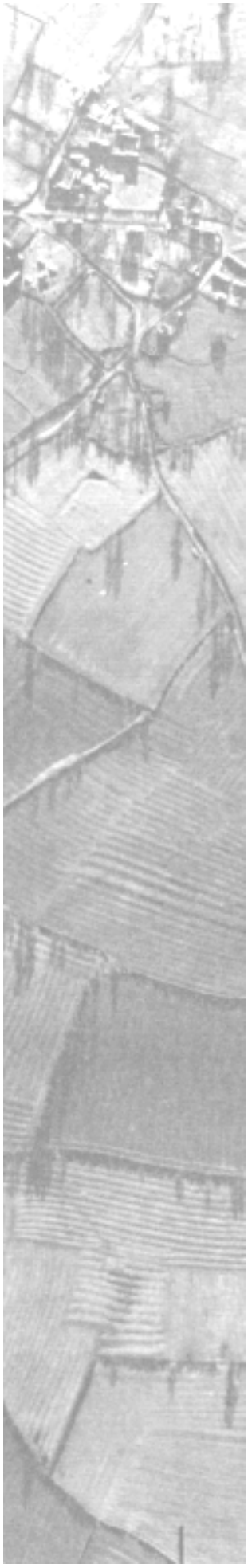

ARCHAEOLOGICAL SURVEYS

GEOPHYSICAL SURVEY REPORT

National Herb Centre
Warmington

Magnetometer and Earth Resistance Survey

for

Lighthorne Herbs Ltd &
Alec Newman

David Sabin and Kerry Donaldson

May 2007

Ref no. 182

ARCHAEOLOGICAL SURVEYS

National Herb Centre
Warmington

Magnetometer and Earth Resistance Survey

for

Lighthorne Herbs Ltd &
Alec Newman

Fieldwork by David Sabin Bsc (Hons) MIFA, Kerry Donaldson Bsc (Hons)
and Francis Sabin
Report by David Sabin and Kerry Donaldson

Survey date – 10th & 11th May 2007
Ordnance Survey Grid Reference – SP 411 473

Archaeological Surveys Limited
2, Westway Close, Castle Combe, Wiltshire, SN14 7QZ
Tel. 01249 782234 FAX 0871 661 8804
Email: info@archaeological-surveys.co.uk
Web: www.archaeological-surveys.co.uk

CONTENTS

LIST OF PLATES

LIST OF TABLES

LIST OF FIGURES

SUMMARY

Magnetometry and earth resistance surveys were carried out at the National Herb Centre near Warmington in south Warwickshire. Magnetometry revealed a complex pattern of former ditches representing land boundaries and enclosures. Earth resistance survey located structural remains probably associated with former Roman buildings. The complex and extensive nature of the magnetic anomalies suggest a long period of occupation and development.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Alec Newman and Lighthorne Herbs Ltd to undertake a geophysical survey of an area of land at the National Herb Centre. This survey formed part of an assessment of the archaeological potential of a Romano-British site currently under investigation by Warmington Heritage group.

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use magnetometry and earth resistance survey to locate potential Romano-British structural remains within a region where surface finds of cultural material and large fragments of masonry indicate a high potential for the survival of Roman features.

1.2.2 Magnetometry survey using a fluxgate gradiometer is a well established technique for rapidly assessing the archaeological potential of a site. The method is particularly suited to the location of former 'cut features' such as ditches and pits and may also respond to masonry remains. The use of magnetometry at this site was mainly intended to define the layout of the landscape immediately adjacent to any structural remains. Magnetometry at similar sites has often revealed complex development associated with Roman structures.

1.2.3 Earth resistance survey is very effective at locating structural remains such as masonry footings. The technique is generally slower than magnetometry and is most effective when targeted on areas of highest archaeological potential, in addition the response to former 'cut features' can be limited.

1.3 Site location

1.3.1 The site is located at the National Herb Centre, Warmington, Warwickshire. OS grid reference SP 411 473.

1.3.2 The survey area is accessed via the main entrance to the National Herb Centre but lies approximately 100m south east of Warmington church.

1.4 Site description and survey conditions

1.4.1 The geophysical survey covered an area of approximately 1.5ha of agricultural land used for growing herbs, see Figure 02. The area contained tracks, hedgerows and fencing with a herb crop of thyme within the northern and south western parts of the surveyed area, however much of the site had been recently ploughed and was rough bare soil.

1.4.2 The southern part of the survey area is relatively flat lying at the north eastern edge of the Marlstone Rock Bed but there is a break of slope along the field tracks running west to east across the site, see Figure 02, with land dropping towards the north and north east. With the position of the site close to the edge of the Marlstone plateau, there are extended views to the north and north west across the Warwickshire clay lands.

1.4.3 Weather conditions during the survey were unfavourable with heavy and extended periods of rainfall and high winds. Although the site is well-drained conditions underfoot were difficult and data quality is slightly degraded.

Plate 1 Survey area looking towards the north east

1.5 Site history and archaeological potential

1.5.1 Romano-British material has been collected during agricultural operations at the site and fieldwork by Warmington Heritage Group identified a range of cultural material associated with the Roman period. This material consists of pottery sherds, terracotta flue tile fragments, stone roofing tiles and stone

debris consistent with building remains. In addition, metal detecting has located a number of Roman coins and a possible military buckle.

1.5.2 The cultural remains would appear to represent a long period of settlement within the Romano-British period. Structural debris suggests that the site would have included substantial masonry buildings. The archaeological potential of the site is considered as very high.

1.6 Geology and soils

1.6.1 The underlying geology is associated with the Middle Lias Marlstone Rock Bed (BGS 1982, Edmonds et al 1965). This forms a plateau of high ground and can be considered as an northern extension to the Cotswolds. The Marlstone is a sandy ferruginous limestone that has been utilised for many centuries for the construction of buildings. The rock has been extensively quarried around Wroxton, approximately 5km to the south, for the production of iron although this no longer occurs as the iron content is relatively low compared to other sources.

1.6.2 The overlying soil is from the Banbury association which is a brown earth derived from Jurassic ironstone. The soil is a well-drained brashy ferruginous soil. (Soil Survey of England and Wales 1983).

1.6.3 The geological/pedological conditions across the site were considered likely to produce very good conditions for magnetic survey. Archaeological Surveys have obtained very good results from similar conditions locally although it is known that other surveyors have reported problems with noise and instrument adjustment due to natural enhancement. The site is well-drained and was considered as likely to give good results for earth resistance survey.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Detailed magnetometry records localised magnetic fields that can relate to former human activity. Alteration of iron minerals present within topsoil is related to activities such as burning and the break down of biological material. These minerals become weakly magnetic within the Earth's magnetic field and can accumulate in features such as ditches and pits that are cut into the underlying subsoil or rock. Mapping this magnetic variation can provide evidence of former settlement and land use. Additional technical details can be found in Appendix A.

2.1.2 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 nanoteslas (nT) which are equivalent to 10^{-9} tesla (T).

2.1.3 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.

2.1.4 The Twin Probe configuration used in this survey is favoured for archaeological prospection and can give a response to features up to 1m in depth with a mobile probe separation of 0.5m.

2.2 Equipment configuration, data collection and survey detail

2.2.1 The detailed magnetic survey was carried out using a Bartington Grad601-2 gradiometer. This instrument effectively measures a magnetic gradient between two fluxgate sensors mounted vertically 1m apart. Two sets of sensors are mounted on a single frame 1m apart horizontally. The instrument is extremely sensitive and is able to measure magnetic variation to 0.1 nanoTesla (nT). All readings are saved to an integral data logger for analysis and presentation.

2.2.2 The instrument is 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. It is often very difficult to obtain optimum balance for the sensors due to localised magnetic vectors that can 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. Archaeological Surveys use a non-magnetic tripod with an additional supporting structure to raise the instrument during the set-up procedure, this has been found to improve the sensor balance.

2.2.3 The Bartington gradiometer undergoes regular servicing and calibration which is carried out by the manufacturer. A current assessment of the instrument is shown in Table 1 below.

Date of calibration/service	August 2006
Sensor type	Bartington Grad - 01 - 1000
Bandwidth	12Hz (100nT range) both sensors
Noise	<100pT peak to peak
Adjustable errors	<2nT

Table 1: Bartington fluxgate gradiometer sensor calibration results

The instrument was considered to be in good working order prior to the survey with no known faults or defects.

2.2.4 Magnetometry data was collected at 0.25m centres along traverses 1m apart. The survey area was separated into 30m by 30m grids 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, 1995).

2.2.5 The earth resistance survey was carried out using TR Systems Ltd Resistance Meter TRCIA 1.31 using a mobile Twin Probe array. The standard mobile frame for the TRCIA instrument has a 0.5m electrode separation and readings were recorded at 1m intervals along 1m traverses across the site.

2.2.6 The resistance meter was operated according to the manufacturer's instructions. No calibration or adjustment is required. The stability of measurements is monitored on site prior to collecting data in order to assess whether any stray earth currents are interfering with the instrument. The instrument can be set to filter stray currents, at this site measurements were considered stable and no additional filtering was used. The position of remote probes is critical to correct resistance measurement, there was no difficulty achieving the minimum 15m required between the remote probes and the survey area.

2.2.7 The survey grids were set out using a Topcon GTS802 robotic total station and Penmap RTK GPS. The GPS was used to establish and reference a baseline orthogonal to the Ordnance Survey National Grid using the OSGB36 datum. Positional accuracy achievable using RTK GPS is considered as better than 10cm. Grid nodes were marked out using wooden pegs and polypropylene ropes with 1m markers were used to establish grid traverses.

2.3 Data processing and presentation

2.3.1 Magnetometry data downloaded from the Grad 601-2 data logger is 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 B 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 magnetometry survey for display. Raw data is 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,
- Zero Median Traverse is applied in order to balance readings along each traverse,

- de-stagger is used to enhance linear anomalies,
- clipping of processed data at ±10nT to enhance low magnitude anomalies
- clipping of trace plots at ±100nT in order to minimise strong readings obscuring low magnitude responses.

(Reference should be made to Appendix B for details on the processing used for each survey area.)

Data processing explanation notes:

Clipping

Clipping replaces the values outside the specified minimum and maximum with those values. The process is useful for displaying detail as extreme values are removed allowing greyscale shades to be allocated to a narrower range of values which improves the definition of anomalies.

Zero Median/Mean Traverse

The median (or mean) of each traverse is calculated ignoring data outside a threshold value, the median (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 is used to remove striping.

De-stagger

Compensates for small positional errors within data collection by shifting the position of the readings along each traverse by a specified amount.

2.3.3 Data logged by the resistance meter is downloaded and processed within ArcheoSurveyor software. Survey grids are used to create a composite file in a similar manner to the magnetometry data, see 2.3.1. Raw data is analysed and displayed within the report as well as processed data. The following processing has been carried out on data in this survey:

- raw earth resistance been clipped at 29.28Ω to 36.15Ω to improve greyscale resolution,
- processed data has been despiked in order to remove spurious high contact resistance responses,
- a high pass filter is passed across the data in order to enhance any archaeological anomalies,
- processed data has been clipped between -4.09Ω and 3.15Ω to enhance any possible archaeological anomalies, negative values are a function of the mathematical operation carried out across the data during filtering.

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

interpretation is possible or where a number of possible origins should be considered, further more detailed discussion is set out in Section 4.

2.3.5 The main form of data display used in this report is the greyscale plot. Magnetic data is also displayed as a trace plot. Both 'raw' and 'processed' data have been shown followed by an abstraction and interpretation plot.

2.3.6 Graphic raster images in BMP format are initially prepared in ArcheoSurveyor. These images are combined with base mapping using AutoCAD LT 2007 creating DWG file formats. 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 2.4 below.

2.4 Archive

2.4.1 Survey results are produced in hardcopy using A4 for text and A3 for plots (all plots are scaled for A3). In addition digital data created during the survey is supplied on CD. Further information on the production of the report and the digital formats involved in its creation are set out below.

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

- ArcheoSurveyor version 2.1.3.3 (geophysical data analysis),
- AutoCAD LT 2007 (report figures),
- JASC Paint Shop Pro 8 (image rotation),
- OpenOffice writer 2.2.0 (document text),
- PDF Creator version 0.9 (PDF archive).

2.4.3 Digital data is supplied on CD ROM and 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 BMP images,
- AutoCAD DWG files in 2000 and 2007 versions,
- report text as a OpenOffice odt file,
- report text as a Word 2000 doc file,
- report text as rich text format (RTF),
- report text as PDF,
- PDFs of all figures,
- photographic record in JPEG format.

2.4.4 The CD ROM structure is formed from a tree of directories under the title J182 Warmington – 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.

2.4.5 The CAD file contains externally referenced graphics, see 2.3.6, 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 eTransmit function to produce a directory containing the digital drawing along with any externally referenced graphics which may need reloading.)

3 RESULTS

3.1 Assessment of survey conditions and data quality

3.1.1 Surface conditions for magnetometry survey were considered poor. Much of the area was open soil that had been recently ploughed resulting in a rough surface and areas to the north and south west of the site had herb beds that created a series of ridges and furrows. In addition heavy and persistent rainfall saturated the soil surface resulting in additional impedance when walking across the site during the data collection process.

3.1.2 The high level of iron minerals within the soil and underlying geology has created relatively high levels of unwanted magnetic noise. It was not possible to locate an adjustment point where no magnetic gradients were present and optimum balancing of the sensors may not have been achieved; this may have been offset to a degree by the very high magnitude and contrast of archaeological anomalies located by the survey.

3.1.3 Earth resistance survey initially revealed frequent high resistance contact problems prior to the onset of heavy rain in the morning of the survey. The rainfall alleviated contact problems as the field surface became damp, it is unlikely that the heavy rainfall has influenced the resistive contrast associated with archaeological features.

3.2 General overview – magnetometry

3.2.1 The detailed magnetic survey covered an area of approximately 1.5ha. Geophysical anomalies located can be generally classified as positive linear, curvilinear, rectilinear and discrete responses of archaeological origin, negative responses of archaeological origin, linear anomalies of an agricultural origin, areas of magnetic debris and strong dipolar anomalies relating to ferrous objects and material in the topsoil. Anomalies located within each survey area have been numbered and will be outlined below with subsequent discussion in Section 4.

3.2.2 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. Sub-headings are then used to group anomalies with similar characteristics for each survey area.

Anomalies with an archaeological origin

Positive anomalies
Negative anomalies

The category is used where positive anomalies have the characteristics of a range of archaeological features such as pits, enclosures etc. Negative anomalies may indicate masonry remains of lower magnetic susceptibility than surrounding soils.

Anomalies with an agricultural origin

Agricultural anomalies

Where confidence is high that anomalies have been caused by agricultural features this category is applied. 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 more modern ploughing.

Anomalies associated with magnetic debris

Magnetic debris
Strong discrete dipolar anomaly

The response often appears as areas containing many small dipolar anomalies that may range from weak to strong in magnitude. Magnetic debris 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.

3.3 Magnetometry results

See Figures 03 - 06.

Anomalies with an archaeological origin

(1) – Linear and curvilinear positive anomalies in the eastern part of the survey area are associated with the magnetically enhanced fill of former cut features. The anomalies possibly form an enclosure with an entrance to the north, however the relationship between the anomalies is not clear suggesting a long period of use and redevelopment.

(2) – Linear and curvilinear anomalies within the central and southern parts of the survey area are associated with the magnetically enhanced fill of former cut features. Similar to anomalies (1) to the east, the features may form an enclosure or series of enclosures although there is some evidence for a change in orientation with a north east – south west alignment.

(3) – Linear and curvilinear anomalies to the west of the survey area suggest a continuation of archaeological features to the west beyond the surveyed area.

(4) – Several linear anomalies extend to the north east and have a north east to south west orientation with perpendicular linear elements orientated north west to south east. The common orientation to these anomalies suggest that they belong to a series of ditches probably related to an early field system. Some of the anomalies are clearly related to linear anomalies (2) within the central southern part of the survey area. There is evidence that anomalies extend to the east beyond the surveyed area.

(5) – An area of negative linear or rectilinear response with adjacent positive linear anomalies corresponds with a zone of masonry debris and to linear high resistance anomalies. The negative response may be associated with a zone of relatively low magnetic susceptibility which can be typical of building debris or remains.

(6) – A number of discrete positive anomalies were located across the survey area. It is likely that these represent pit-like features and may be associated with former quarrying.

Anomalies with an agricultural origin

(7) – A series of linear anomalies extend across the site with an orientation similar to current field boundaries and tracks. These are associated with the current ploughing trend, only a small area has been abstracted as the anomalies are visible across much of the survey area.

Anomalies associated with magnetic debris

(8) – An area of magnetic debris associated with ferrous material probably of modern origin.

(9) – An area of magnetic debris associated with a former fenceline.

3.4 General overview – earth resistance survey

3.4.1 The earth resistance survey covered an area of approximately 0.5ha. Anomalies located have been classified as high resistance linear anomalies associated with structural remains, high and low resistance anomalies of uncertain origin and high resistance anomalies associated with herb beds and modern agricultural tracks.

3.4.2 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 resistance survey. A basic explanation of the characteristics of the anomalies is set out for each category in order to justify interpretation. Sub-headings are then used to group anomalies with similar characteristics for each survey area.

High resistance anomalies associated with structural remains

Structural remains

The category is used where high resistance anomalies have a linear or rectilinear form and are clearly associated with masonry debris.

High resistance anomalies of uncertain origin

Low resistance linear anomaly
High resistance linear anomaly
Area anomaly

High resistance linear anomalies may be associated with former structures although they may be poorly defined and isolated resulting in a low confidence interpretation. An area of high resistance may be related to structural debris although its origin cannot be confidently determined. A low resistance linear anomaly may represent a ditch or agricultural feature.

High resistance anomalies related to agricultural tracks and herb beds

High resistance anomalies caused by low moisture content related to ground compression and to plastic membranes close to herb beds.

3.5 Earth resistance survey results

See Figures 07 – 09.

High resistance anomalies associated with structural remains

(10) – A series of fragmented high resistance linear and rectilinear anomalies within the north western part of the surveyed area are located in the vicinity of Romano-British masonry debris and other cultural material. It is likely that the anomalies represent in-situ Roman structural remains.

(11) – Faint high resistance linear anomalies located within the central part of the site may represent structural remains of Roman origin as there is evidence of masonry debris and other cultural material on the field surface in this area.

High resistance anomalies of uncertain origin

(12) – Poorly defined high resistance linear anomaly may be associated with adjacent structural remains (10).

(13) – Isolated high resistance linear responses of uncertain origin may be structural.

(14) – An amorphous area of high resistance is of uncertain origin although it may be associated with structural debris or a former platform.

(15) – A low resistance linear anomaly appears almost parallel to an agricultural track to the south and may represent a relatively modern agricultural feature. The response may also be consistent with an in-filled ditch.

High resistance anomalies associated with tracks and herb beds

(16) – These anomalies have been caused by modification of soil moisture due to ground compression and the use of plastic membranes. They are not of archaeological interest.

4 DISCUSSION

4.1 Magnetometry survey

4.1.1 Magnetometry proved extremely effective across the survey area and has indicated the presence of an extensive archaeological site probably extending well beyond the survey area. The very strong contrast associated with many of the anomalies is related to the high level of ferrous minerals present within the soils. In addition, there appears to be a tendency for increasing enhancement within the southern half of the survey area which could be associated with a 'settlement effect'. This effect defines a relationship between increasing soil susceptibility and increasing 'intensity' of settlement. This increased 'intensity' may be an indication of an increased frequency of burning episodes (hearths, ovens, furnaces, etc.) related to higher settlement density or longer periods of occupation.

4.1.2 The high magnitude and strong contrast of the magnetic anomalies is considered further. Often the lower fill of a 'cut' feature contains some of the most magnetically enhanced material as this material is often contemporary with the period of occupation; later fills may become less enhanced as the percentage of burnt (enhanced magnetic susceptibility) material becomes lower. If the site is subject to colluviation or other depositional processes where archaeological deposits are located at some depth, the magnetic contrast to the anomalies may be lower when compared to sites where an erosional environment exists and the lower fills are closer to the instrument. The very strong contrast to anomalies observed at this site may support evidence of shallow depth, in addition, there is a lack of small or fine features normally visible on occupation sites and although these may be masked by the strong response to modern agricultural features (plough marks), it should be considered that any shallow features have been completely removed by agricultural activity. The frequent observation of large masonry fragments on

the soil surface and high density of pottery sherds would also support evidence of severe erosion to the archaeological resource.

4.1.3 The pattern of magnetic anomalies located by the survey is complex and geophysics cannot be readily used in the understanding of phasing across such sites. Some basic observations may help to further understand the development of the site but a number of assumptions have to be made. Curvilinear and less regular linear anomalies are often associated with a more 'native' style of land use and settlement. Information from similar sites has revealed that they may undergo many stages of redevelopment over a long period of time. It would appear that the site does contain elements that would be consistent with prehistoric through to early Roman settlement and farming with perhaps a more regular realignment of boundaries later in the Roman period. From similar sites in the region, there is good evidence for continuing occupation back to the Bronze Age (Sabin and Donaldson, 2006) and with Bronze Age occupation known from Nadbury Camp only 2km to the west it is plausible that the site was also occupied in this period.

4.1.4 The magnetic evidence for Romano-British structures is limited, however this is not entirely unexpected as masonry remains are often not located by magnetometry or have a very weak negative response relating to their low magnetic susceptibility. Magnetic susceptibility measurements were not conducted directly on soil or rock samples but the magnetic susceptibility for most sedimentary rocks will be lower than the surrounding soil and despite the high iron content within the rock, magnetic susceptibility is likely to be low unless the material has been subject to high temperatures. A zone of negative magnetic response in the north western part of the site does have poorly defined rectilinear elements and is associated with structural debris, in addition, high resistance anomalies typical of wall remains were located in the vicinity.

4.2 Earth Resistance Survey

4.2.1 The results of earth resistance survey have complemented those from the magnetometry and the technique was targeted on areas considered to be more likely to contain structural remains. This increased potential is based on observation of the spatial distribution of larger masonry fragments that have been dislodged by ploughing.

4.2.2 Structural remains do appear in the data suggesting that there is some survival of in-situ masonry remains, however the results have revealed fragmeted linear responses that may suggest there is either little survival of walls or that there is insufficient contrast between the response to walls and the surrounding soils. Two distinct zones appear to contain structural remains with stronger evidence from the north western part of the survey area. This would indicate that the building was positioned on ground sloping down to the north which may have given shelter from prevailing winds. It is likely that some terracing would have been required to increase structural stability and this may relate to the fragmented response as survival of building footings would be better for walls cut into the slope.

4.2.3 The orientation of the fragmented wall remains tends to reflect positive linear anomalies located by magnetometry to the east. This may indicate that a building faced the south east which would be consistent with a well planned Romano-British site with a series of surrounding small fields or land packages. The extent of masonry remains and their relationship cannot be clearly determined from the geophysics.

5 CONCLUSION

5.1

5.1.1 The results of both magnetometry and earth resistance survey have indicated an extensive archaeological site at Warmington that probably relates to an extended period of settlement and occupation. Magnetic anomalies located at the site are consistent with cut features from the prehistoric and Romano-British periods and high resistance anomalies relate to Roman structural remains.

5.1.2 Analysis of the geophysics, with consideration of the topography and large amount of cultural material present within the site, tends to suggest that there is severe disturbance to the archaeological record that may be in part related to slope processes i.e. the sloping ground is likely to produce an erosional environment effectively resulting in slow loss of topsoil with subsequent lowering of the ploughsoil base.

5.1.3 The site would fit into the relatively high density pattern of 'middle status' villas located along the Middle Lias northern fringe of the Cotswolds. Many of these sites show development from the prehistoric to the late Roman periods.

6 REFERENCES

British Geological Survey, 1982, Banbury*, England and Wales Sheet 201, Solid and Drift Edition, 1:50 000 Series.*

Edmonds, E.A., Poole, E.G. and Wilson, V., 1965, *Geology of the Country around Banbury and Edge Hill.* Memoirs of the Geological Survey of Great Britain, Her Majesty's Stationery Office, London.

English Heritage, 1995, *Geophysical survey in archaeological field evaluation. Research and Professional Service Guideline No 1*.

Sabin, D.J. and Donaldson, K.T., 2006, *Pillerton Priors Romano-British Villa Site Geophysical Survey Report.* Unpublished document.

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 on 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 the 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 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 of 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 – survey and data information

Raw magnetometry

COMPOSITE
Filename: Mag-raw.xcp
Instrument Type: Grad 601 (Magnetometer)
Units: nT
Surveyed by: on 11/05/2007
Assembled by: on 11/05/2007
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: One

Dimensions
Composite Size (readings): 400 x 180
Grid Size: 20 x 20
X Interval: 0.25
Y Interval: 1

Stats
Max: 42.66
Min: -40.04
Std Dev: 9.90
Mean: -2.19

Processes: 3
1 Base Layer
2 Clip from -30 to 30

Source Grids: 39
1 Col:0 Row:2 grids\29.asg
2 Col:0 Row:3 grids\01.asg
3 Col:0 Row:4 grids\02.asg
4 Col:0 Row:5 grids\03.asg
5 Col:0 Row:6 grids\28.asg
6 Col:1 Row:1 grids\30.asg
7 Col:1 Row:2 grids\31.asg
8 Col:1 Row:3 grids\04.asg
9 Col:1 Row:4 grids\05.asg
10 Col:1 Row:5 grids\06.asg
11 Col:1 Row:6 grids\25.asg
12 Col:1 Row:7 grids\26.asg
13 Col:1 Row:8 grids\27.asg
14 Col:2 Row:1 grids\32.asg
15 Col:2 Row:2 grids\33.asg
16 Col:2 Row:3 grids\07.asg
17 Col:2 Row:4 grids\08.asg
18 Col:2 Row:5 grids\09.asg
19 Col:2 Row:6 grids\22.asg
20 Col:2 Row:7 grids\23.asg
21 Col:2 Row:8 grids\24.asg
22 Col:3 Row:0 grids\34.asg
23 Col:3 Row:1 grids\35.asg
24 Col:3 Row:2 grids\36.asg
25 Col:3 Row:3 grids\10.asg
26 Col:3 Row:4 grids\11.asg
27 Col:3 Row:5 grids\12.asg
28 Col:3 Row:6 grids\19.asg
29 Col:3 Row:7 grids\20.asg
30 Col:3 Row:8 grids\21.asg
31 Col:4 Row:0 grids\37.asg
32 Col:4 Row:1 grids\38.asg
33 Col:4 Row:2 grids\39.asg
34 Col:4 Row:3 grids\13.asg
35 Col:4 Row:4 grids\14.asg
36 Col:4 Row:5 grids\15.asg
37 Col:4 Row:6 grids\16.asg
38 Col:4 Row:7 grids\17.asg
39 Col:4 Row:8 grids\18.asg

Processed magnetometry

COMPOSITE
Filename: Mag-proc.xcp
Instrument Type: Grad 601 (Magnetometer)
Units: nT
Surveyed by: on 11/05/2007
Assembled by: on 11/05/2007
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: One

Dimensions
Composite Size (readings): 400 x 180
Grid Size: 20 x 20
X Interval: 0.25
Y Interval: 1

Stats
Max: 11.15
Min: -10.00
Std Dev: 6.32
Mean: 0.19

Processes: 20
1 Base Layer
2 Clip from -30 to 30
3 DeStripe Median Traverse: Grids: All
4 De Stagger: Grids: 29.asg 01.asg 02.asg 03.asg 28.asg Mode: Both By: -2 intervals
5 De Stagger: Grids: 06.asg 25.asg 26.asg 27.asg Mode: Both By: -1 intervals
6 De Stagger: Grids: 32.asg 33.asg Mode: Both By: -1 intervals
7 De Stagger: Grids: 07.asg 08.asg 09.asg 22.asg 23.asg 24.asg Mode: Both By: -1 intervals
8 De Stagger: Grids: 34.asg 35.asg 36.asg 10.asg Mode: Both By: -1 intervals
9 De Stagger: Grids: 11.asg Mode: Both By: -1 intervals
10 De Stagger: Grids: 12.asg Mode: Both By: -1 intervals
11 De Stagger: Grids: 19.asg Mode: Both By: -1 intervals
12 De Stagger: Grids: 20.asg Mode: Both By: -1 intervals
13 De Stagger: Grids: 37.asg 38.asg Mode: Both By: -1 intervals
14 De Stagger: Grids: 39.asg 13.asg 14.asg Mode: Both By: -1 intervals
15 De Stagger: Grids: 15.asg 16.asg 17.asg 18.asg Mode: Both By: -1 intervals
16 De Stagger: Grids: 15.asg Mode: Both By: 1 intervals
17 Clip from -10 to 10
18 DeStripe Median Traverse: Grids: All
19 Clip from -10 to 10
20 De Stagger: Grids: 21.asg Mode: Both By: -1 intervals

Raw resistance data

COMPOSITE
Filename: Res-raw.xcp
Description:
Instrument Type: TR/CIA (Resistance)
Units: Ohm
Surveyed by: on 11/05/2007
Assembled by: on 11/05/2007
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Dummy Value: -2147483648
Origin: Zero

Dimensions
Composite Size (readings): 80 x 80
Grid Size: 20 x 20
X Interval: 1
Y Interval: 1

Stats
Max: 36.15
Min: 29.28
Std Dev: 2.39
Mean: 32.43

Processes: 3
1 Base Layer
2 Clip at 2 SD
3 Clip at 1 SD

Source Grids: 11
1 Col:0 Row:1 grids\03.asg
2 Col:0 Row:2 grids\04.asg
3 Col:1 Row:1 grids\05.asg
4 Col:1 Row:2 grids\06.asg

5 Col:1 Row:3 grids\02.asg
6 Col:2 Row:0 grids\11.asg
7 Col:2 Row:1 grids\07.asg
8 Col:2 Row:2 grids\08.asg
9 Col:2 Row:3 grids\01.asg
10 Col:3 Row:0 grids\10.asg
11 Col:3 Row:1 grids\09.asg

Processed resistance data

COMPOSITE
Filename: Res-proc.xcp
Instrument Type: TR/CIA (Resistance)
Units: Ohm
Surveyed by: on 11/05/2007
Assembled by: on 11/05/2007
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Dummy Value: -2147483648
Origin: Zero

Dimensions
Composite Size (readings): 80 x 80
Grid Size: 20 x 20
X Interval: 1
Y Interval: 1

Stats
Max: 3.15
Min: -4.09
Std Dev: 1.74
Mean: -0.49

Processes: 8
1 Base Layer
2 Clip at 2 SD
3 Despike Threshold: 3 Window size: 6x3
4 Despike Threshold: 3 Window size: 6x6
5 High pass Gaussian filter: Window: 21 x 21
6 Clip at 2 SD
7 Edge Match (Area: Top 60, Left 20, Bottom 79, Right 62) to Top edge
8 Clip at 2 SD