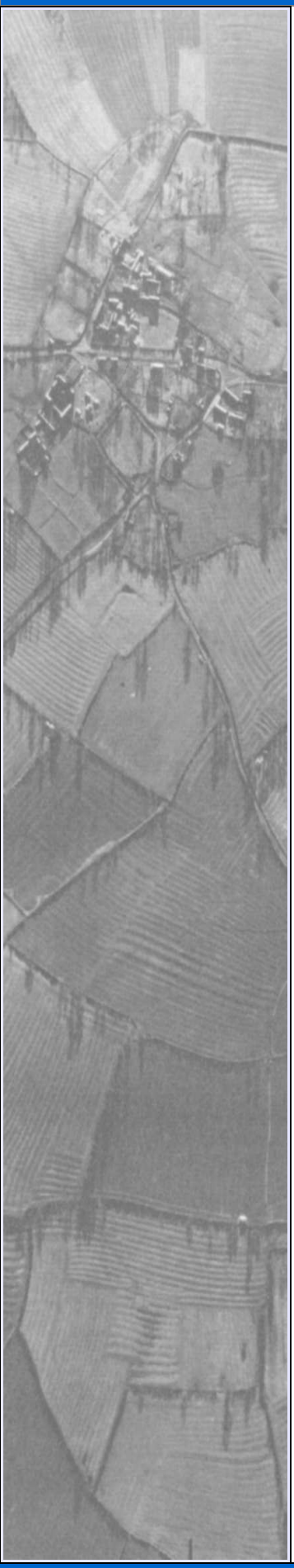

Land at Pack Hill
Wanborough
Swindon

MAGNETOMETER SURVEY REPORT

for

Swindon Borough Council

Kerry Donaldson & David Sabin

August 2016

Ref. no. J682

ARCHAEOLOGICAL SURVEYS LTD

Land at Pack Hill
Wanborough
Swindon

Magnetometer Survey Report

for

Swindon Borough Council

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 date – 9th August 2016
Ordnance Survey Grid Reference – **SU 19790 82695**

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SUMMARY

A detailed magnetometer survey was carried out by Archaeological Surveys Ltd at the request of Swindon Borough Council ahead of a potential purchase of land for planting of trees as part of the Great Western Community Forest at Pack Hill, Wanborough. The results indicate that there are a number of weak, discrete and linear responses, but it is not possible to determine if they relate to features with a natural or anthropogenic origin.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Swindon Borough Council, to undertake a magnetometer survey of an area of land to the south of Pack Hill, Wanborough, Swindon. The site has been outlined by Swindon Borough Council as potential land to purchase for tree planting as part of the Great Western Community Forest. The survey forms part of an archaeological assessment of the site.

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 Pack Hill in Wanborough, Swindon. It is centred on Ordnance Survey National Grid Reference (OS NGR) SU 19790 82695, see Figs 01 and 02.

1.3.2 The geophysical survey covers approximately 2.8ha of pasture land, split within six horse paddocks. It is bounded to the north by Pack Hill, to the south by the Liden Brook, agricultural land lies to the west and to the east there is existing Community Forest Woodland.

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 and warm.

1.4 Site history and archaeological potential

1.4.1 The Wiltshire online Historic Environment Record does not list any designated or undesignated heritage assets within the site; however, there are a number recorded within the wider vicinity. This includes an undated earthwork (MWI 16341), located 170m to the south west which was recorded in 2002, but no dating evidence or evidence for its function was found. It also lies 300m east of the Roman road from Cunetio to Durocornovium (MWI16199) and 400m south of a Roman building (MWI74279) and series of enclosures (MWI16354). A number of 19th century farmsteads and outfarms are recorded within 300m and the site appears to have been under agricultural use since at least the 19th century.

1.4.2 Despite the lack of known archaeological features within the site there is always potential for the survey to locate previously unrecorded archaeology should it be present.

1.5 Geology and soils

1.5.1 The underlying geology is mudstone from the Gault Formation (BGS, 2016).

1.5.2 The site lies on the junction of two soils, with Wickham 3 association (typical stagnogley soil) to the west and Denchworth association (pelo-stagnogley) to the east. They both consist of slowly permeable, seasonally waterlogged clayey soils (Soil Survey of England and Wales, 1983).

1.5.3 The underlying geology and soils are frequently associated with low magnetic contrast and low levels of magnetic susceptibility. However, cut features of archaeological potential may be located where human activity has altered the magnetic characteristics of the soil sufficiently. 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 ±10000nT and clipped for display at ±3nT. 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 survey area.

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 2.8ha within six paddocks.

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 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 within 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 NEG 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. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone and subsoil.
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 AS-ABST MAG SERVICE 	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 419790 182695, see Figs 03 & 04.

Anomalies with an uncertain origin

(1) - The survey area contains a number of weak, discrete responses. These appear pit-like in form, but it is not possible to determine if they are of natural or anthropogenic origin.

(2) - A number of weakly positive linear anomalies have been located, primarily within the northern part of the site. They are very indistinct, short and lack a coherent morphology for them to be characterised as cut features.

(3) - A positive linear anomaly extends across the north western corner of the site. This coincides with a very low linear bank within the field, and it is possible that the anomaly relates to a buried pipe, or possibly unmapped field boundary feature.

(4) - Extending across the northern part of the site is a negative linear anomaly. This corresponds to a very shallow linear depression within the field, which may relate to a drainage gully or other agricultural feature.

Anomalies associated with magnetic debris

(5) - In the southern part of the site are zones of strongly magnetic debris which relate to ferrous and other magnetically thermoremnant material, such as brick and tile which has been used for ground consolidation and infill within former channels and springs associated with the Liden Brook that bounds the southern part of the site.

(6) - The entire site contains widespread and numerous strong, discrete, dipolar anomalies which are a response to ferrous and other magnetically thermoremnant objects which have been spread throughout the site during agricultural processes.

Anomalies with a modern origin

(7) - A positive linear anomaly, associated with a zone of magnetic debris, appears to relate to a possible sewer pipe that extends across the eastern part of the site.

4 CONCLUSION

4.1.1 The detailed magnetometer survey has located a number of weakly positive discrete responses and a number of short, very weak and indistinct positive linear anomalies. Their low magnitude and lack of coherent morphology make it difficult to ascertain if they relate to naturally formed or anthropogenic features. A sewer pipe extends across the eastern part of the site and magnetic debris is evident along the south used as ground consolidation and infill adjacent to the Liden Brook.

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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 ±5nT 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:              J682-mag-proc.xcp
Description:           Imported as Composite from: J682-mag.asc
Instrument Type:       Sensys DLMGPS
Units:                 nT
UTM Zone:              30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner:      419714.063371442, 182807.021632581 m
Southeast corner:      419886.263371442, 182564.621632581 m
Collection Method:     Randomised
Sensors:               5
Dummy Value:           32702

Source GPS Points:     1015800

Dimensions
Composite Size (readings):  1148 x 1616
Survey Size (meters):       172 m x 242 m
Grid Size:             172 m x 242 m
X Interval:            0.15 m
Y Interval:            0.15 m

Stats
Max:                   3.32
Min:                   -3.30
Std Dev:               1.00
Mean:                  0.00
Median:                0.00
Composite Area:        4.1741 ha
Surveyed Area:         2.6327 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 -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 printed copy of the report and a PDF copy will be supplied to the Wiltshire Historic Environment Record. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS).

Archive contents:

Geophysical data - path: J682 Pack Hill, Wanborough\Data				
Path and Filename	**Software**	**Description**	**Date**	**Creator**
swroad19\MX\ .prm .dgb .disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	09/08/16 & 11/08/16	D.J.Sabin
J682-mag.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey area in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	22/08/16	K.T.Donaldson
Mag\comps\J682-mag.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	22/08/16	K.T.Donaldson
Mag\comps\J682-mag-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±3nT).	22/08/16	K.T.Donaldson
Graphic data - path: J682 Pack Hill, WanboroughData				
Mag\graphics\ J682-mag-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±3nT.	22/08/16	K.T.Donaldson
Mag\graphics\ J682-mag-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	22/08/16	K.T.Donaldson
CAD data - path: J682 Pack Hill, WanboroughCAD				
J682 version 1.dwg	ProgeCAD 2016	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	22/08/16	K.T.Donaldson
Text data - path: J682 Pack Hill, Wanborough\Documentation				
J682 report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.	22/08/16	K.T.Donaldson

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Archaeological Surveys Ltd

Geophysical Survey
Land at Pack Hill
Wanborough
Swindon

Map of survey area

Survey location

Site centred on OS NGR
SU 19790 82695

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01

Archaeological Surveys Ltd

Geophysical Survey
Land at Pack Hill
Wanborough
Swindon

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

● 419750 182600

SCALE 1:1500

0m 10 20 30 40 50m

SCALE TRUE AT A3

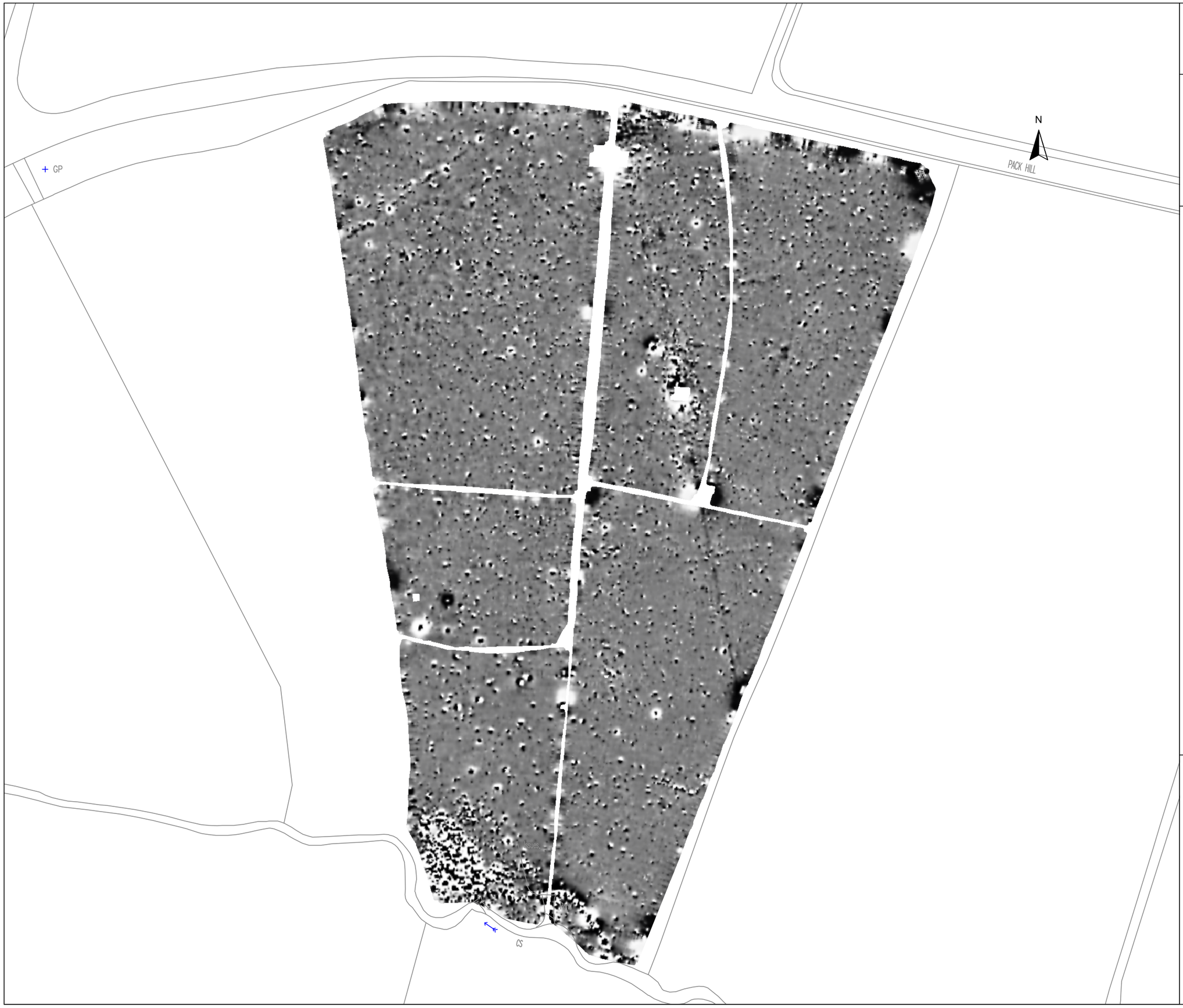
FIG 02

419700 419750 419800 419850 419900

182850 182800 182750 182700 182650 182600 182550

N

Great Moor
Leaze Farm
Pond
GP
PACK HILL
Earthworks
CS



Archaeological Surveys Ltd

Geophysical Survey
Land at Pack Hill
Wanborough
Swindon

Greyscale plot of minimally processed magnetometer data

+3nT

-3nT +3nT

-3nT

SCALE 1:1000

0m 10 20 30 40 50m

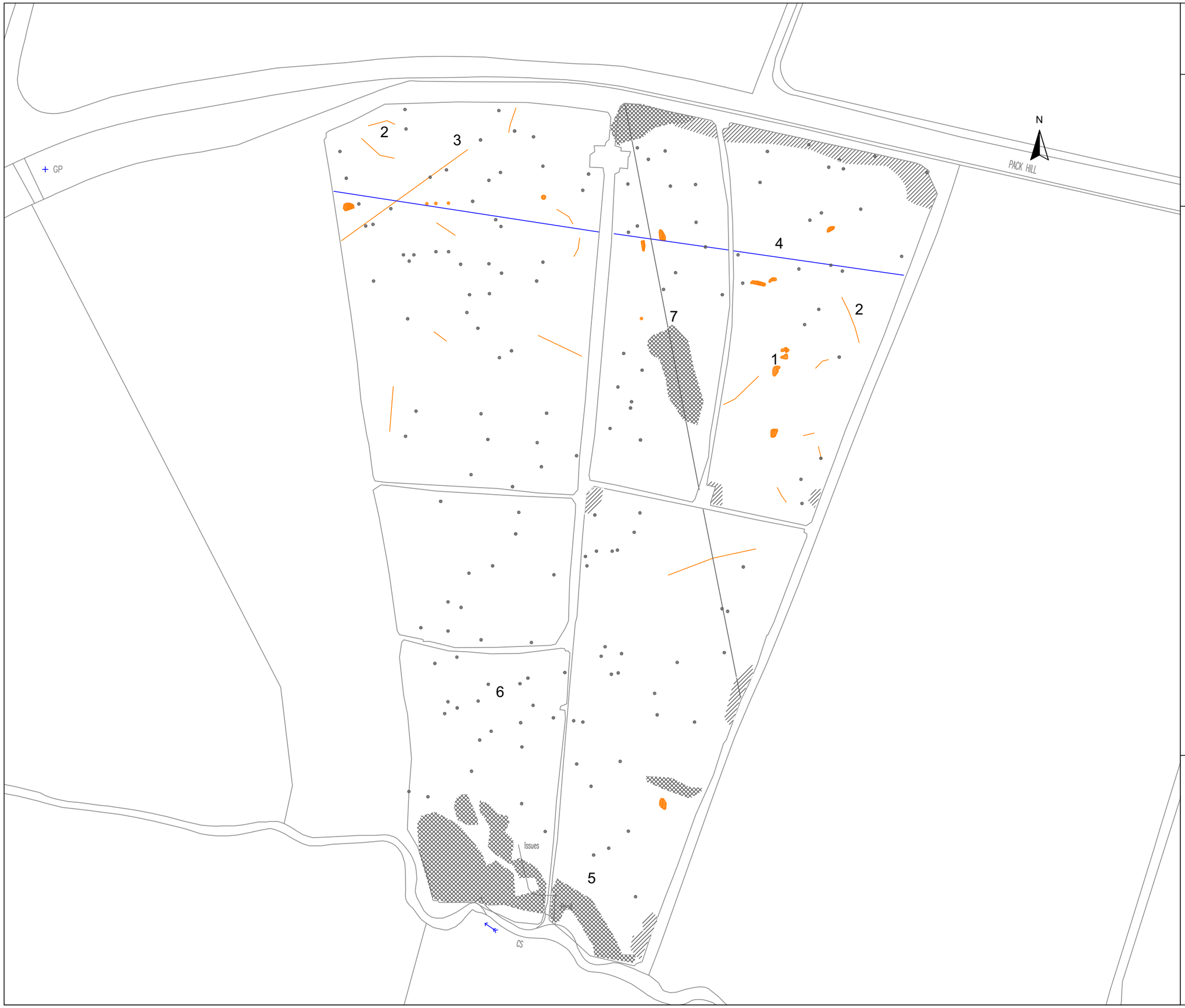
SCALE TRUE AT A3

FIG 03

Archaeological Surveys Ltd

Geophysical Survey
Land at Pack Hill
Wanborough
Swindon

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
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong multiple dipolar linear anomaly - pipeline / cable / service
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 04