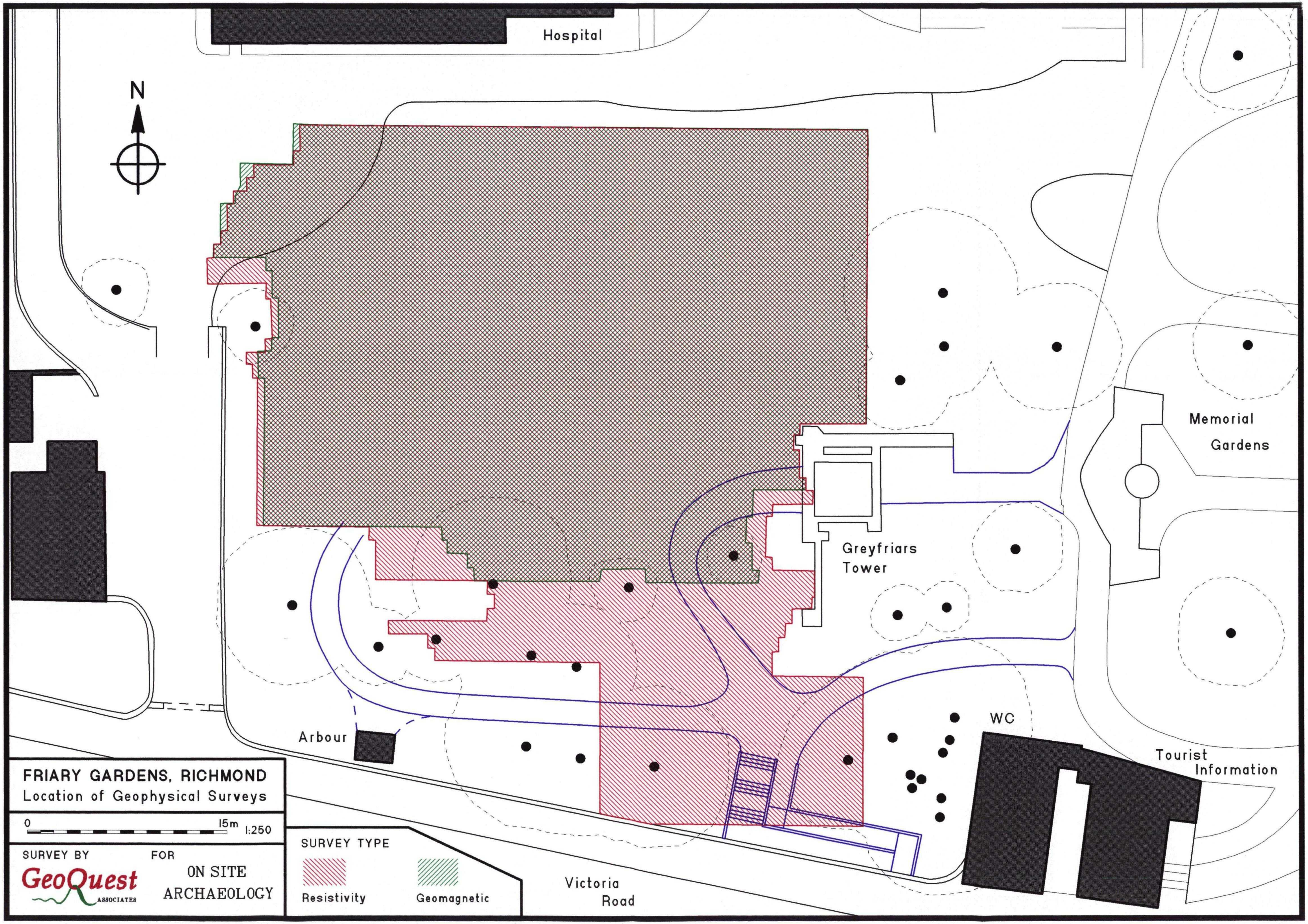


Hospital
N
Memorial
Gardens
Greyfriars
Tower
Arbour
WC
Tourist
Information
Victoria
Road
FRIARY GARDENS, RICHMOND
Location of Geophysical Surveys
0
15m
1:250
SURVEY BY
GeoQuest
ASSOCIATES
FOR
ON SITE
ARCHAEOLOGY
SURVEY TYPE
Resistivity
Geomagnetic

FIGURE 1


Hospital
N
Memorial
Gardens
Greyfriars
Tower
WC
Arbour
Tourist
Information
Victoria
Road
FRIARY GARDENS, RICHMOND
Results of Geomagnetic Survey
0
15m
1:250
SURVEY BY
GeoQuest
ASSOCIATES
FOR
ON SITE
ARCHAEOLOGY
nT/m
-19.8 -2.2 0.0 2.3 19.8

FIGURE 2

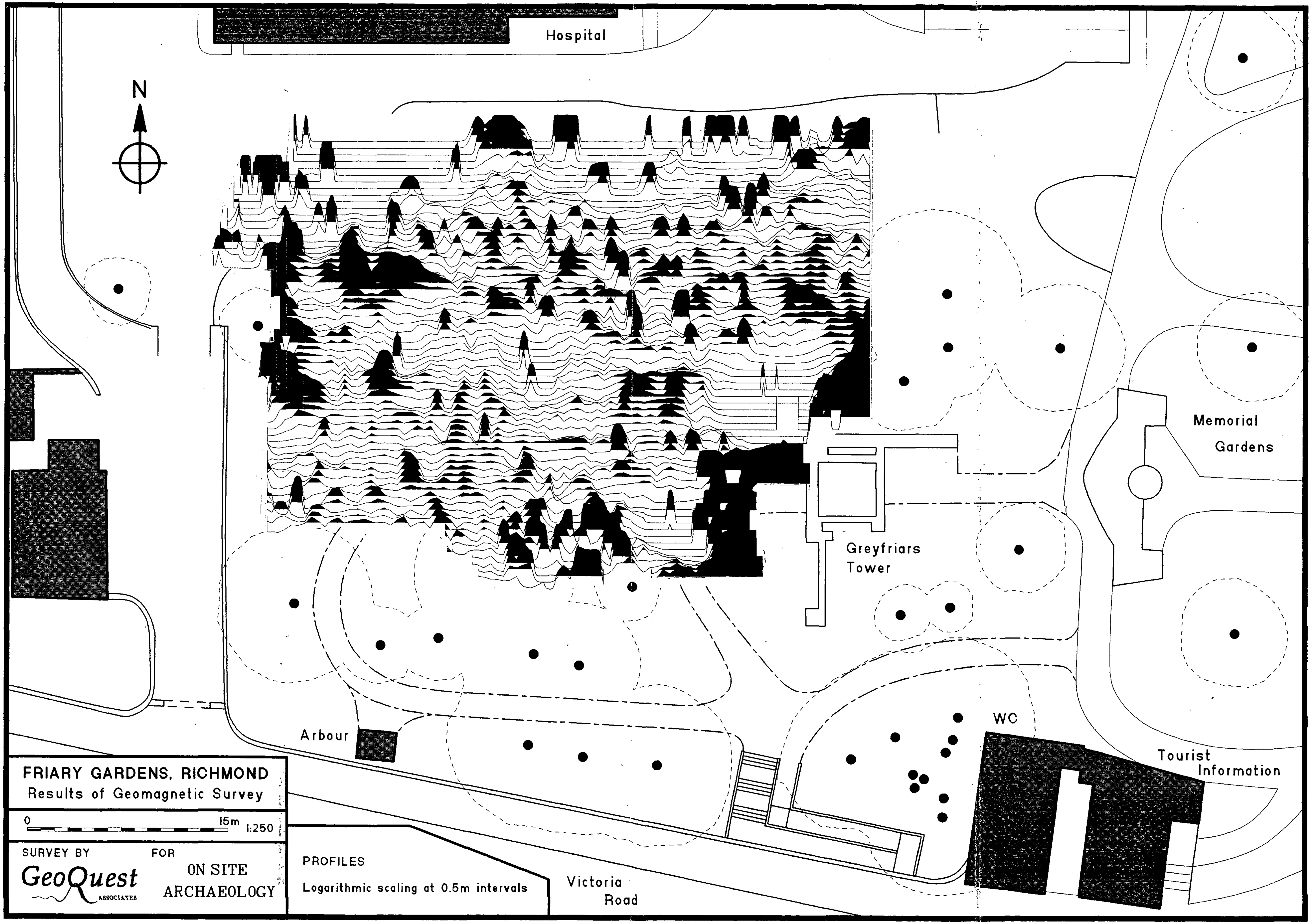

Hospital
N
Memorial
Gardens
Greyfriars
Tower
Arbour
WC
Tourist
Information
Victoria
Road
FRIARY GARDENS, RICHMOND
Results of Geomagnetic Survey
0
15m
1:250
SURVEY BY
GeoQuest
ASSOCIATES
FOR
ON SITE
ARCHAEOLOGY
PROFILES
Logarithmic scaling at 0.5m intervals

FIGURE 3


Hospital
N
Memorial
Gardens
Greyfriars
Tower
WC
Arbour
Tourist
Information
Victoria
Road
FRIARY GARDENS, RICHMOND
Results of Resistivity Survey
0
15m
1:250
SURVEY BY
GeoQuest
ASSOCIATES
FOR
ON SITE
ARCHAEOLOGY
Ohms
-146.3 -91.3 -84.4 -77.5 -22.7

FIGURE 4


Hospital
N
MAGNETIC
RESISTIVITY
Memorial
Gardens
Greyfriars
Tower
Arbour
WC
Tourist
Information
Victoria
Road
FRIARY GARDENS, RICHMOND
Geophysical Interpretation
0
15m
1:250
SURVEY BY
GeoQuest
ASSOCIATES
FOR
ON SITE
ARCHAEOLOGY
ANOMALIES
High Resistivity
Low Resistivity
Positive Magnetic
Negative Magnetic
Magnetic Dipole

FIGURE 5

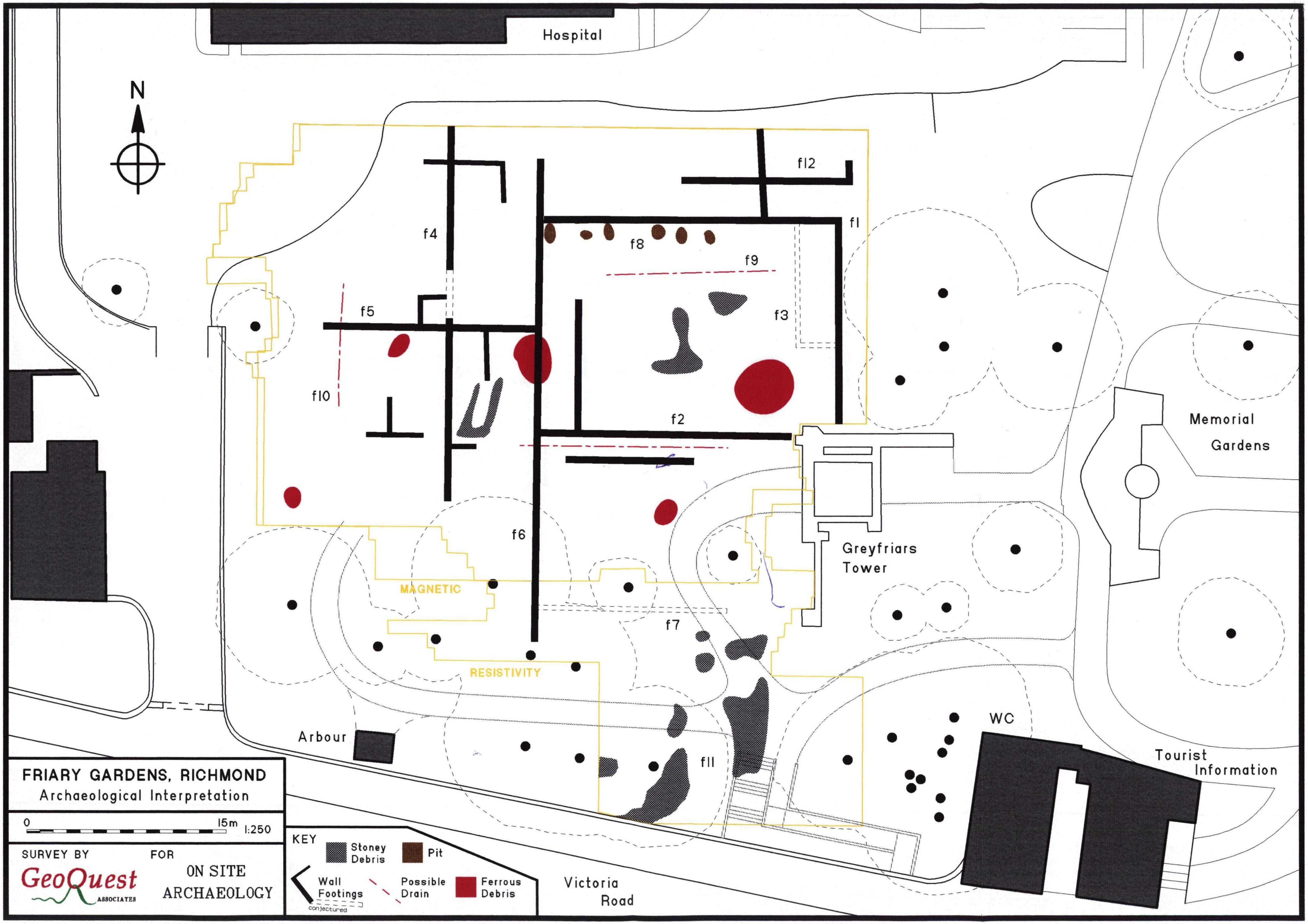

Hospital
N
f12
f1
f4
f8
f9
f5
f3
f10
f2
Memorial
Gardens
f6
Greyfriars
Tower
MAGNETIC
f7
RESISTIVITY
WC
Arbour
f11
Tourist
Information
FRIARY GARDENS, RICHMOND
Archaeological Interpretation
0
15m
1:250
SURVEY BY
GeoQuest
ASSOCIATES
FOR
ON SITE
ARCHAEOLOGY
KEY
Stoney Debris
Pit
Wall Footings
conjectured
Possible Drain
Ferrous Debris
Victoria
Road

FIGURE 6

APPENDIX A

PRINCIPLES 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:

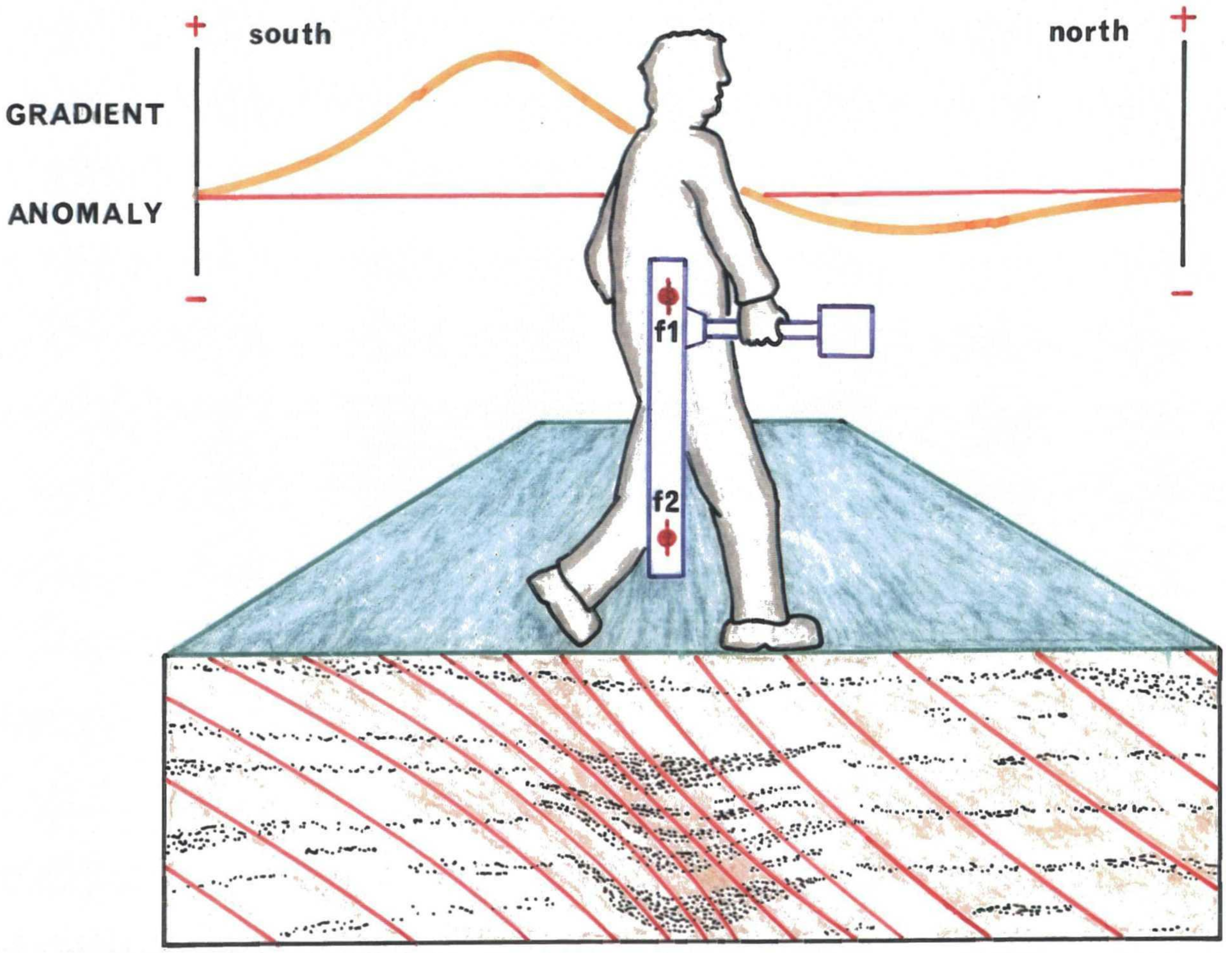
1 Anomalies arising from variations in *magnetic susceptibility* which will modulate the component of magnetisation *induced* in the subsurface by the Earth's magnetic field. For most archaeological sites, this is the dominant factor giving rise to geomagnetic anomalies. In general, susceptibility is relatively weak in sediments, such as sandstones and enhanced in igneous 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.

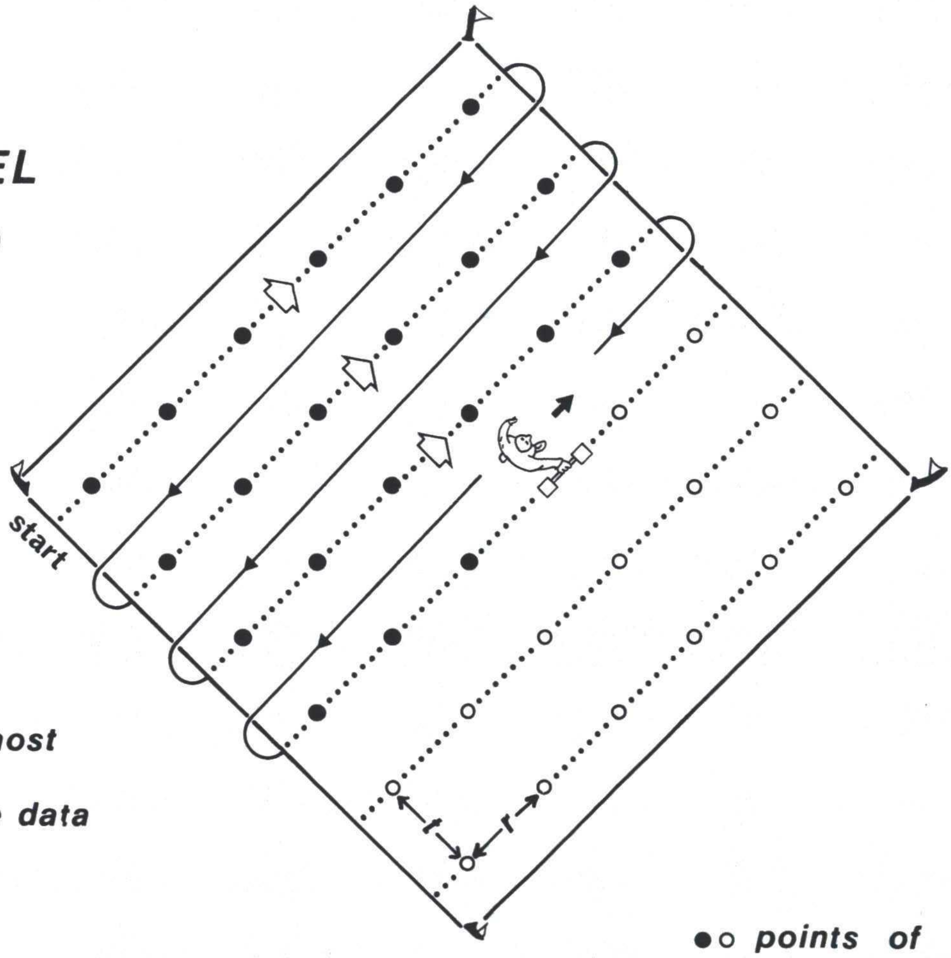
Two techniques can be used to survey gridded areas using the fluxgate magnetometer. In the parallel method the instrument is used to scan the area along traverses which are always in the same direction. This method minimises 'heading errors' due to operator and instrument magnetisation but is time consuming. 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

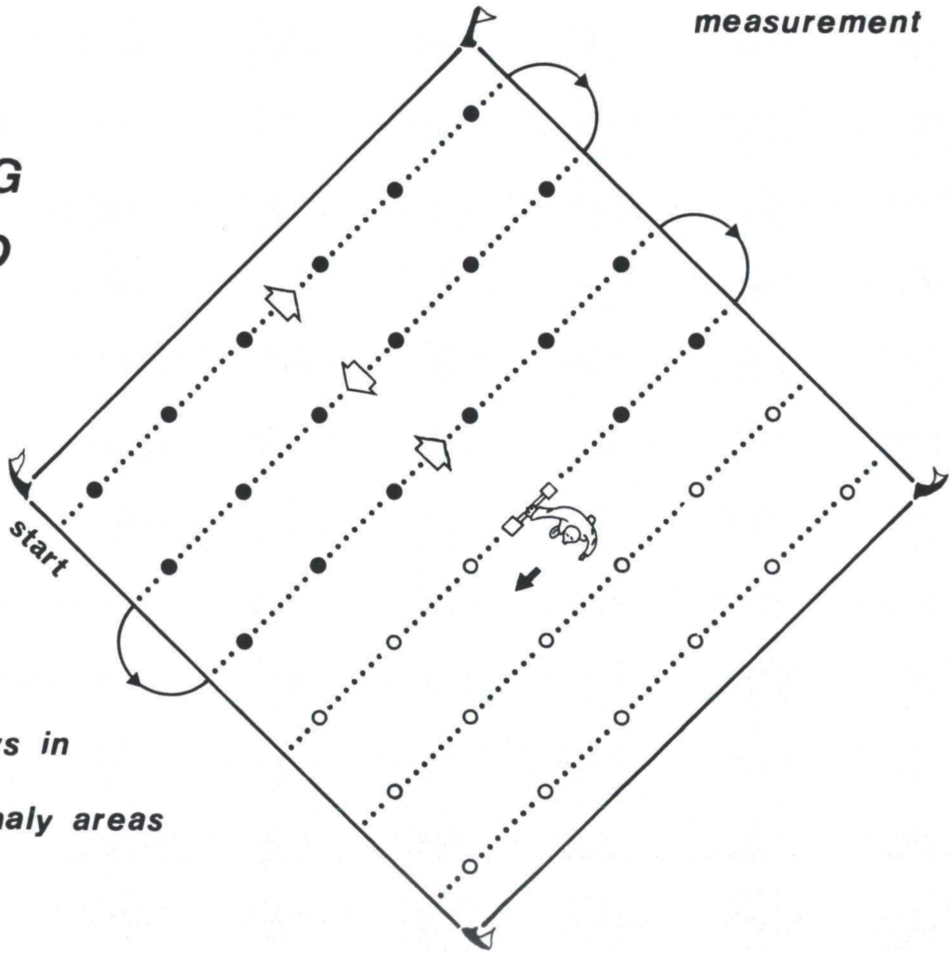
minimises most

errors in the data

●○ points of

measurement

ZIG-ZAG METHOD



suitable for

rapid surveys in

strong anomaly areas

APPENDIX B

PRINCIPLES OF ELECTRICAL RESISTIVITY SURVEYING

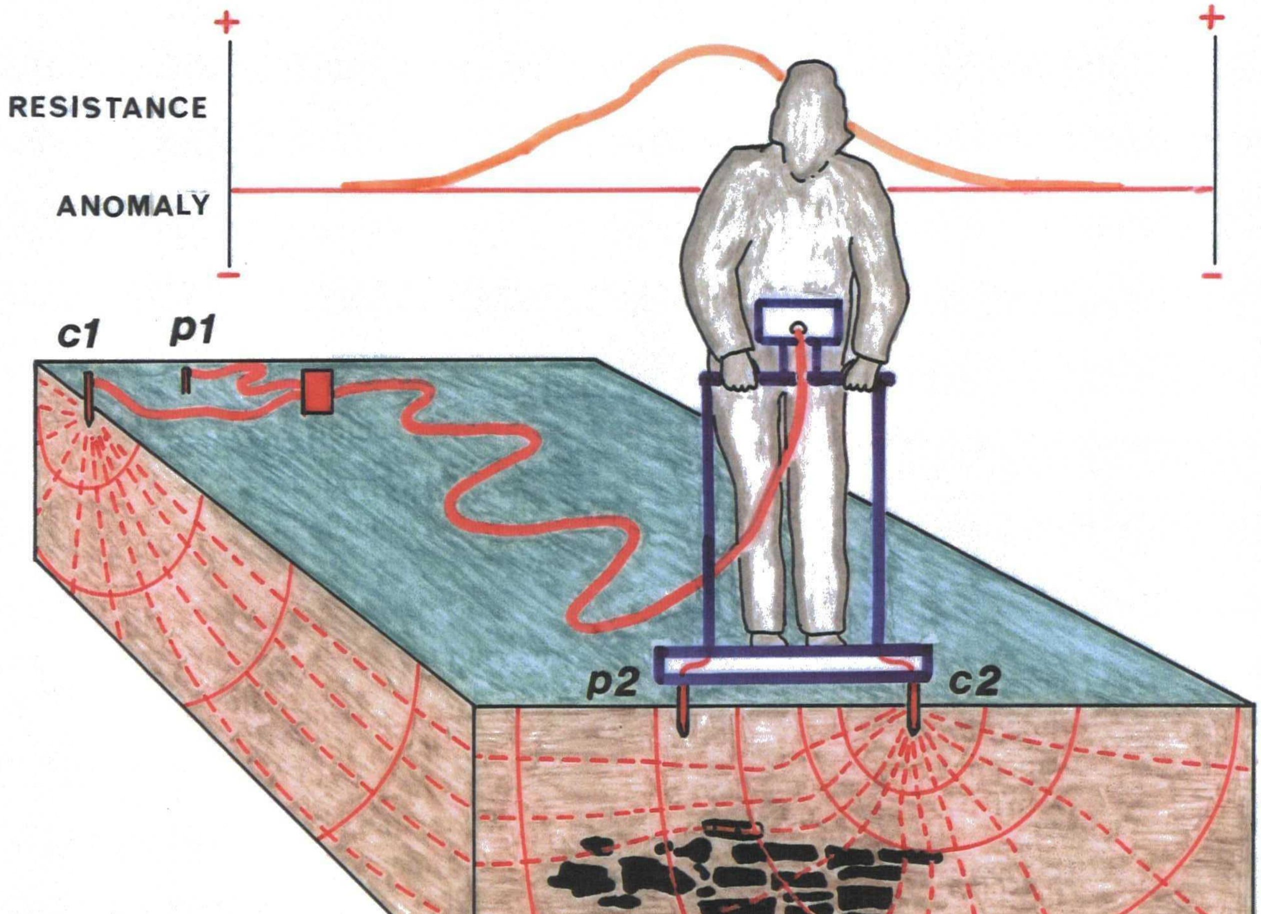
This is an *active* geophysical prospecting technique which detects subsurface features in terms of the resistance they present to the passage of an artificially induced electric current. In the dry state, most soils and rocks are insulators but, when they become moist, electric currents are able to flow through the movement of ions which are always dissolved in the porewater. As the soil or rock absorbs more water the conductivity increases since more ions become available for conduction and their mobility is enhanced. Hence electrical resistivity surveying primarily maps the volume concentration of ground moisture which varies according to lithology, porosity and time of year. Temperature fluctuations can also be important although in mid-latitudes this effect is insignificant.

To record the soil electrical resistivity an alternating current is injected into the ground through a pair of metal electrodes and the surface potential detected between a second pair. This arrangement is needed to minimise errors arising from contact effects, earth currents (usually of mains origin) and polarisation potentials. Several configurations have been evaluated for archaeological use but the 'twin electrode' scheme shown overleaf has proved popular for this purpose. A mobile frame is used to carry one potential and one current electrode (**p2** and **c2**) which are connected, via the meter, to their respective **p1** and **c1** soil electrodes. Alternating current is passed between **c1** and **c2** and the potential measured between **p1** and **p2**. The presence of a zone of anomalous resistivity modifies the distribution of current flow (dotted streamlines) and also the contours of constant potential (curved solid lines) and is depicted for the case of a high resistivity structure such as a wall. The instrument thus senses a maximum (or minimum) in the apparent soil resistance which is centred over the feature.

Through good instrument design, resistivity surveying is now a rapid technique although the need for soil contact and cables makes this a slower method than magnetometry. Our surveys employed a Geoscan RM15 instrument with variable spacing between the mobile electrodes which enables the sensing depth to be optimised.

Measurements are generally taken at regular intervals on a grid. Both parallel and zig-zag traverse schemes are used; the first method is slower but minimises systematic errors in the resulting data.

RESISTIVITY SURVEYING



APPENDIX C
DATA PROCESSING

PROCESSING THE SURVEY DATA

The geophysical images contained in this report were prepared within Microsoft Windows® using the **InSite®** program published by GeoQuest Associates. Geophysical images were then placed onto a map which was digitised from the Ordnance Survey, edited and then plotted using a computer aided drafting (CAD) system and colour inkjet printer.

Data were downloaded from the meter to a portable computer in the field for storage, visualisation and quality control (QC) assessment. These data were then transferred to a laboratory computer for final processing, printing and archiving.

A number of process steps have been applied to the geophysical data obtained during the survey and those which have been used are linked to the main flow path by arrows. Steps were applied in the order shown and are designed to reduce artifacts in the data and enhance geophysical features of archaeological interest. The following sections describe each step in more detail.

REMOVE STRIPING

Reduces a data artifact comprising alternating changes in level in readings logged along zig-zag traverses. This artifact is common in fluxgate magnetometer data. InSite uses a proprietary algorithm to reduce this error.

INFILL SMALL BLANK AREAS

Fills isolated blank data cells with the mean of near-neighbours or a suitable approximation entered manually. Small blank areas will have been logged if it was not possible to obtain a geophysical reading over, for example, a manhole cover in the case of a resistivity survey.

REMOVE SPIKES

Replaces isolated, anomalously high or low values with the mean of near neighbours or a suitable approximation entered manually. 'Spike' readings are commonly associated with ferrous litter or poor electrical contact in the case of geomagnetic and resistivity data, respectively.

REDUCE WALK HARMONICS

Reduces a regular oscillation in traverse data caused by walking movements of the operator during a geomagnetic survey. InSite employs a fast Fourier transform to determine the optimum amplitude and phase of the walk-induced harmonic which is then subtracted from each traverse.

REDUCE SHEAR ARTIFACTS

Corrects for apparent shear in geomagnetic anomalies surveyed by zig-zag traversing in a geomagnetic survey. The shearing effect arises from the interaction of the operator+magnetometer with the geomagnetic field and also from the lag in the instrument response to changes in the field. InSite uses a proprietary algorithm to reduce this error.

CORRECT FOR METER DRIFT

Corrects for a linear drift in the meter calibration with time. Such drift is a common problem with fluxgate magnetometers, particularly during periods of rapid air temperature change. InSite uses least-squares regression on the mean of data along each traverse to estimate the change in calibration level across each grid. This gradient is then removed from the data.

ADJUST GRID MEAN LEVELS

Adjusts for differences in the mean level in data grids due to changes in instrument calibration (fluxgate magnetometer survey) or alteration in remote electrode spacing (resistivity survey).

INTERPOLATE AND COMBINE

Combines grids to form an array of regularly-spaced data on a square mesh. InSite uses bilinear interpolation to accomplish this.

LOW PASS FILTER

If this process task is indicated then a 3x3 or 5x5 boxcar filter has been used to smooth the data and reduce noise or 'speckle' seen in the original image.

HIGH PASS FILTER

If this process task is indicated then a 3x3 or 5x5 filter, with appropriate coefficients, has been used to pass short-wavelength information into the resulting image.

EDGE DETECT FILTER

Signifies that a Sobel, Laplace or other specialised filter has been applied to enhance significant lateral transitions in the geophysical image.

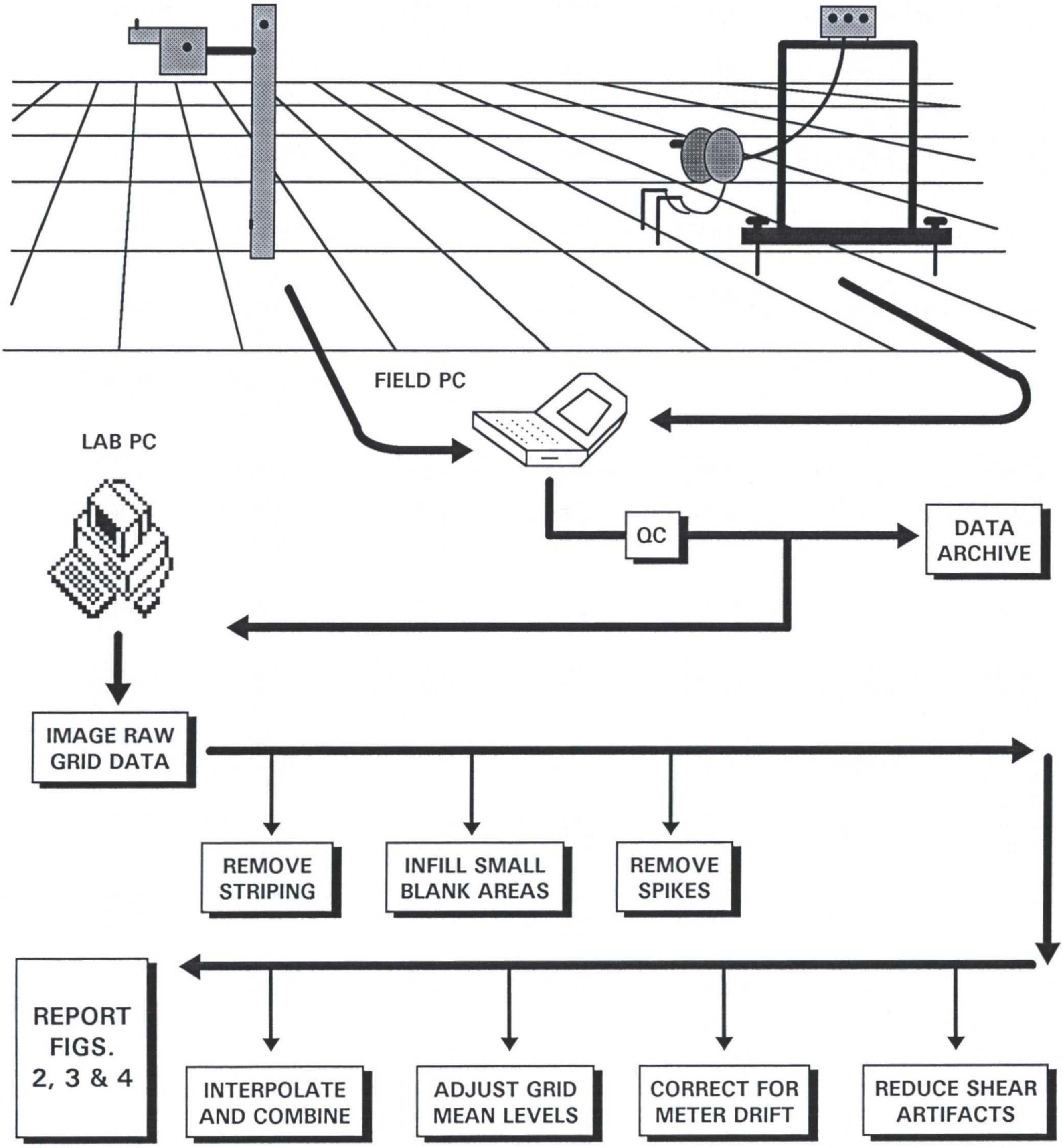
DIRECTIONAL FILTER

This filter is equivalent to illuminating the data from one direction to produce a pseudo-relief image. Directional filtering is usually employed to aid the identification of subtle anomalies in resistivity data. This filter highlights features trending at right angles to the direction of illumination.

NOTE

GeoQuest Associates can supply the geophysical images presented in this report in a variety of digital formats for visualisation on microcomputers running Microsoft Windows. These formats include the TIF, BMP and PCX standards. Please complete the request form at the rear of this report if you would like to receive such image files.

APPENDIX C
DATA PROCESSING



APPENDIX D

SETTING OUT AND ERROR DETAILS

Figure 7 shows the manner in which the site grid was established and the position of 20m grid nodes (red crosses) which were left as paint marks on the ground.

The green contours give the estimated component of error in the location of subsurface features arising from error in setting out and in relating geographic features to those on supplied plans.

We advise that any evaluation that seeks to investigate features detected by the geophysical survey should first re-establish the site grid *in the manner shown*, and then determine coordinates of features *relative to this grid*.

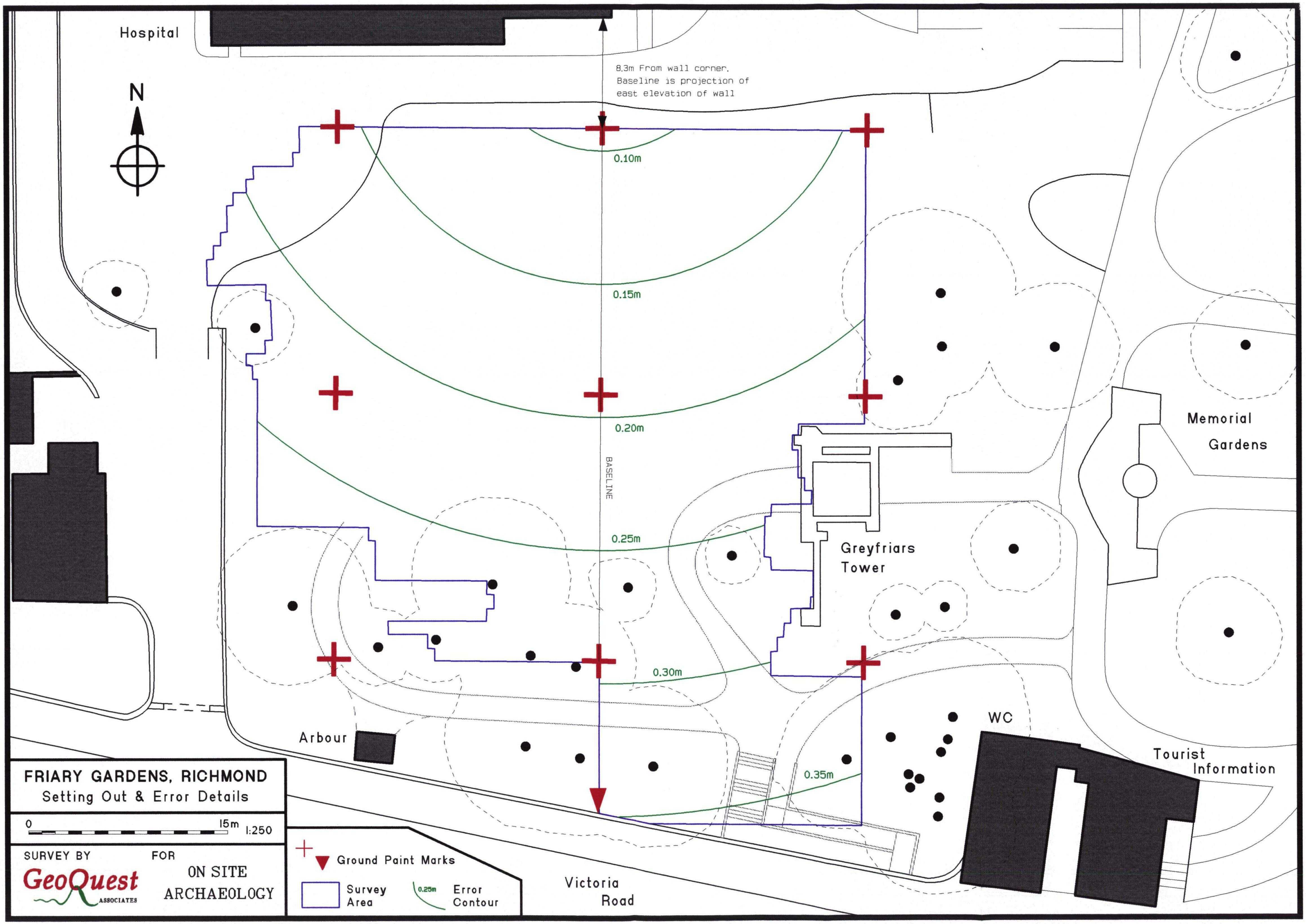

Hospital
8.3m From wall corner.
Baseline is projection of
east elevation of wall
N
0.10m
0.15m
0.20m
0.25m
0.30m
0.35m
BASELINE
Memorial
Gardens
Greyfriars
Tower
Arbour
WC
Tourist
Information
FRIARY GARDENS, RICHMOND
Setting Out & Error Details
0
15m
1:250
SURVEY BY
FOR
GeoQuest
ASSOCIATES
ON SITE
ARCHAEOLOGY
Ground Paint Marks
Survey
Area
0.25m
Error
Contour
Victoria
Road

FIGURE 7