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Report

HUSKISSON ANGLICAN CHURCH – GPR INVESTIGATION

Date: 30 April 2019
Job Number: GBGA2255
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DISTRIBUTION

Revision	Electronic	Paper	Issued to
Draft	1	0	Steve Bartlett, Bartlett & Associates Pty Limited
1	1	0	Steve Bartlett, Bartlett & Associates Pty Limited
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Etc.			

1 INTRODUCTION

GBG Australia Pty Ltd (GBG) carried out a geophysical investigation using Ground Penetrating Radar (GPR) of 4 sections at the Anglican Church site at 17 Hawke Street, Huskisson, NSW, 2540.

Previous GPR works conducted by Peter Ellsmore & Associates Pty. Ltd. (PEA) at the site were obstructed by shipping containers and timber piles. The objective of the works this report presents was to survey the areas under these obstructions. The survey was to assess the subsurface for anomalies that are consistent with grave shafts and burials.

The work was commissioned by Steve Bartlett of Bartlett & Associates Pty Limited. The geophysical data collection, processing and analysis were undertaken by staff from GBG.

The conclusions drawn represent the best professional opinions of the authors, based on their training and extensive experience in analysis of similar geophysical data.

2 GEOPHYSICAL INVESTIGATION SITE

Huskisson is located approximately 140 km south of the Sydney CBD. The church grounds are approximately 10,000 m² and are bounded by Bowen, Hawke, and Currambene Streets. The areas investigated are summarised in figure 1 below. Areas bounded in red were surveyed previously (report reference GBGA1800 and PEA report). Lines surveyed recently presented in this report shown in green.

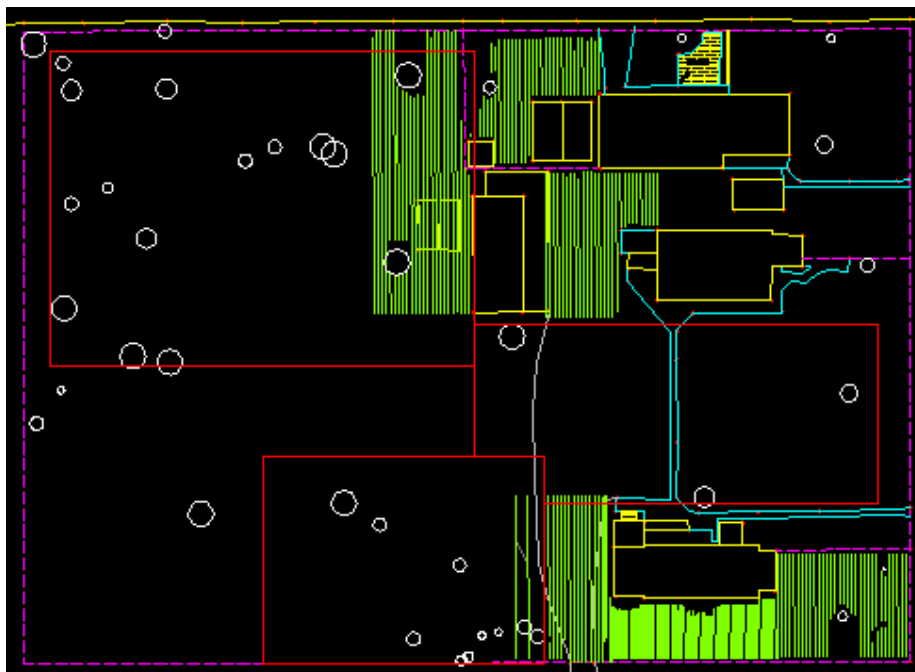


Figure 1. CAD drawing of the Church grounds. Areas surveyed by GBG and PEA previously shown in red. Lines surveyed recently presented in this report shown in green.

3 DATA ACQUISITION

3.1 GPR THEORY AND RATIONALE

Data collection was performed using Ground Penetrating Radar (GPR). GPR is a non-destructive technique that provides reflection profiles of the subsurface. The technique works by pulsing electro-magnetic energy, in the form of radio waves, into the subsurface with a transmitting antenna. This energy propagates through the subsurface material as functions of its electrical properties, which are in turn, are a function of its physical and chemical properties. Reflection of energy occurs at boundaries between media which have contrasting electrical properties such as between disturbed ground and consolidated ground. These reflections are detected by the receiving antenna and converted into electrical signals.

A radargram profile is built up of scans collected along a selected line path. A sample radargram has been selected from the data and is shown in Figure 2 below. Each profile consists of an enhanced radargram that provides subsurface information based on the variations in the Dielectric Constants (the electrical conductivity and resistivity) of materials. The recorded reflections can be analysed in terms of shape, travel time, signal amplitude and phase to provide information about a target's size, depth and orientation in relation to the material around it.

GPR antennae of higher frequency provide higher resolution data but penetrate to shallower depths, whilst lower frequency antennae provide deeper penetration with decreased resolution. The depth of penetration achievable with an antenna of a particular frequency is also dependant on the local subsurface conditions. The GPR method is generally less successful in soils with high clay content due to the clay's high attenuation of radar wave energy. In contrast, clean sands provide a good medium for radar waves to propagate through, with good data often collected under such conditions.

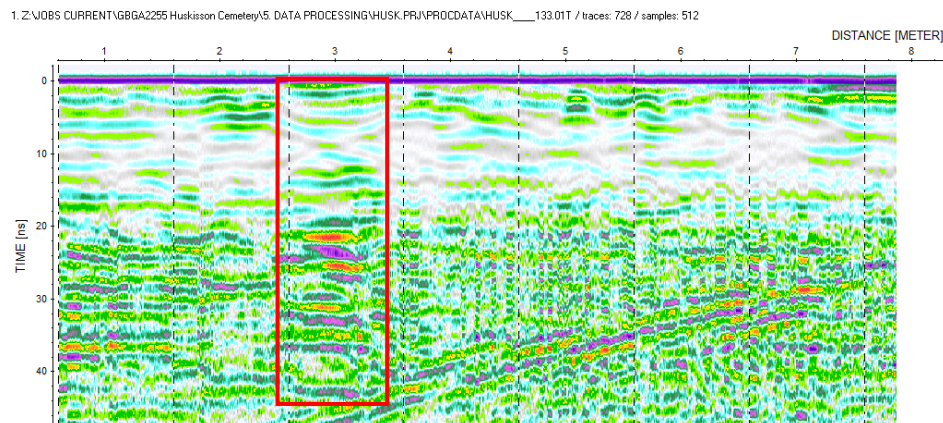


Figure 2: Sample radargram showing suspected grave within the survey area.

GBG Australia has been using GPR for grave detection for 15 years. The GPR method is the optimal method for grave detection over other methods for many reasons including but not limited to the following:

- The data collection speed allows for a relatively high density line spacing ($\leq 0.5\text{m}$) required for detection of graves given their expected dimensions.
- There are many frequencies of Antennae which can be utilised to target specific depths, overcome ground conditions and provide a high resolution data relative to other methods.
- The method provides 2D depth slices allowing for interpretation of the 'shape' of the anomaly and subsequently detection of disturbed ground synonymous with graves as shown in figure 2. Furthermore, interpreting targets between the 2D depth slices allows for determination of shapes and directional trends.

3.2 DATA COLLECTION METHODOLOGY

The data for this investigation was acquired using a GSSI SIR3000 GPR data collection system with a ground coupled antennae. Chainages along the profile line were logged by a calibrated distance measuring device attached to the antenna with an accuracy of better than $\pm 0.5\text{ m}$ every 100 m. The previous investigation trialed both the 400 and 270 MHz antennae at the site, however the 400 MHz antenna was deemed to give the best combination of depth of penetration and resolution. Therefore only the 400 MHz was used on site on this occasion. The survey equipment is shown in Figure 3 below.



Figure 3. A section of the survey area with scan in progress. Tapes were used to ensure correct line separations and directions were achieved.

The GPR data was collected as a series of parallel longitudinal profiles in an approximate north-south direction perpendicular to the expected east-west orientation of the graves. Some sections along the profile lines were not scanned due to the presence of obstacles such as trees. The extent of the survey area, and profile locations are shown in drawing file GBGA2255-01.dwg, which is an amended version of drawing file 'Church site with graves curtilidge.dwg' created by SET Consultants and supplied by Steve Bartlett.

GPR profile lines were collected by pushing the 400 MHz centre-frequency antenna over the ground surface at a constant rate. The GPR system was set to record a two-way-travel time of 47 ns which

equates to an effective depth of investigation of approximately 2.3 m. Data was recorded with 16-bit amplitude resolution, at 512 samples per scan and at a scan rate of 100 scans/m.

The GPR profiles were collected at close line spacing typically at 0.5 m intervals but as close as 0.25m intervals. Closely spaced GPR profile lines provided a higher degree of subsurface target resolution and to ensure a number of profile lines would cross cut any particular grave. This enables the ruling out of point source anomalies such as rocks as potential targets of interest.

Field notes including the line position and the start and end chainages of the GPR profile lines were taken. On-site quality control of the data was achieved in real-time by viewing profiles during acquisition. The profiles were recorded digitally for processing, analysis and interpretation at our Sydney office.

4 GEOPHYSICAL DATA QUALITY AND PROCESSING

The collected data was of moderate quality with limited depth of penetration (approximately 1.2m depth) and low signal to noise ratio. This was principally due to the local subsurface having a moderate clay content which has a high attenuation of radar wave energy. The low signal to noise ratio was partially overcome during processing with filters being applied to the data.

The collected GPR data was processed and analysed using Reflex for Windows Version 8.0 developed by Sandmeier Software. The data processing steps were performed as follows:

- Static correction to the first crossing; set surface reflection interface to zero depth.
- Background removal filter; to eliminate temporally consistent flat noise bands from the whole record, making signals previously covered by this noise visible.
- Move start time and end time; to make all radargrams uniform.
- Combine the 2D files to produce a single 3D image.
- Adjust the colour palette for signal amplitudes, to improve the contrast of phase changes and signal variation.

The typical response from a GPR profile running perpendicular over a grave is a hyperbolic signal of increased amplitude, the peak of which gives the depth to the top of the grave and an indication of the size and width of the grave. With the GPR method it is quite often that features associated with graves are imaged, rather than the graves themselves. This may include depressions in the soil layers above the grave, vertical discontinuities in the soil profile caused by the grave trench and a mottled GPR signal above the grave due to the unconsolidated nature of the fill material.

GPR signals reflected from within a subsurface structure contain a large amount of visual information much relating to the minor variations in the electrical properties of the materials profiled. Consideration was given to the nature and possible cause of the signals recorded by the GPR. The target responses which are consistent with those expected from graves were identified in

the profiles and compared across the complete data set with anomalies that match up across adjacent profiles being joined.

5 RESULTS AND INTERPRETATION

The results of the geophysical investigation carried on the grounds of the Huskisson Anglican Church, have been provided in the following drawings attached in Appendix A of this report:

- GBGA2255-01 – Site Overview
- GBGA2255-02 - Newly Cleared Areas
- GBGA2255-03 - Rectory
- GBGA2255-04 – Church Surrounds

5.1 Newly Cleared Areas

The area to the west of the metal shed (used as the church administration building) was obstructed in previous surveys by shipping containers and general waste. The waste was removed, and the containers relocated prior to the survey in order to survey the ground below them.

The GPR survey found no evidence of graves in this area. A few tree roots were clearly distinguishable in the data and have been plotted on the drawings. The ground below the shipping containers appeared to have been sheltering rabbit burrows and some of these are visible in the data. They were difficult to distinguish from tree roots, but they were too shallow and the wrong length to give a response that could have been interpreted as a grave.

5.2 Rectory

Two areas surrounding the rectory were surveyed. The extent was the backyard of the property, west of the building, and the driveway between the rectory, the church hall and the metal shed. The backyard of the rectory is dominated by a large tree, and all the anomalies seen in that area were consistent in size, depth and shape with tree roots. No evidence of graves was visible.

The driveway area was generally clear. A service runs along the edge of the building and down the fence line and is consistent in the data. This service is plotted as a magenta line on the drawings.

Two anomalies were seen in the data, but their size and shape, and the strength of the anomaly makes them difficult to identify. One long thin anomaly in the data has been confirmed by the church as being a service running to the metal shed on site. One area of this feature that appears to have a wider and stronger response is expected to be the result of the trenching required to place the service.

Another anomaly appears between the church hall and the metal building. This anomaly is wider than the previous one. The strongest response in the anomaly is only 1m square and is quite weak relative to other responses. The church has investigated this anomaly by excavation on the 29th April 2019 and confirmed that the anomaly aligns with an old tree stump that had been burned out after the tree was felled.

5.3 Church Surrounds

The area to the east, south and west of the church building were surveyed. The data here showed tree roots very clearly, such that they were able to be displayed on a 3D cross section of the data (shown in Figure 4 below). On site there were a number of depressions in the ground (marked with a red cross in the drawings). Depressions are common surface expressions of subsurface collapse due to grave stability degrading slightly over time. These depressions aligned with anomalies in the data. One area showed a strong anomaly with significant dipping layers and high amplitudes at depth. This has been reported as an orange rectangle on the drawings to signify a possible grave with a high level of confidence. Surrounding that anomaly were two others. The anomaly that corresponds to the other depression is much weaker and so has been marked as a blue rectangle to show lower confidence in being a grave. The final anomaly is also shown in blue as there was no surface expression and the signal appears very close to a large tree root. It is uncertain what impact the tree root is having on the data here, but the anomaly is of the shape expected from a grave, so it has been plotted.

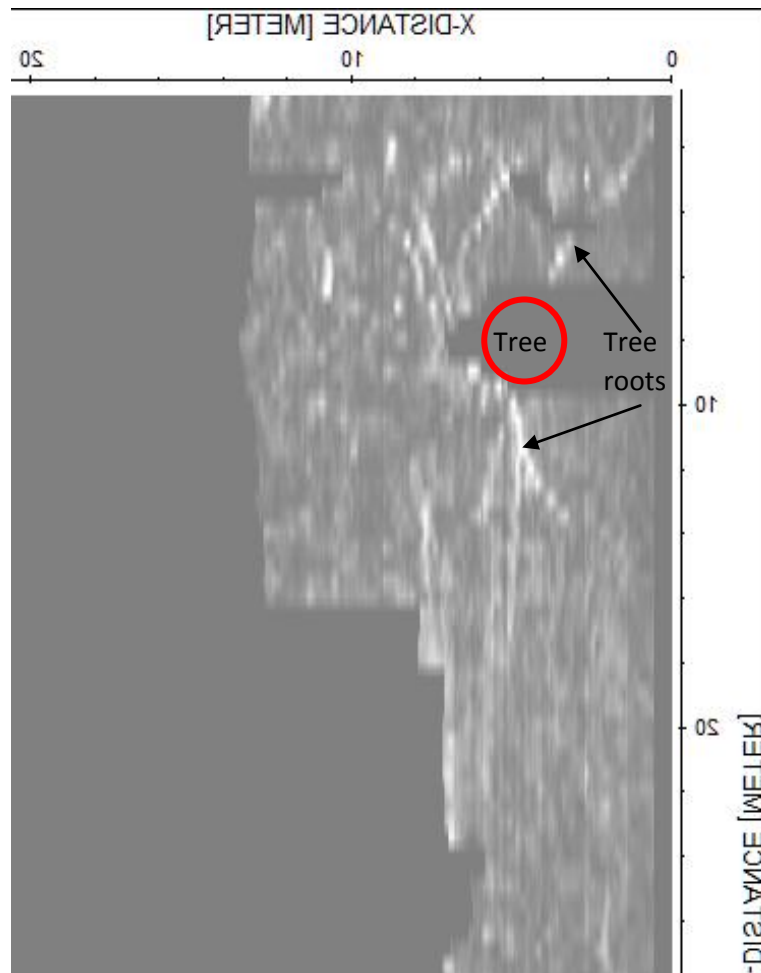


Figure 4: timeslice of the 3D rendering of the data surrounding the church (slice at 150mm) Tree roots are visible in the top section (east to the top).

6 CONCLUSIONS

Four areas of the church property were surveyed.

- The area that had been cleared before surveying showed no evidence of graves.
- The area in the backyard of the rectory showed no evidence of graves
- The driveway area between the rectory, church hall and metal building showed two weak subsurface anomalies. These were subsequently investigated and are not the result of graves.
- The area surrounding the church showed some evidence of one grave being present, and the possibility of another two next to it.

For and on behalf of

GBG Australia



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APPENDIX A. Drawings

- GBGA2255-01 – Site Overview
- GBGA2255-02 - Newly Cleared Areas
- GBGA2255-03 - Rectory
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