STRATASCAN

Geophysical Survey Report

A24 Horsham, West Sussex to Capel, Surrey

February/March 2004

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A24 Horsham, West Sussex to Capel, Surrey

Client: Archaeology South East

Survey dates: 10th February - 18th February & 9th March 2004

Techniques: Magnetic Susceptibility, Detailed Magnetometry, Resistivity

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1 SUMMARY OF RESULTS

Magnetic susceptibility surveys carried out over 15ha indicated several areas with magnetic enhancement which were targeted for detailed magnetometry survey. The results from the detailed magnetometry surveys revealed a number of linear and curvilinear anomalies in several of the areas. These anomalies show some relationship to the areas with the highest magnetic enhancement and anomalies also appear in some of the areas requested by the client for survey. Magnetometry survey Areas 3, 6, 7, 8 and 9 show the greatest potential for archaeology.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned by Archaeology South East to undertake a geophysical survey of the proposed "Recommended Route" of the new A24 trunk road between Horsham in West Sussex and Capel in Surrey prior to development.

2.2 Site location

The site is located in a corridor starting north of Horsham at OS ref. TQ 163 338 and ending south of Capel OS ref. TQ 177 396.

2.3 Description of site

The total survey area is a 15ha linear area, 3.75 kilometres long and split into a 40m wide corridor. Each survey area is approximately centred over the Recommended Route of the new A24. The survey areas are pasture land and are dissected by field boundaries.

The underlying geology is Weald Clay (British Geological Survey South Sheet, Third Edition Solid, 1979). The overlying soils are known as Wickham 1 and Denchworth soils which are typical stagnogley and pelo-stagnogley soils respectively. These consist of slowly permeable seasonally waterlogged clayey soils. (Soil Survey of England and Wales, Sheet 6 South East England).

2.4 Site history and archaeological potential

Several sites and areas with archaeological potential were identified by Archaeology South East during their desk based assessment. This included two sites with ridge and furrow, a post medieval lime kiln and a further possible kiln site. An area with prehistoric flint scatter was not available for geophysical survey due to access issues.

2.5 Survey objectives

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

2.6 Survey methods

The reconnaissance technique of magnetic susceptibility was employed over 15ha in a series of nineteen grids. From this four areas of relatively high magnetic enhancement were targeted with detailed magnetometer survey together with two areas of low enhancement to test 'blank' areas and one further area with moderate enhancement. Further to this three areas of detailed magnetometry and one area of resistivity (0.5ha) were specified by the client for survey. A total area of 6ha was surveyed using magnetometery. 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 8 days from the 9th - 18th February and the 9th March 2004 when the weather was dry.

3.2 Grid locations

The location of the survey grids for magnetic susceptibility has been plotted in Figures 2-4, survey grids for detailed magnetometry in Figures 5 and 6 and survey grid for resistivity in Figure 7.

3.3 Description of techniques and equipment configurations

3.3.1 *Magnetic Susceptibility*

Alteration of iron minerals in topsoil through biological activity and burning can enhance the magnetic susceptibility (MS) of that soil. Measuring the MS of a soil can therefore give a measure of past human activity and can be used to target the more intensive and higher resolution techniques of Magnetometry and Resistivity. Measurements of MS were carried out using a field coil which provides a rapid scan and has the benefit of allowing "insitu" readings to be taken.

The equipment used on this contract was an MS2 Magnetic Susceptibility meter manufactured by Bartington Instruments Ltd. A field coil known as an MS2D was used to take field readings. This assessed the top 200mm or so of topsoil. To overcome the problem of ground contact all readings were taken 4 or 5 times and an average taken. All obvious localised "spikes" were ignored.

3.3.2 *Magnetometer*

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 an 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 one FM256 Fluxgate Gradiometer and two duel FM256 Fluxgate Gradiometers, manufactured by Geoscan Research. The duel 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 are 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.

3.3.3 Resistance Meter

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*

Magnetic susceptibility
The magnetic susceptibility survey was carried out on a 20 m grid with readings being taken at the node points.

Magnetometer
Readings were taken at 0.25m centres along traverses 1m apart. This equates to 1600 sampling points in a full 20m x 20m grid.

Resistivity
Readings were taken at 1.0m centres along traverses 1.0m apart. This equates to 400 sampling points in a full 20m x 20m grid. All traverses were surveyed in a "zigzag" mode.

3.4.2 *Depth of scan and resolution*

Magnetic Susceptibility
The MS2D coil assesses the average MS of the soil within a hemisphere of radius 200mm. This equates to a volume of some $0.016m^3$ and maximum depth of 200mm. As readings are only at 20 m centres this results in a very coarse resolution but adequate to pick up trends in MS variations.

Magnetometer
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.

Resistivity
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 1m centres with a 1m probe spacing provides an appropriate methodology balancing cost and time with resolution.

3.4.3 *Data capture*

Magnetic susceptibility
The readings are logged manually on site, and then transferred to the office where they are entered into a computer and grey scale plots are produced.

Magnetometer
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.

Resistivity
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*

Magnetic susceptibility
No processing of the data has been undertaken.

Magnetometer
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 magnetometer data used in this report:

Zero mean grid	*Threshold = 0.25 std. dev.*
Zero mean traverse	*Last mean square fit = off*
Despike	*X radius = 1 Y radius = 1*
	Threshold = 3 std. dev.
	Spike replacement = mean

Resistivity
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.

Despike	*X radius = 1*
	Y radius = 1
	Spike replacement
High pass filter	*X radius = 10*
	Y radius = 10
	Weighting = Gaussian

3.5.2 *Presentation of results and interpretation*

Magnetic susceptibility
The presentation of the data for this site involves a grey scale plot of the field measurements overlain onto a site plan (eg Figure 9).

Magnetometer
The presentation of the data for each site involves a print-out of the raw data both as grey scale (eg Figure 43) and trace plots (eg Figure 44 and 45), together with a grey scale plot of the processed data (eg Figure 46). Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site (eg Figure 47).

Resistivity
The presentation of the data for the site involves a print-out of the raw data as a grey scale plot (Figure 103), together with a grey scale plot of the processed data (Figure 104). Anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing (Figure 105).

4 RESULTS

4.1 Magnetic susceptibility

In total nineteen separate areas were surveyed using magnetic susceptibility (Figures 8-41). From data collected it can be seen that Area 2 (Figure 11); Area 11 (Figure 27); Area 13 (Figure 31) and the southern half of Area 15 (Figure 34) show a degree of magnetic enhancement. Magnetic susceptibility Areas 11, 13 & 15 lie close to settlement sites. Area 11 lies between Tickfold Farm and Brookhouse Farm; Area 13 lies to the North East of Tickfold Farm and Area 15 lies to the East of Wattlehurst Farm. There may be a correlation between these modern sites and some localised enhancement of magnetic susceptibility in the immediate vicinity.

The magnetic susceptibility survey has allowed targeting of detailed magnetometry to be carried out. This has focussed on the four areas outlined above with "control" surveys on areas of low – moderate magnetic enhancement carried out in Areas 3, 4 and the northern half of Area 15 for comparison of data.

4.2 Detailed magnetometry

Ten areas of detailed magnetometry were surveyed across the site. Four areas were chosen from the results of the magnetic susceptibility survey as those with archaeological potential, three areas were surveyed as a "control" with either low or moderate magnetic enhancement and three areas were specified by the client as having archaeological potential.

Area 1 (North of Andrew's Gill) (Figures 42-47)

This area corresponds with magnetic susceptibility Area 2 (Figure 11) which had moderate magnetic enhancement towards the south end of the survey area.

A series of positive and negative linear anomalies are almost certainly related to agricultural marks cause by ploughing or subsurface drainage. They are aligned across the survey area northwest – southeast and respect the alignment of the field boundary across the site.

The faint positive linear anomalies in the north of the survey area are of uncertain origin. They are aligned approximately north-south and may also relate to agricultural activity.

Two areas of magnetic debris are located in the centre of the survey area and are likely to have been caused by thermoremnant material being dumped at the field boundary.

These anomalies correlate to the high magnetic enhancement results from the magnetic susceptibility survey.

Strong discrete positive anomalies with negative returns located across the survey area relate to ferrous objects within the topsoil.

Area 2 (North of Little London, south of The Geerings) (Figures 48-53)

This area corresponds to magnetic susceptibility Area 3 (Figure 13) with low to moderate magnetic enhancement and was chosen as a "control" site.

Several positive linear anomalies cross the area in a roughly northwest – southeast alignment and others in a southwest – northeast alignment. These are likely to be agricultural in origin and could be related to drainage or other services.

The presence of four discrete low magnitude positive anomalies may be a response to pits. These are aligned roughly north – south and it is not possible to be certain of their origin as they could correspond to the line of a removed fence.

Three linear positive area anomalies are aligned roughly north-south in the northern half of the survey area and mirror the adjacent field boundary. They are likely to have been caused by agricultural activity.

A negative linear anomaly with adjacent positive linear anomaly towards the southern edge of the survey area may relate to an embankment and ditch possibly associated with a former field boundary.

Area 3 (South of Durfold Manor Road) (Figures 54 – 59)

This area (Kiln Platt) was identified by the client as having archaeological potential as a possible former kiln site.

The large area of magnetic debris located in the centre of the survey area is likely to have been caused by a magnetic response from thermoremnant material. This may be modern in origin and caused by the dumping of brick or burnt debris although an archaeological origin cannot be ruled out.

A smaller area of magnetic debris in the south of the area may also be derived from thermoremnant material. Again this may be modern in origin but could have archaeological potential.

A large positive linear anomaly and possible curvilinear anomaly to the north, west and across or under the large central area of magnetic debris may relate to former land boundaries although an archaeological origin may be possible.

There are a number of positive and negative linear anomalies in the north of the survey area which are likely to be agricultural in origin. The linear anomalies in the south of the area are aligned on the same northeast – southwest axis and are also likely to be agricultural in origin or may relate to former land boundaries.

An area of magnetic disturbance in the southeast corner of the survey area is likely to have been caused by ferrous material used within the field boundary.

A number of strong discrete positive anomalies with negative returns across the site indicate ferrous objects within the topsoil.

Area 4 (North of Cox's Shaw) (Figures 60 - 65)

This area was selected from the magnetic susceptibility survey Area 5 (Figure 17) as a "control" site with moderate magnetic enhancement.

A number of positive linear anomalies aligned approximately northeast – southwest are of uncertain origin but may relate to agricultural activity.

The area of magnetic debris in the north of the survey area is likely to be caused by dumped thermoremnant material and may be associated with the infilling of a pond or depression.

A curvilinear anomaly may also be associated with the pond marked on the base mapping, but an archaeological origin cannot be ruled out. The central positive area anomaly is of uncertain origin but roughly corresponds to the area with moderately high magnetic enhancement.

Areas of magnetic disturbance in the north, centre and south of the area are associated with ferrous material used within the fencelines.

A series of strong discrete positive anomalies with negative returns across the area indicate ferrous objects within the topsoil.

Area 5 (170m north-east of Furze Field) (Figures 66 – 71)

This area was identified as a target by the client as "site 49", an area with ridge and furrow.

One discrete low magnitude positive response in the east of the survey area may relate to a pit and is of uncertain origin. Several strong discrete positive anomalies across the area are likely to be caused by ferrous objects within the topsoil.

Area 6 (South of Tickfold Farm) (Figures 72 – 77)

This area was selected from the magnetic susceptibility survey Area 11 (Figure 27) as having relatively high levels of magnetic enhancement.

A number of positive linear anomalies located in the east of the survey area are of uncertain origin but may be of archaeological potential.

A positive linear anomaly in the south of the area oriented northeast – southwest may also be of archaeological origin. However this linear anomaly is aligned parallel to the current southern field boundary and so may relate to agricultural activity.

The eastern side of the survey area has a number of discrete low magnitude positive anomalies which may be pits. A positive area anomaly in the east is of uncertain origin but may also relate to a large pit or group of pits.

A linear area of magnetic disturbance in the north of the area is oriented east-west and is likely to correspond to a ferrous pipeline or cable. The area of magnetic disturbance on the northern edge of the survey area is caused by ferrous material in the fenceline. Strong discrete positive anomalies are likely to be caused by ferrous objects within the topsoil.

Area 7 (South of Wattlehurst Farm Bungalows) (Figures 78 – 83)

This area corresponds to the magnetic susceptibility Area 13 (Figure 31) and was selected due to its high levels of magnetic enhancement across the whole survey area.

A series of positive and negative linear and possible curvilinear anomalies converge towards the northern extremity of the survey area and may extend beyond the limits of the survey area. These anomalies are of uncertain origin and may have been caused by a number of factors including agriculture or archaeology.

One discrete low magnitude positive response towards the southeast of the survey area may be related to a pit. Several strong discrete positive anomalies with negative returns located towards the east and west of the survey area are likely to be related to ferrous objects within the topsoil.

Area 8 (South east of Wattlehurst Farm) (Figures 84 –89)

This area was selected from the southern end of magnetic susceptibility survey Area 15 (Figure 34) which showed relatively high magnetic enhancement.

A series of linear and curvilinear positive anomalies are located towards the south, southeast and east of the survey area. These have no relationship to the alignment of the current field boundaries and may be of archaeological origin.

Several discrete low magnitude positive responses were identified across the area, these may relate to pits. The positive area anomaly located towards the central northeast of the survey area is of uncertain origin but an archaeological origin is possible.

Discrete positive anomalies with negative returns in the southern half of the area may be a magnetic response to a thermoremnant feature although the response is similar to that of a ferrous object.

Several positive linear anomalies are located in the southern half of the survey area and are oriented roughly northeast – southwest and mirror the current field boundaries. They do not seem to extend into the northern half of the survey area and are likely to be agricultural in origin.

Areas of magnetic disturbance lie close to current field boundaries and are likely to be caused by ferrous material in the fenceline. A linear area of magnetic disturbance in the southeast corner of the survey area relates to a modern ferrous pipeline or cable.

Area 9 (East of Wattlehurst Farm) (Figures 90 – 95)

This area was selected from the northern end of magnetic susceptibility survey Area 15 (Figure 34) as an area with low to moderate magnetic enhancement.

Several low magnitude curvilinear anomalies are located towards the southwest of the survey area and although of uncertain derivation, an archaeological origin could be considered.

The parallel positive and negative linear anomalies, located close to the centre of the area and oriented roughly northwest – southeast, may also be of archaeological origin but an agricultural origin or former field boundary cannot be ruled out.

A positive linear oriented roughly north-south in the southern half of the area is of uncertain origin.

Several low magnitude positive linear anomalies are oriented almost east-west and aligned parallel to the current field boundary north of the survey area and the parallel positive and negative linear anomalies in the centre. These are likely to be caused by agricultural activity and may be a response to plough marks.

There are several low magnitude positive anomalies in the north of the survey area which may indicate pits, although they are of uncertain origin. Several strong discrete positive anomalies with negative returns are located mainly in the northeast of the survey area and indicate ferrous objects within the topsoil.

The area of magnetic disturbance near the southwest edge of the survey area is a response to ferrous material used in construction of the fenceline.

Area 10 (East of Bonnetts) (Figures 96 – 101)

This area (Kiln Field) was selected by the client for detailed magnetometry survey as it is known to be the site of a medieval kiln.

A number of positive linear anomalies are aligned northeast – southwest and northwest – southeast across the site. These are likely to have been caused by agricultural activity such as ploughing.

There are two low magnitude positive anomalies of uncertain origin that may represent pits. Several strong discrete positive anomalies with negative returns indicate the presence of ferrous objects within the topsoil.

At the northern extremity of the survey area lie two linear areas of magnetic disturbance that indicates the presence of buried cabling perhaps relating to former fenceline or ferrous pipelines.

4.3 Resistivity

Area 1 (East of Bonnetts) (Figures 102 – 105)

This area (Kiln Field) was selected by the client for detailed resistivity survey as it is known to be the site of a medieval kiln.

A series of high resistance area anomalies are located towards the northern end of the survey area and are aligned northwest – southeast. There is no certainty of their cause and they could be geological in origin. One such area is bounded by a high resistance linear anomaly of uncertain origin. Further moderate resistance linear anomalies are likely to be agricultural in derivation. All linear and area anomalies are aligned on the same northwest – southeast axis.

The area of generally high resistance near the northern edge of the survey site relates to the linear areas of magnetic disturbance discovered during the magnetometry survey and are likely to relate to a cable or pipeline.

5 CONCLUSIONS

The use of magnetic susceptibility survey across the area has highlighted several areas of magnetic enhancement to enable targeting of areas for detailed magnetometry survey.

Due to the physical limitations of a corridor survey often only fragments of features appear as geophysical anomalies. It is therefore difficult to ascertain distinct characteristic archaeological features from the results.

Detailed magnetometry has successfully located a number of anomalies across all of the survey areas, several of which could be considered as archaeological in origin. Magnetometry survey Areas 3, 6, 7, 8, and 9 all show a number of positive linear and curvilinear anomalies. Although it is impossible to be certain of their derivation in these cases an archaeological origin could be considered.