

GEOPHYSICAL SURVEY REPORT

STRATASCAN™



Project name:
Down Hatherley, Gloucestershire

Client:
Mace

October 2015

Job ref:
J8967

Report author:
Rebecca Davies BSc (Hons)

GEOPHYSICAL SURVEY REPORT

Project name:

Down Hatherley, Gloucestershire

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Mace



Job ref:

J8967

Techniques:

**Detailed magnetic survey –
Gradiometry**

Survey date:

18th September 2015

Site centred at:

SO 880 224

Post code:

GL2 9QH

Field team:

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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 1.6 hectares of grassland. No features of archaeological or agricultural origin have been identified, despite the potential for medieval remains. The anomalies that have been identified are all modern in origin and include areas of made ground, underground services, scattered magnetic debris, and disturbance from nearby ferrous objects.

2 INTRODUCTION

2.1 *Background synopsis*

Stratascan were commissioned to undertake a geophysical survey of an area outlined for development. This survey forms part of an archaeological investigation being undertaken by Mace.

2.2 *Site location*

The site is located east of Down Hatherley, Gloucestershire at OS ref. SO 880 224, immediately to the north of Meteor Business Park and adjacent to Dowty Sports and Social Club.

2.3 *Description of site*

The survey area is approximately 3.4 hectares of mostly flat grassland. An area of around 1.8 hectares could not be surveyed due to dense vegetation, reducing the total area surveyed to around 1.6 hectares.

2.4 *Geology and soils*

The underlying geology comprises mudstone and limestone of Rugby Limestone Member (British Geological Survey website). Superficial deposits of Alluvium are recorded along the southern edge of the site (British Geological Survey website).

The overlying soils are known as Evesham 1 which are typical calcareous pelosols. These consist of slowly permeable calcareous clayey soils associated with shallow well drained calcareous soils over limestone (Soil Survey of England and Wales, Sheet 5 South West England).

2.5 **Site history and archaeological potential**

A search of Gloucestershire HER (Gloucestershire County Council, 2015) within a 1km radius of the site has identified a small number of Romano-British and medieval records, along with a number of World War II installations. A scatter of Roman pottery sherds and a stone tile (HER No. 5596) have been discovered to the north-west of the site, along with a Roman coin to the south (HER No. 6677). The village of Staverton, to the east of the study site, is recorded in the Domesday Book as "Staruenton", (HER No. 8825) meaning 'farm made of or marked by stakes' and could indicate that the site lay within agricultural land during the medieval period. Medieval pottery has been discovered in a ditch north-west of the site, along with a section of a medieval trackway (HER No. 9943).

More recent records of WWII pillboxes (HER No. 20884, 205885, 20887, 20888, 7113) are noted in the area surrounding the site, along with the WWII airfield at Staverton (HER No. 21457) and a number of anti-aircraft batteries in the same location (HER No. 27076, 27077, 27078).

A previous geophysical survey at Staverton (Stratascan, 2014), approximately 200m to the south-east of the site, identified areas of ridge and furrow cultivation and former field boundaries, therefore it is likely that the site has been used for agricultural purposes since the medieval period, and has a moderate potential for remains of medieval date. The site also has a moderate potential for WWII installations, and a low potential for remains of all other periods.

2.6 **Survey objectives**

The objective of the survey was to locate any features of possible archaeological origin in order that they may be assessed prior to development.

2.7 **Survey methods**

This report and all fieldwork have been conducted in accordance with both the English Heritage guidelines outlined in the document: *Geophysical Survey in Archaeological Field Evaluation, 2008* and with the Chartered Institute for Archaeologists document *Standard and Guidance for Archaeological Geophysical Survey*.

Due to the moderate potential for medieval remains and evidence of WWII defences, detailed magnetic survey (gradiometry) was used as an efficient and effective method of locating archaeological anomalies. More information regarding this technique is included in Appendix A.

2.8 **Processing, presentation and interpretation of results**

2.8.1 **Processing**

Processing is performed using specialist software. This can emphasise various aspects contained within the data but which are often not easily seen in the raw data. Basic processing

of the magnetic data involves 'flattening' the background levels with respect to adjacent traverses and adjacent grids. Once the basic processing has flattened the background it is then possible to carry out further processing which may include low pass filtering to reduce 'noise' in the data and hence emphasise the archaeological or man-made anomalies.

The following schedule shows the basic processing carried out on all minimally processed gradiometer data used in this report:

1. *Destripe* (Removes striping effects caused by zero-point discrepancies between different sensors and walking directions)
2. *Destagger* (Removes zigzag effects caused by inconsistent walking speeds on sloping, uneven or overgrown terrain)

2.8.2 Presentation of results and interpretation

The presentation of the data for each site involves a print-out of the minimally processed data both as a greyscale plot and a colour plot showing extreme magnetic values. Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site.

3 RESULTS

The detailed magnetic gradiometer survey conducted at Down Hatherley has not identified any anomalies that can be characterised as being either of a *probable* or *possible* archaeological origin.

The following list of numbered anomalies refers to numerical labels on the interpretation plots.

3.1 Probable Archaeology

No probable archaeology has been identified within the survey area.

3.2 Possible Archaeology

No possible archaeology has been identified within the survey area.

3.3 Medieval/Post-Medieval Agriculture

No evidence of medieval or post-medieval agricultural activity has been identified within the survey area.

3.4 *Other Anomalies*

- 1 Large areas of strong magnetic debris across the site. These are likely to be modern in origin and relate to areas of made ground.
- 2 Small areas of weak scattered magnetic debris in the centre of the site. These are likely to be modern in origin.
- 3 A number of strong bipolar linear anomalies across the site. These are hard to distinguish from the background noise, however linear anomalies within the debris are likely to be related to underground services.
- 4 Areas of magnetic disturbance are the result of substantial nearby ferrous metal objects such as fences and underground services. These effects can mask weaker archaeological anomalies.
- 5 A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish.

4 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Rugby Limestone Member geology of interbedded limestone and mudstone generally provide good results for gradiometer survey, with past surveys across the same geology showing evidence of agricultural and archaeological activity (Stratascan 2013; 2014). Despite the conducive nature of the geology for gradiometer survey, the site is dominated by areas of made ground and magnetic disturbance. These areas have the potential to mask weaker archaeological anomalies.

5 CONCLUSION

The survey at Down Hatherley, Gloucestershire has not identified any features of probable or possible archaeological origin, despite the potential for medieval agricultural remains. The site is dominated by areas of magnetic debris and areas of made ground, which have the potential to mask weaker archaeological features. The features identified are all modern in origin and include underground services, areas of scattered magnetic debris, and magnetic disturbance from nearby ferrous metal objects and fencing.

6 REFERENCES

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APPENDIX A – METHODOLOGY & SURVEY EQUIPMENT

Grid locations

The location of the survey grids has been plotted together with the referencing information. Grids were set out using a Leica 705auto Total Station and referenced to suitable topographic features around the perimeter of the site or a Leica Smart Rover RTK GPS.

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. A SmartNet RTK GPS uses Ordnance Survey's network of over 100 fixed base stations to give an accuracy of around 0.01m.

Survey equipment and gradiometer configuration

Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTeslas (nT) in an overall field strength of 48,000nT, can be accurately detected using an appropriate instrument.

The mapping of the anomaly in a systematic manner will allow an estimate of the type of material present beneath the surface. Strong magnetic anomalies will be generated by buried iron-based objects or by kilns or hearths. More subtle anomalies such as pits and ditches can be seen if they contain more humic material which is normally rich in magnetic iron oxides when compared with the subsoil.

To illustrate this point, the cutting and subsequent silting or backfilling of a ditch may result in a larger volume of weakly magnetic material being accumulated in the trench compared to the undisturbed subsoil. A weak magnetic anomaly should therefore appear in plan along the line of the ditch.

The magnetic survey was carried out using a dual sensor Grad601-2 Magnetic Gradiometer manufactured by Bartington Instruments Ltd. The instrument consists of two fluxgates very accurately aligned to nullify the effects of the Earth's magnetic field. Readings relate to the difference in localised magnetic anomalies compared with the general magnetic background. The Grad601-2 consists of two high stability fluxgate gradiometers suspended on a single frame. Each gradiometer has a 1m separation between the sensing elements so enhancing the response to weak anomalies.

Sampling interval

Readings were taken at 0.25m centres along traverses 1m apart. This equates to 3600 sampling points in a full 30m x 30m grid.

Depth of scan and resolution

The Grad 601-2 has a typical depth of penetration of 0.5m to 1.0m, though strongly magnetic objects may be visible at greater depths. The collection of data at 0.25m centres provides an optimum methodology for the task balancing cost and time with resolution.

Data capture

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.

APPENDIX B – BASIC PRINCIPLES OF MAGNETIC SURVEY

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.

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 and material such as brick and tile may be magnetised through the same process.

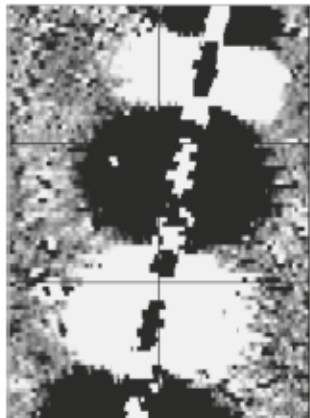
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement 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 field. The difference between the two sensors will relate to the strength of a magnetic field created by a buried 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, disturbance from modern services etc.

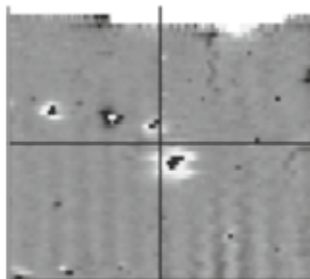
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

Bipolar



A bipolar anomaly is one that is composed of both a positive response and a negative response. It can be made up of any number of positive responses and negative responses. For example a pipeline consisting of alternating positive and negative anomalies is said to be bipolar. See also dipolar which has only one area of each polarity. The interpretation of the anomaly will depend on the magnitude of the magnetic field strength. A weak response may be caused by a clay field drain while a strong response will probably be caused by a metallic service.

Dipolar

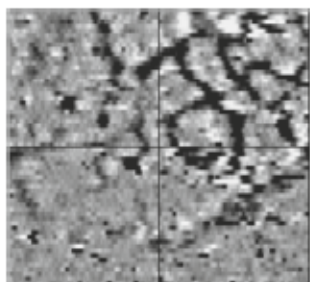


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very strong anomaly is likely to be caused by a ferrous object.

Positive anomaly with associated negative response

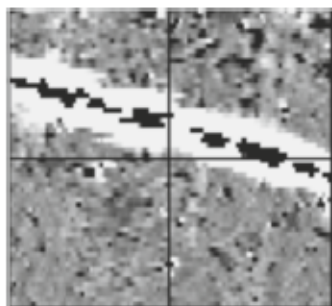
See bipolar and dipolar.

Positive linear



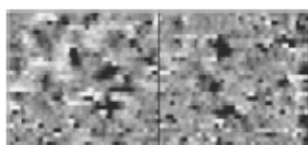
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity and some may even have a natural origin.

Positive linear anomaly with associated negative response



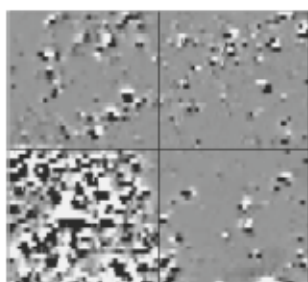
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field boundaries.

Positive point/area



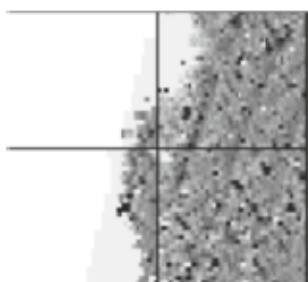
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally occurring depressions in the ground.

Magnetic debris



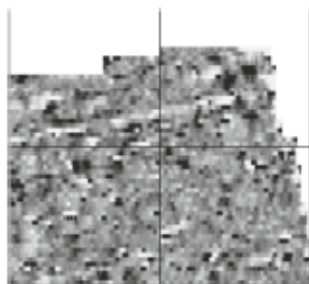
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low ($\pm 3nT$) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly ($\pm 250nT$) is more indicative of a spread of ferrous debris. Moderately strong anomalies may be the result of a spread of themoremanent material such as bricks or ash.

Magnetic disturbance



Magnetic disturbance is high amplitude and can be composed of either a bipolar anomaly, or a single polarity response. It is essentially associated with magnetic interference from modern ferrous structures such as fencing, vehicles or buildings, and as a result is commonly found around the perimeter of a site near to boundary fences.

Negative linear

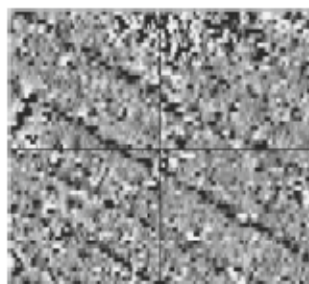


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

Negative point/area

Opposite to positive point anomalies these responses may be caused by raised areas or earthen banks. These could be of an archaeological origin or may have a natural origin.

Ploughing activity



Ploughing activity can often be visualised by a series of parallel linear anomalies. These can be of either positive polarity or negative polarity depending on site specifics. It can be difficult to distinguish between ancient ploughing and more modern ploughing. Clues such as the separation of each linear, straightness, strength of response and cross cutting relationships can be used to aid this, although none of these can be guaranteed to differentiate between different phases of activity.

Polarity

Term used to describe the measurement of the magnetic response. An anomaly can have a positive polarity (values above 0nT) and/or a negative polarity (values below 0nT).

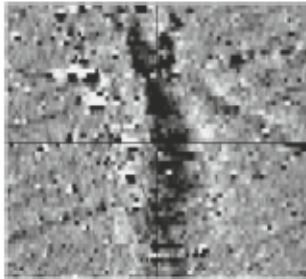
Strength of response

The amplitude of a magnetic response is an important factor in assigning an interpretation to a particular anomaly. For example a positive anomaly covering a 10m² area may have values up to around 3000nT, in which case it is likely to be caused by modern magnetic interference. However, the same size and shaped anomaly but with values up to only 4nT may have a natural origin. Colour plots are used to show the amplitude of response.

Thermoremanent response

A feature which has been subject to heat may result in it acquiring a magnetic field. This can be anything up to approximately +/-100 nT in value. These features include clay fired drains, brick, bonfires, kilns, hearths and even pottery. If the heat application has occurred in situ (e.g. a kiln) then the response is likely to be bipolar compared to if the heated objects have been disturbed and moved relative to each other, in which case they are more likely to take an irregular form and may display a debris style response (e.g. ash).

Weak background variations

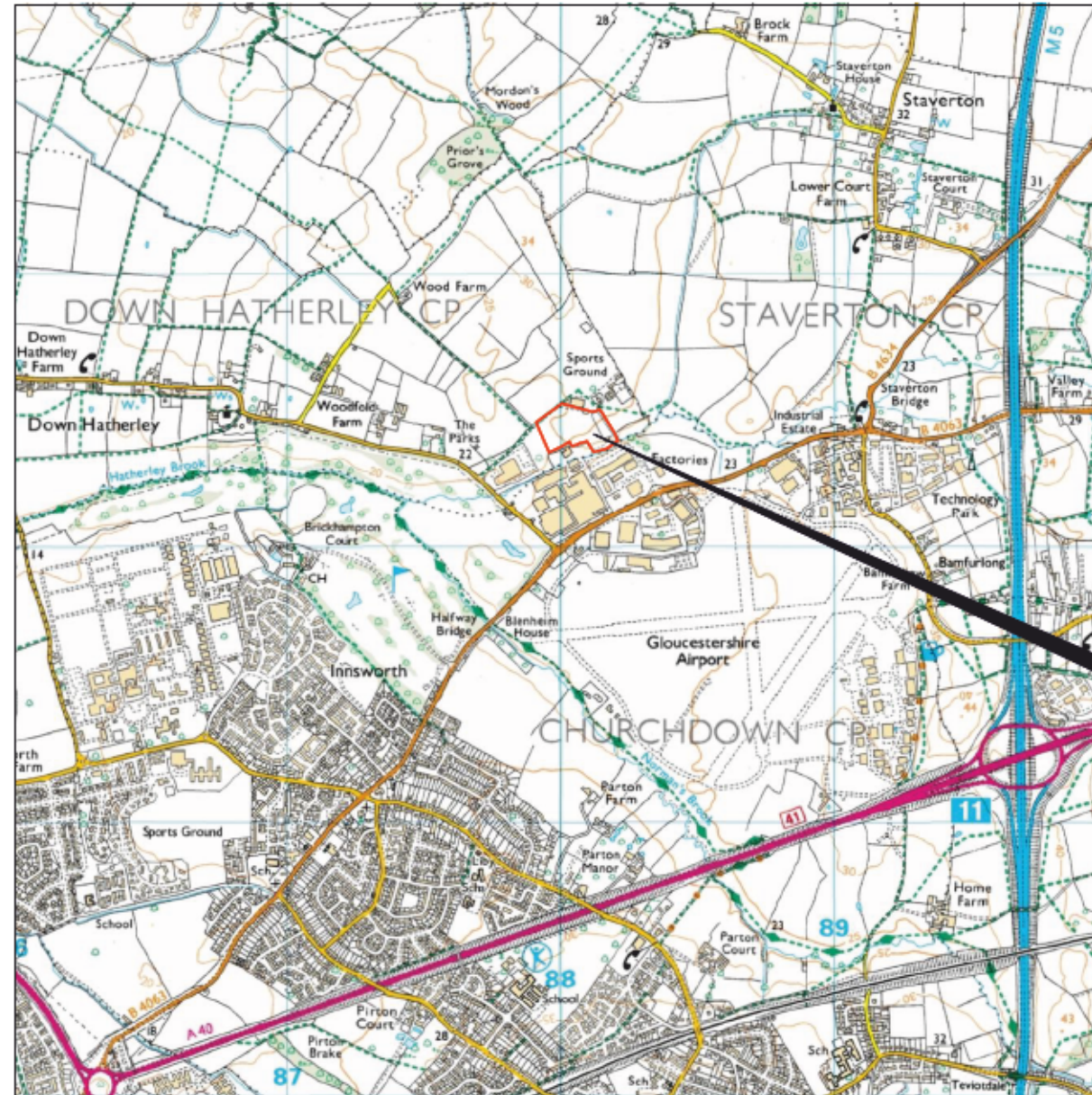


Weakly magnetic wide scale variations within the data can sometimes be seen within sites. These usually have no specific structure but can often appear curvy and sinuous in form. They are likely to be the result of natural features, such as soil creep, dried up (or seasonal) streams. They can also be caused by changes in the underlying geology or soil type which may contain unpredictable distributions of magnetic minerals, and are usually apparent in several locations across a site.

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 WR8 0SA
 OS 100km square = SO



24
23
22
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Survey Area

86 87 88 89 90

Amendments

Issue No.	Date	Description
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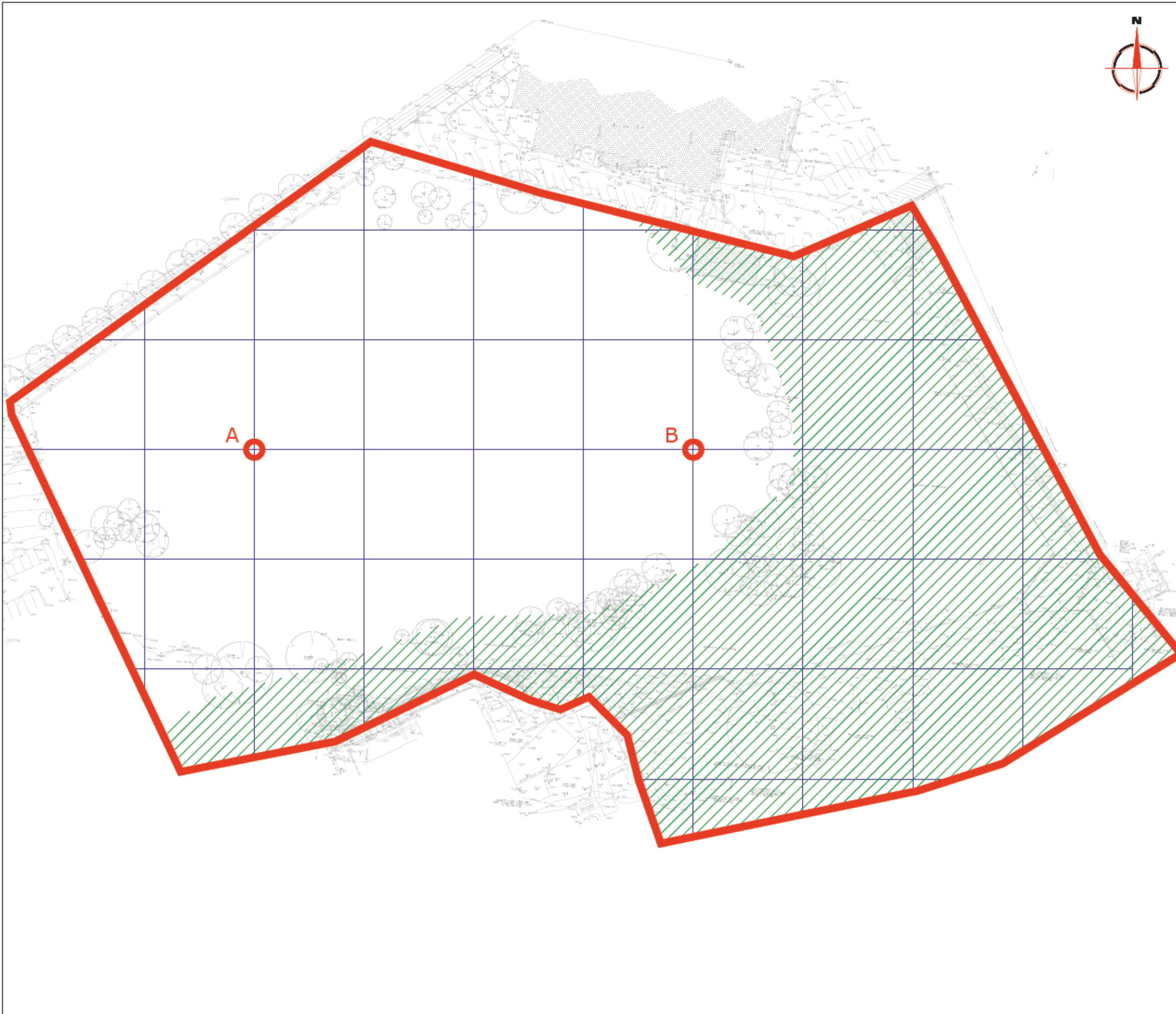
Site centred on NGR	SO 880 224
Client	MACE
Project Title	Job No. 8967 GEOPHYSICAL SURVEY - DOWN HATHERLEY, GLOUCESTERSHIRE
Subject	LOCATION PLAN OF SURVEY AREA

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GPR ASSOCIATED
SUMO SUMO GROUP MEMBER
 ISO 9001 certified ISO 14001 certified

Scale 1:25000 0m 500 1000m

Plot	Checked by	Issue No.
A3	DGE	01
Survey date	Drawn by	Figure No.
SEP 15	RD	01



Amendments

Issue No.	Date	Description
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-	-	-

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Area unsurveyable due to overgrown vegetation

OS GRID REFERENCES

A	387955.05, 222444.11
B	388075.05, 222444.11

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Project Title
GEOPHYSICAL SURVEY - DOWN HATHERLEY, GLOUCESTERSHIRE

Job No. 8967

Subject
LOCATION OF SURVEY GRIDS AND REFERENCING



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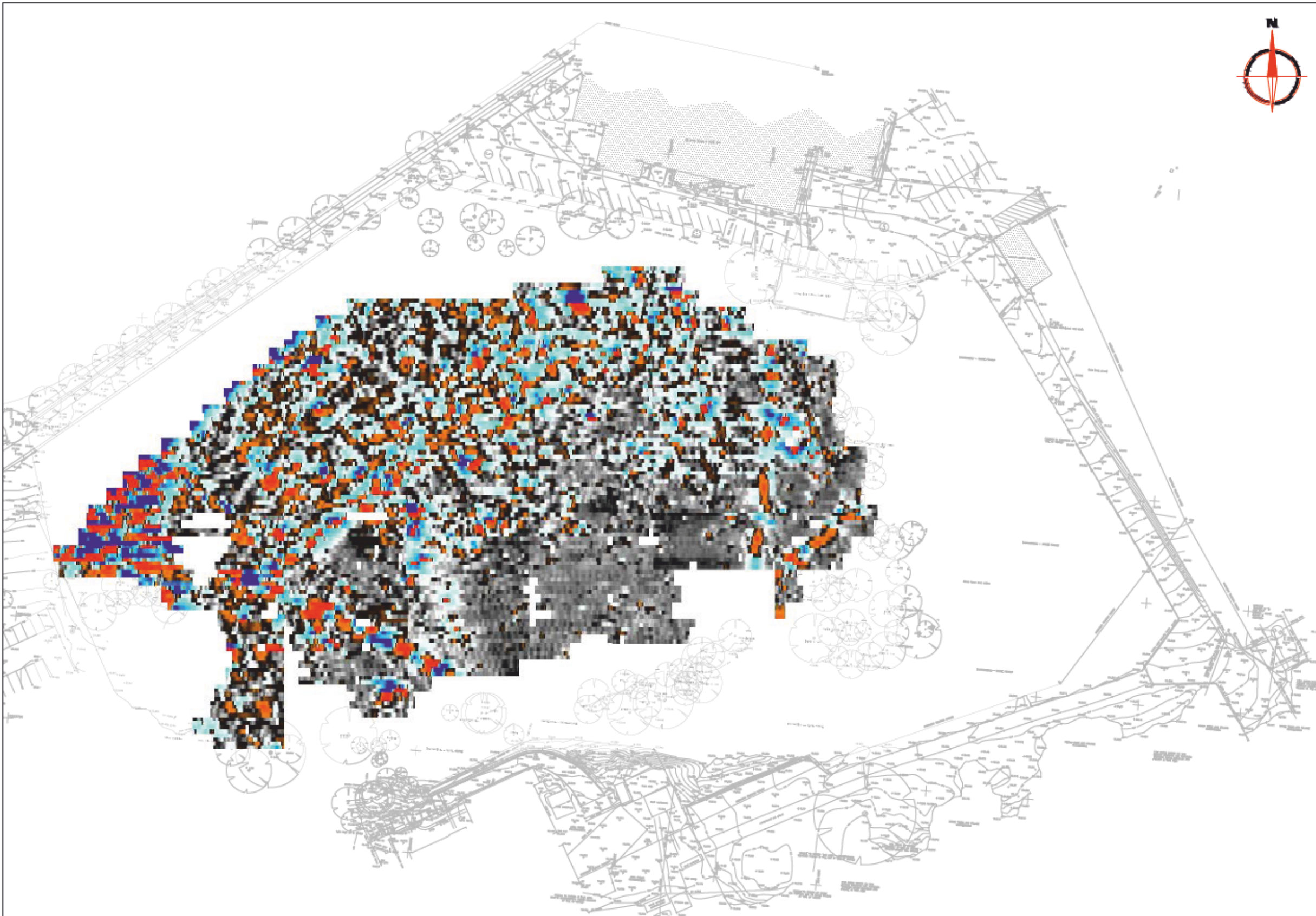


SUMO GROUP MEMBER



Scale 1:1000

Plot A3	Checked by DGE	Issue No. 01
Survey date SEP 15	Drawn by RD	Figure No. 02



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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Plotting parameters

Maximum +100nT (red)
Minimum -100nT (blue)

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Subject
COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES

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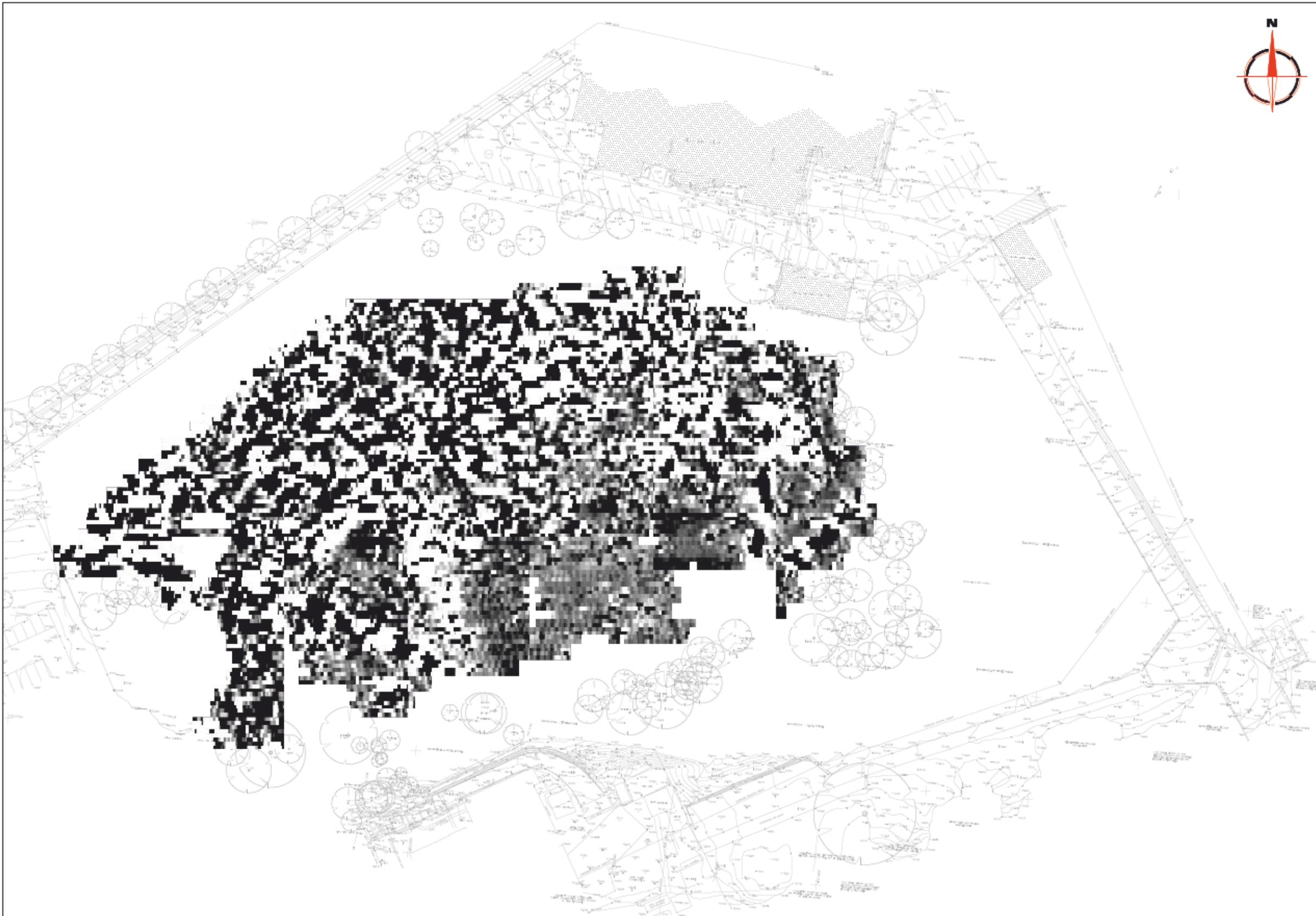
GPR ASSOCIATION

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ims ISO 9001 certified
ims ISO 14001 certified

Scale 1:1000

Plot A3	Checked by DGE	Issue No. 01
Survey date SEP 15	Drawn by RD	Figure No. 03



Amendments		
Issue No.	Date	Description
-	-	-
-	-	-

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Plotting parameters

Maximum +2nT (black)
Minimum -2nT (white)

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Job No.: 8967

Subject: PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA

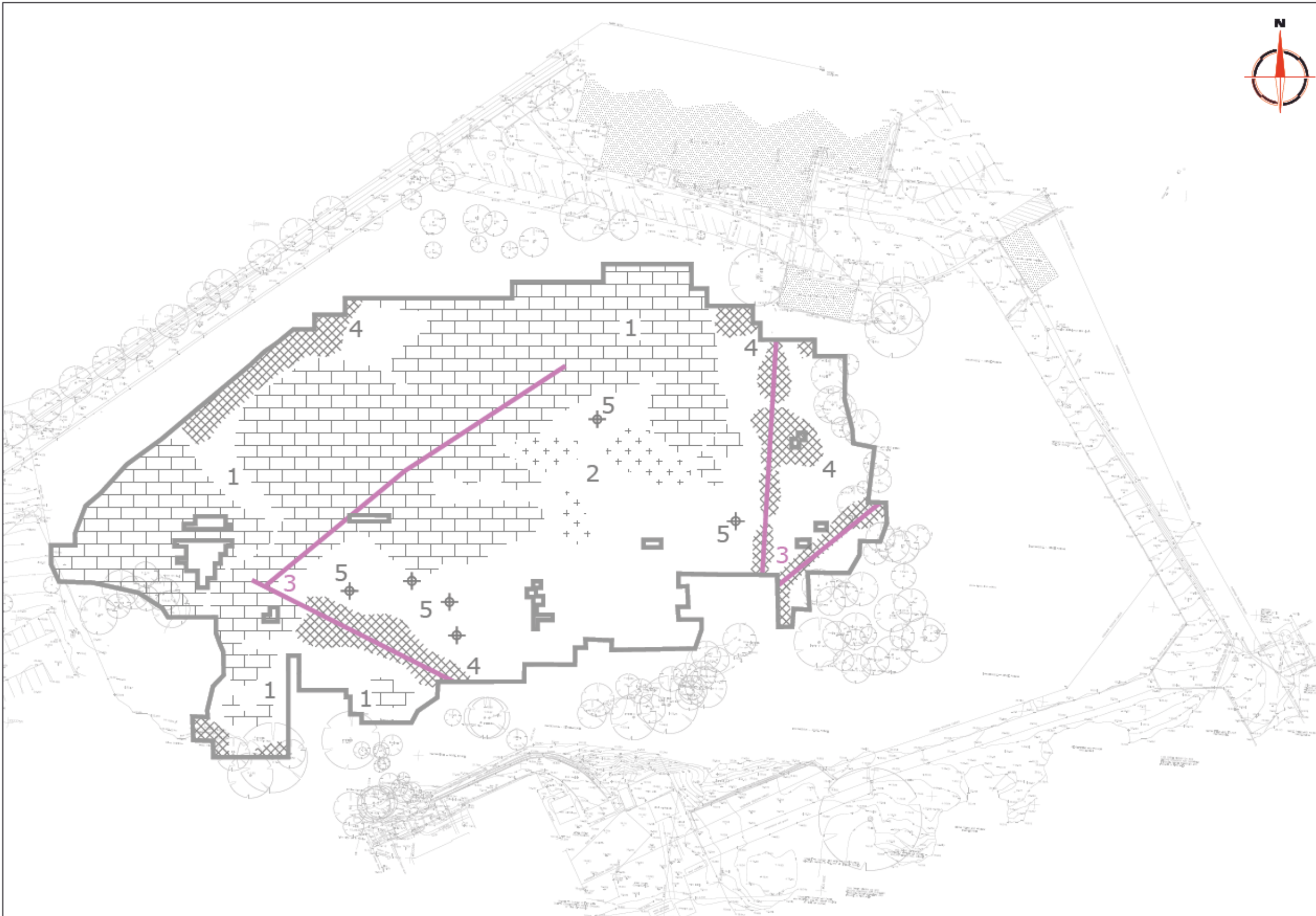
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Scale: 1:1000
0m 10 20 30 40 50

Plot: A3	Checked by: DGE	Issue No.: 01
Survey date: SEP 15	Drawn by: RD	Figure No.: 04



Amendments		
Issue No.	Date	Description
-	-	-
-	-	-
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PROBABLE ARCHAEOLOGY		
	Positive anomaly / weak positive anomaly - probable cut feature of archaeological origin	
	Negative anomaly / weak negative anomaly - probable bank or earthwork of archaeological origin	
POSSIBLE ARCHAEOLOGY		
	Positive anomaly / weak positive anomaly - possible cut feature of archaeological origin	
	Negative anomaly / weak negative anomaly - possible bank or earthwork of archaeological origin	
MEDIEVAL/POST-MEDIEVAL AGRICULTURE		
	Widely spaced curving parallel linear anomalies - probably related to ridge-and-furrow	
	Closely spaced parallel linear anomalies - probably related to agricultural activity such as ploughing	
	Linear anomaly - probably related to a former field boundary not present on available mapping	
	Linear anomaly - related to a former field boundary present on available mapping	
OTHER ANOMALIES		
	Linear anomaly - probably related to pipe, cable or other modern service	
	Linear anomaly - possibly related to land drain	
	Magnetic disturbance associated with nearby metal object such as service or field boundary	
	Strong magnetic debris - possible disturbed or made ground	
	Scattered magnetic debris	
	Area of amorphous magnetic variation - probable natural (e.g. geological or pedological) origin	
	Magnetic spike - probable ferrous object	
Client		
MACE		
Project Title		Job No. 8967
GEOPHYSICAL SURVEY - DOWN HATHERLEY, GLOUCESTERSHIRE		
Subject		
ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES		
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Scale		
1:1000		
Plot	Checked by	Issue No.
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Void Detection

STRATASCAN LTD

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