

CWRP21



Cambridge Waste Water Treatment Plant, Cambridgeshire

GEOPHYSICAL SURVEY REPORT

PLANNING REF. n/a

Headland Archaeology Yorkshire & North
Units 23–25 & 15 | Acorn Business Centre | Balme Road | Cleckheaton BD19 4EZ

for Mott MacDonald for Anglian Water

19/04/2021

PROJECT INFORMATION:

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PROJECT CODE	CWRP21
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LOCAL AUTHORITY	Cambridgeshire County Council
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PROJECT TEAM:

PROJECT MANAGER	Alistair Webb
AUTHOR	Alistair Webb
FIELDWORK	Peter Heykoop, Ross Bishop, Matt Berry, Eleanor Culverhouse, Neil Paveley, Andrew Marke
GRAPHICS	Sam Harrison, Ross Bishop, Matt Berry

PROJECT SUMMARY

Headland Archaeology (UK) Ltd undertook a geophysical (magnetometer) survey on the north-eastern periphery of Cambridge on behalf of Anglian Water who are currently engaging in preliminary studies and investigations for the relocation of the Cambridge Waste Water Treatment Plant (WWTP). The results of the survey will be used to support a Development Consent Order (DCO) application for the proposed scheme and will also inform future archaeological strategy at the site, if required. The survey covered 126 hectares of agricultural land which comprises Site Area 3 (hereafter the proposed development area – PDA). The PDA comprised three zones; the main site (108ha), the site access route (12ha) and the treated effluent pipeline corridor (6ha).

The survey has identified numerous linear and discrete anomalies across all parts of the PDA. Most of these anomalies are due to activity associated with the drainage and subsequent farming of this former fenland landscape being caused by drains, relict field boundaries, ridge and furrow and modern ploughing. However, the survey has identified a single area of definite archaeological potential in the field immediately south of Biggin Abbey (Zone C – the treated effluent pipeline corridor). Part of the moat and possible associated features within the moated complex have been recorded. Other anomalies beyond the moat may also have an archaeological origin.

A cluster of discrete pit-type anomalies is recorded (in Zone A – the main site) adjacent to the Horningsea Road and close to an area of cropmarks (HER MCB13592) which have been interpreted as indicative of Roman settlement. The cropmarks, which are very clearly visible on an air photograph taken in 1970, have not been recorded by the survey. It is possible that the underlying features causing the cropmark may have been degraded by deep ploughing over the last 50 years since the images were taken and by the construction of the A14 in 1990. The anomalies are, however, outside the proposed footprint of the new water treatment works; no anomalies of archaeological potential are recorded within the footprint of the works. It should be noted that this and two other clusters of discrete anomalies, which have also been interpreted as of possible archaeological origin, could equally be due to natural infilled features eroded in the soft chalky bedrock. Within Zone B (the access road corridor) a single curvilinear anomaly of uncertain (and therefore potentially archaeological) origin is recorded. The relatively narrow survey corridor here makes further interpretation difficult.

Sedimentary bedrock (such as chalk) generally provides good results to magnetic survey particularly when there are no overlying superficial deposits and therefore, it is assessed that the survey has given a good indication of the likely archaeological potential of the PDA.

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CAMBRIDGE WASTE WATER TREATMENT PLANT, CAMBRIDGESHIRE

GEOPHYSICAL SURVEY REPORT

1. INTRODUCTION

Headland Archaeology (UK) Ltd was commissioned by Mott MacDonald, on behalf of Anglian Water Ltd (The Client) to undertake a geophysical (magnetometer) survey on land north-east of Cambridge, where Anglian Water is currently engaging in preliminary studies and investigations for the relocation of the Cambridge Waste Water Treatment Plant (WWTP) to make the land currently occupied by the WWTP, available for housing development. The results of the survey will be used to support a Development Consent Order (DCO) application for the proposed scheme and will also inform future archaeological strategy at the site, if required.

The survey (Site Area 3) covered approximately 126 hectares in three zones (Illus 1) and was undertaken to assess the impact of the proposed development on the historic environment. It was undertaken in accordance with a Written Scheme of Investigation for Geophysical Survey (WSI) (Headland 2021) which in turn was informed by a Brief for Archaeological Geophysical Survey provided by Cambridgeshire County Council Historic Environment Team (CCCHET). The WSI was approved by Andy Thomas, Senior Archaeologist on the CCCHET, prior to the commencement of the survey; CCCHET provide archaeological advice to Cambridgeshire County Council. The survey also follows guidance contained in the National Planning Policy Framework (MHCLG 2019) 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 17th 2021 and March 26th 2021.

1.1. SITE LOCATION, TOPOGRAPHY AND LAND-USE

The Proposed Development Area (PDA – Illus 1) is located on land north-east of Cambridge, between Milton to the north-west, Horningsea to the north and Stow Cum Quy to the east, centred approximately 1km north-east of Fen Ditton at NGR TL495610.

The land within the PDA is currently all under arable agricultural production (Illus 2 to Illus 5 inclusive) with open farmland extending to all sides.

The PDA comprised all or part of 16 fields in three specific zones (Illus 6) :-

- The main site (Zone A - 108ha). This comprises the WWTP footprint, construction areas, including compounds and laydown areas,
- The site access route (Zone B - 12ha). This comprises construction and operation access routes; and
- The treated effluent pipeline corridor (Zone C - 6ha). The waste-water transfer corridor to the existing WWTP will be tunnelled and is therefore excluded from the survey area. The Waterbeach transfer pipeline corridor will be subject to a separate phase of survey.

The main site (Zone A) is bound by the A14 to the south-west, by Horningsea Road (B1047) to the north-west and field boundaries to the north.

The access route (Zone B) approaches the main site from the southern side forming a corridor either side of the A14 aligned from south-west to north-east before dog-legging to the south east before connecting to High Ditch Road and Newmarket Road (A1303) just to the south of the A14.

The effluent pipeline (Zone C) approaches the main site at the north-western side of the PDA, just east of the River Cam and south of Biggin Abbey on a broadly east/west alignment corridor.

Topographically all three zones are essentially flat varying between approximately 6m and 10m above Ordnance Datum (AOD).

1.2. GEOLOGY AND SOILS

The underlying bedrock geology comprises West Melbury Marly Chalk Formation across Zone A, Zone B and most of Zone C but Gault Formation Mudstone along the pipeline route between Biggin Abbey and the River Cam. There are no recorded superficial deposits except adjacent to the River Cam in Zone C where there are deposits of Alluvium (UKRI 2021).

The soils are classified in the Soilscape 5 Association which are described as freely draining lime-rich loamy soils (Cranfield University 2021).

2. ARCHAEOLOGICAL BACKGROUND

Information included within the Brief (CCCHET 2021) assessed the area within Design Option L (equivalent to Site Option 3 which encompasses the PDA) as being 'located in an area of high archaeological potential with substantial evidence for prehistoric and Roman settlement within and in the vicinity of the site', although noting that a cropmark complex indicating the location of a Roman settlement within the shortlisted area is outside the indicative WWTP footprint (HER MCB13592). The Brief also stated that the south-western extent of this site falls under the A14, the construction of which was considered likely to have had a substantial impact on any currently unknown assets immediately adjacent to the Roman settlement. There is high potential for archaeological

assets to survive within the proposed WWPT site and transfer corridor.

A high-level archaeological overview is provided in the WWTP Stage 4 Historic Environment Assessment. The list below (abstracted from this document) provides a list of the archaeological assets identified by the Cambridgeshire Historic Environment Record (CHER) located within or directly adjacent to the three survey zones.

Main Site (Zone A)

- Prehistoric pottery, A45 Quy fieldwalking survey field 8, Horningsea (CHER: 11195)
- Roman pottery, A45 Quy fieldwalking survey field 8, Horningsea (CHER: 11195A)
- Medieval pottery, A45 Quy fieldwalking survey field 8, Horningsea (CHER: 11195B)
- Post-medieval pottery, A45 Quy fieldwalking survey field 8, Horningsea (CHER: 11195C)
- Roman cropmark system, Horningsea (CHER: 11555);
- Medieval earthworks, Horningsea (CHER: 05324a);
- Roman artefact scatter (CHER: 05324);
- Ridge and furrow, Horningsea (CHER: 05612)

Site Access Route (Zone B)

- Roman cropmark system, Horningsea (CHER: 11555)
- Medieval earthworks, Horningsea (CHER: 05324a)
- Ridge and furrow, Horningsea (CHER: 05612)
- Multiperiod finds, A45 Girton to Stow cum Quy fieldwalking survey, field 5 (CHER: 11192)
- High Dyke/ northern section of Fleam Dyke (CHER: MCB12150)
- Anglo-Saxon inhumation, Fleam Dyke at junction of Fen Ditton and Newmarket Roads (CHER: 06303)
- Milestone, Newmarket Road (CHER: MCB18062)

Treated Effluent Pipeline Corridor (Zone C)

- Multiperiod finds, A45 Girton to Stow cum Quy fieldwalking survey, field 6 (CHER: 11193)
- Late Saxon - early medieval pottery, Fen Ditton (CHER: 11765)
- Cropmark site, Fen Ditton (CHER: 08327)
- Cropmarks and earthworks associated with Biggin Abbey (CHER: 01095)
- Former clay pit, Fen Ditton (CHER: MCB27455)

3. AIMS, METHODOLOGY AND PRESENTATION

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 the PDA. This will therefore enable an assessment to be made of the impact of the proposed development on any sub-surface archaeological remains, if present, and thereby inform the DCO application and 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.

3.1. MAGNETOMETER SURVEY

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.

The survey was undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid carrying 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. 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 V3.0.36.0 (DWConsulting) software was used to process and present the data.

3.2. REPORTING

A general site location plan is shown in Illus 1 at a scale of 1:25,000. Illus 2 to Illus 5 inclusive are site condition photographs. Illus 6 shows the GPS swaths at 1:10,000 and also the three zones within the PDA. Illus 7 presents the greyscale data for the whole PDA, showing Sector boundaries, with Illus 8 an overall interpretation of the data, both illustrations at a scale of 1:10,000. Fully processed (greyscale) data, minimally processed data (XY trace plot) data and an interpretative plot (by Sector) are presented, at a scale of 1:2,500, in Illus 9 to Illus 26 inclusive. Large scale (1:1,000) plots of the Area of Archaeological Potential (AAP) are presented as Illus 27 to Illus 29 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 2021), 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 management and reporting staff.

4. RESULTS AND DISCUSSION

Ground conditions were generally good across the PDA, although heavy underfoot in places. Data quality was also good with only minimal post-processing required. All the PDA was suitable for survey, with the exception of the eastern half of F8 which was overgrown with teasles (Illus 5). No problems were encountered during the fieldwork.

Overall, the magnetic background was homogenous across the PDA (but with some geological variations – see Section 4.3 below) with numerous anomalies, agricultural, geological, archaeological and modern being identified. This confirms that the soils and geology are suitable for magnetometry and that the results likely provide a reasonably good indication of the extent of sub-surface archaeological features within the PDA, notwithstanding the limitations of magnetometer survey to identify certain types and sizes of archaeological feature and period.

The non-archaeological anomalies have been classified into categories and are discussed generally. Anomalies of probable archaeological origin have been identified at a single location and this area of archaeological potential (AAP) is discussed separately, and in more detail, below.

4.1. 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 any of the

fields or across the PDA more generally to 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.

Halos of magnetic disturbance in F3 and F4 are caused by the proximity of extant electricity pylons. The sub-surface remains of two former pylons are identified on the eastern edge of F7 and at the northern end of F9 as the characteristic arrangement of four equally spaced iron 'spikes' arranged in a square; each 'spike' caused by the steel foot at each corner of the former pylon.

An area of disturbance in the south-eastern corner of F7 correlates with the position of a former building recorded on the first edition OS map. Two linear dipolar anomalies (Illus 8 – SP1 and SP2), one of which terminates at the location of the former building, locate sub-surface pipes. A third pipe (Illus 8 – SP3) is identified running parallel with the disused railway line along the south-eastern boundaries of F5, F6, F10 and F11.

Other linear bands of disturbance located along field edges are due to the accumulation of ferrous debris along the boundary or to the presence of barbed wire or wire mesh in the boundary itself.

4.2. AGRICULTURAL ANOMALIES

Analysis of the first edition Ordnance Survey (OS) County series mapping from the late 19th century and more recent mapping shows that there has been a rationalisation of boundaries over the past 130 years to create larger fields, particularly around the southern ends of F5, F6, F12 and F13. Some of the former boundaries are also inferred by the change in orientation of the ridge and furrow cultivation strips (see below), which are identified as the slightly curving parallel linear anomalies, which are ubiquitous throughout with the notable exception of the field south of Biggin Abbey (F1). The best example of this is the area either side of the current boundary between F5 and F6. The more closely spaced, parallel very straight linear trends are due to modern cultivation.

Also recorded throughout are other linear trend anomalies that are interpreted as field drains. These may form a regular pattern, such as those in F3, although some are also curvilinear and much less regular such as those aligned broadly east/west in the northern half of F5.

4.3. GEOLOGICAL ANOMALIES

Vague low magnitude anomalies forming a 'crazy paving' like effect in the data are noted in three locations; in the north-eastern quarter of F3, towards the southern end of F5 and, to a lesser extent, the western third of F4. These anomalies are all interpreted as geological in origin.

Chalk bedrock is particularly susceptible to erosion by water and ice and so this patterning may be due to fissuring in the bedrock. Similarly, some of the discrete anomalies interpreted as of archaeological potential might also be due to infilled geological water worn hollows or depressions. However, in all instances (see Section 4.4 below) any clusters of discrete anomalies have been interpreted as of possible archaeological origin given the local archaeological context.

4.4. AREA OF ARCHAEOLOGICAL POTENTIAL

Most of F1 has been identified as an AAP. Of clearest potential is a broad low magnitude anomaly (Illus 8 – M1) which locates part of the infilled moat surrounding the eastern side of the Biggin Abbey complex – the moat is also clearly visible on satellite images of the site taken at the end of 2005. The southern side of the moat is also visible as a cropmark in 2005 but has not been recorded as a magnetic anomaly, possibly because the direction of survey traverse was directly along the line of the moat. Within the moated area four short linear anomalies, on the same alignment as the eastern moat, are also recorded possibly suggesting division/partition within the moated area. A single linear ditch type anomaly (Illus 8 – D1), also on the same alignment as the eastern moat, and which terminates (and possibly intersects with the inferred southern moat), is also recorded. Discrete anomalies within the moated area are also interpreted as of possible archaeological origin as they stand out against a very homogenous magnetic background in this field. This 'flat' magnetic background in this field is likely due to the presence of superficial alluvial deposits from the River Cam which are not present elsewhere in the PDA.

Two other clusters of anomalies of possible potential are noted in F1. In neither instance can any coherent pattern be discerned but vague linear and discrete anomalies again clearly stand out against the homogenous magnetic background.

The first cluster is defined by three vague linear anomalies describing a possible small square

'enclosure' with a fourth linear anomaly extending eastward from the 'enclosure'. Discrete, pit-type responses are identified within the possible 'enclosure'.

The second area is in the south-east corner of the F1 survey area and is a cluster of discrete anomalies which again form no definite pattern but which are clearly anomalous against the prevailing magnetic background.

4.5. OTHER ANOMALIES OF POSSIBLE ARCHAEOLOGICAL POTENTIAL

In the south-western corner of F3 another cluster of discrete anomalies is identified just inside the junction of Horningsea Road and the A14. It is also adjacent to the Roman cropmark complex CHER 11555/13592. Potentially these anomalies could be due to archaeological activity associated with the road and/or the settlement complex. Alternatively, the anomalies could be caused by infilled natural geological features (see Section 4.3 above). No anomalies that correspond with the previously identified cropmarks are recorded.

Two other clusters of discrete anomalies, which again stand out against the magnetic background, are recorded towards the southern end of F6. These anomalies have also been interpreted as of possible archaeological origin although a geological origin is considered equally plausible.

In F14 and in F16, either side of the A14, a curvilinear anomaly (Illus 8 – D2) is recorded which cannot be interpreted with certainty as of agricultural origin. For this reason a possible archaeological origin must be considered.

5. CONCLUSION

Across the whole of the PDA the overwhelming majority of magnetic anomalies are due to agricultural activity; ridge and furrow and modern cultivation, field drains and former boundaries.

However, the survey has identified a single area of archaeological potential in the field immediately south of Biggin Abbey (Zone C – the treated effluent corridor). Part of the moat and possible associated features within the moated complex have been recorded. Other anomalies beyond the moat may also have an archaeological origin although no clear pattern can be discerned that would lead to a more confident archaeological interpretation being made.

Elsewhere a cluster of discrete anomalies is recorded (in Zone A – the main site) adjacent to the Horningsea Road and an area of cropmarks which have been interpreted as indicative of Roman settlement. The cropmarks, which are very clearly visible on an air photograph taken in 1970, have not been recorded by the survey. It is possible that the underlying features may have been degraded by deep ploughing over the last 50 years since the images were taken and by the construction of the A14 in 1990. The anomalies are, however, outside the proposed footprint of the new water treatment works; no anomalies of archaeological potential are recorded within the footprint of the works.

Within Zone B (the access road corridor) a single curvilinear anomaly of uncertain (and therefore potentially archaeological) origin is recorded. The relatively narrow survey corridor here makes further interpretation difficult.

Sedimentary bedrock (such as chalk) generally provides good results to magnetic survey particularly when there are no overlying superficial deposits. Therefore, it is assessed that the survey has given a good indication of the likely archaeological potential of the PDA.

6. REFERENCES

Cambridgeshire County Council Historic Environment Team 2020 Brief for Archaeological Geophysical Survey Unpublished Cambridgeshire County Council Document

Chartered Institute for Archaeologists (CIfA) 2014 Standard and guidance for archaeological geophysical survey (Reading) https://www.archaeologists.net/sites/default/files/CIfA%26GGeophysics_3.pdf accessed 19th April 2021

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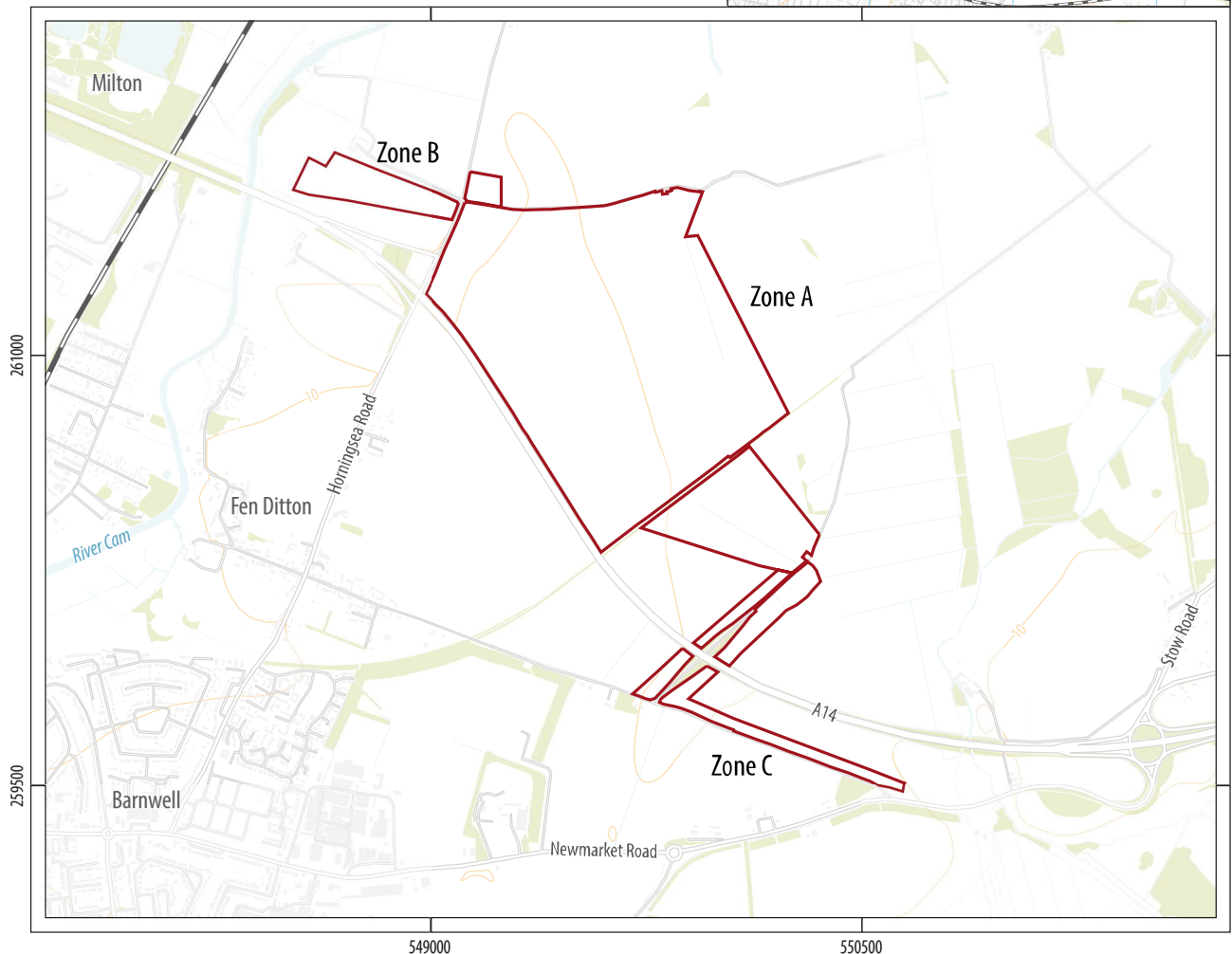
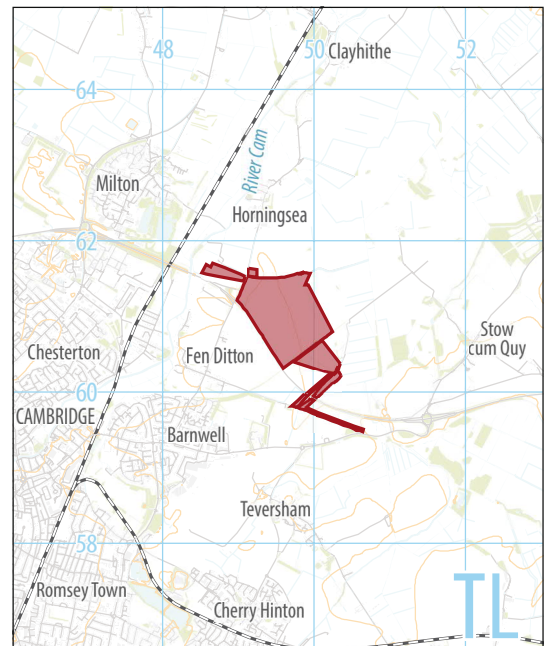
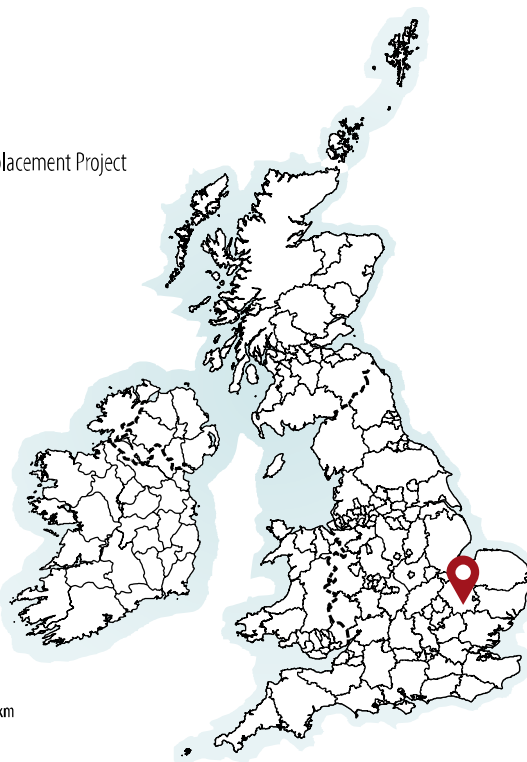
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Mott MacDonald 2021 Cambridge Waste Water Treatment Plant Relocation Scope of Works Unpublished Client Document Ref. 415458-EN-SOW-001

Mott MacDonald 2021 Cambridge Waste Water Treatment Plant Relocation WWTP Stage 4 Historic Environment Assessment Unpublished Client Document

Cambridge Water Replacement Project
Cambridgeshire

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



0 500m
1:25,000 @ A4

proposed development area

**HEADLAND
ARCHAEOLOGY**

Headland Archaeology Yorkshire & North
Units 23-25 & 15 | Acom Business Centre | Balme Road | Clackheaton BD19 4EZ
t 0127 493 8019
e yorkshireandnorth@headlandarchaeology.com
w www.headlandarchaeology.com



Illus 2. F1 looking north-east



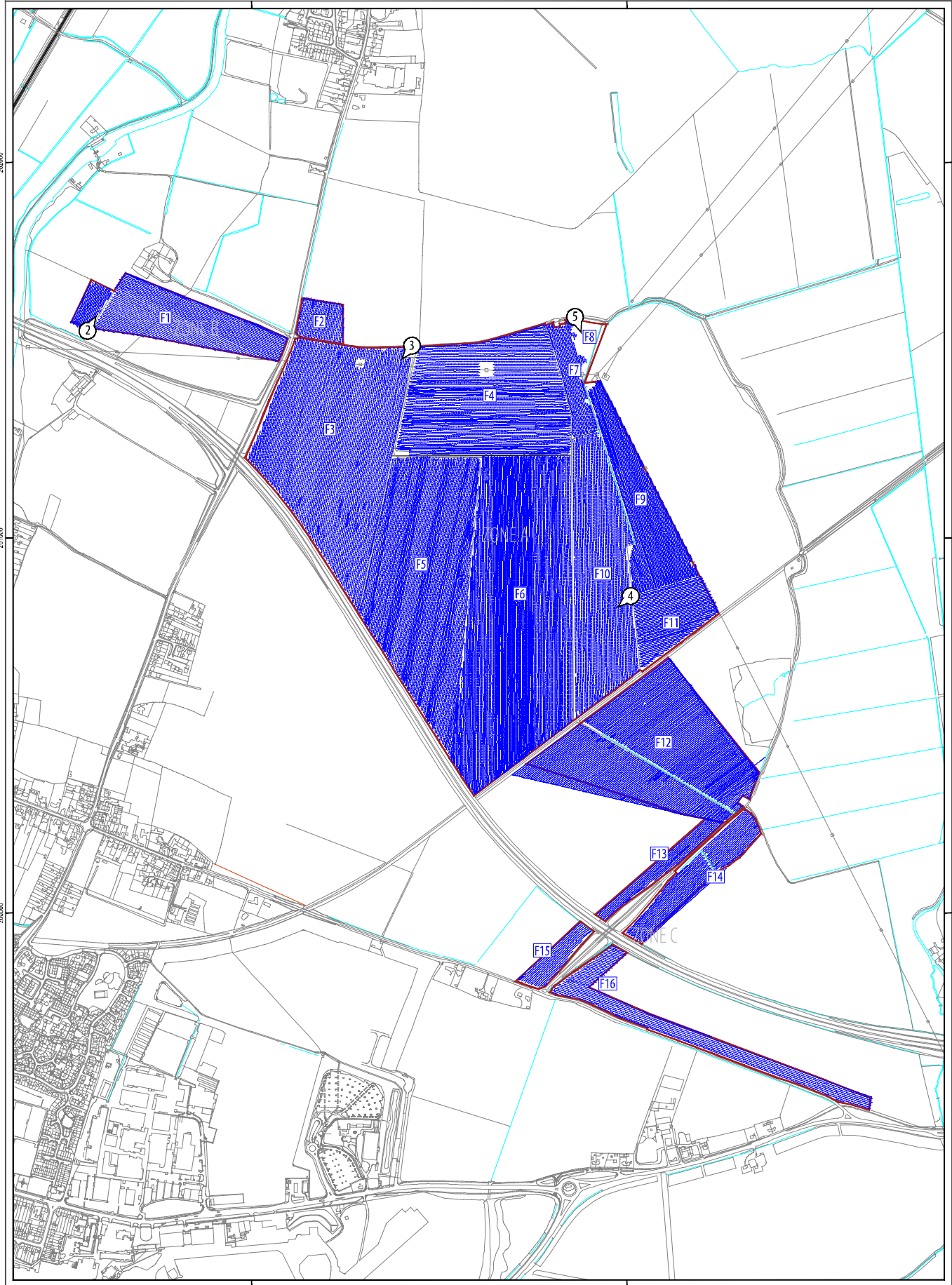
Illus 3. F3 looking south-west



Illus 4. F10 looking south-west



Illus 4. F8 looking south-east



- geophysical survey area
- GPS swaths
- area unsuitable for survey
- 📍 location and direction of ILLUS 2-5



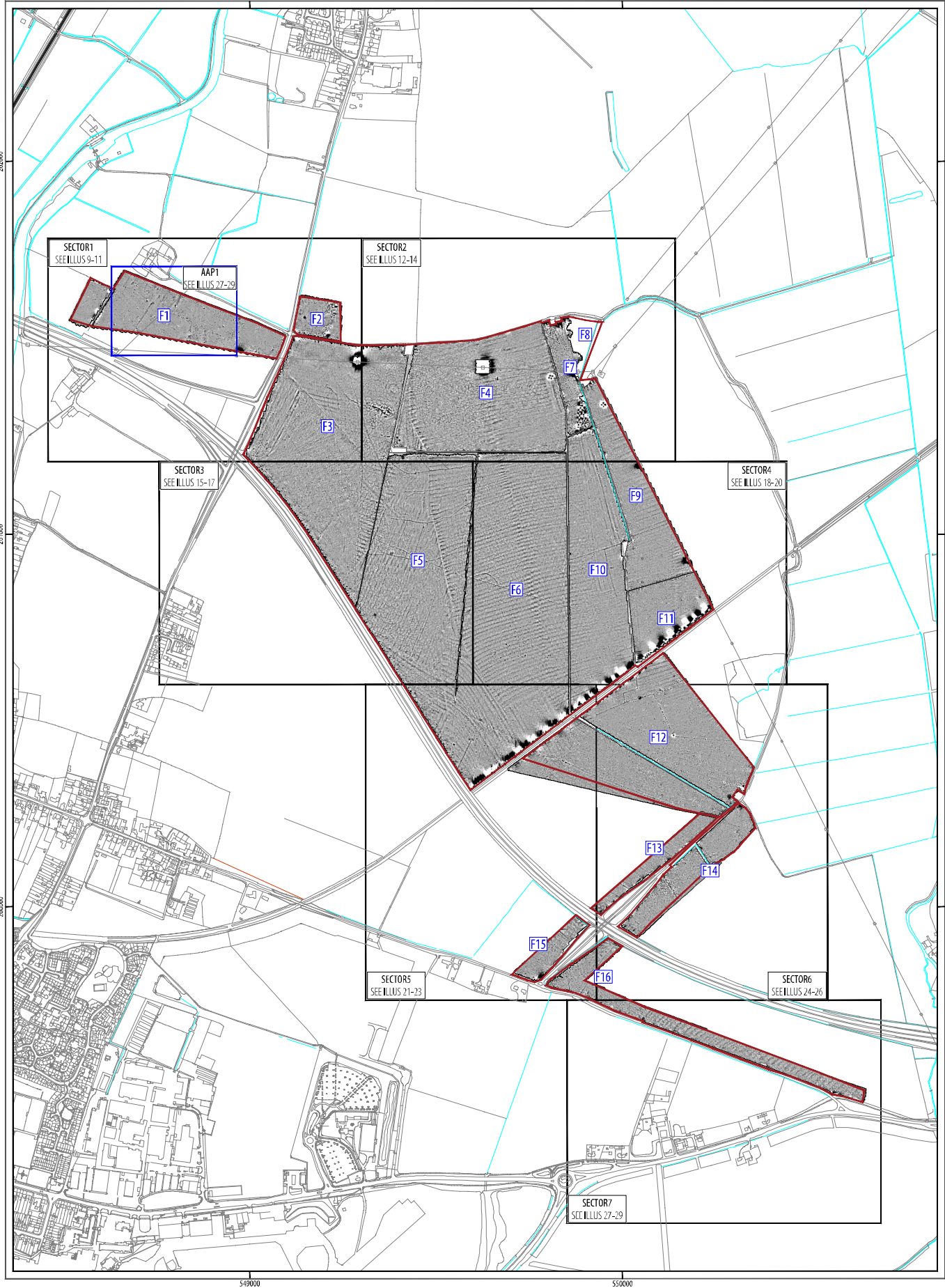
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Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
: 01274 93 8019
www.headlandarchaeology.com

ILLUS 6 Geophysical survey location showing GPS swaths and photo locations



geophysical survey area

-1.0 0.0 2.0 nT

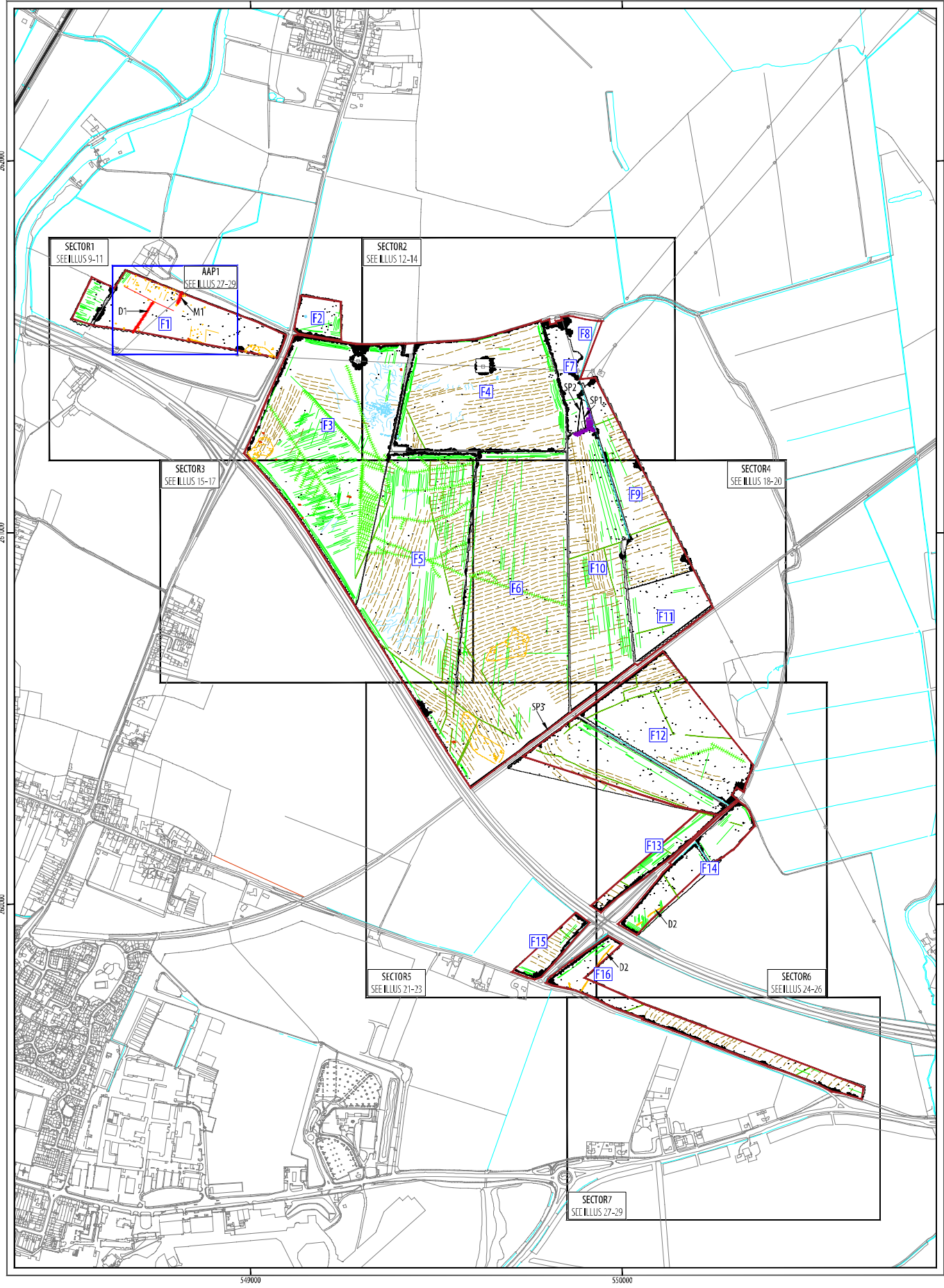
0 200m
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Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
: 01274 93 8019
www.headlandarchaeology.com



geophysical survey area		TYPE OF ANOMALY		INTERPRETATION	
TYPE OF ANOMALY		TYPE OF ANOMALY		TYPE OF ANOMALY	
- dipolar isolated - magnetic disturbance - dipolar linear - magnetic disturbance	linear trend	ridge and furrow		magnetic enhancement	geology
	linear trend	agricultural		linear trend	archaeology?
	linear trend	field drain		magnetic enhancement	archaeology?
	linear	former field boundary		magnetic enhancement	archaeology
	linear	former field boundary?		magnetic enhancement	drain/burning
- ferrous material - ferrous material - service pipe - former building	linear trend	geological variation			
	linear trend				

ILLUS 8 Interpretation of magnetometer data

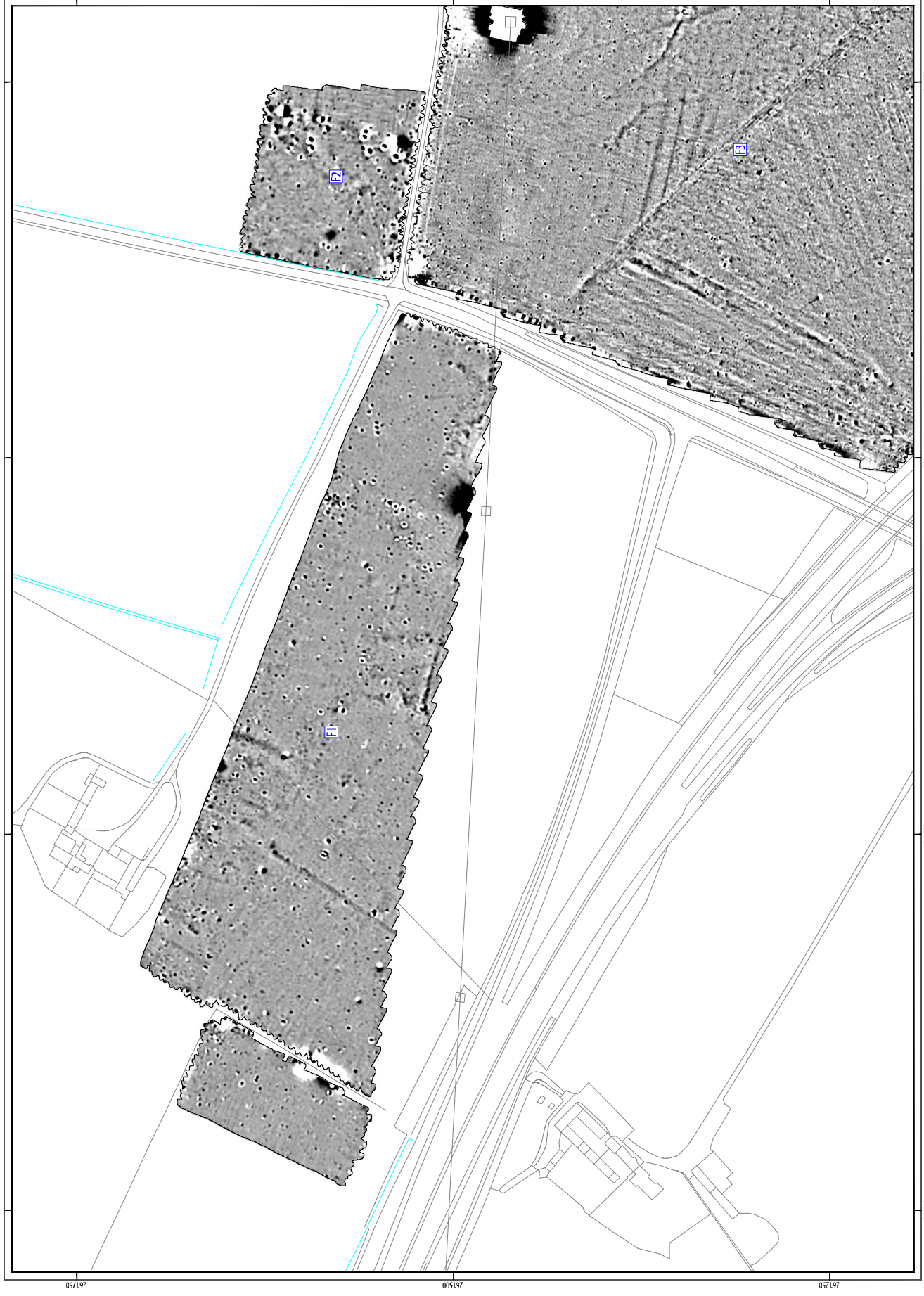


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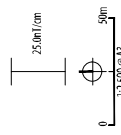
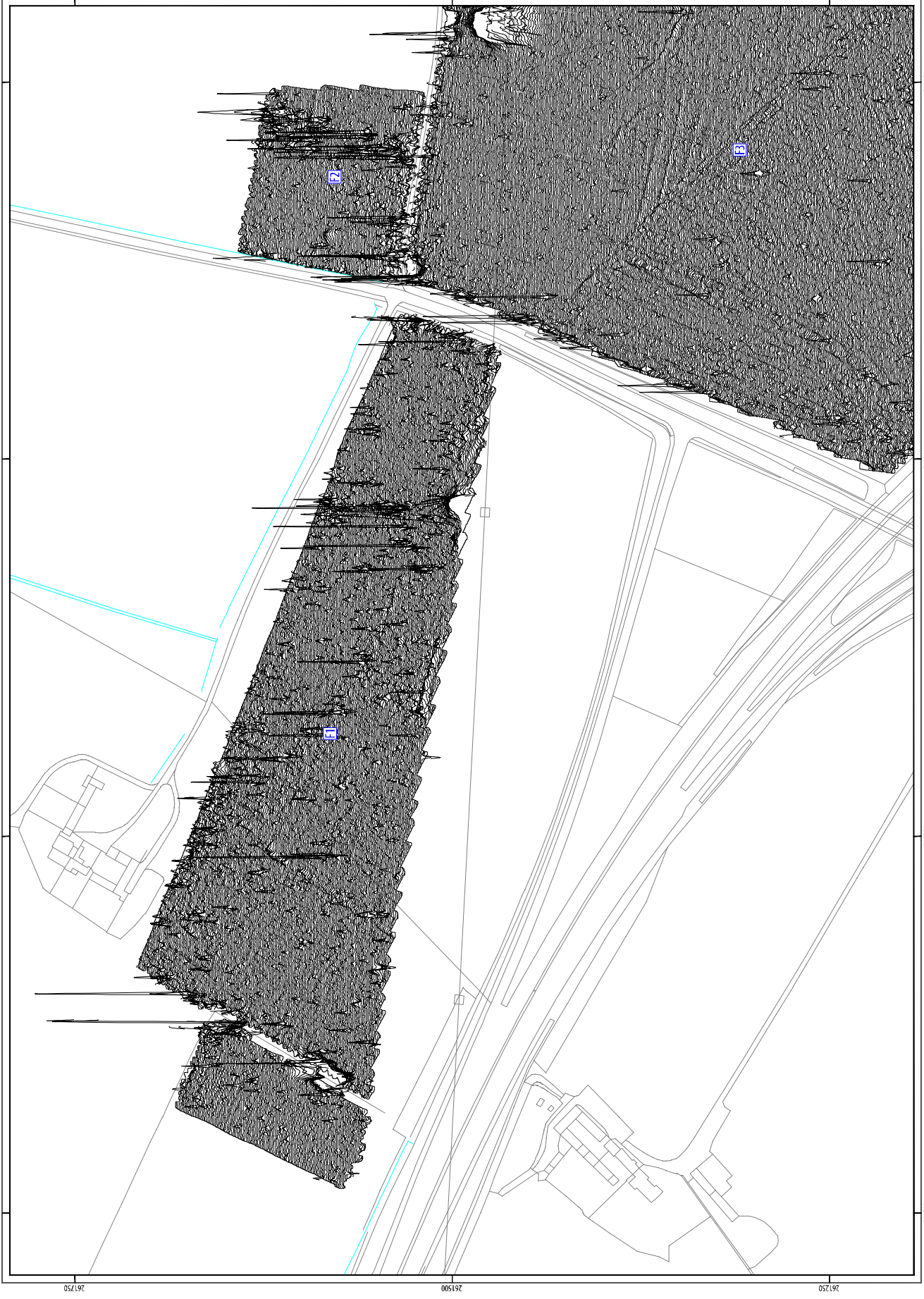


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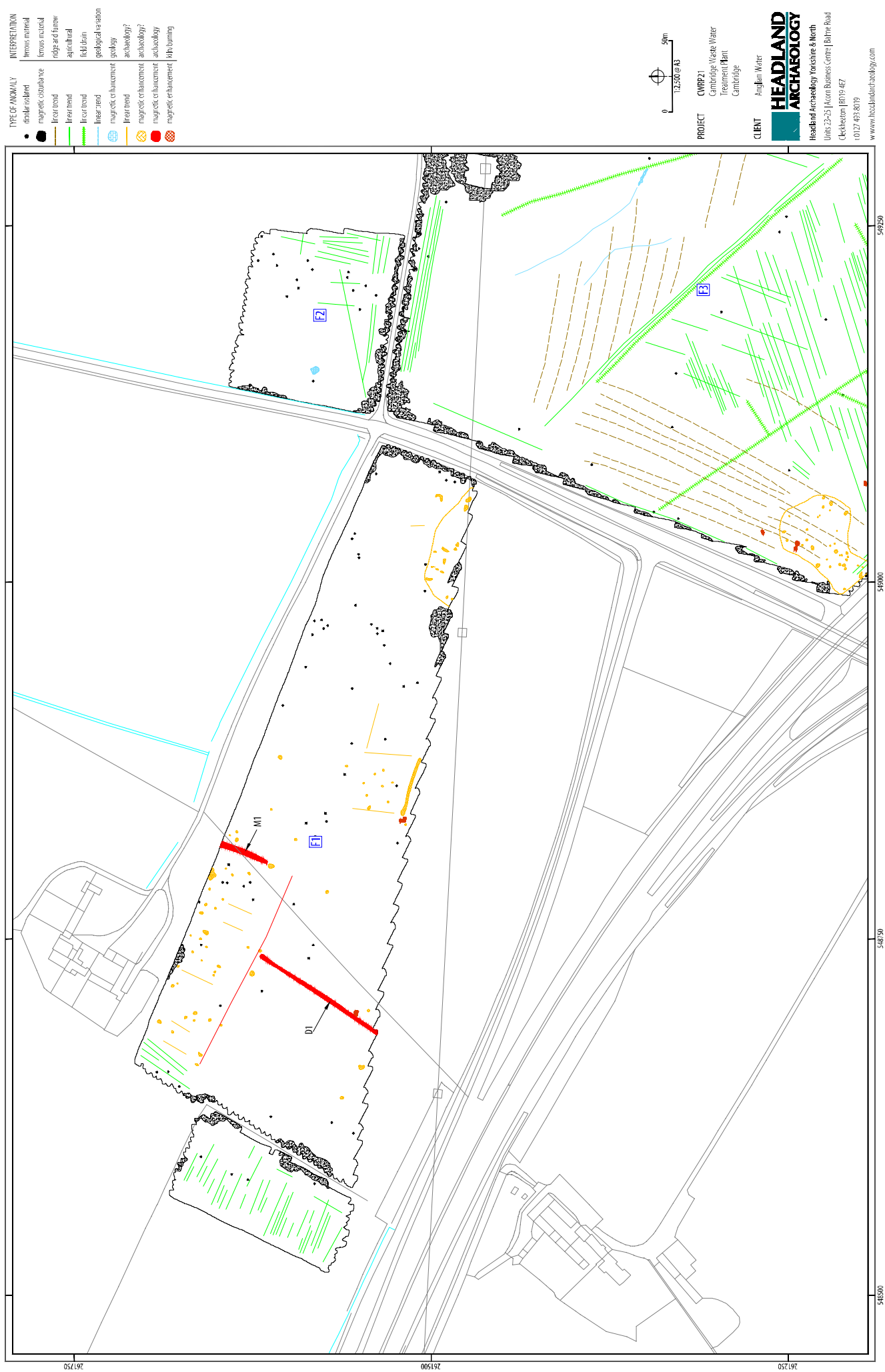
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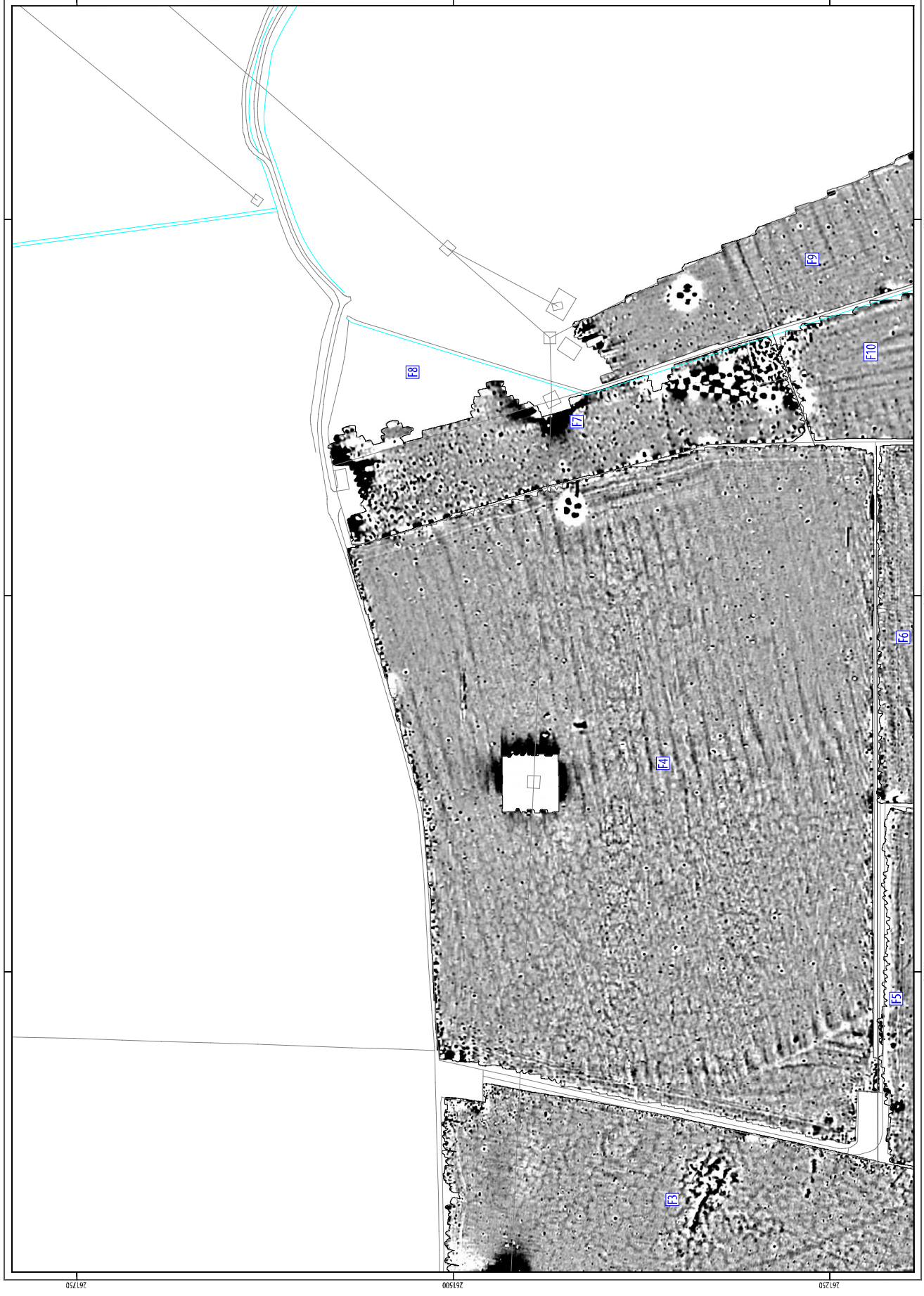


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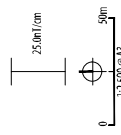
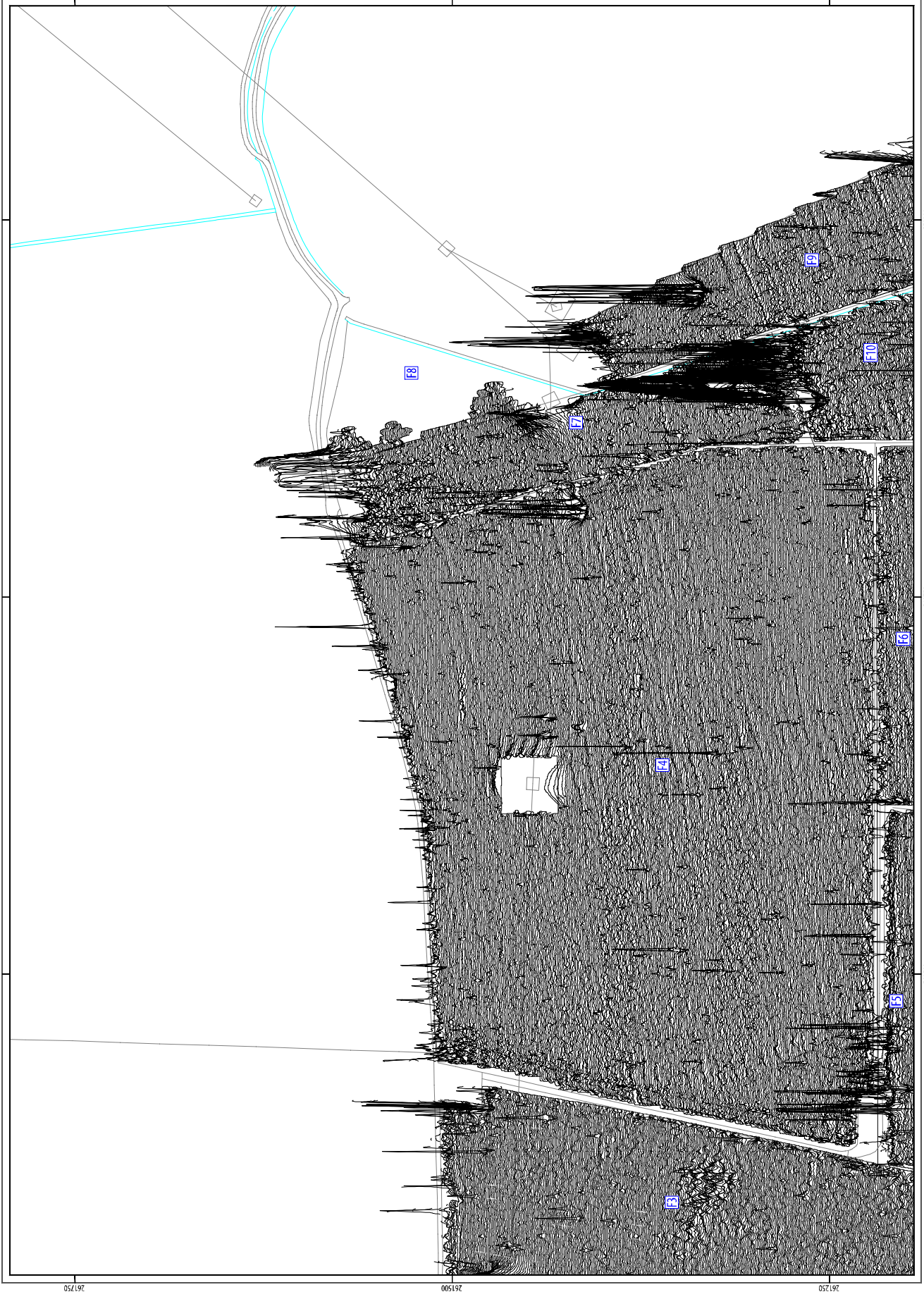
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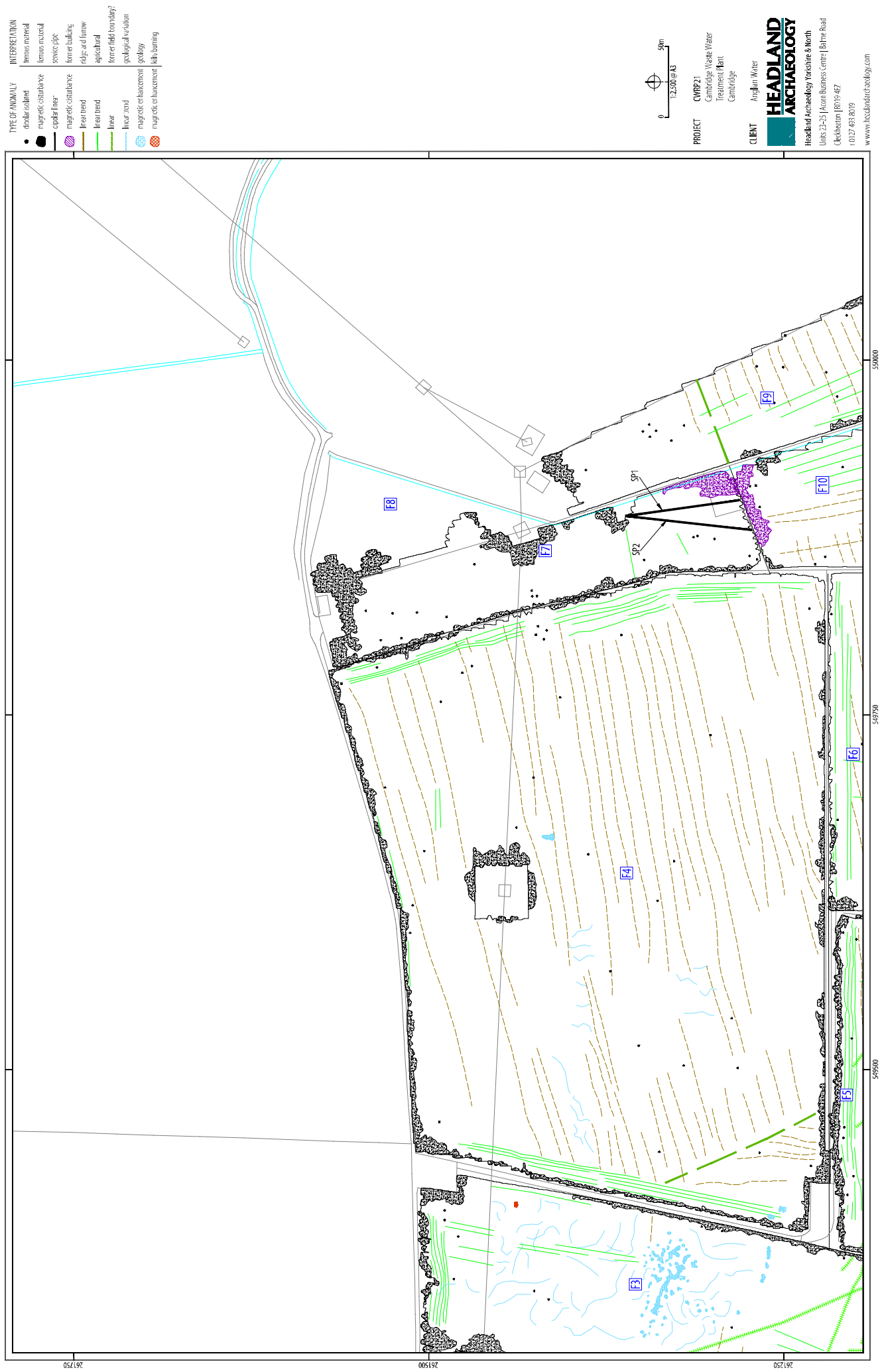


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ILLUS 13 XY Traceplot of minimally processed magnetometer data, Sector 2





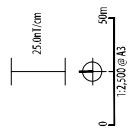
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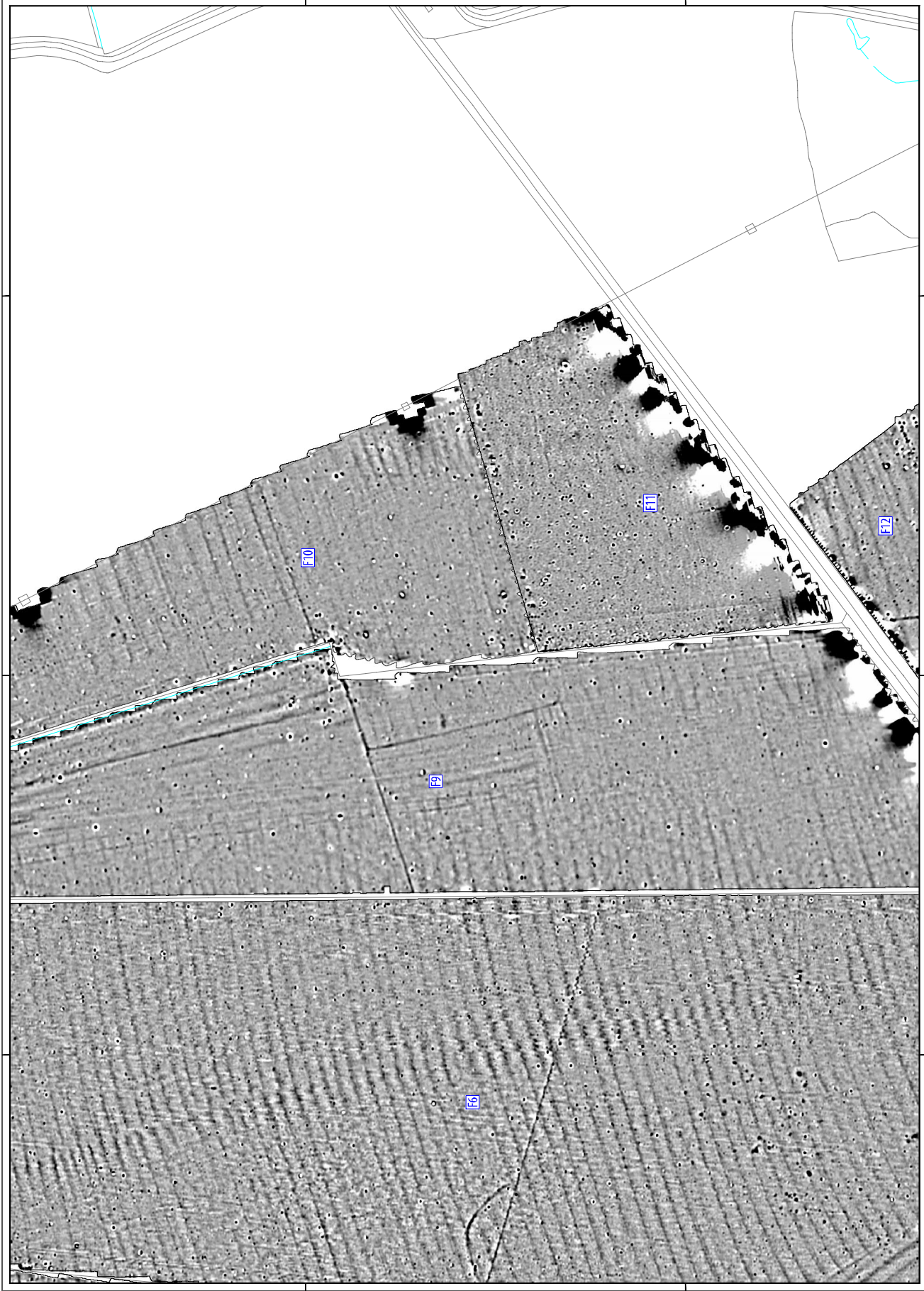


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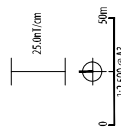
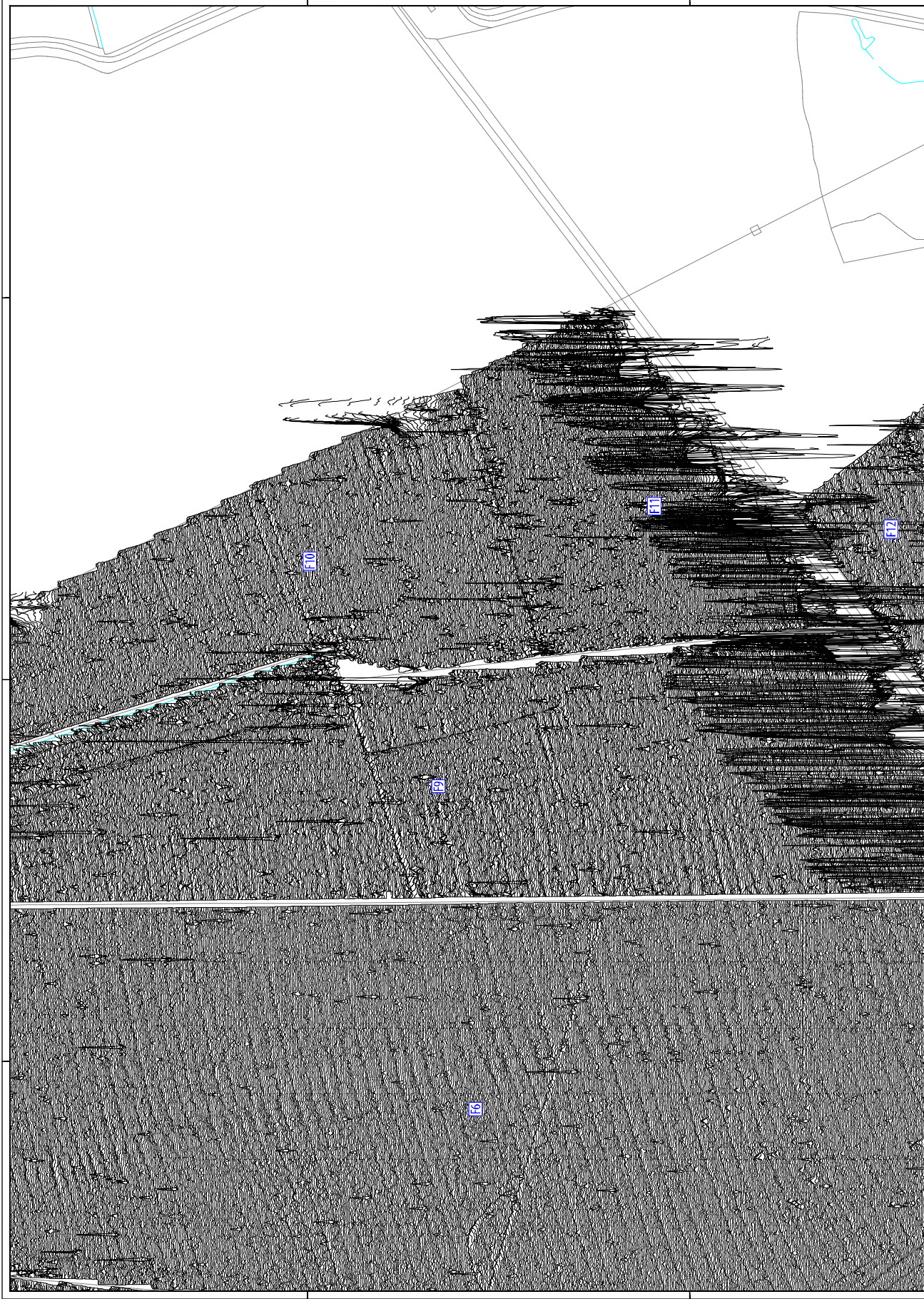


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ILLUS 18 Processed greyscale magnetometer data, Sector 4



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

55020

55000

54970

261000

260750

- TYPE OF ANOMALY

 - dotter isolated
 - magnetic disturbance
 - capillary line
 - linear trend
 - linear trend
 - linear trend
 - linear
 - linear
 - magnetic enhancement
 - magnetic enhancement
- INTERPRETATION

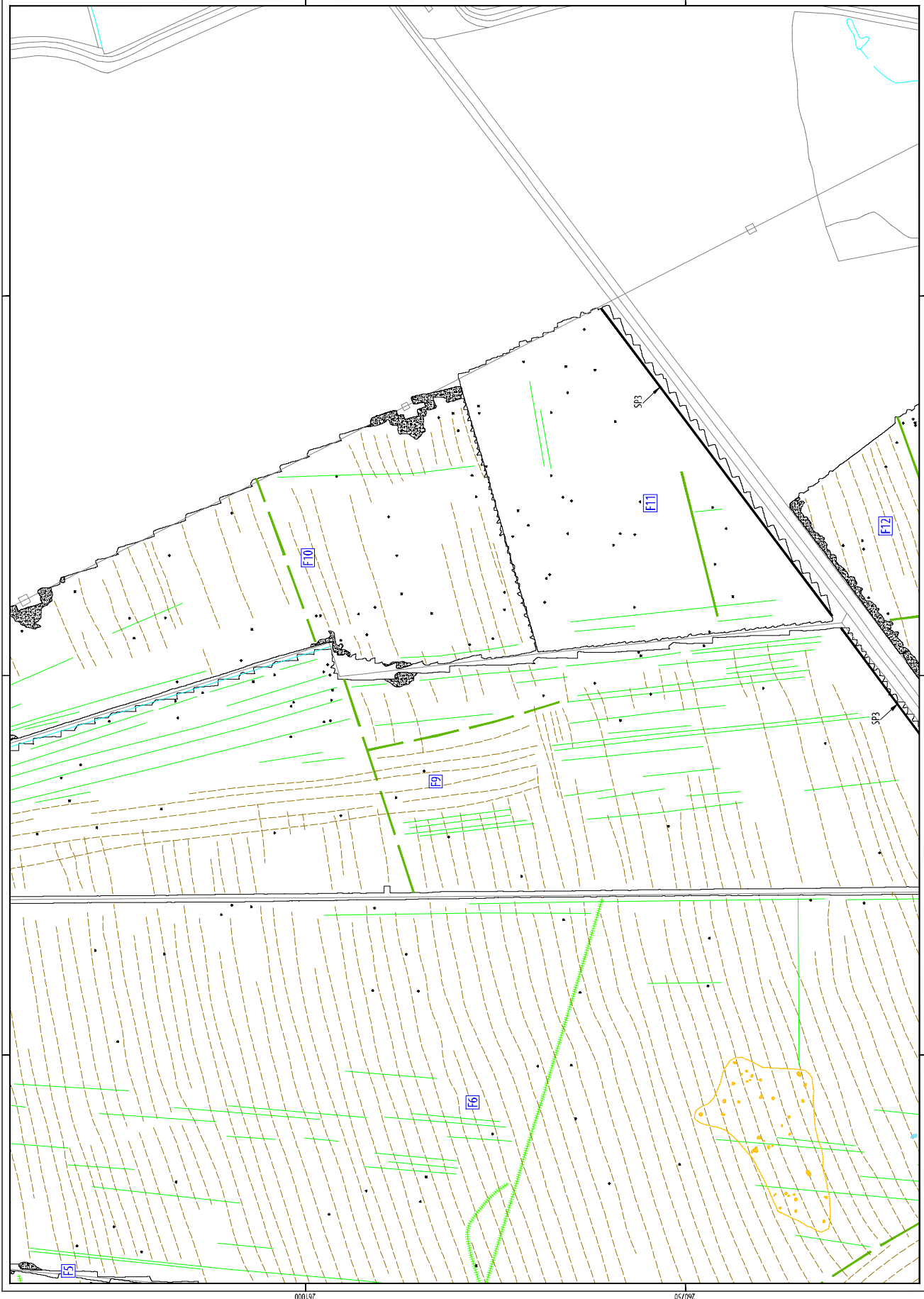
 - terrous material
 - terrous material
 - service pipe
 - ridge and furrow
 - agricultural
 - field drain
 - former field boundary
 - former field boundary
 - geology
 - archaeology?

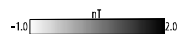
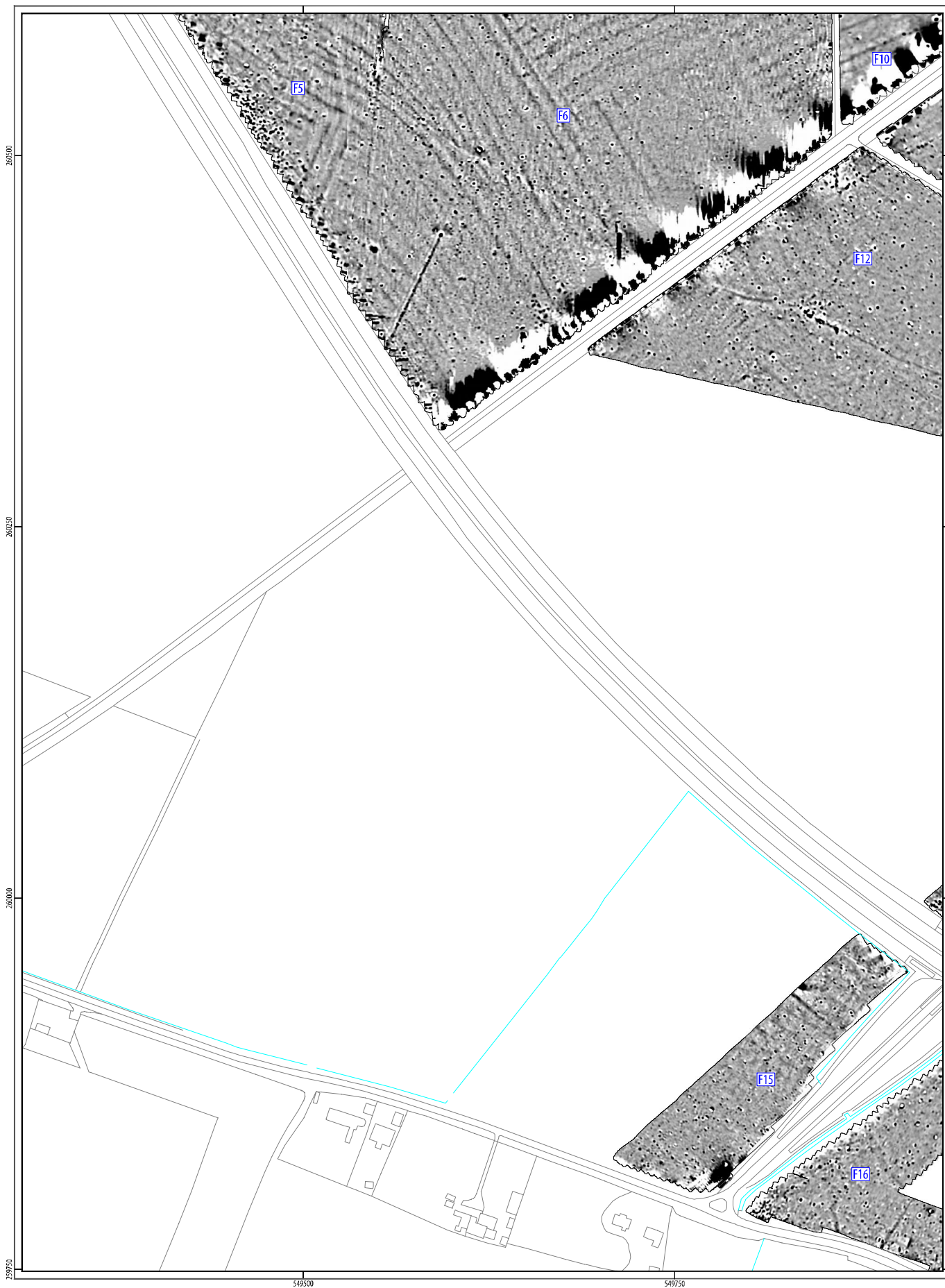


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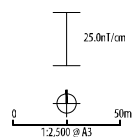
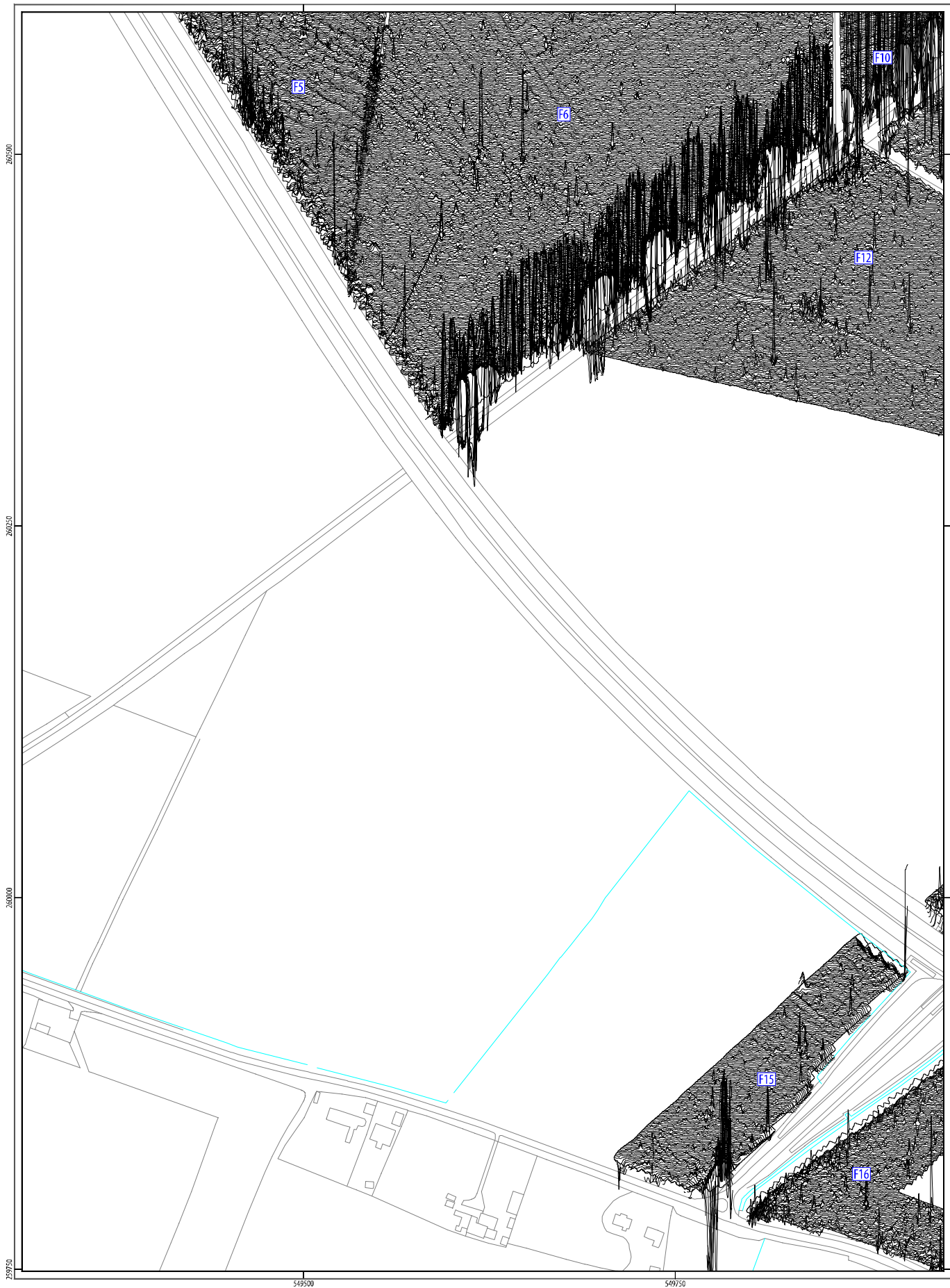


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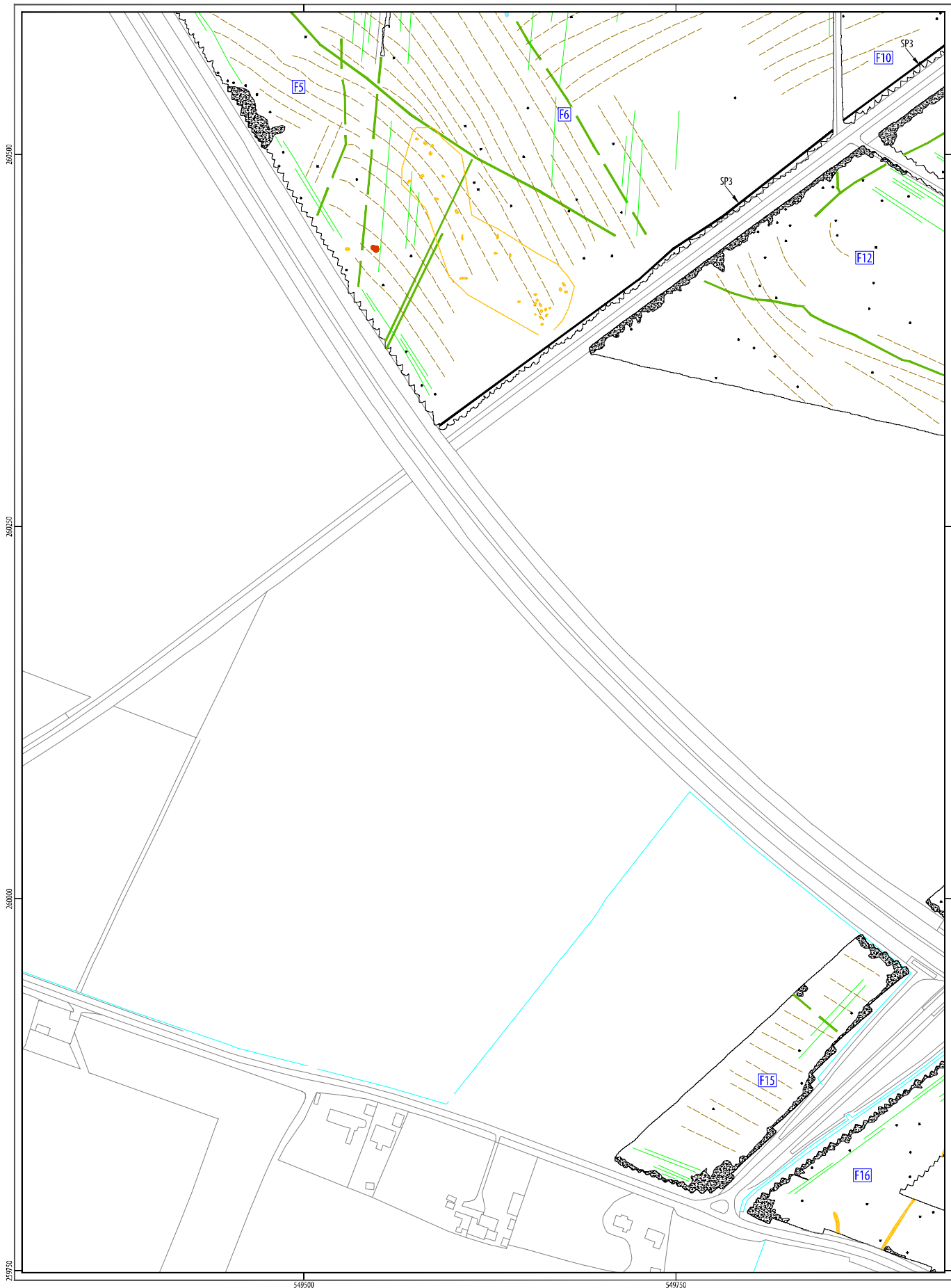


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TYPE OF ANOMALY	INTERPRETATION	TYPE OF ANOMALY	INTERPRETATION
• dipolar isolated	ferrous material	— linear	former field boundary?
• magnetic disturbance	ferrous material	• magnetic enhancement	geology
— dipolar linear	service pipe	• magnetic enhancement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

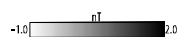
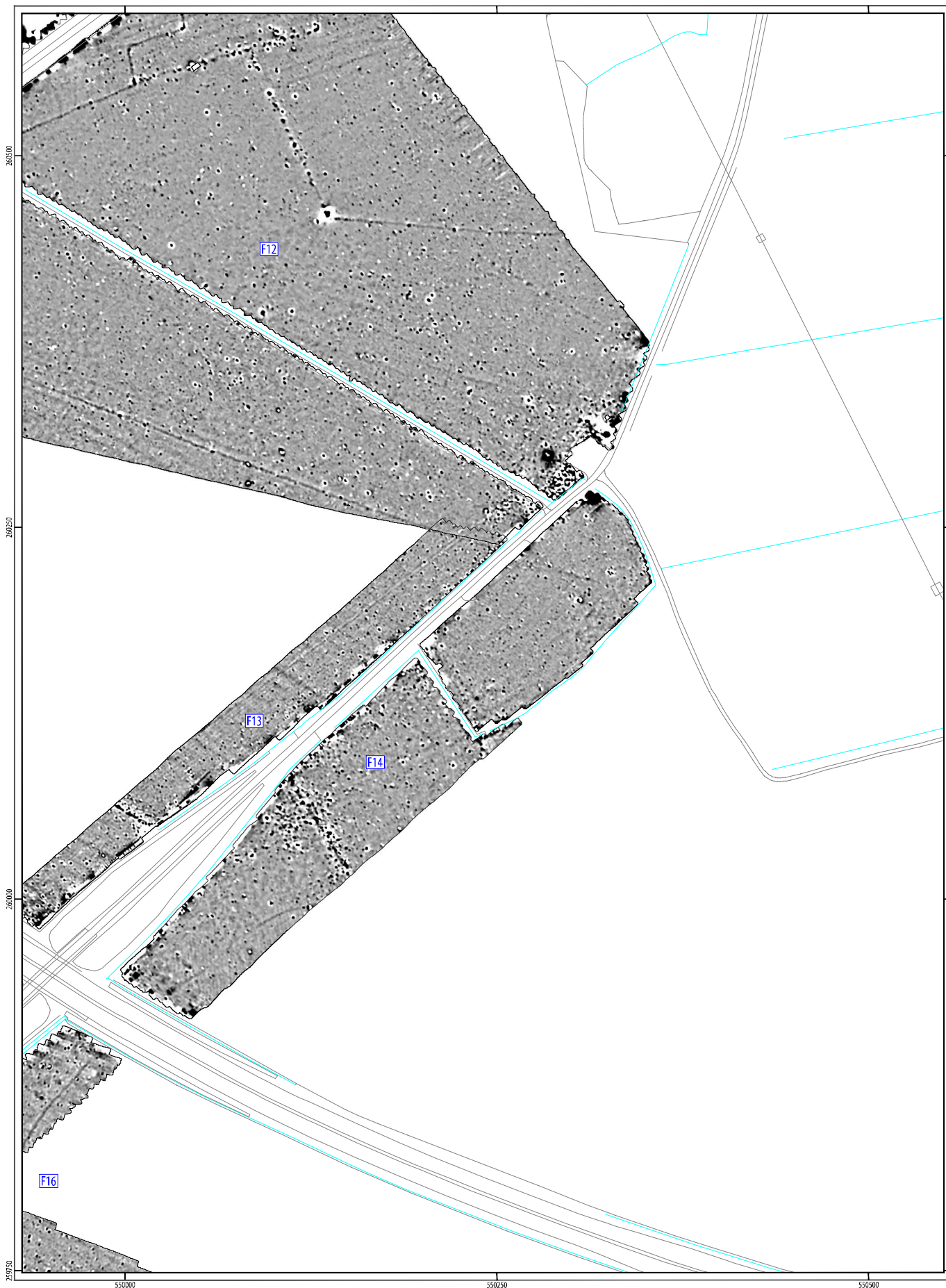


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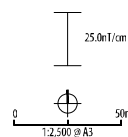
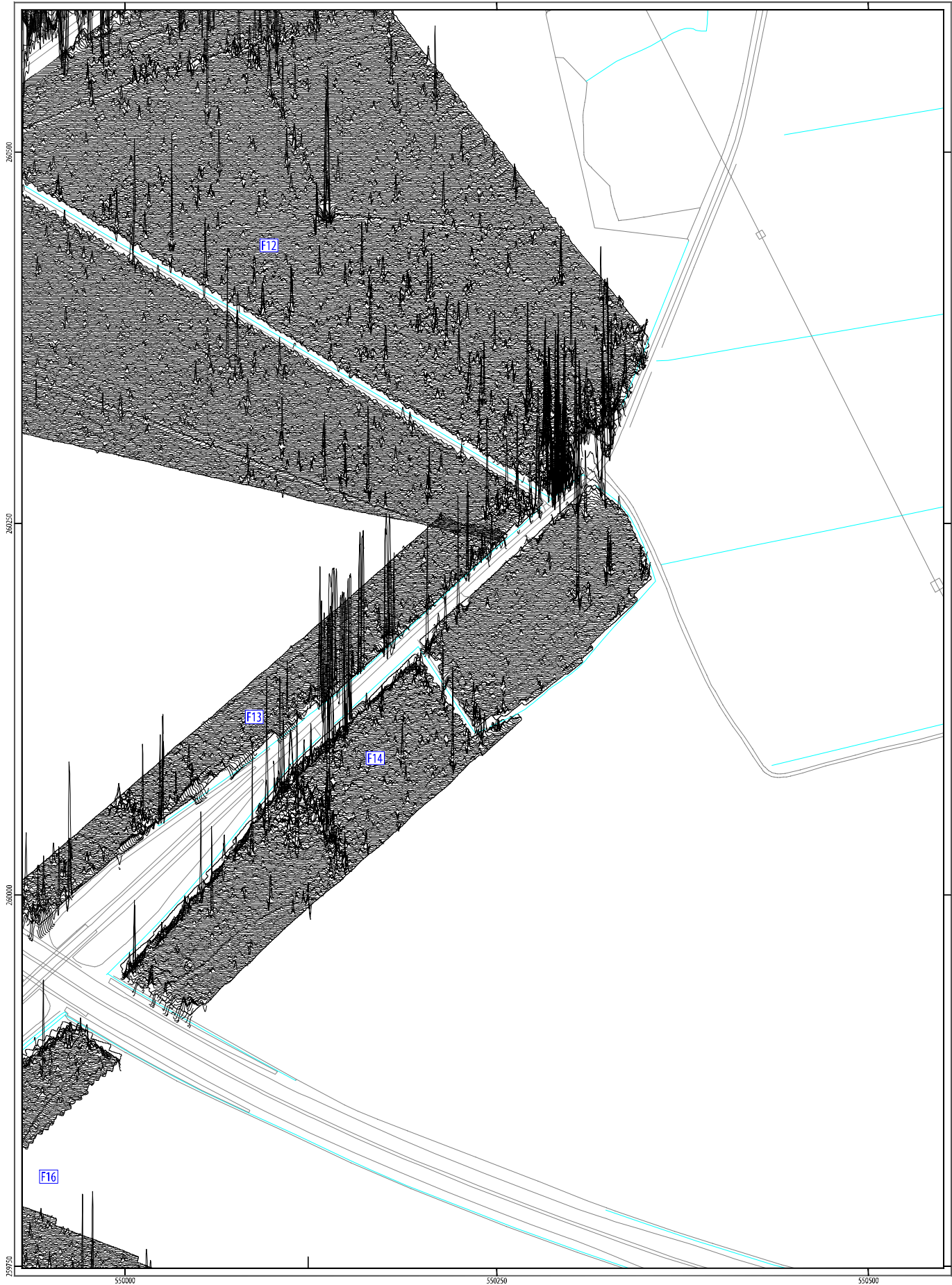


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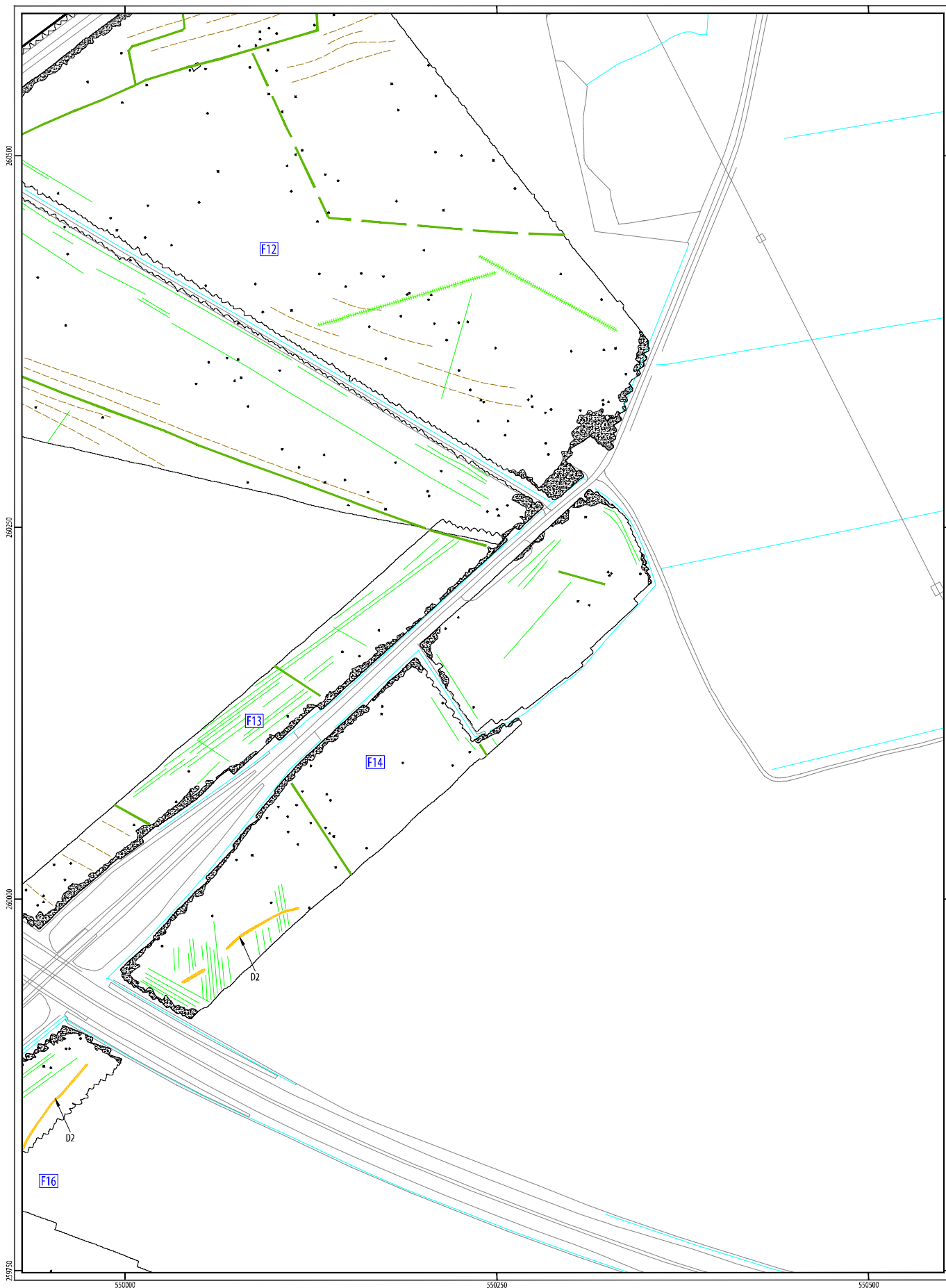


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TYPE OF ANOMALY	INTERPRETATION	TYPE OF ANOMALY	INTERPRETATION
• dipolar isolated	ferrous material	— linear	former field boundary
• magnetic disturbance	ferrous material	— linear	former field boundary?
— dipolar linear	service pipe	⊗ magnetic enhancement	archaeology?
— linear trend	ridge and furrow		
— linear trend	agricultural		
— linear trend	field drain		

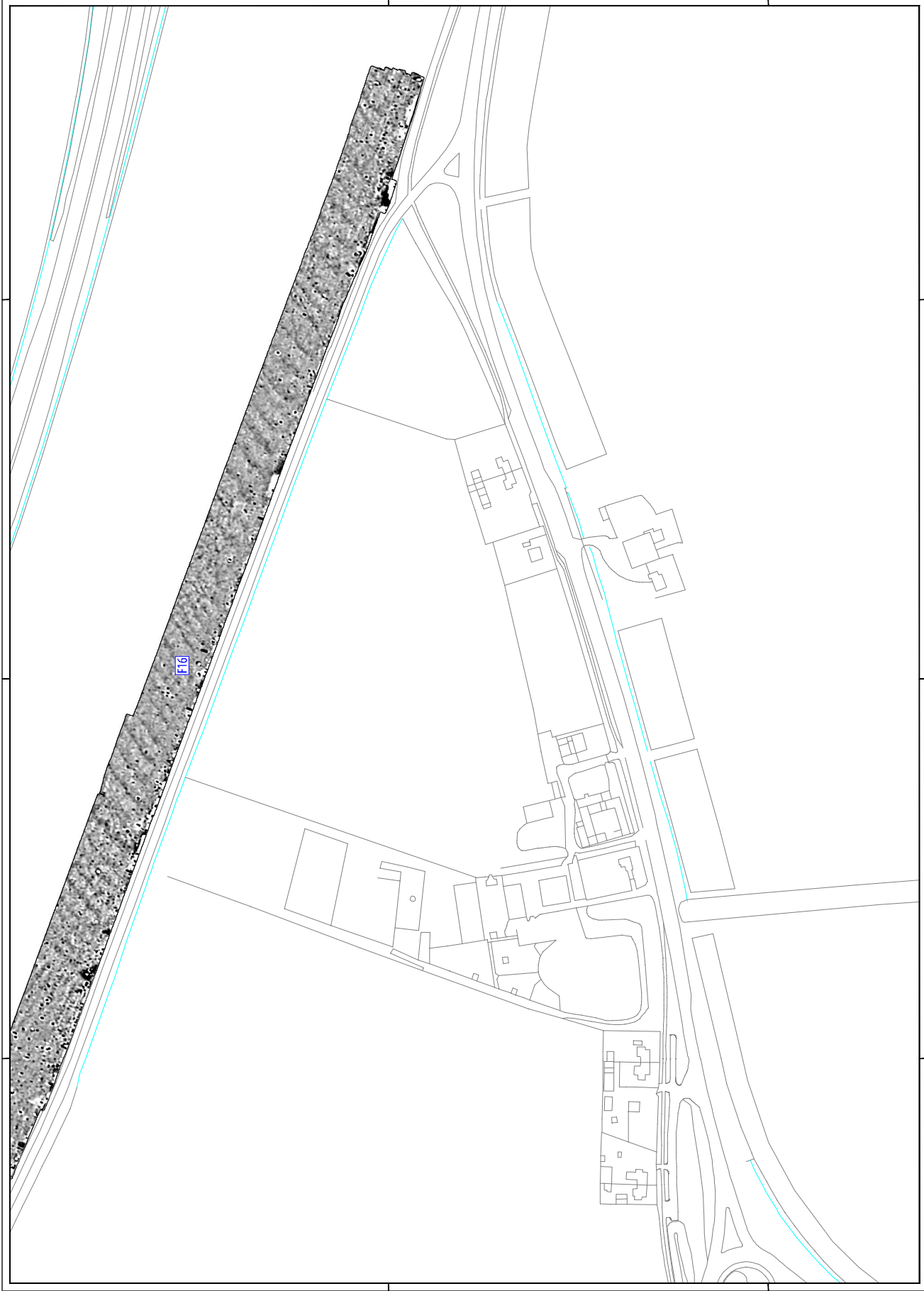
ILLUS 26 Interpretation of magnetometer data; Sector 6

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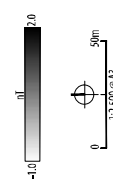
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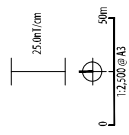
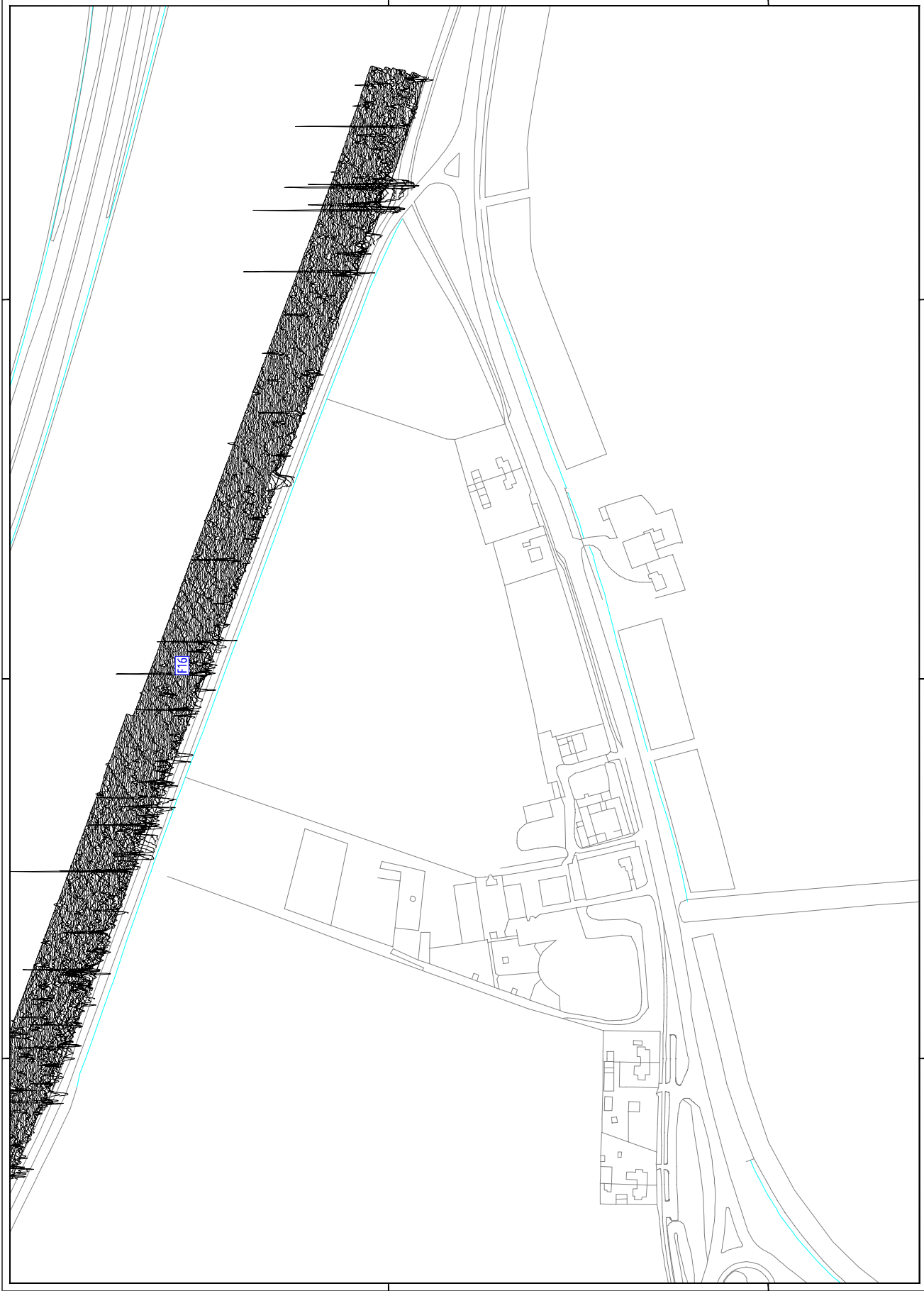


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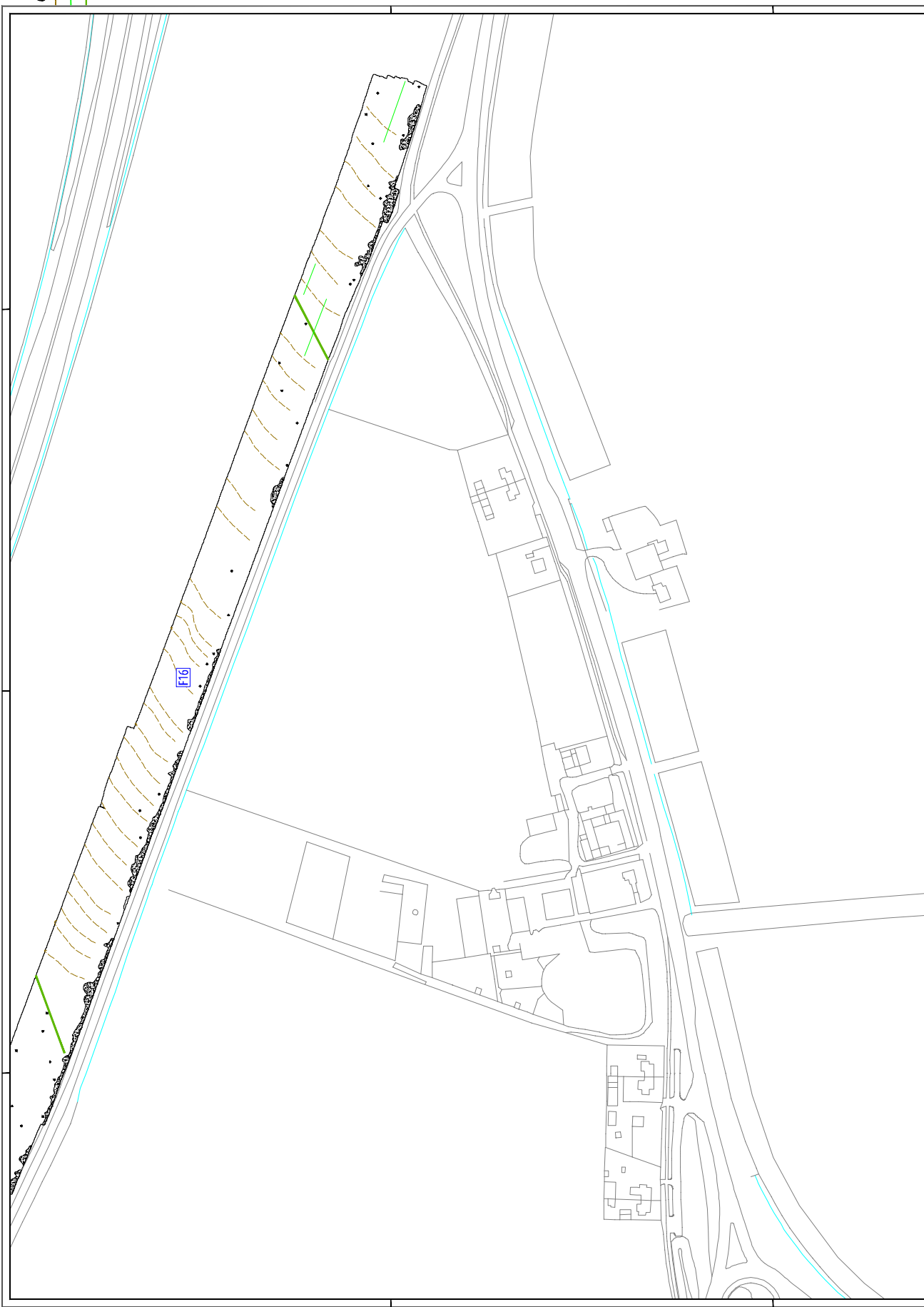
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550000

550250

550500



- TYPE OF ANOMALY**
- dot-like isolated
 - magnetic disturbance
 - linear trend
 - linear trend
 - linear
- INTERPRETATION**
- ferrous material
 - ferrous material
 - ridge and furrow
 - agricultural
 - former field boundary



PROJECT

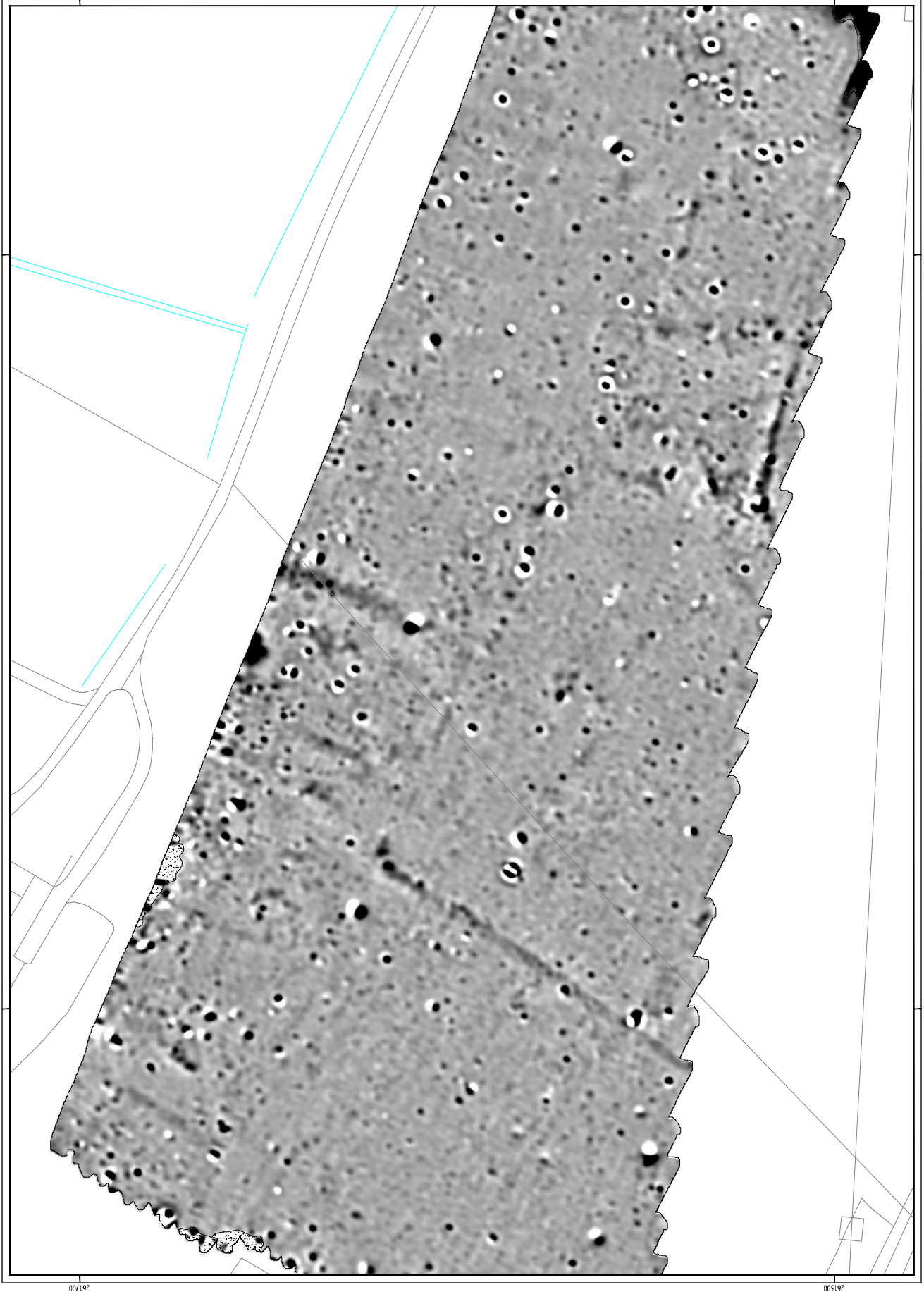
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261700

261500

548000

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ILLUS 30 Processed greyscale magnetometer data, AAP1

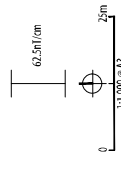
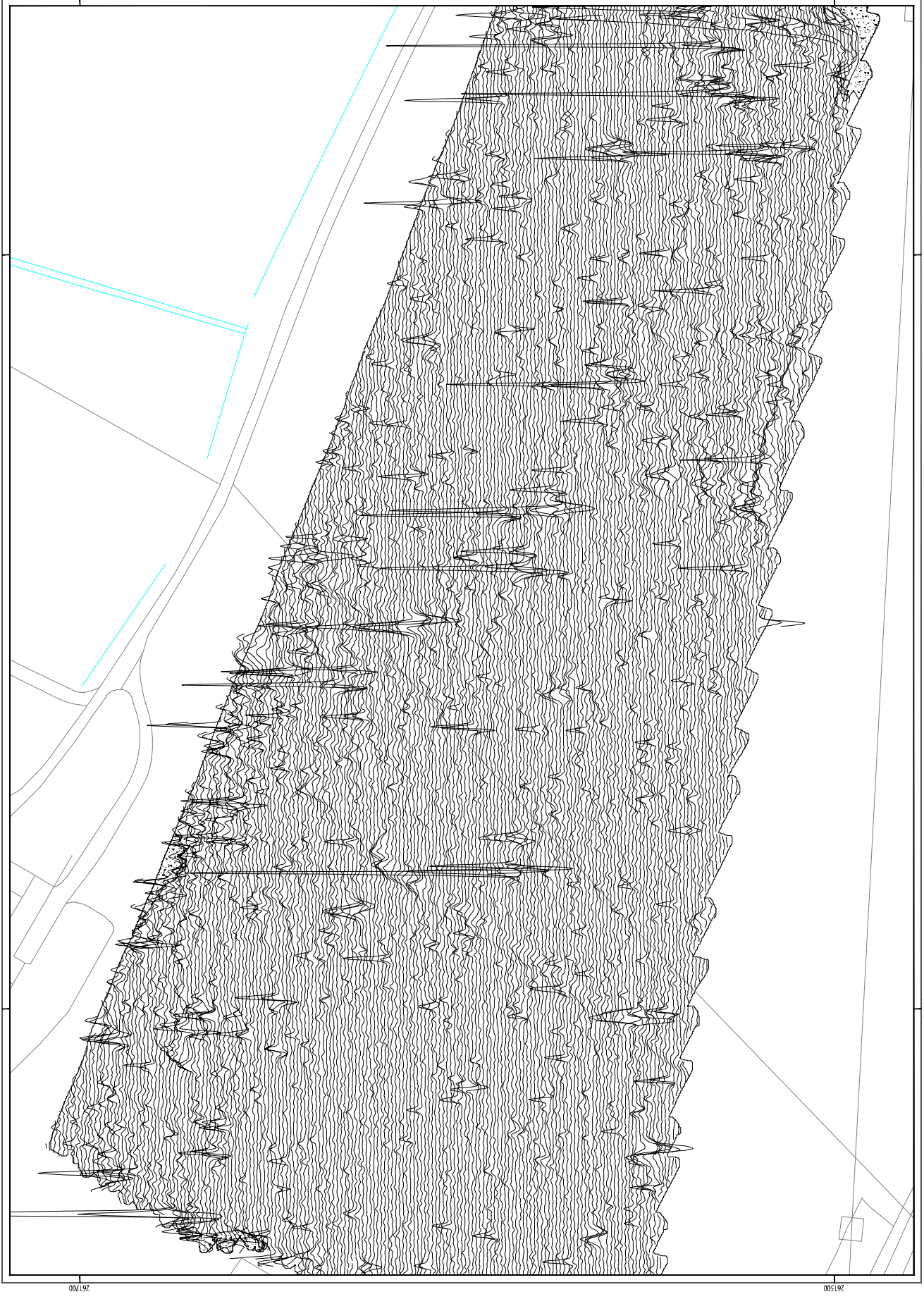


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7. APPENDICES

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 topsoils, subsoils and rocks into which these features have been cut, which causes the most recognisable responses. This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features cut into the subsoil or geology, such as ditches, that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels. Discrete feature, such as pits, can also be detected.

The magnetic susceptibility of a soil can also be enhanced by the application of heat. This effect can lead to the detection of features such as hearths, kilns or areas of burning.

Types of magnetic anomaly

In the majority of instances anomalies are termed 'positive'. This means that they have a positive magnetic value relative to the magnetic background on any given site. However, some features can manifest themselves as 'negative' anomalies that, conversely, means that the response is negative relative to the mean magnetic background.

Where it is not possible to give a probable cause of an observed anomaly a '?' is appended.

It should be noted that anomalies interpreted as modern in origin might be caused by features that are present in the topsoil or upper layers of the subsoil. Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly.

The types of response mentioned above can be divided into five main categories that are used in the graphical interpretation of the magnetic data:

Isolated dipolar anomalies (iron spikes)

These responses are typically caused by ferrous material either on the surface or in the topsoil. They cause a rapid variation in the magnetic response giving a characteristic 'spiky' trace. Although ferrous archaeological artefacts could produce this type of response, unless there is supporting evidence for an archaeological interpretation, little emphasis is normally given to such anomalies, as modern ferrous objects are common on rural sites, often being present as a consequence of manuring.

Areas of magnetic disturbance

These responses can have several causes often being associated with burnt material, such as slag waste or brick rubble or other strongly magnetised/fired material. Ferrous structures such as pylons, mesh or barbed wire fencing and buried pipes can also cause the same disturbed response. A modern origin is usually assumed unless there is other supporting information.

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) in order 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