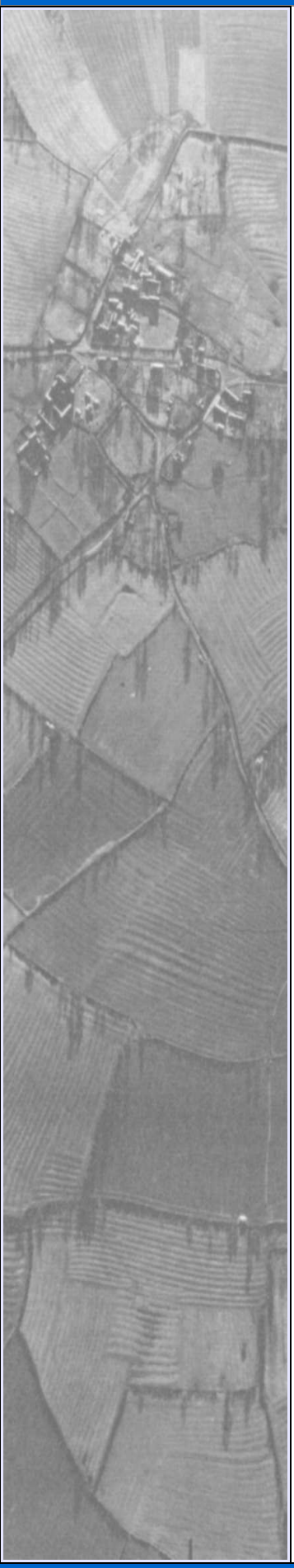

Footpath 5 Rail Bridge
South Marston
Swindon

MAGNETOMETER SURVEY REPORT

for

Swindon Borough Council

Kerry Donaldson & David Sabin

August 2016

Ref. no. J677

ARCHAEOLOGICAL SURVEYS LTD

Footpath 5 Rail Bridge
South Marston
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 – 3rd August 2016
Ordnance Survey Grid Reference – **SU 19410 86840**

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SUMMARY

A geophysical survey, comprising detailed magnetometry, was undertaken by Archaeological Surveys Ltd at the request of Swindon Borough Council within an area of land at Marston Farm, South Marston, Swindon. The site contains Footpath 5 and a new rail footbridge is to be constructed over the railway line to replace the current level crossing. The results of the survey demonstrate that the site contains a number of linear ditches, enclosures and pits which are similar to others located to the south of the A420 and which relate to Roman settlement features. Away from the main core of features in the western and southern parts of the site, the responses appear weaker and more fragmented. It is possible that they relate to further archaeological features but the weak and poorly defined response, coupled with magnetic disturbance from the railway in the northern part of the site and widespread magnetic debris, prevents confident interpretation.

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 containing Footpath 5 at Marston Farm, South Marston, Swindon. The footpath currently crosses the main railway line with a level crossing, and the council aims to replace it with a footbridge.

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 at Marston Farm, South Marston, Swindon. It is centred on Ordnance Survey National Grid Reference (OS NGR) SU 19410 86840, see Figs 01 and 02.

1.3.2 The geophysical survey covers approximately 1.25ha within a single pasture field. It is bounded to the north by the railway line, to the south by the A420, with Marston Farm and the police headquarters to the west and other rough pasture to the 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 The site has been subject to a previous geophysical survey by Archaeological Services University of Durham (ASUD) in 2008. The results show a number of positive magnetic anomalies which were interpreted as possible pits, gullies and ditches. Further geophysical surveys immediately to the north of the railway line show widespread areas containing complexes of ditches, enclosures, trackways, pits and areas of burning indicative of prehistoric and/or Romano-British settlements. Within land immediately to the south of the A420, further archaeological investigations found evidence for an extensive multi-phased Romano-British settlement with a number of enclosures, pits, post holes, gullies and ditches and a large amount of Roman pottery, with tile, slag and possible masonry structures being identified. The range of features tended to indicate a change to linear ditches indicative of field boundaries or paddocks towards the southern part of the site (Archaeological Surveys, 2015; ASUD, 2008; Bartlett, 2013 and TVAS, 2014).

1.4.2 The site lies 1km north of the scheduled area of Wanborough Roman town, identified as *Durocornovium,* situated either side of Ermin Street, with a number of other Roman and Iron Age sites identified through geophysical survey and evaluation within the wider landscape.

1.4.3 There is a very high potential that the geophysical survey will locate anomalies relating to archaeological features within the site.

1.5 Geology and soils

1.5.1 The underlying geology is mudstone from the Ampthill Clay and Kimmeridge Clay Formations (BGS, 2016).

1.5.2 The overlying soil across the site is from the Denchworth association and is a pelo-stagnogley soil. It consists of a slowly permeable, seasonally waterlogged, clayey soil (Soil Survey of England and Wales, 1983).

1.5.3 The site is considered suitable for magnetic survey. Magnetometry carried out over similar geology and soil has produced good results where there is evidence for long term occupation and/or industrial activity. Away from the main areas of activity, cut features may contain material with less magnetic contrast.

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 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 ±5nT. 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.

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 within a single pasture field covering approximately 1.25ha.

3.1.2 Magnetic anomalies located can be generally classified as positive responses of archaeological potential, areas of magnetic disturbance, strong discrete dipolar anomalies relating to ferrous objects and strong multiple dipolar linear anomalies relating to buried services or pipelines.

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. A zone of magnetic disturbance was located at the northern end of the site adjacent to the railway line.

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 archaeological potential AS-ABST MAG POS LINEAR ARCHAEOLOGY AS-ABST MAG POS DISCRETE ARCHAEOLOGY AS-ABST MAG POS ENCLOSURE DITCH 	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as pits, ring ditches, enclosures, etc..
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	Magnetic debris often appears as areas containing many small

AS-ABST MAG STRONG DIPOLAR 	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. 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 419410 186840, see Figs 03 & 04.

Anomalies of archaeological potential

(1) - The south western part of the site contains a number of positive linear, rectilinear and curvilinear anomalies that relate to linear ditches and enclosures. They have a similar orientation as other linear and rectilinear features located immediately south of the A420 and identified through previous geophysical surveys.

(2) - The enclosures are associated with further fragmented positive linear anomalies and discrete responses, but many are indistinct through truncation and obscured by widespread magnetic debris (not abstracted).

(3) - A group of positive linear, rectilinear and discrete responses appear to have some associated negative response. The anomalies are not clearly defined; however, it is possible that they are associated with former structural remains, although their date and function is uncertain.

Anomalies with an uncertain origin

(4) - Away from the main focus of archaeological activity are a number of short positive and discrete positive responses. Due to their lack of clarity and fragmented form they are of uncertain origin, but it is possible that they relate to further cut features.

(5) - A weakly positive and negative linear anomaly extend across the northern part of the survey area. They are parallel with the northern and southern field boundaries and also relate to a shallow linear depression within the ground surface.

It is possible that they relate to a former field boundary, although none has been mapped in this position.

(6) - A number of positive linear anomalies are parallel (5) and although the eastern part of the field does contain shallow linear depressions possibly relating to agricultural activity, they are not located in the same position as the positive linear anomalies.

(7) - Weakly positive linear anomalies are located in the northern part of the site. This area appears to have less activity; however, magnetic disturbance from fencing, the railway line and passing trains may have obscured weaker features.

Anomalies associated with magnetic debris

(8) - The site contains numerous strong, discrete, dipolar anomalies and magnetic debris. Although it is possible that some of the responses, such as around (3), may be archaeological in origin, it is likely that most of it relates to material spread through the agricultural activity.

Anomalies with a modern origin

(9) - Adjacent to the western edge of the site is a strong, multiple dipolar, linear anomaly which relates to a buried service.

4 CONCLUSION

4.1.1 The detailed magnetometer survey located a number of linear ditches, enclosures and pits of archaeological potential within in the site. Some of the anomalies may be associated with structural remains, although there is some uncertainty. The enclosures are consistent in response and orientation with similar Romano-British features located through previous geophysical survey some 50m-200m to the south of the site and the A420.

4.1.2 Beyond the main focus of enclosures, pits and ditches are a number of indistinct positive linear and discrete responses. They are weak and poorly defined; however, it is possible that they relate to further cut features with archaeological potential.

4.1.3 Several linear depressions within the field do not appear to correlate with anomalies of archaeological potential and are considered likely to relate to former agricultural activity.

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TVAS, 2014. *The Hub, Marston Farm, Stratton St Margaret, Swindon, Wiltshire. An Archaeological Evaluation for Gleeson Strategic Land.* Thames Valley Archaeological Services. Unpublished typescript document.

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

Minimally processed data

COMPOSITE
Filename: J677-mag-proc.xcp
Description: Imported as Composite from: J677-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y): OSGB36
Northwest corner: 419342.193518861, 186925.996314909 m
Southeast corner: 419498.643518861, 186773.746314909 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702

Source GPS Points: 400400

Dimensions
Composite Size (readings): 1043 x 1015
Survey Size (meters): 156 m x 152 m
Grid Size: 156 m x 152 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats
Max: 5.53
Min: -5.50
Std Dev: 2.04
Mean: 0.11
Median: 0.01
Composite Area: 2.382 ha
Surveyed Area: 1.2432 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 -5.00 to 5.00 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: J677 South Marston Rail Bridge\Data				
Path and Filename	**Software**	**Description**	**Date**	**Creator**
smarstpath1\MX\ .prm .dgb .disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	03/08/16	D.J.Sabin
smarstpath1\MX\J677-mag.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey area in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	08/08/16	K.T.Donaldson
Mag\comps\J677-mag.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	08/08/16	K.T.Donaldson
Mag\comps\J677-mag-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±5nT).	08/08/16	K.T.Donaldson
Graphic data - path: J677 South Marston Rail Bridge\Data				
Mag\graphics\ J677-mag-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±5nT.	08/08/16	K.T.Donaldson
Mag\graphics\ J677-mag-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	08/08/16	K.T.Donaldson
CAD data - path: J677 South Marston Rail Bridge\CAD				
J677 version 1.dwg	ProgeCAD 2016	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	29/07/16	K.T.Donaldson
Text data - path: J677 South Marston Rail Bridge\Documentation				
J677 report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.	18/08/16	K.T.Donaldson

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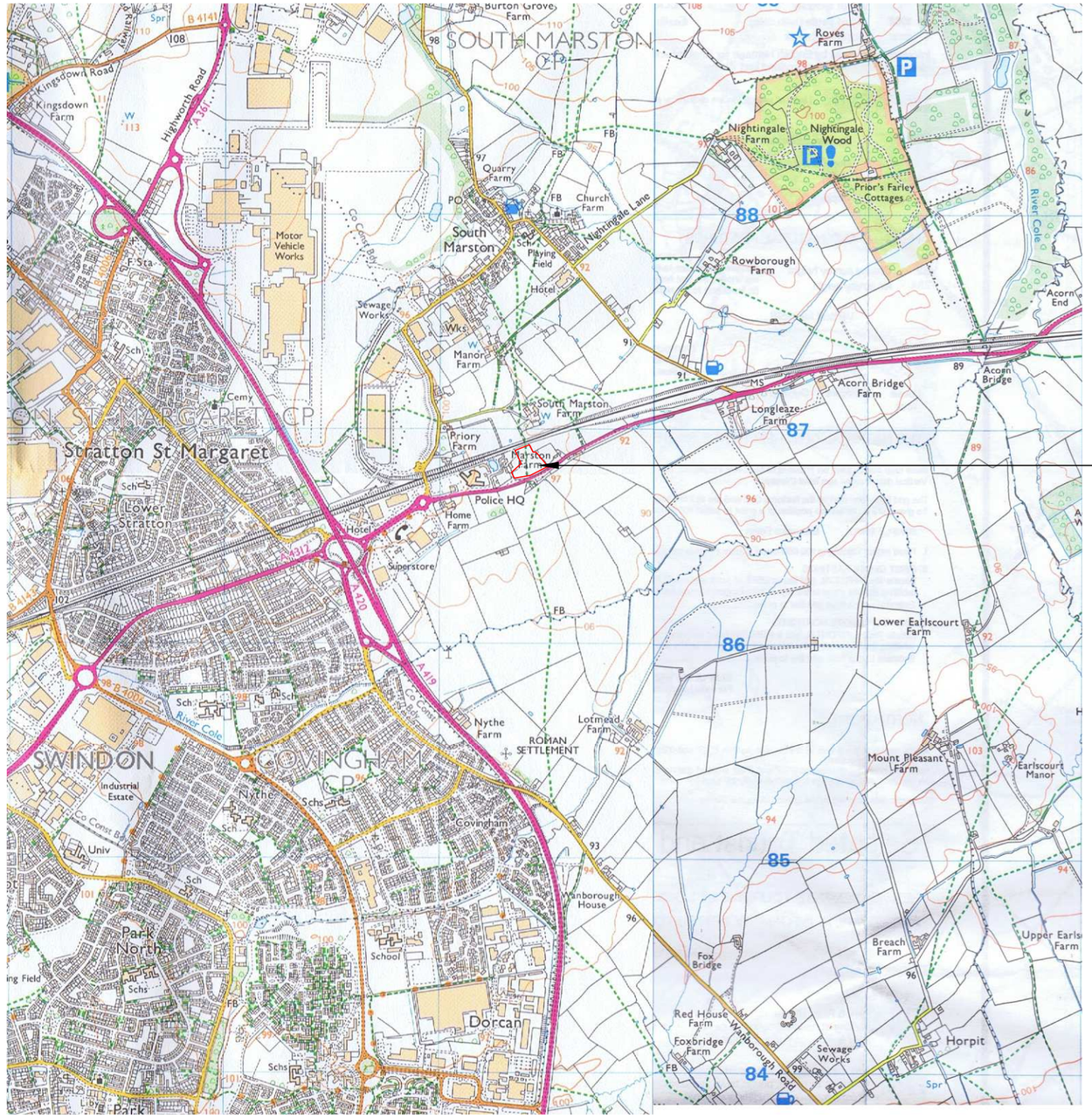


Archaeological Surveys Ltd

Geophysical Survey
Footpath 5 Rail Bridge
South Marston
Swindon

Map of survey area

● Survey location

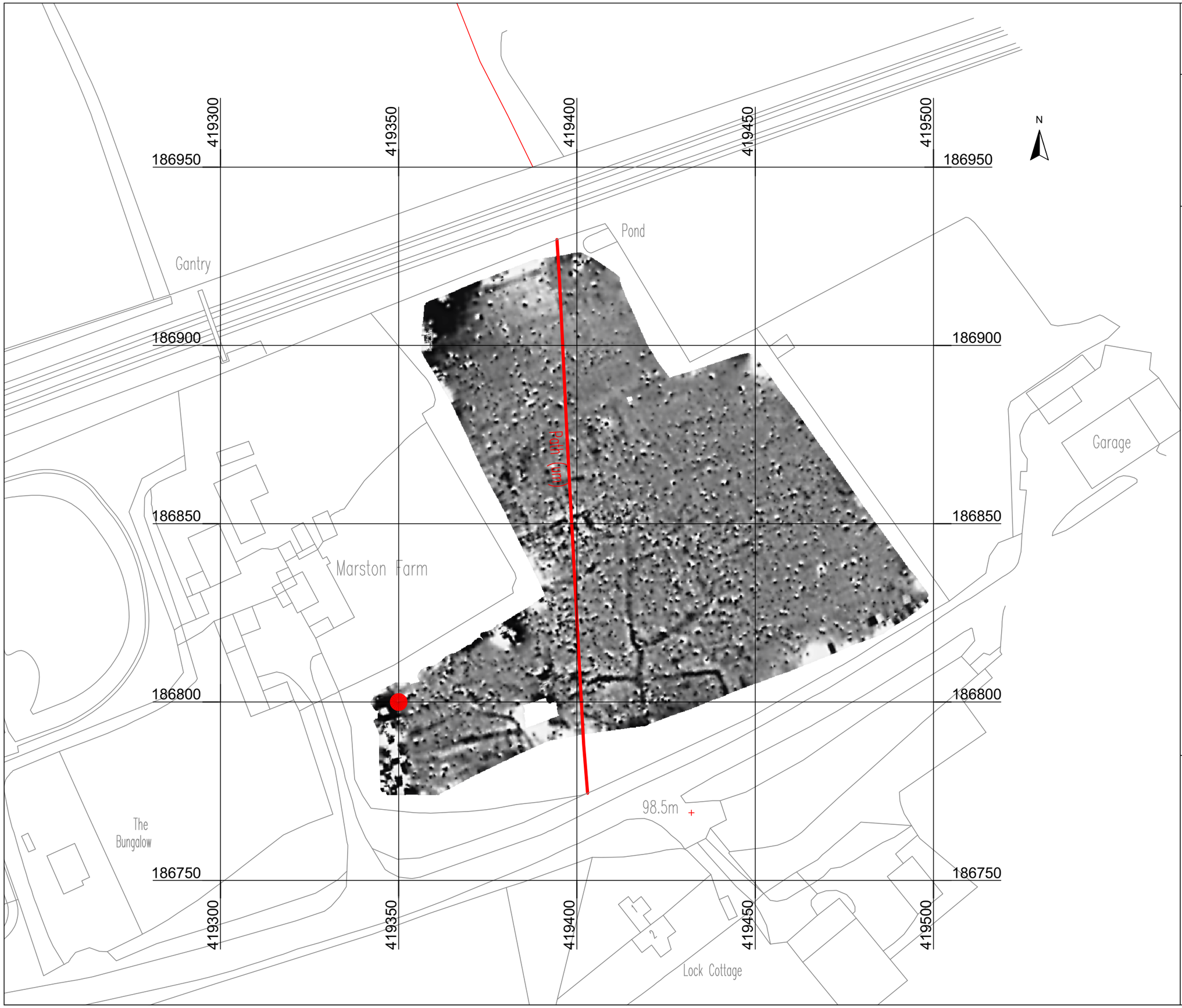
Site centred on OS NGR
SU 19410 86840

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01



Archaeological Surveys Ltd

Geophysical Survey
Footpath 5 Rail Bridge
South Marston
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

● 419350 186800

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 02

Archaeological Surveys Ltd

Geophysical Survey
Footpath 5 Rail Bridge
South Marston
Swindon

Greyscale plot of minimally processed magnetometer data

+5nT

-5nT +5nT

-5nT

N

Gantry

Pond

Garage

Marston Farm

The Bungalow

98.5m

Lock Cottage

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 03

Archaeological Surveys Ltd

Geophysical Survey
Footpath 5 Rail Bridge
South Marston
Swindon

Abstraction and interpretation of magnetometer anomalies

- Positive linear anomaly - cut feature of archaeological potential
- Positive rectilinear anomaly - enclosure ditch
- Positive linear anomaly - possible ditch-like feature
- Negative linear anomaly - material of low magnetic susceptibility
- Discrete positive response - cut feature of archaeological potential
- Discrete positive response - possible pit-like feature
- 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

N

Gantry

Pond

Garage

Marston Farm

The Bungalow

98.5m

Lock Cottage

1 2

1 2 3 4 5 6 7 8 9