Heckington Fen Solar Park

EN010123

Environmental Statement | Volume 3: Technical Appendices

Appendix 10.2: Geophysical Survey Results for Energy Park

Applicant: Ecotricity (Heck Fen Solar) Limited

Document Reference: 6.3.10.2

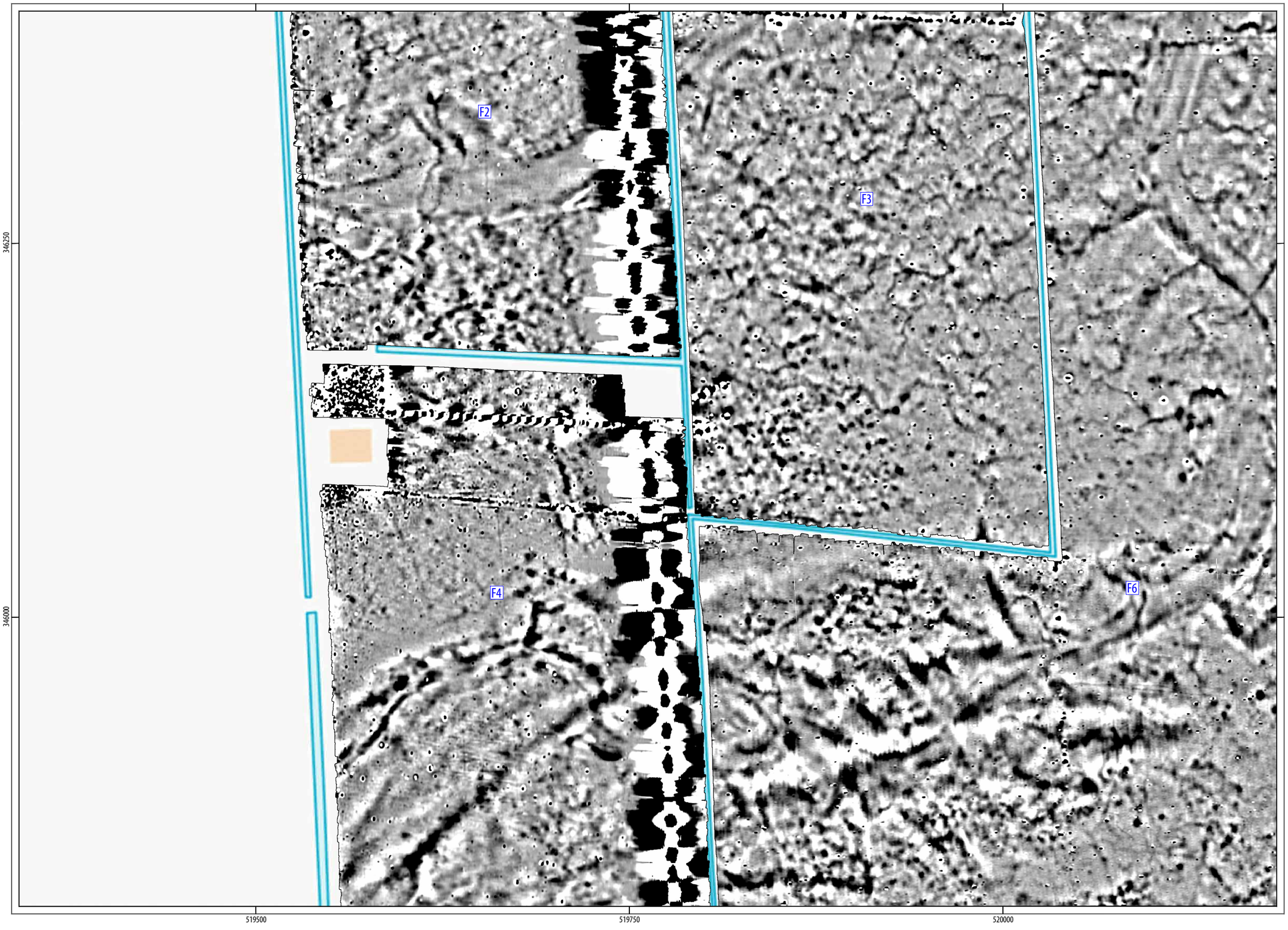
Pursuant to: APFP Regulation 5(2)(a)

February 2023

Planning Act 2008

APPENDIX 10.2 - GEOPHYSICAL SURVEY RESULTS FOR ENERGY PARK

Document Properties		
Regulation Reference	Regulation 5(2)(a)	
Planning Inspectorate Scheme Reference	EN010123	
Application Document Reference	6.3.10.2	
Title	Appendix 10.2 - Geophysical Survey Results for Energy Park	
Prepared By	Heckington Fen Energy Park Project Team (Pegasus) (Sumo) (Headland Archaeology) (ASWYAS) (Magnitude Surveys)	
Version History		
Version	**Date**	**Version Status**
Rev 1	February 2023	Application Version



nT
-1.0 2.0

0 50m
1:2,500 @ A3

PROJECT HFSF22
Heckington Fen Solar Park
Heckington Fen
Lincolnshire

CLIENT Ecotricity

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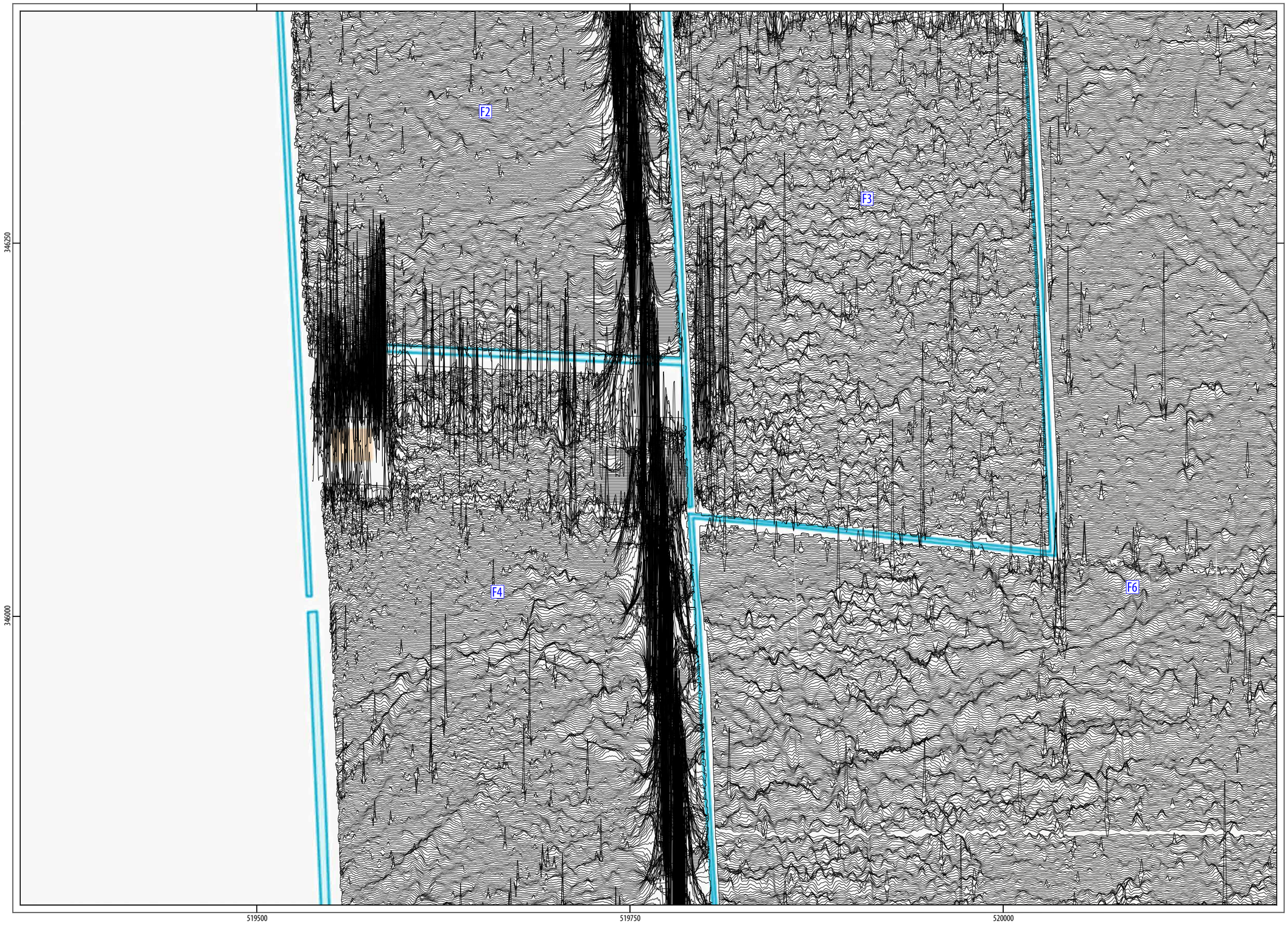

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1:2,500 @ A3

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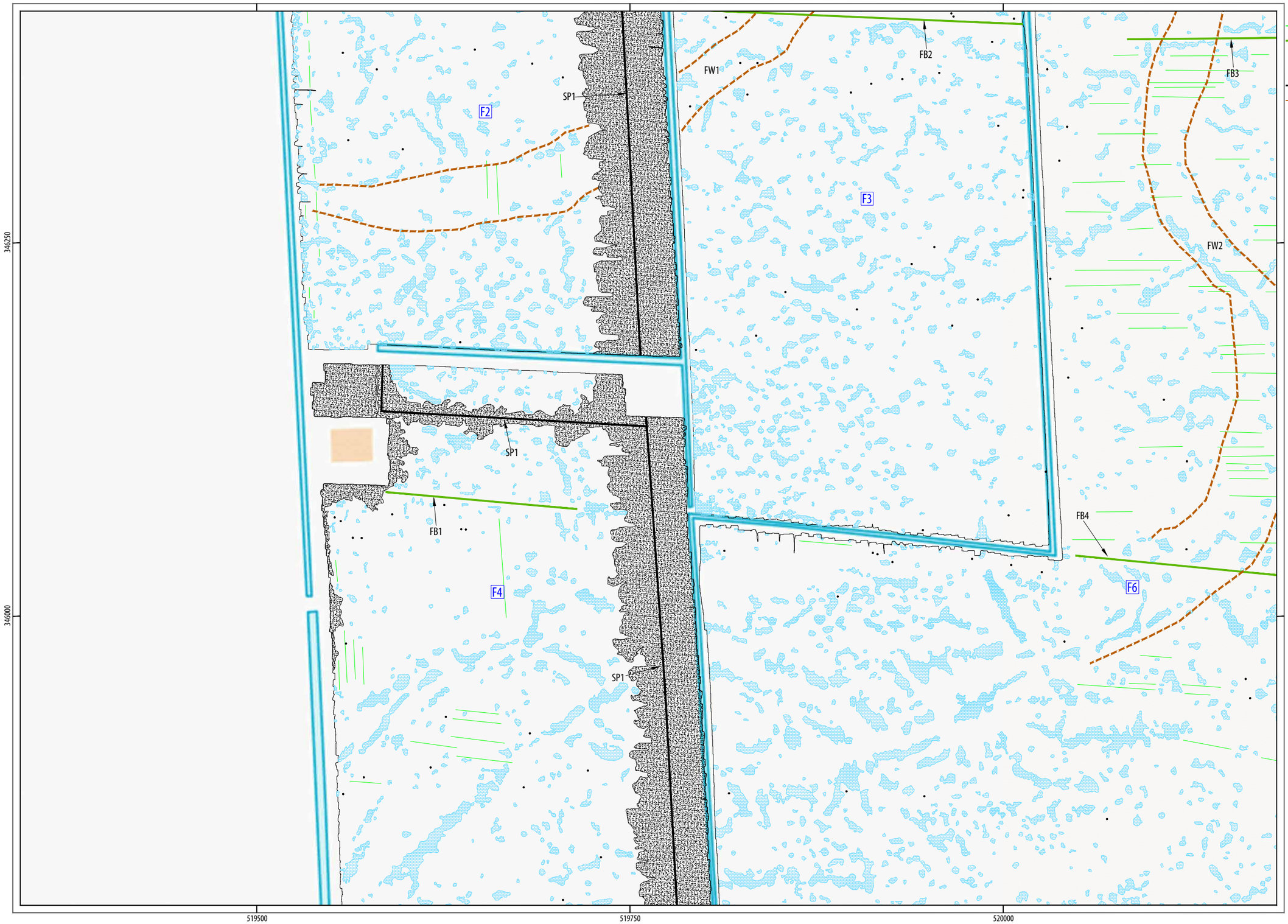
ILLUS 16 XY trace plot of minimally processed magnetometer data; Sector 3



TYPE OF ANOMALY
- agricultural
- agricultural
- ferrous
- ferrous
- ferrous
- geological
- geological

INTERPRETATION
- agricultural
- former field boundary
- ferrous material
- magnetic disturbance
- service pipe
- geological variation
- geological

ABBREVIATION
FB - former boundary
FW - former watercourse
SP -service pipe

0 50m
1:2,500 @ A3

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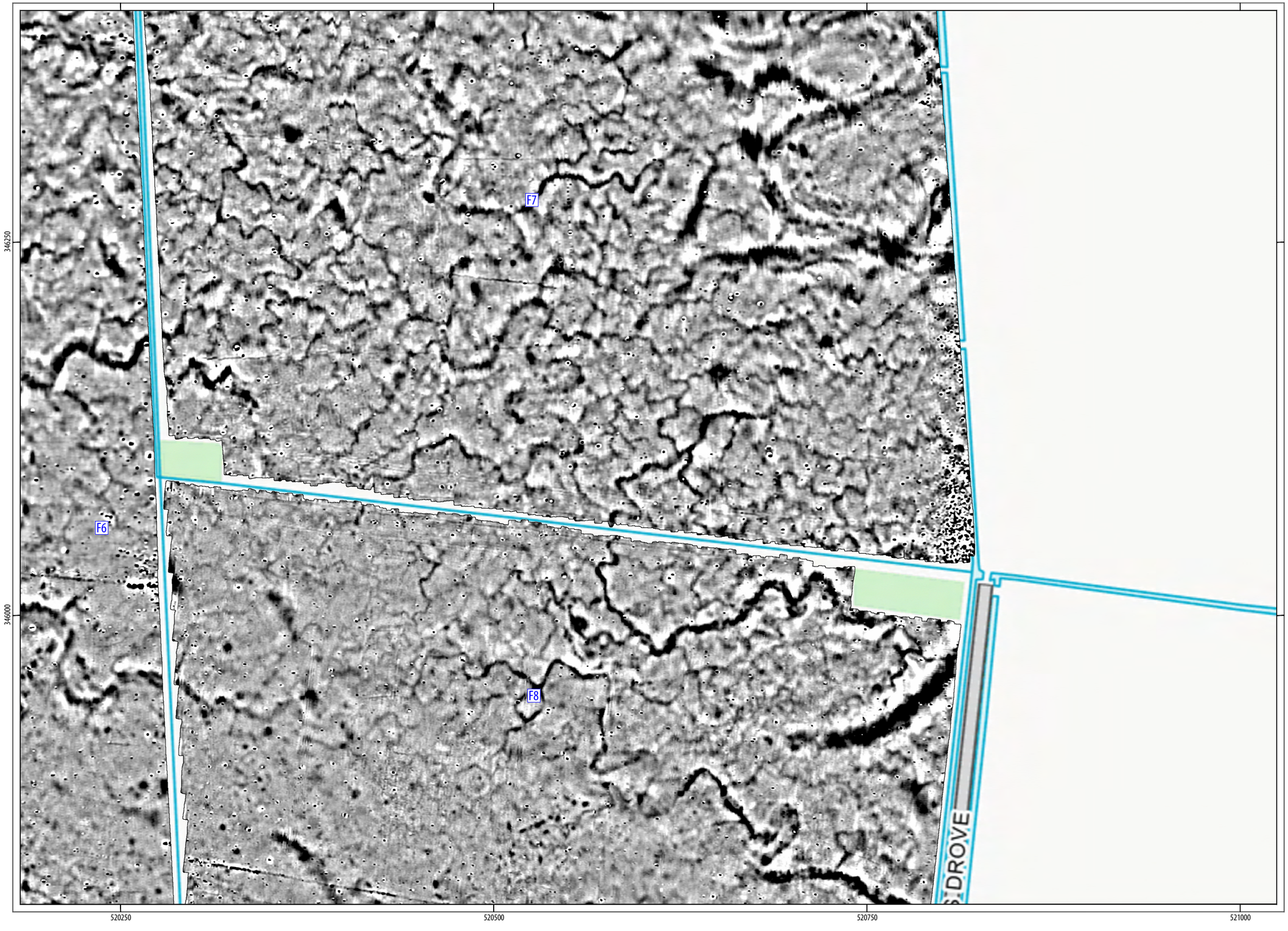
ILLUS 17 Interpretation of magnetometer data; Sector 3



nT
-1.0 2.0

0 50m
1:2,500 @ A3

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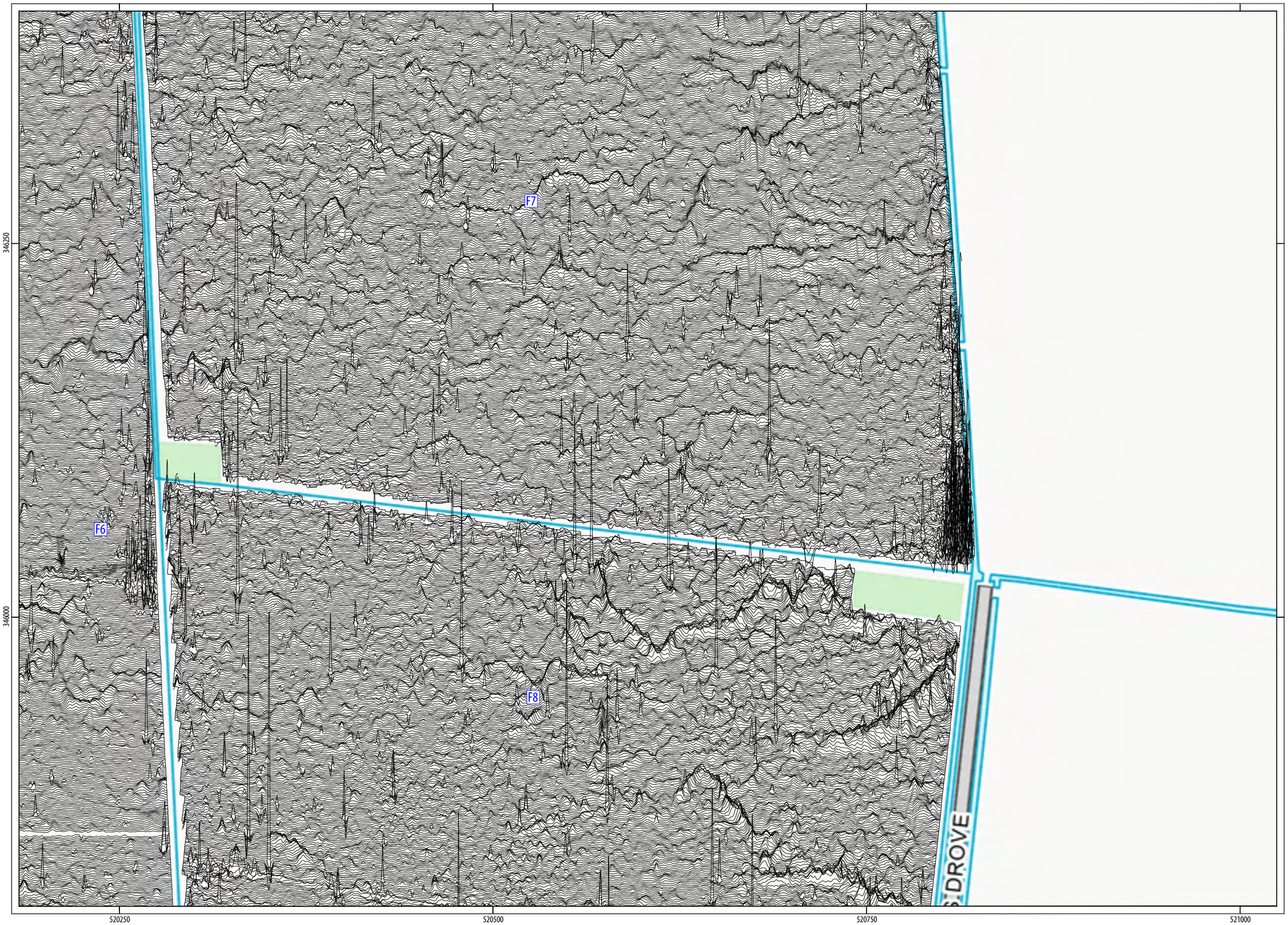

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0 50m

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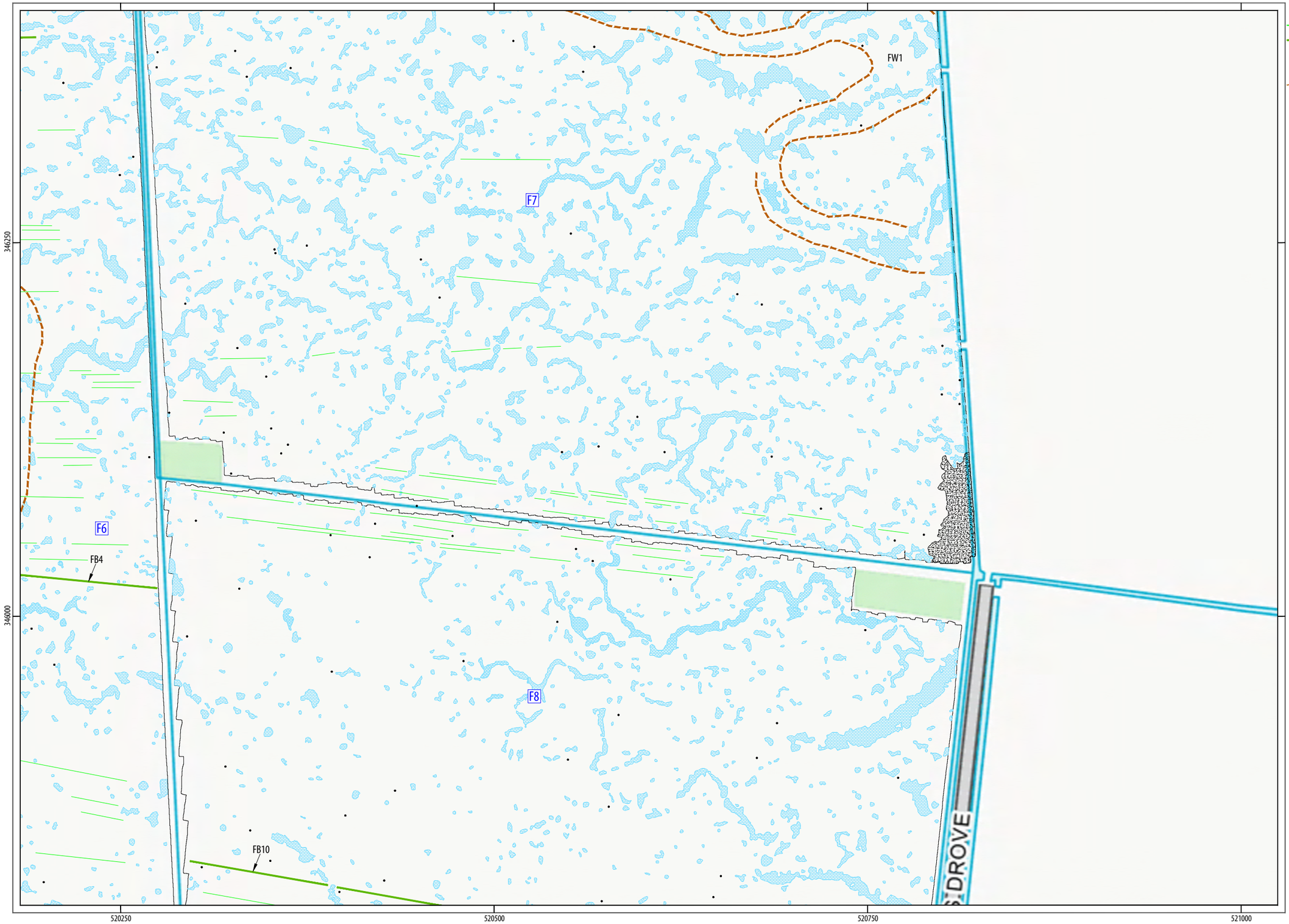
ILLUS 19 XY trace plot of minimally processed magnetometer data; Sector 4



TYPE OF ANOMALY
- agricultural
- agricultural
- ferrous
- ferrous
- geological
- geological

INTERPRETATION
- agricultural
- former field boundary
- ferrous material
- magnetic disturbance
- geological variation
- geological

ABBREVIATION
FB - former boundary
FW - former watercourse

0 50m
1:2,500 @ A3

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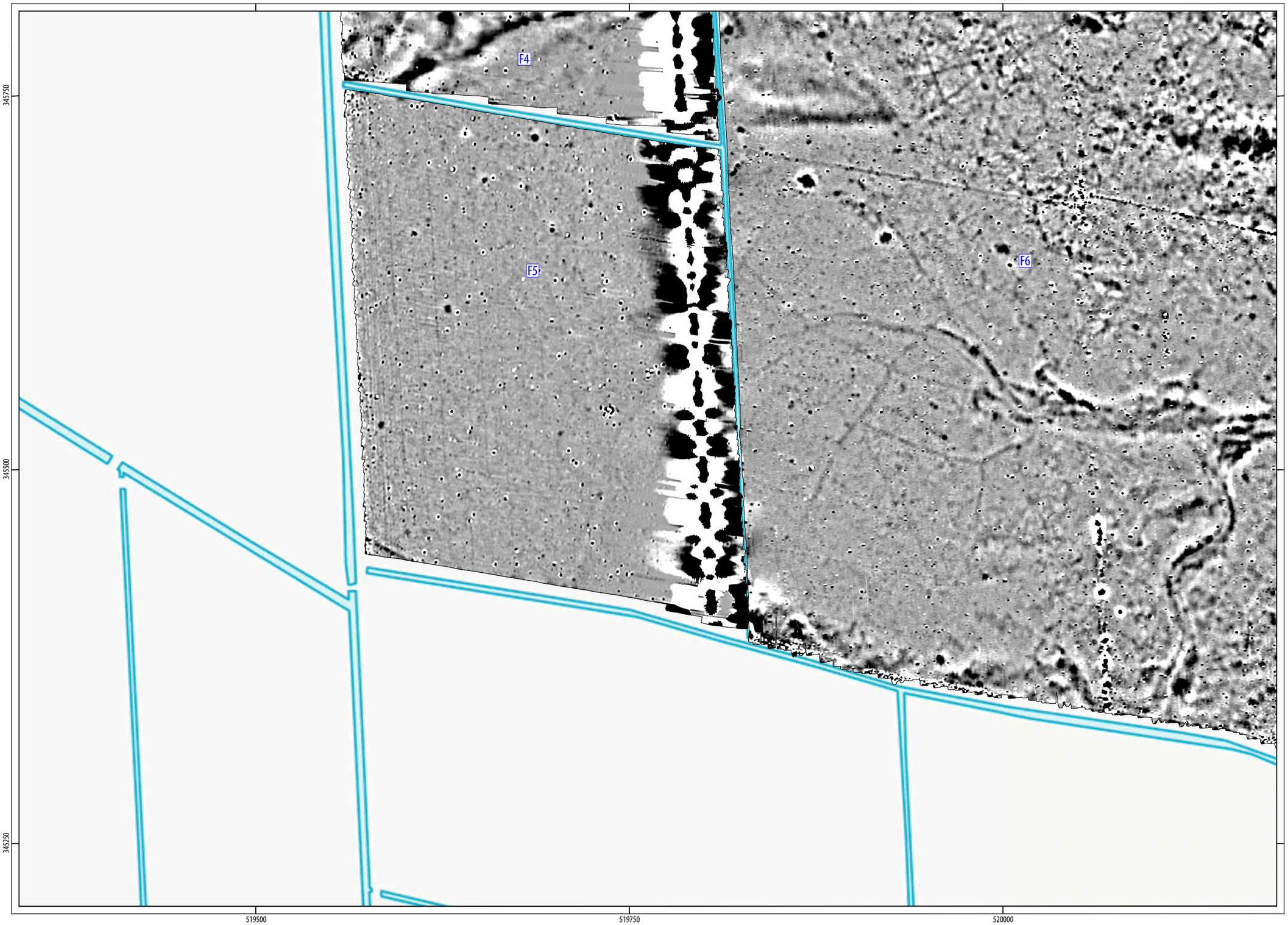
ILLUS 20 Interpretation of magnetometer data; Sector 4



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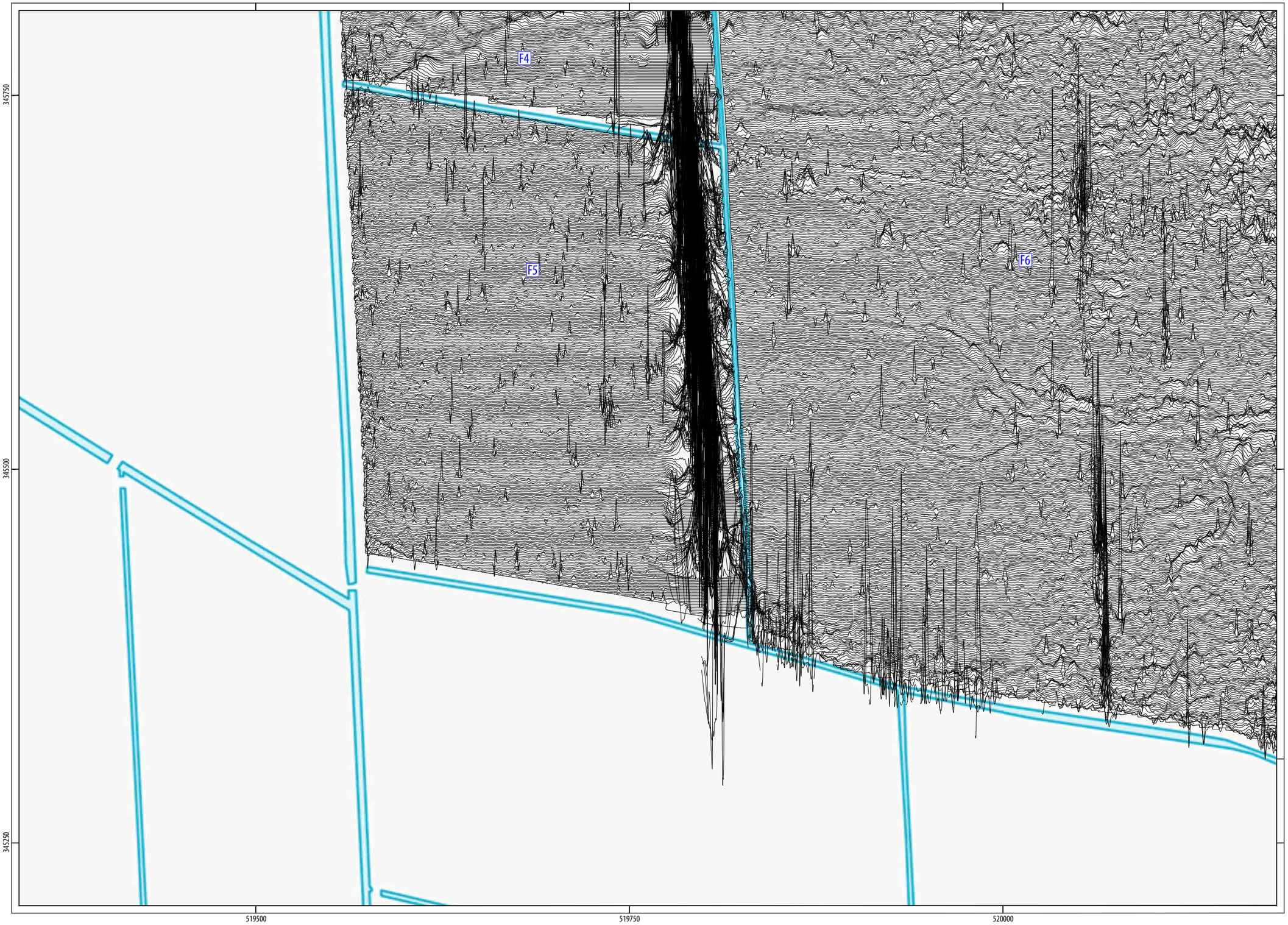

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1:2,500 @ A3

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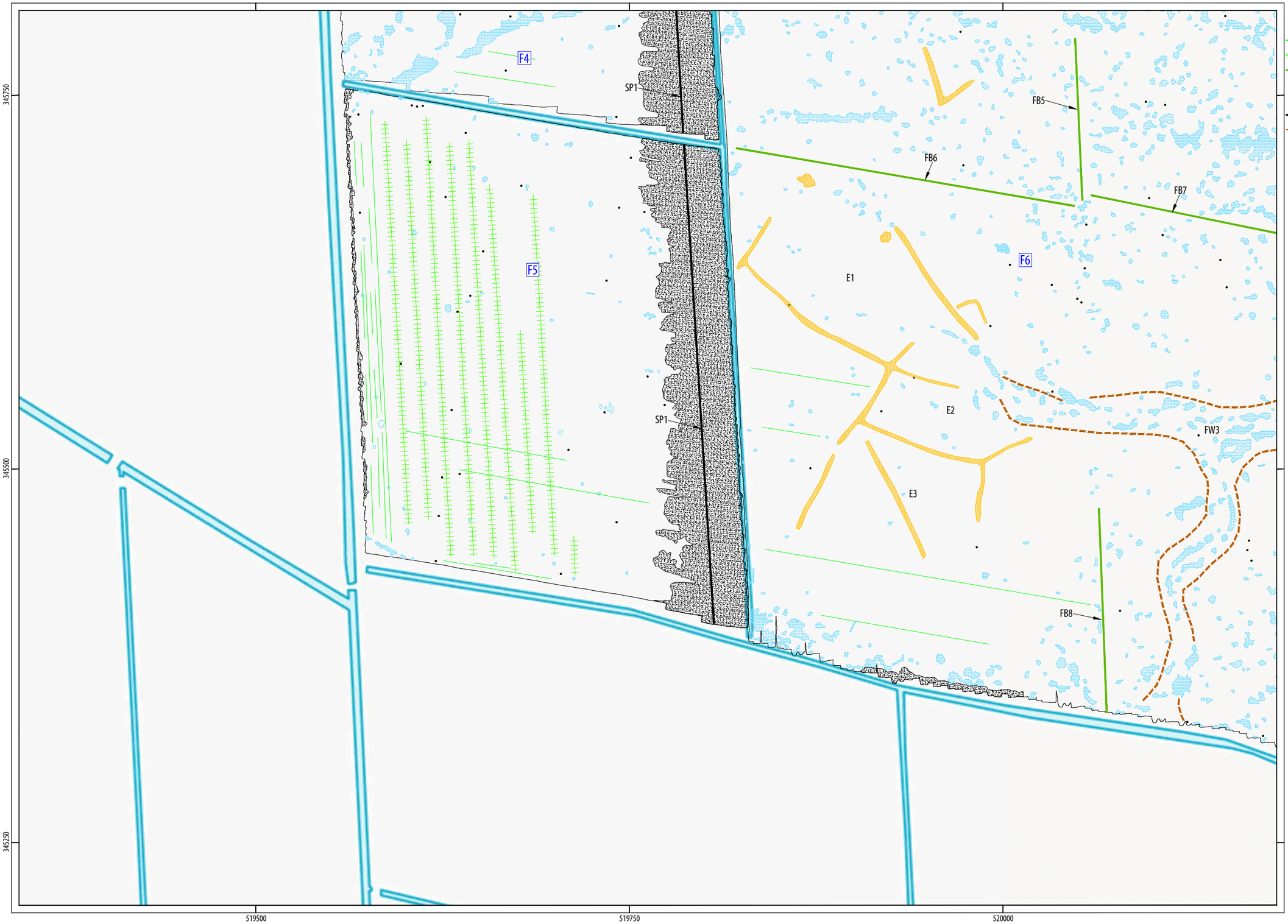
ILLUS 22 XY trace plot of minimally processed magnetometer data; Sector 5



TYPE OF ANOMALY
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- agricultural
- agricultural
- agricultural
- ferrous
- ferrous
- ferrous
- geological
- geological

INTERPRETATION
- possible archaeology
- agricultural
- field drain
- former field boundary
- ferrous material
- magnetic disturbance
- service pipe
- geological variation
- geological

ABBREVIATION
E - enclosure
FB - former boundary
FW - former watercourse
SP -service pipe

0 50m
1:2,500 @ A3

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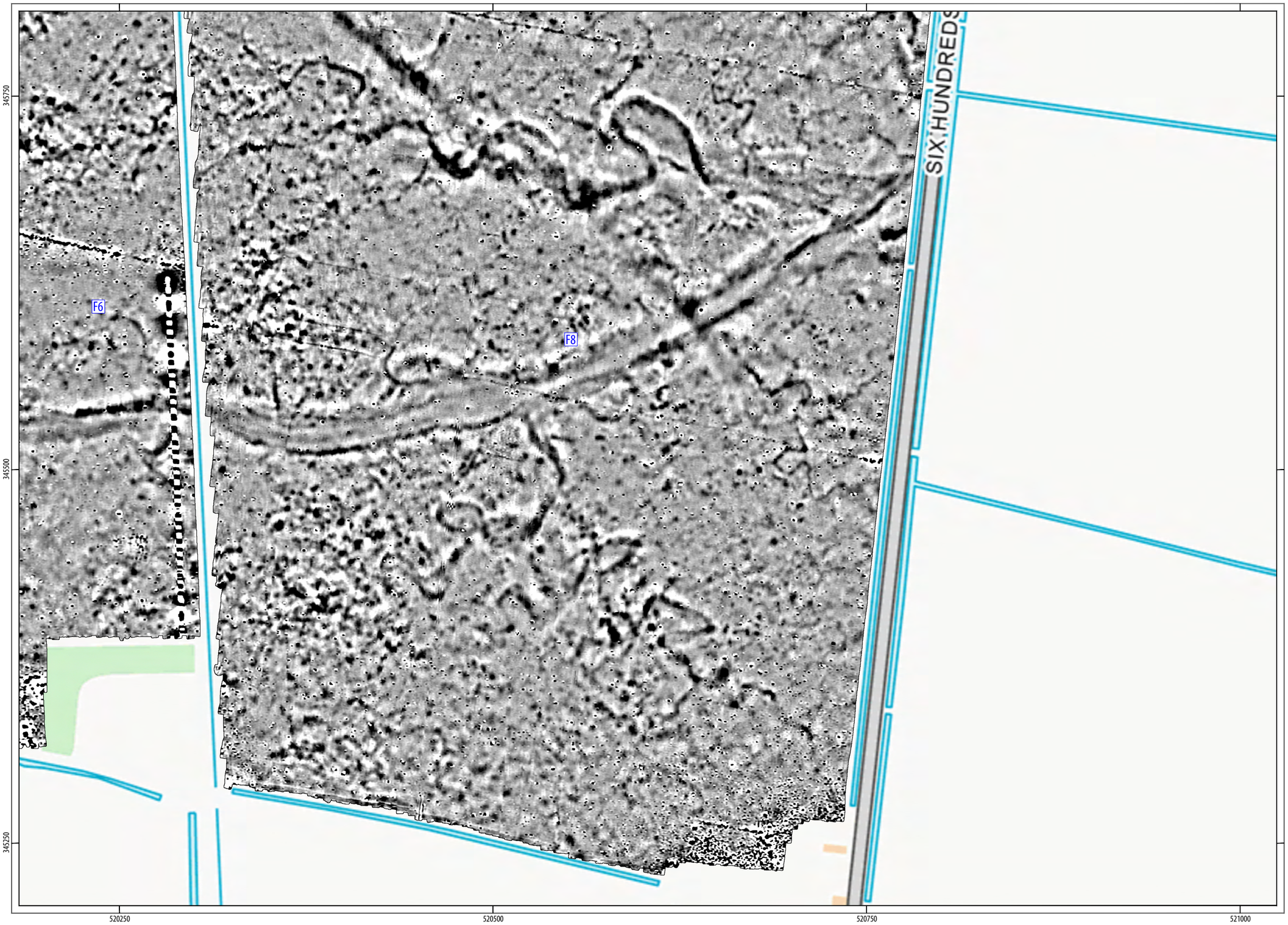
ILLUS 23 Interpretation of magnetometer data; Sector 5



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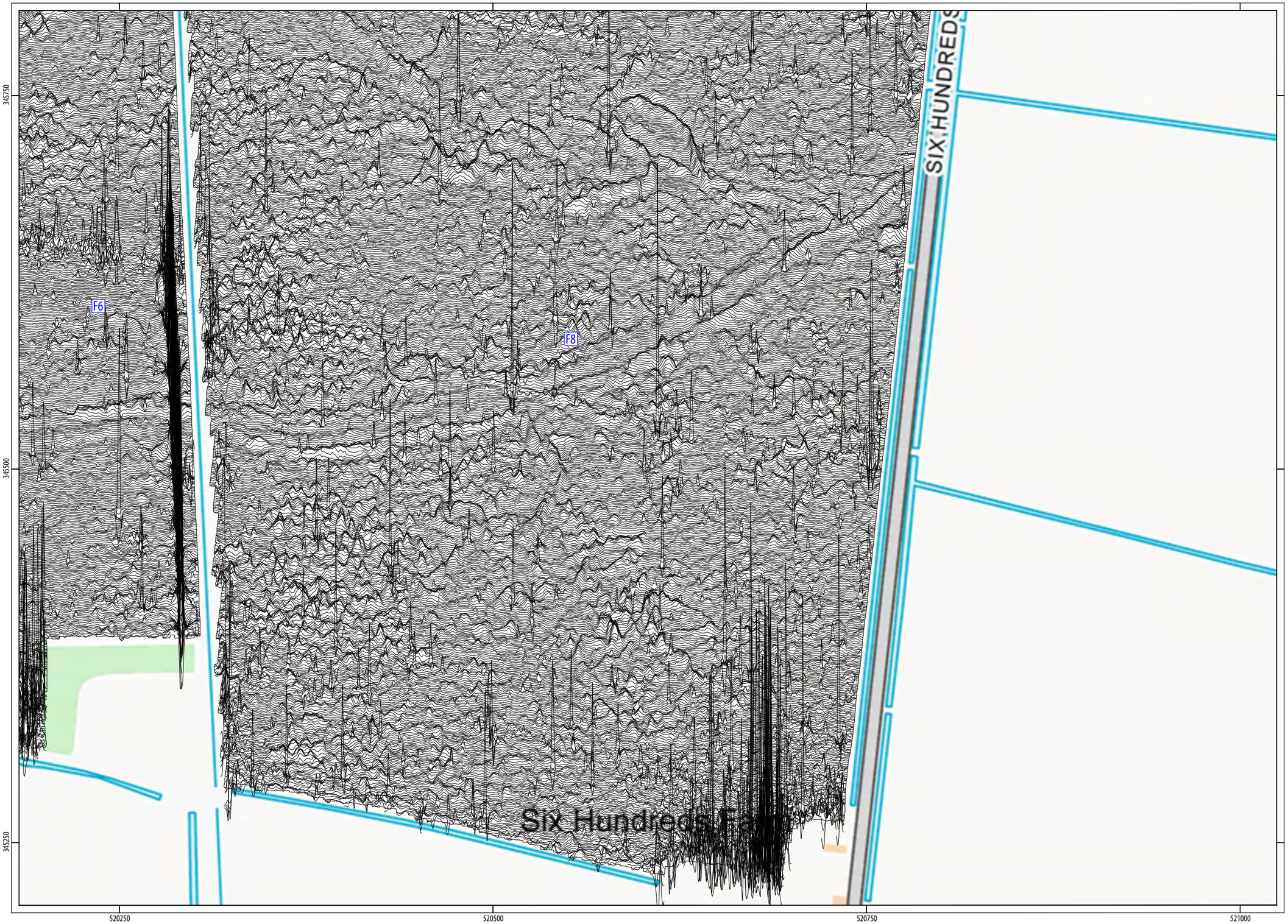
ILLUS 24 Processed greyscale magnetometer data; Sector 6



25.0nT/cm

0 50m

1:2,500 @ A3

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Heckington Fen
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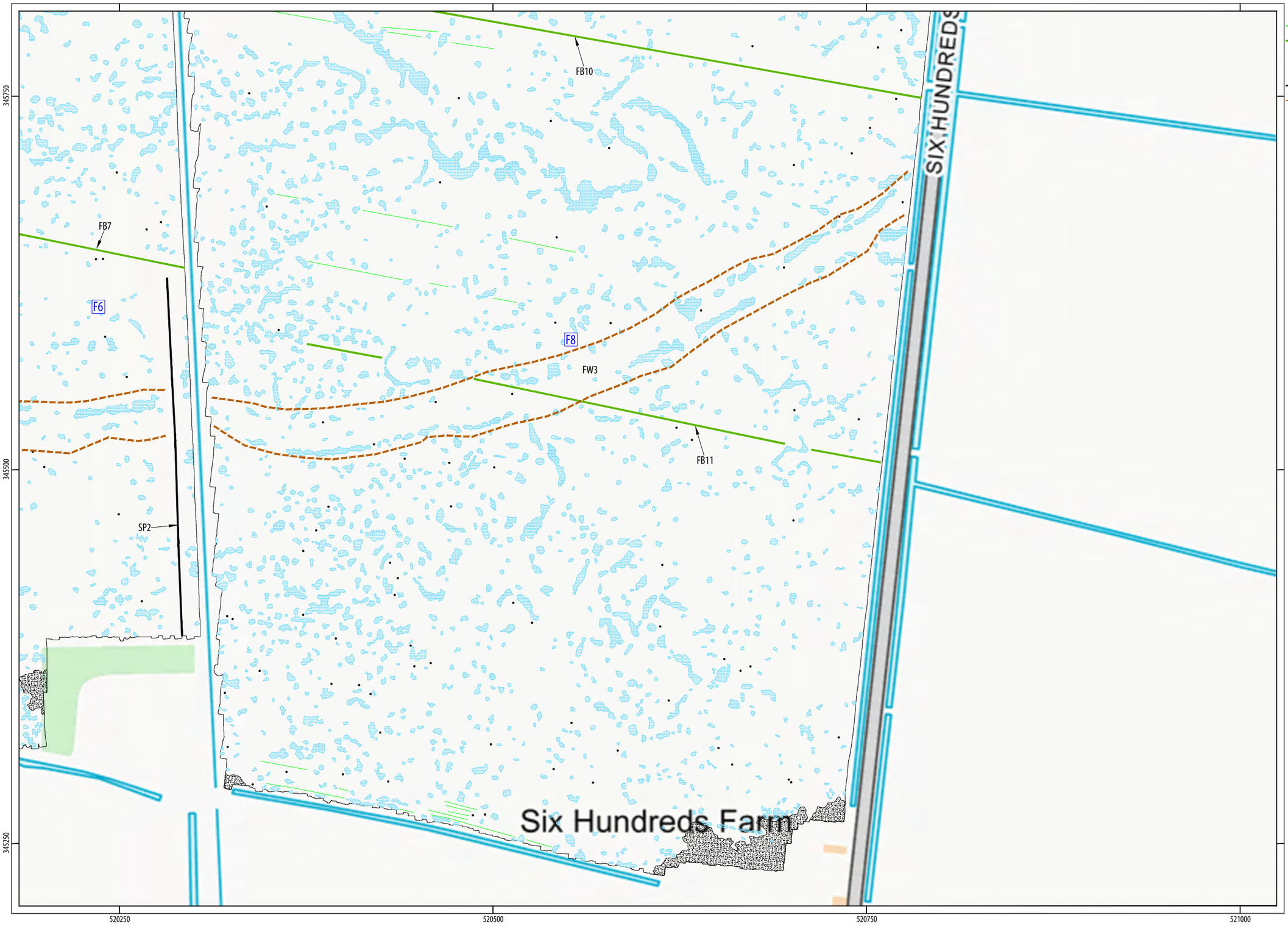
ILLUS 25 XY trace plot of minimally processed magnetometer data; Sector 6



TYPE OF ANOMALY
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ILLUS 26 Interpretation of magnetometer data; Sector 6

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 ARCHIVE

WYAS Archaeological Services

Site 3

Heckington Fen Solar Park

Lincolnshire

Geophysical Survey

Museum Accession Number: LCNCC:2022.55
Museum Site Code: HECS22

Report no. 3759
April 2022

Client: ecotricity

West Yorkshire Joint Services

Site 3
Heckington Fen Solar Park
Lincolnshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey was undertaken on approximately 112 hectares of land located to the north of the A17 in East Heckington, Lincolnshire. Anomalies associated with natural and geological responses dominate the dataset and show former palaeochannels or water courses and possible oxbow lakes. There are no anomalies associated with an archaeological origin although a handful of anomalies have been categorised as uncertain which may have some potential. Former field boundaries have been recorded along with modern ploughing trends. A service pipe has also been recorded in the west of the survey area. Based on the geophysical survey the archaeological potential of the survey area is deemed to be low.

WYAS
Archaeological Services

Report Information

Client:	Ecotricity (Heck Fen Solar) Ltd
Address:	Lion House, Rowcroft, Stroud, Gloucestershire GL5 3BY
Report Type:	Geophysical Survey
Location:	Heckington
County:	Lincolnshire
Grid Reference:	TF 20116 44663
Period(s) of activity:	Modern
Report Number:	3759
Project Number:	XD59
Site Code:	HECS22
Museum Accession Number:	LCNCC:2022.55
OASIS ID:	Archaeol11-506198
Date of fieldwork:	March 2022
Date of report:	April 2022
Project Management:	Emma Brunning BSc MCIfA
Fieldwork:	Jake Freeman BA
	Claire Stephens BA MA
	Haydn Evans BA
Illustrations:	Emma Brunning and Claire Stephens
Photography:	Jake Freeman
Report:	Emma Brunning

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

Nepshaw Lane South, Morley, Leeds LS27 7JQ
Telephone: 0113 535 0163
Email: admin@aswyas.com

Document Issue Record

Ver	Author(s)	Reviewer	Approver	Date
1.0	EB	DW	DW	Apr 2022

Contents

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List of Plates

1 Introduction

Archaeological Services ASWYAS has been commissioned by Pegasus Group on behalf of Ecotricity (Heck Fen Solar) Ltd to undertake a geophysical survey at land at Heckington Fen, Lincolnshire. This survey covered approximately a quarter (hereafter 'Area 3') of the proposed Heckington Fen Solar Park site with the remaining three quarters being surveyed by three other contractors.

The geophysical survey was undertaken in line with current best practice (CIfA 2020; Schmidt *et al.* 2015) and in accordance with a Written Scheme of Investigation submitted to the Archaeological Advisors to Lincolnshire County Council, North Kesteven District Council and Boston Borough Council. The survey was carried out between 21st and 29th March 2022 to provide additional information on the archaeological resource of the Site.

Site location, topography and land-use

Area 3 is located at TF 20116 44663 (approximate centre), comprising *c.* 112ha over multiple fields, and a 30m wide corridor to the south (see Fig. 1).

The survey area is situated to the north of the A17 in East Heckington with land consisting of arable ground (see Plates 1 to 8). It is bounded to the west by the Labour in Vain Drain, to the north by agricultural land, to the east by Holland Dike. The above Ordnance Datum (aOD) is generally level, lying at approximately 2m aOD.

Soils and geology

The underlying bedrock of the survey area comprises mudstone and siltstone of the West Walton Formation. A sedimentary bedrock formed approximately 157 to 164 million years ago in the Jurassic Period. The overlying superficial deposits consist of clay and silt of tidal flat deposits which formed up to 3 million years ago in the Quaternary Period (BGS 2022).

During the last major cold phase, known as the Devensian, glacier ice spread down the east coast. The ice effected major landscape changes through deposition of tills, sands and gravels. One consequence was the impounding of large ice-damned lakes in the Vale of Pickering, Humberhead and the Fens. Lake Humber and Lake Fenland were connected by the Lincoln gap (Straw 2016). The survey area sits in the north of what was Lake Fenland.

Soils of the survey area are described as loamy and clayey soils of coastal flats with naturally high groundwater (Soilscape 21) (CSAI 2022).

2 Archaeological Background

The following archaeological background has been provided by Pegasus Group, and is informed by an initial high-level review of Lincolnshire Historic Environment Record (HER) data sourced for a 2km-radius study area measured from the boundaries of the proposed Heckington Fen Solar Park site (hereafter 'the site')

Finds recorded *c.*0.5-1.5km to the west of the site include a Neolithic polished stone axe (MLI60769) and flint scrapers and other worked flints (MLI87872, MLI60936, MLI87875); Iron Age pottery sherds (MLI87874, MLI88029, MLI88049, MLI88094); and fragments of Roman querns (MLI87877, MLI87889) and pottery (MLI91865, MLI60935, MLI87871, MLI88047, MLI88050, MLI88065). This material likely derives from the settlements indicated by cropmarks to the south and north-west of White House Farm (MLI60731, MLI90708), at Garwick (MLI60631), and to the west of Holme House (MLI84683).

Within the site itself, possible Roman salt-working in the fields extending north of Rectory Farm is indicated by sherds of Roman pottery and briquetage collected after ploughing in 1963 and during observation of the North Sea Gas Pipeline in 1971 (MLI87647, MLI87891, MLI87892). In addition, a geophysical survey carried out for a proposed wind farm identified further possible traces of salt-working in the north-eastern part of the site. More scatters of Roman pottery are recorded to the south-east of the site (MLI12571, MLI12578, MLI12602).

Also recorded at Garwick to the west of the site is a high-status Anglo-Saxon trading centre, identified primarily through metal-detecting survey (MLI116391). It appears to have been in use from at least the mid-6th century to the mid-8th century, and has yielded one of the county's largest assemblages of finds from this period. It lies c.800m south-west of the site at its closest point.

The settlement of East Heckington, located to the south of the site, was in existence by the 18th century (MLI87648). The vast majority of monuments recorded by the HER for the study area comprise 19th-century farmsteads and field barns. Six Hundreds Farm lies within the eastern part of the site (MLI121951) and Elm Grange (MLI121956), Home Farm (MLI121955) and Rectory Farm (MLI121954) lie outside the southern boundary of the site. Four former unnamed farmsteads are recorded in the northern and central parts of the site (MLI121935, MLI121934, MLI121933, MLI121950).

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 Area 3 was undertaken (see Fig. 2).

The general objectives of the geophysical survey were:

- to provide information about the nature and possible interpretation of any magnetic anomalies identified;
- to therefore determine the presence/absence and extent of any buried archaeological features; and

- to prepare a report summarising the results of the survey.

Magnetometer survey

The 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 1:7500 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 45 inclusive at a scale of 1:1250.

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 Her 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 45)

Agricultural anomalies

Former field boundaries (**FB1**) have been recorded which correspond to diamond-shaped copses shown on the first edition Ordnance Survey mapping dating from 1898 (NLS 2022).

Boundaries **FB2** to **FB5** in Area G and **FB6** in Area J are shown on mapping dating from 1906 and are still visible on the edition published in 1956 (NLS 2022). Boundary **FB6** has a strong magnetic signal and it is likely that this is a drainage channel which has been infilled with ferrous materials.

Parallel linear trends can be seen within all areas and are associated with modern ploughing. Only a selection of these have been highlighted on the interpretation diagrams to show the direction of the plough lines.

Uncertain anomalies

A fragmented linear trend (**U1**) in Area A runs on a northwest to southeast alignment. As it does not follow the current plough lines it has the potential to be of interest. However, the trend is on the same alignment as the boundaries to the northwest and therefore may be associated with a former boundary pre-dating the available historic mapping, perhaps associated with earlier or later drainage of the landscape.

Discrete anomalies (**U2**) in Area D have a slightly higher magnetic response than the surrounding natural responses and correspond to a feature shown on historic mapping dated 1906 as a likely pond. These responses may be associated with the pond or could relate to natural features.

A curving anomaly (**U3**) in Area F may have an archaeological origin. However, due to the narrow survey area and the magnetic disturbance it is impossible to be certain. Given the landscape it could well be associated with drainage but could also be natural.

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.

Bisecting the western fields of Area A to Area F a linear dipolar trend has been recorded which corresponds to a buried service.

A circular area of magnetic disturbance in Area G corresponds to a pond marked on historic mapping dating from 1906. Magnetic disturbance in the northeast of Area H are due to interference from the adjacent farm buildings.

Natural/geological anomalies

The majority of the responses detected are of a geological origin and show former palaeochannels and watercourses curving throughout the survey area. The interpretation diagrams show the coverage of natural features with a denser hatch highlighting the discrete features.

Anomalies recorded within Area G show one major palaeochannel in the north which splits into two. A number of other sinuous anomalies have been recorded within this field which could be other, smaller channels.

Areas H and I show possible oxbow lakes with magnetically quieter zones which perhaps reflect various flood level incidents.

These anomalies likely represent the former landform of the area which prior to draining in the 18th and 19th centuries, would have been a low lying area with large areas of fenland and river courses.

5 Conclusions

The geophysical survey has detected magnetic anomalies associated with former field boundaries and modern ploughing. A handful of uncertain responses may indicate some areas of interest but no anomalies of an archaeological origin have been identified.

The majority of the responses are of a natural/geological origin and show former palaeochannels across the survey area and also possible oxbow lakes.

A service pipe has been recorded in the west of the survey area. Magnetic disturbance within the dataset are caused by interference from farm buildings and infilled ponds.

Based on the geophysical survey the archaeological potential of Area 3 of Heckington Fen Solar Park is deemed to be low.

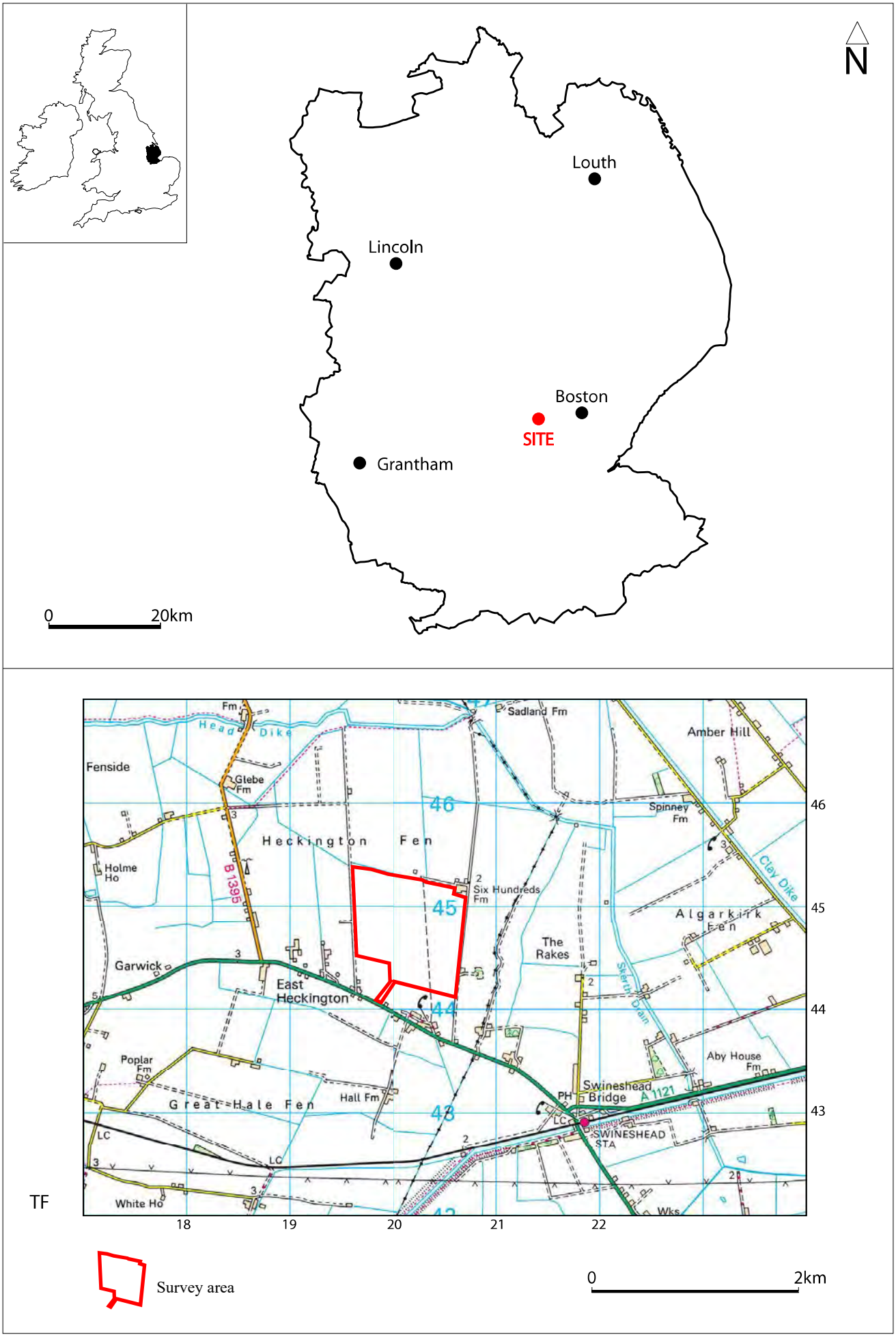
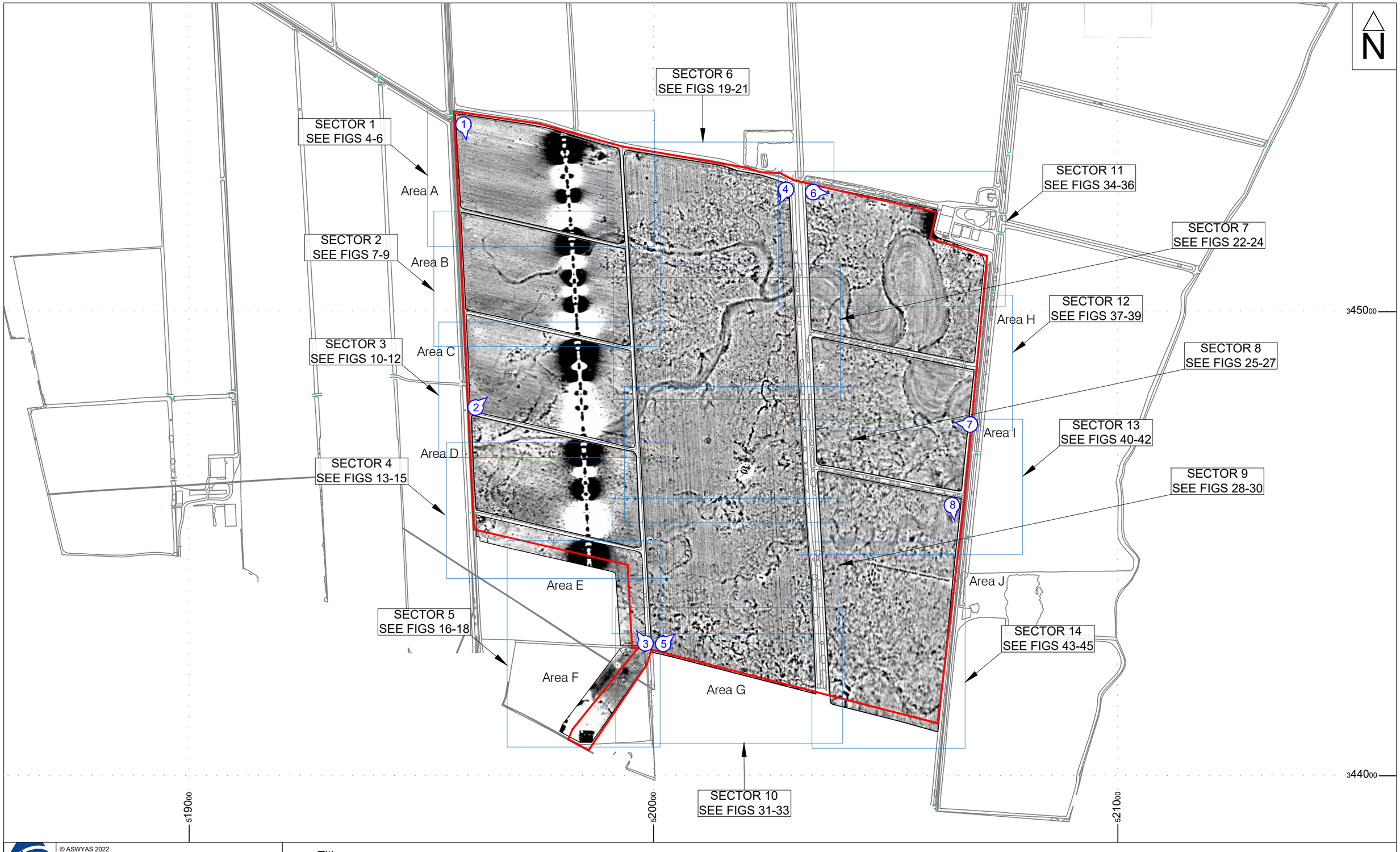


Fig. 1. Site location



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Project ID: XD59_HECS22

Survey location showing processed magnetometer data

Fig. 2

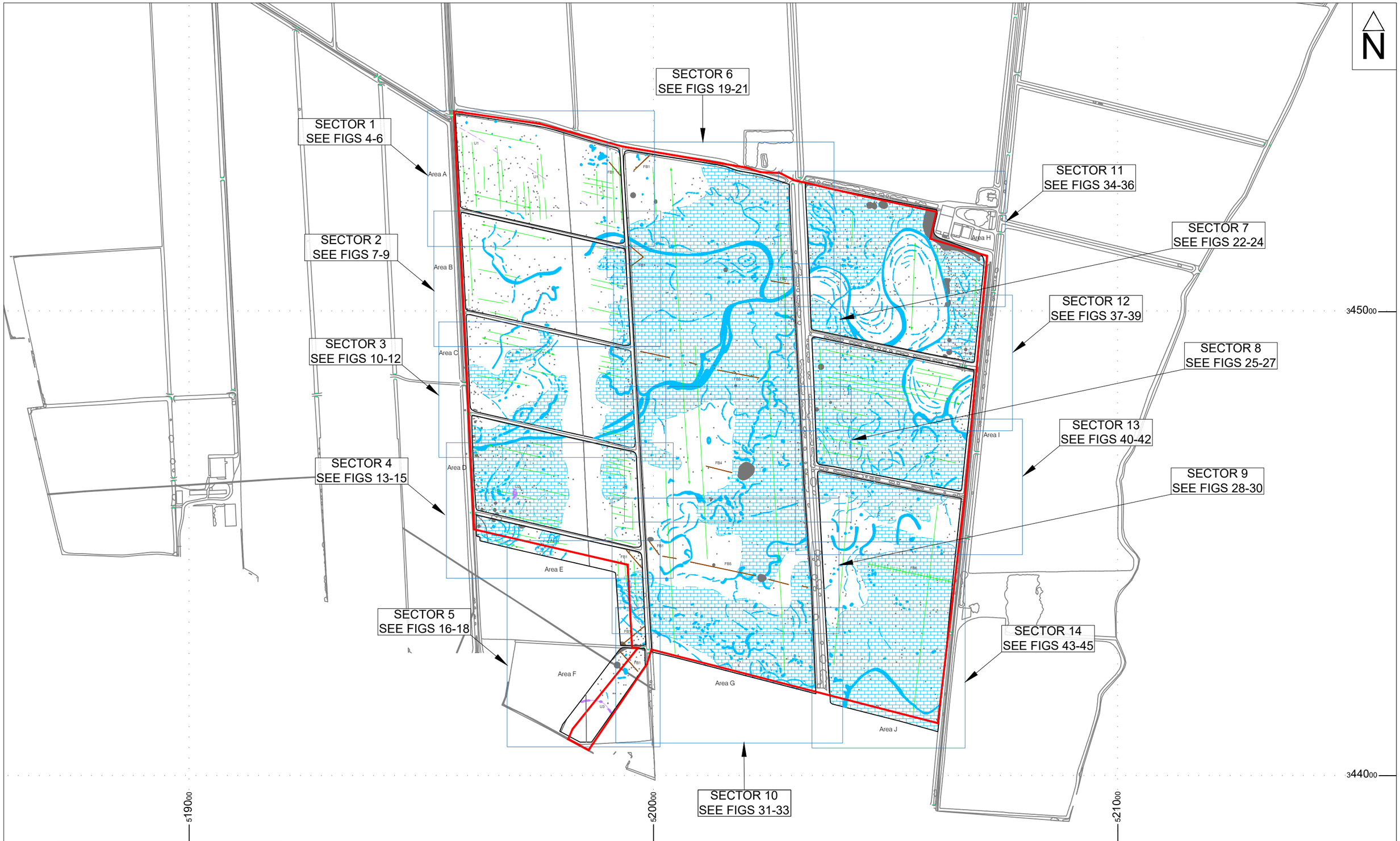
Title

- SURVEY AREA
- SECTOR BOUNDARY
- 1 PHOTO LOCATIONS

nT -1.0 2.0

0 300m

1:7500 @ A3



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Overall interpretation of magnetometer data

Fig. 3

Title

- SURVEY AREA
- SECTOR BOUNDARY

Interpretation

- AGRICULTURE (PLOUGH)
- FIELD DRAIN
- FORMER FIELD BOUNDARY
- UNCERTAIN
- MAGNETIC DISTURBANCE
- FERROUS
- NATURAL/GEOLOGICAL

0 300m

1:7500 @ A3