STRATASCAN

Geophysical Survey Report

St. Mary's Churchyard, Bromley By Bow

For

The Regeneration Practice

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Job No. 1880

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REGISTERED IFA ORGANISATION

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1 SUMMARY OF RESULTS

A GPR (Ground Probing Radar) survey was carried out in St. Mary's Churchyard, Bromley By Bow, London. The site has a long history and is thought to have been the place of thousands of burials over 750 years.

The GPR survey detected many anomalies which correlate with the sites complex past. With so many burials having taken place here it is difficult to define individual graves. Seven areas of complex response have been identified, which may contain significant air voids. Numerous further smaller anomalies have been interpreted as burial sites.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of St. Mary's Churchyard, Bromley by Bow. This survey forms part of a development being undertaken by The Regeneration Practice.

2.2 Site location

The site is located at St. Mary's Churchyard, Bromley By Bow, London, at NGR. TQ 378 828.

2.3 Description of site

The site is currently a disused churchyard which was converted to a public park in 1970.

The underlying geology is Tertiary London Clay (British Geological Survey South Sheet, Third Edition Solid, 1979). The overlying soils are unsurveyed due to the urbanised environment (Soil Survey of England and Wales, Sheet 6, South East England).

2.4 Site history and archaeological potential (Hawkins, 2004)

St. Mary's churchyard is currently consecrated ground, and has been a religious burial site for 750 years. The church itself fell into disuse after bomb damage during the Second World War and was demolished in the 1970's. Some burials have been cleared, and many of the gravestones were removed in 1969 during the construction of the Blackwall Tunnel approach road.

The last burial was in 1856, prior to this it is thought several thousand burials have taken place, with early photographs (pre 1941) indicating the yard was crowded with gravestones.

The archaeological potential of the survey is considered high, with a possibility of locating numerous burial features.

2.5 Survey objectives

The objective of the survey was to locate any vaults and graves which may provide a hazard to the stability of a new building.

2.6 Survey methods

More information regarding GPR is included in the Methodology section below.

3 METHODOLOGY

3.1 Date of fieldwork

The fieldwork was carried out on one day, 25th May 2004, when the weather was fine.

3.2 Grid locations

The location of the survey transects has been plotted in Figure 2.

3.3 Description of techniques and equipment configurations

Ground Probing Radar
Two of the main advantages of radar are its ability to give information of depth as well as work through a variety of surfaces, even in cluttered environments and which normally prevent other geophysical techniques being used.

A short pulse of energy is emitted into the ground and echoes are returned from the interfaces between different materials in the ground. The amplitude of these returns depends on the change in velocity of the radar wave as it crosses these interfaces. A measure of these velocities is given by the dielectric constant of that material. The travel times are recorded for each return on the radargram and an approximate conversion made to depth by calculating or assuming an average dielectric constant (see below).

Drier materials such as sand, gravel and rocks, i.e. materials which are less conductive (or more resistant), will permit the survey of deeper sections than wetter materials such as clays which are more conductive (or less resistant). Penetration can be increased by using longer wavelengths (lower frequencies) but at the expense of resolution (see 3.4.2 below).

As the antennae emit a "cone" shaped pulse of energy an offset target showing a perpendicular face to the radar wave will be "seen" before the antenna passes over it. A resultant characteristic *diffraction* pattern is thus built up in the shape of a hyperbola. A classic target generating such a diffraction is a pipeline when the antenna is travelling across the line of the pipe. However it should be pointed out that if the interface between the target and its surrounds does not result in a marked change in velocity then only a weak hyperbola will be seen, if at all.

The Ground Probing Impulse Radar used was a SIR2000 system manufactured by Geophysical Survey Systems Inc. (GSSI).

The radar surveys were carried out with a 400 MHz antenna. This mid-range frequency offers a good combination of depth of penetration and resolution.

3.4 Sampling interval, depth of scan, resolution and data capture

3.4.1 *Sampling interval*

Ground Probing Radar
Radar scans were carried out along traverses 0.5m apart on a parallel grid as shown in Figure 2. Data was collected at 40 scans/metre. A measuring wheel was used to put markers into the recorded radargram at 1m centres.

3.4.2 *Depth of scan and resolution*

Ground Probing Radar
The average velocity of the radar pulse is calculated to be 0.087m/ns which is typical for the type of sub-soils on the site. With a range setting of 65ns this equates to a maximum depth of scan of 2.75m respectively but it must be remembered that this figure could vary by ± 10% or more. A further point worth making is that very shallow features are lost in the strong surface response experienced with this technique.

Under ideal circumstances the minimum size of a vertical feature seen by a 200MHz (relatively low frequency) antenna in a damp soil would be 0.1m (i.e. this antenna has a wavelength in damp soil of about 0.4m and the vertical resolution is one quarter of this wavelength). It is interesting to compare this with the 400MHz antenna, which has a wavelength in the same material of 0.2m giving a theoretical resolution of 0.05m. A 900MHz antenna would give 0.09m and 0.02m respectively.

3.4.3 *Data capture*

Ground Probing Radar
Data is displayed on a monitor as well as being recorded onto an internal hard disk. The data is later downloaded into a computer for processing.

3.5 Processing, presentation of results and interpretation

3.5.1 *Processing*

Ground Probing Radar
The radar plots included in this report have been produced from the recorded data using Radan software. They have been processed with an FIR filter to remove background noise.

3.5.2 *Presentation of results and interpretation*

Ground Probing Radar
Manual abstraction
Each radargram has been studied and those anomalies thought to be significant were noted and classified as detailed below. Inevitably some simplification has been made to classify the diversity of responses found in radargrams.

i. Strong and weak discrete reflector.
These may be a mix of different types of reflectors but their limits can be clearly defined. Their inclusion as a separate category has been considered justified in order to emphasise anomalous returns which may be from archaeological targets and would not otherwise be highlighted in the analysis.

ii. Complex reflectors.
These would generally indicate a confused or complex structure to the subsurface. An occurrence of such returns, particularly where the natural soils or rocks are homogeneous, would suggest artificial disturbances. These are subdivided into both strong and weak giving an indication of the extent of change of velocity across the interface, which in turn may be associated with a marked change in material or moisture content.

iii. Point diffractions.
These may be formed by a discrete object such as a stone or a linear feature such as a small diameter pipeline being crossed by the radar traverse (see also the second sentence in 4. below).

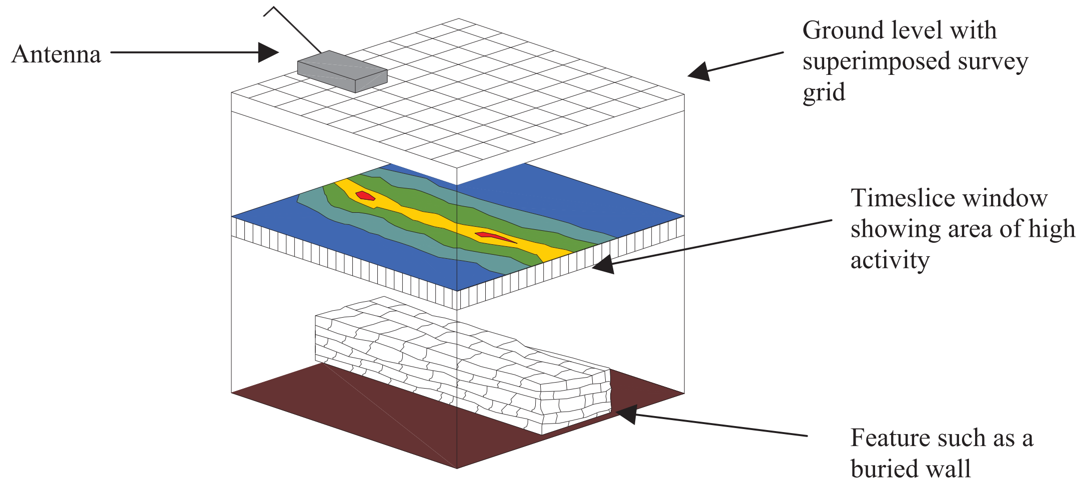
iv. Convex reflectors and broad crested diffractions.
A convex reflector can be formed by a convex shaped buried interface such as a vault or very large diameter pipeline or culvert. A broad crested diffraction as opposed to a point diffraction can be formed by (for example) a large diameter pipe or a narrow wall generating a hybrid of a point diffraction and convex reflector where the central section is a reflection off the top of the target and the edges/sides forming diffractions.

v. Planar returns.
These may be formed by a floor or some other interface parallel with the surface. These are subdivided into both strong and weak giving an indication of the extent of change of velocity across the interface which in turn may be associated with a marked change in material or moisture content.

vi. Deep convex reflector.
These tend to be large anomalies with irregular and rough edges. They may be caused by similar features to broad crested anomalies, though are more likely to be natural effects due to soil and geology.

Timeslice plots

In addition to a manual abstraction from the radargrams, a computer analysis was also carried out. The radar data is interrogated for areas of high activity and the results presented in a plan format known as timeslice plots (Figure 3). In this way it is easy to see if the high activity areas form recognisable patterns.



The GPR data is compiled to create a 3D file. This 3D file can be manipulated to view the data from any angle and at any depth within range. The data was then modelled to produce activity plots at various depths. As the radar is actually measuring the time for each of the reflections found, these are called "time slice windows". Plots for various time slices have been included in the report. Based on an average velocity calculations have been made to show the equivalent depth into the ground. The data was sampled between different time intervals effectively producing plans at different depths into the ground.

The weaker reflections in the time slice windows are shown as dark colours namely blues and greens. The stronger reflections are represented by brighter colours such as light green, yellow, orange, red and white (see key provided in Figure 3).

Reflections within the radar image are generated by a change in velocity of the radar from one medium to another. It is not unreasonable to assume that the higher activity anomalies are related to marked changes in materials within the ground such as foundations or surfaces within the soil matrix.

4 RESULTS

The GPR survey has detected a large quantity of anomalies indicating the site is highly complex (see Figure 4). This complexity is also seen on the time slice plot (Figure 3).

Standard coffin burials over 100 years old are likely to be undetectable by GPR due to decomposition. Considering the last recorded burial was 148 years ago it is likely that only burials with associated structural remains, such as vaults and stone slabs, will be detectable.

Due to the various ages, sizes, states of preservation and materials used in burial features there is no single standard response that is easily identifiable as a burial. One of the best methods to identify burials is to look for anomalies in adjacent transects which produce the general burial shape, about 1m wide by 2m long, with the longest length orientated west-east. In grave yards with a long history overlapping and closely packed burials can be expected, making identification of single burials problematic. Burial areas which include stone/brick structures make detection easier as they will often give a characteristic complex response (see section 3.5.2).

Several possible vault locations have been identified. These tend to be made up of discrete and complex responses seen in four adjacent transects. It is difficult to calculate the depth of burial as the disturbed ground above the burial is also part of the anomaly. See Figures 6 and 7.

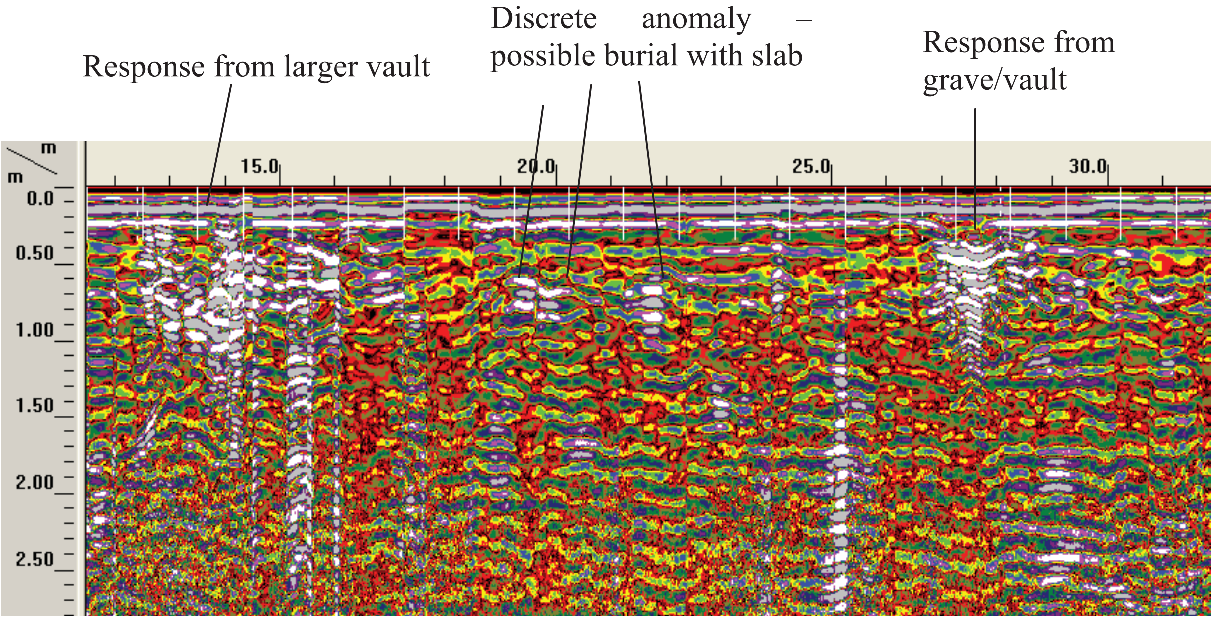


Figure 6. Extract from Transect 5E, Chainage 11.5N – 32N. At 27.5m an anomaly caused by a burial with associated disturbed ground is seen. The smaller discrete anomalies in the centre of the image may also represent burials, possibly with covering stone slabs. From 12.5m to 16m the response from what is interpreted as a larger vault can be seen.

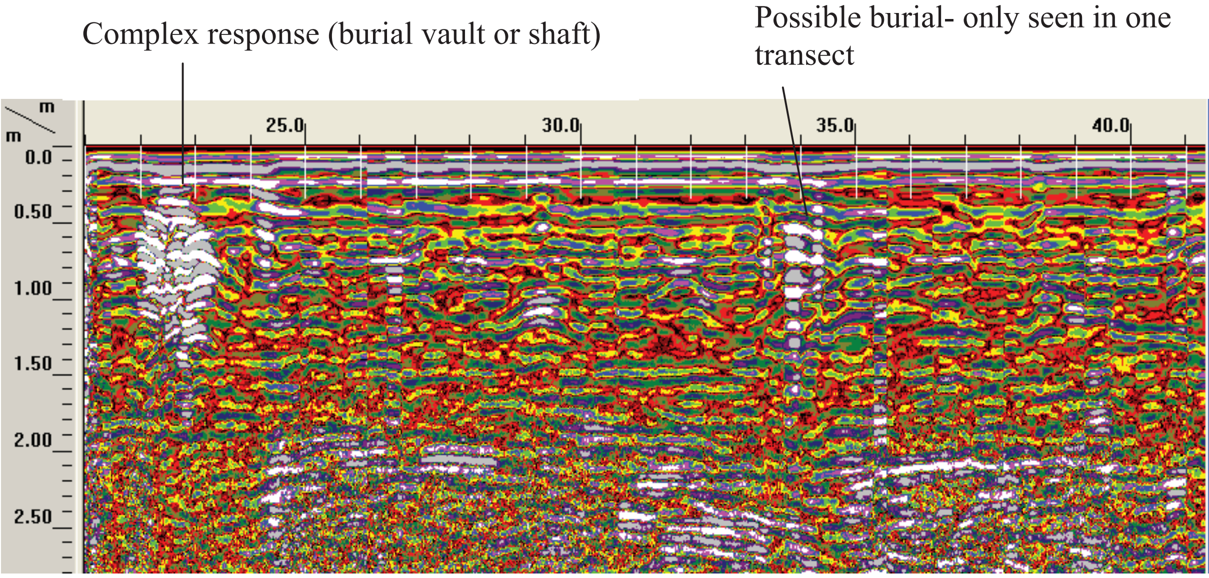


Figure 7. Extract of transect 0E, Chainage 21N – 41N. This shows a strong complex area suggestive of a burial vault.

There are several areas identified which consist of complex responses. These cover a larger area than the burial vaults described above. It is possible these are caused by larger burial vaults with more substantial structural remains (Figure 6). These complex anomalies are also seen in the time slice plot (Figure 3).

There are many places where the general shape of anomalous areas form what would be expected from a burial, even though the composition of individual anomalies is inconsistent. Some of these have been identified on Figure 5.

Several deep convex reflectors have been identified, particularly in the west. It seems likely these are caused by natural features due to their large and irregular shape. See Figure 8.

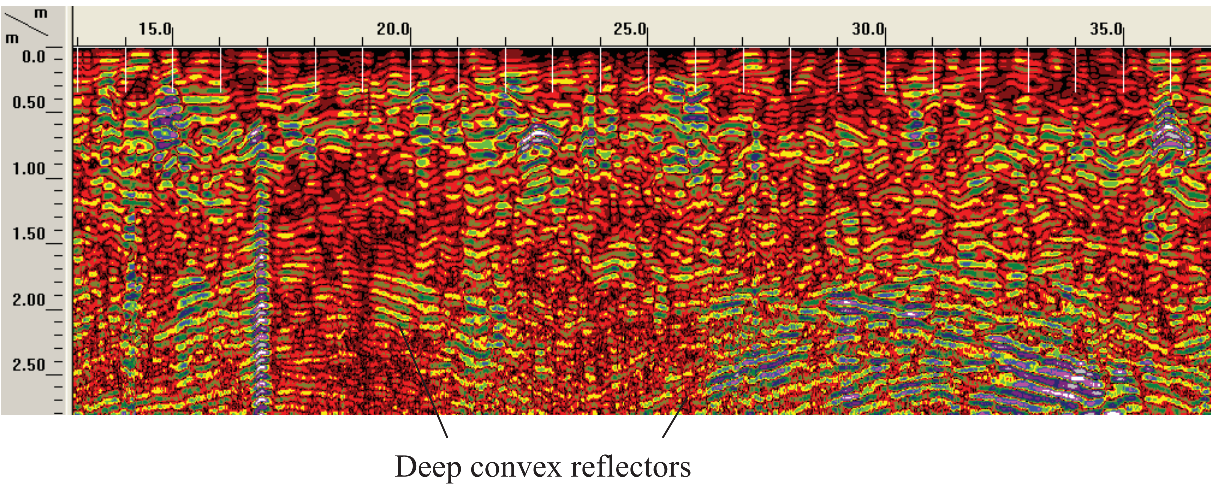


Figure 8. Extract from transect 1E, Chainage 13N – 37N. Showing deep convex reflectors.

The response detected from surveying over some probable burials marked by ledgers or slabs has been negligible. This may be due to decomposition or it may be due to the ledger not actually marking a grave so giving only a near surface response. The response from this would be lost in surface noise and go undetected.

5 CONCLUSION

The results form the GPR survey have shown the churchyard to contain many anomalies, suggesting it has been intensely used in the past.

Due to the varying state and apparent number of burials and hence varying response types it is difficult to define individual graves.

Seven areas of complex response have been identified which are indicative of substantial vault or shaft burials. It is possible these areas are roofed structures which may be prone to collapse under load. Numerous further areas have been detected which are possible burial sites, although these smaller areas are less likely to contain air voids.

6 REFERENCES

Hawkins, Duncan. 2004. *Archaeological Desk Based Assessment: Land at St. Mary's Churchyard, Bromley By Bow*. CgMs Consulting.