



WYAS  
**Archaeological  
Services**

**Land South of Innerwick  
East Lothian**

**Geophysical Survey**

Report no. 3958  
November 2023

**Client:** Braxbess Ltd



# Land South of Innerwick East Lothian

## Geophysical Survey

### *Summary*

*A geophysical (magnetometer) survey was undertaken on approximately 50 hectares of land located to the south of Innerwick, East Lothian. Anomalies of both a definite and a possible archaeological origin have been detected including settlement features and ring ditches. Uncertain anomalies within the dataset include multiple linear responses which may be of some archaeological interest. Due to the geology within the Site many of the uncertain anomalies have been difficult to interpret, they may be of an archaeological origin but also equally likely to be geological or agricultural. Along with the high background levels of geology, further natural occurrences can be seen within the dataset which reflect lightning strikes. Modern ploughing and medieval or post-medieval ridge and furrow has also been recorded along with service pipes, disturbance associated with possible green waste manuring and magnetic disturbance associated with field boundaries and adjacent tracks.*

## Report Information

Client: Braxbess Ltd  
Report Type: Geophysical Survey  
Location: Innerwick  
County: East Lothian  
Grid Reference: NT 7231 7341  
Period(s) of activity: Prehistoric - modern  
Report Number: 3958  
Project Number: XI78  
Site Code: LSI23  
OASIS ID: archaeo111-520869  
Date of fieldwork: February - April 2023  
Date of report: November 2023  
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## 1 Introduction

Archaeological Services ASWYAS has been commissioned by Pegasus Group on behalf of Braxbess Ltd to undertake a geophysical survey at land to the south of Innerwick, East Lothian. This was undertaken in line with current best practice (CIFA 2020; Schmidt *et al.* 2015). The survey was carried out over three separate mobilisations between 20th February and 4th April 2023 due to crops and changes in the development plan. The survey was conducted to provide additional information on the archaeological resource of the Site.

### Site location, topography and land-use

The Site is located at NT 7231 7341 (approximate centre), comprising *c.* 50ha over eleven areas, (some of which are now no longer in the application area) situated to the south of Innerwick (see Fig. 1).

The Site is situated to the north and south of the water course Braidwood Burn and tree cover, the survey areas consist of arable fields (see Plates 1-11). It is bounded on all sides by further arable land. The village of Innerwick lies to the north of the Site. The topography of the Site varies with higher ground at 152m (above Ordnance Datum) aOD in the northwest, which falls to approximately 99m aOD in the east and towards Braidwood Burn. The southern areas, to the south of the water course lie between 140m aOD and 144m aOD.

### Soils and geology

The underlying bedrock of the western half of the Site comprises conglomerate and sandstone of the Great Conglomerate Formation, a sedimentary bedrock formed approximately 443 to 358 million years ago in the Silurian and Devonian periods. Bedrock geology in the eastern half is of the Ballagan Formation - sandstone, siltstone and dolomitic limestone, a sedimentary bedrock formed between 358.9 and 344.5 million years ago during the Carboniferous period. The overlying superficial deposits consist of Till (Diamicton) which formed between 116 and 11 thousand years ago during the Quaternary Period (BGS 2023). Soils of the area belong to the Lauder association consisting of brown soils (SS 2023).

## 2 Archaeological Background

The following archaeological background has been taken from online resources (Canmore 2023) (HES 2023) while awaiting Pegasus Group's forthcoming heritage desk-based assessment. The locations of the sites below have been marked on Fig. 2.

Cropmarks of a settlement, which lie within the survey area, have been recorded on oblique aerial photographs (58920). This site is also a scheduled monument (SM5848). It is likely to be of later prehistoric date, and is probably characterised by a single, substantial domestic building. The monument lies at around 120m aOD on a relatively level area on a hillside sloping gently to the Braidwood Burn some 150m to the south. The enclosure is defined by a

single annular ditch some 4m in width and has an overall diameter of some 40m. A well-defined entrance lies on the eastern part of the circuit. The interior of the enclosure is dominated by a dense dark cropmark which appears to represent the remains of internal deposits. These deposits, which may relate to the remains of an internal house, are sited just off-centre to the north of the interior.

A second scheduled monument (SM5849) lies in the east of the survey area and comprises the remains of an enclosed settlement of later prehistoric date represented by cropmarks visible on oblique aerial photographs. The monument appears to belong to a class of rectilinear and square, defended domestic settlements widely believed to represent native settlements dating to the period around the time of the Roman invasion of Scotland. It comprises a sub-square enclosure defined by a ditch some 3-4m wide enclosing an area approximately 45m by 45m. The northeast quadrant of the interior is occupied by a diffuse, dark, circular cropmark which appears to represent the remains of occupation deposits associated with a substantial structure. The enclosing ditch does not seem to be continuous at this point and it appears that the wall of the structure may have formed this part of the enclosure (58921).

Cropmarks of two ring ditches have been recorded on oblique aerial photographs in the northwest of the survey area (58943). Other linear cropmarks seen in this area may be geological in origin.

To the north of the survey area a pit alignment (58928) is recorded in the HER. No other information is available.

Cropmarks of a rectilinear enclosure (130413) are recorded in the east of the survey area, to the west of SM5849. No other information is available.

Innerwick Castle, fort and ring ditch (SM5771) (58923) lies to the northeast of the survey area and comprises the remains of a multivallate fort and external ring ditch of prehistoric date represented by cropmarks visible on oblique aerial photographs. The fort is semi-circular, defined by a series of five ditches backing onto the break of slope above Thornton Burn. The outermost ditch has a diameter of approximately 180m while the innermost encloses an area approximately 80m across. The ditches measure from 5 to 8m in width with similar spaces between them. There are no visible indications of an entrance or of internal features. Some 30-40m north of the fort is a ring ditch with a diameter of approximately 10m, defined by a broad penannular ditch. Between the fort and the burn, on an outcrop on the sharply sloping banks, is Innerwick Castle, a medieval fortification destroyed in 1547. This lies adjacent to the centre of the fort suggesting that the defences of the latter were extant at the time of the castle's construction.

To the northeast of the survey area, a slightly raised piece of ground is known as Witches Knowe. A number of witches are said to have been burnt here (58969). This site is classified in the HER as a post-medieval execution site.

In the south of the survey area, a short cist was found on 18th May 1939 by Mr W Macnaughton, tenant of the Board of Agriculture's Lot 114 at Thornton when ploughing. The findspot was on the crest of a low ridge running parallel to the Thornton Burn about 18m south of the stream, but not quite at the highest point of the ridge, which rises to about a metre to the west. There was no trace of a cairn. The cist contained the bones of a child, 3 to 5 years old, accompanied by a beaker, of Clarke's N2 type, which was donated to the National Museum of Antiquities of Scotland (58916). The location of the site on Fig 2 is an approximate location according to the HER and is likely to be much closer to the stream.

### **3 Aims, Methodology and Presentation**

The aims and objectives of the programme of geophysical survey were to gather sufficient information to establish the presence/absence, character and extent, of any archaeological remains within the specific area and to inform an assessment of the archaeological potential of the site. To achieve this aim, a magnetometer survey covering all amenable parts of the Site was undertaken (see Fig. 2).

The general aims 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 cart-based survey was undertaken using an eight channel SenSYS MX V3 system containing eight FGM650 sensors. Readings are taken every 20MHz (between 0.05 and 0.1m). Data were recorded onto a device, using a Carlson GNSS Smart antenna, for centimetre accuracy. These readings were stored in the memory of the instrument and downloaded for processing and interpretation. DLMGPS and MAGNETO software, alongside bespoke in-house software was used to process and present the data. Further details are given in Appendix 1.

#### **Reporting**

A general site location plan, incorporating the 1:50000 Ordnance Survey (OS) mapping, is shown in Figure 1. Figure 2 displays processed magnetometer data at a scale of 1:5000 whilst Figure 3 shows an overview of the interpretation at the same scale. Processed and minimally processed data, together with interpretation of the survey results are presented in Figures 4 to 24 inclusive at a scale of 1:1500.

Technical information on the equipment used, data processing and survey methodologies are given in Appendix 1. Technical information on locating the survey area is provided in Appendix 2. Appendix 3 describes the composition and location of the archive. A copy of the completed OASIS form is included in Appendix 4.

The survey methodology, report and any recommendations comply with guidelines outlined by the European Archaeological Council (Schmidt *et al.* 2015) and by the Chartered Institute for Archaeologists (CIfA 2020). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of His Majesty's Stationery Office (© Crown copyright).

*The figures in this report have been produced following analysis of the data in 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 Figures 4 to 24)**

### **Ferrous anomalies and magnetic disturbance**

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

The data from Areas 1 and 2 have produced large areas of disturbance which is possibly a result of 'green manuring'. The green waste is produced from organic and biodegradable household waste as a fertiliser and soil conditioner, but up to 0.25% of this material can be from non-organic waste including metal fragments and batteries (Gerrard *et al.* 2015). The result of this is a 'speckled' appearance and unfortunately it will have masked the majority of anomalies, if present.

Bisecting Areas 8 and 9, a linear dipolar trend has been recorded which has produced a large magnetic halo. According to the local farmer this is a water mains service. Smaller linear dipolar trends have been recorded in Area 9. These services will have masked any archaeological remains that may be present in the immediate vicinity, particularly over the enclosure site in the east of Area 9.

Large circular ferrous responses have been recorded in Areas 1 and 6, it is possible that these represent the foundations of former electricity pylons or other modern buried features.

Magnetic disturbance along the limits of the survey areas is due to metal fencing within the field boundaries and interference from the adjacent tracks.

### **Geological anomalies**

The survey has detected a number of anomalies that have been interpreted as geological in origin, many of which have been recorded as swathes across the survey area, making interpretation of any smaller anomalies difficult. Archaeological features have been recorded within these swathes of geology and without the HER data, they may have been missed or interpreted differently.

A number of anomalies (**G1 - G8**) within the dataset have produced strong positive and negative responses in the appearance of multiple rays extending out from a central point. These are likely to be as a result of lightning strikes when compared to known examples in research papers (Bates *et al.* 2019; Burks *et al.* 2015). According to Bates *et al.* (2019) lightning strikes recorded in geophysical data as magnetic anomalies in the UK are not common. Within this dataset there are at least seven examples of multiple rays and one consisting of only two rays (**G4** in Area 7). The latter anomaly is almost identical to the one published in Burks *et al.* (2015) from a dataset in Ohio, USA.

### **Agricultural anomalies**

A former field boundary has been detected in Area 7 which is recorded on first edition Ordnance Survey mapping published in 1895 (NLS 2023).

Parallel linear trends can be seen within a number of the areas and are associated with both modern ploughing and medieval or post-medieval ridge and furrow cultivation.

Linear trends located in the northwest of Area 7 may be associated with land drains.

### **Uncertain anomalies**

A number of responses have been recorded throughout the dataset which have proved difficult interpret, including the magnetically strong linear anomalies which have been recorded in Areas 3, 6 and 7. It is unclear what these features represent. While they may be some sort of drainage, they do not follow the conventional patterns of land drains. There is nothing to suggest an origin within the fields or on aerial imagery but they are almost certainly of an anthropogenic origin.

Linear trends (**U1** and **U2**) in Area 1 are likely to represent land drains due to their magnetic signature, but they do look similar to the stronger responses mentioned above and may be

associated. The possible green waste manuring in this area is also masking the anomalies a little, making interpretation less confident.

Linear trend (**U3**) in Area 2 may be associated with a former field boundary that pre-dates the available historic mapping. It is possible that it is a continuation of the boundary to the south of the area.

Fragmentary ditch-like anomalies and possible pits (**U4** and **U5**) in Area 3 may be of some archaeological interest. Within this field, a pit alignment has been recorded in the HER (58928) and it is possible that some of these features are associated. It is also possible that they have a geological origin.

A number of pit-like responses (**U6**) have been recorded in Area 6, to the immediate north of a lightning strike (**G3**) and within the strong linear responses. It has been difficult to ascertain an interpretation for these anomalies. They may possibly be associated with the background geology or the strong uncertain linear responses.

Similar pit-like responses (**U7**) have been recorded to the immediate east of the archaeological feature **A2**. They appear in a band and may be associated with the geology in the area. Due to the proximity of the enclosure, however, an archaeological origin cannot be ruled out.

Curving responses (**U8**) located in the west of Area 9 may have some archaeological potential due to the cropmarks nearby, but they may also be associated with the topography of the Site.

Areas 10 and 11 are both dominated by strong responses reflecting the background geology. Within the geological response, however, a number of anomalies have been highlighted, particularly those at **U9** in Area 11. They may represent stronger geological variations, although they do have some rectilinearity to them and appear to coincide with a higher area of ground. As a result, an archaeological origin cannot be ruled out.

### **Possible and definite archaeological anomalies**

Anomalies of both a definite and possible archaeological origin have been recorded within the dataset. A circular feature (**A1**) in Area 2 measures approximately 14m in diameter with some internal features is a definite archaeological response. Despite the disturbed magnetic background from the possible green waste manuring, this response shows up well. A similar but more fragmented response (**P1**) can be seen to the immediate north of **A1**. **P1** has been downgraded to probable archaeology due to its fragmented response within the background disturbance. These two circular responses are likely to be the ring ditches that are recorded in the HER (58943). To the southwest of **A1** a large pit-like response (**P2**) is visible which may be of archaeological interest. It is also possible that it is of a geological origin and as such the interpretation is cautious.

A number of anomalies within Area 5 have been recorded as possible archaeology, which include sections of linear trends (**P3**), a group of magnetically strong responses and ditch-like responses (**P4**) and a group of weaker ditch-like responses (**P5**). A service pipe has been recorded along the southern boundary of this area and the geology in the east is very strong, both of which may well have masked any further archaeological responses. The group of responses (**P4**) may indicate a rectilinear enclosure with possible burnt interior features due to their magnetic strength. There is also a hint of a circular response within the 'enclosure'. Responses (**P5**) may also be associated with an enclosure, again with internal features.

Circular response (**A2**) within Area 7 corresponds to the scheduled monument (SM5848). The circular ditch measures approximately 30m in diameter, with some magnetically strong interior features. The geology of the area may have masked further responses associated with the monument. Another circular response (**P6**) has been recorded to the west, again measuring approximately 30m in diameter. Small pit-like responses can be seen within the outer response. **P6** is not as magnetically strong as **A2**, hence the possible archaeological interpretation. The geology is likely to be a factor in this and as mentioned above may be masking further archaeological anomalies within this area. Ditch response **P7** can be seen to the south of the monument **A1** and may reflect a boundary ditch, but it is also possible it is of a geological origin. Further recorded possible archaeology (**P8**) has been recorded in the east of Area 8. It consists of a ditched response with a 'hook' to the north. It is unclear what this feature represents.

In the far east of the survey area, response (**A3**) in Area 9 represents the north-western corner of a rectilinear enclosure which is recorded as a scheduled monument (SM5849). The monument sits within the strong geological background and the location of a large service pipe has masked any further associated features. To the northeast of the enclosure, a handful of possible pits (**P11**) have been recorded.

A further rectilinear enclosure recorded in the HER (130413) is situated in the east of Area 9. The geophysical data has recorded some linear trends and pit-like features (**P9**) within this area but as before the geology is making interpretation difficult. A linear trend (**P10**) located in the east of Area 9 may be indicative of a boundary ditch or part of a field system.



## 5 Conclusions

The geophysical survey has detected a number of magnetic anomalies associated with archaeological and possible archaeological origins in the forms of circular enclosures with internal features, ring ditches, square enclosures, ditches and pits.

A number of uncertain anomalies have been recorded throughout including magnetically strong linear trends which cross through some of the areas. It is unclear what these reflect but are likely to be anthropogenic, albeit of uncertain date. Due to the geology within the Site many of the uncertain anomalies have been difficult to interpret, they may be of an archaeological origin but also equally likely to be geological or agricultural.

Along with the high background levels of geology, further natural occurrences can be seen within the dataset which reflect lightning strikes. These responses recorded within geophysical datasets are not common and there are at least seven examples within the survey area.

Modern ploughing and medieval or post-medieval ridge and furrow has also been recorded along with service pipes, disturbance associated with possible green waste manuring and magnetic disturbance associated with field boundaries and adjacent tracks.

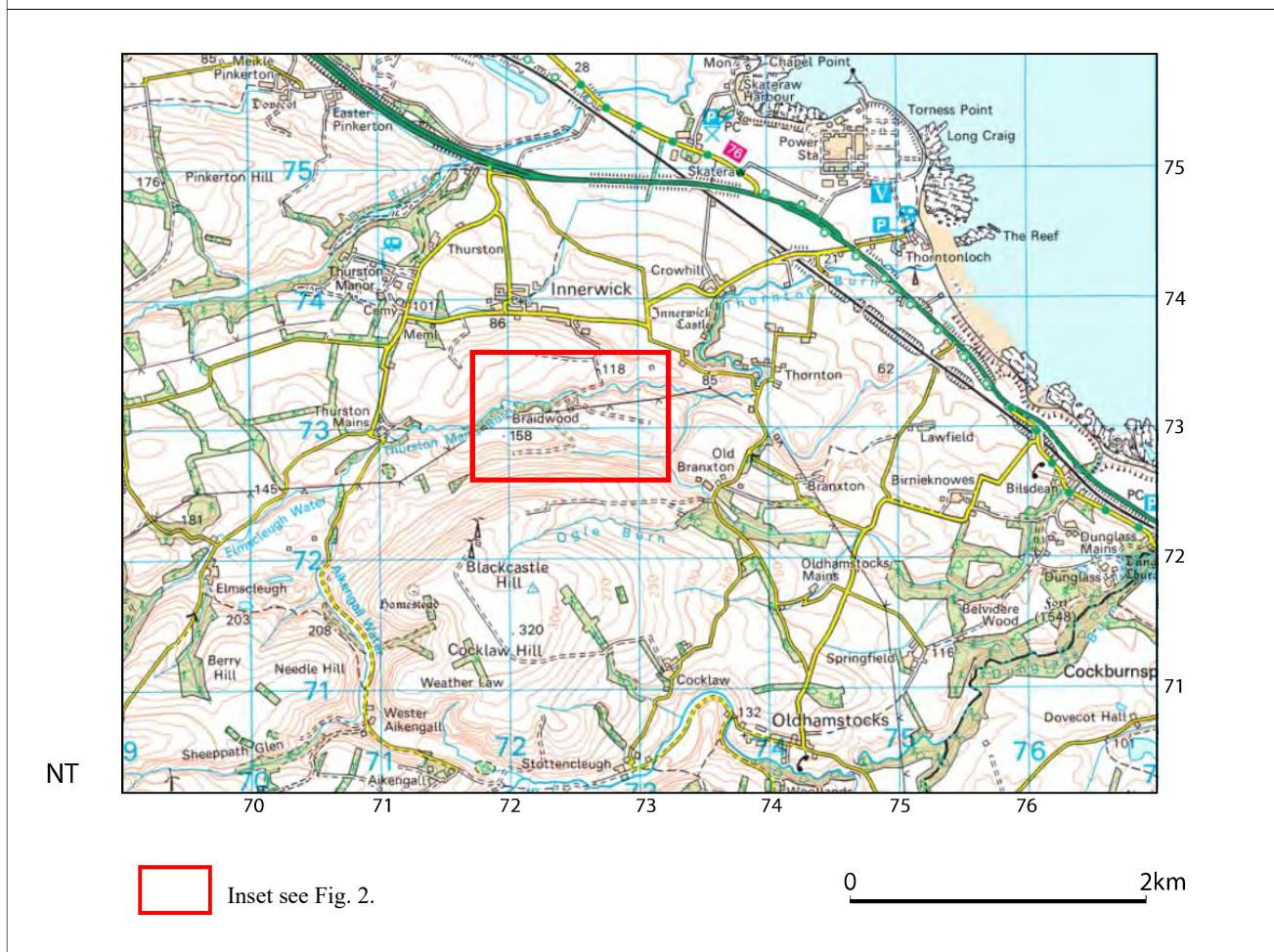
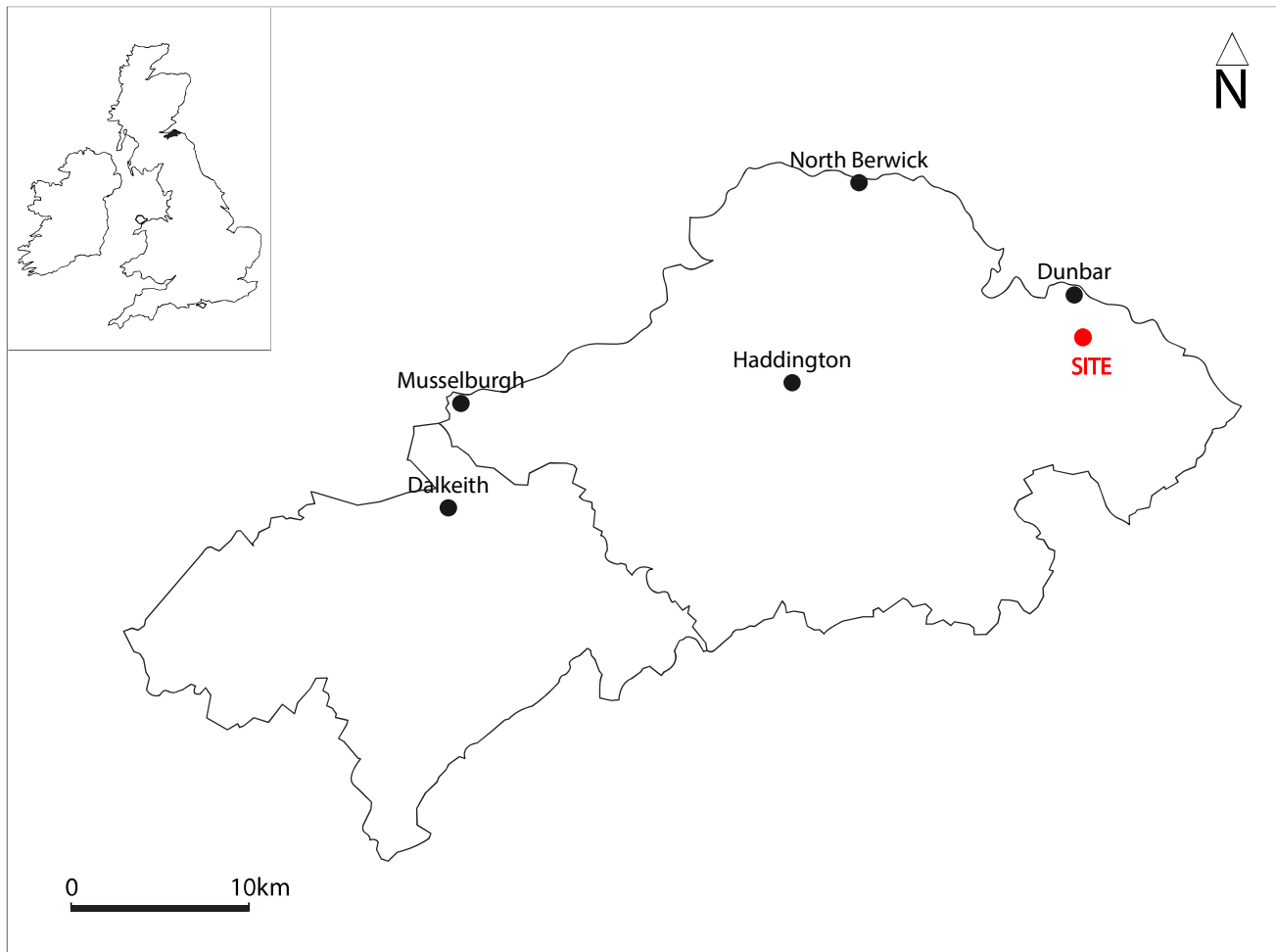
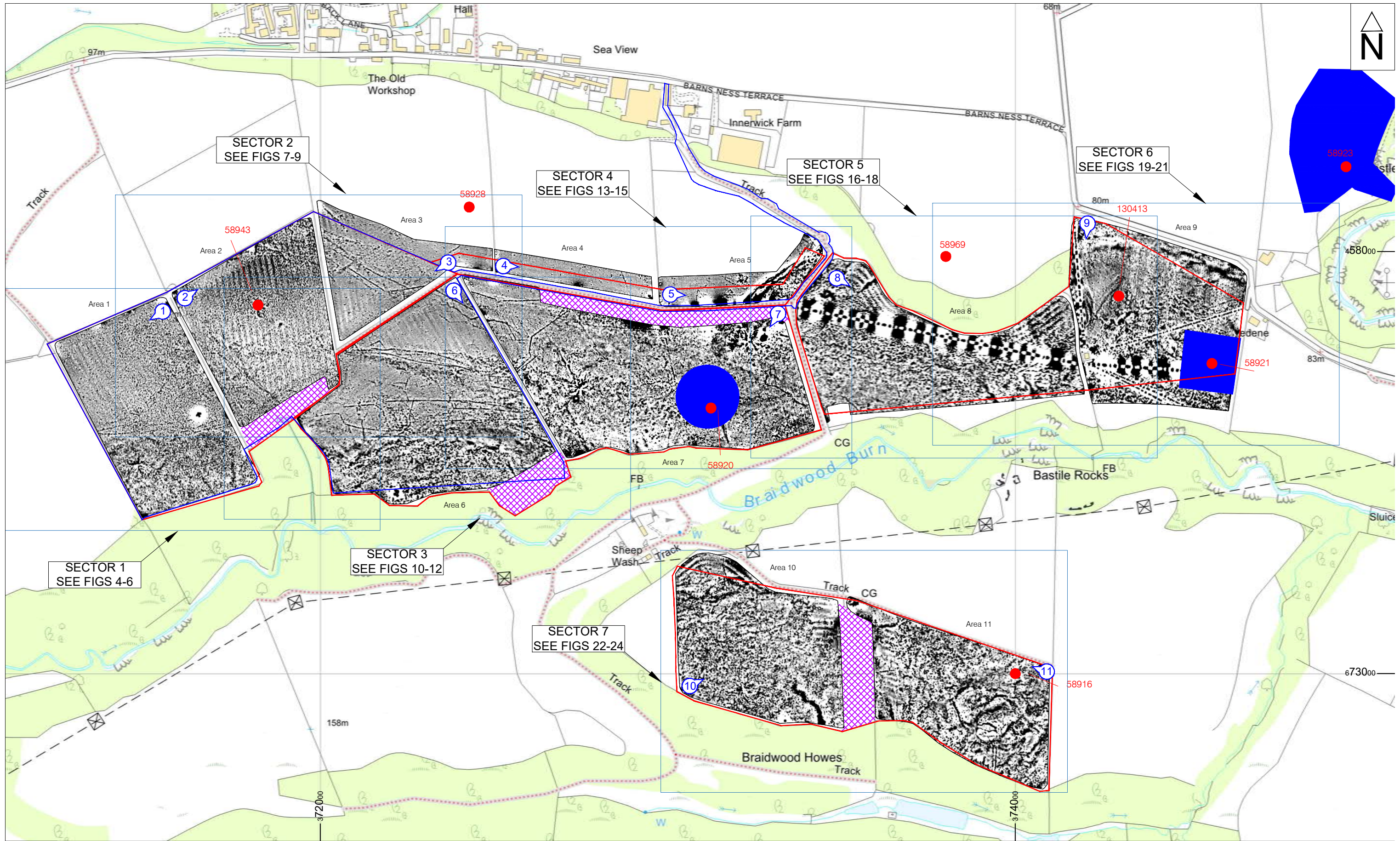



Fig. 1. Site location













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Project ID: XI78\_GES21  
 Survey location showing processed greyscale magnetometer data

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Title	
	SURVEY AREA
	APPLICATION SITE
	SECTOR BOUNDARY
	UNSUITABLE FOR SURVEY
	PHOTO LOCATIONS
	HER SITE
	SCHEDULED MONUMENT

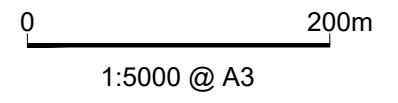
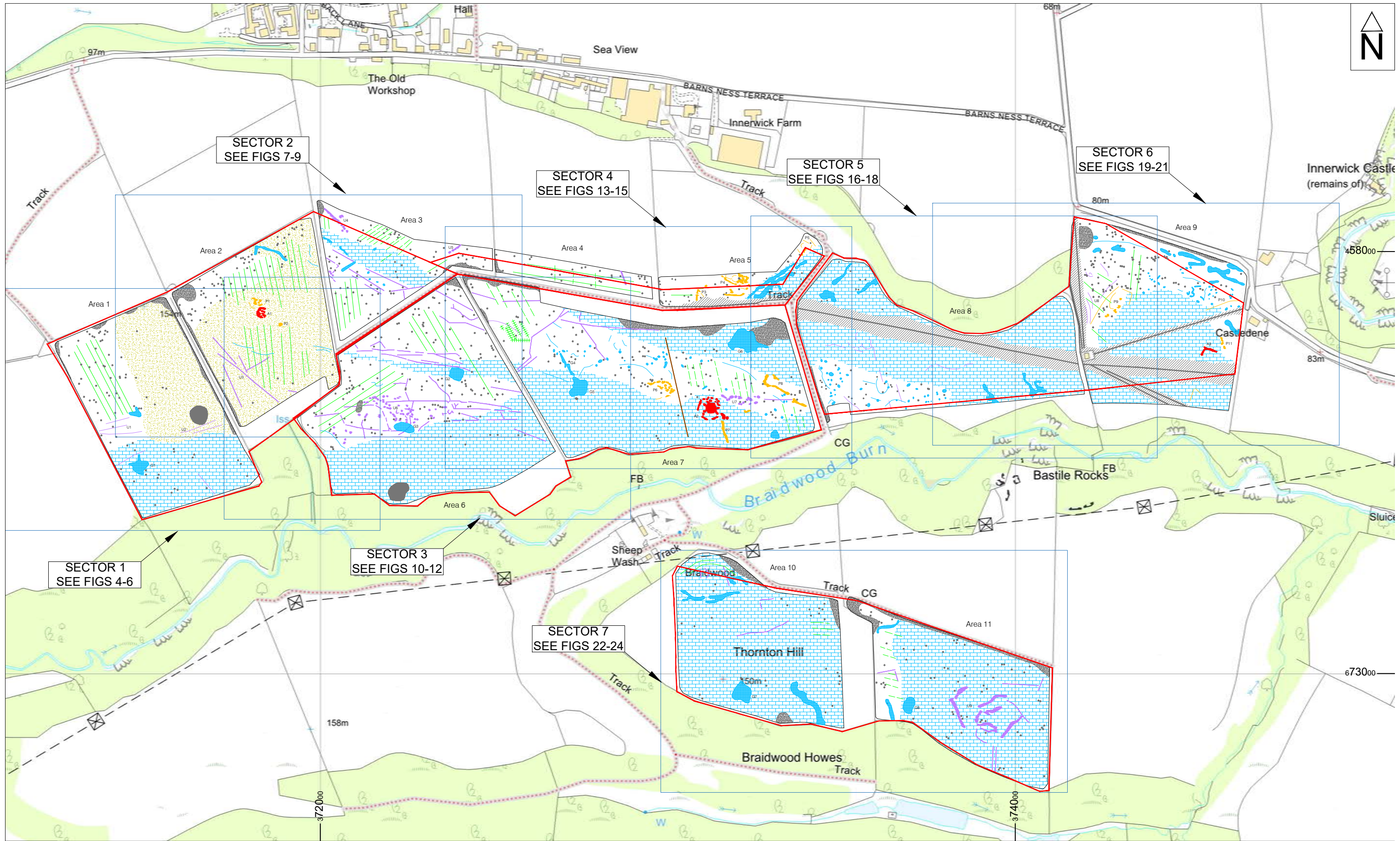



Fig. 2




















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Overall interpretation of magnetometer data

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Title	
	SURVEY AREA
	SECTOR BOUNDARY

Interpretation					
	FERROUS		FIELD DRAIN		GEOLOGY
	SERVICE PIPE		RIDGE & FURROW		UNCERTAIN
	MAGNETIC DISTURBANCE		AGRICULTURAL		ARCHAEOLOGY?
	GREEN WASTE?		FORMER FIELD BOUNDARY		ARCHAEOLOGY

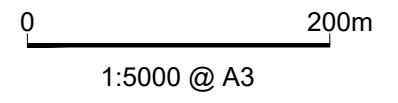
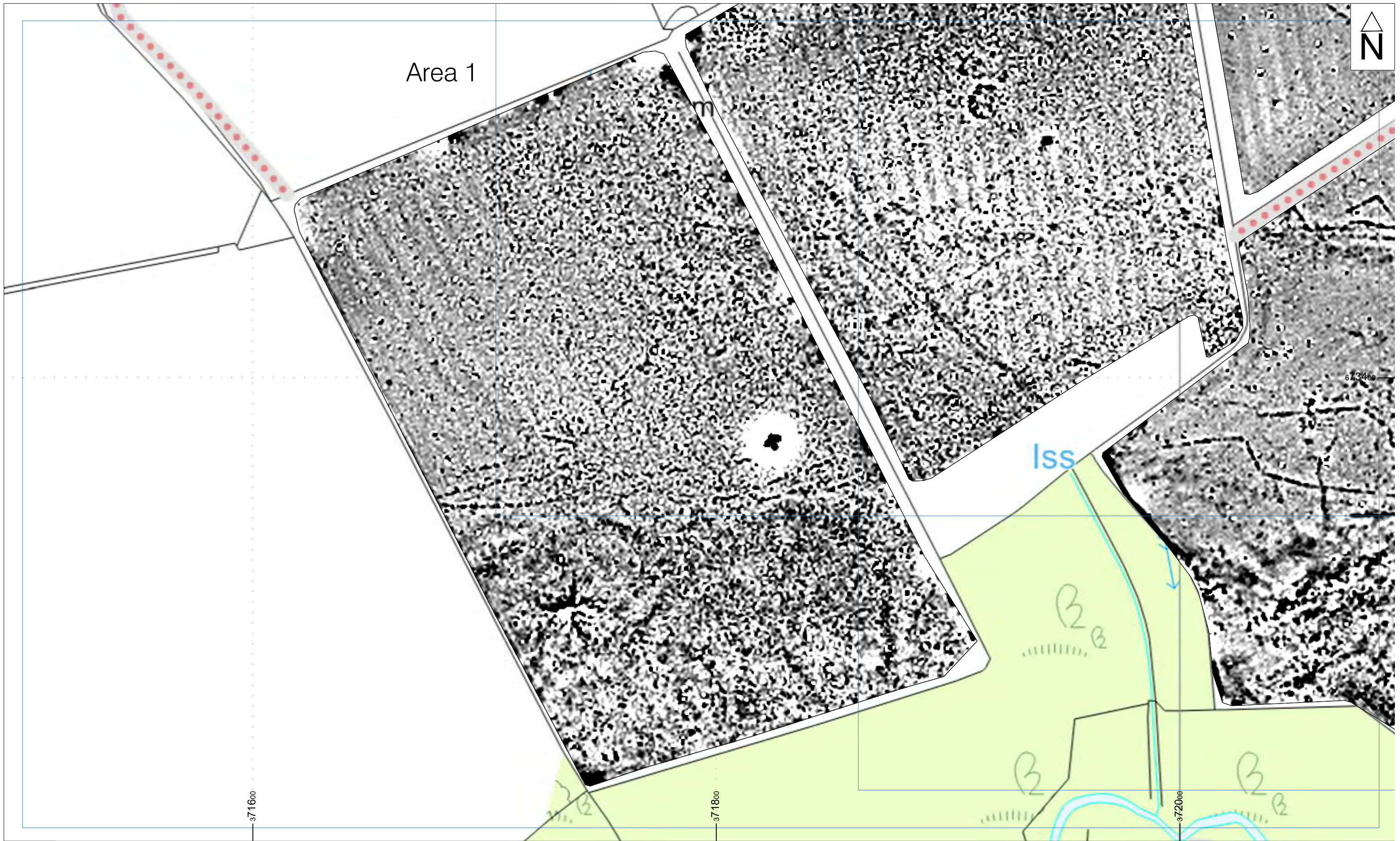



Fig. 3







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Processed greyscale magnetometer data; Sector 1

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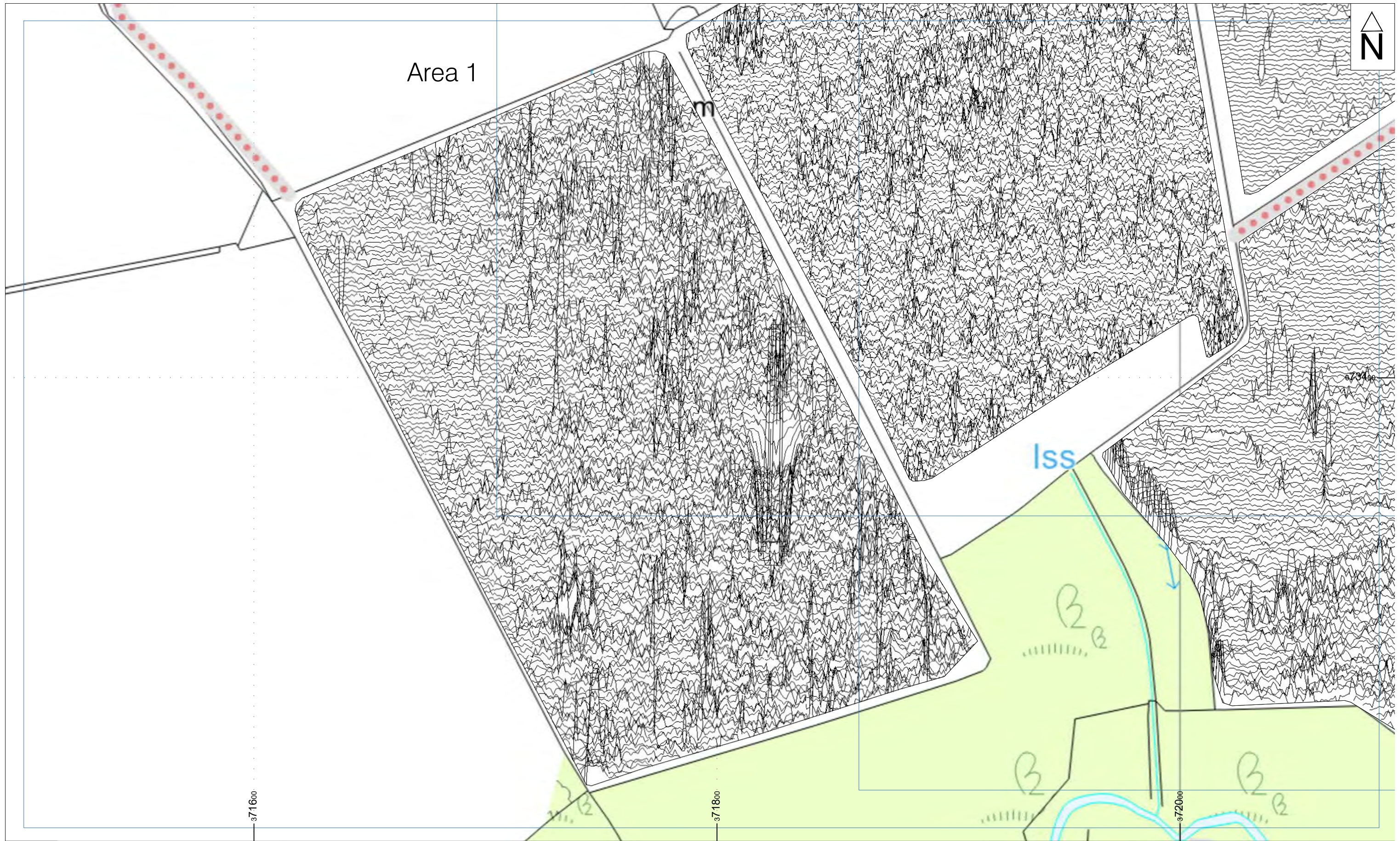
 SECTOR BOUNDARY




1:1500 @ A3

Fig. 4







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 XY trace plot of minimally processed magnetometer data;  
 Sector 1

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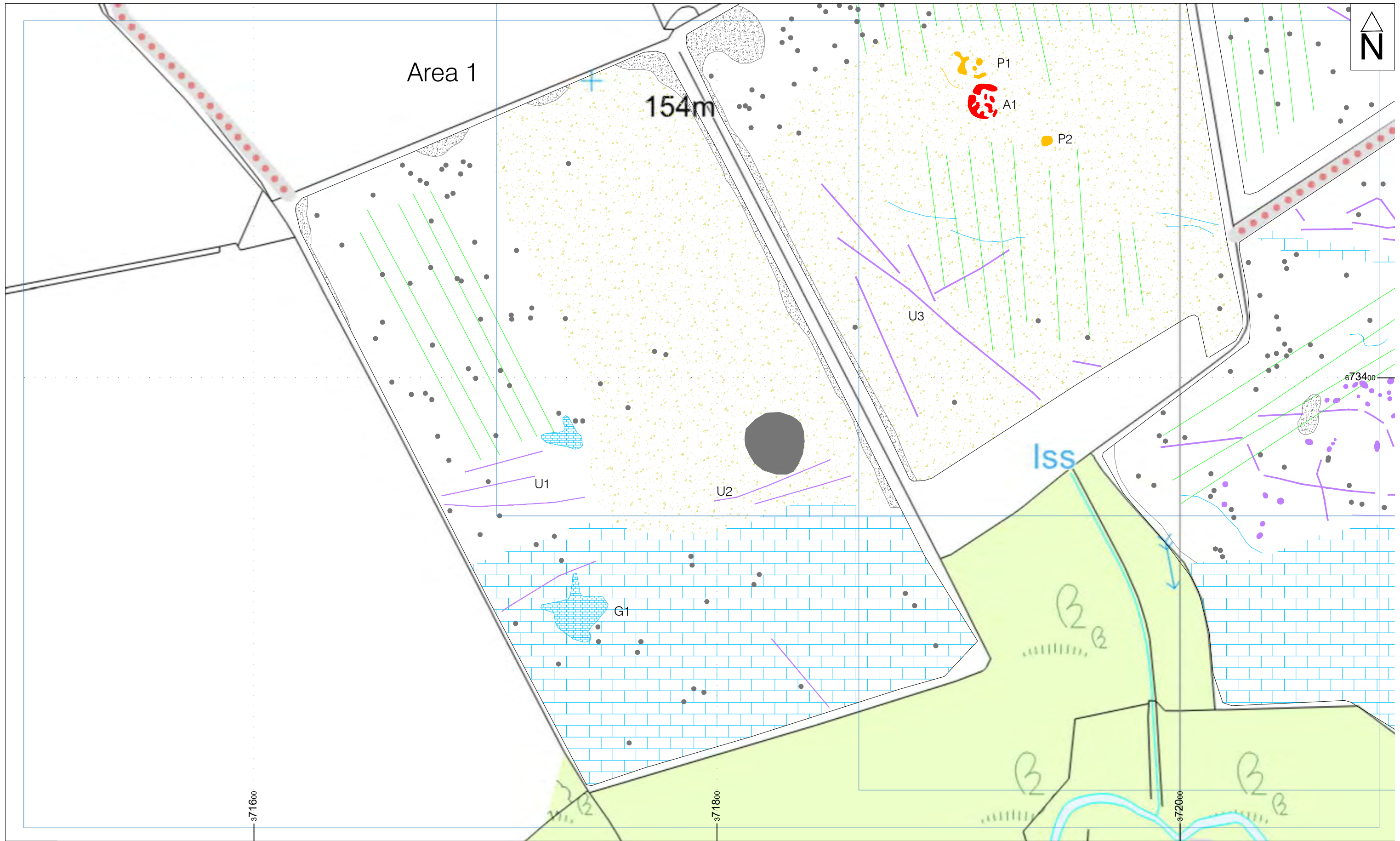
Title  
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15.0 nT/cm

0 50m  
 1:1500 @ A3

Fig. 5







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







Interpretation of magnetometer data; Sector 1

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**Title**

 SECTOR BOUNDARY

**Interpretation**

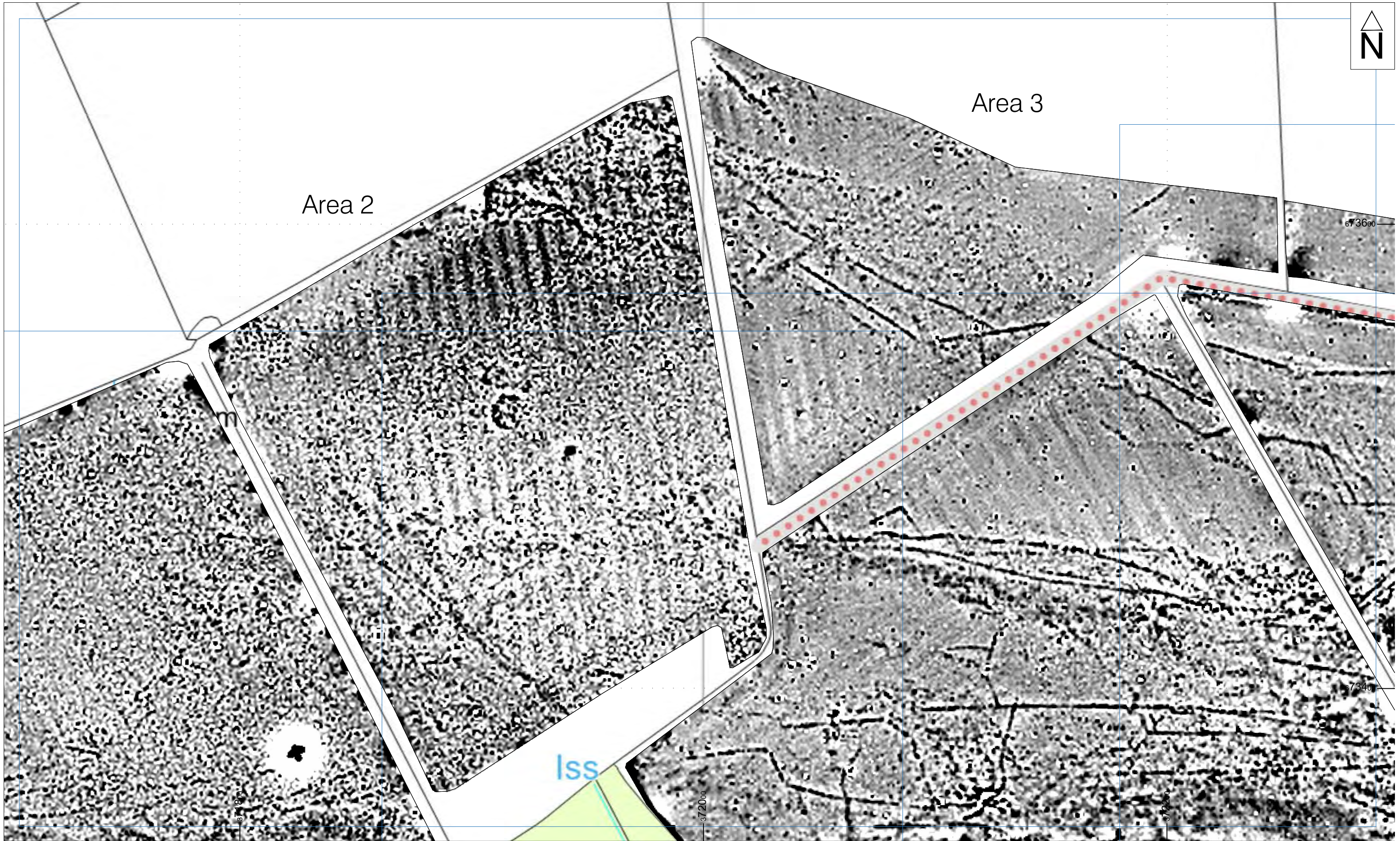
	FERROUS		AGRICULTURAL		ARCHAEOLOGY
	SERVICE PIPE		GEOLOGY		
	MAGNETIC DISTURBANCE		UNCERTAIN		
	GREEN WASTE?		ARCHAEOLOGY?		


0 50m

1:1500 @ A3

Fig. 6







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Processed greyscale magnetometer data; Sector 2

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Title

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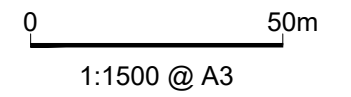
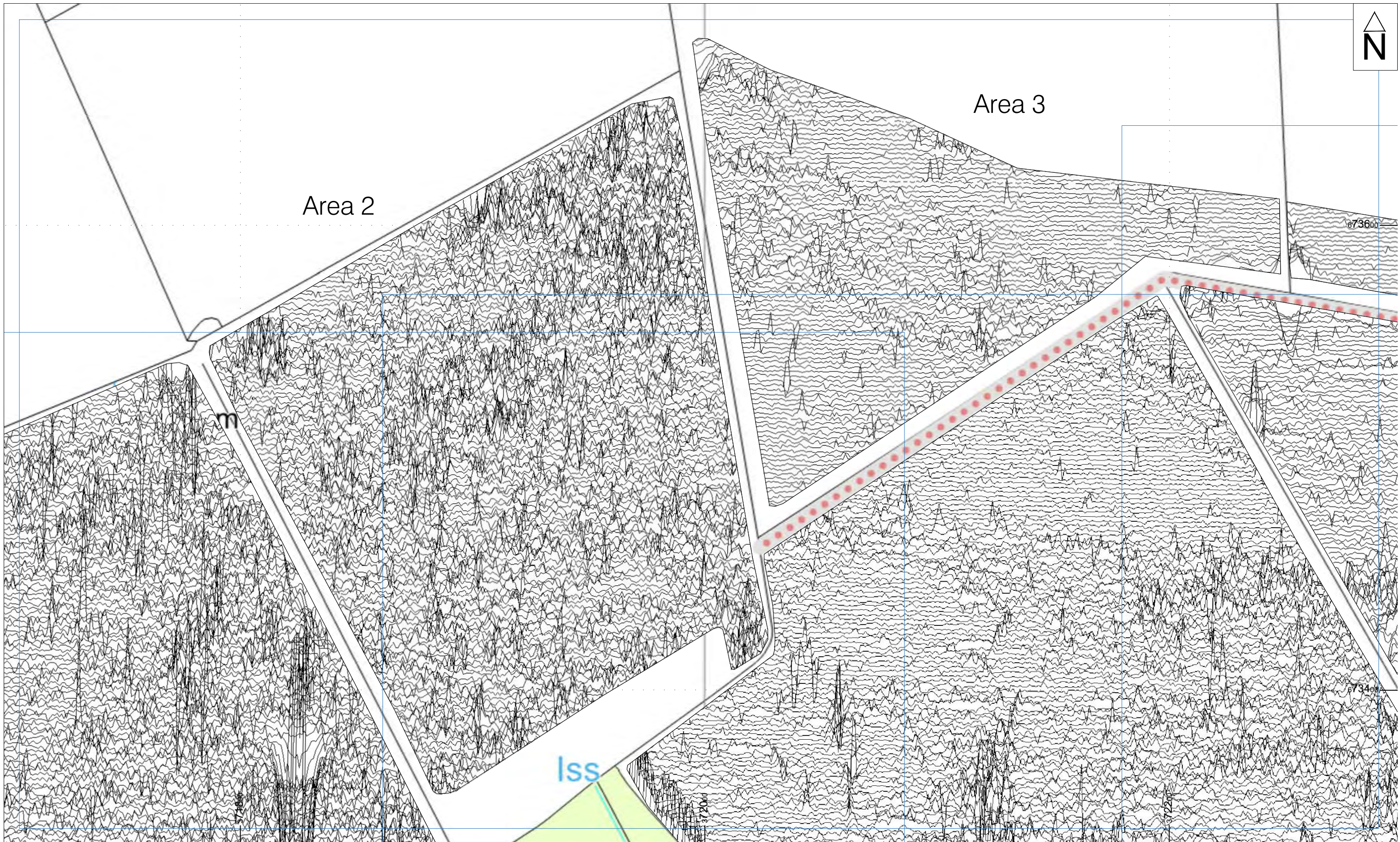



Fig. 7







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XY trace plot of minimally processed magnetometer data;  
Sector 2

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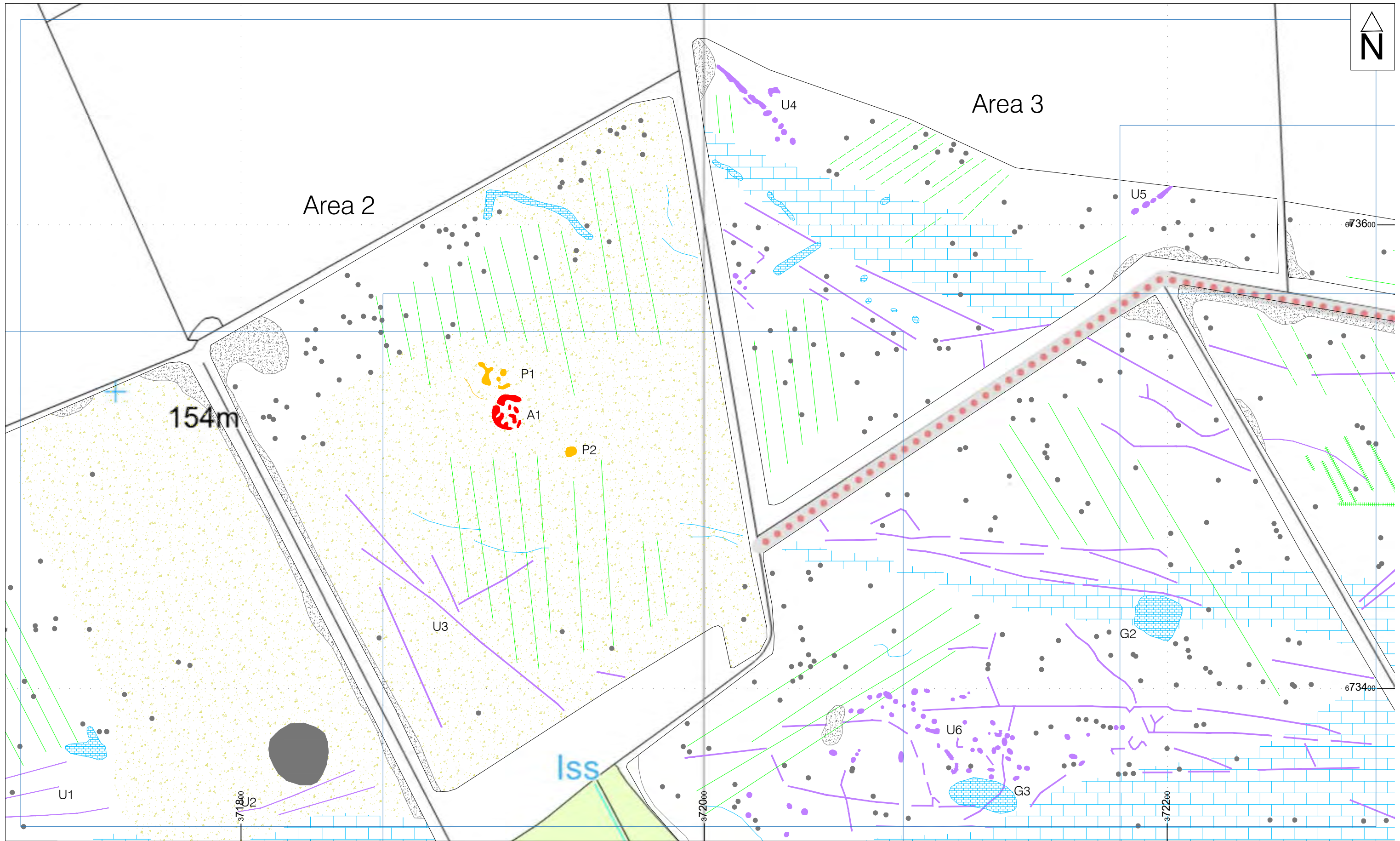
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0 50m

1:1500 @ A3

Fig. 8







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**Title**

	SECTOR BOUNDARY
---	-----------------

**Interpretation**

	FERROUS		FIELD DRAIN		UNCERTAIN
	SERVICE PIPE		RIDGE & FURROW		ARCHAEOLOGY?
	MAGNETIC DISTURBANCE		AGRICULTURAL		ARCHAEOLOGY
	GREEN WASTE?		GEOLOGY		

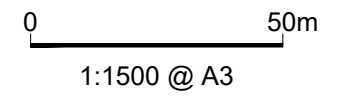



Fig. 8







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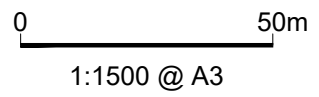
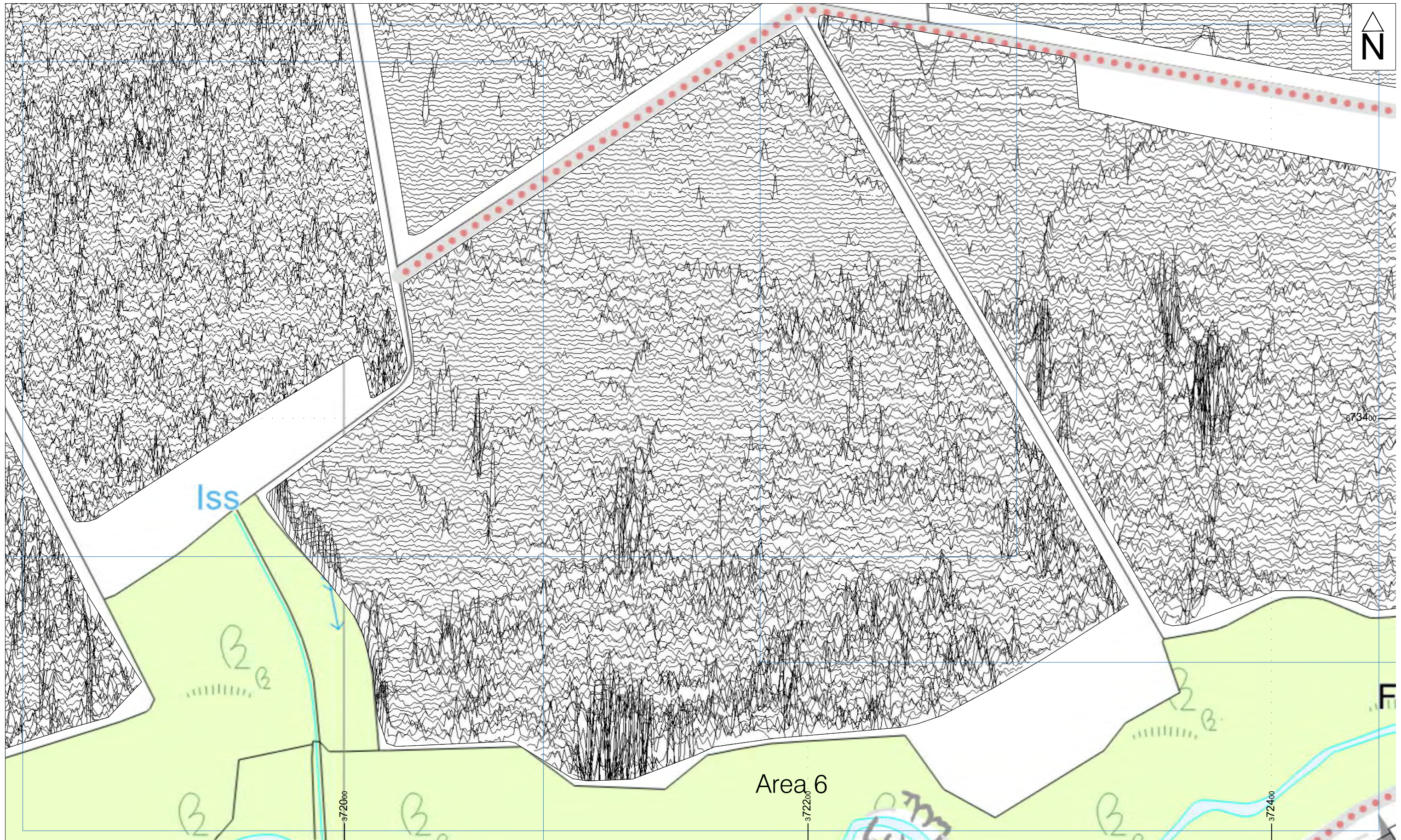



Fig. 10







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 XY trace plot of minimally processed magnetometer data;  
 Sector 3

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 SECTOR BOUNDARY

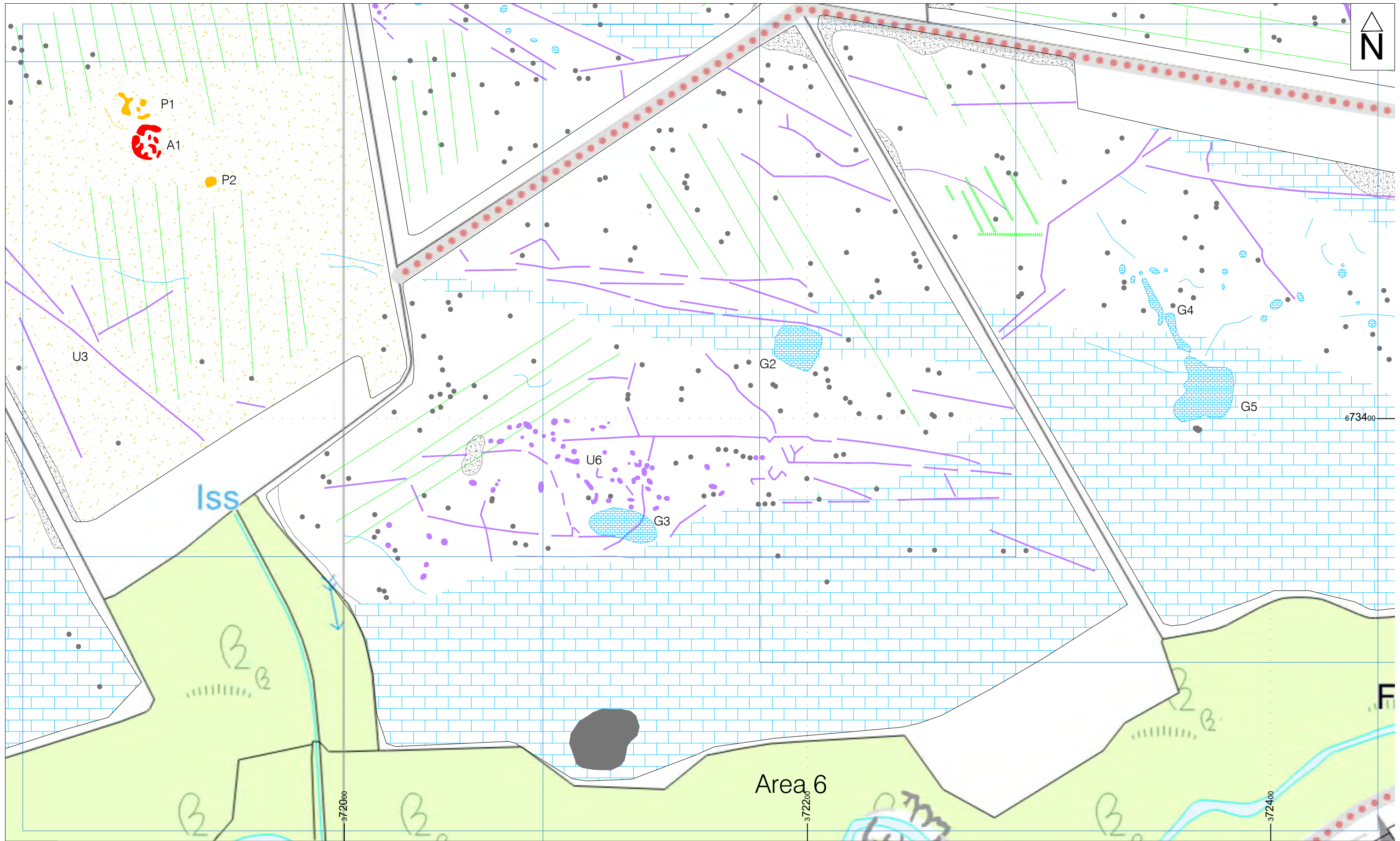
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0 50m

1:1500 @ A3

Fig. 11







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**Title**

 SECTOR BOUNDARY

**Interpretation**

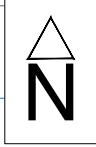
 FERROUS	 FIELD DRAIN	 UNCERTAIN
 SERVICE PIPE	 RIDGE & FURROW	 ARCHAEOLOGY?
 MAGNETIC DISTURBANCE	 AGRICULTURAL	 ARCHAEOLOGY
 GREEN WASTE?	 GEOLOGY	

0 50m

1:1500 @ A3

Fig. 12





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Processed greyscale magnetometer data; Sector 4

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Title

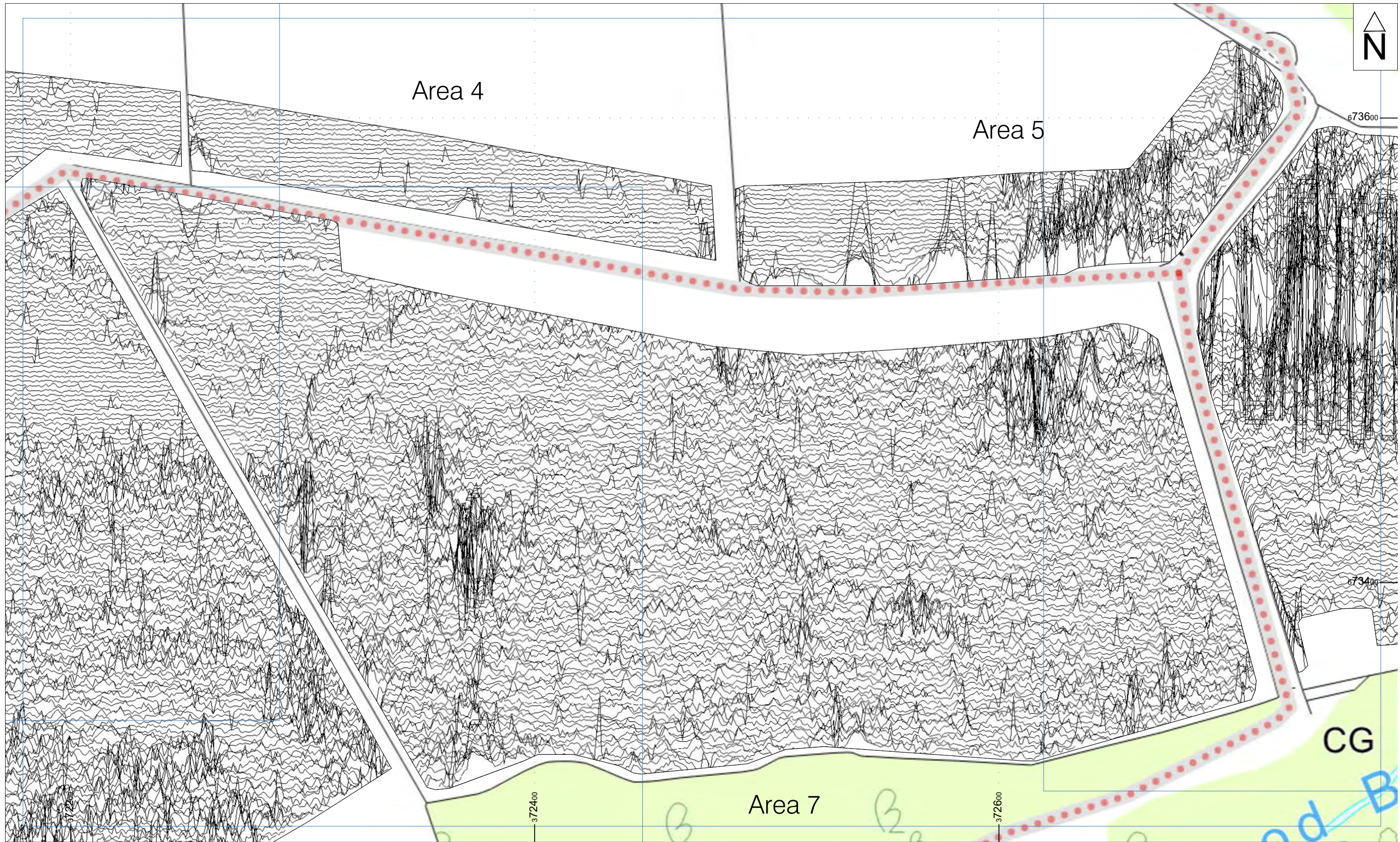
SECTOR BOUNDARY




1:1500 @ A3

Fig. 13






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XY trace plot of minimally processed magnetometer data;  
Sector 4

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Title


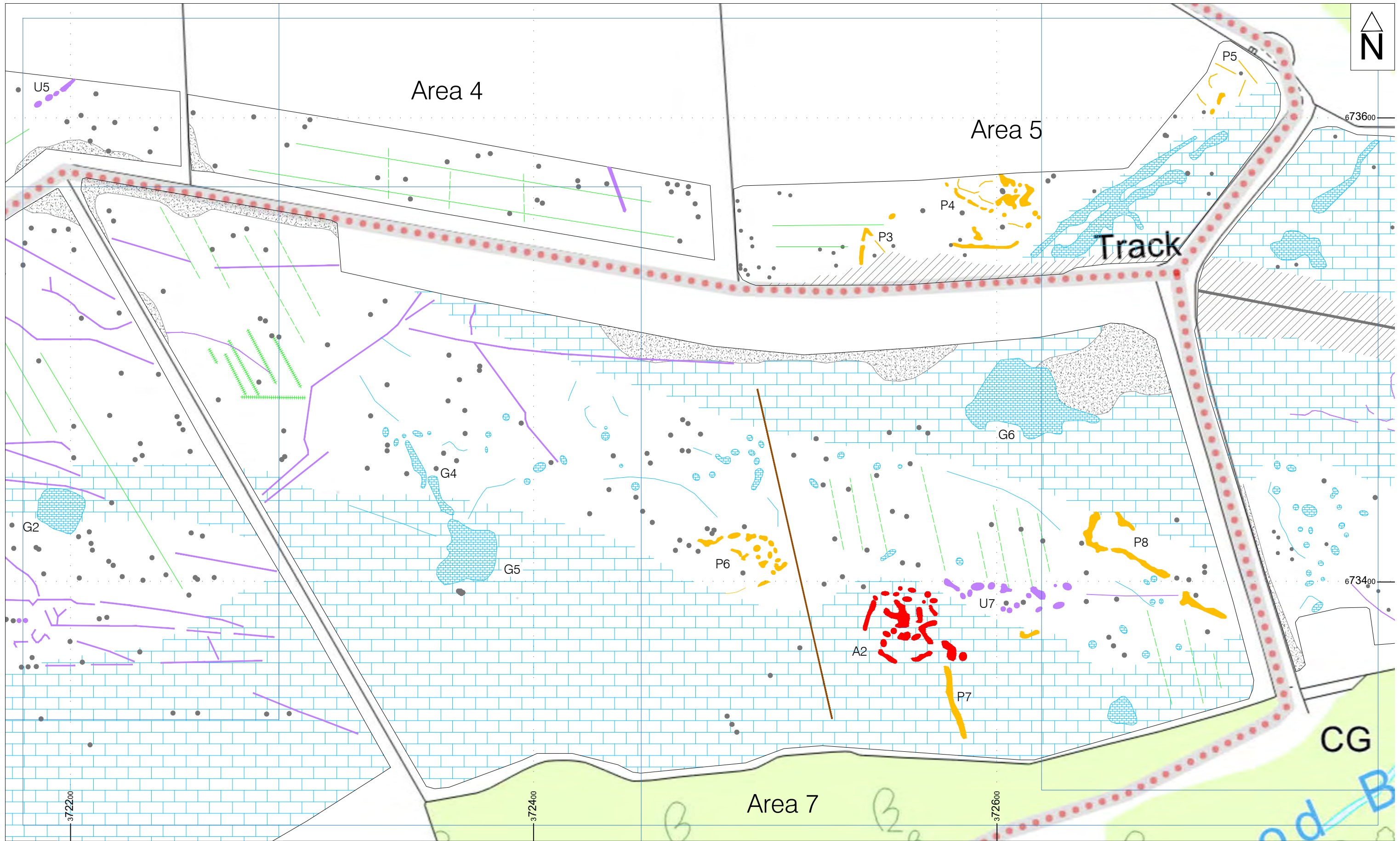
 SECTOR BOUNDARY


Fig. 14

0 50m

1:1500 @ A3






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






Interpretation of magnetometer data; Sector 4

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**Title**

	SECTOR BOUNDARY
---	-----------------

**Interpretation**

	FERROUS		RIDGE & FURROW		UNCERTAIN
	SERVICE PIPE		AGRICULTURAL		ARCHAEOLOGY?
	MAGNETIC DISTURBANCE		FORMER FIELD BOUNDARY		ARCHAEOLOGY
	FIELD DRAIN		GEOLOGY		


0 50m

1:1500 @ A3

Fig. 15







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Project ID: XI78\_GES21

Processed greyscale magnetometer data; Sector 5

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Title

 SECTOR BOUNDARY

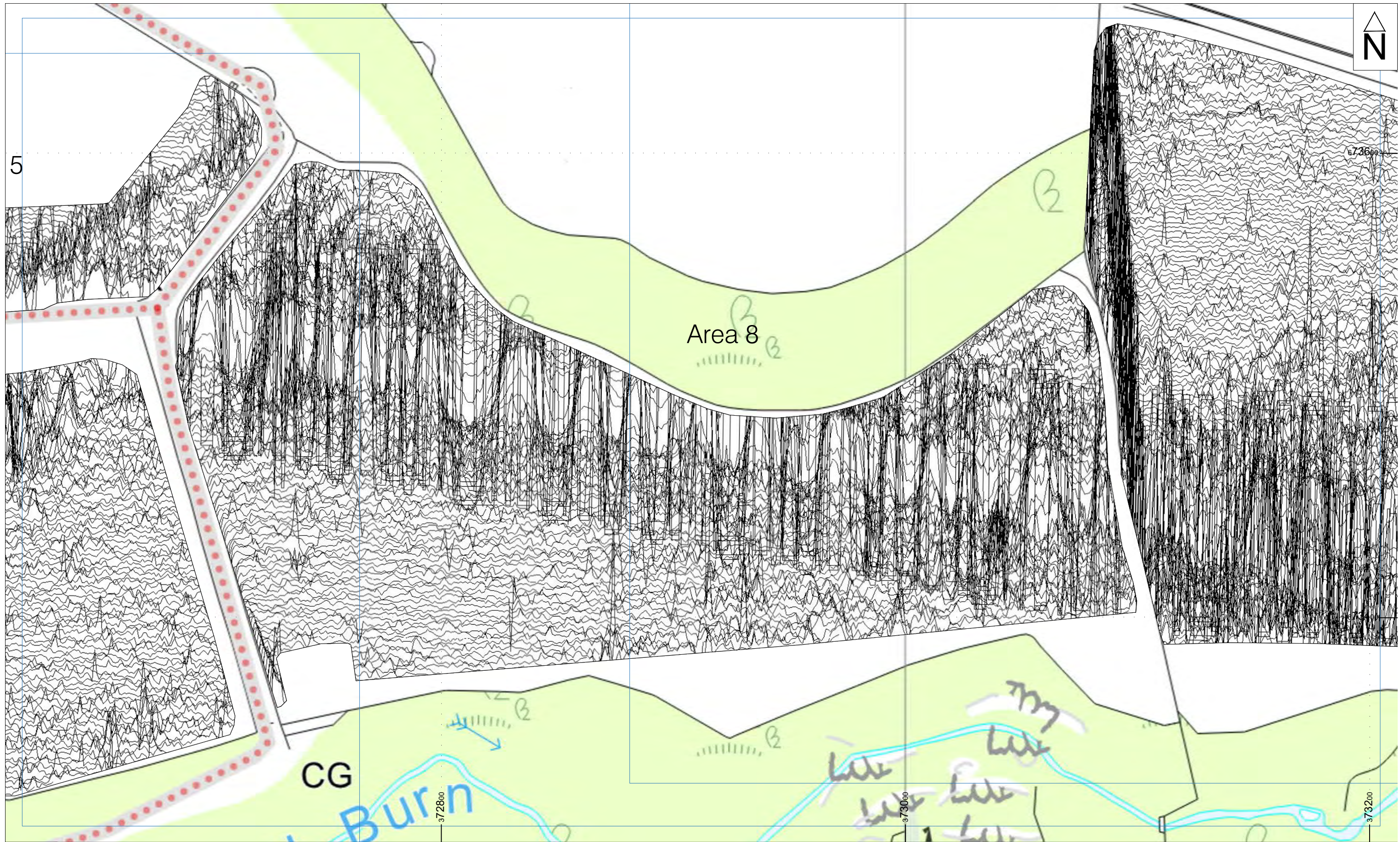



0 50m

1:1500 @ A3

Fig. 16







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Project ID: XI78\_GES21  
 XY trace plot of minimally processed magnetometer data;  
 Sector 5

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Title

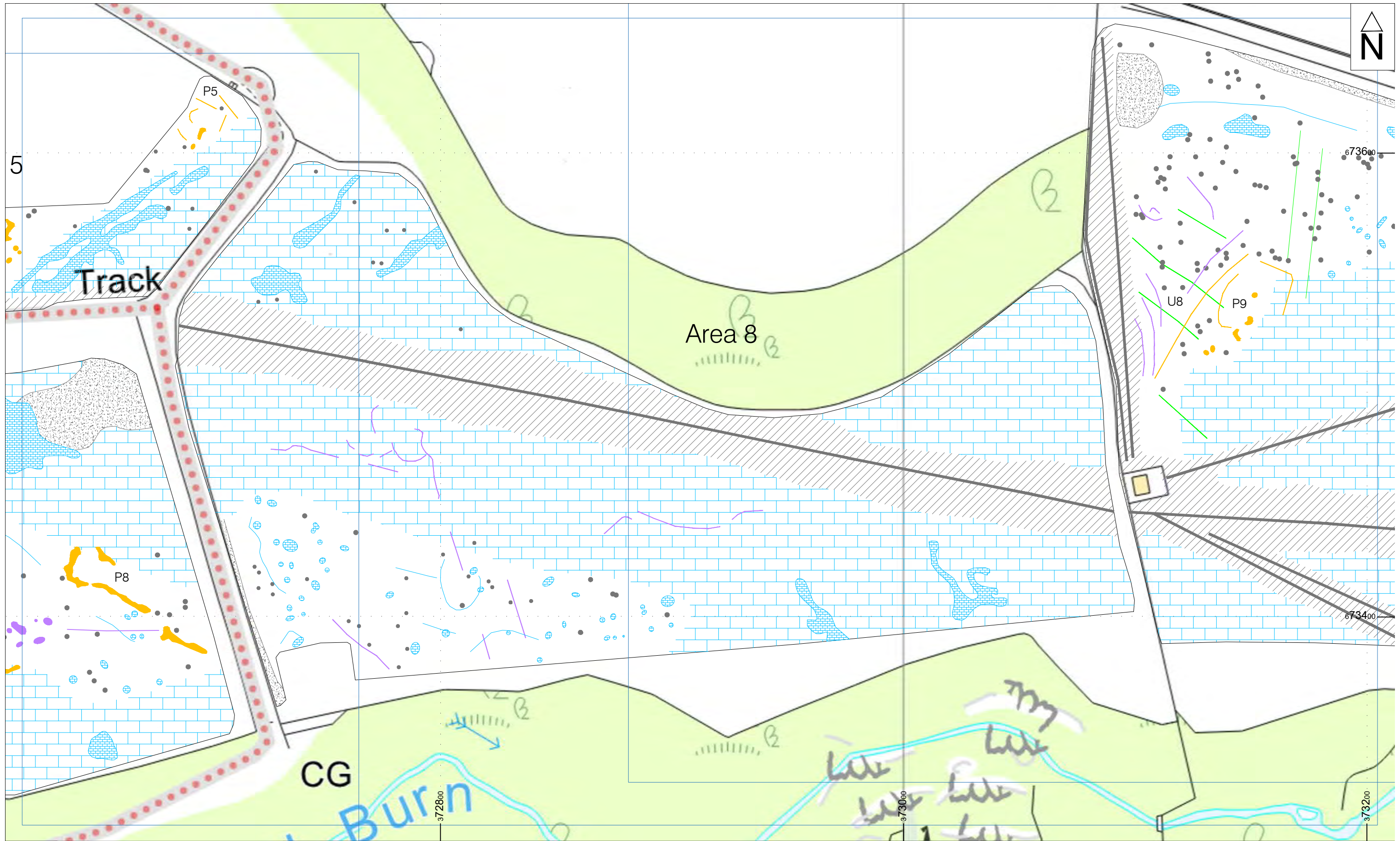
 SECTOR BOUNDARY


15.0 nT/cm

0 50m  
 1:1500 @ A3

Fig. 17







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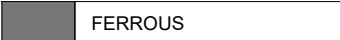
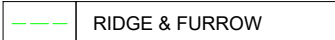




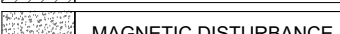
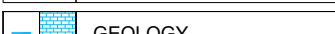
Interpretation of magnetometer data; Sector 5

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**Title**

 SECTOR BOUNDARY

**Interpretation**

 FERROUS	 RIDGE & FURROW	 UNCERTAIN
 SERVICE PIPE	 AGRICULTURAL	 ARCHAEOLOGY?
 MAGNETIC DISTURBANCE	 GEOLOGY	


0 50m

1:1500 @ A3

Fig. 18







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Processed greyscale magnetometer data; Sector 6

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Title

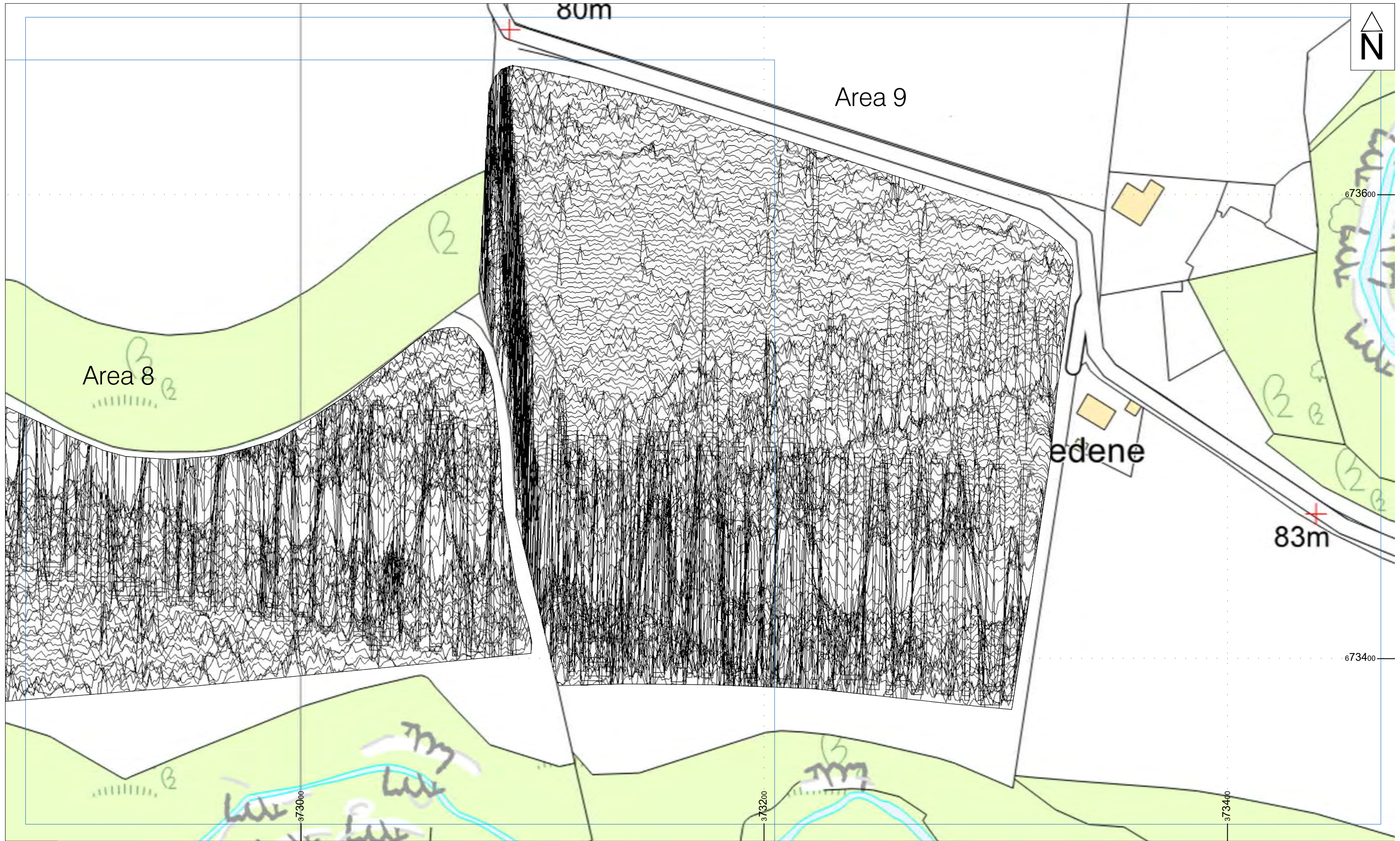
 SECTOR BOUNDARY




1:1500 @ A3

Fig. 19







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Project ID: XI78\_GES21

XY trace plot of minimally processed magnetometer data;  
Sector 6

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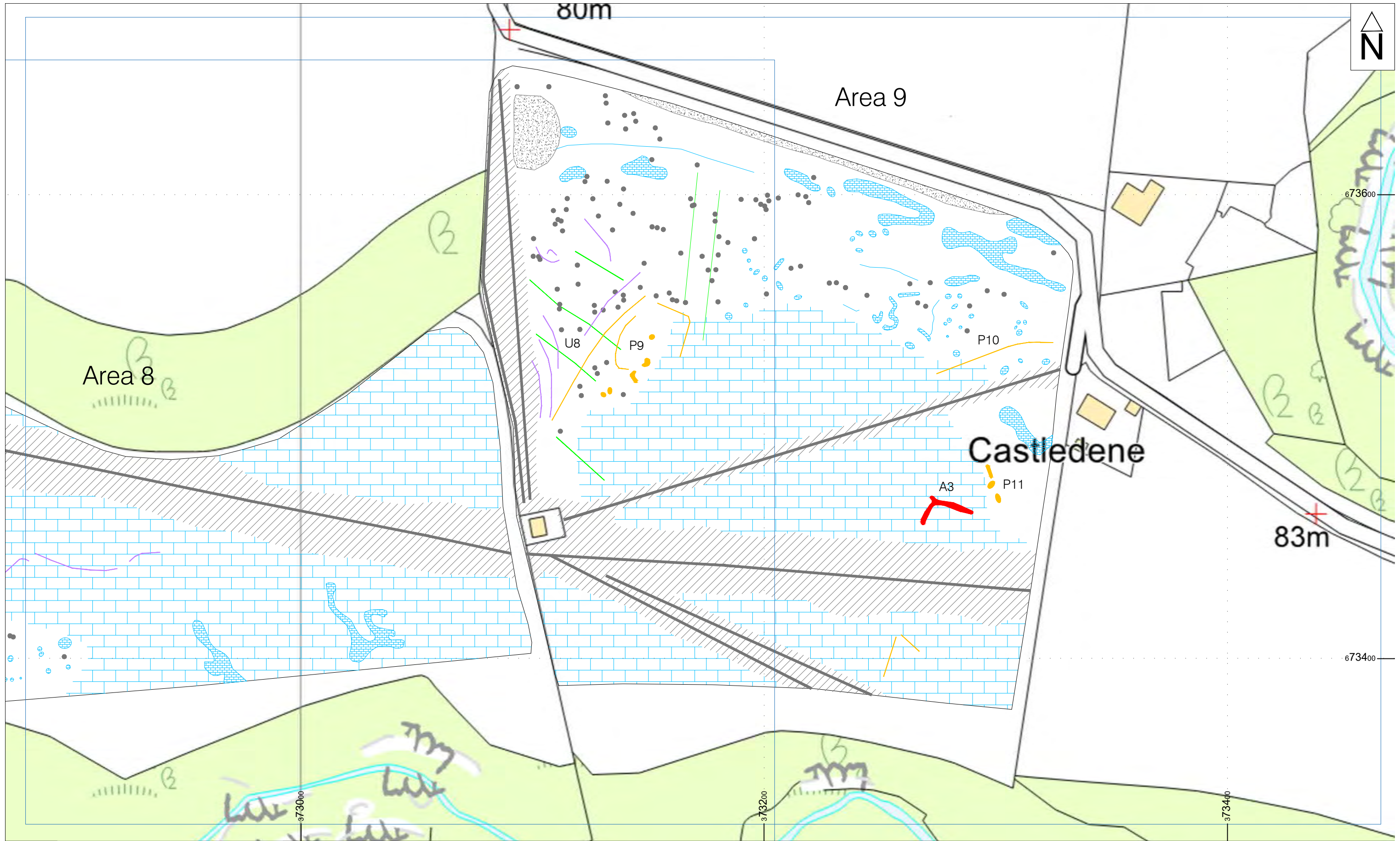
15.0 nT/cm


0 50m


1:1500 @ A3

Fig. 20














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 Interpretation of magnetometer data; Sector 6  
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**Title**  
 SECTOR BOUNDARY

**Interpretation**

 FERROUS	 AGRICULTURAL	 ARCHAEOLOGY?
 SERVICE PIPE	 GEOLOGY	 ARCHAEOLOGY
 MAGNETIC DISTURBANCE	 UNCERTAIN	


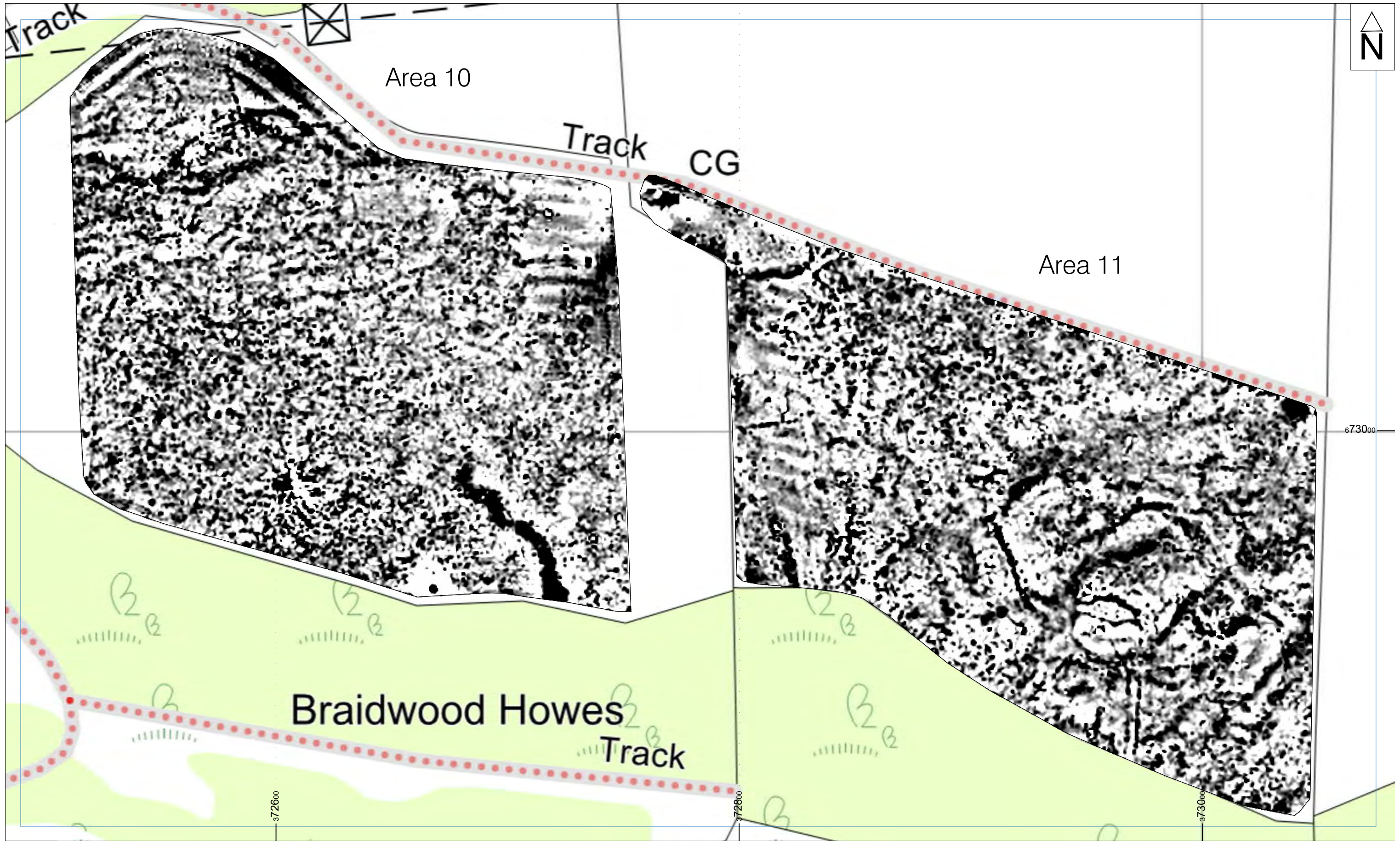

  
 0 50m  
 1:1500 @ A3

Fig. 21







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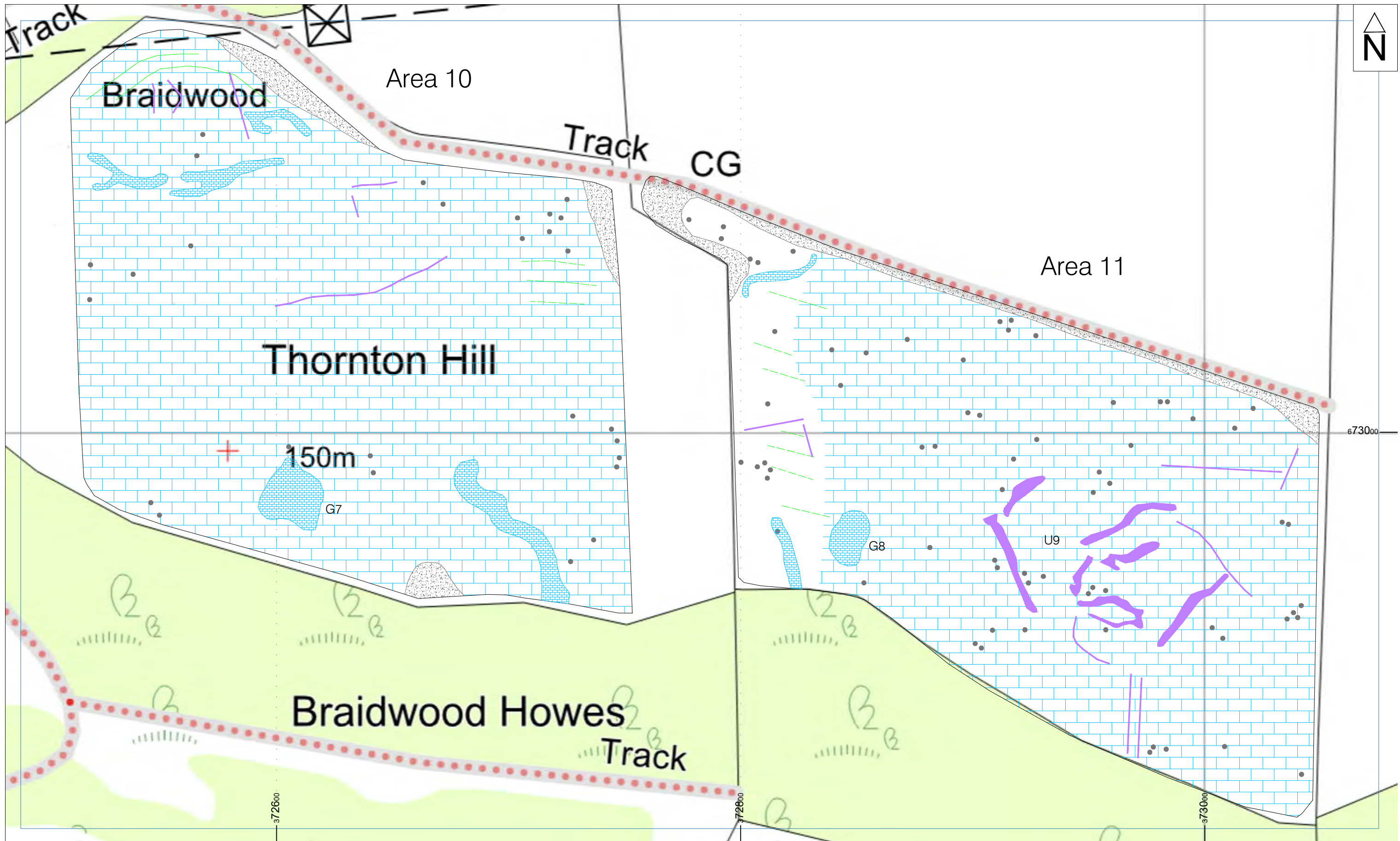
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Fig. 22











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

Interpretation of magnetometer data; Sector 7

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**Title**

	SECTOR BOUNDARY
---	-----------------

**Interpretation**

	FERROUS		AGRICULTURAL
	MAGNETIC DISTURBANCE		GEOLOGY
	RIDGE & FURROW		UNCERTAIN

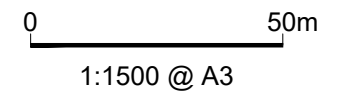


Fig. 24





*Plate 1. General view of Area 1, looking southwest*



*Plate 2. General view of Area 2, looking northeast*



*Plate 3. General view of Area 3, looking west*



*-Plate 4. General view of Area 4, looking east*





*Plate 5. General view of Area 5, looking east*



*Plate 6. General view of Area 6, looking southeast*



*Plate 7. General view of Area 7, looking southwest*



*Plate 8. General view of Area 8, looking southeast*





*Plate 9. General view of Area 9, looking south*



*Plate 10. General view of Area 10, looking northeast*



*Plate 11. General view of Area 11, looking west*

## **Appendix 1: Magnetic survey - technical information**

### **Magnetic Susceptibility and Soil Magnetism**

Iron makes up about 6% of the Earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haemetite. These minerals have a weak, measurable magnetic property termed magnetic susceptibility. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms. 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.

### **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 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: Gradiometer Survey**

The main method of using the fluxgate gradiometer for commercial evaluations is referred to as *detailed survey* and requires the surveyor to walk at an even pace carrying the instrument within a grid system. A sample trigger automatically takes readings at predetermined points, typically at 0.25m intervals, on traverses 1m apart. These readings are stored in the memory of the instrument and are later dumped to computer for processing and interpretation.

During this survey an eight channel Sensys MX V3 system containing eight FGM650 sensors was also used which was towed across the area using an ATV. Readings were taken every 20MHz (between 0.05 and 0.1m). Data was be recorded onto a device, using a Carlson GNSS Smart antenna, for centimetre accuracy. These readings were stored in the memory of the instrument and downloaded for processing and interpretation.

The gradiometer data have been presented in this report in processed greyscale format. The data in the greyscale images have 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.

## **Appendix 2: Survey location information**

Data was recorded onto a device, using a Carlson GNSS BRx7 Smart antenna, for centimetre accuracy. These readings were stored in the memory of the instrument and downloaded for processing and interpretation. The accuracy of the BRx7 is between 0.15cm – 0.8cm. The BRx7 has a built-in tilt sensor to correct collected point coordinates to within 2cm.

The survey data were then super-imposed onto a base map provided by the client to produce the displayed 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 and metadata**

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Microsoft Word 2003), and graphics files (Adobe Illustrator CS6 and AutoCAD 2017) 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 Lothian Historic Environment Record).

## **Appendix 4: Oasis form**

# OASIS Summary for archaeol11-520869

OASIS ID (UID)	archaeol11-520869
Project Name	Geophysical Survey at Land south of Innerwick
Sitename	Land south of Innerwick
Sitecode	LSI23
Activity type	Geophysical Survey, MAGNETOMETRY SURVEY
Reason For Investigation	Planning: Pre application
Organisation Responsible for work	Archaeological Services WYAS
Project Dates	20-Feb-2023 - 04-Apr-2023
Location	Land south of Innerwick NGR : NT 72310 73410 LL : 55.95291502888609, -2.445005200367436 12 Fig : 372310,673410
Administrative Areas	Parish : Innerwick Local Authority District : East Lothian Country : Scotland
Project Methodology	The cart-based survey was undertaken using an eight channel SenSYS MX V3 system containing eight FGM650 sensors. Readings are taken every 20MHz (between 0.05 and 0.1m). Data were recorded onto a device, using a Carlson GNSS Smart antenna, for centimetre accuracy. These readings were stored in the memory of the instrument and downloaded for processing and interpretation. DLMGPS and MAGNETO software, alongside bespoke in-house software was used to process and present the data.
Project Results	A geophysical (magnetometer) survey was undertaken on approximately 50 hectares of land located to the south of Innerwick, East Lothian. Anomalies of both a definite and a possible archaeological origin have been detected including settlement features and ring ditches. Uncertain anomalies within the dataset include multiple linear responses which may be of some archaeological interest. Due to the geology within the Site many of the uncertain anomalies have been difficult to interpret, they may be of an archaeological origin but also equally likely to be geological or agricultural. Along with the high background levels of geology, further natural occurrences can be seen within the dataset which reflect lightning strikes. Modern ploughing and medieval or post-medieval ridge and furrow has also been recorded along with service pipes, disturbance associated with possible green waste manuring and magnetic disturbance associated with field boundaries and adjacent tracks.
Keywords	ENCLOSED SETTLEMENT - Late Prehistoric - Monument Type Thesaurus (Scotland) RING DITCH - Period Unknown - Monument Type Thesaurus (Scotland)
Funder	Private or public corporation Braxbess Ltd
Person Responsible for work	Emma Brunning
Archives	
DES description	
NGR	NT 72310 73410
Previous Work	No
Future Work	No

Caption(s) for illustrations	
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