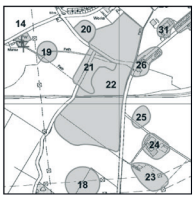
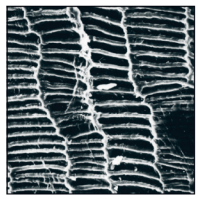
WOOD22








WOOD LODGE SOLAR FARM, NORTHAMPTONSHIRE

GEOPHYSICAL SURVEY REPORT

commissioned by Lighthouse Development Consulting
on behalf of Wood Lodge Solar Farm Limited

March 2023

HEADLAND ARCHAEOLOGY

REGISTERED ORGANISATION CIfA

WOOD LODGE SOLAR FARM, NORTHAMPTONSHIRE

GEOPHYSICAL SURVEY REPORT

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This report adheres to the quality standard of ISO 9001:2015

PROJECT INFO:

HA Project Code **WOOD22** / HA Report No **2023-08** / NGR **TL 03394 77355** / Parish **Titchmarsh** / Local Authority **North Northamptonshire Council** / Fieldwork Date **06.02.23–14.02.23** / OASIS Ref. **headland1- 513880**

PROJECT TEAM:

Project Manager **Christian Adams** / Author **Christian Adams** / Fieldwork **Abigail Calvert, Eoin McLaughlin, Kieran Stemp, Thomas Jenkins** / Graphics **Christian Adams, Matt Berry, Tom Watson**

Approved by **Christian Adams** C H Adams .....

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HEADLAND ARCHAEOLOGY

part of the RSK Group

REGISTERED ORGANISATION CIfA

PROJECT SUMMARY

Headland Archaeology (UK) Ltd was commissioned by Lighthouse Development Consulting on behalf of Wood Lodge Solar Limited (the Client), to undertake a geophysical (magnetometer) survey, covering approximately 65 hectares, at Wood Lodge Farm, Northamptonshire, where a solar farm is being proposed. This geophysical survey report will be submitted in support of the planning application for the future development of the land and may also inform future archaeological strategy at the site, if required.

The survey has recorded anomalies indicative of significant, dense, and extensive archaeological activity following and appending at least three trackways which cross the proposed development area (PDA), covering approximately 18ha. There are three main foci of archaeological activity: one close to the eastern edge of F1 and two in F3. At each location anomalies indicative of multiple, clustered enclosures of varying size and shape are recorded linked by trackways and with numerous discrete anomalies, likely to be caused by activity associated with settlement, also numerous. Archaeological activity (cropmarks interpreted as enclosures, trackways, and other features) is recorded on the Northamptonshire Historic Environment Record at these locations although the survey has provided significantly greater detail on the complexity and extent of the archaeological remains. Although it is not possible to provide an accurate date for the archaeological activity identified, the pattern and morphology of the anomalies suggest an Iron Age to Romano-British origin is likely.

Anomalies due to both historical and recent agricultural activity (ridge and furrow and modern ploughing, drainage and boundary rationalisation), geological variation and modern activity are also identified. Several anomalies of uncertain origin have also been identified. These are likely modern or agricultural in origin, but due to the extensive archaeological activity within the PDA, an archaeological origin cannot be discounted.

Overall, the extent of the three major areas of archaeological activity appears to be restricted to F3 and the eastern extent of F1. Where there are no superficial deposits, there are either no recorded anomalies or they are very low magnitude and difficult to discern. This raises the possibility that the archaeological resource may be more extensive than the survey has revealed in those areas where the prevailing pedological and geological conditions are not as favourable for detection.

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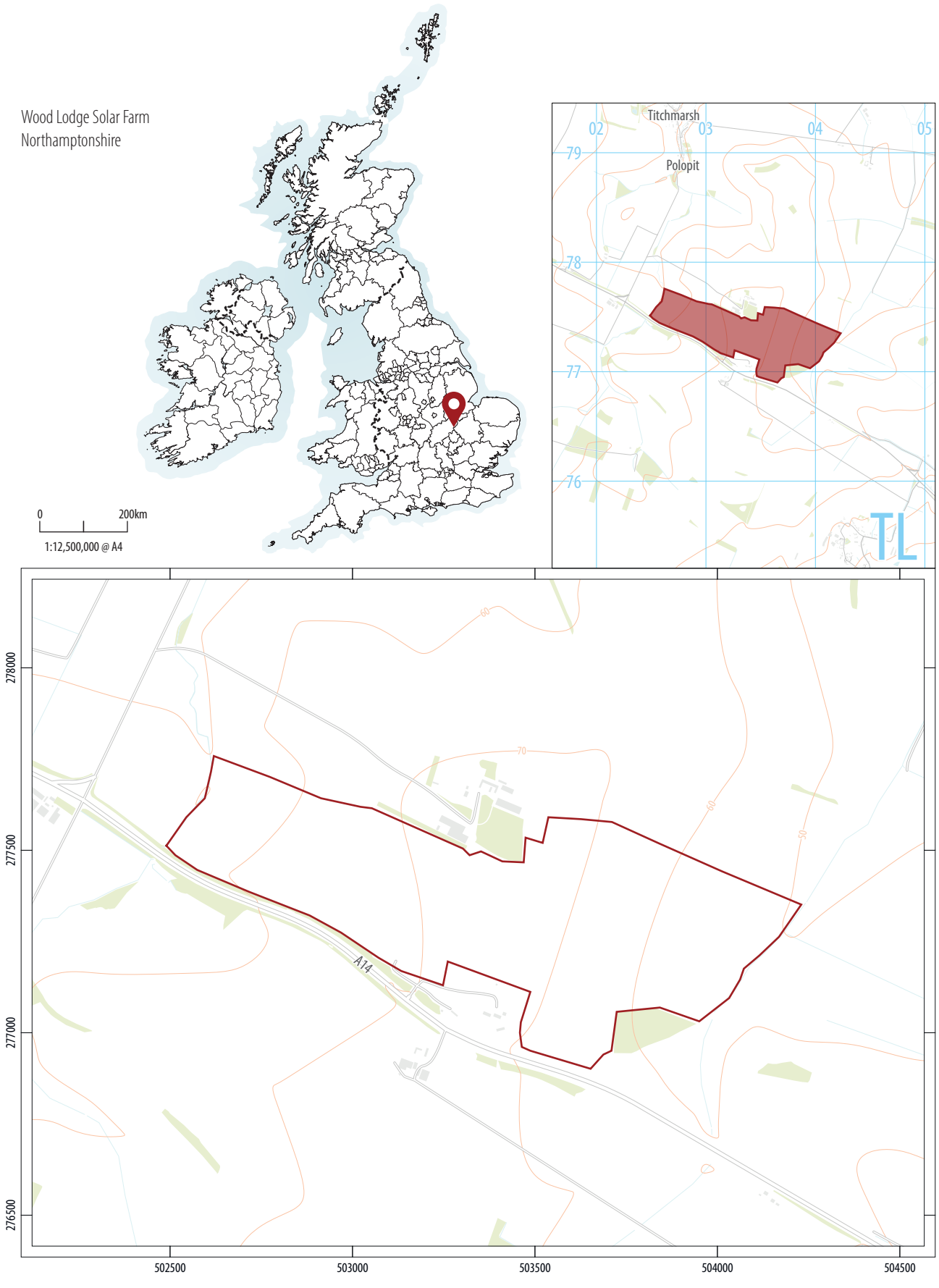
LIST OF ILLUSTRATIONS



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ILLUS 1 Site location

WOOD LODGE SOLAR FARM, NORTHAMPTONSHIRE

GEOPHYSICAL SURVEY REPORT

1 INTRODUCTION

Headland Archaeology (UK) Ltd was commissioned by Lighthouse Development Consulting on behalf of Wood Lodge Solar Limited (the Client), to undertake a geophysical (magnetometer) survey at Wood Lodge Farm, Northamptonshire, (Illus 1) where a solar farm is being proposed.

This geophysical survey report will be submitted as part of a planning application for the proposed Solar Photovoltaic (PV) array and associated infrastructure development. The results will also inform future archaeological strategy, if required.

The scheme of work was undertaken in accordance with the requirements of the National Planning Policy Framework (MHCLG 2021) and with the Written Scheme of Investigation for Geophysical Survey (WSI) (Headland Archaeology 2022). The WSI was approved by Liz Mordue, Lead Planning Archaeologist for North Northamptonshire Council on December 20th 2022.

The WSI was produced to the standards laid down in the European Archaeological Council's guideline publication EAC Guidelines for the Use of Geophysics in Archaeology (Europae Archaeologia Consilium 2016), the Chartered Institute for Archaeologists (CIfA) Standard and Guidance for Archaeological Geophysical Survey (CIfA 2014) and the Northamptonshire County Council's Requirements for a Geophysical Survey (NCC 2021). The survey was also carried out in line with the same best practice guidelines.

The survey was carried out between 6th–14th February, 2023.

1.1 SITE LOCATION, TOPOGRAPHY AND LAND-USE

The Proposed Development Area (PDA) covers an irregularly shaped block of three interconnected agricultural arable fields (F1 to F3) which had all been harvested, covering approximately 65 hectares. Trackways running broadly north to south between Wood Lodge Farm and the A14 separate each of the three fields. The PDA is situated 2km east of Thrapston (centred at NGR TL 03394 77355) and is bounded by the A14 to the south and agricultural fields in all other directions (see Illus 1).

The PDA is gently undulating but has an overall slope up from approximately 53m Above Ordnance Datum (AOD) in the east and west to approximately 75m AOD at the centre of the PDA.

1.2 GEOLOGY AND SOILS

The underlying bedrock geology comprises Oxford Clay Formation – Mudstone, a sedimentary bedrock formed between 166.1 and 157.3 million years ago during the Jurassic period. There are no recorded superficial deposits in the east or west of the PDA. Across the central part of the PDA, Oadby Member – Diamicton, a sedimentary superficial deposit formed between 480,000–423,000 years ago in the Quaternary period, is recorded (UKRI 2022).

The soils are classified in the Soilscape 9 Association which are described as lime-rich and loamy clayey soils with impeded drainage (Cranfield University 2022).

ILLUS 2 F1 looking south-west **ILLUS 3** F2 looking south

2 ARCHAEOLOGICAL BACKGROUND

The following is a summary of a rapid assessment of available background information, including from the National Mapping Programme, historical mapping and a search of Northamptonshire Historic Environment (NHER) data on Heritage Gateway (2023).

Within the PDA known archaeological features are recorded in the form of cropmarks. These include a double ditched trackway running from north-east to south-west across F1. This trackway is thought to be potentially associated with extensive cropmarks of Iron Age and/or Roman enclosures and boundaries. Further extensive enclosures are recorded in the form of cropmarks within F3. These are thought to be of Iron Age and/or Roman origin and likely indicate settlement and associated land division. Two findspots of Iron Age and Roman pottery are also recorded within this field.

Several areas of ridge and furrow cultivation are recorded in the surrounding area and are also visible as cropmarks and extant earthworks on Google Earth satellite images.

3 AIMS, METHODOLOGY & PRESENTATION

3.1 AIMS & OBJECTIVES

The principal aim of the geophysical survey was to gather information to establish the presence/absence, character, and extent of any archaeological remains within the PDA. This will enable an assessment to be made of the impact of the proposed development on any sub-surface archaeological remains, if present, and thereby inform any further investigation strategies, as appropriate.

The specific archaeological objectives of the geophysical survey were:

- to provide information about the nature and possible interpretation of any magnetic anomalies identified;
- to therefore determine the likely presence/absence and extent of any buried archaeological features; and
- to prepare a report summarising the results of the survey.

3.2 METHODOLOGY

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

Magnetometry is the most widely used geophysical survey technique in archaeology as it can quickly evaluate large areas and, under favourable conditions, identify a wide range of archaeological features including infilled cut features such as large pits, gullies and ditches, hearths, and areas of burning and kilns and brick structures. It is therefore good at locating settlements of all periods, prehistoric field systems and enclosures and areas of industrial or modern activity, amongst others. It is less successful in identifying smaller features such as post-holes and small pits (except when using a non-standard sampling interval), unenclosed (prehistoric) settlement sites and graves/burial grounds. However, magnetometry is by far the single most useful technique and was assessed as the best non-intrusive evaluation tool for this site.

The survey was undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid frame. The system was programmed to take readings at a frequency of 10Hz (allowing for a 10–15cm sample interval) on roaming traverses (swaths) 4m apart (Illus 6). These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R8s Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point.

ILLUS 4 F3 looking west **ILLUS 5** Unsuitable area in F1 looking south-west

MLGrad601 and MultiGrad601 (Geomar Software Inc.) software was used to collect and export the data. Terrasurveyor V3.0.37.0 (DWConsulting) software was used to process and present the data.

3.3 DATA PRESENTATION & TECHNICAL DETAIL

A general site location plan is shown in Illus 1 at a scale of 1:15,000. Illus 2 to Illus 5 inclusive are site condition photographs. Illus 6 shows the GPS swaths, and the location and direction of the site condition photographs at 1:7,500. The fully processed (greyscale) data and interpretative plot overviews of the whole of the PDA are presented, also at 1:7,500, in Illus 7 and Illus 8. Fully processed (greyscale) data, minimally processed data (XY trace plot) data and interpretative plots are presented, by Sector, at a scale of 1:2,500, in Illus 9 to Illus 17 inclusive. The data for the three Areas of Archaeological Potential (AAP's) are also presented at 1:1,000 in Illus 18 to Illus 32 inclusive.

Technical information on the equipment used, data processing and magnetic survey methodology is given in Appendix 1. Appendix 2 details the survey location information and Appendix 3 describes the composition and location of the site archive. Data processing details are presented in Appendix 4.

The survey methodology, report and any recommendations comply with the Written Scheme of Investigation (Headland Archaeology 2022), guidelines outlined by Europae Archaeologia Consilium (EAC 2016) and by the Chartered Institute for Archaeologists (CIfA 2014). All illustrations from Ordnance Survey (OS) mapping are reproduced with the permission of the controller of His Majesty's Stationery Office (© Crown copyright).

The illustrations in this report have been produced following analysis of the data in 'raw' (minimally processed) and processed formats and over a range of different display levels. All illustrations are presented to display and interpret the data to best effect. The interpretations are based on the experience and knowledge of Headland management and reporting staff.

4 RESULTS AND DISCUSSION

4.1 SITE CONDITIONS

Magnetometer survey is generally recommended over any sedimentary bedrock (English Heritage 2008; Table 4) although the presence of overlying superficial deposits (as is the case across the central part of the PDA) can lead to variability of results. Nevertheless, magnetometry was still assessed as the most appropriate non-intrusive geophysical technique for evaluating the PDA, taking account of the limitations noted in Section 3.2 above.

Surface conditions across the PDA were very good throughout and subsequently data quality was also good with only minimal post-processing required. No problems were encountered during the fieldwork.

The magnetic background is generally uniform across the PDA. However, there are variations in some areas, notably F1 and F3, where bands of concentrations of discrete anomalies or changes in background texture are present. These either typically align with changes in topography or the presence/absence of superficial deposits.

Against this magnetic background numerous anomalies of geological, agricultural, uncertain, and archaeological origin have been recorded (Illus 8). This confirms that the soils and geology were suitable for magnetometry and that the results likely provide a good indication of the extent of sub-surface archaeological features within the PDA notwithstanding the limitations of magnetometer survey to identify the types, sizes, and period of archaeological feature described in Section 3.2.

The anomalies are discussed below according to their interpreted origin.

4.2 FERROUS AND MODERN ANOMALIES

Ferrous anomalies, characterised as individual 'spikes', 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 is common on most sites, often being introduced into the topsoil during manuring or tipping/infilling. There is no obvious clustering to the ferrous anomalies across the PDA more generally which might indicate an archaeological origin. Far more probable is that the 'spike' responses are likely caused by the random distribution of ferrous debris in the upper soil horizons.

Areas of strong magnetic signals are recorded throughout the PDA. All these responses have modern origins, mainly caused by telecommunication poles and electricity pylons in addition to metal fencing at field edges. It should be noted that where these strong magnetic signals are present, it is possible that anomalies of archaeological origin could be obscured, should they be present.

One very high magnitude linear anomaly aligned north to south (SP1) spanning the length F1, identifies a buried service pipe. A second service pipe is present within F3 (SP2).

Three areas of magnetically enhanced responses (FP1 to FP3 - Illus 8, 11, 14 and 17) have been identified. These anomalies correlate with ponds recorded on the first edition 1884 OS map. The variable magnetic response from these anomalies is indicative of the mixed nature of the material used to infill these ponds.

Bands or small areas of magnetic disturbance are also recorded along or adjacent to some of the current and former field boundaries and entrances. This disturbance is typically due to the accumulation of ferrous debris around field margins, or to barbed wire or mesh in the boundary itself and to the tipping of material in gateways to improve access to/from fields.

4.3 AGRICULTURAL ANOMALIES

Throughout the PDA anomalies of agricultural origin have been identified. These include evidence of modern agricultural practices, including modern ploughing and field drains, in addition to evidence of historical agriculture such as former field boundaries and ridge and furrow cultivation.

As discussed in the archaeological background the surrounding landscape contains vestiges of medieval or post-medieval ridge and furrow cultivation either as slight earthworks or as sub-surface remains. Across most of the PDA, the survey has identified broad, distinctive elongated slightly 'S'-shaped trend anomalies in varying orientations, consistent with ridge and furrow cultivation. Other linear anomalies and trends in the data reflect the direction of more recent cultivation.

Linear anomalies (FB1 to FB7 - Illus 8, 11, 14 and 17), recorded throughout the PDA, locate former field boundaries. First edition 1884 OS maps and aerial photography from 1945 (Google Earth Pro) shows these boundaries to be present and to have been removed sometime in the latter half of the 20th century.

Elsewhere, consistently spaced linear trend anomalies, primarily identified in F2, locate field drains. Other drains are identified in F1 and F2 some of which connect to (now infilled) ponds.

4.4 ANOMALIES OF NATURAL/ GEOLOGICAL ORIGIN

As mentioned in Section 4.1 the magnetic background is generally uniform across most of the PDA. However, there are some areas with anomalies interpreted as of natural/geological origin. Three main areas of geological anomalies are present. These are on the western boundary of F1, a band running across the eastern half of F1 and another in F3. The geological anomalies in the west of F1 align with a change in the superficial geology, where it changes from diamicton to none being recorded or reflect alluvium from the stream to the west. The other areas where concentrations of geological anomalies are present typically align with changes in local topography, specifically slight depressions. These anomalies could therefore relate to accumulations of more magnetically enhanced material transported by colluvial processes.

4.5 ANOMALIES OF UNCERTAIN ORIGIN

Within the centre of F1 a broadly rectangular zone containing a cluster of discrete anomalies has been identified (U1 Illus 8, 11, 14 and 17). These anomalies appear to respect the alignment of former field boundaries within F1 many of which intersect with it. A trackway of probable archaeological origin also runs towards this feature (U1), but it is unlikely the two are related. These anomalies could relate to a former farm building not recorded on historical mapping, but are interpreted as of uncertain origin on the basis that they cannot be confidently ascribed a modern, agricultural, or archaeological origin.

Within F3 a single, discontinuous, linear anomaly (U2 - Illus 17) has been identified. This anomalybroadly respects the pattern of current and former field boundaries within the landscape but is not recorded on any mapping. As such, while it is considered likely to be agricultural in origin, an archaeological origin cannot be discounted.

4.6 ANOMALIES OF PROBABLE OR POSSIBLE ARCHAEOLOGICAL ORIGIN

Evidence of archaeological activity is present throughout most of the PDA, with foci in the east of F1 (4.5ha), the north of F3 (6.5ha) and a band running south-west to north-east across F3 (7ha). Two of these foci of activity (AAA1 and AAA2) broadly align with the location of cropmarks recorded on the NHER, although the anomalies identified are considerably more extensive than the cropmarks visible on the airl photographs. Northamptonshire HER states that these features are likely late prehistoric to Roman in origin. The morphology and fact that the ridge and furrow appear to cut across the anomalies backs up this suggestion. To aid description these clusters of anomalies have been grouped into main areas of archaeological activity (AAA1, AAA2, AAA3 east, centre and west). Unless stated otherwise these anomalies are caused by soil filled (mostly) linear and curvilinear features, usually ditches forming enclosures or fields or defining areas of settlement, or discrete features such as pits.

AAA1 (Illus 18–20)

Within F1 numerous enclosures are present appending and possibly accessed by a central, double ditched trackway (T1 - Illus 18–20). The trackway is visible as a cropmark and extends to the north and south of the PDA along a prominent ridge within the wider landscape. A second trackway (T2 - Illus 8 and Illus 18–20) branches off from this, heading north-west towards anomaly U1, becoming weaker in magnetic signal as distance increases from the main foci of settlement. To the north, running parallel to this, a single linear anomaly (D?1 - Illus 18–20) approximately 250m in length has been interpreted as possible archaeology. Despite its positional relationship with T2 and the other nearby archaeology, it is too weak and discontinuous to allow for a definitive interpretation.

The appending enclosures appear to take two distinct forms, those to the south and west (E1 - Illus 18–20) typically being rectilinear in shape and those to the east more curvilinear (E2 - Illus 18–20). It is not clear whether these two varying morphologies are suggestive of differing periods or phases of activity or of differing activity. Within the enclosures are several sub-enclosures, and discrete anomalies suggestive of settlement activity. In addition, circular or penannular anomalies are also present (RD?1, RD2 and RD3 - Illus 18–20) which have been interpreted as ring ditches. These are indicative of Iron Age/Romano British activity.

AAA2 (Illus 21–23)

Within the north of F3 is a large complex of linear, curvilinear and discrete anomalies of probable and possible archaeological origin. These take the form of numerous enclosures and sub-enclosures typical of settlement activity. Most of these enclosures are constrained to the north of a double ditched trackway running north-east to south-west, possibly linking this complex to that within F1.

Much like the enclosures within F1 (AAA1 - Illus 18–20), the enclosures within this area have two distinct morphologies, the majority being rectilinear in form (E3 - Illus 18–20), with others on a differing alignment more curvilinear (E4 - Illus 18–20). This change in morphology and the fact that the two appear to cut each other is suggestive of multiple periods or phases of activity. The findings of the geophysical survey in this area supports the archaeological background which states that cropmarks are present in this area highlighting a possible Iron Age or Romano British settlement and findspots of pottery of this date in this area too. All these anomalies are clearly visible despite the effect of likely much later ridge and furrow cultivation cutting across these areas.

AAA3 east (Illus 24–26), centre (Illus 27–29) and west (Illus 30–32)

Running from the north-east corner of F3 to the south-west is a single curvilinear anomaly (D2 - Illus 24–32) suggestive of a boundary ditch. This anomaly appears to follow a slight hollow in the topography of the landscape, where the land slopes down from its highpoint in the west and begins to rise again further east. Appending this ditch are several enclosures and further ditches. Along the north-eastern and central part of this linear anomaly are at least 9 enclosures, which are typically round or sub-circular in form (E5 - Illus 30–32) and suggestive of Iron Age activity. To the south are larger, rectilinear enclosures (E5 - Illus 30–32) possibly relating to land division or stock enclosures which also respect anomaly D2. Many of these enclosures contain further discrete and linear anomalies highlighting potential activity within them. Away from these enclosures the ditch (D2) has a much weaker magnetic signal, likely a result of less magnetic material being in the topsoil away from areas of habitation.

In the far south of F3 is a D-shaped enclosure (E6 - Illus 30–32) distinct in both magnetic signal and morphology from the rectilinear enclosures also present in this area.

4.7 FURTHER AREAS OF PROBABLE AND POSSIBLE ARCHAEOLOGY

Outside the three obvious areas of archaeological activity (AAA1 to AAA3) other anomalies of archaeological potential have been recorded in several other locations.

These anomalies form no obvious distinct pattern or definite cluster but are interpreted as being of definite archaeological potential. They are typically weaker and less well defined than those within the areas of archaeological activity and are interpreted as likely further enclosures. These anomalies are of lower magnitude probably due to local changes in geology/pedology or because they are further away from the main focus of settlement activity. Therefore there is likely to be less magnetically enhanced material within the topsoil used to infill these features resulting in a reduced magnetic contrast and anomalies of a weaker magnitude.

Throughout the PDA linear and curvilinear anomalies of possible archaeological origin have been identified. The majority are suggestive of infilled ditches but have been categorised with less certainty because they are either more discontinuous than those of probable archaeological origin or lack any pattern or morphology that would allow for a more definitive interpretation. As such, while an archaeological origin is considered possible, they could also be caused by post-medieval boundary ditches or other more modern activity. Numerous discrete anomalies of possible archaeological origin are also present near to the probable archaeology throughout the PDA. These anomalies are suggestive of infilled pits but without any further supporting evidence could also be related to natural variations in the superficial geology.

Five isolated, very high magnitude anomalies (B?1–B?5), located within or adjacent to enclosures E2 (Illus 18–20), E4 (Illus 18–20), at the junction of E5 and 8 (Illus 30–32) and within E6 (Illus 18–20), have magnetic signatures indicative of localised burning. There is little context for these discrete anomalies to offer a more confident interpretation and their cause remains uncertain. However, an archaeological origin, related to hearths, kilns, or other causes of burning is considered possible.

5 CONCLUSION

The survey has recorded anomalies indicative of significant, dense, and extensive archaeological activity following and appending at least three trackways which cross the PDA, covering approximately 18ha. There are three main foci of archaeological activity: close to the eastern edge of F1 and throughout the majority of F3. At all locations anomalies indicative of multiple, clustered enclosures of varying size and shape are recorded linked by trackways and with numerous discrete anomalies, likely to be caused by activity associated with settlement, also numerous. Archaeological activity (cropmarks interpreted as enclosures, trackways, and other features) is recorded on the NHER at both locations although the survey has provided significantly greater detail on the complexity and extent of the archaeological remains. Although it is not possible to provide an accurate date for the archaeological activity identified, the pattern and morphology of the anomalies, in addition to records within the NHER, suggest an Iron Age to Romano-British origin is likely.

Anomalies due to both historical and recent agricultural activity (ridge and furrow, modern ploughing, drains and former boundaries), geological variation and modern activity are also identified. Several anomalies of uncertain origin have also been identified. These are likely modern or agricultural in origin, but in light of the extensive archaeological activity within the PDA, an archaeological origin cannot be discounted.

Overall, the extent of the three major areas of archaeological activity appears to be restricted to F3 and the eastern extent of F1. Where there are no superficial deposits, there are either no recorded anomalies or they are very low magnitude and difficult to discern. This raises the possibility that the archaeological resource may be more extensive than the survey has revealed in those areas where the prevailing pedalogical and geological conditions are not as favourable for detection.

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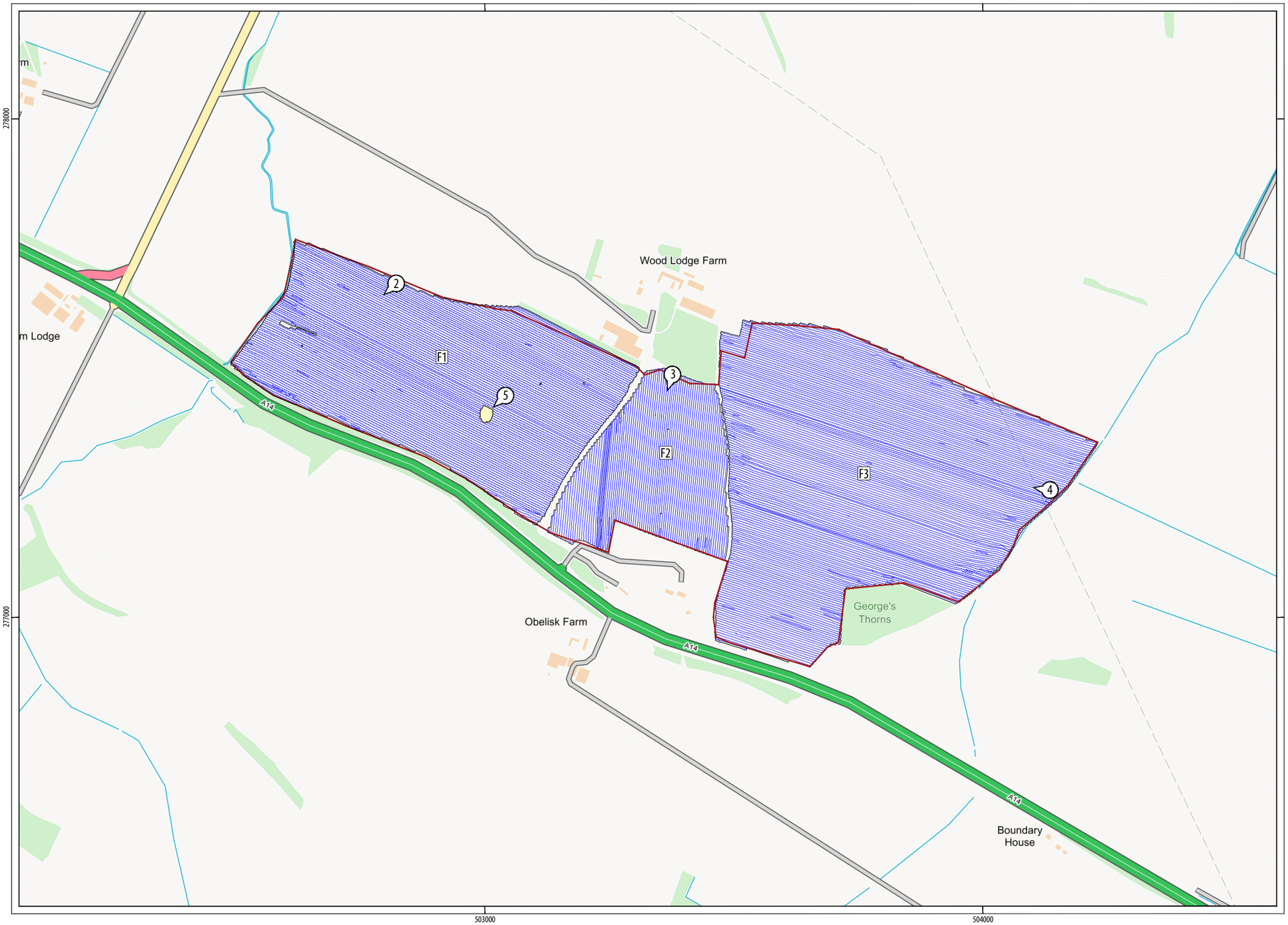

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Wood Lodge Solar Farm
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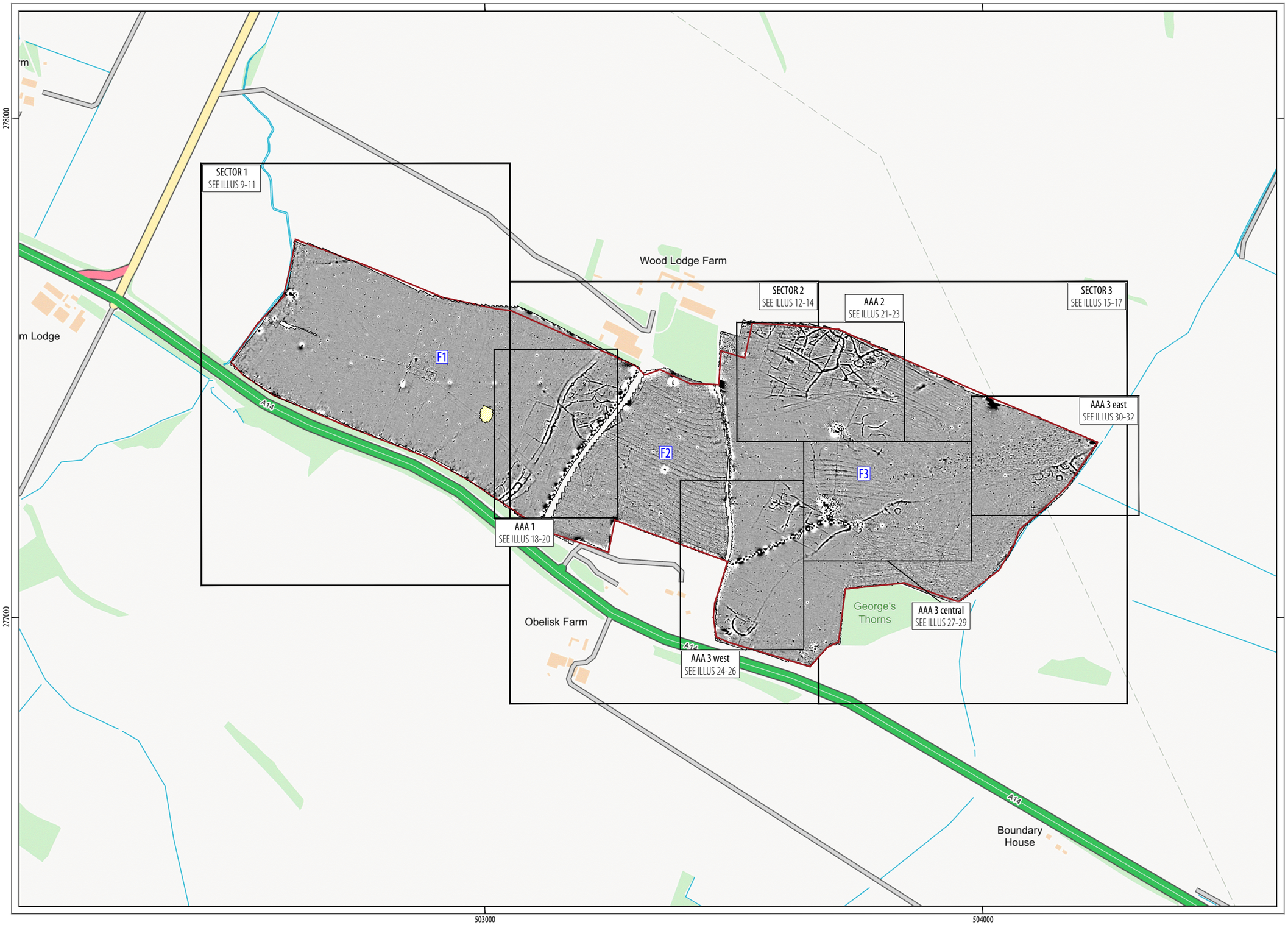
ILLUS 6 Geophysical survey location showing GPS swaths and photograph locations



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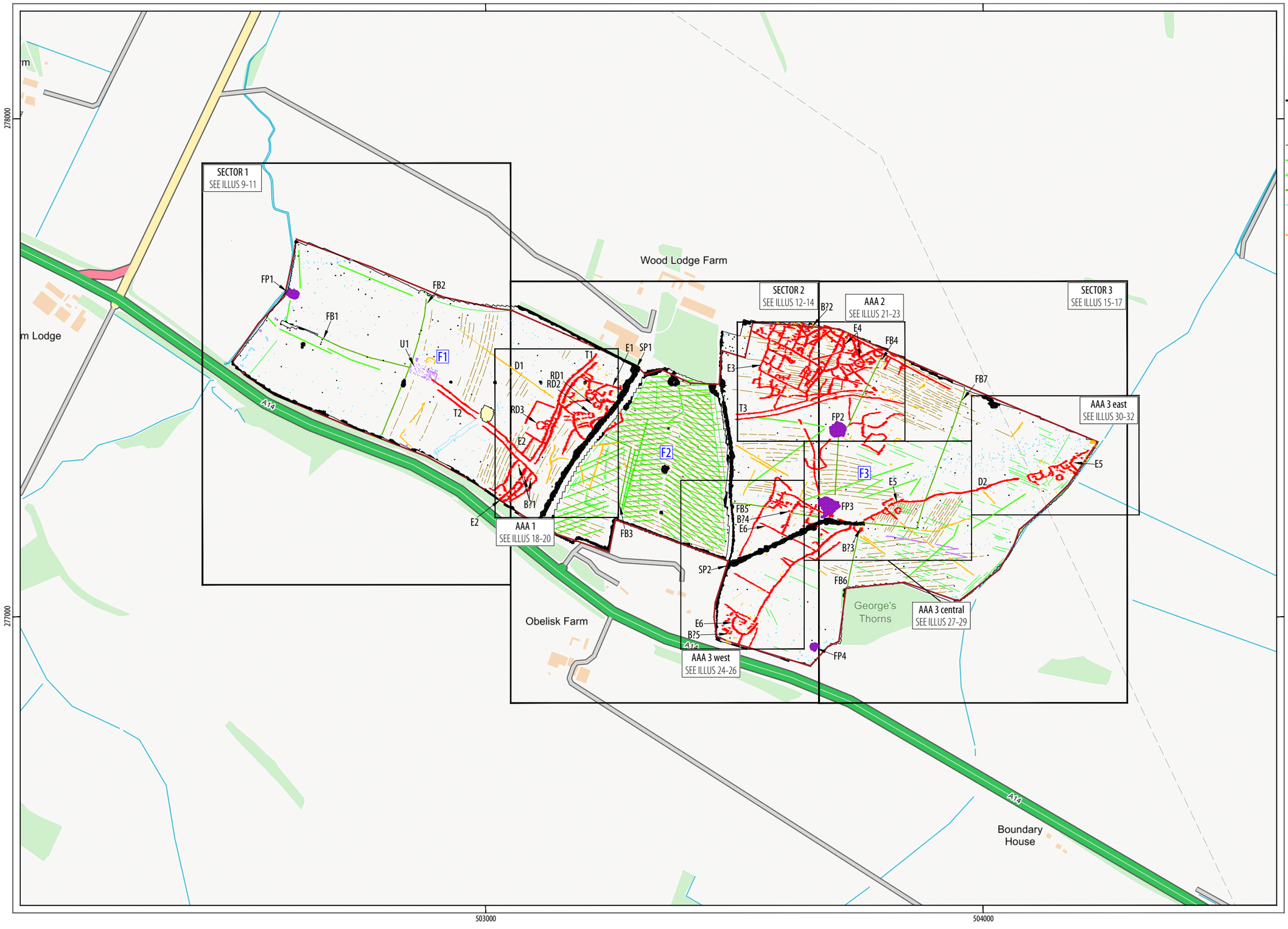
ILLUS 7 Overall greyscale plot of processed magnetometer data



proposed development area

area unsuitable for survey

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
magnetic disturbance	former pond
magnetic enhancement	uncertain
linear trend	ridge and furrow
linear trend	agricultural
linear trend	field drain
linear	former field boundary
linear trend	geological variation
magnetic enhancement	geology
linear trend	archaeology?
magnetic enhancement	archaeology?
magnetic enhancement	burning?
magnetic enhancement	archaeology

ABBREVIATIONS

E - enclosure
RD - ring ditch
T - trackway
B? - burning?
D - ditch
U - uncertain
FP - former pond
FB - former boundary
SP - service pipe

0 200m
1:7,500 @ A3

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ILLUS 8 Overall interpretation of magnetometer data

-1.0 nT 2.0

0 50m
1:2,500 @ A3

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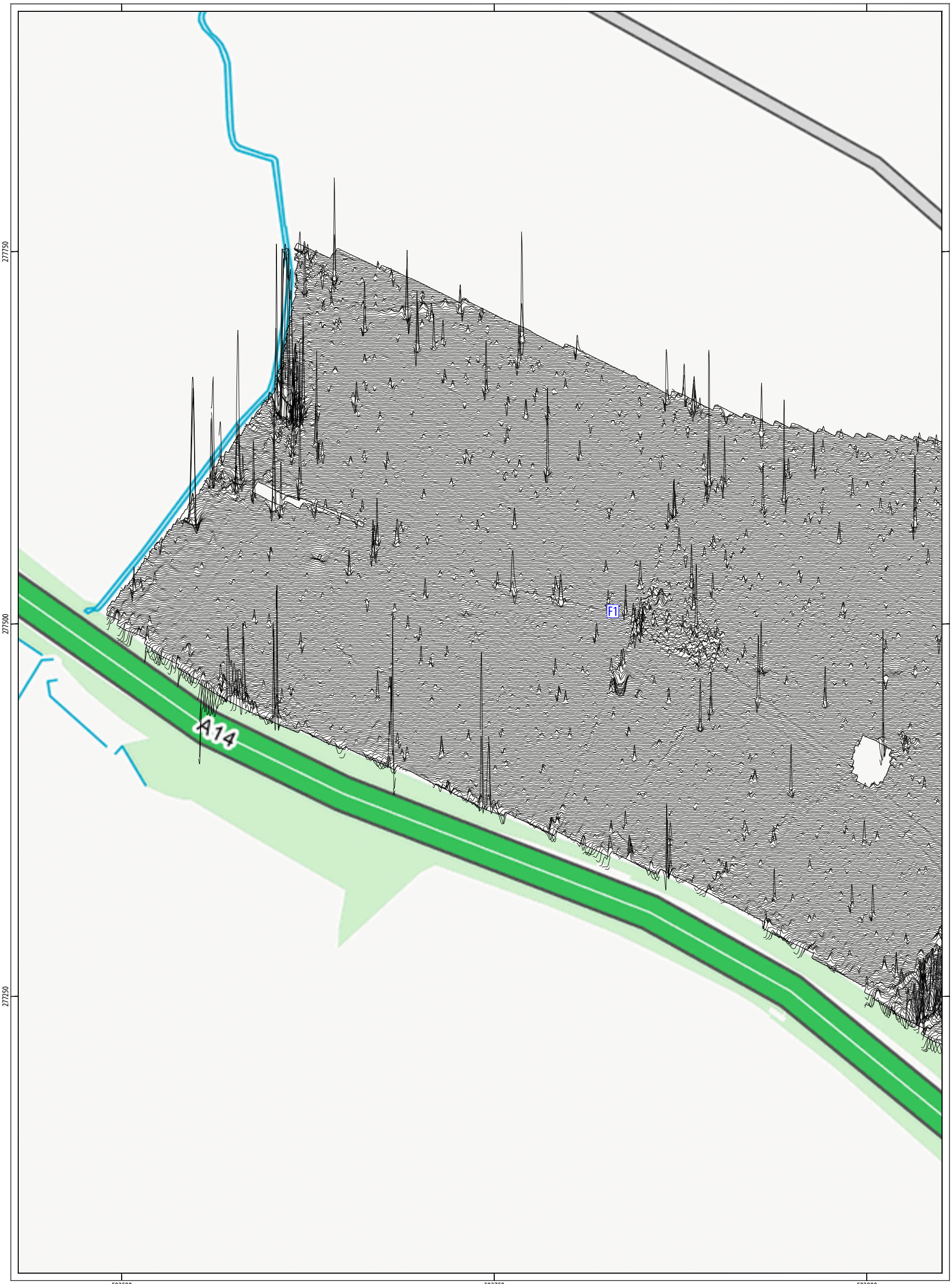
ILLUS 9 Processed greyscale magnetometer data; Sector 1



25.0nT/cm

0 50m

1:2,500 @ A3

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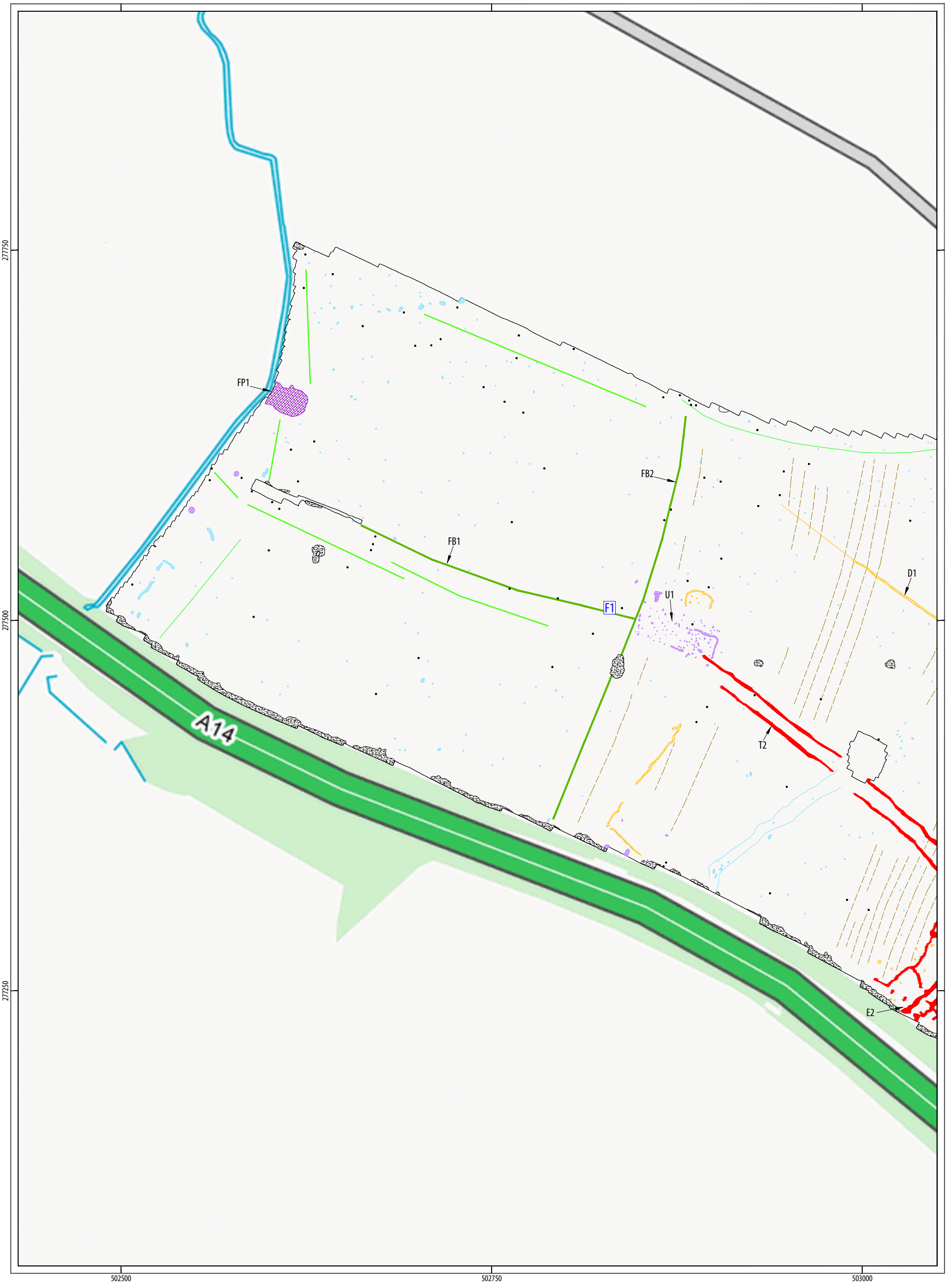
ILLUS 10 XY trace plot of minimally processed magnetometer data; Sector 1



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
magnetic disturbance	former pond
magnetic enhancement	uncertain
linear trend	ridge and furrow
linear trend	agricultural

TYPE OF ANOMALY	INTERPRETATION
linear trend	field drain
linear	former field boundary
linear trend	geological variation
magnetic enhancement	geology
linear trend	archaeology?
magnetic enhancement	archaeology?

TYPE OF ANOMALY	INTERPRETATION
magnetic enhancement	archaeology

ABBREVIATION

E - enclosure

T - trackway

U - uncertain

FP - former pond

FB - former boundary

0 50m

1:2,500 @ A3

ILLUS 11 Interpretation of magnetometer data; Sector 1

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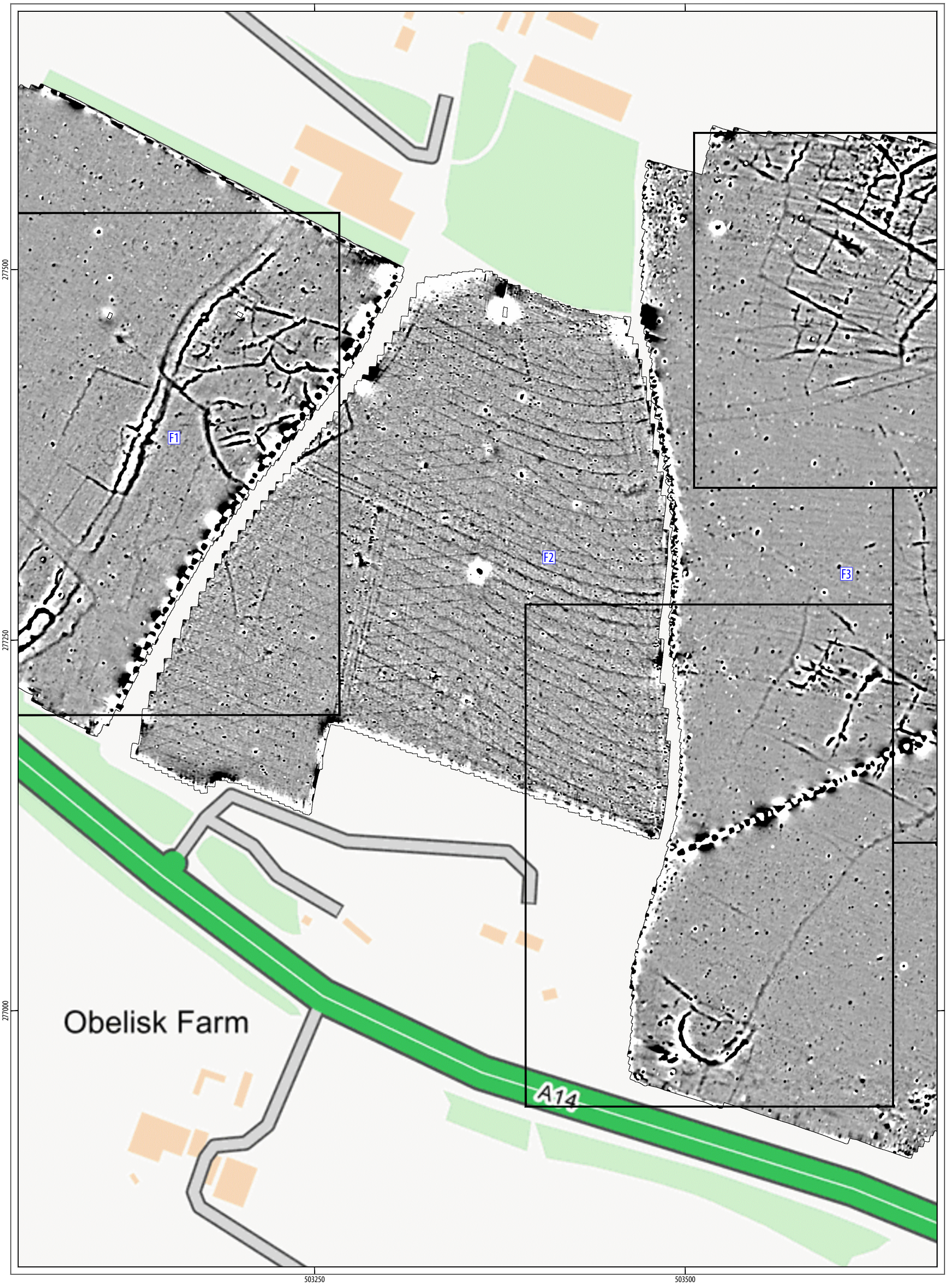

-1.0 nT 2.0

0 50m
1:2,500 @ A3

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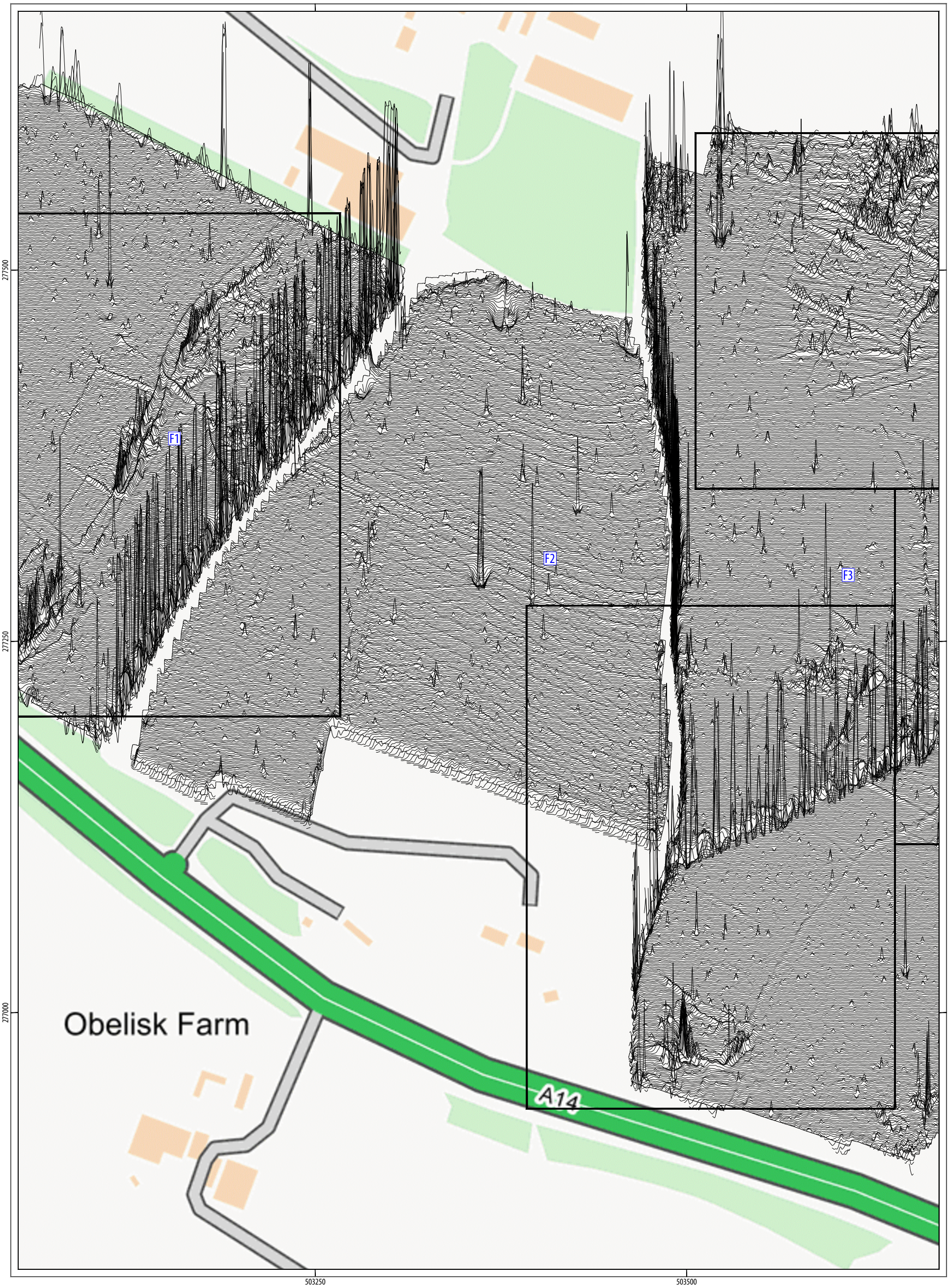
ILLUS 12 Processed greyscale magnetometer data; Sector 2



25.0nT/cm

0 50m

1:2,500 @ A3

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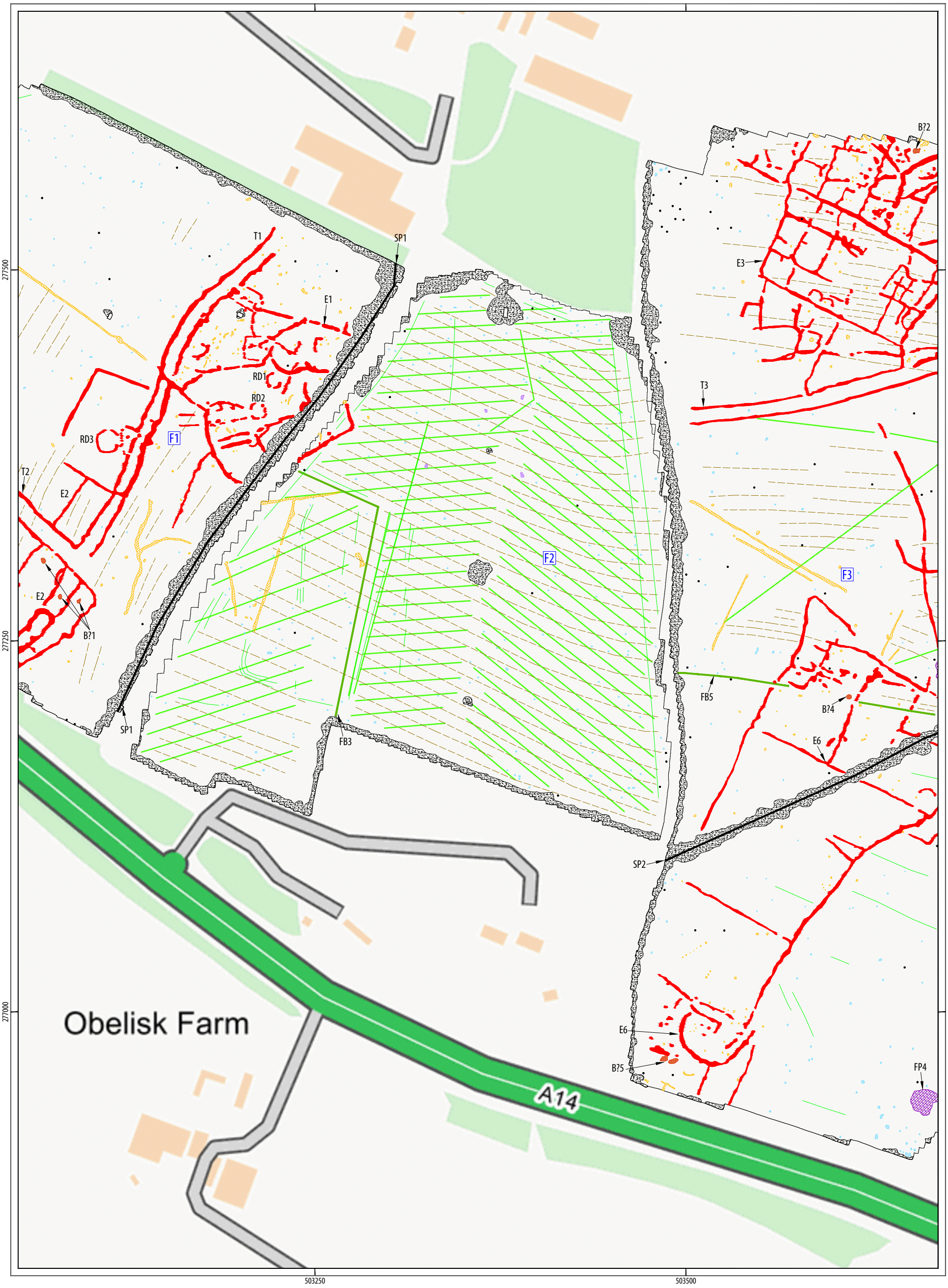
ILLUS 13 XY trace plot of minimally processed magnetometer data; Sector 2



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
magnetic disturbance	former pond
magnetic enhancement	uncertain
linear trend	ridge and furrow

TYPE OF ANOMALY	INTERPRETATION
linear trend	agricultural
linear trend	field drain
linear	former field boundary
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	burning?

TYPE OF ANOMALY	INTERPRETATION
magnetic enhancement	archaeology

ABBREVIATION

E - enclosure
RD - ring ditch
T - trackway
B? - burning?
D - ditch
FP - former pond
FB - former boundary
SP - service pipe

0 50m
1:2,500 @ A3

ILLUS 14 Interpretation of magnetometer data; Sector 2

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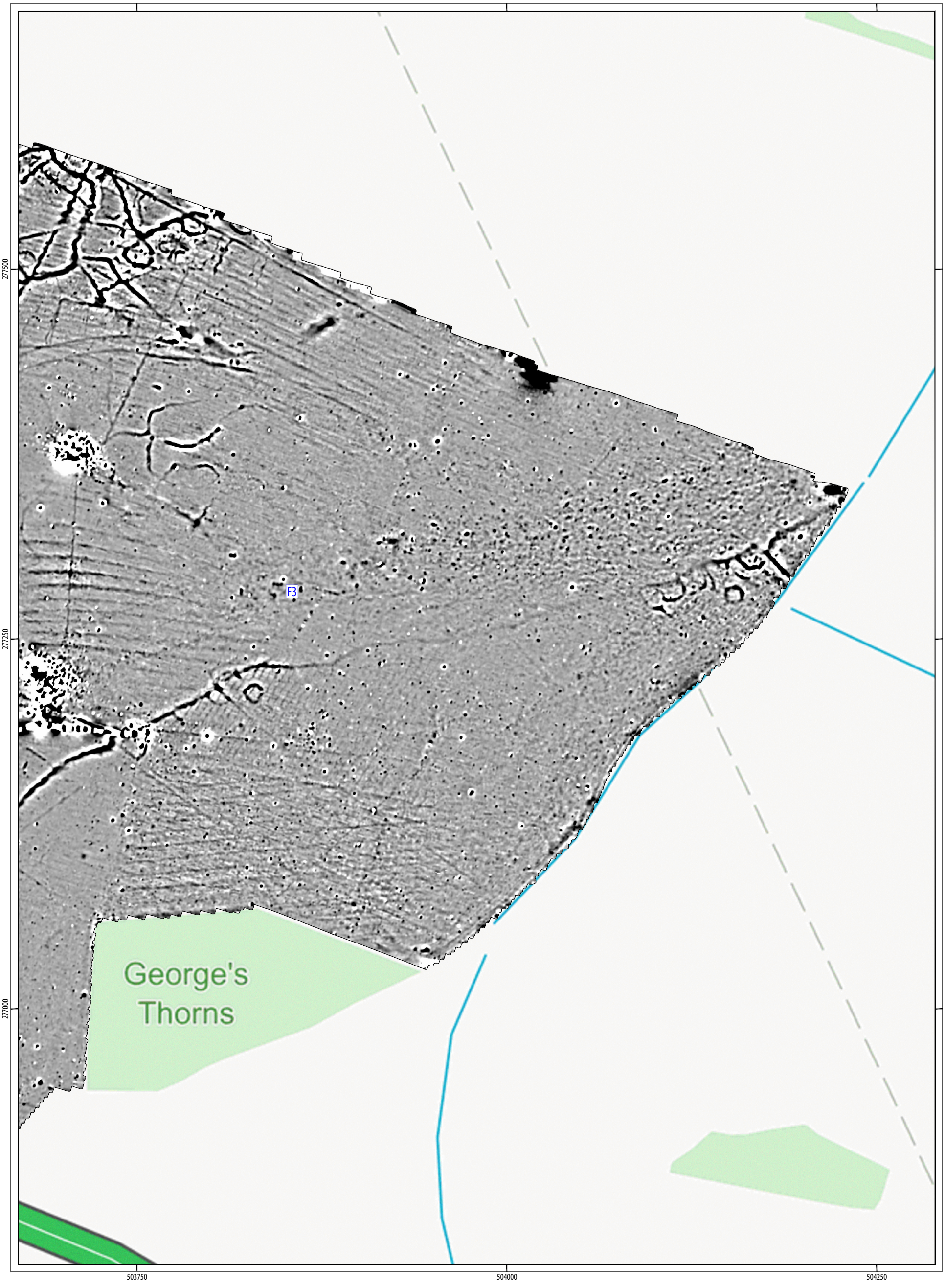

-1.0 nT 2.0

0 50m

1:2,500 @ A3

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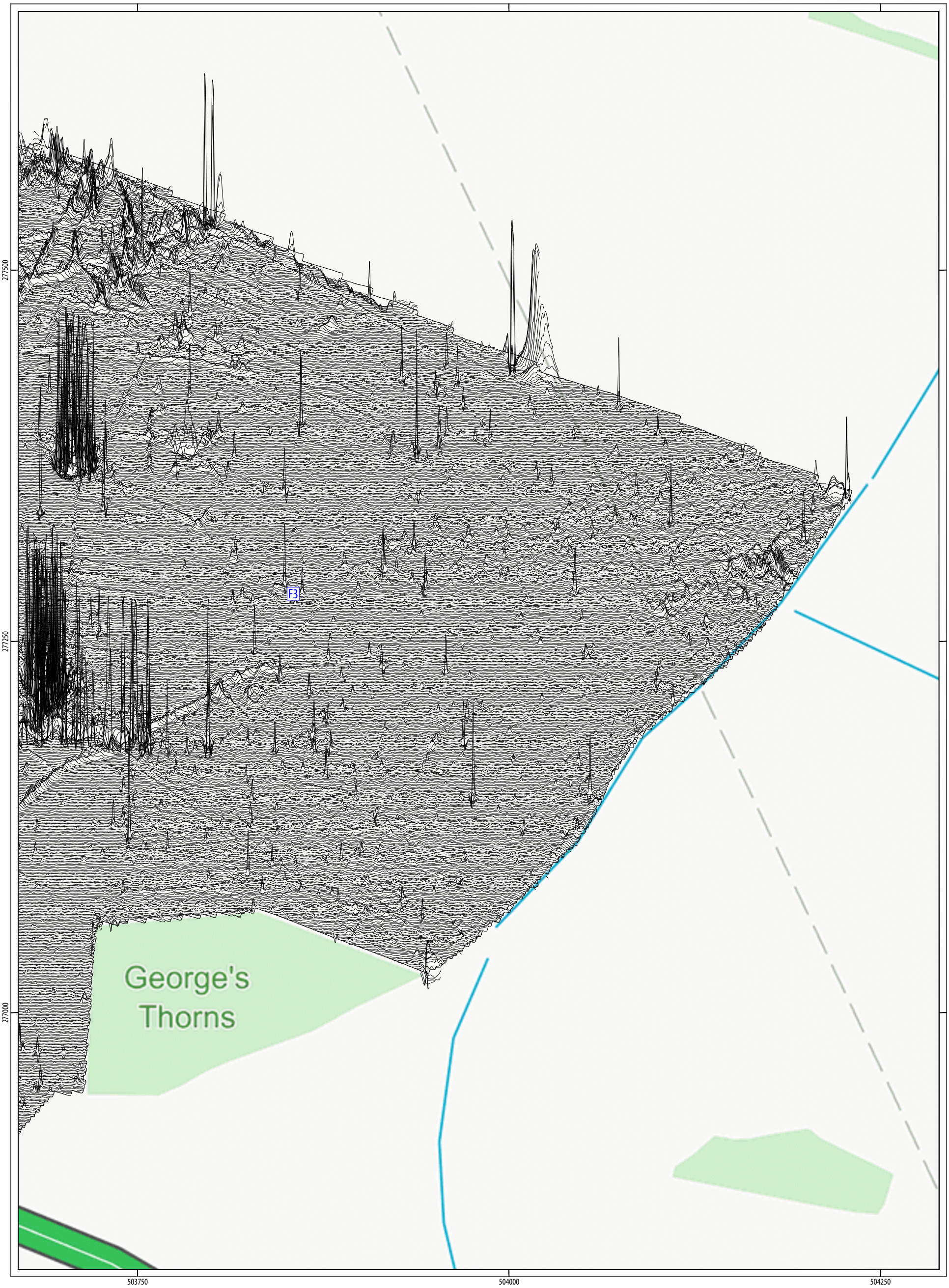
ILLUS 15 Processed greyscale magnetometer data; Sector 3



25.0nT/cm

0 50m

1:2,500 @ A3

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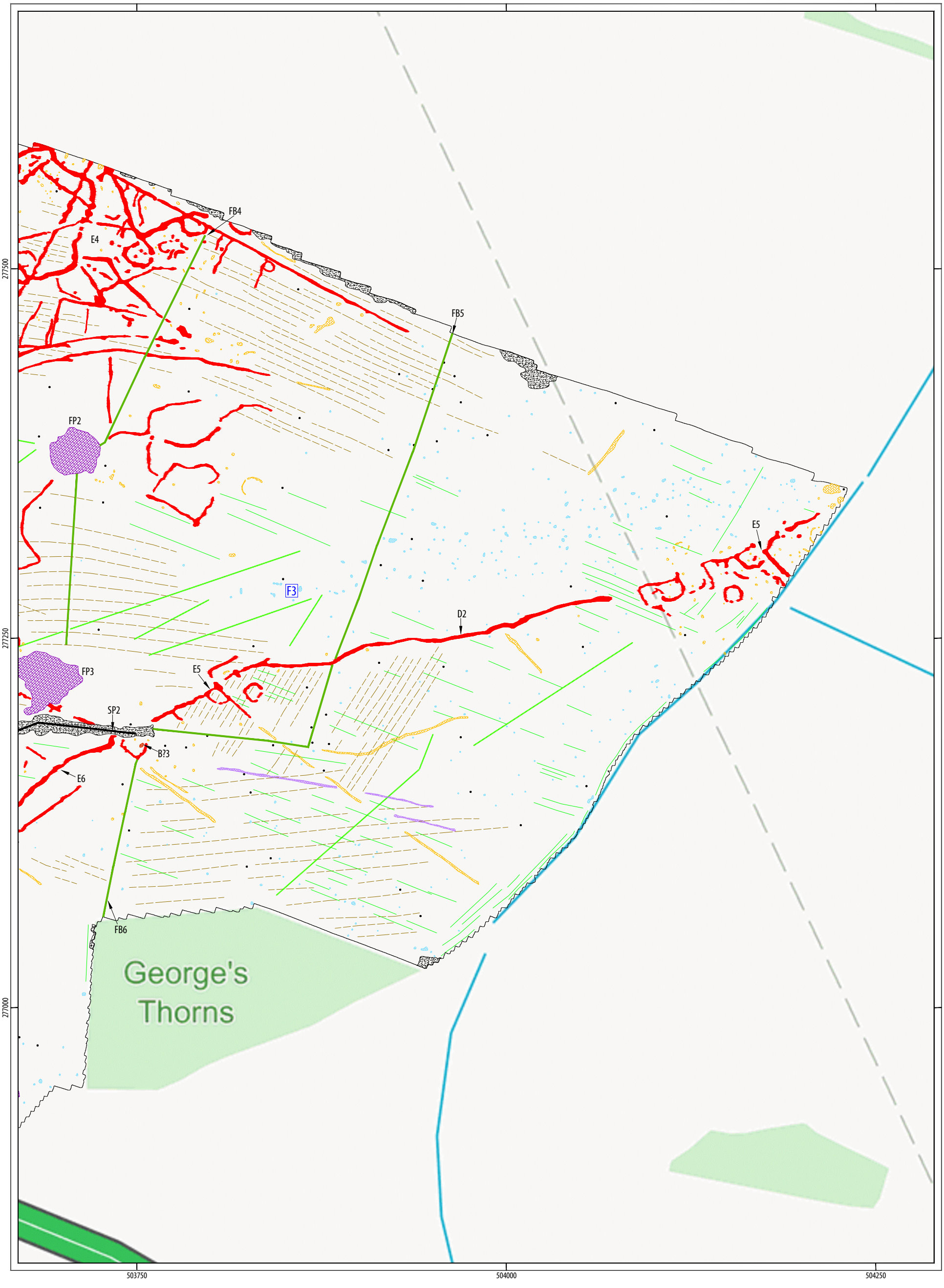
ILLUS 16 XY trace plot of minimally processed magnetometer data; Sector 3



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
magnetic disturbance	former pond
magnetic enhancement	uncertain
linear trend	ridge and furrow

TYPE OF ANOMALY	INTERPRETATION
linear trend	agricultural
linear trend	field drain
linear	former field boundary
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	kiln/burning

TYPE OF ANOMALY	INTERPRETATION
magnetic enhancement	archaeology

ABBREVIATION

E - enclosure
T - trackway
B? - burning?
D - ditch
FP - former pond
FB - former boundary
SP - service pipe

0 50m
1:2,500 @ A3

ILLUS 17 Interpretation of magnetometer data; Sector 3

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277500

277400

277300

503100

503200

-1.0 nT 2.0

0 25m

1:1,000 @ A3

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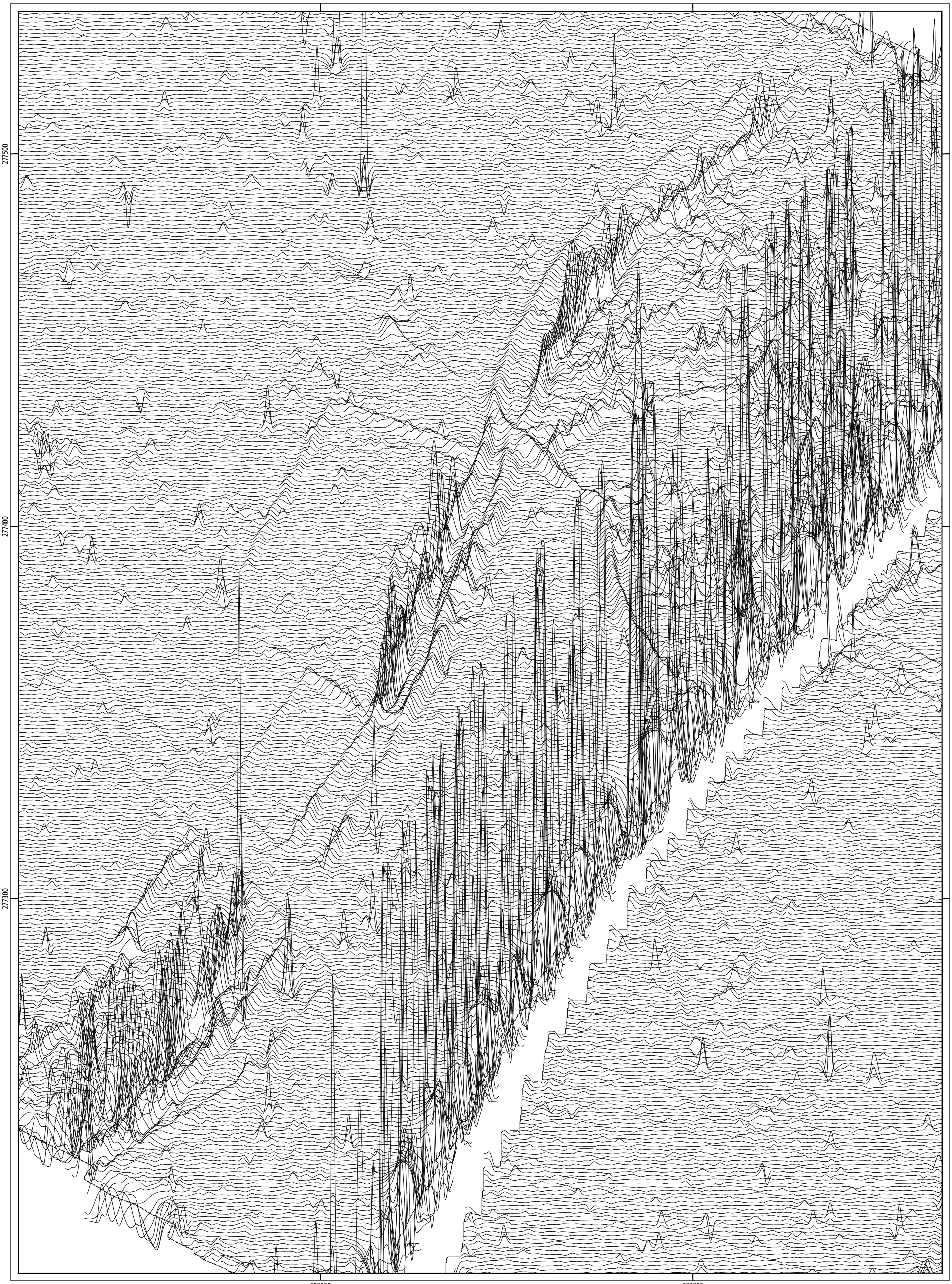
ILLUS 18 Processed greyscale magnetometer data; AAA 1



25.0nT/cm

0 25m

1:1,000 @ A3

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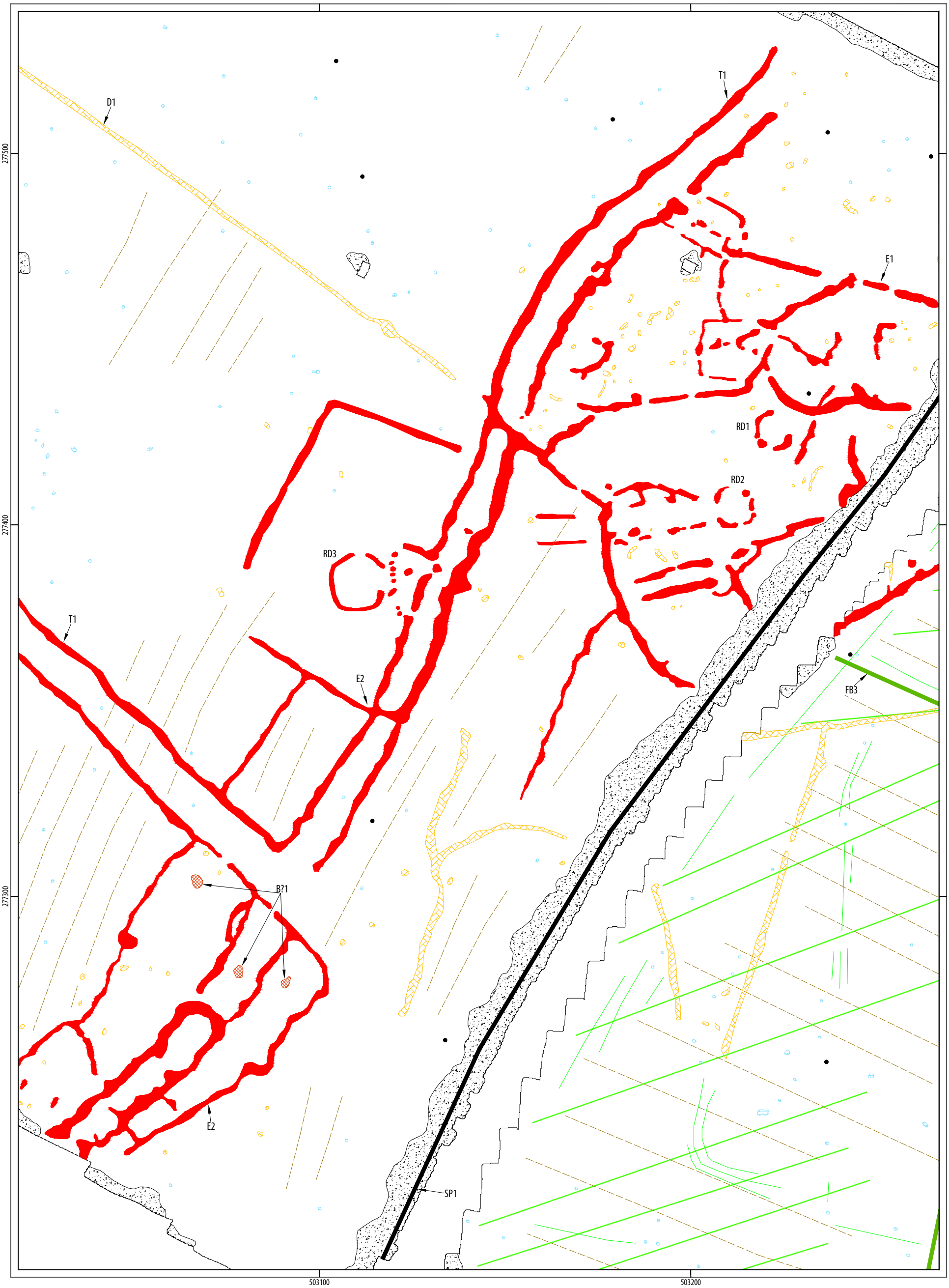
ILLUS 19 XY trace plot of minimally processed magnetometer data; AAA 1



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear trend	ridge and furrow
linear trend	agricultural
linear trend	field drain

TYPE OF ANOMALY	INTERPRETATION
linear	former field boundary
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	burning?
magnetic enhancement	archaeology

ABBREVIATION

E - enclosure
RD - ring ditch
T - trackway
B? - burning?
D - ditch
FB - former boundary
SP - service pipe

0 25m
1:1,000 @ A3

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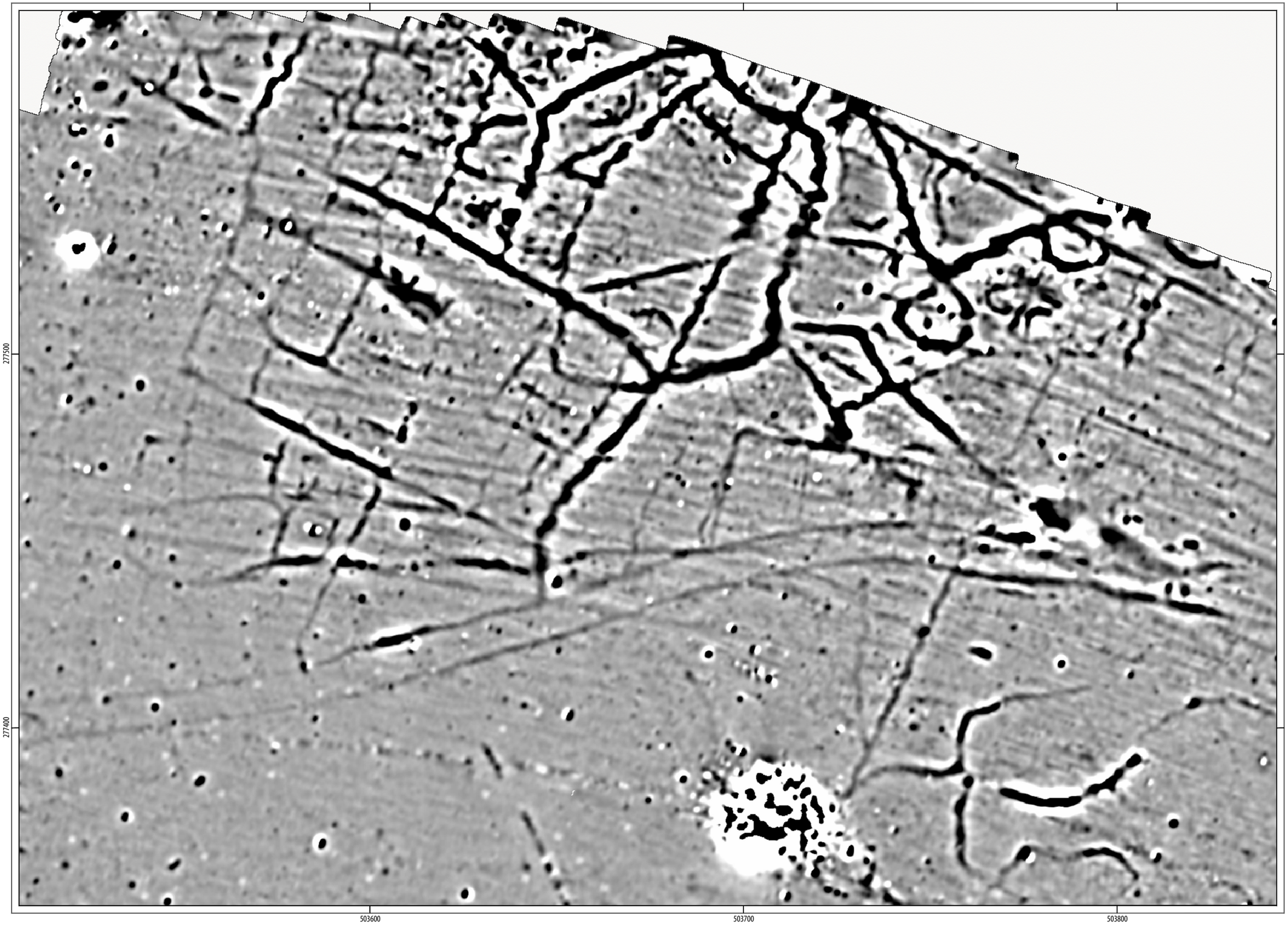
ILLUS 20 Interpretation of magnetometer data; AAA 1



nT
-1.0 2.0

0 25m
1:1,000 @ A3

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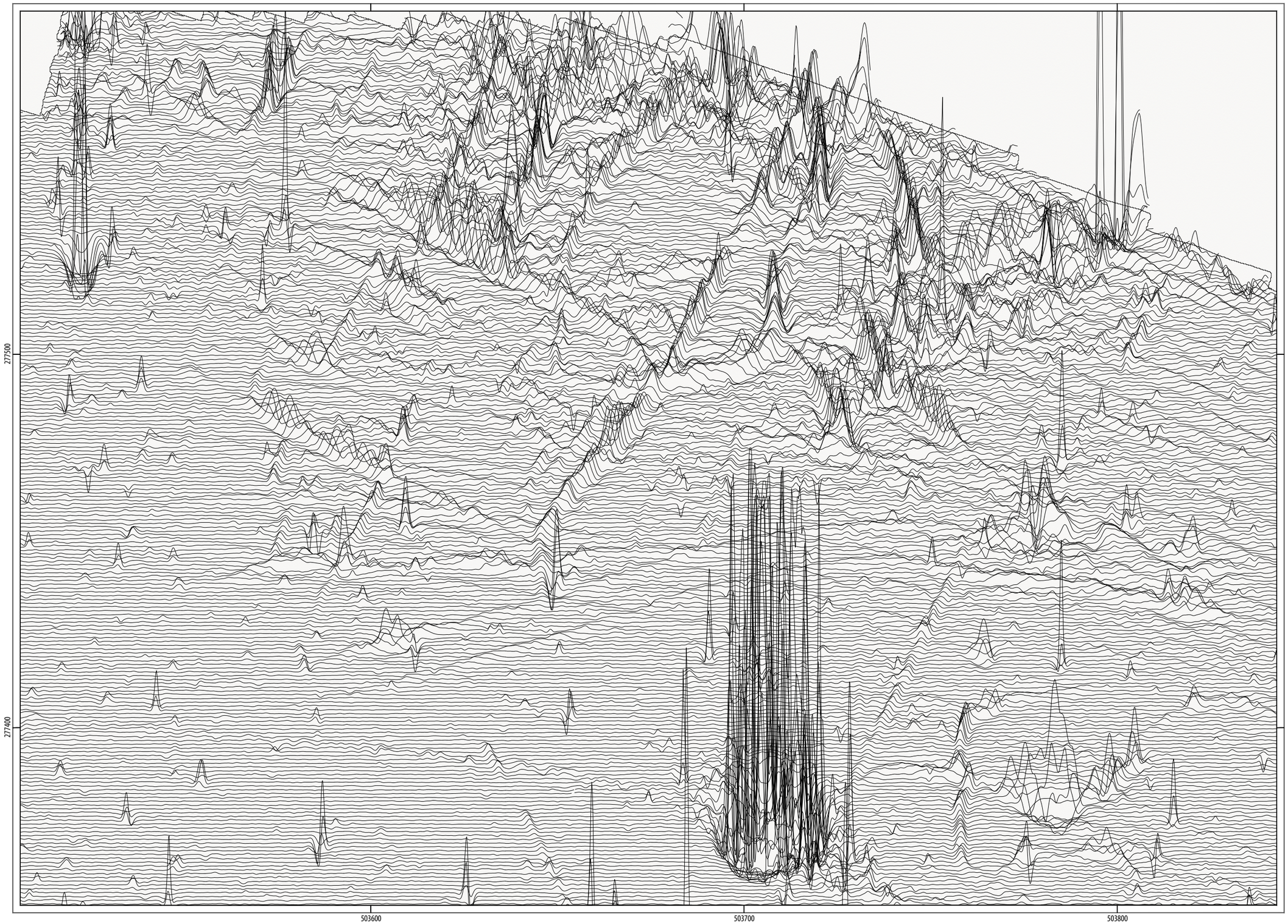
ILLUS 21 Processed greyscale magnetometer data; AAA 2



25.0nT/cm

0 25m

1:1,000 @ A3

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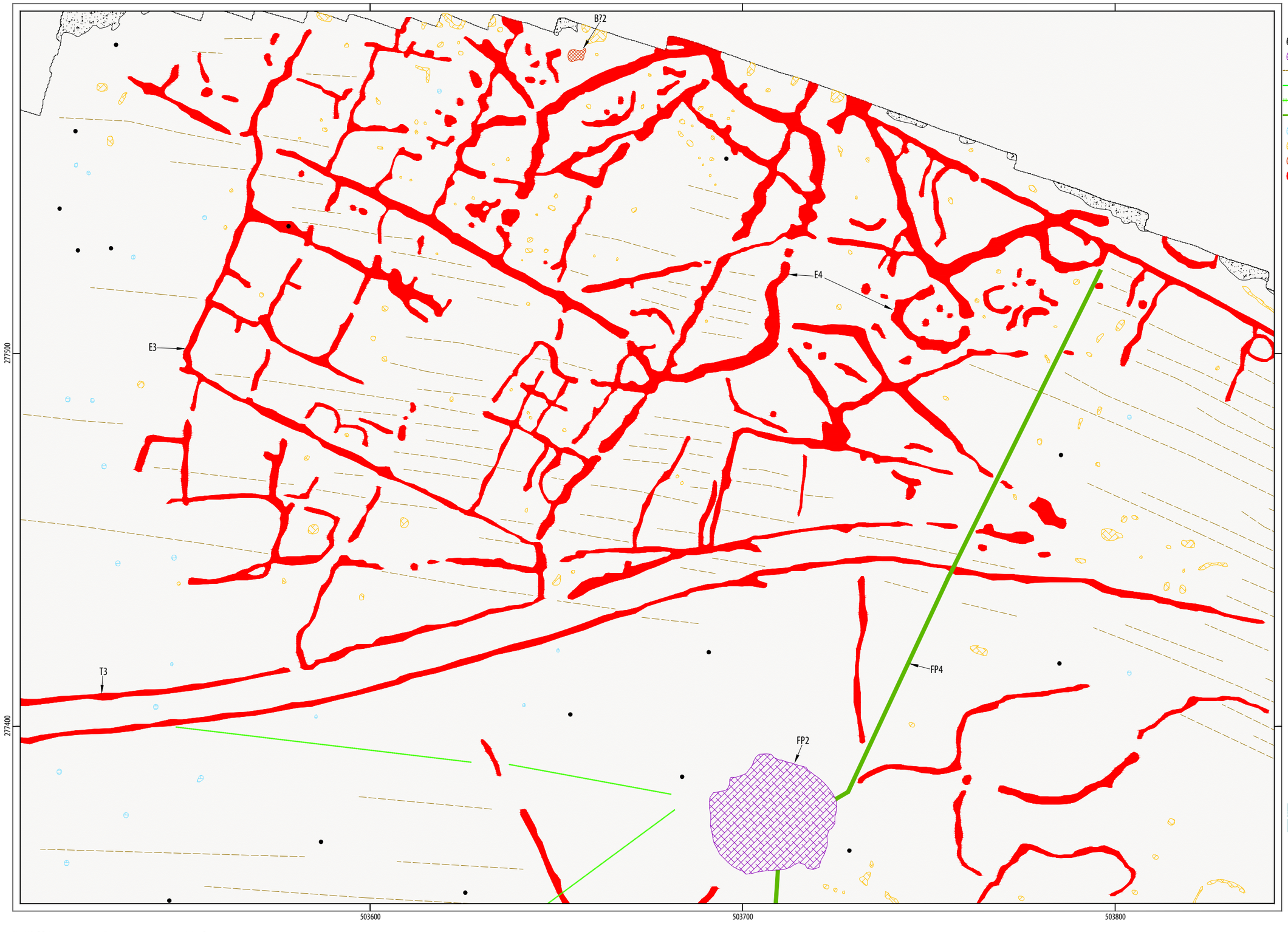
ILLUS 22 XY trace plot of minimally processed magnetometer data; AAA 2



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
magnetic disturbance	former building
linear trend	ridge and furrow
linear trend	agricultural
linear trend	field drain
linear	former field boundary
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	burning?
magnetic enhancement	archaeology

ABBREVIATIONS

E - enclosure
T - trackway
B? - burning?
FP - former pond
FB - former boundary

0 25m
1:1,000 @ A3

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ILLUS 23 Interpretation of magnetometer data; AAA 2

277200
277100
277000
503400
503500
503600
A14
nT
-1.0
2.0
0
25m
1:1,000 @ A3
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ILLUS 24 Processed greyscale magnetometer data; AAA 3 west

277200
277100
277000
503400
503500
503600
A14
25.0nT/cm
0
25m
1:1,000 @ A3
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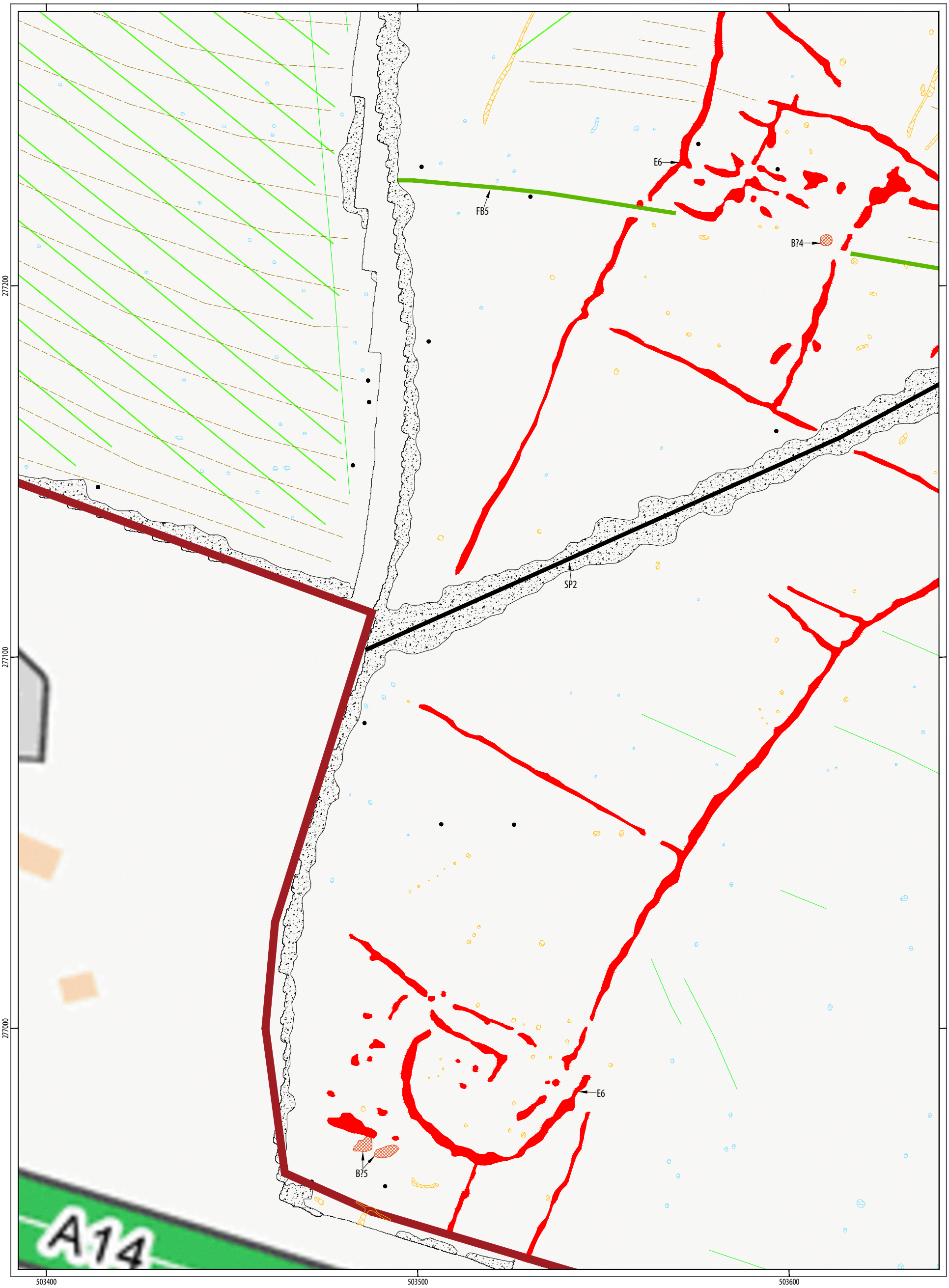
ILLUS 25 XY trace plot of minimally processed magnetometer data; AAA 3 west



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
magnetic disturbance	former building
linear trend	ridge and furrow
linear trend	agricultural

TYPE OF ANOMALY	INTERPRETATION
linear trend	field drain
linear	former field boundary
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	burning?
magnetic enhancement	archaeology

ABBREVIATION
E - enclosure
T - trackway
B? - burning?
FB - former boundary
SP - service pipe

0 25m
1:1,000 @ A3

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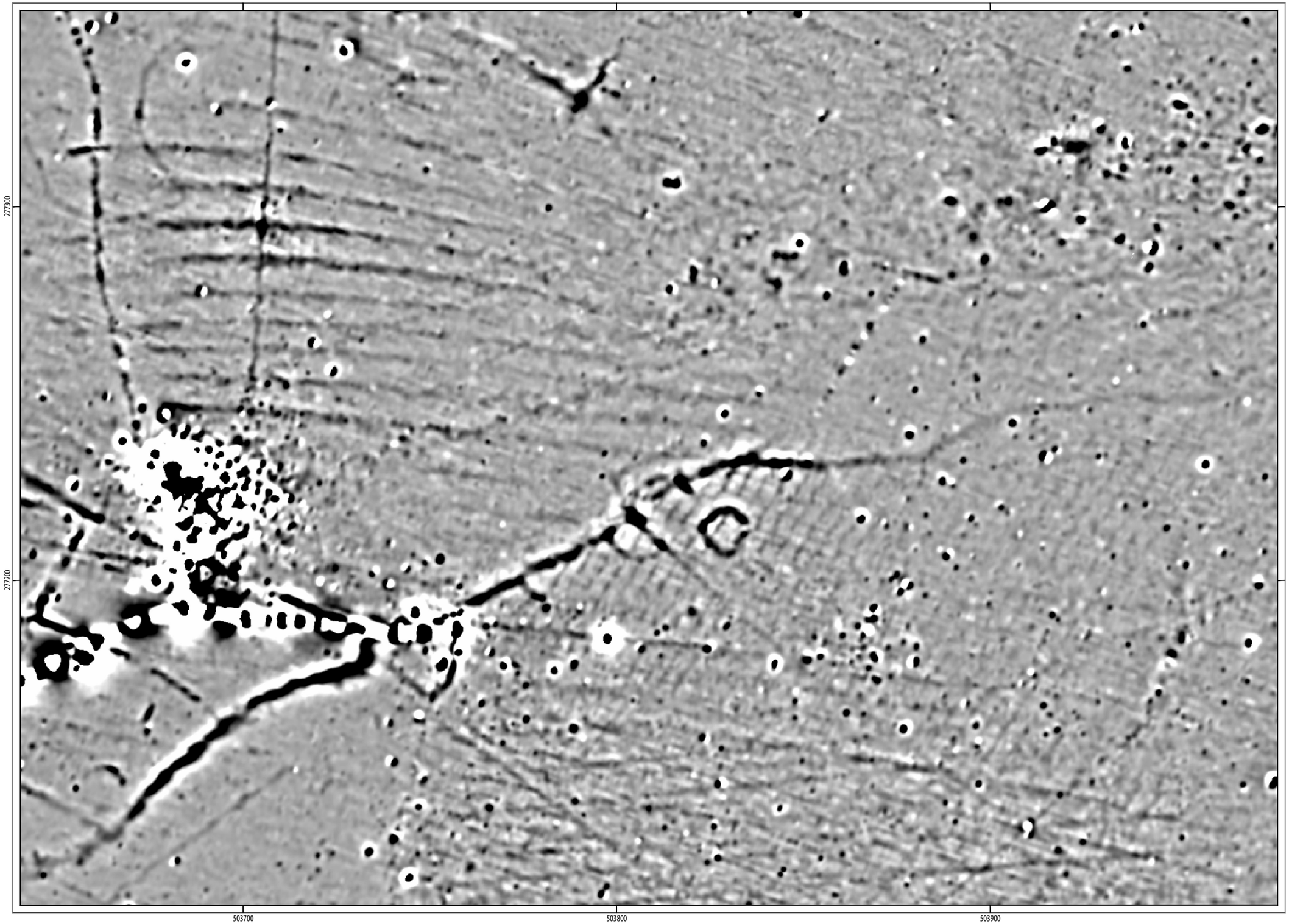
ILLUS 26 Interpretation of magnetometer data; AAA 3 west



nT
-1.0
2.0

0
25m
1:1,000 @ A3

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ILLUS 27 Processed greyscale magnetometer data; AAA 3 central

277300

277200

503700

503800

503900

25.0nT/cm

0 25m

1:1,000 @ A3

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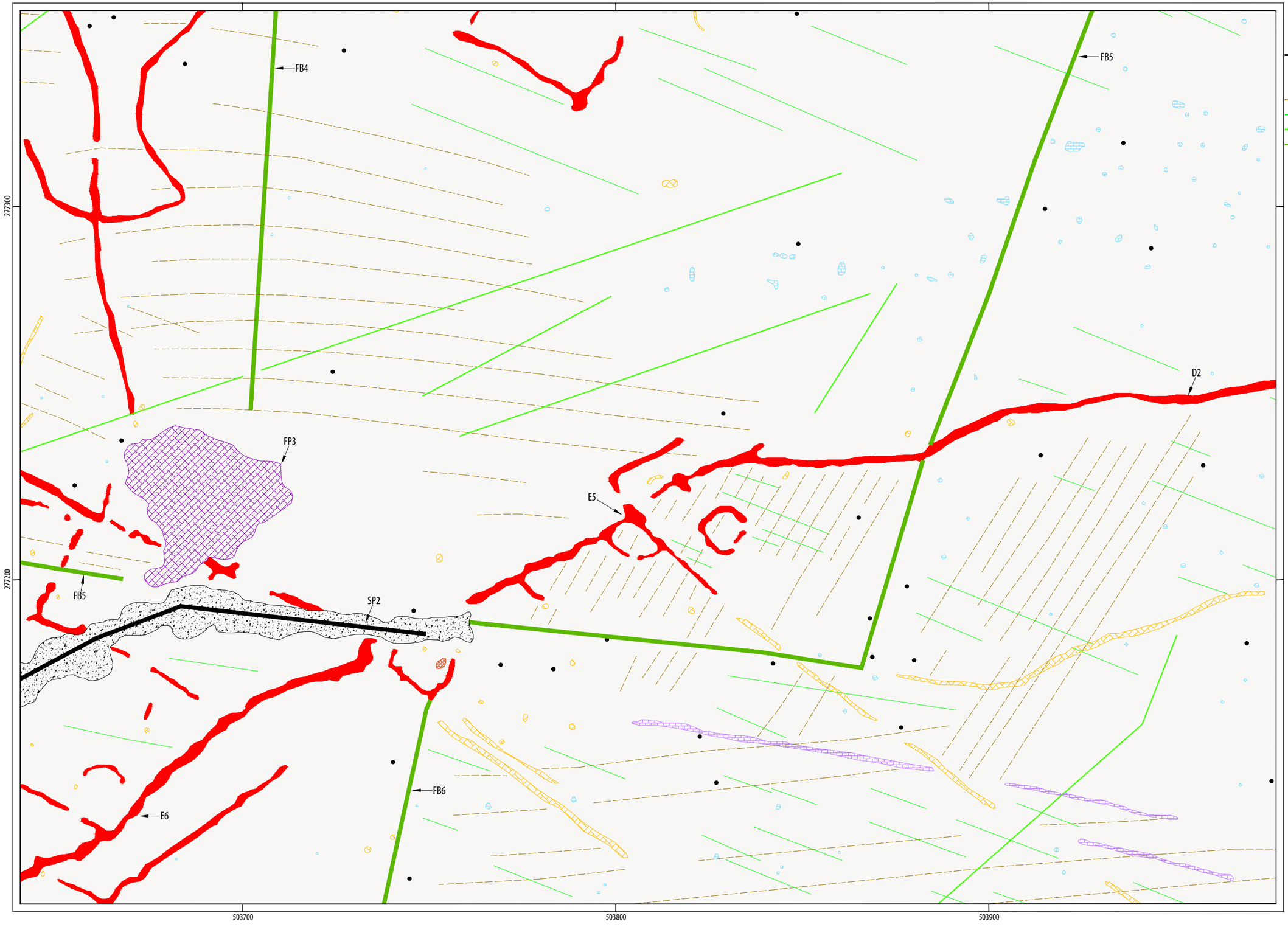
ILLUS 28 XY trace plot of minimally processed magnetometer data; AAA 3 central



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
magnetic disturbance	former building
magnetic enhancement	uncertain
linear trend	ridge and furrow
linear trend	agricultural
linear trend	field drain
linear	former field boundary
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	burning?
magnetic enhancement	archaeology

ABBREVIATIONS

E - enclosure
B? - burning?
D - ditch
FP - former pond
FB - former boundary
SP - service pipe

0 25m
1:1,000 @ A3

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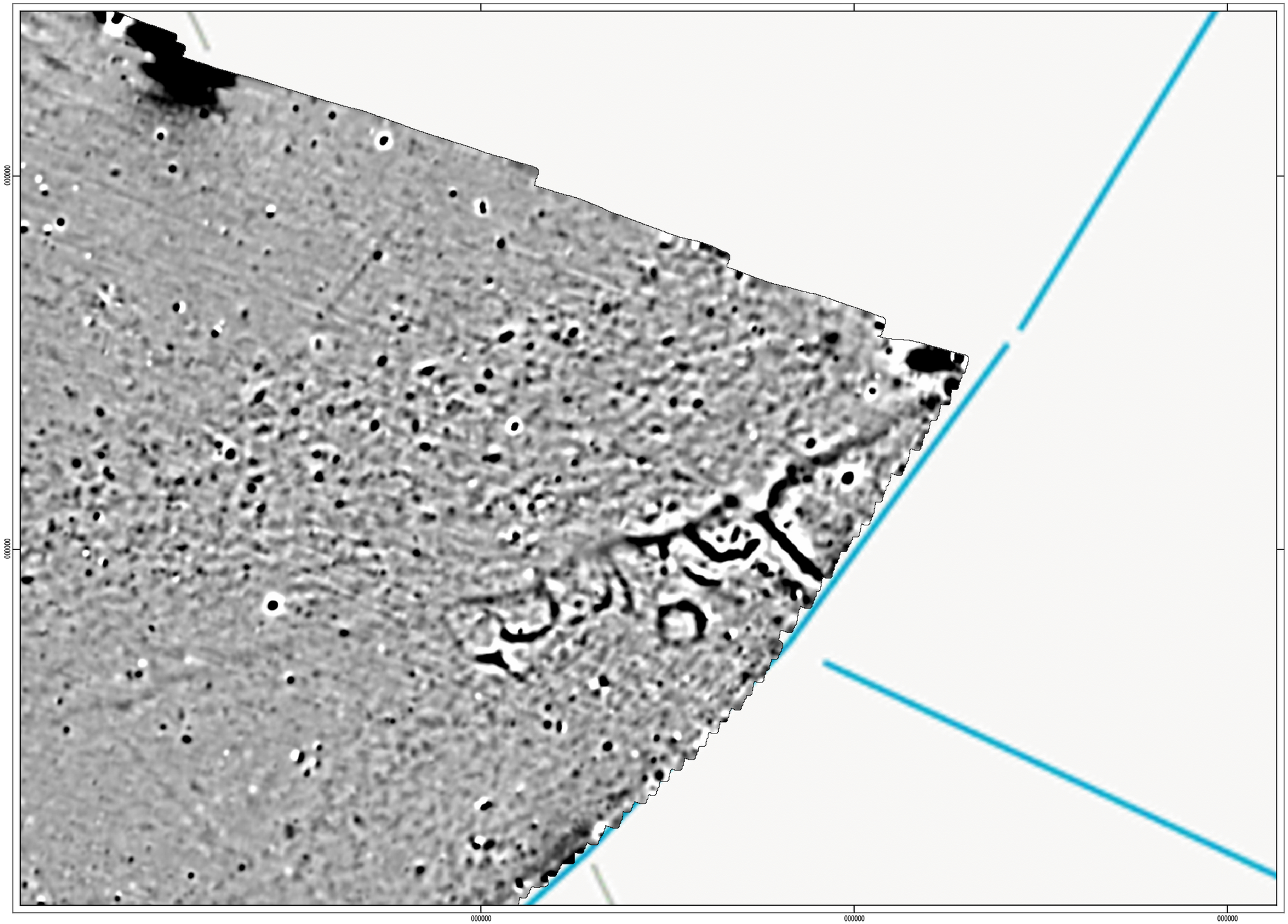
ILLUS 29 Interpretation of magnetometer data; AAA 3 central



-1.0 nT 2.0

0 25m
1:1,000 @ A3

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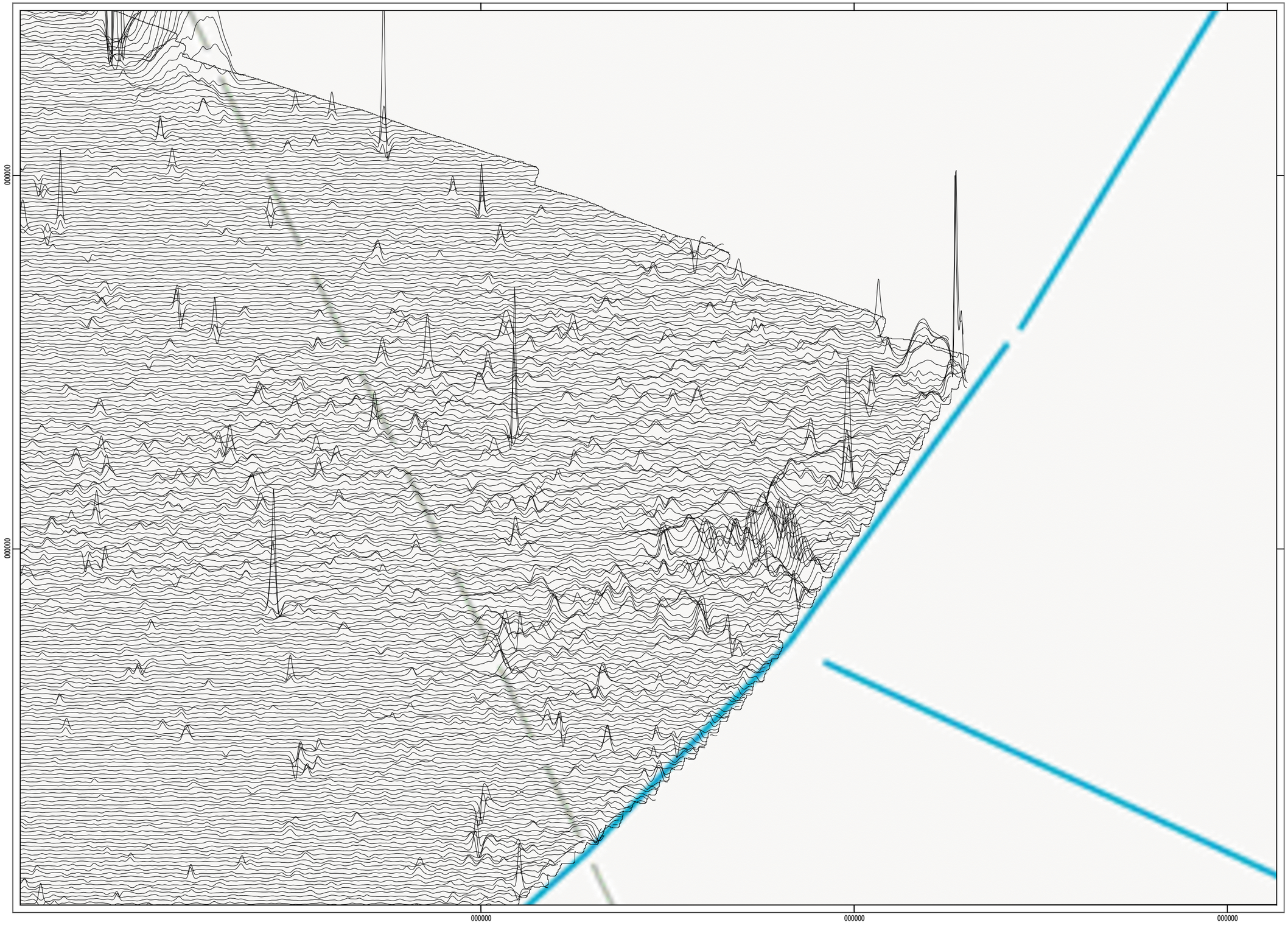
ILLUS 30 Processed greyscale magnetometer data; AAA 3 east



25.0nT/cm

0 25m

1:1,000 @ A3

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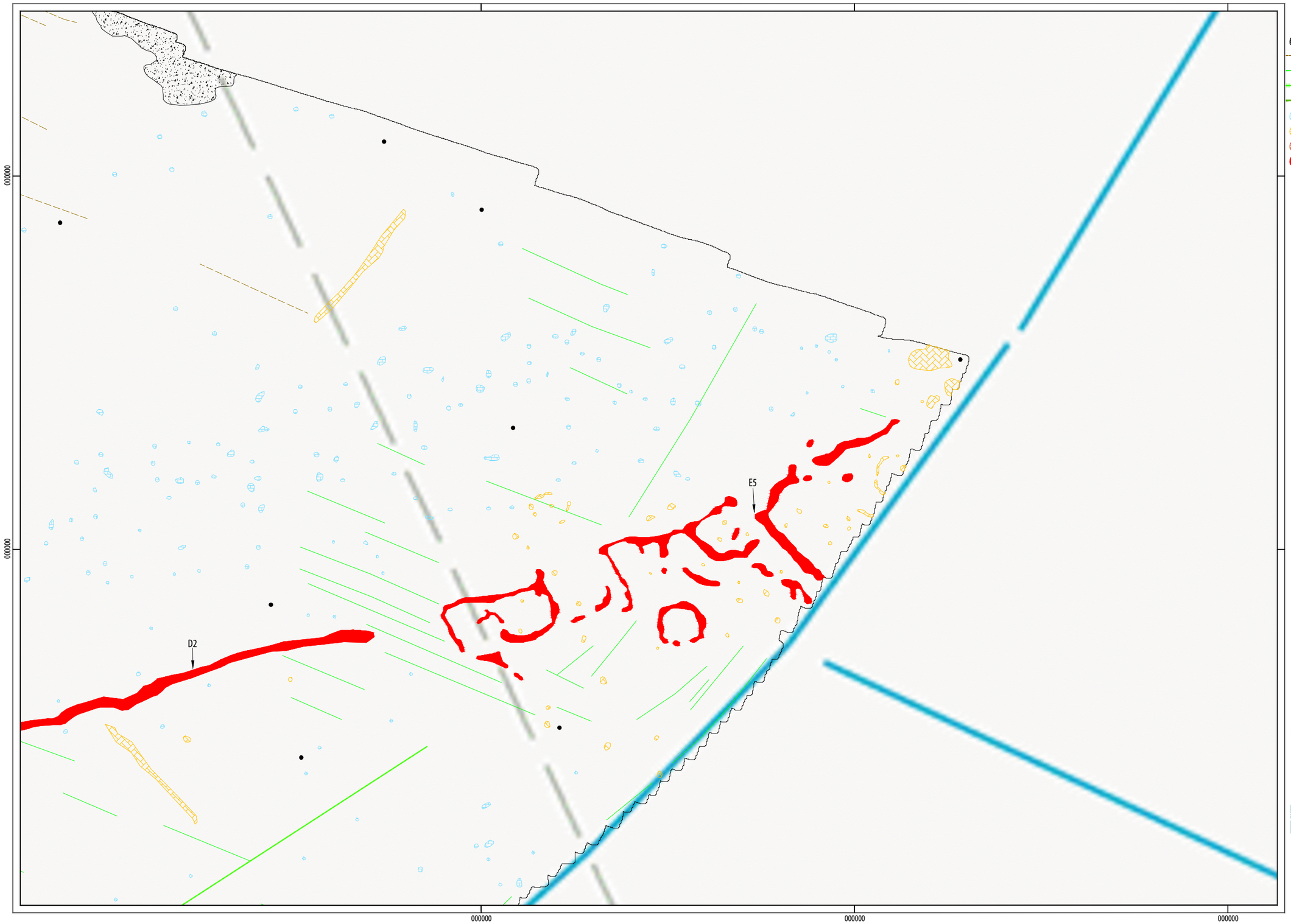
ILLUS 31 XY trace plot of minimally processed magnetometer data; AAA 3 east



TYPE OF ANOMALY | INTERPRETATION

- dipolar isolated | ferrous material
- magnetic disturbance | ferrous material
- linear trend | ridge and furrow
- linear trend | agricultural
- linear trend | field drain
- linear | former field boundary
- magnetic enhancement | geology
- magnetic enhancement | archaeology?
- magnetic enhancement | kiln/burning
- magnetic enhancement | archaeology

ABBREVIATIONS

E - enclosure

D - ditch

0 25m

1:1,000 @ A3

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ILLUS 32 Interpretation of magnetometer data; AAA 3 east

7 APPENDICES

APPENDIX 1 MAGNETOMETER SURVEY

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 haematite. 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 the topsoil, subsoil, and rock, 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. This effect can lead to the detection of features such as hearths, kilns, or areas of burning.

Types of magnetic anomaly

In most 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 introduced into the topsoil during 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 and buried pipes can also cause the same disturbed response. A modern origin is usually assumed unless there is other supporting information.

Lightning-induced remnant magnetisation (LIRM) LIRM anomalies are thought to be caused in the near surface soil horizons by the flow of an electrical current associated with lightning strikes. These observed anomalies have a strong bipolar signal which decreases with distance from the spike point and often appear as linear or radial in shape.

Linear trend This is usually a weak or broad linear anomaly of unknown cause or date. These anomalies are often caused by agricultural activity, either ploughing or land drains being a common cause.

Areas of magnetic enhancement/positive isolated anomalies Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an XY trace plot) on two or three successive traverses. In neither instance is there the intense dipolar response characteristic exhibited by an area of magnetic disturbance or of an 'iron spike' anomaly (see above). These anomalies can be caused by infilled discrete archaeological features such as pits or post-holes or by kilns. They can also be caused by pedological variations or by natural infilled features on certain geologies. Ferrous material in the subsoil can also give a similar response. It can often therefore be very difficult to establish an anthropogenic origin without intrusive investigation or other supporting information.

Linear and curvilinear anomalies Such anomalies have a variety of origins. They may be caused by agricultural practice (recent ploughing trends, earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by infilled archaeological ditches.

APPENDIX 2 SURVEY LOCATION INFORMATION

An initial survey base station was established using a Trimble VRS differential Global Positioning System (dGPS). The magnetometer data was georeferenced using a Trimble RTK differential Global Positioning System (Trimble R8s model).

Temporary sight markers were laid out using a Trimble VRS differential Global Positioning System (Trimble R8s model) to guide the operator and ensure full coverage. The accuracy of this dGPS equipment is better than 0.01m.

The survey data 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 coordinates are measured off hard copies of the mapping rather than using the digital coordinates.

Headland Archaeology cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.

APPENDIX 3 GEOPHYSICAL SURVEY ARCHIVE

The geophysical archive comprises an archive disk containing the raw data in XYZ format, a raster image of each greyscale plot with associate world file, and a PDF of the report.

The project will be archived in-house in accordance with recent good practice guidelines (http://guides.archaeologydataservice.ac.uk/g2gp/Geophysics_3). The data will be stored in an indexed archive and migrated to new formats when necessary.

APPENDIX 4 DATA PROCESSING

The gradiometer data has been presented in this report in processed greyscale and minimally processed XY trace plot format.

Data collected using RTK GPS-based methods cannot be produced without minimal processing of the data. The minimally processed data has been interpolated to project the data onto a regular grid and de-striped to correct for slight variations in instrument calibration drift and any other artificial data.

A high pass filter has been applied to the greyscale plots to remove low frequency anomalies (relating to survey tracks and modern agricultural features) to maximise the clarity and interpretability of the archaeological anomalies.

The data has also been clipped to remove extreme values and to improve data contrast.

APPENDIX 5 OASIS DATA COLLECTION FORM: ENGLAND

OASIS ID (UID): headland1-513880

Project Name:	Wood Lodge Solar Farm, Northamptonshire: Geophysical Survey Report
Activity type:	Geophysical Survey, MAGNETOMETRY SURVEY
Project Identifier(s):	WOOD22
Planning Id:	[no data]
Reason for Investigation:	Planning requirement
Organisation Responsible for work:	Headland Archaeology (UK) Ltd
Project Dates:	06-Feb-2023 – 14-Feb-2023
HER:	Northamptonshire SMR
HER Identifiers:	[no data]
Project Methodology:	The survey was undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid frame. The system was programmed to take readings at a frequency of 10Hz (allowing for a 10–15cm sample interval) on roaming traverses (swaths) 4m apart (Illus 6). These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R8s Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point. MLGrad601 and MultiGrad601 (Geomar Software Inc.) software was used to collect and export the data. Terrasurveyor V3.0.37.0 (DWConsulting) software was used to process and present the data.
Project Results:	The survey has recorded anomalies indicative of significant, dense, and extensive archaeological activity following and appending at least three trackways which cross the proposed development area (PDA), covering approximately 18ha. There are three main foci of archaeological activity: one close to the eastern edge of F1 and two in F3. At each location anomalies indicative of multiple, clustered enclosures of varying size and shape are recorded linked by trackways and with numerous discrete anomalies, likely to be caused by activity associated with settlement, also numerous. Archaeological activity (cropmarks interpreted as enclosures, trackways, and other features) is recorded on the Northamptonshire Historic Environment Record at these locations although the survey has provided significantly greater detail on the complexity and extent of the archaeological remains. Although it is not possible to provide an accurate date for the archaeological activity identified, the pattern and morphology of the anomalies suggest an Iron Age to Romano-British origin is likely. Anomalies due to both historical and recent agricultural activity (ridge and furrow and modern ploughing, drainage and boundary rationalisation), geological variation and modern activity are also identified. Several anomalies of uncertain origin have also been identified. These are likely modern or agricultural in origin, but due to the extensive archaeological activity within the PDA, an archaeological origin cannot be discounted. Overall, the extent of the three major areas of archaeological activity appears to be restricted to F3 and the eastern extent of F1. Where there are no superficial deposits, there are either no recorded anomalies or they are very low magnitude and difficult to discern. This raises the possibility that the archaeological resource may be more extensive than the survey has revealed in those areas where the prevailing pedological and geological conditions are not as favourable for detection.
Keywords:	–
Archive:	–
Reports in OASIS	Adams, C., (2023). Wood Lodge Solar Farm, Northamptonshire: Geophysical Survey Report. Cleckheaton: Headland Archaeology (UK) Ltd.

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