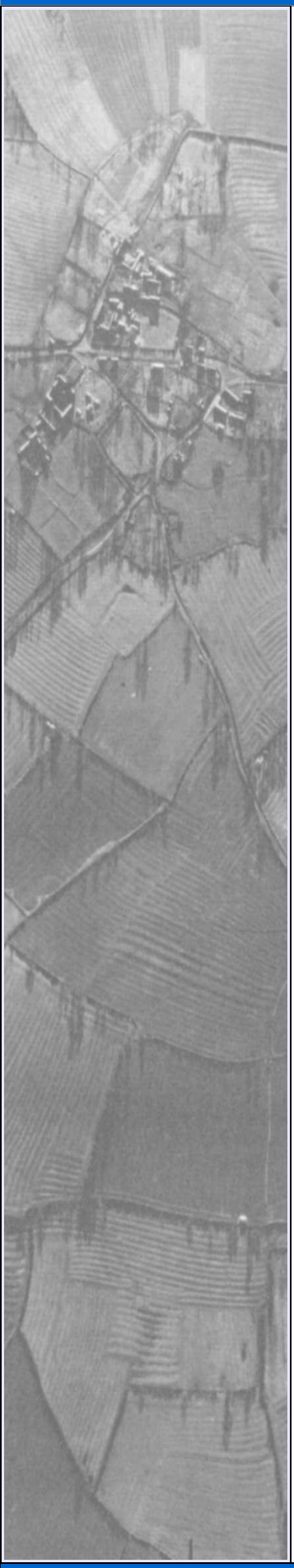

Former RAF Upper Heyford
Southern Bomb Store
Access Road
Oxfordshire

MAGNETOMETER AND EARTH RESISTANCE SURVEY REPORT

for

Oxford Archaeology

David Sabin and Kerry Donaldson

May 2015

Ref. no. 610

ARCHAEOLOGICAL SURVEYS LTD

Former RAF Upper Heyford
Southern Bomb Store
Access Road
Oxfordshire

Magnetometer and Earth Resistance Survey

for

Oxford Archaeology

Fieldwork by David Sabin (Hons) MCIfA
Report by David Sabin BSc (Hons) & Kerry Donaldson (BSc (Hons)
Primary archive location - Archaeological Surveys Ltd, Yatesbury, Wiltshire

Survey dates 28th & 29th May and June 1st 2015
Ordnance Survey Grid Reference – **SP 52275 26686**

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SUMMARY

A linear zone on the eastern edge of the former RAF Upper Heyford airbase was subject to geophysical survey by Archaeological Surveys Ltd. The survey zone covered the potential route of a new access road related to redevelopment of the southern bomb store site. The survey area lies immediately adjacent to the line of Aves Ditch, a prehistoric tribal boundary and the survey. Resistivity survey was carried out within the airbase due to numerous sources of magnetic disturbance. Magnetometry was carried out over agricultural land lying within the survey corridor immediately outside the perimeter fence. The results of the magnetometry demonstrated the presence of widespread magnetic debris relating to agricultural activity and an area of made ground or the site of former buildings. A small number of linear anomalies of uncertain origin were located. The resistivity indicated variability likely to relate to shallow solid geology and ground disturbance caused by construction of features within the airbase during its operational lifetime.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Oxford Archaeology to undertake a magnetometer and earth resistance survey of an area of land at the former RAF Upper Heyford airbase in Oxfordshire. The survey was carried out in order to provide information on the archaeological potential of land likely to be disturbed by the development of a new access road to the site southern bomb store which is also due to be redeveloped.

1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2015). Planning permission has been sought from Cherwell District Council for the demolition of the southern bomb store and site clearance within the former RAF Upper Heyford airbase (15/00474/OUT). The survey area encompasses a section of the proposed access road to the west of Chilgrove Drive, within the former airbase, and a section to the east of Chilgrove Drive and north of Camp Road within agricultural land. The geophysical survey is being carried out as a requirement of the Brief for Archaeological Field Evaluation (Oram, 2014)

1.2 Survey objectives and techniques

1.2.1 The objectives of the survey were to use non-intrusive geophysical techniques to establish the presence/absence, extent, condition, character, quality and date of any archaeological deposits within the proposed development area.

1.2.2 The site of the southern bomb store is not included within the survey area due to the presence of military structures. The north western part of the access route is within the curtilage of the former airbase. It contains a number of extant and removed structures, is surrounded by steel fencing and also

contains buried structures and services, all of which are likely to cause magnetic disturbance. Although magnetometry is generally used to locate cut features, as a consequence of the magnetic disturbance within the former airbase, the survey was carried out using earth resistance within this part of the site. The south eastern part of the new route lies within open agricultural land and magnetometry was carried out within this part of the site.

1.2.3 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 on the south eastern side of former RAF Upper Heyford, partly within the airbase and partly within agricultural land to the south east. It is centred on Ordnance Survey National Grid Reference SP 52275 26686, see Figures 01 and 02.

1.3.2 The geophysical survey covers land along a narrow corridor, two sections of which are separated by high wire mesh fencing and lie within the former airbase. The northern section (Area 4) was approximately 180m long and contained variable grass cover with some briar close to the eastern boundary fence. Numerous anthills were present across the area. Survey was not carried out over the eastern flanks of two large reservoirs that impinged into the area. Survey was also impeded by two small concrete buildings.

1.3.3 The second and more southerly section within the airbase boundary (Area 3) could not be surveyed. The area was thoroughly examined during an additional day of survey. Upon close inspection it was clear that the surface along the whole section had been made up by approximately 0.3 - 0.5m of rubble. Attempts to pass current through the surface for earth resistance survey failed due to very high contact resistance. Ferrous debris in the surface make-up and tall fencing surrounding the site precluded the use of magnetometry.

1.3.4 Two separate survey sections were located further to the south east in two fields (Areas 1 and 2). A tall rape crop had been cleared from the road corridor in both fields prior to the survey. The northern field contained a large mound of green waste compost, in preparation for soil conditioning, which impeded survey at its southern end. Magnetometry survey was successfully carried out over the majority of the two areas.

1.3.5 Weather conditions during the survey were variable with periods of heavy rain and high winds. Earth resistance survey was carried out after a period of very heavy rain; however, this aided contact between the probes and ground surface. Prior to the rain the surface appeared very dry and the site very well drained.

Plate 1: Survey Area 2 looking north

Plate 2: Survey Area 4 looking north

1.4 Site history and archaeological potential

1.4.1 The proposed access road lies either side of the line of Aves Ditch, a prehistoric tribal boundary. A number of Iron Age banjo enclosures have been recorded along the line of Aves Ditch with other prehistoric features identified from aerial photography in the close vicinity. Several Roman and Anglo Saxon

burials are also recorded within the vicinity (Oram, 2014).

1.4.2 The location of Aves Ditch within the line of the survey area, and other archaeological sites and cropmarks nearby, indicates that there is potential for the survey to record anomalies that may relate to the linear boundary or other archaeological features. However, there is likely to be widespread disturbance within the former airbase, which may obscure or have truncated earlier features.

1.4.3 The surface conditions within the southern part of the site were suitable for the observation of cultural material during the course of the survey. No significant scatters were noted.

1.5 Geology and soils

1.5.1 The underlying solid geology across the site is limestone from the Great Oolite group (BGS 2015).

1.5.2 The overlying soil across the survey area is from the Aberford association and is a typical brown calcareous earth. It consists of a shallow, locally brashy, well drained, calcareous, fine, loamy soil over limestone (Soil Survey of England and Wales, 1983).

1.5.3 Magnetometry carried out over similar geology and soil has produced good results. The site is, therefore, considered suitable for magnetic survey. Earth resistance survey may locate natural anomalies within the soil and limestone interface due to the shallow nature of the soil.

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).

2.1.5 The electrical resistance or resistivity of the soil depends upon the moisture content and distribution within the soil. Buried features such as walls can affect the moisture distribution and are usually more moisture resistant than other features such as the infill of a ditch. A stone wall will generally give a high resistance response and the moisture retentive content of a ditch can give a low resistance response. Localised variations in resistance are measured in ohms (Ω) which is the SI unit for electrical impedance or resistance.

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 system is linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged computer.

2.2.2 Magnetic 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. 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).

2.2.3 The earth resistance survey was carried out with a Geoscan Research RM85 mounted on a MSP25 Mobile Sensor Platform. The platform comprises a wheeled resistance array with four spiked wheels that act as the four probes of a square array which are set 0.75m apart on an aluminium frame. It is configured as a multiplexed 0.75m square array recording alpha and beta measurements every 0.25m along traverses separated by 1m. Readings are triggered by distance encoder pulses from an MSP25 wheel after an initial calibration. The survey was carried out in a zig-zag fashion over grids 30m in size.

2.2.4 The alpha and beta measurements are represented by changes in the configuration of the current and potential probes achieved by rapid switching with the multiplexer. There is often little difference between the two; however, some directional effects may be apparent.

2.2.5 The earth resistance survey grids were set out to the Ordnance Survey OSGB36 datum using a Leica GS10 RTK GPS. The GPS is used in

conjunction with Leica's SmartNet 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 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 magnetometer data are collected between limits of ±10000nT and clipped for display. 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 magnetic 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 magnetic data display used in the report is the minimally processed greyscale plot.

2.3.5 Data logged by the resistance meter are downloaded and processed within Geoplot 4 software. Raw data are analysed and displayed within the report as well as processed data. The software does not automatically provide metadata but the processing sequence consisted of despiking and the use of a low pass filter. TIF files are prepared in Geoplot 4 for the earth resistance data.

2.3.6 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.

2.3.7 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.

2.3.8 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.

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

3 RESULTS

3.1 General assessment of survey results - magnetometry

3.1.1 The detailed magnetic survey was carried out over a total of 2 survey areas covering approximately 1.6ha.

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

3.1.3 Anomalies located within each survey area have been numbered and are described below.

3.2 Statement of data quality - magnetometry

3.2.1 Data are considered representative of the magnetic anomalies present within the site. There are no significant defects within the dataset.

3.3 Data interpretation - magnetometry

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 for each survey area.

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG NEG LINEAR UNCERTAIN	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone and subsoil.
Anomalies associated with magnetic debris AS-ABST MAG DEBRIS AS-ABST MAG STRONG DIPOLAR	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. It often occurs where there has been dumping or ground make-up and is related to magnetically thermoremnant materials such as brick or tile or other small fragments of ferrous material. This type of response is occasionally associated with kilns, furnace structures, or hearths and may therefore be archaeologically significant. It is also possible that the response may be caused by natural material such as certain gravels and fragments of igneous or metamorphic rock. Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.
Anomalies with a modern origin AS-ABST MAG DISTURBANCE	The magnetic response is often strong and dipolar indicative of ferrous material and may be associated with extant above surface features such as wire fencing, cables, pylons etc.. Often a significant area around such features has a strong magnetic flux which may create magnetic disturbance; such disturbance can effectively obscure low magnitude anomalies if they are present. Fluxgate sensors may respond erratically and with hysteresis adjacent to strong magnetic sources. Buried services may produce characteristic multiple dipolar anomalies dependant upon their construction.

Table 1: List and description of magnetometry interpretation categories

3.4 General assessment of survey results - resistivity

3.4.1 The earth resistance survey was carried out over 1 survey area (Area 4) covering approximately 0.6ha. Area 3 was unsurveyable due to recently made ground.

3.4.2 Resistive anomalies located can be generally classified as high resistance linear anomalies of uncertain origin, areas of high resistance possibly associated with former airbase features and/or their construction and variable resistance possibly related to shallow solid geology.

3.5 Statement of data quality - resistivity

3.5.1 Data are considered representative of the resistive anomalies present within the site. Variable and often poor surface conditions are likely to have caused high frequency noise within the data.

3.6 Data interpretation - resistivity

3.6.1 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 earth resistance survey. A basic explanation of the characteristics of the 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. Sub-headings are then used to group anomalies with similar characteristics.

Report sub-heading CAD layer names and plot colour	**Description and origin of anomalies**
Anomalies with an uncertain origin AS-ABST RES HIGH LINEAR UNCERTAIN AS-ABST RES HIGH AREA UNCERTAIN AS-ABST RES VARIABLE AREA 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. High resistance anomalies are indicative of comparatively low moisture and may indicate stone, compacted soil, changes in drainage, etc. Low resistance anomalies are indicative of comparatively high moisture and may relate to the fill of cut features, organic material within the soil, damp areas etc..

Table 2: List and description of resistivity interpretation categories

3.7 List of anomalies – magnetometry Area1

Area centred on OS NGR 452260 225730, see Figures 03 & 04.

Anomalies with an uncertain origin

(1) - Very weakly positive linear anomalies within the survey area are of uncertain origin. They may be associated with agricultural activity.

(2) - A narrow negative linear anomaly may well be associated with cultivation.

Anomalies associated with magnetic debris

(3) - A wide zone of magnetic debris within the survey area is probably associated with ferrous material incorporated into the field during soil conditioning.

(4) - Strong discrete dipolar anomalies indicate the presence of ferrous objects within the topsoil. Small discrete dipolar responses may indicate metal fragments derived from composted green waste spread as a soil conditioner. A mound of this type of compost was observed at the southern end of Area 2.

Anomalies with a modern origin

(5) - Magnetic disturbance close to the boundary of the survey area is likely to have

been caused by nearby services and other ferrous objects within the hedgerows.

3.8 List of anomalies – magnetometry Area 2

Area centred on OS NGR 452290 225925, see Figures 03 & 04.

Anomalies with an uncertain origin

(6) - Several positive linear and curvilinear anomalies were located in the central part of the area. They are weak and unclear due to ferrous contaminants within the topsoil. The anomalies may represent former ditch-like features and their archaeological potential should be considered.

Anomalies associated with magnetic debris

(7) - High magnitude magnetic debris is located in a well-defined zone at the southern end of the survey area. Concrete and brick appears to be located on a slightly raised area that correlates with the magnetic responses. It is likely that the material is derived from demolished buildings, perhaps associated with the airbase, or that it has been used as ground make-up or infill.

(8) - The survey area is contaminated with widespread ferrous waste. This type of material is likely to be derived from composted green waste. A large mound of this compost prevented survey at the southern end of the field.

Anomalies with a modern origin

(9) - Magnetic disturbance along the western edge of the survey area was caused by ferrous fencing.

3.9 List of anomalies – resistivity Area 4

Area centred on OS NGR 452320 226365, see Figures 05 & 06.

Anomalies with an uncertain origin

(10) - Two high resistance linear anomalies are located in the vicinity of a small concrete building. The anomalies may relate to underground services.

(11) - Small zones of high resistance within the vicinity of a small concrete building may relate to its former use.

(12) - A zone of high resistance in the vicinity of a concrete pill box. The response may indicate made ground.

(13) - A small area of high resistance that may be associated with former airbase features.

(14) - A zone of variable resistance correlates with short grass within the survey area. It is possible that the variability is associated with shallow solid geology or other forms of ground disturbance that have occurred during the lifetime of the airbase.

4 CONCLUSION

4.1.1 Geophysical survey was successfully carried out along the majority of the route of the access road, the exception being a section of ground made up with concrete, tarmac, stone etc. No anomalies could be confidently interpreted as having archaeological potential based on their morphology alone; however, several anomalies of uncertain origin were located with magnetometry outside of the former airbase and with resistivity across the interior.

4.1.2 Several weak, positive, linear and curvilinear anomalies were located in close proximity within magnetometry survey Area 2. This type of response can be indicative of former ditch-like features and their archaeological potential should be considered. However, the majority of the arable land surveyed indicated that ferrous contamination is widespread and this has the potential to obscure more significant magnetic features. As a consequence, there is some uncertainty to the morphology of the anomalies located and it has not been possible to provide a more detailed interpretation. The ferrous contamination may well have been spread with composted green waste, a large mound of which prevented survey across a small part of the site.

4.1.3 The resistivity survey demonstrated widespread variability in the resistance of the soil across the northern part of the access road. Generally amorphous anomalies appear in the vicinity of extant concrete buildings and are likely to relate to former ground disturbance, make-up and services. It is also likely that shallow solid geology has formed numerous amorphous zones of relatively high and low resistance.

5 REFERENCES

Archaeological Surveys, 2015. *Former RAF Upper Heyford, Southern Bomb Store Access Road, Geophysical Survey Written Scheme of Investigation*. Unpublished typescript document.

Aspinall, A., Gaffney, C. and Schmidt, A., 2009. *Magnetometry for Archaeologists*. Lanham (US), AltaMira Press.

British Geological Survey, 2015. *Geology of Britain viewer, 1:50 000 scale [online]* available from http://mapapps.bgs.ac.uk/geologyofbritain/home.html [accessed 1/5/2015].

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

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

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

Oram, R., 2014. *Land and Southern Stores, Chilgrove Drive, Upper Heyford, Design Brief for Archaeological Field Evaluation.* Unpublished typescript document.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 4 Eastern 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 0.65m apart. The instrument is carried about 10-20cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried field. The difference between the two sensors will relate to the strength the magnetic field created by the buried feature. If no enhanced feature is present the field measured by both sensors will be similar and the difference close to zero.

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

Appendix B – data processing notes

Clipping

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

Zero Median/Mean Traverse

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

High Pass Filtering

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

Appendix C – survey and data information

Magnetometry - Area 1 minimally processed

Filename: J610-mag-Area1-proc.xcp
Description: Imported as Composite from: J610-mag-Area1.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y): OSGB36
Northwest corner: 452194.768989139, 225769.912363789 m
Southeast corner: 452366.218989139, 225691.912363789 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702

Source GPS Points: 1184750

Dimensions
Composite Size (readings): 1143 x 520
Survey Size (meters): 171 m x 78 m
Grid Size: 171 m x 78 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats
Max: 15
Min: -15
Std Dev: 5.46
Mean: -0.03
Median: -0.08
Composite Area: 1.3373 ha
Surveyed Area: 0.74743 ha

PROGRAM
Name: TerraSurveyor
Version: 3.0.23.0

Processes: 1
1 Base Layer

GPS based Proce3
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 Clip from -15.00 to 15.00 nT

Magnetometry - Area 2 minimally processed

Filename: J610-mag-Area2-proc.xcp
Description: Imported as Composite from: J610-mag-Area1.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y): OSGB36
Northwest corner: 452249.728582533, 226118.406489528 m
Southeast corner: 452316.628582533, 225771.906489528 m
Collection Method: Randomised
Sensors: 1
Dummy Value: 32702

Source GPS Points: 1735500

Dimensions
Composite Size (readings): 446 x 2310
Survey Size (meters): 66.9 m x 347 m
Grid Size: 66.9 m x 347 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats
Max: 15
Min: -15
Std Dev: 5.04
Mean: -0.01
Median: -0.02
Composite Area: 2.3181 ha
Surveyed Area: 0.89356 ha

PROGRAM
Name: TerraSurveyor
Version: 3.0.23.0

Processes: 1
1 Base Layer

GPS based Proce3
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 Clip from -15.00 to 15.00 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.

Magnetometer data Area 1 - path: J610 Upper Heyford\Data\Mag				
Path and Filename	**Software**	**Description**	**Date**	**Creator**
heyford2\MX\ .prm .dgb .disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	28/05/15	D.J.Sabin
heyford2\MX\J610-mag-Area1.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey Area 1 in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	10/06/15	D.J.Sabin
Area1\comps\J610-mag-Area1.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	10/06/15	D.J.Sabin
Area1\comps\J610-mag-Area1-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±15nT).	10/06/15	D.J.Sabin
Magnetometer data Area 2 - path: J610 Upper Heyford\Data\Mag				
heyford1\MX\ .prm .dgb .disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	28/05/15	D.J.Sabin
heyford1\MX\J610-mag-Area2.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey Area 1 in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	10/06/15	D.J.Sabin
Area2\comps\J610-mag-Area2.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	10/06/15	D.J.Sabin
Area2\comps\J610-mag-Area2-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±15nT).	10/06/15	D.J.Sabin
Resistivity data Area 4 - path: J610 Upper Heyford\Data\Res				
Grid\ .dat .grd .grs	Geoplot 4	Proprietary data formats representing 13 survey grids logged by RM85.	05/06/15	D.J.Sabin
J610-res-Area4a .cmd .cmp .cms .plm	Geoplot 4	Composite data for Area 4 representing the alpha cart configuration.	05/06/15	D.J.Sabin
J610-res-Area4a-proc .cmd .cmp .cms .plm	Geoplot 4	Composite processed data for Area 4 representing the alpha cart configuration.	05/06/15	D.J.Sabin
J610-res-Area4b	Geoplot 4	Composite data for Area 4 representing the beta cart configuration.	05/06/15	D.J.Sabin

.cmd .cmp .cms .plm				
J610-res-Area4b-proc .cmd .cmp .cms .plm	Geoplot 4	Composite processed data for Area 4 representing the beta cart configuration.	05/06/15	D.J.Sabin
Graphic data - path: J610 Upper Heyford\Data				
Mag\Area1\graphics\ J610-mag-Area1-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±15nT.	10/06/15	D.J.Sabin
Mag\Area1\graphics\ J610-mag-Area1-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	10/06/15	D.J.Sabin
Mag\Area2\graphics\ J610-mag-Area2-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±15nT.	10/06/15	D.J.Sabin
Mag\Area2\graphics\ J610-mag-Area2-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	10/06/15	D.J.Sabin
Res\J610-res-Area4a-raw.tif	Geoplot 4	TIF file showing a raw greyscale plot of alpha configuration clipped at 1Ω to 30Ω.	05/06/15	D.J.Sabin
Res\J610-res-Area4b-raw.tif	Geoplot 4	TIF file showing a raw greyscale plot of beta configuration clipped at 1Ω to 30Ω.	05/06/15	D.J.Sabin
Res\J610-res-Area4a-proc.tif	Geoplot 4	TIF file showing a processed greyscale plot of alpha configuration clipped at 1Ω to 30Ω.	05/06/15	D.J.Sabin
Res\J610-res-Area4b-proc.tif	Geoplot 4	TIF file showing a processed greyscale plot of beta configuration clipped at 1Ω to 30Ω.	05/06/15	D.J.Sabin
CAD data - path: J610 Upper Heyford\CAD				
J610 version 1.dwg	ProgeCAD 2014	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	01/05/15	K.T.Donaldson
Text data - path: J610 Upper Heyford\Documentation				
J610 report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.		D.J.Sabin

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N

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Oxfordshire

Map of survey area

● Survey location

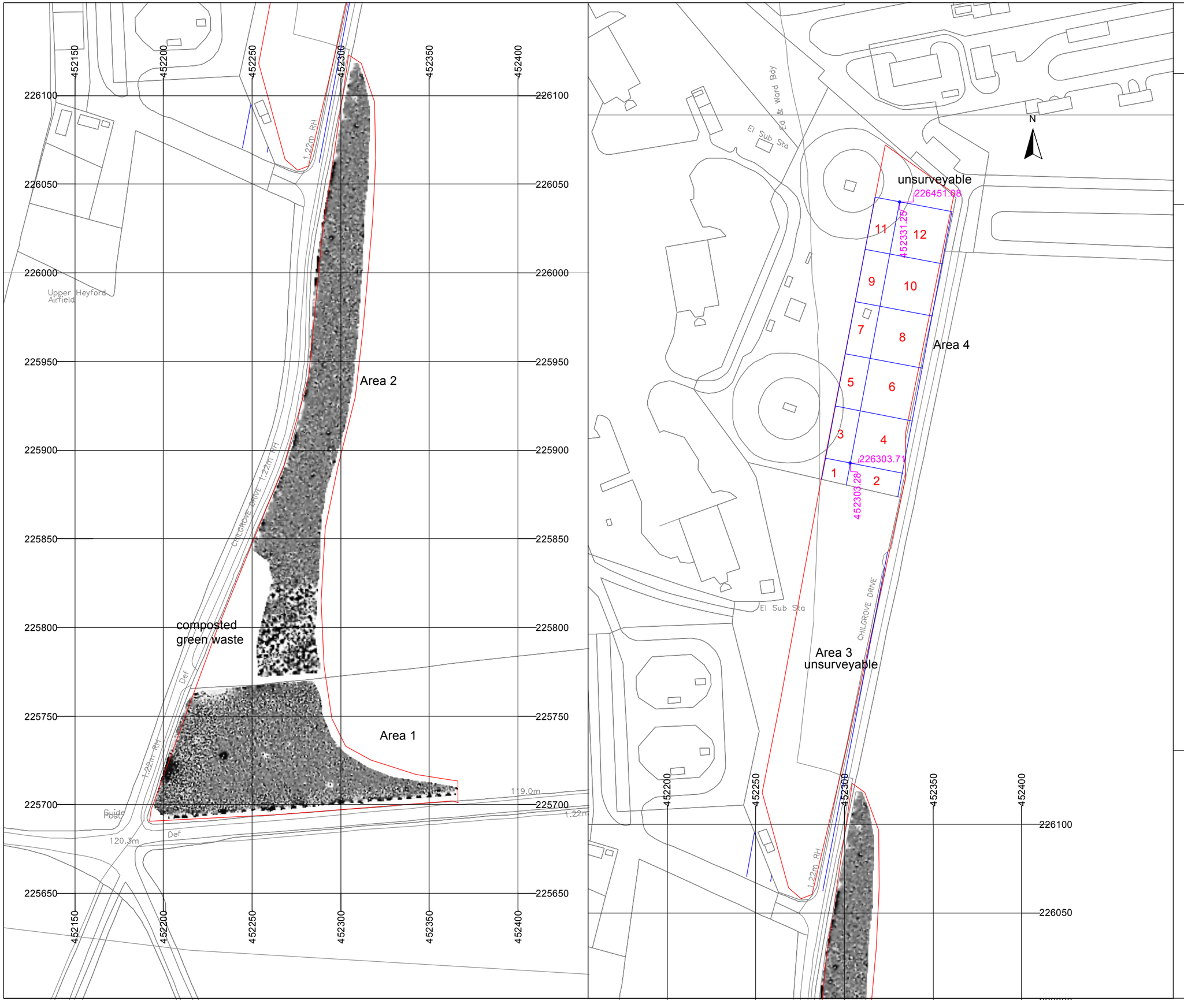
Site centred on OS NGR
SP 52275 26686

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01



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Referencing information

Coordinates based on Ordnance Survey OSGB36 datum.

Grids set out using RTK GPS with Leica SmartNet correction data RTCMv3 format OSTN02 transformation.

Areas 1 and 2 surveyed by magnetometer as randomised data fixed to RTK GPS positions.

Area 3 unsurveyable, Area 4 surveyed by resistance cart across fixed grids.

1 — 30m x 30m Resistivity grid and number (Area 4)

SCALE 1:2000

0m 20 40 60 80 100m

SCALE TRUE AT A3

FIG 02

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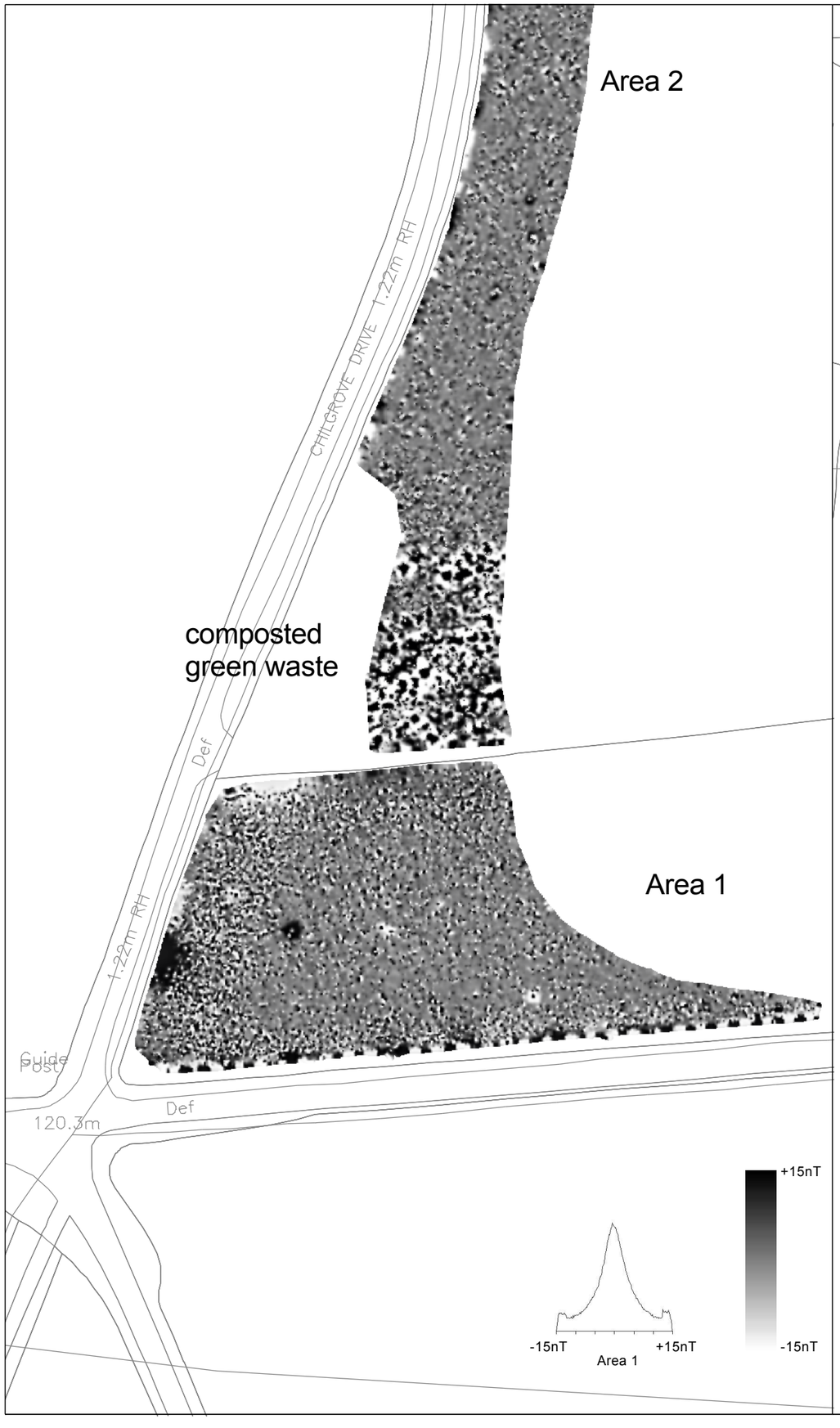
Greyscale plot of minimally processed magnetometer data



SCALE 1:1250

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 03

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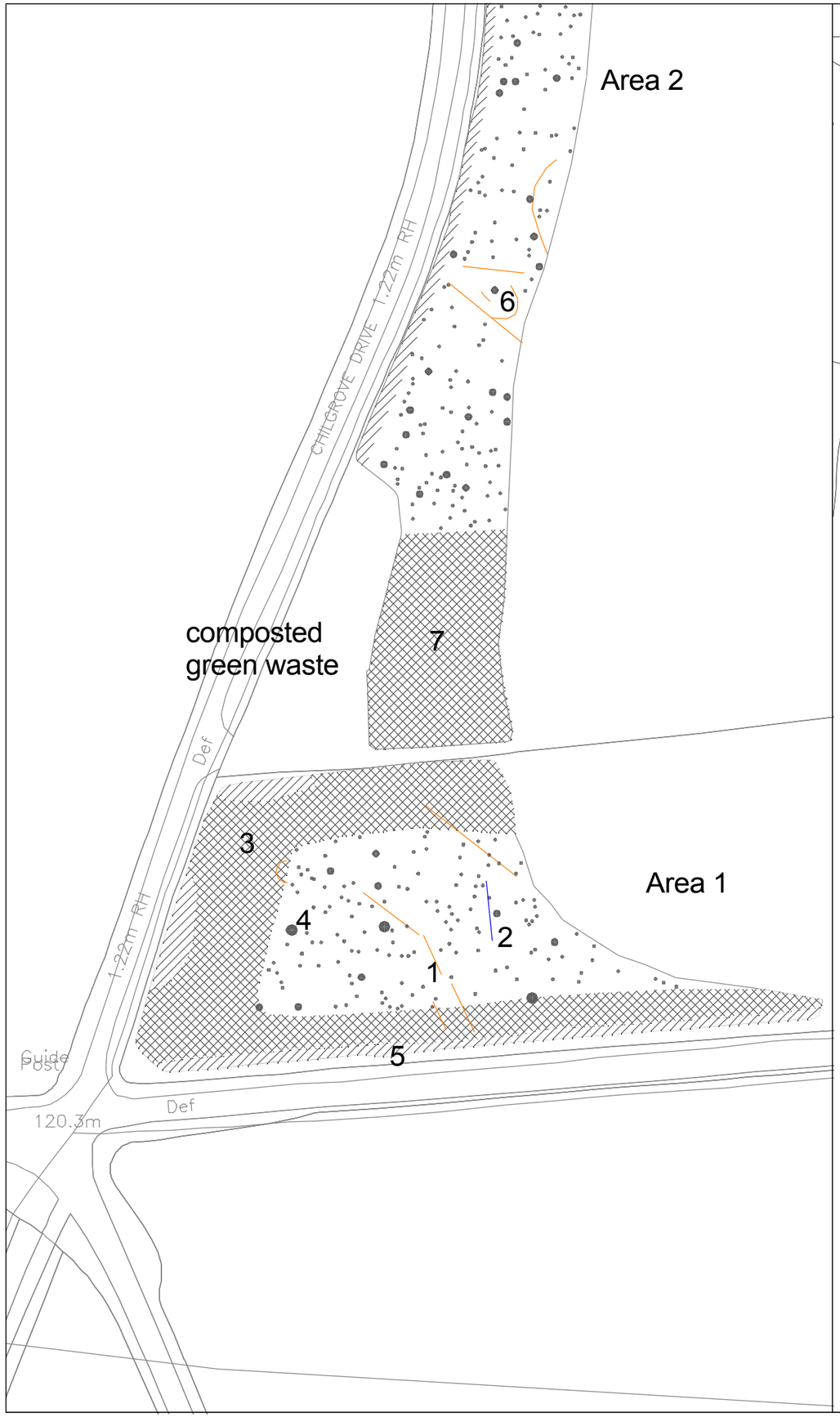
Abstraction and interpretation of magnetometer anomalies



- Positive linear anomaly - possible ditch-like feature
- Negative linear anomaly - material of low magnetic susceptibility
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:1250

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 04

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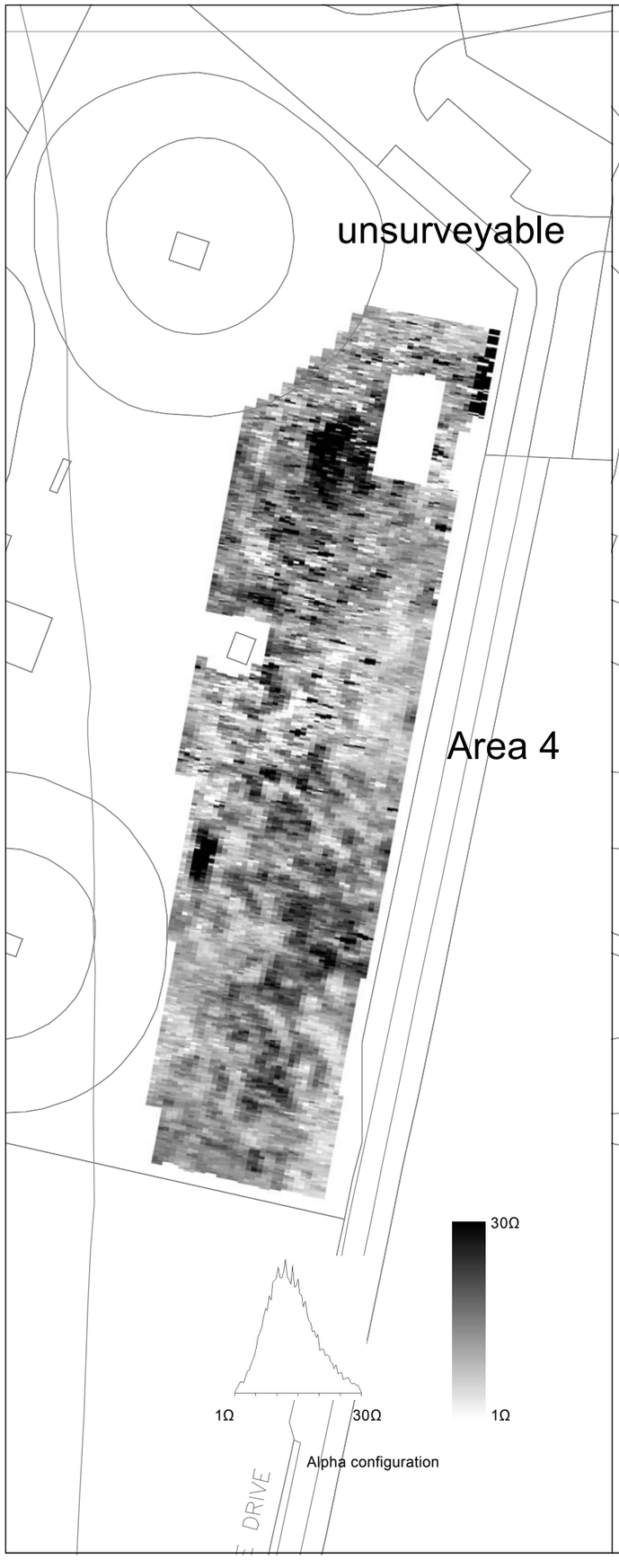
Greyscale plot of raw resistance data - alpha and beta

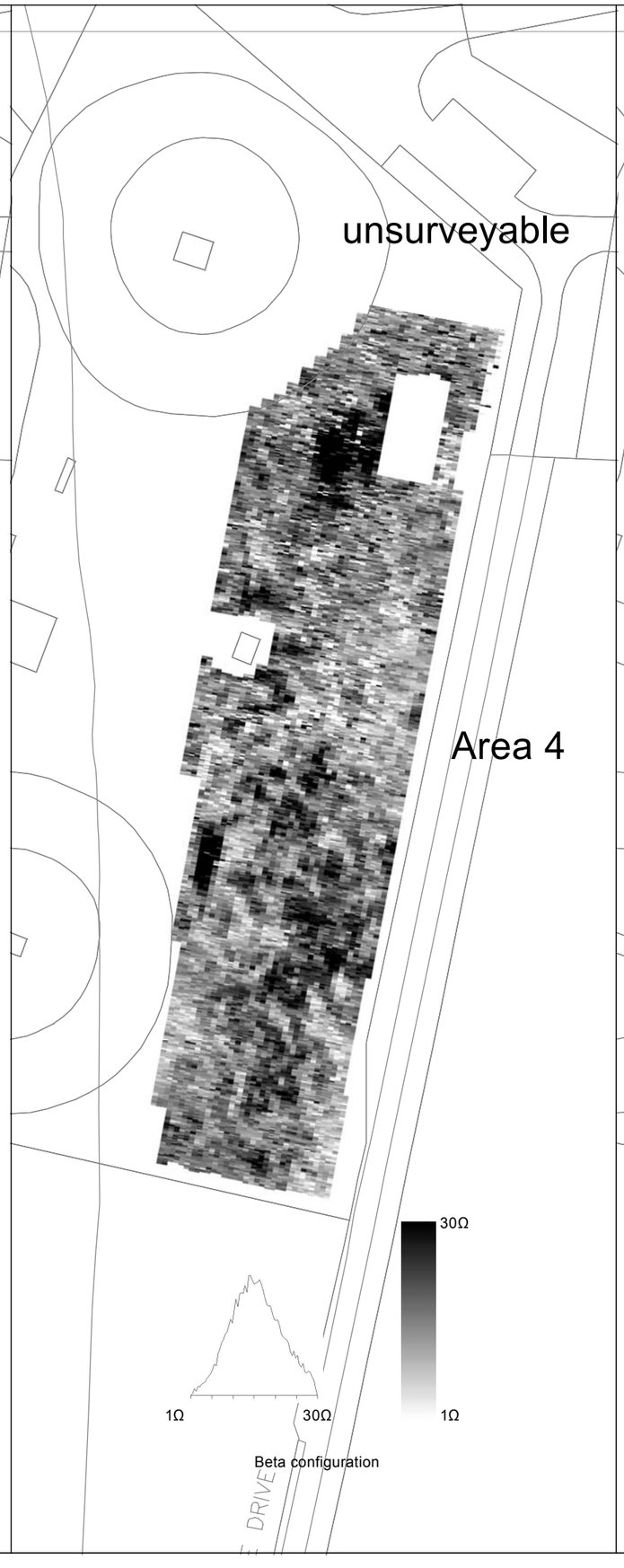
SCALE 1:1000

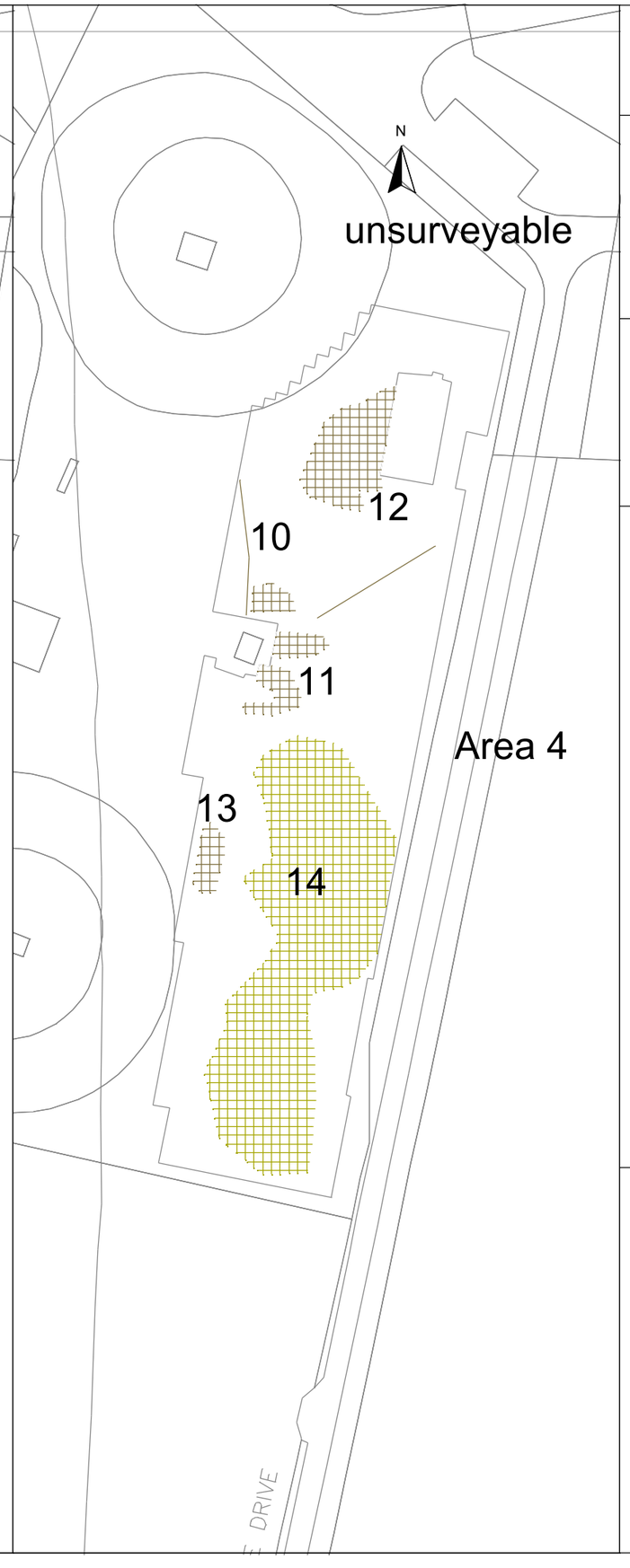
0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 05







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Greyscale plot of processed resistance data - alpha and beta

Abstraction and interpretation of resistance anomalies

- High resistance linear anomaly of uncertain origin
- Area of high resistance possibly associated with airbase features
- Area of variable resistance possibly related to shallow solid geology

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 06