Substrata Ltd.
Archaeological Geophysical Surveyors

Gradiometer survey at Fairplay Enclosure Gloucestershire NGR SO 6570 1619 SMR 4353

March 2005

A geophysical survey by Substrata Limited

Report R-FAI05-3105

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1. Survey Summary

Table 1: Survey Summary	
Name of Site: Fairplay Enclosure	**Grid Reference:** SO 6570 1619
Address of Site (including county): Gloucestershire	
Client: Environment Directorate, Gloucester County Council, Shire Hall, Gloucester GL1 2TH	
Substrata Survey No.(s): fai05-l1 **Date (s) of Survey:** 31Jan05 to 11Feb05 **Author & Lead Surveyor:** Ross Dean	**Report Reference:** R-FAI-3103 **Report Submitted:** 3rd April 2005 **Assistant Surveyor:** Colin Wakeham
Site Type: a square earthwork enclosure **Description:** A square enclosure with surrounding bank and a ditch on the southern side and south-west corner. **Known archaeological sites in survey area (SMR/NMR/appropriate other designation):** Gloucestershire SMR 4353: two possible entrances at the south-western corner and mid-way on the eastern bank and two possible charcoal hearths on the south-eastern part of the earthwork.	
Solid Geology: The geology comprises sandstones of the Carboniferous Upper Coal Measures Pennant Group (BGS 1974).	
Survey Aims: This survey was a pilot study for The Forest of Dean Archaeological Survey and was commissioned as one of two surveys designed to investigate the potential of archaeological geophysical surveying for finding non-iron working features within the woodlands of the Forest of Dean. A two-tier survey strategy was recommended by Substrata as follows: **Level-One Survey Objectives:** To prospect and delimit non-iron working archaeological sites situated within relatively dense woodland using 1-metre by 1-metre sampling intervals. **Level-Two Survey Objectives:** To locate, record and provisionally classify potential archaeological features in areas highlighted by the level-one survey assuming approximately 12% of level 1 survey area and using 0.5-metre by 0.5-metre sampling intervals.	
Type (s) of Survey: Magnetometer **(**fluxgate gradiometer).	
Area Surveyed: 0.35 ha.	
Survey Summary (detailed in section 3): The magnetic response across the site was low and the “interference” of a phase of cultivation, probably associated with tree planting, was a significant limiting factor in quality of data collected, as was the unexpected presence of a buried water pipe. Given these difficulties, it was decided not to conduct a level-two survey but to increase the area of the level-one survey to include areas on the outside of the extant enclosure bank to prospect for evidence of an external ditch corresponding to the visible section of ditch to the south of the enclosure (see figure 1). Some evidence was found to support the case for an external bank or possible ditch to the north and east of the enclosure but it was not conclusive. Evidence was found for one and possibly three charcoal production areas within the enclosure to the north-east and east.	
Recommendations (detailed in section 4): This was a pilot survey designed to assess various environments for their potential to yield good archaeological geophysical survey data. With this in mind, it is recommended that areas of relatively recent tree plantation, in combination with magnetically unresponsive soils, be treated with caution when assessing sites for future geophysical survey within The Forest of Dean.	

Figure 1: gradiometer survey fai05-l1 interpretation of processed data

2. Results

Refer to figure 1 and figures 3 to 5 in appendix A. Specific anomalies and groups of anomalies are numbered left to right and top to bottom in figure 1.

4 An area of linear anomalies representing cultivation traces that are very likely associated with tree planting. Similar anomaly patterns can be seen across the survey area. The associated cultivation activity has disrupted much of the upper soil levels across the site making an archaeological characterisation of the magnetic anomalies difficult.

1 Two linear anomalies, the southern-most of which represents part of the extant enclosure bank. The northern linear anomaly may represent part of a ditch (see also locations 5 and 10 below).

3 The anomalies at this location, although disrupted by later cultivation activities, have a similar pattern to those exhibited by charcoal production platforms elsewhere in the Forest of Dean (Dean 2005) and it is possible that location 3 was a charcoal production area. Two possible charcoal hearths were noted in the SMR in the south-eastern part of the enclosure but any magnetic anomalies in this area were masked by the presence of an iron pipe (location 7 below).

2 and 6 These groups of anomalies represent deposits of material with a relatively high response compared to the background soils. They are disturbed by later cultivation activities but may be deposits of burnt soil and, as with location 3, could represent past charcoal production areas.

5 The western-most linear anomaly represents the extant enclosure bank. Based on the pattern of anomalies seen at location 10 (below), the eastern anomaly may represent an outer bank (also see location 1 above).

7 The line of an iron water pipe (Hoyle 2005, *pers com*.) that runs across the site but was not known at the time of the survey.

8 A sequence of linear anomalies that may represent a ditch.

9 A group of anomalies that may signify a tree bole but they have a pattern not seen elsewhere in the survey area and so may represent an archaeological feature.

10 A sequence of linear anomalies corresponding to visible earthworks defining the enclosure bank and a section of outer ditch. The anomalies represent (from north to south):

- a: earthen bank,
- b: ditch,
- c: fill deposits within the ditch,
- d: the same ditch,
- e: a possible outer bank.

3. Conclusions

3.1 General Considerations

The magnetic response across the site was low. This inevitably means fewer magnetic anomalies to analyse and a reduction in the archaeological interpretation of those identified magnetic anomalies. The “interference” of a phase of cultivation, probably associated with tree planting, was a significant limiting factor in quality of data collected, as was the unexpected presence of a buried water pipe.

3.2 Objectives and Results

Given the difficulties discussed above, it was decided not to conduct a level-two survey as specified in the survey objectives (section 1) but to increase the area of the level-one survey to include areas on the outside of the extant enclosure bank to prospect for evidence of an external ditch corresponding to the visible section of ditch to the south of the enclosure (see figure 1).

Some evidence was found to support the case for an external bank or possible ditch to the north and east of the enclosure but it was not conclusive.

Evidence was found for one and possibly three charcoal production areas within the enclosure to the north-east and east.

4. Recommendations

4.1 This was a pilot survey designed to assess various environments for their potential to yield good archaeological geophysical survey data. With this in mind, it is recommended that areas of relatively recent tree plantation, in combination with magnetically unresponsive soils, be treated with caution when assessing sites for future geophysical survey within The Forest of Dean.

5. Disclaimer

Every effort has been made to provide accurate descriptions and interpretations of the geophysical data described in this report. The nature of archaeological geophysical surveying is such, however, that interpretations based on geophysical data can only be provisional and so cannot be taken as conclusive evidence for significant archaeological features. Geophysical surveys are one step in the multi-phase process that is archaeology.

6. Acknowledgements

We would like to thank Jon Hoyle, Senior Project Officer, Gloucester County Council Environment Department Archaeology Service, for commissioning Substrata to complete this survey and for his efficient and knowledgeable project management .

7. Standards

The standards used to complete this survey are defined in David (1995), English Heritage (1991, 1999) and Schmitt (2002).

8. References

British Geological Survey, 1974, Monmouth, England & Wales Sheet 233, Solid and Drift map, 1:50 000, Keyworth, Nottingham

Clark, A. 2000 (new publisher re-print), *Seeing Beneath the Soil, Prospecting methods in archaeology*. London, Routledge

David, A., 1995, *Geophysical survey in archaeological field evaluation: Research and Professional Services Guideline No 1*. Portsmouth, Ancient Monuments Laboratory, English Heritage.

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(English Heritage) Royal Commission on the Historical Monuments of England, 1999, *Recording Archaeological Field Monuments; A Descriptive Specification*. ISBN 1-873592-40-X

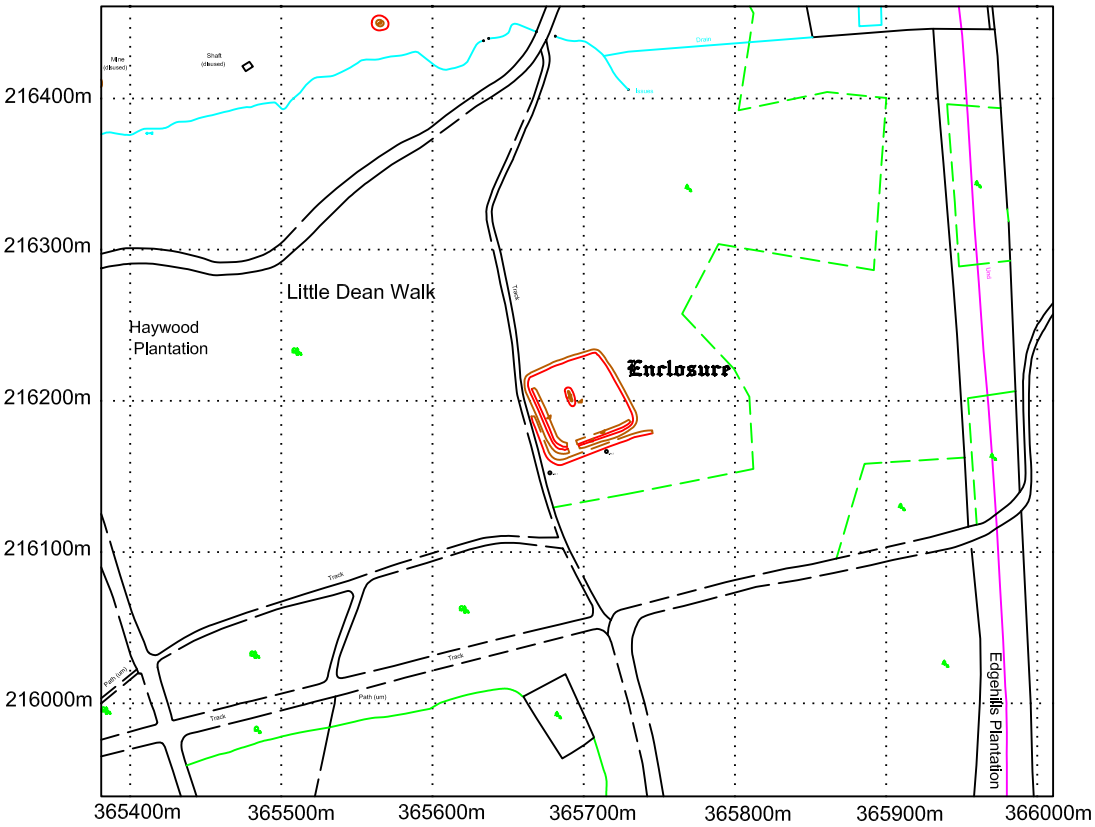
Schmidt, A., 2002, Geophysical Data in Archaeology: A Guide to Good Practice, ADS series of Guides to Good Practice. Oxford: Oxbow Books, ISBN 1-900188-71-6 (2001 on-line version: http://ads.ahds.ac.uk/project/goodguides/geophys/)

Appendix A: Survey Plots

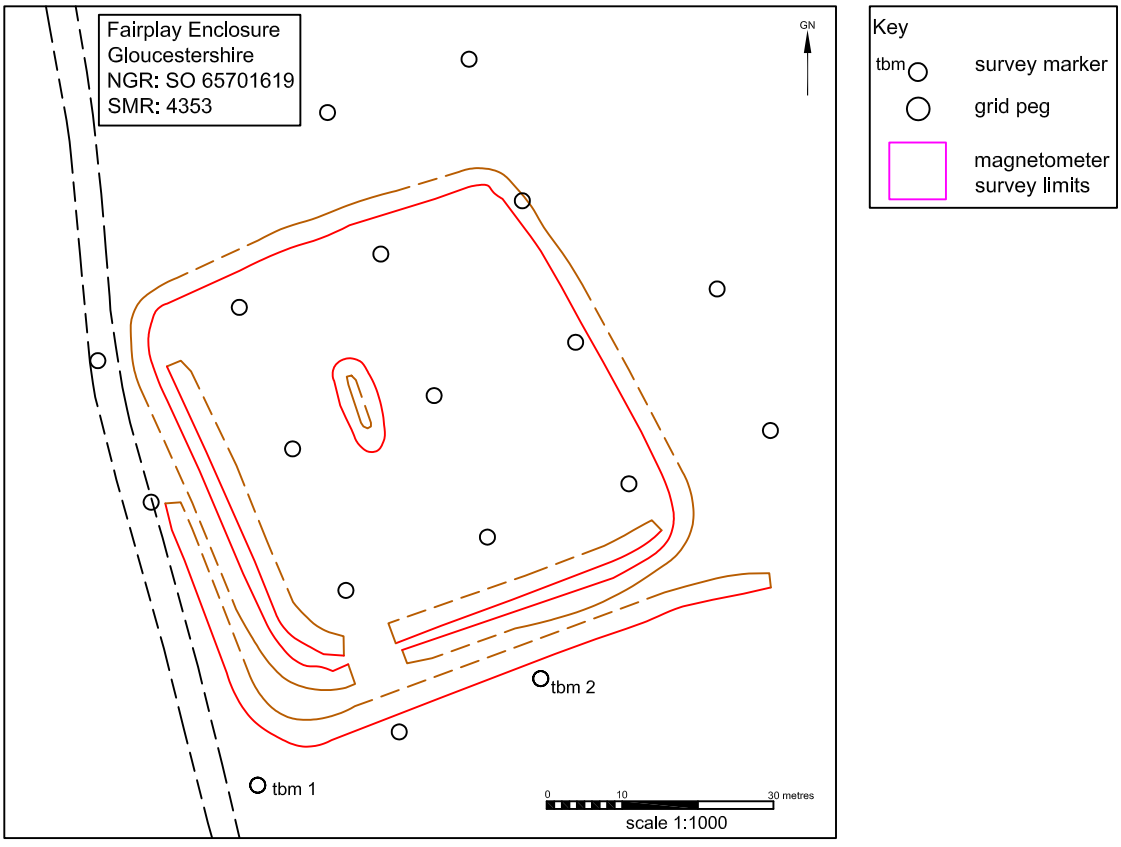
A1 General Guidance

The anomalies represented in the survey plots provided in this appendix are magnetic anomalies. The apparent sizes of the such anomalies and anomaly patterns are likely not to correspond exactly to the dimensions of any associated archaeological features.

A rough guide for interpreting the dimensions of magnetic anomalies is that the width of an anomaly at half its maximum reading is equal to the width of the buried feature, or its depth if this is greater (Clark 2000, 83). Caution must be applied when using this rule as it depends on the anomalies being clearly identifiable and distinct from adjacent anomalies. In northern latitudes the position of the maximum of a magnetic anomaly will be displaced slightly to the south of any associated physical feature.



a: Ordnance Survey map of area at scale 1:5000



b: location of survey grids

Figure 3: location of survey

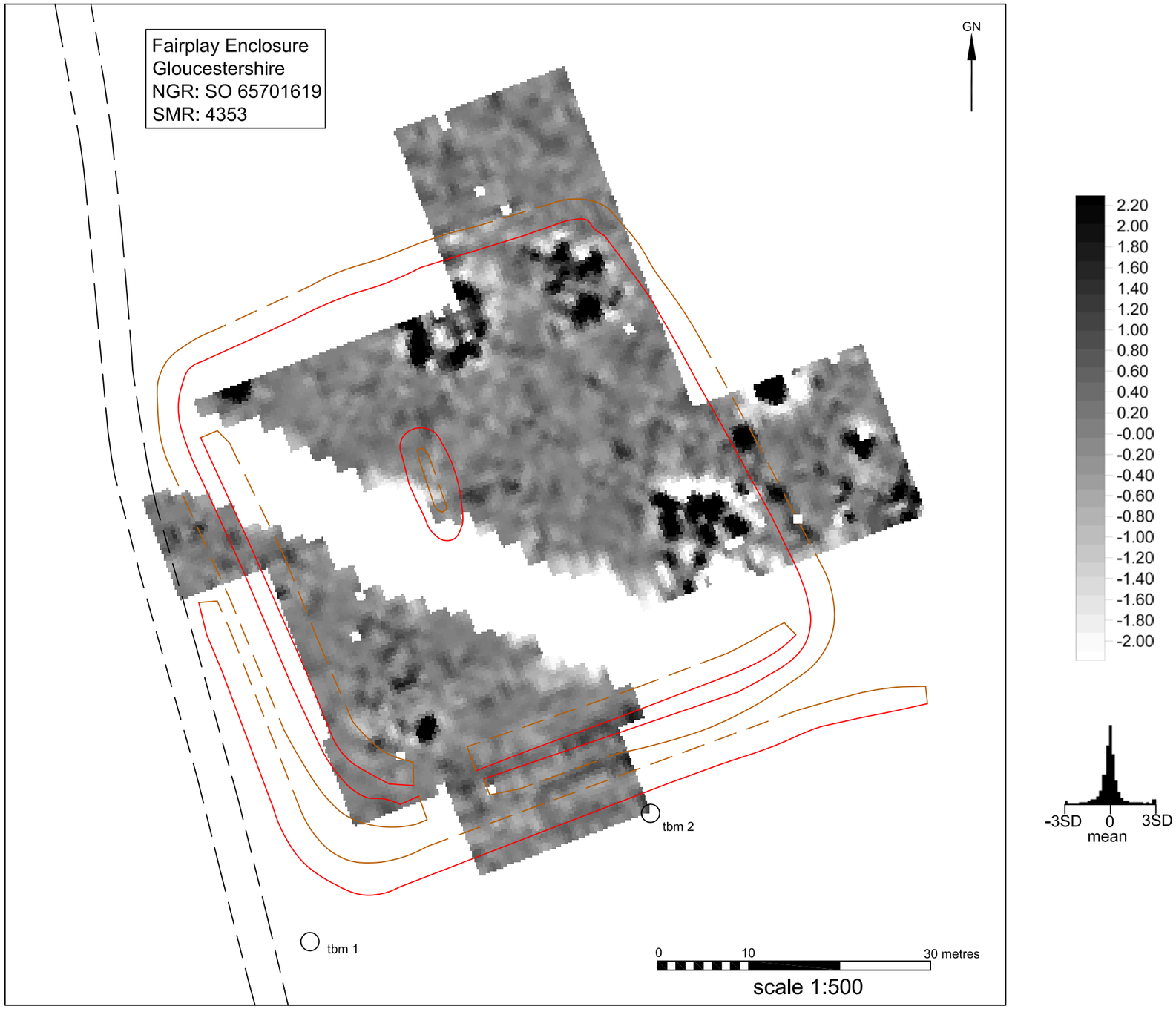


Figure 3: gradiometer survey fai05-l1 shade plot of processed data
(data range -11.50 to 12.00 nT, mean = 0.05 nT, sd = 1.12)

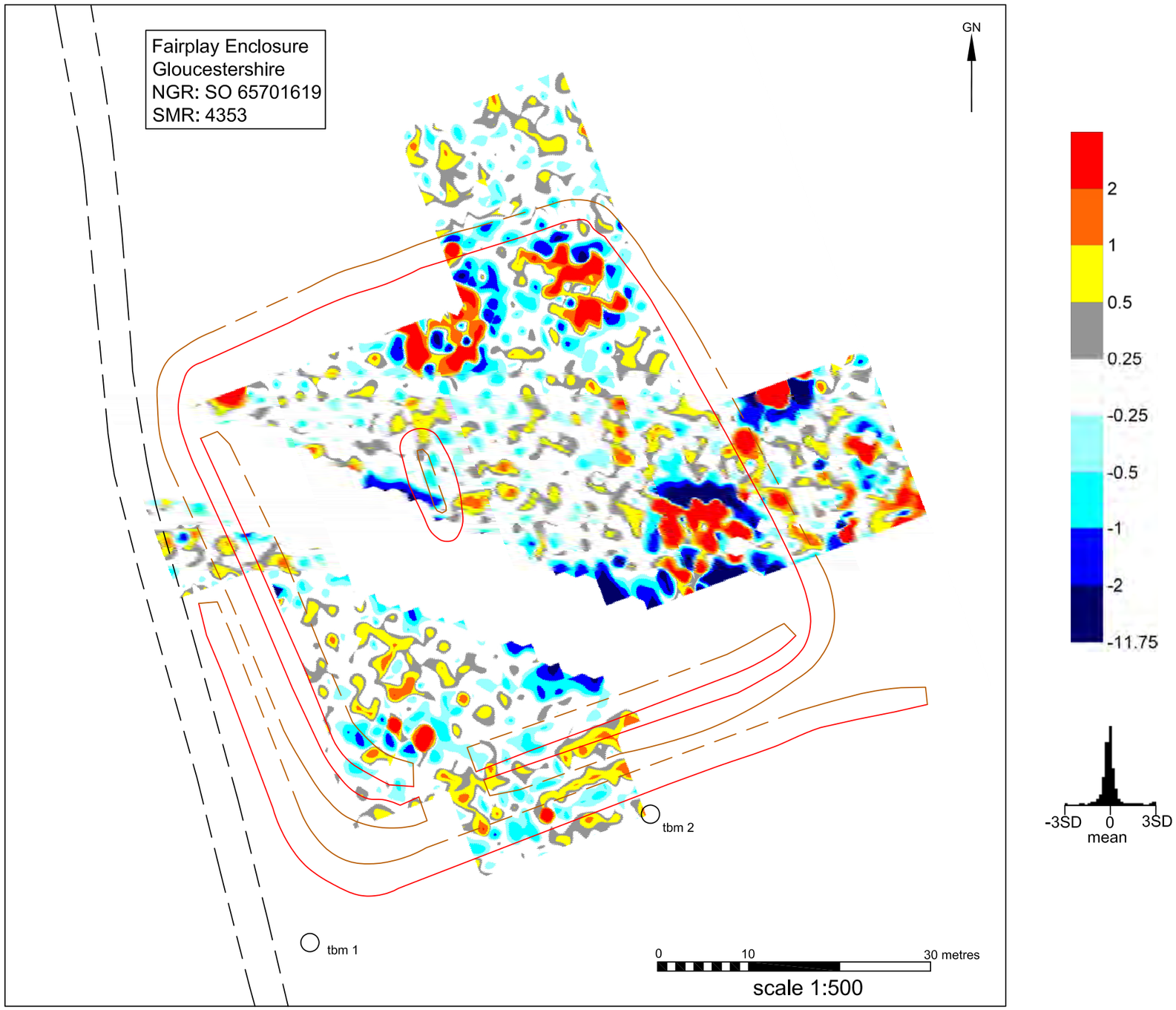
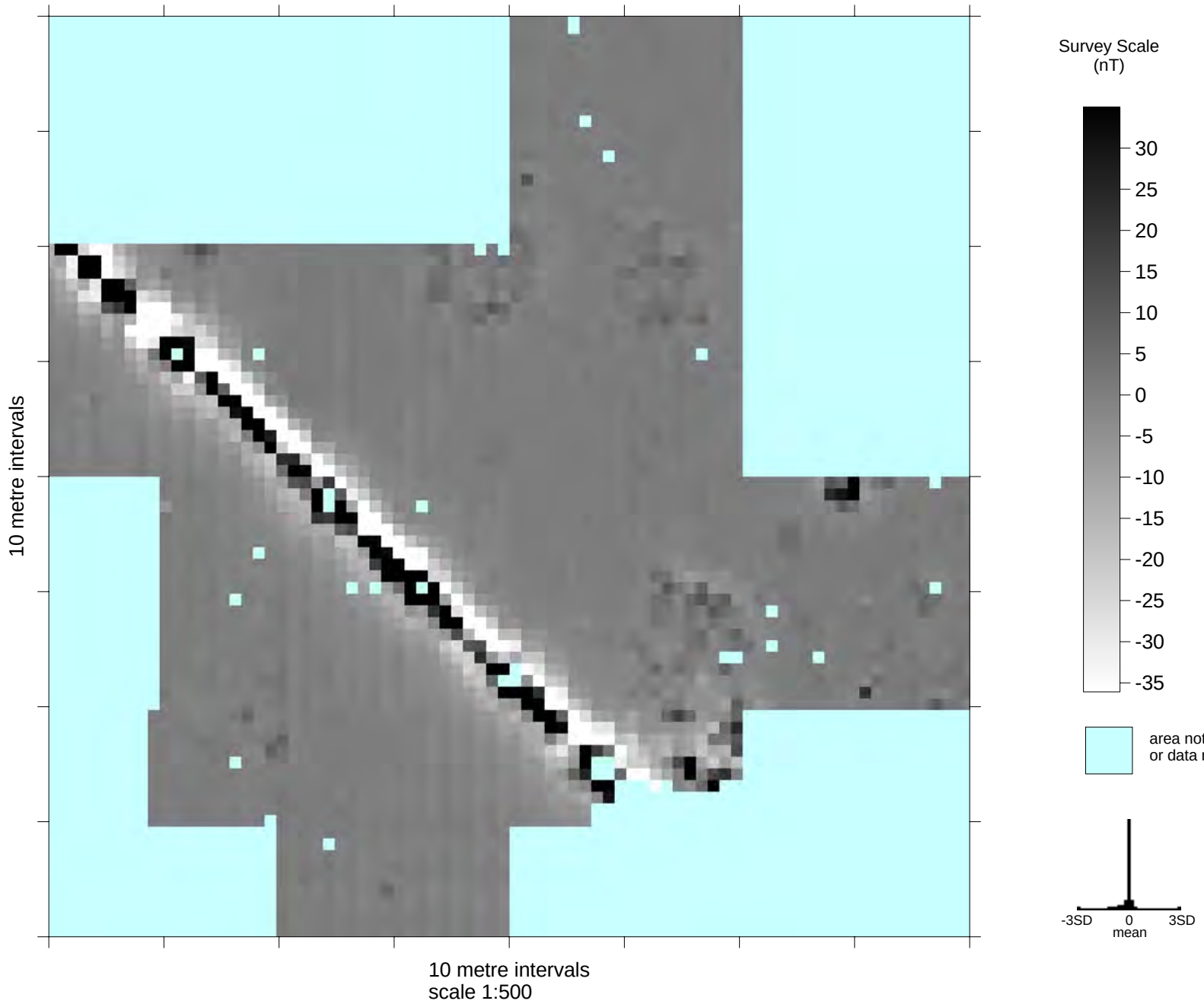
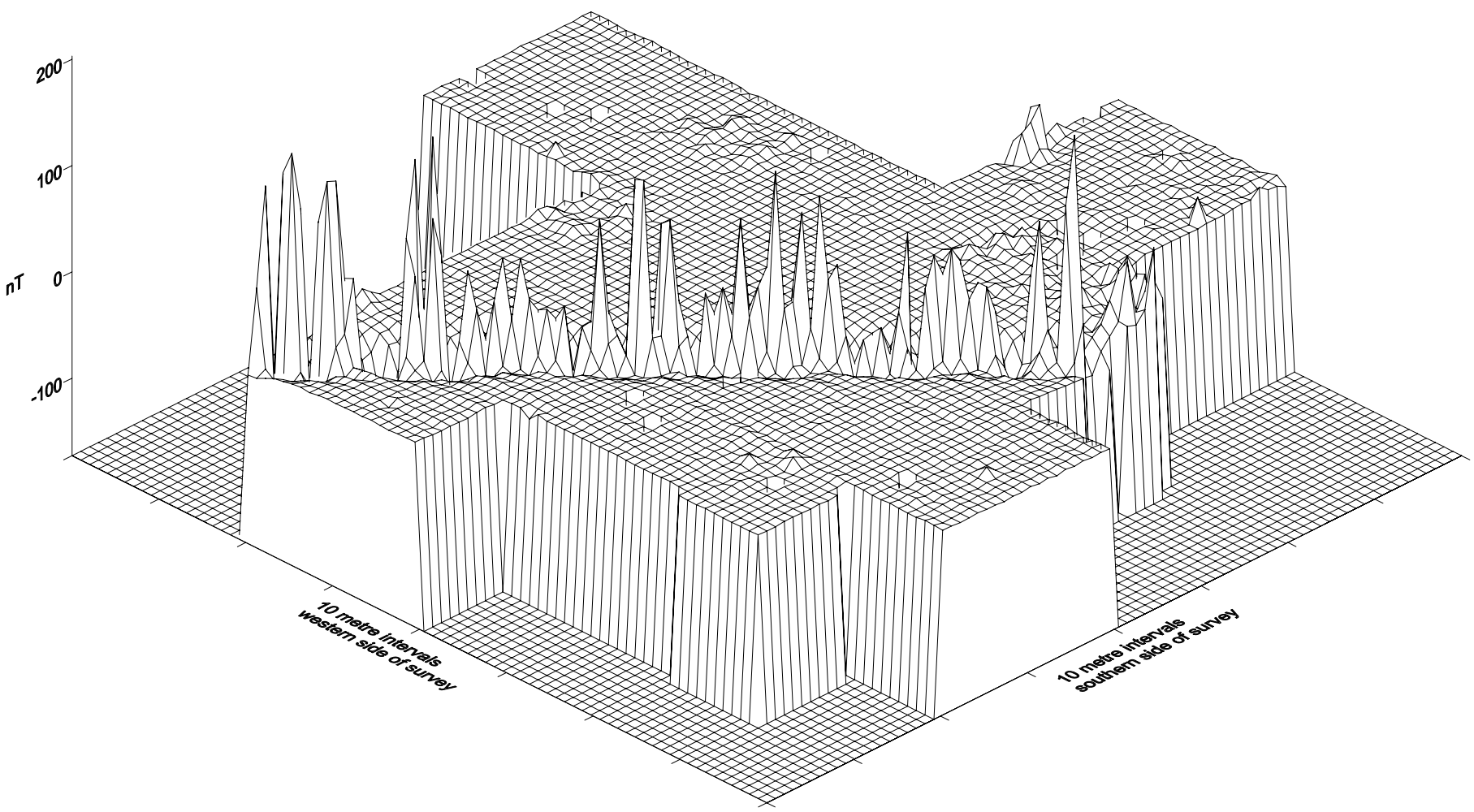


Figure 4: gradiometer survey fai05-l1 contour plot of processed data
(data range -11.75 to 41.59 nT, mean = 0.13 nT, sd = 1.85)



a: shade plot of unprocessed data for survey fai05-l1



b: wireframe plot of unprocessed data for survey fai05-l1
(scale 1:500)

Figure 5: plots of unprocessed data for survey fai05-l1 (data range --172.87 to 202.84 nT, mean=0.57 nT, sd=17.77)

Appendix B: Methodology

<table>
<tr><th colspan="2">Table 2: Gradiometer Survey Methodology</th></tr>
<tr><td colspan="2">Grid:
Method of Fixing: total station layout tied to earthworks and tracks.
Composition: survey fai05-l1: 20-metre by 20-metre grids
Recording:
On to Ordnance Survey digital map tiles using Autodesk’s AutoCAD 2002. A total station survey of the survey grid, surveyed sections of the earthworks and local tracks was placed best fit to the Ordnance Survey map.</td></tr>
<tr><td>Equipment:
Instrument:
Geoscan Research FM36 with manual trigger
Instrument resolution: 1 nT</td><td>Data Capture:
Sample Interval: 1 metre
Traverse Interval: 1 metre
Traverse Method: zig-zag
Traverse Orientation: GN 339.4</td></tr>
<tr><td colspan="2">Data Processing, Analysis and Presentation Software:
Geoscan’s Geoplot 3.00p, Golden Software Inc.’s Surfer 8, Autodesk’s AutoCAD 2002, Microsoft Corp.’s Office Publisher 2003.</td></tr>
</table>

Appendix C: Data Processing

Table 3: Fluxgate Gradiometer Survey Data Processing	
	All data processing was completed using Geoscan's Geoplot 3.00p.
Survey fai05-l1	
Figure 3	• Zero-mean traverse (all grids, LMS on, threshold = +/- 5nT) • Search and replace to remove data affected by buried iron pipe • Clip min at +/- 11.12 nT • Despike (x = 1, y = 1, threshold = 3, spike replacement = mean) • Low pass filter (x = 1, y = 1, weight = Gaussian) • Interpolate x and y (expand - sin x/x, times 2)
Figure 4	• Zero-mean traverse (all grids, LMS on, threshold = +/- 5nT) • Search and replace to remove data affected by buried iron pipe
	Complete data processing details are provided in the survey electronic data archive.

Appendix D: Geophysical Surveying Techniques

D1 Introduction

Substrata specialises in magnetometry (gradiometer) and resistance surveying. The particular method or combination of methods used depends on local soil conditions and the survey requirements. Magnetometry and resistance surveying are frequently complementary. In large geophysical surveys it is good practice to assess an area with a magnetometer survey and then selectively apply resistance surveys to areas identified as being likely to contain building remains and other buried archaeology.

The geophysical surveying equipment Substrata uses is specifically developed for archaeological surveying and is the latest generation of proven technology. When used in conjunction with software designed to analyse and present the recorded data, these systems are capable of delivering fast and accurate assessments of the archaeology of both large and small sites. If excavation is required, the geophysical assessment can be used to place trenches over potential archaeological features. The gradiometers (a type of magnetometer) and resistance meters employed are sensitive to depths of between 0 and 3 metres below ground level, with maximum sensitivity at depths of 1.5 metres or less. Most surveys are designed to work within the 0 to 1.5 metre range.

D2 Magnetometry Scanning and Area Surveying

General Concepts

Magnetometry surveying is used to detect and map small changes in the earth's magnetic field caused by magnetised materials buried beneath the surface. While these differences are too small to affect a compass needle, they can be detected and mapped by sensitive field equipment. During surveys the different magnetic properties of topsoils, subsoils, rocks and archaeological features are recorded as variations against a background value. Subsequently magnetic anomalies resulting from potential archaeology can be identified and interpreted. Identifiable archaeological features include areas of occupation, hearths, kilns, furnaces, ditches, pits, post-holes, ridge-and-furrow, timber structures, wall footings, roads, tracks and similar buried features.

Surveying Instruments

A gradiometer is an instrument sensitive to relatively small changes in the earth's magnetic field. Substrata uses two types of gradiometer both specifically designed for field use by archaeologists. Our primary surveying instruments are Bartington *Grad*601-2 (dual sensor) flux-

gate gradiometers with automatic data loggers. We also use a Geoscan FM36 fluxgate gradiometer with an automatic and manual sampling triggers. The Bartington gradiometers provide the latest proven technology in archaeological magnetic surveying and offer fast, accurate set-up and survey rates. The Geoscan FM36 provides an effective solution when surveys are required in difficult terrain such as woodland. More technical details can be provided as required.

Magnetic Scanning Surveys

When speed and general assessment are key requirements, scanning with gradiometers facilitate fast, on-site data analysis. This method allows rapid assessment of large areas of land such as proposed main communications routes, pipeline routes and significant commercial developments. Scanning is useful in complementing aerial surveys across wooded areas or fields under permanent pasture. This technique can also be effectively used in exploring suspected archaeological sites found during field walking surveys.

Magnetic Area Surveys

These are detailed area surveys employing a greater density of traverses and readings across the area of interest compared to scanning surveys. The current typical sampling interval for detailed area surveys is 0.25 metres on traverses 1.0 metre apart.

Typically, area surveys are undertaken when archaeological features are expected to be relatively concentrated or when a comprehensive survey is required. They are used to clarify areas of archaeological interest and to enable decisions to be made on the location of features to be preserved or excavated. Recent developments in the speed of surveying equipment such as the *Grad*601-2 system means that area surveys are often cost-effective alternatives to scanning surveys.

D3 Resistance Area and Linear Surveying

General Concepts

This method measures changes in the electrical resistance of the ground being surveyed. In practice, differences in the electrical resistance of materials facilitates the detection and interpretation of masonry and brick foundations, paving and floors, drains and other cavities, large pits, building platforms, robber trenches, timber structures, ditches, graves and similar buried features.

Resistance to electrical current flow in the ground depends on the moisture content and structure of the soil and other materials buried beneath the surface. For example, the higher the moisture content of a soil, the less resistant it is to electrical current flow. A ditch completely

buried beneath the present ground surface is likely to have an infill soil different to that surrounding the ditch in terms of compactness and composition. As a result, the soil filling the buried ditch will retain moisture in a different way to the surrounding soil which means it will have an electrical resistance at variance with the surrounding environment. By passing a small current through the ground it is possible to detect, record, plot and interpret such changes in electrical resistance.

Surveying Instruments

For resistance surveying Substrata uses the Geoscan Research RM 15 multi-probe resistance meters and purpose-built automatic data-loggers. The MPX 15 multi-probe facility can be used to speed up standard surveys and it is also useful when simultaneous multiple-depth analysis is required.

Resistance area surveys

Resistance area surveys are excellent tools for the detailed planning of likely archaeological sites and particularly useful in the surveying of areas likely to contain building footings or similar structures.

Resistance linear surveys

Resistance linear surveys are useful when searching a large area for buried buildings or roads and similar large linear archaeological features.

A reading interval of 1.0 metres by 1.0 metres is standard for both area surveys and the linear surveys.

D4 Other methodologies offered: Magnetic Susceptibility Surveying

Human activities such as burning, rubbish accumulation, fertilisation and animal husbandry enhance the magnetic susceptibility of topsoils. This means some archaeological sites having no remaining buried features can still be detected by examining modern topsoils for patterns of susceptibility that indicate likely past human activity. Sampling intervals for this type of survey are usually 20 metres or less.

Magnetic susceptibility surveys using a portable field system and data-logger are sometimes used to prospect for areas of higher magnetic susceptibility that may indicate the presence of archaeological structures. Such portable systems are also used explore the extent of suspected sites during archaeological field walking surveys.

Magnetic susceptibility surveys using sample collection and laboratory analysis are useful when there is a need to examine topsoil that is no longer *in situ* but has been deposited in, for example, lake sediments or alluvium. Analysis of such sediments in cores and sections can detect traces of past activities such as land clearance and cultivation.

In most cases, magnetic susceptibility surveys of *in situ* topsoils are best undertaken in conjunction with partial sampling using other geophysical survey techniques (such as fluxgate gradiometer surveys across selected areas of at least 60 metres by 60 metres) to provide an acceptable degree of positional and interpretative analysis.