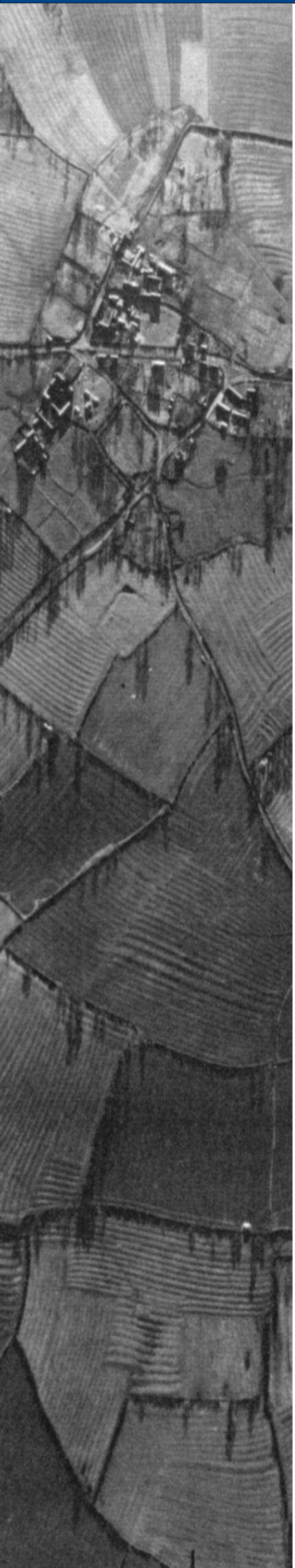

E Site MOD Bicester
Oxfordshire

MAGNETOMETER SURVEY REPORT

for

Entec UK Ltd

David Sabin and Kerry Donaldson

August 2010

Ref. no.332

ARCHAEOLOGICAL SURVEYS LTD

E Site MOD Bicester Oxfordshire

Magnetometer Survey

for

Entec UK Ltd

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

Survey date - **from 16th to 20th August 2010**
Ordnance Survey Grid Reference – **SP 586 209**

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SUMMARY

A geophysical survey was carried out at E Site, MOD Bicester at the request of Entec UK Ltd on behalf of Defence Estates. The site has been identified by Defence Estates for possible residential redevelopment. As the majority of the site has been disturbed by buildings and infrastructure associated with the Graven Hill Depot, three areas were identified by Entec for geophysical survey. Area A (Fields 1-4), on the western edge of the site, lies within 250m of the Scheduled Monument of Alchester Roman town, and comprised four pasture fields suitable for geophysical survey. Area B (Field 5), was also a pasture field, while Area C (Field 6) had been a former sports field. The aim of the survey was to identify if any potential archaeological remains were present within the survey areas, especially with regard to any features extending eastwards from Alchester Roman town.

The detailed magnetometer survey located a number of positive linear anomalies within Field 1, closest to the archaeological remains associated with Alchester and its surrounding environs. These anomalies appear to relate to cut ditch-like features; however, it is not possible to determine if they are directly associated with any known archaeological remains. The remaining survey areas contained widespread magnetic debris and disturbance indicating the presence of buried strongly magnetic objects and material, as well as modern features such as services. With the exception of Field 1, no other anomalies of archaeological potential could be confidently identified although a number of anomalies of uncertain origin were located.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Entec, on behalf of Defence Estates, to undertake a magnetometer survey of an area of land at E Site, MOD Bicester, Oxfordshire. The site has been identified as potentially suitable for residential redevelopment. The survey forms part of an archaeological assessment of the site.

1.1.2 The geophysical survey was carried out according to the requirements of a Brief for geophysical survey issued by the Client (Entec, 2010). The majority of the site is used as a storage depot, containing buildings, hardstanding, roads and railway lines. It has been agreed by Defence Estates and the Oxfordshire County Planning Archaeologist that full pre-determination evaluation is not required, however, a geophysical survey should be targeted within areas suitable for survey, predominantly within the north western section 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. As the site lies some 500m north west of the Roman town of Alchester, it is an objective of the survey to determine if any associated archaeological features extend into the development area.

1.2.2 The methodology is considered an efficient and effective approach to archaeological prospection. The survey and report generally follow the recommendations set out by: English Heritage, 2008, *Geophysical survey in archaeological field evaluation;* Institute for Archaeologists, 2002, *The use of Geophysical Techniques in Archaeological Evaluations*.

1.3 Site location, description and survey conditions

1.3.1 The site is located to the north of Graven Hill near Bicester, Oxfordshire and is centred on Ordnance Survey National Grid Reference (OS NGR) SP 586 209, see Figures 01 and 02.

1.3.2 The geophysical survey covers an area of approximately 13ha split within Areas A, B and C. Area A consists of approximately 10.5ha within Fields 1-4 which contain pasture with thistles and long grass. Area B consists of approximately 2ha within Field 5, which is also a pasture field with thistles , areas of thorn and uneven ground. Area C is approximately 0.5ha and has been labelled Field 6 for the purposes of the survey. The area is a former football pitch, now containing thistles and long grass.

1.3.3 The geophysical survey was hindered and restricted in places by tall grass, thistles and thorn bushes within all the survey areas. Weather conditions during the survey were variable with sunny periods and very heavy rain and high winds.

1.4 Site history and archaeological potential

1.4.1 The Brief issued by Entec (2010) outlines the archaeological potential of the site. There are no known sites or findspots within the site itself, however, the western edge of the site lies within 250m of the Roman Town of Alchester (SAM OX18). This includes the remains of a vexillation fort and town with a cemetery to the east and further Iron Age-Romano British settlement to the north. There is, therefore, some potential for archaeological features, associated with the Roman town of Alchester, to extend to within the site.

1.4.2 In the vicinity there is varying evidence for archaeological sites. It has been proposed that the site of Graven Hill is an Iron Age hill fort although there is no archaeological evidence to support this. The suggested line of the Roman road, Akeman Street, is believed to extend across the north of the site towards the Roman town of Alchester. To the north east of the site are the remains of the Deserted Medieval Village of Wretchwick (SAM 28148).

1.5 Geology and soils

1.5.1 The underlying geology over the majority of the site is Peterborough member of the Oxford Clay formation consisting of mudstone with Kellaways sand member across the northern and western parts of the site (BGS, 2010).

1.5.2 The overlying soils across the majority of the site are from the Denchworth association which are pelo-stagnogley soils. The soils across the western part of the site are from the Wickham 2 association which are typical stagnogley soils. They both consist of slowly permeable, seasonally waterlogged clayey soils (Soil Survey of England and Wales, 1983).

1.5.3 The geology and soils are considered to provide useful conditions for magnetic survey. Previous magnetometry surveys have located archaeological features in very similar conditions.

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 Bartington Grad601-2 gradiometers. The instruments effectively measure a magnetic gradient between two fluxgate sensors mounted vertically 1m apart. Two sets of sensors are mounted on a single frame 1m apart horizontally.

2.2.2 The instruments are extremely sensitive and are able to measure magnetic variation to 0.01nanoTesla (nT), with an effective resolution of 0.03nT. The data are limited to ±100nT when surveying with the highest sensitivity. All readings are saved to an integral data logger for analysis and presentation.

2.2.3 The instruments are operated according to the manufacturer's instructions with consideration given to the local conditions. An adjustment procedure is required, prior to collection of data, in order to balance the sensors and remove the effects of the Earth's magnetic field; further adjustment is required during the survey due to instrument drift often associated with temperature change.

2.2.4 It can be very difficult to obtain optimum balance for the sensors due to localised magnetic vectors that may be associated with large ferrous objects, geological/pedological features, 'magnetic debris' within the topsoil and natural temperature fluctuations. Imperfect balance results in a heading error often visible as striping within the data; this can be effectively removed by software processing and generally has little effect on the data unless extreme.

2.2.5 The Bartington gradiometers undergo regular servicing and calibration by the manufacturer. A current assessment of the instruments is shown in Table 1 below.

Sensor type	Bartington Grad - 01 – 1000
Date of calibration/service	August 2010 (sensors 084, 085) May 2009 (sensors 242, 356)
Bandwidth	12Hz (100nT range) both sensors
Noise	<100pT peak to peak
Adjustable errors	<2nT

Table 1: Bartington fluxgate gradiometer sensor calibration results

The instruments were considered to be in good working order prior to the survey, with no known faults or defects.

2.2.6 Data were collected at 0.25m centres along traverses 1m apart. The survey area was separated into 30m by 30m grids (900m²) giving 3600 recorded measurements per grid. This sampling interval is very effective at locating archaeological features and is the recommended methodology for archaeological prospection (English Heritage, 2008).

2.2.7 The survey grids were set out set out parallel to field boundaries in order to minimise partial grids. This was to the Ordnance Survey OSGB36 datum using a Penmap RTK GPS. The GPS is used in conjunction with Topcon's TopNet service, where positional corrections are sent via a mobile telephone link. Positional accuracy of around 10 – 20mm is possible using the system.

The instrument is regularly checked against the ETRS89 reference framework using Ordnance Survey ground marker C1ST7784 (Horton).

2.3 Data processing and presentation

2.3.1 Magnetometry data downloaded from the Grad 601-2 data logger are analysed and processed in specialist software known as ArcheoSurveyor. The software allows greyscale and trace plots to be produced for presentation and display. Survey grids are assembled to form an overall composite of data (composite file) creating a dataset of the complete survey area. Appendix C contains specific information concerning the survey and data attributes and is derived directly from ArcheoSurveyor; this should be used in conjunction with information provided by Figure 02.

2.3.2 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:

- clipping of the raw data at ±30nT to improve greyscale resolution,
- clipping of processed data at ±3nT to enhance low magnitude anomalies,
- zero median/mean traverse is applied in order to balance readings along each traverse.

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 for each survey area.

2.3.3 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 each survey area.

2.3.4 The main form of data display used in this report is the greyscale plot. Both 'raw' and 'processed' data have been shown 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.

2.3.5 Graphic raster images in bitmap format (.BMP) are initially prepared in ArcheoSurveyor. Regardless of survey orientation, data captured along each traverse are displayed and processed by ArcheoSurveyor from left to right. Prior to displaying against base mapping, raster graphics require a rotation in AutoCAD of 145.85° for Fields 1 and 2, 127.84° for Fields 3 and 4, 114.06° for Field 5 and 211.34° for Field 6 to restore north to the top of the image.

2.3.6 The raster images are combined with base mapping using ProgeCAD Professional 2009 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.. A digital archive, including raster images, is produced with this report allowing separate analysis if necessary, see Appendix D below.

3 RESULTS

3.1 General overview

3.1.1 The detailed magnetic survey was carried out over a total of 6 Fields within survey areas A, B and C, covering approximately 13ha. Geophysical 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, linear anomalies relating to land management, 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 below with subsequent discussion in Section 4.

3.1.2 Data are considered to be of good quality with minor positional errors, caused by uneven ground, ruts, tall vegetation etc., unlikely to have degraded quality significantly. Magnetic disturbance has been caused by modern above ground ferrous objects.

3.1.3 The listing 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 reference 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 for each 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 relating to land management AS-ABST MAG LAND DRAIN	Land drains can appear in a classic herringbone pattern of interconnected multiple dipolar linear anomalies, or as parallel linear anomalies. The multiple dipolar response indicates a ceramic land drain.
Anomalies with an agricultural origin AS-ABST MAG AGRICULTURAL 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 2: List and description of interpretation categories

3.2 Area A – Field 1

Field centred on OS NGR 457971, 220772, see Figures 03 – 08.

Anomalies of archaeological potential

(1) – Positive linear and curvilinear anomalies that appear to relate to cut ditch-like features with archaeological potential.

Anomalies with an uncertain origin

(2) – A positive linear anomaly, parallel with the boundary between Fields 1 and 2, appears to relate to a ditch-like feature. It may be associated with the field boundary.

(3) – Positive linear anomalies may relate to cut features or agricultural anomalies.

Anomalies with an agricultural origin

(4) – Parallel linear anomalies likely to relate to ridge and furrow.

Anomalies associated with magnetic debris

(5) – Patches of magnetic debris indicate the presence of magnetically thermoremnant material.

(6) – Strong discrete dipolar anomalies indicate the presence of ferrous objects within the topsoil.

Anomalies with a modern origin

(7) – A strong multiple dipolar linear anomaly is a response to a buried service.

(8) – Magnetic disturbance from ferrous material.

3.3 Area A – Field 2

Field centred on OS NGR 458034, 220730, see Figures 03 – 08.

Anomalies with an uncertain origin

(9) – Discrete positive anomalies may indicate pit-like features; however, it is not possible to determine if they are anthropogenic in origin.

Anomalies with an agricultural origin

(10) – Parallel linear anomalies relate to extant ridge and furrow.

(11) – Parallel linear anomalies, orthogonal to the ridge and furrow, appear also to have been caused by agricultural activity.

Anomalies associated with magnetic debris

(12) – A patch of magnetic debris, close to field entrance, is a response to magnetically thermoremnant material.

(13) – Strong discrete dipolar anomalies indicate the presence of ferrous objects within the topsoil.

Anomalies with a modern origin

(14) – Magnetic disturbance from ferrous material.

3.4 Area A – Field 3

Field centred on OS NGR 458242, 220961, see Figures 03 – 06 & 09 – 14.

Anomalies with an uncertain origin

(15) – Short, weakly positive linear anomalies of uncertain origin.

(16) – Discrete positive anomalies may indicate pit-like features; however, it is not possible to determine if they are anthropogenic in origin.

Anomalies associated with magnetic debris

(17) – Patches of magnetic debris indicate the presence of magnetically thermoremnant material.

(18) – Field 3 contains a large number of strong discrete dipolar anomalies, which indicate the presence of numerous ferrous objects within the topsoil.

Anomalies with a modern origin

(19) – Two strong multiple dipolar linear anomalies relate to buried services.

(20) – Magnetic disturbance from ferrous material.

3.5 Area A – Field 4

Field centred on OS NGR 458160, 221067, see Figures 03 – 06 & 09 – 14.

Anomalies with an uncertain origin

(21) – A weakly positive linear anomaly, parallel with and 50m away from the north eastern field boundary. It is possible that this is a continuation of anomaly (7) in Field 1, where it can be seen as strong multiple dipolar linear anomaly indicating an iron pipe; however, in Field 4, the lack of a strong response may indicate that this part of the pipe is either made from non-ferrous material or that it has been removed.

(22) – Positive linear anomalies, associated with anomaly (23), and located in a raised area of the field.

Anomalies associated with magnetic debris

(23) – Magnetic debris, associated with anomaly (22), has been caused by magnetically thermoremnant material. This type of anomaly may indicate the location of a former structure or it may be a response to dumped material and

ground disturbance.

(24) – The northernmost corner of the site contains very strong dipolar responses which indicate magnetically thermoremnant material with a high ferrous content. Large amount of iron slag were visible in this part of the field during survey.

(25) – Field 4 contains widespread strong discrete dipolar anomalies which indicate the presence of ferrous objects within the topsoil.

Anomalies with a modern origin

(26) – A strong multiple dipolar linear anomaly has been caused by a buried service which extends northwestwards from Field 3.

3.6 Area B – Field 5

Field centred on OS NGR 458601, 220912, see Figures 15 – 17.

Anomalies with an uncertain origin

(27) – Three parallel negative linear anomalies located on the eastern side of the survey area. It is difficult to be certain of the origin of these anomalies as the survey area contains widespread magnetic debris and visible evidence for ground make-up and disturbance.

Anomalies with an agricultural origin

(28) – Parallel linear anomalies are likely to relate to former ridge and furrow.

Anomalies associated with magnetic debris

(29) – Widespread patches of very strong magnetic debris indicate the presence of ferrous and other magnetically thermoremnant material.

(30) – Strong discrete dipolar anomalies which indicate the presence of ferrous objects within the topsoil.

Anomalies with a modern origin

(31) – Magnetic disturbance from ferrous material within the survey area.

3.7 Area C – Field 6

Field centred on OS NGR 458987, 221246, see Figures 18 – 20.

Anomalies with an uncertain origin

(32) – Three positive linear anomalies located in the southern part of the survey area, may indicate ditch-like features, although they may be associated with former cultivation.

(33) – Three linear or curvilinear anomalies located in the northern part of the survey area may be similar in origin to (32).

(34) – A positive linear anomaly in the centre of survey area may indicate a ditch-like feature.

Anomalies associated with land management

(35) – Multiple dipolar linear anomalies appear to relate to land drains.

Anomalies associated with magnetic debris

(36) – Strong discrete dipolar anomalies which indicate the presence of ferrous objects within the topsoil.

Anomalies with a modern origin

(37) – Strong multiple dipolar linear anomalies are likely to relate to buried services.

(38) – Magnetic disturbance from ferrous material within the survey area.

4 CONCLUSION

4.1.1 The detailed magnetometer survey located a number of positive linear anomalies considered to have archaeological potential within Field 1 of Area A, close to the western boundary of the site. The anomalies lie within 250m of the scheduled area of Alchester Roman town, and although a direct association cannot be made, they may indicate an extension of features into the extreme western part of the survey area.

4.1.2 The remaining fields within Area A do not appear to contain other anomalies of archaeological potential. Field 2 contains evidence for ridge and furrow, and Fields 3 and 4 contain widespread ferrous objects and very little evidence of cut features. Relatively high levels of magnetic material at the northern end of

Field 4 suggest some dumping or industrial activity in the vicinity. The high frequency of discrete dipolar response across Fields 3 and 4 may indicate magnetic material spread through episodic manuring.

4.1.3 Area B (Field 5) contains very strong magnetic responses indicating ferrous material is present in the near surface make-up. This survey area contains irregular undulations indicative of relatively recent ground disturbance, dumping or ground make-up, although there is some evidence for extant ridge and furrow earthworks in the southern part of the area.

4.1.4 Area C (Field 6) was a former sports pitch and several positive linear anomalies have been located; however, it is not possible to confidently determine their origin. The area also contains land drains and buried services as well as magnetic disturbance from surrounding metal fencing and goal posts.

5 REFERENCES

British Geological Survey, 2010. *Geology of Britain viewer, 1:50 000 scale [online]* available from http://maps.bgs.ac.uk/geologyviewer/ [accessed 26/8/2010].

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

Entec, 2010. *MOD Bicester, Graven Hill, E Site: Specification for Geophysical Survey.* Unpublished typescript document.

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

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 3 Midland and Western 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 gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 1m apart. The instrument is carried about 30cm 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 ±5nT and ±1nT 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.

De-stagger

Compensates for small positional errors within data collection by shifting the position of the readings along each traverse by a specified amount. Data lost at the end of each traverse are extrapolated from adjacent value in the same row.

Deslope

Corrects for striping and distortion caused by metal objects/services etc.. The process calculates a curve based on a polynomial best fit mathematical function for each traverse. This curve is then subtracted from the actual data.

FFT (Fast Fourier Transform) spectral filtering

A mathematical process used to determine the frequency components of a traverse. Repetitive features, such as plough marks, produce characteristic spectral zones that can be suppressed allowing greyscale images to appear clearer.

Appendix C – survey and data information

Area A Field 1 raw data

COMPOSITE
Filename: J332-mag-Field1-raw.xcp

Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 16/08/2010
Assembled by: on 16/08/2010
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 240 x 240
Survey Size (meters): 60 m x 240 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 10.50
Mean: -3.85
Median: -0.77
Composite Area: 1.44 ha
Surveyed Area: 0.6689 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 13
1 Col:0 Row:2 07.xgd
2 Col:0 Row:3 08.xgd
3 Col:0 Row:4 15.xgd
4 Col:0 Row:5 16.xgd
5 Col:0 Row:6 17.xgd
6 Col:1 Row:0 01.xgd
7 Col:1 Row:1 02.xgd
8 Col:1 Row:2 03+05.xgd
9 Col:1 Row:3 04+06.xgd
10 Col:1 Row:4 09+13.xgd
11 Col:1 Row:5 10+14.xgd
12 Col:1 Row:6 11.xgd
13 Col:1 Row:7 12.xgd

Area A Field 1 processing

COMPOSITE
Filename: J332-mag-Field1-proc.xcp

Processes: 4
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: All
4 Clip from -3.00 to 3.00 nT

Stats
Max: 3.00
Min: -3.00
Std Dev: 1.75
Mean: -0.31
Median: 0.00

Area A Field 2 raw data

COMPOSITE
Filename: J332-mag-Field2-raw.xcp

Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 16/08/2010
Assembled by: on 16/08/2010
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 480 x 210
Survey Size (meters): 120 m x 210 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 2.86
Mean: -0.28
Median: -0.10
Composite Area: 2.52 ha
Surveyed Area: 1.7849 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 27
1 Col:0 Row:0 13.xgd
2 Col:0 Row:1 14.xgd
3 Col:0 Row:2 15.xgd
4 Col:0 Row:3 16.xgd
5 Col:0 Row:4 17.xgd
6 Col:0 Row:5 18.xgd
7 Col:0 Row:6 19.xgd
8 Col:1 Row:0 09.xgd
9 Col:1 Row:1 10.xgd
10 Col:1 Row:2 11.xgd
11 Col:1 Row:3 12.xgd
12 Col:1 Row:4 20.xgd
13 Col:1 Row:5 21.xgd
14 Col:1 Row:6 22.xgd
15 Col:2 Row:0 05.xgd
16 Col:2 Row:1 06.xgd
17 Col:2 Row:2 07.xgd
18 Col:2 Row:3 08.xgd
19 Col:2 Row:4 23.xgd
20 Col:2 Row:5 24.xgd
21 Col:2 Row:6 25.xgd
22 Col:3 Row:0 01.xgd
23 Col:3 Row:1 02.xgd
24 Col:3 Row:2 03.xgd
25 Col:3 Row:3 04.xgd
26 Col:3 Row:4 26.xgd
27 Col:3 Row:5 27.xgd

Area A Field 2 processing

COMPOSITE
Filename: J332-mag-Field2-proc.xcp

Stats
Max: 3.00
Min: -3.00
Std Dev: 0.87
Mean: 0.02
Median: 0.00

Processes: 12
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: 15.xgd 16.xgd 17.xgd 18.xgd 19.xgd 11.xgd 12.xgd 20.xgd 21.xgd 22.xgd 07.xgd 08.xgd 23.xgd 24.xgd 25.xgd 03.xgd 04.xgd 26.xgd 27.xgd
4 DeStripe Median Traverse: Grids: 10.xgd 06.xgd
5 DeStripe Median Traverse: Grids: 09.xgd 05.xgd
6 DeStripe Median Traverse: Grids: 01.xgd 02.xgd
7 DeStripe Median Sensors: 14.xgd
8 Clip from -3.00 to 3.00 nT
9 De Stagger: Grids: 01.xgd Mode: Both By: 1 intervals
10 De Stagger: Grids: 17.xgd Mode: Both By: 1 intervals
11 De Stagger: Grids: 24.xgd Mode: Both By: 1 intervals
12 De Stagger: Grids: 02.xgd Mode: Both By: 1 intervals

Area A Field 3 raw data

COMPOSITE
Filename: J332-mag-Field3-raw.xcp

Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 18/08/2010
Assembled by: on 18/08/2010
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 600 x 450
Survey Size (meters): 150 m x 450 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 5.66
Mean: -0.43
Median: -0.29
Composite Area: 6.75 ha
Surveyed Area: 4.6442 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 63
1 Col:0 Row:0 13.xgd
2 Col:0 Row:1 14.xgd
3 Col:0 Row:2 15.xgd
4 Col:0 Row:3 16.xgd
5 Col:0 Row:4 17.xgd
6 Col:0 Row:5 18.xgd
7 Col:0 Row:6 19.xgd
8 Col:0 Row:7 20.xgd
9 Col:0 Row:8 45.xgd
10 Col:0 Row:9 46.xgd
11 Col:0 Row:10 47.xgd
12 Col:0 Row:11 48.xgd
13 Col:0 Row:12 49.xgd
14 Col:0 Row:13 50.xgd
15 Col:0 Row:14 51.xgd
16 Col:1 Row:0 09.xgd
17 Col:1 Row:1 10.xgd
18 Col:1 Row:2 11.xgd
19 Col:1 Row:3 12.xgd
20 Col:1 Row:4 21.xgd
21 Col:1 Row:5 22.xgd
22 Col:1 Row:6 23.xgd
23 Col:1 Row:7 24.xgd
24 Col:1 Row:8 41.xgd
25 Col:1 Row:9 42.xgd
26 Col:1 Row:10 43.xgd
27 Col:1 Row:11 44.xgd
28 Col:1 Row:12 52.xgd
29 Col:1 Row:13 53.xgd
30 Col:1 Row:14 54.xgd
31 Col:2 Row:0 05.xgd
32 Col:2 Row:1 06.xgd
33 Col:2 Row:2 07.xgd
34 Col:2 Row:3 08.xgd
35 Col:2 Row:4 25.xgd
36 Col:2 Row:5 26.xgd
37 Col:2 Row:6 27.xgd
38 Col:2 Row:7 28.xgd
39 Col:2 Row:8 37.xgd
40 Col:2 Row:9 38.xgd
41 Col:2 Row:10 39.xgd
42 Col:2 Row:11 40.xgd
43 Col:2 Row:12 55.xgd
44 Col:2 Row:13 56.xgd
45 Col:2 Row:14 57.xgd
46 Col:3 Row:0 01.xgd
47 Col:3 Row:1 02.xgd
48 Col:3 Row:2 03.xgd
49 Col:3 Row:3 04.xgd
50 Col:3 Row:4 29.xgd
51 Col:3 Row:5 30.xgd
52 Col:3 Row:6 31.xgd
53 Col:3 Row:7 32.xgd
54 Col:3 Row:8 33.xgd
55 Col:3 Row:9 34.xgd
56 Col:3 Row:10 35.xgd
57 Col:3 Row:11 36.xgd
58 Col:3 Row:12 58.xgd
59 Col:3 Row:13 59.xgd
60 Col:3 Row:14 60.xgd
61 Col:4 Row:12 61.xgd
62 Col:4 Row:13 62.xgd
63 Col:4 Row:14 63.xgd

Area A Field 3 processing

COMPOSITE
Filename: J332-mag-Field3-proc.xcp

Stats
Max: 3.00
Min: -3.00
Std Dev: 1.12
Mean: 0.01
Median: 0.00

Processes: 7
1 Base Layer

2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: 13.xgd 14.xgd 15.xgd 16.xgd 17.xgd 18.xgd 19.xgd 20.xgd 09.xgd 10.xgd 11.xgd 12.xgd 21.xgd 22.xgd 23.xgd 24.xgd 05.xgd 06.xgd 07.xgd 08.xgd 25.xgd 26.xgd 27.xgd 28.xgd 01.xgd 02.xgd 03.xgd 04.xgd 29.xgd 30.xgd 31.xgd 32.xgd
4 DeStripe Median Traverse: Grids: 47.xgd 48.xgd 49.xgd 50.xgd 51.xgd 43.xgd 44.xgd 52.xgd 53.xgd 54.xgd 39.xgd 40.xgd 55.xgd 56.xgd 57.xgd 35.xgd 36.xgd 58.xgd 59.xgd 60.xgd 61.xgd 62.xgd 63.xgd
5 DeStripe Median Traverse: Grids: 41.xgd 42.xgd 37.xgd 38.xgd 33.xgd 34.xgd
6 DeStripe Mean Traverse: Grids: 45.xgd 46.xgd
Threshold: 0.5 SDs
7 Clip from -3.00 to 3.00 nT

Area A Field 4 raw data

COMPOSITE
Filename: J332-mag-Field4-raw.xcp

Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 18/08/2010
Assembled by: on 18/08/2010
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 600 x 450
Survey Size (meters): 150 m x 450 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 5.28
Mean: -0.43
Median: -0.15
Composite Area: 6.75 ha
Surveyed Area: 3.1239 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 49
1 Col:0 Row:0 01.xgd
2 Col:0 Row:1 02.xgd
3 Col:0 Row:2 03.xgd
4 Col:0 Row:3 04.xgd
5 Col:0 Row:4 08.xgd
6 Col:0 Row:5 09.xgd
7 Col:0 Row:6 10.xgd
8 Col:0 Row:7 11.xgd
9 Col:0 Row:8 20.xgd
10 Col:0 Row:9 21.xgd
11 Col:0 Row:10 22.xgd
12 Col:0 Row:11 23.xgd
13 Col:0 Row:12 36.xgd
14 Col:0 Row:13 37.xgd
15 Col:0 Row:14 38.xgd
16 Col:1 Row:1 05.xgd
17 Col:1 Row:2 06.xgd
18 Col:1 Row:3 07.xgd
19 Col:1 Row:4 12.xgd
20 Col:1 Row:5 13.xgd
21 Col:1 Row:6 14.xgd
22 Col:1 Row:7 15.xgd
23 Col:1 Row:8 24.xgd
24 Col:1 Row:9 25.xgd
25 Col:1 Row:10 26.xgd
26 Col:1 Row:11 27.xgd
27 Col:1 Row:12 39.xgd
28 Col:1 Row:13 40.xgd
29 Col:1 Row:14 41.xgd
30 Col:2 Row:4 16.xgd
31 Col:2 Row:5 17.xgd
32 Col:2 Row:6 18.xgd
33 Col:2 Row:7 19.xgd
34 Col:2 Row:8 28.xgd
35 Col:2 Row:9 29.xgd
36 Col:2 Row:10 30.xgd
37 Col:2 Row:11 31.xgd
38 Col:2 Row:12 42.xgd
39 Col:2 Row:13 43.xgd
40 Col:2 Row:14 44.xgd
41 Col:3 Row:8 32.xgd
42 Col:3 Row:9 33.xgd
43 Col:3 Row:10 34.xgd
44 Col:3 Row:11 35.xgd
45 Col:3 Row:12 45.xgd
46 Col:3 Row:13 46.xgd
47 Col:3 Row:14 47.xgd
48 Col:4 Row:13 48.xgd
49 Col:4 Row:14 49.xgd

Area A Field 4 processing

COMPOSITE
Filename: J332-mag-Field4-proc.xcp

Stats
Max: 3.00
Min: -3.00
Std Dev: 1.17
Mean: -0.06
Median: 0.00

Processes: 8
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: 01.xgd 02.xgd 03.xgd 04.xgd 08.xgd 09.xgd 10.xgd 11.xgd 20.xgd 21.xgd 22.xgd 23.xgd 36.xgd 37.xgd 38.xgd 05.xgd 06.xgd 07.xgd 12.xgd 13.xgd 14.xgd 15.xgd 24.xgd 25.xgd 26.xgd 27.xgd 39.xgd 40.xgd 41.xgd 16.xgd 17.xgd 18.xgd 19.xgd 28.xgd 29.xgd 30.xgd 31.xgd 42.xgd 43.xgd 44.xgd
4 DeStripe Median Traverse: Grids: 32.xgd 33.xgd
5 DeStripe Median Traverse: Grids: 45.xgd 46.xgd 47.xgd
6 DeStripe Mean Traverse: Grids: 34.xgd 35.xgd
Threshold: 0.5 SDs
7 DeStripe Median Traverse: Grids: 48.xgd 49.xgd
8 Clip from -3.00 to 3.00 nT

Area B Field 5 raw data

COMPOSITE
Filename: J332-mag-Field5-raw.xcp

Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 19/08/2010
Assembled by: on 19/08/2010
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 480 x 240
Survey Size (meters): 120 m x 240 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 7.80
Mean: -1.14
Median: -0.05
Composite Area: 2.88 ha
Surveyed Area: 1.6358 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 29
1 Col:0 Row:0 26.xgd
2 Col:0 Row:1 27.xgd
3 Col:0 Row:2 28.xgd
4 Col:0 Row:3 29.xgd
5 Col:0 Row:4 19.xgd
6 Col:0 Row:5 20.xgd
7 Col:0 Row:6 21.xgd
8 Col:1 Row:0 22.xgd
9 Col:1 Row:1 23.xgd
10 Col:1 Row:2 24.xgd
11 Col:1 Row:3 25.xgd
12 Col:1 Row:4 15.xgd
13 Col:1 Row:5 16.xgd
14 Col:1 Row:6 17.xgd
15 Col:1 Row:7 18.xgd
16 Col:2 Row:1 04.xgd
17 Col:2 Row:2 05.xgd
18 Col:2 Row:3 06.xgd
19 Col:2 Row:4 11.xgd
20 Col:2 Row:5 12.xgd
21 Col:2 Row:6 13.xgd
22 Col:2 Row:7 14.xgd
23 Col:3 Row:1 01.xgd
24 Col:3 Row:2 02.xgd
25 Col:3 Row:3 03.xgd
26 Col:3 Row:4 07.xgd
27 Col:3 Row:5 08.xgd
28 Col:3 Row:6 09.xgd
29 Col:3 Row:7 10.xgd

Area B Field 5 processing

COMPOSITE
Filename: J332-mag-Field5-proc.xcp

Stats
Max: 3.00
Min: -3.00
Std Dev: 1.50
Mean: -0.18
Median: -0.03
Composite Area: 2.88 ha
Surveyed Area: 1.6357 ha

Area C Field 6 raw data

COMPOSITE
Filename: J332-mag-Field6-raw.xcp

Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 19/08/2010
Assembled by: on 19/08/2010
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 240 x 120
Survey Size (meters): 60 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 7.69
Mean: -0.25
Median: 0.42
Composite Area: 0.72 ha
Surveyed Area: 0.5997 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 8
1 Col:0 Row:0 01.xgd
2 Col:0 Row:1 02.xgd
3 Col:0 Row:2 03.xgd
4 Col:0 Row:3 04.xgd
5 Col:1 Row:0 05.xgd
6 Col:1 Row:1 06.xgd
7 Col:1 Row:2 07.xgd
8 Col:1 Row:3 08.xgd

Area C Field 6 processing

COMPOSITE
Filename: J332-mag-Field6-proc.xcp

Processes: 4
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: All
4 Clip from -3.00 to 3.00 nT

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at Castle Combe, 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. Digital data are also supplied to the client on CD ROM, see below.

Surveys are reported on in hardcopy (recycled paper) using A4 for text and A3 for plots (all plots are scaled for A3). The distribution of both hardcopy report and digital data is considered the responsibility of the Client unless explicitly stated in the survey Brief, Written Scheme of Investigation or other contractual agreement.

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

- ArcheoSurveyor version 2.5.6.68 (geophysical data analysis),
- ProgeCAD Professional 2009 (report graphics),
- AutoCAD LT 2007 (report figures),
- OpenOffice.org 3.0.1 Writer (document text),
- PDF Creator version 0.9 (PDF archive).

Digital data are supplied on CD ROM which includes the following files:

- ArcheoSurveyor 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.

The CD ROM structure is formed from a tree of directories under the title J332 Bicester – CD. Directory titles include Data, Documentation, CAD, PDFs and Photos. Multiple directories exist under Data and hold Grid, Composite and Graphic files with CSV composite data held in Export.

The CAD file contains externally referenced graphics that are rotated with separate A3 size layouts for each figure. Layouts are fixed using frozen layers and named views allowing straightforward plotting or analysis on screen. (Note – CAD files are prepared using AutoCAD's e Transmit function to produce a directory containing the digital drawing along with any externally referenced graphics which may need reloading).