Heckington Fen Solar Park

ENO10123

Environmental Statement | Volume 3: Technical Appendices
Appendix 10.4: Geophysical Survey Report of Cable Route Corridor

Applicant: Ecotricity (Heck Fen Solar) Limited

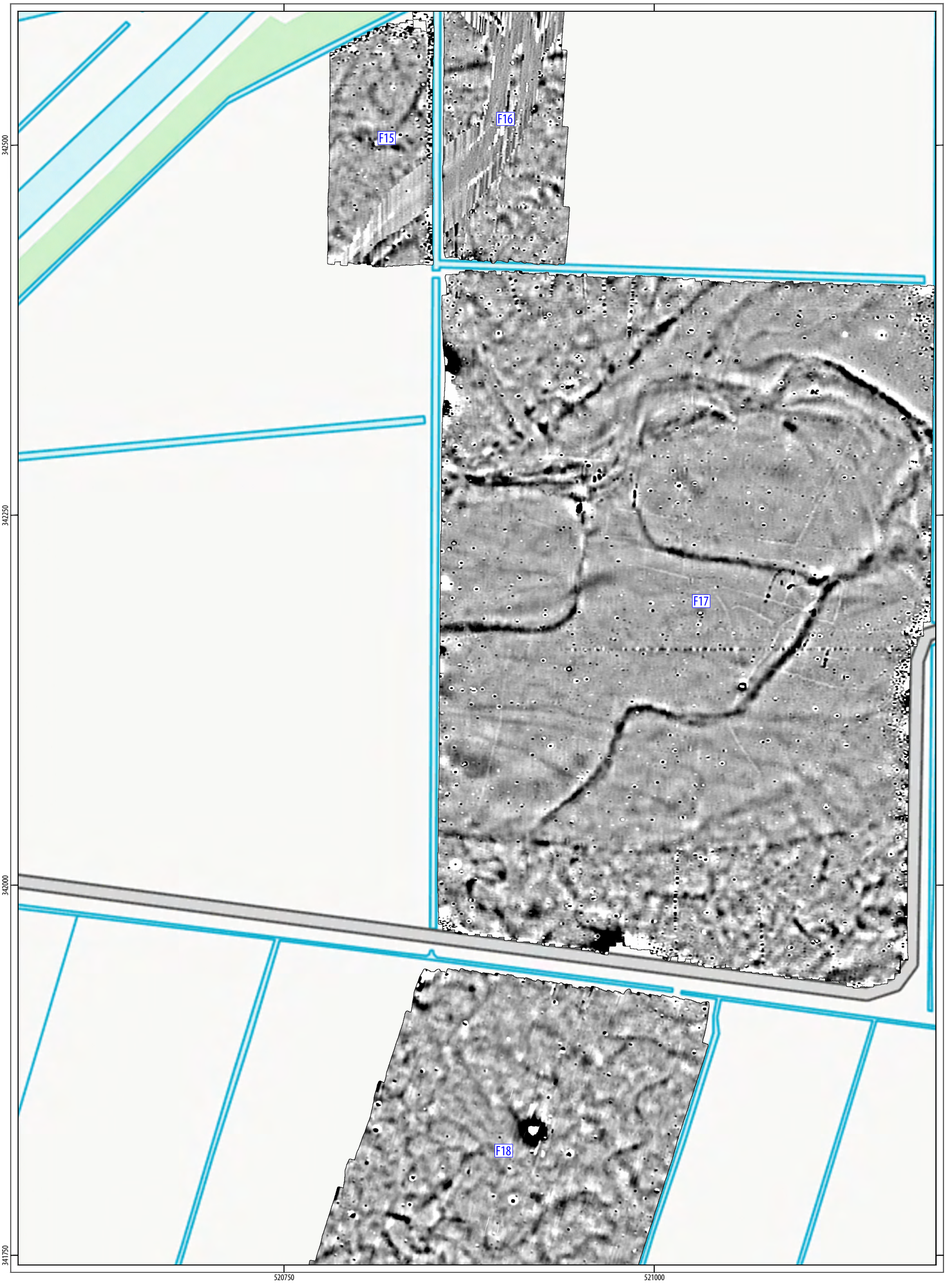
Document Reference: 6.3.10.4
Pursuant to: APFP Regulation 5(2)(a)

February 2023

Planning Act 2008

APPENDIX 10.4 - GEOPHYSICAL SURVEY REPORT OF CABLE ROUTE CORRIDOR

Document Properties		
Regulation Reference	Regulation 5(2)(a)	
Planning Inspectorate Scheme Reference	EN010123	
Application Document Reference	6.3.10.4	
Title	Appendix 10.4 - Geophysical Survey Report of Cable Route Corridor	
Prepared By	Heckington Fen Energy Park Project Team (Headland Archaeology)	
Version History		
Version	**Date**	**Version Status**
Rev 1	February 2023	Application Version



-1.0 nT 2.0

0 50m
1:2,500 @ A3

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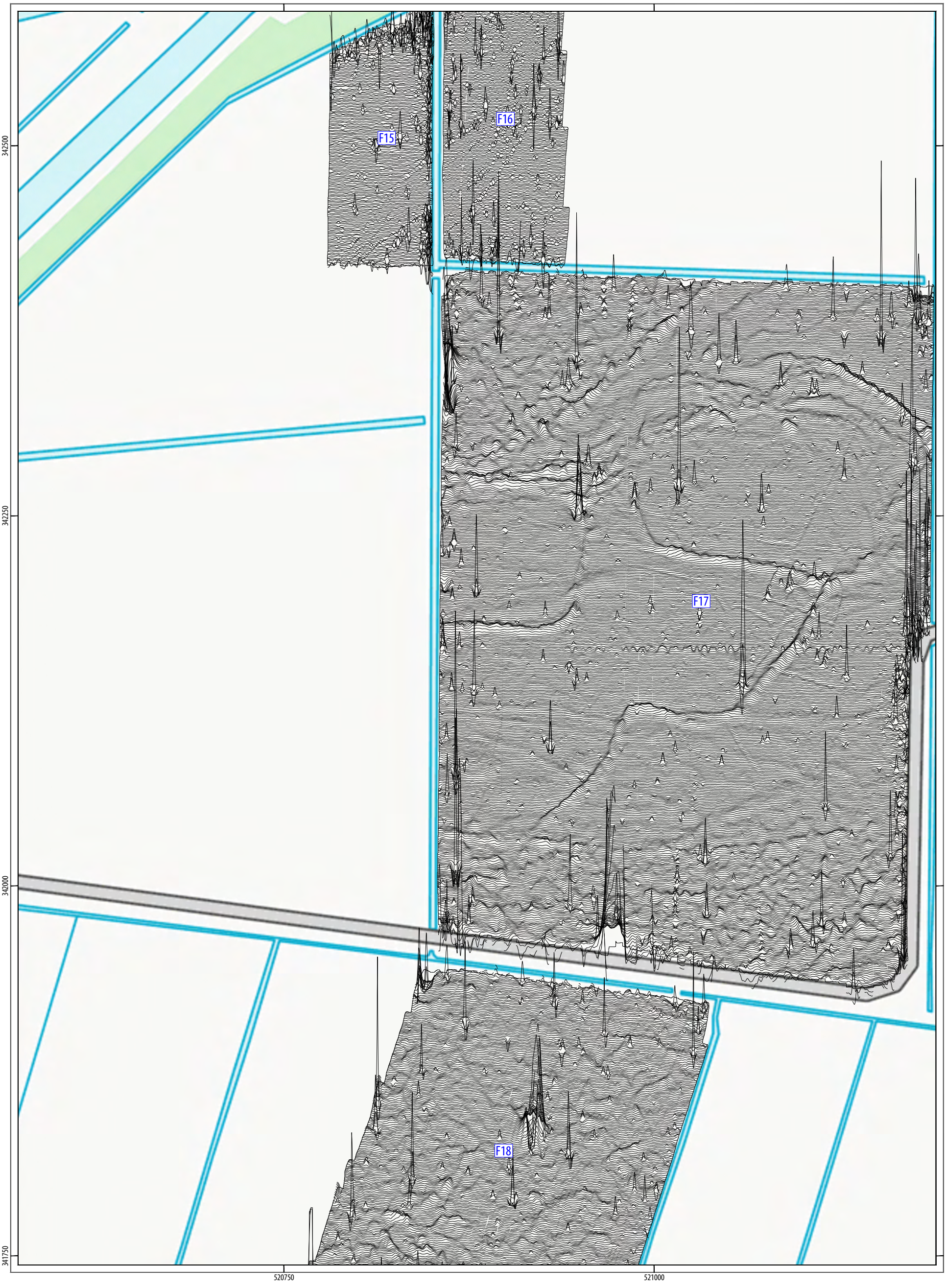
ILLUS 25 Processed greyscale magnetometer data; Sector 6



25.0nT/cm

0 50m

1:2,500 @ A3

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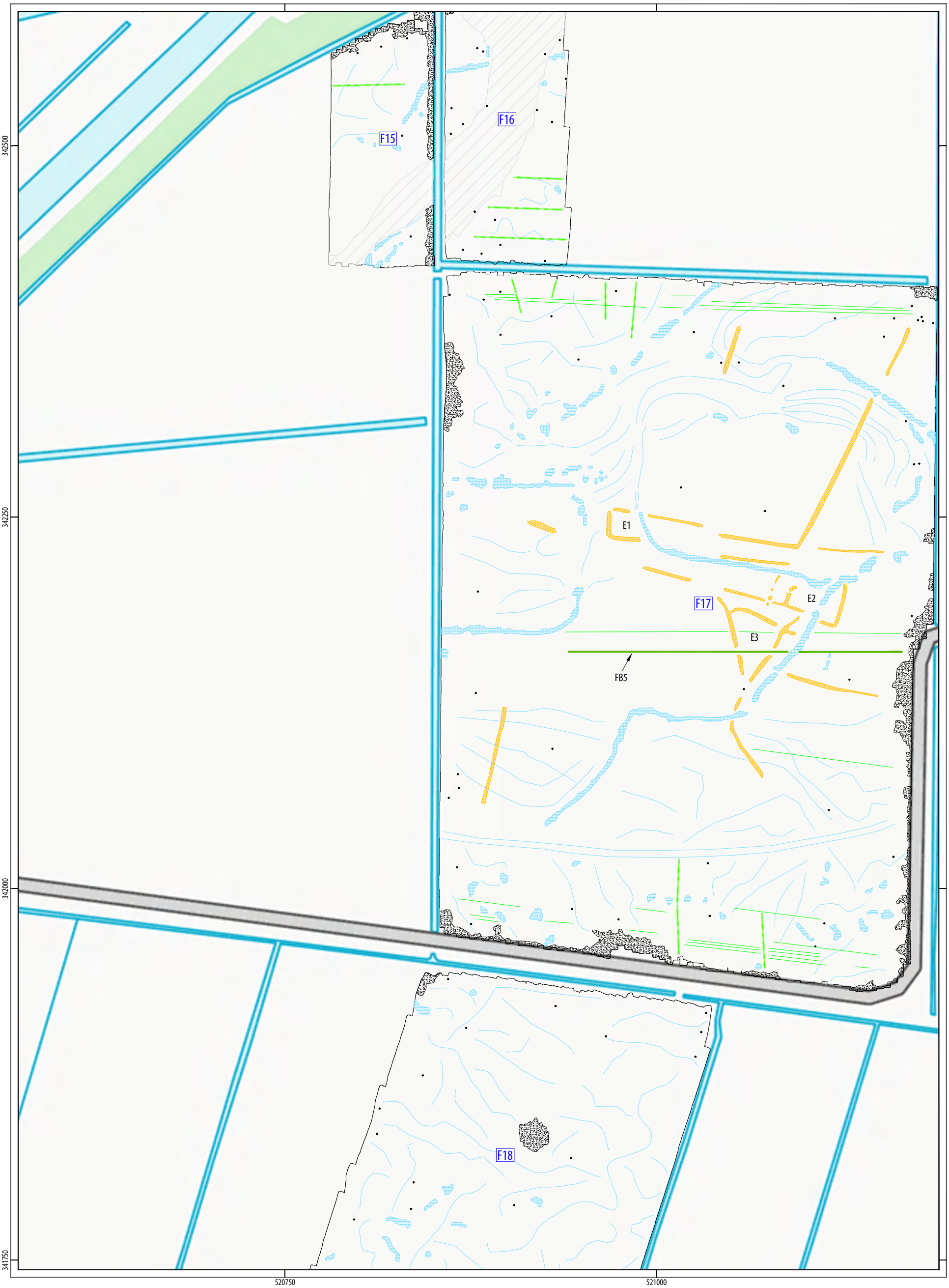
ILLUS 26 XY trace plot of minimally processed magnetometer data; Sector 6



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
null value	buried cables
linear trend	agricultural
linear trend	field drain

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

ABBREVIATIONS

E - enclosure

FB - former boundary

0 50m

1:2,500 @ A3

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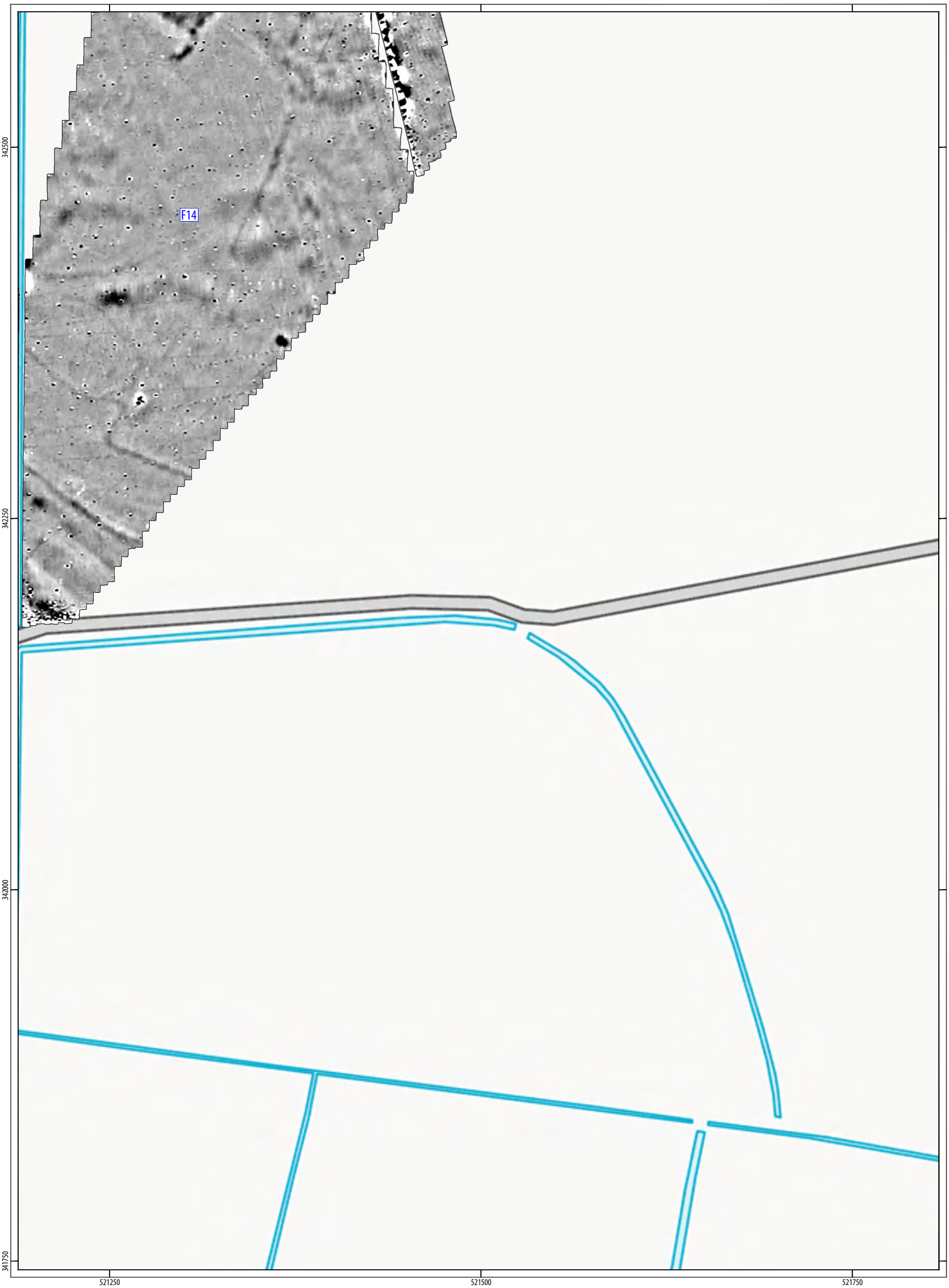
ILLUS 27 Interpretation of magnetometer data; Sector 6



-1.0 nT 2.0

0 50m

1:2,500 @ A3

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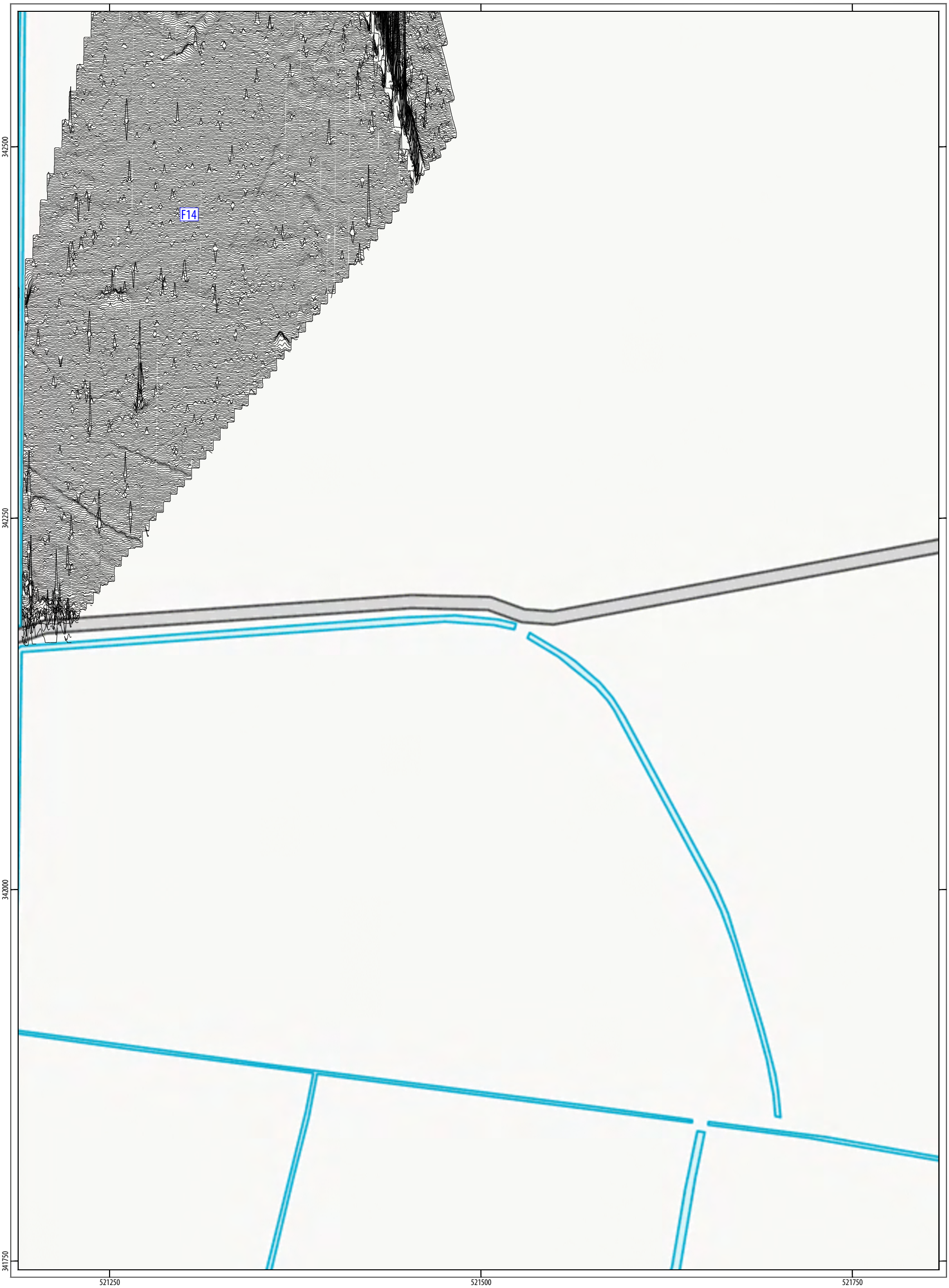
ILLUS 28 Processed greyscale magnetometer data; Sector 7



25.0nT/cm

0 50m

1:2,500 @ A3

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ILLUS 29 XY trace plot of minimally processed magnetometer data; Sector 7

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear trend	agricultural
linear trend	field drain
linear trend	geological variation

TYPE OF ANOMALY	INTERPRETATION
magnetic enhancement	geology

ABBREVIATIONS

SP - service pipe

0 50m

1:2,500 @ A3

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ILLUS 30 Interpretation of magnetometer data; Sector 7

F18

F19

F20

F21

341500

341250

341000

520500

520750

521000

Wes

Gro

-1.0 nT 2.0

0 50m

1:2,500 @ A3

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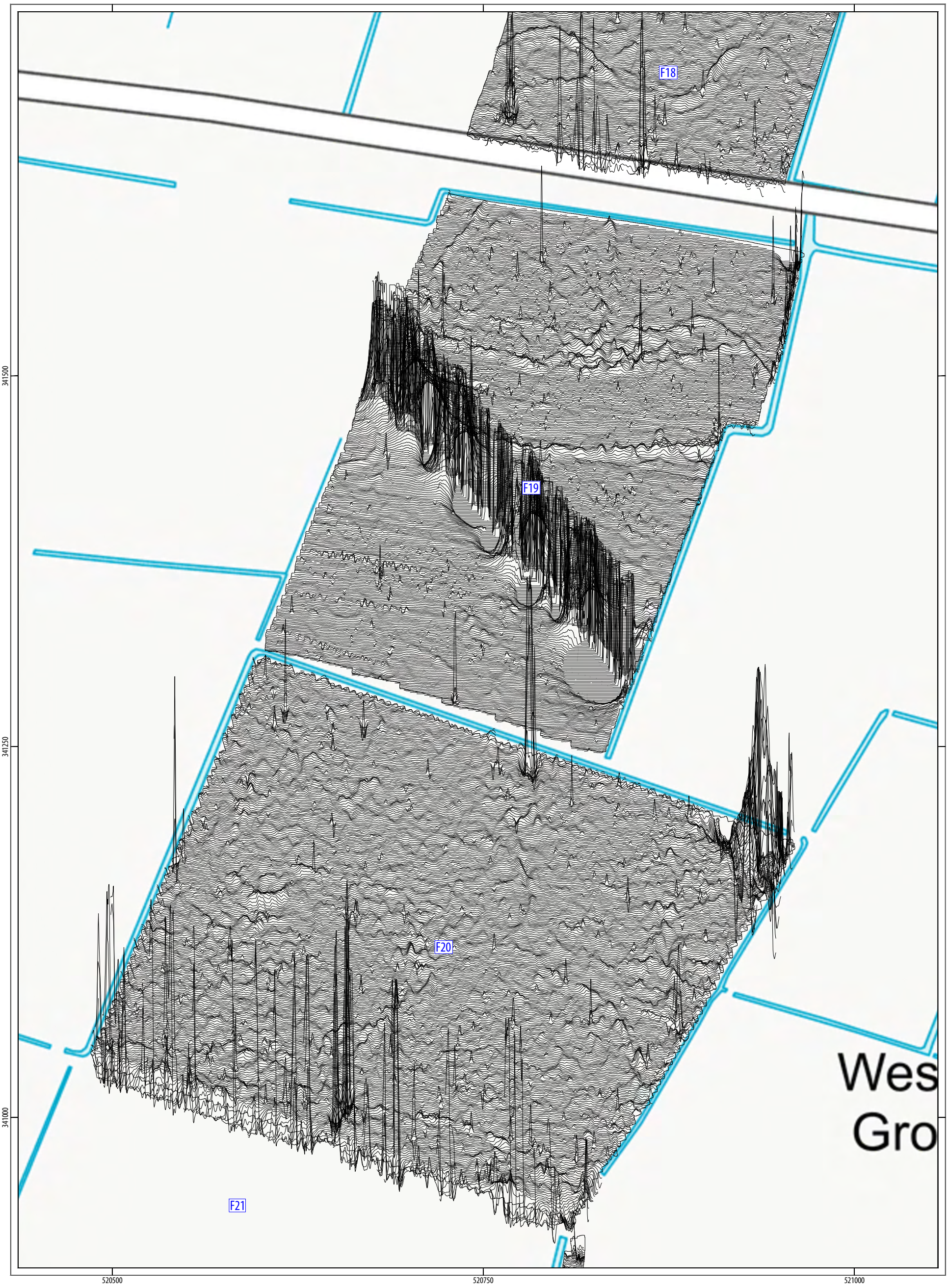
ILLUS 31 Processed greyscale magnetometer data; Sector 7



25.0nT/cm

0 50m

1:2,500 @ A3

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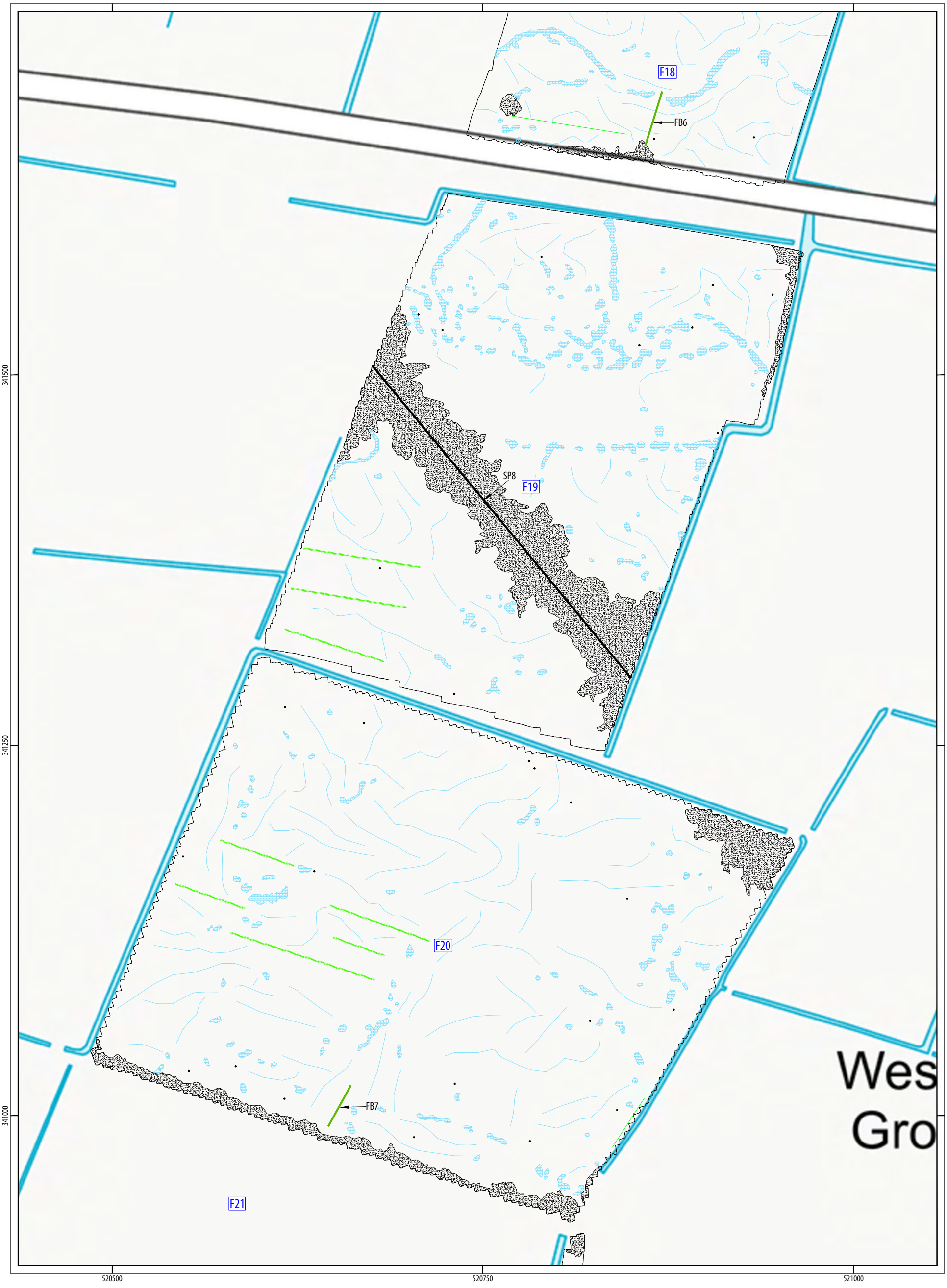
ILLUS 32 XY trace plot of minimally processed magnetometer data; Sector 7



TYPE OF ANOMALY	INTERPRETATION	TYPE OF ANOMALY	INTERPRETATION	ABBREVIATIONS
dipolar isolated	ferrous material	linear trend	geological variation	FB - former boundary
magnetic disturbance	ferrous material	magnetic enhancement	geology	SP - service pipe
dipolar linear	service pipe			
linear trend	agricultural			
linear trend	field drain			
linear	former field boundary			

0 50m
1:2,500 @ A3

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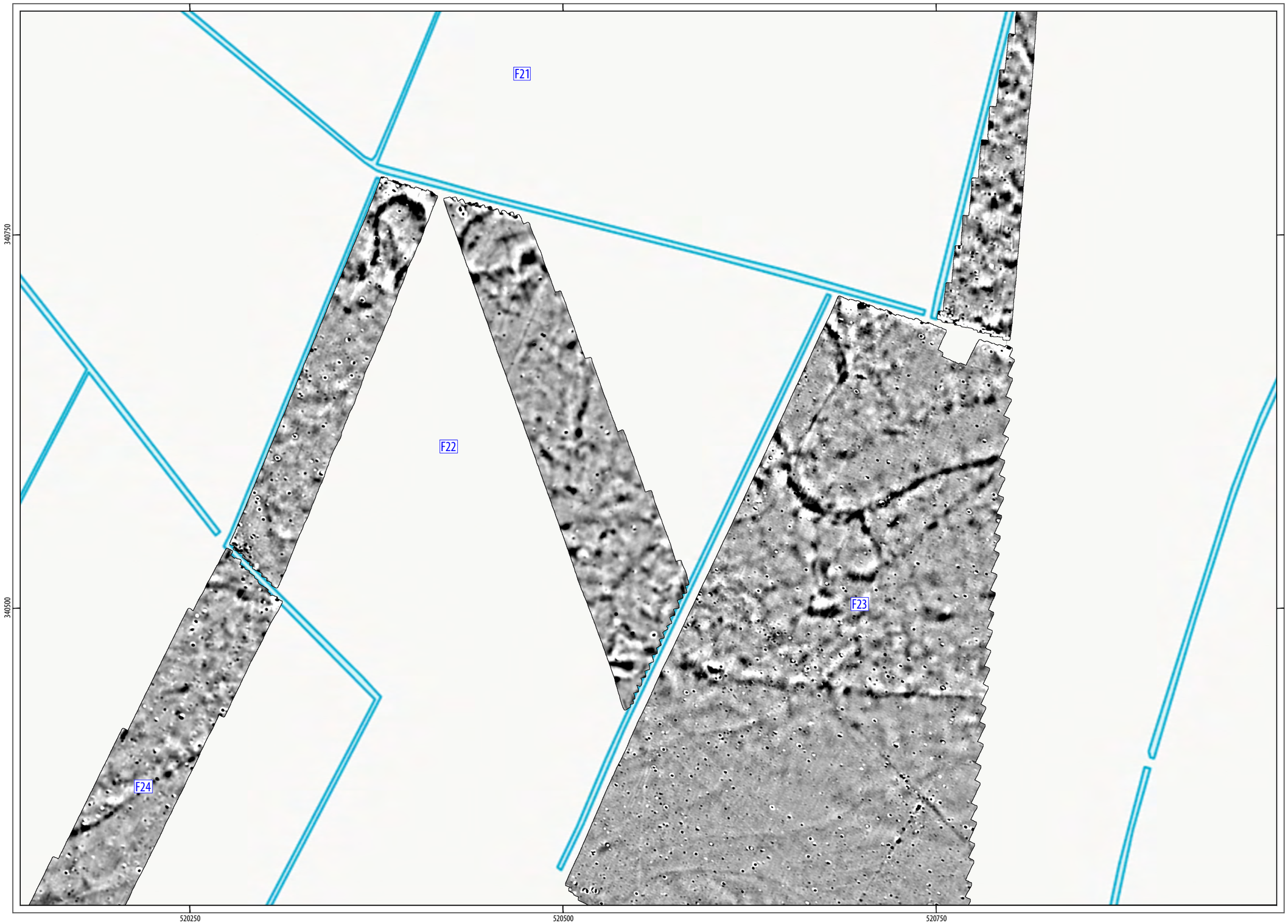
ILLUS 33 Interpretation of magnetometer data; Sector 7



nT
-1.0 2.0

0 50m
1:2,500 @ A3

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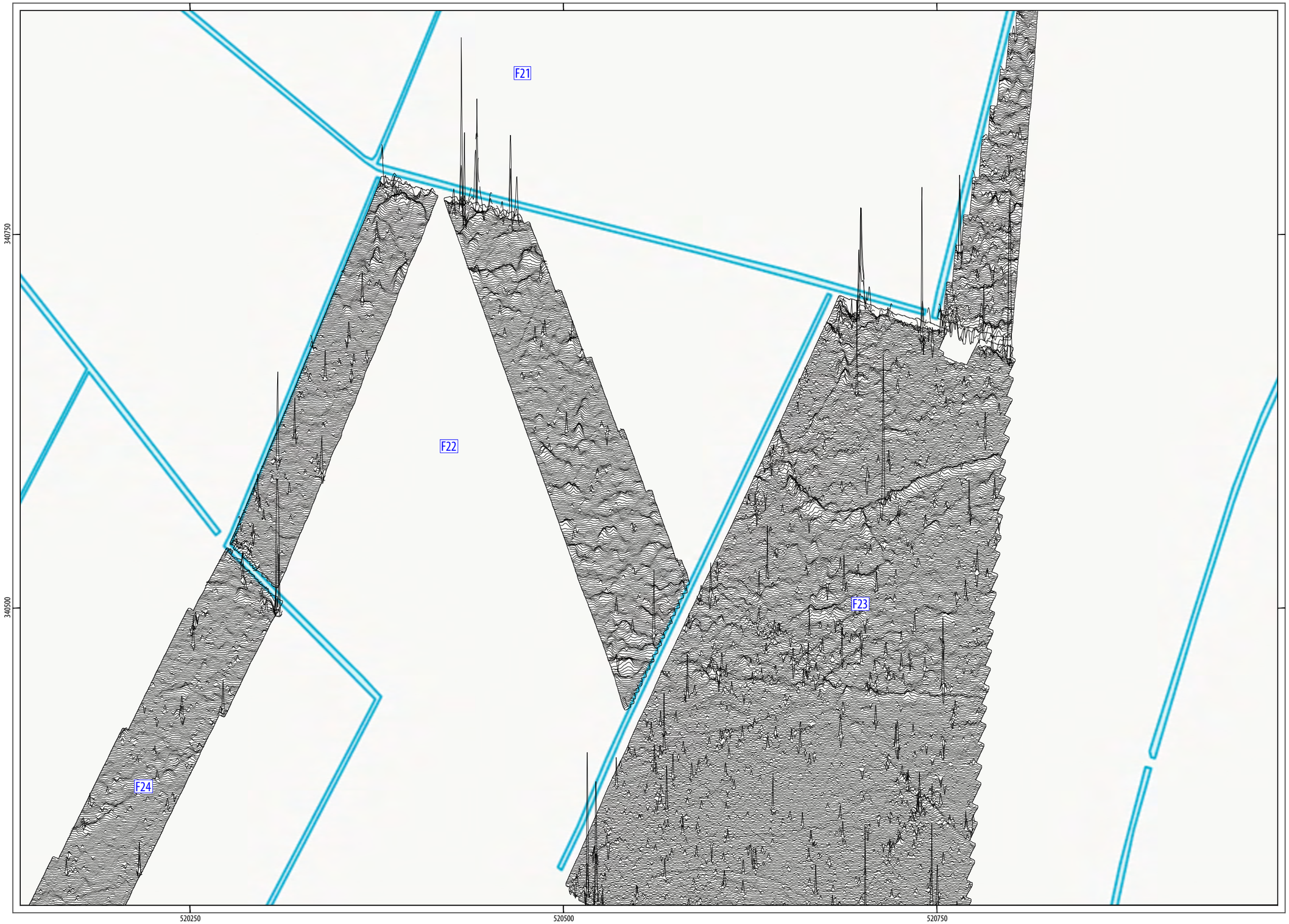
ILLUS 34 Processed greyscale magnetometer data; Sector 8



25.0nT/cm

0 50m

1:2,500 @ A3

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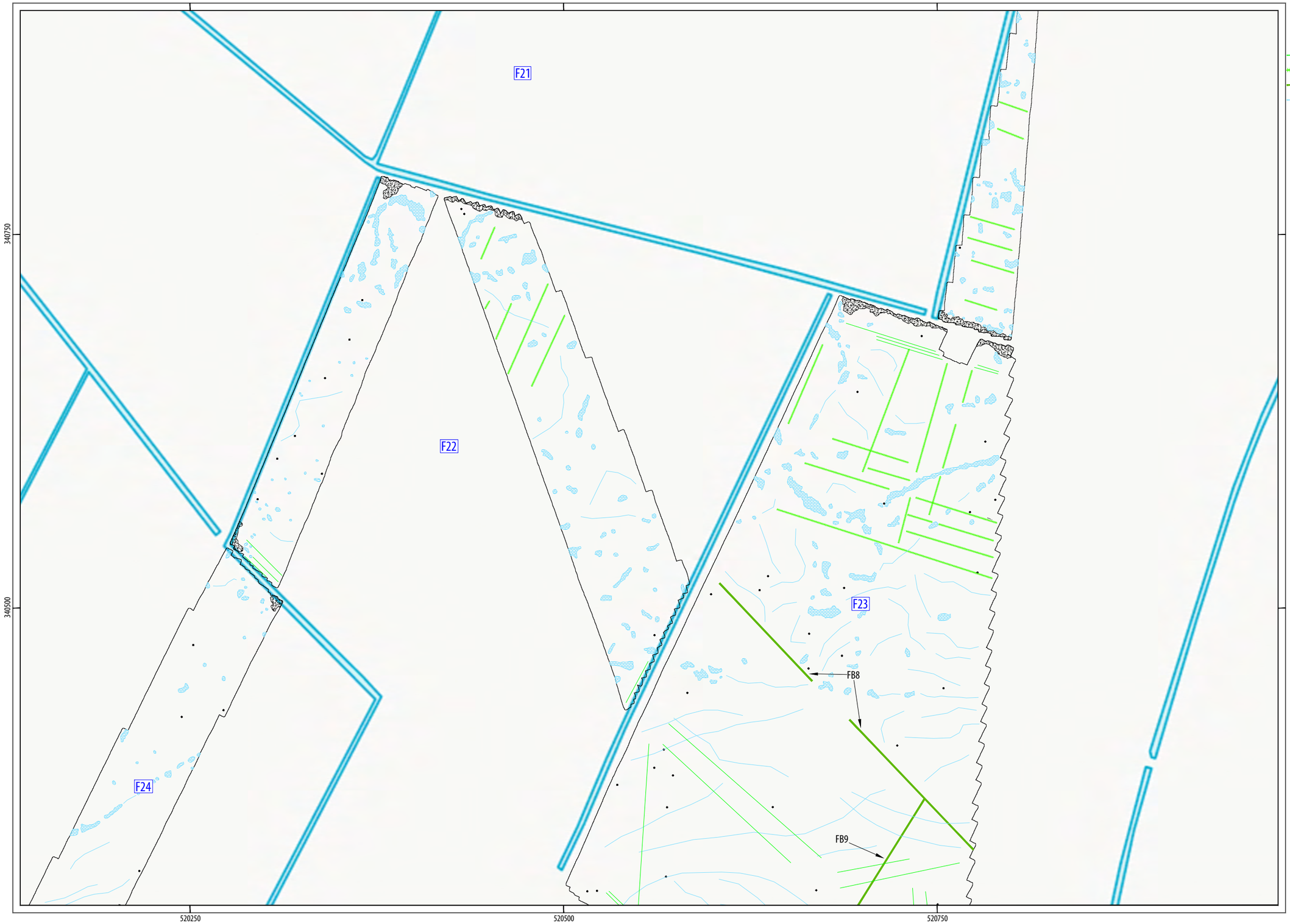
ILLUS 35 XY trace plot of minimally processed magnetometer data; Sector 8



TYPE OF ANOMALY | INTERPRETATION

- dipolar isolated | ferrous material
- magnetic disturbance | ferrous material
- linear trend | agricultural
- linear trend | field drain
- linear | former field boundary
- linear trend | geological variation
- magnetic enhancement | geology

ABBREVIATIONS

FB - former boundary

0 50m

1:2,500 @ A3

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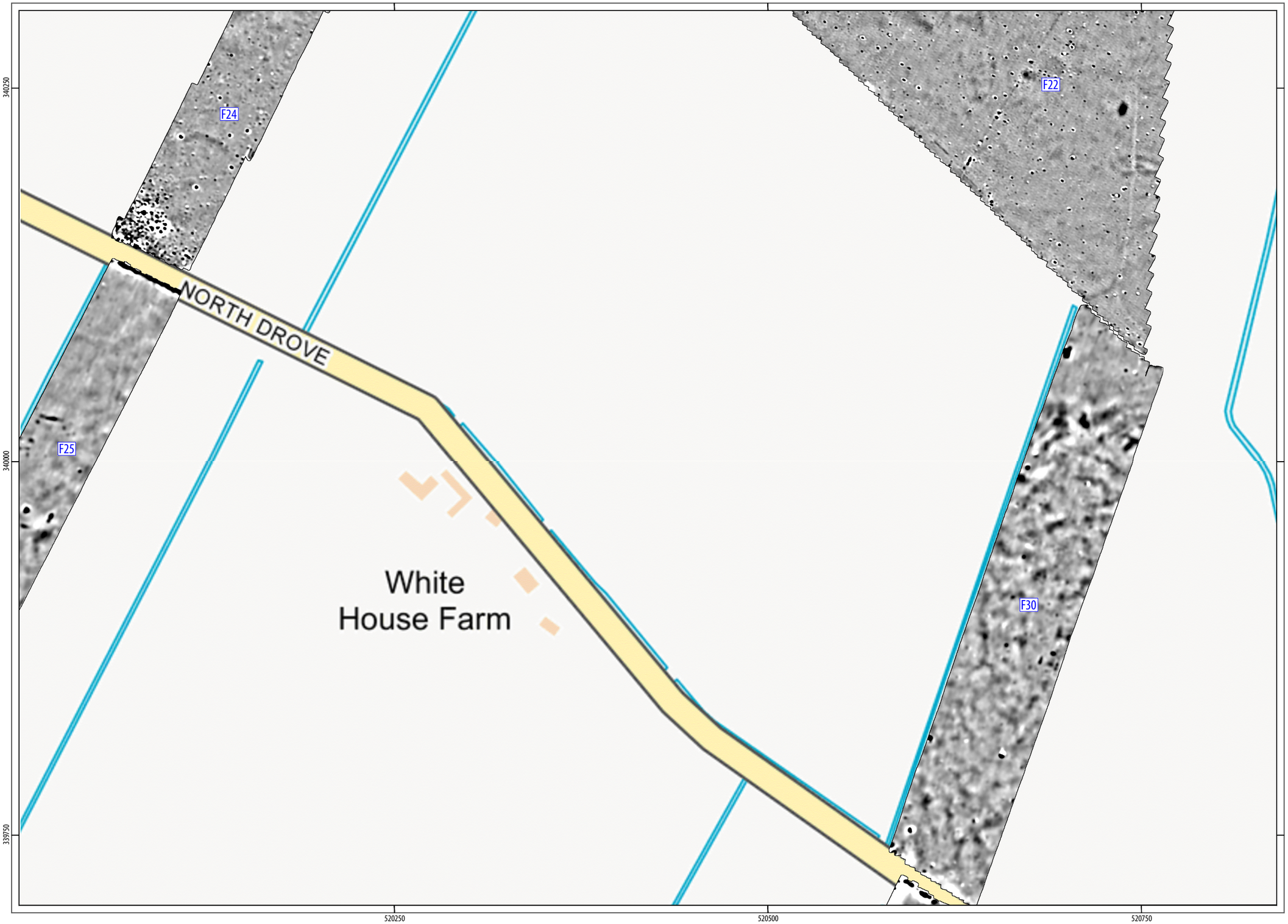
ILLUS 36 Interpretation of magnetometer data; Sector 8



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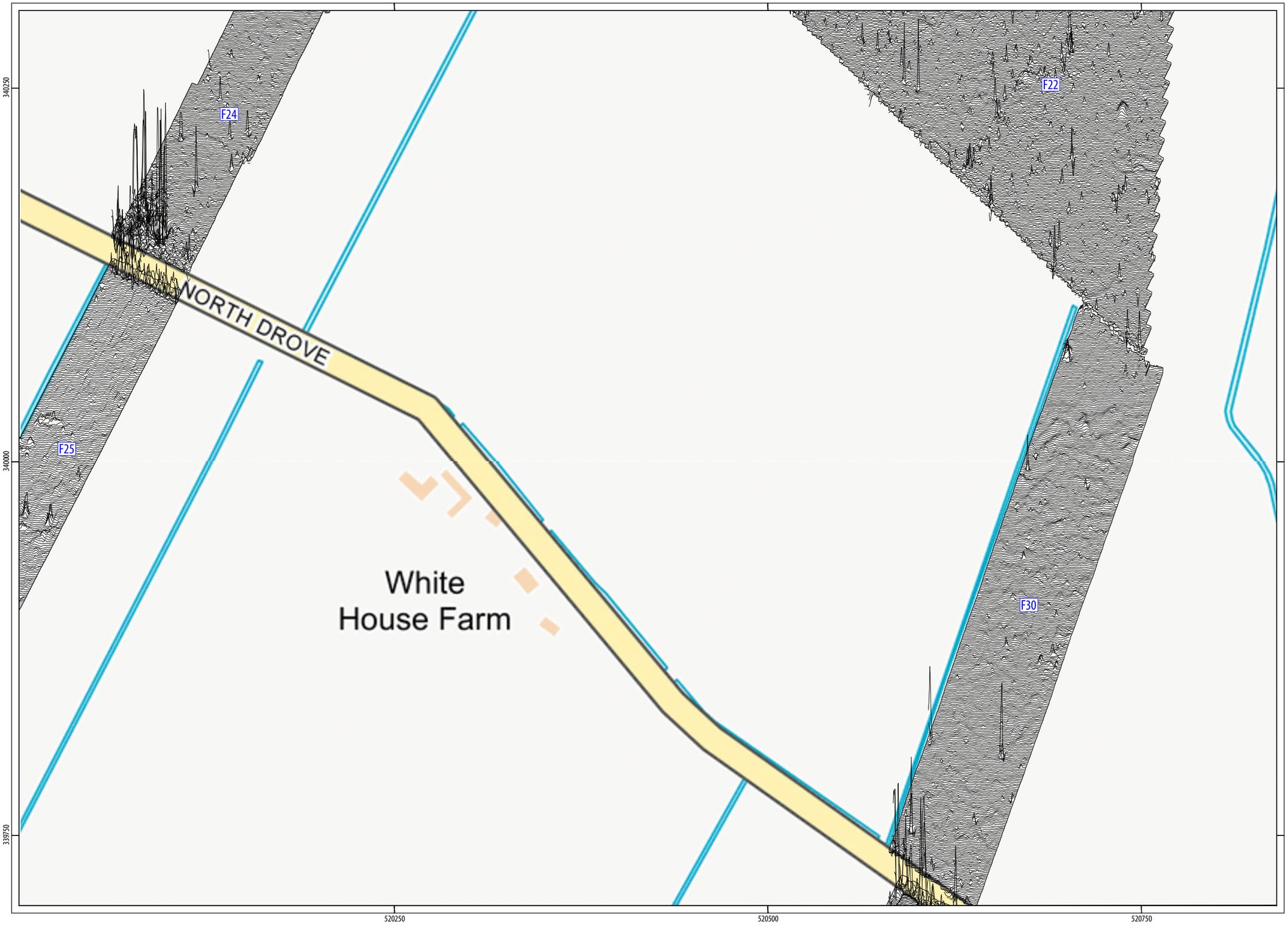
ILLUS 37 Processed greyscale magnetometer data; Sector 9



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ILLUS 38 XY trace plot of minimally processed magnetometer data; Sector 9

TYPE OF ANOMALY / INTERPRETATION

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	agricultural
linear	former field boundary
linear trend	geological variation
magnetic enhancement	geology

ABBREVIATIONS

FB - former boundary

0 50m

1:2,500 @ A3

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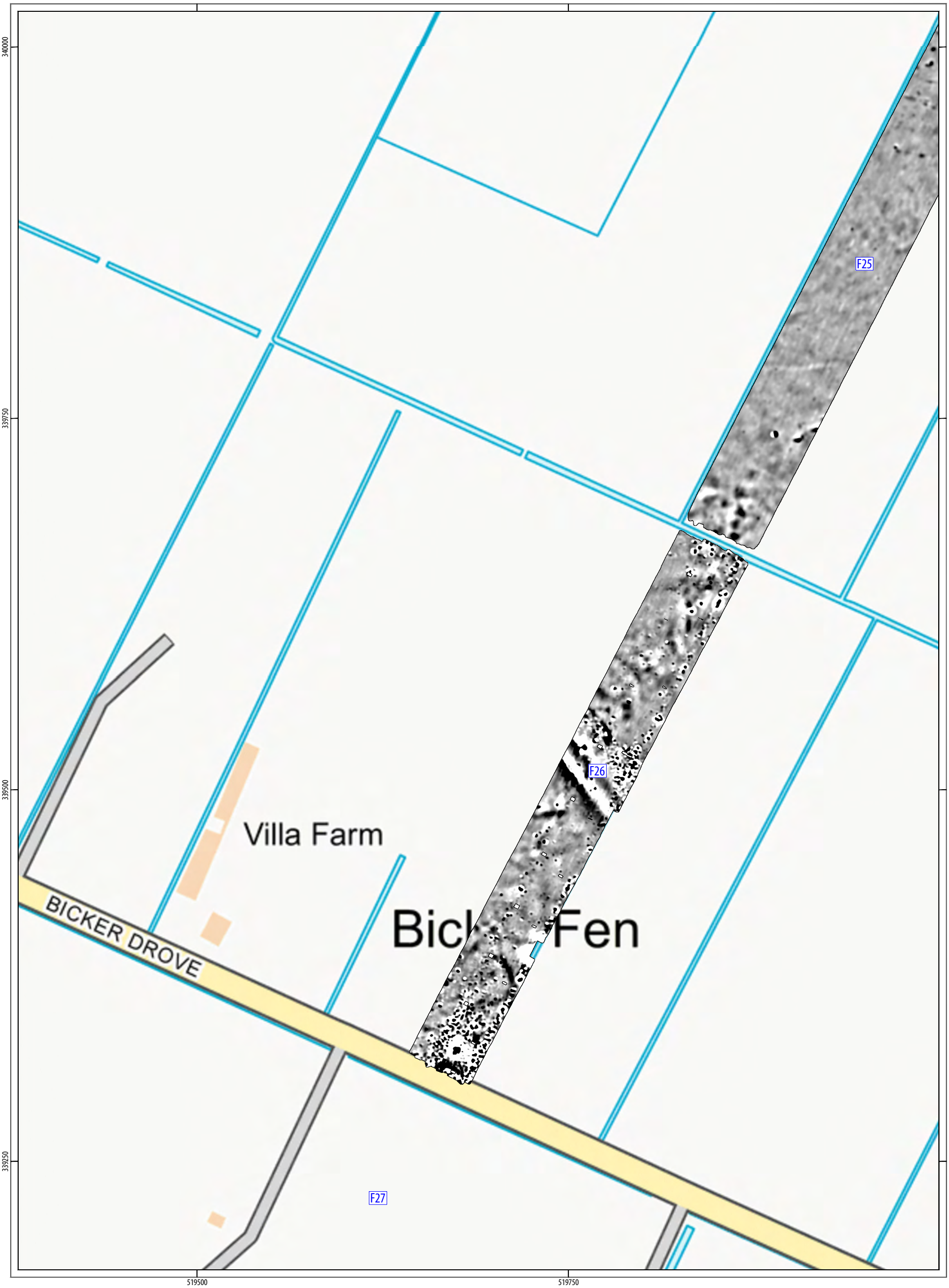
ILLUS 39 Interpretation of magnetometer data; Sector 9



nT
-1.0
2.0

0
50m
1:2,500 @ A3

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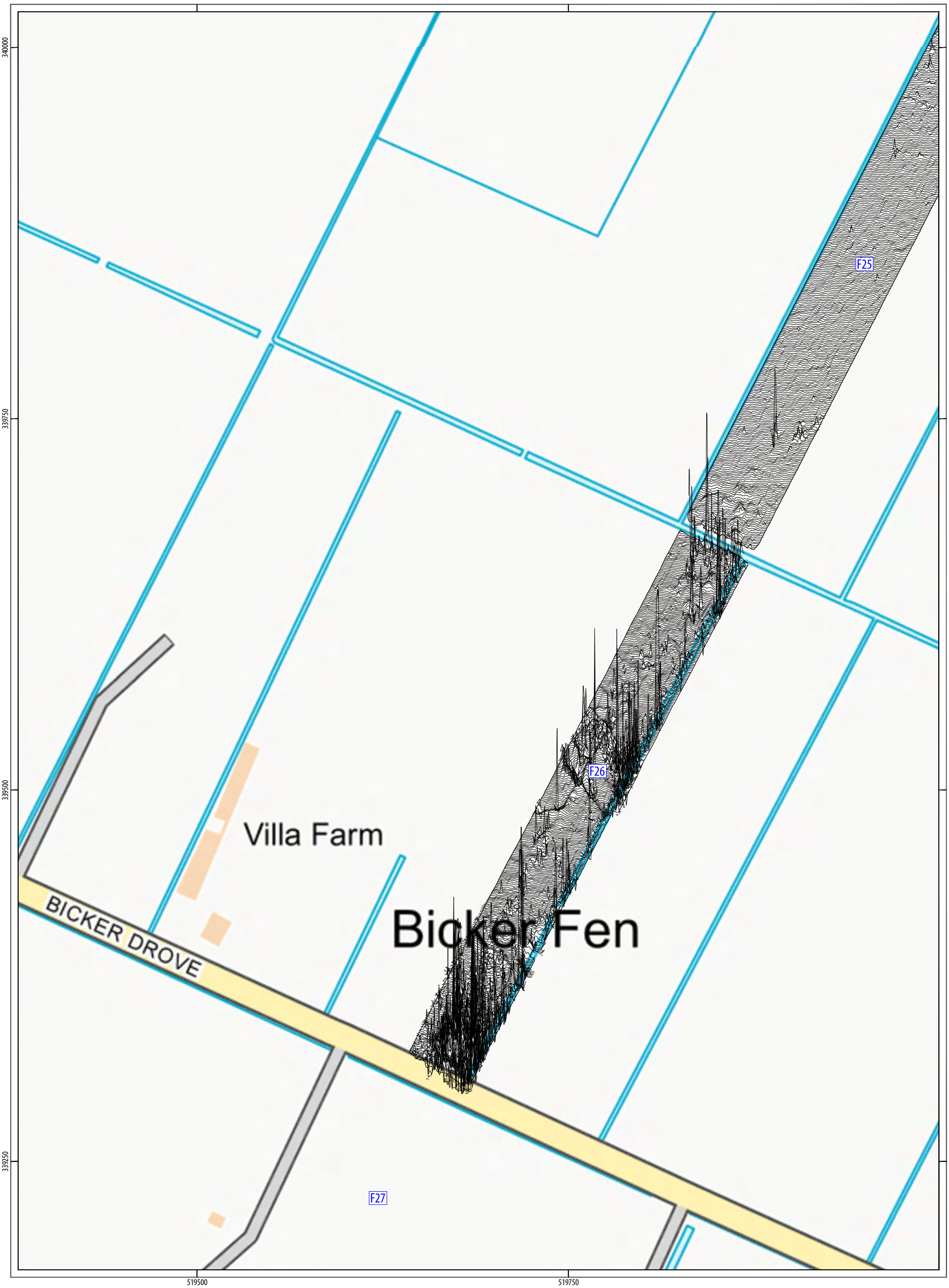
ILLUS 40 Processed greyscale magnetometer data; Sector 10



25.0nT/cm

0 50m

1:2,500 @ A3

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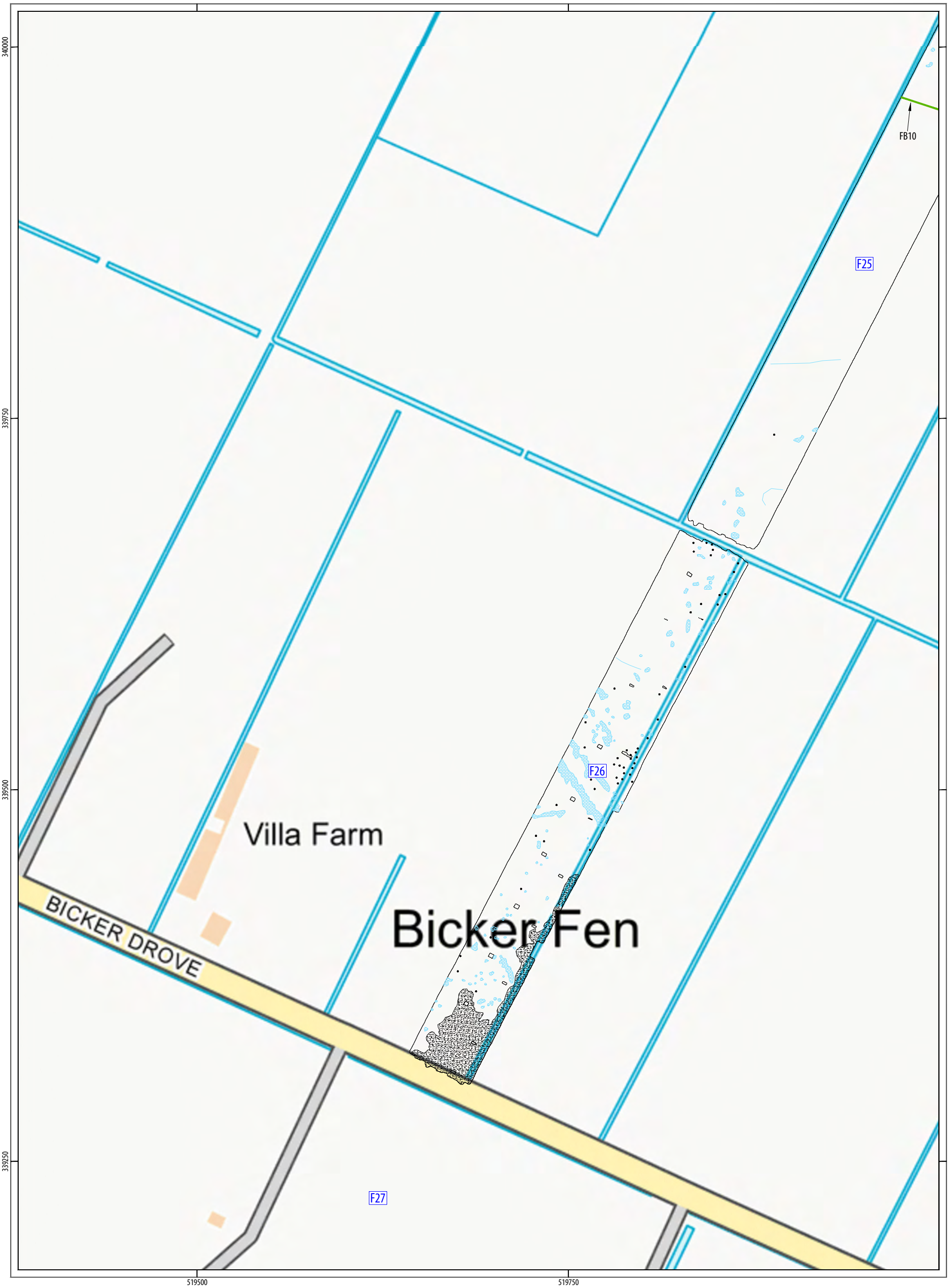
ILLUS 41 XY trace plot of minimally processed magnetometer data; Sector 10



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	agricultural
linear trend	field drain
linear	former field boundary
linear trend	geological variation

TYPE OF ANOMALY	INTERPRETATION
magnetic enhancement	geology

ABBREVIATIONS

FB - former boundary

0 50m

1:2,500 @ A3

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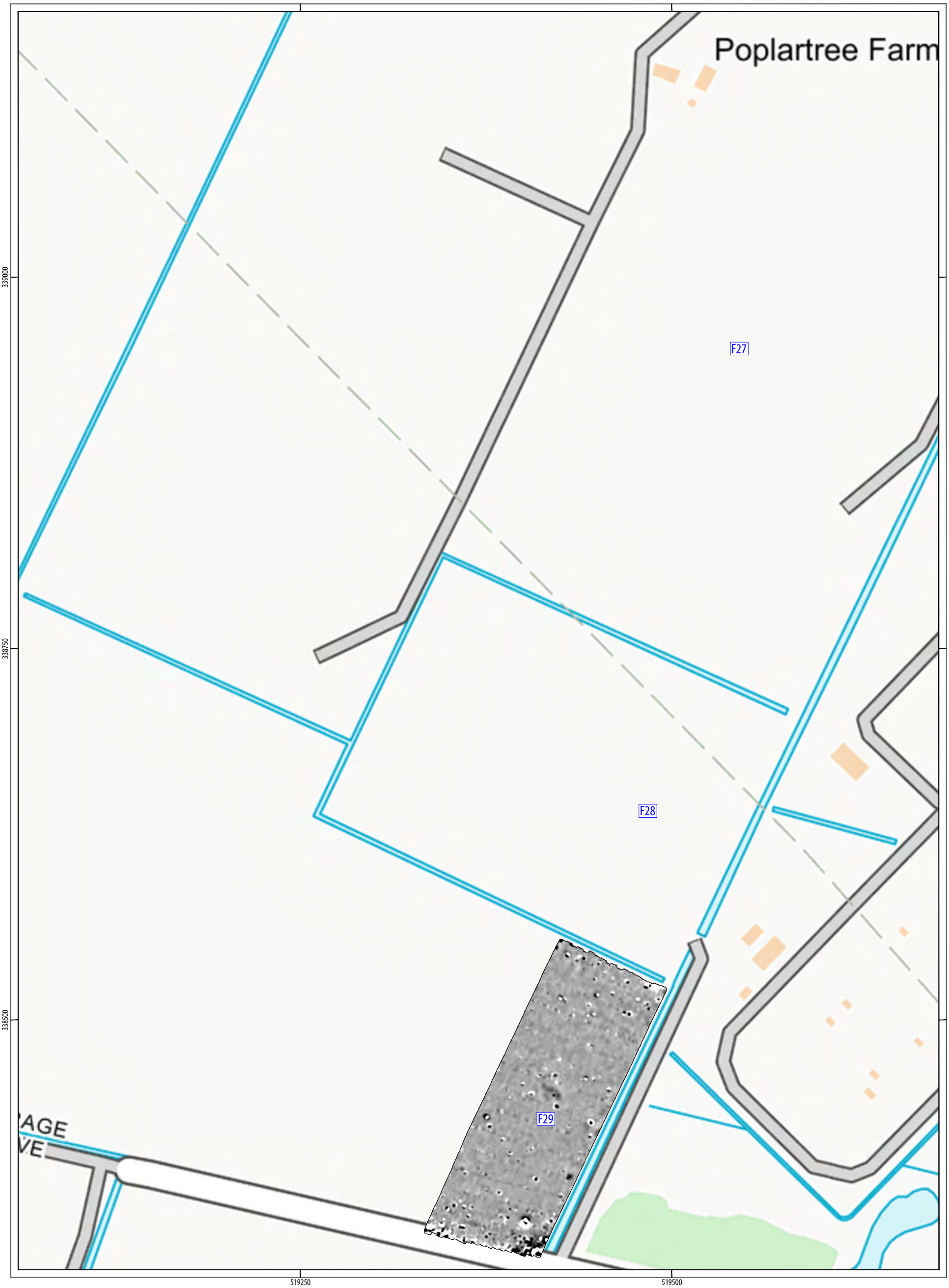
ILLUS 42 Interpretation of magnetometer data; Sector 10



-1.0 nT 2.0

0 50m

1:2,500 @ A3

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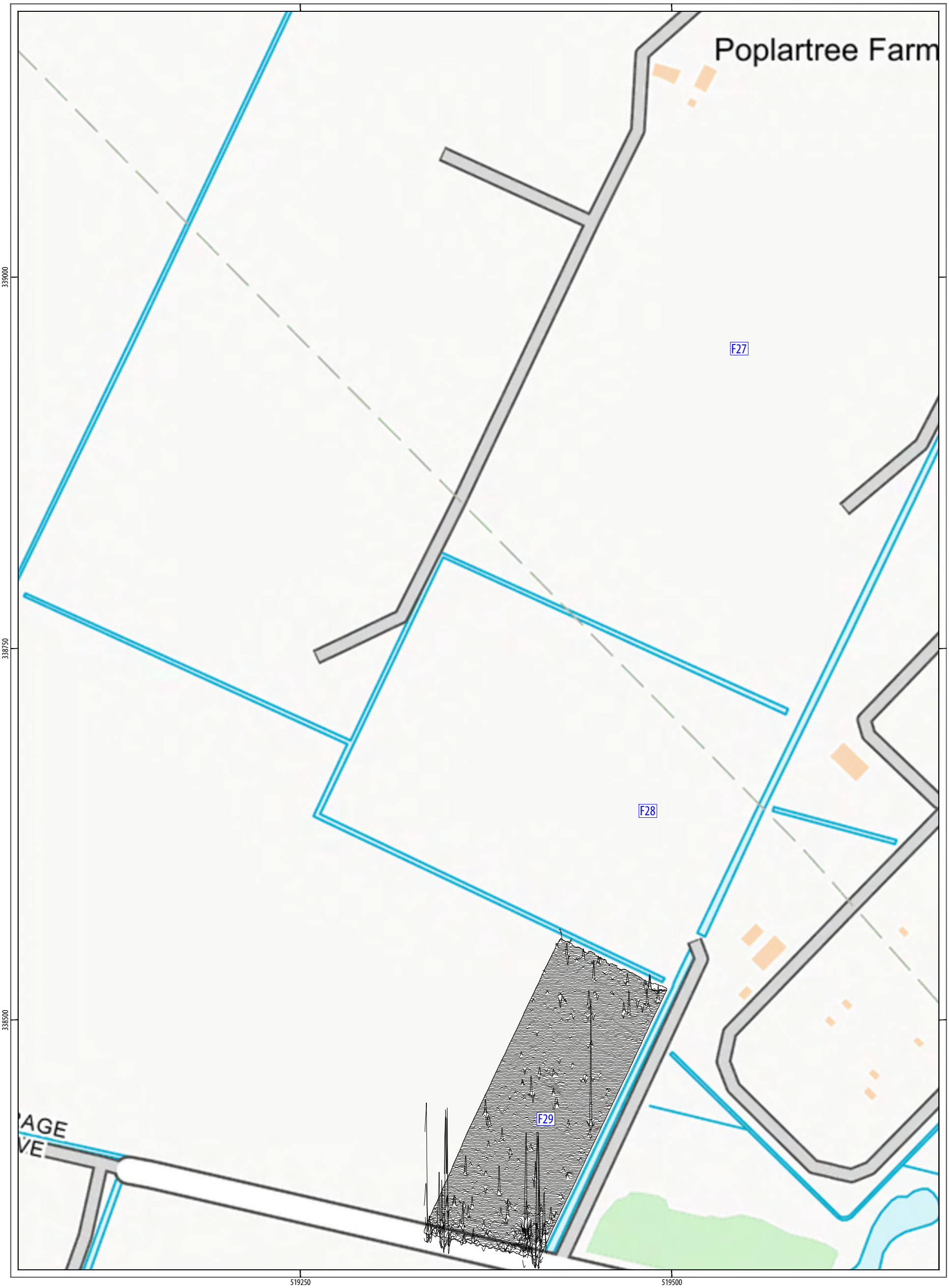
ILLUS 43 Processed greyscale magnetometer data; Sector 11



25.0nT/cm

0 50m

1:2,500 @ A3

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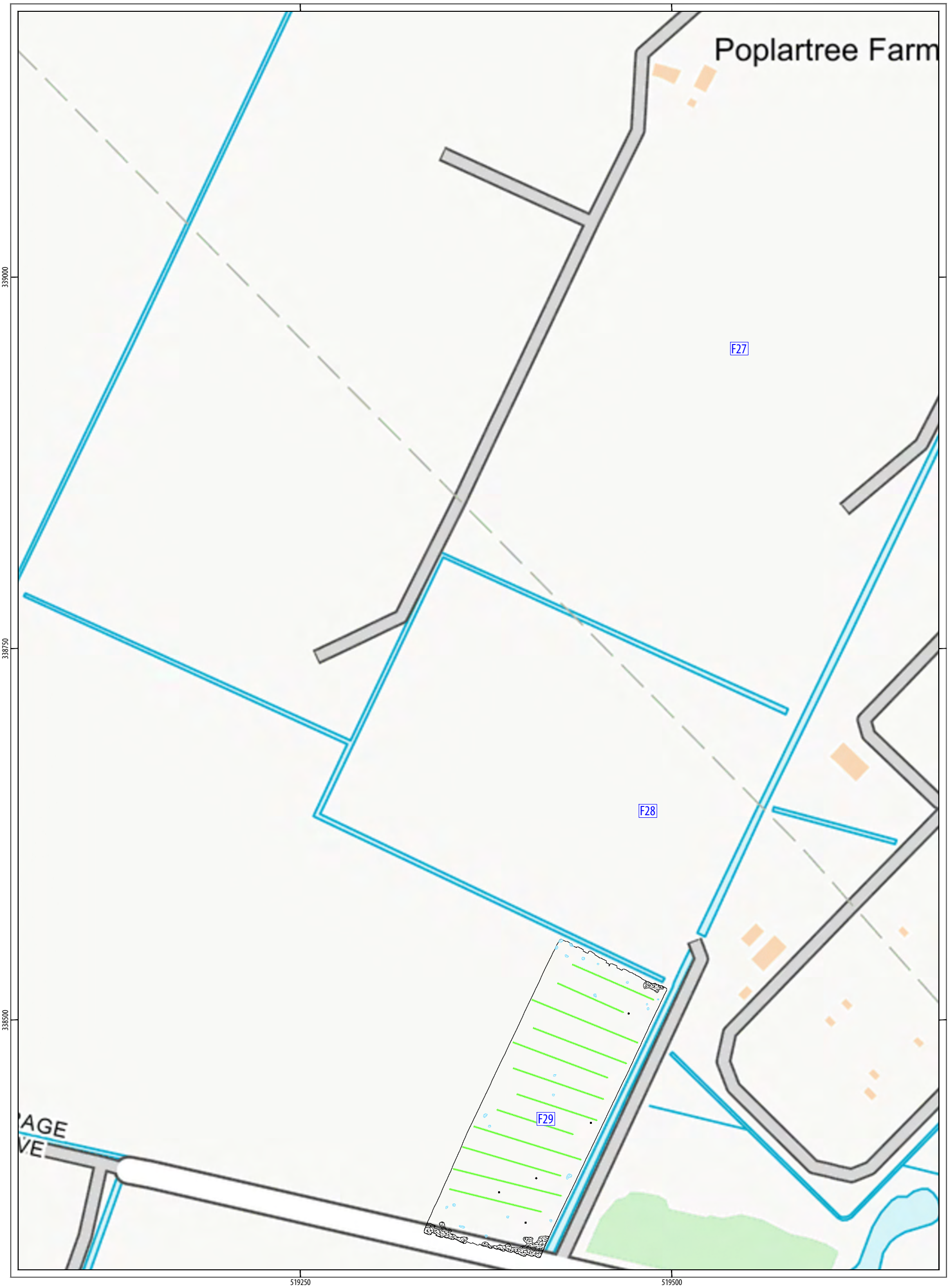
ILLUS 44 XY trace plot of minimally processed magnetometer data; Sector 11



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	field drain
linear trend	geological variation
magnetic enhancement	geology

0 50m
1:2,500 @ A3

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ILLUS 45 Interpretation of magnetometer data; Sector 11

339500
339250
339000
520250
520500
NORTH
F31
F32
F33
BICKER DROVE
ICARAGE DROVE
nT
-1.0
2.0
0
50m
1:2,500 @ A3
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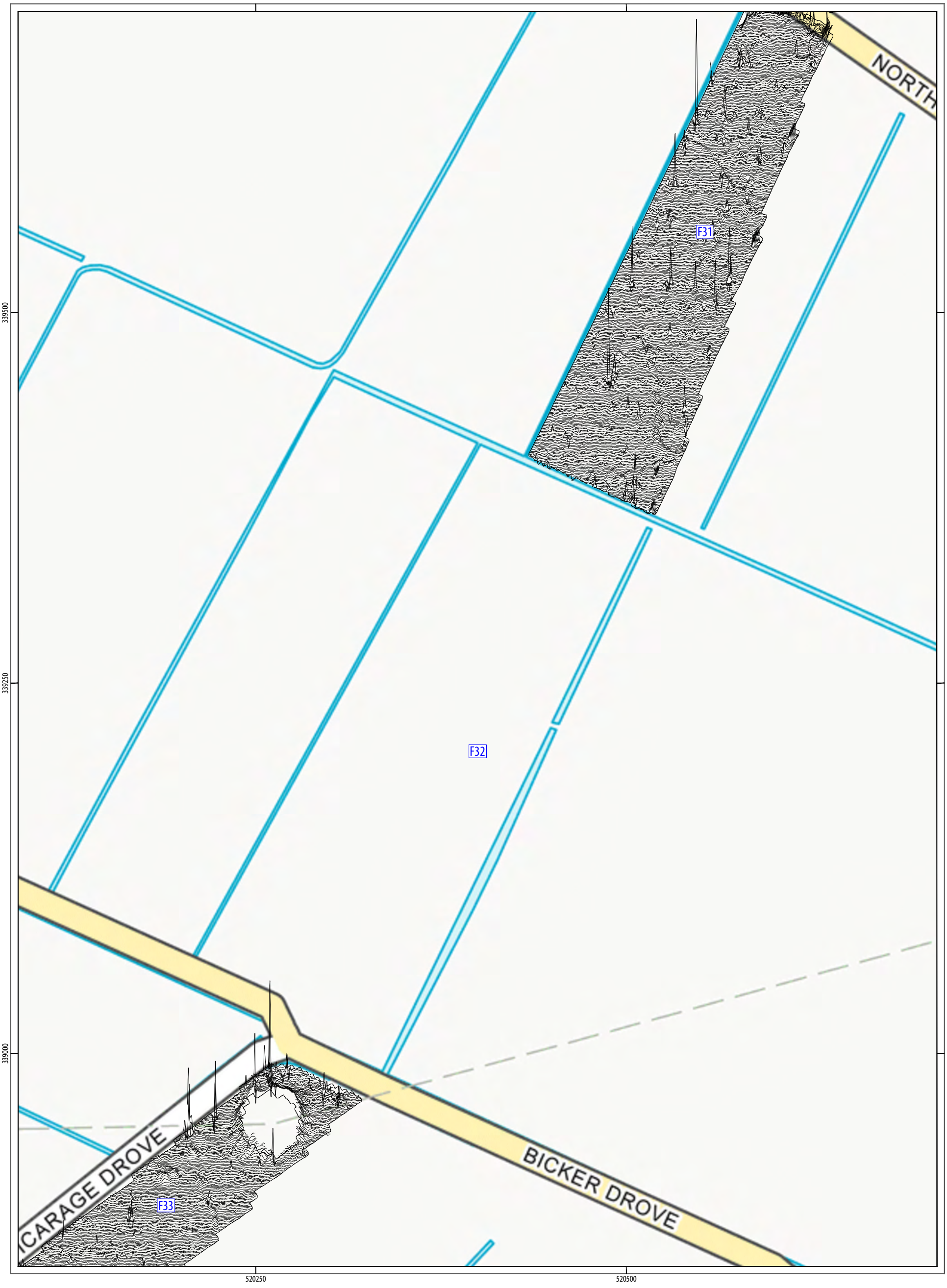
ILLUS 46 Processed greyscale magnetometer data; Sector 12



25.0nT/cm

0 50m

1:2,500 @ A3

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ILLUS 47 XY trace plot of minimally processed magnetometer data; Sector 12

339500

339250

339000

520250

520500

NORTH

F31

F32

F33

BICKER DROVE

CARAGE DROVE

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	agricultural
linear trend	geological variation
magnetic enhancement	geology

0 50m

1:2,500 @ A3

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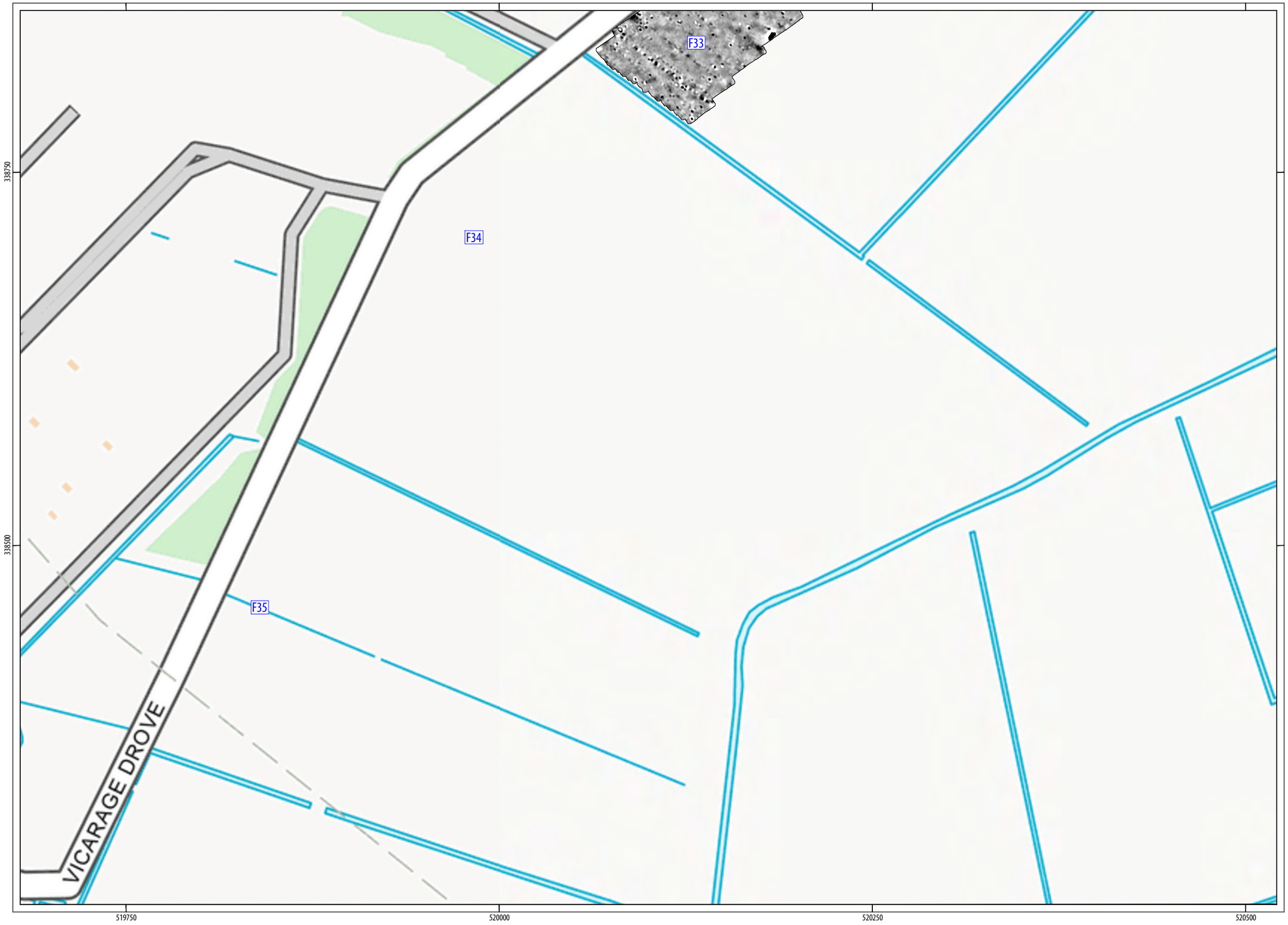
ILLUS 48 Interpretation of magnetometer data; Sector 12



-1.0 nT 2.0

0 50m
1:2,500 @ A3

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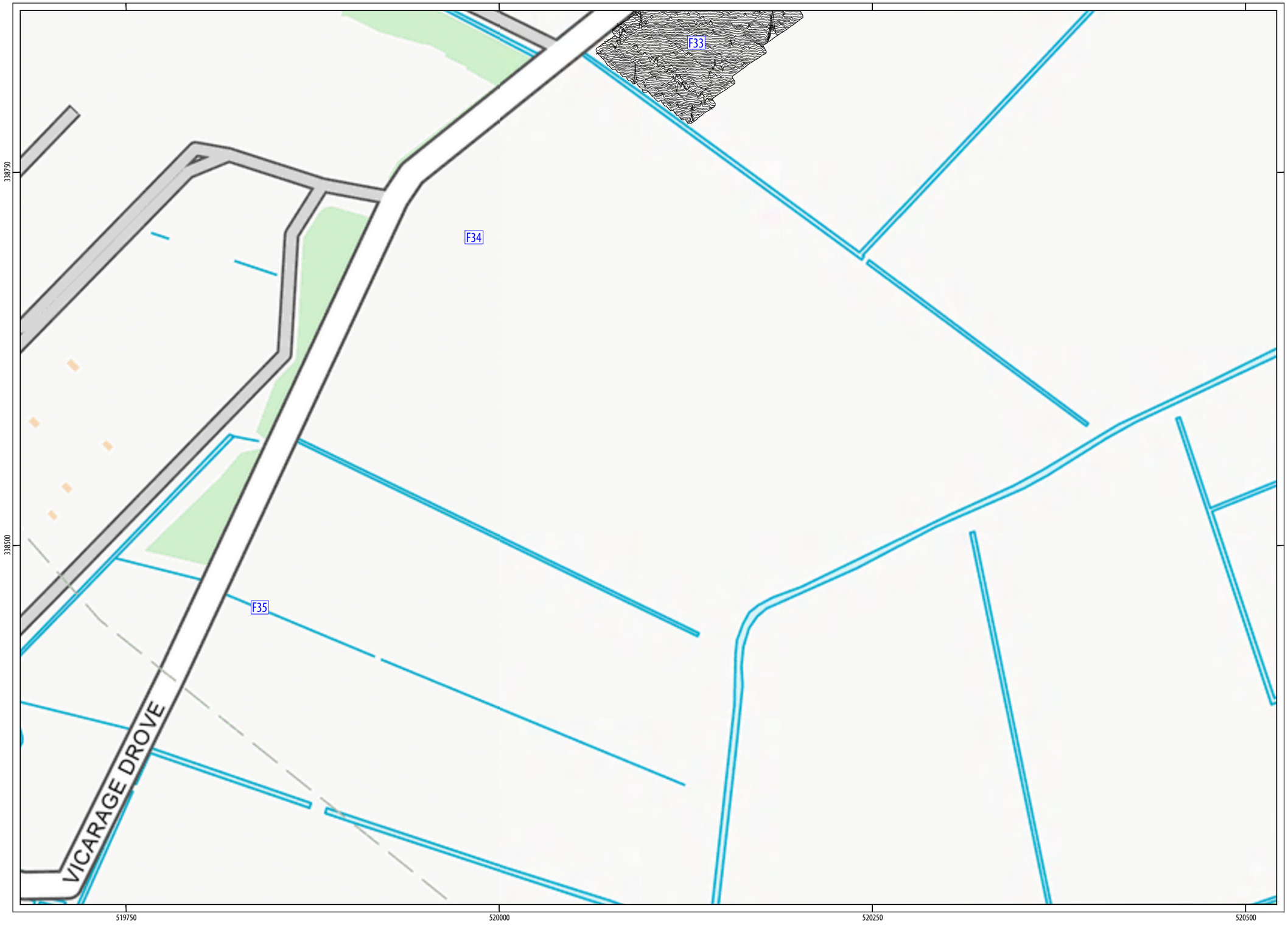
ILLUS 49 Processed greyscale magnetometer data; Sector 13



25.0nT/cm

0 50m

1:2,500 @ A3

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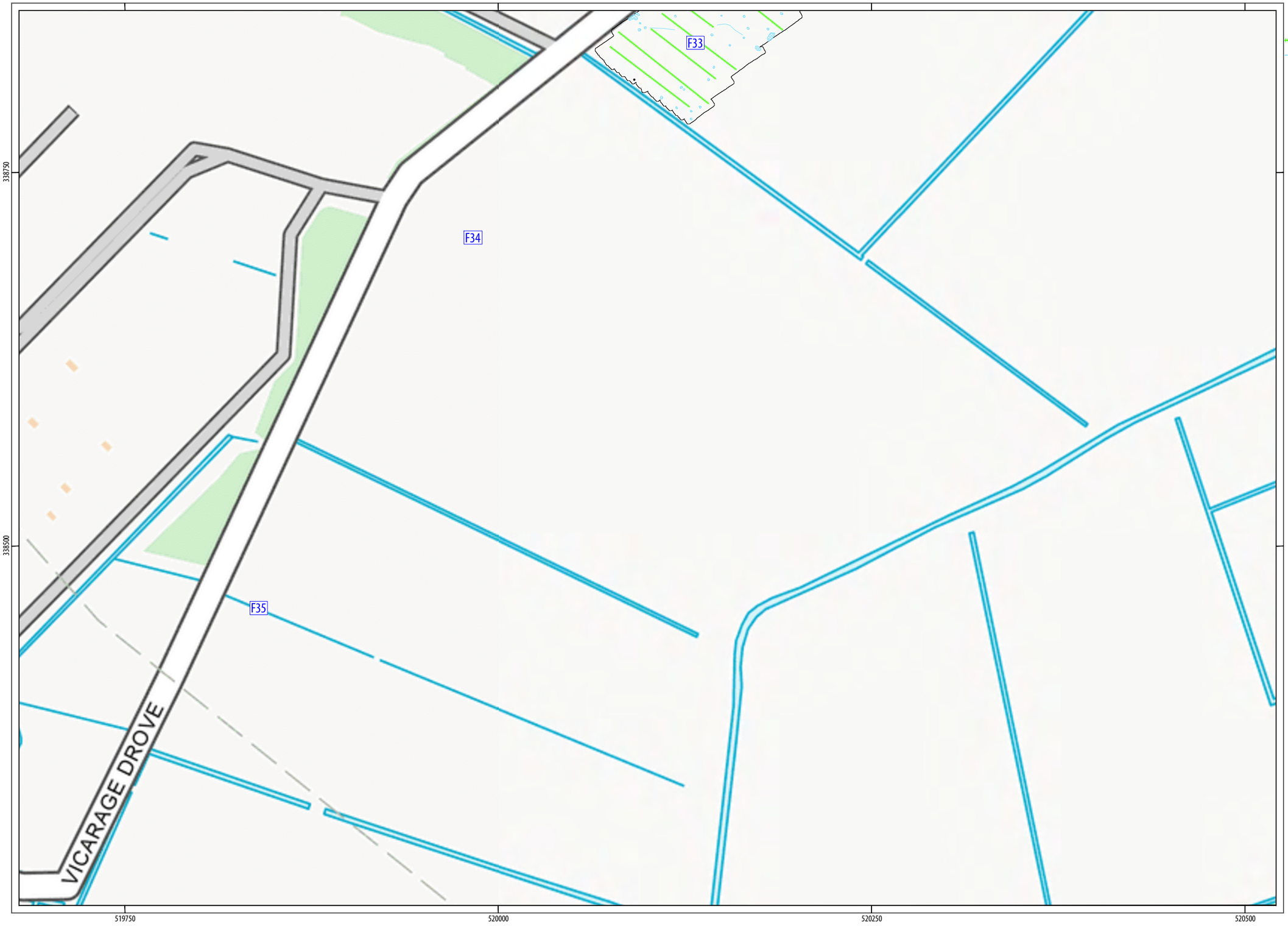
ILLUS 50 XY trace plot of minimally processed magnetometer data; Sector 13



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
linear trend	field drain
linear trend	geological variation
magnetic enhancement	geology

0 50m
1:2,500 @ A3

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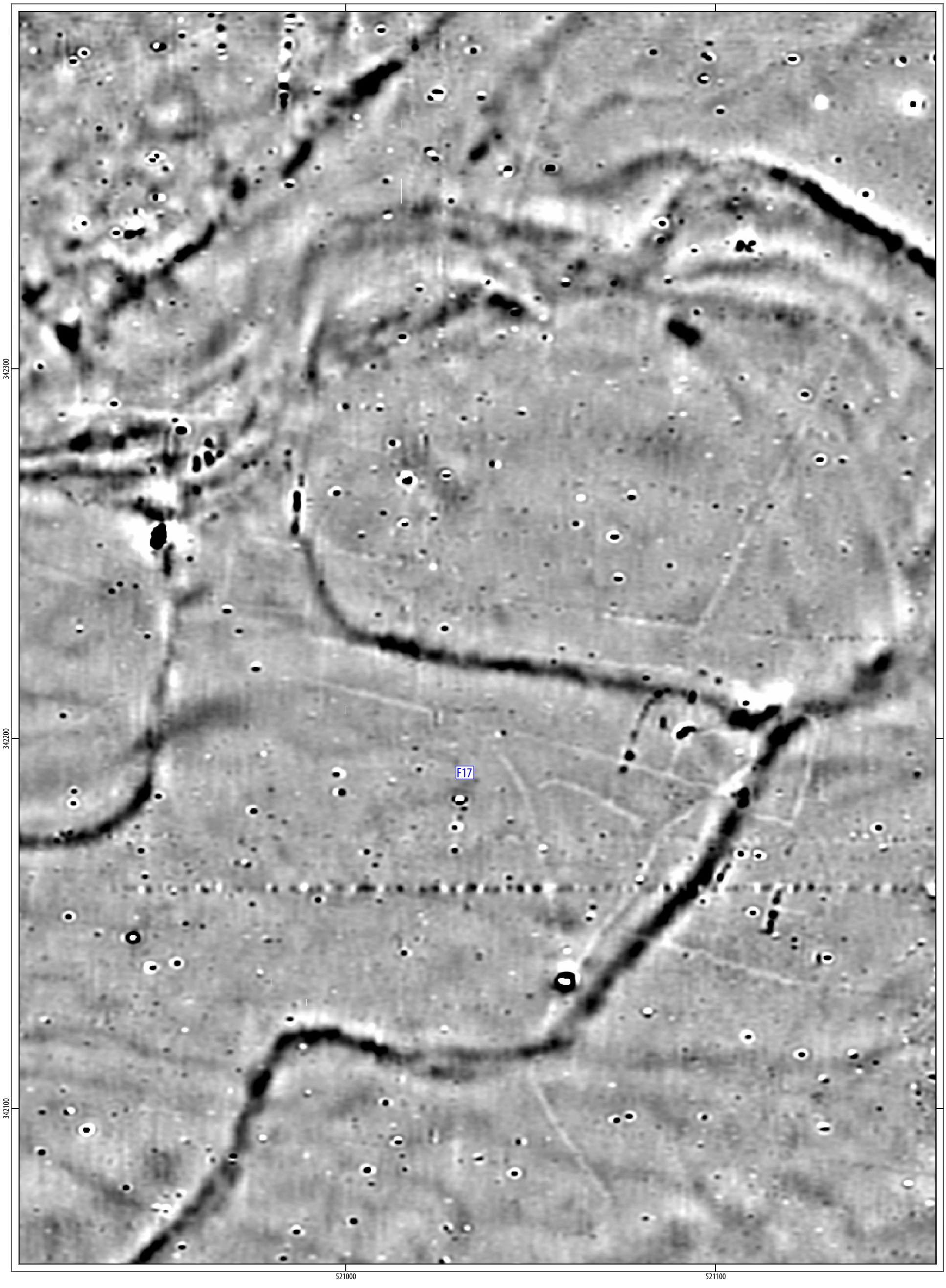
ILLUS 51 Interpretation of magnetometer data; Sector 13



-1.0 nT 2.0

0 25m

1:1,000 @ A3

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ILLUS 52 Processed greyscale magnetometer data; AAA 1

342300

342200

F17

342100

521000

521100

25.0nT/cm

0 25m

1:1,000 @ A3

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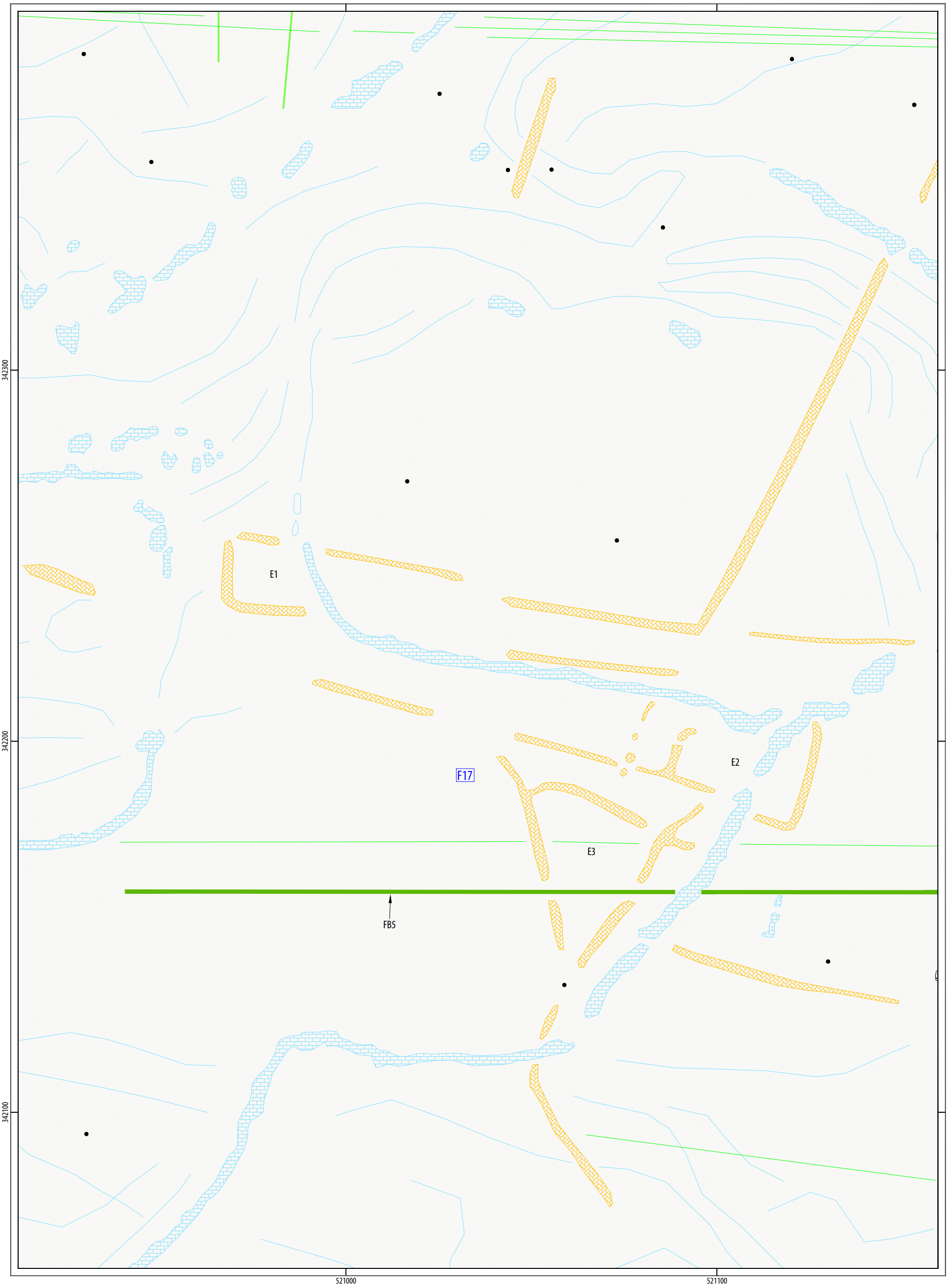
ILLUS 53 XY trace plot of minimally processed magnetometer data; AAA 1



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
linear trend	agricultural
linear trend	field drain
linear	former field boundary
linear trend	geological variation
magnetic enhancement	geology

TYPE OF ANOMALY	INTERPRETATION
magnetic enhancement	archaeology?

ABBREVIATIONS

E - enclosure

FB - former boundary

0 25m

1:1,000 @ A3

PROJECT HFCC22
Heckington Fen Solar Park, Cable Corridors
Lincolnshire

CLIENT Pegasus Group for Ecotricity Ltd

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ILLUS 54 Interpretation of magnetometer data; AAA 1

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 [redacted] 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

OASIS ID (UID): headland1-506896

Project Name: Geophysical Survey, Magnetometry Survey at Heckington Fen Solar Farm

Activity type: Magnetometry Survey, Geophysical Survey, MAGNETOMETRY SURVEY

Project Identifier(s): P22-032

Reason for Investigation: Planning: Pre application

Organisation Responsible for work: Headland Archaeology (UK) Ltd

Project Dates: 23-Mar-2022 - 06-Apr-2022

HER: Lincolnshire HER

HER Identifiers: HER Event No - HECN22, HER Event No - LCNCC:2022.55

Project Methodology: Headland Archaeology (UK) Ltd was instructed by Pegasus Group on behalf of Ecotricity (Heck Fen Solar) Ltd to undertake a

geophysical (magnetometer) survey on land at Heckington Fen, midway between Sleaford and Boston in Lincolnshire, where Ecotricity intend to make a Development Consent Order (DCO) application for a solar farm comprising ground-mounted solar panels, an energy storage facility with below-ground grid connection to Bicker Fen substation, and associated infrastructure works (Heckington Fen Solar Park). The Proposed Development Area (PDA) covers an area of approximately 590 hectares currently under arable cultivation. To ensure the completion of the survey within an optimal 4-week window the PDA was divided into four geophysical survey areas (GSA), each area surveyed by a different geophysical contractor. This report covers the results of the 178-hectare survey undertaken in Area 2, the largest of the four GSA's. The results of this survey, together with the results from the other three GSA's, will help inform future archaeological strategy at the site. The data from more than 80% of the GSA is completely dominated by anomalies of a geological/natural origin which are due to the nature of the fenland landscape prior to the draining of the fen and/or the effects of the almost universal presence of the tidal flat superficial deposits which cover the bedrock geology. The nature of this former environment is clearly visible in the data with several broad sinuous anomalies clearly locating former channels meandering across the GSA. These major channels connect to a more extensive network of much smaller interconnecting channels. In the only part of the GSA where the magnetic data is not dominated by these geological/natural anomalies (in the south-western corner of the GSA in F5), where the magnetic background is completely homogenous, several very low magnitude, possibly interconnecting, linear ditch-type anomalies are recorded. No clear pattern is evident, but these anomalies may describe a cluster of irregularly shaped enclosures; two discrete anomalies on the periphery of this cluster of linear anomalies are also recorded and interpreted as of possible archaeological origin. It is postulated that this small area may have been located on the edge of the former fen and so was possibly suitable for farming. Analysis of the data from the surrounding GSA's (Pegasus Group, forthcoming) will help determine whether this is a viable hypothesis.

Project Results: Headland Archaeology (UK) Ltd was instructed by Pegasus Group on behalf of Ecotricity (Heck Fen Solar) Ltd to undertake a geophysical (magnetometer) survey on land at Heckington Fen, midway between Sleaford and Boston in Lincolnshire, where Ecotricity intend to make a Development Consent Order (DCO) application for a solar farm comprising ground-mounted solar panels, an energy storage facility with below-ground grid connection to Bicker Fen substation, and associated infrastructure works (Heckington Fen Solar Park). The Proposed Development Area (PDA) covers an area of approximately 590 hectares currently under arable cultivation. To ensure the completion of the survey within an optimal 4-week window the PDA was divided into four geophysical survey areas (GSA), each area surveyed by a different geophysical contractor. This report covers the results of the 178-hectare survey undertaken in Area 2, the largest of the four GSA's. The results of this survey, together with the results from the other three GSA's, will help inform future archaeological strategy at the site. The data from more than 80% of the GSA is completely dominated by anomalies of a geological/natural origin which are due to the nature of the fenland landscape prior to the draining of the fen and/or the effects of the almost universal presence of the tidal flat superficial deposits which cover the bedrock geology. The nature of this former environment is clearly visible in the data with several broad sinuous anomalies clearly locating former channels meandering across the GSA. These major channels connect to a more extensive network of much smaller interconnecting channels. In the only part of the GSA where the magnetic data is not dominated by these geological/natural anomalies (in the south-western corner of the GSA in F5), where the magnetic background is completely homogenous, several very low magnitude, possibly interconnecting, linear ditch-type anomalies are recorded. No clear pattern is evident, but these anomalies may describe a cluster of irregularly shaped enclosures; two discrete anomalies on the periphery of this cluster of linear anomalies are also recorded and interpreted as of possible archaeological origin. It is postulated that this small area may have been located on the edge of the former fen and so was possibly suitable for farming. Analysis of the data from the surrounding GSA's (Pegasus Group, forthcoming) will help determine whether this is a viable hypothesis.

Digital Archive - to be deposited with Lincolnshire Archives and Archaeology Data Service