STRATASCAN

Geophysical Survey Report

Grangе Farm Quarry, Horstead

for

Archaeological Solutions

September 2011

Job ref. J2951

Richard Smalley BA (Hons) AIFA

REGISTERED ORGANISATION IfA

Document Title:	**Geophysical Survey Report** **Grange Farm Quarry, Horstead**
Client:	**Archaeological Solutions**
Stratascan Job No:	**J2951**
Techniques:	**Detailed magnetic survey (gradiometry)**
National Grid Ref:	**TG 249 202**

Field Team:	**Glenn Rose BA (Hons) and Adam Cooper MSc.**
Project Manager:	**Simon Haddrell B.Eng (Hons) AMBCS PIFA**
Report written by:	**Richard Smalley BA (Hons) AIFA**
CAD illustration by:	**Simon Haddrell and Richard Smalley**
Checked by:	**Peter Barker C.Eng MICE MCIWEM MIFA FCInstCES**

Stratascan Ltd.

Vineyard House
Upper Hook Road
Upton upon Severn
WR8 0SA

Tel: 01684 592266
Fax: 01684 594142
Email: ppb@stratascan.co.uk
www.stratascan.co.uk

LIST OF FIGURES

1 SUMMARY OF RESULTS

The detailed magnetic gradiometer survey undertaken over approximately 4.9ha of land proposed for development as a quarry extension has identified weak evidence of cut features. These anomalies may be of an archaeological origin, however they do not conform to any sort of recognisable pattern and as such may be of a geological or pedological origin.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of an area outlined for development as part of a quarry extension. This survey forms part of an archaeological investigation being undertaken by Archaeological Solutions.

2.2 Site location

The site is located near Grange Farm, north of Buxton Road, Horstead, Norfolk at OS ref. TG 249 202.

2.3 Description of site

The survey area comprises approximately 4.9ha of arable land currently used for potatoes. The southern boundary of the survey area is formed by the B1354 “Buxton Road” and to the east by a farm track. Grange Farm Quarry is located immediately north of the survey area.

2.4 Geology and soils

The underlying geology is Red Crag, Norwich Crag and Wroxham Crag formations of shelly sand and gravel (British Geological Survey South Sheet, Fourth Edition Solid, 2001). The drift geology is Crag (British Geological Survey South Sheet, First Edition Quaternary, 1977). The overlying soils are known as Wick 2 which are typical brown earths. These consist of deep well drained coarse loamy soils (Soil Survey of England and Wales, Sheet 4 Eastern England).

2.5 Site history and archaeological potential

The brief provided by Norfolk County Council indicates that investigations to the east of the survey area have identified cropmarks of a Bronze Age ring ditch, enclosures and a findspot of a Bronze Age axe head. This would suggest that there is potential for anomalies of a possible archaeological origin within the geophysical survey data.

2.6 Survey objectives

The objective of the survey was to determine the nature and extent of any archaeological deposits at the proposed development site.

2.7 Survey methods

Detailed magnetic survey (gradiometry) was used as an efficient and effective method of locating archaeological anomalies. More information regarding this technique is included in the Methodology section below.

3 METHODOLOGY

3.1 Date of fieldwork

The fieldwork was carried out over three days from 31st August 2011. Weather conditions during the survey were 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 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.

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

3.4.1 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.

3.4.2 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.

3.4.3 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.

3.5 Processing, presentation of results and interpretation

3.5.1 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 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)

3.5.2 Presentation of results and interpretation

The presentation of the data for each site involves a print-out of the raw data as a greyscale plot (Figure 3) and a colour plot showing extreme magnetic values (Figure 4), together with a greyscale plot of the processed data (Figure 5). Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site (Figure 6).

4 RESULTS

The following list of numbered anomalies refers to numerical labels on the interpretation plot (Figure 6).

Probable Archaeology

No anomalies that can confidently be attributed to being of a probable archaeological origin have been identified in the geophysical survey data.

Possible Archaeology

1. A number of weak positive anomalies have been identified within the survey area. These anomalies may be related to cut features such as pits and ditches of a possible archaeological origin. However, their amorphous character may suggest that they are of a geological or pedological origin.

2. A number of magnetic ‘spikes’ (strong focussed values with associated antipolar response) indicate ferrous metal objects. Although most of these are likely to be modern debris, some may be of archaeological interest. Particular attention may be paid to those found in association with other potentially archaeological anomalies.

Other Anomalies

3. A large swathe of discrete positive anomalies can be noted throughout the survey area. These anomalies are characteristic of pits of a possible archaeological origin; however the large numbers present at this site may suggest that they are related to former tree boles or geological variances.

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, but on this site have not affected a significant proportion of the area.

5 CONCLUSION

The geophysical survey undertaken at Grange Farm Quarry has identified little in the way of anomalies of a possible archaeological origin. A number of weak positive anomalies can be noted in the central and south eastern regions of the survey area which may be related to cut features such as pits and ditches. However, a geological or pedological origin cannot be ruled out.

A large number of discrete positive anomalies are evident throughout the survey area. These anomalies have been interpreted as being related to former tree boles or changes in geology.

6 REFERENCES

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

British Geological Survey, 2007. *Geological Survey Ten Mile Map, South Sheet, Fifth Edition (Solid)*. British Geological Society.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 4 Eastern 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 *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.

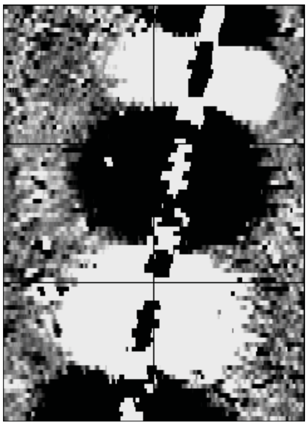
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

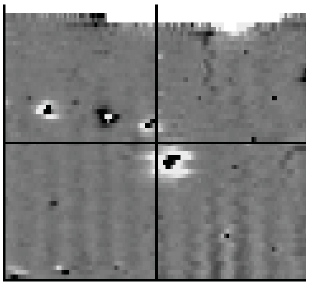
APPENDIX B – Glossary of magnetic anomalies

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

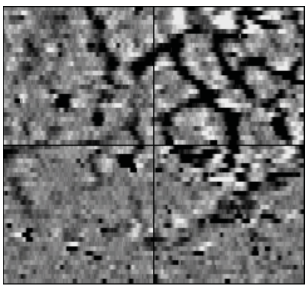


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

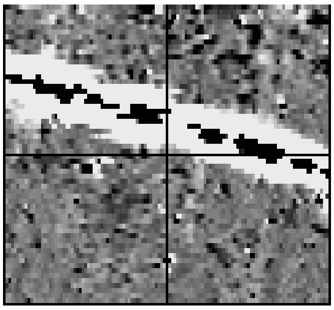
See bipolar and dipolar.

Positive linear



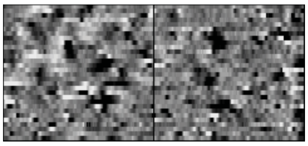
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



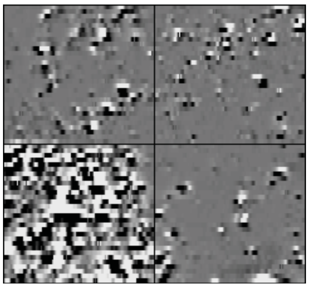
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



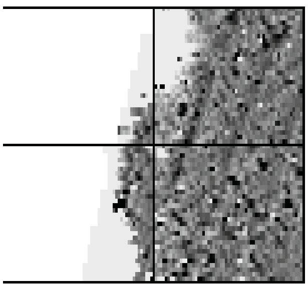
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



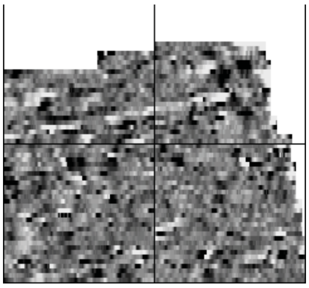
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

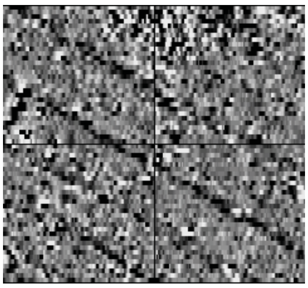


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

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).

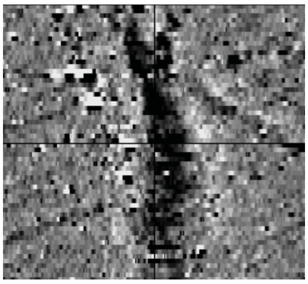
Strength of response

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. Colour plots are used to show the amplitude of response.

Thermoremanent response

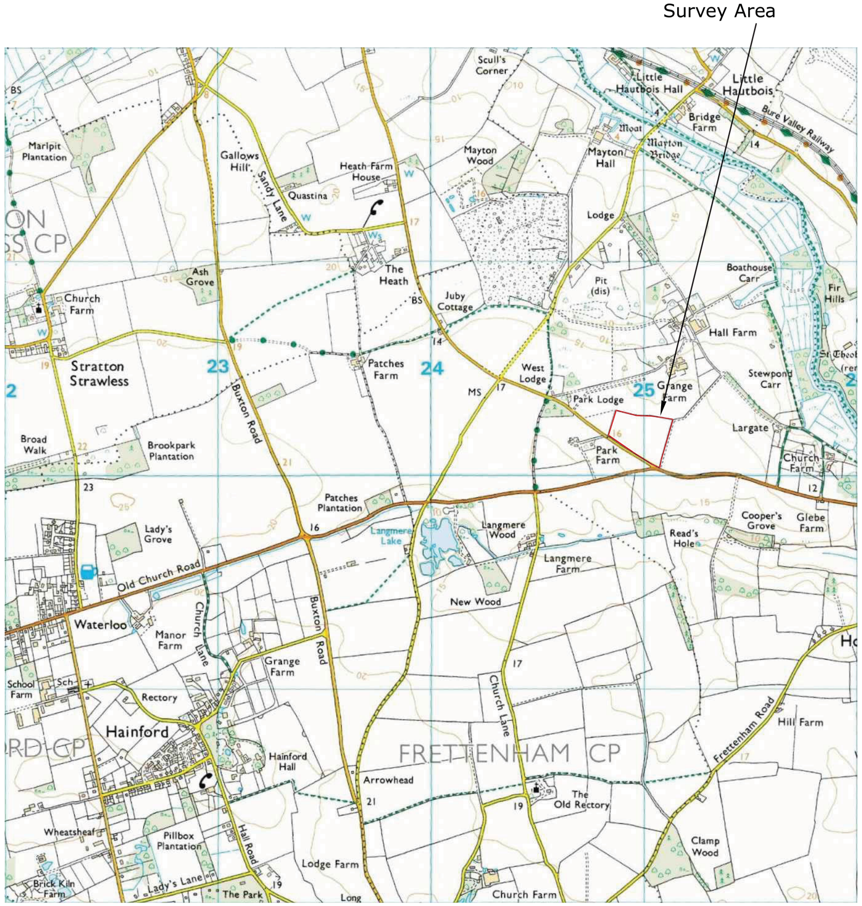
A feature which has been subject to heat may result in it acquiring a magnetic field. This can be anything up to approximately +/-100 nT in value. These features include clay fired drains, brick, bonfires, kilns, hearths and even pottery. If the heat application has occurred in situ (e.g. a kiln) then 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.

OS 100km square = TG



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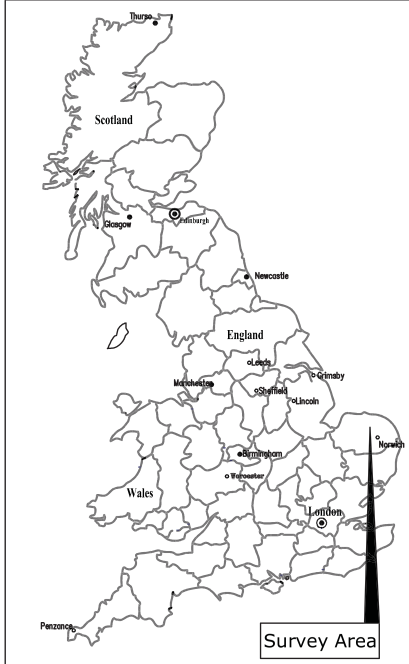

Site centred on NGR: TG 249 202

Client: ARCHAEOLOGICAL SOLUTIONS

Project Title: GEOPHYSICAL SURVEY - GRANGE FARM QUARRY - HORSTEAD

Job No. 2951

Subject: LOCATION PLAN OF SURVEY AREA

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk

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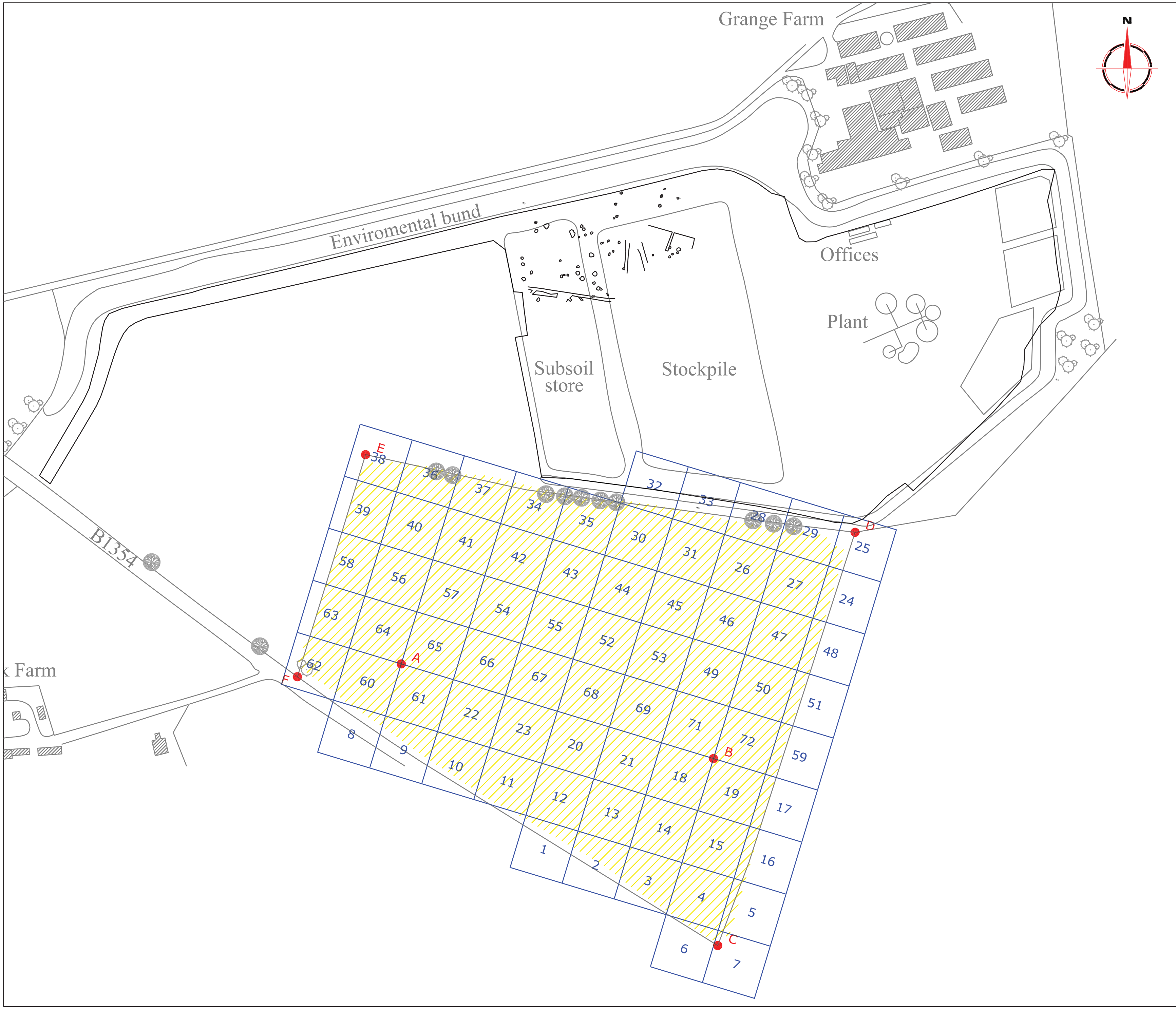

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KEY

12	Numbered survey grid
	Area surveyed within grid

REFERENCING INFORMATION

A-B Base line - 180.00m

A-C	233.69m	A-D	260.69m	A-E	117.11m
A-F	57.71m	B-C	103.16m	B-D	147.25m
B-E	254.87m	B-F	233.93m		

Client

ARCHAEOLOGICAL SOLUTIONS

Project Title Job No. 2951

GEOPHYSICAL SURVEY - GRANGE FARM QUARRY - HORSTEAD

Subject

LOCATION AND REFERENCING OF SURVEY GRIDS

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk

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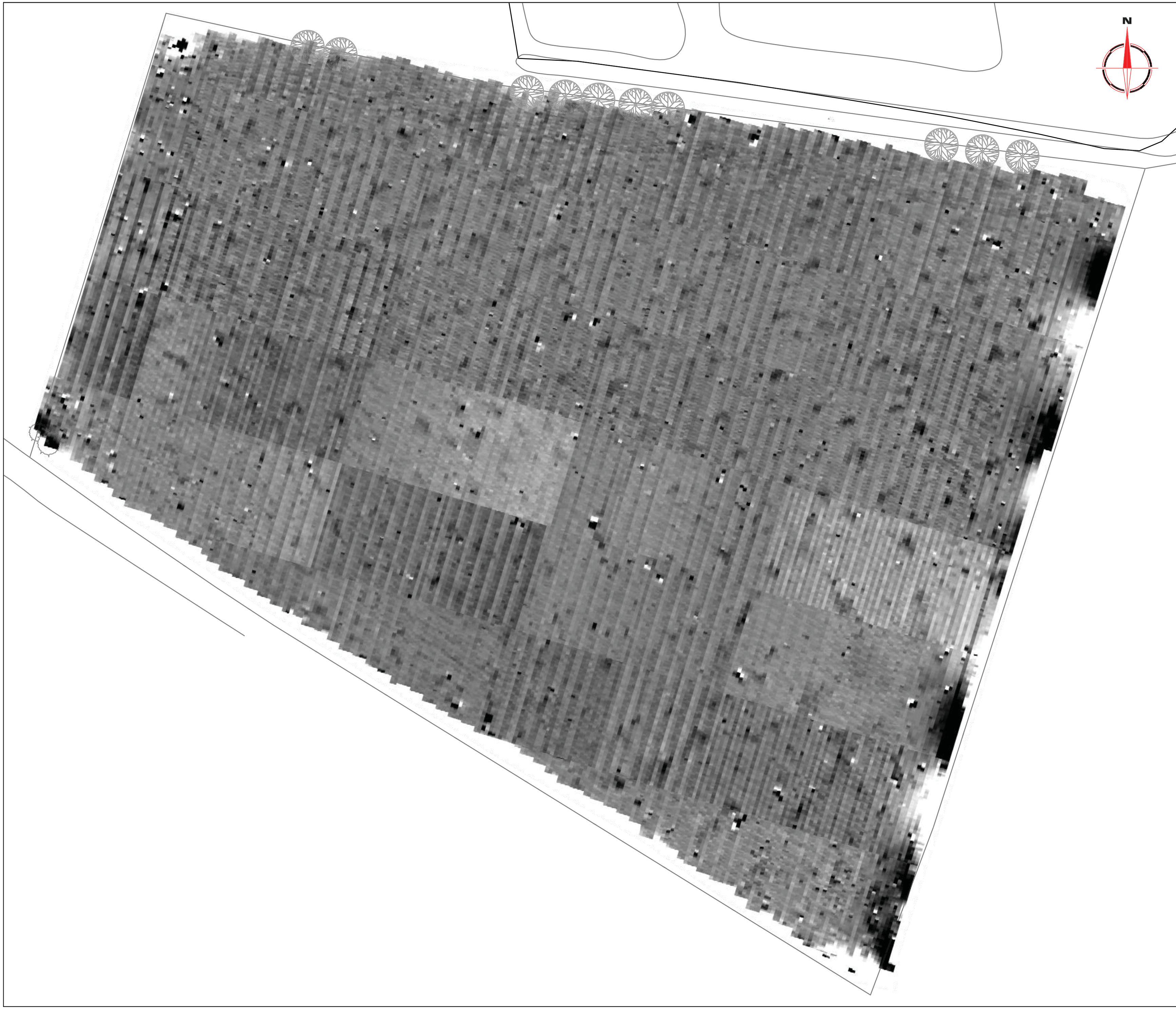
Survey date AUG 11	Drawn by SDH	Figure No. 02



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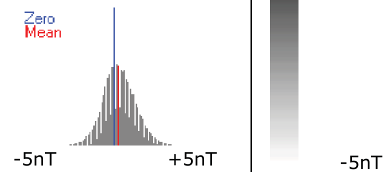
Maximum +5nT (black)
Minimum -5nT (white)



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ARCHAEOLOGICAL SOLUTIONS

Project Title — Job No. 2951

GEOPHYSICAL SURVEY - GRANGE FARM QUARRY - HORSTEAD

Subject

PLOT OF RAW GRADIOMETER DATA

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk

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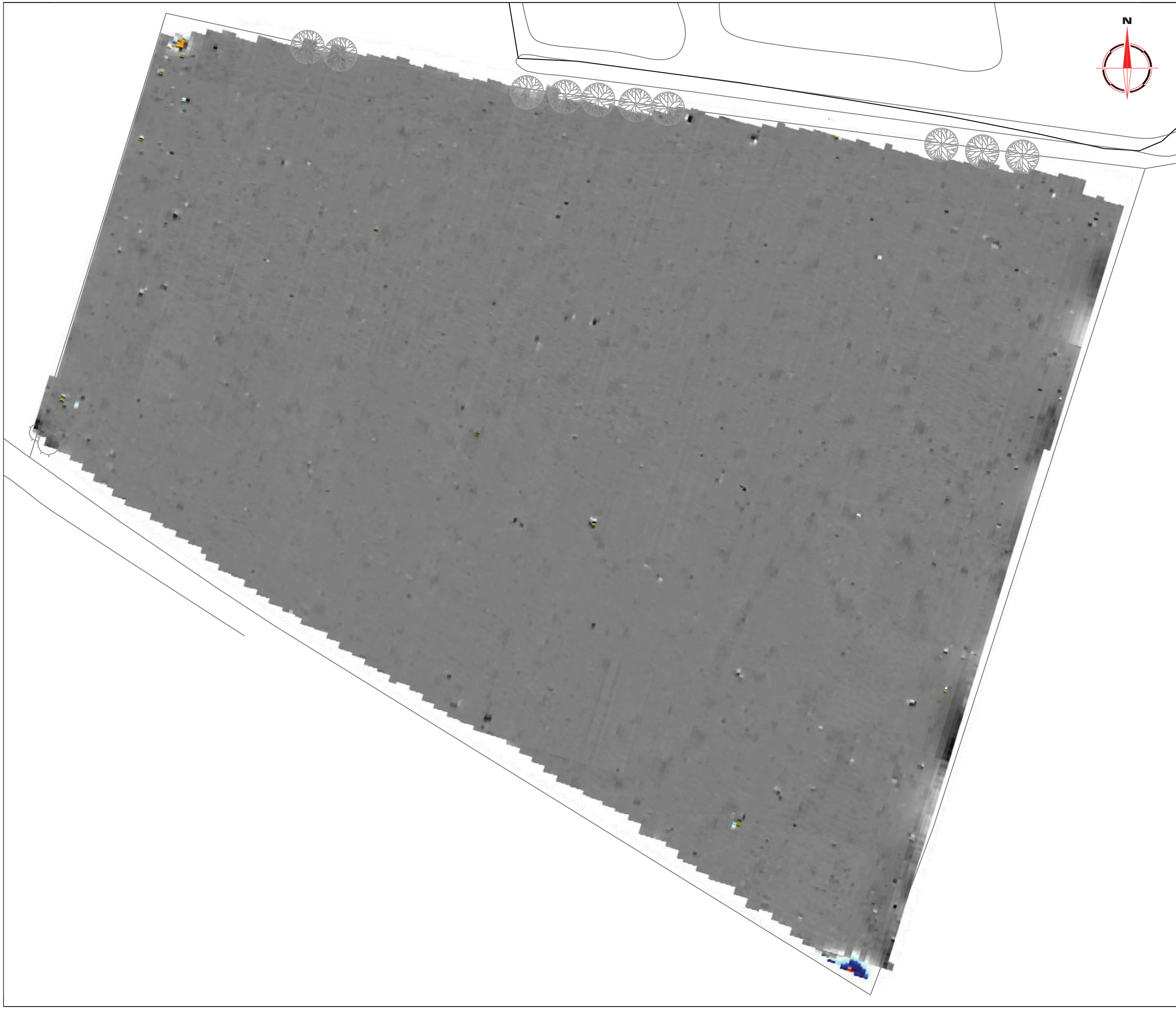

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Issue No.	Date	Description
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-	-	-

Plotting parameters

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

+250nT
-250nT

Client
ARCHAEOLOGICAL SOLUTIONS

Project Title — Job No. 2951
GEOPHYSICAL SURVEY - GRANGE FARM QUARRY - HORSTEAD

Subject
COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
www.stratascan.co.uk

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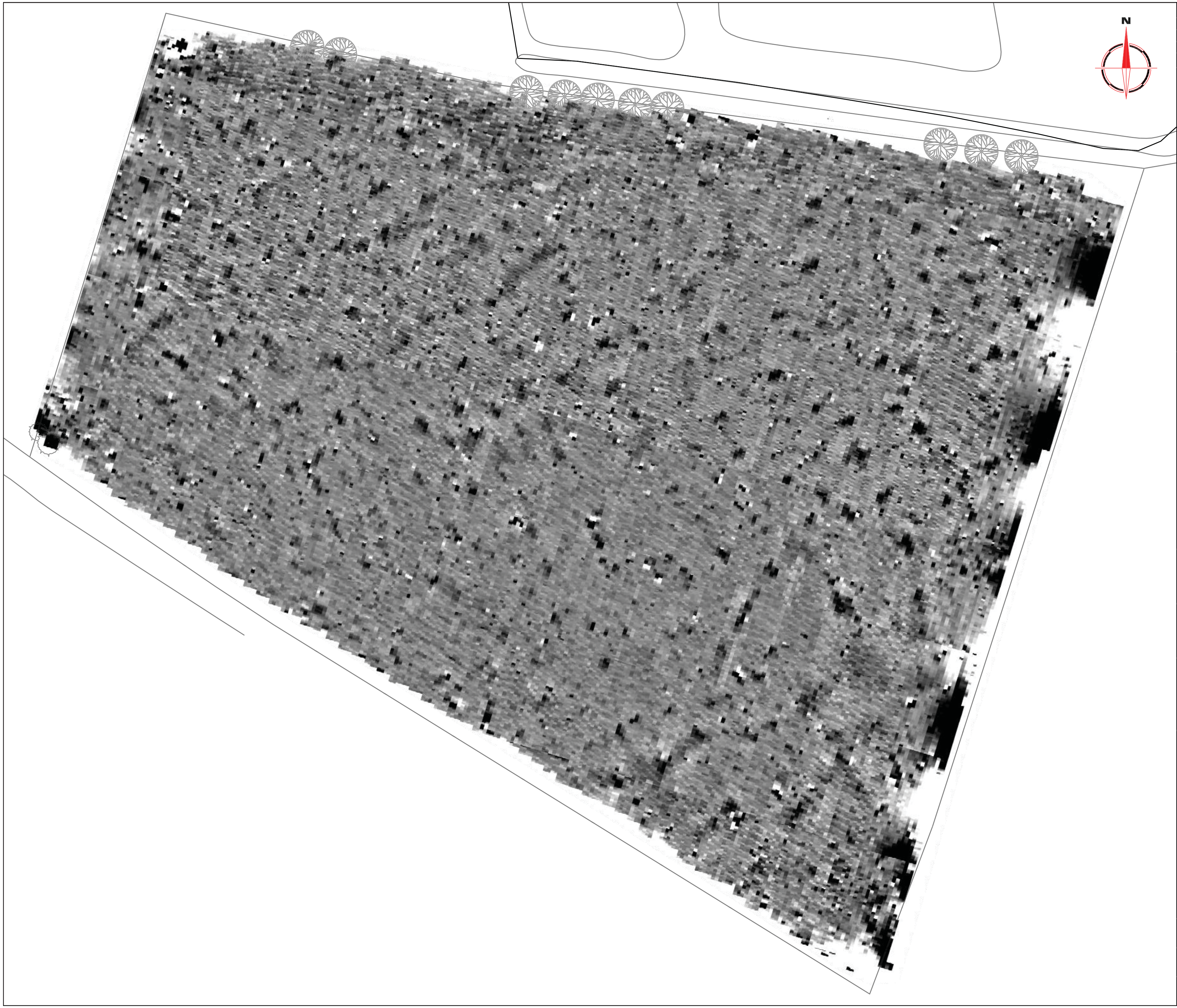

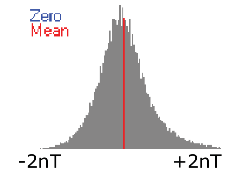

+2nT
-2nT

Issue No.	Date	Description
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-	-	-

Plotting parameters

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

Client
ARCHAEOLOGICAL SOLUTIONS

Project Title — Job No. 2951
GEOPHYSICAL SURVEY - GRANGE FARM QUARRY - HORSTEAD

Subject
PLOT OF PROCESSED GRADIOMETER DATA

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GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
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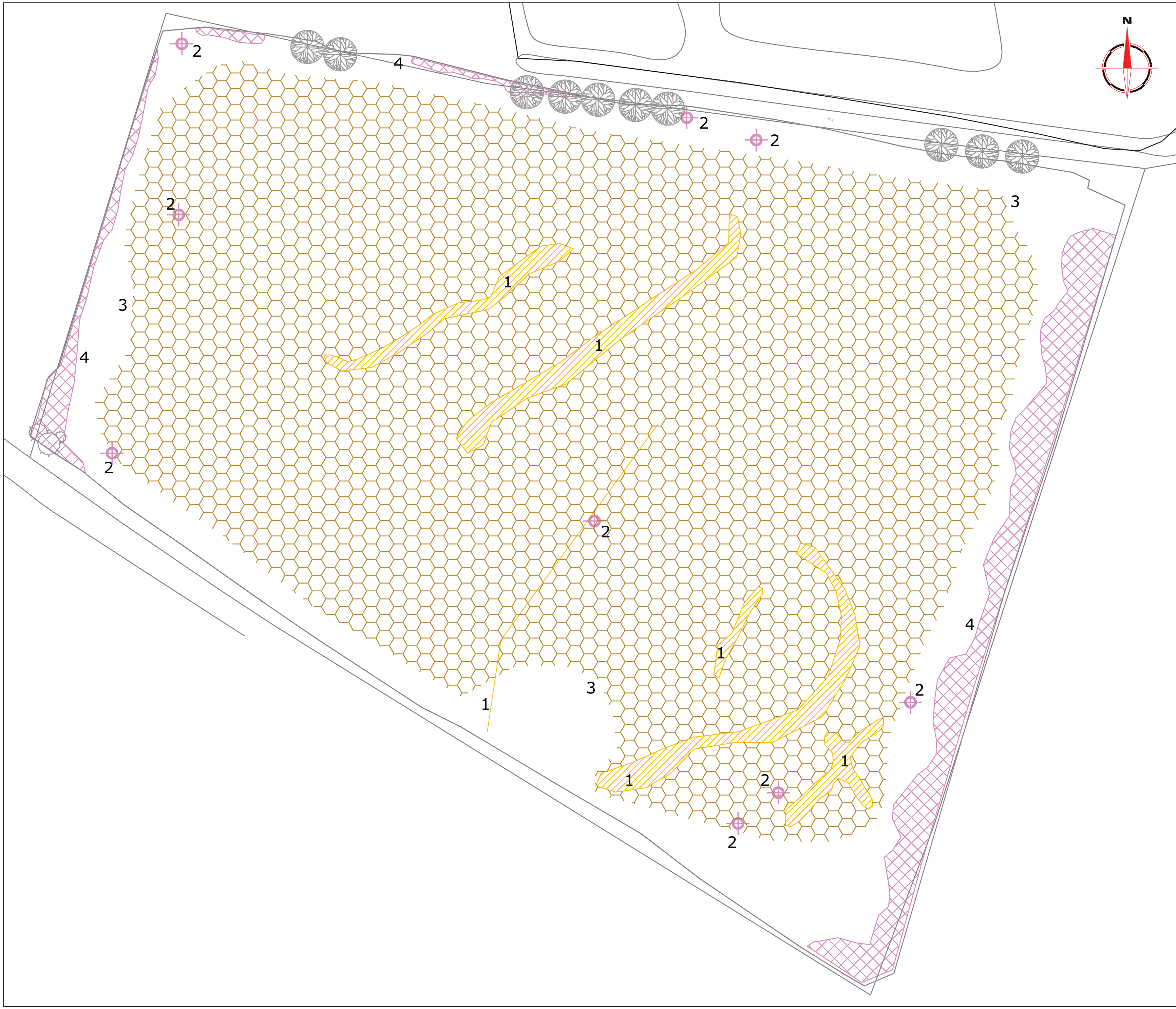

Amendments

Issue No.	Date	Description
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-	-	-

KEY

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
- Moderate strength discrete anomaly - probable thermoremanent feature
- Widely spaced curving parallel linear anomalies - probably related to ridge-and-furrow

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
- Moderate strength discrete anomaly - possible thermoremanent feature
- Magnetic spike - probable ferrous object

OTHER ANOMALIES

- Closely spaced parallel linear anomalies - probably related to agricultural activity such as ploughing
- 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 - probably related to geological variances or former tree boles

Client

ARCHAEOLOGICAL SOLUTIONS

Project Title Job No. 2951

GEOPHYSICAL SURVEY - GRANGE FARM QUARRY - HORSTEAD

Subject

ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES

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VINEYARD HOUSE
UPPER HOOK ROAD
UPTON UPON SEVERN
UK
WR8 0SA
T: +44 (0)1684 592266
F: +44 (0)1684 594142
E: info@stratascan.co.uk
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Scale 1:1000 (0m 10 20 30 40 50)

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