

GEOPHYSICAL SURVEY REPORT

STRATASCAN™



Project name:

Fire Service College, Moreton-in-Marsh

Client:

Cotswold Archaeology

February 2014

Job ref:

J6414

Report author:

Orlando J. Prestidge BA(Hons) MA AlFA

GEOPHYSICAL SURVEY REPORT

Project name:

Fire Service College, Moreton-in-Marsh

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Job ref:

J6414

Techniques:

**Detailed magnetic survey –
Gradiometry**

Survey date:

12th - 14th February 2014

Site centred at:

SP 216 332

Post code:

GL56 9NL

Field team:

**Andrew Bateman BSc(Hons), Rebecca
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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 10.5 hectares of grass and waste ground at Moreton-in-Marsh. No features of archaeological interest have been located. Areas of agricultural activity are present in the western section of the survey area, and extensive areas of modern services are present across the survey area. These services most likely relate to the continued use of the site as an RAF base and fire training college.

The UXO interpretation located a number of small and medium sized ferrous objects throughout the survey area. These objects may relate to buried ordnance but could also be the result of modern magnetic debris.

Other anomalies observed are likely modern or natural in origin including magnetic disturbance relating to field boundaries and fences and spreads of magnetic debris and magnetic spikes in the topsoil.

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 Cotswold Archaeology.

2.2 *Site location*

The site is located near Moreton-in-Marsh, Gloucestershire at OS ref. SP 216 332. The survey area sits to the west of the Fire Service Technical College buildings and north east of the town itself.

2.3 *Description of site*

The survey area is 10.5 hectares of grass and waste ground surrounding the concreted and built up areas of the technical college. The survey area had originally been 21 hectares, but large areas were unsurveyable due to wooded and built up areas. The topography was mostly flat.

2.4 *Geology and soils*

The underlying geology is Charmouth Mudstone Formation - Mudstone (British Geological Survey website). The drift geology is Moreton Member – Sand, silt and clay (British Geological Survey website).

The overlying soils are known as Oak 2 which are typical slowly permeable seasonally waterlogged fine loamy over clayey and fine silty over clayey soils (Soil Survey of England and Wales, Sheet 5 South West England).

2.5 **Site history and archaeological potential**

The Fire Service College site was a former RAF airbase and the following has been written using information provided by the Wellington Aviation Museum and the Airfields of Britain Conservation Trust:

RAF Moreton-in-Marsh was a Royal Air Force station near Moreton-in-Marsh, Gloucestershire. The base was opened for flying in November 1940 and served as a home to squadrons of Hawker Hurricane and Vickers Wellington Aircraft amongst others. The base was attacked a number of times by the Luftwaffe in 1941, including two 500lb bombs and a large number of incendiary bombs being dropped in April, causing damage to telegraph wires and drums of cabling. There was a further attack of incendiary bombs in May. The base was closed for operational flying in early 1948. The base remained in use as a relief runway and for training and after a period of care and maintenance, the Station was handed over to the Home Office in 1955.

The former airfield is now home to the Fire Service College where senior fire officers from brigades all over the UK undergo operational, management and leadership training.

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 Institute for Archaeologists document *Standard and Guidance for Archaeological Geophysical Survey*.

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 and 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, together with a greyscale plot of the processed data. 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 Moreton-in-Marsh 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 Other Anomalies

- 1 Closely spaced parallel linear anomalies, probably related to agricultural activity such as ploughing.
- 2 Linear anomaly probably related to pipe, cable or other modern service.
- 3 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.
- 4** Strong magnetic debris, possibly disturbed or made ground.
- 5** Scattered magnetic debris.
- 6** A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish.

4 CONCLUSION

A detailed gradiometry survey was conducted over approximately 10.5 hectares of grass and waste ground at Moreton-in-Marsh. No features of archaeological interest have been located. Areas of agricultural activity are present in the western section of the survey area, and extensive areas of modern services are present throughout the survey area. These services most likely relate to the continued use of the site as an RAF base and fire training college.

The UXO interpretation located a number of small and medium sized ferrous objects throughout the survey area. These objects may relate to buried ordnance but could also be the result of modern magnetic debris.

Other anomalies observed are likely modern or natural in origin including magnetic disturbance relating to field boundaries and fences and spreads of magnetic debris and magnetic spikes in the topsoil.

5 REFERENCES

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

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

British Geological Survey, n.d., *website*:
(<http://www.bgs.ac.uk/opengeoscience/home.html?Accordion1=1#maps>) Geology of Britain viewer.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 5 South West England*.

English Heritage, 2008. *Geophysical Survey in Archaeological Field Evaluation*.

Institute For Archaeologists. *Standard and Guidance for Archaeological Geophysical Survey*.
<http://www.archaeologists.net/sites/default/files/nodefiles/Geophysics2010.pdf>

Wellington Aviation Museum, *website*:
<http://www.wellingtonaviation.org/history/docs/index.htm>

Airfield of Britain Conservation Trust, *website*:
<http://www.abct.org.uk/airfields/moreton-in-marsh>

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.

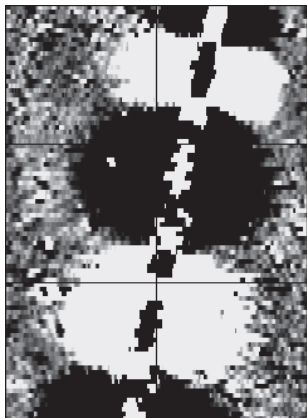
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

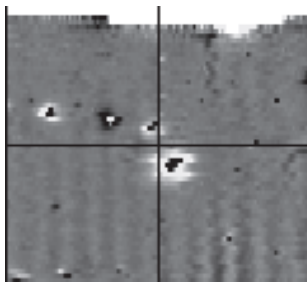
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

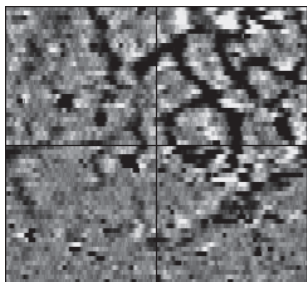


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

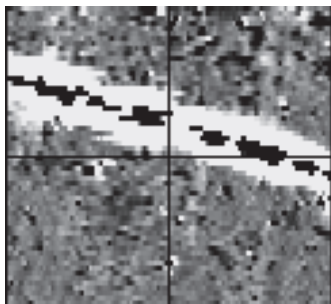
See bipolar and dipolar.

Positive linear



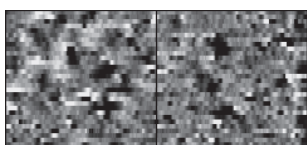
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

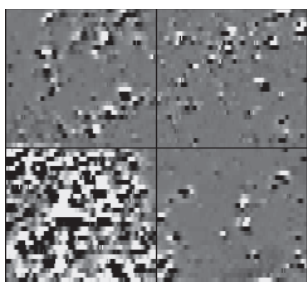
Positive point/area



depressions in the ground.

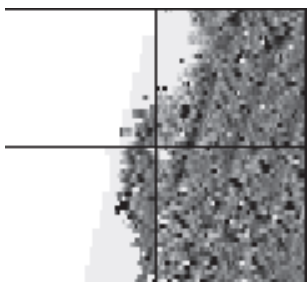
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



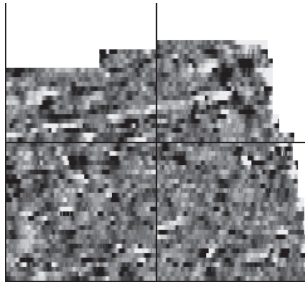
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low ($\pm 3\text{nT}$) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly ($\pm 250\text{nT}$) 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

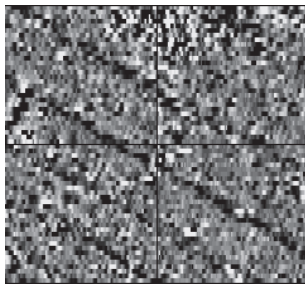


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

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).

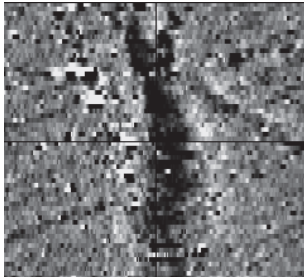
Strength of response

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 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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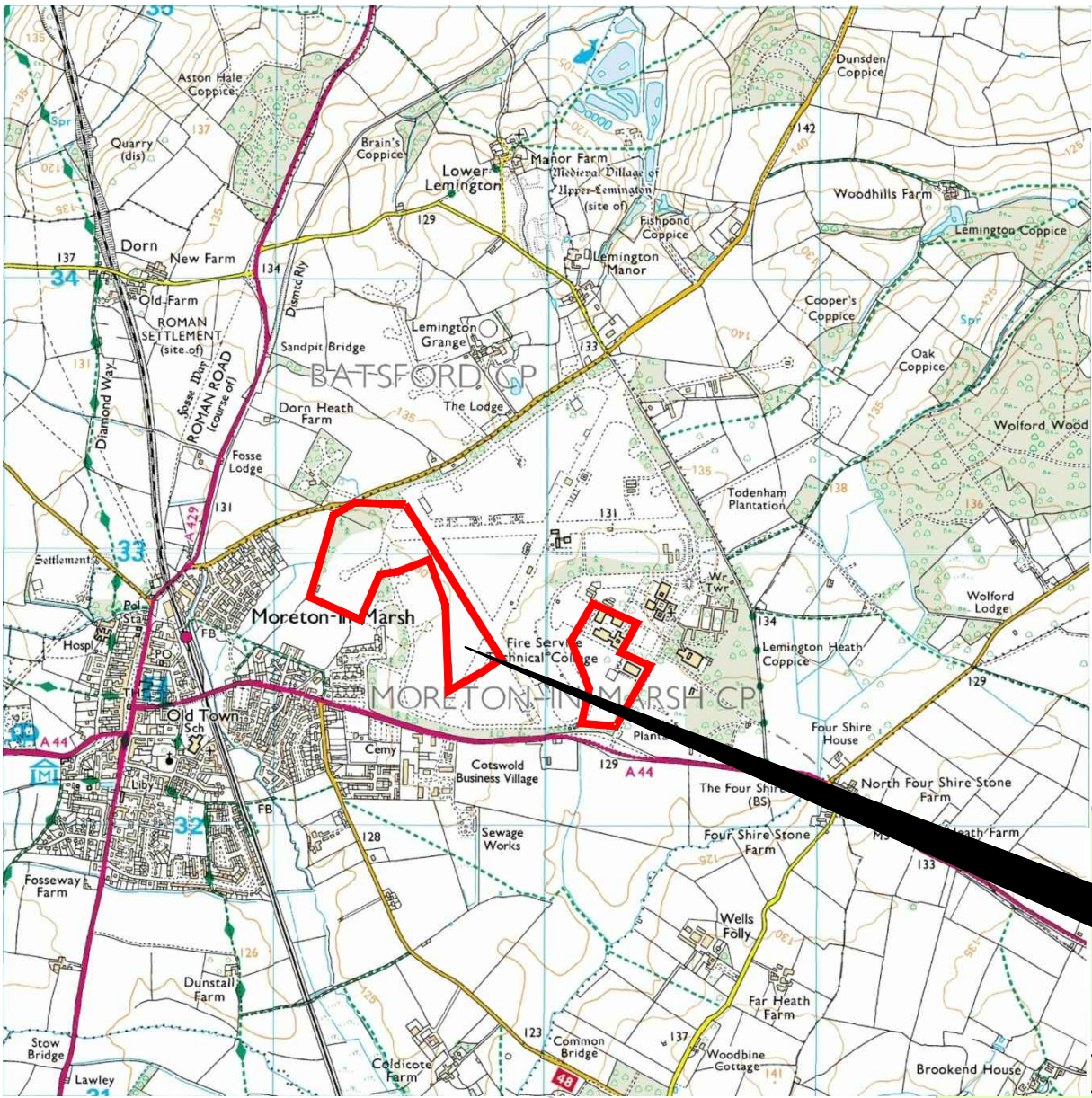


SUMO
Group
Member

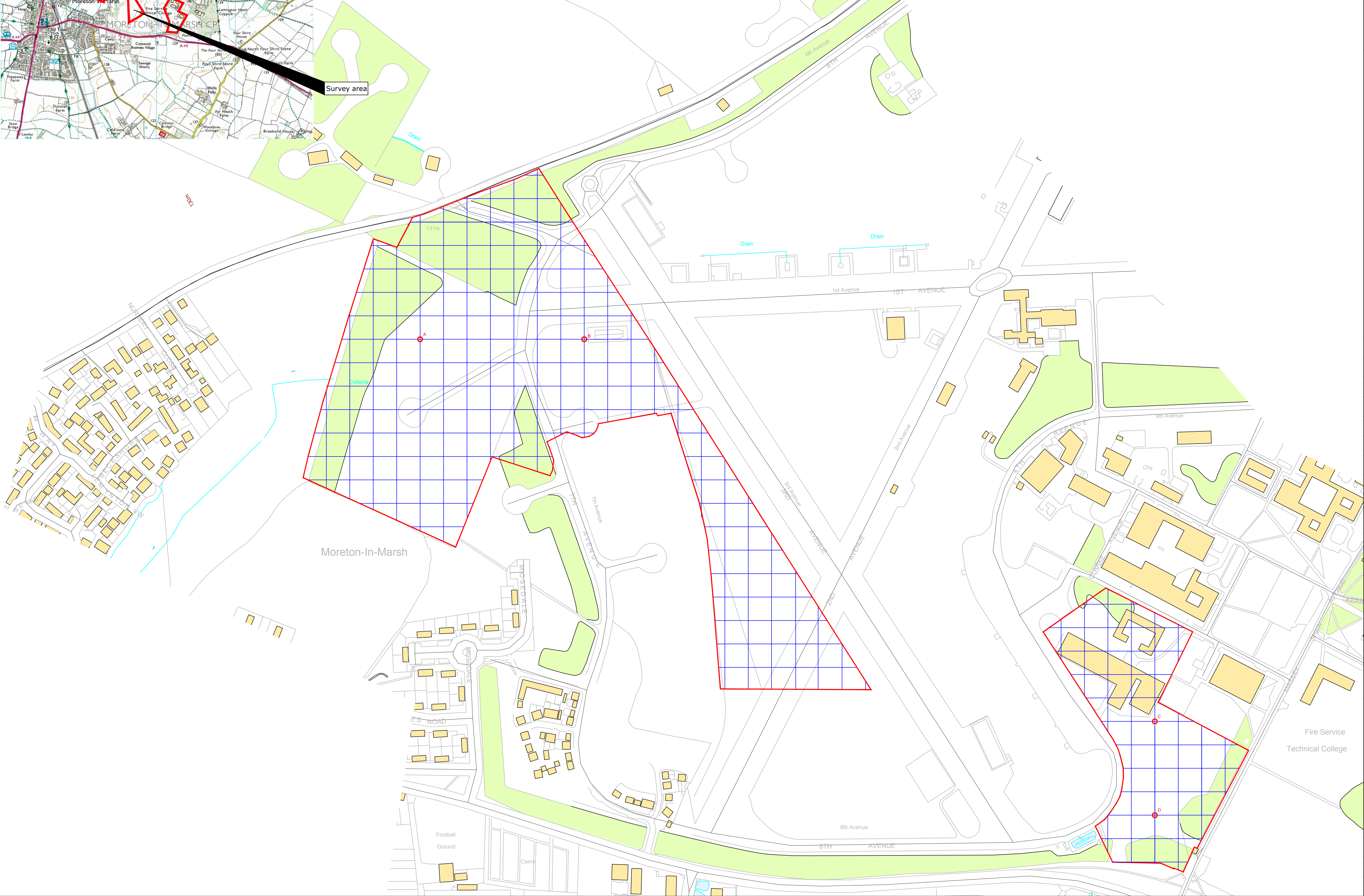
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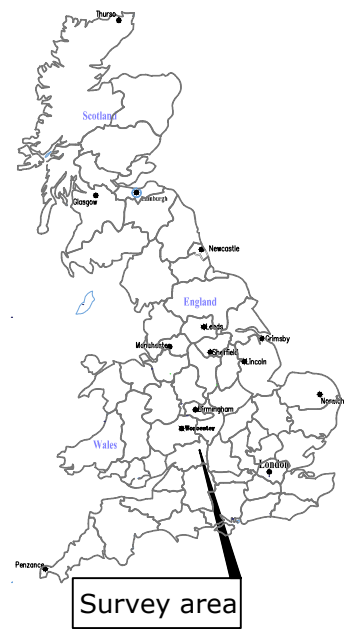
Reproduced from Ordnance Survey's 1:25 000 map of 1998 with the permission of the controller of Her Majesty's Stationary Office. Crown Copyright reserved. Licence No: AL 50125A
Licence: Stratascan Ltd. Vineyard House Upper Hook Road Upton Upon Severn WR8 0SA
OS 100km square = SP



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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Site centred on NGR SP 216 332

KEY

- Survey area
- Survey grid
- GPS referencing point

OS REFERENCING INFORMATION

A	421266.76, 233014.03
B	421476.76, 233014.03
C	422207.06, 232524.88
D	422207.06, 232404.88

Job No.	6414	Survey Date	FEB 2014
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Client

COTSWOLD ARCHAEOLOGY

Project Title

FIRE SERVICE COLLEGE, MORETON-IN-MARSH

Subject

SITE LOCATION AND SURVEY AREA & REFERENCING

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Scale	0m	50	100	150m
1:2500				

Plot	A1	Checked by	DGE	Issue No.	01
Date	FEB 2014	Drawn by	OJP	Figure No.	01



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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Plotting parameters

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

+100nT

+10nT

-10nT

-100nT

Job No.

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Survey Date

FEB 2014

Client

COTSWOLD ARCHAEOLOGY

Project Title

FIRE SERVICE COLLEGE,
MORETON-IN-MARSH

Subject

COLOUR PLOT OF MINIMALLY
PROCESSED GRADIOMETER
DATA SHOWING EXTREME
VALUES - EAST

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ISO 14001
certified

Scale

0m 10 20 30 40 50 60 70 80m

1:1250

Plot

A1

Checked by

DGE

Issue No.

01

Date

FEB 2014

Drawn by

OJP

Figure No.

02



Amendments		
Issue No.	Date	Description
-	-	-
-	-	-
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Plotting parameters		
Maximum +100nT (red)		
Minimum -100nT (blue)		

Job No.	6414	Survey Date	FEB 2014
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COTSWOLD ARCHAEOLOGY			
Project Title			
FIRE SERVICE COLLEGE, MORETON-IN-MARSH			
Subject			
COLOUR PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA SHOWING EXTREME VALUES - WEST			
VINEYARD HOUSE UPTON UPON SEVERN WR8 0SA			
T: 01684 592266 E: info@stratascan.co.uk www.stratascan.co.uk			
Scale			
0m 10 20 30 40 50 60 70 80m			
1:1250			
Plot	A1	Checked by	DGE
Date	FEB 2014	Drawn by	OJP
		Issue No.	01
		Figure No.	03



Amendments

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

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Zero

Mean

-2nT

0

+2nT

+2nT

-2nT

Job No.

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Survey Date

FEB 2014

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COTSWOLD ARCHAEOLOGY

Project Title

FIRE SERVICE COLLEGE,
MORETON-IN-MARSH

Subject

PLOT OF MINIMALLY
PROCESSED GRADIOMETER
DATA - EAST

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MEMBER

Scale

0m 10 20 30 40 50 60 70 80m

1:1250

Plot

A1

Checked by

DGE

Issue No.

01

Date

FEB 2014

Drawn by

OJP

Figure No.

04



Amendments

Issue No.	Date	Description
-	-	-
-	-	-
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Zero

Mean

-2nT

+2nT

+2nT

-2nT

Job No.

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Client

COTSWOLD ARCHAEOLOGY

Project Title

FIRE SERVICE COLLEGE,
MORETON-IN-MARSH

Subject

PLOT OF MINIMALLY
PROCESSED GRADIOMETER
DATA - WEST

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ISO 14001
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ims
ISO 18001
certified

Scale

0m 10 20 30 40 50 60 70 80m

1:1250

Plot

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01

Date

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Figure No.

05



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 - probable natural (e.g. geological or pedological) origin

Job No.	6414	Survey Date	FEB 2014
Client			

COTSWOLD ARCHAEOLOGY

Project Title

**FIRE SERVICE COLLEGE,
MORETON-IN-MARSH**

Subject

INTERPRETATION - EAST

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY
AND ENGINEERING

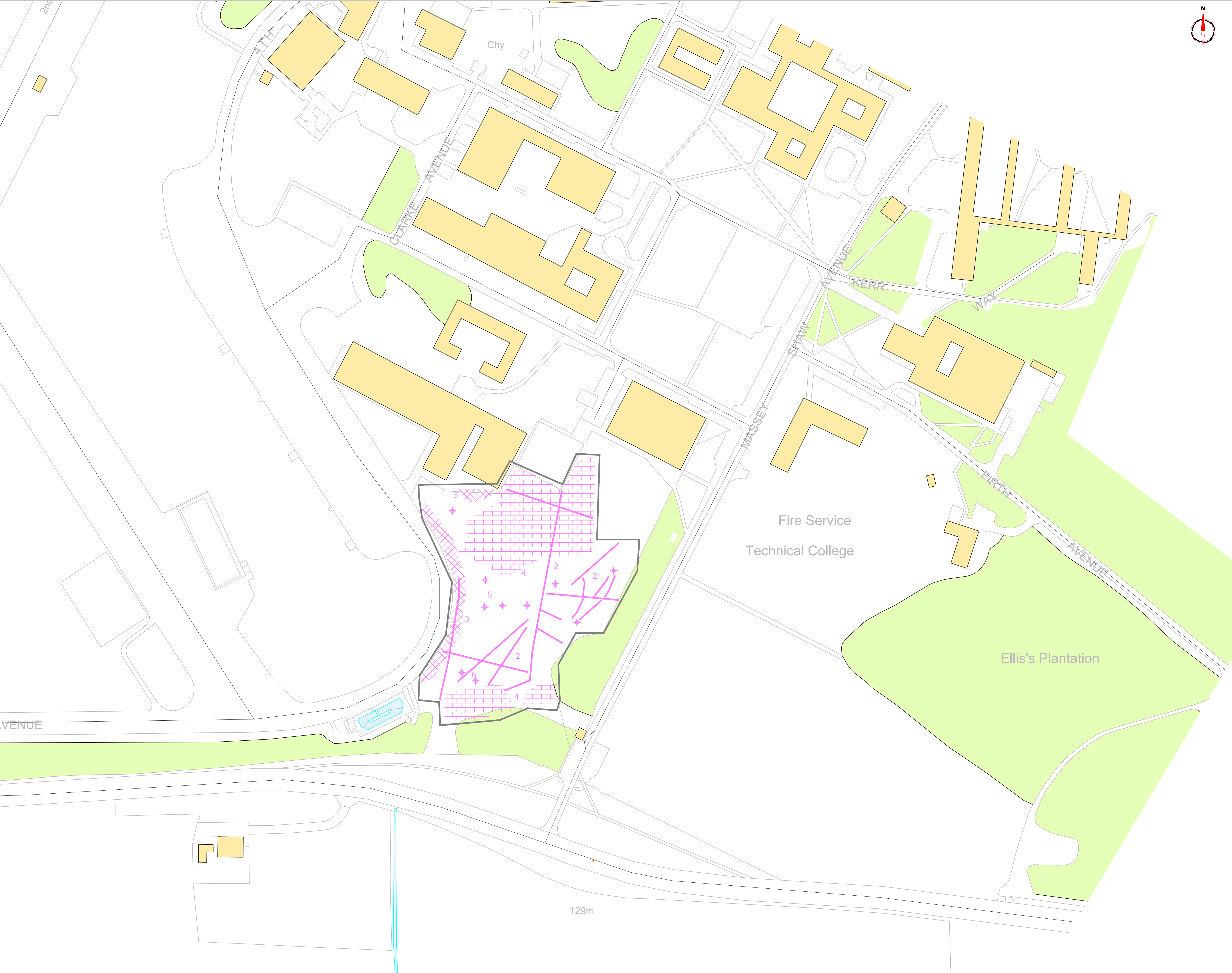
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Scale 1:1250 0m 10 20 30 40 50 60 70 80m		
Plot A1	Checked by DGE	Issue No. 01
Date FEB 2014	Drawn by OJP/SP	Figure No. 06



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 originNegative anomaly / weak negative anomaly - possible bank or earthwork of archaeological originModerate strength discrete anomaly - possible thermoremanent featureMagnetic spike - probable ferrous object

OTHER ANOMALIES

Closely spaced parallel linear anomalies - probably related to agricultural activity such as ploughingLinear anomaly - probably related to pipe, cable or other modern serviceLinear anomaly - possibly related to land drainMagnetic disturbance associated with nearby metal object such as service or field boundaryStrong magnetic debris - possible disturbed or made groundScattered magnetic debrisArea of amorphous magnetic variation - probable natural (e.g. geological or pedological) origin

Job No.

6414

Survey Date

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COTSWOLD ARCHAEOLOGY

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0m 10 20 30 40 50 60 70 80m

1:1250

Plot

A1

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Figure No.

07



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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POSSIBLE UXO

- Small ferrous object
- Medium-sized ferrous object
- Large ferrous object
- Strong magnetic debris - likely to include significant quantities of ferrous material
- Magnetic disturbance masking anomalies - no information on ferrous objects

Job No.

6414

Survey Date

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COTSWOLD ARCHAEOLOGY

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Plot

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Issue No.

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OJP

Figure No.

08



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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POSSIBLE UXO

Small ferrous object

Medium-sized ferrous object

Large ferrous object

Strong magnetic debris - likely to include significant quantities of ferrous material

Magnetic disturbance masking anomalies - no information on ferrous objects

Job No.

6414

Survey Date

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Client

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1:1250

Plot

A1

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Issue No.

01

Date

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Figure No.

09