JOHN MOORE HERITAGE SERVICES

A GEOPHYSICAL SURVEY

AT

THE HAWK STONE, SPELSBURY,

OXFORDSHIRE

NGR SP 339 235

On behalf of
Natural England

OCTOBER 2010

Document Title:	**Geophysical Survey Report** **The Hawk Stone, Spelsbury, Oxfordshire**
Client:	**John Moore Heritage Services**
Stratascan Job No:	**J2772**
Techniques:	**Detailed magnetic gradiometry** **Earth resistance survey**
National Grid Ref:	**SP 339 235**

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1 SUMMARY OF RESULTS

Stratascan were commissioned to undertake a geophysical survey of an area around the Hawk Stone near Chipping Norton in Oxfordshire (at OS NGR SP 339 235) for John Moore Heritage Services.

The survey has revealed several anomalies of potential archaeological interest. The most significant of these are a number of apparent cut features (possible ditches and pits) that are evident in both the gradiometer and resistance surveys. There is also evidence of possible banks or compacted ground, and several ferrous objects.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of an area around the Hawk Stone near Chipping Norton in Oxfordshire for John Moore Heritage Services.

2.2 Site location

The site is located approximately 2km north-north-west of Spelsbury, Oxfordshire at OS NGR ref. SP 339 235.

2.3 Description of site

The site comprised approximately 0.2ha of flat arable farmland that had been recently ploughed. The survey area encompasses a standing stone, the Hawk Stone (SAM 28199).

The underlying solid geology is mapped as Great Oolite (British Geological Survey South Sheet, Fourth Edition Solid, 2001), with no overlying superficial geology (British Geological Survey, South Sheet, First Edition Quaternary, 1977). The overlying soils are mapped as Elmton 3 which are brown rendzinas. These consist of shallow well drained brashy calcareous fine loamy soils over limestone (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.4 Site history and archaeological potential

The survey area is centred on a standing stone of probable late Neolithic or early Bronze Age date.

2.5 Survey objectives

The objective of the survey was to locate any anomalies that may be of archaeological significance prior to trenching.

2.6 Survey methods

Magnetic gradiometry and earth resistance survey were carried out on the site. More information regarding these techniques is included in the Methodology section below.

3 METHODOLOGY

3.1 Date of fieldwork

The fieldwork was carried out over 2 days on 8th and 15th September when the weather was fine.

3.2 Grid locations

The location of the survey grids has been plotted in Figure 2 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.

3.3 Description of techniques and equipment configurations

Gradiometer
Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTesla (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.

Resistance
This method relies on the relative inability of soils (and objects within the soil) to conduct an electrical current which is passed through them. As resistivity is linked to moisture content, and therefore porosity, hard dense features such as rock will give a

relatively high resistivity response, while features such as a ditch which retains moisture give a relatively low response
The resistance meter used was an RM15 manufactured by Geoscan Research incorporating a mobile Twin Probe Array. The Twin Probes are separated by 0.5m and the associated remote probes were positioned approximately 15m outside the grid. The instrument uses an automatic data logger which permits the data to be recorded as the survey progresses for later downloading to a computer for processing and presentation.

Though the values being logged are actually resistances in ohms they are directly proportional to resistivity (ohm-metres) as the same probe configuration was used through-out.

3.4 Sampling interval, depth of scan, resolution and data capture

3.4.1 *Sampling interval*

Gradiometer
Readings were taken at 0.25m centres along traverses 1m apart. This equates to 1600 sampling points in a full 20m x 20m grid. All traverses were surveyed in a "zigzag" mode.

Resistance
Readings were taken at 0.5m centres along traverses 0.5m apart. This equates to 1600 sampling points in a full 20m x 20 grid. All traverses were surveyed in a "zigzag" mode.

3.4.2 *Depth of scan and resolution*

Gradiometer
The Grad 601 has a typical depth of penetration of 0.5m to 1.0m. This would be increased if strongly magnetic objects have been buried in the site. The collection of data at 0.5m centres provides an optimum methodology for the task balancing cost and time with resolution.

Resistance
The 0.5m probe spacing of a twin probe array has a typical depth of penetration of 0.5m to 1.0m. The collection of data at 0.5m centres with a 0.5m probe spacing provides an optimum resolution for the task.

3.4.3 *Data capture*

Gradiometer
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 job, data is transferred to the office for processing and presentation.

Resistance
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 job, data is transferred to the office for processing and presentation.

3.5 Processing, presentation of results and interpretation

3.5.1 *Processing*

Gradiometer

Processing is performed using specialist software which 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.

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

1. *Destripe* (equalises the mean of adjacent traverses to remove striping effects from sensor zero-errors)

2. *Destagger* (shifts adjacent traverses to remove zig-zag errors from inconsistent walking speeds on uneven or overgrown terrain)

Resistance

The processing was carried out using specialist software known as *Geoplot 3* and involved the 'despiking' of high contact resistance readings and the passing of the data though a high pass filter. This has the effect of removing the larger variations in the data often associated with geological features. The nett effect is aimed at enhancing the archaeological or man-made anomalies contained in the data.

The following schedule shows the processing carried out on the processed resistance plots.

1. *Despike* Removes isolated anomalous readings resulting from poor probe contact with soil

2. *Flatten* Subtracts a large-radius (6m) moving average to remove large-scale natural soil variations

2. *Smooth* Applies a small-radius (1.3m) moving average to smooth out small-scale noise

3.5.2 *Presentation of results and interpretation*

Gradiometer

The presentation of the data for the survey involves a print-out of the raw data both as grey scale (Figure 3) and as a colour plot showing extreme values (Figure 4), together with a grey scale plot of the processed data (Figure 5) and the abstraction and interpretation of magnetic anomalies (Figure 6).

Resistance

The presentation of the data for the site involves a print-out of the raw data as a grey scale plot (Figure 7), together with a grey scale plot of the processed data (Figure 8). Anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing (Figure 9).

The gradiometer and resistance interpretations have been combined in Figure 10.

4 RESULTS

Gradiometer

The survey has revealed a number of anomalies of archaeological interest. These include two broken linear positive anomalies that may indicate former ditches – the broken nature of the anomalies perhaps indicating significant plough damage. There is also a dense scatter of discrete positive anomalies that may indicate pits or post-holes.

There are a few strong discrete bipolar anomalies that probably represent ferrous metallic objects. These are most likely to be modern debris (e.g. broken plough fragments), however it is also possible that some could be of historical/archaeological interest.

A few straight parallel linear anomalies are most likely to be a result of modern agriculture.

An area of magnetic disturbance on the northern boundary of the site is most likely the result of a large ferrous object just outside the survey area.

Resistance

The resistance survey has also revealed several anomalies of interest, some of which correlate well with anomalies identified in the magnetic gradiometer survey.

There are a number of low-resistance anomalies apparent in the data that may indicate cut features such as ditches or pits. Those that correlate with positive magnetic anomalies are most likely to represent such features and may therefore be the most worthy of further investigation.

A few high resistance anomalies may indicate former banks or areas of compacted ground (for example from former paths or trackways).

5 CONCLUSION

The survey has revealed several anomalies of potential archaeological interest. The most significant of these are a number of apparent cut features (possible ditches and pits) that are evident in both the gradiometer and resistance surveys. There is also evidence of possible banks or compacted ground, and several ferrous objects.

6 REFERENCES

British Geological Survey, 1977. *Geological Survey Ten Mile Map, South Sheet, First Edition (Quaternary).* British Geological Society.

British Geological Survey, 2001. *Geological Survey Ten Mile Map, South Sheet, Fourth Edition (Solid).* British Geological Society.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 3 Midland and Western England.*

APPENDIX A – 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 *thermoremnant* 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.

Thermoremnance 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. Thermoremnant archaeological features can include hearths and kilns and material such as brick and tile may be magnetised through the same process.

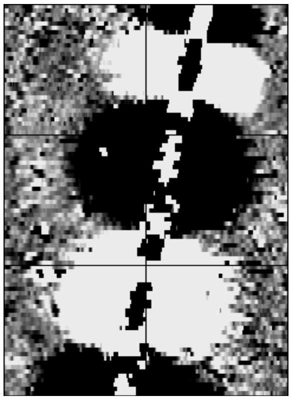
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement 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 either 0.5 or 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.

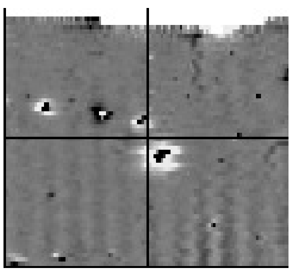
APPENDIX B – Glossary of magnetic anomalies

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

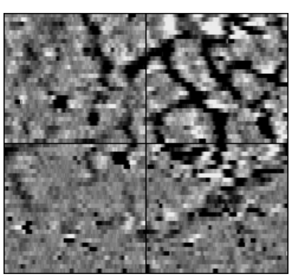


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

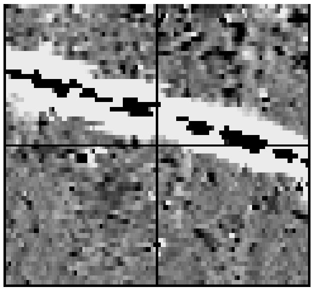
See bipolar and dipolar.

Positive linear



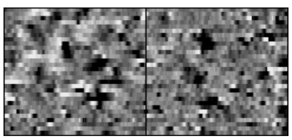
A linear response which is entirely positive in polarity. These are usually related to infilled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



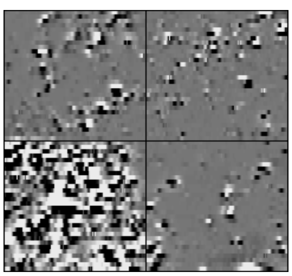
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



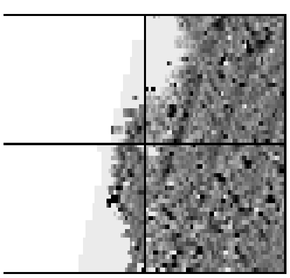
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by infilled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



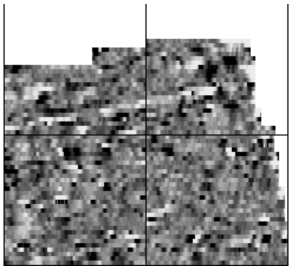
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

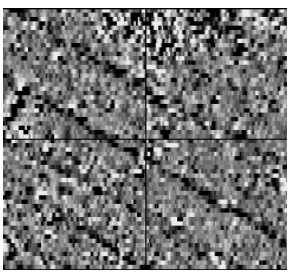


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

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).

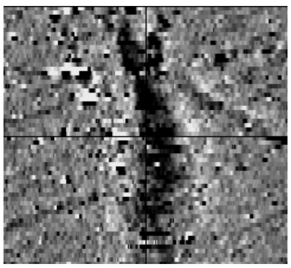
Strength of response

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 $10m^2$ 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. Trace plots are used to show the amplitude of response.

Thermoremnant 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 insitu (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.

OS 100km square = SP

TRUE N

Issue No.	Date	Description
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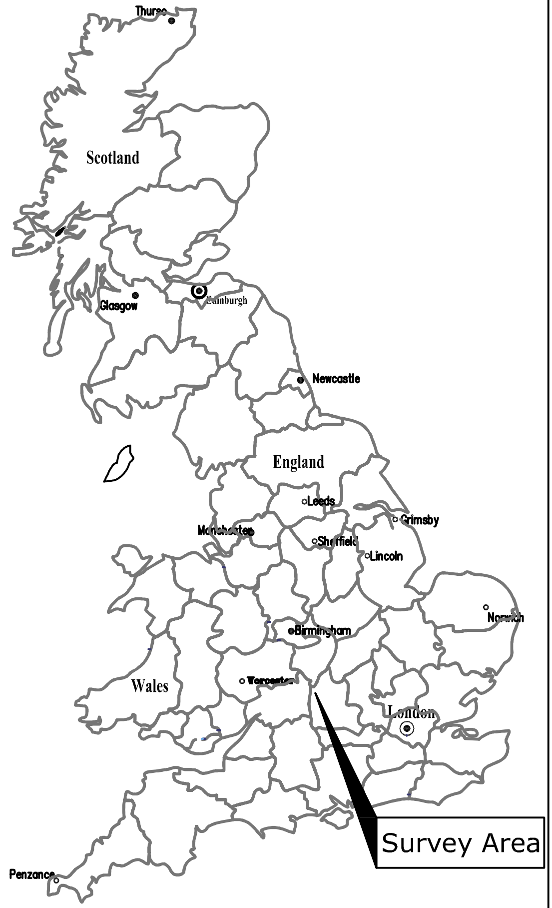
Amendments



Site centred on NGR SP 339 235

Client
JOHN MOORE HERITAGE SERVICES

Project Title: GEOPHYSICAL SURVEY - THE HAWK STONE, SPELSBURY
Job No. 2772

Subject
LOCATION PLAN OF SURVEY AREA

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REGISTERED ORGANISATION IfA

Scale 1:25000 (0m, 500, 1000m)

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Survey date	**Drawn by**	**Figure No.**
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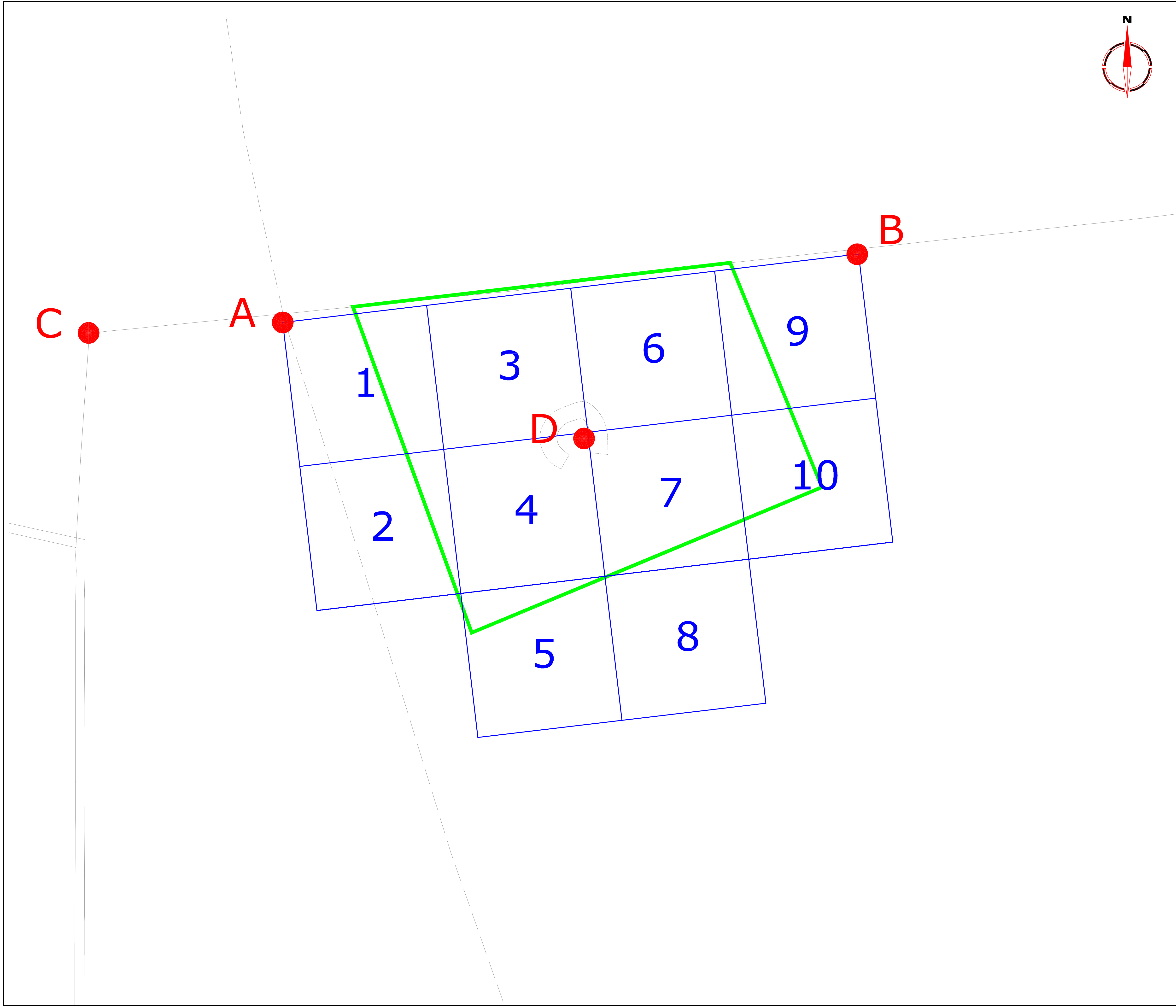

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KEY

A-B	SURVEY BASELINE
C-D	REFERENCING POINTS
1-10	SURVEY GRIDS
	SURVEY AREA

REFERENCE MEASUREMENTS

A-C	26.81m
A-D	44.55m
B-C	69.88m
B-D	45.44m

Client
JOHN MOORE HERITAGE SERVICES

Project Title
GEOPHYSICAL SURVEY - THE HAWK STONE, SPELSBURY

Job No. 2772

Subject
LOCATION AND REFERENCING OF SURVEY GRIDS

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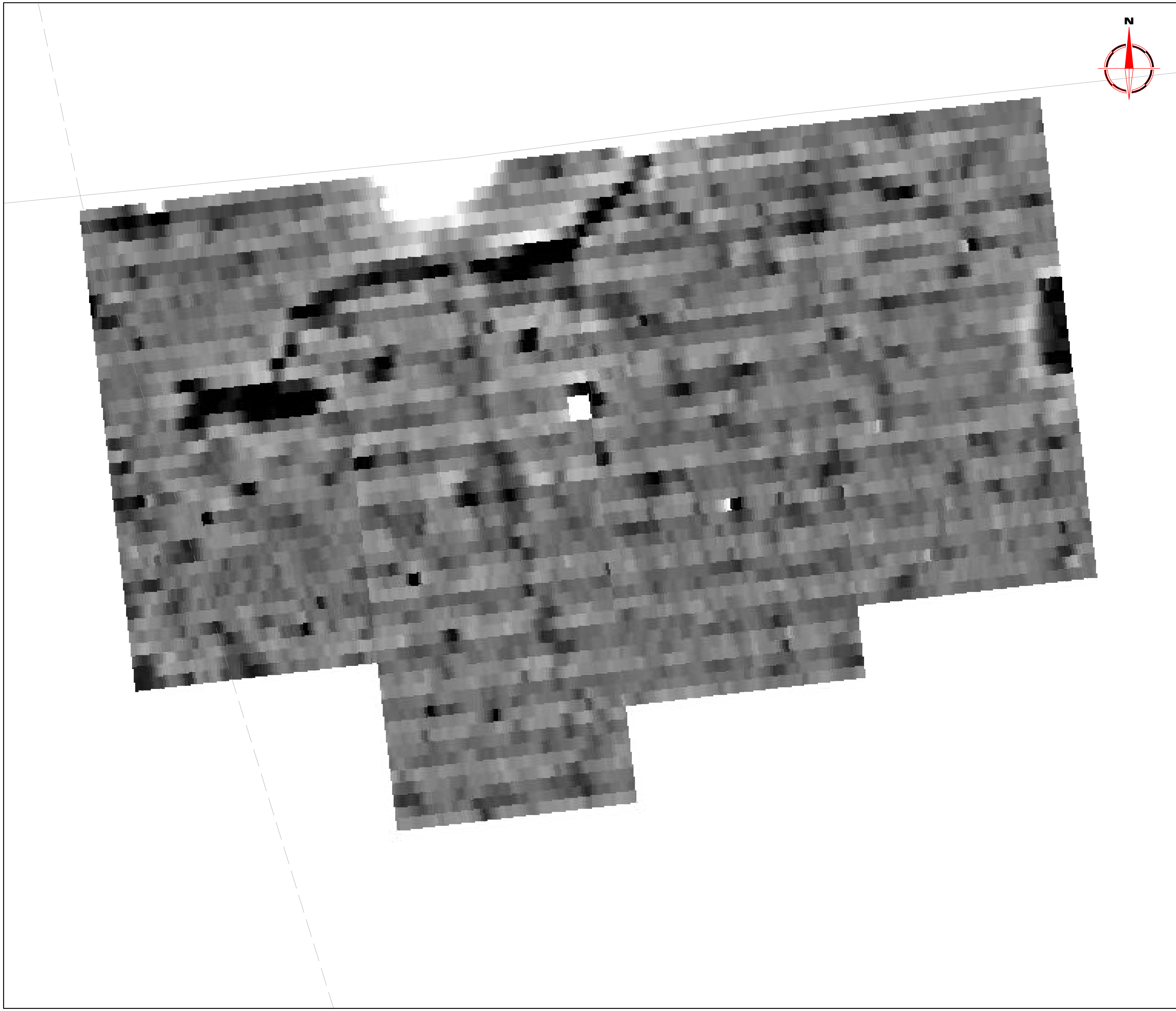

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Plotting parameters

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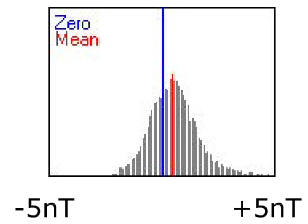
Minimum -5nT (white)



+5nT
-5nT

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Project Title
Job No. 2772
GEOPHYSICAL SURVEY - THE HAWK STONE, SPELSBURY

Subject
PLOT OF RAW GRADIOMETER DATA

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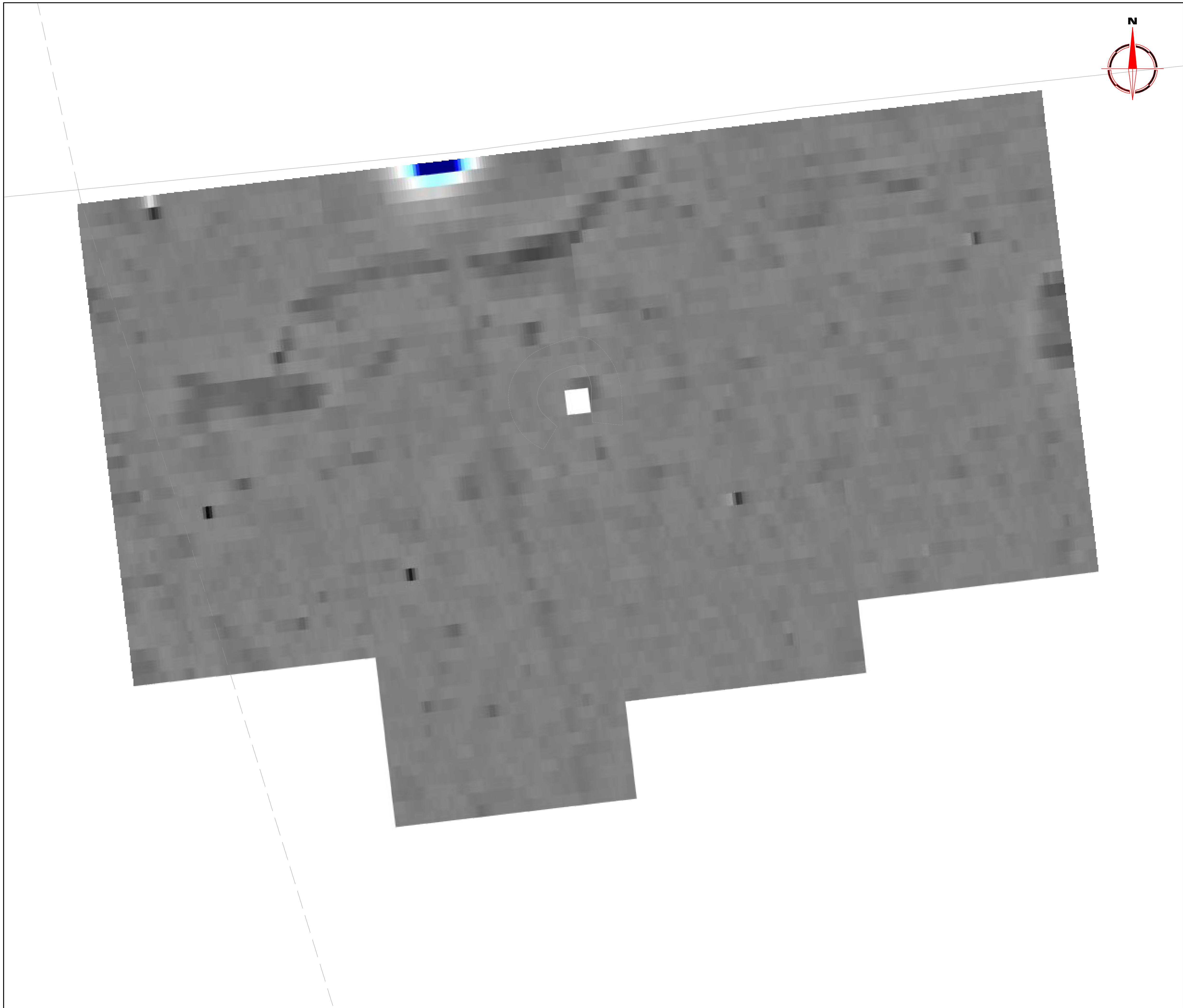

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Issue No.	Date	Description
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-	-	-

Plotting parameters

Maximum +250nT (red)
Minimum -250nT (blue)

+250nT
-250nT

Client
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Project Title
Job No. 2772
GEOPHYSICAL SURVEY - THE HAWK STONE, SPELSBURY

Subject
COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES

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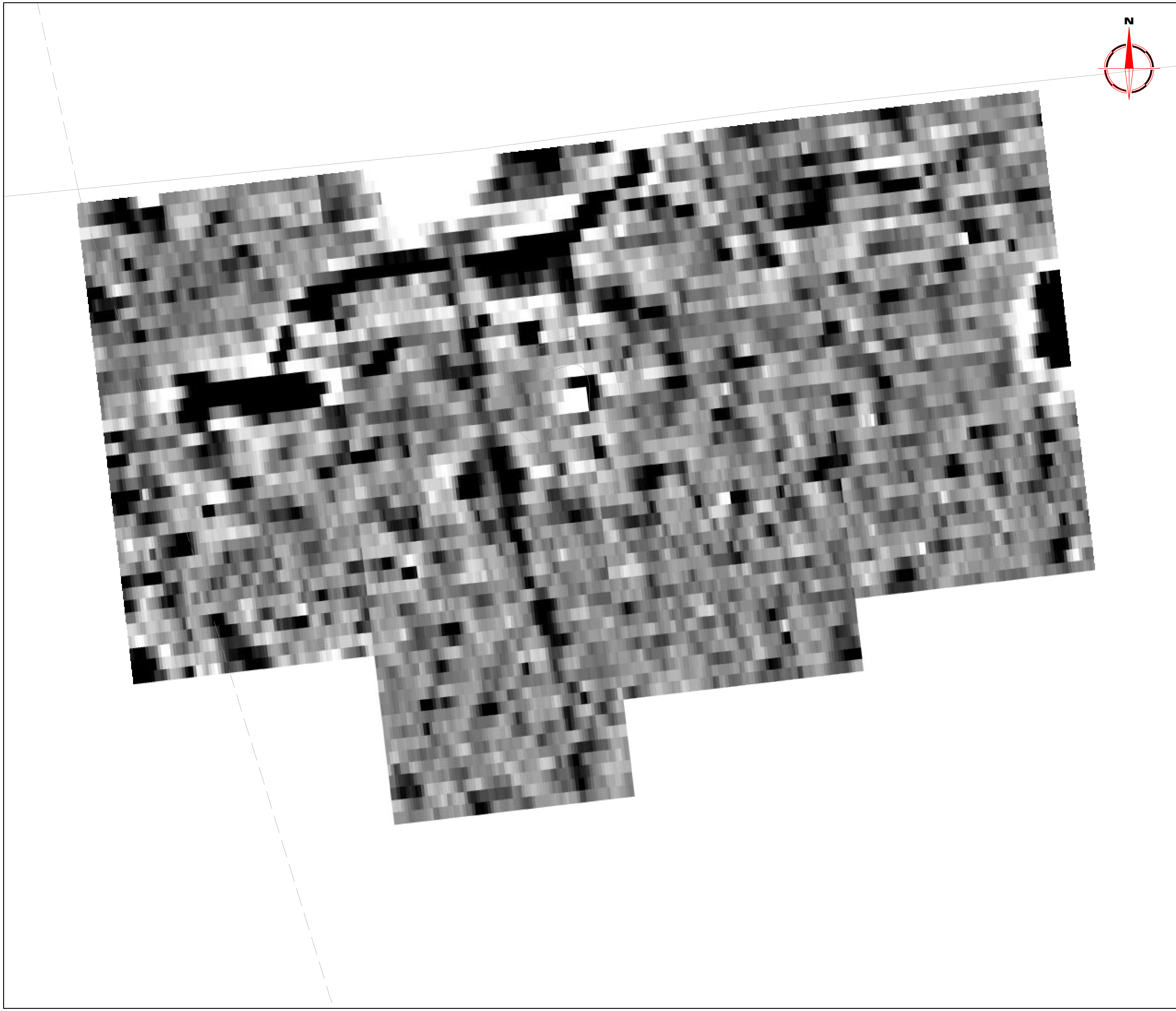
Survey date SEPT 2010	Drawn by BPM/RA	Figure No. 04



Amendments

Issue No.	Date	Description
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Plotting parameters

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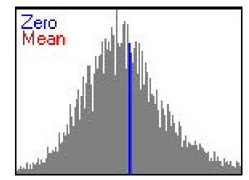
Minimum -2nT (white)



+2nT
-2nT

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Project Title
Job No. 2772

GEOPHYSICAL SURVEY - THE HAWK STONE, SPELSBURY

Subject

PLOT OF PROCESSED GRADIOMETER DATA

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Scale 1:300 — 0m 2 4 6 8 10m

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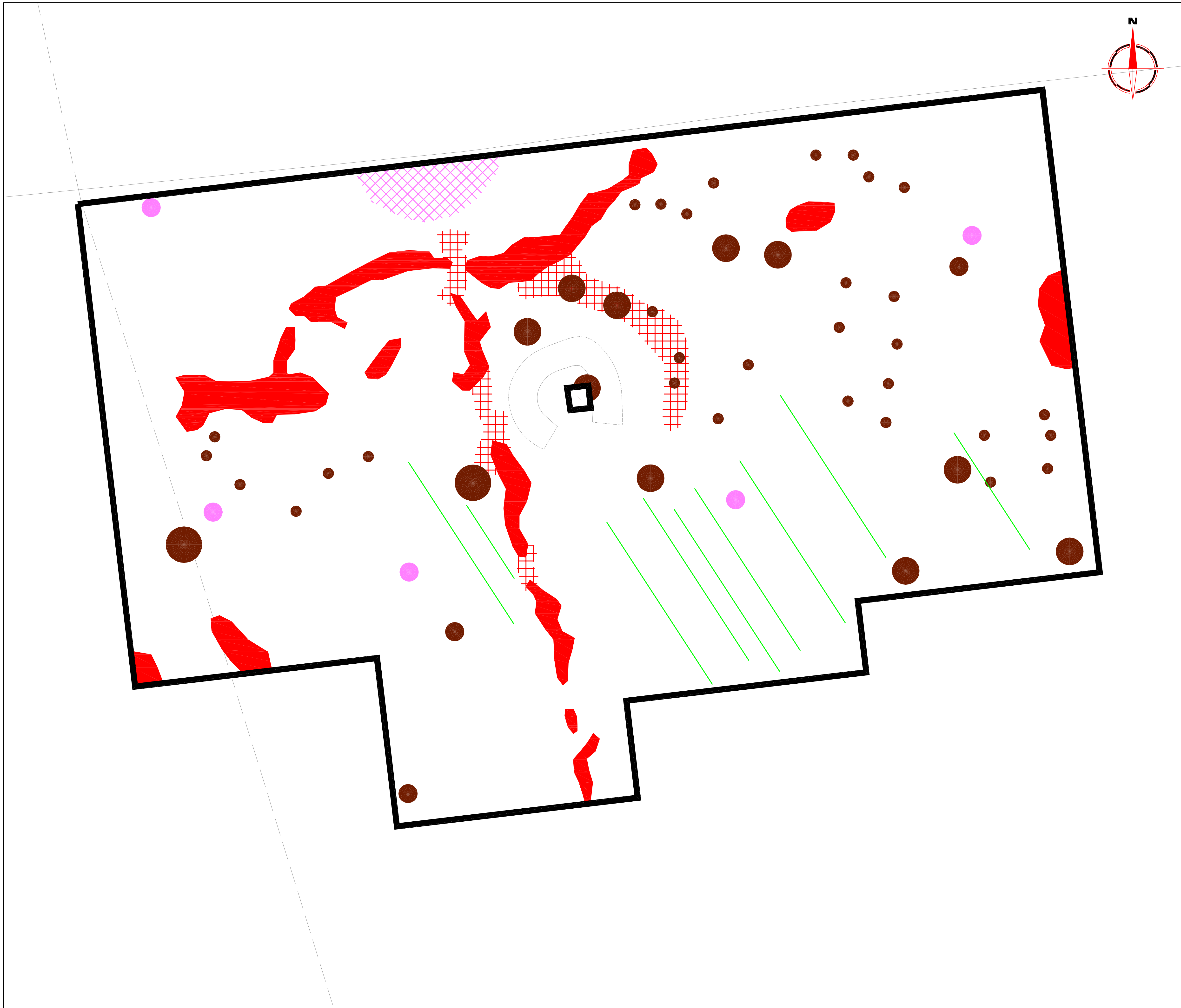

Amendments

Issue No.	Date	Description
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KEY

	Parallel linear anomalies - probably of modern agricultural origin
	Positive area anomaly - possible cut feature of archaeological origin
	Weak positive area anomaly - possible cut feature of archaeological origin
	Discrete positive anomaly - possible pit
	Strong discrete bipolar anomaly - ferrous object
	Magnetic disturbance - related to large ferrous metallic object

Client
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Project Title　Job No. 2772
GEOPHYSICAL SURVEY - THE HAWK STONE, SPELSBURY

Subject
ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES

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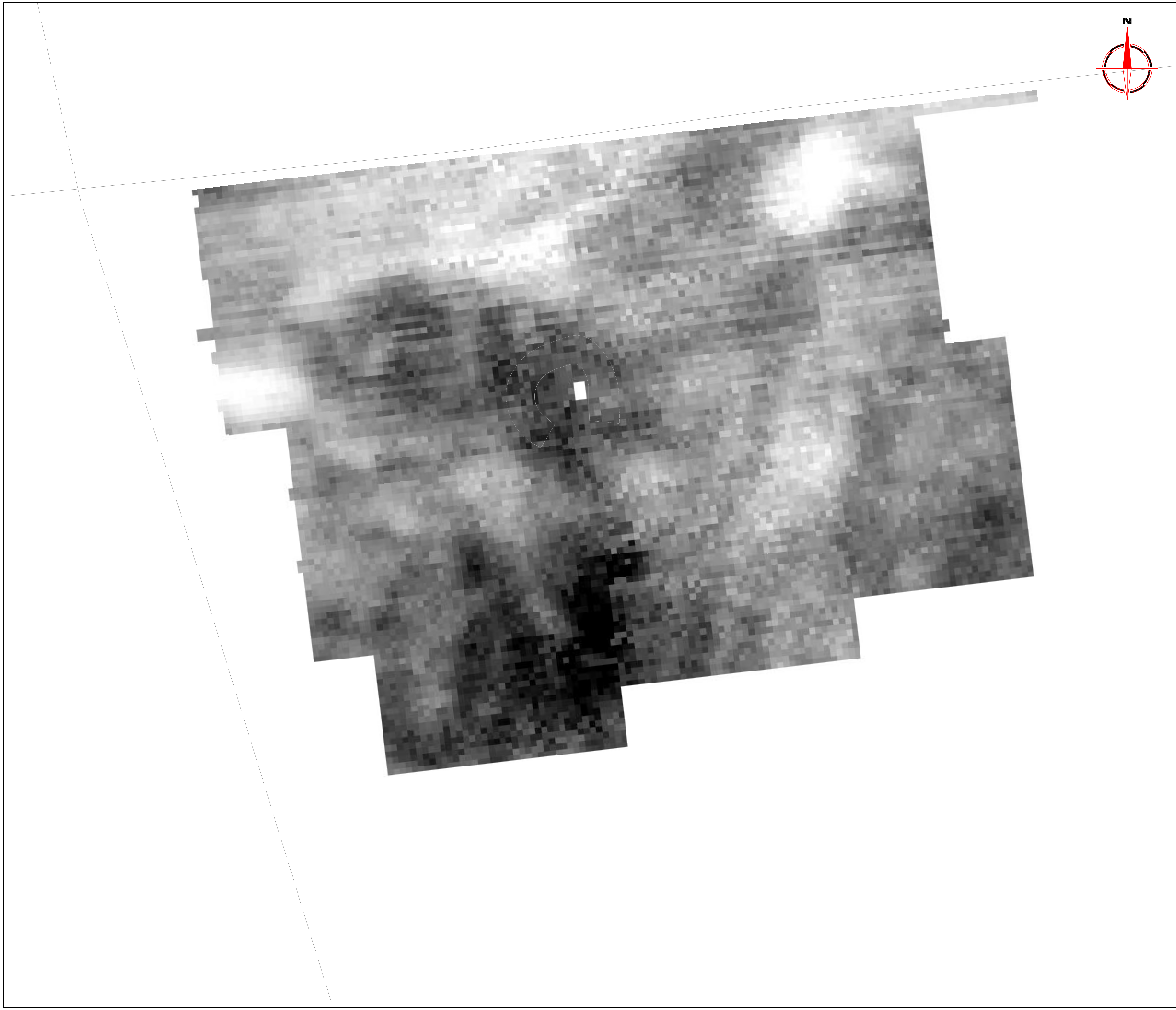
REGISTERED ORGANISATION IfA

Scale 1:300　0m 2 4 6 8 10m

Plot	Checked by	Issue No.
A3	PPB	01
Survey date	**Drawn by**	**Figure No.**
SEPT 2010	RA	06

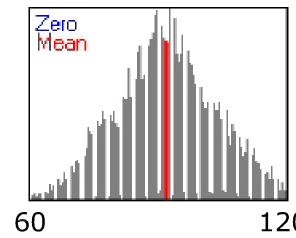


Amendments

Issue No.	Date	Description
-	-	-
-	-	-

Plotting parameters

Maximum +120Ω (black)
Minimum +60Ω (white)



+120Ω
+60Ω

Client
JOHN MOORE HERITAGE SERVICES

Project Title
Job No. 2772
GEOPHYSICAL SURVEY - THE HAWK STONE, SPELSBURY

Subject
PLOT OF MINIMALLY PROCESSED RESISTANCE DATA

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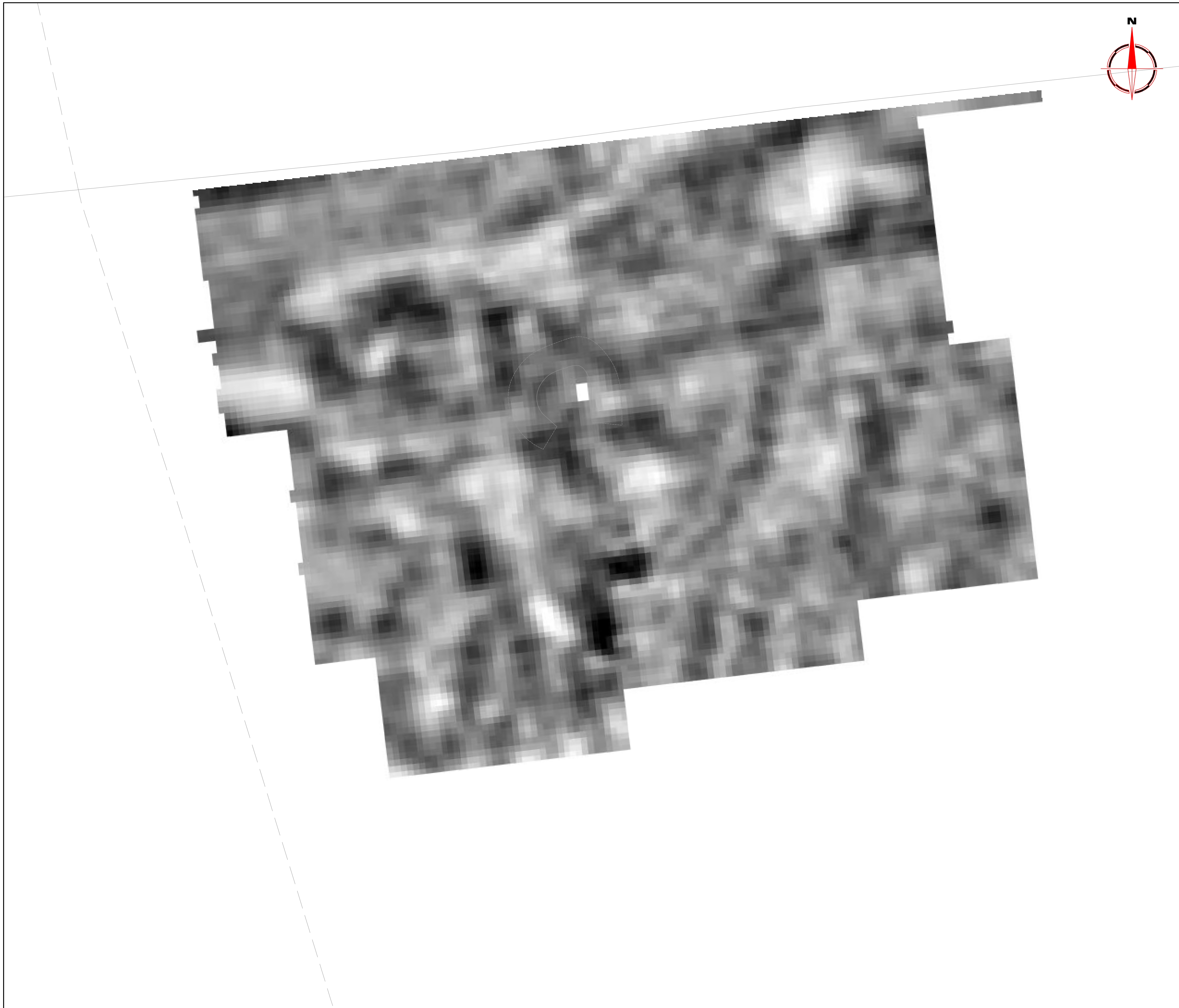
REGISTERED ORGANISATION IfA

Scale 1:300	0m 2 4 6 8 10m	
Plot: A3	Checked by: PPB	Issue No.: 01
Survey date: SEPT 2010	Drawn by: RA	Figure No.: 07

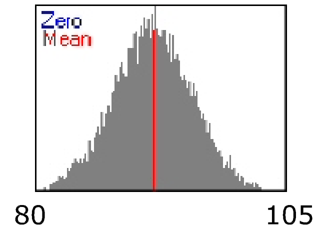


Amendments

Issue No.	Date	Description
-	-	-
-	-	-

Plotting parameters

Maximum +105Ω (black)
Minimum +80Ω (white)



+105Ω

+80Ω

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Subject

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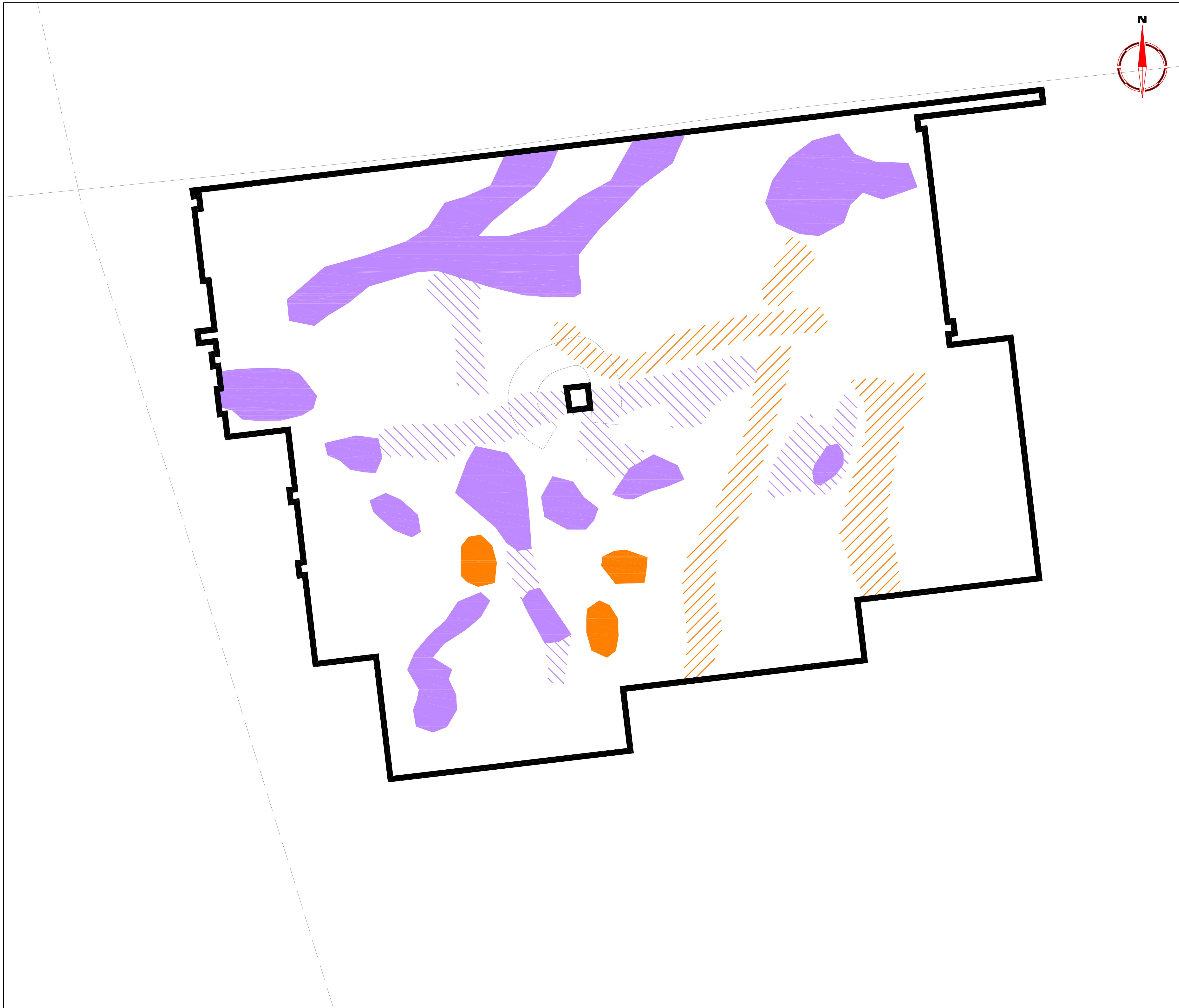
REGISTERED ORGANISATION IfA

Scale 1:300 — 0m 2 4 6 8 10m

Plot	Checked by	Issue No.
A3	PPB	01
Survey date	**Drawn by**	**Figure No.**
SEPT 2010	RA	08



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

KEY

High resistance anomaly - possible compacted ground or former bank / earthwork	
Moderate high resistance anomaly - possible compacted ground or former bank / earthwork	
Low resistance area anomaly - possible cut feature such as ditch or pit	
Moderate low resistance area anomaly - possible cut feature such as ditch or pit	

Client

JOHN MOORE HERITAGE SERVICES

Project Title Job No. 2772

GEOPHYSICAL SURVEY - THE HAWK STONE, SPELSBURY

Subject

ABSTRACTION AND INTERPRETATION OF RESISTANCE ANOMALIES

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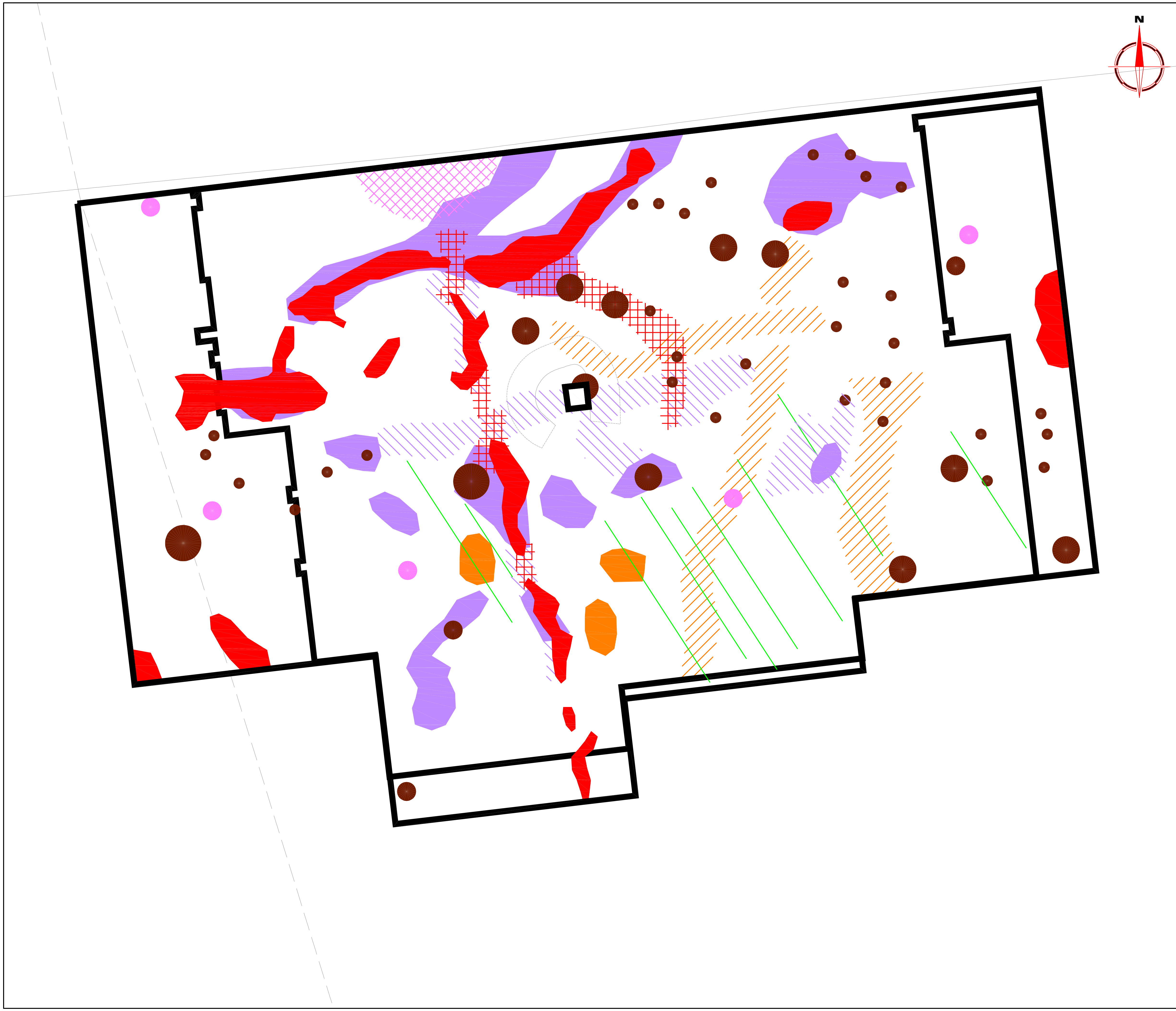
Scale 1:300 (0m 2 4 6 8 10m)

Plot	Checked by	Issue No.
A3	PPB	01
Survey date	Drawn by	Figure No.
SEPT 2010	RA	09



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

GRADIOMETER ANOMALIES

- Parallel linear anomalies - probably of modern agricultural origin
- Positive area anomaly - possible cut feature of archaeological origin
- Weak positive area anomaly - possible cut feature of archaeological origin
- Discrete positive anomaly - possible pit
- Strong discrete bipolar anomaly - ferrous object
- Magnetic disturbance - related to large ferrous metallic object

RESISTANCE ANOMALIES

- High resistance anomaly - possible compacted ground or former bank / earthwork
- Moderate high resistance anomaly - possible compacted ground or former bank / earthwork
- Low resistance area anomaly - possible cut feature such as ditch or pit
- Moderate low resistance area anomaly - possible cut feature such as ditch or pit

Client

JOHN MOORE HERITAGE SERVICES

Project Title Job No. 2772

GEOPHYSICAL SURVEY - THE HAWK STONE, SPELSBURY

Subject

COMBINED ABSTRACTION AND INTERPRETATION OF ANOMALIES

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Scale 1:300 (0m 2 4 6 8 10m)

Plot	Checked by	Issue No.
A3	PPB	01
Survey date	Drawn by	Figure No.
SEPT 2010	RA	10