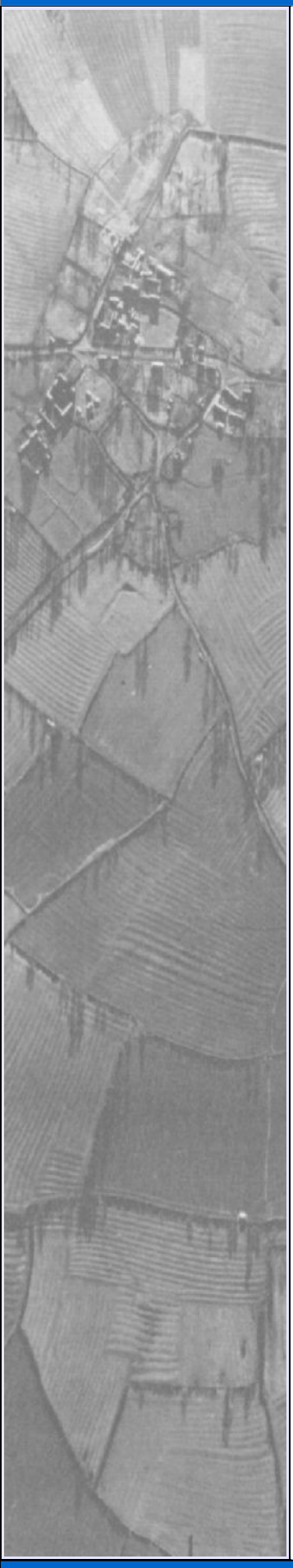

Land off Alkerton Road
Eastington
Gloucestershire

MAGNETOMETER SURVEY REPORT

for

Cotswold Archaeology

David Sabin and Kerry Donaldson

March 2015

Ref. no. 595

ARCHAEOLOGICAL SURVEYS LTD

Land off Alkerton Road
Eastington
Gloucestershire

Magnetometer Survey Report

for

Cotswold Archaeology

Fieldwork by David Sabin (Hons) MCIfA
Report by Kerry Donaldson BSc (Hons)
Report checked by David Sabin
Primary archive location - Archaeological Surveys Ltd, Yatesbury, Wiltshire

Survey dates – 6th March 2015
Ordnance Survey Grid Reference – **SO 77297 05550**

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SUMMARY

A detailed magnetometer survey was carried out by Archaeological Surveys Ltd, at the request of Cotswold Archaeology, over 1.1ha within the southern part of a single arable field off Alkerton Road, Eastington, Gloucestershire. The results demonstrate the presence of a small number of weak, broad, linear responses of uncertain origin, which may have been crossed by a number of land drains. The site contains numerous land drains with two separate series crossing one another. A central zone of weakly magnetic debris indicates the presence of magnetically thermoremnant material but, it is unclear as to whether it has been brought onto site, or is associated with industrial activity.

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 off Alkerton Road, Eastington. The site has been outlined for a proposed housing development (Stroud District Council outline planning application S.14/2879/OUT) 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 Archaeological Surveys (2015) and issued to 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 north of Alkerton Road, Eastington in Gloucestershire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SO 77297 05550, see Figures 01 and 02.

1.3.2 The geophysical survey covers approximately 1.1ha within the southern half of an arable field. The surface conditions consisted of soil with a low cover of senescent or dead vegetation and evidence of manuring with slurry. The southern edge of the field contained standing water and was very boggy and rutted.

1.3.3 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry data. Weather conditions during the survey were fine.

1.4 Site history and archaeological potential

1.4.1 The site lies to the south of the location of a number of Roman and possibly Saxon finds, discovered during gravel extraction in the 1920s and 1930s and also during construction of the M5 motorway during the 1970s. Finds include pottery, burials and building remains of a possible Roman villa complex. The postulated Roman road from Easton Grey to Arlingham (Margary, 1955 road 543) is believed to be located to the north of the site.

1.4.2 There is potential for the geophysical survey to locate anomalies that may relate to archaeological features, should they be present within the site.

1.5 Geology and soils

1.5.1 The underlying solid geology mudstone of the Blue Lias Formation and Charmouth Mudstone Formation (BGS, 2015)

1.5.2 The overlying soil across the survey area is from the Evesham 2 association, which are typical calcareous pelosols. These consist of slowly permeable, calcareous clayey soils (Soil Survey of England and Wales, 1983).

1.5.3 Magnetometry survey carried out across similar soils has produced good results, although at times they can be associated with low magnetic susceptibility. 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 20 Hz. The gradiometers have a range of recording data between 0.1nT and 10,000nT. The system is 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.

2.2.3 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 ±10000nT and clipped for display at ±10nT. Data are interpolated to a resolution of effectively 0.5m between tracks and 0.12m 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 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 offered 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. 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.

2.3.7 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 1.1ha within the southern part of a single arable field.

3.1.2 Magnetic anomalies located can be generally classified as positive anomalies of an uncertain origin, anomalies associated with land management, linear anomalies of an agricultural origin, areas of magnetic debris and strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within each survey area 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.

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 the survey area.

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 relating to land management AS-ABST MAG LAND DRAIN AS-ABST MAG PATH 	Anomalies are mainly linear and may be positive, negative or both, or associated with magnetic debris. They will correspond to a current or formerly mapped footpath or track. Land drains can appear in a classic herringbone pattern of interconnected multiple dipolar linear anomalies, or as parallel linear anomalies. The multiple dipolar response indicates a ceramic land drain.
Anomalies with an agricultural origin AS-ABST MAG AGRICULTURAL	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; narrow response is often related to modern ploughing.
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.

Table 1: List and description of interpretation categories

3.4 List of anomalies

Area centred on OS NGR 377297 205550, see Figures 03 & 04.

Anomalies with an uncertain origin

(1) – A broad, weakly positive band extends across the western part of the survey area towards the centre of the site and anomaly (11). The response is very weak (<0.5nT). The anomaly cannot be seen to the east of the patch of magnetic debris (11); however, an association with anomaly (2) at the eastern edge of the survey area is possible. This type of response can indicate a former bank/boundary/lynchet feature, but the origin of the anomaly is uncertain.

(2) – A broad, positive response can be seen at the eastern edge of the field. It is stronger than anomaly (1) at c5nT; however, it does not appear to extend beyond the footpath (9). It is not possible to determine its origin.

(3) – Close to the south western corner of the survey area is a weakly positive response. It is a broad weak linear anomaly to the west (1.5nT), becoming much narrower and stronger towards the east (8nT). It appears to have been crossed by a number of land drains and may relate to a cut, ditch-like feature. It should be considered that it is a combination of two features, with the broad, weak response being similar to anomaly (1) and the narrow, stronger response possibly associated with land drainage.

(4) – There are a number of positive linear anomalies in the southern part of the survey area with no coherent form or pattern and it is not possible to determine their origin.

(5) – In the northern part of the survey area are a number of positive linear anomalies. It is possible that they are associated with land drainage, but this is not certain.

Anomalies associated with land management

(6) – The survey area contains two sets of land drains with a herringbone formation.

(7) – Two series of linear anomalies , roughly parallel with the western field boundary, appear to relate to land drains that extend northwards and southwards into collectors running along the edge of the mapped footpath (8).

(8) – Extending across the site from the north eastern corner towards the western edge are a number of positive and negative linear anomalies that are located in the vicinity of a formerly mapped footpath.

(9) – Extending along the eastern edge of the survey area are a series of parallel positive and negative linear anomalies which are also in the position of a footpath.

Anomalies with an agricultural origin

(10) – A number of narrow, closely spaced, linear anomalies can be seen within the site, oriented almost north east to south west. These are associated with a modern cultivation trend.

Anomalies associated with magnetic debris

(11) – A zone of weakly magnetic debris is evident within the centre of the site. Although it is possible that this relates to dumped magnetically thermoremnant material, it is not concentrated and does not include large ferrous objects.

(12) – Strong, discrete, dipolar anomalies are a response to ferrous objects within the topsoil.

4 CONCLUSION

4.1.1 The detailed magnetometer survey located a small number of weak, broad linear responses. Their origin cannot be determined from the results; however, they may have been crossed by a number of land drains, indicating that they pre-date them.

4.1.2 The results also demonstrate that the site contains a large number of land drains, with one set out in a herringbone formation and the other in a parallel formation. The location of two footpaths can also be seen as a series of anomalies along the eastern edge and crossing the site. The one crossing the site also appears to be defined by land drains.

4.1.3 A large zone of magnetic debris within the central part of the site is consistent with magnetically thermoremnant material such as brick, tile or slag. It is unclear whether it represents material brought onto site within soil or manure, or whether it is associated with industrial activity.

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 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.

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 ±20nT and ±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

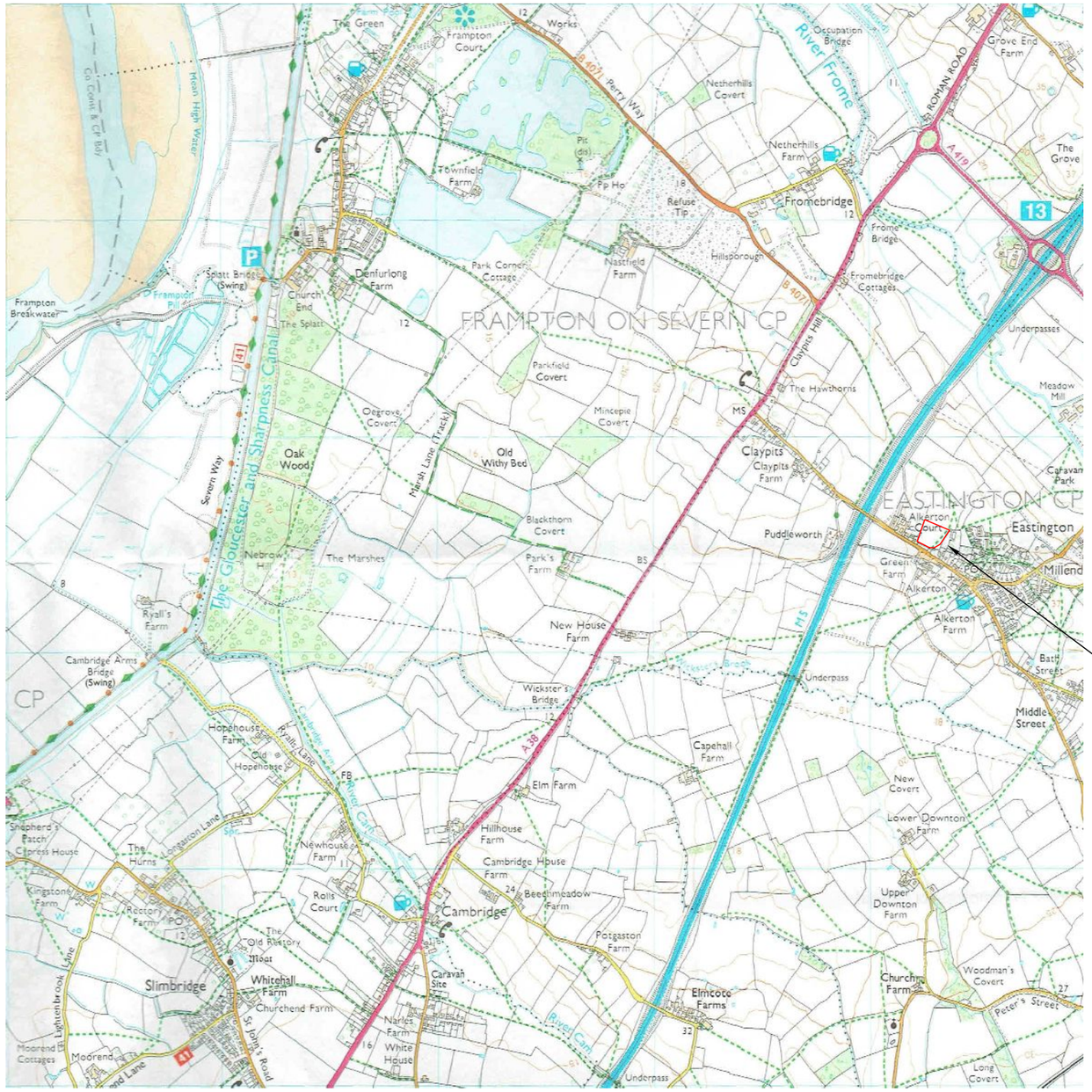
```
COMPOSITE
Filename:              J595-mag-proc.xcp
Description:           Imported as Composite from: J595-mag.asc
Instrument Type:       Sensys DLMGPS
Units:                 nT
UTM Zone:              30U
Survey corner coordinates (OSGB36
Northwest corner:      377231.153100207, 205619.034277152 m
Southeast corner:      377372.873100207, 205489.674277152 m
Collection Method:     Randomised
Sensors:               5
Dummy Value:           32702

Source GPS Points:     419700

Dimensions
Composite Size (readings):  1181 x 1078
Survey Size (meters):       142 m x 129 m
X Interval:            0.12 m
Y Interval:            0.12 m

Stats
Max:                   11.05
Min:                   -11.00
Std Dev:               3.17
Mean:                  0.21
Median:                0.00
Composite Area:        1.8333 ha
Surveyed Area:         1.1391 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:
 4  Clip from -10.00 to 10.00 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 issued to the Gloucestershire Historic Environment Record, together with a DXF of the survey boundary.

Appendix E – copyright and intellectual property



Archaeological Surveys Ltd

Geophysical Survey
Land off Alkerton Road
Eastington
Gloucestershire

Map of survey area

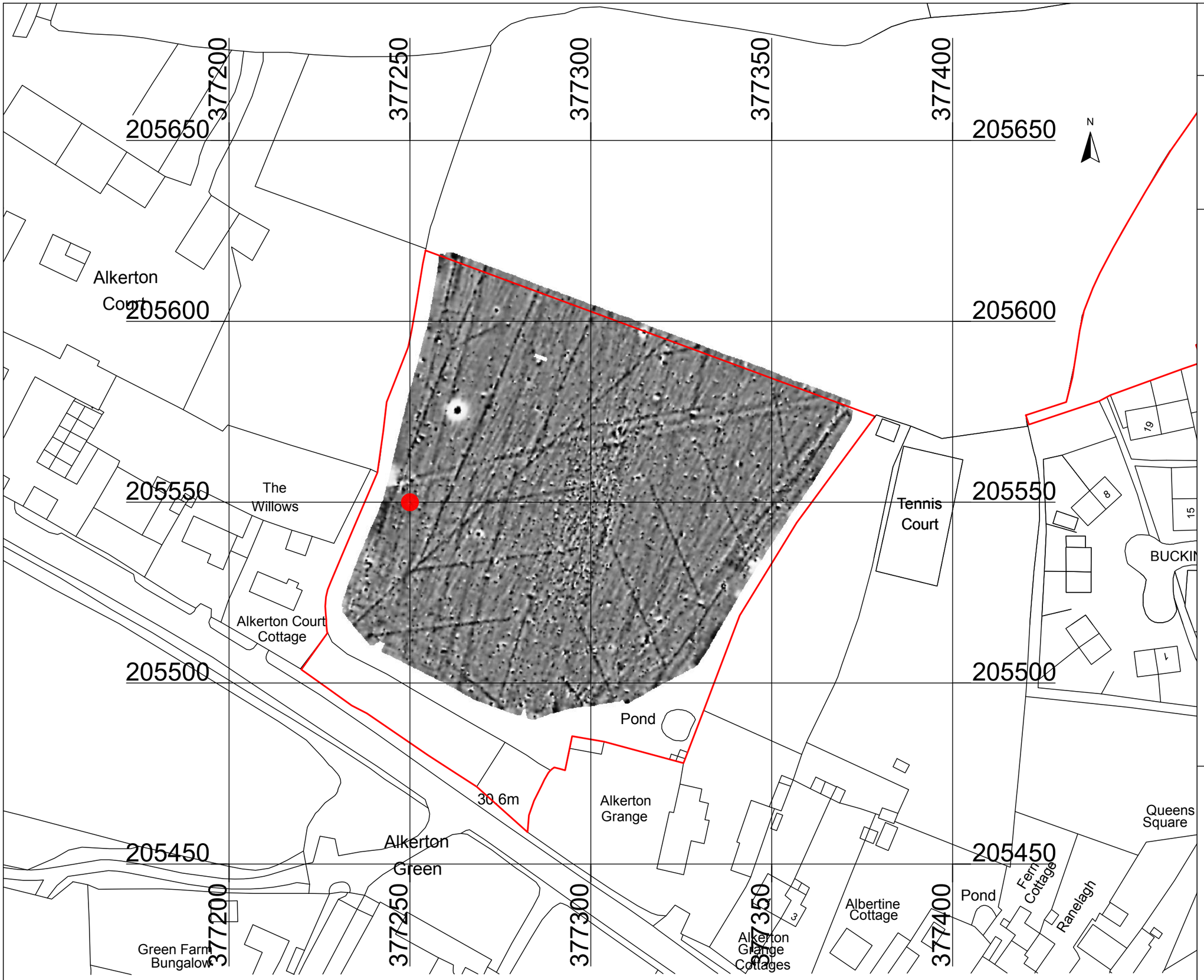
Site centred on OS NGR
SO 77300 05550

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01



Archaeological Surveys Ltd

Geophysical Survey
Land off Alkerton Road
Eastington
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

● 377250 205550

SCALE 1:1000

0m 20 40 60 80 100m

SCALE TRUE AT A3

FIG 02

Archaeological Surveys Ltd

Geophysical Survey
Land off Alkerton Road
Eastington
Gloucestershire

Greyscale plot of minimally processed magnetometer data

+10nT

-10nT +10nT

-10nT

N

Alkerton Court

The Willows

Alkerton Court Cottage

Tennis Court

19

8

15

BUCKI

Pond

30.6m

Alkerton Grange

Alkerton Green

Green Farm Bungalow

4

3

Alkerton Grange Cottages

Albertine Cottage

Pond

Fern Cottage

Ranelagh

Queens Square

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 03

Archaeological Surveys Ltd

Geophysical Survey
Land off Alkerton Road
Eastington
Gloucestershire

Abstraction and interpretation of magnetometer anomalies

- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - of agricultural origin
- Positive linear anomaly - land drain
- Positive anomaly - magnetically enhanced material
- Negative anomaly flanked by positive responses - footpath
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 04

N

Alkerton Court

The Willows

Alkerton Court Cottage

Tennis Court

Pond

30.6m

Alkerton Grange

Alkerton Green

Green Farm Bungalow

Alkerton Grange Cottages

Albertine Cottage

Pond

Fern Cottage

Ranelagh

Queens Square

BUCKIN

1 2 3 4 5 6 7 8 9 10 11 12

19 15 8 1