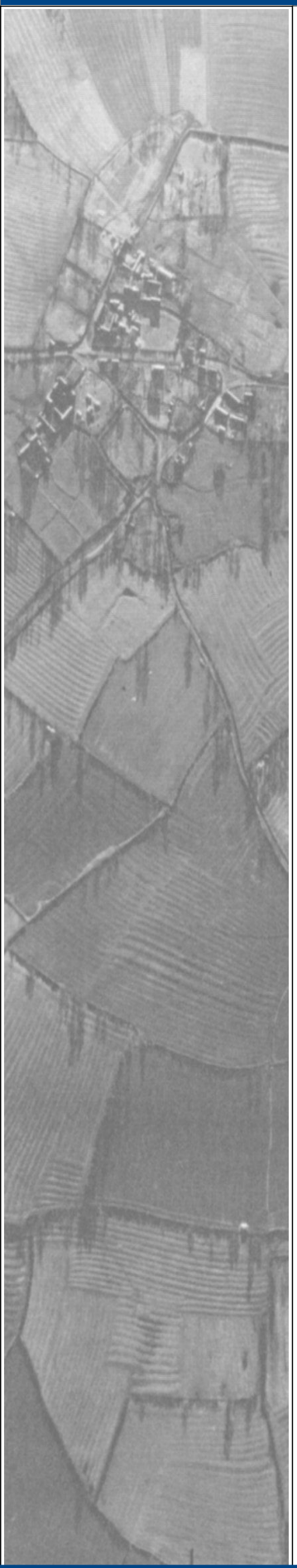

Berkeley Farm Dairy Solar Array
Wroughton
Swindon

MAGNETOMETER & EARTH RESISTANCE SURVEY REPORT

for

Avon Archaeology Ltd

Kerry Donaldson & David Sabin

November 2022

Ref. no. J941

ARCHAEOLOGICAL SURVEYS LTD

Berkeley Farm Dairy Solar Array
Wroughton
Swindon

Magnetometer & Earth Resistance Survey Report

for

Avon Archaeology Ltd

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Report checked by David Sabin
Primary archive location - Archaeological Surveys Ltd, Yatesbury, Wiltshire

Survey dates – 31st October & 1st November 2022
Ordnance Survey Grid Reference – **SU 15221 81147**

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SUMMARY

A geophysical survey was carried out by Archaeological Surveys Ltd over a small area of land at Berkeley Farm, Wroughton that has been outlined for a proposed solar array. As a previous magnetometry survey did not locate clearly defined anomalies within an adjacent site where excavation located Iron Age and Roman occupation, both earth resistance and magnetometry surveys were carried out. The results revealed responses by both techniques to the extant ridge and furrow. The magnetometry results revealed a line of pit-like features, but it is not clear if they are of anthropogenic or natural origin. Weakly positive magnetic linear anomalies were very poorly defined and did not correspond to any responses located by resistivity. A number of low resistance anomalies may relate to former cut features, some appear to cut through the ridge and furrow and are, therefore, later features, possibly associated with land drainage. Despite the significantly lower resolution of the resistivity data compared to the magnetometry, the technique appears to provide more clearly contrasting anomalies across the site.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Avon Archaeology Ltd to undertake a magnetometer and earth resistance (resistivity) survey of an area of land at Berkeley Farm, Wroughton. The site has been outlined for a proposed solar array and the survey forms part of an archaeological assessment.

1.1.2 Previous magnetometry survey in the fields to the west and north west did not locate well defined cut features, which were subsequently identified through evaluation excavation and, therefore, the survey targeted the area outlined for the proposed solar array with both magnetometry and resistivity.

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use magnetometry and earth resistance survey (resistivity) to locate geophysical anomalies that may be archaeological in origin so that they may be assessed prior to development of the site. The methodology is considered an efficient and effective approach to archaeological prospection.

1.2.2 Geophysical survey can provide useful information on the archaeological potential of a site; however, the outcome of any survey relies on a number of factors and as a consequence results can vary. The success in meeting the aims and objectives of a survey is, therefore, often impossible to predetermine.

1.3 Standards, guidance and recommendations for the use of this report

1.3.1 Archaeological Surveys Ltd is a Registered Organisation with the Chartered Institute for Archaeologists and both company directors are Members of the Chartered Institute for Archaeologists (MCIfA) and have therefore been assessed for their technical competence and ethical suitability and abide by the CifA Codes of Conduct. The survey and report generally follow the recommendations set out by: European Archaeological Council (2015) *Guidelines for the Use of Geophysics in Archaeology;* 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) (updated 2020) *Standard and Guidance for Archaeological Geophysical Survey.*

1.3.2 Archaeological Surveys Ltd provide a detailed geophysical survey report and it is recommended that where possible the contents should be considered in full. The Summary provides a brief overview of the results with more detail available in the Discussion and/or Conclusion. The *List of anomalies* within the Results provides a detailed assessment of the anomalies within separate categories which can be useful in inferring a level of confidence to the interpretation. Quality and factors influencing the interpretation of anomalies is also set out within the results.

1.3.3 It is recommended that the full report should always be considered when using data and interpretation plots; where this is not possible, in the field for example, the abstraction and interpretation plots should retain their colour coding and be used with a corresponding legend.

1.3.4 Where targeting of anomalies by excavation is to be carried out, care should be taken to place trenches over solid lines or features visible on the abstraction and interpretation plots. Archaeological Surveys abstraction and interpretation avoids the use of dashed or dotted line formats, and broken or fragmented lines used in interpretive plots may well correspond closely with truncation of archaeological features.

1.4 Site location, description and survey conditions

1.4.1 The site is located at Berkeley Farm, Wroughton, Swindon. It is centred on Ordnance Survey National Grid Reference (OS NGR) SU 15221 81147, see Figs 01 and 02.

1.4.2 The geophysical survey covers approximately 1ha within the southern half of a pasture field. The site is generally on level ground at around 110m AODN. It is comparatively low lying land drained towards the north by field ditches. A new residential development is located on land to the west and separated from the site by an earth bank. Field boundaries are mainly hedgerows. The southern part of field contained steel animal feeders and these were avoided

by the magnetometry survey; during the resistivity survey they were moved allowing coverage of the full area.

1.4.3 The ground conditions across the site were generally considered to be suitable for the collection of geophysical data; however, the southern part of the field was waterlogged and muddy due to high rainfall in the period prior to the survey. Weather conditions during the survey were mainly fine.

1.5 Site history and archaeological potential

1.5.1 A previous geophysical survey was carried out on land immediately to the west and north west (Archaeological Surveys, 2014). A small number of positive responses were located, but these were very weak and poorly defined, although natural palaeochannels did produce a magnetic response. Subsequent evaluation identified a number of features to the north west containing Roman pottery with generally unstratified pottery dating to the 12th to 15th century across the site (Cotswold Archaeology, 2014). Later excavation in the north western part of the site revealed evidence for prehistoric activity as well as a late Iron Age to early Roman settlement (Foundations Archaeology 2021), none of the features were clearly identifiable in the earlier magnetometry data.

1.6 Geology and soils

1.6.1 The underlying geology is mudstone from the Kimmeridge Clay Formation with overlying head deposits (BGS, 2022).

1.6.2 The overlying soil across the site is from the Denchworth association (712b) and is a pelo-stagnogley soil. It consists of a slowly permeable, seasonally waterlogged, clayey soil (Soil Survey of England and Wales, 1983).

1.6.3 Magnetometry carried out over similar geology and soil has produced variable results as there can often be a lack of magnetic contrast between the fill of cut features and the material into which they are cut. Resistivity was also carried out in this instance, due to the known low magnetic susceptibility of the soils, and has produced useful results from similar damp clay geology.

2 METHODOLOGY

2.1 Technical synopsis - magnetometry

2.1.1 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance (also known as thermoremanence) are factors associated with the formation of localised fields.

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). Additional details are set out in 2.2 below and within Appendix A.

2.2 Technical synopsis - resistivity

2.2.1 The electrical resistance or resistivity of the soil depends upon moisture content and distribution. 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 although in certain conditions it may also produce a high resistance anomaly.

2.2.2 Localised variations in resistance are measured in ohms (Ω) which is the SI unit for electrical impedance or resistance. Additional details are set out in 2.2 below and within Appendix B.

2.3 Equipment configuration, data collection and survey detail - magnetometry

2.3.1 The detailed magnetic survey was carried out using a SENSYS MAGNETO® MX V3 6 channel cart-based system. The instrument has 6 fluxgate gradiometers (FGM650) spaced 0.5m apart with readings recorded at 20Hz. Each sensor is not zeroed in the field as the vertical axis alignment is precisely fixed leaving sensor offsets that are removed during data processing. The fixing of the vertical alignment ensures the sensors are not unduly influenced by localised magnetic fields and that the vertical component of a magnetic anomaly is measured. The gradiometers have a range of recording data between ±0.1nT and ±8000nT. They are linked to a Leica GS10 RTK GNSS with data recorded by SENSYS MonMX software on a rugged notebook computer system.

2.3.2 Due to the fixed offsets within the fluxgate sensors, as a result of the manufacturing and tensioning process, the survey data do not provide a visually useful dataset until a zero median traverse algorithm is applied. It is recognised that this has the potential to affect some anomalies detrimentally by removing linear features

orientated parallel to survey transects. However, this has not been noted as a particular problem with the system due to the high resolution data collection, generally long length of traverses and variability within the magnetic characteristics of a linear anomaly.

2.3.3 Data are collected along a series of parallel survey transects to achieve 100% coverage of the surveyable land. The length of each transect is variable and relates to the size of the survey area and other factors including ground conditions. A visual display allows accurate placing of transects and helps maintain the correct separation between adjacent traverses. Data are not collected within fixed grids and data points are considered to be random even though the data are collected in a systematic manner covering all accessible areas (Aspinall, Gaffney and Schmidt, 2009).

2.3.4 Fluxgate sensors are highly sensitive to temperature change and this manifests as drift during the course of a survey. This can be particularly noticeable during the morning as temperatures rise and the equipment warms or cools. Sensor drift within the course of a traverse will appear as a line trending from negative to positive after processing with a zero median traverse algorithm. To remove the potential for temperature drift, data were collected after a 20 minute stabilisation period and traverses were limited to a time of generally <100s.

2.4 Equipment configuration, data collection and survey detail - resistivity

2.4.1 The earth resistance survey was carried out using a Geoscan Research Ltd RM85 resistance meter using a mobile twin probe array with a 0.5m electrode separation. Data were recorded at 1m intervals along traverses separated by 1m. The instrument was set to filter stray earth currents which can cause errors within the resistance measurements. The survey was carried out in a zig-zag fashion over grids 30m x 30m in size.

2.4.2 The survey grids were set out to the Ordnance Survey OSGB36 datum using a Leica GS10 RTK GNSS. The GNSS 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).

2.5 Data processing and presentation

2.5.1 Magnetic data collected by the MAGNETO® MX V3 cart-based system are initially prepared using SENSYS MAGNETO® DLMGPS software. The software effectively allocates a geographic position for each data point and can compensate for fixed offsets present within the FGM650 sensors. The offsets are positive or negative values present on all fluxgate gradiometer sensors. Some systems use manual or electronic balancing to effectively zero the sensors; however, this is a short term measure that is prone to drift through temperature changes and vibration and can easily be incorrectly set

due to localised magnetic fields. The FGM650 sensors are very accurately aligned to the vertical magnetic gradient and are highly stable showing negligible drift on long traverses. The offset values are removed using TerraSurveyor software.

2.5.2 Survey tracks are analysed and georeferenced raw data (UTM Z30N) are then exported in ASCII format for further analysis and display within TerraSurveyor. The removal of the offset values (compensation) of the sensors is also carried out in TerraSurveyor using a zero median traverse function. Data are then considered to be minimally processed. Note: without the zero median traverse function it is not possible to create a meaningful data plot as all sensors have a different offset value. 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.

2.5.3 The minimally processed magnetic data are collected between limits of ±8000nT and clipped for display at ±3nT. Data are interpolated to a resolution of effectively 0.5m between tracks and 0.15m along each survey track.

2.5.4 Additional data processing has been carried out in the form of high pass filtering. This effectively removes low frequency variation along a traverse that has been caused by large magnetic bodies, cultivation or rapid temperature change. Data treated to additional processing have been compared to unprocessed data to ensure that no significant anomalies have been removed. Filtered data has been clipped at ±2nT in order to highlight very weak anomalies.

2.5.5 Appendix D contains metadata concerning the magnetometer survey and data attributes and is derived directly from TerraSurveyor. Reference should be made to Appendix C for further information on processing.

2.5.6 For magnetometry data a TIF file is produced by TerraSurveyor software along with an associated world file (.TFW) that allows automatic georeferencing (OSGB36 datum) when using GIS or CAD software. The main form of data display used in the report is the minimally processed greyscale plot. Minimally processed data is considered by the manufacturer to be data that is compensated by SENSYS MAGNETO DLMGPS software, see 2.3.3 and 2.3.4. Note: traceplots are not considered to be appropriate as they do not provide an accurate or useful assessment of the magnetic anomalies due to very high density of data collection.

2.5.7 Data logged by the RM85 resistance meter are downloaded using Geoplot 4 software and processed within TerraSurveyor. Appendix D metadata sets out the data range and the processing sequence, with further details regarding the processing functions set out within Appendix C.

2.5.8 TIF files are prepared in TerraSurveyor for the earth resistance data. The main form of resistivity data display used in the report is the minimally processed

greyscale raster graphic image. A filtered image is also displayed where a high pass filter is used to smooth the data and enhance anomalies.

2.5.9 The raster images are combined with base mapping using ProgeCAD Professional 2021 creating DWG (2018) 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.

2.5.10 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.

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

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

3 RESULTS

3.1 Data interpretation

3.1.1 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 geophysical anomalies is set out for each category in order to justify interpretation, see Table 1.

Interpretation category	Description and origin of anomalies
Anomalies with an uncertain origin	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. Morphology may be unclear or uncharacteristic and there may be a lack of additional supporting information.
Anomalies with an agricultural origin	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. This category does not include agricultural features of early date or considered to be of archaeological potential (e.g. animal stockades, enclosures, farmsteads, etc).
Anomalies associated with magnetic	Strong discrete dipolar anomalies are responses to ferrous objects within

debris	the topsoil.
Anomalies with a modern origin	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 these 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 adjacent to strong magnetic sources. Buried services may produce characteristic multiple dipolar anomalies dependant upon their construction. Resistivity anomalies may be high or low and are clearly associated with extant modern features.

Table 1: List and description of interpretation categories

3.2 General assessment of survey results - magnetometry

3.2.1 The detailed magnetic survey was carried out over approximately 1ha.

3.2.2 Magnetic anomalies located can be generally classified as positive anomalies of an uncertain origin, linear anomalies of an agricultural origin, areas of magnetic disturbance and strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within the survey area have been numbered and are described in 3.4 below.

3.3 Statement of data quality - magnetometry

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

3.3.2 With the exception of magnetic debris that is probably mainly within the topsoil, magnetic anomalies potentially relating to former cut features are extremely weak and of poor contrast. The response to known ridge and furrow within the field is barely detectable within the results. The data area similar to that obtained from previous surveys in the vicinity of the site and infer low levels of magnetic susceptibility and low magnetic contrast. Although the soils and underlying geology can be associated with poor to moderate results with magnetometry, the particularly weak anomalies at this location may relate to a combination of generally moist soil, due to the local topography, combined with head deposits of low magnetic susceptibility derived from chalk.

3.4 List of anomalies – magnetometry

Area centred on OS NGR 415221 181147, see Fig 03.

Anomalies with an uncertain origin

(1) – A linear group of discrete positive responses can be seen in the central western part of the survey area. The linear formation may indicate an association

with ridge and furrow; however, it is not clear if they relate to features disturbed by the ridge and furrow and have an anthropogenic origin or if they relate to natural features.

(2) – The survey area contains a small number of very weakly positive linear and curvilinear anomalies. They lack a coherent morphology and cannot be confidently interpreted. They do not generally correspond to any anomalies identified in the resistivity survey.

Anomalies with an agricultural origin

(3) – A number of very weak linear anomalies are a response to extant ridge and furrow.

Anomalies associated with magnetic debris

(4) – The entire survey area contains widespread and numerous strong, discrete, dipolar anomalies which are a response to ferrous and other magnetically thermoremnant objects, such as brick and tile which has been spread around the site.

Anomalies with a modern origin

(5) – Magnetic disturbance from metal animal feeders.

3.5 General assessment of survey results – resistivity

3.5.1 The earth resistance survey was carried out over approximately 1ha.

3.5.2 Resistance anomalies located can be generally classified as high and low resistance anomalies of uncertain origin, anomalies associated with agricultural activity and anomalies associated with modern land use. Anomalies located have been numbered and will be outlined in 3.7 below.

3.6 Statement of data quality and other factors influencing the results - resistivity

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

3.6.2 Generally the data demonstrate useful resistive contrast despite the very limited range between relatively high and low resistance, likely to be a consequence of damp clayey topsoil and subsoil. Numerous high and low resistance anomalies are present as well as clear anomalies relating to the former ridge and furrow cultivation.

3.7 List of anomalies – resistivity

Area centred on OS NGR 415221 181147, see Fig 04.

Anomalies of uncertain origin

(6) – A number of low resistance linear anomalies can be seen within the data. There appears to be some truncation of the ridge and furrow and an association with modern land drainage is possible.

(7) – Low resistance curvilinear anomalies could relate to cut features but it is not clear if they over or underlie the ridge and furrow.

(8) – A zone of high resistance is located in the northern part of the survey area and appears to be bounded by ridge and furrow. Such a response could be a natural feature.

Anomalies with an agricultural origin

(9 & 10) - A series of linear anomalies relate to extant ridge and furrow. They generally fan outwards from north north west to south south east in the west, through to north south in the centre and then north north east to south south west in the east (9). Those in the southern part of the site are on a different orientation and appear to form a headland (10).

Anomalies with a modern origin

(11) – Low resistance anomalies located towards the south western corner of the survey area appear to relate to patches of damp and compressed soil or hay previously under or associated with removed animal feeders.

4 CONCLUSION

4.1.1 The geophysical survey comprised resistivity and magnetometry within the site. The results of the magnetometry indicate the presence of a linear group of pit-like responses; however, it is not clear if they relate to natural features or those with an anthropogenic origin. A number of positive linear anomalies have also been located, but they are very weak and indistinct and cannot be confidently interpreted. The results of the resistivity survey indicate a number of linear anomalies that appear to truncate the ridge and furrow and could be associated with land drainage. An area of high resistance has also been located, and although it is possible this is a natural feature, its origin is uncertain. With the exception of anomalies relating to former ridge and furrow cultivation, there is no correlation between magnetic and resistive anomalies; however, anomalies appear more clearly defined by the resistivity despite the considerably lower resolution of the data.

5 REFERENCES

Archaeological Surveys, 2014. *Land at Berkeley Farm, Wroughton, Swindon, Magnetometer Survey Report.* Ref: J543. Unpublished typescript document.

British Geological Survey, 2022. *Geology Viewer, [online]* available from https://geologyviewer.bgs.ac.uk [accessed 10/11/2022].

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

Cotswold Archaeology, 2014. *Land at Berkeley Farm, Wroughton, Wiltshire, Archaeological Evaluation*. Ref: 14303. Unpublished typescript document.

European Archaeological Council, 2015. *EAC Guidelines for the Use of Geophysics in Archaeology: Questions to Ask and Points to Consider.* Europae Archaeologia Consilium and Association Internationale sans But Lucratif, Belgium.

Foundations Archaeology, 2021. *Berkeley Farm, Wroughton, Wiltshire, Archaeological Excavation and Watching Brief: Post Excavation Assessment.* Ref 1406. Unpublished typescript document.

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

Schmidt, A., 2013. *Geophysical Data in Archaeology: A Guide to Good Practice.* Oxbow Books.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 5 South West England.*

Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material. Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field. Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field upon cooling.

Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths, and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to the topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The SENSYS gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 65cm apart. The instrument is carried about 10-20cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried magnetic field. The difference between the two sensors will relate to the strength of the magnetic field created by the buried feature.

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

Appendix B – basic principles of earth resistance survey (resistivity)

Earth resistance survey, commonly known as resistivity, relies on the variability of conduction of current through soil and the subsurface matrix. The variability relates to the distribution of moisture within different materials so that non-porous features, such as foundations, produce a relatively high resistance response and more moisture retentive soil, such as found within the fill of a former ditch, produces a low resistance measurement. The technique is, therefore, influenced by climatic factors although the success of a survey can be difficult to predict based on these alone. Soil type, ground use, vegetative cover and the nature of buried features and subsoil are all factors that will influence the outcome of a survey.

The technique involves inputting a small electrical current into the ground and measuring subtle variations to the current at regular intervals across an area. The current input and measurement requires a series of probes to be inserted into the ground and the configuration of these can influence the resolution of resistive anomalies and the depth of response. Research has demonstrated that the twin electrode configuration is one of the most useful for archaeological prospection. It requires a mobile frame with two electrodes separated usually by 0.5m and a pair of remote probes linked to the logging instrument using a long cable.

Cart-based systems are also regularly used in archaeological prospection, and generally these require four spiked wheels to inject current into the ground and take measurements. The four wheels act as a square array which can be electronically switched to change the orientation of measurement and current input. Two

or three readings are rapidly logged at each recording station and these are referred to as alpha, beta and gamma. The gamma is often not recorded as this represents the difference between the alpha and beta configurations and can be derived during data processing. The alpha and beta datasets often demonstrate subtle differences that relate to the orientation of subsurface features and both are analysed as part of the abstraction and interpretation process. Advantages of cart systems are speed and resolution and they do not require a trailing cable; however, ground conditions are more critical and problems can be encountered with ground cover and in areas that are excessively damp or dry.

When using the twin probe configuration a useful reading interval for archaeological prospection across an area is 1m. Data are logged at 1m centres along traverses separated by 1m. Where areas contain known archaeological features 0.5m x 0.5m or 1m x 0.5 readings are considered more informative. Data collected by cart-based systems are typically at 0.25m centres along traverses separated by 1m.

Appendix C – 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. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

High Pass Filter

Removes low frequency anomalies within the data that are not considered to be archaeologically significant and may be natural in origin. A window passes over the data, the mean of all the data within the window is subtracted from the centre value. The size of the window is adjusted as is the weighting which may be uniform or Gaussian. The process is used to improve the visibility of anomalies of interest.

Zero Median/Mean Traverse

The median (or mean) of data from each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise differences between the offset values of the gradiometer sensors. The process can remove archaeological features that run along a traverse but with the high resolution datasets created by the Sensys FGM650 sensors and the method of data collection this has not been a notable problem. In fact, the removal of offsets using software avoids carrying out a balancing procedure on site, which inevitably can never be done in magnetically clean conditions and results in improperly aligned fluxgate sensors and/or electronic adjustment values.

Appendix D – survey and data information

Magnetometry minimally processed data
Filename: J941-mag-proc.xcp
Instrument Type: Sensys DLMGPS
Units:
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 415158.16, 181226.80 m
Southeast corner: 415305.01, 181065.85 m
Collection Method: Randomised
Sensors: 6
Dummy Value: 32702
Dimensions
Survey Size (meters): 147 m x 161 m
X&Y Interval: 0.15 m
Source GPS Points: Active: 456935, Recorded: 456935
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.11
Mean: 0.04
Median: 0.02
Composite Area: 2.3636 ha
Surveyed Area: 1.8318 ha
PROGRAM
Name: TerraSurveyor
Version: 3.0.37.0

GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (UTM to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00

Magnetometry filtered data
Filename: J941-mag-proc.-hpf.xcp
Stats
Max: 2.21
Min: -2.20
Std Dev: 0.85
Mean: 0.03
Median: 0.01
GPS based Proce5
1 Base Layer.
2 Unit Conversion Layer (UTM to OSGB36).
3 DeStripe Median Traverse:
4 High pass Uniform (median) filter: Window dia: 300
5 Clip from -2.00 to 2.00

Earth resistance minimally processed data

Filename: J941-res-proc.xcp
Description: Imported as Composite from GeoPlot : wroughton

Instrument Type: Resist. (RM85)
Units: ohm
Collection Method: zig-zag
Sensors: 4
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 180 x 240
Survey Size (meters): 90 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 0.5 m (surveyed @ 1 m)
Y Interval: 0.5 m (surveyed @ 1 m)
Stats
Max: 5.91
Min: 3.20
Std Dev: 0.61
Mean: 4.54
Median: 4.50
Composite Area: 1.08 ha
Surveyed Area: 0.9882 ha
Processes: 3
1 Base Layer
2 Clip at 2.00 SD
3 Interpolate: X & Y Doubled.

Earth resistance filtered data

Filename: J941-res-proc.-hpf.xcp

Max: 0.51
Min: -0.48
Std Dev: 0.21
Mean: 0.01

Median: 0.00

Processes: 5
1 Base Layer
2 Despike Threshold: 2 Window size: 3x3
3 High pass Uniform (median) filter: Window: 13 x 13
4 Clip at 2.00 SD
5 Interpolate: X & Y Doubled.

Appendix E – digital archive

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

A PDF copy will be supplied to the Wiltshire Historic Environment Record. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS).

File type	Naming scheme	Description
Data	J-mag-**[area number/name]**.asc J-mag-**[area number/name]**.xcp J-mag-**[area number/name]**-proc.xcp	Raw data as ASCII CSV TerraSurveyor raw data TerraSurveyor minimally processed data
Graphics	J-mag-**[area number/name]**-proc.tif	Image in TIF format
Drawing	J-**[version number]**.dwg	CAD file in 2010 dwg format
Report	J report.odt	Report text in Open Office odt format

Table 2: Archive metadata

Appendix F – CAD layers for abstraction and interpretation plots

The table below sets out Archaeological Surveys Ltd CAD layer names with associated colours and graphical content. Where CAD files are available layers may be extracted for further CAD/GIS use. Note: hatched polygon boundaries are contained within layers with the RGB colour code 254, 255, 255 (near white) in order to prevent their visibility.

Report sub-heading and associated CAD layer names	Colour with RGB index		Layer content
Anomalies with an uncertain origin			
AS-ABST MAG POS LINEAR UNCERTAIN		255,127,0	Line, polyline or polygon (solid)
AS-ABST MAG POS DISCRETE UNCERTAIN		255,127,0	Solid donut, point or polygon (solid)
AS-ABST MAG NEG DISCRETE UNCERTAIN		Blue 0,0,255	Solid donut, point or polygon (solid)
AS-ABST RES HIGH AREA UNCERTAIN		153,133,76	Polygon (net)
AS-ABST RES LOW LINEAR UNCERTAIN		127, 223, 255	Line, polyline or polygon (solid)
Anomalies with an agricultural origin			
AS-ABST MAG RIDGE AND FURROW		0,127,63	Line, polyline or polygon (cross hatched ANSI37)
AS-ABST RES RIDGE AND FURROW		0,127,63	Line, polyline or polygon (cross hatched net)
Anomalies associated with magnetic debris			
AS-ABST MAG STRONG DIPOLAR		132, 132, 132	Solid donut, point or polygon (solid)
Anomalies with a modern origin			
AS-ABST MAG DISTURBANCE		132, 132, 132	Polygon (hatched ANSI31)

Table 3: CAD layering

Appendix G – copyright and intellectual property

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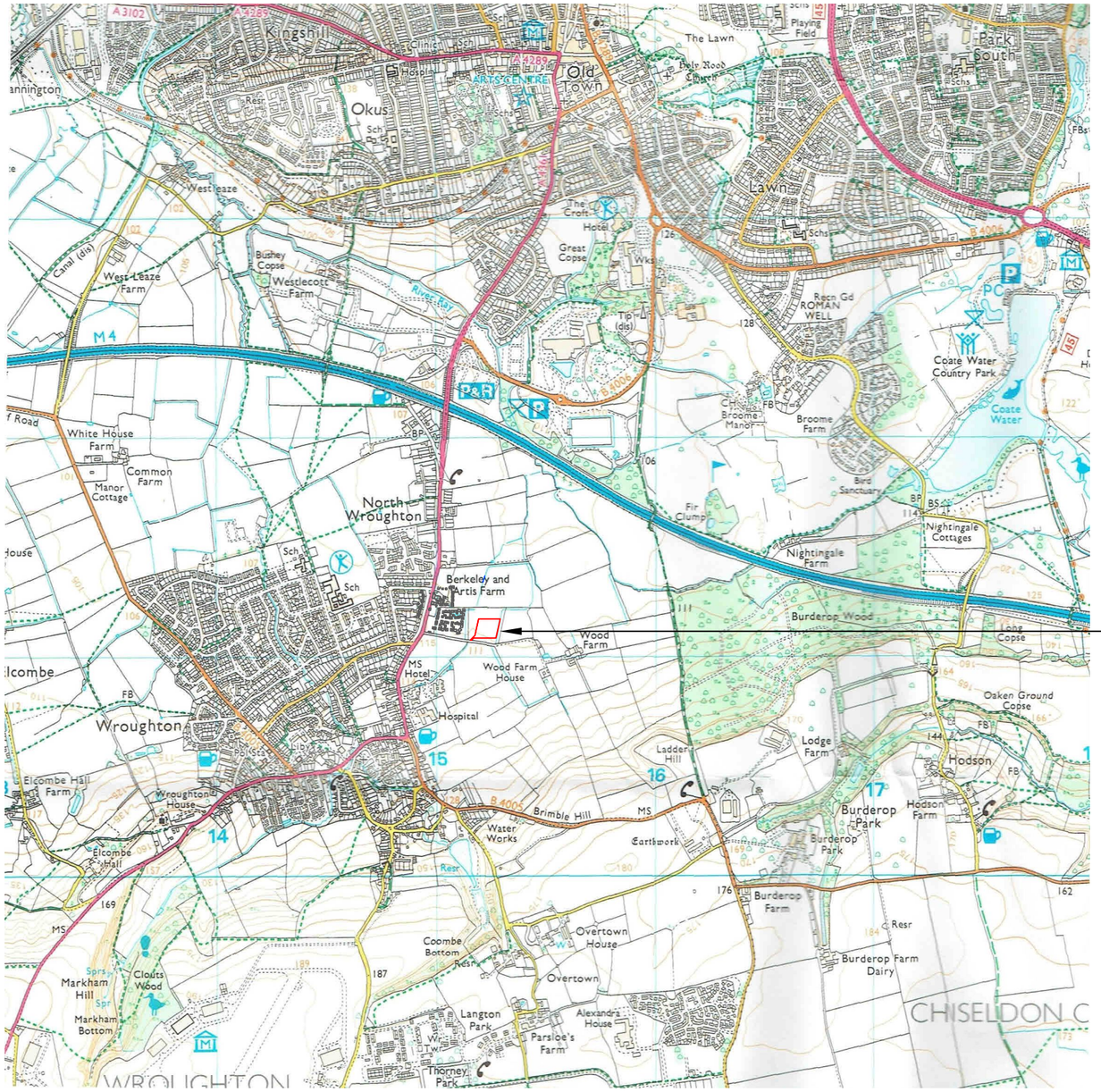
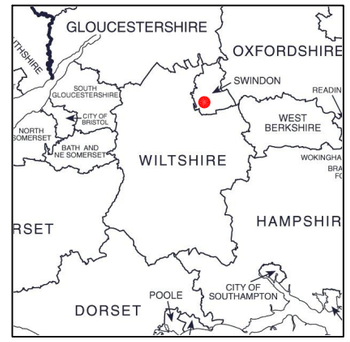
Specialist Geophysical Surveyors

Geophysical Survey
Berkeley Farm Dairy Solar Array
Wroughton
Swindon

Map of survey area



Survey location



Survey location

Site centred on OS NGR
SU 15221 81147

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 01

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Wroughton
Swindon

Magnetometry referencing information

181400
181350
181300
181250
181200
181150
181100
181050
181000

414950
415000
415050
415100
415150
415200
415250
415300
415350

N

111.3m
114.6m

Berkeley Farm Dairy
Berkeley and Artis Farm
SWINDON ROAD
KINGS ROAD
BAILEYS WAY
WAYTES CLOSE
OWER CLOSE
Sewage Pumping Station
Balancing Pond
Drain
Feeder
Feeder

Referencing grid to OSGB36 datum at 50m intervals

- 415200 181100
- Survey tracks
- Survey track start
- Survey track stop
- Development boundary

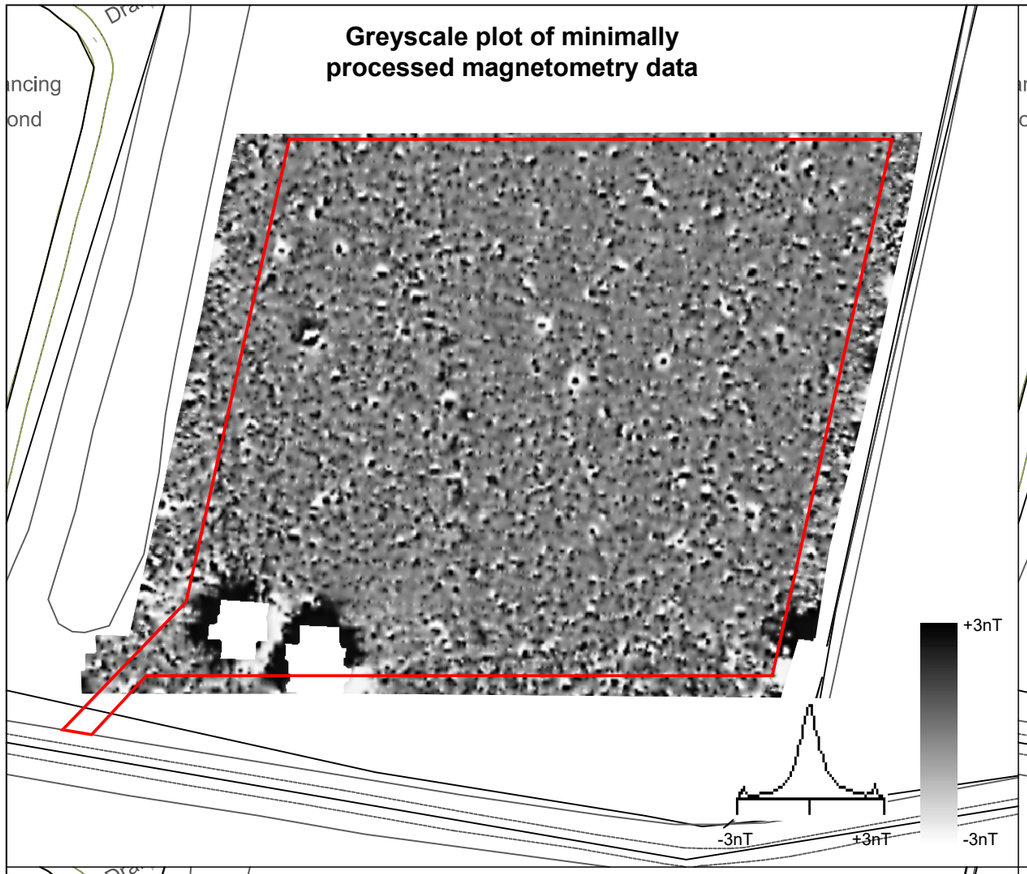
SCALE 1:1500

0m 10 20 30 40 50m

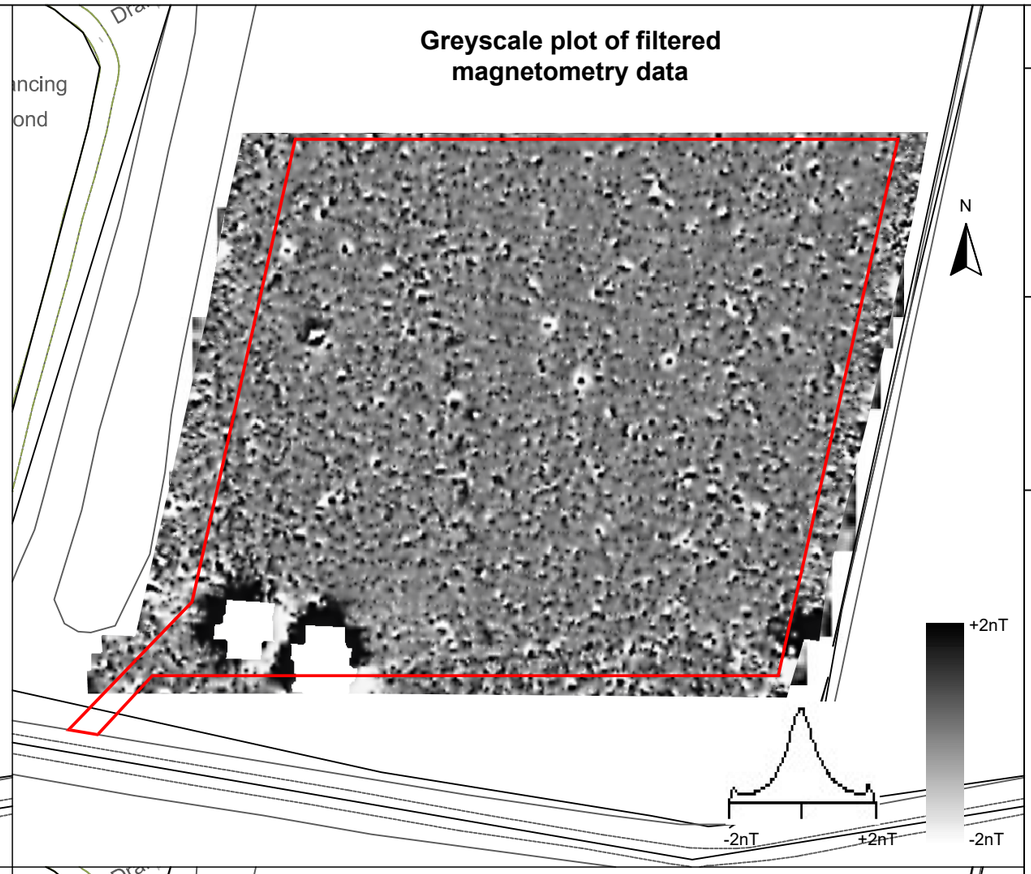
SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 02

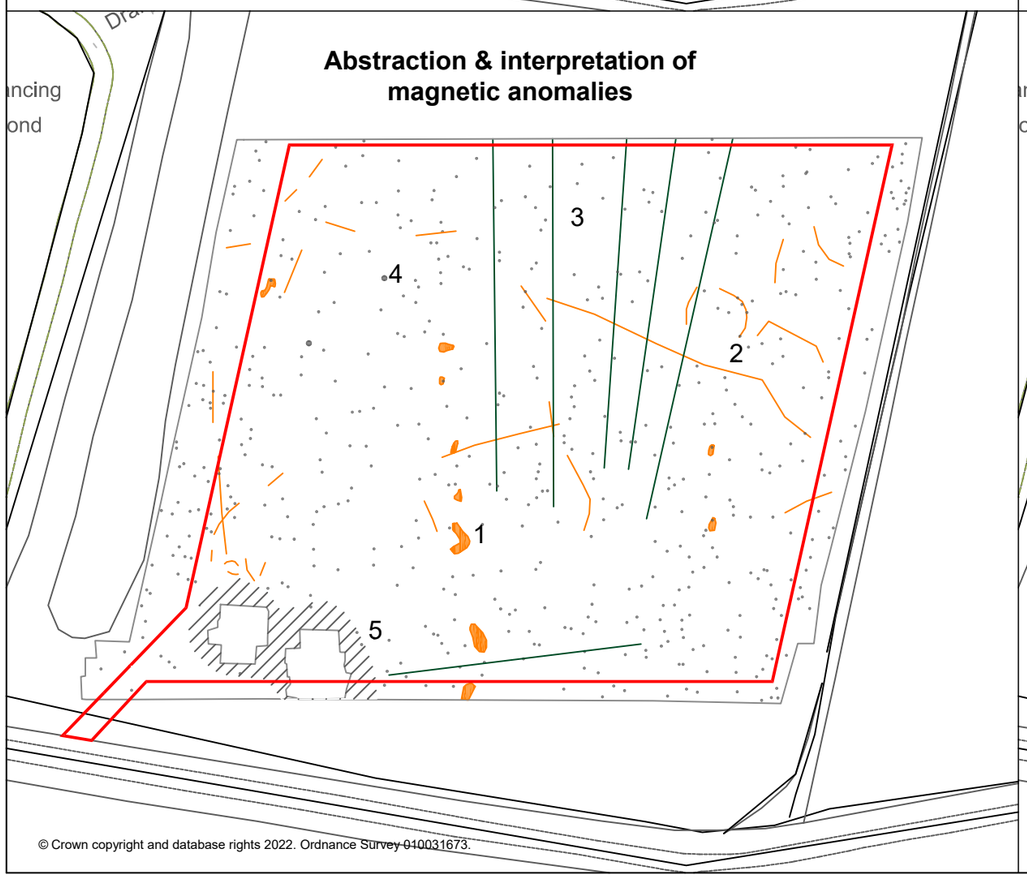
Greyscale plot of minimally processed magnetometry data



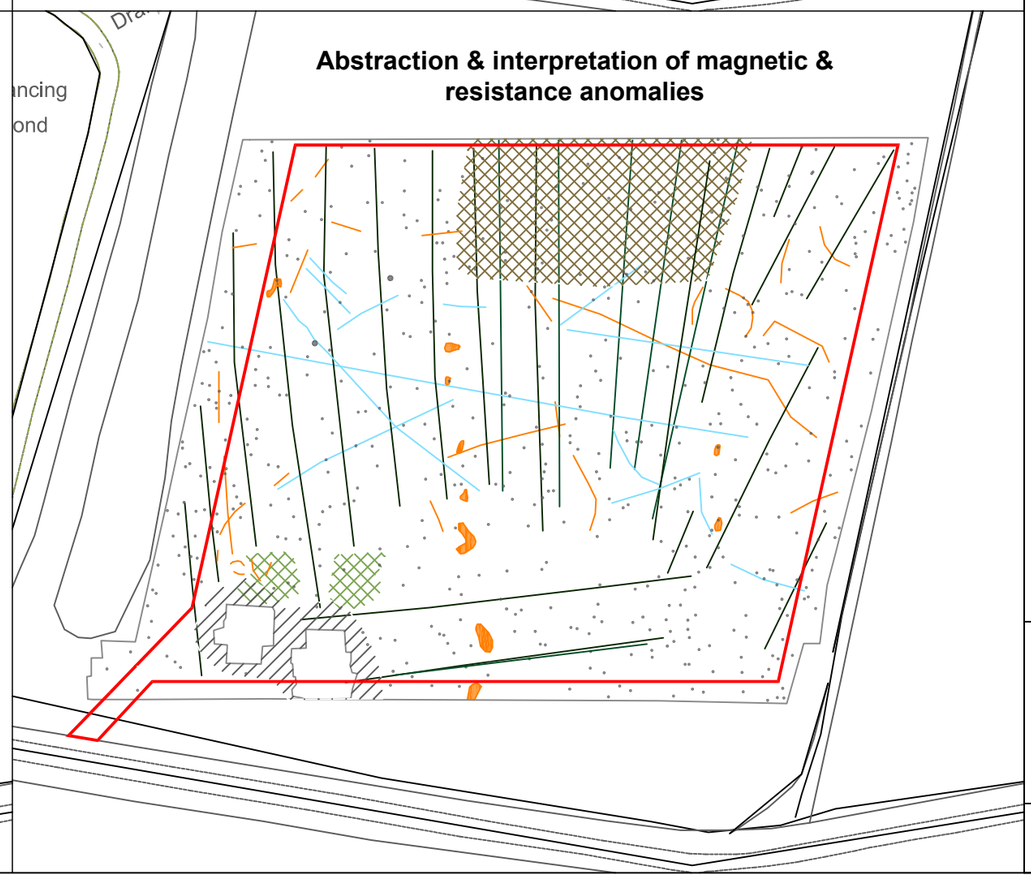
Greyscale plot of filtered magnetometry data



Abstraction & interpretation of magnetic anomalies



Abstraction & interpretation of magnetic & resistance anomalies



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Greyscale plot of processed magnetometer data & abstraction & interpretation of magnetic anomalies

- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - ridge and furrow
- Discrete positive response - possible pit-like feature
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object
- Low resistance linear anomaly - cut feature of uncertain origin
- Linear anomaly - ridge and furrow
- High reisistance anomaly - of uncertain origin
- Low reisistance anomaly - damp/compressed soil associated with removed animal feeders
- Development boundary

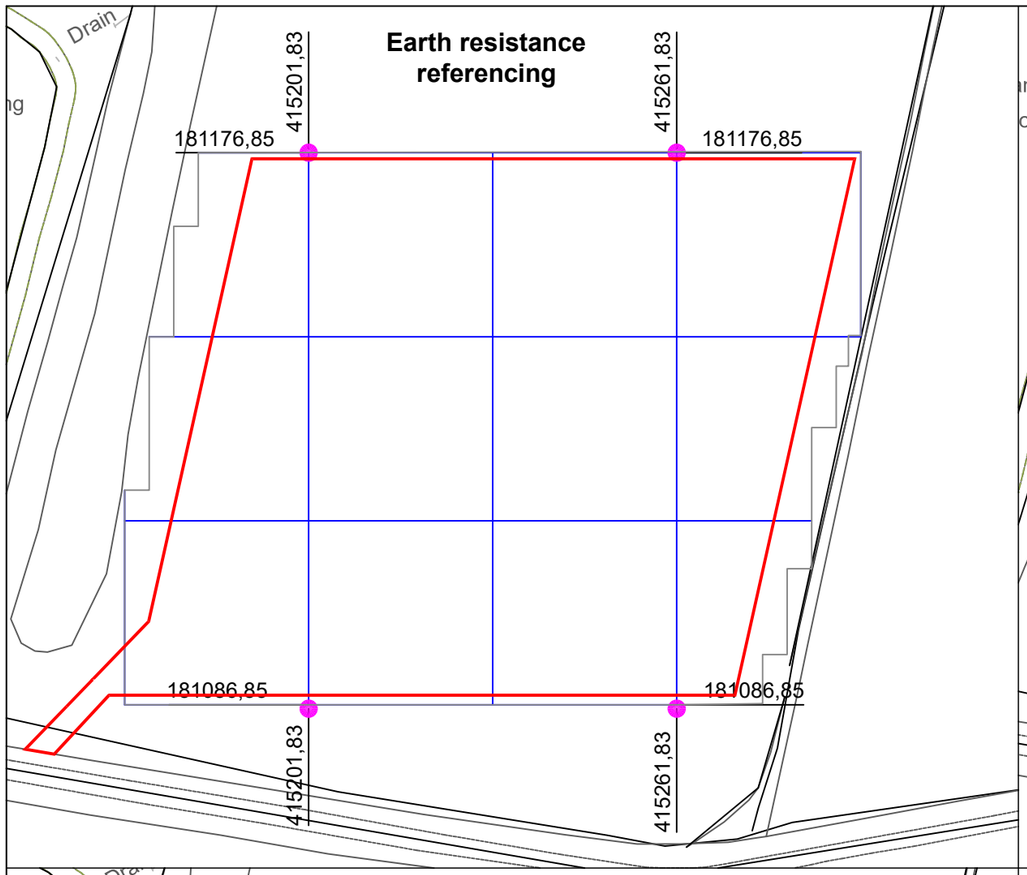
SCALE 1:1000

0m 10 20 30 40 50m

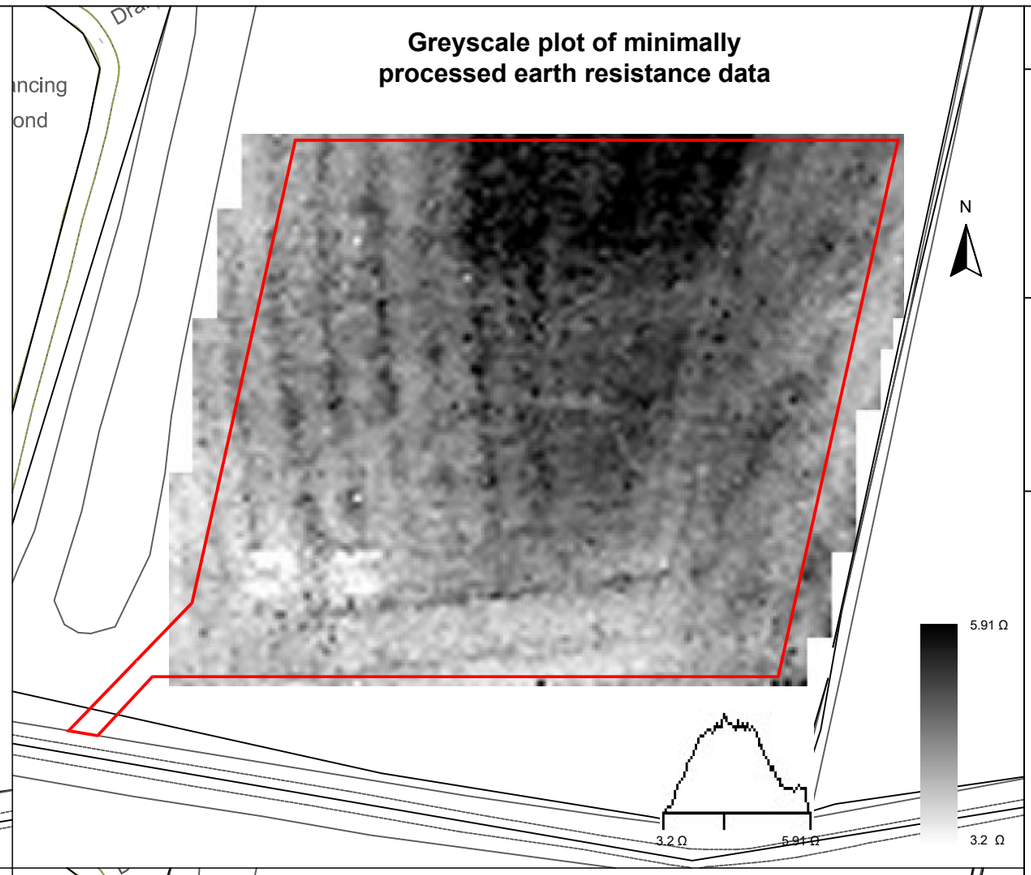
SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 03

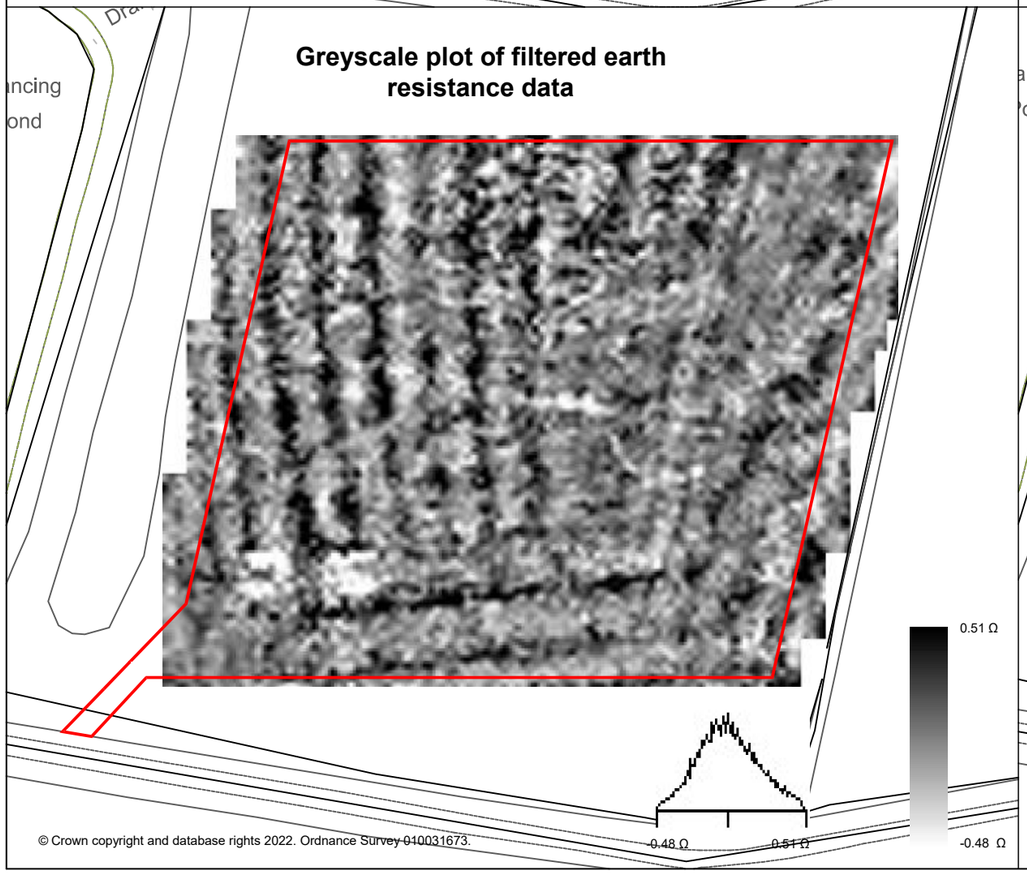
Earth resistance referencing



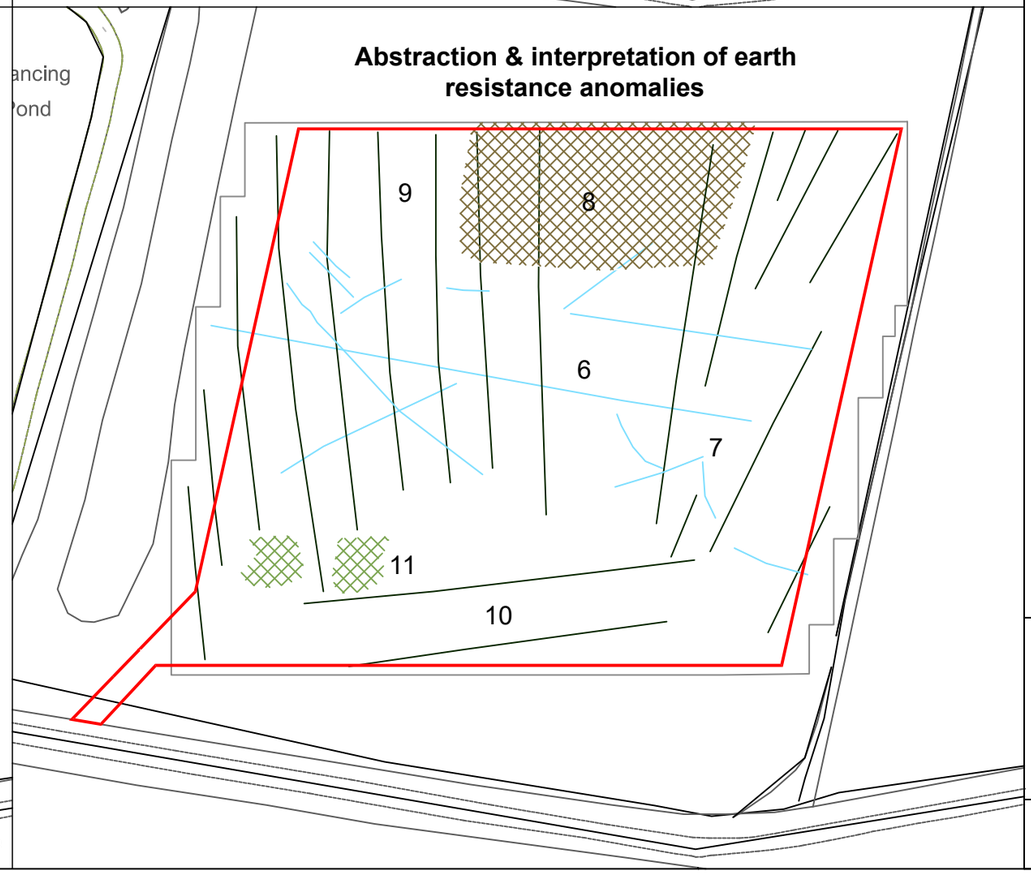
Greyscale plot of minimally processed earth resistance data



Greyscale plot of filtered earth resistance data



Abstraction & interpretation of earth resistance anomalies



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Geophysical Survey
Berkeley Farm Dairy Solar Array
Wroughton
Swindon

Greyscale plot of earth resistance data & abstraction & interpretation of resistance anomalies

- Low resistance linear anomaly - cut feature of uncertain origin
- Linear anomaly - ridge and furrow
- High reisistance anomaly - of uncertain origin
- Low reisistance anomaly - damp/compressed soil associated with removed animal feeders
- Development boundary

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 04