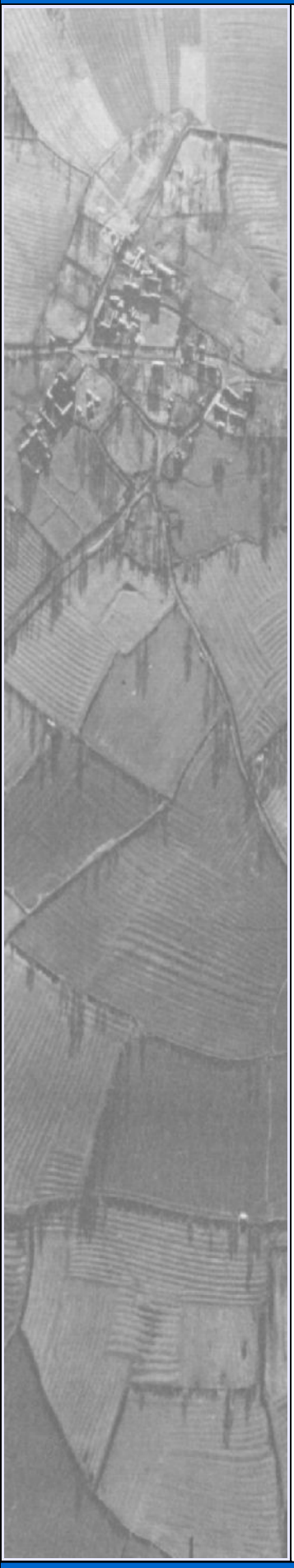


Land adjacent to the Crossroads Tredington Warwickshire

MAGNETOMETER SURVEY REPORT

for

Archaeology Warwickshire

David Sabin and Kerry Donaldson

July 2014

Ref. no. 556

ARCHAEOLOGICAL SURVEYS LTD

Land adjacent to the Crossroads Tredington Warwickshire

Magnetometer Survey Report

for

Archaeology Warwickshire

Fieldwork by David Sabin
Report by David Sabin BSc (Hons) MIFA and Kerry Donaldson BSc (Hons)

Survey date – 16th & 20th July 2014
Ordnance Survey Grid Reference – **SP 25435 44045**

Archaeological Surveys Ltd
1 West Nolands, Nolands Road, Yatesbury, Calne, Wiltshire, SN11 8YD
Tel: 01249 814231 Fax: 0871 661 8804
Email: info@archaeological-surveys.co.uk
Web: www.archaeological-surveys.co.uk

Archaeological Surveys Ltd is a company registered in England and Wales under registration number 6090102, Vat Reg no. 850 4641 37.
Registered office address, Griffon House, Seagry Heath, Great Somerford, Chippenham, SN15 5EN. It is a Registered Organisation with the Institute for Archaeologists.

CONTENTS

LIST OF FIGURES

LIST OF PLATES

LIST OF TABLES

SUMMARY

A detailed magnetometer survey was undertaken by Archaeological Surveys Ltd, at the request of Archaeology Warwickshire, over an area of land at Tredington in Warwickshire. The survey revealed a number of anomalies that appear to relate to naturally formed features adjacent to Back Brook and the River Stour, as well as a number of discrete pit-like responses which may also relate to naturally formed features. Evidence for former ridge and furrow can also be seen in the western part of the survey area orientated perpendicular to the Fosse Way. A broad linear and a sinuous positive response located above the floodplain in the south western part of the site may also relate to natural features.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Archaeology Warwickshire to undertake a magnetometer survey of an area of land at Tredington in Warwickshire. The site has been outlined for a proposed residential development, and the survey forms part of an archaeological assessment of the site.

1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeology Warwickshire (2014).

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use magnetometry to locate geophysical anomalies that may be archaeological in origin so that they may be assessed prior to development of the site. The methodology is considered an efficient and effective approach to archaeological prospection.

1.2.2 The survey and report generally follow the recommendations set out by: English Heritage (2008) *Geophysical survey in archaeological field evaluation;* and Institute for Archaeologists (2002) *The use of Geophysical Techniques in Archaeological Evaluations*. The work has been carried out to the Institute for Archaeologists (2011) *Standard and Guidance for Archaeological Geophysical Survey.*

1.3 Site location, description and survey conditions

1.3.1 The site is located at Tredington in Warwickshire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SP 25435 44045, see Figures 01 and 02.

1.3.2 The geophysical survey covers approximately 2.3ha over the majority of an arable field that contained a mature wheat crop at the time of survey. The field

is bounded to the west by the Fosse Way (A429) and to the east by the A3400 Stratford to Shipston-on-Stour road. The land slopes down towards the south and south east with the valley base containing Back Brook that flows into the River Stour located immediately east of the A3400. The valley base is prone to flooding and is effectively an extension of the River Stour floodplain.

Plate 1: Survey area looking south west

1.3.3 The ground conditions across the site were generally considered to be very difficult for the collection of magnetometry data due to the height and density of the crop cover, see Plate 1. Weather conditions during the survey were very hot and sunny.

1.4 Site history and archaeological potential

1.4.1 The site contains no designated or undesignated heritage assets; however, it lies adjacent to the Fosse Way Roman road with several Roman finds located in the surrounding area. Tredington was an established settlement during the medieval period, with the site probably under agricultural use within the open field system (Archaeology Warwickshire, 2014).

1.4.2 Given the proximity to the Roman road, there is some potential for the geophysical survey to locate anomalies that relate to previously unknown archaeological features. Evidence for agricultural practices, such as ridge and furrow and later ploughing may also be encountered.

1.5 Geology and soils

1.5.1 The underlying geology is from the Rugby Limestone Member (BGS, 2014).

1.5.2 The overlying soil across the site is from the Evesham 2 association and is a typical calcareous pelosol. It consists of a slowly permeable, calcareous, clayey soil (Soil Survey of England and Wales, 1983).

1.5.3 Magnetometry carried out over similar geology and soil has produced good results. The site is, therefore, considered suitable for magnetic survey.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance are factors associated with the formation of localised fields. Additional details are set out below and within Appendix A.

2.1.2 Iron minerals within the soil may become altered by burning and the break down of biological material; effectively the magnetic susceptibility of the soil is increased, and the iron minerals become magnetic in the presence of the Earth's magnetic field. Accumulations of magnetically enhanced soils within features, such as pits and ditches, may produce magnetic anomalies that can be mapped by magnetic prospection.

2.1.3 Magnetic thermoremnance can occur when ferrous minerals have been heated to high temperatures such as in a kiln, hearth, oven etc. On cooling, a permanent magnetisation may be acquired due to the presence of the Earth's magnetic field. Certain natural processes associated with the formation of some igneous and metamorphic rock may also result in magnetic thermoremnance.

2.1.4 The localised variations in magnetism are measured as sub-units of the Tesla, which is a SI unit of magnetic flux density. These sub-units are nano Teslas (nT), which are equivalent to 10^{-9} Tesla (T).

2.2 Equipment configuration, data collection and survey detail

2.2.1 The detailed magnetic survey was carried out using a SENSYS MAGNETO®MXPDA 5 channel cart-based system. The instrument has 5 fluxgate gradiometers spaced 0.5m apart with readings recorded at 20 Hz. The gradiometers have a range of recording data between 0.1nT and 10,000nT. They are linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged PDA computer system.

2.2.2 Data are collected along a series of parallel survey transects wherever

possible. The length of each transect is variable and relates to the size of the survey area and other factors including ground conditions. A visual display allows accurate placing of transects and helps maintain the correct separation between adjacent traverses.

2.3 Data processing and presentation

2.3.1 Magnetic data collected by the MAGNETO®MXPDA cart-based system are initially prepared using SENSYS MAGNETO®DLMGPS software. Georeferenced data are then exported in ASCII format for compensation (destriping), interpolation and clipping using TerraSurveyor. Greyscale images are also produced using TerraSurveyor.

2.3.2 Appendix C contains specific information concerning the survey and data attributes and is derived directly from TerraSurveyor; this should be used in conjunction with information provided by Figure 02.

2.3.3 Only minimal processing is carried out in order to enhance the results of the survey for display. Raw data are always analysed, as processing can modify anomalies. The following schedule sets out the data and image processing used in this survey for the SENSYS MAGNETO data:

- clipping of processed data at ±10 nT to enhance low magnitude anomalies,
- zero median traverse is applied in order to balance readings along each traverse.

2.3.4 An abstraction and interpretation is offered for all geophysical anomalies located by the survey. A brief summary of each anomaly, with an appropriate reference number, is set out in list form within the results (Section 3) to allow a rapid and objective assessment of features within the survey area.

2.3.5 Reference should be made to Appendix B for further information on the specific processes carried out on the data. Appendix C metadata includes details on the processing sequence used.

2.3.6 The main form of data display prepared for this report is the 'processed' greyscale plot followed by an abstraction and interpretation plot. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.

2.3.7 Data captured with the SENSYS MAGNETO cart-based system are resampled to a resolution of effectively 0.5m between tracks and 0.15m along each survey track. A TIFF file (OSGB36) is produced by TerraSurveyor software along with an associated world file (.TFW) that allows automatic georeferencing when using GIS or CAD software.

2.3.8 The raster images are combined with base mapping using ProgeCAD Professional 2014 and AutoCAD LT 2007, creating DWG file formats. All

images are externally referenced to the CAD drawing in order to maintain good graphical quality. Quality can be compromised by rotation of graphics in order to allow the data to be orientated with respect to grid north; this is considered acceptable as the survey results are effectively georeferenced allowing relocation of features using GPS, resection method, etc.

2.3.9 A digital archive is produced with this report, see Appendix D below. The main archive is held at the offices of Archaeological Surveys Ltd.

3 RESULTS

3.1 General assessment of survey results

3.1.1 The detailed magnetic survey was carried out over approximately 2.3ha within a single arable field. The work progressed very slowly over two days due to the density and height of the crop cover.

3.1.2 Magnetic anomalies located can be generally classified as positive anomalies of an uncertain origin, linear anomalies of an agricultural origin, anomalies with a natural origin, areas of magnetic debris and disturbance and strong discrete dipolar anomalies relating to ferrous objects.

3.2 Statement of data quality

3.2.1 Data are considered representative of the magnetic anomalies present within the site. Despite the dense crop cover there are no distortions to the morphology of anomalies due to the use of RTK GPS in data positioning. Some minor data artefacts have been created by processing high magnitude anomalies caused by services and other modern ferrous objects; however, these are unlikely to obscure or be confused with anomalies of archaeological potential.

3.3 Data interpretation

3.3.1 The list of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the survey. A basic explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross referencing to the abstraction and interpretation plot. CAD layer names are included to aid reference to associated digital files (.dwg/.dxf). Sub-headings are then used to group anomalies with similar characteristics .

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN AS-ABST MAG POS UNCERTAIN 	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone and subsoil.
Anomalies with an agricultural origin AS-ABST MAG RIDGE AND FURROW 	The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries. Where the response is broad, former ridge and furrow is likely.
Anomalies with a natural origin AS-ABST MAG NATURAL FEATURES	Naturally formed magnetic anomalies are are caused by localised variability in the magnetic susceptibility of soils, subsoils and other drift or solid geologies. Anomalies may be amorphous, linear or curvilinear and may appear 'fluvial' or discrete; the latter are almost impossible to distinguished from pit-like anomalies with an anthropogenic origin. Fluvial, glacial and periglacial processes may be responsible for their formation within drift material and subsoil. Igneous and metamorphic activity can lead to anomalies within more solid geology.
Anomalies associated with magnetic debris AS-ABST MAG DEBRIS AS-ABST MAG STRONG DIPOLAR 	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. It often occurs where there has been dumping or ground make-up and is related to magnetically thermoremnant materials such as brick or tile or other small fragments of ferrous material. This type of response is occasionally associated with kilns, furnace structures, or hearths and may therefore be archaeologically significant. It is also possible that the response may be caused by natural material such as certain gravels and fragments of igneous or metamorphic rock. Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.
Anomalies with a modern origin AS-ABST MAG DISTURBANCE 	The magnetic response is often strong and dipolar indicative of ferrous material and may be associated with extant above surface features such as wire fencing, cables, pylons etc.. Often a significant area around such features has a strong magnetic flux which may create magnetic disturbance; such disturbance can effectively obscure low magnitude anomalies if they are present. Fluxgate sensors may respond erratically and with hysteresis adjacent to strong magnetic sources. Buried services may produce characteristic multiple dipolar anomalies dependant upon their construction.

Table 1: List and description of interpretation categories

3.4 List of anomalies

Area centred on OS NGR 425435 244045, see Figures 03 & 04.

Anomalies with an uncertain origin

(1) – A cluster of discrete positive responses and a linear anomaly are located at the eastern edge of the survey area. Although it is possible that they relate to cut features, they are located adjacent to anomalies of natural origin and may be associated.

(2) – Weakly positive broadly linear and sinuous responses are located at the south western corner of the survey area. They are generally 0.5nT in magnitude and may relate to naturally formed features above the floodplain.

(3) – The survey area contains a number of weak, discrete positive responses. They are generally small and may be natural in origin or relate to low magnitude magnetic debris.

Anomalies with an agricultural origin

(4) – The western part of the field contains a series of parallel broad linear anomalies that are a response to former ridge and furrow cultivation.

Anomalies with a natural origin

(5) – A group of weakly positive amorphous responses are visible at the south eastern corner of the survey area and relate to palaeochannels, alluvium/colluvium or other naturally formed features.

Anomalies associated with magnetic debris

(6) – A small area of very strongly magnetic debris is located in the central eastern part of the field. It is a response to ferrous material that may have been used to infill a depression, possibly associated with tree removal.

(7) – The survey area contains strong, discrete, dipolar anomalies which are responses to ferrous and other magnetically thermoremant objects within the topsoil.

Anomalies with a modern origin

(8) – A liner zone of magnetic disturbance is a response to a discontinuous multiple dipolar linear anomaly that relates to a buried service that may be constructed of non-magnetic material where it is not visible within the data. An inspection chamber with a steel cover was noted within the northern part of the field.

4 CONCLUSION

4.1.1 The detailed magnetometer survey located a number of positive anomalies within the site. Some of them are discrete and appear to relate to pit-like features, while others are linear or sinuous in form. It is possible that these relate to natural features and a group of anomalies at the south eastern corner of the field appear to be related to former palaeochannels or alluvial/colluvial deposits.

4.1.2 Weak linear anomalies indicate former ridge and furrow cultivation perpendicular to the Fosse Way. The northern part of the site contains a service and zones of magnetic debris that may indicate relatively modern ground disturbance and/or consolidation.

5 REFERENCES

Archaeology Warwickshire, 2014. *Archaeological Desk-Based Assessment and Written Scheme of Investigation for Archaeological Evaluation at Land Adjacent to the Crossroads, Tredington, Warwickshire.* Unpublished typescript document.

British Geological Survey, 2014. *Geology of Britain viewer, 1:50 000 scale [online]* available from http://mapapps.bgs.ac.uk/geologyofbritain/home.html [accessed 21/7/2014].

English Heritage, 2008. *Geophysical survey in archaeological field evaluation. Research and Professional Service Guideline No.1.* 2nd ed. Swindon: English Heritage.

Institute for Archaeologists, 2002. *The use of Geophysical Techniques in Archaeological Evaluations*. IfA Paper No. 6. IfA, University of Reading.

Institute for Archaeologists, 2011. *Standard and Guidance for archaeological geophysical survey*. IfA, University of Reading.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 5 South West England.*

Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material.

Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field.

Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field upon cooling.

Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths, and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to the topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The SENSYS gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 65cm apart. The instrument is carried about 10-20cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried field. The difference between the two sensors will relate to the strength the magnetic field created by the buried feature. If no enhanced feature is present the field measured by both sensors will be similar and the difference close to zero.

There are a number of factors that may affect the magnetic survey and these include soil type, local geology and previous human activity. Situations arise where magnetic disturbance associated with modern services, metal fencing, dumped waste material etc., obscures low magnitude fields associated with archaeological features.

Appendix B – data processing notes

Clipping

Minimum and maximum values are set and replace data outside of the range with those values. Extreme values are removed improving colour or greyscale contrast associated with data values that may be archaeologically significant. It has been found that clipping data to ranges between ±15nT and ±10nT often improves the appearance of features associated with archaeology. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Zero Median/Mean Traverse

The median (or mean) of each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise slight differences between the set-up and stability of gradiometer sensors and can remove striping. The process can remove archaeological features that run along a traverse so data analysis is also carried out prior its application.

High Pass Filtering

A mathematical process used to remove low frequency anomalies relating to survey tracks and modern agricultural features.

Appendix C – survey and data information

COMPOSITE
Filename: J556-mag.xcp
Description: Imported as Composite from: J556-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):
Northwest corner: 425342.459774473, 244151.583092284 m
Southeast corner: 425545.409774473, 243957.483092284 m
Direction of 1st Traverse: 90 deg
Collection Method: Parallel
Sensors: 1
Dummy Value: 32702

Source GPS Points: 1443600

Dimensions
Composite Size (readings): 1353 x 1294
Survey Size (meters): 203 m x 194 m
Grid Size: 203 m x 194 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats
Max: 10.00
Min: -10.00
Std Dev: 3.96
Mean: -0.02
Median: 0.00
Composite Area: 3.9393 ha
Surveyed Area: 2.2646 ha

Processes: 2
1 Base Layer
2 Clip from -10.00 to 10.00 nT

GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (to OSGB36).
3 DeStripe Median Traverse: Threshold: 1.5 SDs
4 Clip from -20.00 to 20.00 nT

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at their offices in Wiltshire (see inside cover for address). Data are backed-up onto an on-site data storage drive and at the earliest opportunity data are copied to CD ROM for storage on-site and off-site.

Surveys are reported on in hardcopy (recycled paper) using A4 for text and A3 for plots (all plots are scaled for A3).

Archaeological Surveys Ltd shall retain intellectual property rights for the materials and records created as part of this project. A non-exclusive, transferable, sub-licensable, perpetual, irrevocable and royalty-free licence shall be granted to the client in order for them to use, reproduce and enhance the reports, documentation, graphics and illustrations produced as part of this project for the purpose for which they were commissioned. Copyright licence will also be granted to the local authority for planning use and within in the Historic Environment Record for public dissemination upon instruction by the client. Archaeological Surveys Ltd shall retain the right to be identified as the author and originator of the material.

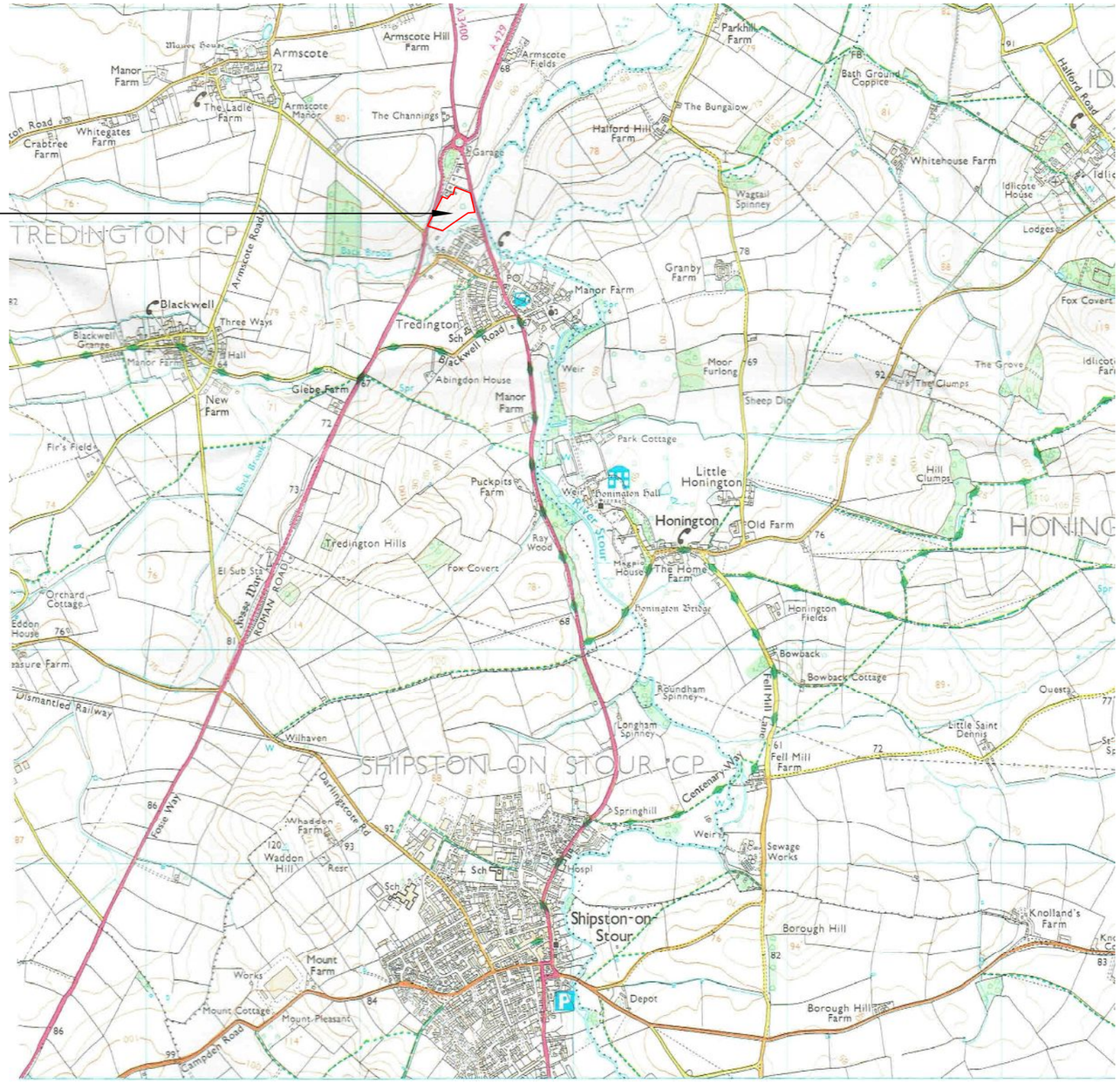
This report has been prepared using the following software on a Windows XP platform:

- TerraSurveyor version 3.0.23.0 (geophysical data analysis),
- SENSYS MAGNETO®ARCH version 1.00-04(geophysical data analysis),
- ProgeCAD Professional 2014 (report graphics),
- AutoCAD LT 2007 (report figures),
- OpenOffice.org 3.0.1 Writer (document text),
- PDF Creator version 0.9 (PDF archive).

Digital data produced by the survey and report include the following files:

- TerraSurveyor grid and composite files for all geophysical data,
- CSV files for raw and processed composites,
- geophysical composite file graphics as Bitmap images,
- AutoCAD DWG files in 2000 and 2007 versions,
- report text as OpenOffice.org ODT file,
- report text as Word 2000 doc file,
- report text as rich text format (RTF),
- report text as PDF,
- PDFs of all figures.

Survey location

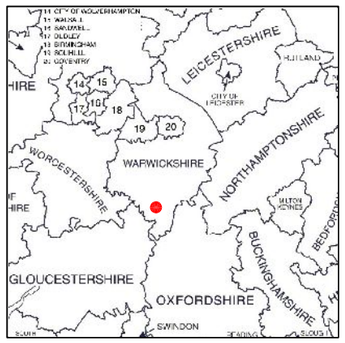


Archaeological Surveys Ltd

Geophysical Survey
Land adjacent to the Crossroads
Tredington
Warwickshire

Map of survey area

Reproduced from OS Explorer map no.205 1:25 000 by permission of Ordnance Survey on behalf of The Controller of Her Majesty's Stationery Office.
© Crown copyright. All rights reserved.
Licence number 100043739.



● Survey location

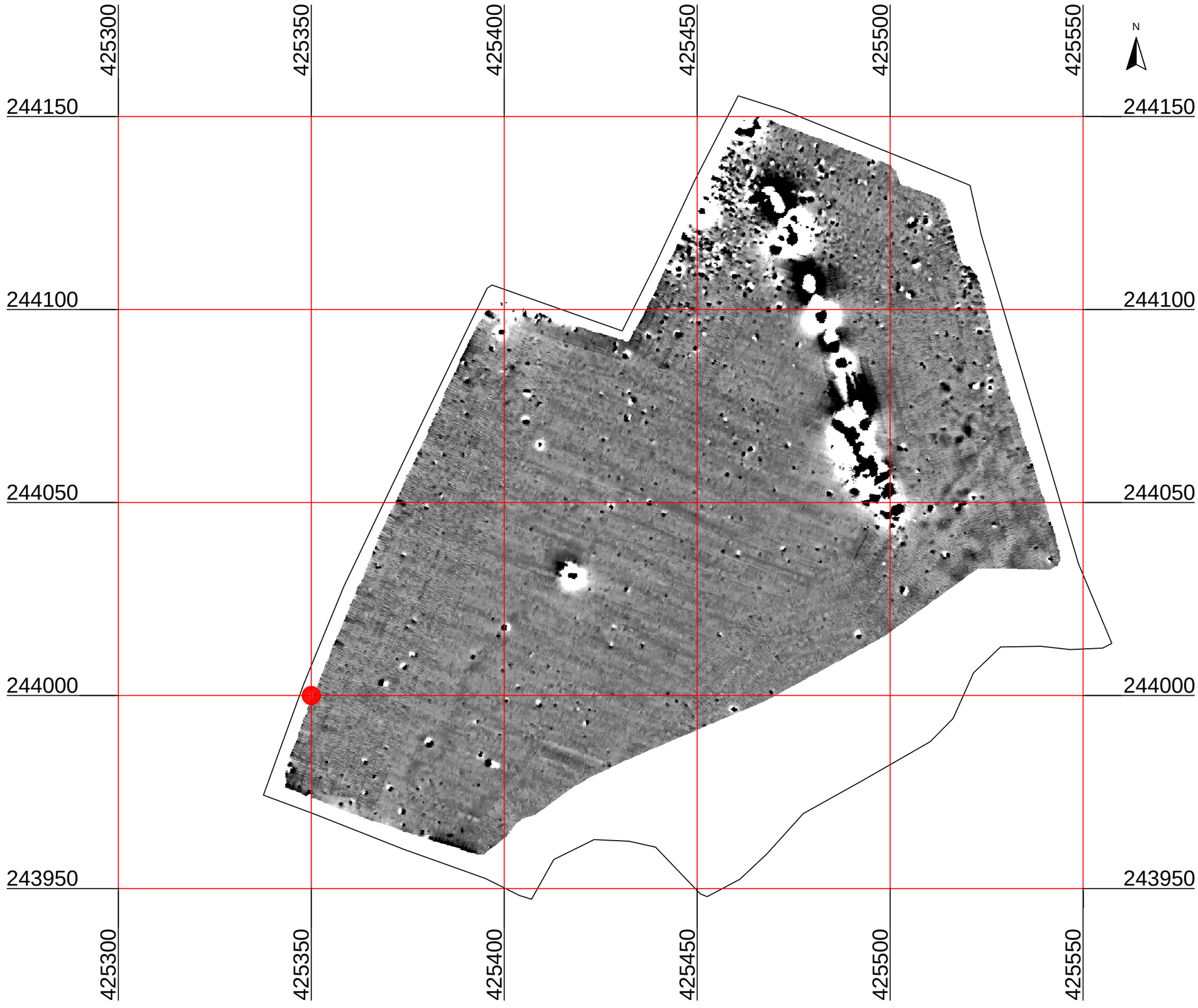
Site centred on OS NGR
SP 25435 44045

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01



Archaeological Surveys Ltd

Geophysical Survey
Land adjacent to the Crossroads
Tredington
Warwickshire

Referencing information

Referencing grid to OSGB36 datum at 50m intervals

Data collected at 20Hz and georeferenced to ETRS89 zone 30 with conversion to OSGB36 using OSTN02

425350 244000

SCALE 1:1000

0m 10 20 30 40 50m

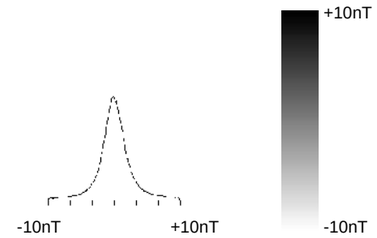
SCALE TRUE AT A3

FIG 02

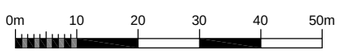
Archaeological Surveys Ltd

Geophysical Survey
Land adjacent to the Crossroads
Tredington
Warwickshire

Greyscale plot of processed magnetometer data



SCALE 1:1000

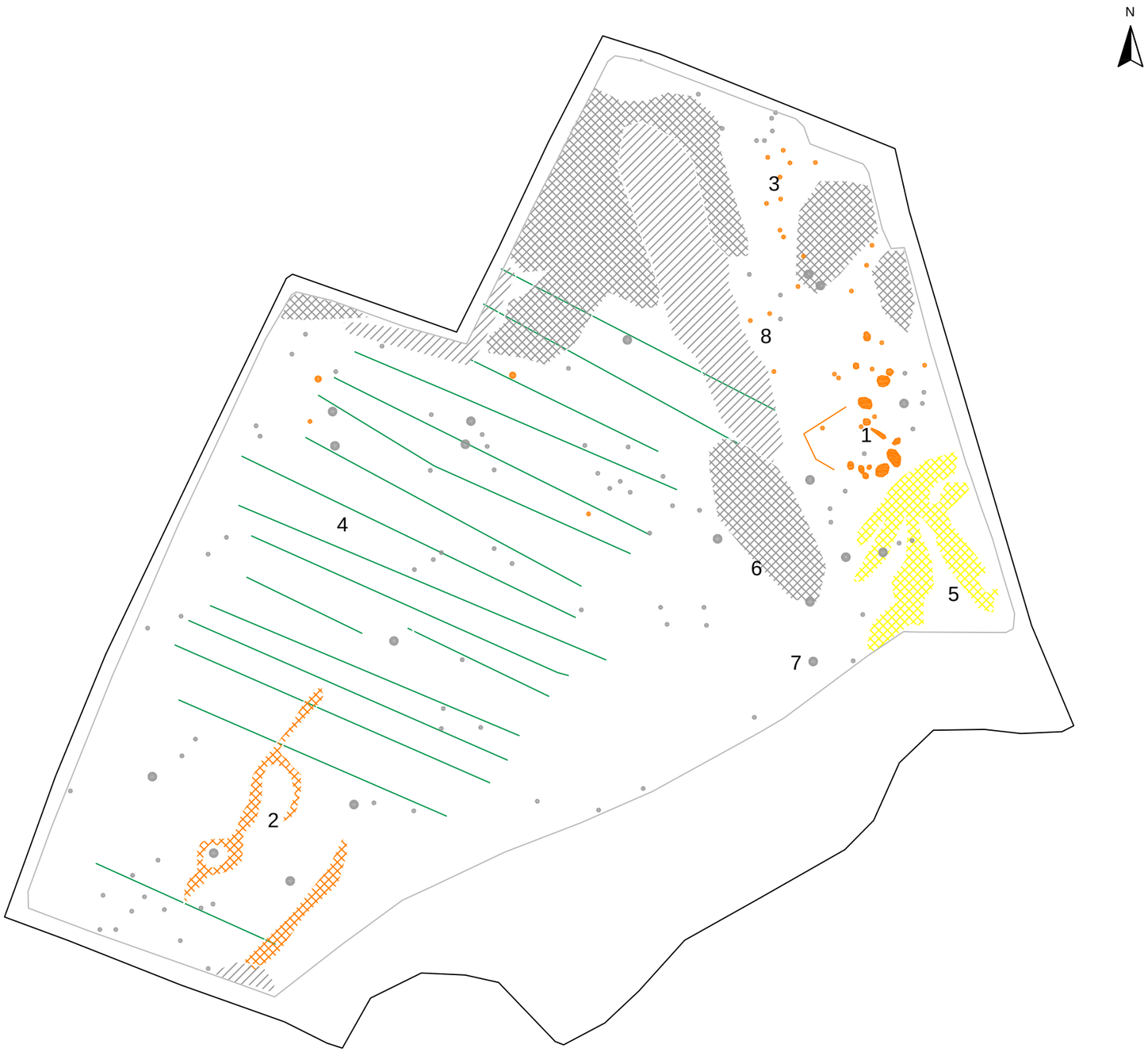


SCALE TRUE AT A3

FIG 03

Archaeological Surveys Ltd

Geophysical Survey
Land adjacent to the Crossroads
Tredington
Warwickshire



Abstraction and interpretation of magnetometer anomalies

- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - ridge and furrow
- Discrete positive response - possible pit-like feature
- Positive anomaly - magnetically enhanced material
- Variable magnetic response - of natural origin
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous materia
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 04