GEOPHYSICAL SURVEY REPORT

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SUMO Survey Services
SUMO Group Member

Project name:

West Haddon Road, Crick, Northamptonshire

Client:

University of Leicester Archaeological Services

August 2015

Job ref:
J8712

Report author:
Rebecca Davies BSc (Hons)

GEOPHYSICAL SURVEY REPORT

Project name:
West Haddon Road, Crick, Northamptonshire
Client:
University of Leicester Archaeological Services

Job ref:
J8712

Techniques:
Detailed magnetic survey – Gradiometry

Survey date:
22nd-23rd July & 9th August 2015

Site centred at:
SP 594 724

Post code:
NN6 7GT

Field team:
Christian Adams BA (Hons), **Lukasz Krawec** BSc, **Magdalena Udyrysz** MSc ACIfA

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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 4 hectares of grassland. No features of probable archaeological origin have been identified. A small number of features of possible archaeological origin have been identified, though these may have an agricultural origin. Evidence of ridge and furrow, field boundaries and modern agriculture suggests that the site has been used for agricultural purposes since the medieval period. The remaining features are natural or modern in origin and include debris related to a former farm building, scattered magnetic debris, disturbance from nearby ferrous objects such as fencing, and magnetic spikes that are likely to be modern rubbish.

2 INTRODUCTION

2.1 *Background synopsis*

Stratascan were commissioned to undertake a geophysical survey of an area outlined for residential development. This survey forms part of an archaeological investigation being undertaken by University of Leicester Archaeological Services.

2.2 *Site location*

The site is located south of West Haddon Road, Crick at OS ref. SP 594 724 with the Grand Union Canal to the east and pasture to the south.

2.3 *Description of site*

The survey area covers approximately 4 hectares of pasture, comprising two adjacentrectangular fields, sloping downwards in a north-easterly direction.

2.4 *Geology and soils*

The underlying geology comprises siltstone and mudstone of Dyrham Formation across the west, and mudstone of Charmouth Mudstone Formation across the east of the site (British Geological Survey website). No drift geology is recorded (British Geological Survey website).

The overlying soils are known as Wickham 2 which are typical stagnogley soils. These consist of slowly permeable seasonally waterlogged fine loamy over clayey, fine silty over clayey and clayey soils (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.5 *Site history and archaeological potential*

Extract from "A Heritage and Archaeological Desk-Based Assessment of Land at West Haddon Road, Crick, Northamptonshire" (University of Leicester Archaeological Services, 2014):

"An examination of the HER and cartographic data for the area of the proposed residential housing development at West Haddon Road, Crick indicates that the site of the proposed development appears to be located in the medieval field system associated with the nearby village, as indicated by the presence of standing ridge and furrow earthworks. However, the discovery of Iron Age and Romano-British archaeology in the vicinity suggests that there is potential for archaeological remains of prehistoric or Romano-British date to be present within the application area."

2.6 *Survey objectives*

The objective of the survey was to locate any features of possible archaeological origin in order that they may be assessed prior to development.

2.7 *Survey methods*

This report and all fieldwork have been conducted in accordance with both the English Heritage guidelines outlined in the document: *Geophysical Survey in Archaeological Field Evaluation, 2008* and with the Chartered Institute for Archaeologists document *Standard and Guidance for Archaeological Geophysical Survey.*

Due to the potential for prehistoric or Romano-British remains to be discovered, detailed magnetic survey (gradiometry) was used as an efficient and effective method of locating archaeological anomalies. More information regarding this technique is included in Appendix A.

2.8 *Processing, presentation and interpretation of results*

Handheld Collection:

Processing is performed using specialist software. This can emphasise various aspects contained within the data but which are often not easily seen in the raw data. Basic processing of the magnetic data involves 'flattening' the background levels with respect to adjacent traverses and adjacent grids. Once the basic processing has flattened the background it is then possible to carry out further processing which may include low pass filtering to reduce 'noise' in the data and hence emphasise the archaeological or man-made anomalies.

The following schedule shows the basic processing carried out on all minimally processed gradiometer data used in this report:

1. *Destripe* (Removes striping effects caused by zero-point discrepancies between different sensors and walking directions)

2. *Destagger* (Removes zigzag effects caused by inconsistent walking speeds on sloping, uneven or overgrown terrain)

Cart Collected Data:

Data has been processed using an in house software package (CartEasy^{N}) and a colour plot has been produced using Surfer 8 software. The processes applied were:

Zero Median Traverse	This process sets the background median of each traverse to zero. Limits are applied to reduce the effect of extreme readings which can skew the statistics. The operation minimises the differences between adjacent sensors.
Projection	Greyscale images require data to be sampled at regular intervals on each traverse. Due to the high precision of the RTK GNSS on the CartEasy^{N} magnetometer cart small velocity & traverse separation variations result in an irregular sampling interval. Projection involves converting WGS84 coordinates to OSGB36 and re-sampling the collected data at regular intervals during the post processing stage.
Colouring extreme values	Surfer 8 software is used to colour extreme values within the dataset. A colour scale is used with plotting parameters set at +100nT and -100nT.

2.8.1 Presentation of results and interpretation

The presentation of the data for each site involves a print-out of the minimally processed data both as a greyscale plot and a colour plot showing extreme magnetic values. Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site.

3 RESULTS

The detailed magnetic gradiometer survey conducted at Crick has identified a small number of anomalies that have been characterised as being of a *possible* archaeological origin.

The difference between *probable* and *possible* archaeological origin is a confidence rating. Features identified within the dataset that form recognisable archaeological patterns or seem to be related to a deliberate historical act have been interpreted as being of a probable archaeological origin.

Features of possible archaeological origin tend to be more amorphous anomalies which may have similar magnetic attributes in terms of strength or polarity but are difficult to classify as being archaeological or natural.

The following list of numbered anomalies refers to numerical labels on the interpretation plots.

3.1 Probable Archaeology

No probable archaeology has been identified within the survey area.

3.2 Possible Archaeology

1 A small number of positive linear anomalies in the east, south and centre of the site. These are indicative of former cut features of possible archaeological origin, though they may also be related to agricultural activity.

3.3 Medieval/Post-Medieval Agriculture

2 A positive linear anomaly running north-south in the northern field of the site. This is related to a former field boundary present on available mapping from 1900 to 1965.

3 An area of magnetic disturbance in the west of the site. This is related to a former field boundary present on available mapping from 1884 to 1991.

4 Widely spaced parallel linear anomalies in the west of the site. These are related to ridge and furrow cultivation.

5 Parallel linear anomalies in the north of the site. These are likely to be related to modern agricultural activity, such as ploughing.

3.4 Other Anomalies

6 An area of strong magnetic debris in the centre of the site. This is related to a former farm building, or barn, present on available mapping from 1970 to 1991.

7 An area of scattered magnetic debris in the centre of the site. This is related to a former farm building, or barn, present on available mapping from 1970 to 1991.

8 Small areas of amorphous magnetic variation in the north-east of the site. These are likely to be natural, i.e. geological, in origin.

9 An area of scattered magnetic debris in the east of the site. This is likely to be modern in origin.

10 Areas of magnetic disturbance are the result of substantial nearby ferrous metal objects such as fences and underground services. These effects can mask weaker archaeological anomalies, but on this site have not affected a significant proportion of the area.

11 A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish.

4 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Mudstone geologies can give variable results for gradiometer survey, though Charmouth Mudstone generally gives good results. The data across the site is relatively uniform in appearance, however a small number of features of possible archaeological origin have been identified, along with evidence of ridge and furrow. It can therefore be assumed that the survey has been effective.

5 CONCLUSION

The survey at West Haddon Road, Crick has not identified any features of probable archaeological origin, despite the potential for prehistoric and Romano-British remains. A small number of linear anomalies of possible archaeological origin have been identified, though these may also be agricultural in origin. Evidence of ridge and furrow cultivation and former field boundaries supports information from the desk-based assessment suggesting the site has been used for agricultural purposes since the medieval period. The remaining features are natural or modern in origin and include debris from a former barn, scattered magnetic debris, magnetic disturbance from nearby ferrous objects. and magnetic spikes that are likely to be modern rubbish.

6 REFERENCES

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University of Leicester Archaeological Services, 2014. *A Heritage and Archaeological Desk-Based Assessment of Land at West Haddon Road, Crick, Northamptonshire.*

APPENDIX A – METHODOLOGY & SURVEY EQUIPMENT

Hand-held Collection

Grid locations

The location of the survey grids has been plotted together with the referencing information. Grids were set out using a Leica 705auto Total Station and referenced to suitable topographic features around the perimeter of the site or a Leica Smart Rover RTK GPS.

An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. An RTK system uses a single base station receiver and a number of mobile units. The base station re-broadcasts the phase of the carrier it measured, and the mobile units compare their own phase measurements with those they received from the base station. A SmartNet RTK GPS uses Ordnance Survey's network of over 100 fixed base stations to give an accuracy of around 0.01m.

Sampling interval

Readings were taken at 0.25m centres along traverses 1m apart. This equates to 3600 sampling points in a full 30m x 30m grid.

For cart collected data readings were taken at intervals of 0.125m along traverses 0.75m apart.

Depth of scan and resolution

The Grad 601-2 has a typical depth of penetration of 0.5m to 1.0m, though strongly magnetic objects may be visible at greater depths. The collection of data at 0.25m centres provides an optimum methodology for the task balancing cost and time with resolution.

Cart-Collected Data

All survey data points had their position recorded using Trimble R8 Real Time Kinematic (RTK) VRS Now GNSS equipment. The geophysical survey area is georeferenced relative to the Ordnance Survey National Grid.

An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. An RTK system uses a single base station receiver and a number of mobile units. The base station re-broadcasts the phase of the carrier it measured, and the mobile units compare their own phase measurements with those they received from the base station.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	CARTEASY^{N} cart system (Bartington 1000L Sensors)	0.75m	10Hz (approximating 0.125m)

Survey equipment and gradiometer configuration

Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTeslas (nT) in an overall field strength of 48,000nT, can be accurately detected using an appropriate instrument.

The mapping of the anomaly in a systematic manner will allow an estimate of the type of material present beneath the surface. Strong magnetic anomalies will be generated by buried iron-based objects or by kilns or hearths. More subtle anomalies such as pits and ditches can be seen if they contain more humic material which is normally rich in magnetic iron oxides when compared with the subsoil.

To illustrate this point, the cutting and subsequent silting or backfilling of a ditch may result in a larger volume of weakly magnetic material being accumulated in the trench compared to the undisturbed subsoil. A weak magnetic anomaly should therefore appear in plan along the line of the ditch.

The magnetic survey was carried out using a dual sensor Grad601-2 Magnetic Gradiometer and a CartEasyN magnetometer cart system utilizing Bartington 1000L Gradiometer sensors manufactured by Bartington Instruments Ltd. The instruments consist of two fluxgates very accurately aligned to nullify the effects of the Earth's magnetic field. Readings relate to the difference in localised magnetic anomalies compared with the general magnetic background. The Grad601-2 consists of two high stability fluxgate gradiometers suspended on a single frame.

APPENDIX B – BASIC PRINCIPLES OF MAGNETIC SURVEY

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremanent* material.

Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

Thermoremanence is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremanent archaeological features can include hearths and kilns and material such as brick and tile may be magnetised through the same process.

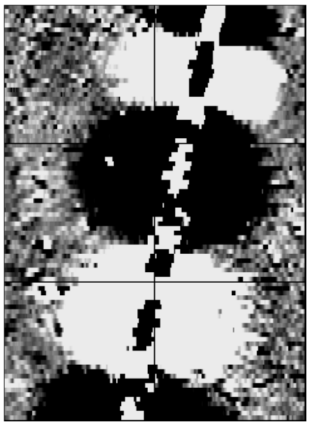
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried field. The difference between the two sensors will relate to the strength of a magnetic field created by a buried feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity, disturbance from modern services etc.

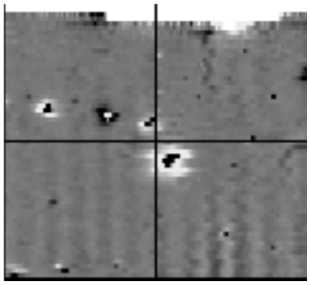
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

Bipolar



A bipolar anomaly is one that is composed of both a positive response and a negative response. It can be made up of any number of positive responses and negative responses. For example a pipeline consisting of alternating positive and negative anomalies is said to be bipolar. See also dipolar which has only one area of each polarity. The interpretation of the anomaly will depend on the magnitude of the magnetic field strength. A weak response may be caused by a clay field drain while a strong response will probably be caused by a metallic service.

Dipolar

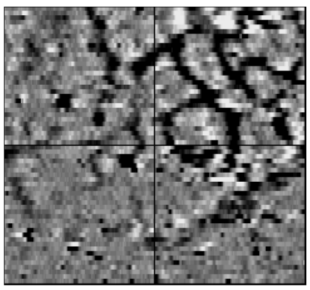


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very strong anomaly is likely to be caused by a ferrous object.

Positive anomaly with associated negative response

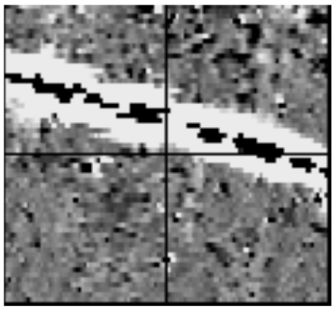
See bipolar and dipolar.

Positive linear



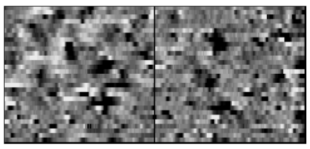
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity and some may even have a natural origin.

Positive linear anomaly with associated negative response



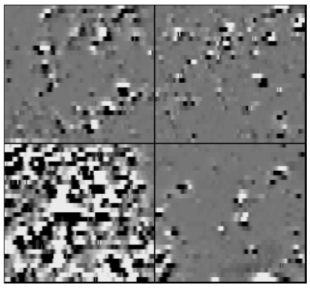
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field boundaries.

Positive point/area



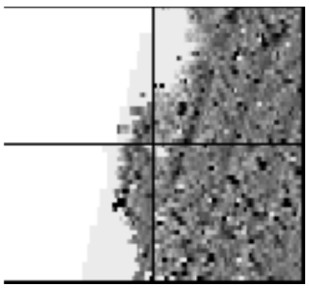
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally occurring depressions in the ground.

Magnetic debris



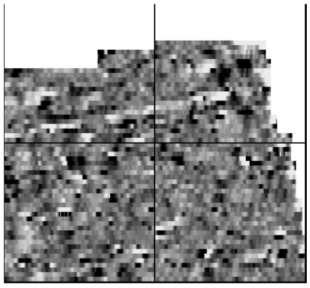
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly (+/-250nT) is more indicative of a spread of ferrous debris. Moderately strong anomalies may be the result of a spread of thermoremanent material such as bricks or ash.

Magnetic disturbance



Magnetic disturbance is high amplitude and can be composed of either a bipolar anomaly, or a single polarity response. It is essentially associated with magnetic interference from modern ferrous structures such as fencing, vehicles or buildings, and as a result is commonly found around the perimeter of a site near to boundary fences.

Negative linear

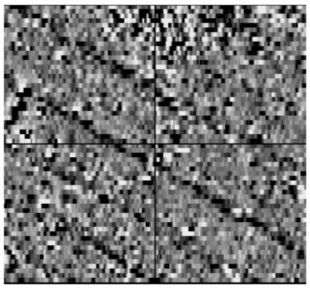


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

Negative point/area

Opposite to positive point anomalies these responses may be caused by raised areas or earthen banks. These could be of an archaeological origin or may have a natural origin.

Ploughing activity



Ploughing activity can often be visualised by a series of parallel linear anomalies. These can be of either positive polarity or negative polarity depending on site specifics. It can be difficult to distinguish between ancient ploughing and more modern ploughing. Clues such as the separation of each linear, straightness, strength of response and cross cutting relationships can be used to aid this, although none of these can be guaranteed to differentiate between different phases of activity.

Polarity

Term used to describe the measurement of the magnetic response. An anomaly can have a positive polarity (values above 0nT) and/or a negative polarity (values below 0nT).

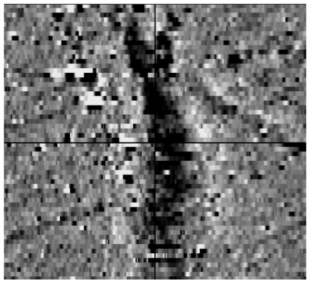
Strength of response

The amplitude of a magnetic response is an important factor in assigning an interpretation to a particular anomaly. For example a positive anomaly covering a 10m^2 area may have values up to around 3000nT, in which case it is likely to be caused by modern magnetic interference. However, the same size and shaped anomaly but with values up to only 4nT may have a natural origin. Colour plots are used to show the amplitude of response.

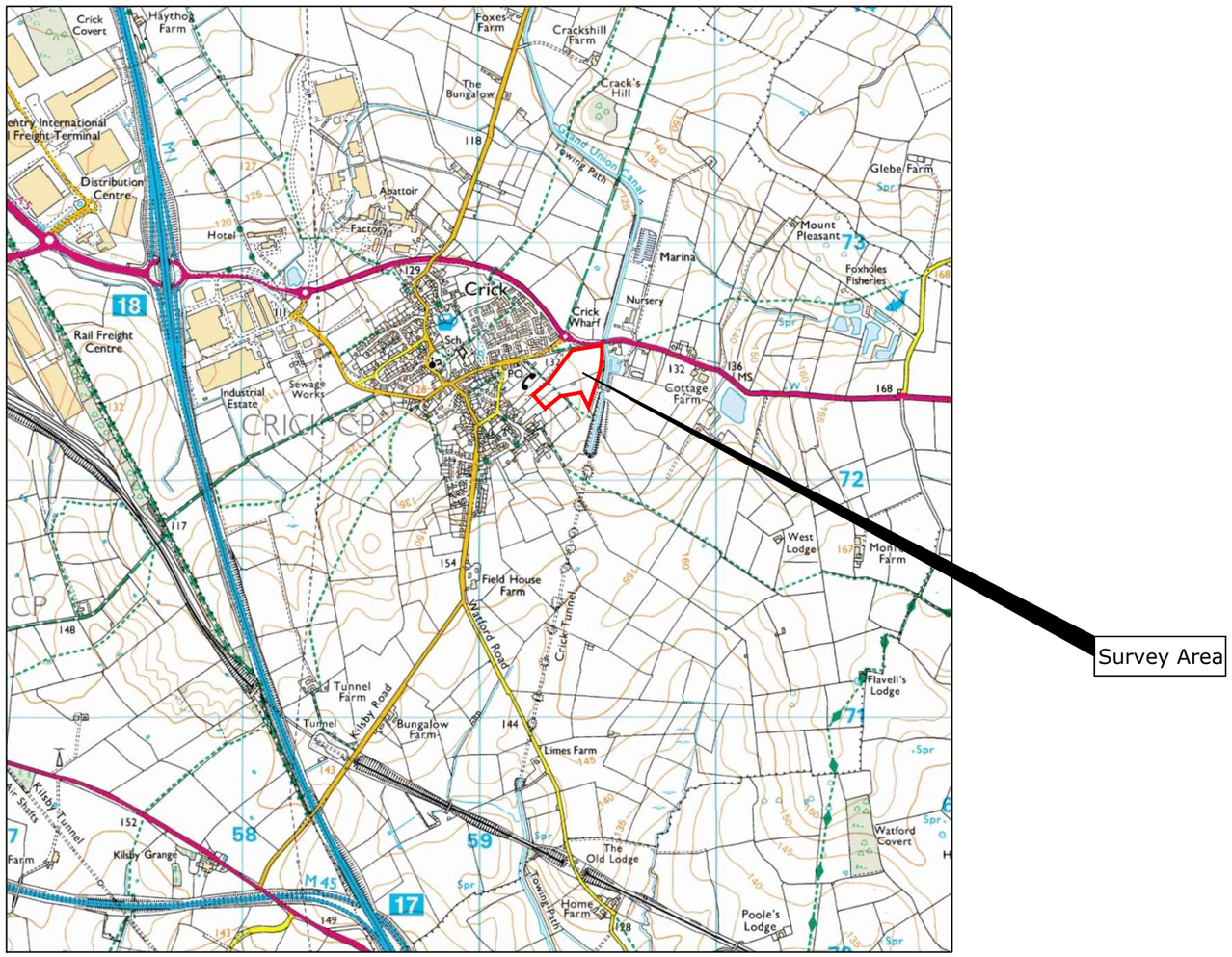
Thermoremanent response

A feature which has been subject to heat may result in it acquiring a magnetic field. This can be anything up to approximately +/-100 nT in value. These features include clay fired drains, brick, bonfires, kilns, hearths and even pottery. If the heat application has occurred in situ (e.g. a kiln) then the response is likely to be bipolar compared to if the heated objects have been disturbed and moved relative to each other, in which case they are more likely to take an irregular form and may display a debris style response (e.g. ash).

Weak background variations



Weakly magnetic wide scale variations within the data can sometimes be seen within sites. These usually have no specific structure but can often appear curvy and sinuous in form. They are likely to be the result of natural features, such as soil creep, dried up (or seasonal) streams. They can also be caused by changes in the underlying geology or soil type which may contain unpredictable distributions of magnetic minerals, and are usually apparent in several locations across a site.



N

Amendments

Issue No.	Date	Description
-	-	-
-	-	-

Site centred on NGR SP 594 724

Client
UNIVERSITY OF LEICESTER ARCHAEOLOGICAL SERVICES

Project Title Job No. 8712
GEOPHYSICAL SURVEY - WEST HADDON ROAD, CRICK, NORTHAMPTONSHIRE

Subject
LOCATION PLAN OF SURVEY AREA

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SUMO GROUP MEMBER

Scale 1:25000 (0m 500 1000m)

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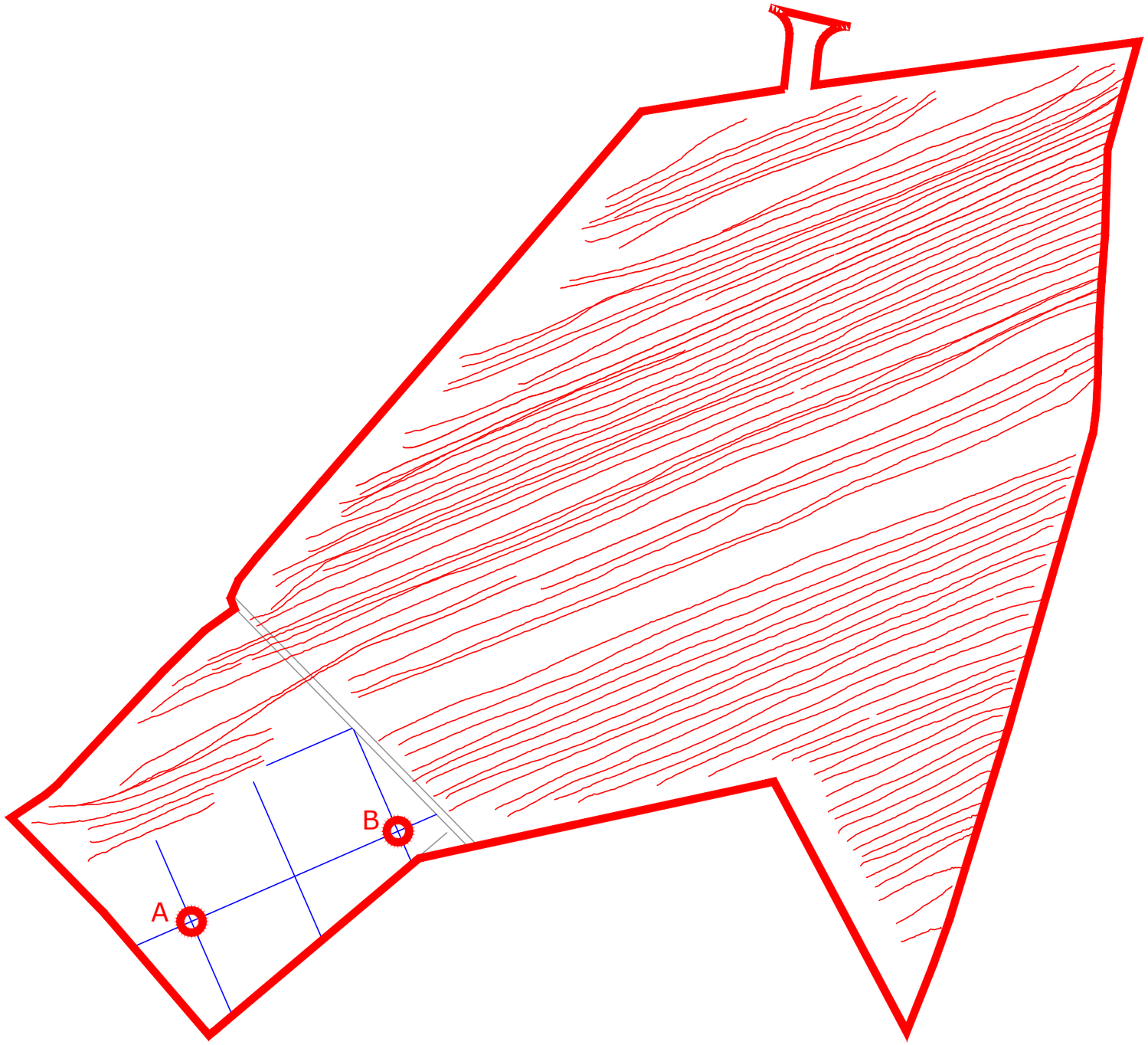
A3	DGE	01
Survey date	Drawn by	Figure No.
JUL 15	RD	01



Amendments

Issue No.	Date	Description
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-	-	-

Hand-collected data

Cart traverses

OS GRID REFERENCES

A	459280.22, 272326.68
B	459335.20, 272350.69

Client
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Project Title — Job No. 8712
GEOPHYSICAL SURVEY - WEST HADDON ROAD, CRICK, NORTHAMPTONSHIRE

Subject
CART TRAVERSES, LOCATION OF SURVEY GRIDS AND REFERENCING

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Scale 1:1250 — 0m 10 20 30 40 50m

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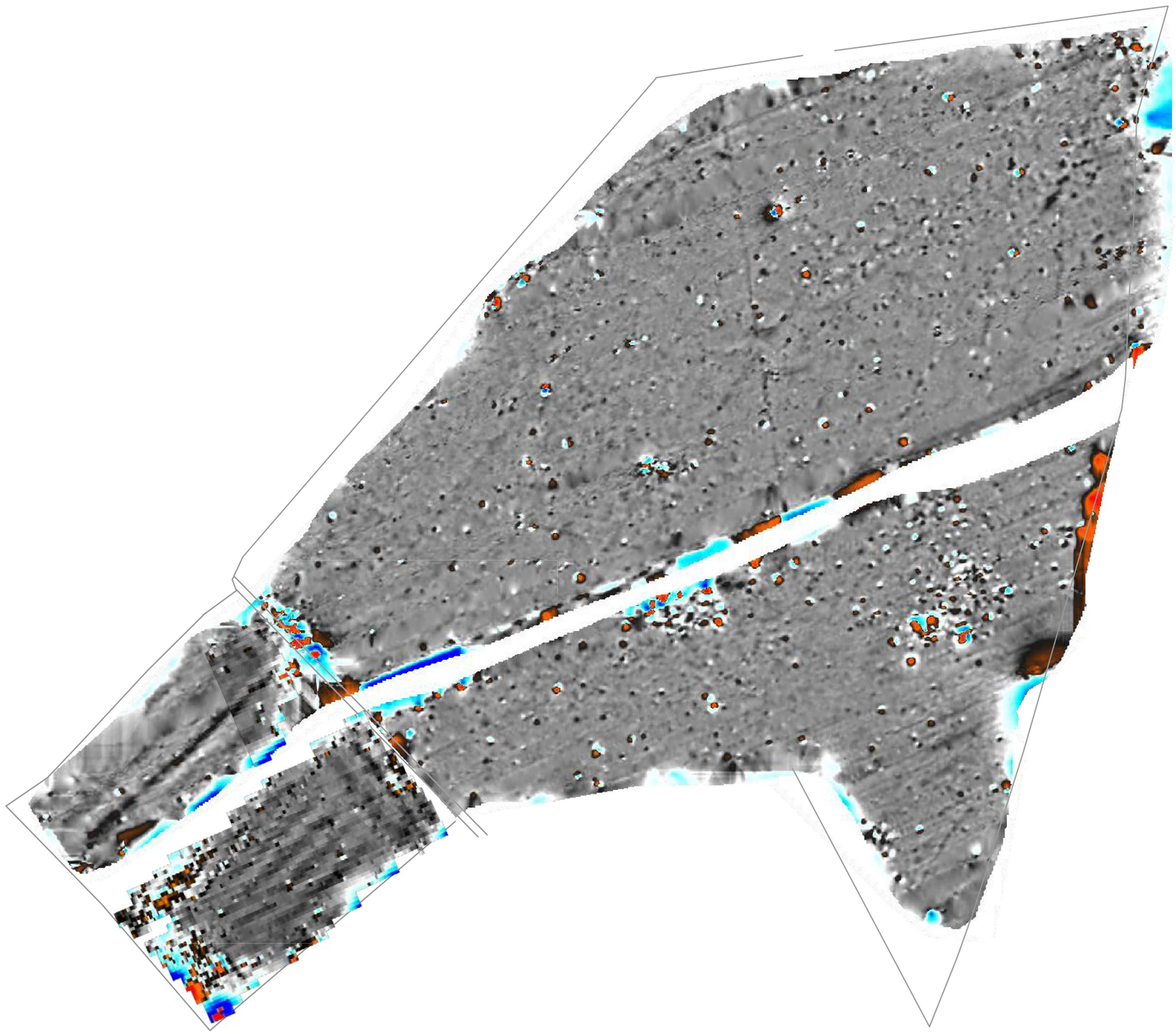

Amendments

Issue No.	Date	Description
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-	-	-

Plotting parameters

Maximum +100nT (red)
Minimum -100nT (blue)

+100nT
+25nT
+3nT
-3nT
-25nT
-100nT

Client
UNIVERSITY OF LEICESTER ARCHAEOLOGICAL SERVICES

Project Title — Job No. 8712
GEOPHYSICAL SURVEY - WEST HADDON ROAD, CRICK, NORTHAMPTONSHIRE

Subject
COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES

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Scale 1:1250

0m 10 20 30 40 50m

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Survey date	**Drawn by**	**Figure No.**
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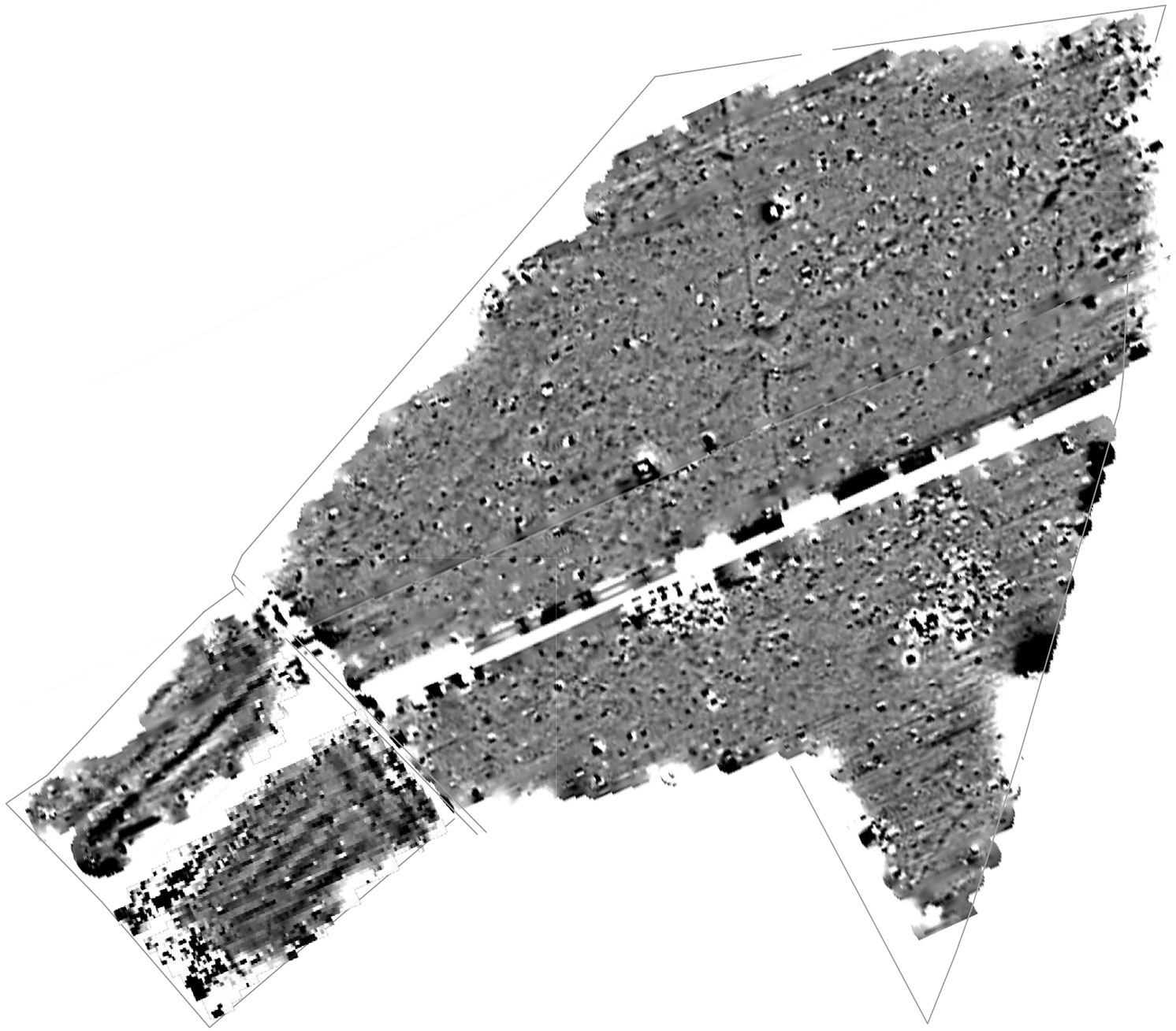

Amendments

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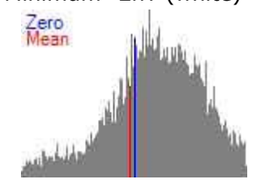

Client
UNIVERSITY OF LEICESTER ARCHAEOLOGICAL SERVICES

Project Title
GEOPHYSICAL SURVEY - WEST HADDON ROAD, CRICK, NORTHAMPTONSHIRE

Job No. 8712

Subject
PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPTON UPON SEVERN
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SUMO GROUP MEMBER

Scale 1:1250

0m 10 20 30 40 50m

Plot	Checked by	Issue No.
A3	DGE	01
Survey date	Drawn by	Figure No.
JUL 15	RD	04

Amendments

Issue No.	Date	Description
-	-	-
-	-	-

PROBABLE ARCHAEOLOGY

- Positive anomaly / weak positive anomaly - probable cut feature of archaeological origin
- Negative anomaly / weak negative anomaly - probable bank or earthwork of archaeological origin

POSSIBLE ARCHAEOLOGY

- Positive anomaly / weak positive anomaly - possible cut feature of archaeological origin
- Negative anomaly / weak negative anomaly - possible bank or earthwork of archaeological origin

MEDIEVAL/POST-MEDIEVAL AGRICULTURE

- Widely spaced curving parallel linear anomalies - probably related to ridge-and-furrow
- Closely spaced parallel linear anomalies - probably related to agricultural activity such as ploughing
- Magnetic disturbance related to former field boundary present on available mapping
- Linear anomaly - related to a former field boundary present on available mapping

OTHER ANOMALIES

- Magnetic disturbance associated with nearby metal object such as service or field boundary
- Strong magnetic debris related to former barn visible on available mapping
- Scattered magnetic debris related to former barn visible on available mapping
- Scattered magnetic debris
- Area of amorphous magnetic variation - probable natural (e.g. geological or pedological) origin
- Magnetic spike - probable ferrous object

Client
UNIVERSITY OF LEICESTER ARCHAEOLOGICAL SERVICES

Project Title
GEOPHYSICAL SURVEY - WEST HADDON ROAD, CRICK, NORTHAMPTONSHIRE

Job No. 8712

Subject
ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES

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