

Heckington Fen Solar Park

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Appendix 10.2: Geophysical Survey Results for Energy Park
Applicant: Ecotricity (Heck Fen Solar) Limited

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February 2023



APPENDIX 10.2 - GEOPHYSICAL SURVEY RESULTS FOR ENERGY PARK

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HFSF22



Area 2, Heckington Fen Solar Park, Lincolnshire

GEOPHYSICAL SURVEY REPORT

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Pegasus Group for Ecotricity (Heck Fen Solar) Ltd
29/04/2022

PROJECT INFORMATION:

PROJECT NAME	Area 2, Heckington Fen Solar Park, Lincolnshire
TYPE OF WORK	Geophysical Survey
PROJECT ACCESSION NO.	LCNCC:2022.55
SITE CODE	HECN22
CONSULTANT/AGENT	Pegasus Group
CLIENT	Ecotricity (Heck Fen Solar) Ltd
PROJECT CODE	HFSF22
NGR	NGR 520000, 345997
PARISH	Heckington
LOCAL AUTHORITY	Lincolnshire County Council; North Kesteven District Council
FIELDWORK DATES	23/03/2022 – 06/04/2022
OASIS REF.	headland1-
ARCHIVE REPOSITORY	ADS

PROJECT TEAM:

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PROJECT SUMMARY

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.

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AREA 2, HECKINGTON FEN SOLAR PARK, LINCOLNSHIRE

GEOPHYSICAL SURVEY REPORT

1. INTRODUCTION

Headland Archaeology (UK) Ltd was instructed by Pegasus Group on behalf of Ecotricity (Heck Fen Solar Ltd - the Client) to undertake a geophysical (magnetometer) survey on land at Heckington Fen, midway between Sleaford and Boston in Lincolnshire (Illus 1), where Ecotricity intend to make a Development Consent Order (DCO) application for ground-mounted solar panels and an energy storage facility with a below-ground grid connection to Bicker Fen substation, and all associated infrastructure works.

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, when the ground was expected to be relatively dry and the arable crops established but not susceptible to excessive trample damage nor yet too high or dense to preclude survey, the PDA was divided into four parts each to be covered by a different geophysical survey contractor. This report covers the survey undertaken in Area 2 (the geophysical survey area – GSA), the largest of the four parts of the PDA.

The results of the geophysical survey will be submitted in support of the DCO application for the future development of the land and may also inform future archaeological strategy at the site, if required. The scheme of work will be undertaken in accordance with the requirements of the National Planning Policy Framework (MHCLG 2021).

The survey was undertaken in accordance with a Written Scheme of Investigation for Geophysical Survey (WSI) (Headland Archaeology 2022), submitted to Lincolnshire County Council prior to

the commencement of the work and was carried out in line with current best practice (Chartered Institute for Archaeologists 2014, Europae Archaeologia Consilium 2016).

The survey was carried out between March 23rd and April 6th, 2022.

1.1. SITE LOCATION, TOPOGRAPHY AND LAND-USE

The overall PDA comprises an irregularly shaped block of arable farmland, covering approximately 590 hectares, outlying Six Hundreds Farm at East Heckington and is centred at NGR 520105, 345447. It is bound by the A17 to the south, the B1395 (Side Bar Lane) to the west, Six Hundreds Drove to the east and Head Dike to the north.

Area 2 (the GSA) comprises eight large fields (Illus 6 – F1 to F8 inclusive) under a maturing cereal crop (Illus 2 to Illus 5) in the north central part of the PDA. The GSA is bound by the northern PDA boundary to the north (Head Dyke) with Area 4 to the east, Area 1 to the west and Area 3 to the south. It is centred at NGR 520000, 345997 and covers 178 hectares, approximately 30% of the overall PDA.

Topographically Area 2 is flat, lying at between 1m and 3m Above Ordnance Datum (AOD).

1.2. GEOLOGY AND SOILS

The underlying bedrock geology comprises Mudstone of the Ampthill Clay Formation to the eastern side of the PDA, sedimentary bedrock formed approximately 157 to 164 million years ago in the Jurassic Period in a local environment previously dominated by shallow seas. Mudstone and Siltstone of the West Walton Formation (also

sedimentary rock formed in the Jurassic Period) is recorded to the western side of the PDA; almost the entirety of Area 2 is mudstone.

The whole of the PDA is overlain by superficial Tidal Flat Deposits comprising Clay and Silt formed up to 3 million years ago in the Quaternary Period in a local environment previously dominated by shorelines (NERC 2022).

The soils are classified in the Soilscape 21 Association being described as loamy and clayey soils of coastal flats with naturally high groundwater (Cranfield University 2021).

2. ARCHAEOLOGICAL BACKGROUND

The following archaeological background is informed by an initial high-level review of Lincolnshire Historic Environment Record (HER) data sourced from a 2km-radius study area measured from the boundaries of the main site undertaken by Pegasus Group.

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, 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). Most of the 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).

Further research to be undertaken for a forthcoming heritage desk-based assessment will include a review of historic maps, historic aerial photographs and LiDAR imagery as well as a walkover survey of the site.

3. AIMS, METHODOLOGY & PRESENTATION

3.1. AIMS & OBJECTIVES

The principal aim of the programme of geophysical survey was to gather information to establish the presence/absence, character, and extent of any archaeological remains within Area 2 of the PDA. This will enable an assessment to be made of the impact of any proposed development on any sub-surface archaeological remains.

The overall objective was to inform the DCO application and thereby inform any further investigation strategies, as appropriate.

The specific archaeological objectives of the geophysical survey were:

- to gather enough information to inform the extent, condition, character, and date (as far as circumstances permit) of any archaeological features and deposits within the PDA,
- to obtain information that will contribute to an evaluation of the significance of the scheme upon cultural heritage assets, 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.

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 1:30,000. Illus 2 to Illus 5 inclusive are site

condition photographs. Illus 6 shows the GPS swaths and photograph locations at 1:7,500. Overall greyscale magnetometer data and interpretation are displayed at 1:7,500 in Illus 7 and Illus 8 respectively. Fully processed (greyscale) data, minimally processed data (XY trace plot) data and interpretative plots are presented, at a scale of 1:2,500, in Illus 9 to Illus 26 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. A copy of the OASIS entry (Online Access to the Index of Archaeological Investigations) is reproduced in Appendix 5.

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 Her 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 can generally be recommended over any sedimentary bedrock, (English Heritage 2008; Table 4), although in this case the Quaternary Tidal Flats superficial deposits comprising clays and silts are more likely to be the primary determinant of the success or otherwise of the technique. Nevertheless, magnetometry is the most appropriate geophysical technique for evaluating the PDA taking account of the limitations noted above and in Section 3.2.

Surface conditions across the GSA 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 data itself is completely dominated by the effects of the almost universal presence of the tidal flat superficial deposits and the nature of the fenland landscape prior to the draining of the fen. The effects of these deposits are discussed in more detail in Section 4.2 below.

4.2. GEOLOGICAL/NATURAL ANOMALIES

The data from all parts of the GSA reflect the marginal tidal and inter-tidal environments in which these deposits were laid down. The exception is in the south-western corner of the GSA in F5 where the magnetic background is completely homogenous.

The nature of this former environment is clearly visible in the data. Several broad sinuous anomalies clearly locate former channels or watercourses meandering across the GSA. These major channels connect to a more extensive network of much smaller interconnecting channels. This pattern is particularly dense and complicated across the northern half of the GSA in F1 to F3 and F7. The major channels are picked out with dashed lines on Illus 8 (FW1, FW2 and FW3) and the 1:2,500 scale interpretation graphics. The extent and density of these anomalies is such that only those of a magnitude above 2nT are shown on the interpretation graphics.

Against this background very few anomalies which are not geological/natural in origin are recorded. The few anomalies that do not fall into this category are described below according to their interpreted origin.

4.3. 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 within the GSA that would suggest an archaeological origin was likely. Far more probable is that the 'spike' responses

are caused by the random distribution of ferrous debris in the upper soil horizons.

A single linear dipolar anomaly (Illus 8 – SP1) running north/south along the eastern edges of F1, F2, F4 and F5 is due to a sub-surface pipe.

Larger areas of magnetic disturbance are recorded in the south-eastern corners of F7 and F8 and around the agricultural building in the south-western corner of F2. This disturbance is likely due to the tipping of modern material and/or the proximity to current structures and is of no archaeological significance.

4.4. AGRICULTURAL ANOMALIES

Vague low magnitude linear anomalies across the GSA (Illus 8 – FB1 to FB9 inclusive) attest to the fact that some of the current large fields were formerly sub-divided into several smaller fields. These former boundaries clearly align with other extant boundaries outwith the GSA and are recorded on first edition and later Ordnance Survey maps.

Other linear trends recorded across the PDA are also due to agricultural activity and either reflect the orientation of modern or recent cultivation or possibly land drains.

4.5. ANOMALIES OF POSSIBLE ARCHAEOLOGICAL ORIGIN

As described in Section 4.2 the only part of the GSA where the data is not completely dominated by geological/natural anomalies is in the south-western part of the GSA in F5. Here several very low magnitude possibly interconnecting linear ditch-type anomalies are recorded against the homogenous magnetic background to the east of the sub-surface pipe, SP1. No clear pattern is evident, but these anomalies may describe a cluster of irregularly shaped enclosures; three enclosures where three possible 'sides' are recorded are highlighted on Illus 8 (E1, E2 and E3).

Two discrete anomalies on the periphery of this cluster of linear anomalies are also recorded. Here the magnetic response is slightly different from the ubiquitous natural/geological anomalies recorded across the rest of the GSA and so these anomalies have also been interpreted as of possible archaeological origin. It may be that this small area was on the edge of the former fen and so was possibly suitable for farming. Analysis of the data from the surrounding survey areas will help determine whether this is a viable hypothesis.

5. CONCLUSION

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. The nature of this former environment is clearly visible. Several broad sinuous anomalies clearly locate 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. 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 survey areas (Pegasus Group, forthcoming) will help determine whether this is a viable hypothesis.

6. REFERENCES

Chartered Institute for Archaeologists (CIfA) 2014 Standard and guidance for archaeological geophysical survey (Reading) https://www.archaeologists.net/sites/default/files/CIfAS%26GGeophysics_3.pdf accessed 28th April 2022

Cranfield University 2020 Cranfield Soil and Agrifood Institute Soilscales

<http://www.landis.org.uk/soilscales/> accessed 28th April 2022

English Heritage 2008 Geophysical Survey in Archaeological Field Evaluation

Europae Archaeologia Consillium (EAC) 2016 EAC Guidelines for the Use of Geophysics in Archaeology: Question to Ask and Points to Consider (Namur, Belgium) <https://www.europae-archaeologiae-consilium.org/eac-guidlines> accessed 28th April 2022

Gaffney, C & Gater, J 2003 Revealing the Buried Past: Geophysics for Archaeologists Stroud

Headland Archaeology 2022 Heckington Fen Solar Park, Lincolnshire Written Scheme of Investigation for Geophysical Survey Unpublished Client Document Ref. HECK22

Ministry of Housing, Communities and Local Government (MHCLG) 2021 National Planning Policy Framework https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf accessed 28th April 2022

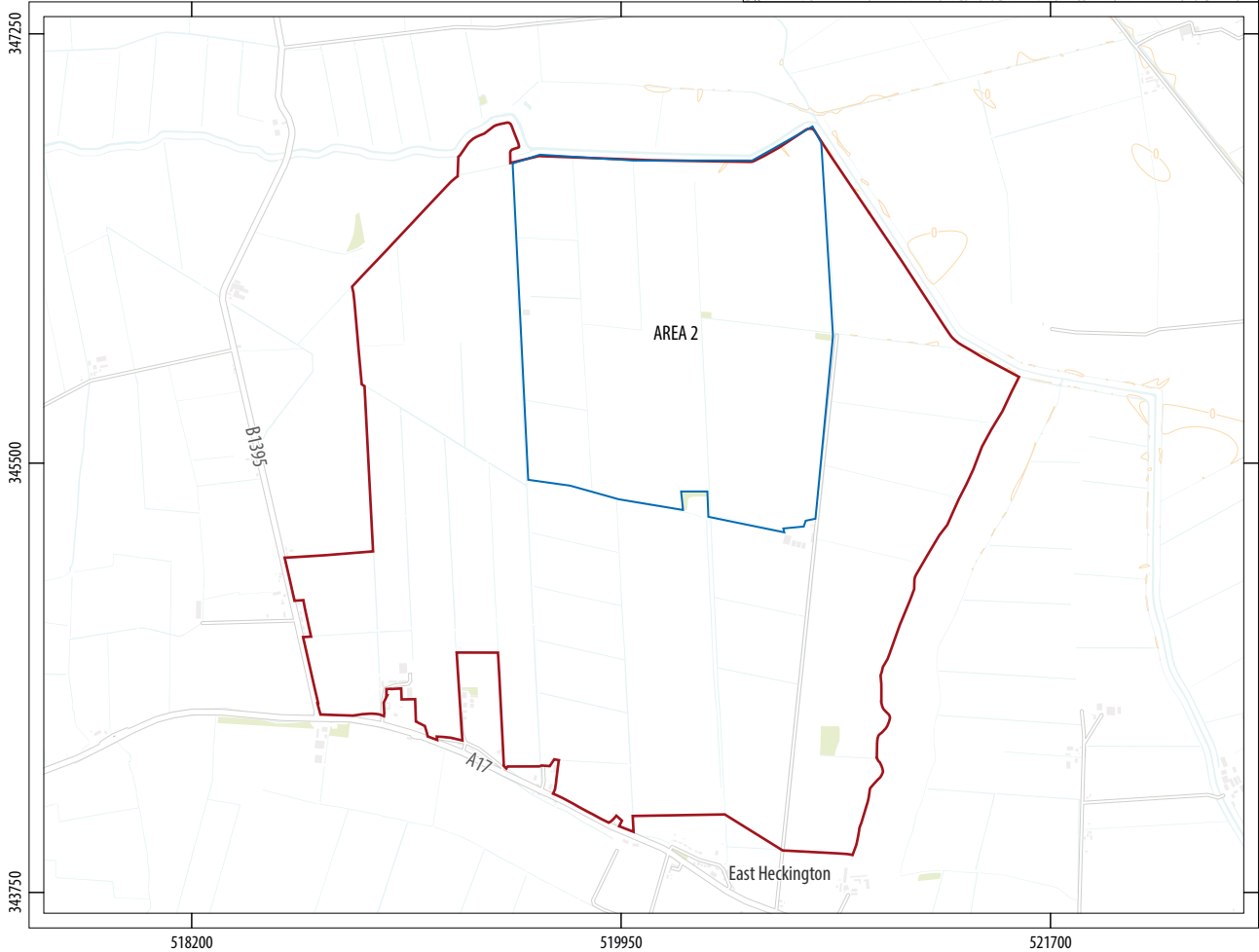
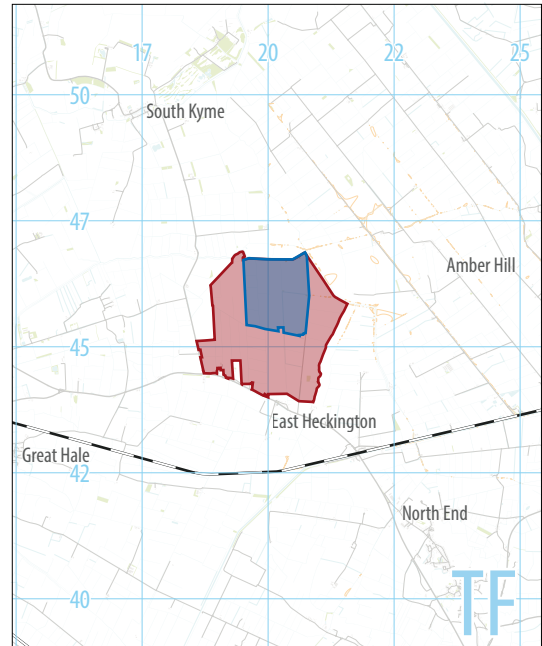
Natural Environment Research Council (BGS) 2022 British Geological Survey <http://www.bgs.ac.uk/> accessed 28th April 2022

Pegasus Group 2022 Heckington Fen Solar Park Written Scheme of Investigation for Geophysical Survey Unpublished client document Ref P20-2370

Heckington Fen Solar Park
Lincolnshire



0 200km
1:12,500,000 @ A4



0 600m
1:30,000 @ A4

proposed development area
geophysical survey area



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Illus 2 F1, looking east



Illus 3 F4, looking south-east



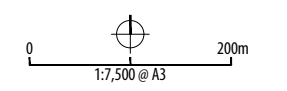
Illus 4 F6, looking east



Illus 5 F8, looking north



- ▭ geophysical survey area
- ▭ proposed development area
- ▨ GPS swaths
- 📍 location and direction of ILLUS 2-5

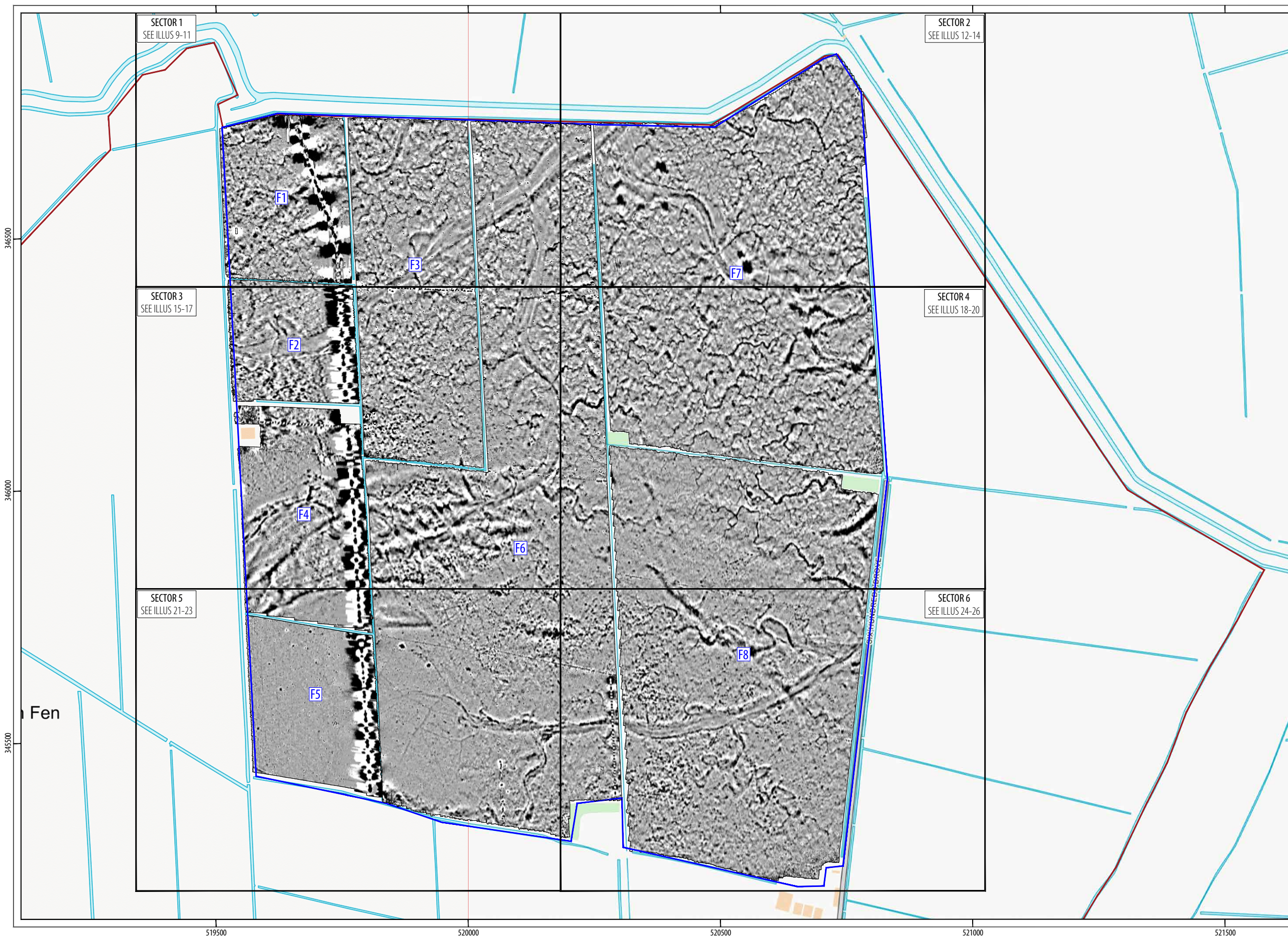


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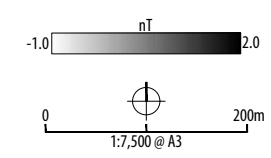


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ILLUS 6 Survey location showing GPS swaths and photograph locations



□ geophysical survey area
□ proposed development area

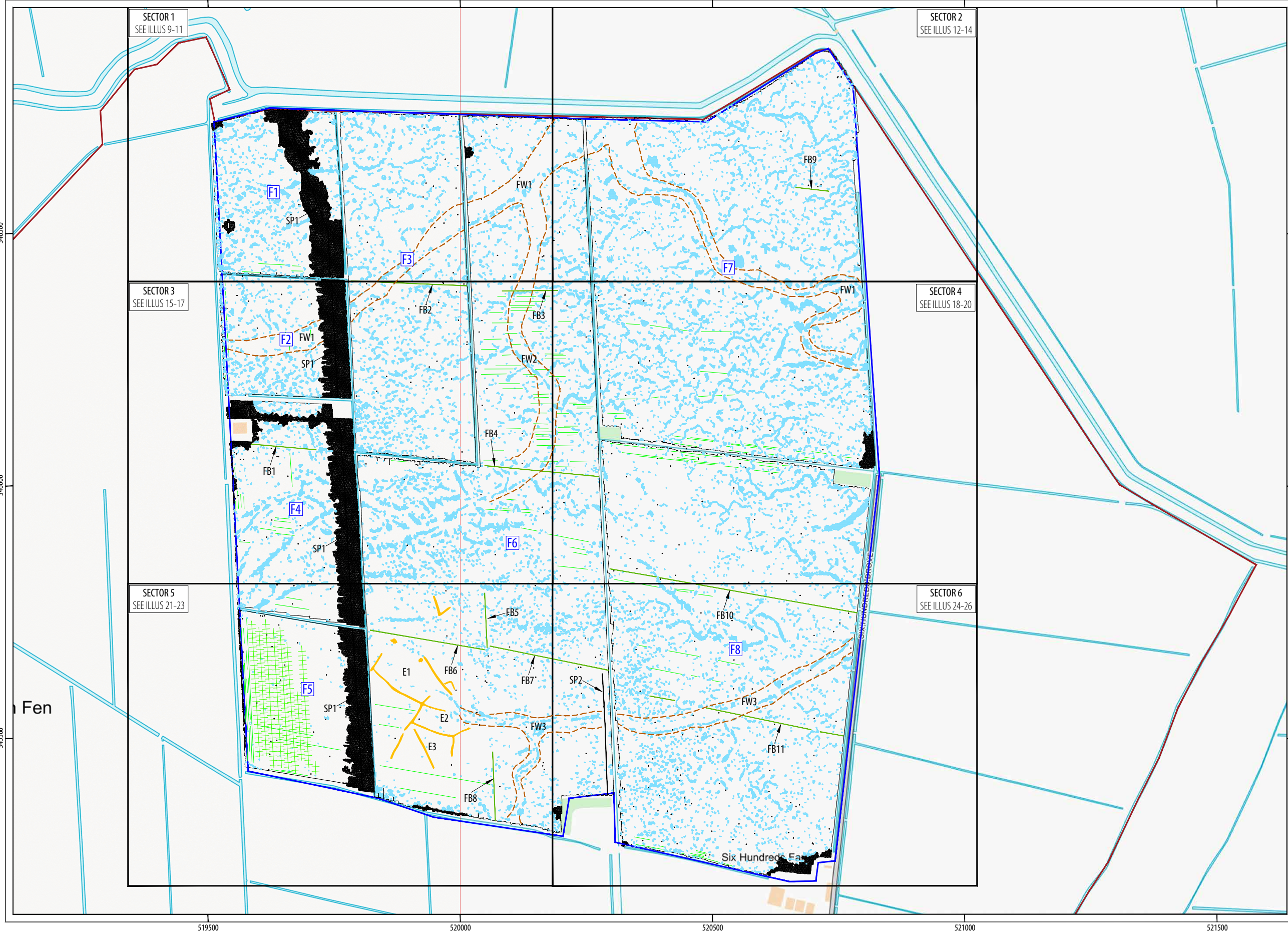


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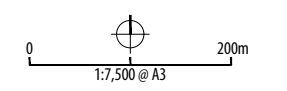
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ILLUS 7 Overall greyscale plot of processed magnetometer data



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

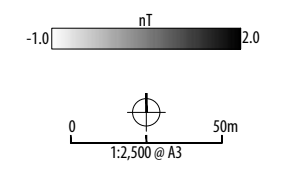
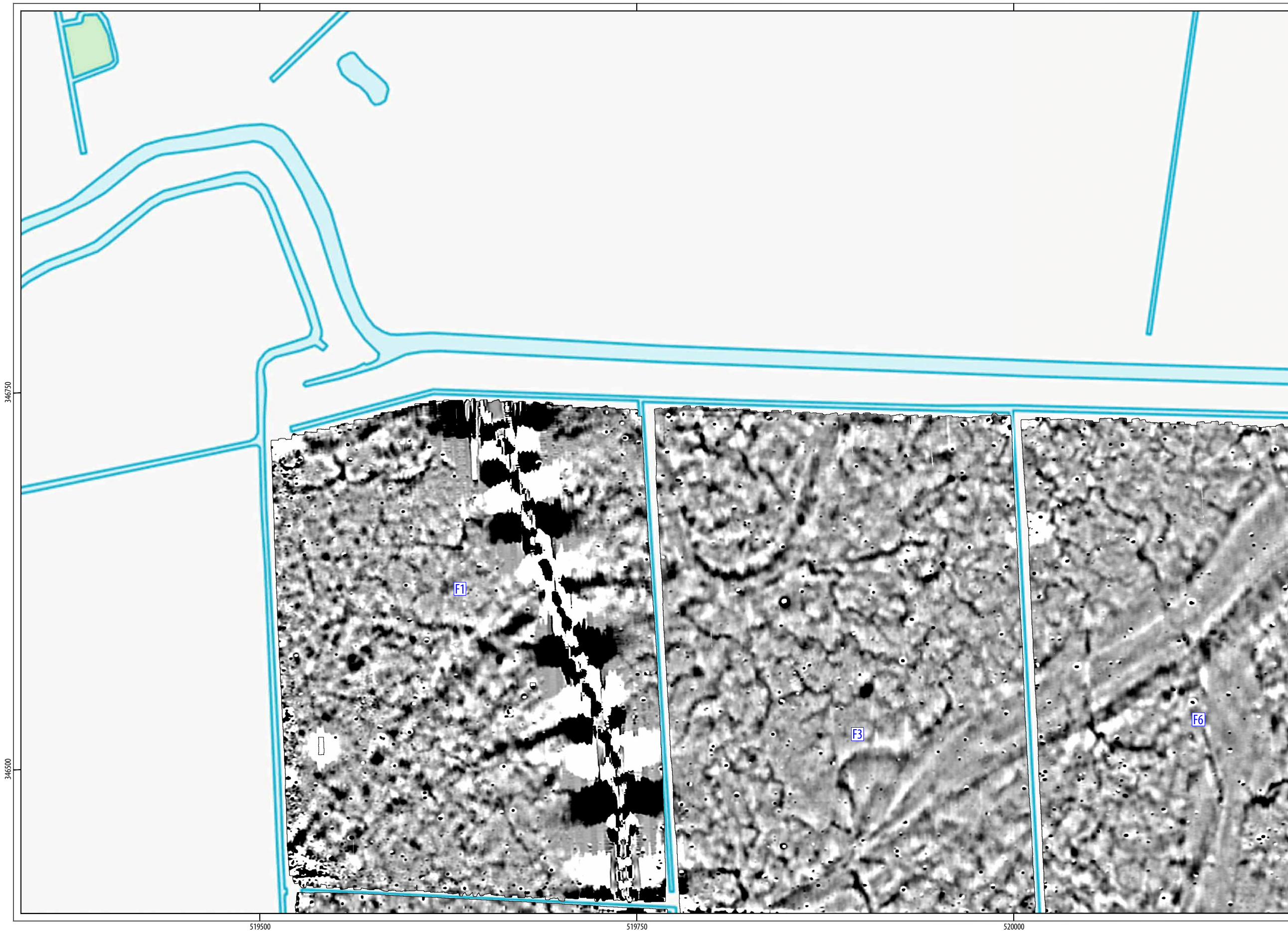
ABBREVIATION	INTERPRETATION
E	enclosure
FB	former boundary
FW	former watercourse
SP	service pipe



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ILLUS 8 Overall interpretation of magnetometer data

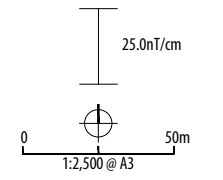
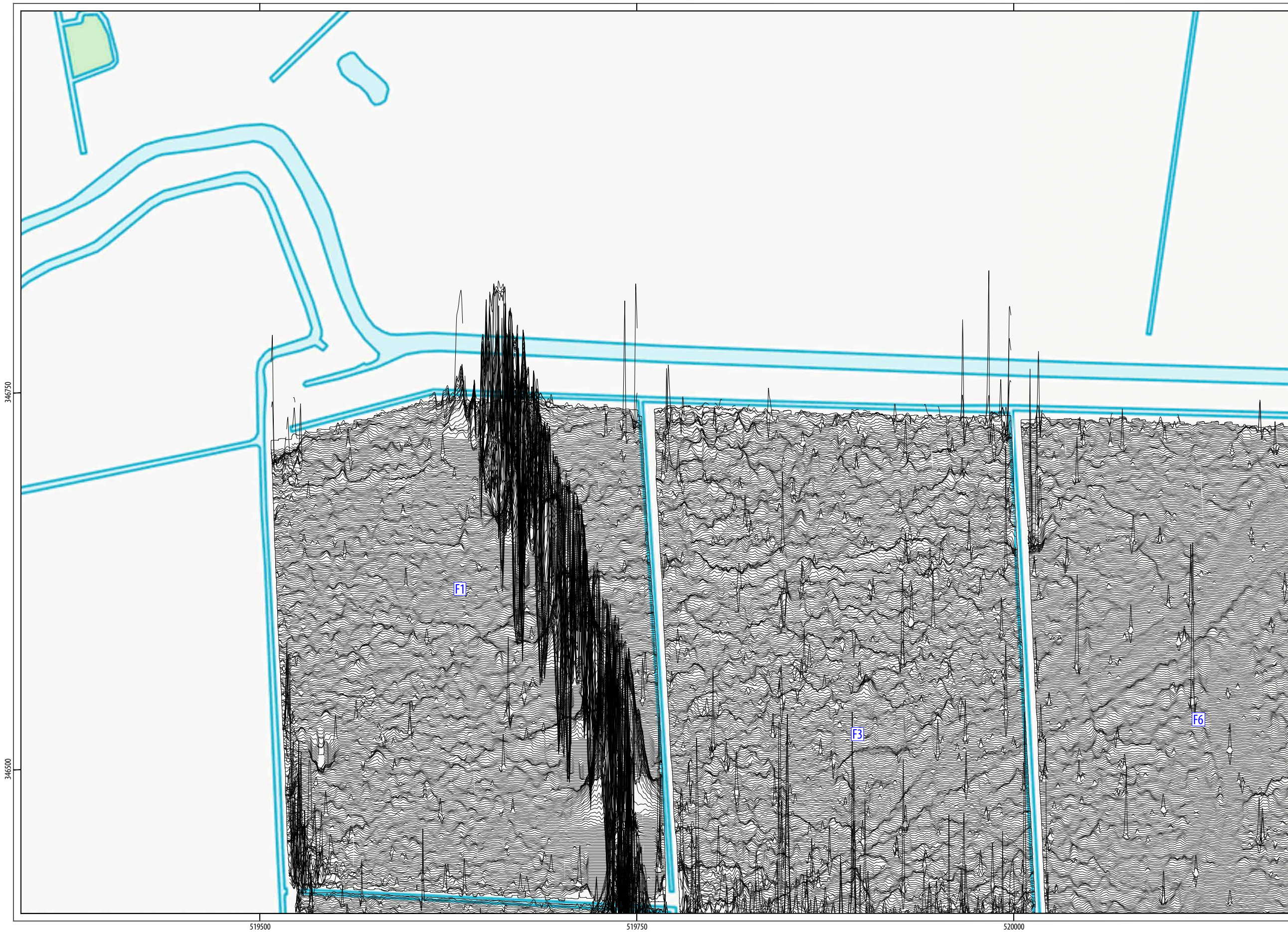


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ILLUS 9 Processed greyscale magnetometer data; Sector 1



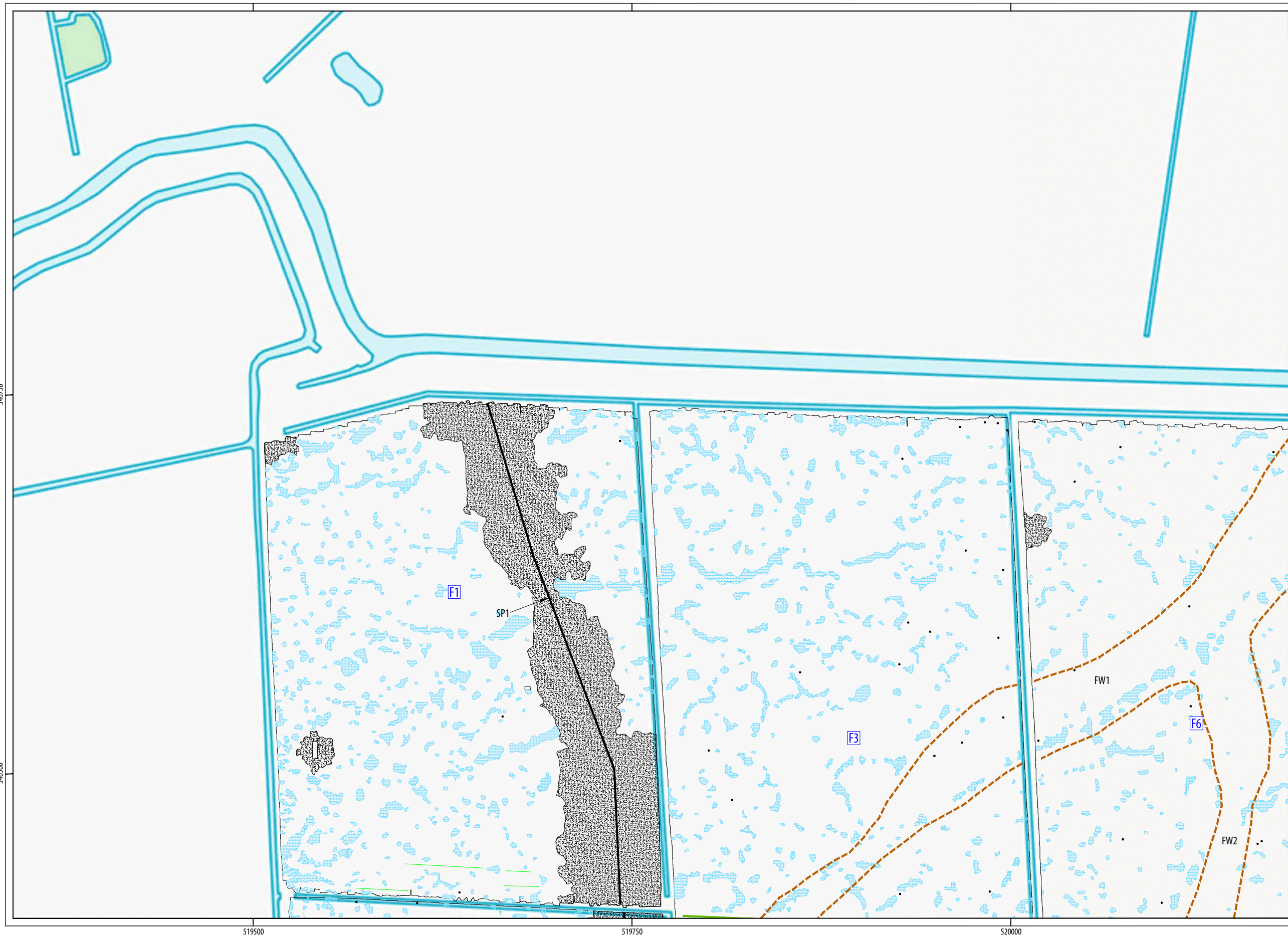
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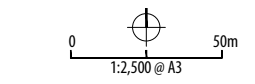
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ILLUS 10 XY trace plot of minimally processed magnetometer data; Sector 1



TYPE OF ANOMALY	INTERPRETATION
agricultural	agricultural
ferrous	ferrous material
ferrous	magnetic disturbance
ferrous	service pipe
geological	geological variation
geological	geological

ABBREVIATION
FW - former watercourse
SP - service pipe



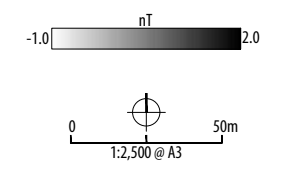
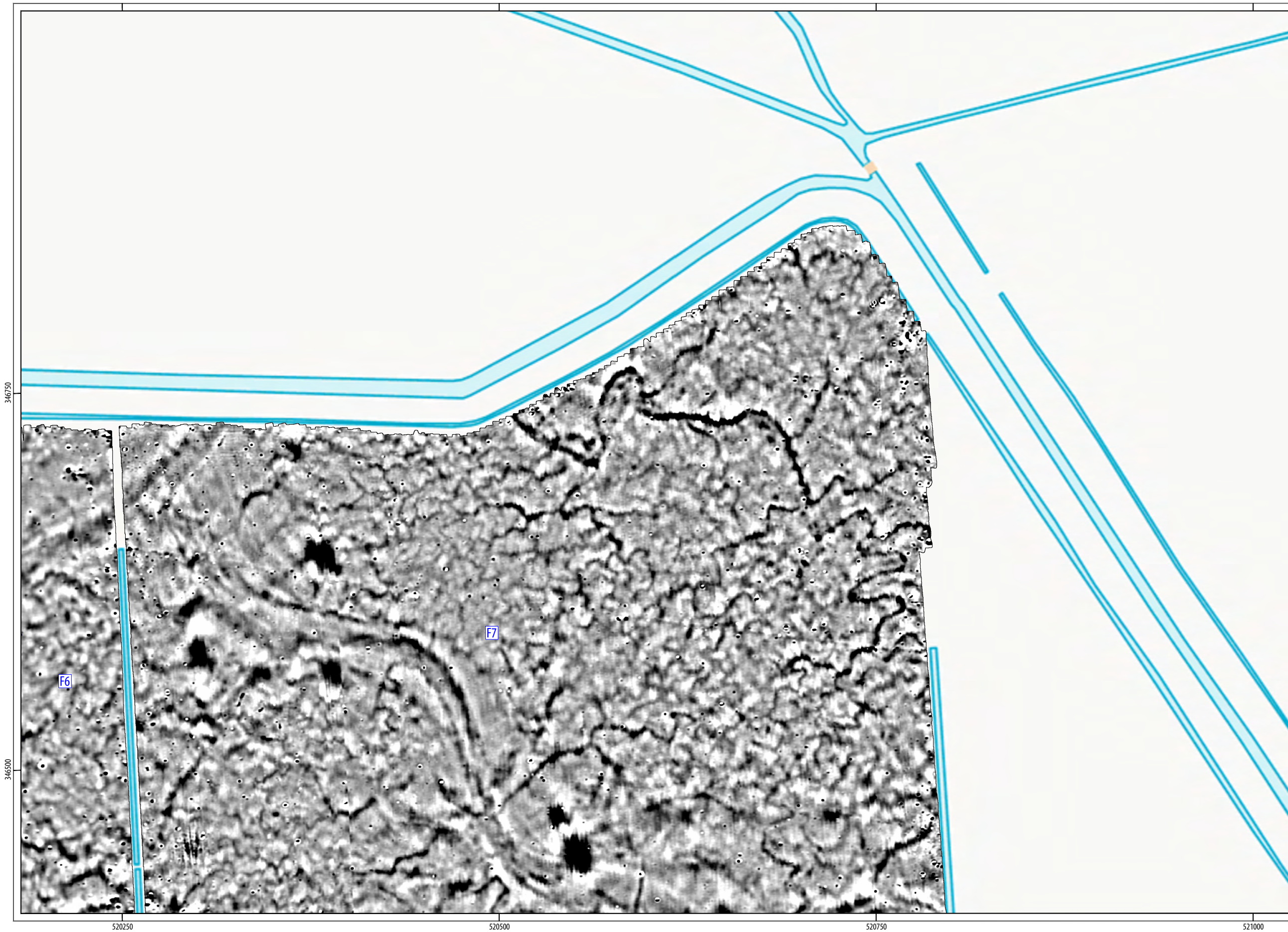
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ILLUS 11 Interpretation of magnetometer data; Sector 1



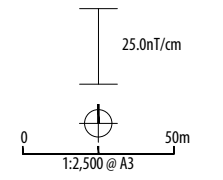
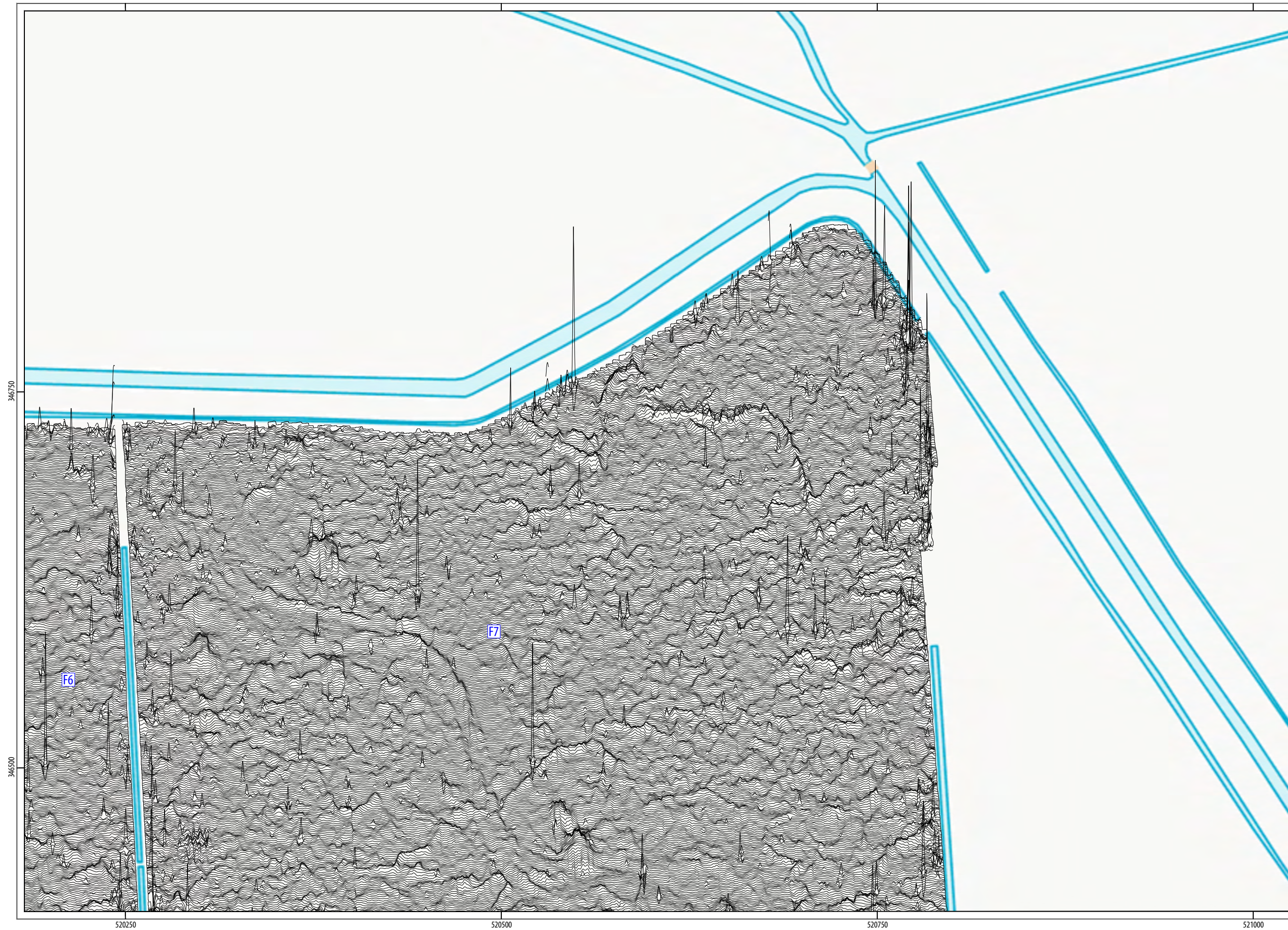
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ILLUS 12 Processed greyscale magnetometer data; Sector 2



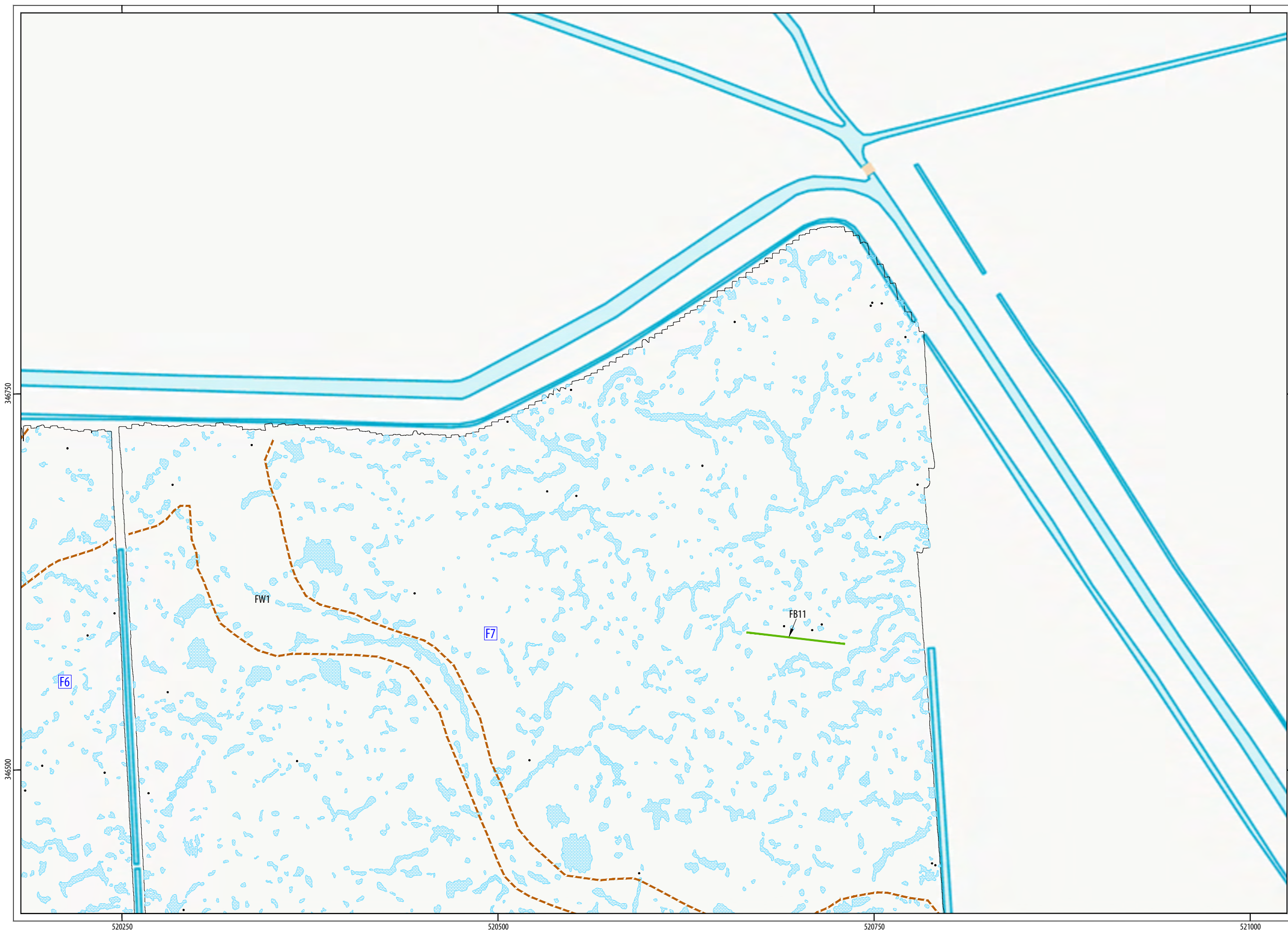
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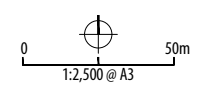
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ILLUS 13 XY trace plot of minimally processed magnetometer data; Sector 2



TYPE OF ANOMALY	INTERPRETATION
— agricultural	former field boundary
• ferrous	ferrous material
— geological	geological variation
⊞ geological	geological

ABBREVIATION
FB - former boundary
FW - former watercourse



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ILLUS 14 Interpretation of magnetometer data; Sector 2