

**Land south of Eastington Trading Estate
Eastington
Gloucestershire**

MAGNETOMETER SURVEY REPORT

for

Cotswold Archaeology

Kerry Donaldson & David Sabin

January 2016

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ARCHAEOLOGICAL SURVEYS LTD

**Land south of Eastington Trading Estate
Eastington
Gloucestershire**

Magnetometer Survey Report

for

Cotswold Archaeology

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Primary archive location - Archaeological Surveys Ltd, Yatesbury, Wiltshire

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Ordnance Survey Grid Reference – **SO 78055 05955**



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SUMMARY

A detailed magnetometer survey was undertaken by Archaeological Surveys Ltd, at the request of Cotswold Archaeology, on land to the south of Eastington Trading Estate in Gloucestershire. The site comprised two pasture fields that were very waterlogged during the survey period. The results show that much of the site contains widespread strongly magnetic debris, but much of this is contained within former channels and watercourses. The response indicates that there is a high ferrous content and it is likely to be modern in origin. There is also a zone in the north eastern corner which contains numerous discrete positive responses. These may relate to ground disturbance associated with the infilling of the watercourses. Other positive responses are weak and amorphous, and it is possible that they relate to former fluvial features.

1 INTRODUCTION

1.1 Survey background

- 1.1.1 Archaeological Surveys Ltd was commissioned by Cotswold Archaeology to undertake a magnetometer survey of an area of land to the south of Eastington Trading Estate, north east of Eastington in Gloucestershire. The site has been outlined for a proposed development of three warehouses and associated parking and infrastructure. 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 Archaeological Surveys (2016) and approved by Charles Parry, Archaeologist for Gloucestershire County Council.

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 Chartered Institute for Archaeologists (2014) *Standard and Guidance for Archaeological Geophysical Survey*.

1.3 Site location, description and survey conditions

- 1.3.1 The site is located to the south of Eastington Trading Estate, north east of Eastington in Gloucestershire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SO 78055 05955, see Figures 01 and 02.
- 1.3.2 The geophysical survey covers approximately 2.5ha within two pasture fields divided by a watercourse. The northern part of the site is bounded by the trading estate, with the access road to the west and the River Frome immediately beyond and to the east further rough pasture land.
- 1.3.3 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry data although large areas of standing water were encountered. Weather conditions during the survey were fine.

1.4 Site history and archaeological potential

- 1.4.1 A Heritage Desk-Based Assessment has been carried out by Cotswold Archaeology (2015). It outlines that there is evidence for Iron Age and Romano-British activity within the wider area, including a number of inhumations found during gravel extraction to the north, and the site of a possible Roman villa, known as the Whitminster villa, 430m to the north. Further possible Romano-British settlement has been identified 520m to the north west of the site, from a scatter of building and occupation debris. The route of a Roman road (Margary 543) passes 750m west of the site. A number of Saxon grass-tempered pottery sherds were identified during construction of the M5 to the north, with the settlement of Eastington recorded from the medieval period. The site is situated to the south of the former Meadow Mill, and 90m south west of the Stroudwater Navigation Canal.
- 1.4.2 The site is divided into two by a minor watercourse, and contains a number of linear features which may be associated with further watercourses, or possible water meadows. Slight earthwork features may be associated with earth moving and infilling of watercourses.

1.5 Geology and soils

- 1.5.1 The underlying solid geology across the site is from the Blue Lias and Charmouth Mudstone Formations with overlying alluvial deposits from the River Frome (BGS, 2016).
- 1.5.2 The overlying soil across the survey area is from the Fladbury 1 association and is a pelo-alluvial gley soil. It consists of a stoneless, clayey soil variably affected by groundwater (Soil Survey of England and Wales, 1983).
- 1.5.3 Magnetometry survey carried out across similar soils has produced variable results due to low magnetic susceptibility. However, where long term occupation or industrial activity occurs there can be sufficient magnetic

contrast for anomalies to be recorded. The underlying geology and soils are therefore considered acceptable 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 20Hz. The gradiometers have a range of recording data between 0.1nT and 10,000nT. The sensors are not zeroed in the field, as the vertical axis alignment is fixed using a tension band system. In order to produce visible, useful greyscale images a zero median traverse process is undertaken in TerraSurveyor. The system is linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO@MXPDA software on a rugged computer.
- 2.2.2 Data are collected along a series of parallel survey tracks wherever possible. The length of each track is variable and relates to the size of the survey area and other factors including ground conditions. A visual display aids accurate placing of tracks and their separation.
- 2.2.3 Data are not collected within fixed grids and data points are considered to be

random even though the data are collected in a systematic manner covering all accessible areas (Aspinall, Gaffney and Schmidt, 2009).

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. Survey tracks are analysed and georeferenced raw data (UTM Z30N) are then exported in ASCII format for further analysis and display using TerraSurveyor.
- 2.3.2 The data are collected between limits of ± 10000 nT and clipped for display at ± 3 nT. Data are interpolated to a resolution of effectively 0.5m between tracks and 0.15m along each survey track. A zero median traverse function is required in order to remove fixed offset values present within the sensors which do not undergo a zeroing procedure in the field. The approach ensures that the gradiometer sensors are very accurately aligned and fixed to the vertical magnetic field and are not influenced by localised magnetic fields or disturbed by vibration. Although a zero median traverse algorithm can remove anomalies aligned with the survey tracks, in practice this rarely occurs due to the use of long traverses, high resolution measurement and variability within the magnetic susceptibility of long linear features.
- 2.3.3 Appendix C contains metadata concerning the survey and data attributes and is derived directly from TerraSurveyor. Reference should be made to Appendix B for further information on any processes, such as clipping, carried out on the data.
- 2.3.4 A TIF file is produced by TerraSurveyor software along with an associated world file (.TFW) that allows automatic georeferencing (OSGB36 datum) when using GIS or CAD software. The main form of data display used in the report is the minimally processed greyscale plot.
- 2.3.5 The raster images are combined with base mapping using ProgeCAD Professional 2014, creating DWG (2010) file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. The CAD plots are effectively georeferenced facilitating relocation of features using GPS, resection method, etc.
- 2.3.6 An abstraction and interpretation is also drawn and plotted for all geophysical anomalies located by the survey. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.
- 2.3.7 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 site.
- 2.3.8 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 a total of two survey areas covering approximately 2.5ha, the results will be considered as a single survey area.
- 3.1.2 Magnetic anomalies located can be generally classified as positive and negative anomalies of an uncertain origin, areas of magnetic debris and disturbance, strong discrete dipolar anomalies relating to ferrous objects and strong multiple dipolar linear anomalies relating to buried services or pipelines. Anomalies located have been numbered and are described in 3.4 below.

3.2 Statement of data quality

- 3.2.1 Data are considered representative of the magnetic anomalies present within the site. There are no significant defects within the dataset. Areas of magnetic debris and disturbance are widespread across the site and these have the potential to obscure more minor magnetic anomalies.

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 for each survey area.

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
<p>Anomalies with an uncertain origin</p> <p>AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG NEG LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN AS-ABST MAG POS UNCERTAIN</p> 	<p>The category applies to a range of anomalies where <u>there is not enough evidence to confidently suggest an origin</u>. Anomalies in this category <u>may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered</u>. 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.</p>
<p>Anomalies associated with magnetic debris</p>	<p>Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in</p>



<p>AS-ABST MAG DEBRIS AS-ABST MAG STRONG DIPOLAR</p> 	<p>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 <u>may therefore be archaeologically significant</u>. 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.</p>
<p>Anomalies with a modern origin</p> <p>AS-ABST MAG DISTURBANCE AS-ABST MAG SERVICE</p> 	<p>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.</p>

Table 1: List and description of interpretation categories

3.4 List of anomalies

Area centred on OS NGR 378055 205955, see Figures 03 & 04.

Anomalies with an uncertain origin

(1) - Within the north eastern corner of the site are numerous discrete positive responses that appear as pit-like features. It is likely that these are related to ground disturbance, either through scraping up the topsoil, or depositing material.

(2) - In the central part of the site are a number of weakly positive responses. It is possible that these relate to former fluvial features, or are associated with repeated waterlogging and periods of drying out.

(3) - In the southern part of the site (Area 2) are two positive linear anomalies. One is short and parallel with a service, the other extends between two patches of magnetic debris and may be associated.

(4) - A negative linear anomaly can be seen extending throughout much of Area 1. It is not possible to determine if this relates to agricultural activity or if it is associated with a buried pipe.

Anomalies associated with magnetic debris

(5 & 6) - In the northern part of the site a sinuous linear zone of highly magnetic debris relates to ferrous material that has been used to infill a former channel (5). The channel is mapped as extending from the eastern edge, heading north westwards, then westwards, then towards the northwestern corner. However the

magnetic debris can be seen to clearly extend northwards (6) and south westwards (7) as a curvilinear zone, forming conjoined, but also distinct features. The infilling has resulted in parts of these features now existing as raised mounds or earthworks.

(8) - Also in the northern part of the site is a narrow band of strongly magnetic debris that relates to an infilled, ditch. This still exists as a shallow depression.

(9) - Within the southern part of the site there are a number of zones of magnetic debris. Some with a stronger response again indicate a ferrous content, some with a weaker response will include other magnetically thermoremnant material. Many of the responses are associated with channel infilling, but other dumping is also likely.

(10) - Strong, discrete, dipolar anomalies relate to magnetically thermoremnant objects within the topsoil.

Anomalies with a modern origin

(11) - A strong, multiple dipolar, linear anomaly extends throughout the site and relates to a buried service.

4 CONCLUSION

- 4.1.1 The results of the detailed magnetometer survey demonstrate the presence of several patches and linear zones of very strongly magnetic debris. The magnetic responses relate to ferrous and other magnetically thermoremnant material being used to infill former water channels within the site.
- 4.1.2 Towards the north eastern corner is a zone containing numerous discrete positive responses, and it is possible that these are related to ground disturbance associated with the infilling of the channels. In the central part of the site, are a number of weakly positive responses. These are likely to relate to natural features, associated with waterlogging/fluvial features.

5 REFERENCES

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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 thermoremanent 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.

Thermoremanent 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. Thermoremanent features include ovens, hearths, and kilns. In addition thermoremanent 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.

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 $\pm 5nT$ and $\pm 3nT$ 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 (destripe) 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 differences between the baseline value of gradiometer sensors.

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

Area 1

COMPOSITE
 Filename: J644-mag-Area1-proc.xcp
 Description: Imported as Composite from: J644-mag-Area1.asc
 Instrument Type: Sensys DLMGPS
 Units: nT
 UTM Zone: 30U
 Survey corner coordinates (X/Y): OSGB36
 Northwest corner: 377936.081659654, 206118.565464956 m
 Southeast corner: 378109.481659654, 205916.365464956 m
 Direction of 1st Traverse: 90 deg
 Collection Method: Randomised
 Sensors: 5
 Dummy Value: 32702

Source GPS Points: 536500

Dimensions

Composite Size (readings): 1156 x 1348
 Survey Size (meters): 173 m x 202 m
 Grid Size: 173 m x 202 m
 X Interval: 0.15 m
 Y Interval: 0.15 m

Stats

Max: 3.32
 Min: -3.30
 Std Dev: 2.03
 Mean: -0.15
 Median: 0.00
 Composite Area: 3.5061 ha
 Surveyed Area: 1.8552 ha

PROGRAM

Name: TerraSurveyor
 Version: 3.0.23.0

Processes: 1
 1 Base Layer

GPS based Proce4

1 Base Layer.
 2 Unit Conversion Layer (Lat/Long to OSGB36).

3 DeStripe Median Traverse: Threshold: 1.5 SDs
 4 Clip from -3.00 to 3.00 nT

Area 2

COMPOSITE
 Filename: J644-mag-Area2-proc.xcp
 Description: Imported as Composite from: J644-mag-Area2.asc
 Instrument Type: Sensys DLMGPS
 Units: nT
 UTM Zone: 30U
 Survey corner coordinates (X/Y): OSGB36
 Northwest corner: 378029.389159128, 205929.674626917 m
 Southeast corner: 378164.539159128, 205825.724626917 m
 Collection Method: Randomised
 Sensors: 5
 Dummy Value: 32702

Source GPS Points: 193400

Dimensions

Composite Size (readings): 901 x 693
 Survey Size (meters): 135 m x 104 m
 Grid Size: 135 m x 104 m
 X Interval: 0.15 m
 Y Interval: 0.15 m

Stats

Max: 3.32
 Min: -3.30
 Std Dev: 2.12
 Mean: -0.05
 Median: 0.06
 Composite Area: 1.4049 ha
 Surveyed Area: 0.6224 ha

Processes: 1
 1 Base Layer

GPS based Proce4

1 Base Layer.
 2 Unit Conversion Layer (Lat/Long to OSGB36).
 3 DeStripe Median Traverse:
 4 Clip from -3.00 to 3.00 nT

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at their offices in Wiltshire. 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.

A copy of the report in PDF/A format will be supplied to the Gloucestershire Historic Environment Record, together with a DXF of the survey boundary. The report will also be uploaded to the Online Access to the Index of archaeological investigationS (OASIS).

Archive contents:

Geophysical data - path: J644 Eastington \Data\				
Path and Filename	Software	Description	Date	Creator
eastin1\MX\ eastin2\MX\ .prm .dgb .disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	08/01/16	D.J.Sabin
eastin1\MX\J644-mag- Area1.asc eastin2\MX\J644-mag- Area2.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey Area 1 in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	08/01/16	D.J.Sabin
Area1\comps\J644-mag- Area1.xcp Area2\comps\J644-mag- Area2.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	08/01/16	D.J.Sabin
Area1\comps\J644-mag- Area1-proc.xcp Area2\comps\J644-mag- Area2-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to $\pm 3nT$).	08/01/16	D.J.Sabin
Graphic data - path: J644 Eastington\Data\				
Area1\graphics\ J644-mag-Area1-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to $\pm 3nT$.	08/01/16	D.J.Sabin
Area1\graphics\ J644-mag-Area1-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	08/01/16	D.J.Sabin
Area2\graphics\ J644-mag-Area2-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to $\pm 3nT$.	08/01/16	D.J.Sabin
Area2\graphics\ J644-mag-Area2-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	08/01/16	D.J.Sabin
CAD data - path: J644 Eastington\CAD\				
J644 version 1.dwg	ProgeCAD 2016	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	11/01/16	K.T.Donaldson
Text data - path: J644 Eastington\Documentation\				
J644 report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.	15/01/16	K.T.Donaldson

Appendix E – copyright and intellectual property

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Geophysical Survey Land south of Eastington Trading Estate Gloucestershire

Map of survey area

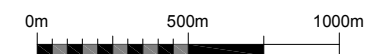
Reproduced from OS Explorer map nos.OL 45 & 179
1:25 000 by permission of Ordnance Survey on behalf
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● Survey location

SO 78055 05955

SCALE 1:25 000



SCALE TRUE AT A3



Survey location

**Geophysical Survey
Land south of Eastington
Trading Estate
Gloucestershire**

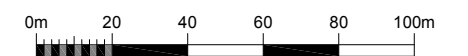
Referencing information

Referencing grid to OSGB36 datum at 50m intervals

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

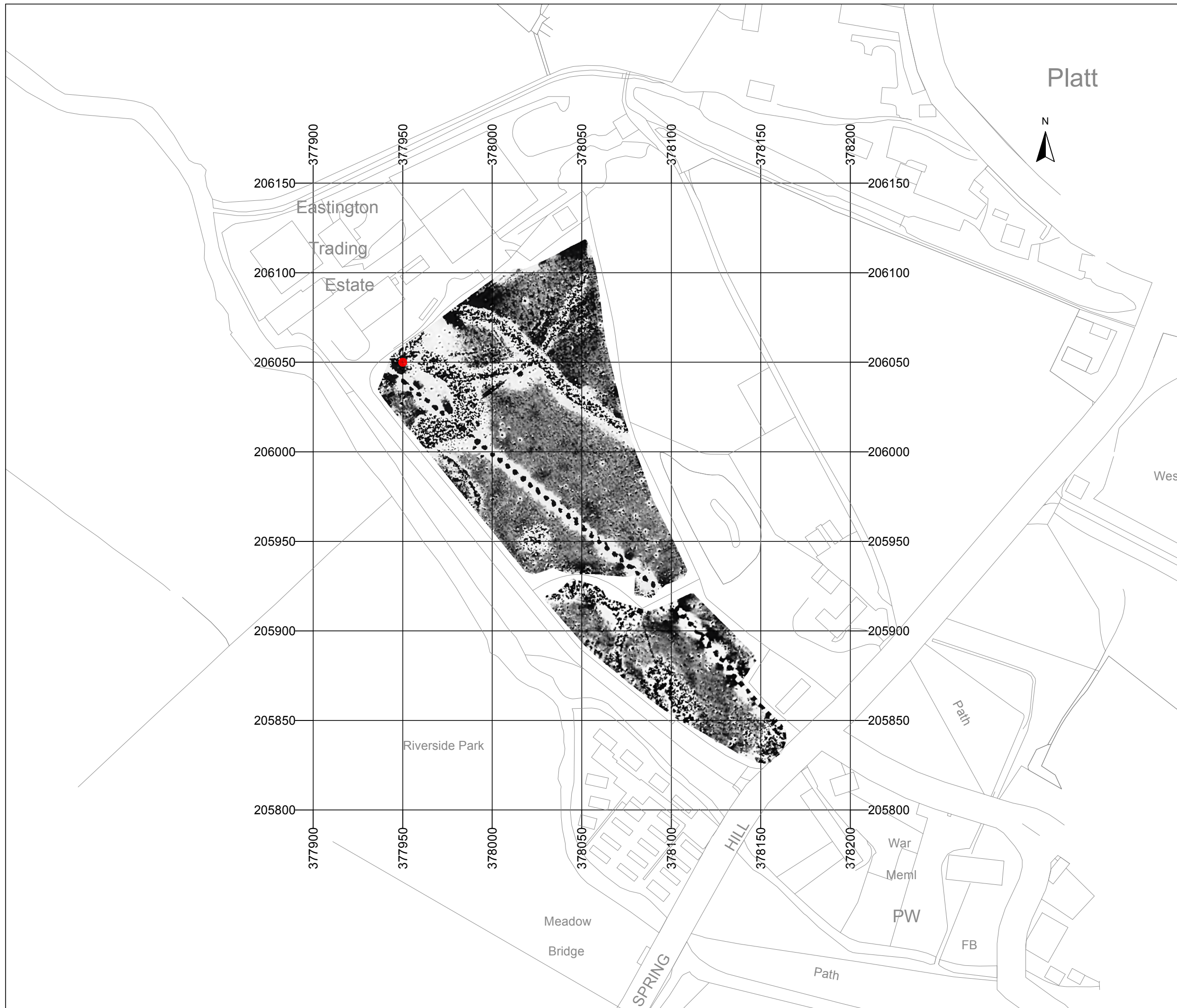
● 377950 206050

SCALE 1:2000



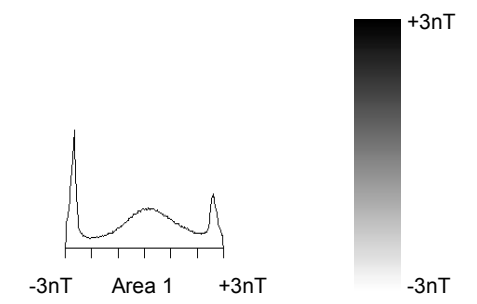
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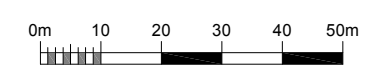


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**Greyscale plot of minimally
processed magnetometer data**



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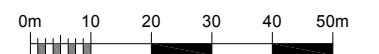
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**Abstraction and interpretation of
magnetometer anomalies**

-  Positive linear anomaly - possible ditch-like feature
-  Negative linear anomaly - material of low magnetic susceptibility
-  Discrete positive response - possible pit-like feature
-  Positive anomaly - magnetically enhanced material
-  Magnetic debris - spread of magnetically thermoremanent/ferrous material
-  Magnetic disturbance from ferrous material
-  Strong multiple dipolar linear anomaly - pipeline / cable / service
-  Strong dipolar anomaly - ferrous object

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