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**Geophysical Survey Report
of
Belton Brickworks**

**For
ArchHeritage**

Magnitude Surveys Ref: MSSK397

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Unit 17, Commerce Court

Challenge Way

Bradford

BD4 8NW

01274 926020

info@magnitudesurveys.co.uk

Version	Purpose/Revision	Author	Interpretation/Figures	Approved By	Date Issued
1.0	Draft to line manager	Hugo Kesterton BA William Rigby BA MA PCifA	Ed Burton BA Pgce William Rigby BA MA PCifA	Marta Fortuny BA Ma	31 October 2018
1.1	Internal Review	William Rigby BA MA PCifA	N/A	Finnegan Pope-Carter BSc MSc FGS	01 November 2018

Abstract

Magnitude Surveys was commissioned to assess the subsurface archaeological potential of a c. 2ha area of land at Belton, North Lincolnshire. A fluxgate magnetometer survey was successfully completed. The geophysical results primarily reflect anomalies which represent historic agricultural activity such as a former field boundary and ridge and furrow ploughing. Anomalies reflecting the site's geological processes and modern activity have also been recorded.

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1. Introduction

- 1.1. Magnitude Surveys Ltd (MS) was commissioned by ArcHeritage to undertake a geophysical survey on a c.2ha area of land at Belton Brickworks, Belton, North Lincolnshire. (SE 786 056).
- 1.2. The geophysical survey comprised hand-pulled cart-mounted GNSS-positioned fluxgate magnetometer survey.
- 1.3. The survey was conducted in line with the current best practice guidelines produced by Historic England (David et al., 2008), the Chartered Institute for Archaeologists (CIfA, 2014) and the European Archaeological Council (Schmidt et al., 2015).
- 1.4. The survey commenced on 19th October and took 1 day to complete.

2. Quality Assurance

- 2.1. Magnitude Surveys is a Registered Organisation of the Chartered Institute for Archaeologists (CIfA), the chartered UK body for archaeologists, and a corporate member of ISAP (International Society of Archaeological Prospection).
- 2.2. Director Graeme Attwood is a Member of CIfA, as well as the Secretary of GeoSIG, the CIfA Geophysics Special Interest Group. Director Finnegan Pope-Carter is a Fellow of the London Geological Society, the chartered UK body for geophysicists and geologists, as well as a member of GeoSIG, the CIfA Geophysics Special Interest Group. Director Chrys Harris has a PhD in archaeological geophysics from the University of Bradford and is the Vice-Chair of the International Society for Archaeological Prospection.
- 2.3. All MS managers have relevant degree qualifications to archaeology or geophysics. All MS field and office staff have relevant archaeology or geophysics degrees and/or field experience.

3. Objectives

- 3.1. The geophysical survey aimed to assess the subsurface archaeological potential of the survey area.

4. Geographic Background

4.1. The site is located in Belton, North Lincolnshire on land to east of High Street and approximately 2 km village centre (Figure 1). Survey was undertaken over 2 areas of flat grassland positioned to the east of High Street totalling 2ha (Figure 2).

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1	Flat rough terrain	Bounded by hedgerows to the south and to the north in the top right corner. Ditches bound the field to the north, east and west.
2	Flat grassland	Bounded by a ditch to the east and a treeline boundary to the north-west. A signpost is located in the bottom left corner to the south.

4.3. The underlying geology comprises of mudstone of the Mercia Mudstone Group. No records regarding superficial deposits have been found. (British Geological Survey, 2018).

4.4. The soils consist of slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils (Soilscapes, 2018).

5. Archaeological Background

5.1. The following section provides a brief overview of the archaeological background of the site summarising a search on Heritage Gateway (2018) within 1km of NGR: SE 785 056, and a desk-based assessment produced by ArcHeritage (Stenton, 2018)

5.2. There are no heritage assets recorded within the survey area.

5.3. Two ring ditches that have been identified from aerial photographs are located c.900m south to the survey area: one Bronze Age single ditch (HER No. 17989) feature measuring 25m in diameter and another one which is assumed to be a searchlight battery (HER No. 21385) from the Second World War.

5.4. A single piece of pottery (HER No. 21987) from Iron age was identified following an excavation pit which is located c.500m north to the survey area.

5.5. Roman settlement (HER No. 19903), located c.500m to the east of the site, and Roman occupation (HER No. 20210), located c.600m south-east to the survey area, have been identified.

5.6. Anglo-Saxon occupation (HER No. 19755, MLS19755) is located 30m to 40m northwest to the site, where a 'grubenhauser' was discovered and some pottery sherds (HER No. 21519) located 35m and 170m northeast to the survey area. An open field system (HER No. 7911) dating between Medieval to Post Medieval has also been identified within the proximity of the survey area (Stenton, 2018).

5.7. Large numbers of small flint assemblages and lithic scatters have been found in the proximity of the survey area during field-walking and excavation pits but unfortunately the vast majority of could not dated accurately.

6. Methodology

6.1. Data Collection

6.1.1. Geophysical prospection comprised the magnetic method as described in the following table.

6.1.2. Table of survey strategies:

Method	Instrument	Traverse Interval	Sample Interval
Magnetic	Bartington Instruments Grad-13 Digital Three-Axis Gradiometer	1m	200Hz reprojected to 0.125m

6.1.3. The magnetic data were collected using MS' bespoke hand-pulled cart system GNSS-positioned system.

6.1.3.1. MS' cart system was comprised of Bartington Instruments Grad 13 Digital Three-Axis Gradiometers. Positional referencing was through a multi-channel, multi-constellation GNSS Smart Antenna RTK GPS outputting in NMEA mode to ensure high positional accuracy of collected measurements. The RTK GPS is accurate to 0.008m + 1ppm in the horizontal and 0.015m + 1ppm in the vertical.

6.1.3.2. Magnetic and GPS data were stored on an SD card within MS' bespoke datalogger. The datalogger was continuously synced, via an in-field Wi-Fi unit, to servers within MS' offices. This allowed for data collection, processing and visualisation to be monitored in real-time as fieldwork was ongoing.

6.1.3.3. A navigation system was integrated with the RTK GPS, which was used to guide the surveyor. Data were collected by traversing the survey area along the longest possible lines, ensuring efficient collection and processing.

6.2. Data Processing

6.2.1. Magnetic data were processed in bespoke in-house software produced by MS. Processing steps conform to Historic England's standards for "raw or minimally processed data" (see sect 4.2 in David et al., 2008: 11).

Sensor Calibration – The sensors were calibrated using a bespoke in-house algorithm, which conforms to Olsen et al. (2003).

Zero Median Traverse – The median of each sensor traverse is calculated within a specified range and subtracted from the collected data. This removes striping effects caused by small variations in sensor electronics.

Projection to a Regular Grid – Data collected using RTK GPS positioning requires a uniform grid projection to visualise data. Data are rotated to best fit an orthogonal grid

projection and are resampled onto the grid using an inverse distance-weighting algorithm.

Interpolation to Square Pixels – Data are interpolated using a bicubic algorithm to increase the pixel density between sensor traverses. This produces images with square pixels for ease of visualisation.

6.3.Data Visualisation and Interpretation

6.3.1. This report presents the gradient of the sensors' total field data as greyscale images, as well as the total field data from the upper and/or lower sensors. The gradient of the sensors minimises external interferences and reduces the blown-out responses from ferrous and other high contrast material. However, the contrast of weak or ephemeral anomalies can be reduced through the process of calculating the gradient. Consequently, some features can be clearer in the respective gradient or total field datasets. Multiple greyscale images at different plotting ranges have been used for data interpretation. Greyscale images should be viewed alongside the XY trace plot (Figure 7). XY trace plots visualise the magnitude and form of the geophysical response, aiding in anomaly interpretation.

6.3.2. Geophysical results have been interpreted using greyscale images and XY traces in a layered environment, overlaid against open street maps, satellite imagery, historic maps, LiDAR data, and soil and geology maps. Google Earth (2018) was consulted as well, to compare the results with recent land usages.

7. Results

7.1. Qualification

7.1.1. Geophysical results are not a map of the ground and are instead a direct measurement of subsurface properties. Detecting and mapping features requires that said features have properties that can be measured by the chosen technique(s) and that these properties have sufficient contrast with the background to be identifiable. The interpretation of any identified anomalies is inherently subjective. While the scrutiny of the results is undertaken by qualified, experienced individuals and rigorously checked for quality and consistency, it is often not possible to classify all anomaly sources. Where possible an anomaly source will be identified along with the certainty of the interpretation. The only way to improve the interpretation of results is through a process of comparing excavated results with the geophysical reports. MS actively seek feedback on their reports as well as reports of further work in order to constantly improve our knowledge and service.

7.2. Discussion

7.2.1. The geophysical results are presented in consideration with satellite imagery (Figure 5) and historic maps (Figure 6).

7.2.2. The fluxgate magnetometer survey has responded well to the survey areas environment. Characterised by a relatively quiet background with little magnetic disturbance throughout; identification of weaker, more ephemeral responses has been possible. Modern interference is limited to the field's edges and is produced by neighbouring fences and buildings; however, this ferrous interference is broader in Area 2 than Area 1, making interpretation of features in Area 2 slightly more complicated.

7.2.3. Evidence for agricultural activity has been detected across both areas. Within Area 2, several agricultural responses characteristic of ridge and furrow and a historic field boundary have been identified. These run perpendicular to those interpreted in Area 1 possibly extending further to the east outside of the survey area.

7.2.4. Recorded throughout Area 1, several natural trend lines have been identified; they intersect the historic ridge and furrow responses running east to west throughout the Area 1. Further natural anomalies are detected in the north-eastern corner of Area 1, they appeared to corroborate an interpretation of an angular feature illustrated on historic mapping, yet the size and scope do not agree, therefore, has been classified as a natural feature. Undetermined features noted within Area 1 can be seen extending in the same alignment as the agricultural trend; however, their difference in magnitude response and nature has made the latter to be interpreted as undetermined in origin.

7.3. Interpretation

7.3.1. General Statements

7.3.1.1. Geophysical anomalies will be discussed broadly as classification types across the survey area. Only anomalies that are distinctive or unusual will be discussed individually.

- 7.3.1.2. **Undetermined** – Anomalies are classified as Undetermined when the anomaly origin is ambiguous through the geophysical results and there is no supporting or correlative evidence to warrant a more certain classification. These anomalies are likely to be the result of geological, pedological or agricultural processes, although an archaeological origin cannot be entirely ruled out. Undetermined anomalies are generally not ferrous in nature.
- 7.3.1.3. **Ferrous (Discrete/Spread)** – Discrete ferrous-like, dipolar anomalies are likely to be the result of modern metallic disturbance on or near the ground surface. A ferrous spread refers to a concentrated deposition of these discrete, dipolar anomalies. Broad dipolar ferrous responses from modern metallic features, such as fences, gates, neighbouring buildings and services, may mask any weaker underlying archaeological anomalies should they be present.

7.3.2. Magnetic Results - Specific Anomalies

- 7.3.2.1. **Agricultural** – In Area 2, an anomaly on a west-southwest to east-northeast alignment has been identified which relates to a historic field boundary illustrated on the 2nd Edition Ordnance Survey Map (Figure 6). Parallel broad linear anomalies have been identified, mostly aligned northwest to southeast (Area 1) and northeast to southwest (Area 2). The spacing of these responses and their magnetic signal indicate that they are evidence for historic ridge and furrow cultivation across the site.
- 7.3.2.2. **Undetermined** – A strong, magnetically enhanced anomaly [1a] has been recorded to the east of Area 1; a linear, weaker elongated anomaly is located south of and adjacent to 1a. This linear response is in same alignment as the ridge and furrow recorded in Area 1; however, its magnetic response and width differs from the historic ploughing trend. The feature, therefore, has been classified as undetermined and may possibly represent drainage or trenching.
- 7.3.2.3. **Natural** – Natural trends which reflect possible geological processes have been identified running east to west in Area 1. Further natural readings, to the north-eastern corner of Area 1, appear to correspond with an angular feature illustrated on the 2nd Ordnance Survey Map (Figure 6). The anomalies do not have a strong magnetic response yet are enhanced in comparison to surrounding environs.

8. Conclusions

- 8.1. A fluxgate magnetometer survey has been successfully carried out across the site. The survey identified anomalies associable with historic agricultural ploughing, former field boundary illustrated on historic mapping, natural changes in the site's soils and anomalies of undetermined origin. Modern interference is limited to the edges of the fields.
- 8.2. Agricultural activity on site has been identified in the form of ridge and furrow ploughing trend in two opposite alignments; a former field boundary has also been recorded.
- 8.3. An undetermined response in Area 1 possibly represents drainage or trenching; however, a more accurate determination of their origin cannot be made from the geophysical data.
- 8.4. Natural anomalies reflecting the site's geological processes are recorded across Area 1. A small concentration of responses appears to correspond with an angular feature illustrated on the 2nd Edition Ordnance Survey Map.

9. Archiving

- 9.1. MS maintains an in-house digital archive, which is based on Schmidt and Ernenwein (2013). This stores the collected measurements, minimally processed data, georeferenced and un-georeferenced images, XY traces and a copy of the final report.
- 9.2. MS contributes reports to the ADS Grey Literature Library upon permission from the client, subject to the any dictated time embargoes.

10. Copyright

- 10.1. Copyright and the intellectual property pertaining to all reports, figures, and datasets produced by Magnitude Services Ltd. is retained by MS. The client is given full licence to use such material for their own purposes. Permission must be sought by any third party wishing to use or reproduce any IP owned by MS.

11. References

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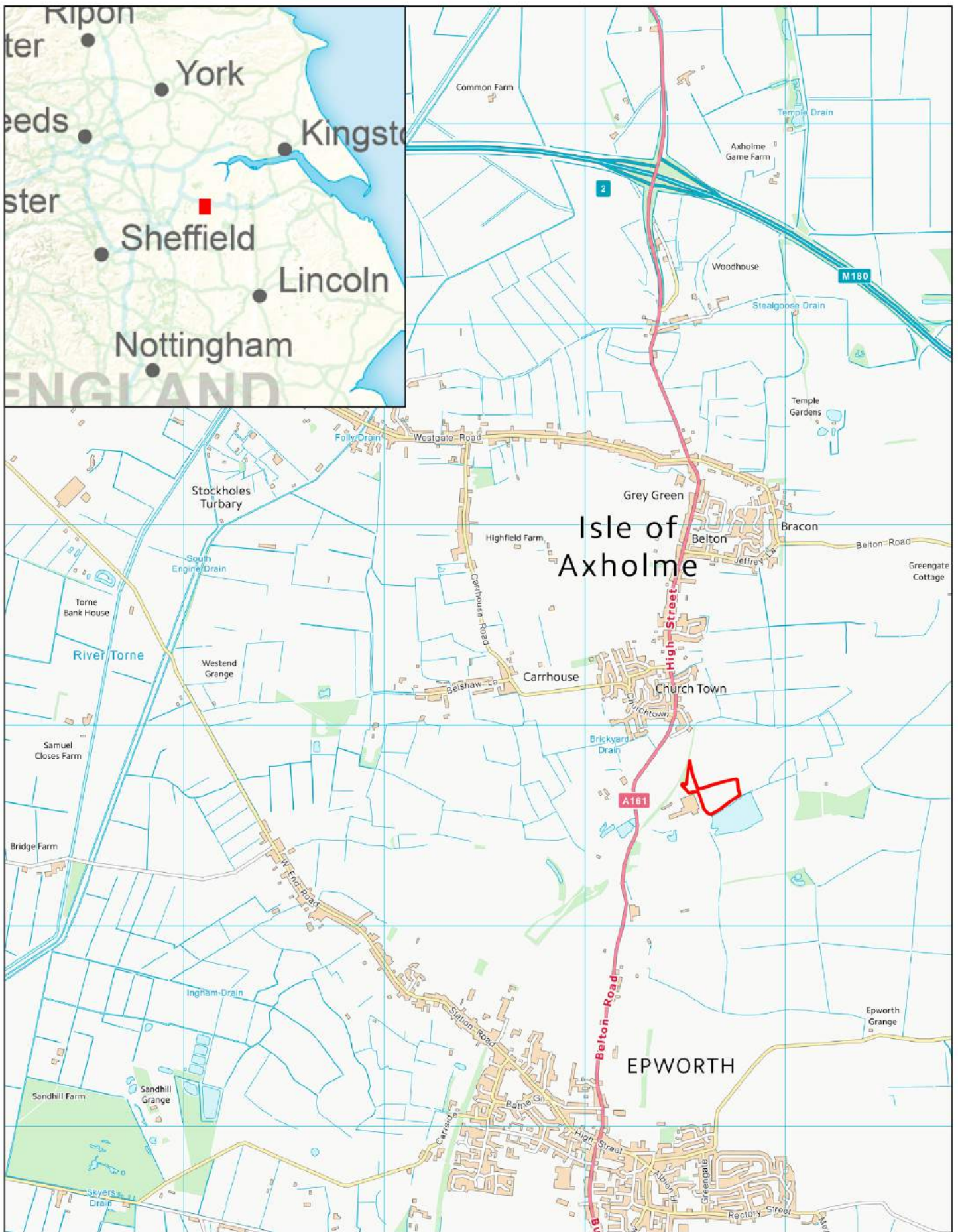
Schmidt, A. and Ernenwein, E., 2013. Guide to good practice: geophysical data in archaeology. 2nd ed., Oxbow Books, Oxford.

Schmidt, A., Linford, P., Linford, N., David, A., Gaffney, C., Sarris, A. and Fassbinder, J., 2015. Guidelines for the use of geophysics in archaeology: questions to ask and points to consider. EAC Guidelines 2. European Archaeological Council: Belgium.

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Figure 1 - Site Location

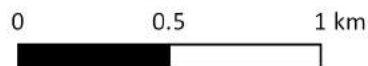
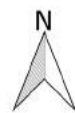
1:25,000 @ A4

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OS (100056946)


 Site Boundary

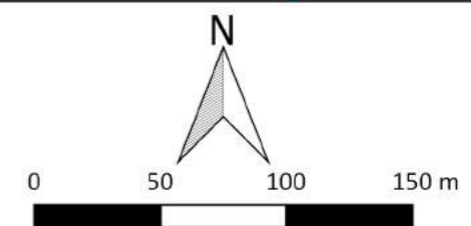


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Figure 2 - Location of Survey Areas
1:5,000 @ A3
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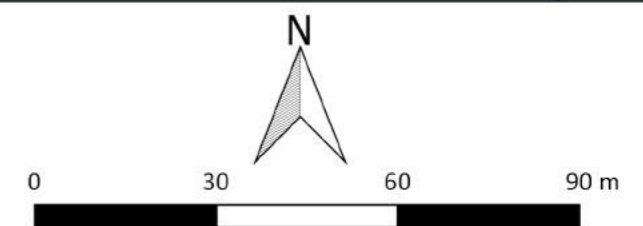
 Survey Extent



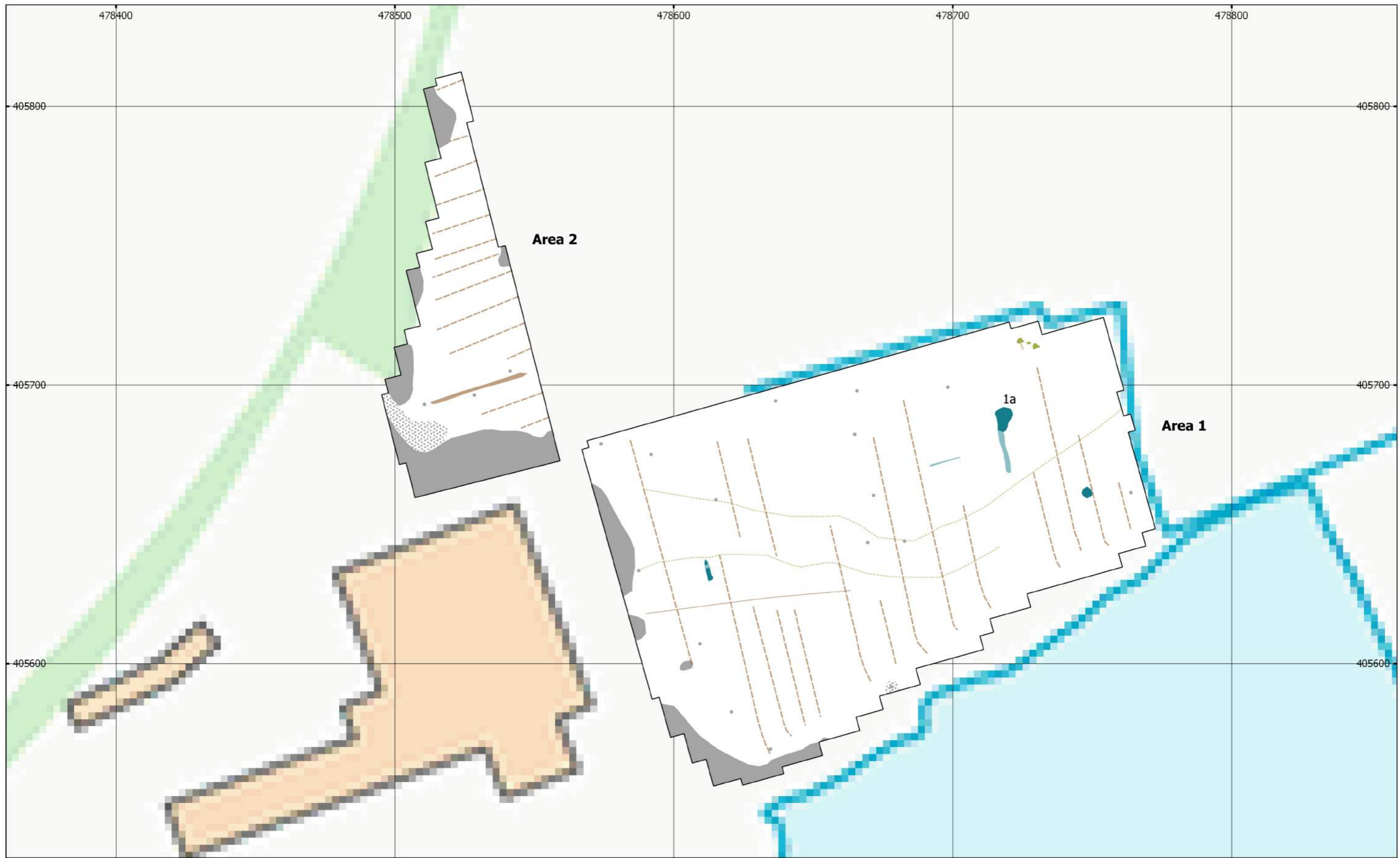
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Figure 3 - Magnetic Gradient
1:1,250 @ A3
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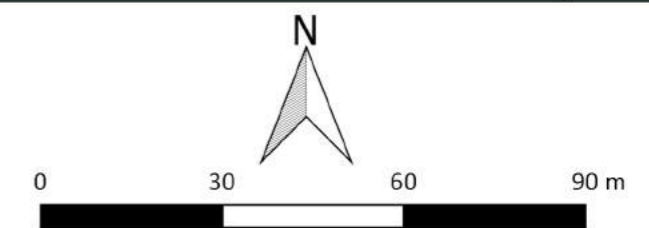


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 Figure 4 - Magnetic Interpretation
 1:1,250 @ A3
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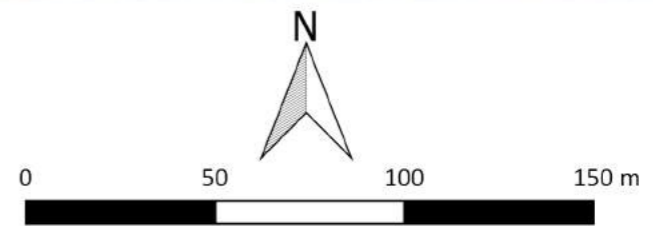
- | | |
|--------------------------|------------------|
| Agricultural (Weak) | Natural (Strong) |
| Agricultural (Trend) | Natural (Weak) |
| Ridge and Furrow (Trend) | Natural (Trend) |
| Ferrous (Dipolar) | |
| Ferrous (Spread) | |
| Undetermined (Strong) | |
| Undetermined (Weak) | |





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 Figure 5 - Magnetic Interpretation Over Satellite Imagery
 1:2,000 @ A3
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 Contains satellite imagery © 2018 Bing Satellite

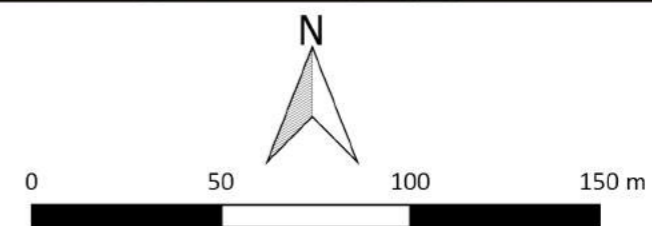
- | | |
|--------------------------|------------------|
| Agricultural (Weak) | Natural (Strong) |
| Agricultural (Trend) | Natural (Weak) |
| Ridge and Furrow (Trend) | Natural (Trend) |
| Ferrous (Dipolar) | |
| Ferrous (Spread) | |
| Undetermined (Strong) | |
| Undetermined (Weak) | |

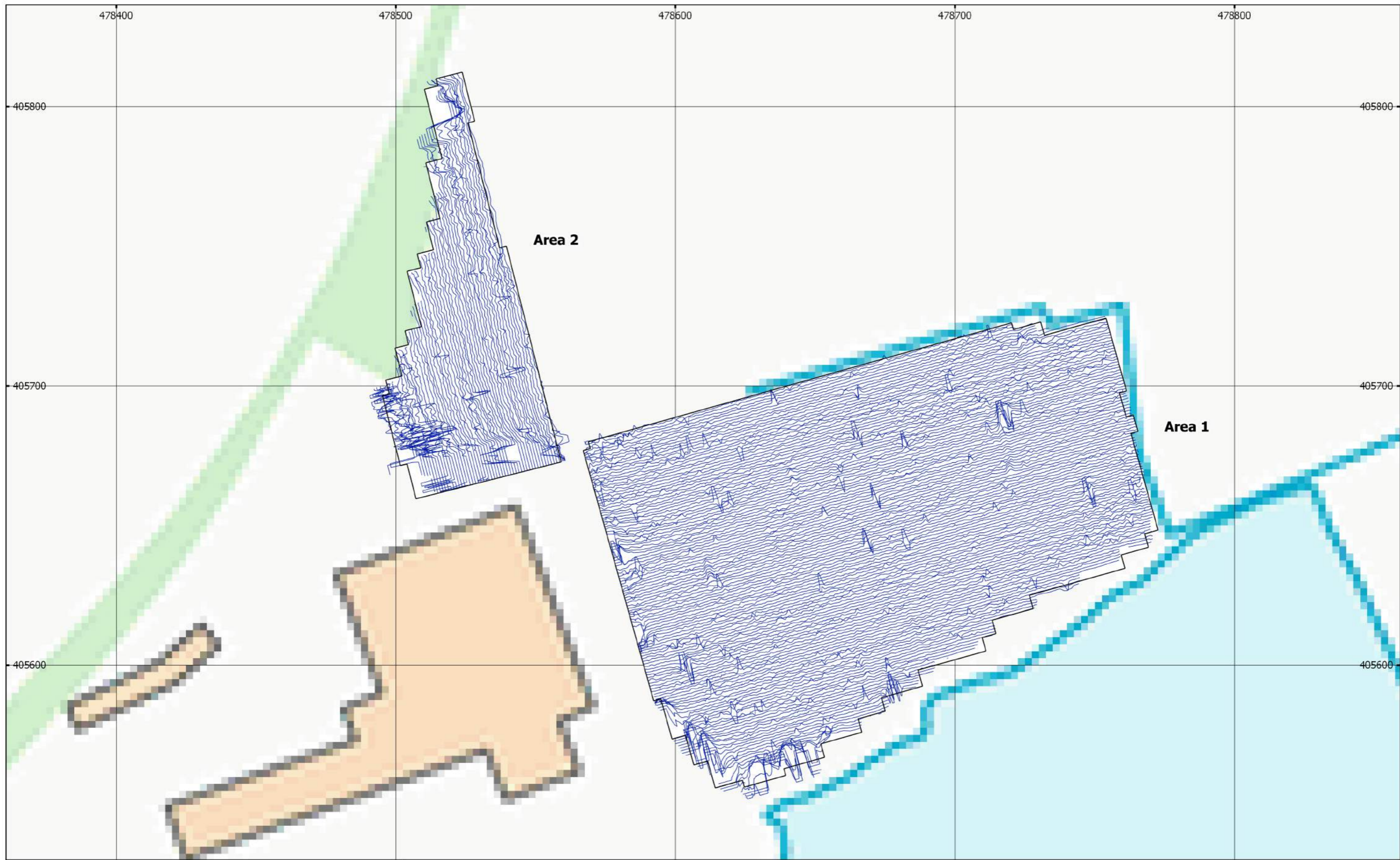




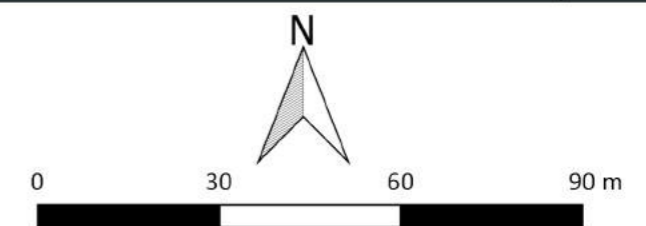
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 Figure 6 - Magnetic Interpretation Over Historic Mapping
 1:2,000 @ A3
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 Contains historic maps: Ordnance Survey, 6" 2nd edition c. 1882-1913 ©
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- | | |
|--------------------------|------------------|
| Agricultural (Weak) | Natural (Strong) |
| Agricultural (Trend) | Natural (Weak) |
| Ridge and Furrow (Trend) | Natural (Trend) |
| Ferrous (Dipolar) | |
| Ferrous (Spread) | |
| Undetermined (Strong) | |
| Undetermined (Weak) | |





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Figure 4 - Magnetic Interpretation
25nT/cm @ 1:1,250 @ A3
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