

**Bicester Gateway Phase 2
Bicester
Oxfordshire**

MAGNETOMETER SURVEY REPORT

for

Cotswold Archaeology

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ARCHAEOLOGICAL SURVEYS LTD

Bicester Gateway Phase 2
Bicester
Oxfordshire

Magnetometer Survey Report

for

Cotswold Archaeology

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SUMMARY

A geophysical survey, comprising detailed magnetometry, was carried out over 14ha of land proposed to be developed as Phase 2 of the Bicester Gateway business park. The results indicate the presence of a number of positive linear, rectilinear and discrete anomalies that may relate to cut features with archaeological potential in the northern and western parts of the site. Elsewhere, clusters of discrete positive responses have also been located, although it is not possible to determine if these relate to modern anthropogenic features, or if they have archaeological potential or whether they relate to possible natural features. Numerous naturally formed pit-like anomalies can be seen in the centre of the site. Ridge and furrow in the north western part of the site has also been identified, with possible land drainage elsewhere and infilling of former meanders in the watercourse adjacent to the eastern edge of the site.

1 INTRODUCTION

1.1 *Survey background*

- 1.1.1 Archaeological Surveys Ltd was commissioned by Cotswold Archaeology to undertake a magnetometer survey of an area of land at Bicester in Oxfordshire. The site has been identified for a mixed use development and is Phase 2 of the Bicester Gateway scheme. Phase 1, situated just to the west of Wendlebury Road, immediately west of the site, has been previously investigated through geophysical survey and evaluation and has been granted planning permission by Cherwell District Council for a new business park including a hotel (planning application number 16/02586/OUT).
- 1.1.2 This geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2018) and approved by Richard Oram, Planning Archaeologist for Oxfordshire County Council, prior to commencing the fieldwork.

1.2 *Survey objectives and techniques*

- 1.2.1 The objective of the survey was to use magnetometry to locate geophysical anomalies that may be archaeological in origin so that they may be assessed prior to development of the site. 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 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) *Standard and Guidance for Archaeological Geophysical Survey*. Note: currently Historic England (2018) no longer support the guidelines set out in English Heritage (2008) *Geophysical survey in archaeological field evaluation* and there are currently no plans to update the document. As a consequence other sources of written guidance referring to this document may be out of date and/or contain unsupported information (e.g. Chartered Institute for Archaeologists, 2014).
- 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 lines; broken or fragmented anomalies may well correspond closely with subsurface truncation.

1.4 Site location, description and survey conditions

- 1.4.1 The site is located at Promised Land Farm, within the parish of Chesterton, to the south of Bicester in Oxfordshire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SP 57550 21000 see Figs 01 and 02.
- 1.4.2 The area covered by the Phase 2 development area is 15.13ha, but the red-line boundary includes a chicken farm in the south western corner of the site and this was not suitable for survey. The geophysical survey covers 14ha within three pasture fields, labelled Areas 1 – 3 for the purposes of this report.
- 1.4.3 Area 1 is approximately 4.5ha and forms the northern part of the site. The western part of the field is slightly higher with a very slight slope down towards the eastern field boundary which is demarcated by a stream which is a

tributary of the River Ray. Area 2 is approximately 4ha and forms the south eastern part of the site. The area is also bounded on its eastern side by the stream. Area 3 is approximately 6ha and forms the south western part of the site. Land towards the northern corner of the field is slightly higher and the southern part of the field contains a small pond.

- 1.4.4 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry data. Potential sources of magnetic disturbance are related to electricity poles and steel stays, water troughs and gateways. Survey was avoided in the immediate vicinity of these features. Weather conditions during the survey were mainly fine and cold. Rapidly rising temperatures during the early part of the day were considered likely to produce some drift within the sensors, and data collection was modified appropriately to minimise the effects of any drift (see 3.2).



Plate 1: Area 1 looking north west



Plate 2: Area 2 looking south



Plate 3: Area 3 looking south east

1.5 *Site history and archaeological potential*

- 1.5.1 A Heritage Desk-Based Assessment has been carried out for both phases of the Bicester Gateway development (Cotswold Archaeology, 2016a). It outlines that the Phase 2 development area (the site) lies just to the north of the scheduled Roman town of Alchester (Historic England List Entry number 1006365) and that several earthwork and cropmark features have been recorded within the the site. They appear to relate to linear ditches and rectilinear enclosures; however, their north east to south west and north west to south east orientation is different to the planned north to south orientation of the Roman town and the extra-mural settlement and field systems directly to

the south. It has therefore been suggested that the cropmarks may not be Roman in date. The Phase 1 area, located just to the west of the Phase 2 area and separated by Wendlebury Road, has been previously subject to geophysical survey (PCG, 2016) and archaeological evaluation (Cotswold Archaeology, 2016b). This revealed a number of Roman ditches, pits and floor surfaces less than 50m from the present site.

- 1.5.2 The surface conditions within the site were not suitable for the observation of cultural material during the course of the survey. Low earthworks relating to former ridge and furrow cultivation were noted in the western part of Area 1. Several shallow linear features crossing the site were considered likely to relate to land drainage.

1.6 *Geology and soils*

- 1.6.1 The underlying solid geology across the northern part of the site is mudstone from the Kellaways Clay Member. The majority of the site is underlain by sandstone and siltstone from the Kellaways Sand Member. The north western corner and part of the western edge of the site has overlying sand and gravel River Terrace Deposits, with alluvial deposits across the rest of the site (BGS, 2018).
- 1.6.2 The overlying soil in the western part of the site is from the Wickham 2 association which is a typical stagnogley soil and consists of a slowly permeable, seasonally waterlogged fine loamy over clayey soil. The rest of the site has soil from the Shabbington association which is a typical argillic gley consisting of a deep, fine loamy and fine loamy over sandy soil (Soil Survey of England and Wales, 1983).
- 1.6.3 Mudstone geologies, such as Kellaways Clay, stagnogley soils and alluvial deposits can all be associated with poor magnetic contrast between the fill of cut features and the material into which they are cut. However, long term occupation and industrial activity can significantly enhance the contrast.

2 METHODOLOGY

2.1 *Technical synopsis*

- 2.1.1 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance are factors associated with the formation of localised fields. Additional details are set out below and within Appendix A.
- 2.1.2 Iron minerals within the soil may become altered by burning and the break down of biological material; effectively the magnetic susceptibility of the soil is increased, and the iron minerals become magnetic in the presence of the

Earth's magnetic field. Accumulations of magnetically enhanced soils within features, such as pits and ditches, may produce magnetic anomalies that can be mapped by magnetic prospection.

- 2.1.3 Magnetic thermoremnance can occur when ferrous minerals have been heated to high temperatures such as in a kiln, hearth, oven etc. On cooling, a permanent magnetisation may be acquired due to the presence of the Earth's magnetic field. Certain natural processes associated with the formation of some igneous and metamorphic rock may also result in magnetic thermoremnance.
- 2.1.4 The localised variations in magnetism are measured as sub-units of the Tesla, which is a SI unit of magnetic flux density. These sub-units are nano Teslas (nT), which are equivalent to 10^{-9} Tesla (T).

2.2 Equipment configuration, data collection and survey detail

- 2.2.1 The detailed magnetic survey was carried out using a SENSYS MAGNETO®MXPDA 5 channel cart-based system. The instrument has 5 fluxgate gradiometers (FGM650) spaced 0.5m apart with readings recorded at 20 Hz. 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 range of recording data between ± 0.1 nT and $\pm 10,000$ nT. They are linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged PDA computer system.
- 2.2.2 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.
- 2.2.3 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).
- 2.2.4 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 or <50s where temperatures were rising most rapidly.

2.3 *Data processing and presentation*

- 2.3.1 Magnetic data collected by the MAGNETO®MXPDA cart-based system are initially prepared using SENSYS MAGNETO®DLMGPS software. 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.
- 2.3.2 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 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.
- 2.3.3 The minimally processed data are collected between limits of $\pm 10000\text{nT}$ and clipped for display at $\pm 3\text{nT}$. Data are interpolated to a resolution of effectively 0.5m between tracks and 0.15m along each survey track.
- 2.3.4 Appendix C contains metadata concerning the survey and data attributes and is derived directly from TerraSurveyor. Reference should be made to Appendix B for further information on processing.
- 2.3.5 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 are considered by the manufacturer to be data that are compensated by SENSYS MAGNETO DLMGPS software, see 2.3.1 and 2.3.2. Note: traceplots are not considered to be appropriate as they do not

provide an accurate or useful assessment of the magnetic anomalies due to the very high density of data collection.

- 2.3.6 The raster images are combined with base mapping using ProgeCAD Professional 2016, creating DWG (2010) file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. The CAD plots are effectively georeferenced facilitating relocation of features using GPS, resection method, etc.
- 2.3.7 An abstraction and interpretation is 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. Appendix E sets out CAD layer names with colour and graphic content for each interpretation category, see 3.3.
- 2.3.8 A brief summary of each anomaly, with an appropriate reference number, is set out in list form within the results (Section 3) to allow a rapid and objective assessment of features within each survey area.
- 2.3.9 A digital archive is produced with this report, see Appendix D below. The main archive is held at the offices of Archaeological Surveys Ltd.

3 RESULTS

3.1 *General assessment of survey results*

- 3.1.1 The detailed magnetic survey was carried out over a total of three survey areas covering approximately 14ha.
- 3.1.2 Magnetic anomalies located can be generally classified as positive linear and discrete positive responses of archaeological potential, positive and negative anomalies of an uncertain origin, anomalies associated with land management, linear anomalies of an agricultural origin, anomalies with a natural origin, areas of magnetic debris and disturbance and strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within each survey area have been numbered and are described in 3.4 to 3.6 below.

3.2 *Statement of data quality and factors influencing the interpretation of anomalies*

- 3.2.1 Data are considered representative of the magnetic anomalies present within the site. There are no significant defects within the dataset.
- 3.2.2 Localised magnetic disturbance is associated with modern above surface steel objects and most notable adjacent to field boundaries and electricity pole stays. There is no evidence that magnetic disturbance has obscured archaeologically significant features although this may be possible if they are

of very limited extent.

3.2.3 Several linear anomalies considered to have archaeological potential appear weak and poorly contrasting and this may relate to the magnetic properties of the soil and underlying geology. Site hydrology may also be a significant factor in limiting the magnetic susceptibility of the soil, communication with the landowner indicated that ground water levels were generally high and most of the area was unsuitable for arable cultivation as a consequence. Former ridge and furrow cultivation appears to be confined to a small area of slightly higher ground in the north western part of the site that correlates with a thin layer of sand and gravel deposited on a river terrace.

3.2.4 In order to further determine the magnetic properties of the soil, with respect to the very weak anomalies located by the survey, soil and subsoil samples were retrieved from a recently infilled geotechnical investigation pit, located in Area 1 in the vicinity of possible archaeological anomalies. The mass specific magnetic susceptibility of these samples was measured using a Bartington MS2 with MS2B sensor. The values (X_{if}) obtained were $4.5 \cdot 10^{-8} \text{m}^3 \text{kg}^{-1}$ for subsoil and $10.5 \cdot 10^{-8} \text{m}^3 \text{kg}^{-1}$ for topsoil. These values are similar to other sites with low contrast magnetic anomalies and probably confirm that although the soils are less than optimum, sufficient contrast should exist for the location of former cut features; however, no confident assessment can be made from a single sample. Low contrast anomalies are associated with ridge and furrow and suggest that soils, in the north western part of the site at least, are capable of producing useful anomalies.

3.3 Data interpretation

3.3.1 The list of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the survey. A basic explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, see Table 1.

Interpretation category	Description and origin of anomalies
<i>Anomalies with archaeological potential</i>	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as pits, ring ditches, enclosures, etc. The category is used where there is a high level of confidence which may be due to additional supporting information where morphology is unclear or uncharacteristic.
<i>Anomalies with an uncertain origin</i>	The category applies to a range of anomalies where <u>there is not enough evidence to confidently suggest an origin</u> . Anomalies in this category <u>may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered</u> . Morphology may be unclear or uncharacteristic and there may be a lack of additional supporting information. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone

	and subsoil.
<i>Anomalies relating to land management</i>	Anomalies are mainly linear and may be indicative of the magnetically enhanced fill of cut features (i.e. ditches). The anomalies may be long and/or form rectilinear elements and they may relate to topographic features or be visible on early mapping. Associated agricultural anomalies (e.g. headlands, plough marks and former ridge and furrow) may support the interpretation. Land drains can appear in a classic herringbone pattern of interconnected multiple dipolar linear anomalies, or as parallel linear anomalies. The multiple dipolar response indicates ceramic land drains.
<i>Anomalies with an agricultural origin</i>	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).
<i>Anomalies associated with magnetic debris</i>	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 thermoremanent 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 <u>may, therefore, be archaeologically significant</u> . 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.
<i>Anomalies with a modern origin</i>	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.
<i>Anomalies with a natural origin</i>	Naturally formed magnetic anomalies are caused by localised variability in the magnetic susceptibility of soils, subsoils and other drift or solid geologies. Anomalies may be amorphous, linear or curvilinear and may appear 'fluvial' or discrete; the latter are <u>almost impossible to distinguish from pit-like anomalies with an anthropogenic origin</u> . Fluvial, glacial and periglacial processes may be responsible for their formation within drift material and subsoil. Igneous and metamorphic activity can lead to anomalies within more solid geology.

Table 1: List and description of interpretation categories

3.4 List of anomalies - Area 1

Area centred on OS NGR 457590 221175, see Figs 03 – 06.

Anomalies of archaeological potential

(1) - Positive linear and rectilinear anomalies appear to relate to cut, ditch-like features, possibly parts of enclosures. The north east to south west axis corresponds to a very shallow linear depression within the ground surface and this

is parallel with the edge of a low river terrace earthwork situated 35m to the north west. It is possible that it continues south westwards into Area 3 as anomaly (12). Although many of the anomalies within the site are magnetically enhanced through natural processes, the morphology of anomalies (1) indicates that they should be considered of archaeological potential.

Anomalies with an uncertain origin

(2) - Fragmented positive linear anomalies that could be a north eastward continuation of anomalies (1).

(3) - A number of short, positive linear, rectilinear and curvilinear anomalies are situated in the vicinity of anomalies (1). They lack a coherent morphology and are generally weak and indistinct; however, it is possible that they relate to further cut features.

(4) - Positive linear anomalies that could be associated with anomalies (1).

(5) - A number of short weakly positive linear anomalies are located in the western part of the survey area and some appear to have been truncated by former ridge and furrow (8) that is situated primarily on a low river terrace in this part of the site.

(6) - A positive and parallel negative linear anomaly extends across the south eastern corner of the survey area and continues south westwards into Area 3. Although it may appear ditch-like, it is possible that it relates to a modern drain or pipe.

Anomalies associated with land management

(7) – A weakly positive linear anomaly and associated magnetic debris relate to a former field boundary.

Anomalies with an agricultural origin

(8) - Parallel linear anomalies relate to former ridge and furrow. The furrows are defined by negative linear anomalies and some may have truncated other weakly positive linear anomalies (5).

(9) - Parallel linear anomalies are likely to relate to agricultural activity, possibly former mole drainage.

3.5 List of anomalies - Area 2

Area centred on OS NGR 457650 220880, see Figs 09 & 10.

Anomalies with an uncertain origin

(10) - A number of discrete, positive responses have been located in the southern part of the survey area. They have a response of 10-13nT, much stronger than those that clearly relate to natural features, which are generally less than 1nT. It is not possible to determine if they have been caused by further natural features, relatively modern features, or if they are pit-like features with archaeological potential. Similar responses are located 90m to the west in Area 3 (19).

Anomalies associated with magnetic debris

(11) - Curvilinear zones of magnetic debris along the eastern edge of the field are a response to magnetically thermoremanent material that has been used to infill former meanders in the adjacent watercourse.

3.6 List of anomalies - Area 3

Area centred on OS NGR 457485 220965, see Figs 03 – 08.

Anomalies of archaeological potential

(12) - A positive linear anomaly may be a continuation of anomaly (1) located 90m to the north east in Area 1.

(13) - A number of positive linear, rectilinear and discrete responses are located just north west of anomaly (12) and appear to be associated.

Anomalies with an uncertain origin

(14) - A number of short, positive linear anomalies are located to the north of anomaly (12). It is not clear if these relate to naturally formed features, but given the proximity to anomaly (12) it is worth considering that they may be of archaeological potential.

(15) - A group of discrete, positive responses are located 20m south of anomalies (13). They have a response of up to 13nT, and are formed in small clusters. It is possible that they relate to pit-like features with archaeological potential.

(16) - Located close to the north western edge of the survey area is a linear group of discrete, positive anomalies. They are formed of discrete clusters or "U" shaped features, fairly regularly spaced c3.5m apart. It seems likely that these are

anthropogenic features, but their date and function cannot be determined.

(17) - Two positive curvilinear anomalies forming a penannular feature approximately 4m across are located 20m west south west of anomalies (16). It is not clear if they are associated, or if they relate to a feature with archaeological potential.

(18) - The survey area contains a number of weakly positive linear, amorphous and discrete responses. They do not have a coherent morphology, and it is not possible to determine if they relate to cut features as a natural origin is likely.

(19) - A large number of discrete, positive responses are located in the south eastern part of the survey area. They are moderately enhanced, with many between 5-10nT and some peaking at over 25nT. They may relate to pit-like features or areas of burning with some archaeological potential, but a natural origin could also be possible.

Anomalies associated with land management

(20) - A number of negative linear anomalies correspond to shallow linear depressions in the ground surface. They are likely to be associated with land drainage.

Anomalies with a natural origin

(21) - Zones of weak magnetic enhancement in the southern part of the survey area are indicative of former palaeochannels.

(22) - A widespread zone containing numerous weak, discrete, positive responses can be seen in the eastern part of the survey area, extending into the northern part of Area 2 to the east. These relate to naturally formed pit-like responses.

Anomalies associated with magnetic debris

(23) - The entire site contains numerous and widespread strong, discrete, dipolar responses that relate to ferrous and other magnetically thermoremanent objects within the topsoil. This type of material is usually spread through the process of manuring or soil conditioning. Concentrations of it can be seen associated with the ridge and furrow in Area 1.

Anomalies with a modern origin

(24) - The edges of the survey areas have been affected by magnetic disturbance from nearby fencing. Electricity poles and their stays have also caused magnetic disturbance within the site.

4 CONCLUSION

- 4.1.1 Positive linear, rectilinear and discrete anomalies in the northern and western parts of the site appear to relate to cut features with archaeological potential. They are generally weak, fragmented and not well defined, but could relate to ditches and pits or areas of burning. Numerous discrete anomalies of natural origin have also been located, and there can be little to distinguish a naturally formed anomaly from those with an anthropogenic origin. Other discrete anomalies can be seen in the southern part of the site, and while these could relate to further natural features, they have a much stronger response, possibly indicating magnetic enhancement through human activity and burning.
- 4.1.2 The survey also revealed evidence for more recent land use, with a zone of ridge and furrow in the north western part of the site, evidence for mole drainage and land drainage. Evidence for infilled watercourse meanders along the eastern edge of the site was also identified.

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Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 6 South East 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 thermoremanent 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. Thermoremanent 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. Thermoremanent features include ovens, hearths, and kilns. In addition thermoremanent 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 – data processing notes

Clipping

Minimum and maximum values are set and replace data outside of the range with those values. Extreme values are removed improving colour or greyscale contrast associated with data values that may be archaeologically significant. It has been found that clipping data to ranges between $\pm 5nT$ and $\pm 3nT$ often improves the appearance of features associated with archaeology. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Zero (dstrip) Median/Mean Traverse

The median (or mean) of each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise differences between the baseline value of gradiometer sensors.

High Pass Filtering

A mathematical process used to remove low frequency anomalies relating to survey tracks, modern agricultural features and other large magnetic bodies within or adjacent to survey areas.

Low Pass Filtering

A mathematical process used to remove high frequency anomalies relating to uneven ground, vibration, etc.

Appendix C – survey and data information

<p>Area 1</p> <p>Filename: J769-mag-Area1-proc.xcp Description: Imported as Composite from: J769-mag-Area1.asc Instrument Type: Sensys DLMGPS Units: nT UTM Zone: 30U Survey corner coordinates (X/Y):OSGB36 Northwest corner: 457412.68, 221307.94 m Southeast corner: 457761.58, 221043.19 m Collection Method: Randomised Sensors: 5 Dummy Value: 32702 Source GPS Points: 955800 Dimensions Composite Size (readings): 2326 x 1765 Survey Size (meters): 349 m x 265 m Grid Size: 349 m x 265 m X Interval: 0.15 m Y Interval: 0.15 m Stats Max: 3.32 Min: -3.30 Std Dev: 1.15 Mean: 0.02 Median: 0.01 Composite Area: 9.2371 ha Surveyed Area: 4.226 ha PROGRAM Name: TerraSurveyor Version: 3.0.23.0 GPS based Proce4 1 Base Layer. 2 Unit Conversion Layer (Lat/Long to OSGB36). 3 DeStripe Median Traverse: 4 Clip from -3.00 to 3.00 nT</p> <p>Area 2</p> <p>Filename: J769-mag-Area2-proc.xcp Description: Imported as Composite from: J769-mag-Area2.asc Instrument Type: Sensys DLMGPS Units: nT UTM Zone: 30U Survey corner coordinates (X/Y):OSGB36 Northwest corner: 457528.13 221055.90 m Southeast corner: 457715.33, 220705.80m Source GPS Points: 1063600</p>	<p>Dimensions Composite Size (readings): 1248 x 2334 Survey Size (meters): 187 m x 350 m Grid Size: 187 m x 350 m X Interval: 0.15 m Y Interval: 0.15 m Stats Max: 3.32 Min: -3.30 Std Dev: 0.98 Mean: 0.03 Median: 0.01 Composite Area: 6.5539 ha Surveyed Area: 3.9101 ha GPS based Proce4 1 Base Layer. 2 Unit Conversion Layer (Lat/Long to OSGB36). 3 DeStripe Median Traverse: 4 Clip from -3.00 to 3.00 nT</p> <p>Area 3</p> <p>Filename: J769-mag-Area3-proc.xcp Description: Imported as Composite from: J769-mag-Area3.asc Instrument Type: Sensys DLMGPS Units: nT UTM Zone: 30U Survey corner coordinates (X/Y):OSGB36 Northwest corner: 457312.48, 221173.81 m Southeast corner: 457631.53, 220762.81m Source GPS Points: 1678000 Dimensions Composite Size (readings): 2127 x 2740 Survey Size (meters): 319 m x 411 m Grid Size: 319 m x 411 m X Interval: 0.15 m Y Interval: 0.15 m Stats Max: 3.32 Min: -3.30 Std Dev: 0.91 Mean: 0.01 Median: 0.00 Composite Area: 13.113 ha Surveyed Area: 5.9218 ha GPS based Proce4 1 Base Layer. 2 Unit Conversion Layer (Lat/Long to OSGB36). 3 DeStripe Median Traverse: 4 Clip from -3.00 to 3.00 nT</p>
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Appendix D – digital archive

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

A draft digital copy of the summary report (in PDF format) shall be supplied to the client for review and this will be forwarded to the office of the Oxfordshire County Archaeological Officer; for verification and assessment by the CAO or his representative. When the report has been agreed a final digital copy will then be supplied to the Oxfordshire Historic Environment Record (HER) at archaeology@oxfordshire.gov.uk on the understanding that it will become a public document after an appropriate period of time (generally not exceeding six months).

Archive contents:

File type	Naming scheme	Description
Data	J769-mag-[area number/name].asc J769-mag-[area number/name].xcp J769-mag-[area number/name]-proc.xcp	Raw data as ASCII CSV TerraSurveyor raw data TerraSurveyor minimally processed data
Graphics	J769-mag-[area number/name]-proc.tif	Image in TIF format
Drawing	J769-[version number].dwg	CAD file in 2010 dwg format
Report	J769 report.odt	Report text in Open Office odt format

Table 2: Archive metadata

Appendix E – 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 archaeological potential		
AS-ABST MAG POS DISCRETE ARCHAEOLOGY	 Red 255,0,0	Solid donut, point or polygon (solid)
AS-ABST MAG POS LINEAR ARCHAEOLOGY	 Red 255,0,0	Line, polyline or polygon (solid)
Anomalies with an uncertain origin		
AS-ABST MAG POS LINEAR UNCERTAIN	 255,127,0	Line, polyline or polygon (solid)
AS-ABST MAG NEG LINEAR UNCERTAIN	 Blue 0,0,255	Line, polyline or polygon (solid)
AS-ABST MAG POS DISCRETE UNCERTAIN	 255,127,0	Solid donut, point or polygon (solid)
AS-ABST MAG POS UNCERTAIN	 255,127,0	Polygon (cross hatched ANSI37)
Anomalies relating to land management		
AS-ABST MAG BOUNDARY	 127,0,0	Line, polyline or polygon (solid or cross hatched ANSI37)
AS-ABST MAG LAND DRAIN	 Cyan 0,255,255	Line or polyline
Anomalies with an agricultural origin		
AS-ABST MAG AGRICULTURAL	 Green 0,255,0	Line or polyline
AS-ABST MAG RIDGE AND FURROW	 0,127,63	Line, polyline or polygon (cross hatched ANSI37)
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)
Anomalies with a natural origin		
AS-ABST MAG NATURAL FEATURES	 Yellow 255,255,0	Polygon (cross hatched ANSI37) and/or Dots

Table 3: CAD layering

Appendix F – copyright and intellectual property

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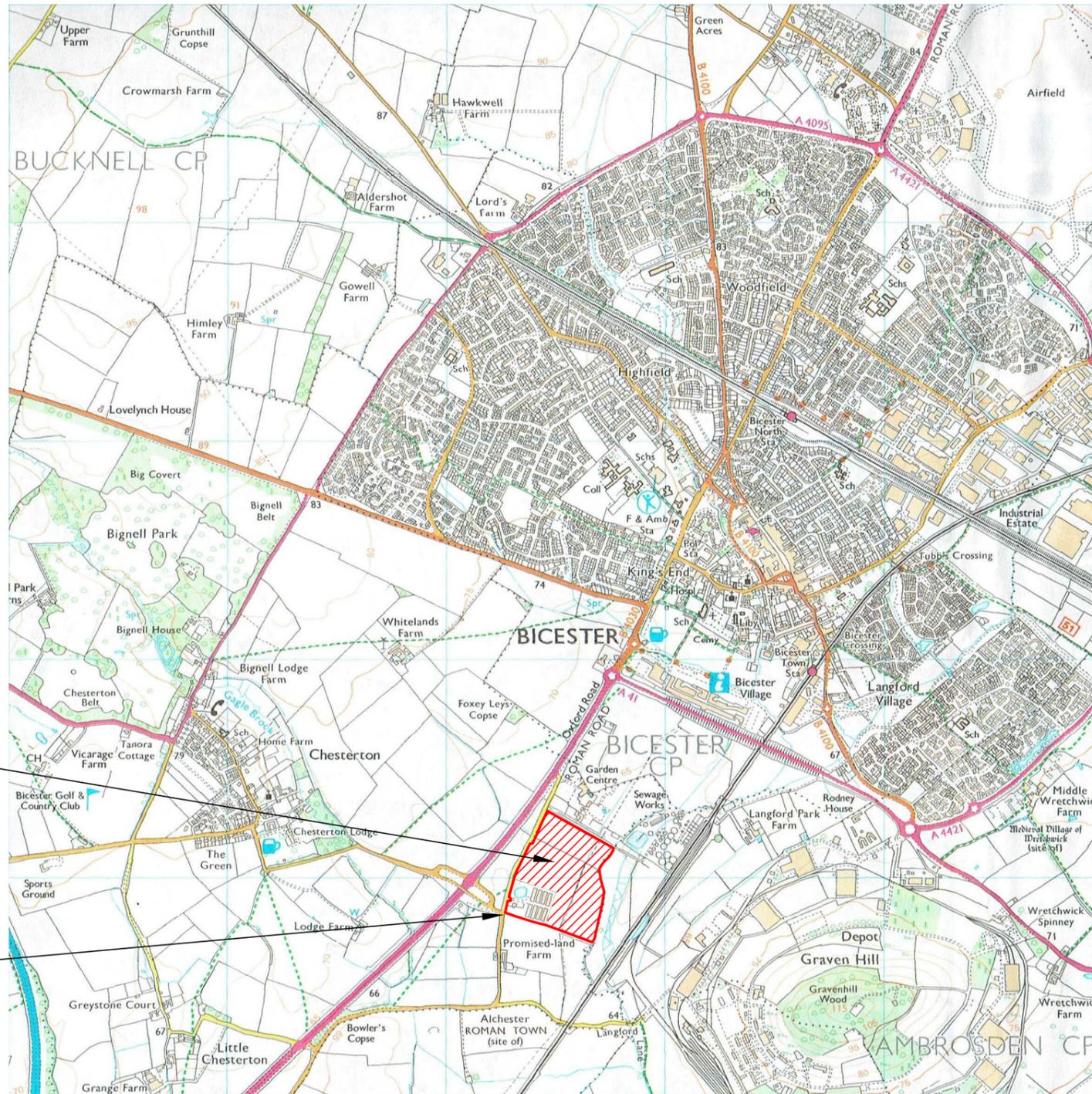
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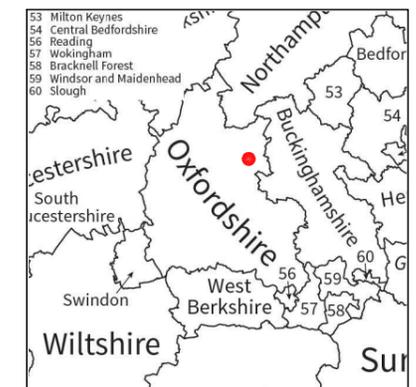
**Geophysical Survey
Bicester Gateway Phase 2
Bicester
Oxfordshire**

Map of survey area



Survey location

Proposed application boundary



Survey location

Site centred on OS NGR
SP 57550 21000

Reproduced from OS Explorer map no.191 1:25 000
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Controller of Her Majesty's Stationery Office.
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FIG 01



**Geophysical Survey
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Bicester
Oxfordshire**

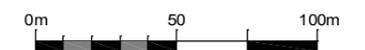
Referencing information

Referencing grid to OSGB36 datum at 50m intervals

Data collected at 20Hz and georeferenced to ETRS89 zone 30 with conversion to OSGB36 using OSTN02

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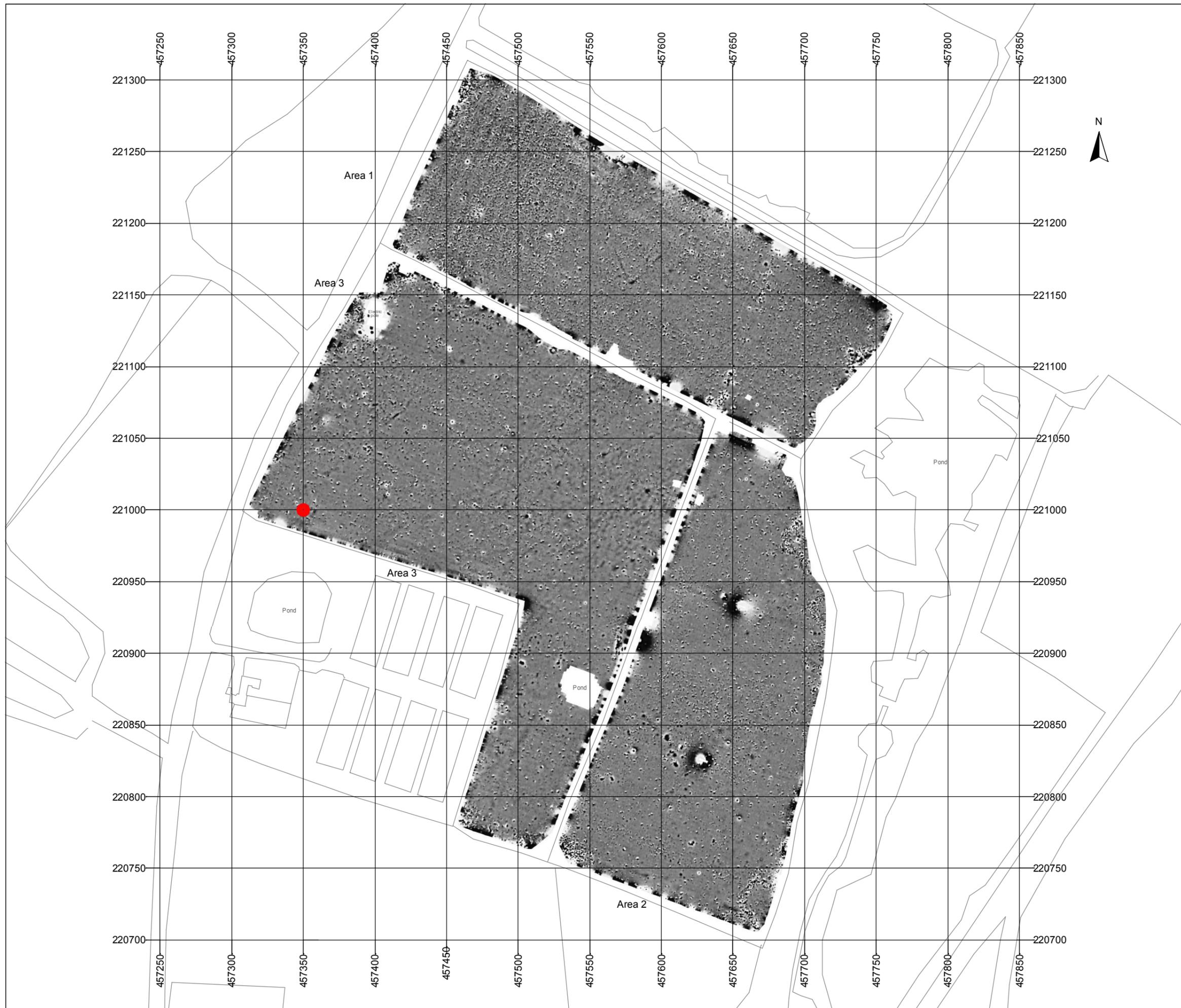


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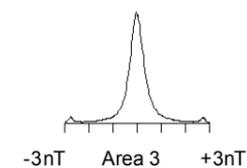
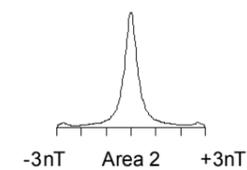
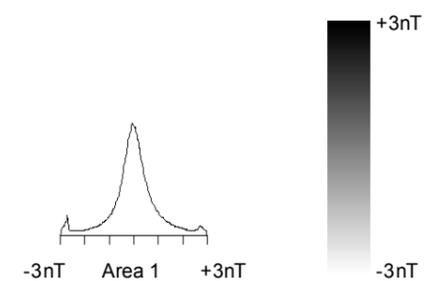
FIG 02





**Geophysical Survey
Bicester Gateway Phase 2
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Oxfordshire**

Greyscale plot of minimally processed magnetometer data



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FIG 03

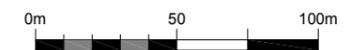


**Geophysical Survey
Bicester Gateway Phase 2
Bicester
Oxfordshire**

**Abstraction and interpretation of
magnetic anomalies**

-  Positive linear anomaly - cut feature of archaeological potential
-  Positive linear anomaly - possible ditch-like feature
-  Linear anomaly - of agricultural origin
-  Linear anomaly - ridge and furrow
-  Negative linear anomaly - linear depression related to land drainage
-  Positive linear anomaly - former field boundary
-  Negative linear anomaly - material of low magnetic susceptibility
-  Discrete positive response - cut feature of archaeological potential
-  Discrete positive response - possible pit-like feature
-  Positive anomaly - magnetically enhanced material
-  Variable magnetic response - of natural origin
-  Zone of numerous pit-like anomalies - of natural origin
-  Magnetic debris - spread of magnetically thermoremanent/ferrous material
-  Magnetic disturbance from ferrous material
-  Strong dipolar anomaly - ferrous object

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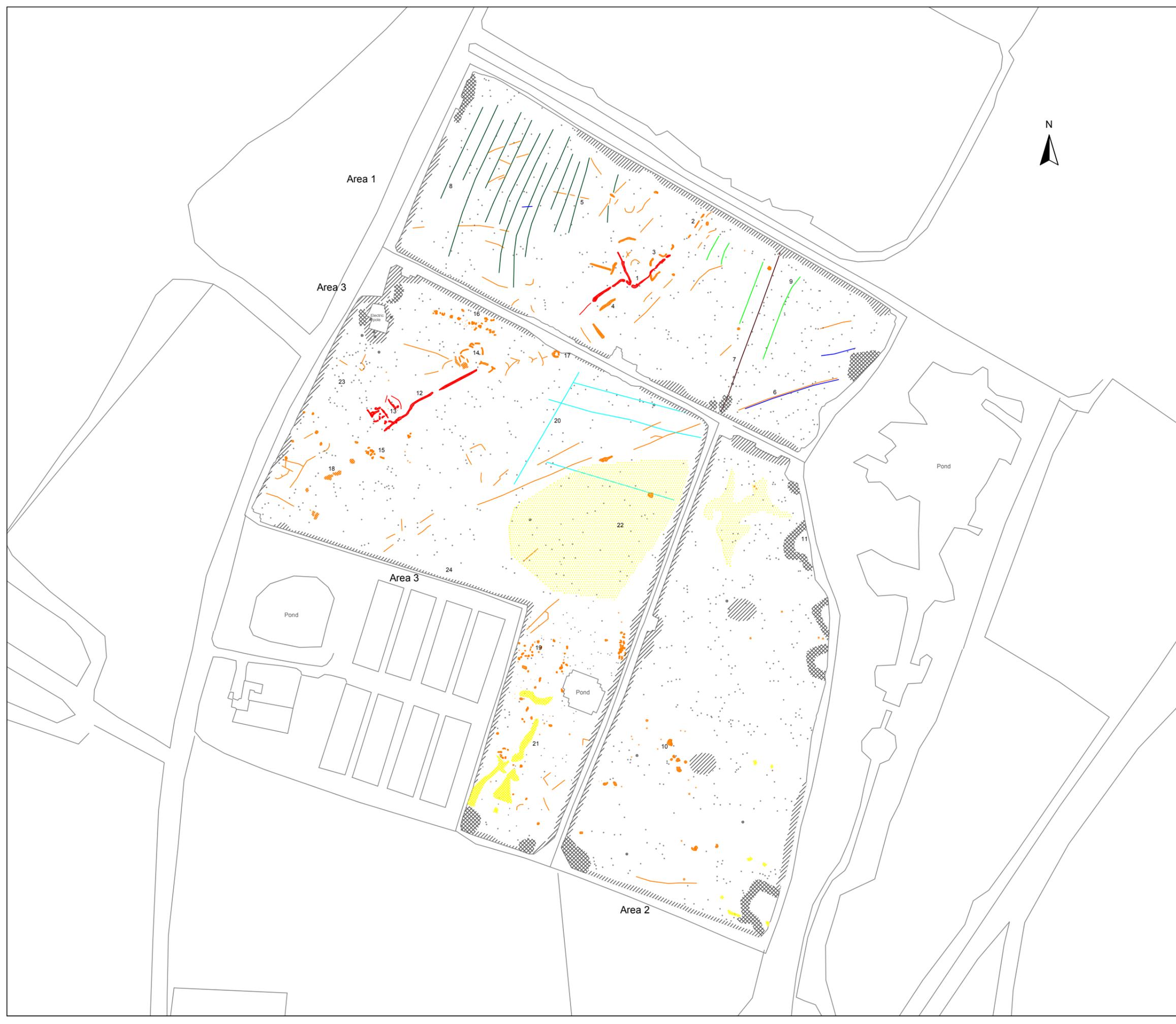


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FIG 04





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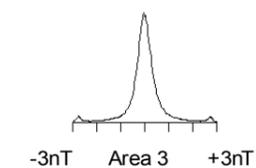
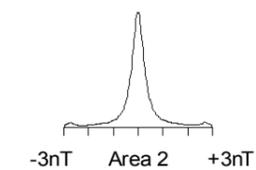
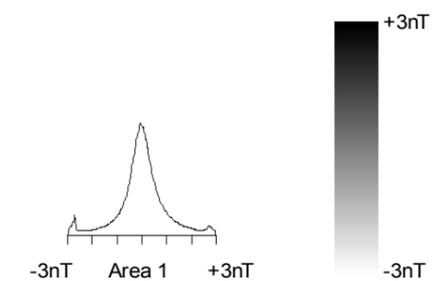
**Greyscale plot of minimally
processed magnetometer data -
north**



Area 1

Area 3

Electric
pole



SCALE 1:1250



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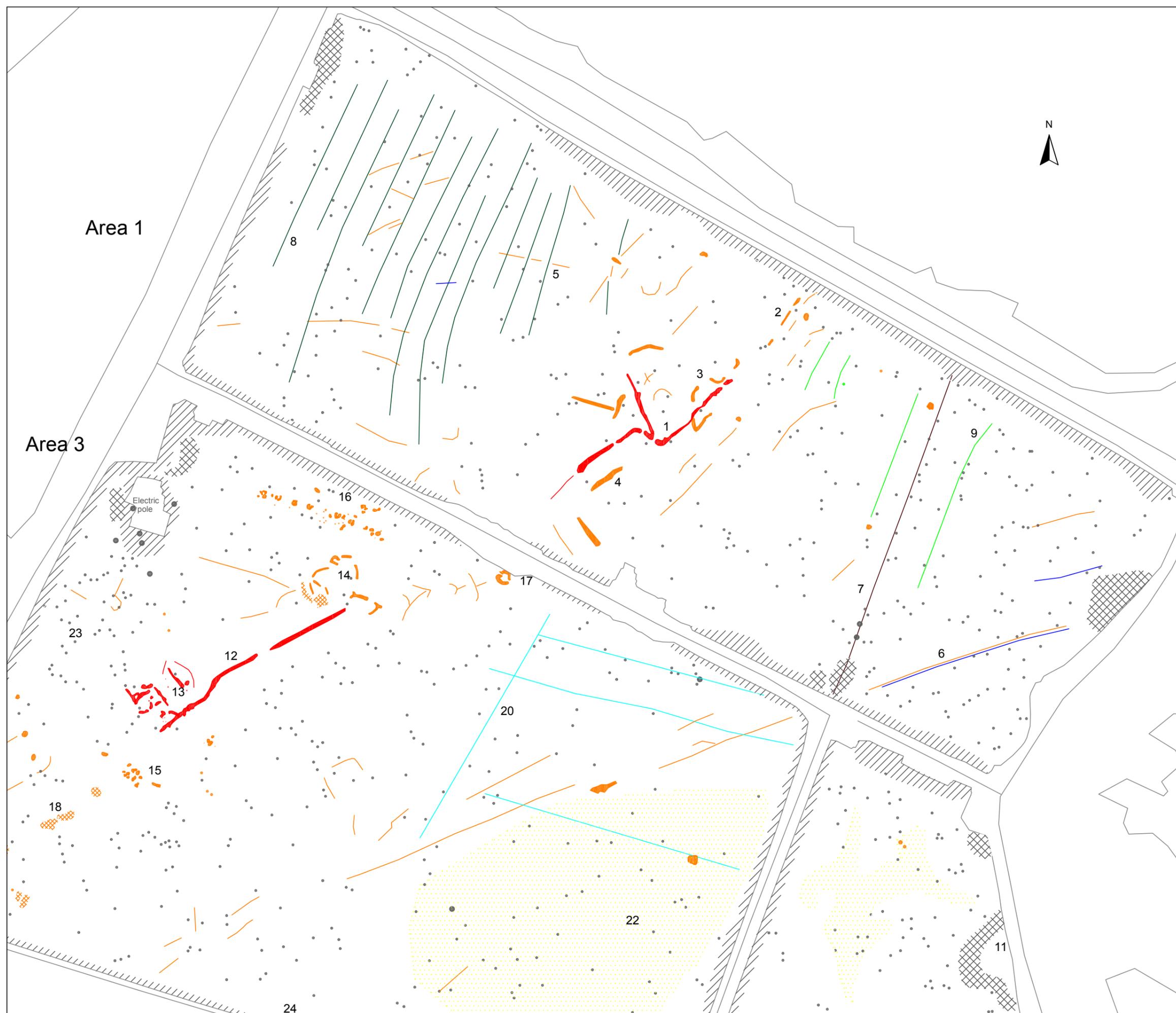
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FIG 05



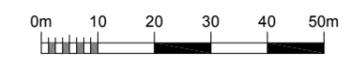
**Geophysical Survey
Bicester Gateway Phase 2
Bicester
Oxfordshire**

**Abstraction and interpretation of
magnetic anomalies - north**



-  Positive linear anomaly - cut feature of archaeological potential
-  Positive linear anomaly - possible ditch-like feature
-  Linear anomaly - of agricultural origin
-  Linear anomaly - ridge and furrow
-  Negative linear anomaly - linear depression related to land drainage
-  Positive linear anomaly - former field boundary
-  Negative linear anomaly - material of low magnetic susceptibility
-  Discrete positive response - cut feature of archaeological potential
-  Discrete positive response - possible pit-like feature
-  Positive anomaly - magnetically enhanced material
-  Variable magnetic response - of natural origin
-  Zone of numerous pit-like anomalies - of natural origin
-  Magnetic debris - spread of magnetically thermoremanent/ferrous material
-  Magnetic disturbance from ferrous material
-  Strong dipolar anomaly - ferrous object

SCALE 1:1250



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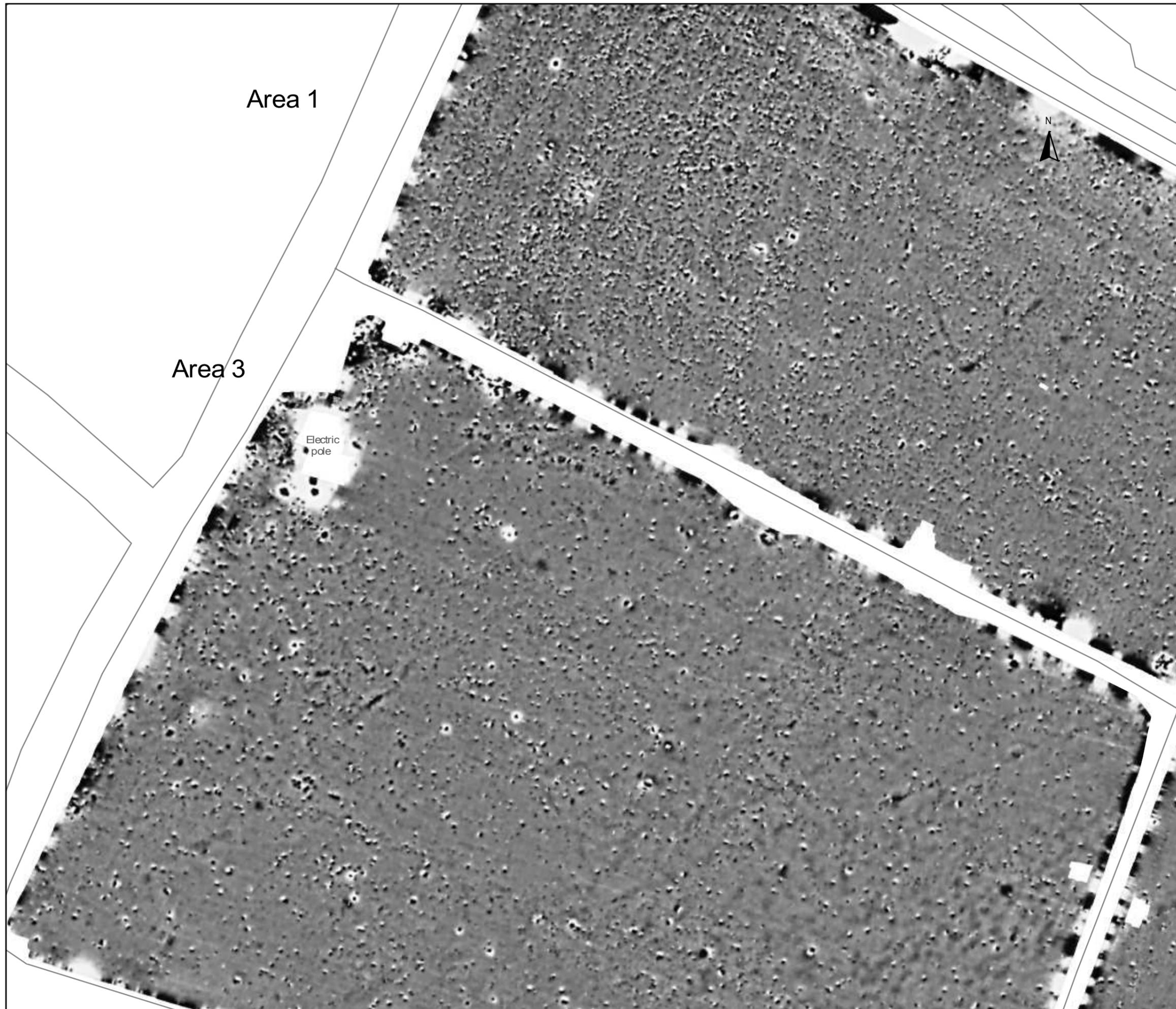
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FIG 06



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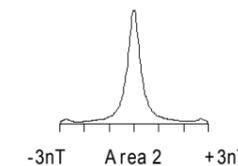
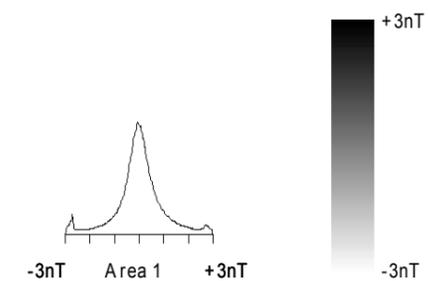
**Greyscale plot of minimally
processed magnetometer data -
west**



Area 1

Area 3

Electric pole



SCALE 1:1000



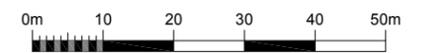


**Geophysical Survey
Bicester Gateway Phase 2
Bicester
Oxfordshire**

**Abstraction and interpretation of
magnetic anomalies - west**

-  Positive linear anomaly - cut feature of archaeological potential
-  Positive linear anomaly - possible ditch-like feature
-  Linear anomaly - of agricultural origin
-  Linear anomaly - ridge and furrow
-  Negative linear anomaly - linear depression related to land drainage
-  Positive linear anomaly - former field boundary
-  Negative linear anomaly - material of low magnetic susceptibility
-  Discrete positive response - cut feature of archaeological potential
-  Discrete positive response - possible pit-like feature
-  Positive anomaly - magnetically enhanced material
-  Variable magnetic response - of natural origin
-  Zone of numerous pit-like anomalies - of natural origin
-  Magnetic debris - spread of magnetically thermoremanent/ferrous material
-  Magnetic disturbance from ferrous material
-  Strong dipolar anomaly - ferrous object

SCALE 1:1000

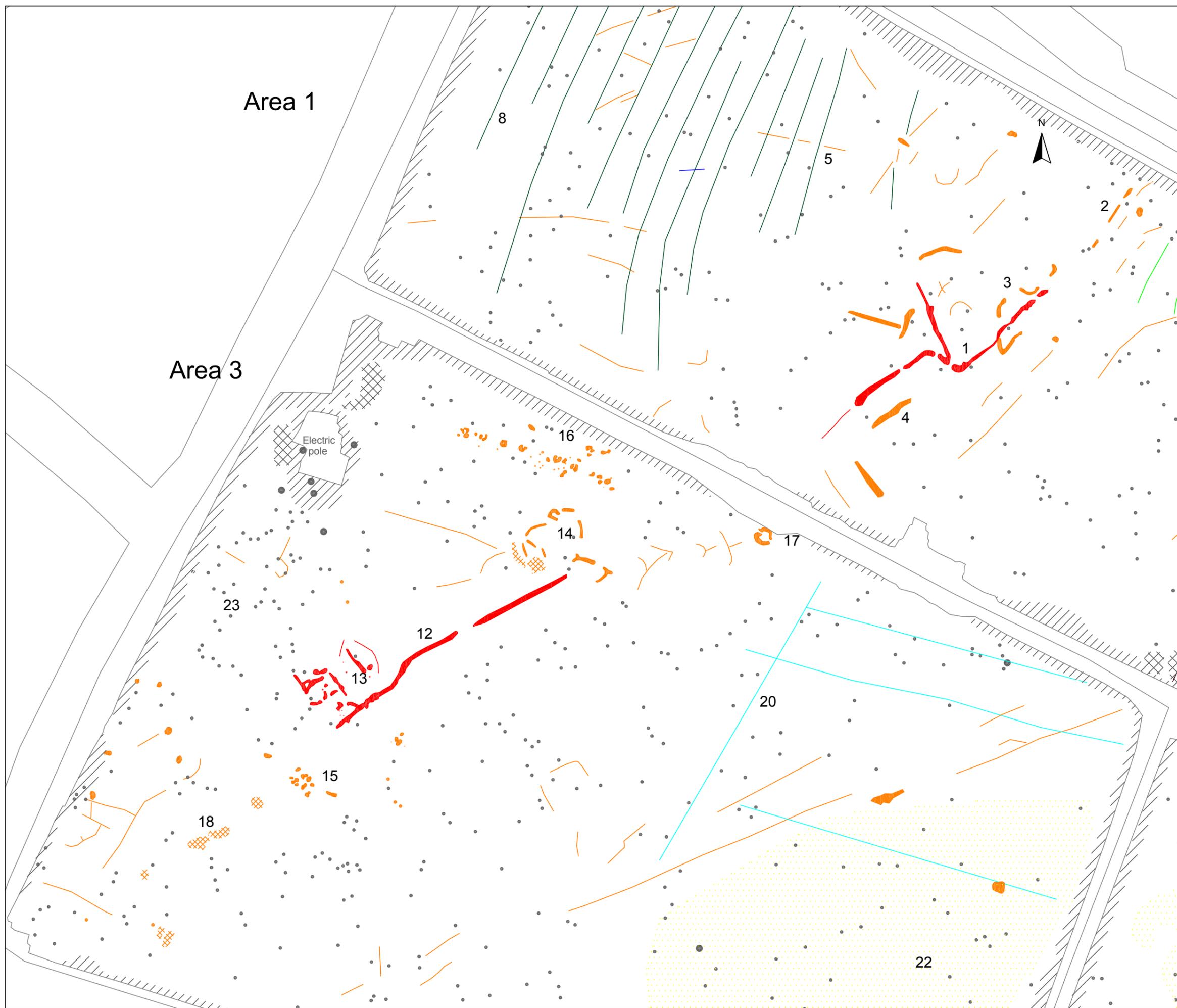


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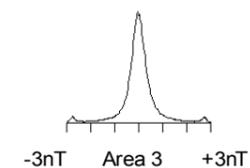
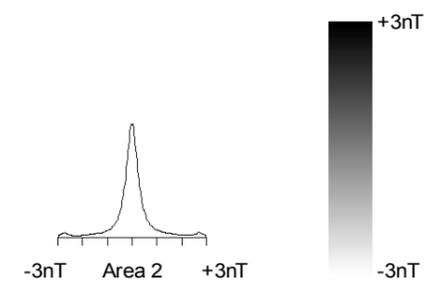
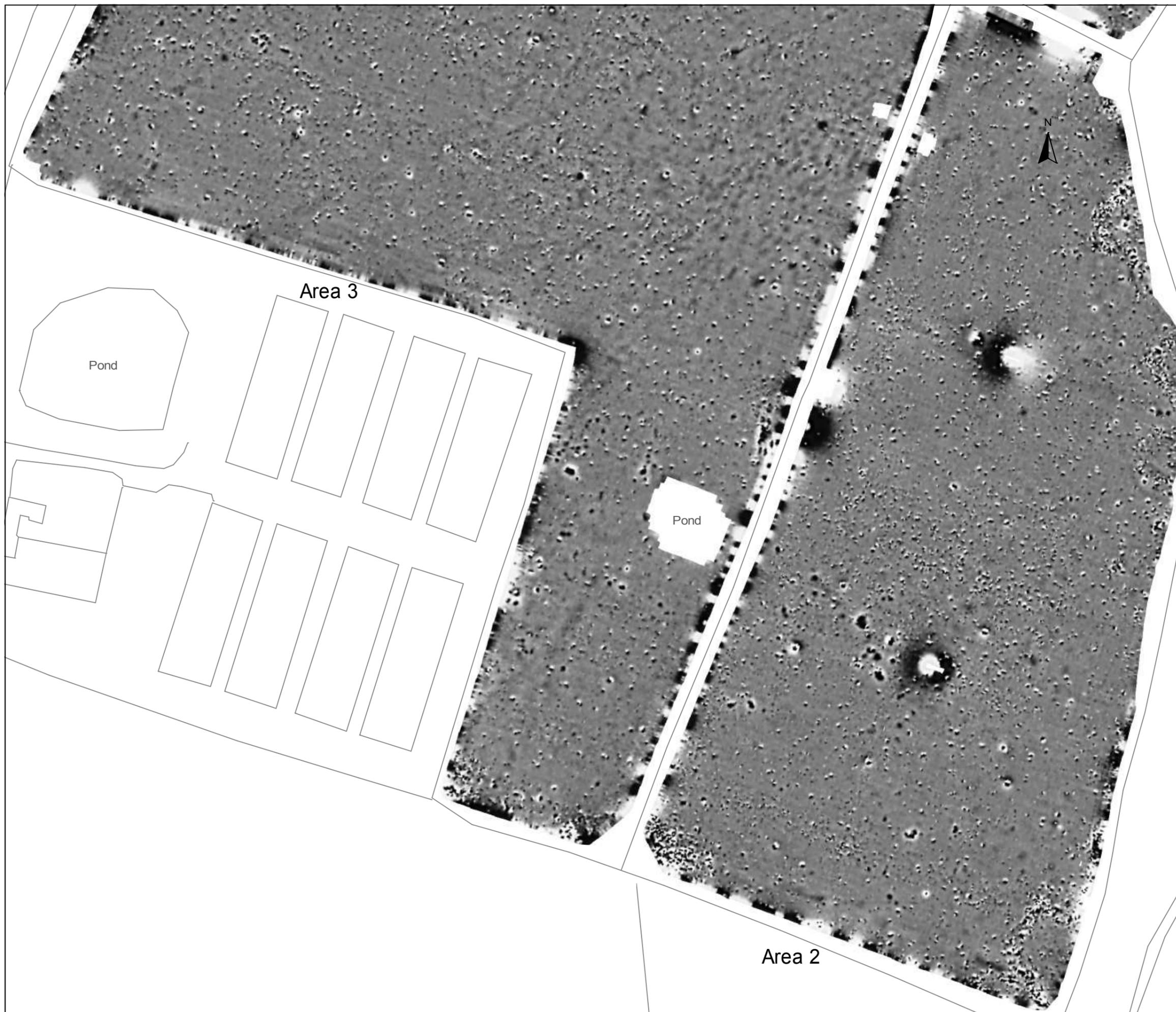
FIG 08





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**Greyscale plot of minimally
processed magnetometer data -
south**



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FIG 09

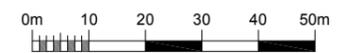


**Geophysical Survey
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Oxfordshire**

**Abstraction and interpretation of
magnetic anomalies - south**

-  Positive linear anomaly - cut feature of archaeological potential
-  Positive linear anomaly - possible ditch-like feature
-  Linear anomaly - of agricultural origin
-  Linear anomaly - ridge and furrow
-  Negative linear anomaly - linear depression related to land drainage
-  Positive linear anomaly - former field boundary
-  Negative linear anomaly - material of low magnetic susceptibility
-  Discrete positive response - cut feature of archaeological potential
-  Discrete positive response - possible pit-like feature
-  Positive anomaly - magnetically enhanced material
-  Variable magnetic response - of natural origin
-  Zone of numerous pit-like anomalies - of natural origin
-  Magnetic debris - spread of magnetically thermoremanent/ferrous material
-  Magnetic disturbance from ferrous material
-  Strong dipolar anomaly - ferrous object

SCALE 1:1250



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FIG 10

