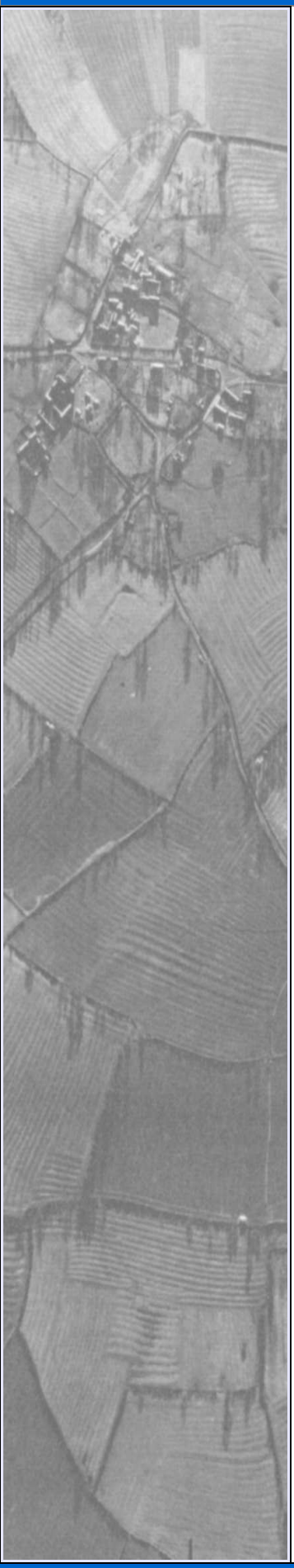

Moreton Morrell College
Sports Hall
Warwickshire

MAGNETOMETER SURVEY REPORT

for

Archaeology Warwickshire

Kerry Donaldson & David Sabin

April 2016

Ref. no. 657

ARCHAEOLOGICAL SURVEYS LTD

Moreton Morrell College
Sports Hall
Warwickshire

Magnetometer Survey Report

for

Archaeology Warwickshire

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 – 13th April 2016
Ordnance Survey Grid Reference – **SP 30550 55375**

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SUMMARY

A magnetometer survey was carried out by Archaeological Surveys Ltd, at the request of Archaeology Warwickshire, across land at Moreton Morrell College in Warwickshire. The site has been outlined for a new sports hall and sports pitch. The area of the proposed sports hall had been subject to modern disturbance with widespread magnetic debris encountered. In the area of the new sports pitch a positive linear anomaly, over 2m in width, appears to relate to a former ditch with a narrower linear response indicating a parallel ditch 2.5m to the north west. There is some evidence for partial truncation by ridge and furrow. A further ditch-like anomaly extends from the parallel pair towards the south east, and it is possible that the group are associated with enclosures extending beyond the limit of the survey. Negative linear and rectilinear anomalies can be seen in the north eastern part of the survey area but their origin is uncertain. Other positive linear and discrete responses of uncertain origin have also been located.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Archaeology Warwickshire to undertake a magnetometer survey of an area of land at Moreton Morrell College, Warwickshire. The site has been outlined for a proposed development of a new sports hall and all weather sports pitch. 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 in the grounds of Moreton Morrell College in Warwickshire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SP 30550 55375, see Figures 01 and 02.

1.3.2 The geophysical survey covers approximately 1.2ha within the grounds of Moreton Morrell College. The site is generally flat although the western part, outlined for the construction of the sports hall, is located on a raised platform or terrace that contains sheds, beds, paths etc. The sports pitch lies within an area of open grass that contains a small number of young trees.

Plate 1: Survey area looking south

1.3.3 The ground conditions across the majority of the site were generally considered to be favourable for the collection of magnetometry data. However, parts of the western side of the area were unsurveyable due to a shed, beds, disturbed ground and high levels of magnetic disturbance. Weather conditions during the survey were fine.

1.4 Site history and archaeological potential

1.4.1 Just to the north west of the survey area a number of Iron Age and Roman pottery sherds were located during an excavation of a small trench during construction of an experimental Roman pottery kiln (Warwickshire Historic Environment Record MWA 4834). Other Roman pottery sherds, coins and a brooch have been located 600m to the south east (MWA7259). The Fosse Way Roman road is situated 1km to the east, with the Saltway located 500m to the south. The medieval core of Moreton Morrell (MWA9013) is located around Holy Cross Church (MWA1181), 480m to the north east. The site also lies to the north and west of an area containing surviving ridge and furrow (MWA19559) within the grounds of Moreton Hall, constructed and landscaped in 1906/07 (MWA8578). The area was also utilised as a military camp during

the Second World War, including over 40 buildings, sports pitches and a firing range (MWA19333).

1.4.2 The location of Iron Age and Roman pottery immediately to the north of the site may indicate that there are some associated features. It is also possible that there will be some disturbance from the wartime military camp and the modern use of the site.

1.5 Geology and soils

1.5.1 The underlying geology is limestone from the Langport Member (Lower Lias) (BGS, 2015).

1.5.2 The overlying soil across the site is from the Evesham 2 association and is a typical calcareous pelosol. It consists of a slowly permeable, calcareous clayey soil (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.

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 ±8nT. 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 over a total of 1.2ha, mainly in the open college grounds.

3.1.2 Magnetic anomalies located can be generally classified as positive linear responses of archaeological potential, positive and negative linear anomalies of an uncertain origin, linear anomalies of an agricultural 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.

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. Widespread magnetic debris has the potential to obscure weak anomalies of archaeological potential.

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	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 with an agricultural origin AS-ABST MAG RIDGE AND FURROW	The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries. Where the response is broad, former ridge and furrow is likely; narrow response is often related to modern ploughing.
Anomalies associated with magnetic debris AS-ABST MAG DEBRIS AS-ABST MAG STRONG DIPOLAR	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. It often occurs where there has been dumping or ground make-up and is related to magnetically thermoremnant materials such as brick or tile or other small fragments of ferrous material. This type of response is occasionally associated with kilns, furnace structures, or hearths and may therefore be archaeologically significant. It is also possible that the response may be caused by natural material such as certain gravels and fragments of igneous or metamorphic rock. Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.
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 430550 255375, See Fig 03.

Anomalies of archaeological potential

(1) - A positive linear anomaly over 2m in width extends across the north-western corner of the main survey area. It has a moderately strong response of 4-11nT, indicating that it relates to a linear ditch-like feature with a magnetically enhanced fill. It appears to be associated with a narrower linear ditch running parallel 2.5m to the north-west and may have been truncated by ridge and furrow (8).

(2) - A positive linear anomaly extends towards anomaly (1). It is on a different orientation to the ridge and furrow (8) and may form a rectilinear feature at the eastern end with anomaly (5).

Anomalies with an uncertain origin

(3) - Negative linear and rectilinear anomalies are located in the north-eastern part of the survey area. Although a negative linear anomaly can be associated with a buried pipe, this appears to partly form a rectilinear feature, and is also parallel with anomaly (2) to the south. The archaeological potential of the anomalies should, therefore, be considered.

(4) - A number of weakly positive linear anomalies extend across the centre of the site and are oriented parallel with the western edge. It is not clear if they relate to cut features or agricultural features crossing the ridge and furrow (8).

(5) - Weakly positive linear anomalies, oriented north-east to south-west can be seen in the eastern part of the survey area. One may be associated with anomaly (2).

(6) - The survey area contains a number of weakly positive linear anomalies. They are generally short, weak and poorly defined and although it is possible that they relate to cut features, their date and function is not certain.

(7) - The survey area contains a number of discrete positive responses. It is not possible to determine if they relate to pit-like features with a natural or anthropogenic origin.

Anomalies with an agricultural origin

(8) - A series of parallel linear anomalies cross the site on a north-west to south-east orientation. It appears that the positive responses (abstracted) relate to the ridges and the negative responses to the furrows and these may have truncated anomaly (1).

Anomalies associated with magnetic debris

(9) - Towards the south eastern part of the site is a linear zone containing patches of strongly magnetic debris with strongly dipolar discrete responses. It is possible that they are associated with a linear group of trees, removed during the 20th century, or dumped material. However the response may indicate an association with industrial activity.

(10) - In the northern part of the survey area are a number of patches of magnetic debris. This is likely to relate to modern bonfires.

(11) - The western smaller area contains widespread very strongly magnetic debris. This area has been subject to modern disturbance and ground make-up.

(12) - The survey area contains widespread and numerous strong, discrete, dipolar anomalies. They generally indicate modern dumped material.

Anomalies with a modern origin

(13) - Extending along the north-eastern corner of the survey area is a buried service.

4 CONCLUSION

4.1.1 The magnetometer survey indicates the presence of a linear ditch in the north-western part of the survey area. There is evidence for a narrower parallel ditch approximately 2.5m to the north-west, and it is possible that there has been partial truncation by ridge and furrow. An associated linear anomaly appears almost perpendicular and extends towards the south-east. This group of anomalies may relate to enclosures extending beyond the survey area.

4.1.2 In the north-eastern part of the site are negative linear and rectilinear anomalies. This type of response would indicate a response to material with a lower magnetically susceptibility than the surrounding soil such as stone, clay subsoil or some types of service (plastic, concrete, etc.).

4.1.3 Other positive linear and discrete responses can also be seen within the site. It is not clear if some relate to agricultural activity crossing the ridge and furrow. Widespread magnetic debris obscures some of the weaker anomalies. The material is likely to relate to burning, dumping and ground make-up. A linear zone of debris is located in the vicinity of a former line of trees and may be associated with fencing or material used to backfill holes; however, their origin cannot be confidently determined.

5 REFERENCES

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British Geological Survey, 2016. *Geology of Britain viewer, 1:50 000 scale [online]* available from http://mapapps.bgs.ac.uk/geologyofbritain/home.html [accessed 14/4/2016].

Chartered Institute for Archaeologists, 2014. *Standard and Guidance for archaeological geophysical survey*. IfA, University of Reading.

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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 ±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:               J657-mag-proc.xcp
Description:            Imported as Composite from: J657-mag.asc
Instrument Type:        Sensys DLMGPS
Units:                  nT
UTM Zone:               30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner:       430482.413415995, 255444.820091857 m
Southeast corner:       430615.013415995, 255306.340091857 m
Collection Method:      Randomised
Sensors:                5
Dummy Value:            32702

Source GPS Points:      310100

Dimensions
Composite Size (readings):  1105 x 1154
Survey Size (meters):       133 m x 138 m
Grid Size:              133 m x 138 m
X Interval:             0.12 m
Y Interval:             0.12 m

Stats
Max:                    8.00
Min:                    -8.00
Std Dev:                3.88
Mean:                   -0.10
Median:                 0.03
Composite Area:         1.8362 ha
Surveyed Area:          1.1549 ha

PROGRAM
Name:                   TerraSurveyor
Version:                3.0.23.0

Processes:  2
 1  Base Layer
 2  Clip from -8.00 to 8.00 nT

GPS based Proce4
 1  Base Layer.
 2  Unit Conversion Layer (Lat/Long to OSGB36).
 3  DeStripe Median Traverse:
 4  Clip from -10.00 to 10.00 nT
```

Appendix D – digital archive

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

Three printed copies of the report and a PDF copy will be supplied to the Warwickshire Historic Environment Record. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS). A summary of the survey will also be supplied to *West Midlands Archaeology.*

Archive contents:

Geophysical data - path: J657 Moreton Morrell\Data				
Path and Filename	**Software**	**Description**	**Date**	**Creator**
moretonmorr1\MX\ .prm .dgb .disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	13/04/16	D.J.Sabin
moretonmorr1\MX\J657-mag.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey Area 1 in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	14/04/16	K.T.Donaldson
Mag\comps\J657-mag.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	14/04/16	K.T.Donaldson
Mag\comps\J657-mag-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±3nT).	14/04/16	K.T.Donaldson
Graphic data - path: J657 Moreton Morrell \Data				
Mag\graphics\ J657-mag-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±3nT.	14/04/16	K.T.Donaldson
Mag\graphics\ J657-mag-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	14/04/16	K.T.Donaldson
CAD data - path: J657 Moreton Morrell\CAD				
J657 version 1.dwg	ProgeCAD 2016	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	08/04/16	K.T.Donaldson
Text data - path: J657 Moreton Morrell\Documentation				
J657 report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.	12/04/16	K.T.Donaldson

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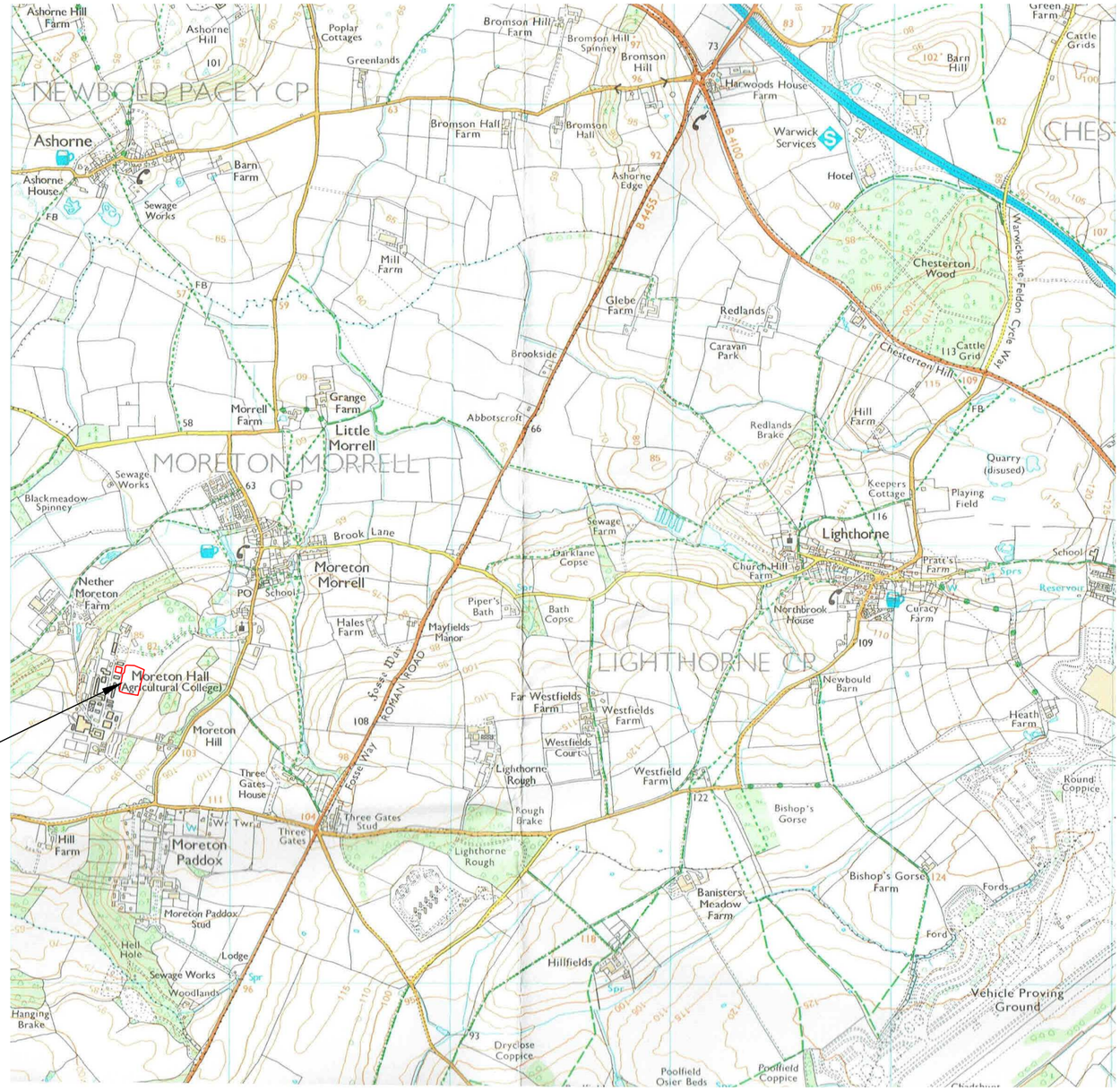


Survey location

N

Archaeological Surveys Ltd

Geophysical Survey
Moreton Morrell College
Sports Hall
Warwickshire

Map of survey area

Survey location

Site centred on OS NGR
SP 30550 55375

SCALE 1:25 000

0m 500m 1000m

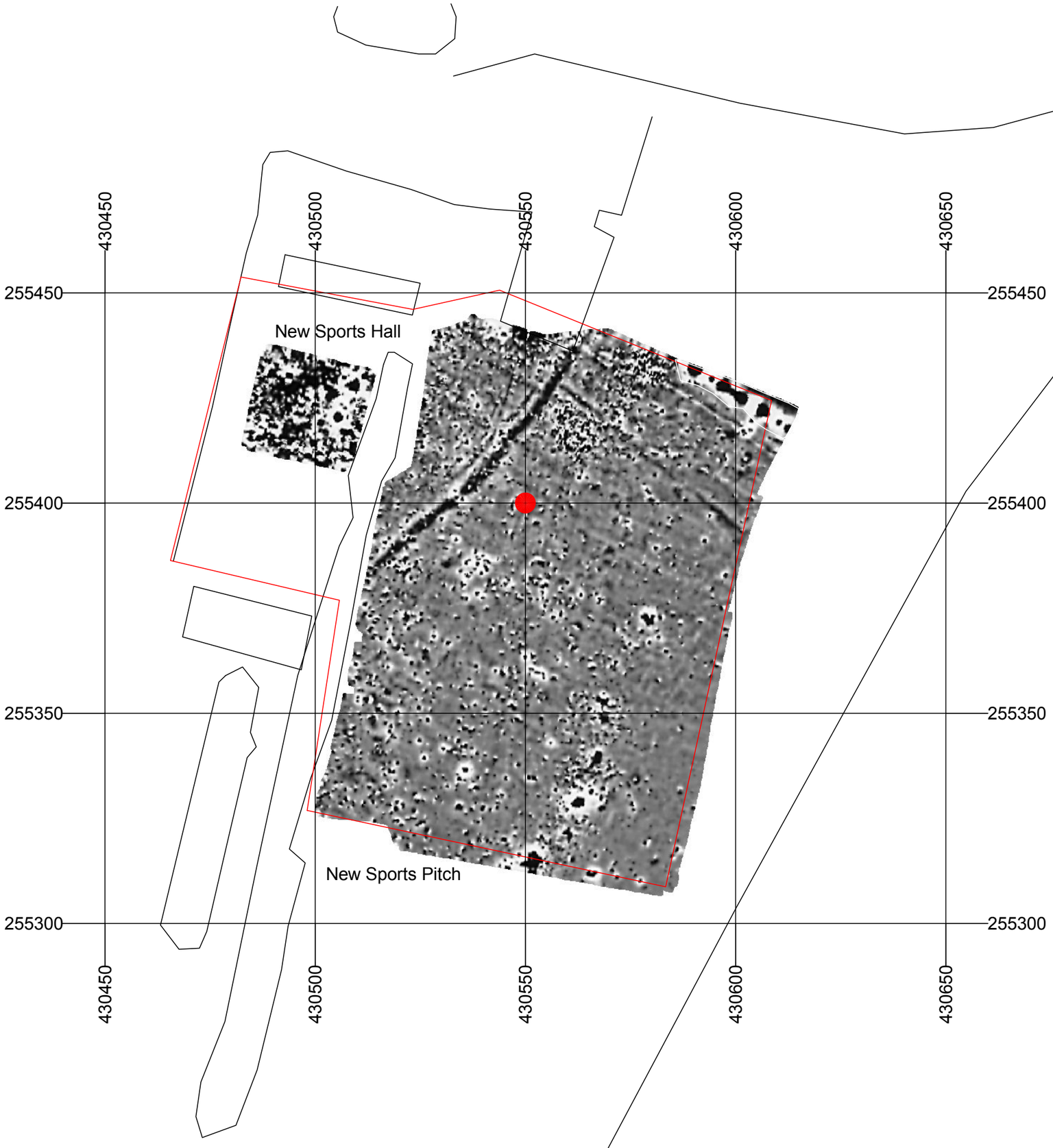
SCALE TRUE AT A3

FIG 01

Archaeological Surveys Ltd

Geophysical Survey
Moreton Morrell College
Sports Hall
Warwickshire

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

430550 255400

Development boundary

SCALE 1:1000

0m 10 20 30 40 50m

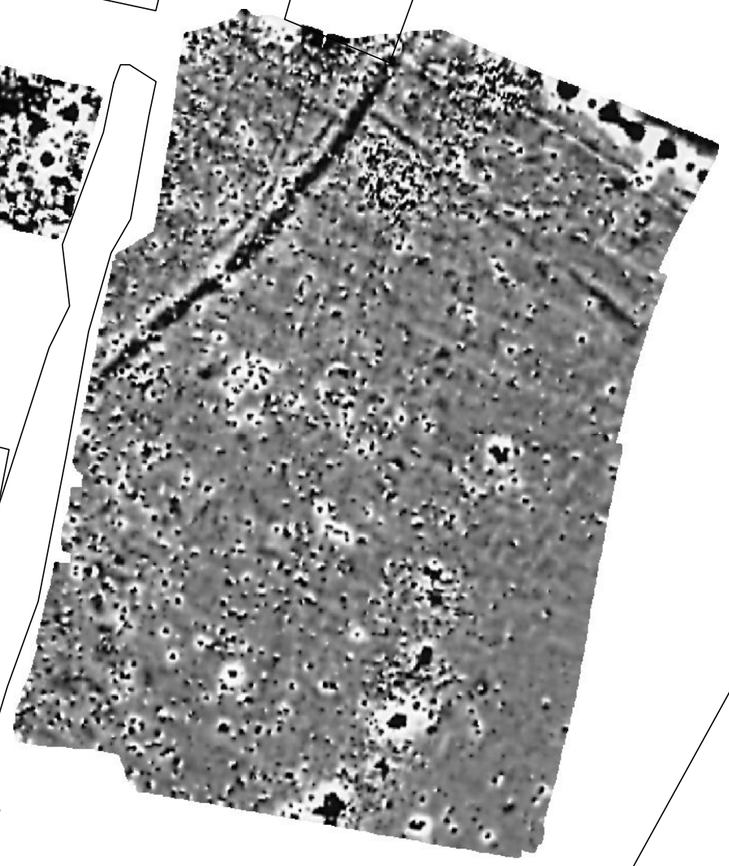
SCALE TRUE AT A3

FIG 02

Archaeological Surveys Ltd

Geophysical Survey
Moreton Morrell College
Sports Hall
Warwickshire

Greyscale plot of processed magnetometer data

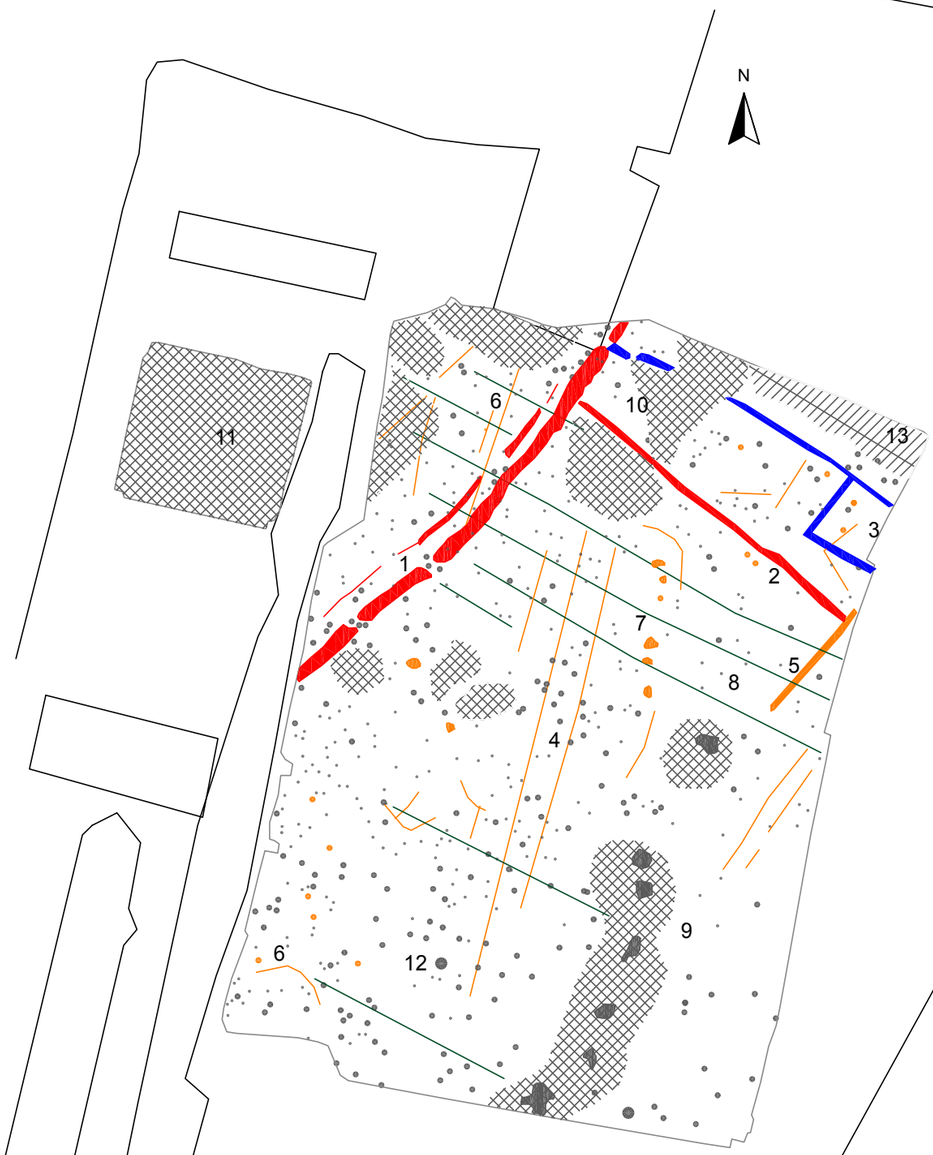


+8nT

-8nT

-8nT +8nT

Abstraction and interpretation of magnetometer anomalies



- Positive linear anomaly - cut feature of archaeological potential
- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - ridge and furrow
- 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 / magnetically thermoremnant object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 03