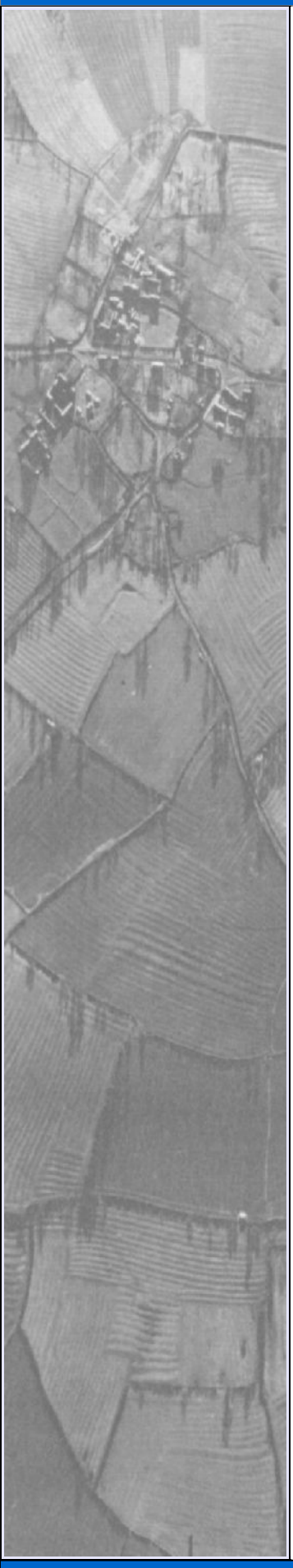

Land north of Knight's Furlong Plantation
Tarlton
Gloucestershire

MAGNETOMETER SURVEY REPORT

for

Cotswold Archaeology

Kerry Donaldson & David Sabin

May 2015

Ref. no. 607

ARCHAEOLOGICAL SURVEYS LTD

Land north of Knight's Furlong Plantation
Tarlton
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 – 11th May 2015
Ordnance Survey Grid Reference – **ST 96935 98380**

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

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SUMMARY

A detailed magnetometer survey was carried out on land to the north of Knight's Furlong Plantation, Tarlton, Gloucestershire by Archaeological Surveys Ltd. The survey was requested by Cotswold Archaeology, on behalf of the Bathurst Estate, within a small area of land outlined for the development of an agricultural lagoon. The site covers 0.7ha with a slightly larger area covered by the geophysical survey to enable better definition of potential anomalies that may lie within the development area. The results of the survey reveal two positive linear anomalies and discrete responses that lie to the east of the development area and appear to relate to possible ditch-like and pit-like features, although their origin is uncertain. Several other discrete positive responses have also been located within and beyond the development area and again it is not possible to determine if these relate to pit-like features with a natural or anthropogenic origin. Evidence for agricultural activity and also a zone of naturally formed pit-like responses have also been located.

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 north of Knight's Furlong Plantation, Tarlton in Gloucestershire. A planning application to Cotswold District Council has been made by Cirencester Park Farms Ltd (15/00861/FUL) for the construction of an agricultural lagoon and the survey aims to provide information on the archaeological potential of land likely to be disturbed by this development.

1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2015) and approved by Charles Parry, Archaeologist for Gloucestershire County Council, prior to the fieldwork stage. Although the WSI stated that the survey would be undertaken using a Bartington Grad 601-2, with readings taken at 0.25m centres along 1m traverses, it was carried out using a SENSYS MAGNETO®MXPDA 5 channel cart-based system collecting readings at 100Hz with 5 magnetometers spaced 0.5m apart (see 2.2).

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 lies approximately 1.4km south east of the village of Tarlton and 1.5km north west of Kemble in Gloucestershire. The central OS Grid Reference is ST 96915 98390. The area covered by the site is approximately 0.7ha within a corner of an arable field immediately north of Knight's Furlong Plantation, see Figures 01 and 02.

1.3.2 The development area covers 0.7ha; however, the geophysical survey covers approximately 1.16ha within the corner of an arable field that had been cleared of a rape crop just prior to survey, see Plate 1. The survey was carried out within a slightly wider zone in order to better understand any potential features that may be located within the development site.

Plate 1: Survey area looking south east

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 variable with periods of light rain.

1.4 Site history and archaeological potential

1.4.1 The site lies approximately 2km north east of a number of Scheduled bowl barrows, and 1.5km south west of Trewsbury Iron Age hillfort. It is also located 500m north west of the section of the Fosse Way Roman road that extends between Bath (*Aquae Sulis*) and Cirencester (*Corinium*), 6km to the north east. Roman activity is also recorded within Hailey Woods, 2km to the north west and within Kemble village 2km to the south east. The site lies 750m south west of the Scheduled Monument of Hullasey Grove Medieval Village (National Monument No: 1003359).

1.4.2 Although the site does not contain any designated or non-designated heritage assets, it lies within an area containing a number of archaeological sites dating from the prehistoric, Roman and medieval periods. There is potential that the geophysical survey could locate anomalies that may relate to previously unrecorded archaeological remains, should they be present within the site.

1.4.3 The surface conditions within the site were suitable for the observation of cultural material during the course of the survey. No significant scatters were noted.

1.5 Geology and soils

1.5.1 The underlying solid geology across the site is Jurassic Limestone from the Forest Marble Formation (BGS, 2015).

1.5.2 The overlying soil across the survey area is from the Sherborne association and is a brown rendzina. It consists of a shallow, well drained, brashy, calcareous, clayey soil over limestone (Soil Survey of England and Wales, 1983).

1.5.3 Magnetometry survey carried out across similar soils has produced good results, although naturally formed anomalies can be present, and at times can be difficult to distinguish from those with an anthropogenic origin. 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 100 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. 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 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 1.16ha within the corner of a single arable field.

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 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.

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	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.
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.
Anomalies associated with magnetic debris AS-ABST MAG STRONG DIPOLAR	Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.
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 discrete and these are almost impossible to distinguished from pit-like anomalies with an anthropogenic origin. Periglacial processes may be responsible for their formation within drift material and subsoil.

Table 1: List and description of interpretation categories

3.4 List of anomalies

Area centred on OS NGR 396935 198380, see Figures 03 & 04.

Anomalies with an uncertain origin

(1) - A positive linear anomaly extends south westwards from close to the north eastern corner for 35m, where it then appears to extend southwards for 11m

towards a discrete positive response, 3m to the south. These anomalies lie just beyond the development boundary, but it is possible that they relate to cut ditch-like and pit-like features.

(2) - Located in the south eastern corner of the survey area is a positive linear anomaly with what appears to be an associated discrete positive response in the centre. Although this also lies outside of the development boundary, it is possible that they relate to cut ditch-like and pit-like features.

(3) - The survey area contains a number of discrete positive anomalies with a response of around 8nT. These appear to relate to pit-like features and although a natural origin is possible, an anthropogenic origin should be considered.

(4) - A small number of weakly positive linear anomalies have been located within the survey area. The majority of these are within the vicinity of anomaly (1) and beyond the limits of the development area. It is not possible to determine if they relate to naturally or anthropogenically formed features.

Anomalies with an agricultural origin

(5) - Parallel with the western and south western field boundaries are a pair of negative linear anomalies with a positive linear anomaly further to the west. These relate to ruts and the edge of cultivation respectively.

(6) - Extending across the survey area, and oriented west north west to east south east, are a number of parallel linear anomalies that relate to the cultivation trend.

Anomalies with a natural origin

(7) - In the western part of the survey area is a zone containing numerous pit-like responses with no coherent form or pattern. These are likely to relate to naturally formed features.

Anomalies associated with magnetic debris

(8) - A number of strong, discrete, dipolar anomalies are a response to ferrous and other magnetically thermoremnant objects within the topsoil.

4 CONCLUSION

4.1.1 Two positive linear anomalies appear to be associated with pit-like features and lie just to the east of the development area. Although it is not possible to determine the origin of these features, it should be considered that they may relate to linear ditches with associated pits.

4.1.2 The site also contains a number of discrete positive responses that appear to form pit-like features. Although several of these again lie outside the limits of the development area, a number lie within. It is not possible to determine if these relate to naturally or anthropogenically formed pits. A zone of numerous pit-like responses can be seen within the western part of the survey area, and these do appear to relate to naturally formed features.

5 REFERENCES

Archaeological Surveys, 2015. *Land north of Knight's Furlong Plantation, Tarlton, Gloucestershire, Geophysical Survey Written Scheme of Investigation.* Unpublished typescript document.

Aspinall, A., Gaffney, C. and Schmidt, A., *Magnetometry for Archaeologists*. Lanham (US), AltaMira Press.

British Geological Survey, 2015. *Geology of Britain viewer, 1:50 000 scale [online]* available from http://mapapps.bgs.ac.uk/geologyofbritain/home.html [accessed 27/4/2015].

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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.

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 ±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 (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: J607-mag-proc.xcp
Description: Imported as Composite from: J607-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y): OSGB36
Northwest corner: 396873.290078731, 198457.187955078 m
Southeast corner: 396999.740078731, 198300.137955078 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702

Source GPS Points: 1897500

Dimensions
Composite Size (readings): 843 x 1047
Survey Size (meters): 126 m x 157 m
Grid Size: 126 m x 157 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats
Max: 5.00
Min: -5.00
Std Dev: 1.15
Mean: -0.05
Median: -0.09
Composite Area: 1.9859 ha
Surveyed Area: 1.1627 ha

PROGRAM
Name: TerraSurveyor
Version: 3.0.23.0

Processes: 2
1 Base Layer
2 Clip from -5.00 to 5.00 nT

GPS based Proce2
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).

Appendix D – digital archive

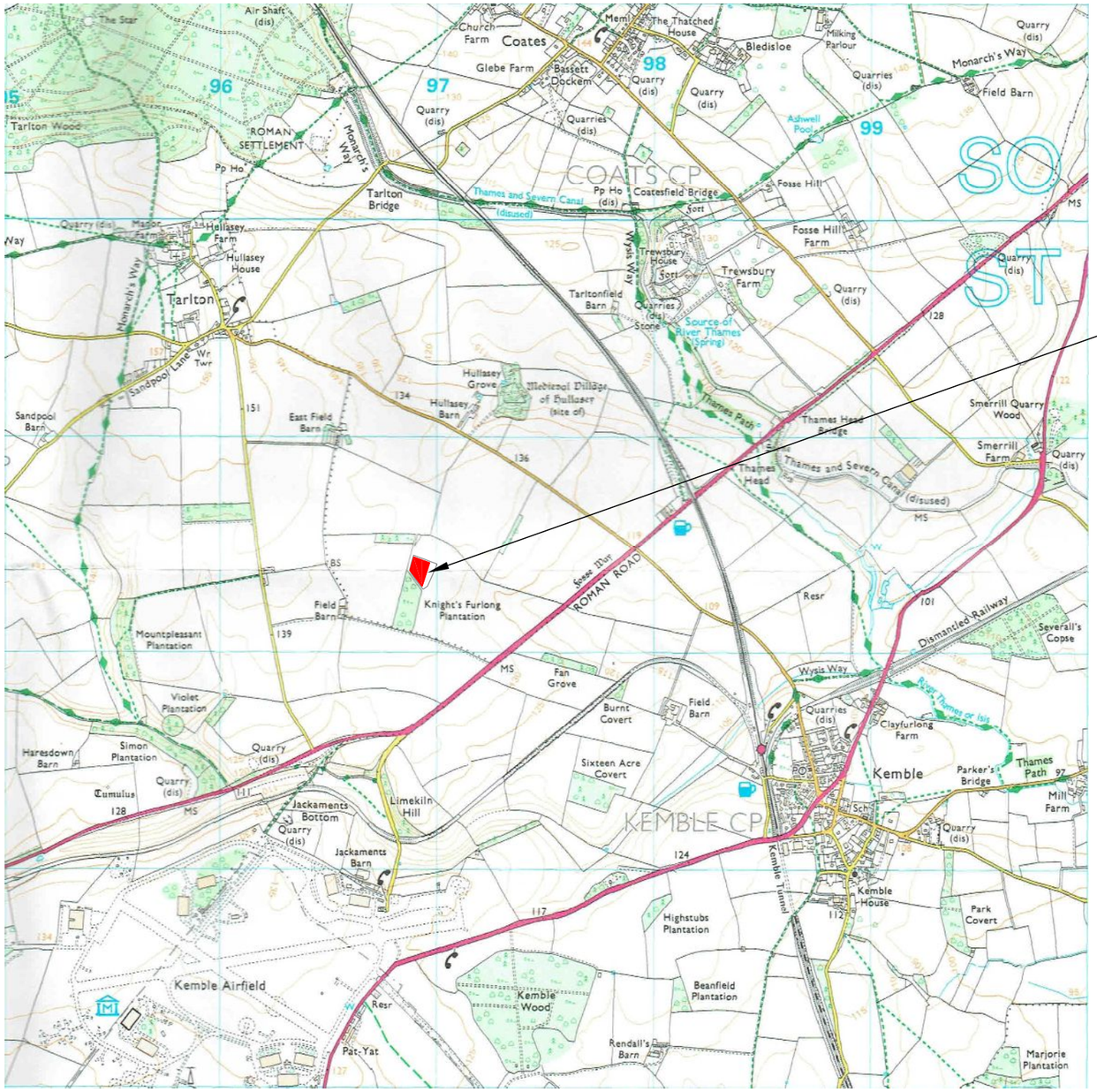
Archaeological Surveys Ltd hold the primary digital archive at their offices in Wiltshire. Data are backed-up onto an on-site data storage drive and at the earliest opportunity data are copied to CD ROM for storage on-site and off-site.

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: J607 Tarlton1\Data				
Path and Filename	**Software**	**Description**	**Date**	**Creator**
Tarlton1\MX\ .prm .dgb .disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	11/05/15	D.J.Sabin
Tarlton1\MX\J607-mag.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	13/05/15	K.T.Donaldson
Mag\comps\J607-mag.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	13/05/15	K.T.Donaldson
Mag\comps\J607-mag-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±5nT).	13/05/15	K.T.Donaldson
Graphic data - path: J607 Tarlton\Data				
Mag\graphics\ J607-mag-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±5nT.	13/05/15	K.T.Donaldson
Mag\graphics\ J607-mag-proc..tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	13/05/15	K.T.Donaldson
CAD data - path: J607 Tarlton\CAD				
J607 version 1.dwg	ProgeCAD 2014	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	13/05/15	K.T.Donaldson
Text data - path: J607 Tarlton\Documentation				
J607 report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.	13/05/15	K.T.Donaldson

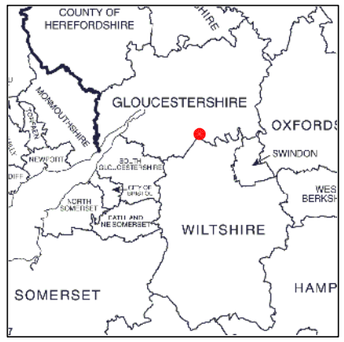
Appendix E – copyright and intellectual property



Archaeological Surveys Ltd

Geophysical Survey
Land north of Knight's Furlong Plantation
Tarlton
Gloucestershire

Map of survey area



Survey location

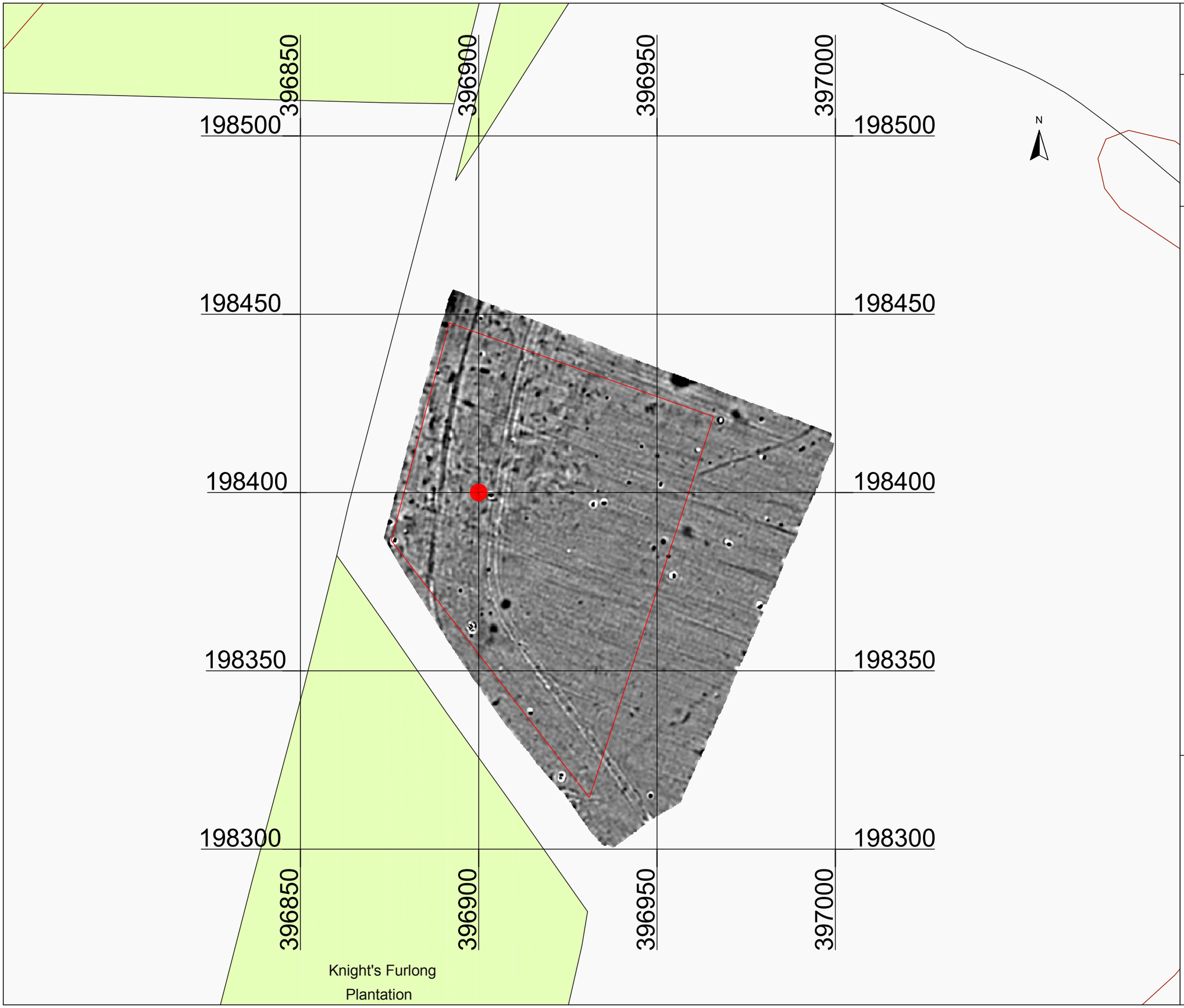
Site centred on OS NGR
ST 96935 98380

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01



Archaeological Surveys Ltd

Geophysical Survey
Land north of
Knight's Furlong Plantation
Tarlton
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

396900 198400

Development boundary

SCALE 1:1000

0m 20 40 60 80 100m

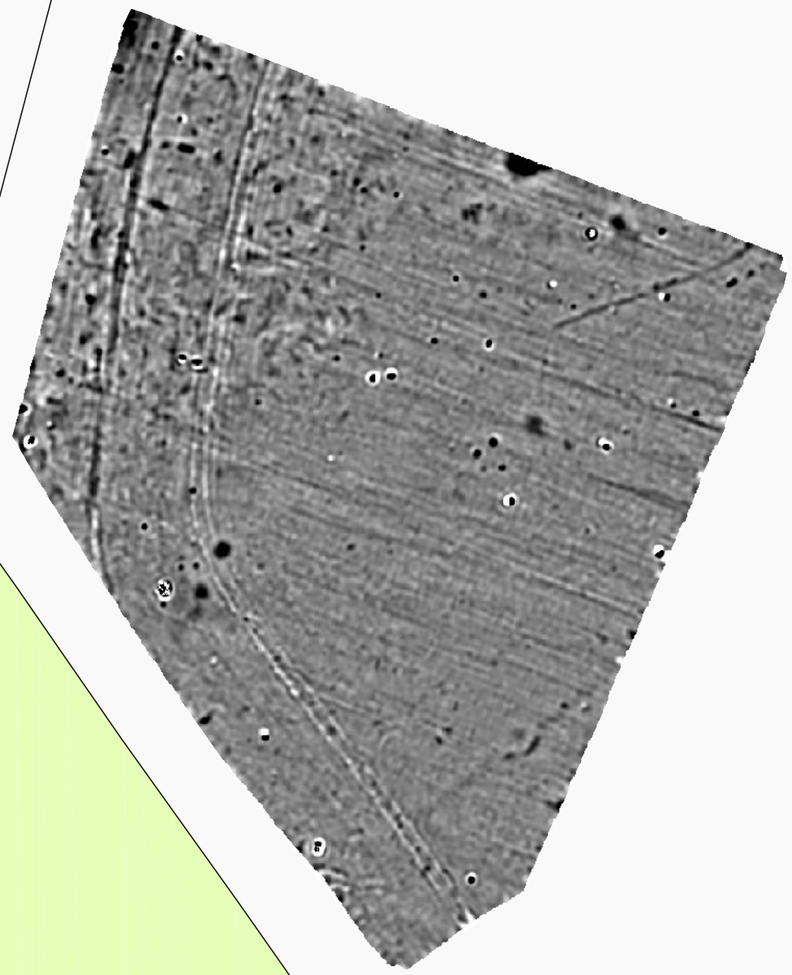
SCALE TRUE AT A3

FIG 02

Archaeological Surveys Ltd

Geophysical Survey
Land north of
Knight's Furlong Plantation
Tarlton
Gloucestershire

Greyscale plot of minimally processed magnetometer data



+5nT

-5nT

-5nT

+5nT

Knight's Furlong
Plantation

Abstraction and interpretation of magnetometer anomalies

Knight's Furlong
Plantation

139m

- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - of agricultural origin
- Discrete positive response - possible pit-like feature
- Variable magnetic response - of natural origin
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

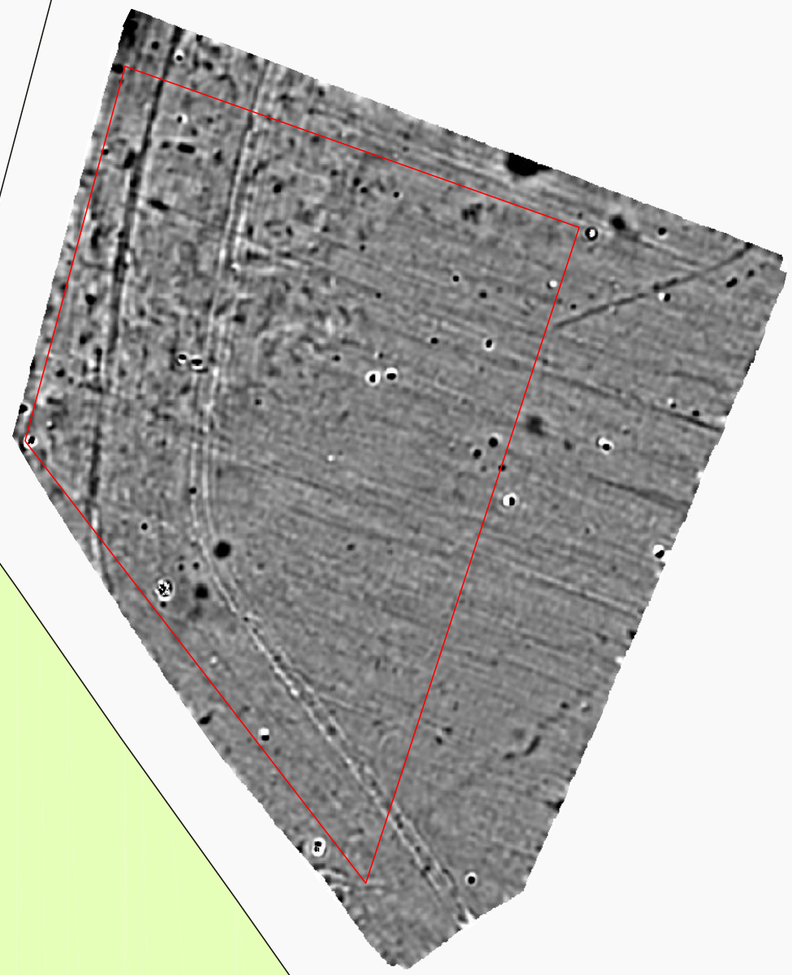
SCALE TRUE AT A3

FIG 03

Archaeological Surveys Ltd

Geophysical Survey
Land north of
Knight's Furlong Plantation
Tarlton
Gloucestershire

Greyscale plot of minimally processed magnetometer data



+5nT

-5nT

-5nT

+5nT

Knight's Furlong
Plantation

Abstraction and interpretation of magnetometer anomalies with development boundary

Positive linear anomaly - possible ditch-like feature

Linear anomaly - of agricultural origin

Discrete positive response - possible pit-like feature

Variable magnetic response - of natural origin

Strong dipolar anomaly - ferrous object

Development boundary

Knight's Furlong
Plantation

139m

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 04