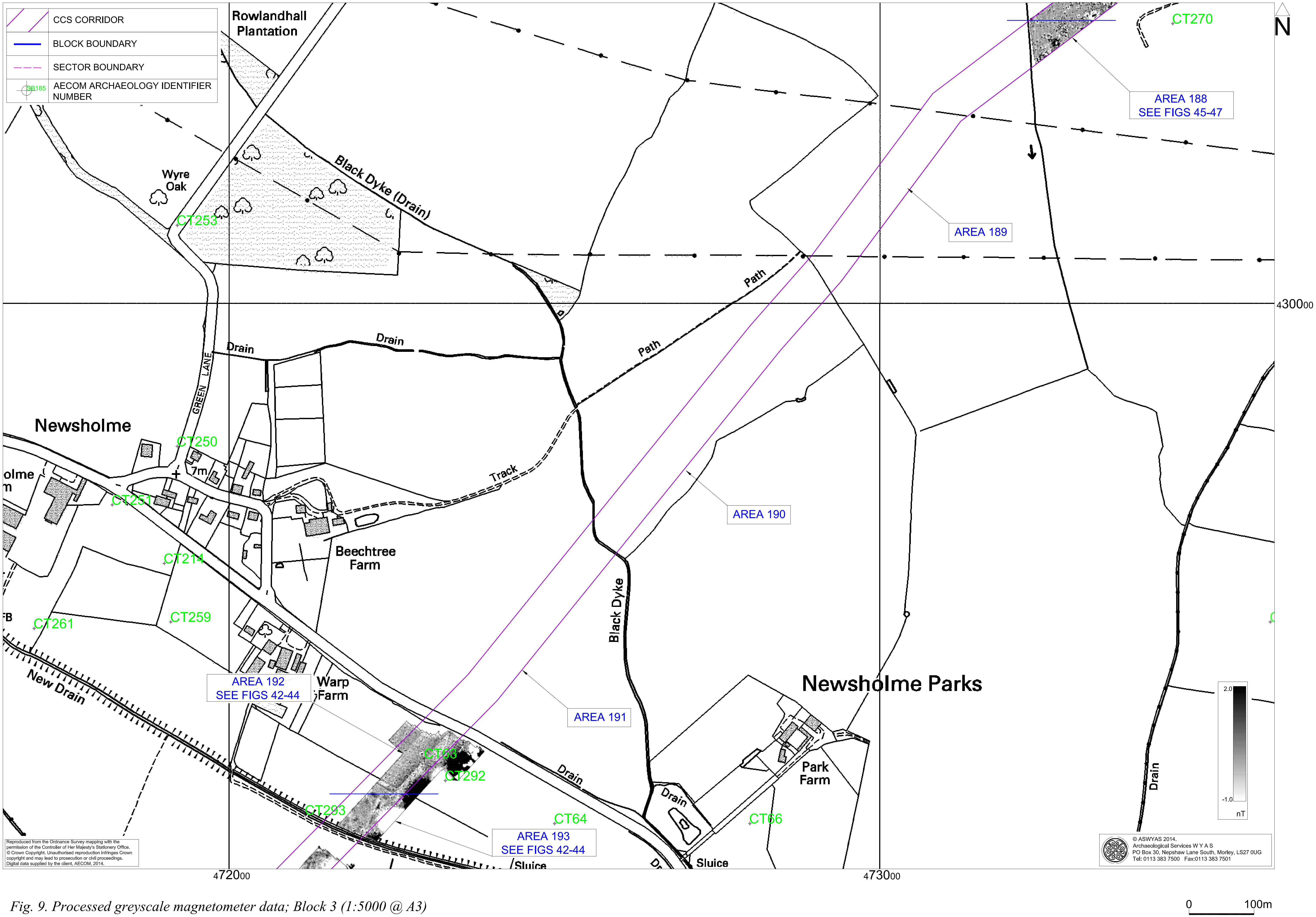

Fig. 9. Processed greyscale magnetometer data; Block 3 (1:5000 @ A3)

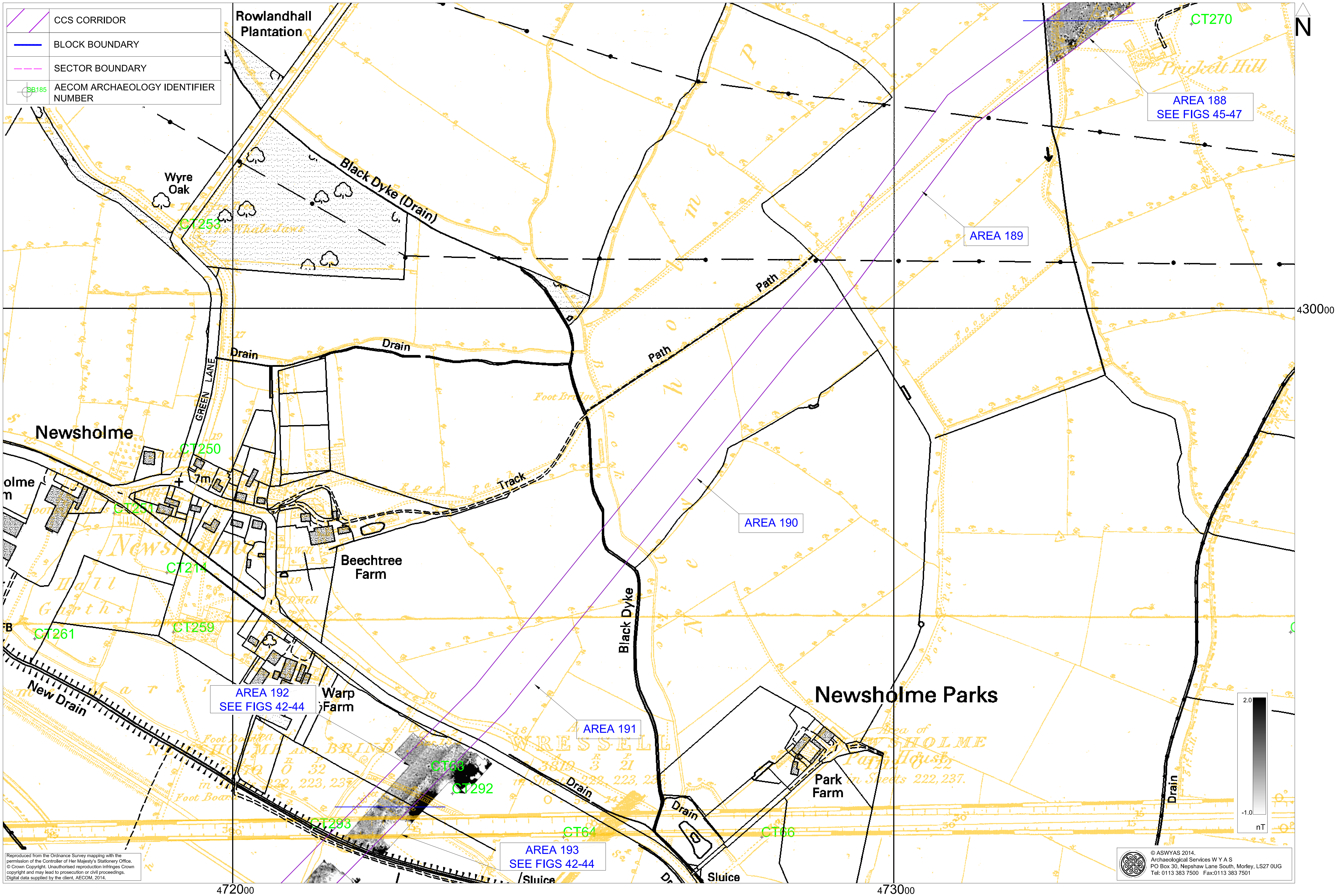

Fig. 10. Processed greyscale magnetometer data and first edition Ordnance Survey mapping; Block 3 (1:5000 @ A3)

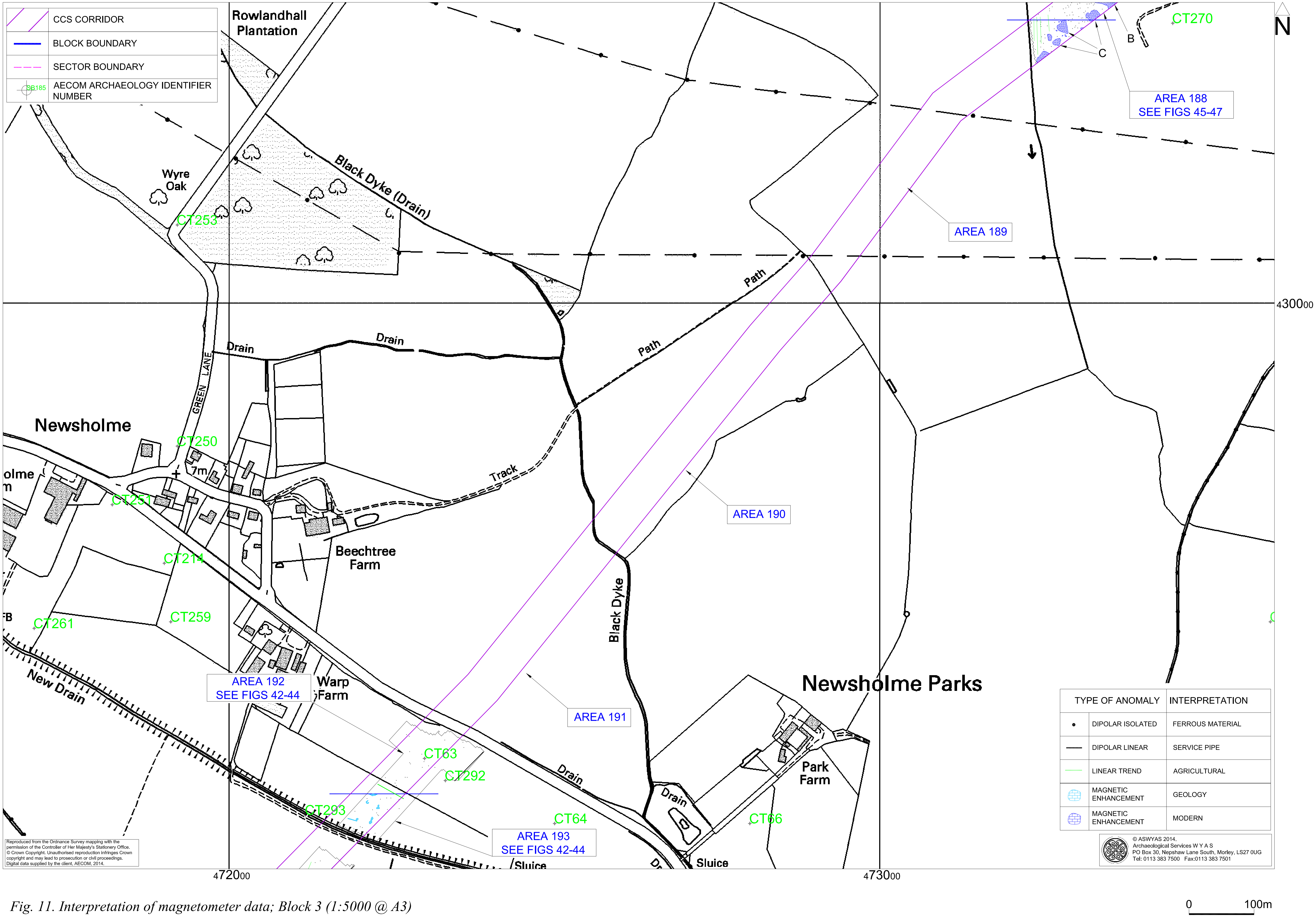

Fig. 11. Interpretation of magnetometer data; Block 3 (1:5000 @ A3)

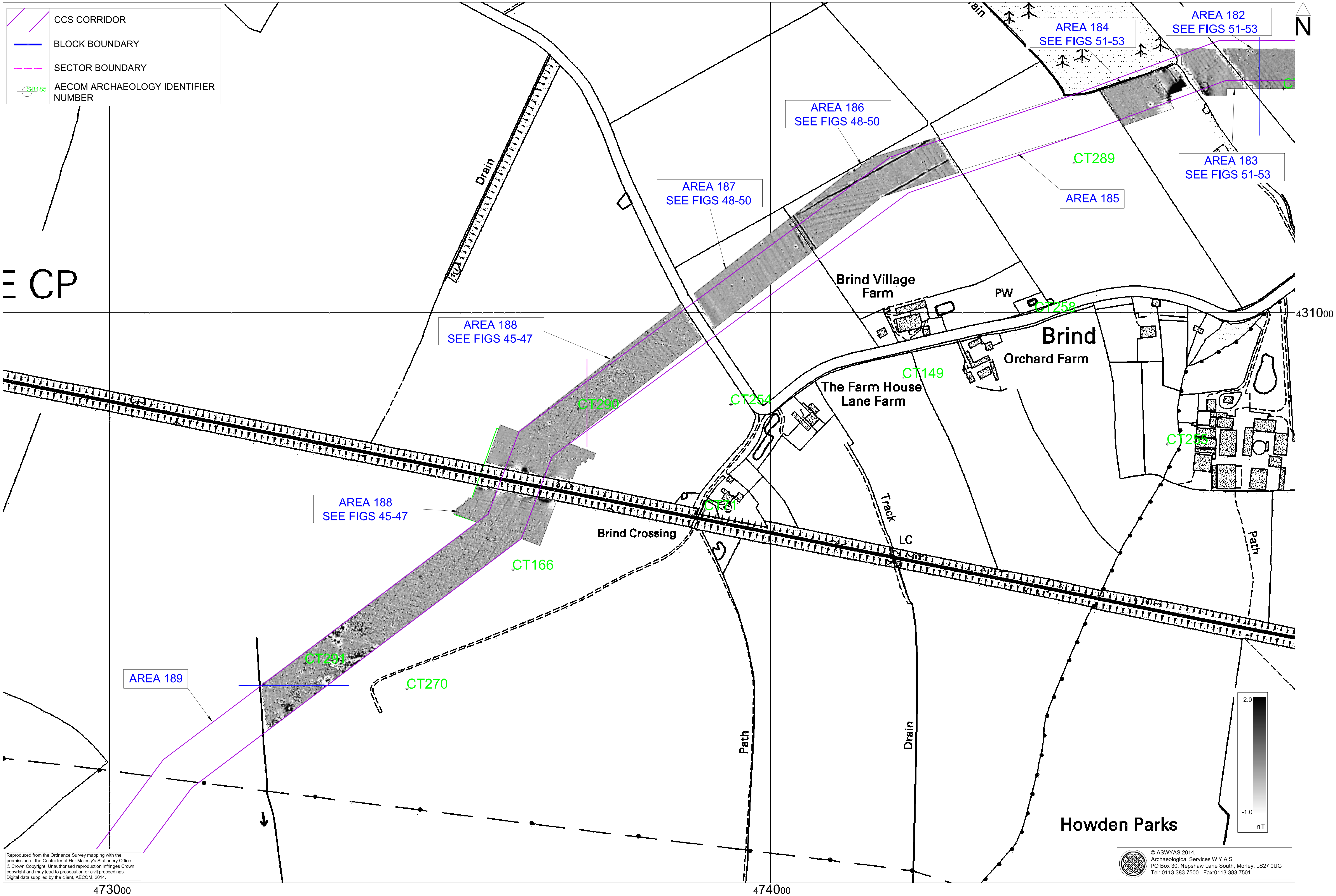

Fig. 12. Processed greyscale magnetometer data; Block 4 (1:5000 @ A3)

0 100m

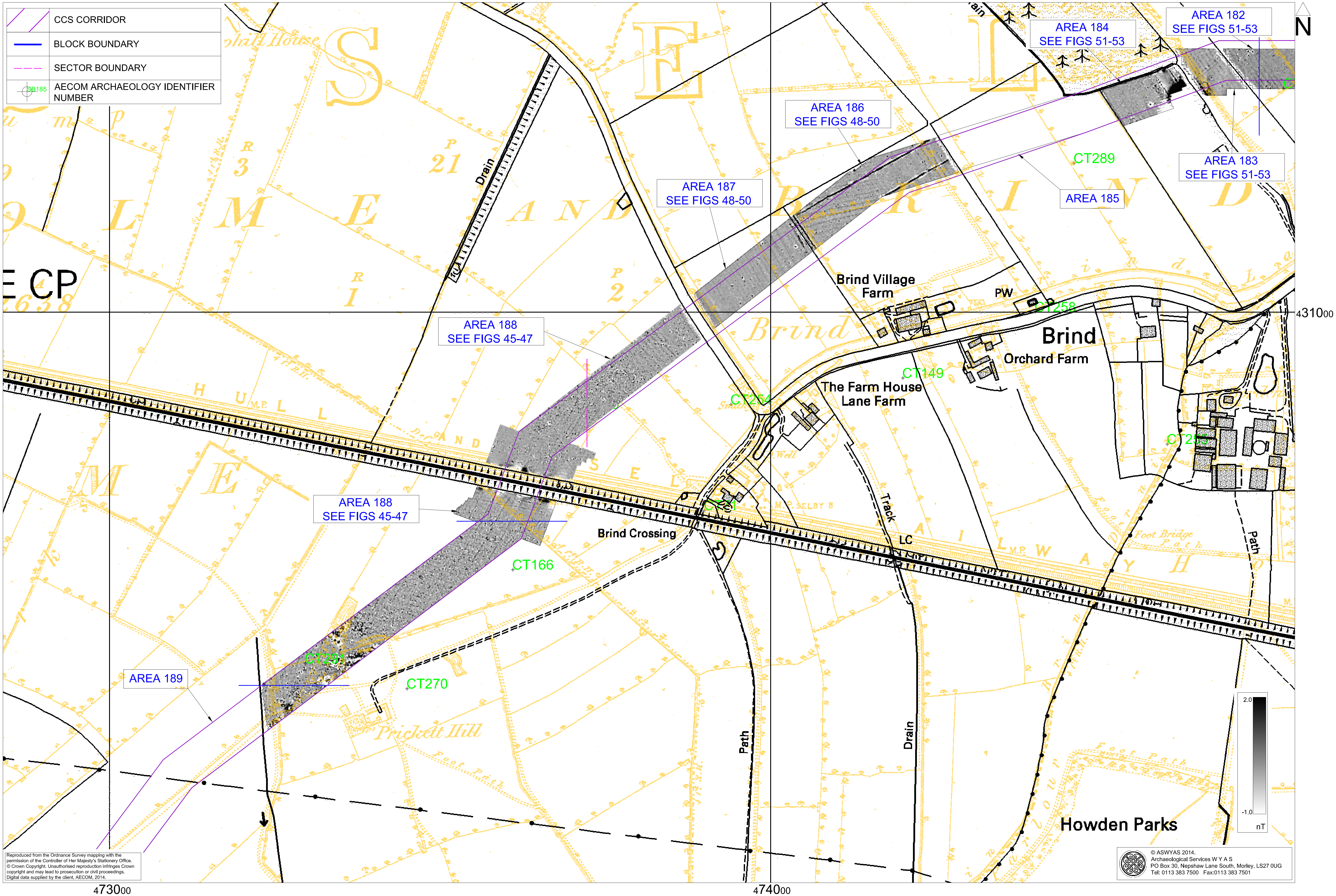

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Fig. 13. Processed greyscale magnetometer data and first edition Ordnance Survey mapping; Block 4 (1:5000 @ A3)

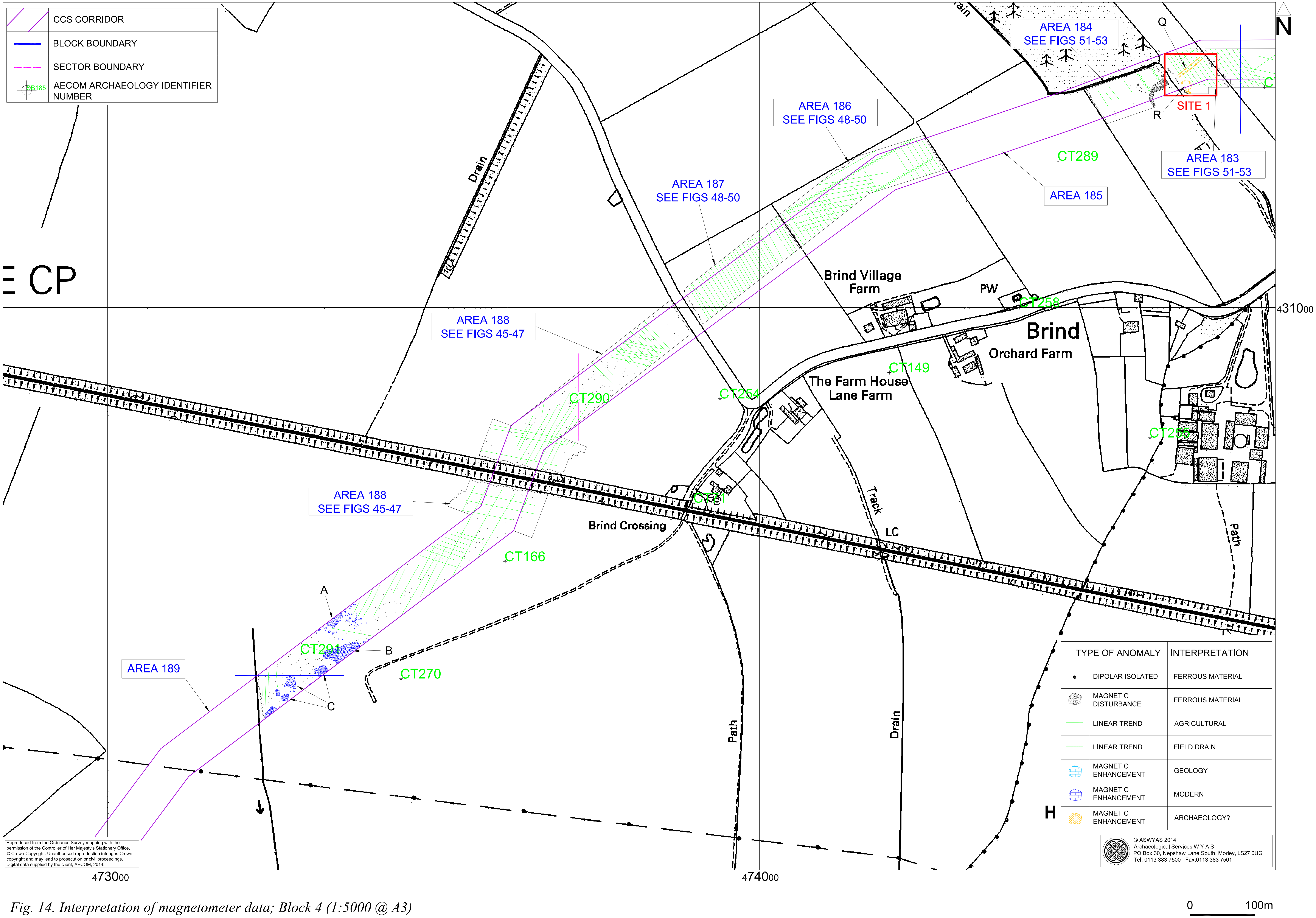


Fig. 14. Interpretation of magnetometer data; Block 4 (1:5000 @ A3)

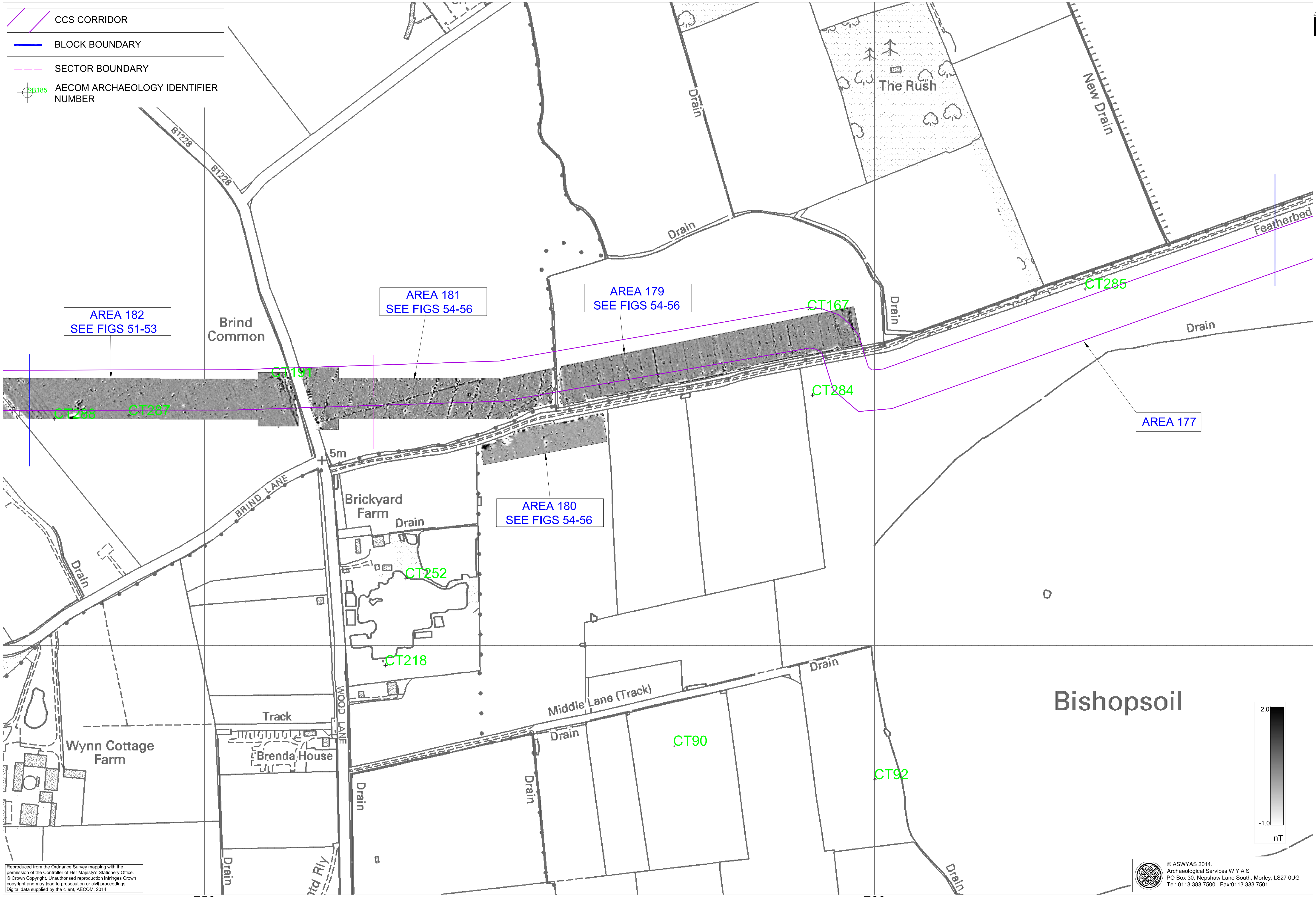


Fig. 15. Processed greyscale magnetometer data; Block 5 (1:5000 @ A3)

0 100m

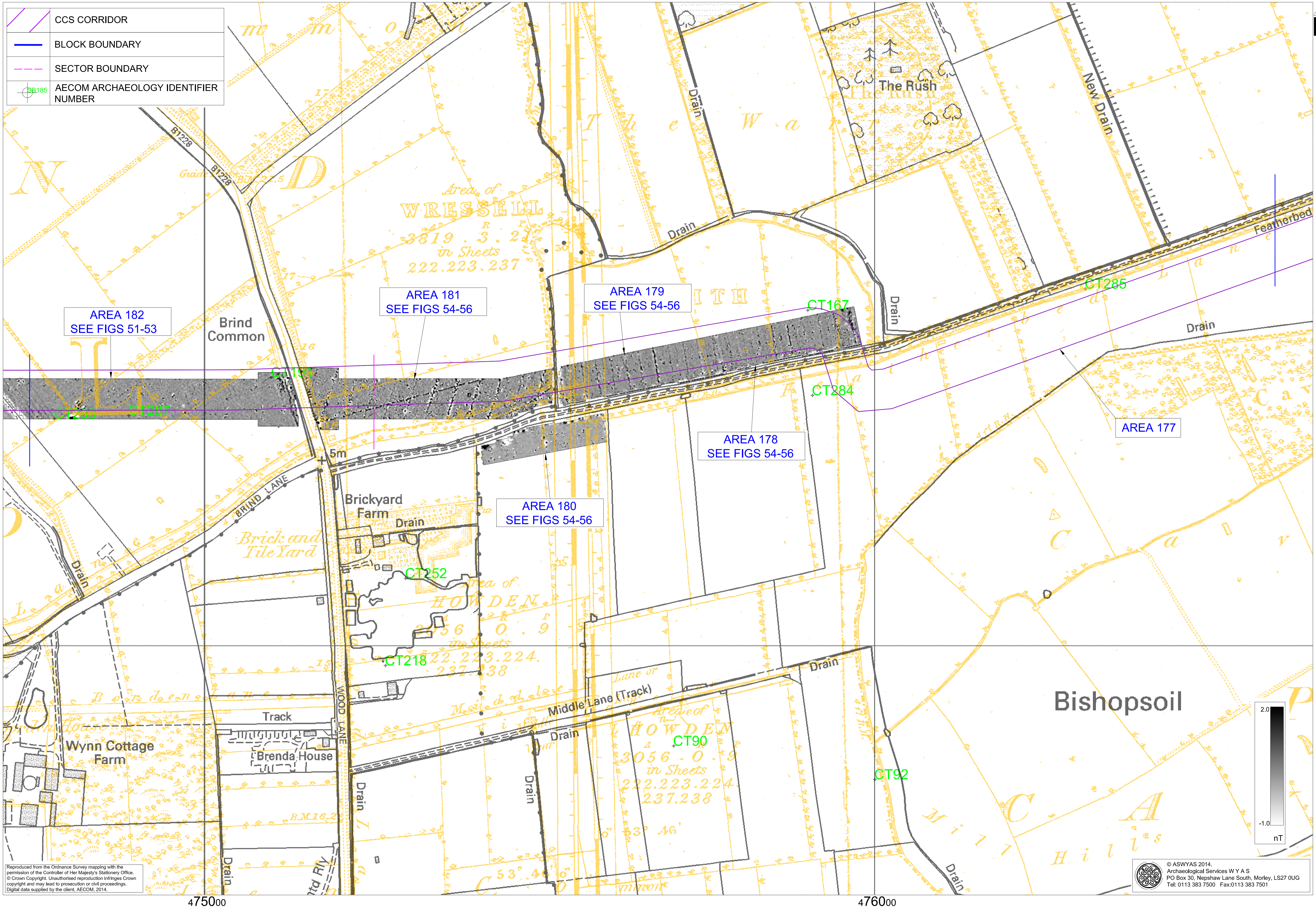


Fig. 16. Processed greyscale magnetometer data and first edition Ordnance Survey mapping; Block 5 (1:5000 @ A3)

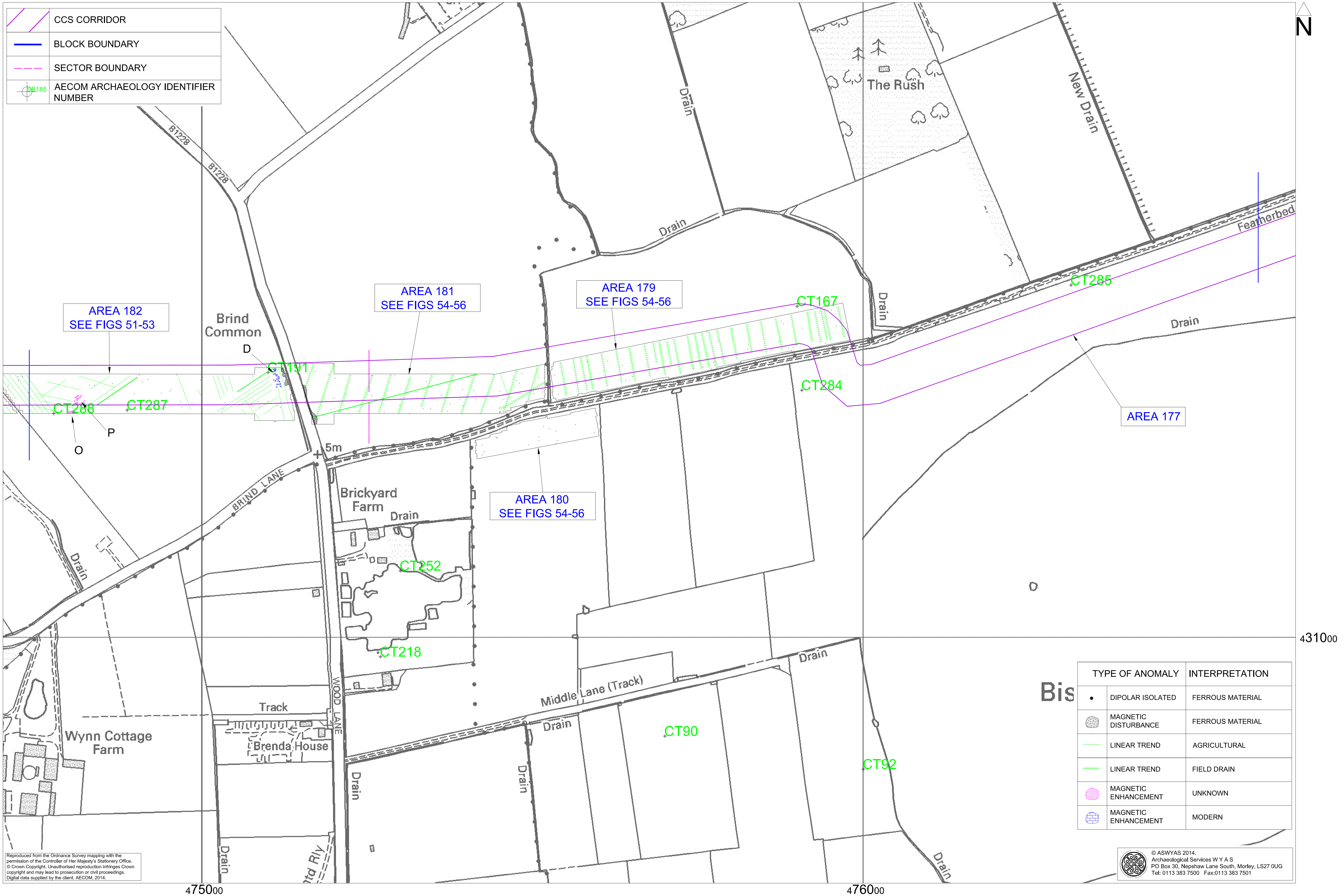


Fig. 17. Interpretation of magnetometer data; Block 5 (1:5000 @ A3)

0 100m

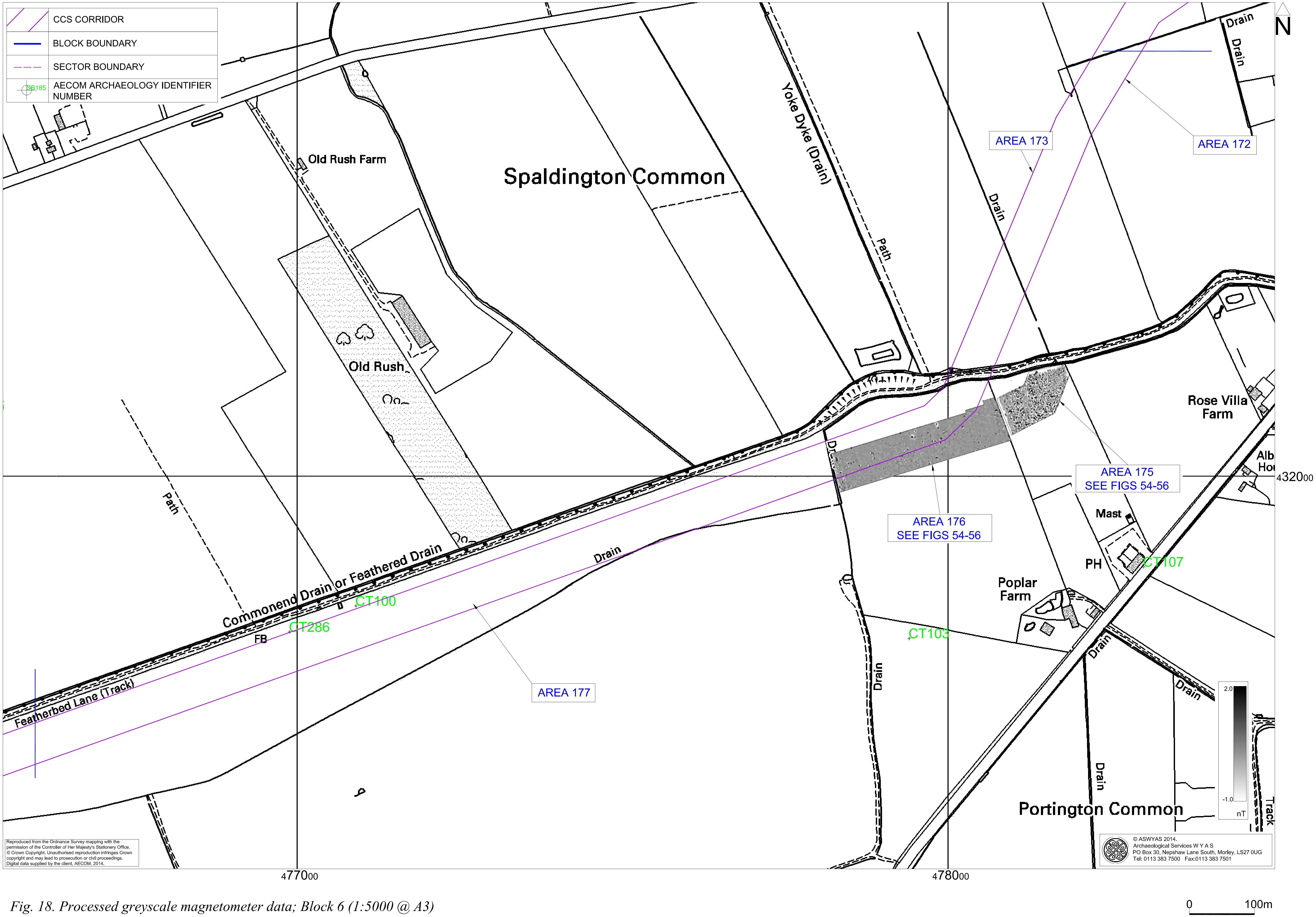


Fig. 18. Processed greyscale magnetometer data; Block 6 (1:5000 @ A3)

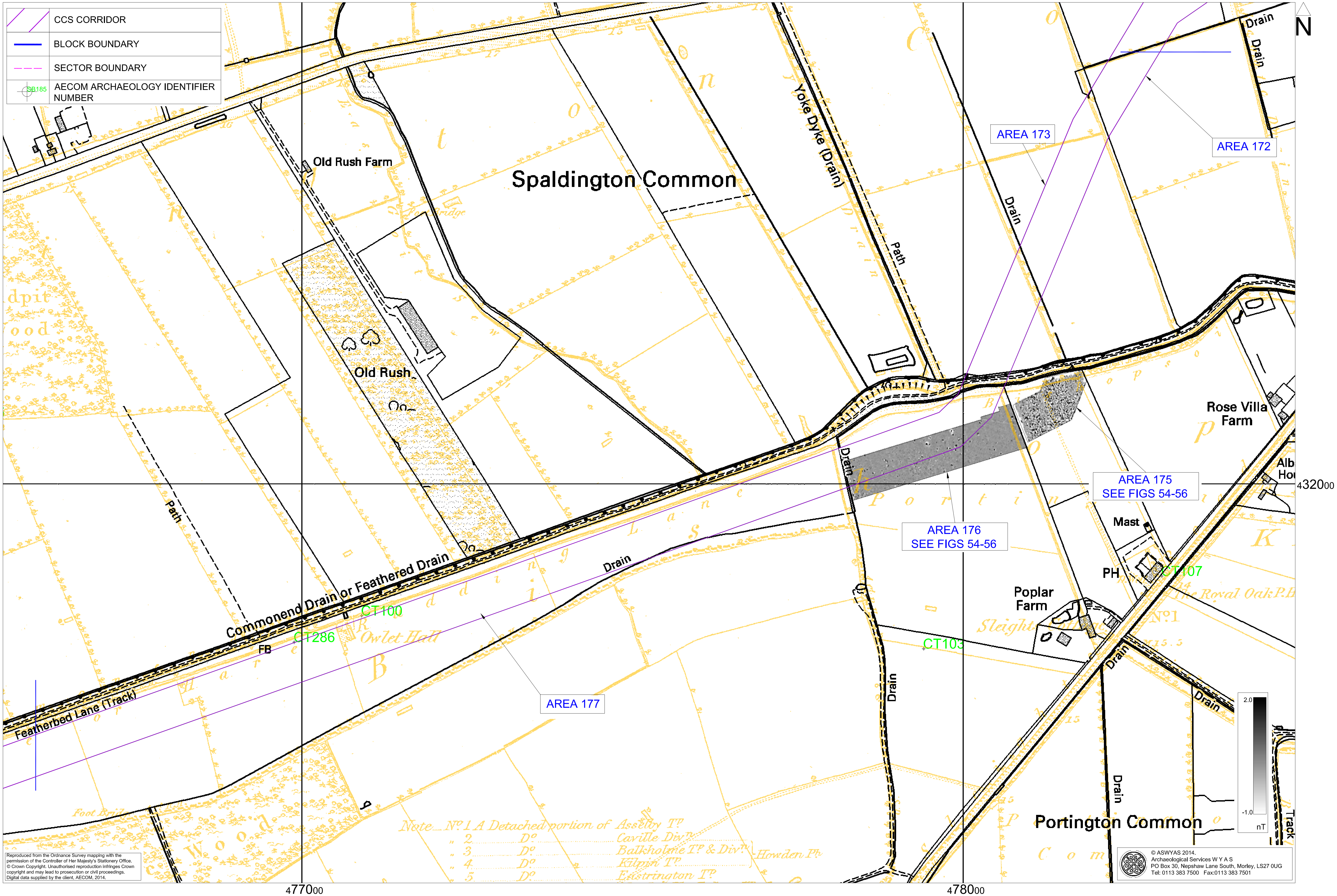


Fig. 19. Processed greyscale magnetometer data and first edition Ordnance Survey mapping; Block 6 (1:5000 @ A3)

0 100m

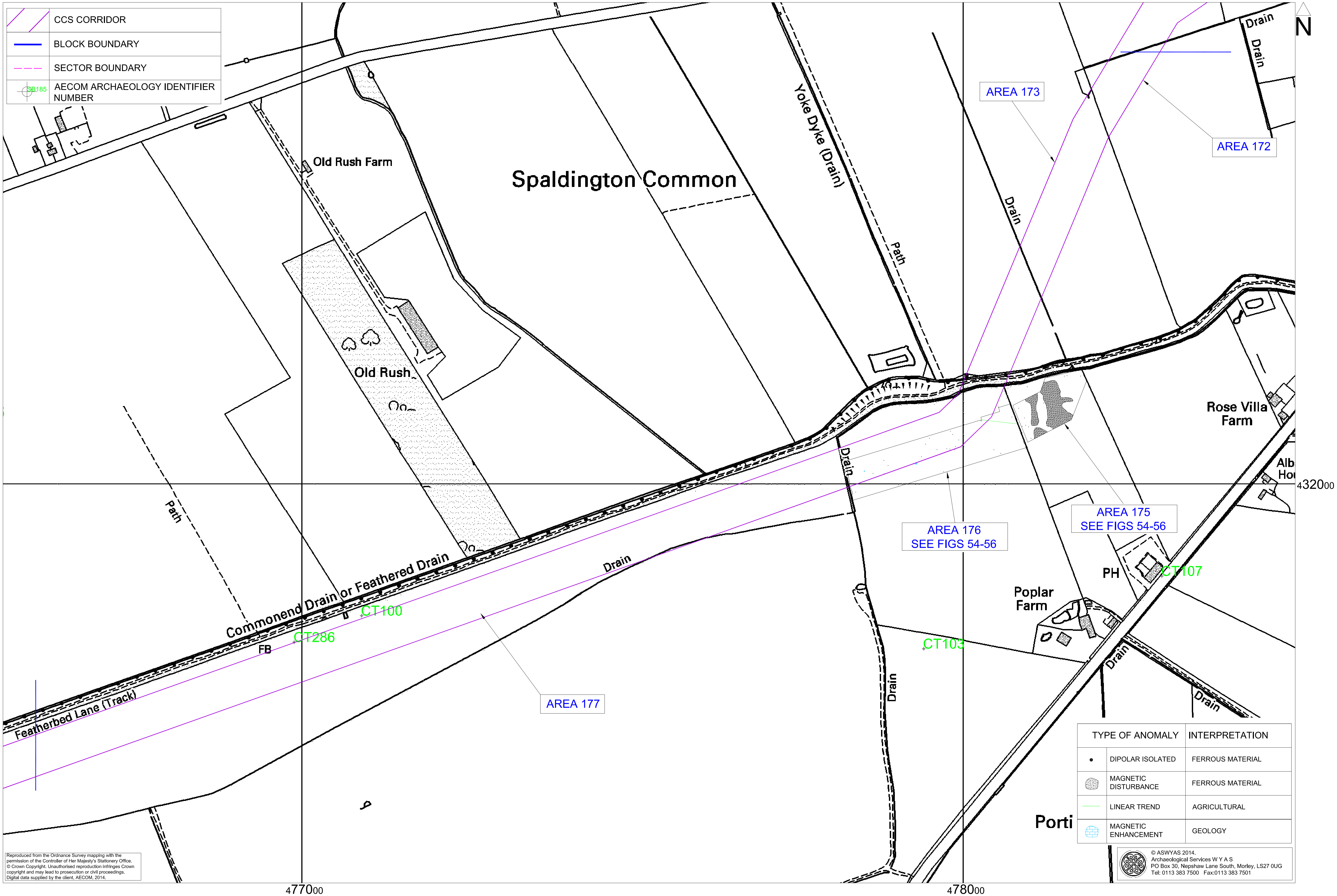


Fig. 20. Interpretation of magnetometer data; Block 6 (1:5000 @ A3)

0 100m

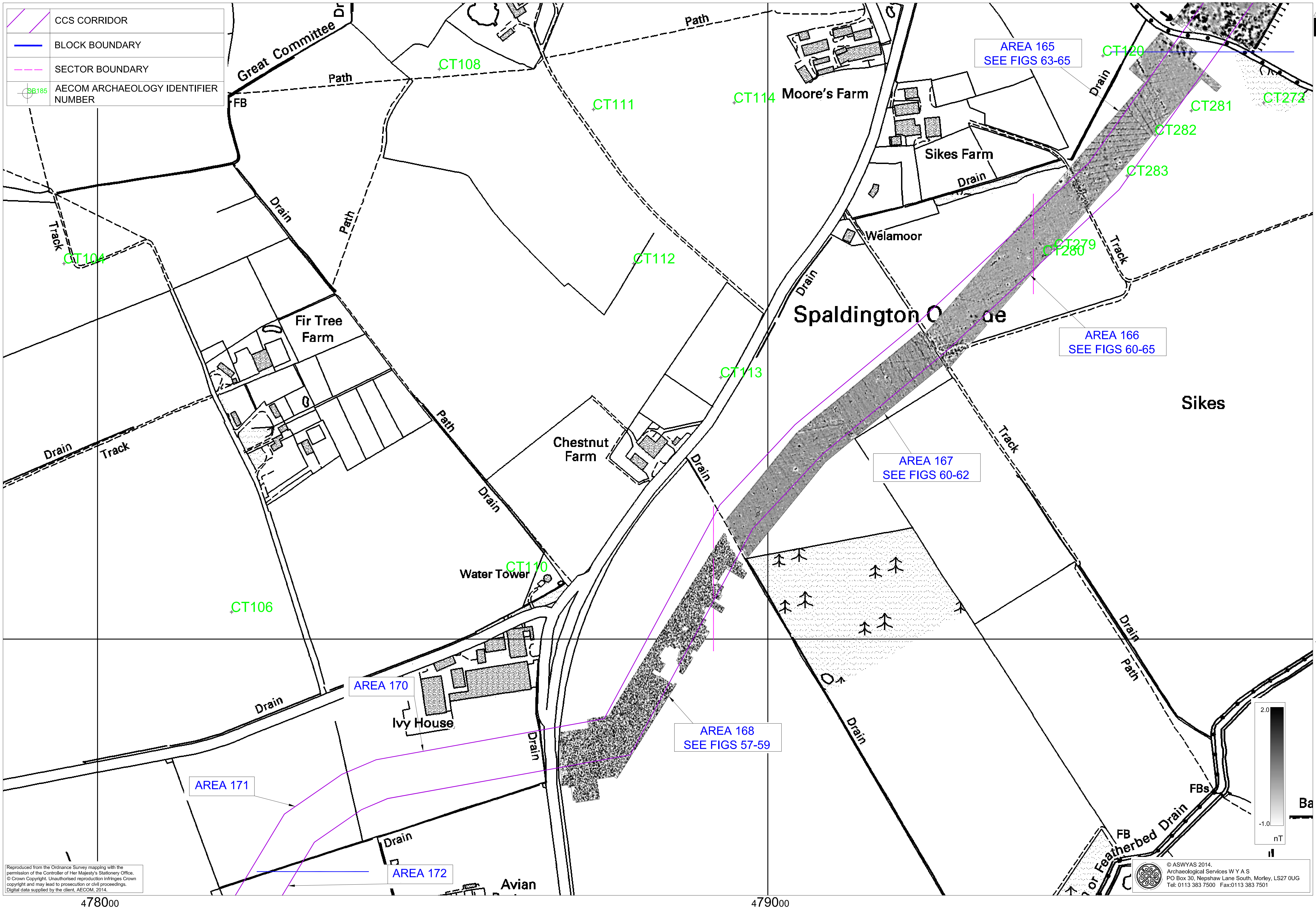


Fig. 21. Processed greyscale magnetometer data; Block 7 (1:5000 @ A3)

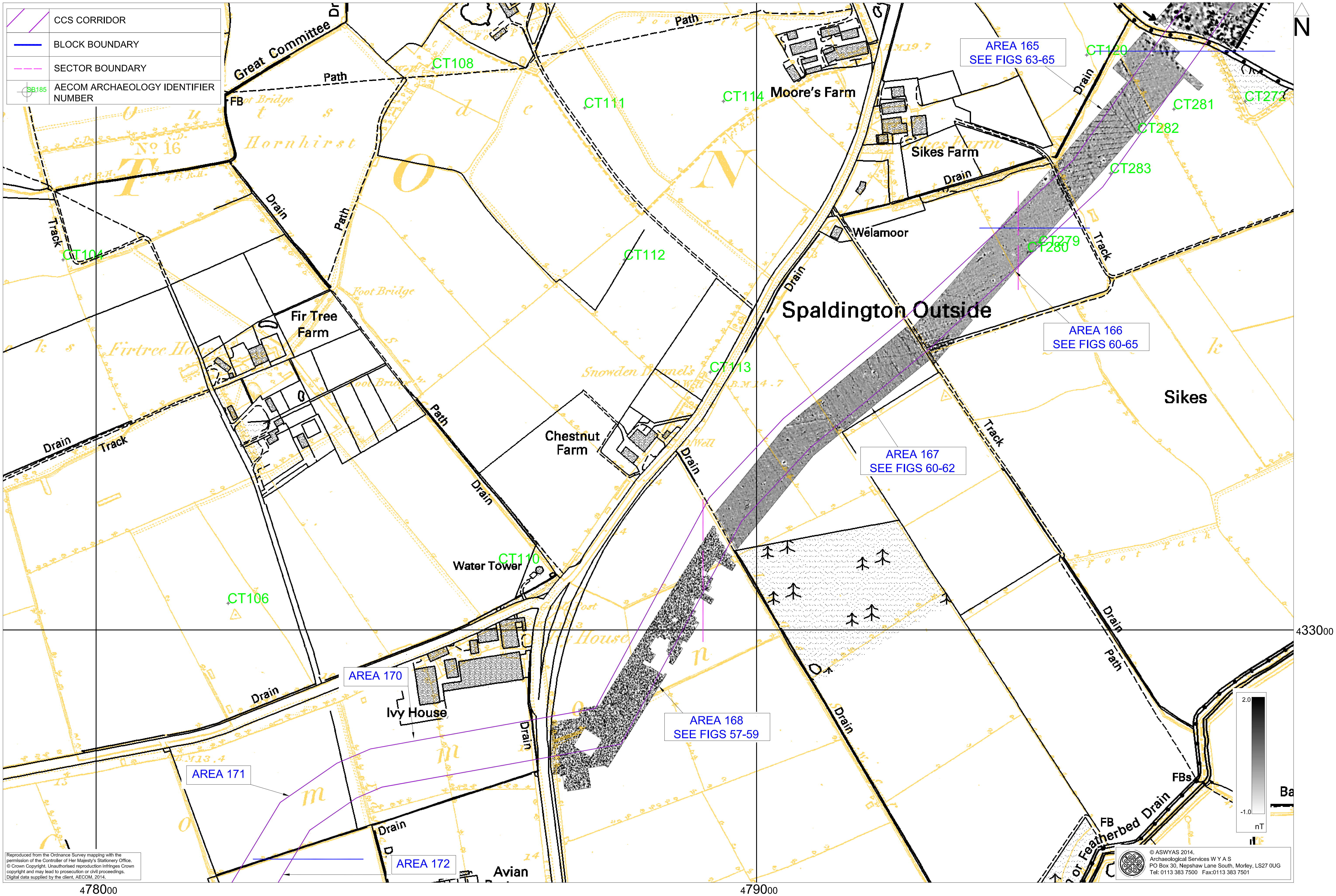


Fig. 22. Processed greyscale magnetometer data and first edition Ordnance Survey mapping; Block 7 (1:5000 @ A3)

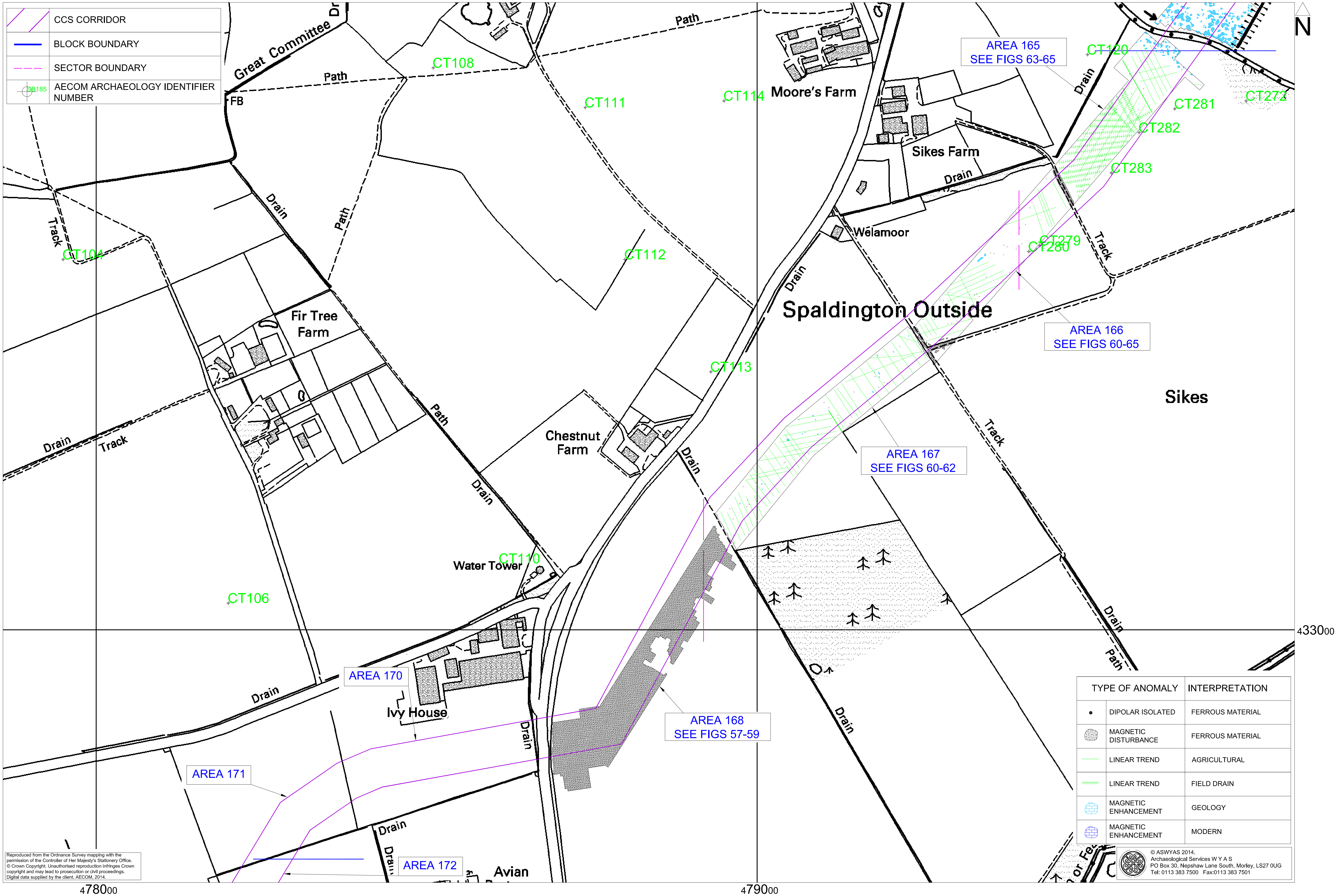


Fig. 23. Interpretation of magnetometer data; Block 7 (1:5000 @ A3)

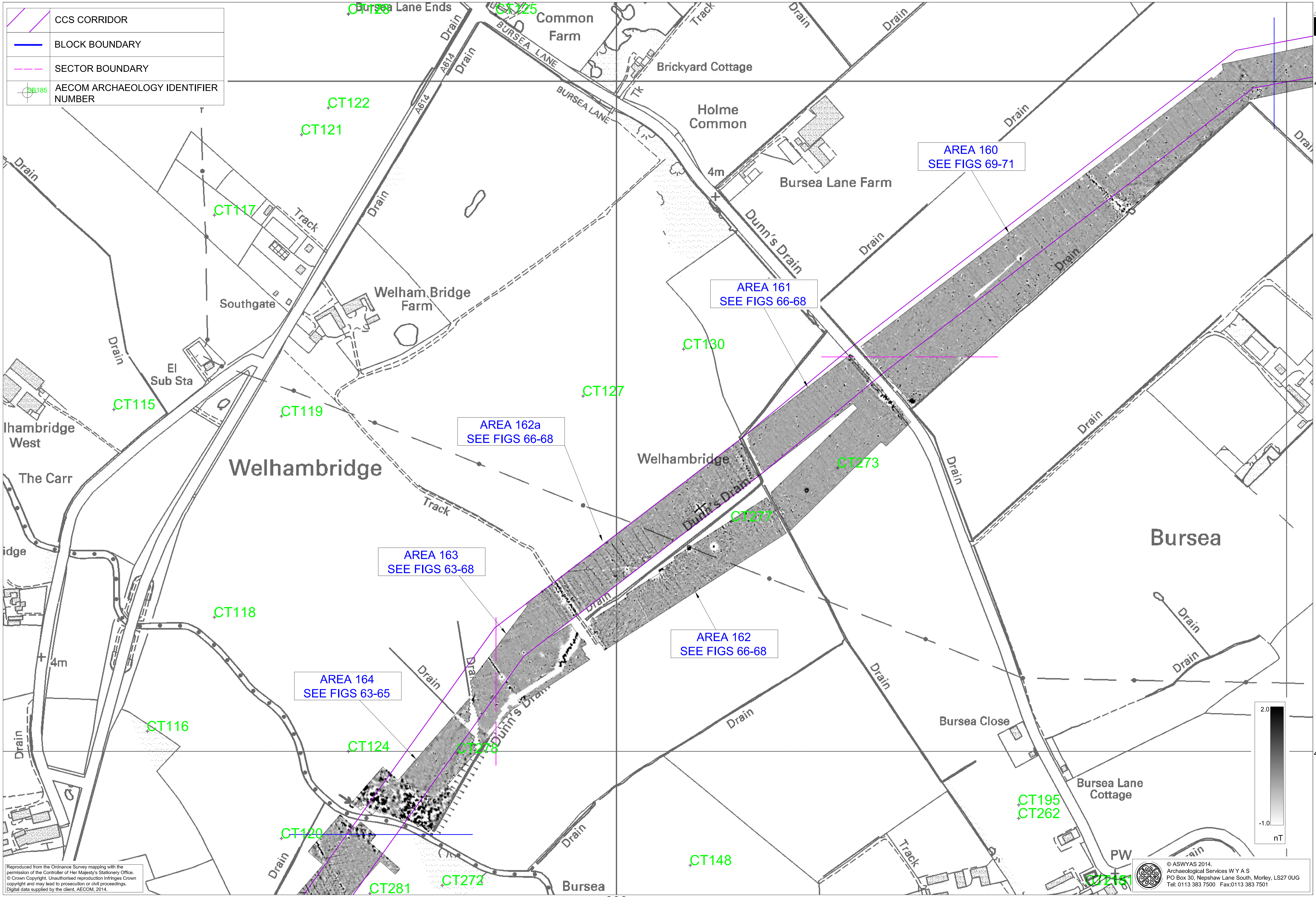


Fig. 24. Processed greyscale magnetometer data; Block 8 (1:5000 @ A3)

0 100m

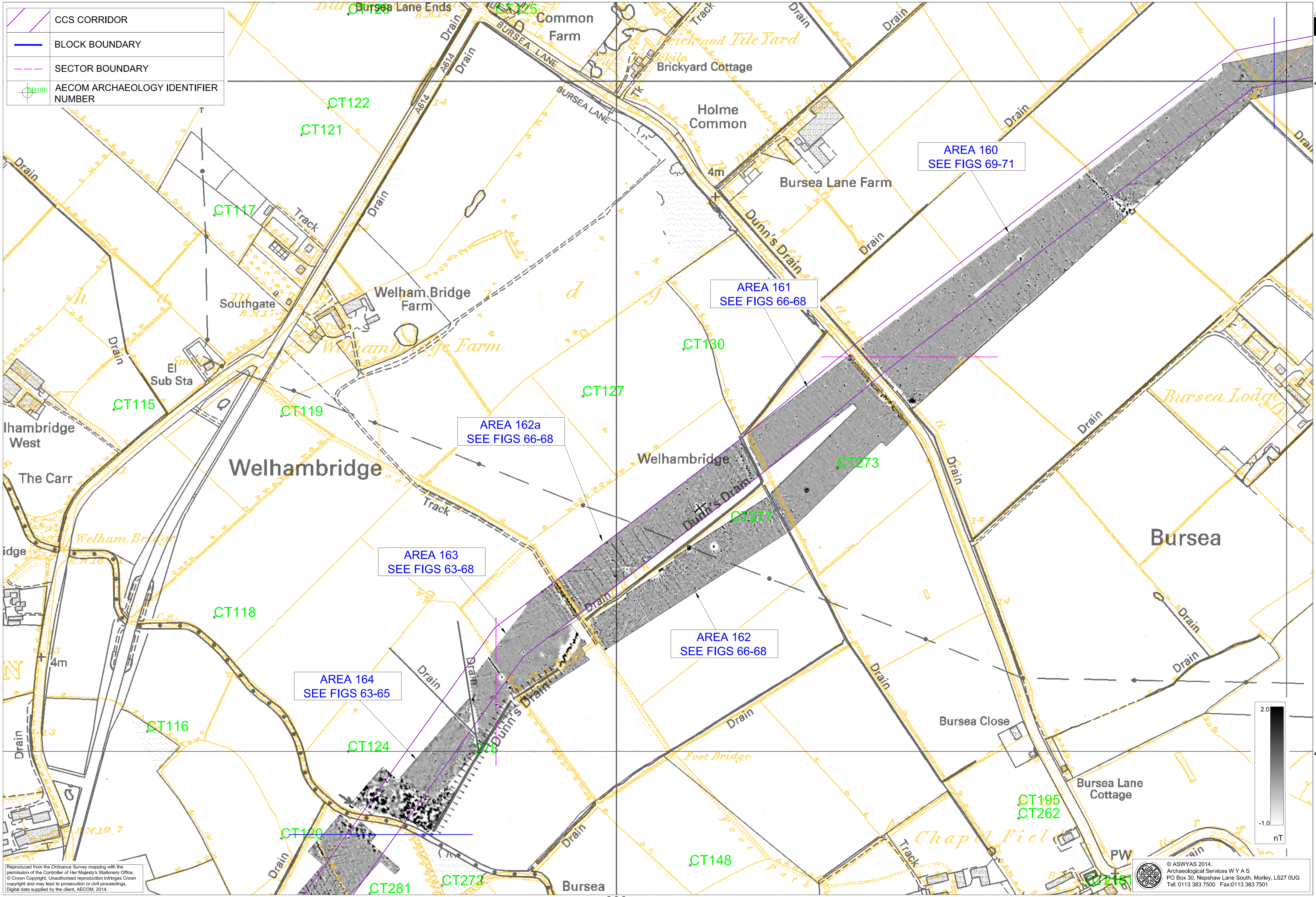


Fig. 25. Processed greyscale magnetometer data and first edition Ordnance Survey mapping; Block 8 (1:5000 @ A3)

0 100m

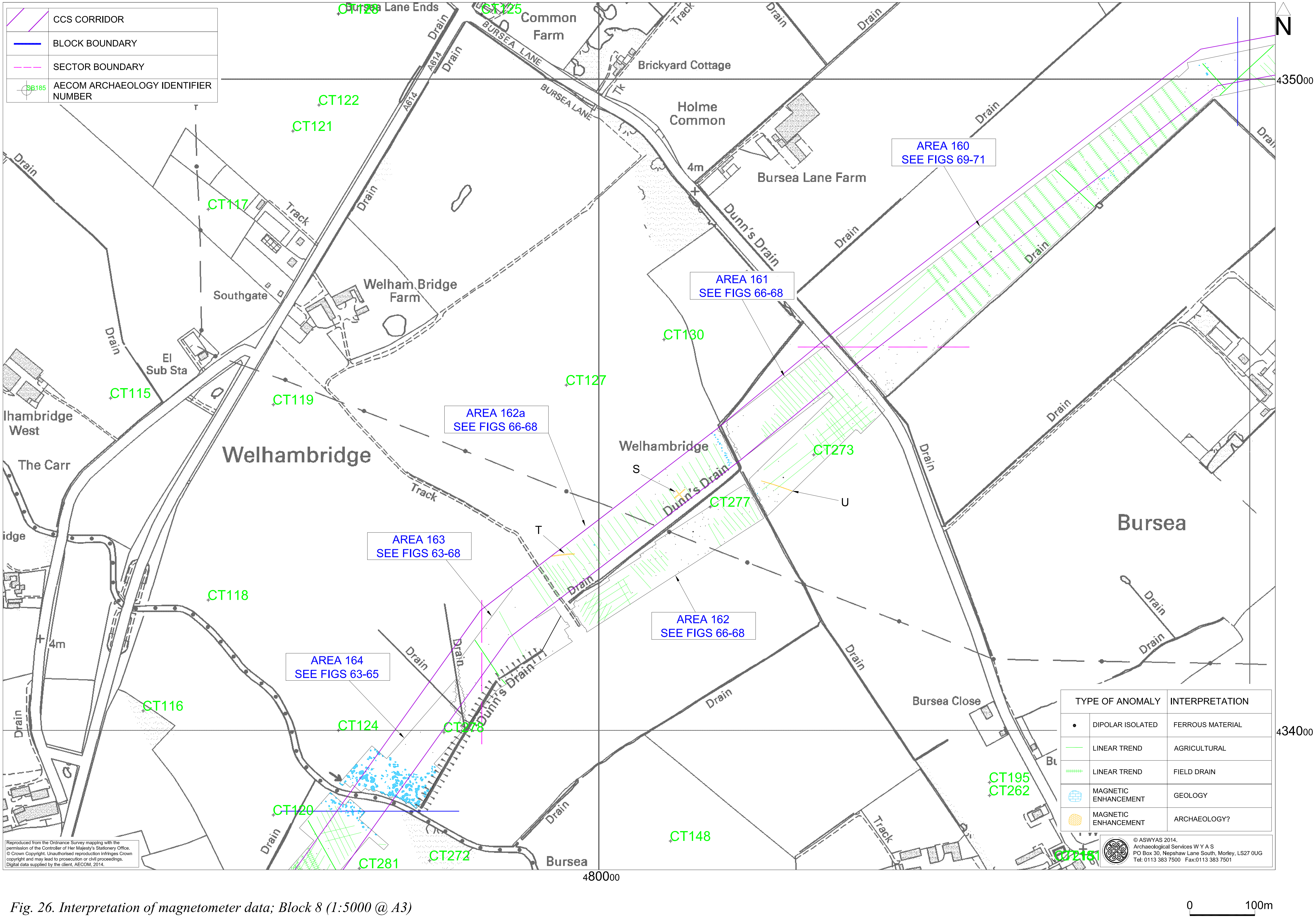


Fig. 26. Interpretation of magnetometer data; Block 8 (1:5000 @ A3)

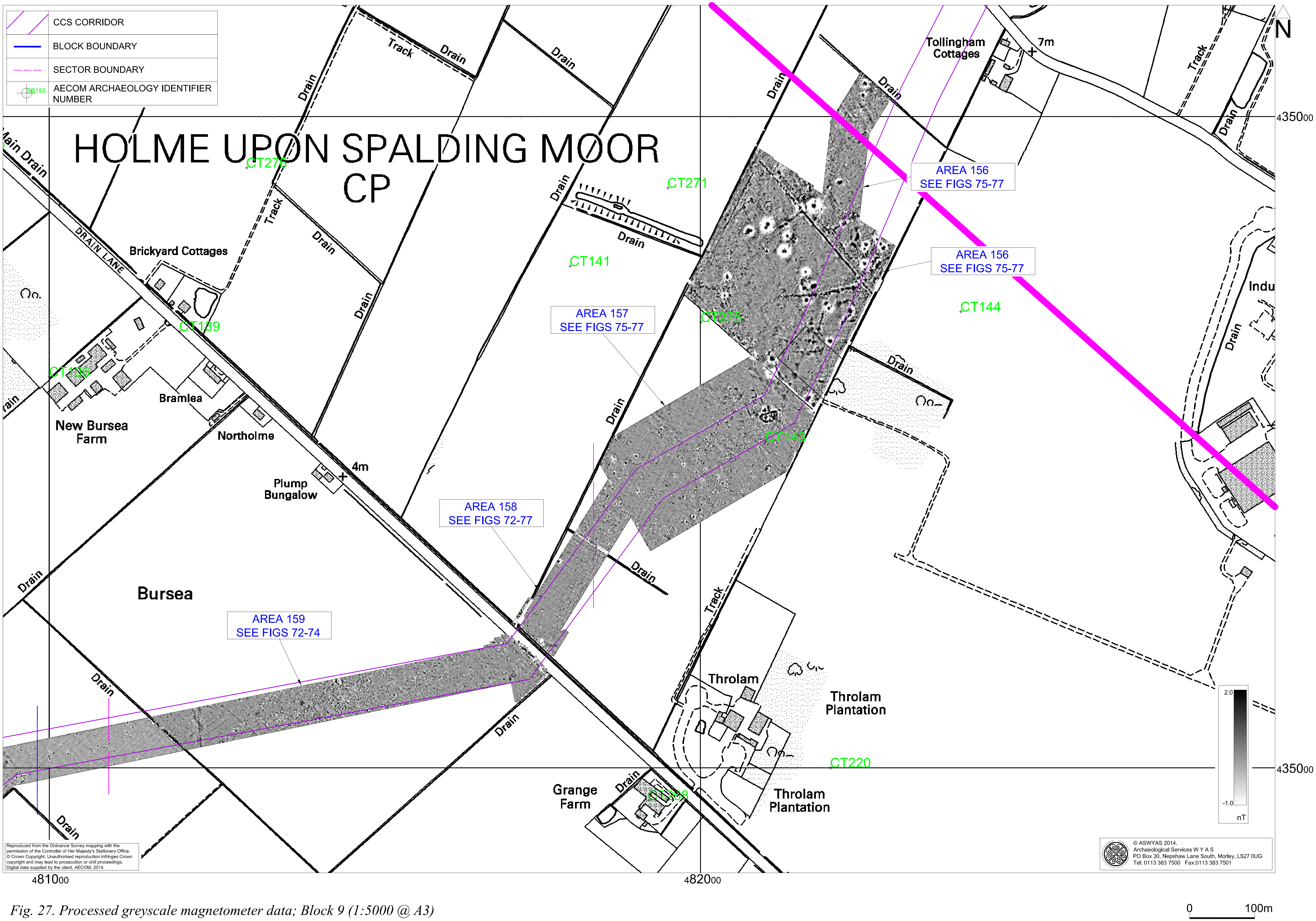


Fig. 27. Processed greyscale magnetometer data; Block 9 (1:5000 @ A3)

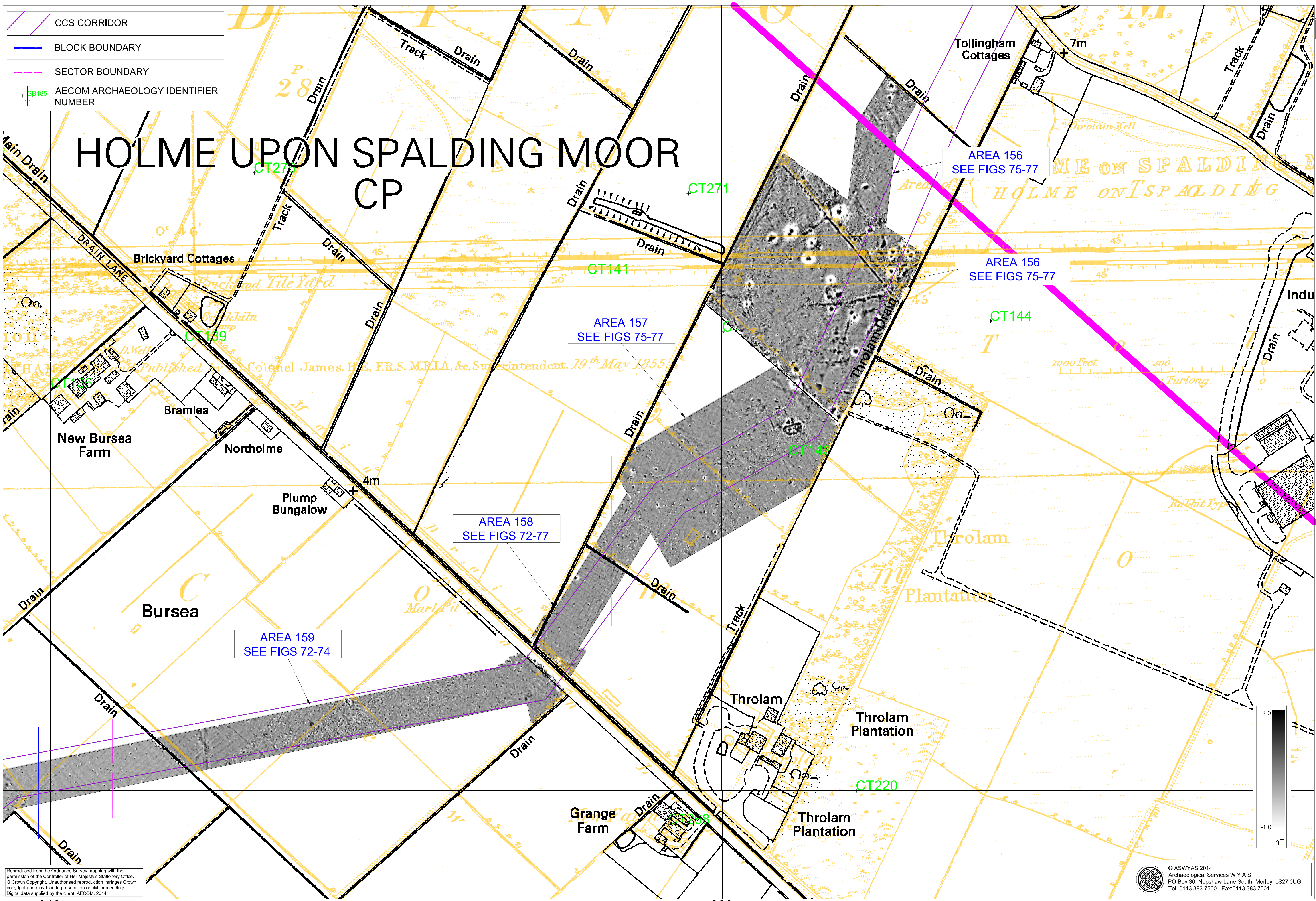


Fig. 28. Processed greyscale magnetometer data and first edition Ordnance Survey mapping; Block 9 (1:5000 @ A3)

0 100m

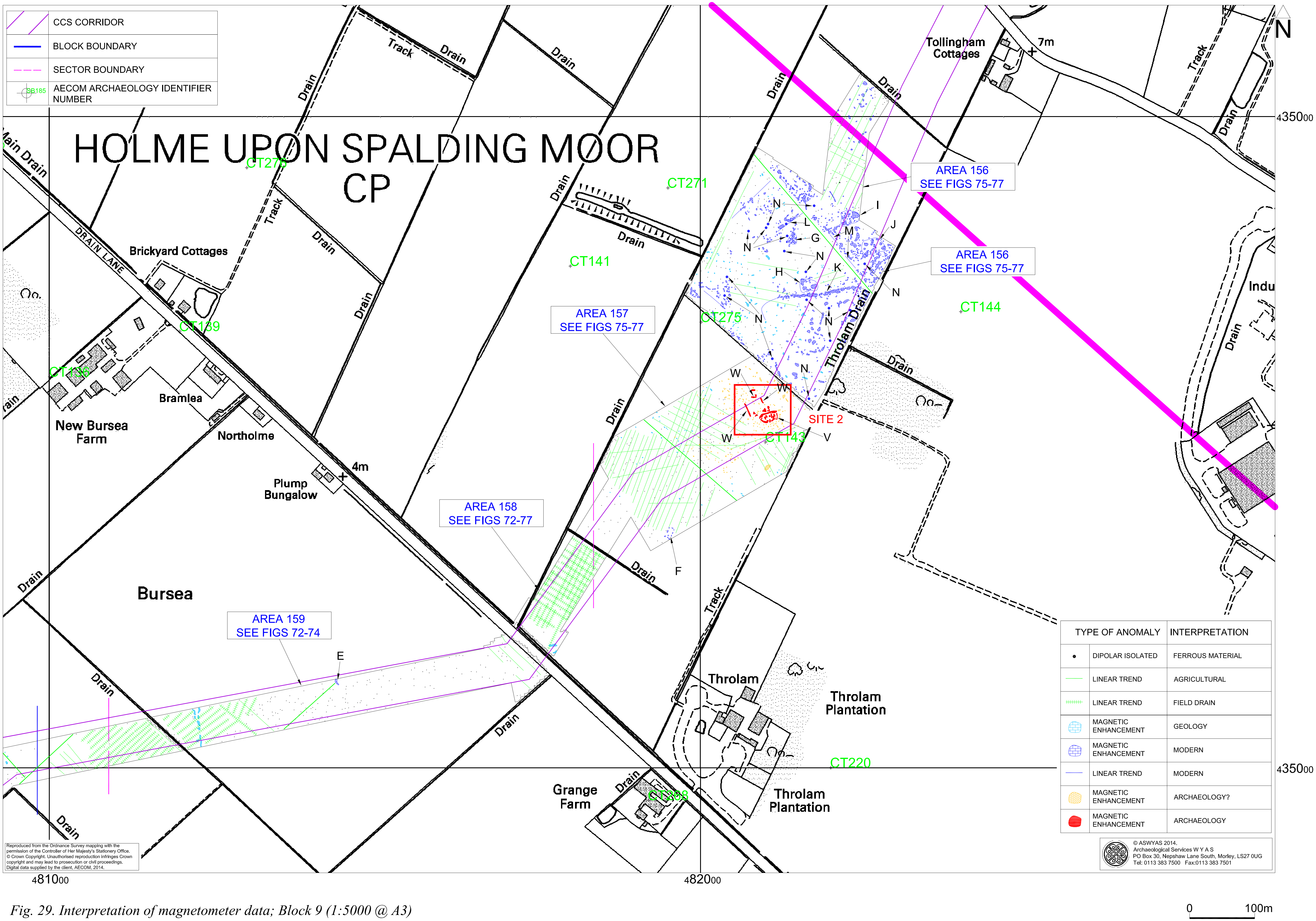


Fig. 29. Interpretation of magnetometer data; Block 9 (1:5000 @ A3)

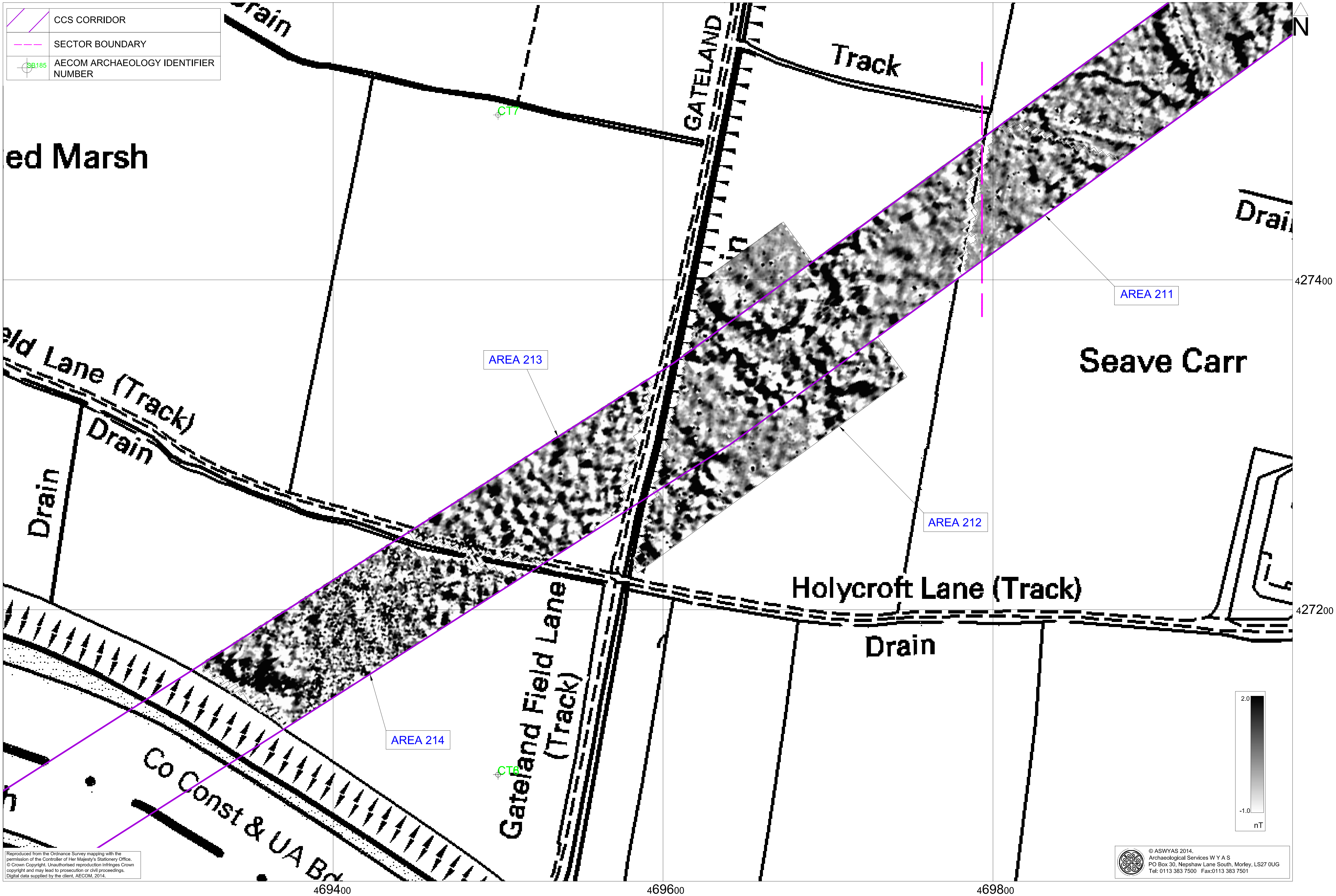


Fig. 30. Processed greyscale magnetometer data; Sector 1 (1:2000 @ A3)

0 40m

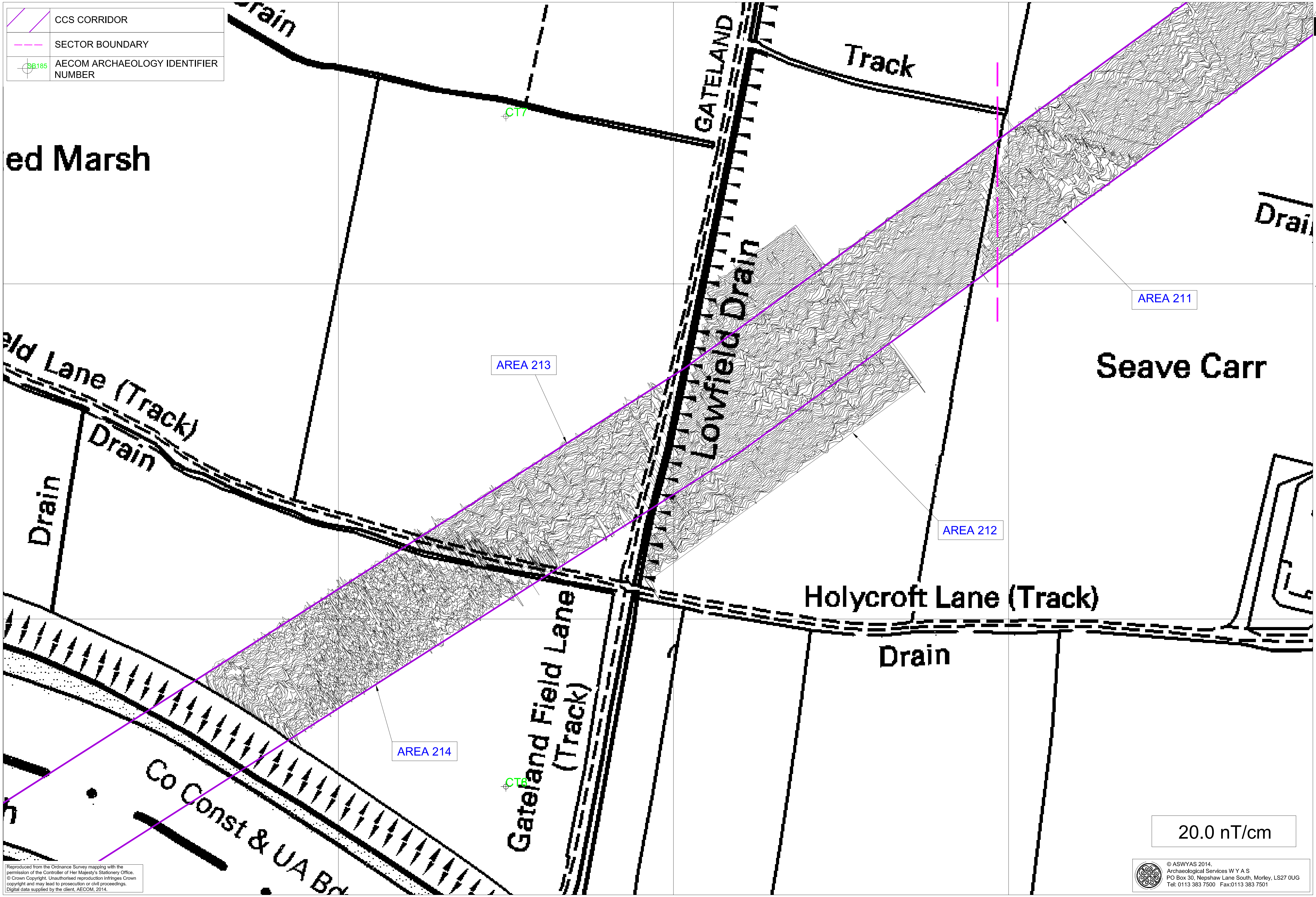


Fig. 31. XY trace plot of minimally processed magnetometer data; Sector 1 (1:2000 @ A3)

0 40m

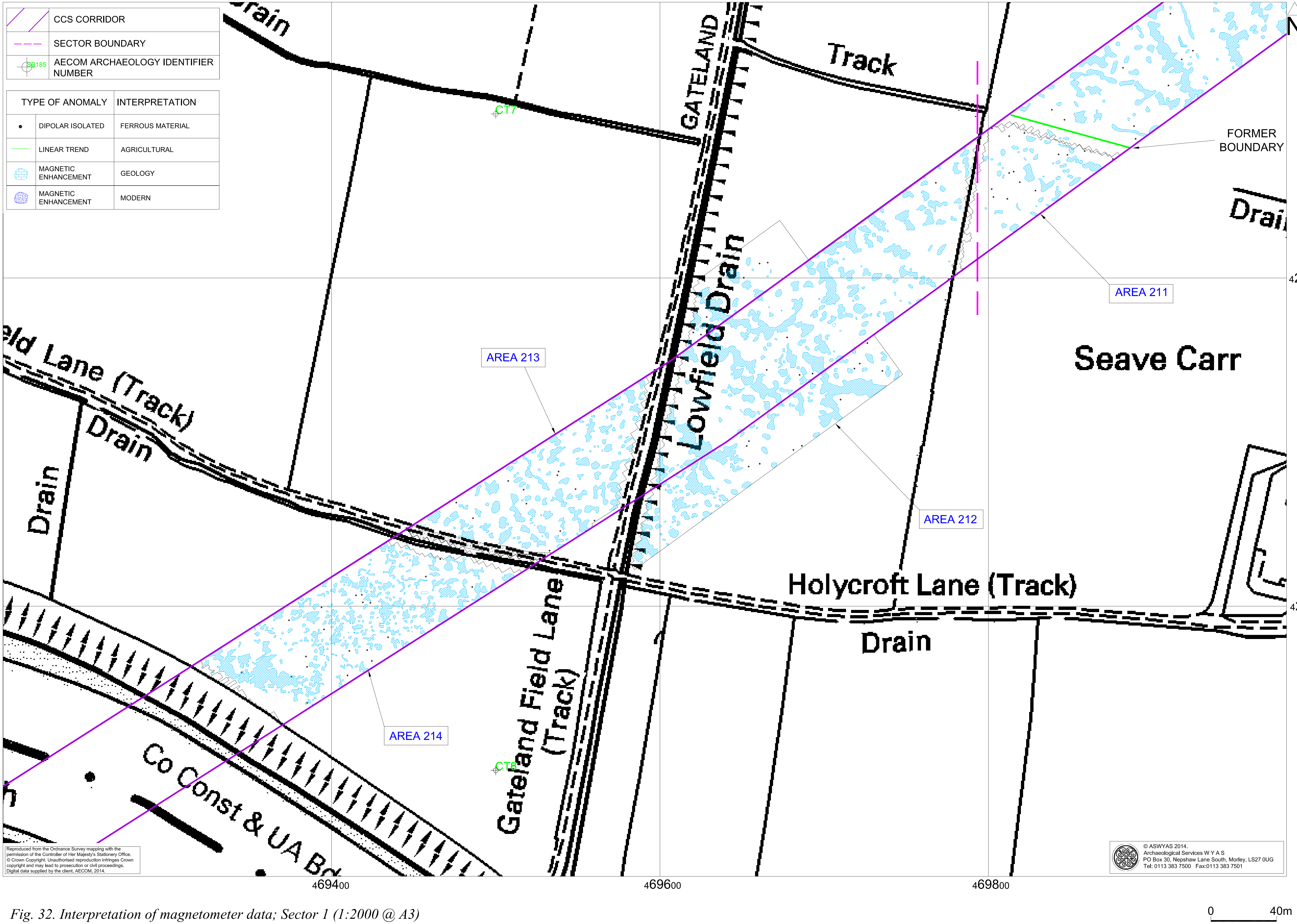


Fig. 32. Interpretation of magnetometer data; Sector 1 (1:2000 @ A3)

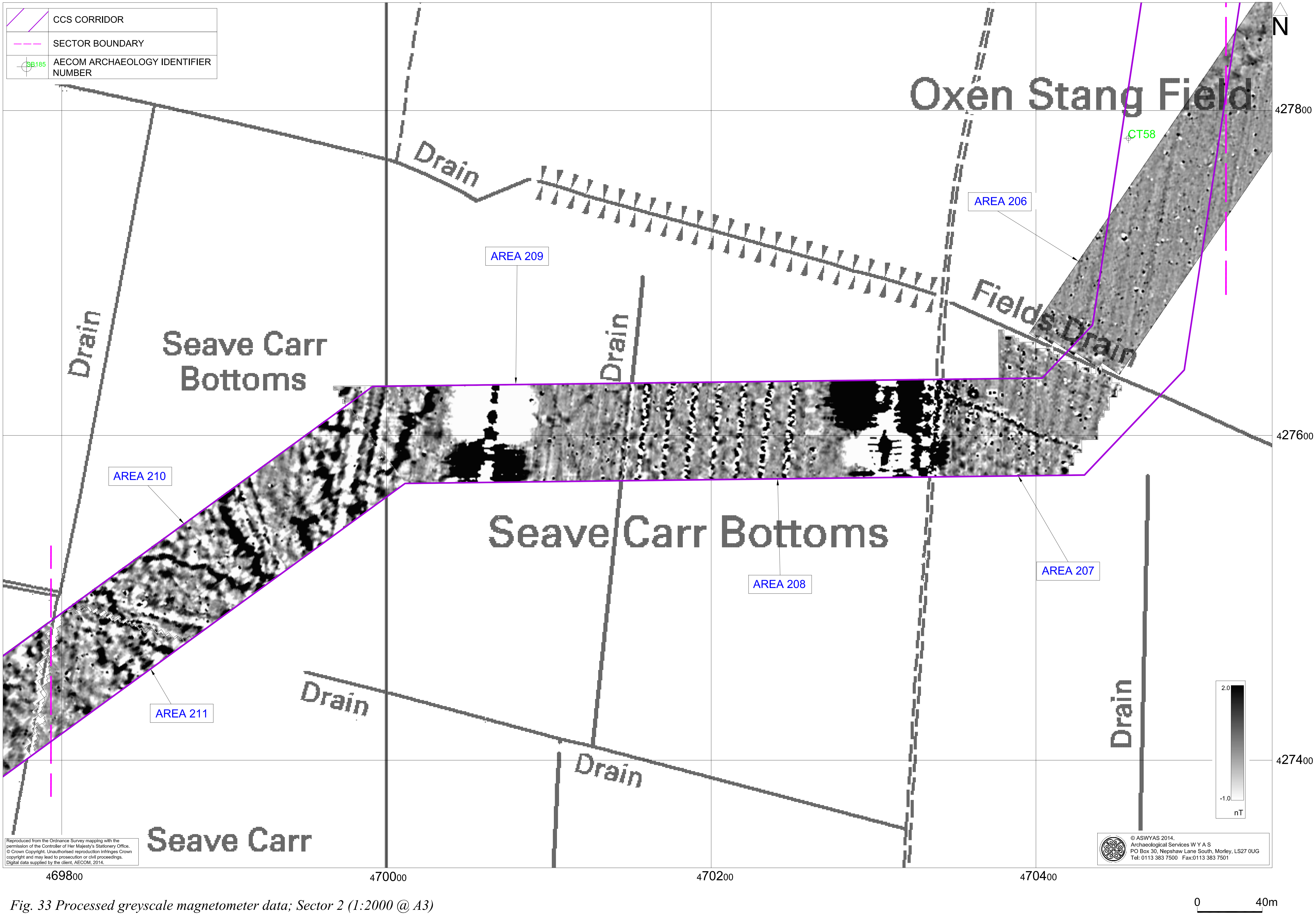


Fig. 33 Processed greyscale magnetometer data; Sector 2 (1:2000 @ A3)

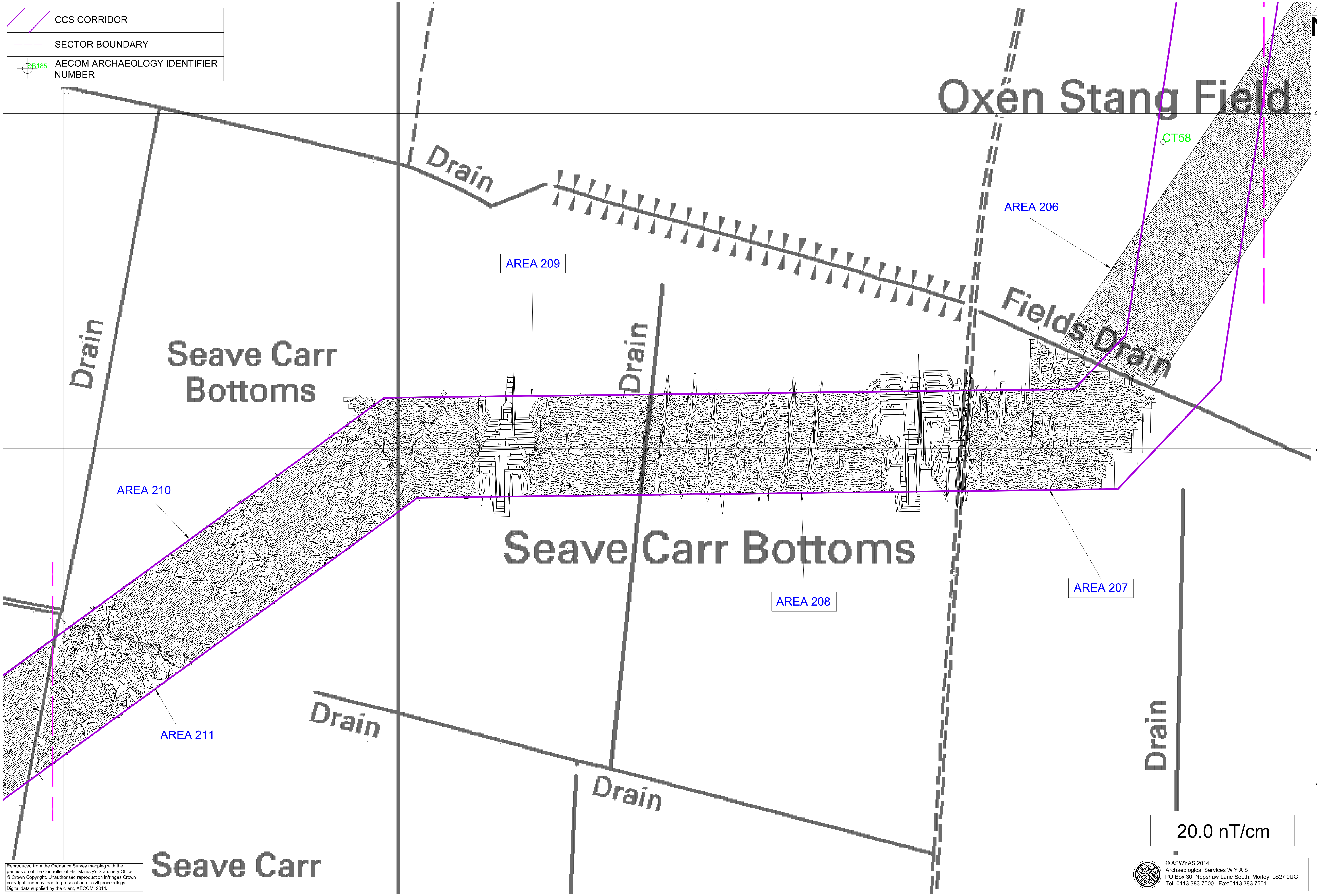


Fig. 34. XY trace plot of minimally processed magnetometer data; Sector 2 (1:2000 @ A3)

0 40m

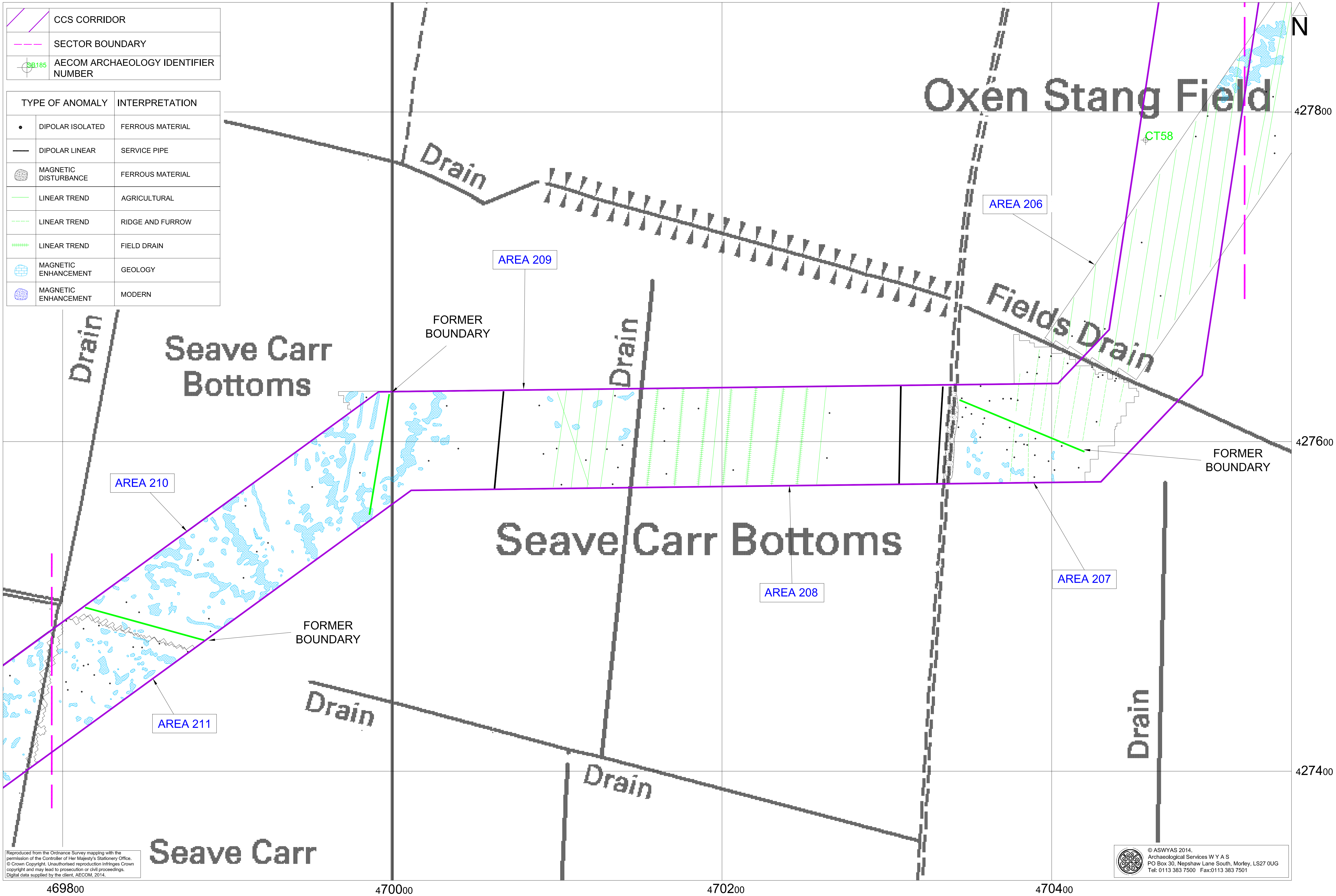


Fig. 35. Interpretation of magnetometer data; Sector 2 (1:2000 @ A3)

0 40m

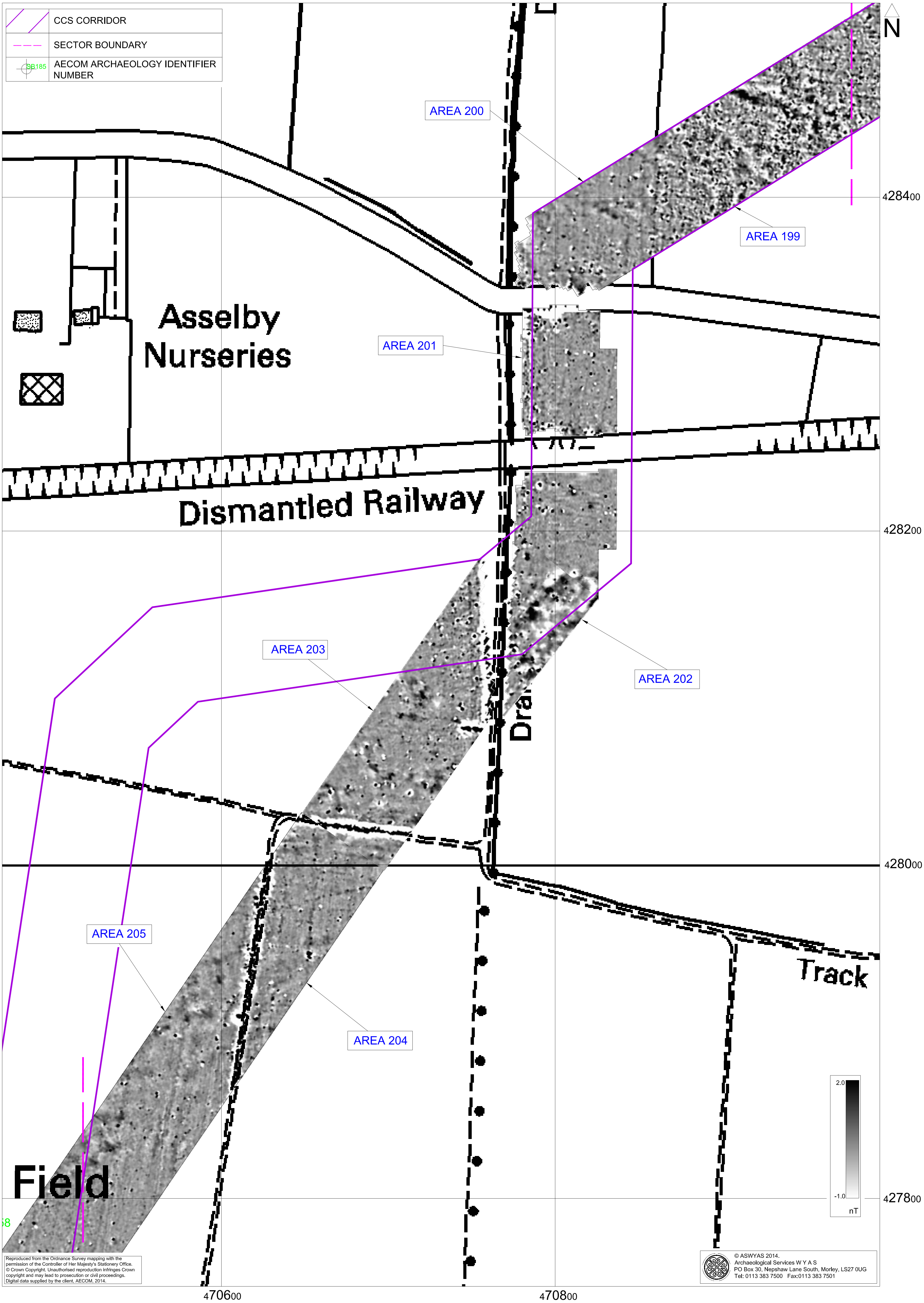


Fig. 36. Processed greyscale magnetometer data; Sector 3 (1:2000 @ A3)

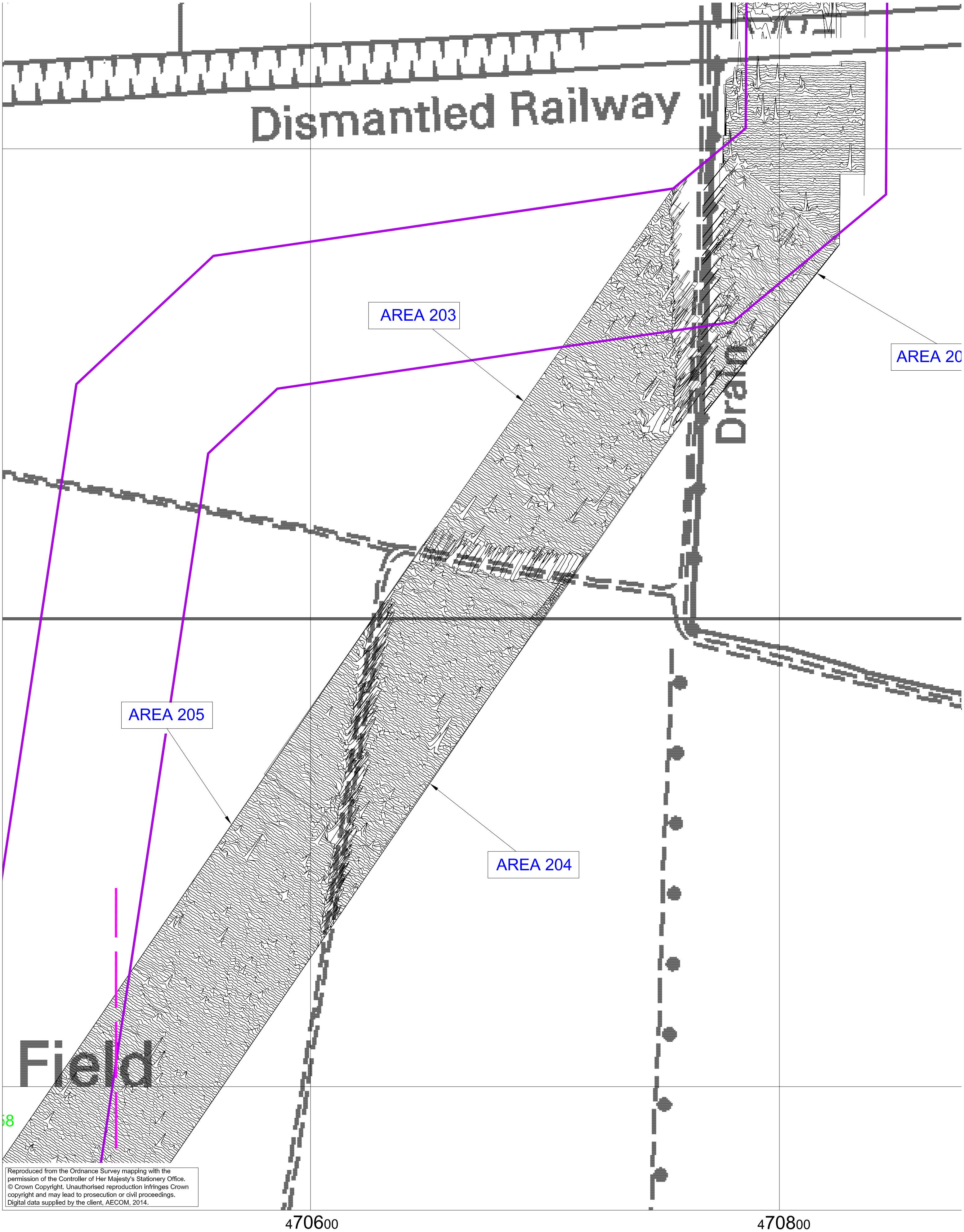


Fig. 37. XY trace plot of minimally processed magnetometer data; Sector 3 (1:2000 @ A3)

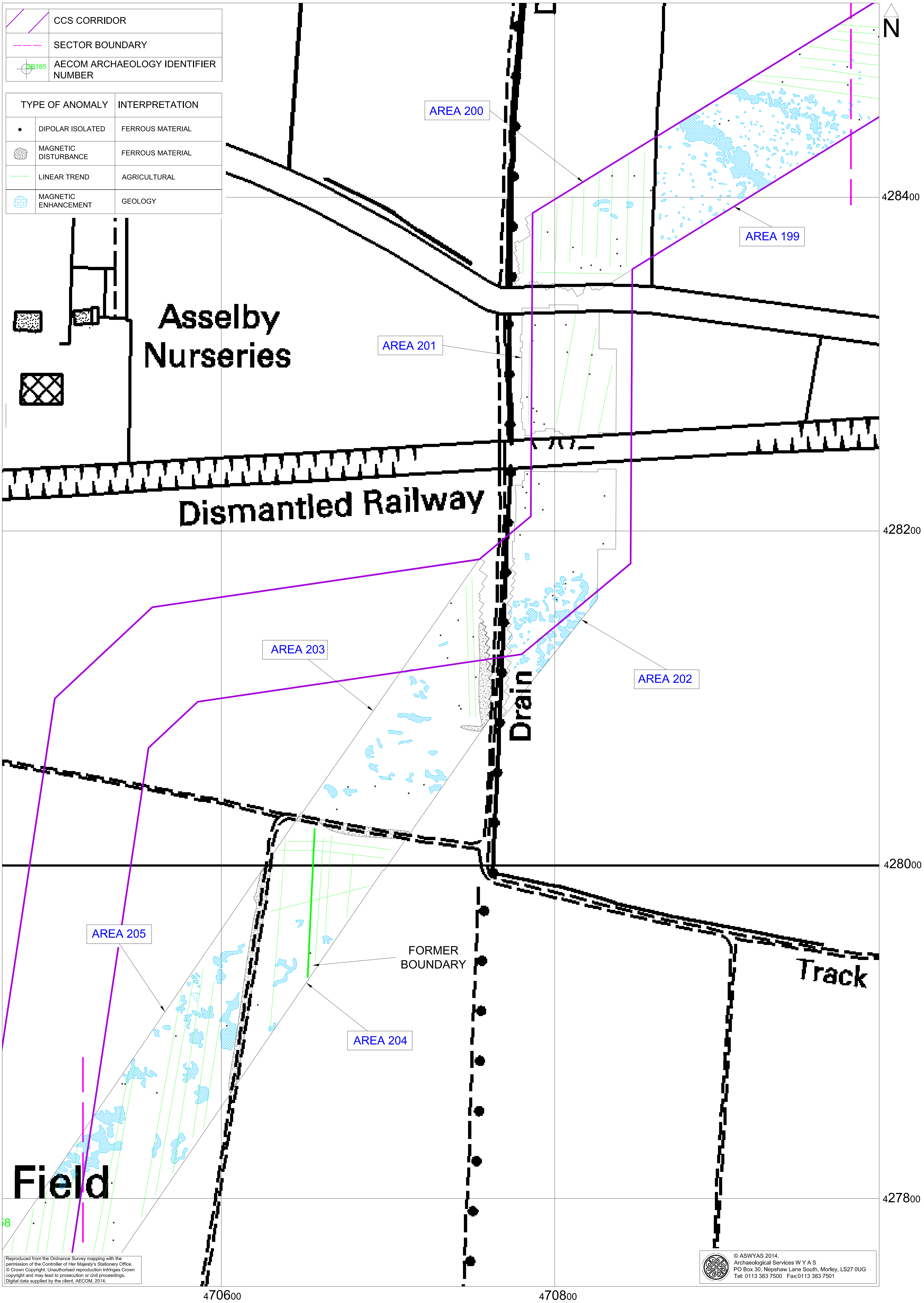


Fig. 38. Interpretation of magnetometer data; Sector 3 (1:2000 @ A3)

0 40m

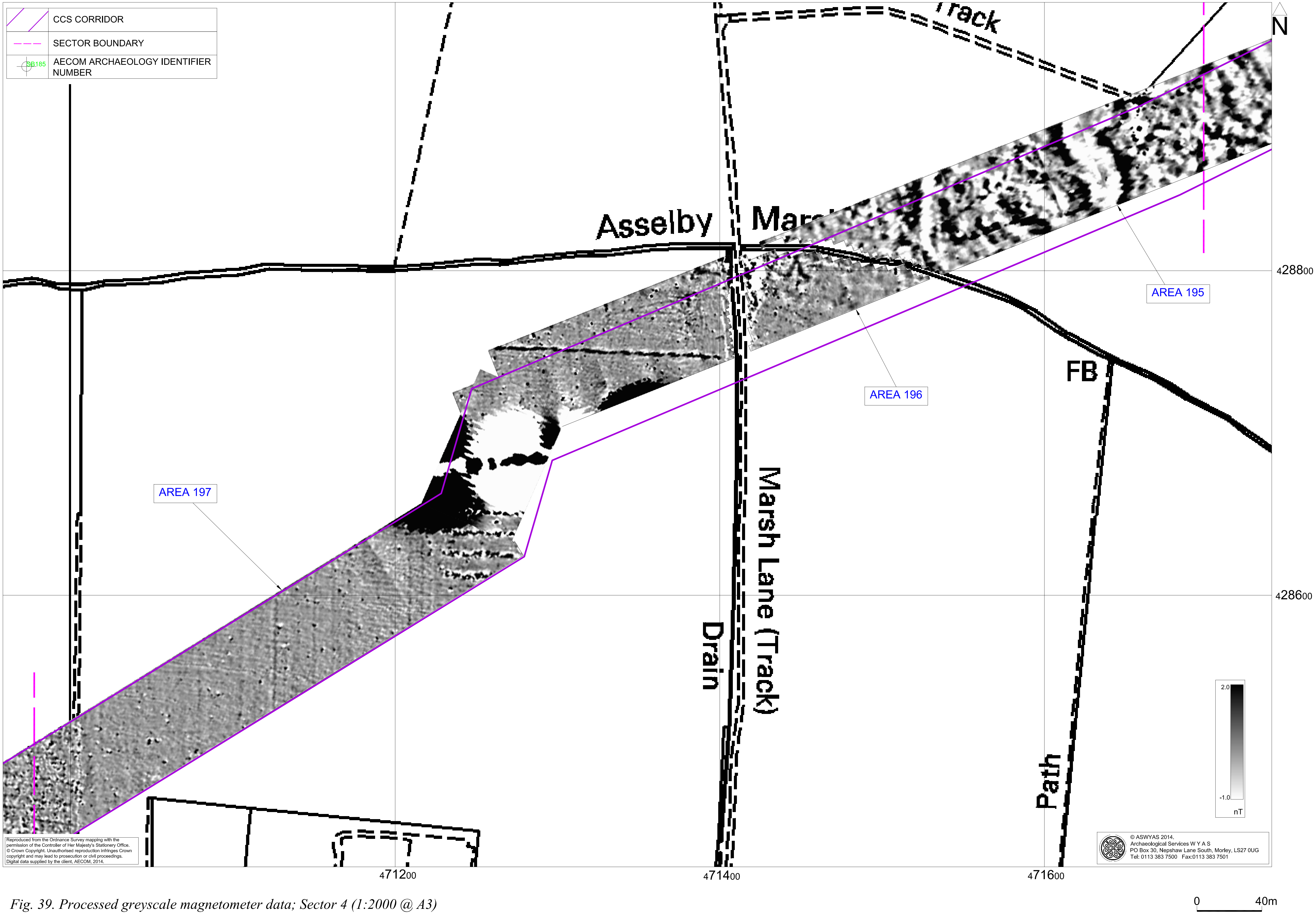


Fig. 39. Processed greyscale magnetometer data; Sector 4 (1:2000 @ A3)

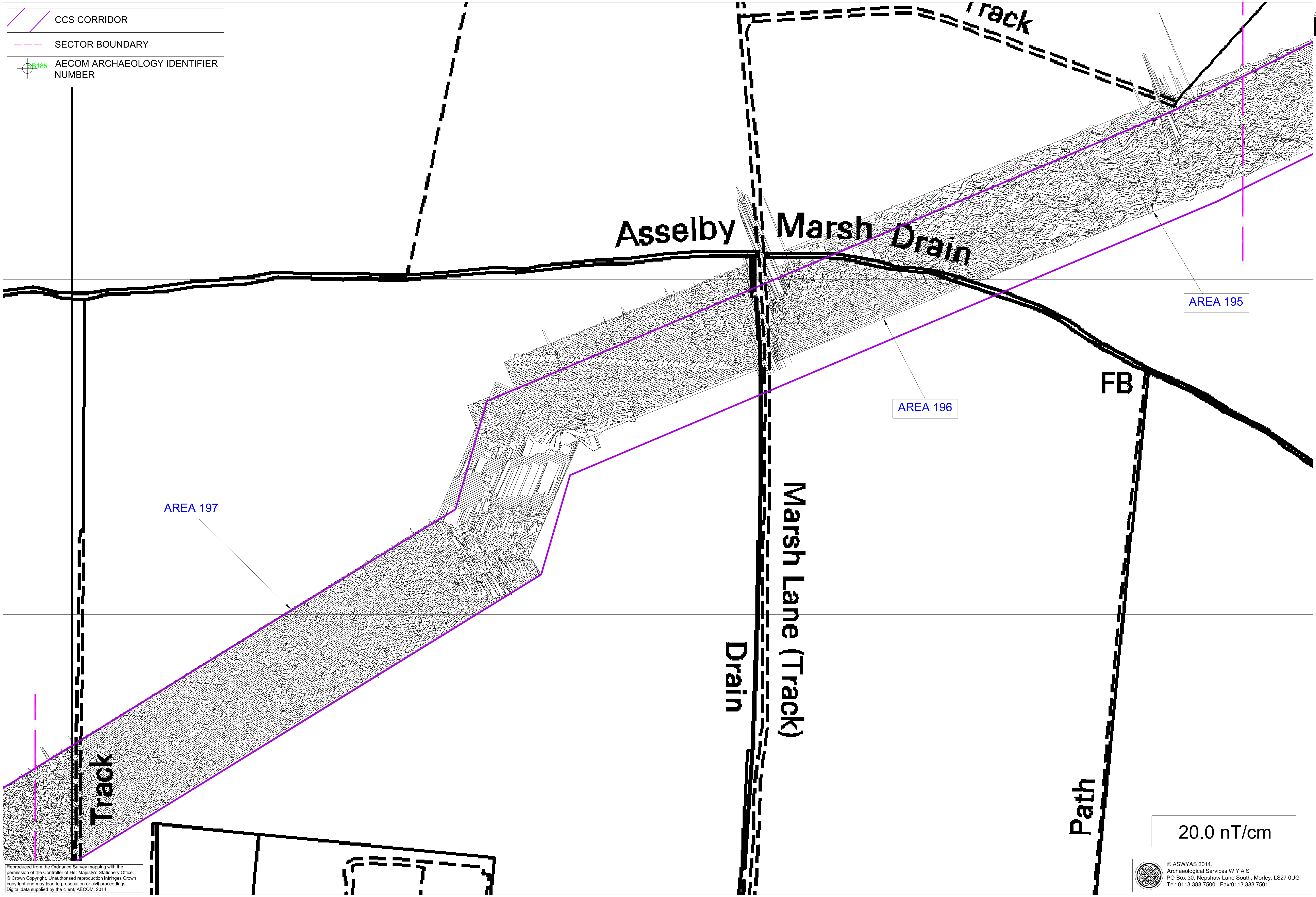


Fig. 40. XY trace plot of minimally processed magnetometer data; Sector 4 (1:2000 @ A3)

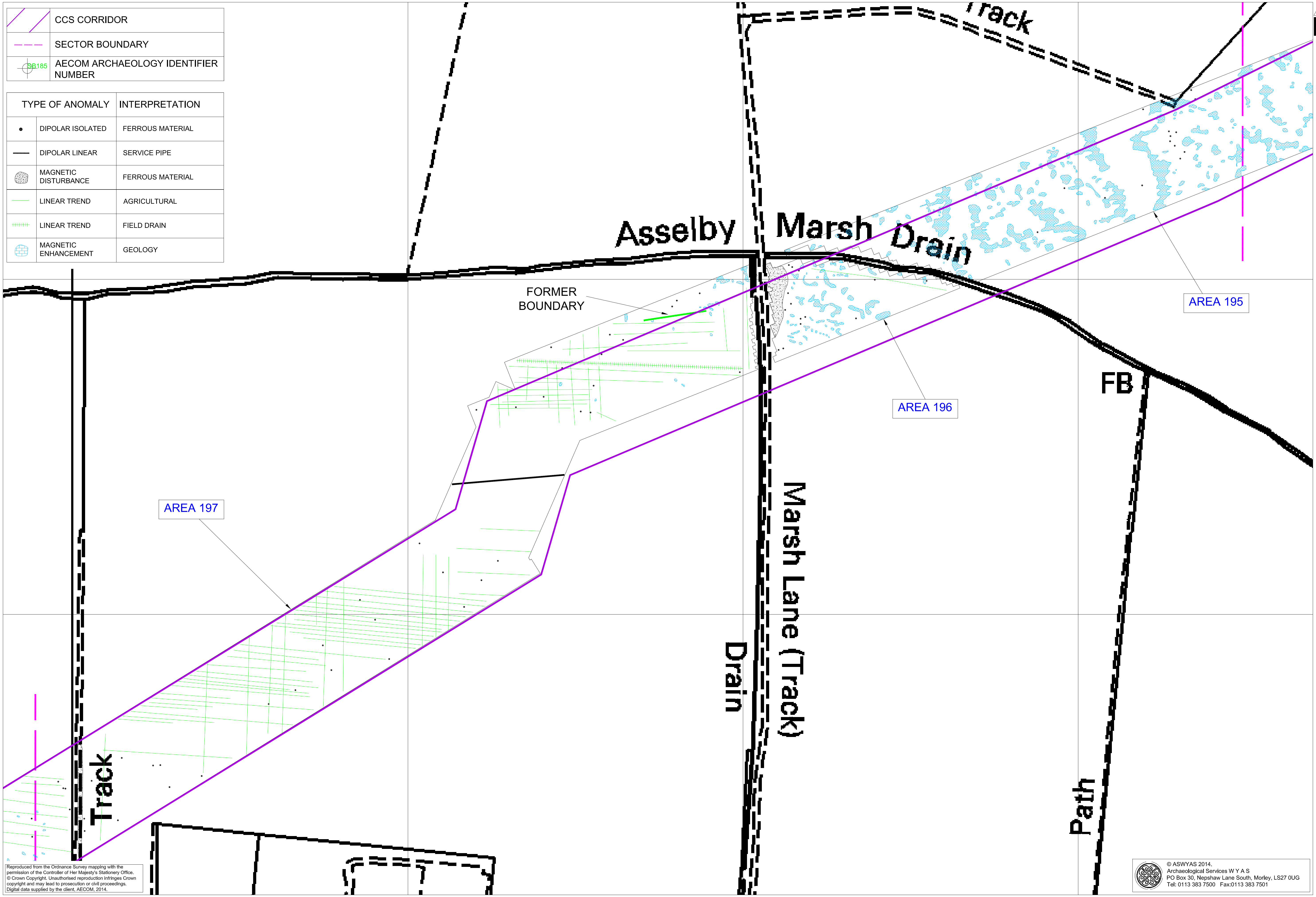


Fig. 41. Interpretation of magnetometer data; Sector 4 (1:2000 @ A3)

Fig. 42. Processed greyscale magnetometer data; Sector 5 (1:2000 @ A3)

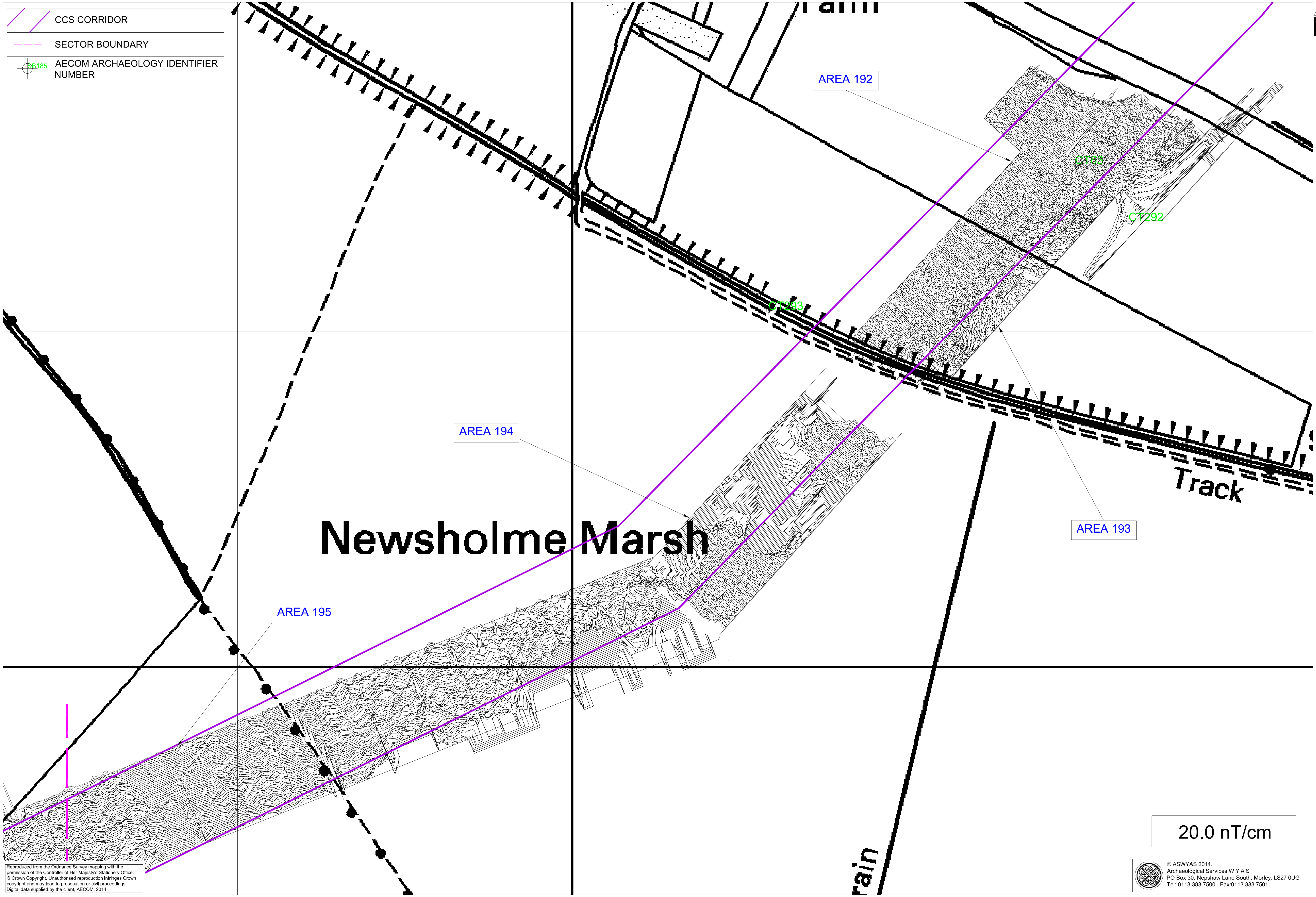


Fig. 43. XY trace plot of minimally processed magnetometer data; Sector 5 (1:2000 @ A3)

0 40m

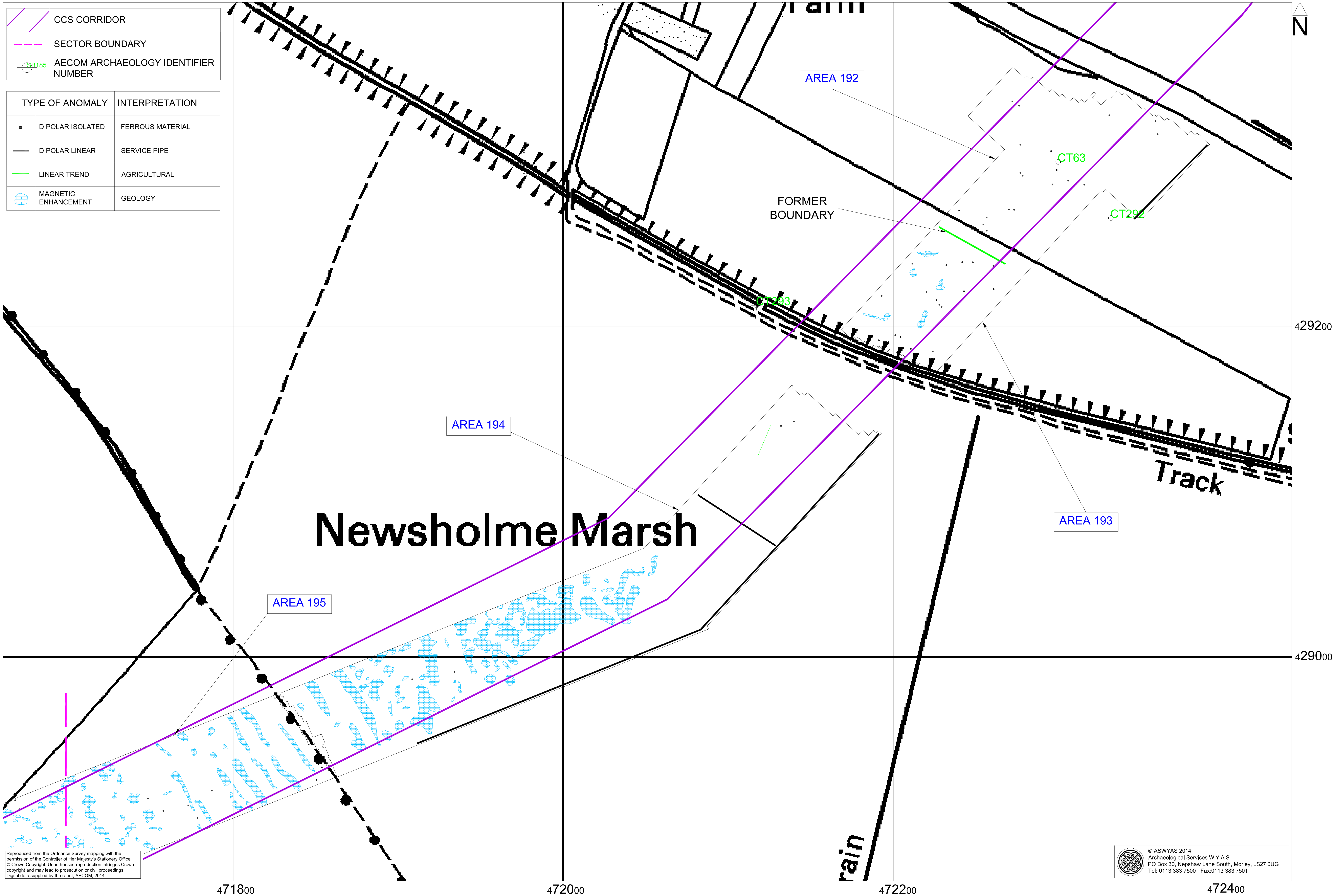


Fig. 44. Interpretation of magnetometer data; Sector 5 (1:2000 @ A3)

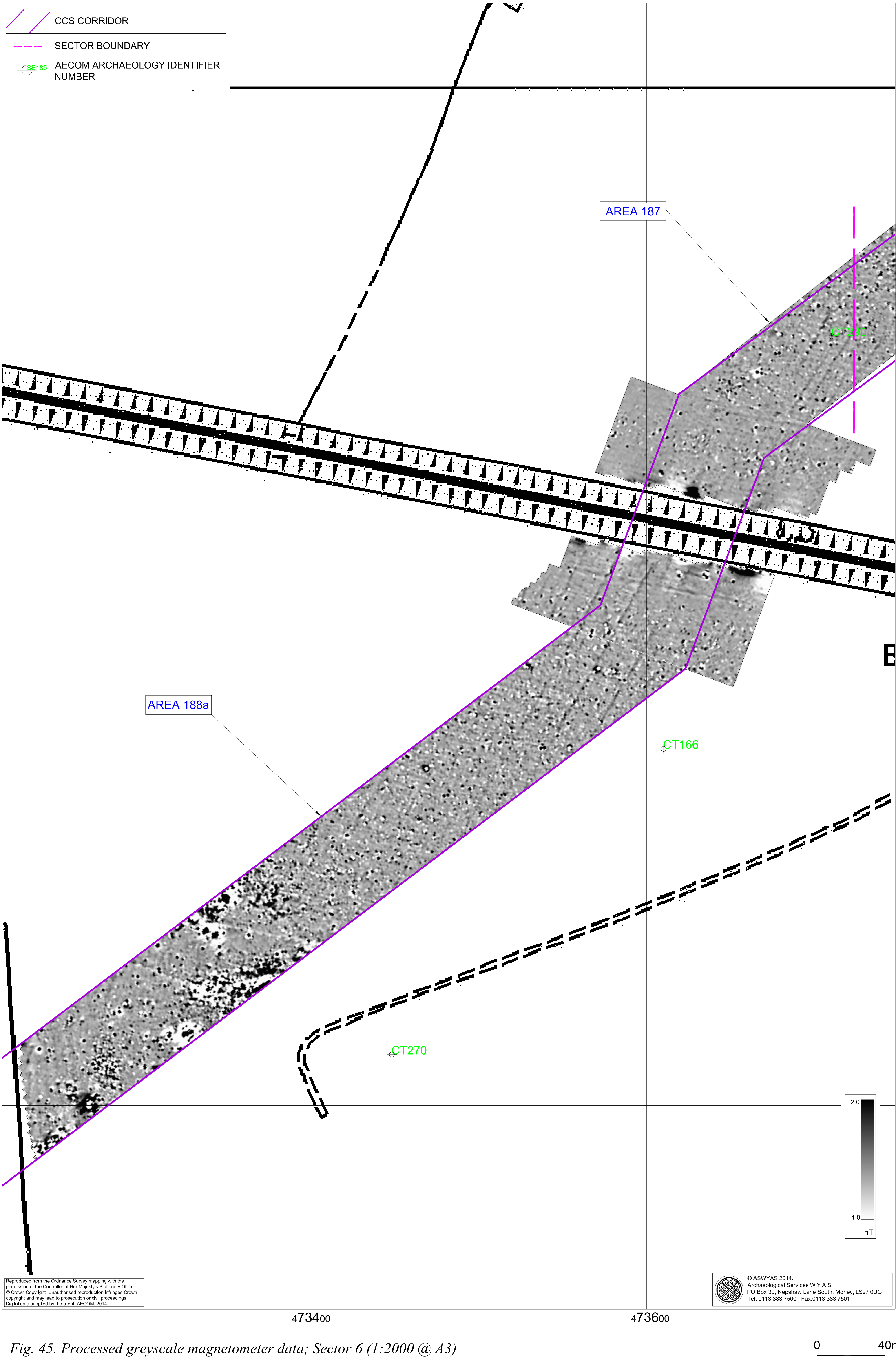


Fig. 45. Processed greyscale magnetometer data; Sector 6 (1:2000 @ A3)

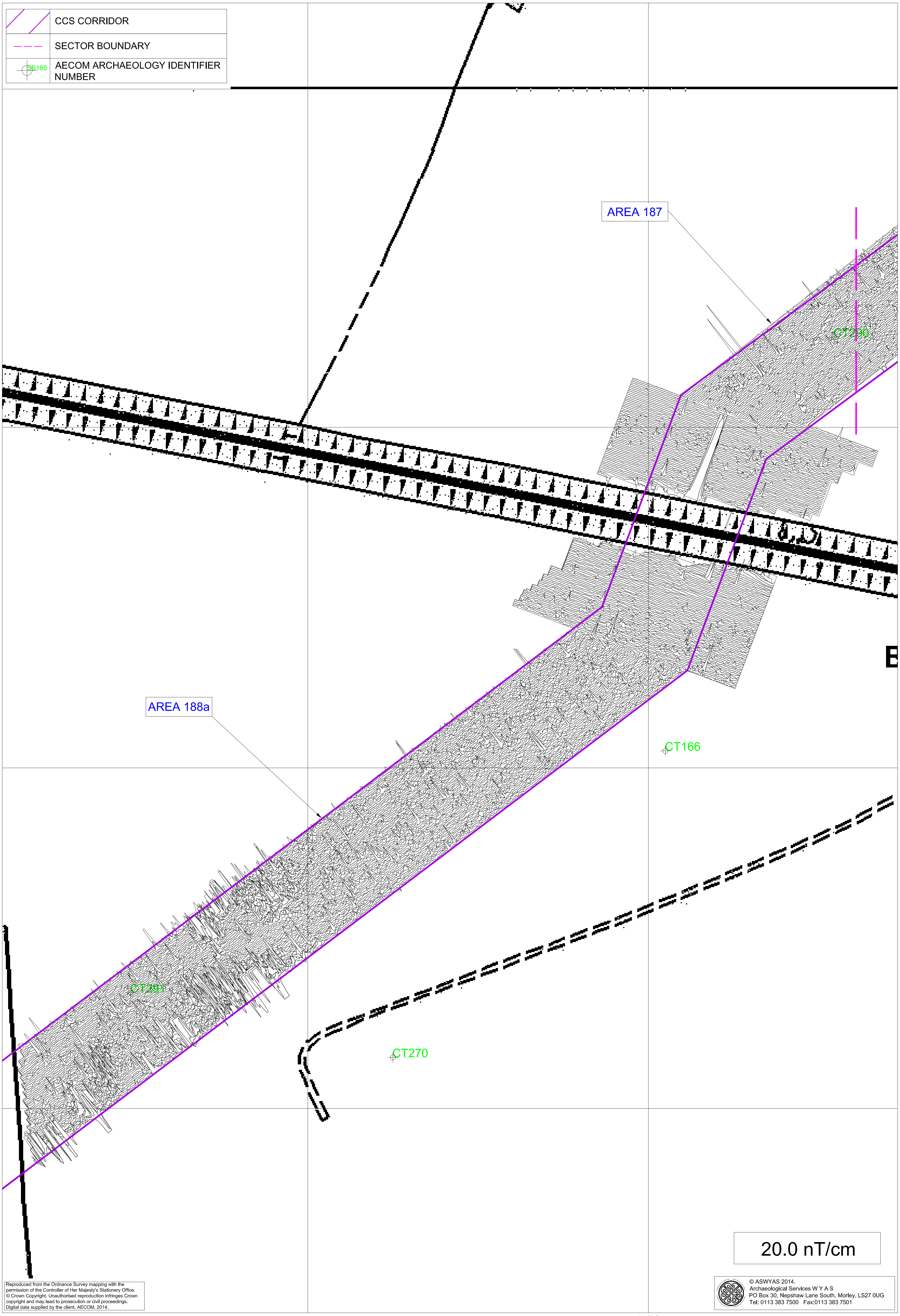


Fig. 46. XY trace plot of minimally processed magnetometer data; Sector 6 (1:2000 @ A3)

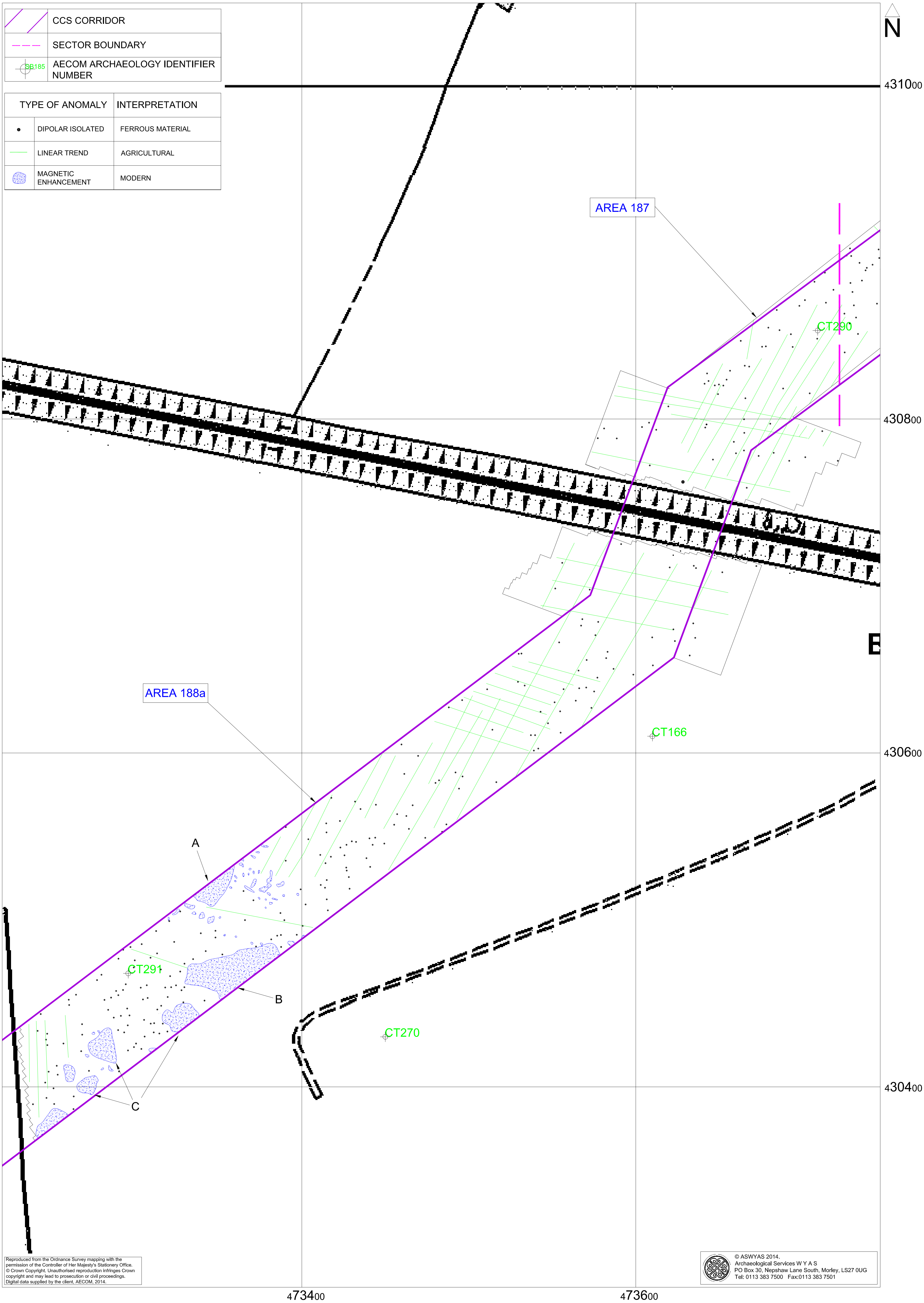


Fig. 47. Interpretation of magnetometer data; Sector 6 (1:2000 @ A3)

0 40m

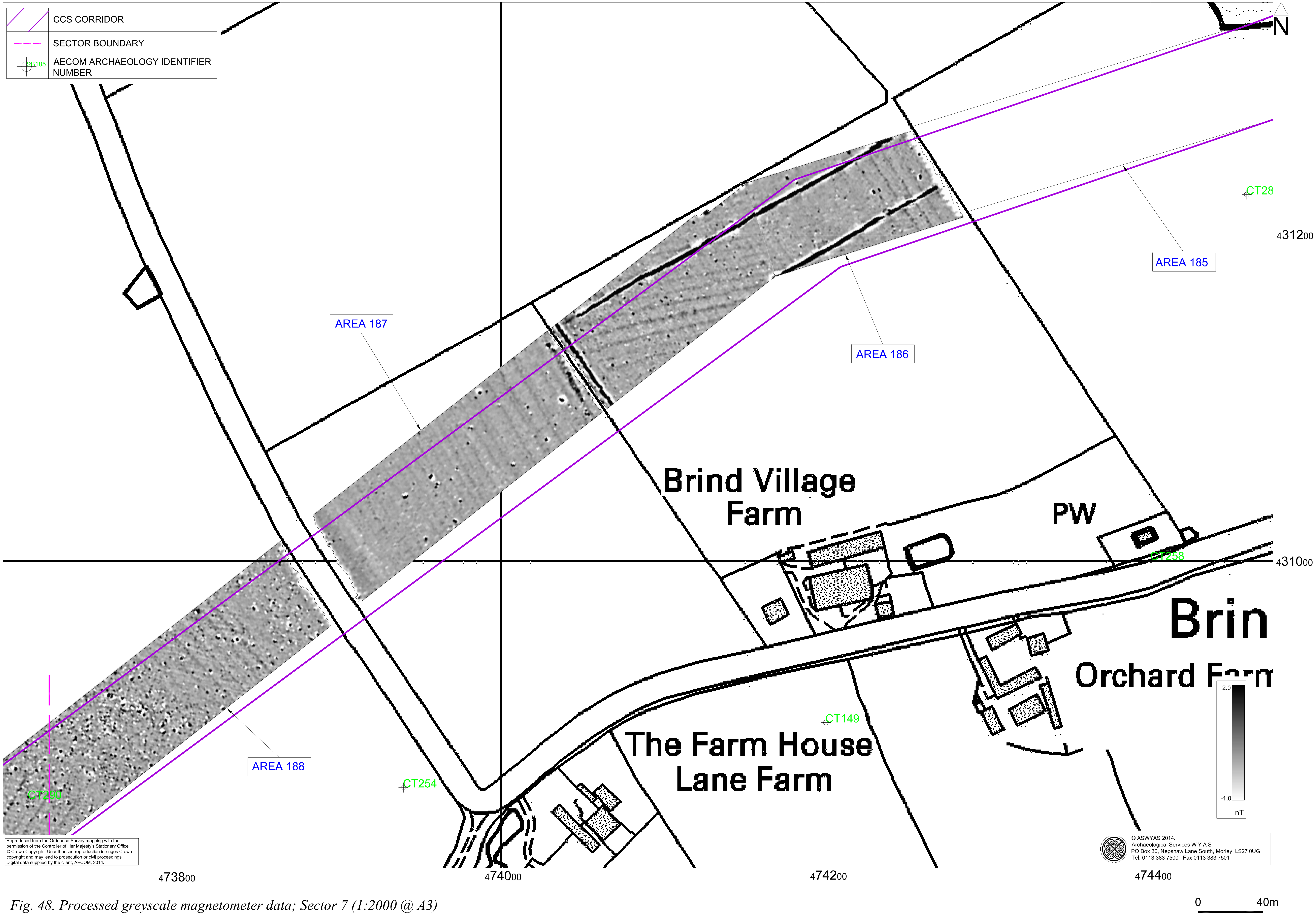


Fig. 48. Processed greyscale magnetometer data; Sector 7 (1:2000 @ A3)

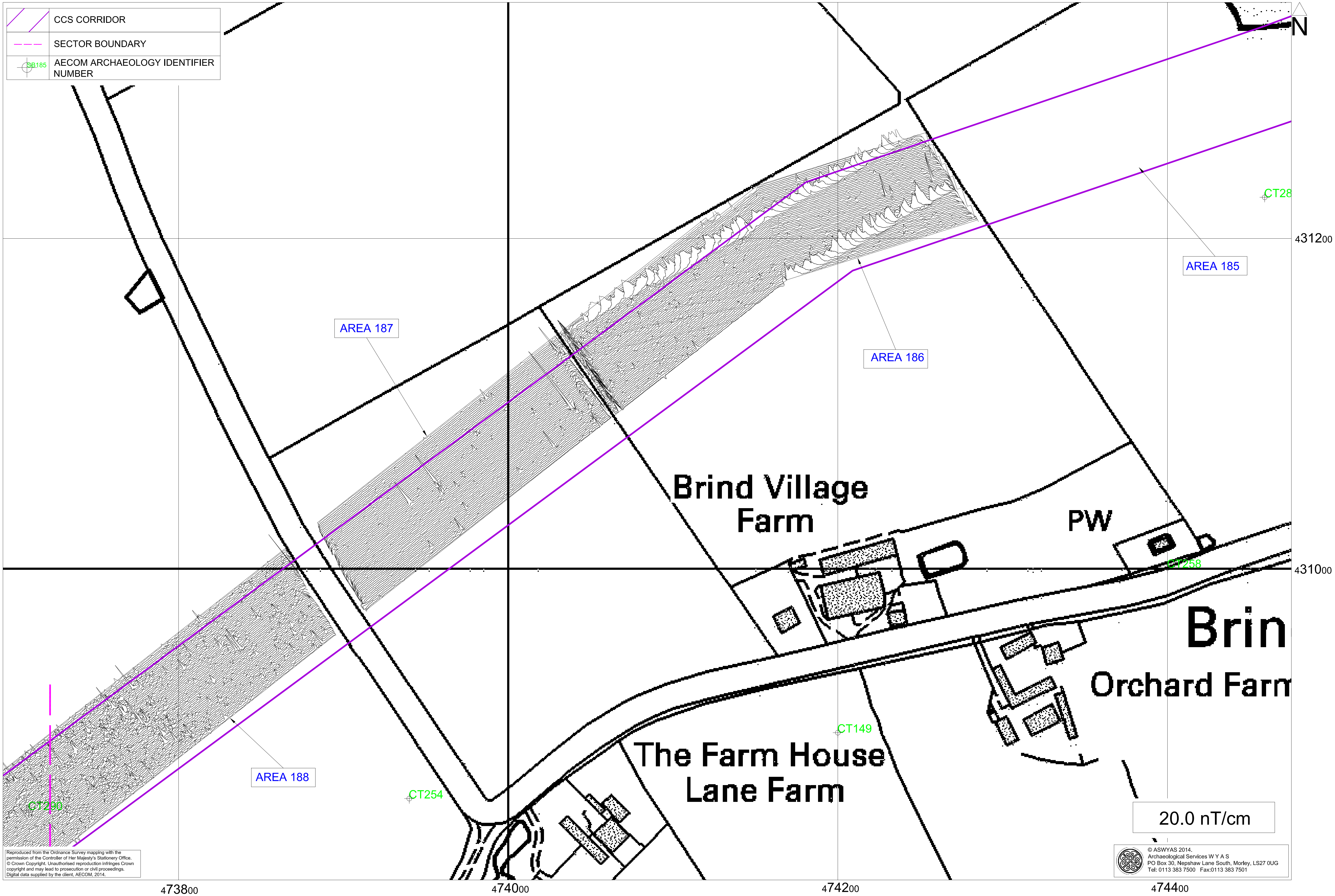


Fig. 49. XY trace plot of minimally processed magnetometer data; Sector 7 (1:2000 @ A3)

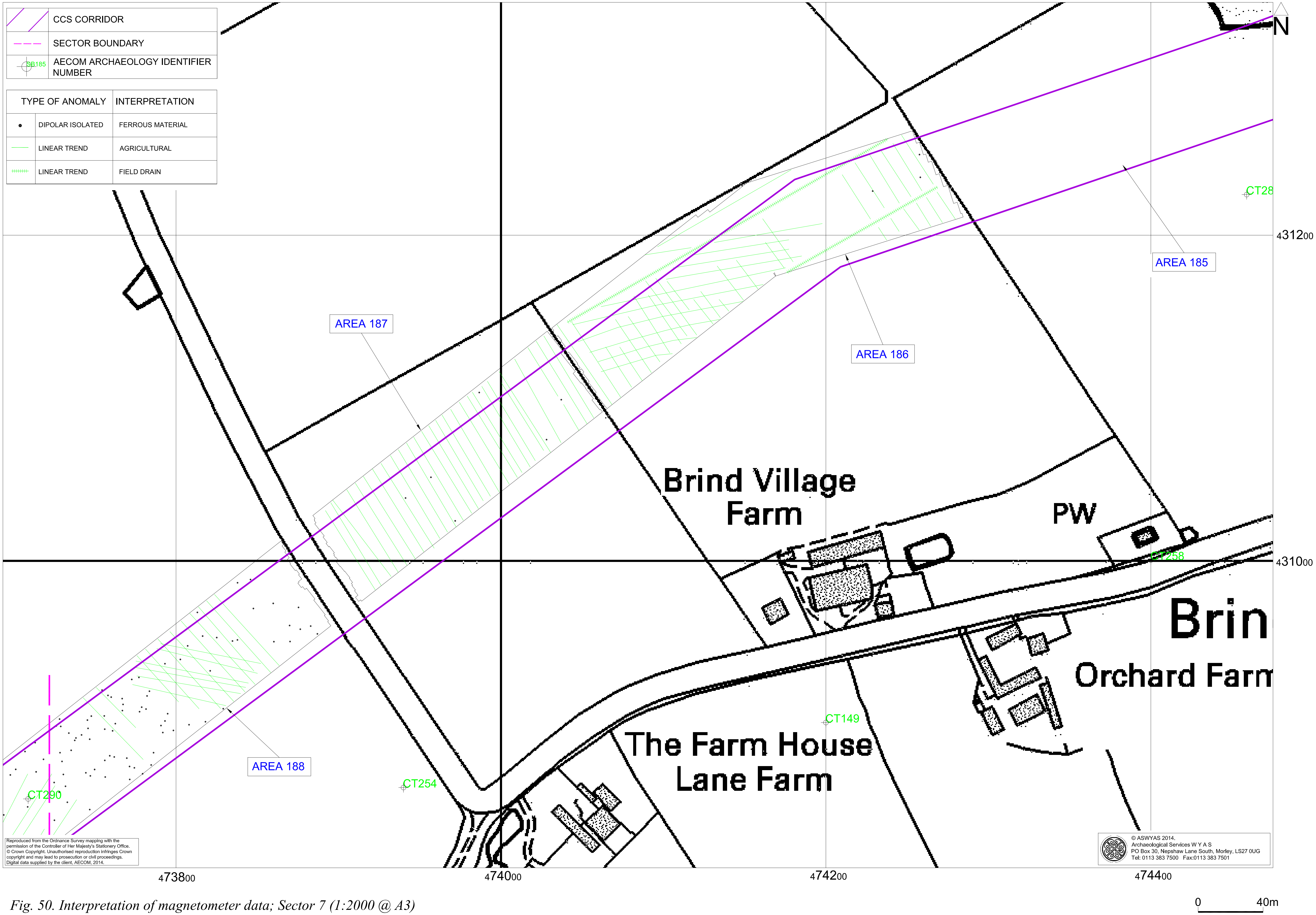


Fig. 50. Interpretation of magnetometer data; Sector 7 (1:2000 @ A3)

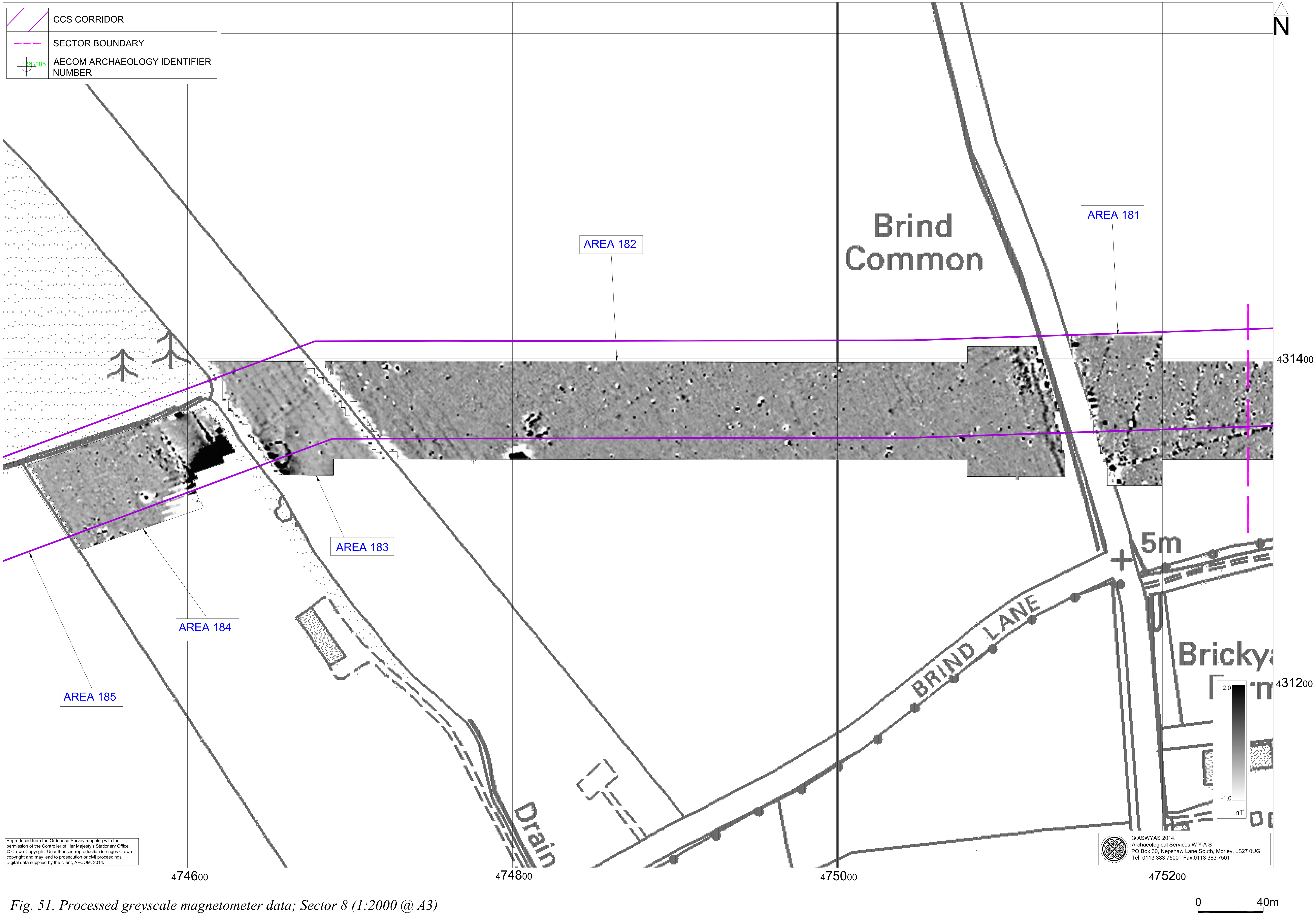
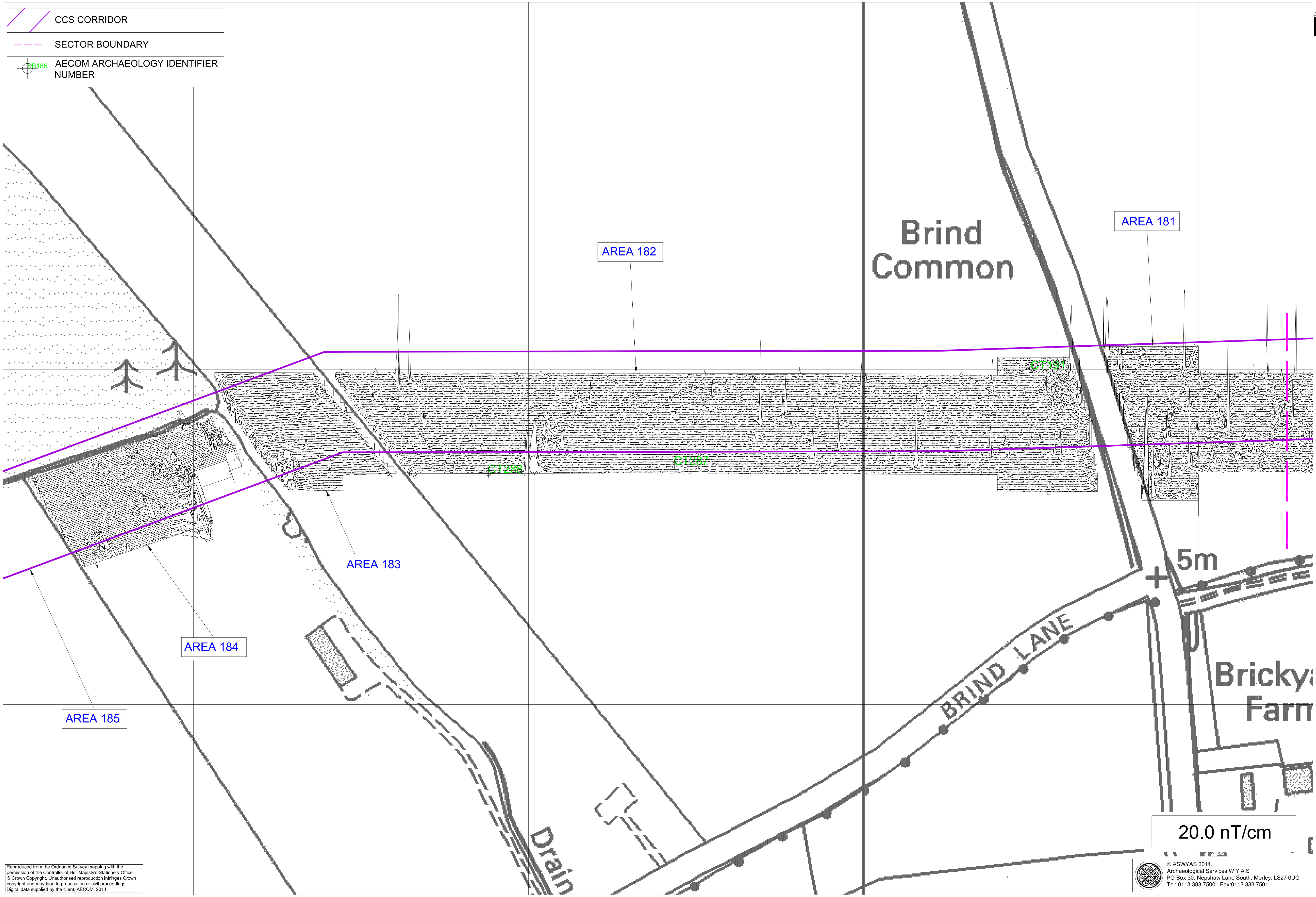


Fig. 51. Processed greyscale magnetometer data; Sector 8 (1:2000 @ A3)



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Tel: 0113 383 7500 Fax:0113 383 7501

Fig. 52. XY trace plot of minimally processed magnetometer data; Sector 8 (1:2000 @ A3)

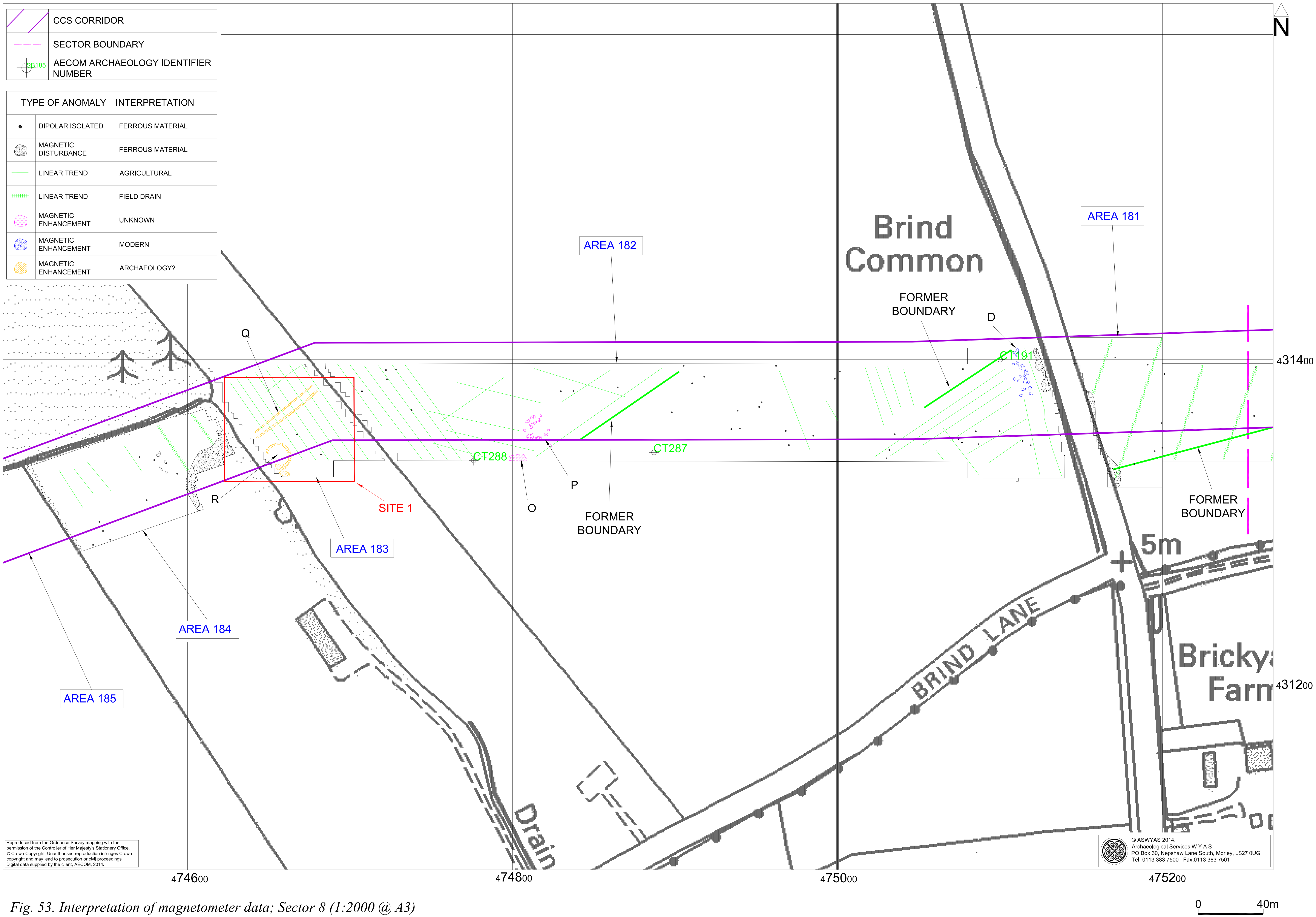

Fig. 53. Interpretation of magnetometer data; Sector 8 (1:2000 @ A3)

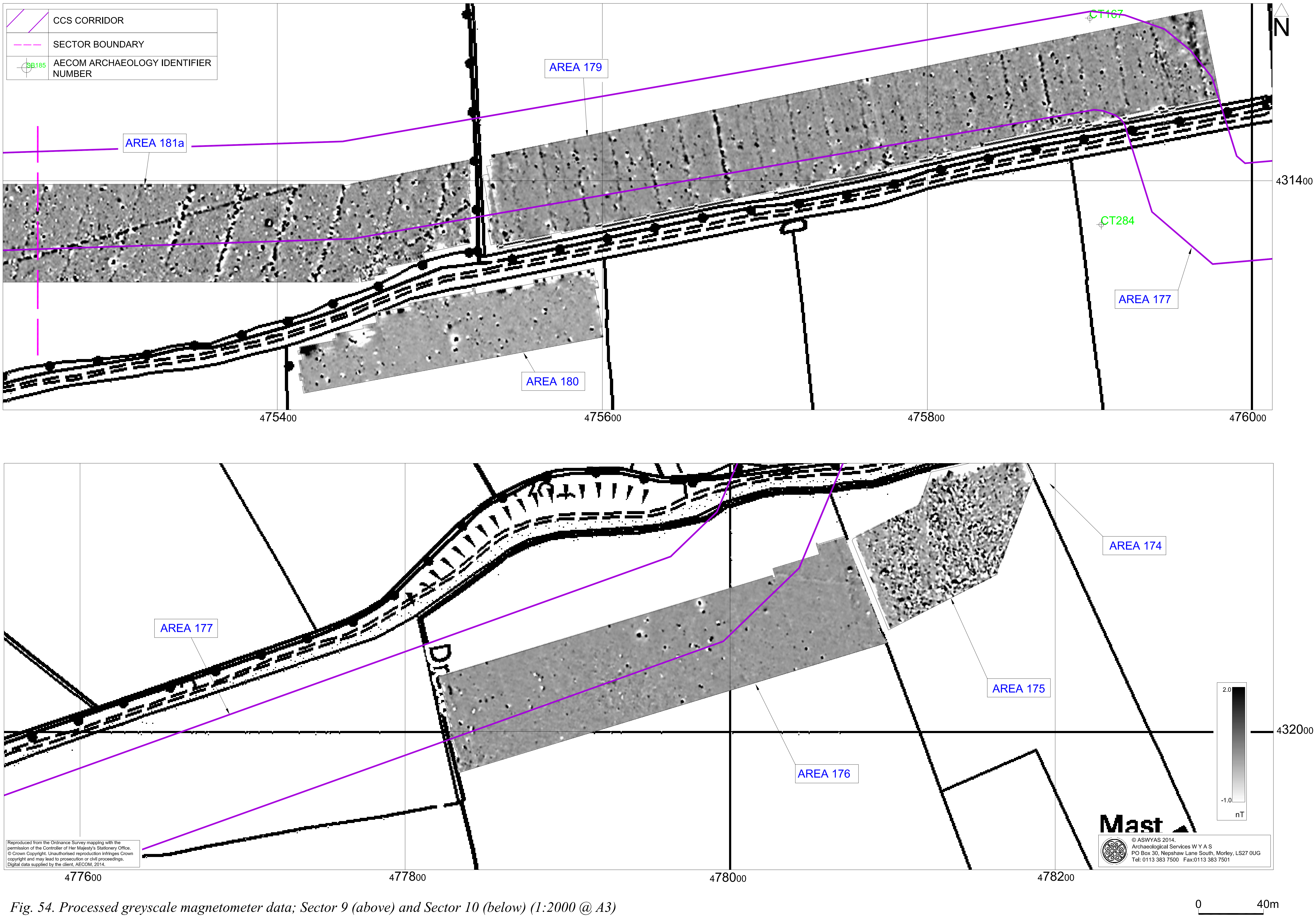

Fig. 54. Processed greyscale magnetometer data; Sector 9 (above) and Sector 10 (below) (1:2000 @ A3)

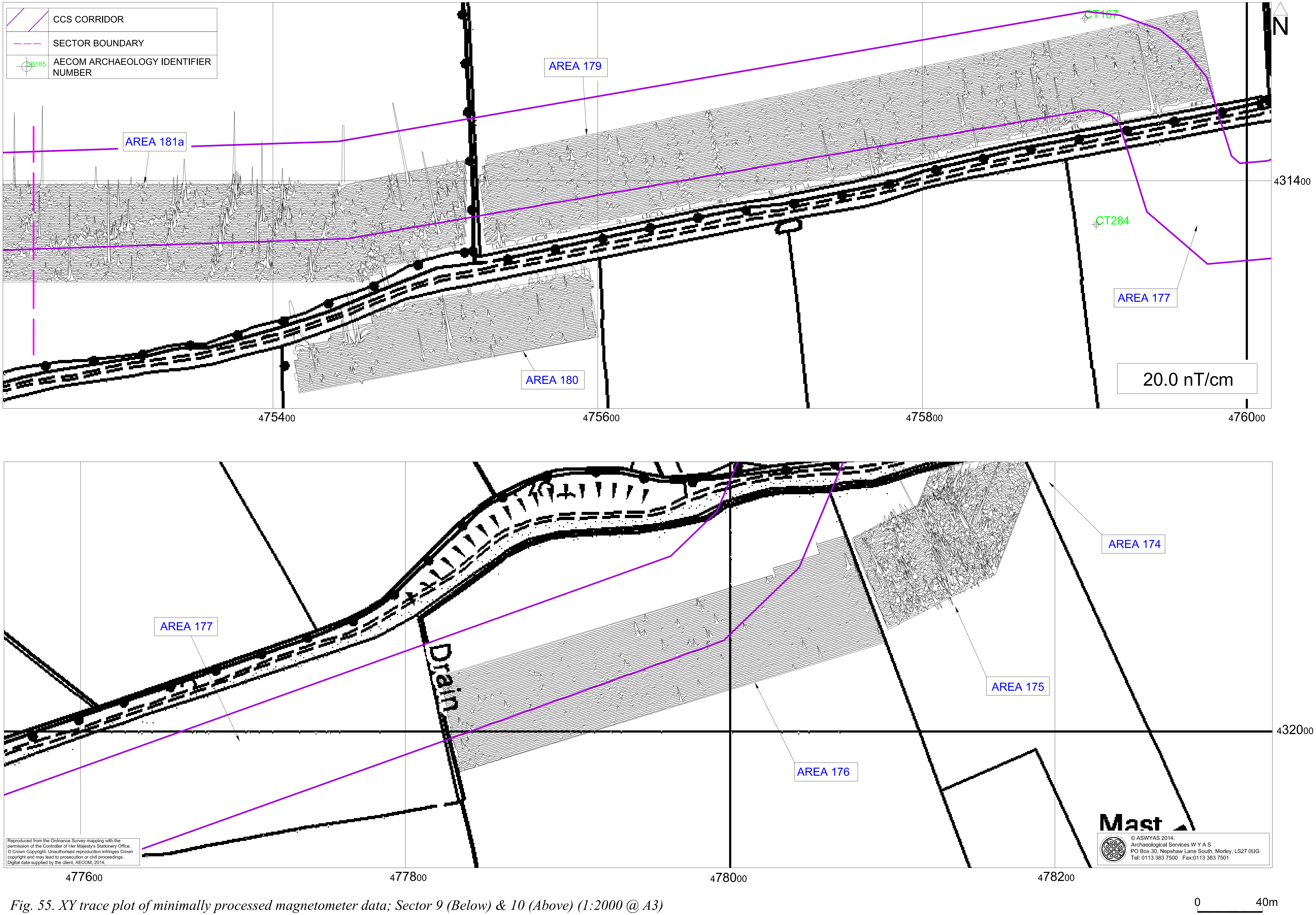

Fig. 55. XY trace plot of minimally processed magnetometer data; Sector 9 (Below) & 10 (Above) (1:2000 @ A3)

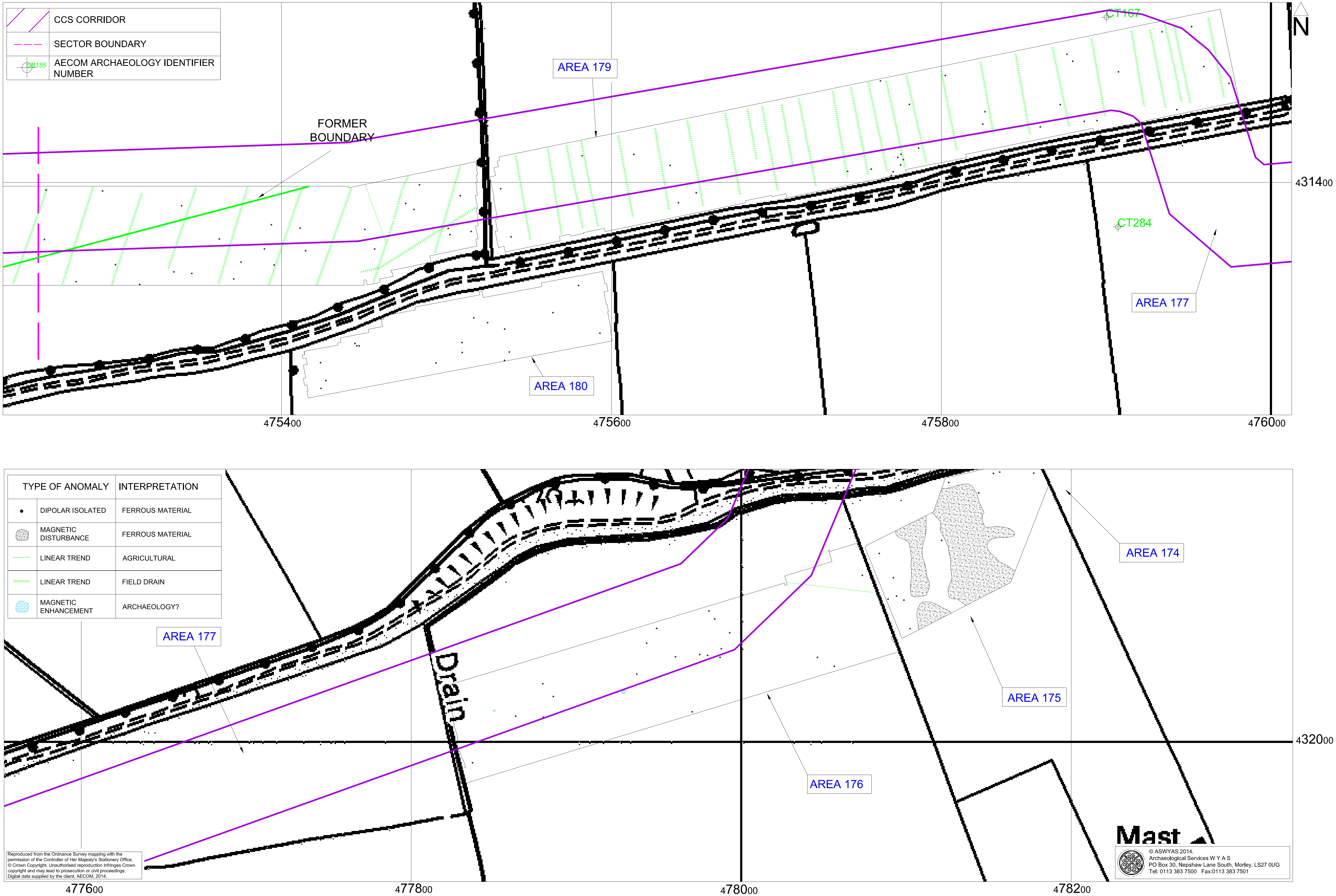

Fig. 56. Interpretation of magnetometer data; Sector 9 (above) and Sector 10 (below) (1:2000 @ A3)

0 40m

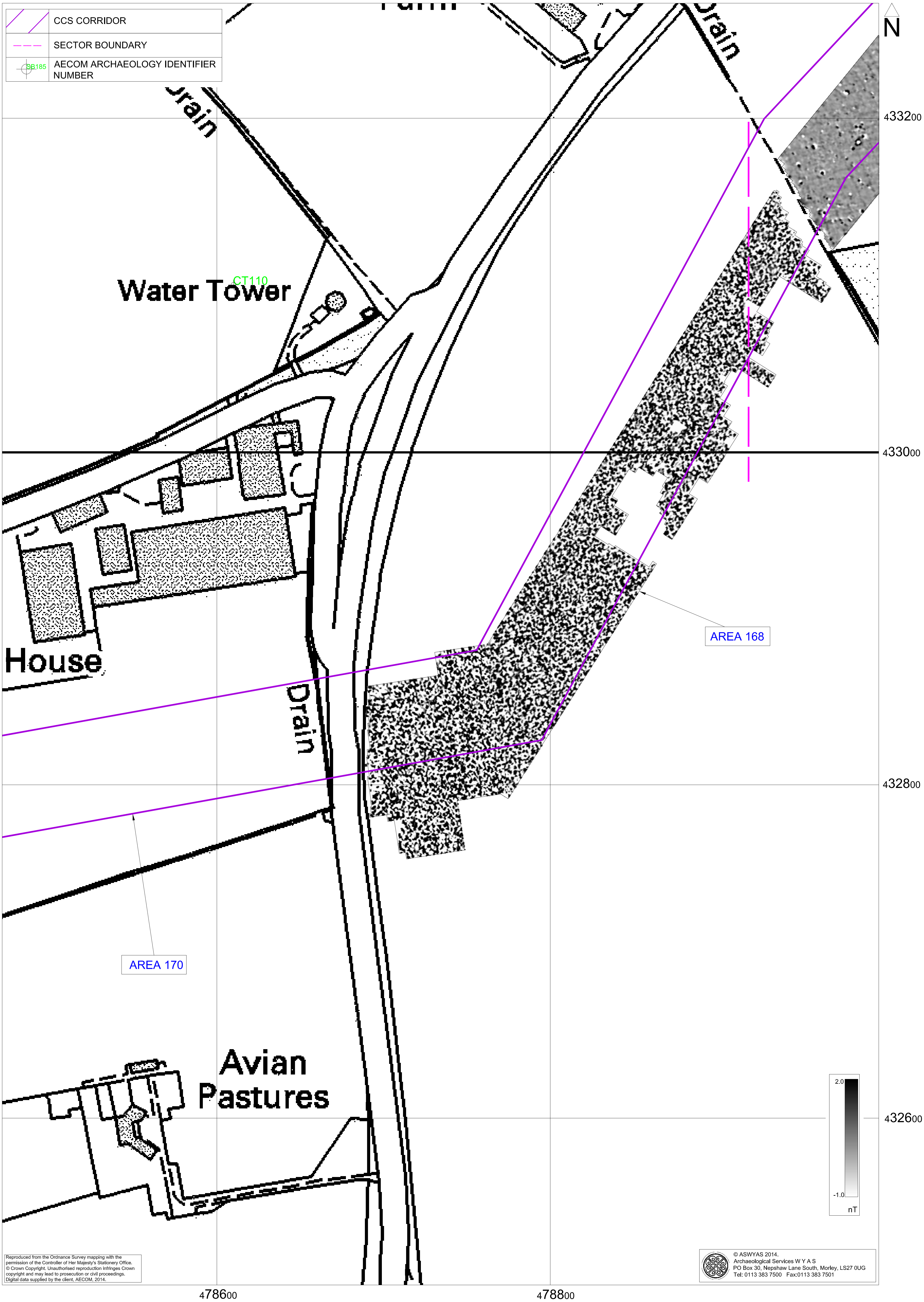

Fig. 57. Processed greyscale magnetometer data; Sector 11 (1:2000 @ A3)

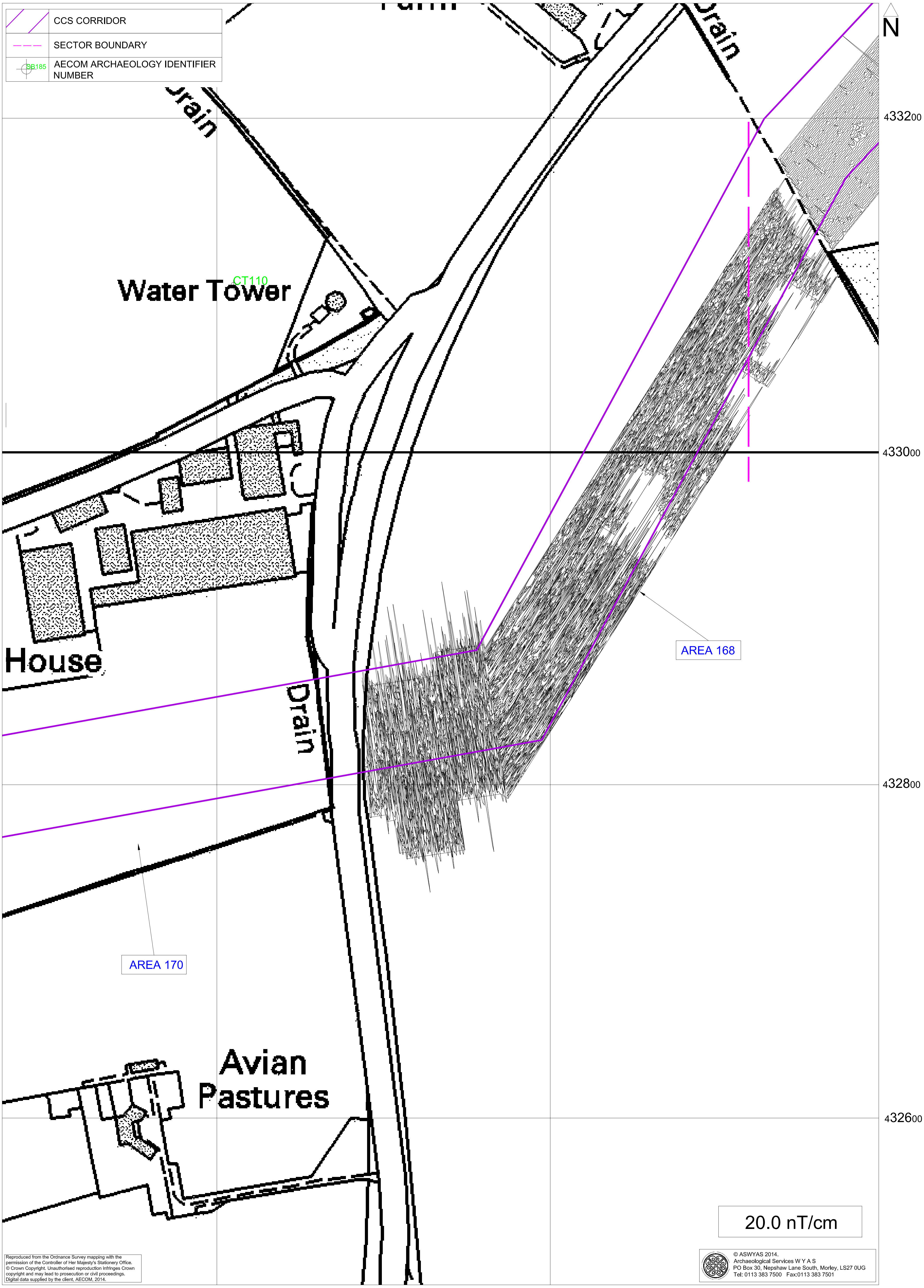

Fig. 58. XY trace plot of minimally processed magnetometer data; Sector 11 (1:2000 @ A3)

0 40m

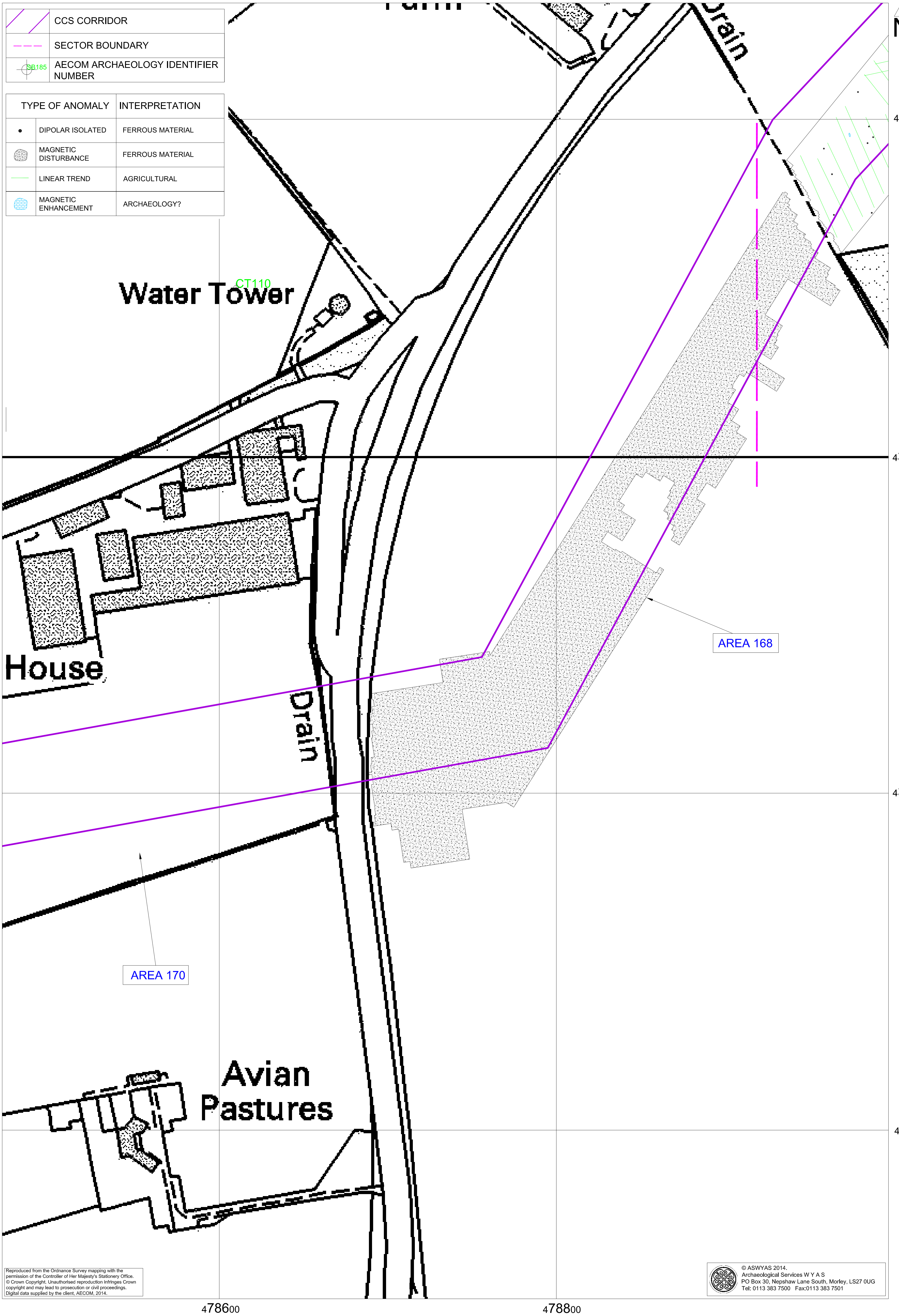

Fig. 59. Interpretation of magnetometer data; Sector 11 (1:2000 @ A3)

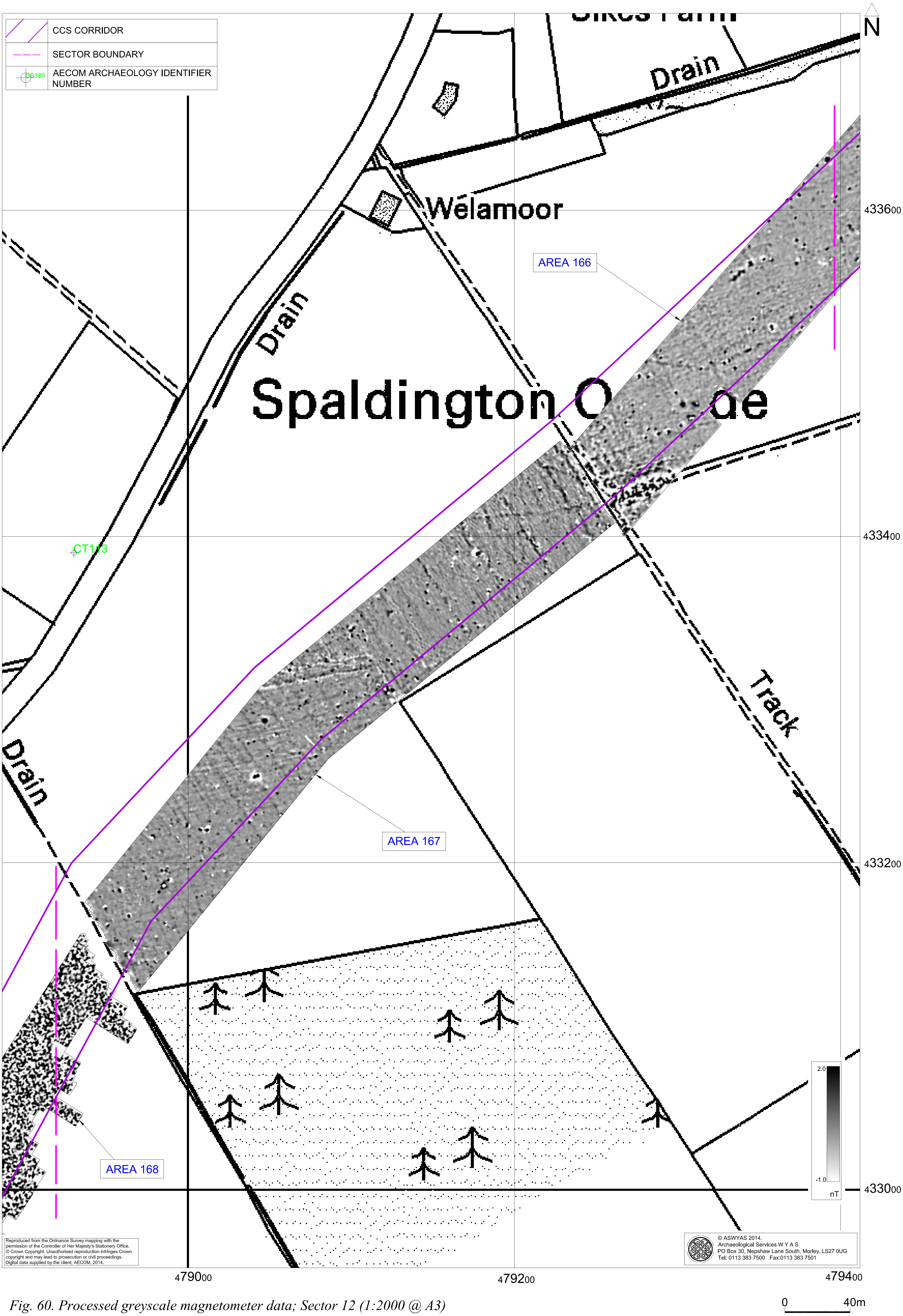

Fig. 60. Processed greyscale magnetometer data; Sector 12 (1:2000 @ A3)

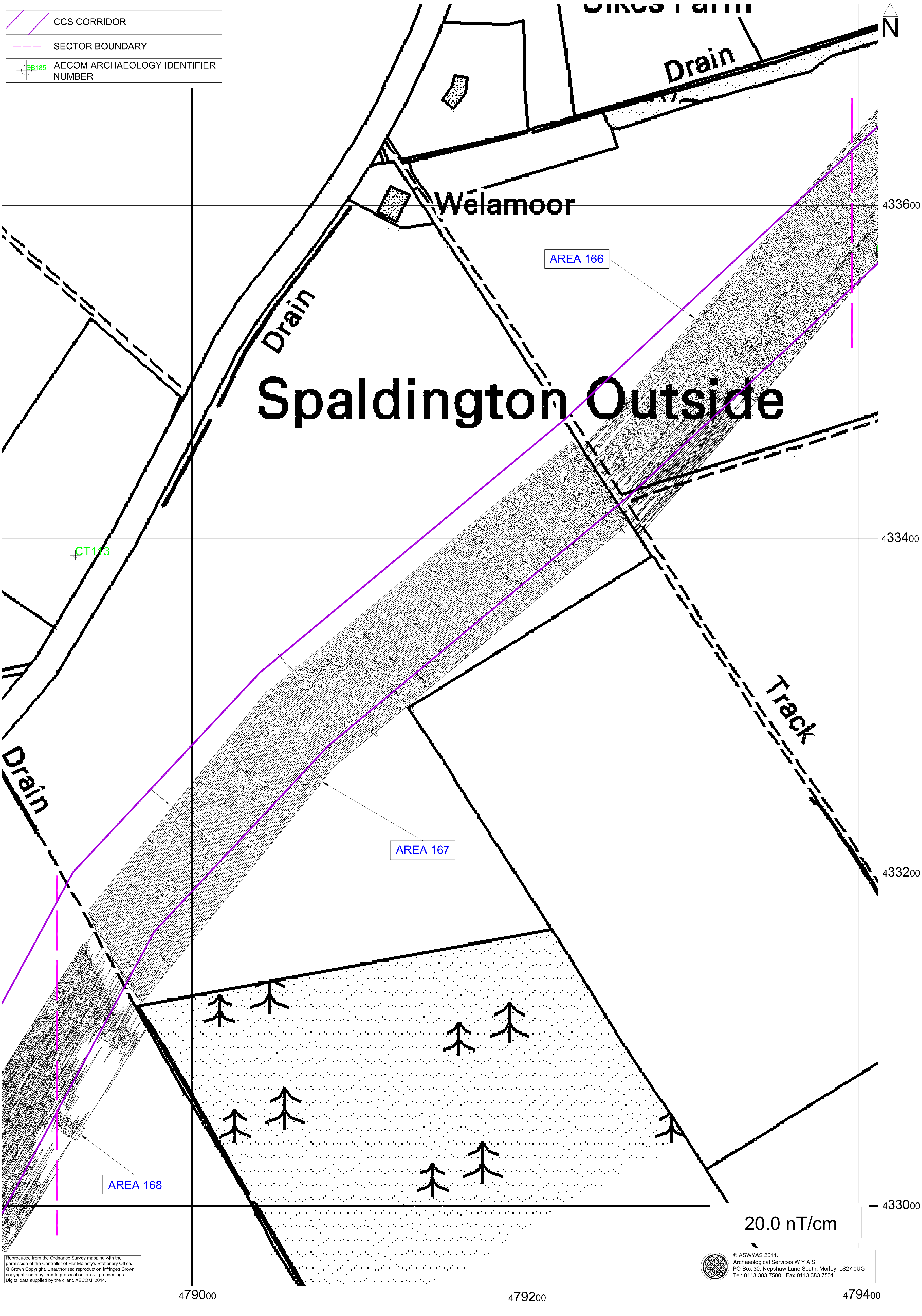

Fig. 61. XY trace plot of minimally processed magnetometer data; Sector 12 (1:2000 @ A3)

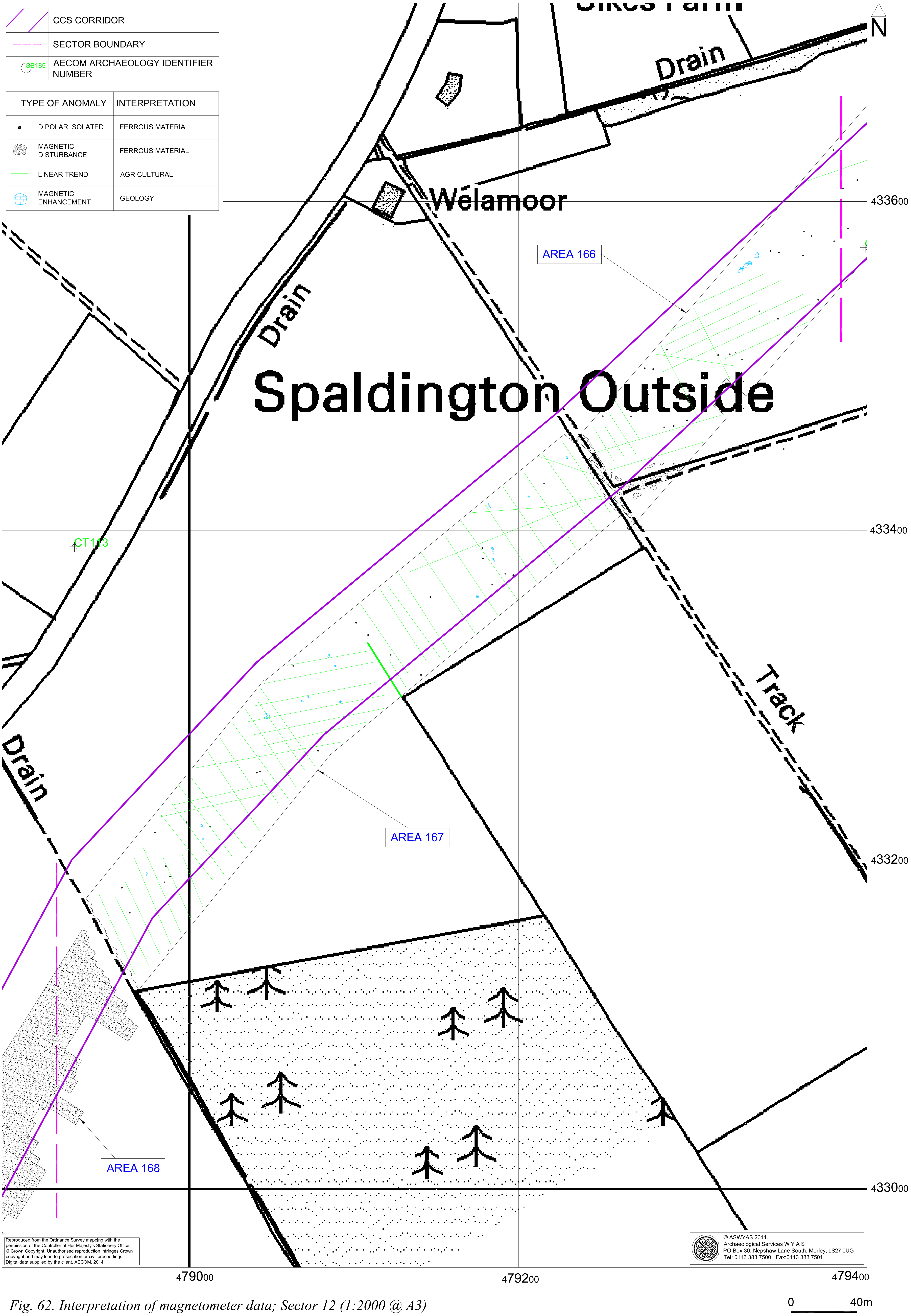

Fig. 62. Interpretation of magnetometer data; Sector 12 (1:2000 @ A3)

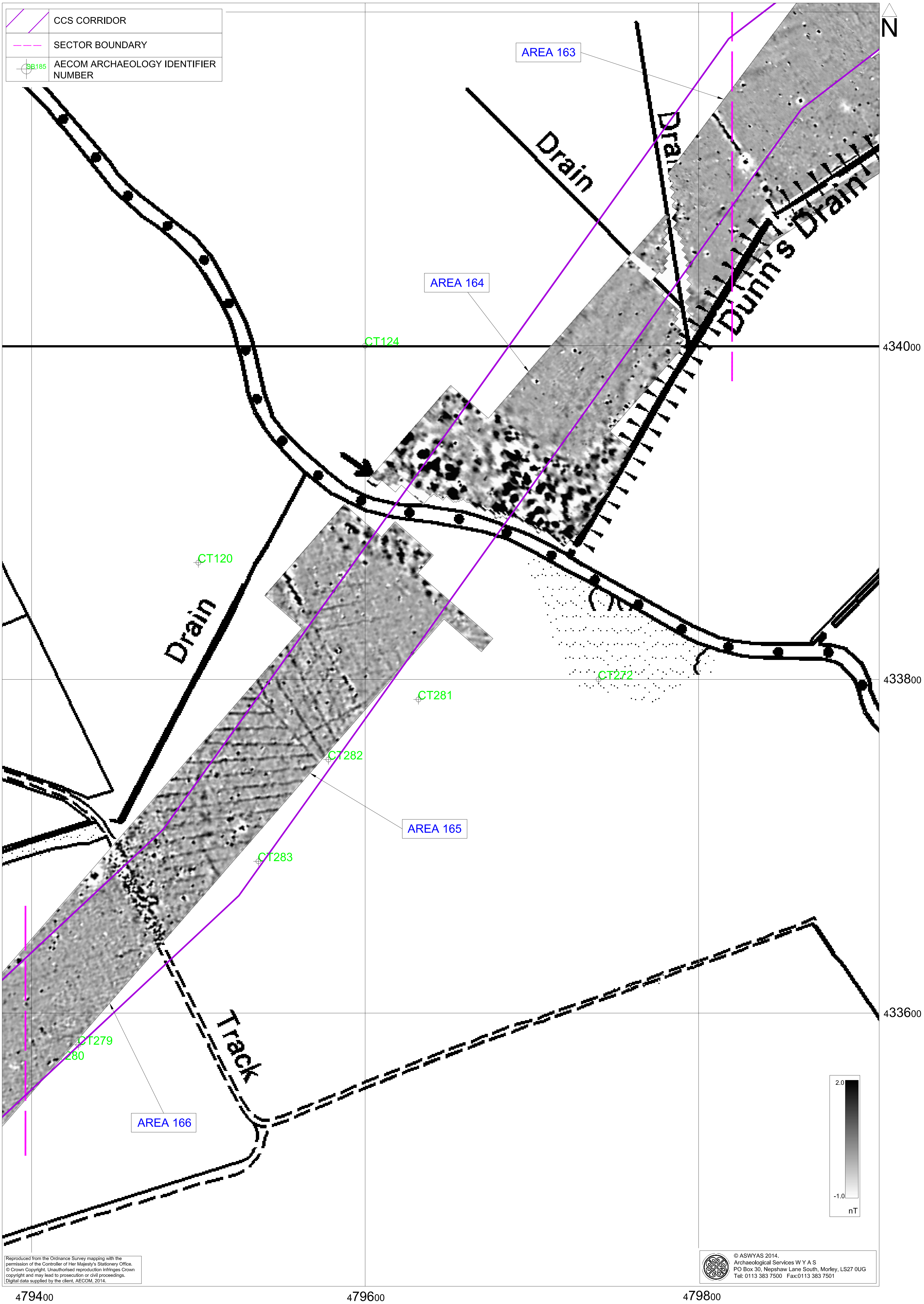

Fig. 63. Processed greyscale magnetometer data; Sector 13 (1:2000 @ A3)

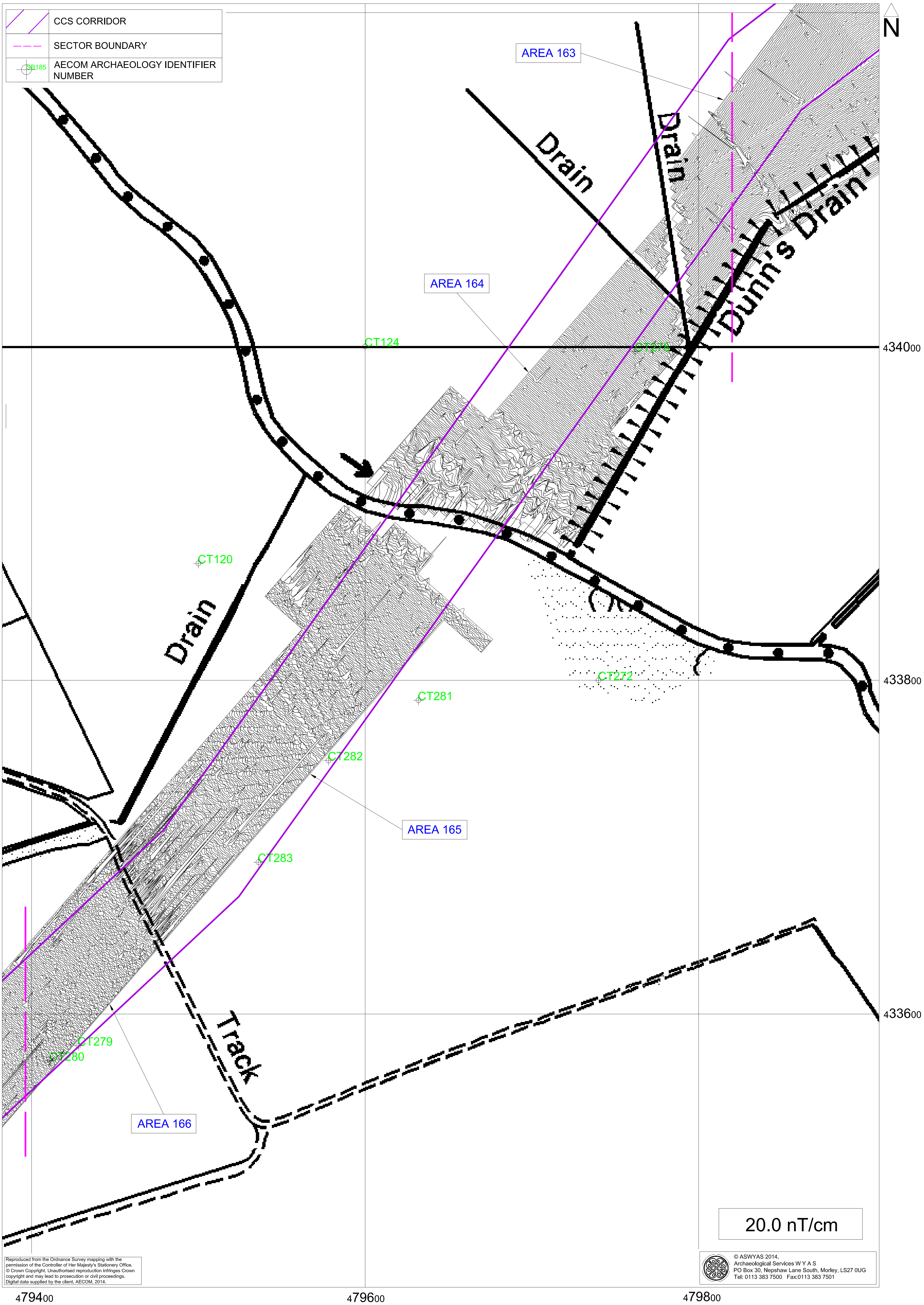

Fig. 64. XY trace plot of minimally processed magnetometer data; Sector 13 (1:2000 @ A3)

0 40m

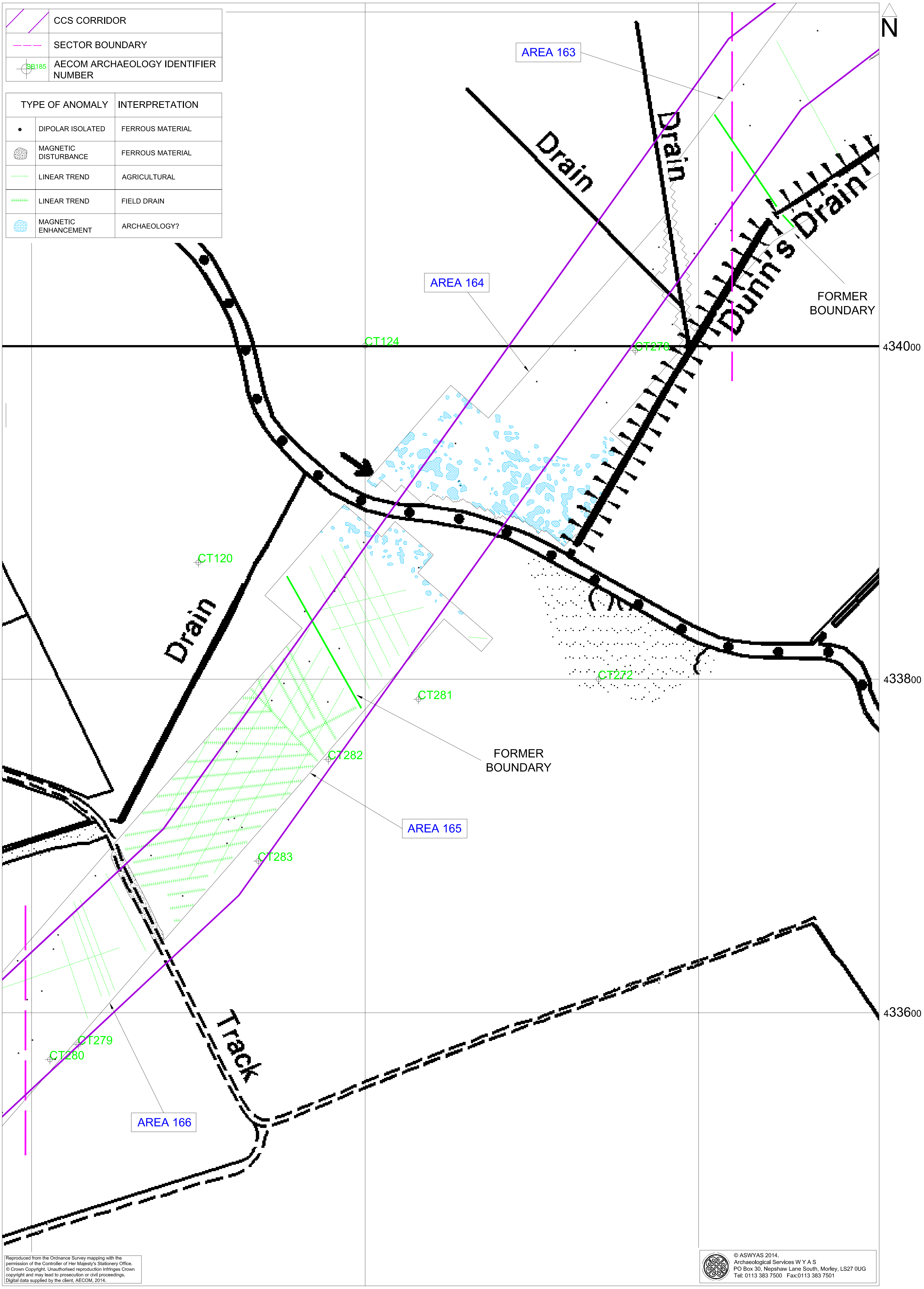

Fig. 65. Interpretation of magnetometer data; Sector 13 (1:2000 @ A3)

0 40m

Fig. 66. Processed greyscale magnetometer data; Sector 14 (1:2000 @ A3)

0 40m

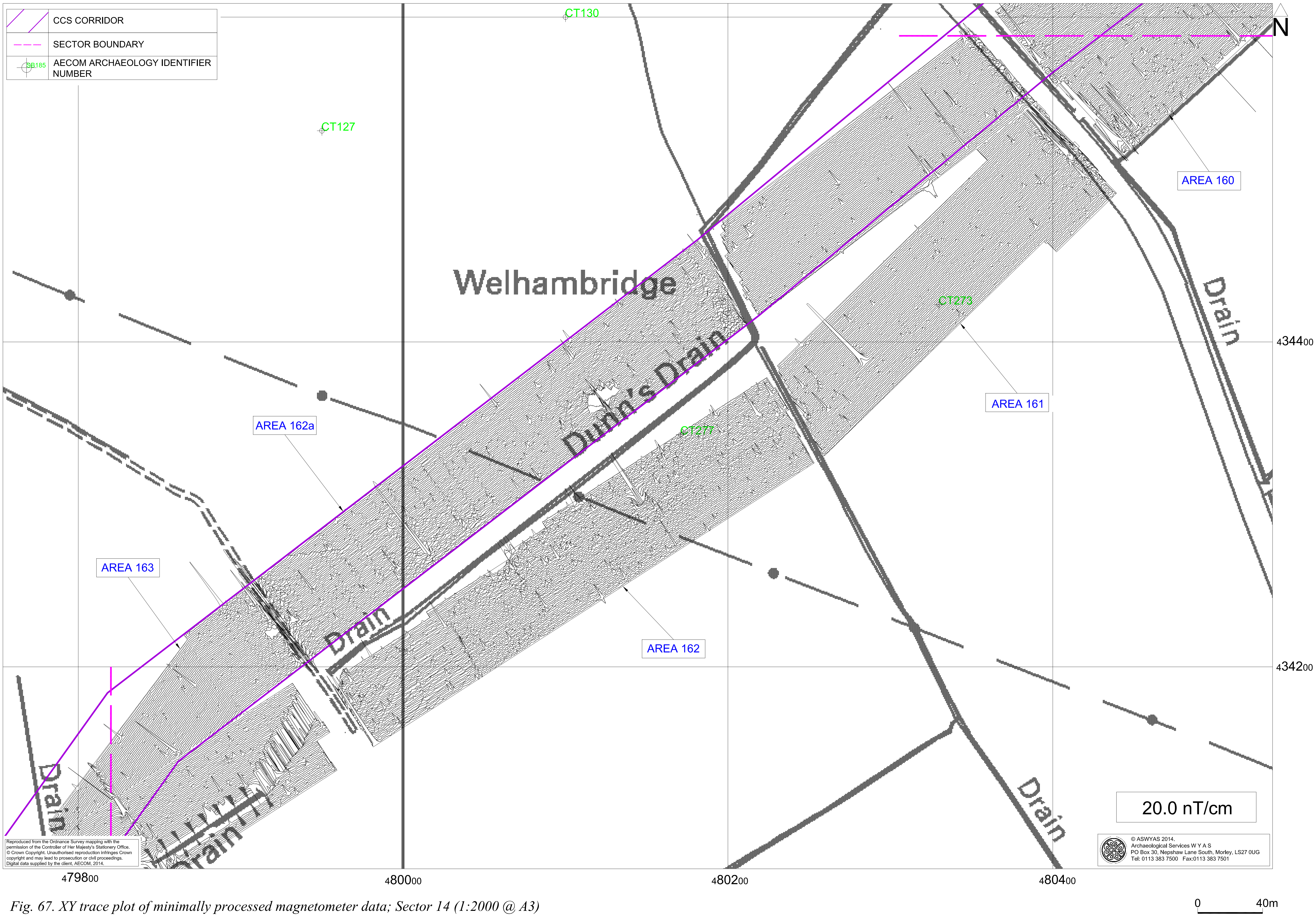

Fig. 67. XY trace plot of minimally processed magnetometer data; Sector 14 (1:2000 @ A3)

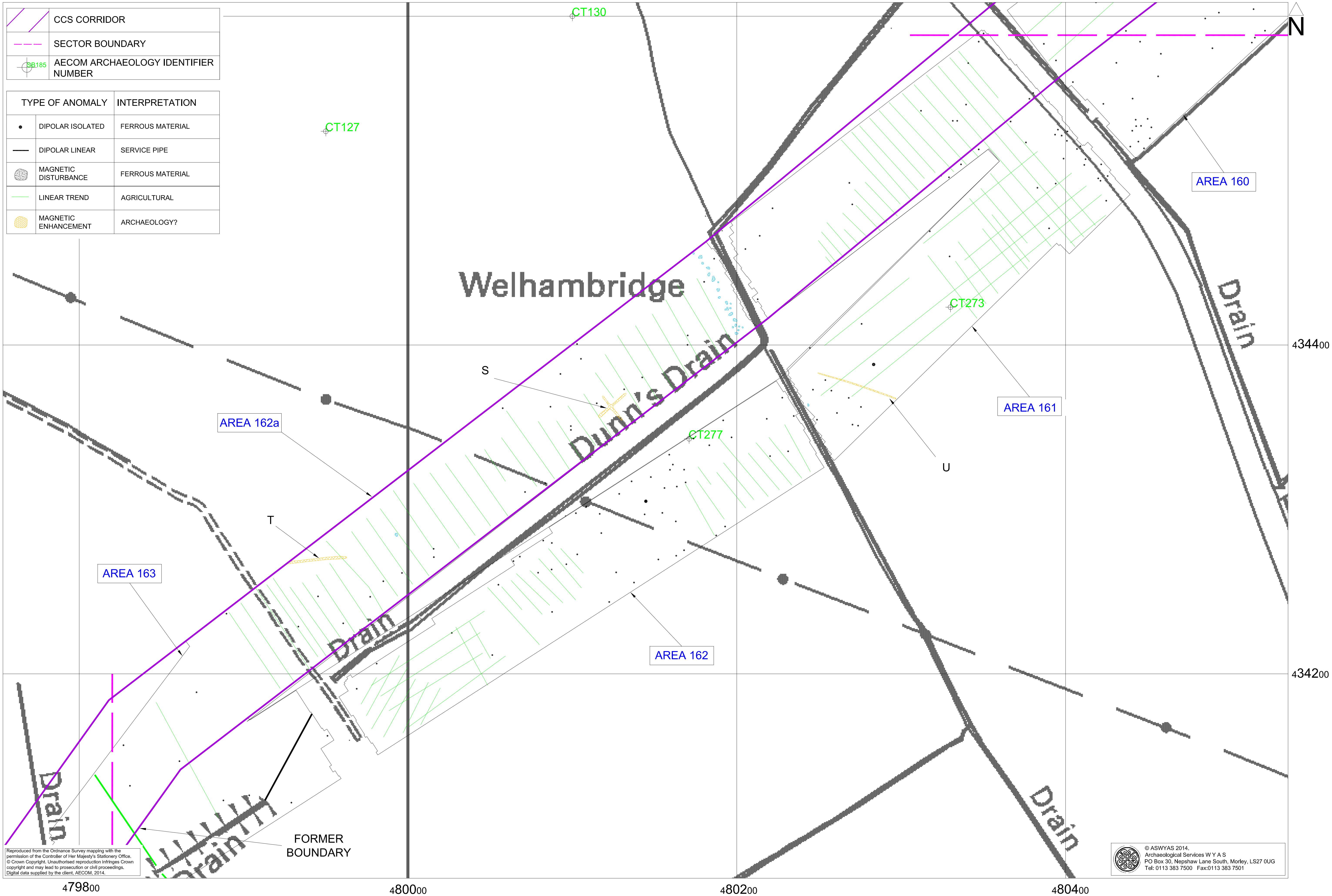

Fig. 68. Interpretation of magnetometer data; Sector 14 (1:2000 @ A3)

0 40m

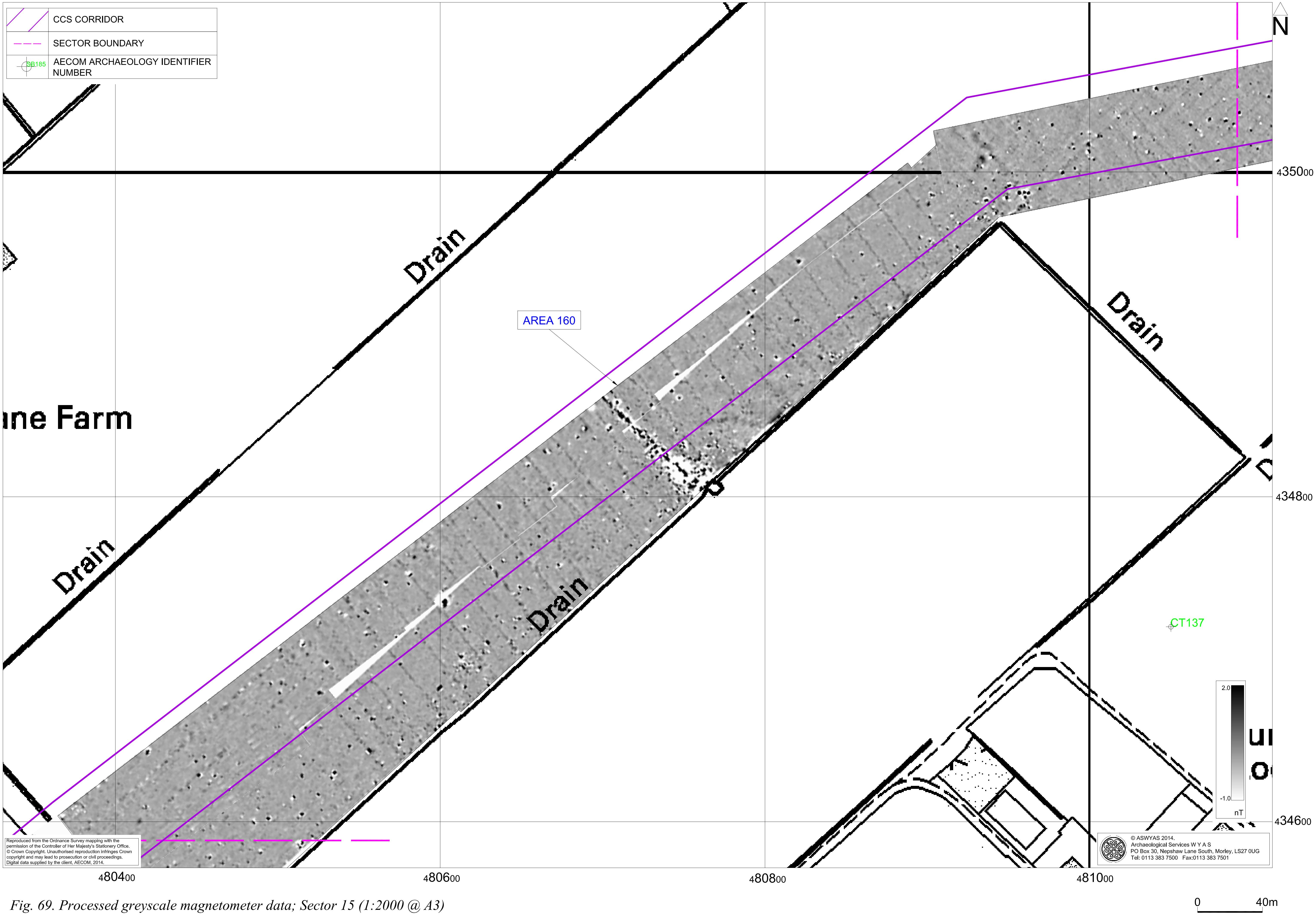

Fig. 69. Processed greyscale magnetometer data; Sector 15 (1:2000 @ A3)

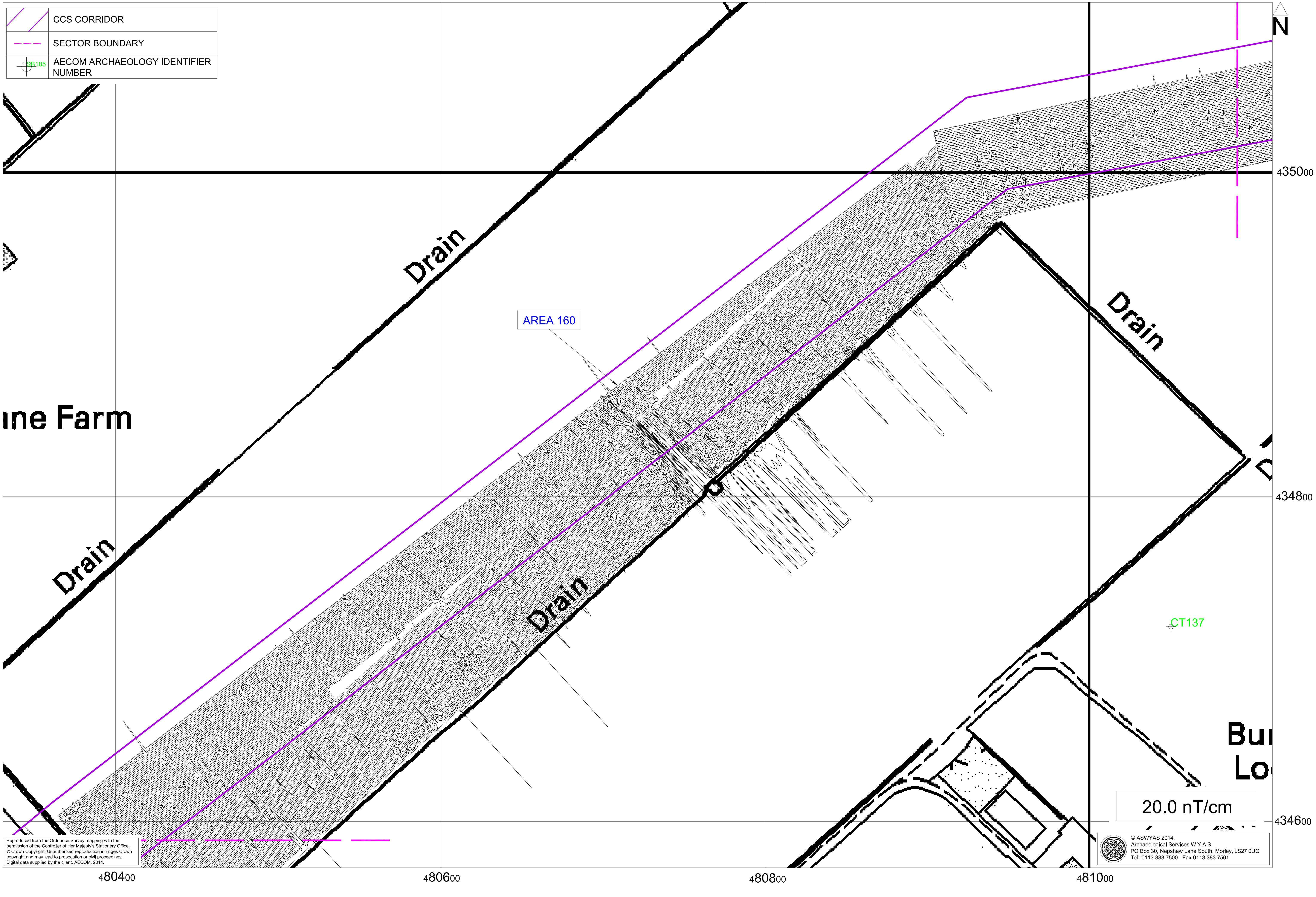

Fig. 70. XY trace plot of minimally processed magnetometer data; Sector 15 (1:2000 @ A3)

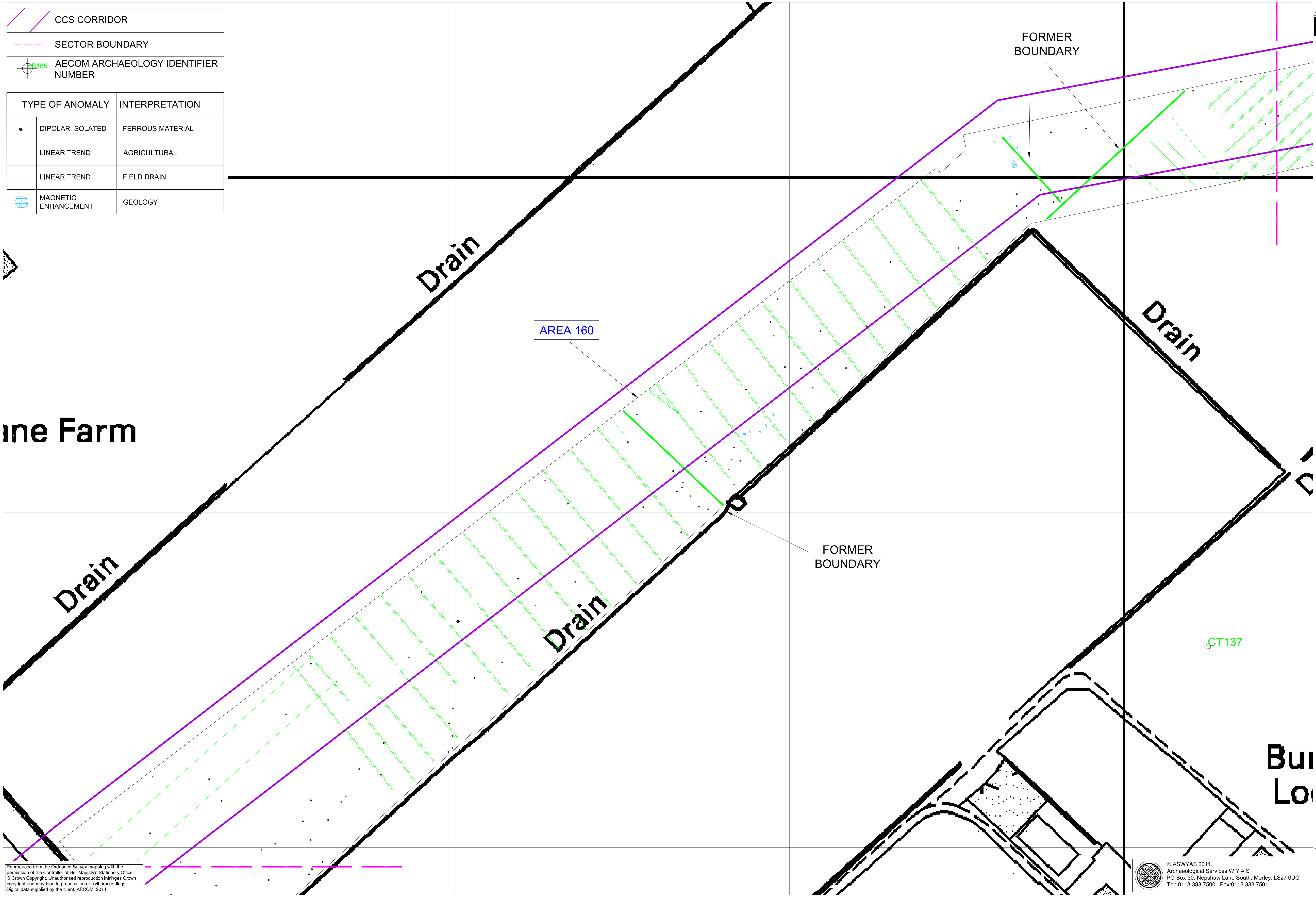

Fig. 71. Interpretation of magnetometer data; Sector 15 (1:2000 @ A3)

0 40m

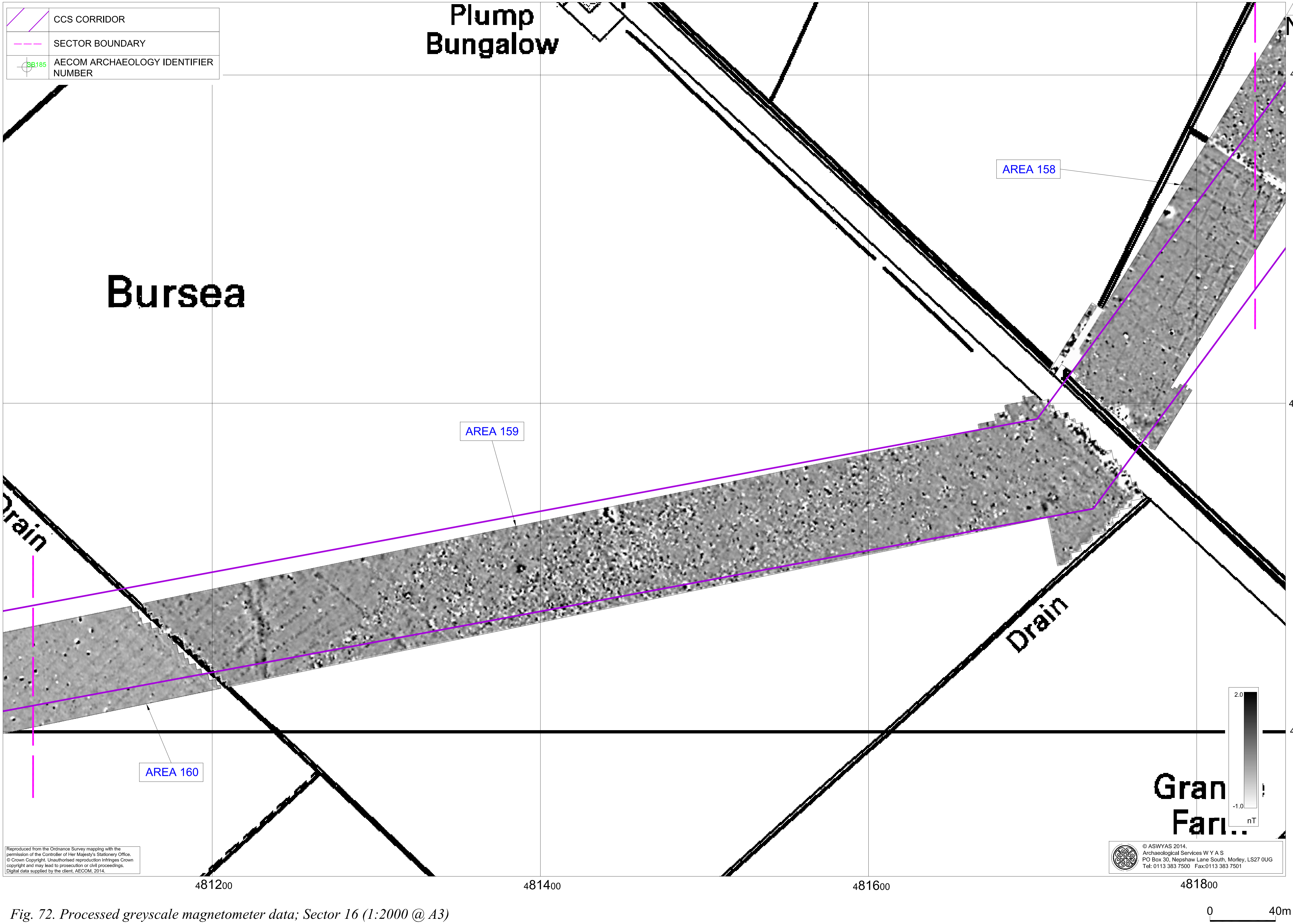

Fig. 72. Processed greyscale magnetometer data; Sector 16 (1:2000 @ A3)

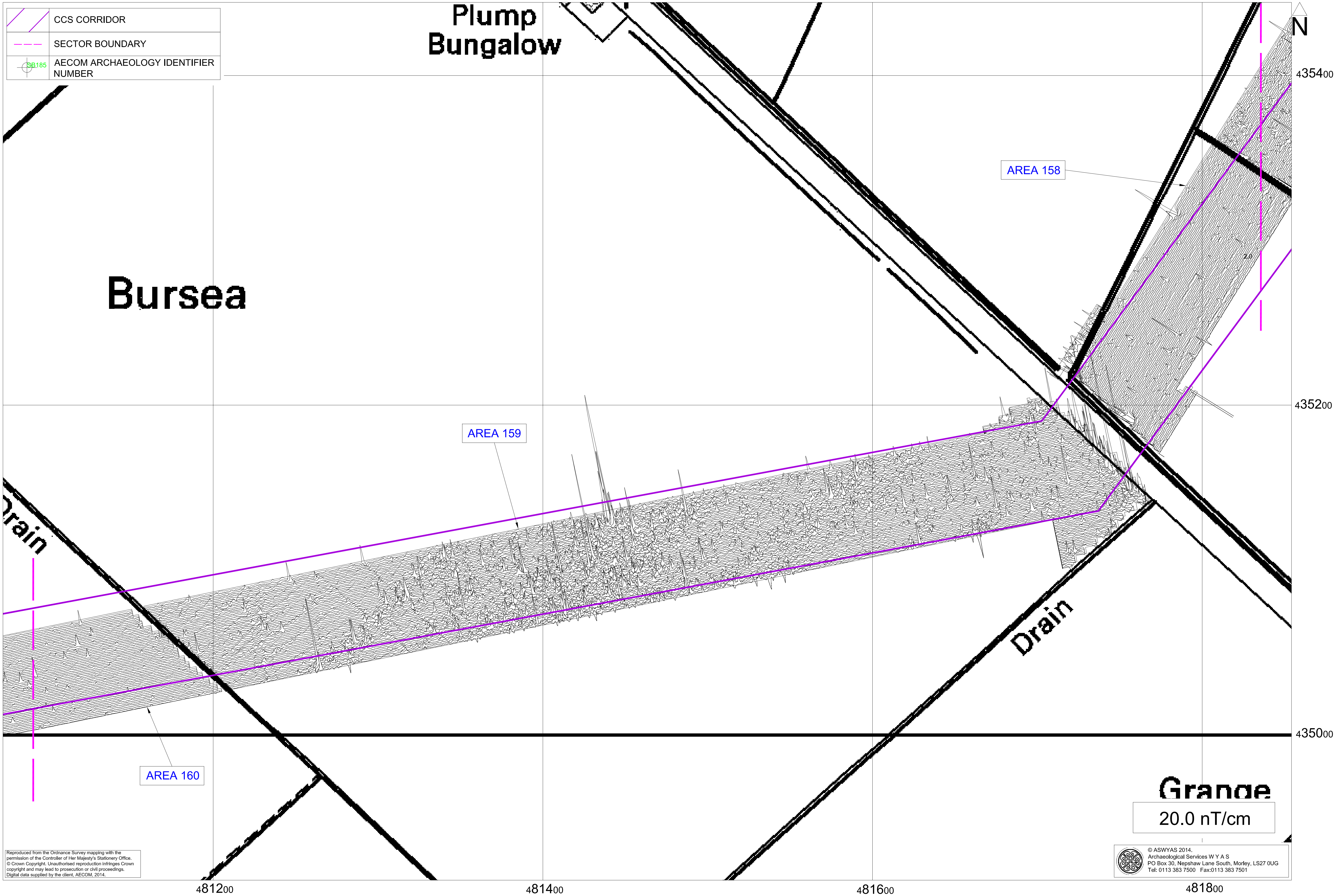

Fig. 73. XY trace plot of minimally processed magnetometer data; Sector 16 (1:2000 @ A3)

0 40m

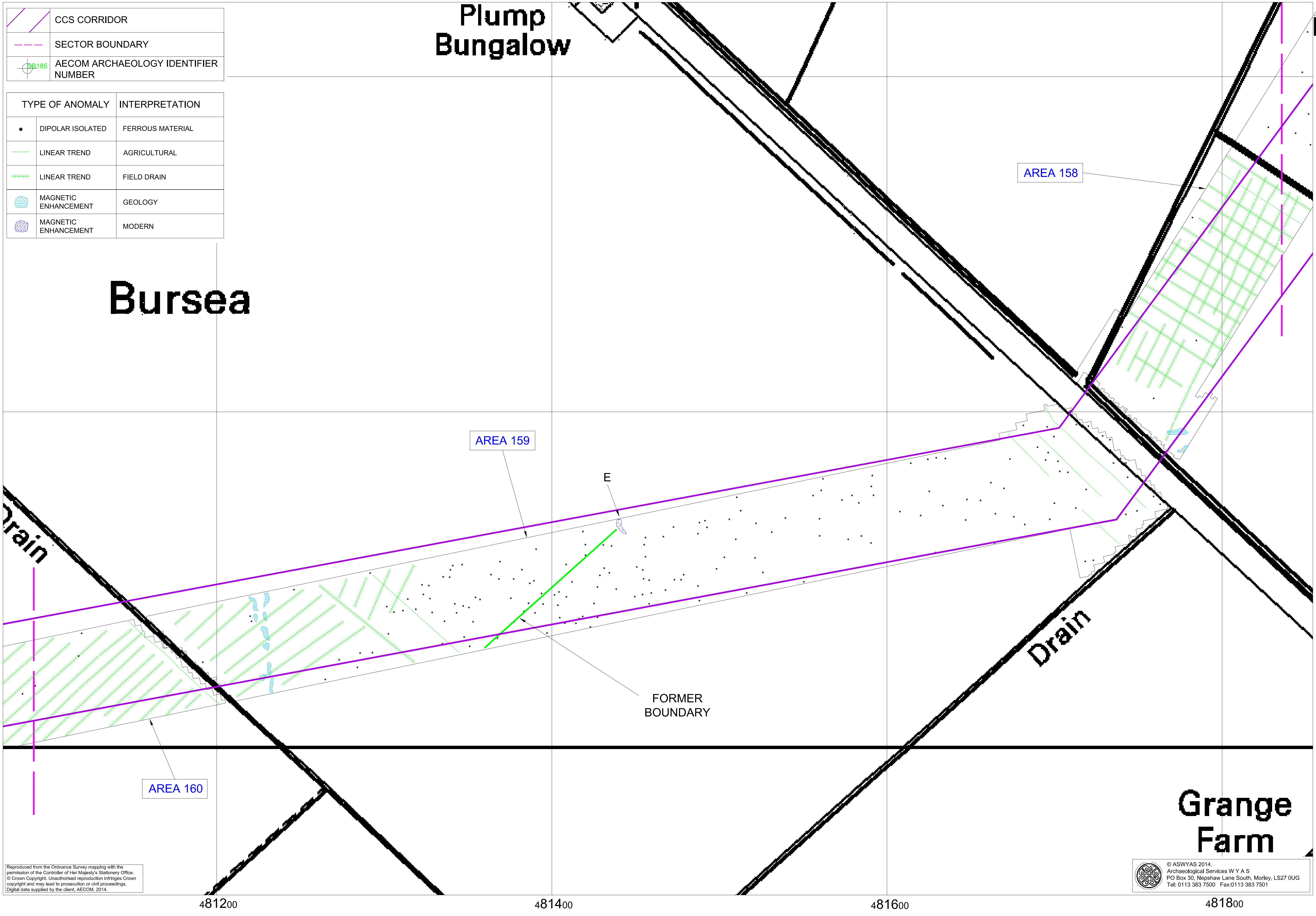

Fig. 74. Interpretation of magnetometer data; Sector 16 (1:2000 @ A3)

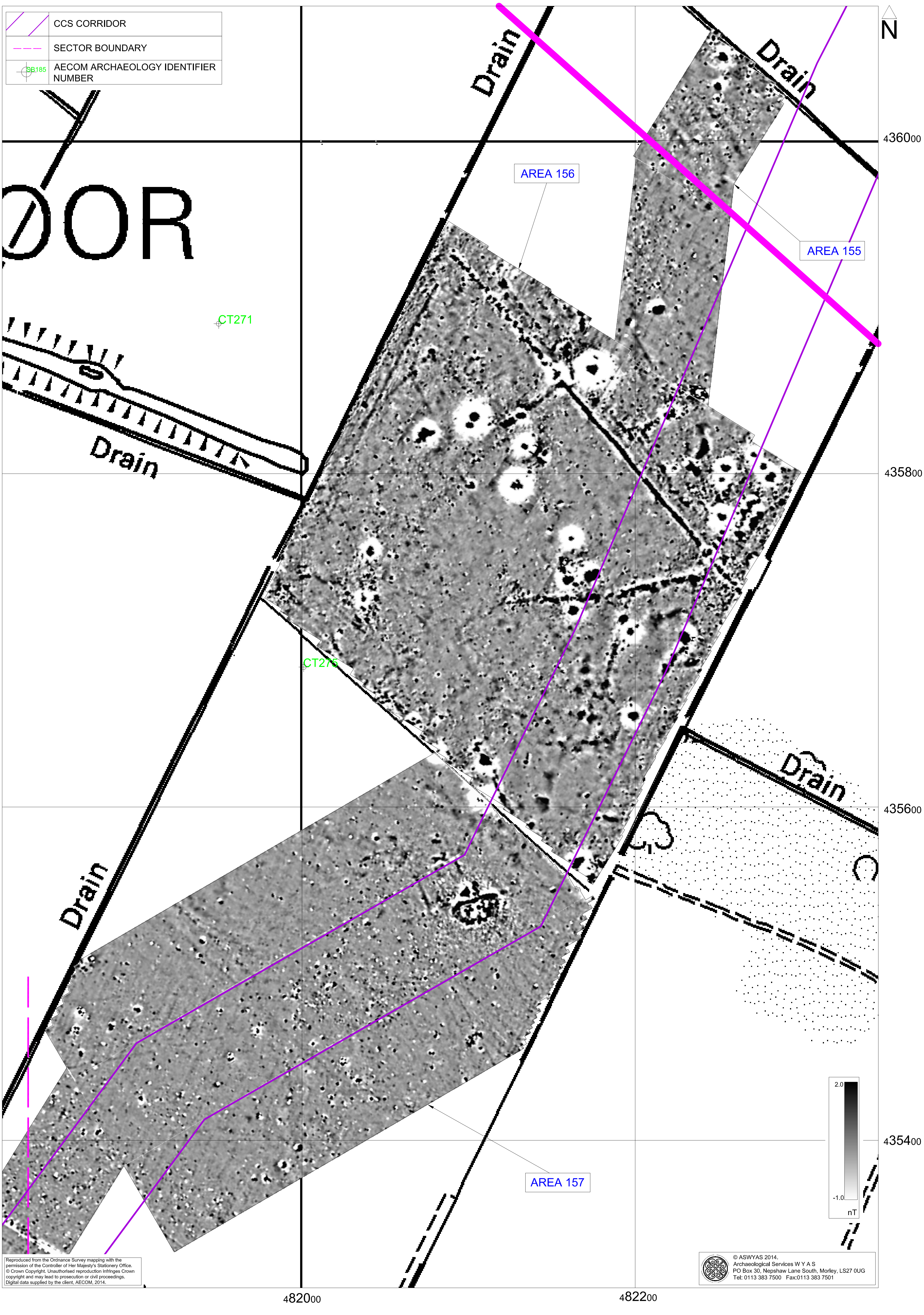

Fig. 75. Processed greyscale magnetometer data; Sector 17 (1:2000 @ A3)

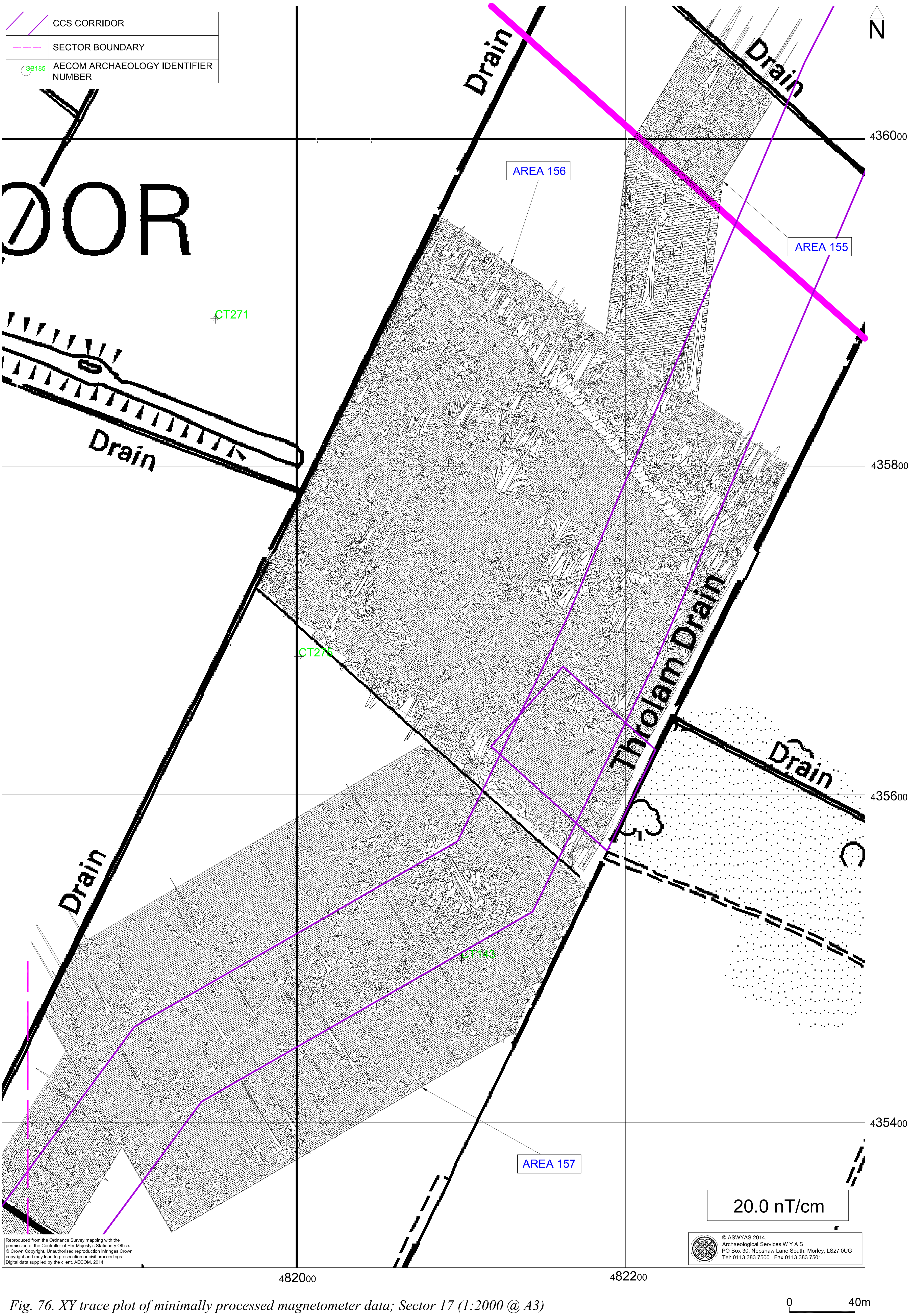

Fig. 76. XY trace plot of minimally processed magnetometer data; Sector 17 (1:2000 @ A3)

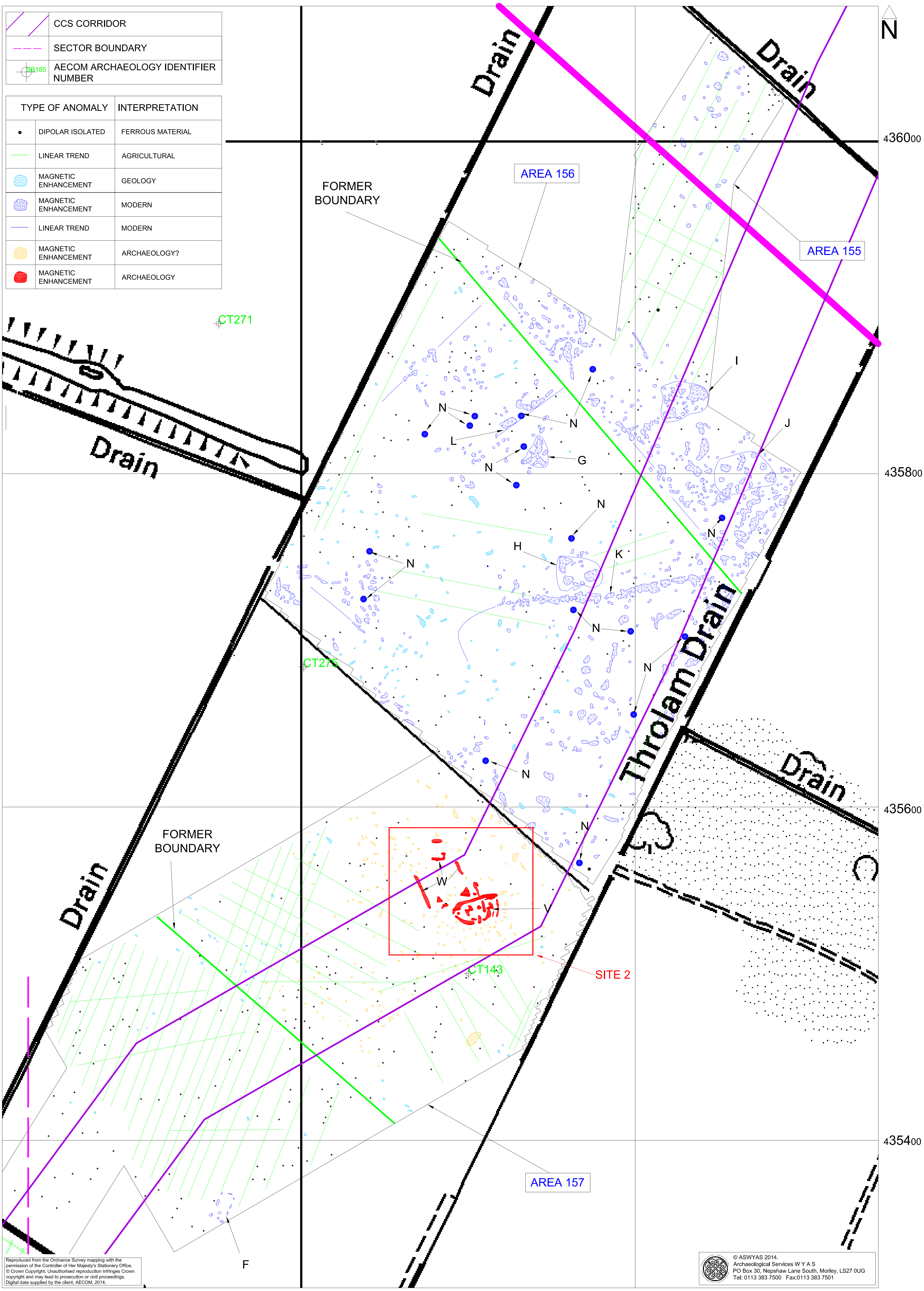

Fig. 77. Interpretation of magnetometer data; Sector 17 (1:2000 @ A3)

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 East Yorkshire Historic Environment Record).

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