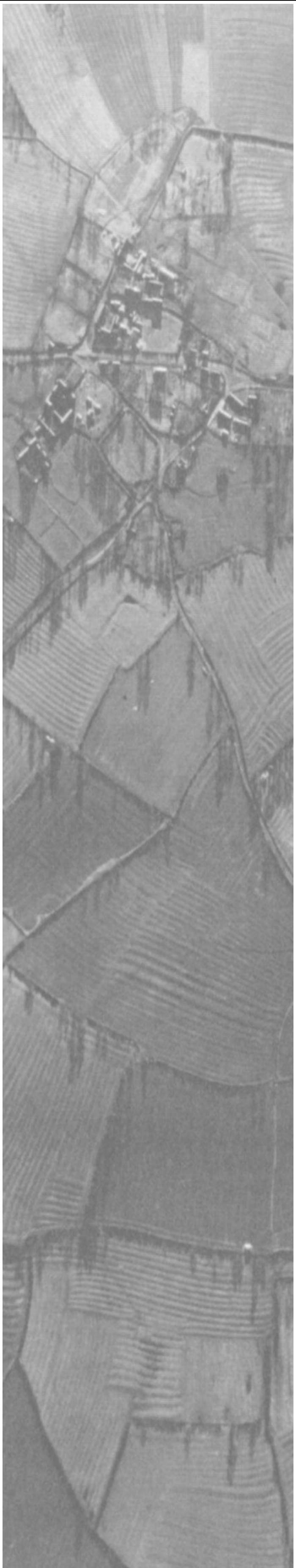

Archaeological Surveys
Specialist Geophysical Surveyors

Land at Court House Farm
Toot Baldon
Oxfordshire

MAGNETOMETER & EARTH RESISTANCE SURVEY REPORT

for

Blue Cedar Homes

Kerry Donaldson & David Sabin

February 2023

Ref. no. J951

ARCHAEOLOGICAL SURVEYS LTD

Land at Court House Farm
Toot Baldon
Oxfordshire

Magnetometer & Earth Resistance Survey Report

for

Blue Cedar Homes

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

Survey date – 3rd February 2023
Ordnance Survey Grid Reference – **SP 56773 00695**

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It is a Registered Organisation with the Chartered Institute for Archaeologists.

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SUMMARY

A geophysical survey, comprising magnetometry and resistivity, was carried out within a small area of land at Toot Baldon, Oxfordshire by Archaeological Surveys Ltd ahead of a proposed residential development. The results indicate widespread magnetic debris from dumping, ground make-up and modern ferrous objects. Two discrete positive responses in the north eastern part of the site could indicate pit-like features. The resistivity results also indicate areas of ground disturbance and make-up. Several high resistance anomalies in the northern, central part of the site may be associated with a formerly mapped building but there is no coherent morphology indicative of walling foundations. Several anomalies in the north eastern and central and north western parts of the site are not clearly associated with modern disturbance or mapped features, with several having a north east to south west trend; however, it is not clear if they relate to features with any archaeological potential or more modern activity.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by the Bristol & Bath Heritage Consultancy (BBHC), on behalf of Blue Cedar Homes, to undertake a magnetometer and earth resistance (resistivity) survey of an area of land at Court House Farm, Toot Baldon, Oxfordshire. The site has been outlined for the proposed development of six residential dwellings and the survey forms Stage 1 of an archaeological assessment.

1.1.2 The geophysical survey was carried out in accordance with a Specification for a Programme of Archaeological Evaluation issued by BBHC (2023) and approved by Steven Weaver, Planning Archaeologist for Oxfordshire County Council and archaeological adviser to South Oxfordshire District Council, prior to commencing the survey.

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 (CIfA) 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 Toot Baldon in Oxfordshire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SP 56773 00695, see Figs 01 and 02.

1.4.2 The site comprises approximately 0.6ha; however much of the site was unsurveyable due to areas of hardstanding, driveways, trees, hedges and barns. The geophysical survey covers approximately 0.3ha within 5 separate areas. Area 1, in the north eastern part of the site, is a small patch of grassland, Area 2 was an area of recently cleared scrub and brambles within a former old garden, Area 3 was also an area of cleared brambles, Area 4 and the south western corner of Area 3 were lawns and Area 5 was a narrow strip of recently cleared grassland.

1.4.3 The ground conditions across the site were variable with much evidence of former ground disturbance, make-up and removed structures, associated with agricultural activity and gardens, considered likely to produce resistive anomalies. A plethora of ferrous objects and extant buildings containing steel were considered sources of high magnitude magnetic disturbance. Weather conditions during the survey were fine.

Plate 1: Area 1 looking south west

Plate 2: Area 2 looking west

Plate 3: Area 3 looking east

Plate 4: Area 4 looking west

Plate 5: Area 5 looking north

1.5 Site history and archaeological potential

1.5.1 The settlement of Toot Baldon is a Shrunken Medieval Village with 18th century mapping showing a track or road extending through the centre of the site from the northern edge to the south eastern corner. By 1886 this had been removed but a group of buildings with a central courtyard have been built in the vicinity, the remainder of the site is mapped as gardens and orchards. The majority of the buildings have been removed by 1921 with possibly a small structure remaining within the north eastern part of the site. A number of barns were constructed in the southern part of the site in the later 20th century, with two recently removed within Areas 3 and 4.

1.5.2 In the wider vicinity a geophysical survey located a number of linear ditches and enclosures to the west of St Lawrence's Church, 350-500m to the south west, with a small number of rectilinear features approximately 350m to the east (Archaeological Surveys, 2021).

1.6 Geology and soils

1.6.1 The underlying geology is Jurassic limestone and calcareous sandstone from the Portland Group (BGS, 2023).

1.6.2 The overlying soil across the site is from the Frilford association (554a) and is an argillic brown sand. It consists of a deep, well drained, sandy and coarse loamy soil (Soil Survey of England and Wales, 1983).

1.6.3 The underlying geology and soils can be associated with low magnetic contrast and low levels of magnetic susceptibility. However, cut features of archaeological potential may be located where human activity has altered the magnetic characteristics of the soil sufficiently. The underlying geology and soils are, therefore, considered acceptable for magnetic survey.

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®MXPDA 5 channel cart-based system. The instrument has 5 fluxgate gradiometers (FGM650) spaced 0.5m apart with readings recorded at 20Hz. The cart is pushed at walking speed and not towed. 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 recorded range is ±3000nT, and resolution is approximately 0.1nT. 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 <30s.

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 with multiplexer and a mobile parallel twin probe array with a 0.5m electrode separation. Four probes on the 1.5m long array allow the collection of two readings at 1m intervals along a traverse, equating to two parallel 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 with each reading representing 1m x 1m. The twin probe array requires the use of two fixed remote probes located at least 15m beyond the limit of each survey grid and linked to the mobile array by cable. Occasionally the fixed remote probes are repositioned due to limited cable length or to ensure the minimum distance (15m) between them and the mobile probes. To ensure no offset values occur between grids when the probes are repositioned, the mobile probes remain in a fixed location and the separation between the fixed probes at their new location is adjusted until the RM85 displays the same resistance value as the original location.

2.4.2 The survey grids were set out using a Topcon GTS802A robotic total station. Control points along a baseline were referenced to the 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®MXPDA 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 data are collected between limits of ±3000nT and clipped for display at ±100nT with high and low values highlighted in red and blue. 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. The filtered images has been clipped for display at ±10nT. Data treated to additional processing have been compared to unprocessed data to ensure that no significant anomalies have been removed.

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. With regard to the Sensys MXPDA, minimally processed data is considered by the manufacturer to be data that is compensated by SENSYS MAGNETO DLMGPS software, see 2.5.1 and 2.5.2. 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. In addition, traceplots cannot be meaningfully plotted against base mapping and in areas of complexity traces may be lost or highly confused. Traceplots may be used to demonstrate characteristic magnetic profiles across discrete features where it is considered beneficial.

2.5.7 Data logged by the RM85 resistance meter are downloaded using Geoplot 4 and processed within TerraSurveyor software. 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 resistivity data. The main form of resistivity data display used in the report is the minimally processed greyscale raster graphic image which has been de-spiked in order to remove high contact resistance anomalies and clipped at 2 SD to improve contrast.

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 GNSS, 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.

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 associated with magnetic debris	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. They often occur where there has been dumping or ground make-up and are 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, hearths and nail spreads from former wooden structures or rooves 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	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 0.3ha.

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

3.3 Statement of data quality and other factors influencing the results - 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 The presence of widespread magnetic debris across a large part of the site has limited the effectiveness of the technique. Magnetic debris may well mask weaker magnetic anomalies should they be present within the site.

3.4 List of anomalies – magnetometry

Area centred on OS NGR 456773 200695, see Figs 03 - 05 & 09.

Anomalies with an uncertain origin

(1) – Two discrete positive anomalies are located in Area 1 in the north eastern part of the site. They are surrounded by magnetic debris and could be associated; however, it is possible that they relate to cut, pit-like features.

Anomalies associated with magnetic debris

(2) – Magnetic debris in the northern part of Area 2 is situated in the vicinity of a mapped 19th century building and may be associated.

(3) – Magnetic debris in the central and southern parts of Area 2 are associated with demolished garden features and dumped material.

(4) – Strongly magnetic debris in Areas 3 and 4 is associated with dumped material.

(5) – Area 5 contains widespread magnetic debris associated with dumping, a former fence line in the south east and a group of strongly magnetic dipolar responses correspond to anomaly (17) in the resistivity data which suggests a modern origin for the response.

Anomalies with a modern origin

(6) – A strong, multiple dipolar linear anomaly crosses Area 1 in the north eastern part of the site and relates to a buried service.

3.5 General assessment of survey results – resistivity

3.5.1 The earth resistance survey was carried out over approximately 0.3ha.

3.5.2 Resistance anomalies located can be generally classified as high and low resistance anomalies of uncertain origin and anomalies associated with modern land use. Anomalies located within each survey area have been numbered and will be outlined in 3.6 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 With the exception of Areas 1 and 5 much of the ground surface appeared to be disturbed, recently landscaped or contain made ground associated with its former agricultural use and a former garden. Some resistive anomalies are, therefore, likely to relate to shallow and relatively modern features.

3.6.3 Generally the data demonstrate useful resistive contrast and numerous high and low resistance anomalies are present.

3.7 List of anomalies – resistivity

Area centred on OS NGR 456773 200695, see Figs 06 – 09.

Anomalies of uncertain origin

(7) – Several high resistance anomalies are located within Area 1. They are generally associated with magnetic debris and although an association with dumped material is possible, an archaeological origin should be considered.

(8) – A high resistance anomaly along the edge of the track is likely to be associated with it.

(9) – Low resistance anomalies appear to form an arc in the western part of Area 1. The response suggests a possible cut feature or material with high moisture content, but it is not possible to determine the origin of the anomalies.

(10) – High resistance anomalies in the northern part of Area 2 could be associated with a formerly mapped building although possible former garden beds were observed in the area.

(11) – A low resistance linear anomaly with a high resistance response on the north eastern side are associated with a linear depression or pathway.

(12) – High resistance anomalies in Area 2 with a north east to south west trend, similar to anomalies (17) & (18) in Area 5. This is different to the main trend of anomalies further north which are parallel with the road. It is not possible to determine if these relate to modern activity or if they relate to earlier features.

(13) – Low resistance responses in the south eastern corner of Area 2 correspond to highly magnetic material and may indicate made ground.

(14 & 15) – High resistance linear anomalies (14) in Area 3 relate to compacted

material to the south of an extant barn. Low resistance responses (15) probably relate to less compacted, moisture retentive soil in between the extant barn and a removed barn immediately to the south of the survey area.

(16) – A high resistance response lies within Area 4. This appears to be associated with infilled or compacted ground. High resistance along the western edge is associated with a compacted surface adjacent to the barn.

(17) – A discrete high resistance response in the western part of Area 5 corresponds with highly magnetic anomalies. A high resistance linear anomaly extends south westwards. This is on a similar trend to anomalies (12) to the east and also with the road, 37m to the west; however, it is not possible to determine if this relates to a feature with any archaeological potential, or if it relates to a more modern feature, such as a soakaway and pipe.

(18) – An area of high resistance, with some continuation of the north east to south west trend of anomaly (17) can be seen in the northern part of Area 5. It is not possible to determine if it relates to buried remains with archaeological potential, or if there is an association with modern dumping and ground disturbance.

(19) – A high resistance linear anomaly of uncertain origin.

(20) – Low resistance anomalies are associated with areas of modern dumping and ground disturbance.

4 CONCLUSION

4.1.1 The geophysical survey comprised resistivity and magnetometry within the site. The magnetometry results have revealed widespread magnetic debris mainly associated with dumping and ground make-up but with responses in the northern part of the site possibly associated with a formerly mapped building. The results of the resistivity demonstrate the presence of a number of high resistance responses in the northern part of the site that may be associated with the former building but do not indicate clearly defined walling. Other high resistance responses are generally associated with ground make-up and disturbance, but a zone in the north eastern part of the site and two discrete magnetic responses in this area could indicate some archaeological potential. High resistance responses with a north east to south west orientation could also indicate an earlier trend of features; however, all the anomalies are poorly defined and the area has been subject to a large amount of modern activity so that it is not possible to confidently identify the origin of the anomalies.

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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.

Despike

Removal of data points that exceed the mean/median/threshold by selecting a window size of data points and replace by mean/median/threshold. Spikes in resistivity data are often related to poor electrical contact often associated with ground conditions. Despike can improve the appearance of data and remove extreme readings that may affect further processing.

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: J951-mag-proc.xcp
Description: Imported as Composite from: J951-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 456721.92, 200739.26 m
Southeast corner: 456823.17, 200655.71 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702
Dimensions
Survey Size (meters): 101 m x 83.6 m
X&Y Interval: 0.15 m
Source GPS Points: Active: 109878, Recorded: 109883
Stats
Max: 110.50
Min: -110.00
Std Dev: 40.69
Mean: -0.22
Median: 0.10
Composite Area: 0.84594 ha
Surveyed Area: 0.34518 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 -100.00 to 100.00 nT

Magnetometry filtered data
Filename: J951-mag-proc-hpf.xcp

Stats
Max: 11.05
Min: -11.00
Std Dev: 6.49
Mean: -0.28
Median: -0.05
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: 103
5 Clip from -10.00 to 10.00 nT

Area 1 resistivity raw data
Filename: J951-res-Area1.xcp
Description: Imported as Composite from GeoPlot : J951-res-Area1
Instrument Type: Resist. (RM85)
Units: ohm
Collection Method: zig zag
Sensors: 1
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 30 x 30
Survey Size (meters): 30 m x 30 m
Grid Size: 30 m x 30 m
X Interval: 1 m
Y Interval: 1 m
Stats
Max: 57.15
Min: 24.15
Std Dev: 6.09
Mean: 37.19
Median: 36.63
Composite Area: 0.09 ha
Surveyed Area: 0.068 ha

Area 1 processed resistivity data
Filename: J951-res-Area1-proc.xcp
Stats
Max: 49.37
Min: 25.01
Std Dev: 5.98
Mean: 37.14
Median: 36.63
Processes: 2
1 Base Layer
2 Clip at 2.00 SD

Area 2 raw resistivity data
Filename: J951-res-Area2.xcp
Description: Imported as Composite from GeoPlot : J951-res-Area2
Dimensions
Composite Size (readings): 60 x 30
Survey Size (meters): 60 m x 30 m
Grid Size: 30 m x 30 m
X Interval: 1 m
Y Interval: 1 m
Stats
Max: 204.70
Min: 8.35
Std Dev: 16.53
Mean: 36.38
Median: 35.03
Composite Area: 0.18 ha
Surveyed Area: 0.0986 ha

Area 2 processed resistivity data
Filename: J951-res-Area2-proc.xcp
Stats
Max: 51.60
Min: 18.63
Std Dev: 7.72
Mean: 34.94
Median: 35.01
Processes: 3
1 Base Layer
2 Despike Threshold: 0.5 Window size: 5x5
3 Clip at 2.00 SD

Area 3 raw resistivity data
Filename: J951-res-Area3.xcp
Dimensions
Composite Size (readings): 60 x 30
Survey Size (meters): 60 m x 30 m
Grid Size: 30 m x 30 m
X Interval: 1 m
Y Interval: 1 m
Stats
Max: 77.50
Min: 18.00
Std Dev: 8.28
Mean: 31.70
Median: 30.30
Composite Area: 0.18 ha
Surveyed Area: 0.0256 ha

Area 3 processed resistivity data
Filename: J951-res-Area3-proc.xcp
Stats
Max: 48.25
Min: 18.00
Std Dev: 6.85
Mean: 31.28
Median: 30.30
Processes: 2
1 Base Layer
2 Clip at 2.00 SD

Area 4 raw resistivity data
Filename: J951-res-Area4.xcp
Description: Imported as Composite from GeoPlot : J951-res-Area4
Dimensions
Composite Size (readings): 30 x 30
Survey Size (meters): 30 m x 30 m
Grid Size: 30 m x 30 m
X Interval: 1 m
Y Interval: 1 m
Stats
Max: 94.50
Min: 17.25
Std Dev: 8.54
Mean: 41.47
Median: 40.00
Composite Area: 0.09 ha
Surveyed Area: 0.0236 ha

Area 4 processed resistivity data
Filename: J951-res-Area4-proc.xcp
Stats
Max: 58.56
Min: 24.38
Std Dev: 7.42
Mean: 41.21
Median: 40.00
Processes: 2
1 Base Layer
2 Clip at 2.00 SD

Area 5 raw resistivity data
Filename: J951-res-Area5.xcp
Dimensions
Composite Size (readings): 60 x 30
Survey Size (meters): 60 m x 30 m
Grid Size: 30 m x 30 m
X Interval: 1 m
Y Interval: 1 m
Stats
Max: 204.70
Min: 18.70
Std Dev: 10.18
Mean: 30.39
Median: 29.65
Composite Area: 0.18 ha
Surveyed Area: 0.0844 ha

Area 5 processed resistivity data
Filename: J951-res-Area5-proc.xcp
Stats
Max: 39.13
Min: 20.37
Std Dev: 4.34
Mean: 29.65
Median: 29.95
Processes: 4
1 Base Layer
2 Clip at 2.00 SD
3 Despike Threshold: 0.5 Window size: 3x3
4 Clip at 2.00 SD

Appendix E – digital archive

The main archive is held at the offices of Archaeological Surveys Ltd which allows for long-term storage including refreshing and migration of files so that they can be accessed for re-analysis in the future. The archive includes the raw and processed geophysical data, greyscale images, CAD, PDF figures and report text. In addition, digital data created during the survey will be archived with the Archaeology Data Service (ADS).

A draft copy will be supplied to the Oxfordshire county archaeological officer for comment and the agreed final copy supplied in PDF format to the Oxfordshire 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	J951-mag-**[area number/name]**.asc J951-mag.xcp J951-mag-proc.xcp J951-res-**[area number/name]**.xcp J951-res-**[area number/name]**-proc.xcp	Raw data as ASCII CSV TerraSurveyor raw magnetometry data TerraSurveyor minimally processed data TerraSurveyor raw resistivity data TerraSurveyor minimally processed data
Graphics	J951-mag-proc.tif J951-mag-proc-hpf.tif J951-res-raw-**[area number/name]**.tif J951-res-proc-**[area number/name]**.tif	Image in TIF format
Drawing	J951-**[version number]**.dwg	CAD file in 2010 dwg format
Report	J951 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 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 MAG POS UNCERTAIN		255,127,0	Polygon (cross hatched ANSI37)
AS-ABST RES HIGH LINEAR UNCERTAIN		153,133,76	Line, polyline 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 associated with magnetic debris			
AS-ABST MAG DEBRIS		132, 132, 132	Polygon (cross hatched ANSI37)
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)
AS-ABST MAG SERVICE		132, 132, 132	Line or polyline

Table 3: CAD layering

Appendix G – copyright and intellectual property

This report may contain material that is non-Archaeological Surveys Ltd copyright (eg Ordnance Survey, Crown Copyright) or the intellectual property of third parties, which we are able to provide for limited reproduction under the terms of our own copyright licences, but for which copyright itself is non-transferable by Archaeological Surveys Ltd. Users remain bound by the conditions of the Copyright, Design and Patents Act 1988 with regard to multiple copying and electronic dissemination of this report.

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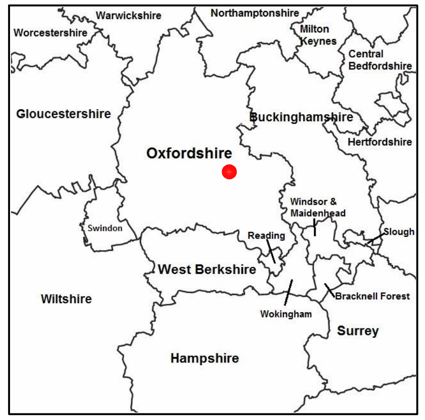
Oxfordshire

Map of survey area

N

Survey location



● Survey location

Site centred on OS NGR
SP 56773 00695

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 01

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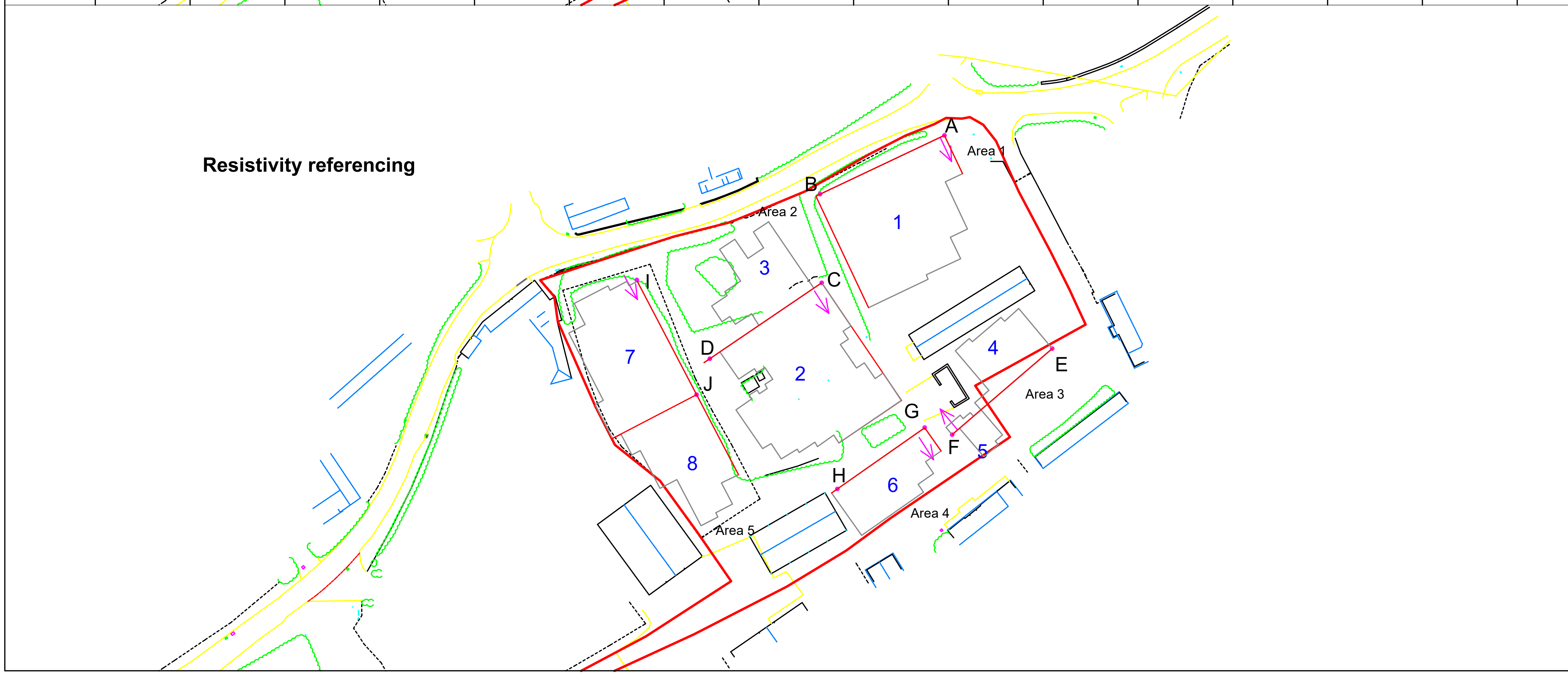

Referencing information

Magnetometry referencing grid to OSGB36 datum at 20m intervals. Data collected at 20Hz and georeferenced to ETRS89 zone 30 with conversion to OSGB36 using OSTN02

- 456780 200680
- Survey tracks
- Survey track start
- Survey track stop
- Development boundary

Resistivity grid coordinates based on Ordnance Survey OSGB36 datum

Grids set out using RTK GPS with Leica SmartNet correction data RTCMv2 format OSTN02 transformation

Survey grid size = 30m

Survey start and traverse direction

1 Grid reference number and filename

A	456799.15 200739.52
B	456772.98 200727.12
C	456773.25 200708.41
D	456749.64 200692.45
E	456821.89 200694.54
F	456800.78 200676.38
G	456794.99 200677.81
H	456776.56 200664.92
I	456734.31 200709.02
J	456746.88 200684.82

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 02

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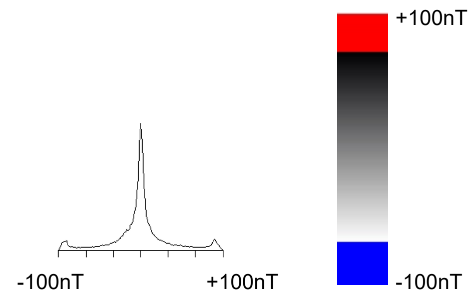
Greyscale plot of minimally processed magnetometer data

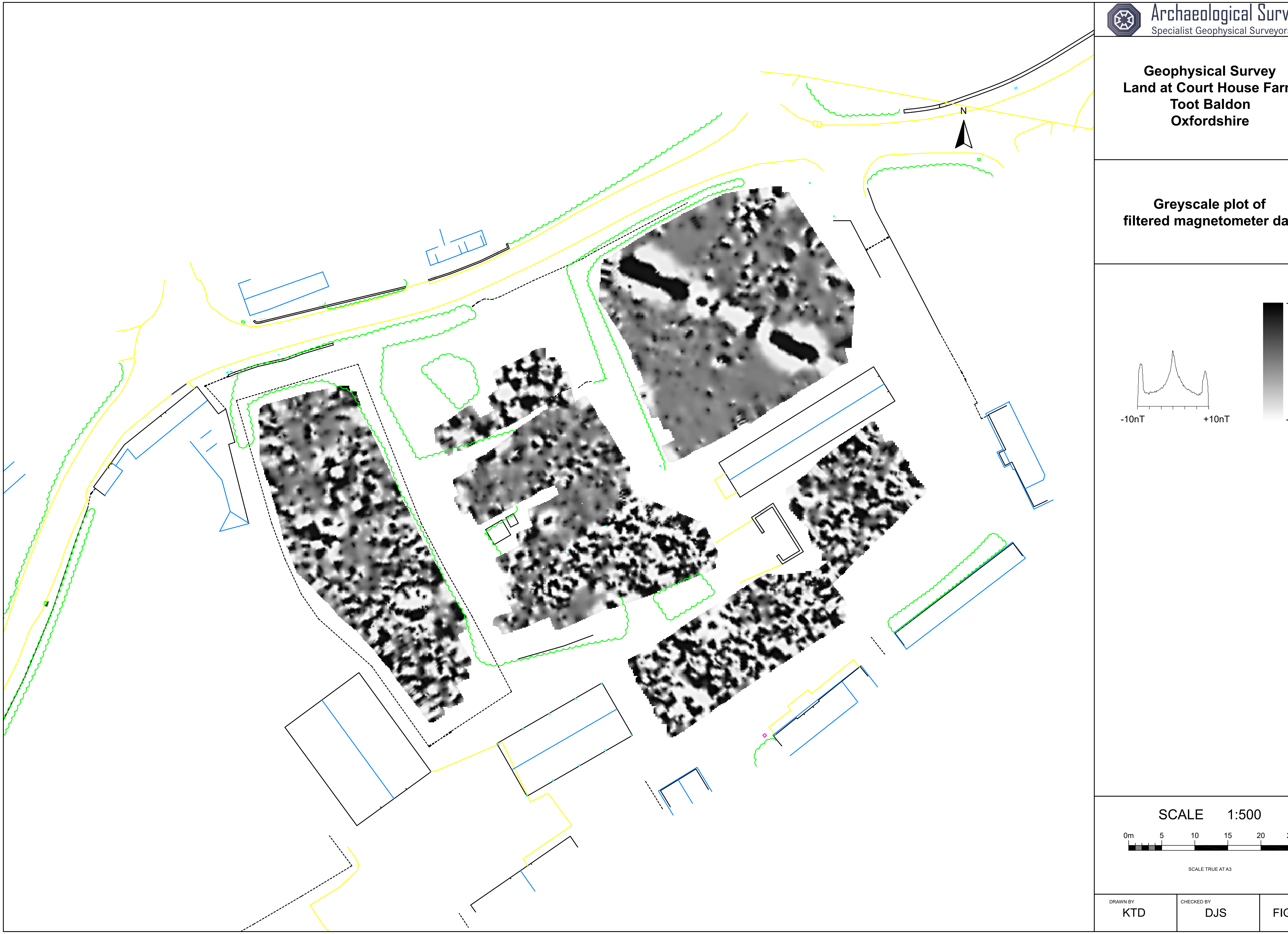


SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 03



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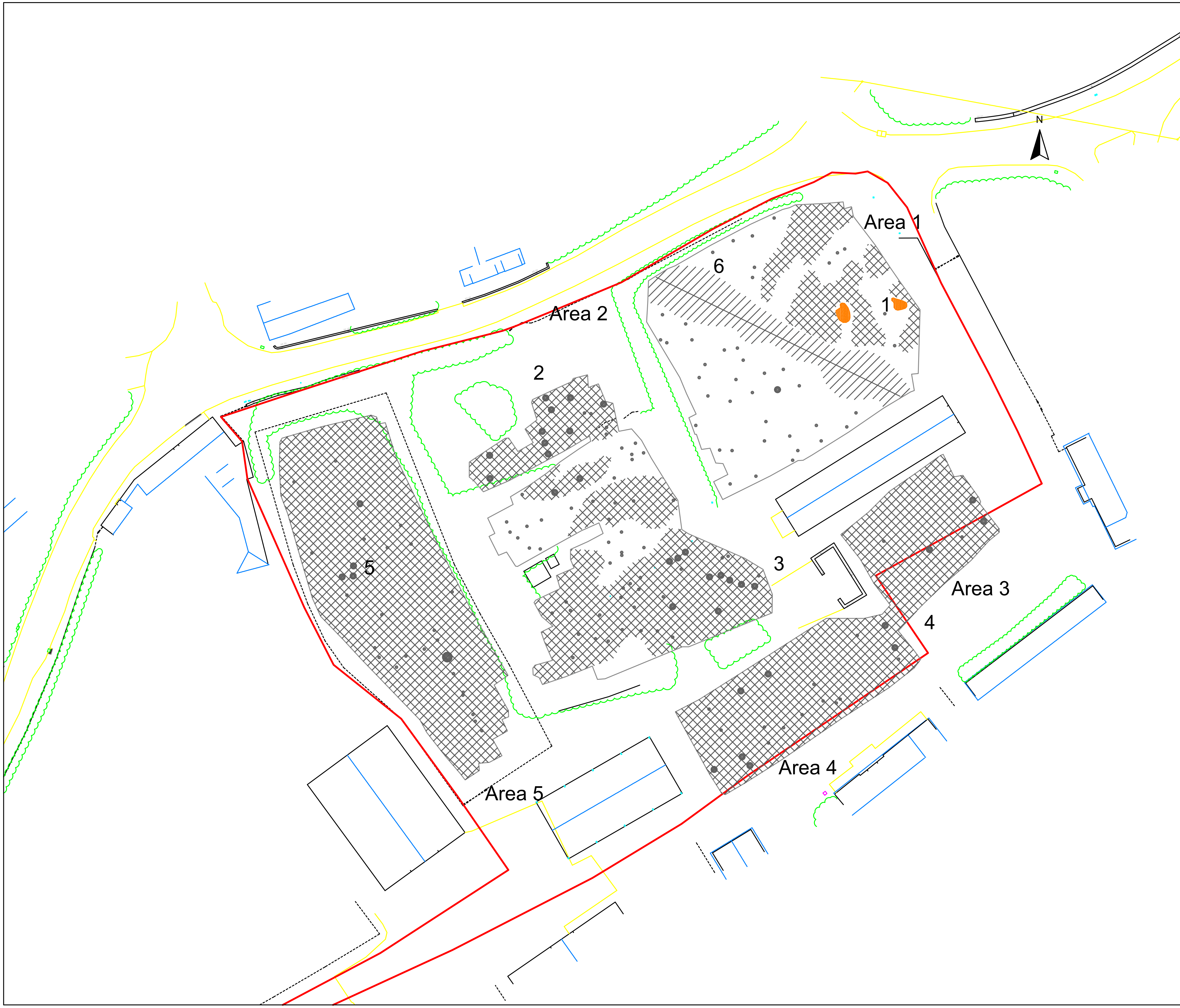
Greyscale plot of filtered magnetometer data

SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 04



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Abstraction and interpretation of magnetic anomalies

- Discrete positive response - magnetic enhancement of uncertain origin
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong multiple dipolar linear anomaly - pipeline / cable / service
- Strong dipolar anomaly - ferrous / magnetically thermoremnant object

SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 05

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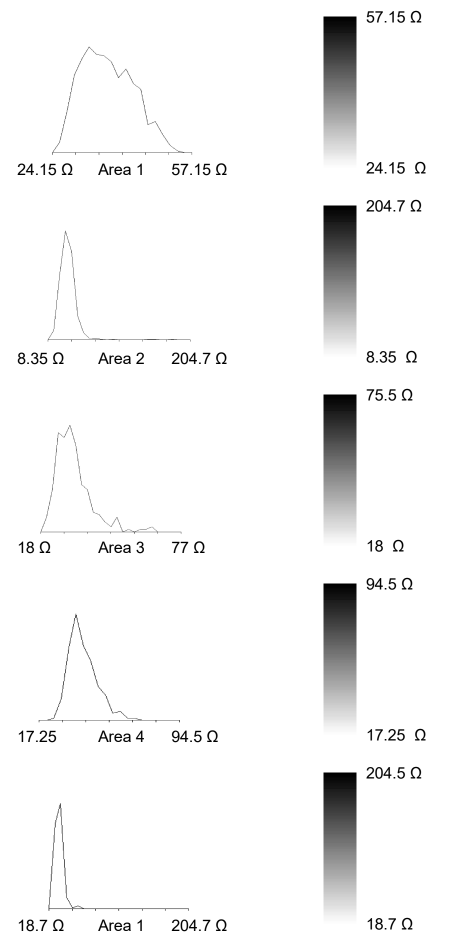
Greyscale plot of raw earth resistance data



SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 06

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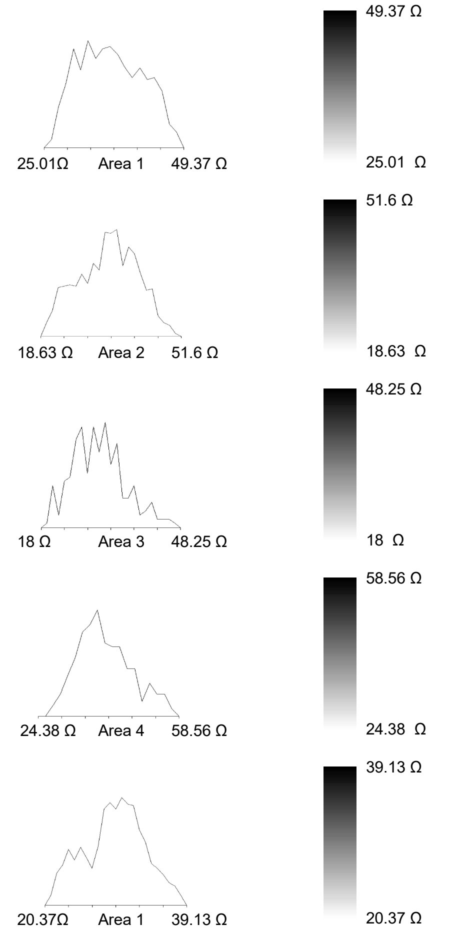
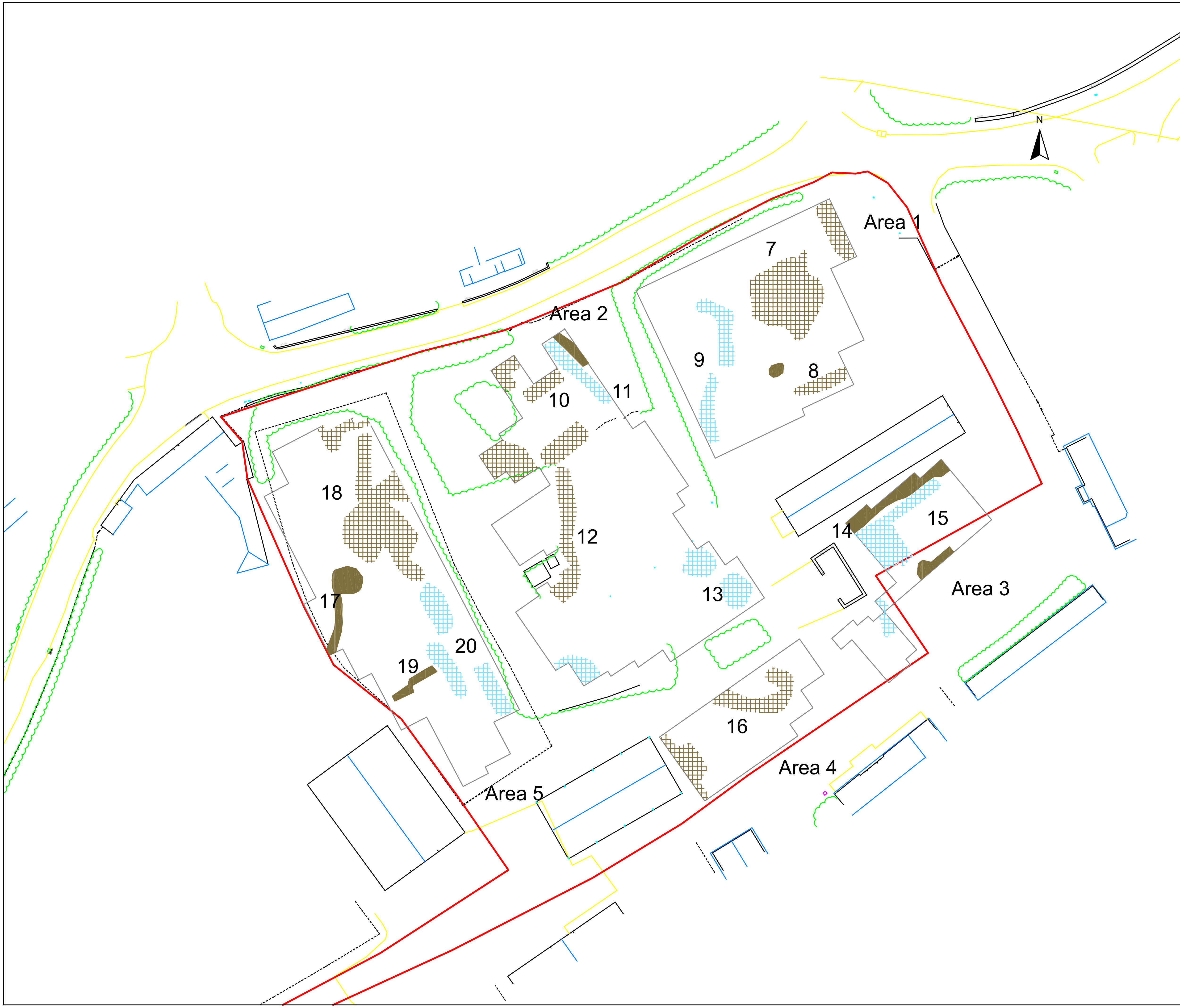
Greyscale plot of processed earth resistance data



SCALE 1:500

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 07



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Abstraction and interpretation of earth resistance anomalies

High resistance linear anomaly - of uncertain origin

Area of high resistance - of uncertain origin

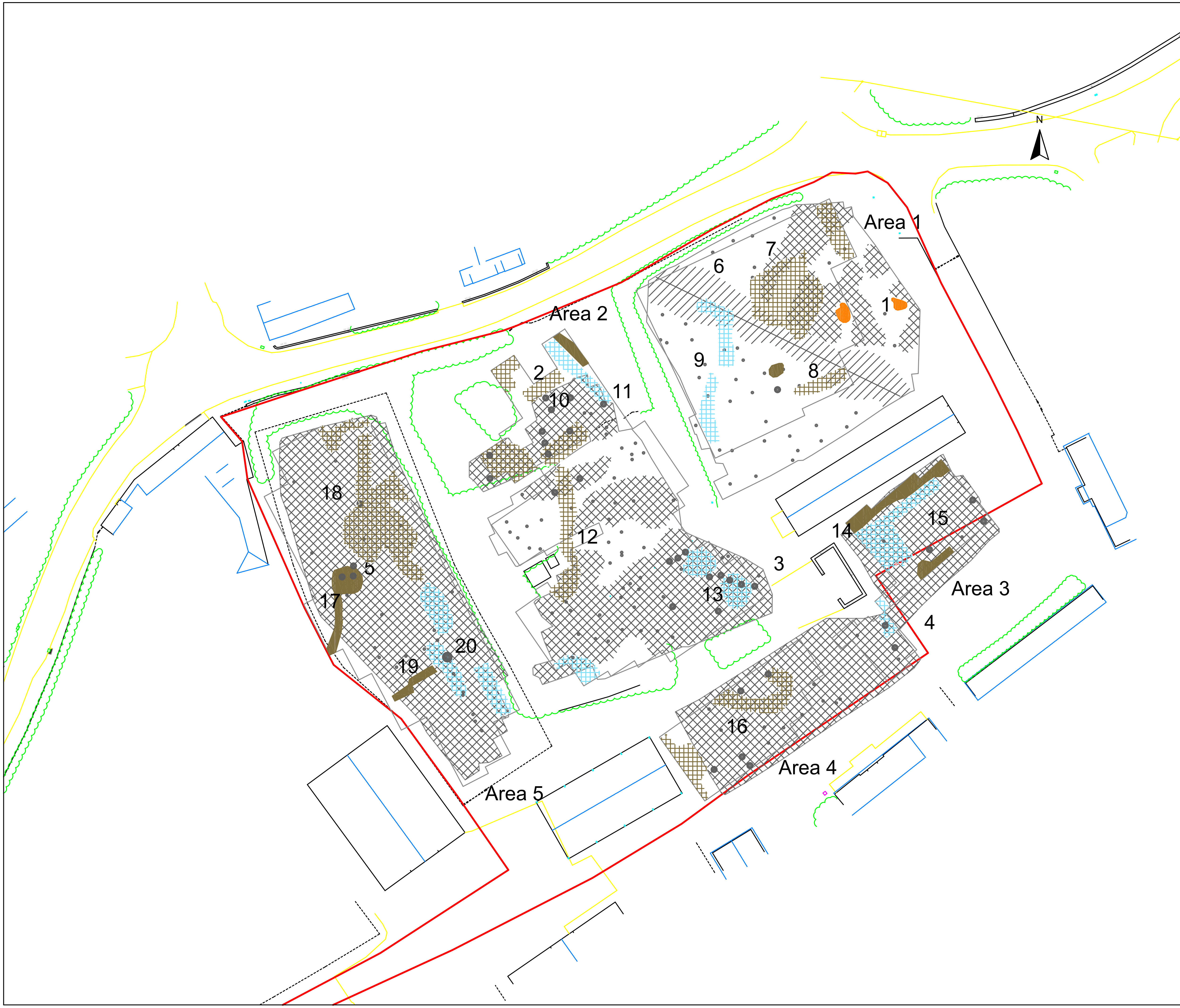
Area of low resistance - of uncertain origin

SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 08



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Abstraction and interpretation of magnetic & resistance anomalies

- Discrete positive response - magnetic enhancement of uncertain origin
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong multiple dipolar linear anomaly - pipeline / cable / service
- High resistance linear anomaly - of uncertain origin
- Area of high resistance - of uncertain origin
- Area of low resistance - of uncertain origin

SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 09