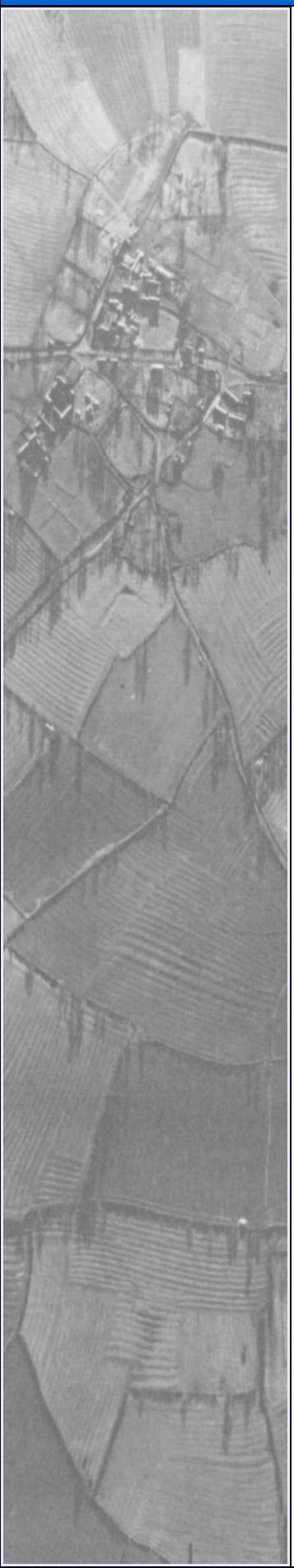

Land at Manor Farm
Castle Cary
Somerset

MAGNETOMETER SURVEY REPORT

for

AC Archaeology Ltd

David Sabin and Kerry Donaldson

July 2014

Ref. no. 554

ARCHAEOLOGICAL SURVEYS LTD

Land at Manor Farm
Castle Cary
Somerset

Magnetometer Survey Report

for

AC Archaeology Ltd

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

Survey date – 2nd July 2014
Ordnance Survey Grid Reference – **ST 64365 31380**

Somerset HER number 32576

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SUMMARY

A detailed magnetometer survey was carried out by Archaeological Surveys Ltd, at the request of AC Archaeology, on land at Manor Farm, to the south of Castle Cary in Somerset. The survey was undertaken over a 2.6ha site which has been outlined for a solar development. The results show a number of positive linear anomalies, some of which may relate to cut, ditch-like features. A number of positive discrete anomalies and an area of magnetically variable responses appear to relate to former quarrying. The site also contains a large number of widespread discrete positive responses which may to relate to naturally formed pit-like features.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by AC Archaeology Ltd to undertake a magnetometer survey of an area of land at Manor Farm, to the south of Castle Cary in Somerset. The site has been outlined for a proposed solar development and the survey forms part of an archaeological assessment of the site. The survey has been issued with Somerset Historic Environment number 32576.

1.2 Survey objectives and techniques

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

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

1.3 Site location, description and survey conditions

1.3.1 The site is located at Manor Farm, on high ground approximately 800m south of Castle Cary in Somerset. It is centred on Ordnance Survey National Grid Reference (OS NGR) ST 64365 31380, see Figures 01 and 02.

1.3.2 The geophysical survey covers approximately 2.6ha within the northern part of a larger pasture field. The area is generally flat though located on a hilltop at approximately 155m ODN.

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 fine.

1.4 Site history and archaeological potential

1.4.1 A Historic Environment Assessment has been carried out by AC Archaeology (2014). It outlines that the site is bounded on its eastern edge by the eastern boundary of the former Castle Cary Park, which is probably a medieval deer park. There are no archaeological sites, findspots or features recorded within the application area; however, it lies on high ground with a prominent position and extensive views and there is potential for the site to contain previously unrecorded features.

1.5 Geology and soils

1.5.1 The underlying geology is inferior oolite (BGS, 2014).

1.5.2 The overlying soil across the site is from the Elmton 2 association and is a brown rendzina. It consists of a shallow, well drained brashy calcareous fine loamy soil over limestone (Soil Survey of England and Wales, 1983).

1.5.3 Magnetometry carried out over similar geology and soil has produced good results. The site is, therefore, considered suitable for magnetic survey. However, inferior oolite can contain naturally formed pits and depressions which can be difficult to distinguish from those with an anthropogenic origin.

2 METHODOLOGY

2.1 Technical synopsis

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

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

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

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

2.2 Equipment configuration, data collection and survey detail

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

2.2.2 Data are collected along a series of parallel survey transects wherever possible. The length of each transect is variable and relates to the size of the survey area and other factors including ground conditions. A visual display allows accurate placing of transects and helps maintain the correct separation between adjacent traverses.

2.3 Data processing and presentation

2.3.1 Magnetic data collected by the MAGNETO®MXPDA cart-based system are initially prepared using SENSYS MAGNETO®DLMGPS software. Georeferenced data are then exported in ASCII format for compensation

(destriping), interpolation and clipping using TerraSurveyor. Greyscale images are also produced using TerraSurveyor.

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

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

- clipping of processed data at ±20 nT to enhance low magnitude anomalies,
- zero median traverse is applied in order to balance readings along each traverse,
- a high pass filter is applied to smooth data and remove slight variations along survey tracks.

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

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

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

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

2.3.8 The raster images are combined with base mapping using ProgeCAD Professional 2014 and AutoCAD LT 2007, creating DWG file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. Quality can be compromised by rotation of graphics in order to allow the data to be orientated with respect to grid north; this is considered acceptable as the survey results are effectively georeferenced allowing relocation of features using GPS, resection method, etc.

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

3 RESULTS

3.1 General assessment of survey results

3.1.1 The detailed magnetic survey was carried out over 2.6ha within the northern part of a single pasture field.

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

3.2 Statement of data quality

3.2.1 Data are considered representative of the magnetic anomalies present within the site. Some very small positional errors are apparent within the dataset although they are not detrimental to the appearance of anomalies. They may relate to increased latency within the RTK GPS system.

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 NEG LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN AS-ABST MAG POS UNCERTAIN AS-ABST MAG NEG 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 	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.
Anomalies associated with quarrying AS-ABST MAG QUARRYING	Naturally formed magnetic anomalies are are caused by localised variability in the magnetic susceptibility of soils, subsoils and other drift or solid geologies. Anomalies may be amorphous, linear or curvilinear and may appear 'fluvial' or discrete; the latter are almost impossible to distinguished from pit-like anomalies with an anthropogenic origin. Fluvial, glacial and periglacial processes may be responsible for their formation within drift material and subsoil. Igneous and metamorphic activity can lead to anomalies within more solid geology.

Table 1: List and description of interpretation categories

3.4 List of anomalies

Area centred on OS NGR 364365 131380, see Figures 03 & 04.

Anomalies with an uncertain origin

(1) – A positive linear anomaly extends eastwards from close to the north western corner of the survey area for approximately 100m, where it then extends in a south easterly direction towards the south eastern edge of the survey area. It has a response of generally between 10-20nT and may relate to a linear ditch with archaeological potential.

(2) – A positive linear anomaly extends westwards from the south eastern corner of the survey area for 167m where it appears to end abruptly. It is narrower and weaker than anomaly (1) at generally 5nT, and although it is possible that it relates to a cut, linear ditch-like feature, a modern origin, such as a pipe trench cannot be ruled out.

(3) – A narrow, positive linear anomaly extends from the northern edge of the survey area in a south westerly direction for 40m. It is possible that it relates to a cut, ditch-like feature.

(4) – A broad, positive linear anomaly crosses along the western edge of the survey area. It is stronger (5-8nT) at the northern and southern ends than in the centre, where it is weaker (1-2nT) and indistinct. It is possible that it relates to a cut feature, or possible former bank.

(5) – A group of short positive linear and possible rectilinear and curvilinear

anomalies are located in the western part of the survey area. Several other similar responses are seen elsewhere within the data. It is not possible to determine if they have a natural or anthropogenic origin.

(6) – Three positive linear and two broad negative responses are located in the south western corner of the survey area. They are oriented north west to south east and appear to extend towards and possibly across anomaly (4). It is possible that they relate to a former boundary feature but this is uncertain.

(7) – The survey area contains a large number of widespread discrete positive anomalies that appear to relate to pit-like features. The weakest are 2nT, the strongest over 30nT, and although it is possible that some have an anthropogenic origin, it is likely that many relate to naturally formed features.

(8) – A negative curvilinear anomaly is located close to the north western corner of the survey area. This type of anomaly may be a response to a rut or cultivation edge.

Anomalies associated with quarrying/ground disturbance

(9) – A magnetically variable anomaly 34m in length and 14m wide at the widest point, tapering to 4m at the western end, has been located. This type of response is generally associated with former quarrying and a very slight depression is evident within the field.

(10) – A sub-circular positive anomaly with dimensions of 5.7m by 4.5m is located 23m to the east of anomaly (9) and may be associated with it.

(11) – A group of positive responses are located 72m east of anomaly (9) and relate to a group of pits, also associated with a slight depression in the ground. They are on the same linear alignment as anomalies (9) and (10) and may also relate to quarry pits.

Anomalies associated with magnetic debris

(12) – A patch of magnetic debris is located close to the south eastern corner of the site. It appears to relate to a zone of magnetically thermoremnant material in the vicinity of a removed electricity pole. Magnetic debris at the north western corner is associated with ground consolidation.

(13) – The site contains numerous and widespread strong, discrete dipolar anomalies which relate to ferrous and other magnetically thermoremnant objects within the topsoil.

Anomalies with a modern origin

(14) – Magnetic disturbance from adjacent ferrous fencing.

4 CONCLUSION

4.1.1 The detailed magnetometer survey located a number of positive linear and discrete anomalies within the survey area. It is possible that several of the linear anomalies relate to cut features, such as linear ditches, although their origin is uncertain.

4.1.2 Several small discrete anomalies and a large area of magnetically variable response were also located within the northern part of the survey area. These appear to relate to former quarrying and very slight depressions in the field are associated with them.

4.1.3 The entire site contains numerous and widespread discrete positive responses. Although these appear to relate to pit-like features, a natural origin is likely.

5 REFERENCES

AC Archaeology, 2014. *Land at Manor Farm, Castle Cary, Somerset, Historic Environment Assessment.* Unpublished typescript document.

British Geological Survey, 2013. *Geology of Britain viewer, 1:50 000 scale [online]* available from http://mapapps.bgs.ac.uk/geologyofbritain/home.html [accessed 7/7/2014].

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

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

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

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

Appendix A – basic principles of magnetic survey

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

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

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

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

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

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

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

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

Appendix B – data processing notes

Clipping

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

Zero Median/Mean Traverse

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

High Pass Filtering

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

Appendix C – survey and data information

COMPOSITE
Filename: J554-mag-proc.xcp
Description: Imported as Composite from: J554-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):
Northwest corner: 364253.311951679, 131465.455215234 m
Southeast corner: 364477.711951679, 131298.805215234 m
Direction of 1st Traverse: 90 deg
Collection Method: Parallel
Sensors: 1
Dummy Value: 32702

Source GPS Points: 929800

Dimensions
Composite Size (readings): 1496 x 1111
Survey Size (meters): 224 m x 167 m
Grid Size: 224 m x 167 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats
Max: 20.00
Min: -20.00
Std Dev: 7.32
Mean: 0.34
Median: 0.01
Composite Area: 3.7396 ha
Surveyed Area: 2.6023 ha

PROGRAM
Name: TerraSurveyor
Version: 3.0.23.0

Processes: 2
1 Base Layer
2 Clip from -20.00 to 20.00 nT

GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse: Threshold: 1.5 SDs
4 Clip from -20.00 to 20.00 nT
5 High pass Uniform (median) filter: Window dia: 300

Appendix D – digital archive

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

Surveys are reported on in hardcopy (recycled paper) using A4 for text and A3 for plots (all plots are scaled for A3). A digital copy of the report in PDF format will be provided to the Somerset Historic Environment Service together with a printed copy of the report. This will also be uploaded to Oasis upon permission of the client.

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

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

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

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

Archaeological Surveys Ltd

Geophysical Survey
Land at Manor Farm
Castle Cary
Somerset

Map of survey area

● Survey location

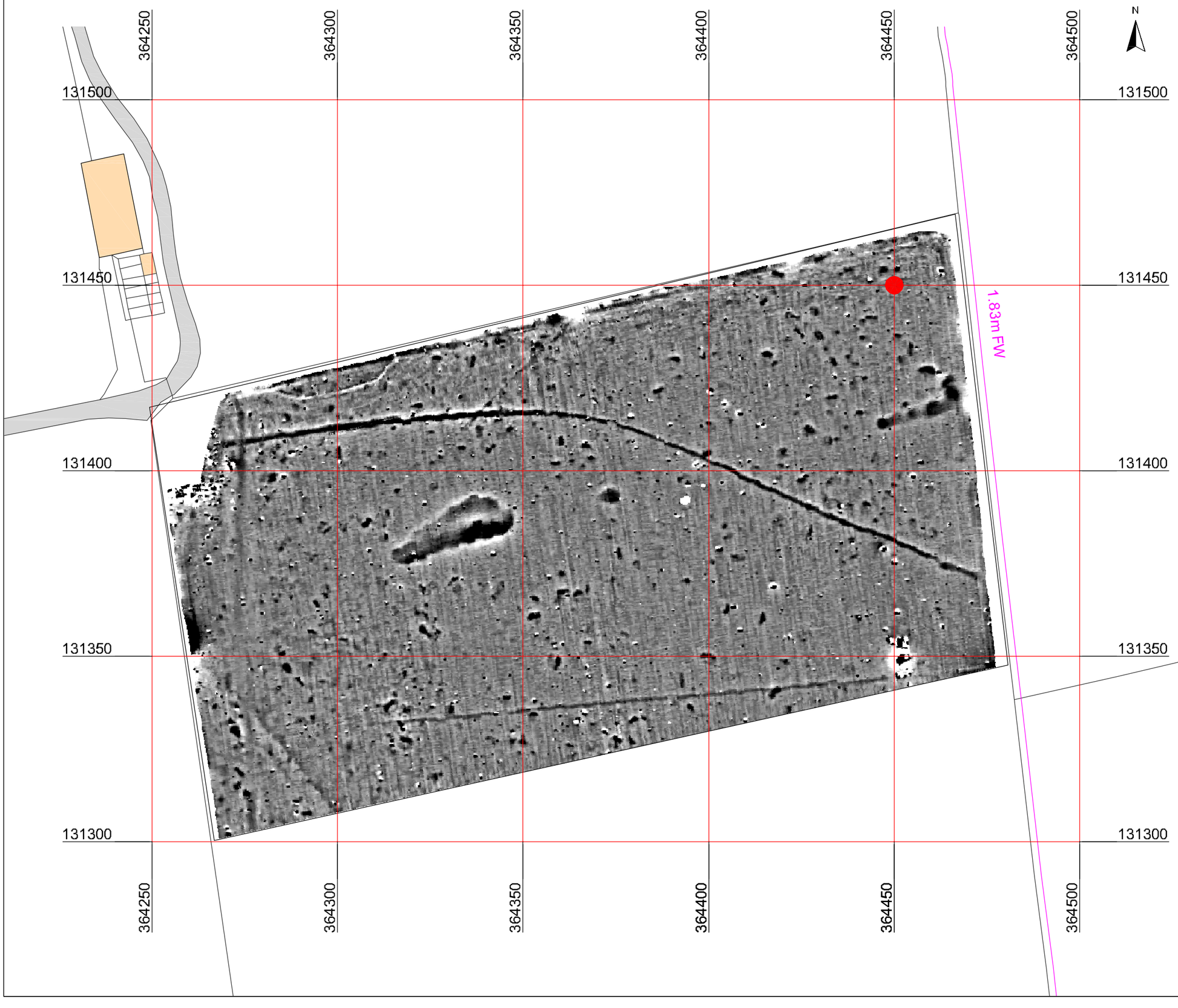
Site centred on OS NGR
ST 64365 31380

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01



Archaeological Surveys Ltd

Geophysical Survey
Land at Manor Farm
Castle Cary
Somerset

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

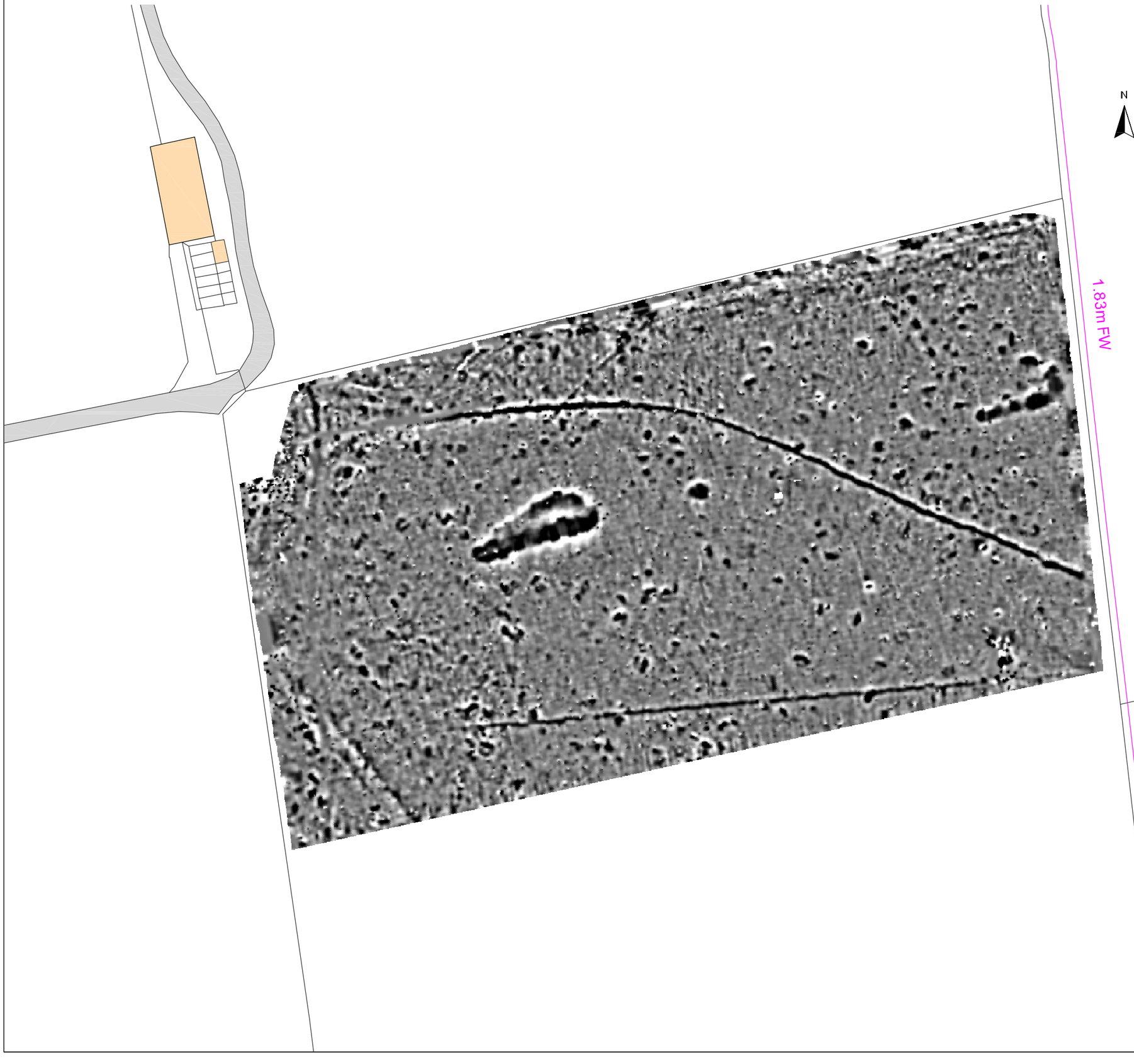
● 364450 131450

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 02



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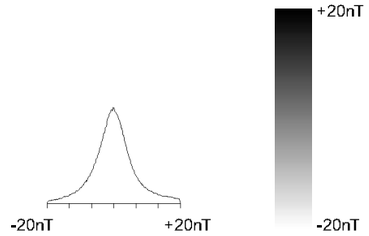
Geophysical Survey
Land at Manor Farm
Castle Cary
Somerset

Greyscale plot of processed magnetometer data



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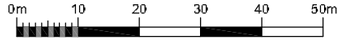


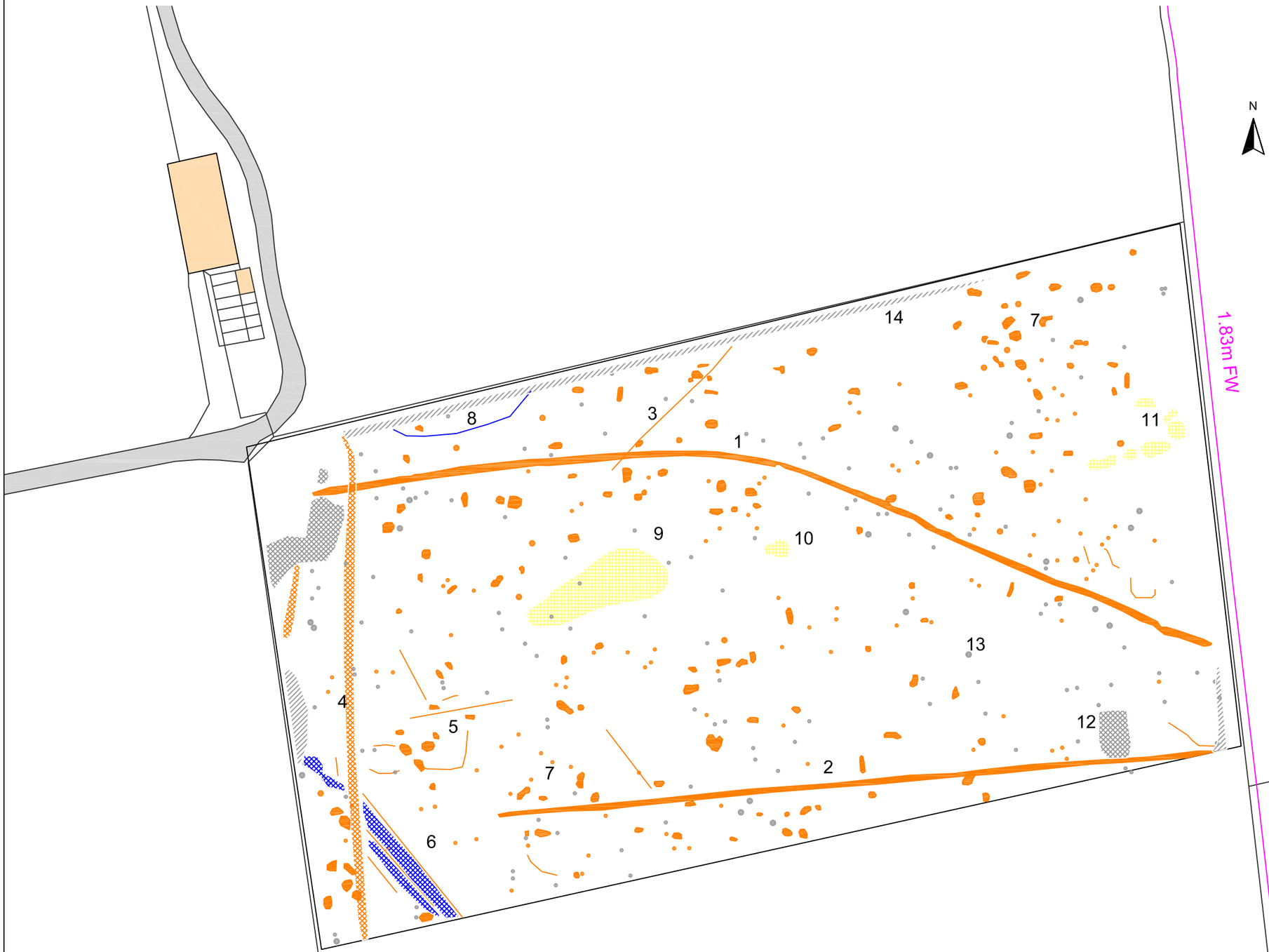
SCALE TRUE AT A3

FIG 03

Archaeological Surveys Ltd

Geophysical Survey
Land at Manor Farm
Castle Cary
Somerset

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
- Negative anomaly - material with low magnetic susceptibility
- Variable magnetic response - possible quarrying
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 04