RPS Planning, Transport and Environment

INDEX DATA	RPS INFORMATION
Scheme Title A1 Ferrybridge - Hook Moor	Details Geomagnetic & Susceptibility Surveys
Road Number A1	Date 1994
Contractor RPS / GSB	
County Yorkshire	
OS Reference SE 5209	
Single sided ✓ Double sided A3 1 Colour 3	

A1 FERRYBRIDGE-HOOK MOOR GEOMAGNETIC AND SUSCEPTIBILITY SURVEYS

A PROGRAMME OF RESEARCH CARRIED OUT
ON BEHALF OF

RPS CLOUSTON

By

GeoQuest Associates

INTRODUCTION

This report presents the results of a programme of geophysical survey aimed at archaeologically characterising areas to be affected by the A1(M) Ferrybridge-Hook Moor Road Improvement Scheme. The research was carried out on behalf of RPS Clouston acting as consultants to The Department of Transport's Highways Agency.

The aims of this study were as follows:

1 Test for the presence of archaeological features within about 1ha of site RPS21, located 3km NE of Pointer Inn near Ledsham (Figure 1).

2 Carry out a geophysical reconnaisance along c.10km of the proposed roadline to detect areas of archaeological potential.

The report first describes the methods of survey employed and the forms of data presentation. Results are then presented and the archaeological findings from the study finally discussed. Appendices at the rear of the report provide further technical detail.

GEOLOGY, TOPOGRAPHY AND LANDUSE

The geophysical traverse extended from Darrington, near Pontefract, north as far as Micklefield, east of Garforth. Most of this line comprised areas of arable land while woodland, metalled roads, industrial and urban areas were not surveyed. The detailed geophysical survey near Pointer Inn was carried out within a gently undulating field bearing cereal stubble.

The solid geology throughout the study area comprises Permian Magnesian Limestone with small outliers of Permian mudstones. No surface rock outcrops were encountered at RPS21 nor at any point along the geophysical traverse. Fragments of tile field drains were visible in a number of the fields which had been harrowed or ploughed immediately prior to the survey.

THE GEOPHYSICAL SURVEY

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Geophysical surveying provides a rapid method for the detection of subsoil features within archaeological landscapes. Two methods are most frequently used. *Geomagnetic* surveying employs a portable magnetometer to detect small perturbations in the Earth's magnetic field caused by changes in soil magnetic susceptibility or

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permanent magnetisation. The *resistivity* method, on the other hand, maps differences in soil electrical resistance which mainly reflect variations in water content.

The magnetic susceptibility of a material is the property relating the strength of an induced magnetisation to the intensity of an applied magnetic field. In most soils, the susceptibility is dominated by the fraction of strongly susceptible iron oxides which have ferri- and ferro-magnetic properties. These include the minerals titanomagnetite and haematite as well as various amorphous iron hydroxides. The archaeological processes of manuring, tillage and land clearance by burning, are known to enhance the soil magnetic susceptibility and this provides the basis for a regional prospecting method using field or laboratory measurement data.

The Geomagnetic Survey

Measurements of vertical geomagnetic field gradient were made at 1.0x0.5m intervals, in gridded units of 20x20m within the area shown yellow in Figure 1. This measurement scheme will detect geophysical anomalies on a scale of 1.0-2.0m and this approximately equates to the archaeological resolution. Note that setting-out coordinates are provided in the plan of Figure 1 to assist in relocating features of archaeological interest. The instrument used was a Geoscan FM36 fluxgate gradiometer with ST1 sample trigger. A zig-zag traverse scheme was employed and data were periodically downloaded in the field to a portable graphics computer for storage and verification. Appendix A provides more information about this method of archaeological geophysical surveying.

The Soil Susceptibility Survey

Measurements of soil magnetic susceptibility were made at 25m intervals along traverses spaced 25m apart within the proposed road improvement corridor. The instrument used was a Bartington MS2 portable meter with search loop MS2D measuring mean soil susceptibility to a depth of about 20cm. This device is particularly sensitive to small scale topography and thus care had to be taken to ensure placement on a level surface, in direct contact with the soil. This was achieved on pasture by temporarily removing an area of turf; on arable land the soil was tamped smooth. Nevertheless, some noise will be present in the data due to residual topography and variable soil aeration.

Data Processing

The geomagnetic survey results from site RPS21 were processed into a grey-scale image showing the residual geomagnetic anomalies which is presented on a basemap digitised from the O.S. 1:2500 plan in Figure 2. Appendix B describes the computer processing of the fluxgate gradiometer field data in more detail.

Susceptibility values along the proposed roadline have been coded to 32 shades of grey for each field and plotted as rows of 25x25m blocks on the relevant OS 1:2500 map sheet (portfolio of Appendix C).

DISCUSSION

General

Soil magnetic susceptibility values were highly variable with systematic patterns visible across none of the fields surveyed. It is worth noting that a 25m sampling interval is only capable of detecting inherent trends with wavelengths >50m, emphasising the regional, rather than site specific, character of this mapping scheme. Unfortunately, despite careful examination of these data, it is apparent that no information of archaeological value can be extracted.

Site RPS21 was found to be generally characterised by weak geomagnetic anomalies although a buried metal pipeline has induced a chain of intense magnetic dipoles along the SW margin of the survey block. Fortunately, this site is relatively free from contamination by surface ferrous litter and this has facilitated the discrimination of subtle geophysical anomalies.

As a first stage in the interpretation, the geomagnetic map has been classified into characteristic styles of geophysical terrain as follows:

1 Significant regions of anomalously *high magnetic field gradient* which might be associated with high susceptibility, soil-filled structures such as *pits or ditches.*

2 Scattered *dipolar anomalies* (paired positive-negative) whose most probable source in this context are *iron objects* with very high susceptibility.

No significant areas of low magnetic field gradient, which might have reflected concentrations of stone in the subsoil, were detected. A geophysical interpretation is presented in Figure 3 which includes a key defining the colour used for each class of anomaly.

Site RPS21 Interpretation

The site is characterised by a NNW-aligned geophysical texture of closely spaced, parallel lineations due to recent ploughing and the ferrous pipeline mentioned above. In addition, the following anomalies of archaeological interest have been detected (Figures 2, 3 & 4):

1 A strong, positive magnetic lineation, with right angled inflection, near the northern limit of the surveyed area reflecting a dich containing material with

enhanced magnetic susceptibility. The ditch may continue, and form part of an enclosure, to the north of the surveyed area.

2 A diffuse, positive magnetic anomaly can be detected extending SW from the point where the ditch described in 1 abruptly changes direction. This anomaly may reflect a smaller (or less well preserved) ditch attached to the main feature.

3 The survey area is bisected in a SSW direction by a further diffuse, positive magnetic lineation which appears to be discontinuous. This anomaly is interpreted as another ditch, which may have been excavated in sections. The geophysical data are unable to establish any physical or chronological association with those ditches described above.

CONFIDENCE RATINGS

The percentage levels of confidence which we assign to the features interpreted from the geophysical survey are as follows:

Ditches: Near north limit of survey 90%; Attached to S angle 50%; Central 70%.
Pipe: Along SW margin of survey area 99%.

SUMMARY AND CONCLUSIONS

The results of this research can be summarised as follows:

1 Geomagnetic anomalies in study area RPS21 were weak, reflecting modest susceptibility contrasts between subsoil features and their surroundings. The geophysical data on this site were not degraded significantly by the effects of surface iron contamination although a ferrous pipeline was detected along the SW margin of the survey block.

2 Good evidence was found for a linear ditch with right angle turn near the northern limit of the area surveyed at site RPS21. This feature may form the limb of an enclosure.

3 Further ditches, one apparently attached to that described in 2, were also detected at site RPS21.

4 Unfortunately, no coherent pattern could be extracted from the magnetic susceptibility data logged within the proposed road improvement corridor. Thus, it has not been possible to highlight any further areas of archaeological potential on the basis of the geophysical assessment.

Credits *Field survey*: C. Lambert, D.N. Hale
Report: M.J. Noel, C. Lambert
Date: 14/11/94

Note Whilst every effort has been taken in the preparation and submission of this report in order to provide as complete an assessment as possible within the terms of the brief, GeoQuest Associates cannot accept any responsibility for consequences arising as a result of unknown and undiscovered sites or artifacts.

FIGURE 1

Map showing the location of the area surveyed at site RPS21 on the A1(M) Ferrybridge-Hook Moor Improvement Scheme (yellow). Digitised from a 1:2500 plan supplied by Bullen Consultants.

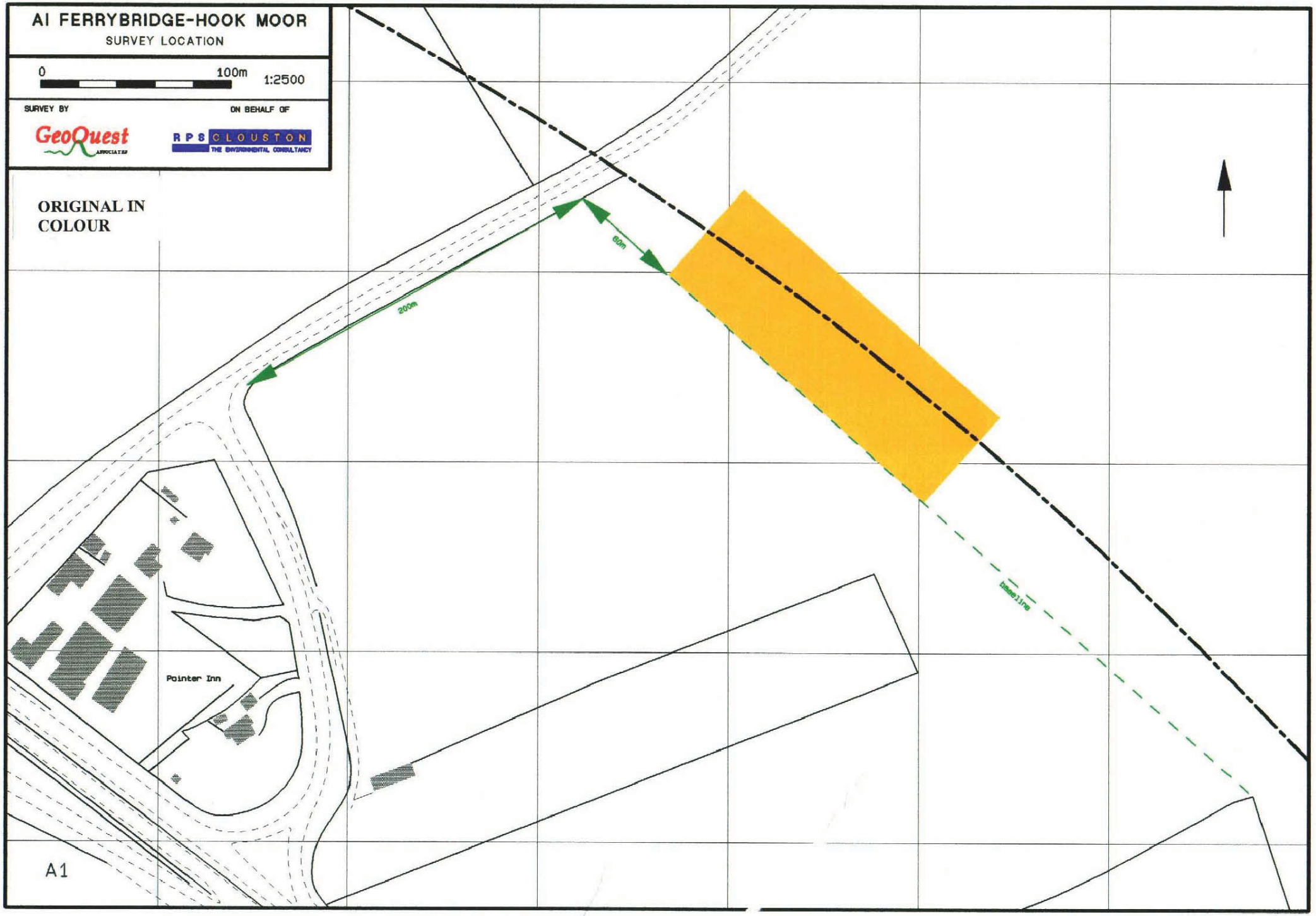
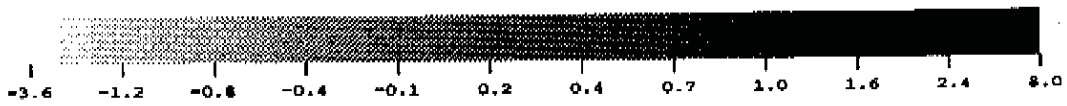
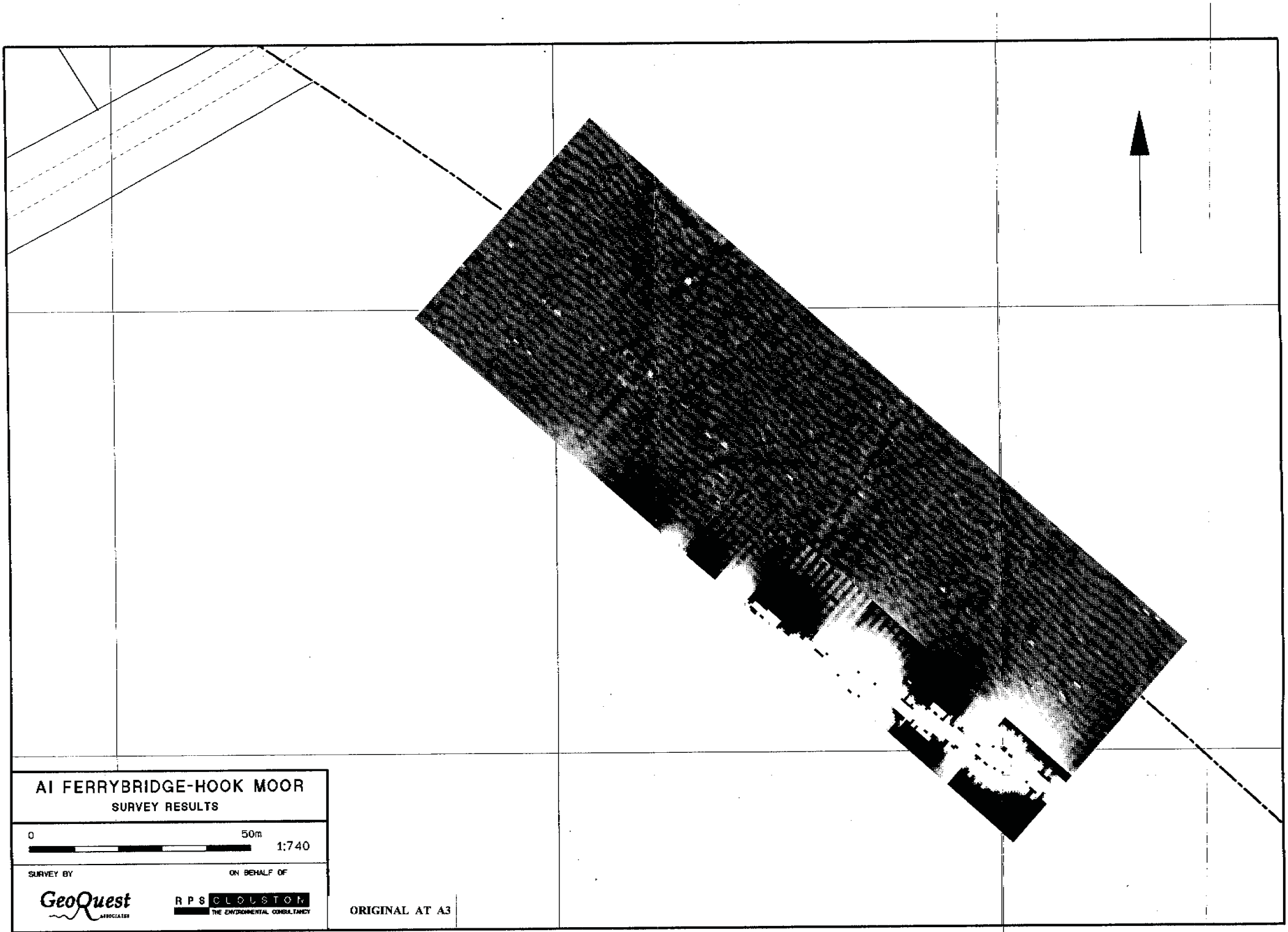

A1 FERRYBRIDGE-HOOK MOOR
SURVEY LOCATION
0
100m
1:2500
SURVEY BY
GeoQuest
ASSOCIATES
ON BEHALF OF
RPS CLOUSTON
THE ENVIRONMENTAL CONSULTANCY
ORIGINAL IN COLOUR
60m
200m
Pointer Inn
A1

FIGURE 2

Results of the geomagnetic survey at site RPS21. Refer to the scale below for absolute values.



nTesla/metre



A1 FERRYBRIDGE-HOOK MOOR

SURVEY RESULTS

0 50m

1:740

SURVEY BY

GeoQuest ASSOCIATES

ON BEHALF OF

RPS CLOUSTON THE ENVIRONMENTAL CONSULTANCY

ORIGINAL AT A3

FIGURE 3

Geophysical interpretation of the survey results obtained at site RPS21. Refer to the key for an explanation of the symbols used.

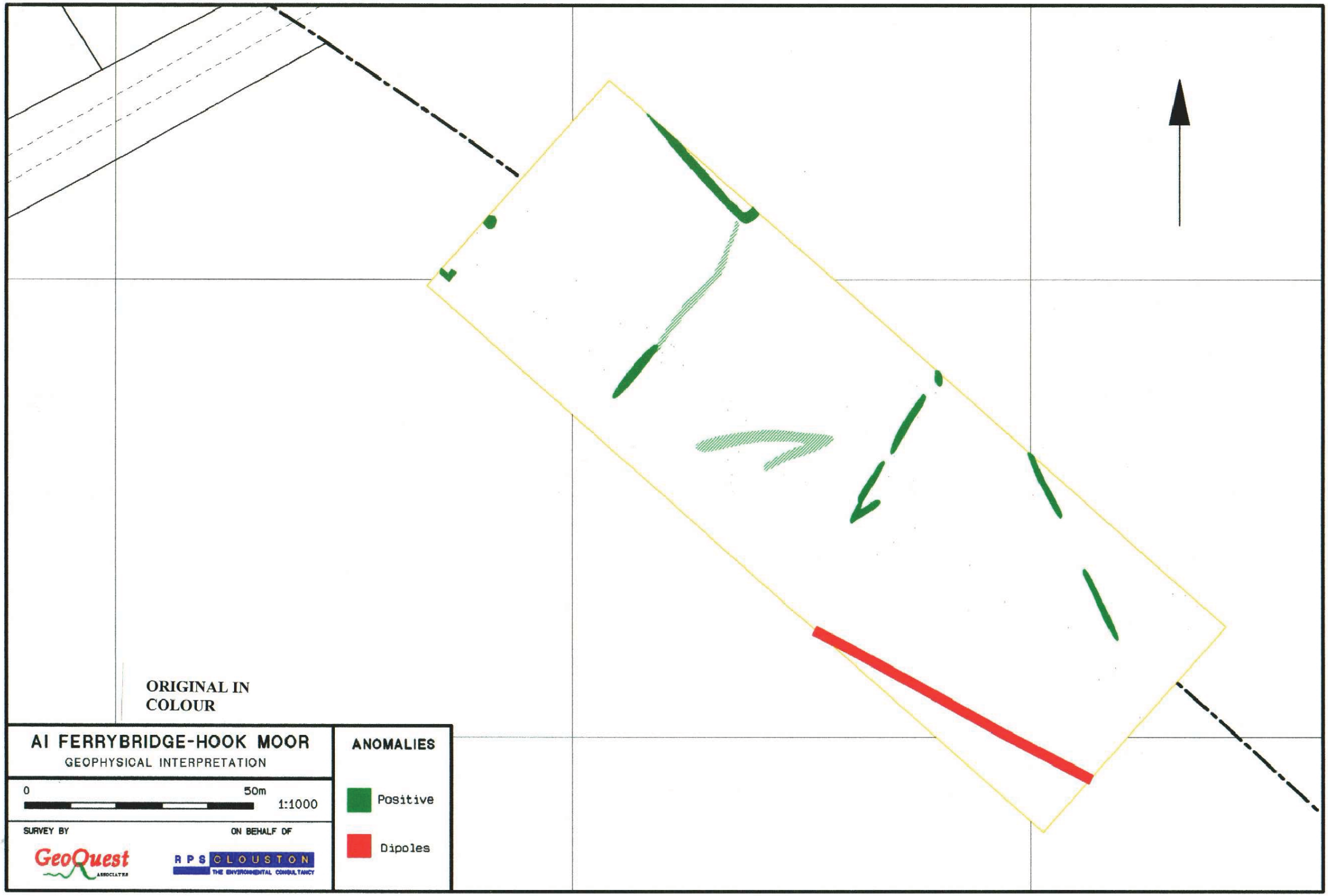
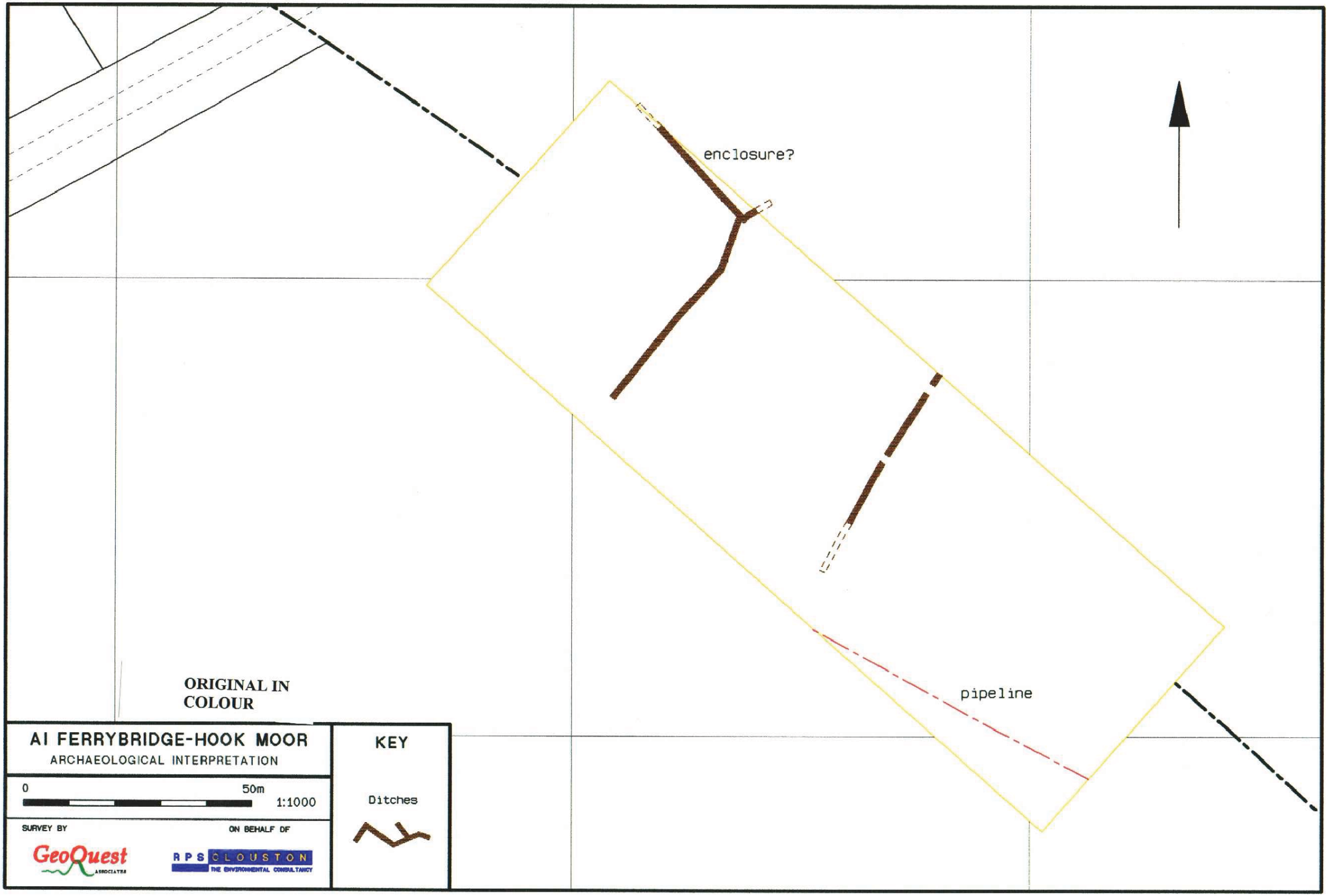

ORIGINAL IN
COLOUR
A1 FERRYBRIDGE-HOOK MOOR
GEOPHYSICAL INTERPRETATION
0
50m
1:1000
SURVEY BY
GeoQuest
ASSOCIATES
ON BEHALF OF
RPS CLOUSTON
THE ENVIRONMENTAL CONSULTANCY
ANOMALIES
Positive
Dipoles

FIGURE 4

An interpretation of the geophysical survey results from site RPS21. Refer to the key for an explanation of the symbols used.


enclosure?
pipeline
ORIGINAL IN COLOUR
A1 FERRYBRIDGE-HOOK MOOR
ARCHAEOLOGICAL INTERPRETATION
0
50m
1:1000
SURVEY BY
GeoQuest
ASSOCIATES
ON BEHALF OF
APS CLOUSTON
THE ENVIRONMENTAL CONSULTANCY
KEY
Ditches

APPENDIX A

Theory of Geomagnetic Surveying

Geomagnetic prospecting detects subsurface features in terms of the perturbations or 'anomalies' that they induce in the Earth's magnetic field. In contrast to resistivity, seismic or electromagnetic surveying, no energy is injected into the subsoil and hence this is one of a class of *passive* geophysical techniques that includes gravity and thermal surveying. In an archaeological setting two types of magnetic anomalies can be distinguished:

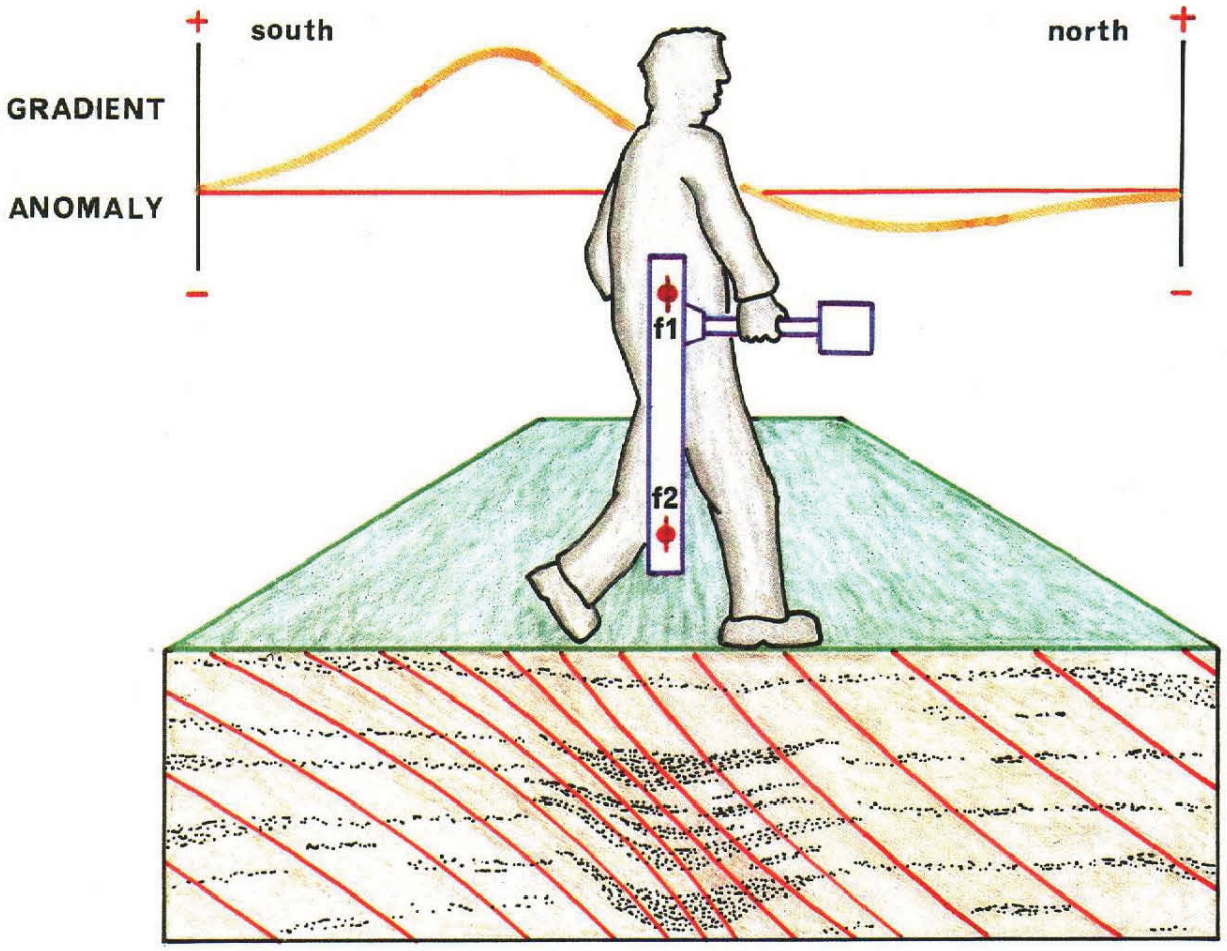
1 Anomalies arising from variations in *magnetic susceptibility* which will modulate the component of magnetisation *induced* in the subsurface by the Earth's magnetic field. For most archaeological sites, this is the dominant factor giving rise to geomagnetic anomalies. In general, susceptibility is relatively weak in sediments, such as sandstones and enhanced in ingeous rocks and soils, especially those which have been burnt or stratified with organic material.

2 Anomalies due to large, *permanently magnetised* structures. Such permanent magnetisation or 'remanence' arises when earth materials are heated to above ~600°C and cooled in the geomagnetic field. Thus kilns and hearths are often detected as strong permanent magnets causing highly localised anomalies that dominate effects due to background susceptibility variations. Remanence can result from other physical and chemical processes but these give rise to anomalies that are usually unimportant for geophysical prospecting.

There are several approaches towards the practical measurement of geomagnetic anomalies. In this study measurements were made using a Geoscan FM36 fluxgate gradiometer which records the change with height in the vertical component of the Earth's magnetic field, as shown overleaf. This method has the advantage of being insensitive to diurnal variations while the Geoscan instrument also benefits from an integrated data logger. Note that in mid northern latitudes the magnetic anomaly will be asymmetric with the main peak displaced to the south of the archaeological feature. Thus, a ditch filled with a soil of enhanced susceptibility, for example, will generate a positive anomaly to the south, mirrored by a weak negative anomaly north of the feature. When portrayed as an area map of grey tones this gives rise to a 'shadowing' or pseudo relief effect which must be borne in mind when making an archaeological interpretation.

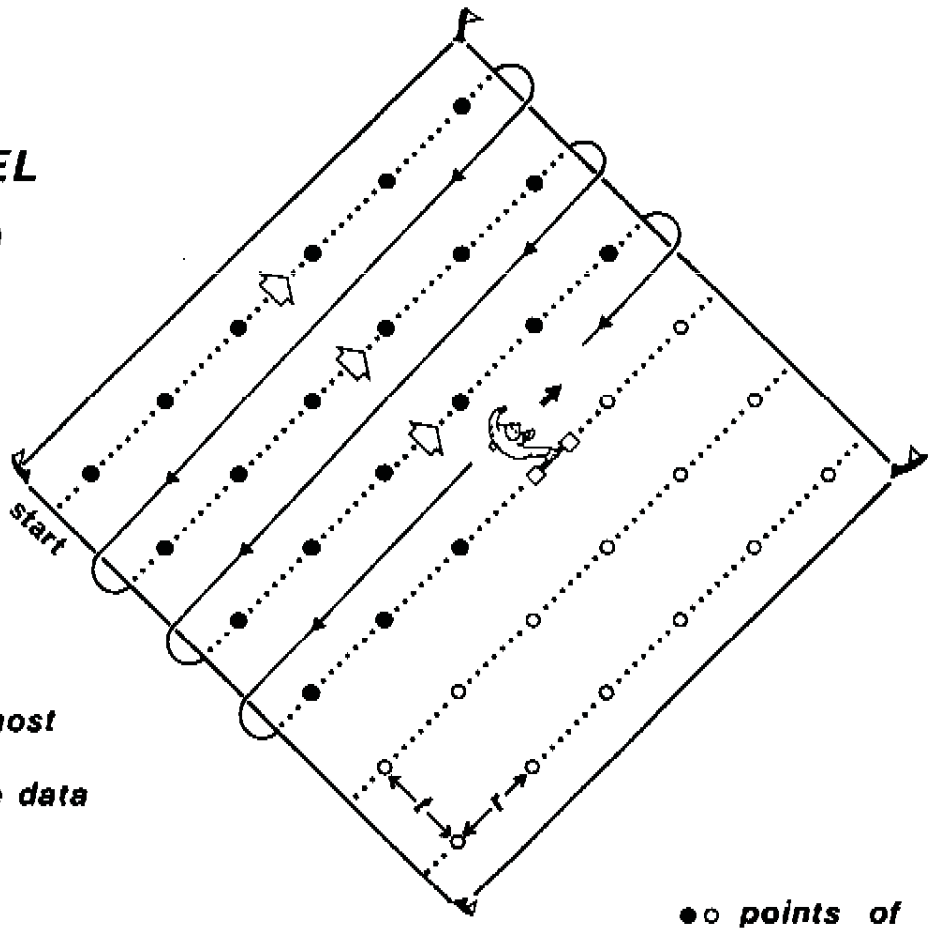
Two techniques can be used to survey gridded areas using the fluxgate magnetometer. In the parallel method the instrument is used to scan the area along traverses which are always in the same direction. This method minimises 'heading errors' due to operator and instrument magnetisation but is time consuming. The alternative zig-zag method is significantly faster and suitable for areas where anomalies are large compared to these and other sources of error.

MAGNETIC SURVEYING



SURVEY SCHEMES

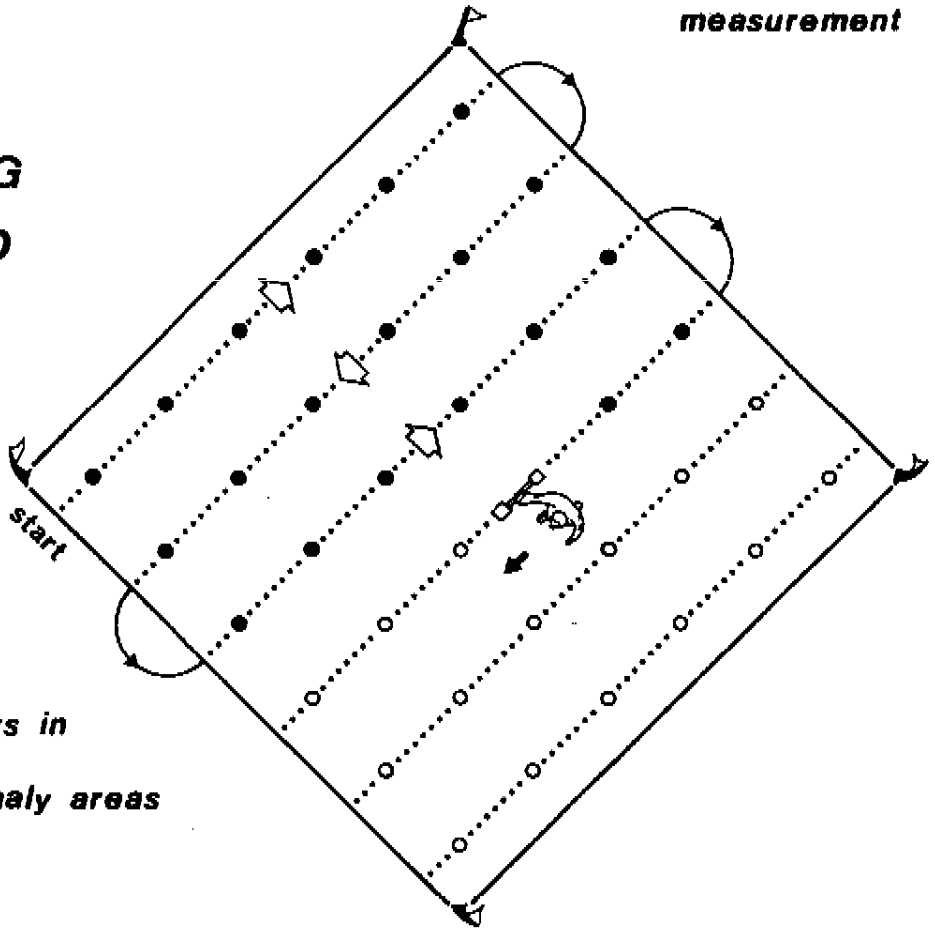
PARALLEL METHOD



slower but minimises most errors in the data

●○ *points of measurement*

ZIG-ZAG METHOD



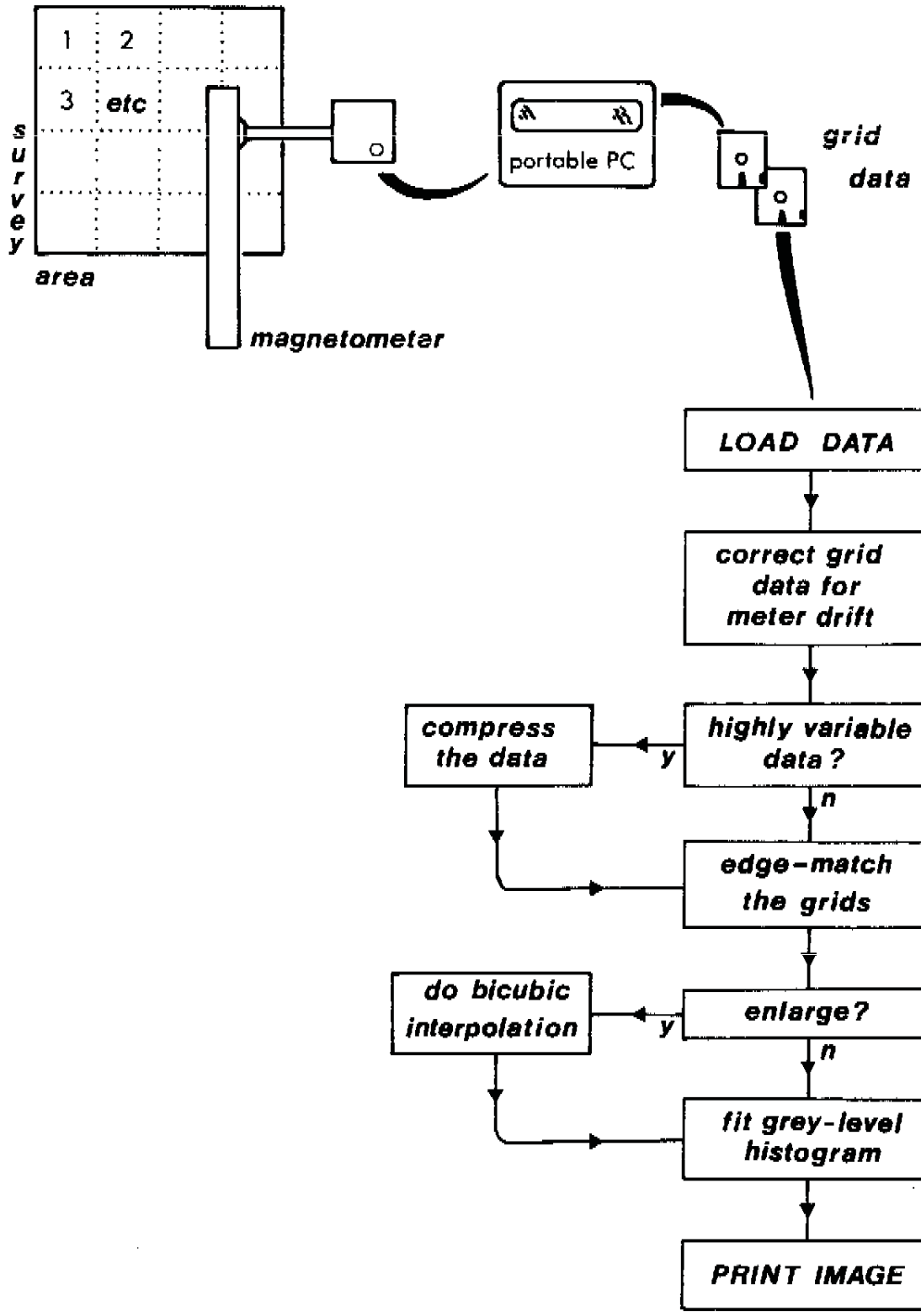
suitable for rapid surveys in strong anomaly areas

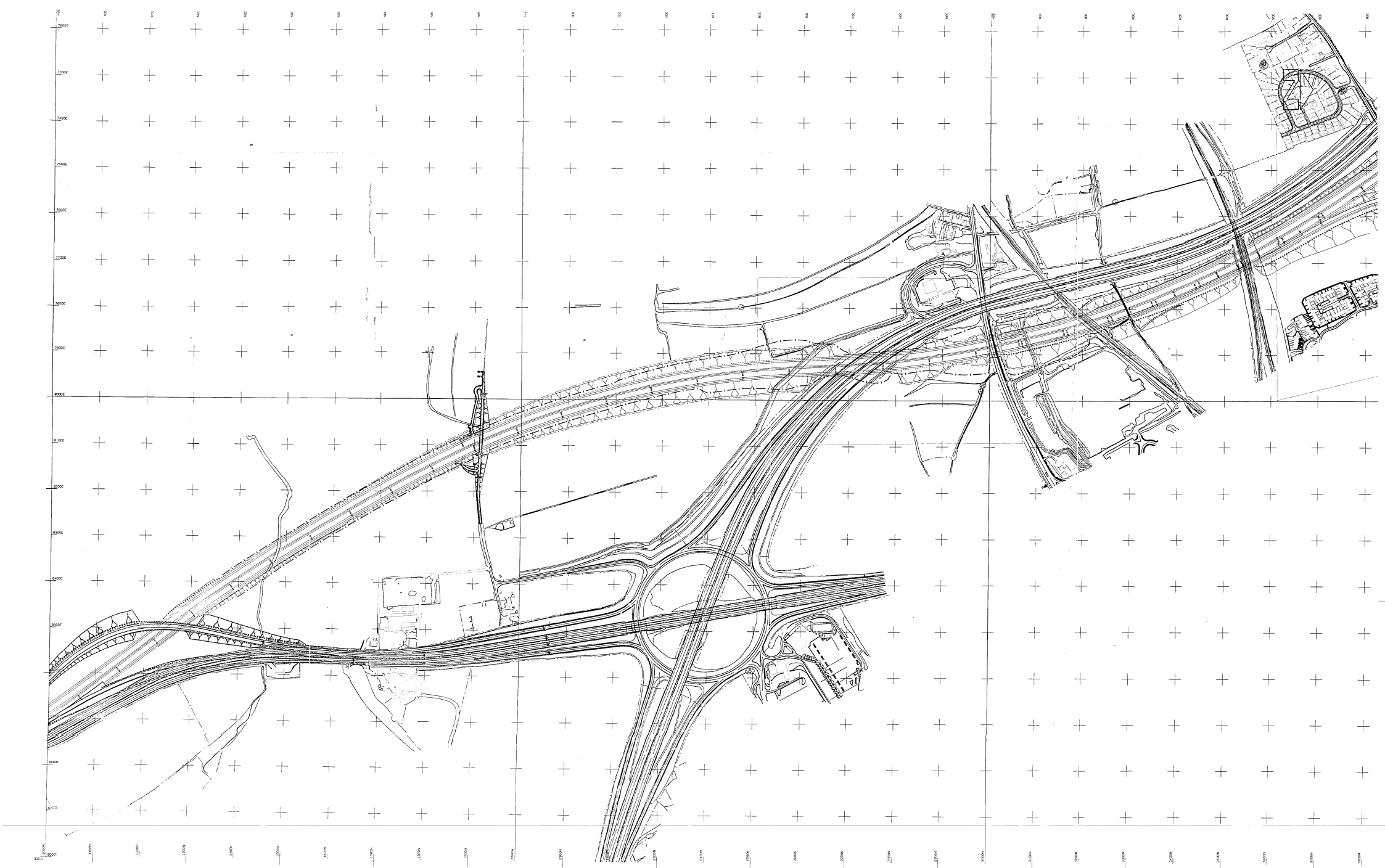
APPENDIX B

Data Processing Procedure

The various stages involved in gathering and manipulating the field measurements are summarised in the flow diagram overleaf. Data are downloaded from the magnetometer or resistivity meter to a portable computer, via a serial cable, inspected graphically and then stored on disc. Once the survey is completed, the data from individual grids are corrected for instrument drift (typically a few % per hour for the magnetometer) and then their dynamic range reduced if they contain highly variable values. This is often necessary where an area contains strong dipole sources if one is to make the best use of the grey scales available from the printer. Next, the area image is constructed by 'tiling' together adjacent grids. To achieve this, a special graphical technique is applied that minimises 'seams' in the image which would otherwise mask the anomalies of archaeological interest. If enlargement of a selected area is required, then this is achieved by expanding the data with bicubic splines; an approach which helps to reduce blurring. Finally, the data are numerically mapped to a set of 33 grey levels (true half tones) which are programmed to have a normal distribution in the printed image. From experience, it has been found that such a distribution is pleasing to the eye and by adjusting the mean density and variance the appearance of the anomalies can be optimised. All processing is carried out by proprietary GeoQuest software.

DATA PROCESSING





89D263. A1 MOTORWAY : FERRYBRIDGE TO HOOK MOOR.

GENERAL ARRANGEMENT FOR A1(M) UNDER M62 OPTION. Scale 1:2500

FOR LAND & ENVIRONMENTAL ASPECTS. DSS-29/03 00

PLOT_09