STRATASCAN

Geophysical Survey Report

Harrington Wind Farm, Northamptonshire

for

CgMs Consulting Ltd

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J2510

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LIST OF FIGURES

1 SUMMARY OF RESULTS

A detailed magnetometry survey was carried out over seven 1ha blocks of arable land near Harrington, Northamptonshire. The survey identified a significant level of archaeological activity in one of these areas. Lower levels of archaeological activity were also identified in each of the other survey areas.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned by CgMs Consulting Ltd to undertake a geophysical survey of an area outlined for development. This survey forms part of an archaeological investigation.

2.2 Site location

The site is located near Harrington, Northamptonshire at OS ref. SP 771 778.

2.3 Description of site

The survey area consists of seven 1ha blocks over gently sloping arable land recently harvested with some deep plough.

2.4 Geology and soils

The underlying geology is Inferior Oolite (British Geological Survey South Sheet, Forth Edition Solid, 2001). The drift geology consists of Boulder Clay and Morainic drift (British Geological Survey Ten Mile Map South Sheet First Edition (Quaternary), 1977). The overlying soils are Hanslope soils which are typical calcareous pelosols. These consist of slowly permeable calcareous clayey soils (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.5 Site history and archaeological potential

No specific details were available to Stratascan.

2.6 Survey objectives

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

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 6 days from 1st September to 4th September and on 15th and 16th of September 2008. Weather conditions during the survey were dry and sunny at first changing to heavy rain later.

3.2 Grid locations

The location of the survey grids has been plotted in Figure 1 together with the referencing information. Grids were set out using 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.

3.3 Survey equipment

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 dual FM256 Fluxgate Gradiometers, manufactured by Geoscan Research and a dual sensor Grad601-2 Magnetic Gradiometer manufactured by Bartington Instruments Ltd. The FM256 gradiometers are suspended on a frame CF6. One gradiometer acts as a master trigger that controls the second slave gradiometer. The instruments each consist of two fluxgates mounted 0.5m vertically apart, and 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 sensor 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 1600 sampling points in a full 20m x 20m grid.

3.4.2 Depth of scan and resolution

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.

The FM256 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 0.25m centres provides an appropriate methodology balancing cost and time with resolution. The data is collected at a reading resolution of 0.1nT.

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 job, 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 known as *Geoplot 3*. 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. 'Despiking' is also performed to remove the anomalies resulting from small iron objects often found on agricultural land. 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. *Despike* (useful for display and allows further processing functions to carried out more effectively by removing extreme data values)

   Geoplot parameters:
   X radius = 1, y radius = 1, threshold = 3 std. dev.
   Spike replacement = mean

2. *Zero mean grid* (sets the background mean of each grid to zero and is useful for removing grid edge discontinuities)

   Geoplot parameters:
   Threshold = 0.25 std. dev.

3. *Zero mean traverse* (sets the background mean of each traverse within a grid to zero and is useful for removing striping effects)

   Geoplot parameters:
   Least mean square fit = off

3.5.2 Presentation of results and interpretation

The presentation of the data for each site involves a print-out of the raw data both as greyscale and trace plots, together with a greyscale plot of the processed data. Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawings for the site (Figures 3-9).

4 RESULTS

The abstracted anomalies have been divided into varying types. The types have then been tabulated and assessed as to the level of activity in each area according to the following table.

Level of activity	
-	None
*	Minimal
**	Moderate
***	Significant

Description	Area A	Area B	Area C	Area D	Area E	Area F	Area G
Discrete positive anomaly – possible pit	-	-	-	**	-	**	-
Positive anomaly with associated negative response – ferrous object	**	*	-	-	-	-	-
Positive linear anomaly – agricultural mark	***	-	-	-	***	**	-
Linear debris – unknown origin							
Positive linear anomaly – cut feature of possible archaeological origin	-	-	-	*	**	**	-
Linear anomaly – possibly related to land drains	-	-	-	**	-	-	-
Positive area anomaly – cut feature of possible archaeological origin	**	**	***	**	**	**	*
Negative area anomaly – possible bank or earthwork of archaeological origin	-	-	**	-	-	-	-
Magnetic disturbance associated with nearby service or field boundary	-	-	-	-	-	-	**
Magnetic disturbance associated with nearby metallic objects	-	-	-	**	-	-	-
Magnetic debris	***	***	-	**	-	**	*
Area of magnetic variation – possible geological/pedological response	-	-	-	-	**	-	-

Thermoremnant anomaly – possible former area of burning such as a bonfire or kiln.	-	-	-	-	-	*	-

5 DISCUSSION

The data collected at Harrington has been of reasonable quality. The data was collected over areas of gently sloping arable land with some deep plough. Areas A to F had no problems with access. However access for magnetometry survey over Area G was limited due to the remains of RAF Harrington and thick undergrowth.

5.1 Area A

Area A contains a moderate level of evidence for archaeological activity with several cut features. A significant level of agricultural activity can be seen in Area A although no evidence of phasing is visible. Significant areas of magnetic debris occur across Area A.

5.2 Area B

A moderate level of archaeological activity is observed in Area B. Cut features can be seen across the area although the interpretation of archaeological features is made difficult by a significant level of magnetic debris.

5.3 Area C

A significant level of archaeological activity is visible in Area C in the form of rectilinear and curvilinear anomalies representing enclosures of probable late Iron-Age or Romano-British date. The intercutting nature of these anomalies indicates several phases of activity. The strength of some of the anomalies seen in Area C suggests that the fill or fills of these features may be thermoremanent.

5.4 Area D

A moderate level of archaeological activity is also observed in Area D in the form of pits and ditches. Evidence for three field drains can be seen running across the survey area. Areas of magnetic debris can be seen along the eastern edge of the survey area along with a linear cut feature. These features may relate to the former runway of RAF Harrington. A large anomaly towards the centre of the area probably relates to a ferrous object. The location of the anomaly in close proximity to RAF Harrington means that there is a possibility that this feature relates to activity at the airfield.

5.5 Area E

A moderate level of possible archaeological features can be seen in Area E with cut features indicated across the survey area. A significant level of agricultural activity is evidenced and at least two phases of activity can be identified. A large area of magnetic variation is observed in Area E probably of geological or pedological origin.

5.6 Area F

A moderate level of archaeological activity is indicated in Area F mainly in the form of probable pits. Several anomalies relating to agricultural activity can also be seen in the north and south of the area. An area of magnetic debris runs across the southern half of Area F. To the north of this a thermoremanent anomaly can be seen indicating a former area of burning such as a bonfire.

5.7 Area G

A single cut feature can be seen running through the west of Area G. A pipe is observed in the middle of the area which may relate to the former airfield of RAF Harrington.

6 CONCLUSION

The detailed magnetometer survey undertaken at Harrington has been successful in identifying probable archaeological features. The survey has indicated significant areas of probable archaeological activity in Area C. More modest evidence for archaeological activity can be seen in the other areas surveyed. The anomalies occurring in Area C are largely consistent with that of late Iron-Age or Romano-British activity.

Features relating to agricultural activity were observed in Areas A, D, E and F.

Several areas of magnetic debris and disturbance found in Areas D and G may relate to the former RAF airfield and Thor missile station.

7 REFERENCES

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

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

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 *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.

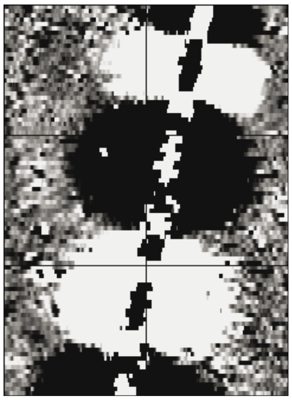
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

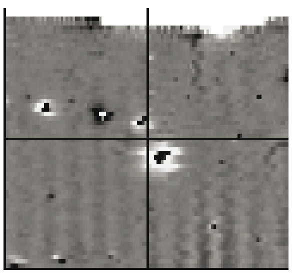
APPENDIX B – Glossary of magnetic anomalies

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

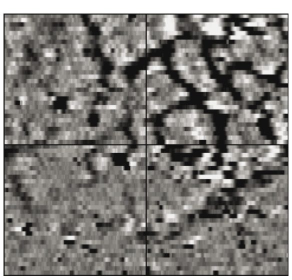


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

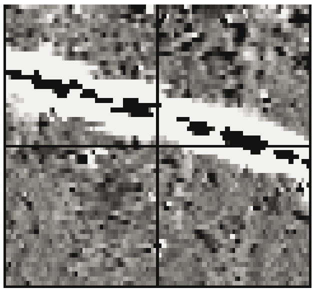
See bipolar and dipolar.

Positive linear



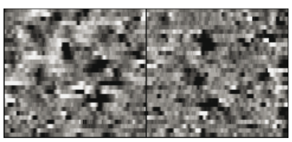
A linear response which is entirely positive in polarity. These are usually related to infilled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



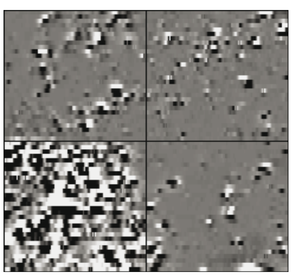
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



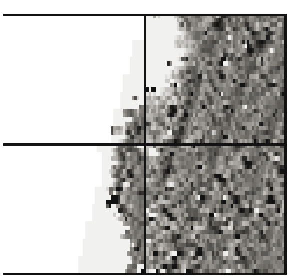
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by infilled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



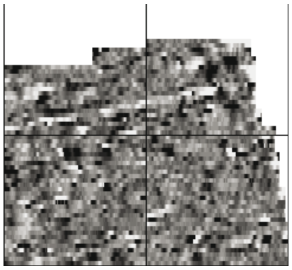
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

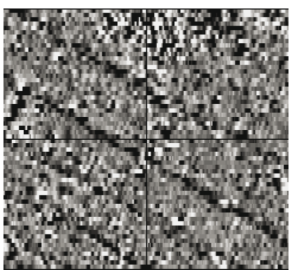


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

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).

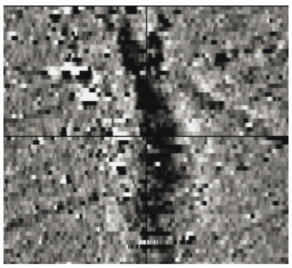
Strength of response

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.