

GEOPHYSICAL SURVEY REPORT

sumo

Survey

**GEOPHYSICS FOR
ARCHAEOLOGY &
ENGINEERING**

**Castle Donnington,
Leicestershire**

Client
**University of Leicester
Archaeological Services**

Survey Report
11998

Date
December 2017

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GEOPHYSICAL SURVEY REPORT

Project name:
Castle Donnington, Leicestershire

SUMO Job reference:
11998

Client:
**University of Leicester
Archaeological Services**

Survey date:
30 October, 4, 8 December 2017

Report date:
19 December 2017

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DIGITAL CONTENT (Archive Data CD/DVD)

- Minimally Processed Greyscale Images and XY Trace Plots in DWG format
- Digital Copies of Report Text and Figures (both PDF and native formats)

1 SUMMARY OF RESULTS

A detailed magnetometer survey was conducted over approximately 8.8 ha of grassland. No definite archaeological responses have been detected, though several linear anomalies of uncertain origin have been identified. Ridge and furrow is visible in the south of the area. Areas of natural magnetic variation and areas of magnetic disturbance from nearby ferrous metal objects are also present in the data.

2 INTRODUCTION

2.1 Background synopsis

SUMO Services Ltd were commissioned to undertake a geophysical survey of an area outlined for residential development. This survey forms part of an archaeological investigation being undertaken by **University of Leicester Archaeological Services**.

2.2 Site details

NGR / Postcode	SK 449 279 / DE74 2HP
Location	The site is located to the north-east of Castle Donnington, Leicestershire. The area is bound to the west by commercial units, with agricultural land to the north, south and east.
HER/SMR	Leicestershire
District	North West Leicestershire
Parish	Castle Donnington CP
Topography	Mostly level
Current Land Use	Grassland
Weather	Overcast, dry
Geology	Solid: Edwalton Member – mudstone. Superficial: Holme Pierrepont Sand and Gravel Member – sand and gravel is recorded across the majority of the area, with Hemington Member – silt and gravel recorded across the north (BGS 2017).
Soils	Bromsgrove Association (541b) – well drained reddish coarse loamy soils (SSEW 1983).
Archaeology	In the medieval period, the area was probably part of the open field system surrounding the historic town core. Historical and archaeological evidence suggests the site has probably remained in agricultural usage for much of the historic period. Its location on the northern edge of the town and the historical agricultural nature of the site might suggest a low potential for medieval and post-medieval remains (ULAS 2017).
Survey Methods	Magnetometer survey (fluxgate gradiometer)
Study Area	8.8 ha

2.3 Aims and Objectives

To locate and characterise any anomalies of possible archaeological interest within the study area.

3 METHODS, PROCESSING & PRESENTATION

3.1 Standards & Guidance

This report and all fieldwork have been conducted in accordance with the latest guidance documents issued by Historic England (EH 2008) (then English Heritage), the Chartered Institute for Archaeologists (CIfA 2014) and the European Archaeological Council (EAC 2016).

3.2 Survey methods

Detailed magnetic survey was chosen as an efficient and effective method of locating archaeological anomalies.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	Bartington Grad 601-2	1.0m	0.25m

More information regarding this technique is included in Appendix A.

3.3 Data Processing

The following basic processing steps have been carried out on the data used in this report:

De-stripe; de-stagger; interpolate

3.4 Presentation of results and interpretation

The presentation of the results for each site involves a grey-scale plot of processed data. Magnetic anomalies are identified, interpreted and plotted onto the 'Interpretation' drawings. The minimally processed data are provided as a greyscale image in the Archive Data Folder with an XY trace plot in CAD format. A free viewer is available: <https://viewer.autodesk.com>

When interpreting the results, several factors are taken into consideration, including the nature of archaeological features being investigated and the local conditions at the site (geology, pedology, topography etc.). Anomalies are categorised by their potential origin. Where responses can be related to other existing evidence, the anomalies will be given specific categories, such as: *Abbey Wall* or *Roman Road*. Where the interpretation is based largely on the geophysical data, levels of confidence are implied, for example: *Probable*, or *Possible Archaeology*. The former is used for a confident interpretation, based on anomaly definition and/or other corroborative data such as cropmarks. Poor anomaly definition, a lack of clear patterns to the responses and an absence of other supporting data reduces confidence, hence the classification *Possible*.

4 RESULTS

The survey has been divided into four survey areas (Areas 1-4).

4.1 **Probable / Possible Archaeology**

4.1.1 No magnetic responses have been recorded that could be interpreted as being of archaeological interest.

4.2 **Uncertain**

4.2.1 Several weak linear trends are present across the site, though their origin is unknown. Given their lack of context, an archaeological origin is thought unlikely but cannot be entirely ruled out. It is more probable that they are of natural origin, or relate to agricultural activity on the site.

4.3 **Agricultural – Ridge and Furrow**

4.3.1 Widely spaced, slightly curved, parallel linear responses are visible in Area 4 and are a result of ridge and furrow cultivation.

4.4 **Natural / Geological / Pedological / Topographic**

4.4.1 Several amorphous areas of increased magnetic response have been detected, particularly in Area 1. These are of natural origin, and reflect variations in the geology below or superficial deposits of silt and gravel recorded in the north (BGS 2017).

4.5 **Ferrous / Magnetic Disturbance**

4.5.1 A strong bipolar linear anomaly is visible running east-west through Area 2. This relates to an underground service, such as a pipe or cable.

4.5.2 Ferrous responses close to boundaries are due to adjacent fences and gates. Smaller scale ferrous anomalies ("iron spikes") are present throughout the data and their form is best illustrated in the XY trace plots. These responses are characteristic of small pieces of ferrous debris (or brick / tile) in the topsoil and are commonly assigned a modern origin. Only the most prominent of these are highlighted on the interpretation diagram.

5 DATA APPRAISAL & CONFIDENCE ASSESSMENT

5.1 Historic England guidelines (EH 2008) Table 4 states that the average magnetic response on mudstone can be variable, as can results over superficial sand, silt and gravel. Given that responses of uncertain origin have been identified, along with evidence of ridge and furrow, it can be determined that the technique has been effective.

6 CONCLUSION

- 6.1 The survey at Castle Donnington has not revealed any definite archaeological responses. Several linear anomalies of uncertain origin are visible in the data, though these are more likely to be natural or agricultural. Evidence of ridge and furrow is present across the south of the area, while natural responses are detected in both the north and south. The remaining responses are modern, and include an underground service and areas of disturbance from nearby ferrous metal objects.

7 REFERENCES

- BGS 2017 British Geological Survey, Geology of Britain viewer [Accessed 19/12/2017] *website:* (<http://www.bgs.ac.uk/opengeoscience/home.html?Accordion1=1#maps>)
- ClfA 2014 *Standard and Guidance for Archaeological Geophysical Survey*. Amended 2016. ClfA Guidance note. Chartered Institute for Archaeologists, Reading
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- SSEW 1983 *Soils of England and Wales. Sheet 3, Midland and Western England*. Soil Survey of England and Wales, Harpenden.
- ULAS 2017 *An archaeological desk-based assessment for land at Carnival Way, Castle Donnington, Leicestershire*. University of Leicester Archaeological Services; unpublished report. (Report No. 2017-034).

Appendix A - Technical Information: Magnetometer Survey Method

Grid Positioning

For hand held gradiometers the location of the survey grids has been plotted together with the referencing information. Grids were set out using a Trimble R8 Real Time Kinematic (RTK) VRS Now GNSS GPS system.

An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. An RTK system uses a single base station receiver and a number of mobile units. The base station re-broadcasts the phase of the carrier it measured, and the mobile units compare their own phase measurements with those they received from the base station. This results in an accuracy of around 0.01m.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	Bartington Grad 601-2	1m	0.25m

Instrumentation: **Bartington Grad 601-2**

Bartington instruments operate in a gradiometer configuration which comprises fluxgate sensors mounted vertically, set 1.0m apart. The fluxgate gradiometer suppresses any diurnal or regional effects. The instruments are carried, or cart mounted, with the bottom sensor approximately 0.1-0.3m from the ground surface. At each survey station, the difference in the magnetic field between the two fluxgates is measured in nanoTesla (nT). The sensitivity of the instrument can be adjusted; for most archaeological surveys the most sensitive range (0.1nT) is used. Generally, features up to 1m deep may be detected by this method, though strongly magnetic objects may be visible at greater depths. The Bartington instrument can collect two lines of data per traverse with gradiometer units mounted laterally with a separation of 1.0m. The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each site survey, data is transferred to the office for processing and presentation.

Data Processing

Zero Mean Traverse	This process sets the background mean of each traverse within each grid to zero. The operation removes striping effects and edge discontinuities over the whole of the data set.
Step Correction (De-stagger)	When gradiometer data are collected in 'zig-zag' fashion, stepping errors can sometimes arise. These occur because of a slight difference in the speed of walking on the forward and reverse traverses. The result is a staggered effect in the data, which is particularly noticeable on linear anomalies. This process corrects these errors.

Display

Greyscale/ Colourscale Plot	This format divides a given range of readings into a set number of classes. Each class is represented by a specific shade of grey, the intensity increasing with value. All values above the given range are allocated the same shade (maximum intensity); similarly, all values below the given range are represented by the minimum intensity shade. Similar plots can be produced in colour, either using a wide range of colours or by selecting two or three colours to represent positive and negative values. The assigned range (plotting levels) can be adjusted to emphasise different anomalies in the data-set.
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Interpretation Categories

In certain circumstances (usually when there is corroborative evidence from desk-based or excavation data) very specific interpretations can be assigned to magnetic anomalies (for example, *Roman Road, Wall, etc.*) and where appropriate, such interpretations will be applied. The list below outlines the generic categories commonly used in the interpretation of the results.

<i>Archaeology / Probable Archaeology</i>	This term is used when the form, nature and pattern of the responses are clearly or very probably archaeological and /or if corroborative evidence is available. These anomalies, whilst considered anthropogenic, could be of any age.
<i>Possible Archaeology</i>	These anomalies exhibit either weak signal strength and / or poor definition, or form incomplete archaeological patterns, thereby reducing the level of confidence in the interpretation. Although the archaeological interpretation is favoured, they may be the result of variable soil depth, plough damage or even aliasing as a result of data collection orientation.
<i>Industrial / Burnt-Fired</i>	Strong magnetic anomalies that, due to their shape and form or the context in which they are found, suggest the presence of kilns, ovens, corn dryers, metal-working areas or hearths. It should be noted that in many instances modern ferrous material can produce similar magnetic anomalies.
<i>Former Field Boundary (probable & possible)</i>	Anomalies that correspond to former boundaries indicated on historic mapping, or which are clearly a continuation of existing land divisions. Possible denotes less confidence where the anomaly may not be shown on historic mapping but nevertheless the anomaly displays all the characteristics of a field boundary.
<i>Ridge & Furrow</i>	Parallel linear anomalies whose broad spacing suggests ridge and furrow cultivation. In some cases, the response may be the result of more recent agricultural activity.
<i>Agriculture (ploughing)</i>	Parallel linear anomalies or trends with a narrower spacing, sometimes aligned with existing boundaries, indicating more recent cultivation regimes.
<i>Land Drain</i>	Weakly magnetic linear anomalies, quite often appearing in series forming parallel and herringbone patterns. Smaller drains may lead and empty into larger diameter pipes, which in turn usually lead to local streams and ponds. These are indicative of clay fired land drains.
<i>Natural</i>	These responses form clear patterns in geographical zones where natural variations are known to produce significant magnetic distortions.
<i>Magnetic Disturbance</i>	Broad zones of strong dipolar anomalies, commonly found in places where modern ferrous or fired materials (e.g. brick rubble) are present. They are presumed to be modern.
<i>Service</i>	Magnetically strong anomalies, usually forming linear features are indicative of ferrous pipes/cables. Sometimes other materials (e.g. pvc) or the fill of the trench can cause weaker magnetic responses which can be identified from their uniform linearity.
<i>Ferrous</i>	This type of response is associated with ferrous material and may result from small items in the topsoil, larger buried objects such as pipes, or above ground features such as fence lines or pylons. Ferrous responses are usually regarded as modern. Individual burnt stones, fired bricks or igneous rocks can produce responses similar to ferrous material.
<i>Uncertain Origin</i>	Anomalies which stand out from the background magnetic variation, yet whose form and lack of patterning gives little clue as to their origin. Often the characteristics and distribution of the responses straddle the categories of <i>Possible Archaeology / Natural</i> or (in the case of linear responses) <i>Possible Archaeology / Agriculture</i> ; occasionally they are simply of an unusual form.

Where appropriate some anomalies will be further classified according to their form (positive or negative) and relative strength and coherence (trend: weak and poorly defined).

Appendix B - Technical Information: Magnetic Theory

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock. Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.1 nanoTeslas (nT) in an overall field strength of 48,000 (nT), can be accurately detected.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremanent* material.

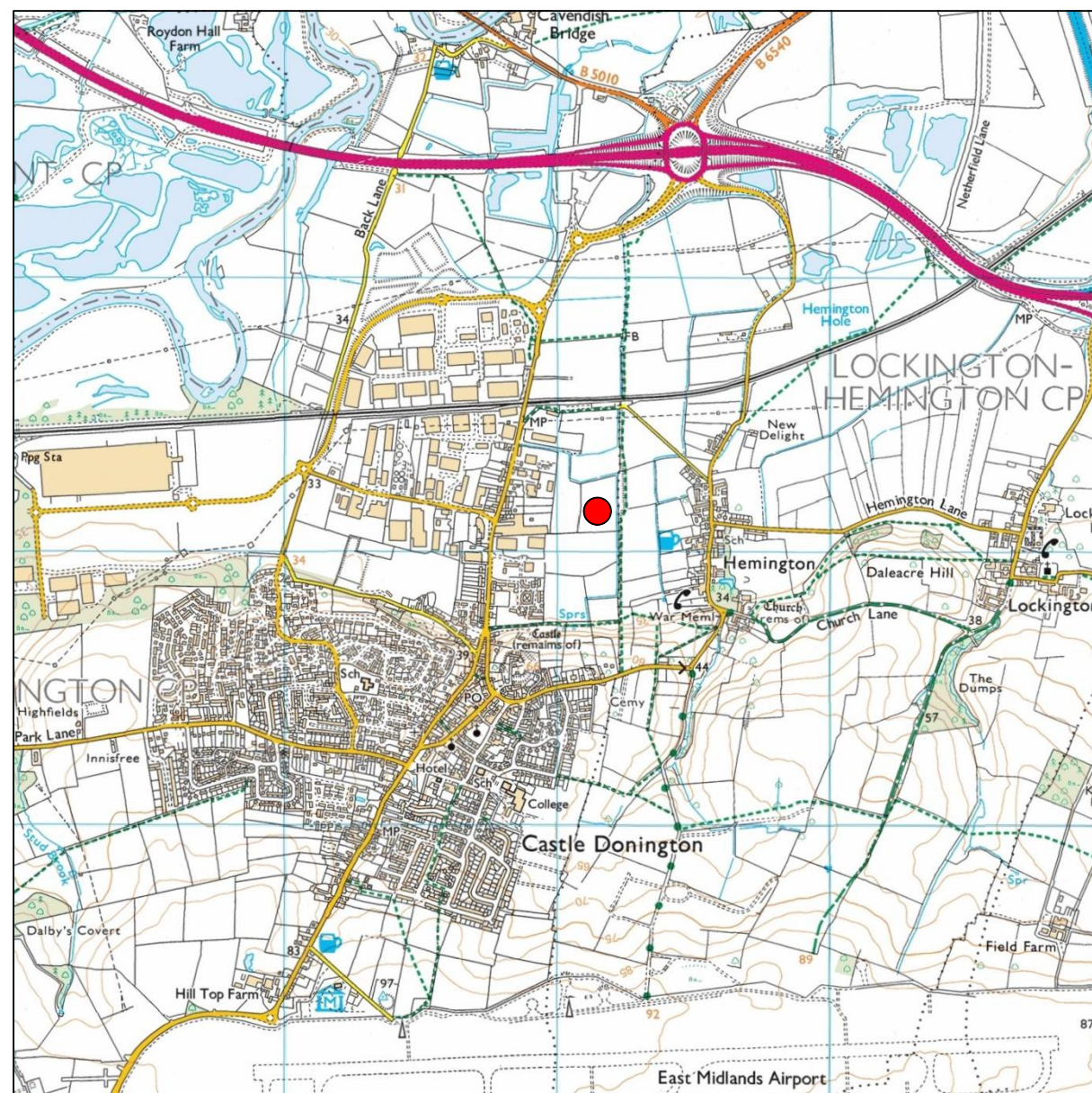
Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

Thermoremanence is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremanent archaeological features can include hearths and kilns; material such as brick and tile may be magnetised through the same process.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried feature. The difference between the two sensors will relate to the strength of a magnetic field created by this feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity and disturbance from modern services.



 Site Location

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Title:
Site Location Diagram

Client:
University of Leicester Archaeological Services

Project:
11998 - Castle Donington, Leicestershire


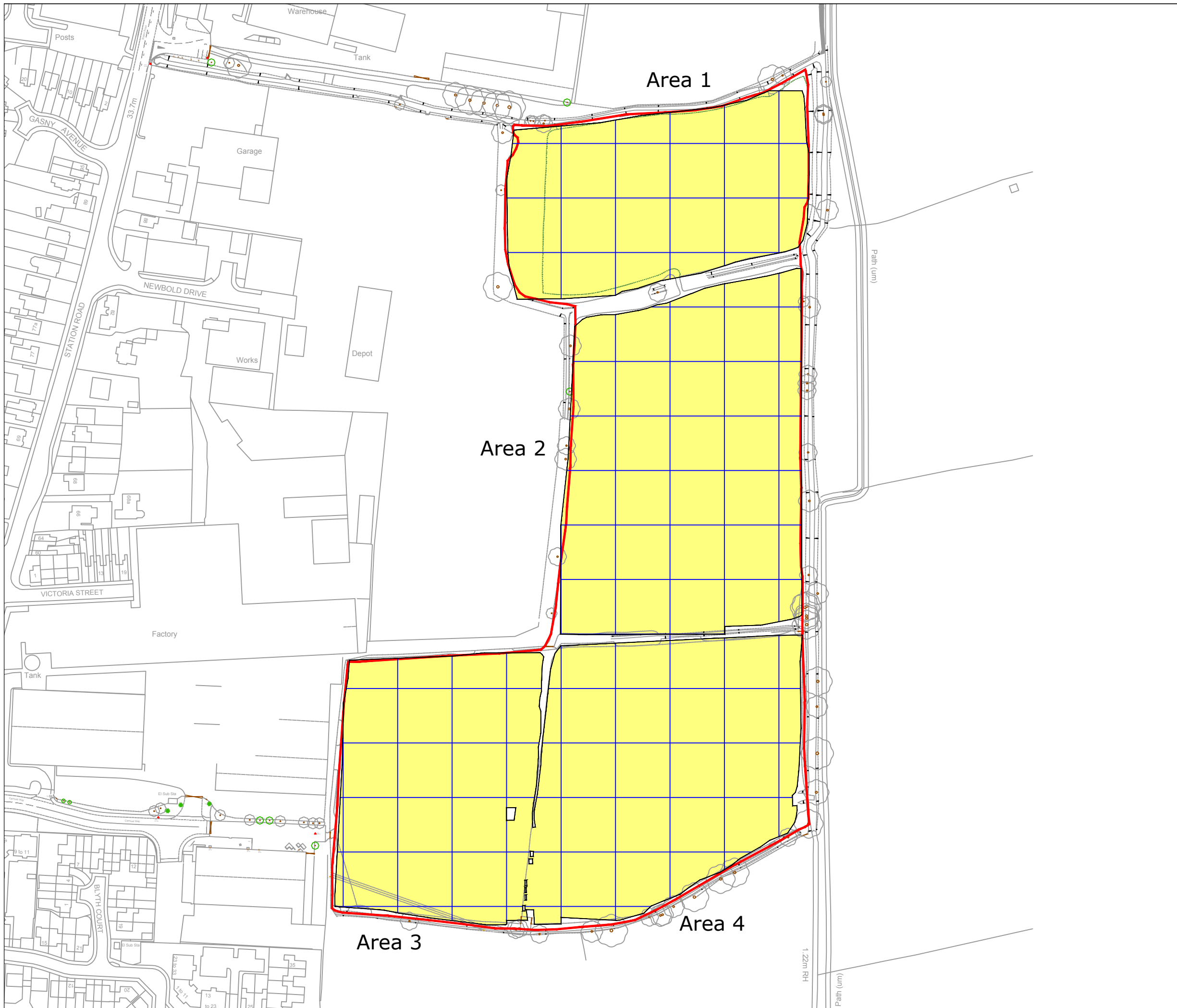

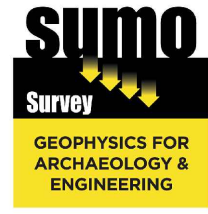
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1:25000 @ A3

Fig No:
01



 Survey Area - showing 30m grid



Title: Location of Survey Areas

Client: University of Leicester Archaeological Services

Project: 11998 - Castle Donnington, Leicestershire

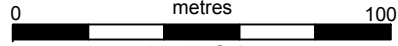
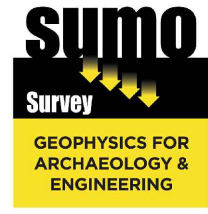
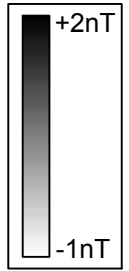
Scale:  metres
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Fig No: 02



Title:
Magnetometer Survey - Greyscale Plots

Client:
University of Leicester Archaeological Services

Project:
11998 - Castle Donnington, Leicestershire

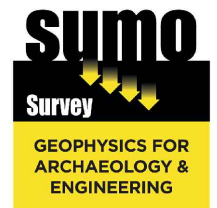
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Fig No:
03



KEY

	Uncertain Origin (trend)
	Agriculture (ridge and furrow)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous



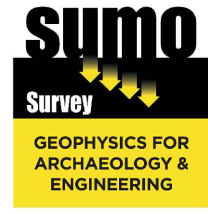
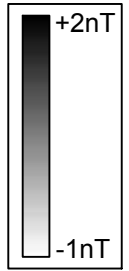
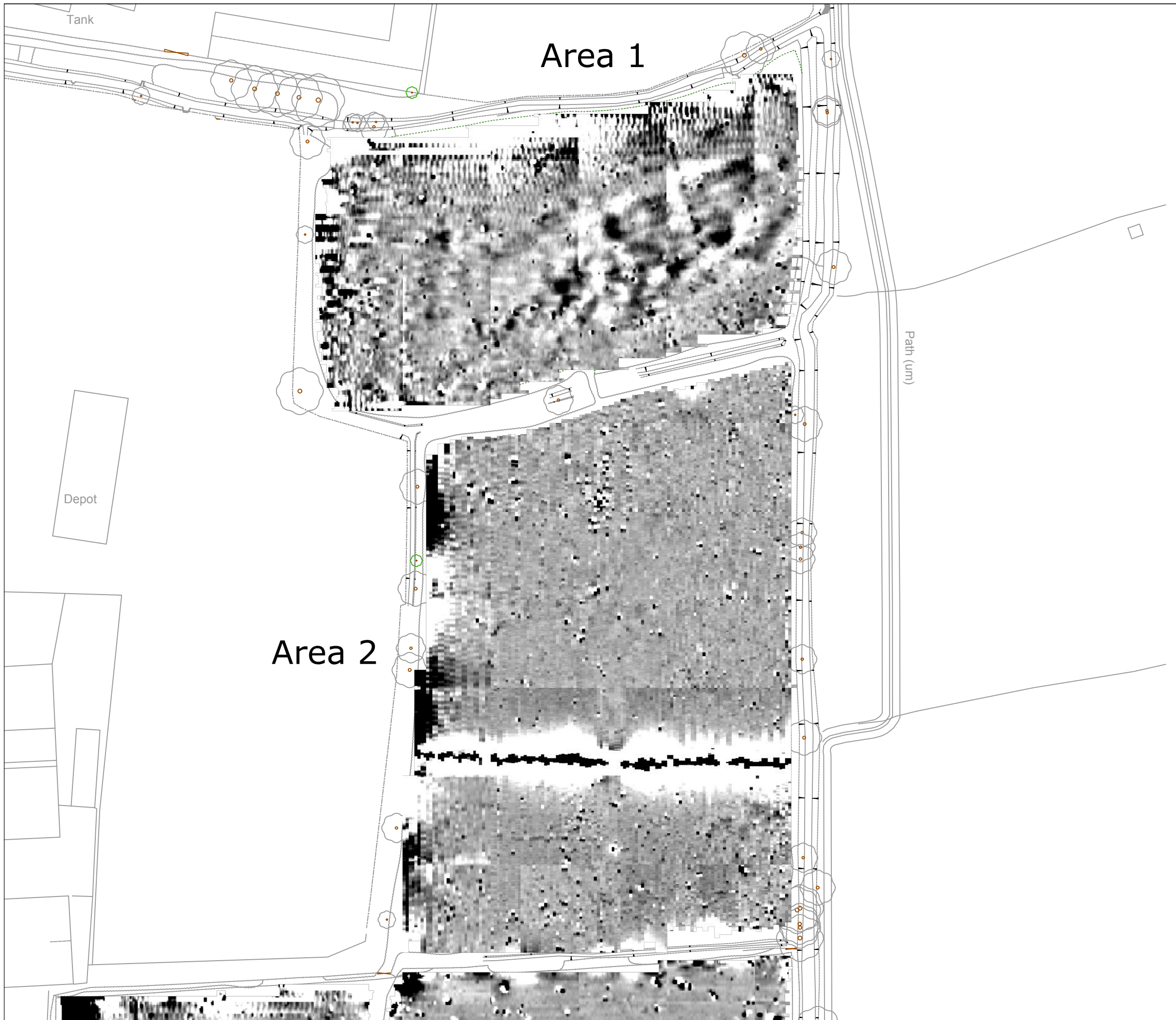
Title: Magnetometer Survey - Interpretation

Client: University of Leicester Archaeological Services

Project: 11998 - Castle Donnington, Leicestershire

Scale: 0 metres 100
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Fig No: 04



Title:
Magnetometer Survey - Greyscale Plots -
Areas 1 and 2

Client:
University of Leicester Archaeological Services

Project:
11998 - Castle Donnington, Leicestershire

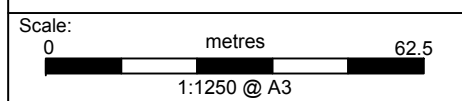






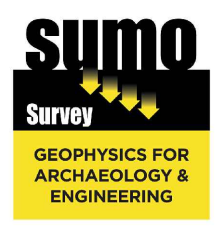


Fig No:
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KEY

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	Agriculture (ridge and furrow)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous



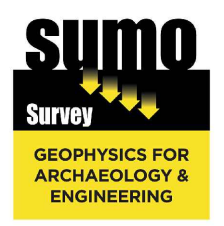
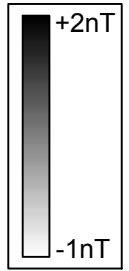
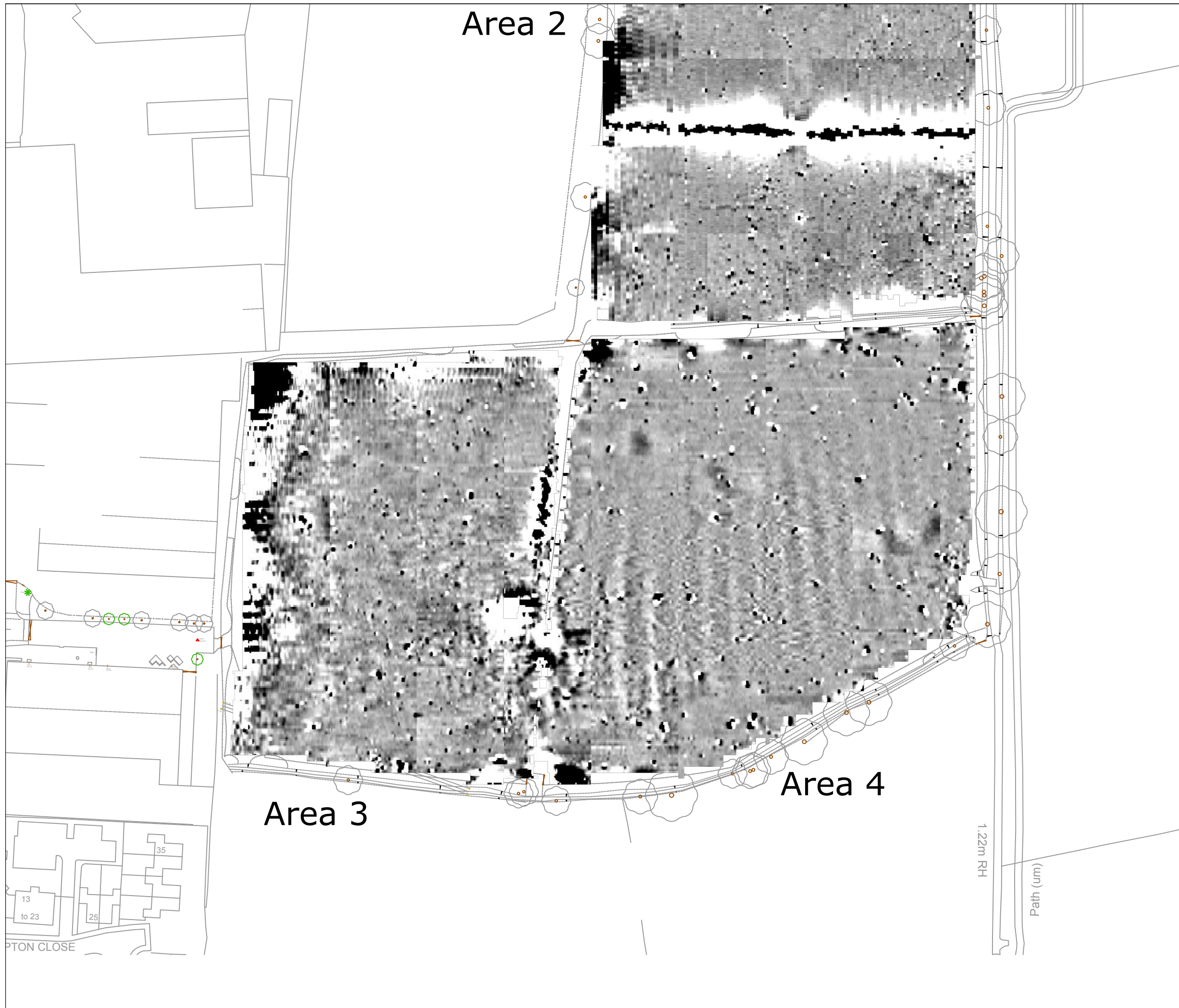
Title:
Magnetometer Survey - Interpretation - Areas 1 and 2

Client:
University of Leicester Archaeological Services

Project:
11998 - Castle Donnington, Leicestershire

Scale: 0 metres 62.5
1:1250 @ A3

Fig No: 06



Title: Magnetometer Survey - Grayscale Plots - Area 3

Client: University of Leicester Archaeological Services

Project: 11998 - Castle Donnington, Leicestershire

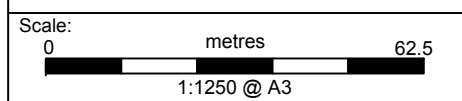






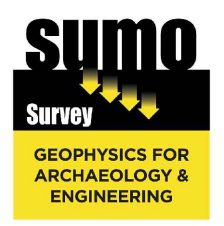


Fig No: 07



KEY

	Uncertain Origin (trend)
	Agriculture (ridge and furrow)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous



Title: Magnetometer Survey - Interpretation - Area 3

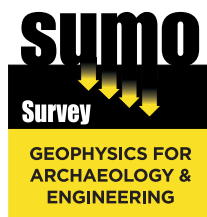
Client: University of Leicester Archaeological Services

Project: 11998 - Castle Donnington, Leicestershire

Scale: 0 metres 62.5
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Fig No: 08

13 to 23
25
35
PTON CLOSE



- Archaeological
- Geophysical
- Laser Scanning
- Measured Building
- Topographic
- Utility Mapping

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