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Report

HUSKISSON ANGLICAN CHURCH – GPR INVESTIGATION

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Contents

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1 INTRODUCTION

GBG Australia Pty Ltd (GBG) carried out a geophysical investigation using Ground Penetrating Radar (GPR) of two primary and three secondary sections at the Anglican Church site at 17 Hawke Street, Huskisson, NSW, 2540. The work was undertaken on the 12th to 13th of September 2019.

Previous GPR works on the site have been conducted by Peter Ellsmore & Associates Pty. Ltd. (PEA), and by GBG Australia, with both surveys aiming to determine the presence and location of any anomalies consistent with grave shafts and burials. While previous investigations have had a common aim, infrastructure and debris have constrained the surveyable area over the site. The objective of the current work this report presents, was to survey the areas under two recently removed buildings, and infill areas that were previously beyond the scope of investigation. The aim of 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 author, based on his 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 m^2 and are bounded by Bowen, Hawke, and Currambene Streets. The history of the areas investigated is summarised in Figure 1 below and in drawing GBGA2304-01. Areas bounded in red were surveyed previously (report reference GBGA1800 and PEA report). Lines in grey were surveyed by GBG in April 2019. Green lines represent the survey locations of the data presented in this report.

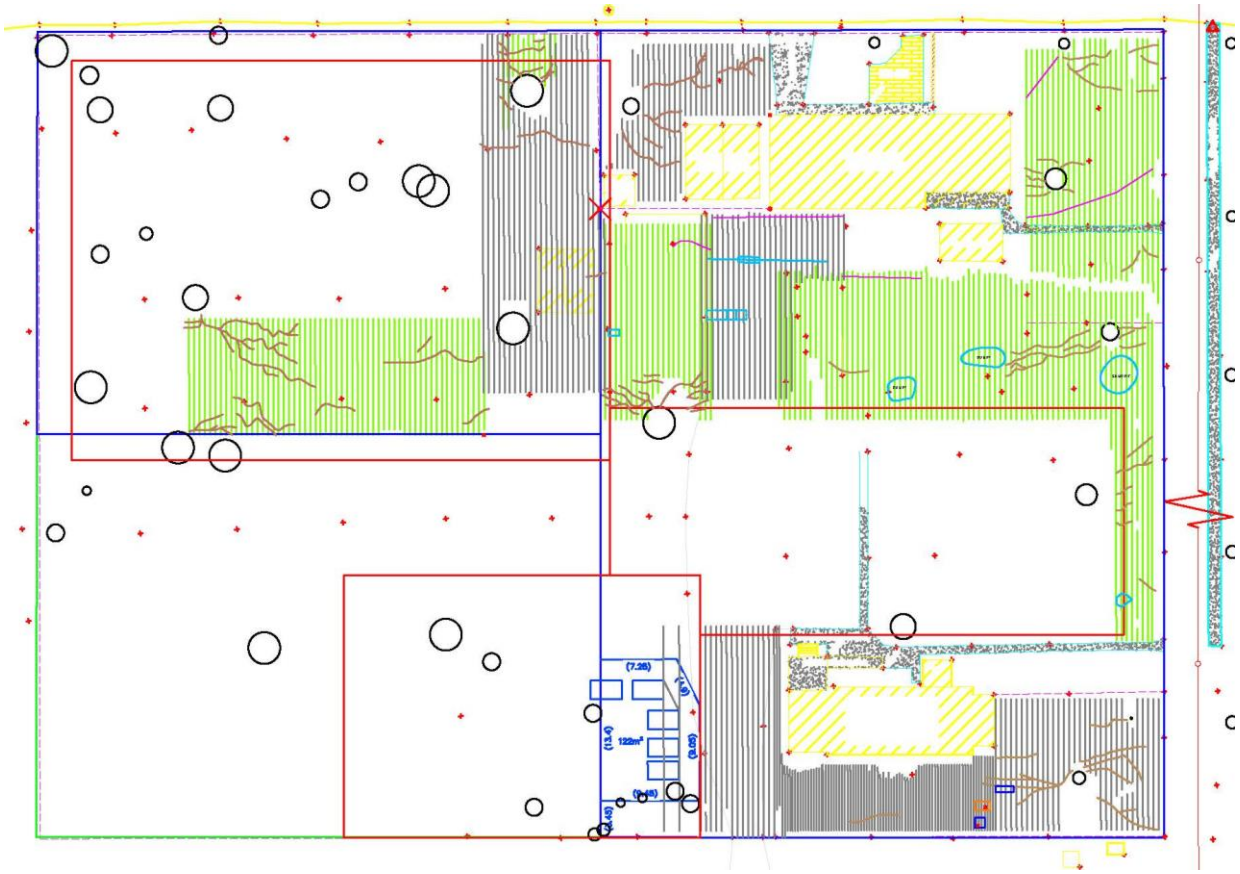

Figure 1: CAD drawing of the Church grounds. Areas surveyed by PEA previously shown in red. Lines. The GBG survey from April 2019 is marked in grey lines, and the surveyed areas presented in this report shown in green.

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 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.

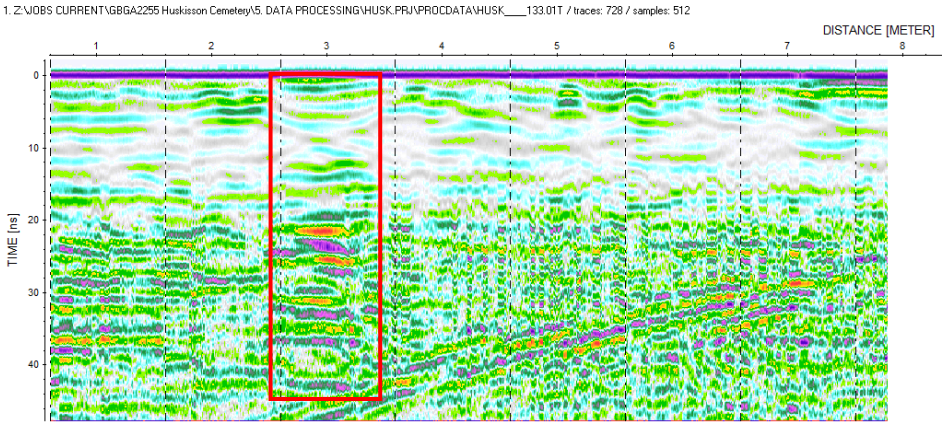

Figure 2: Sample radargram showing a suspected grave from a previous survey.

GBG Australia has been using GPR for grave detection for over 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 (<=0.5m) 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 Cobra GPR data acquisition system with a Dual Frequency antenna. Chainages along the profile line are logged by an odometer, which tracks the chainage and ensures scans per trace are evenly distributed along a profile. Data was acquired using 500MHz and and 900MHz simultaneously, providing both high resolution at the near surface and significant depth to approximately 3.5m below ground level. 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.

Figure 4: An example of obstacles impeding data acquisition during a transect recording.

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 and fences. There were also areas of disturbed ground that interfered with the results such as the sand pit as illustrated in Figure 4 above. The extent of the survey area, and profile locations are shown in drawing file

GBGA2304-01.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 Cobra GPR Dual-Frequency unit over the ground surface at a constant rate. The GPR system was set to record a two-way-travel time of 50 ns and 25 ns for the 500 and 900 MHz frequencies respectively. These times equate to approximate respective depths of 1.5 m and 3.5 m. Data was recorded with 32-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. 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 good depth of penetration (approximately 3.5m depth) and reasonable signal to noise ratio. This was principally due to the local subsurface having a low clay and high sand content which has a low attenuation of radar wave energy.

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:

- Adjust the line locations to ensure accurate chainages.
- Static correction to the first crossing; set surface reflection interface to zero depth.
- Fusion of the two frequency data sets to allow for the optimal depth and resolution in the one file.
- Butterworth Bandpass filter to remove high frequency noise.
- Background removal filter; to eliminate temporally consistent flat noise bands from the whole record, making signals previously obscured by this noise visible.
- 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 with a coffin burial 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 had any resemblance to that 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:

- GBGA2304-01 – Site Overview
- GBGA2304-02 – Metal Shed & Small Area Beside Tree
- GBGA2304-03 – Hall
- GBGA2304-04 – Adjacent Hawke Street
- GBGA2304-05 – Rectory Front Yard
- GBGA2304-06 – Vacant Area

5.1 Metal Shed

The area previously covered by the metal shed (used as the church administration building) was overlain with a reinforced concrete slab until this survey. The survey over the area after its removal showed one small anomaly near the western edge of the area. This anomaly (seen in Figure 5) shows a shallow dip in the near surface (0.3 m) across two lines. The dip has a high amplitude, and that zone of higher amplitude extends to the depth of the record. The signal might be ringing off a shallow conductor sitting just under the surface (perhaps some metal buried under the newly disturbed soil) but there is the possibility that the dipping is because of an anomaly buried deeper (0.6 m). It is recommended that this anomaly be investigated further to determine its cause. Because of the length not exceeding 1 m this anomaly has not been marked as a suspected grave.

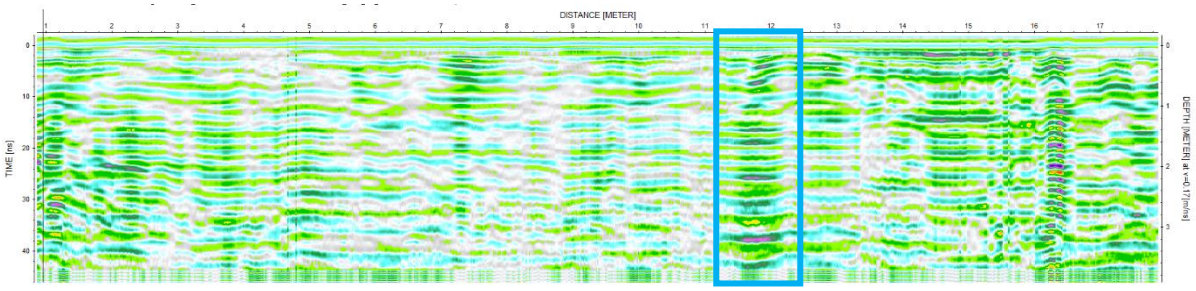

Figure 5:Anomaly at site of metal shed.

5.2 Hall

The old hall that was located on the site has also been removed and the site was surveyed.

Apart from the tree roots discovered on the site, there are a few other anomalies marked. The fist two found under the Hall are large rounded areas. GBG has been informed that during the demolition of the hall, two holes were filled with rubbish and covered over with soil. The exact sites were not known, but the GPR data has found two large areas of high amplitude and dipping layers. These are believed to be these dumps. The anomalies are approximately 1 m deep. The character of these anomalies is unlike what would be expected in a grave, as the amplitudes are very high, and their size is much larger than a grave would be expected to be. The anecdotal evidence also correlates with the rough size, shape and location of the anomalies.

The sandpit has been mentioned above, it was visible in the data as an area of higher amplitude but generally flat shape.

The lines along the front of the property along Hawke Street found one anomaly near the church building (see Figure 6). The anomaly may continue past the extent of the survey and knowing its size might have allowed GBG to narrow the likely cause of this anomaly. As it stands it is an area 1.2 m by at least 1.5 m in size. The GPR response is dipping above a slightly higher amplitude response at ~ 0.8 m. The response is shallower than responses presented as graves in previous reports and also a weaker amplitude, these factors and because of the size being uncertain, this anomaly has not been characterised as a possible grave, but it is recommended to investigate the cause of this anomaly closer. Caution is urged as there is some possibility that this is a service running into the property and only the trench is visible.

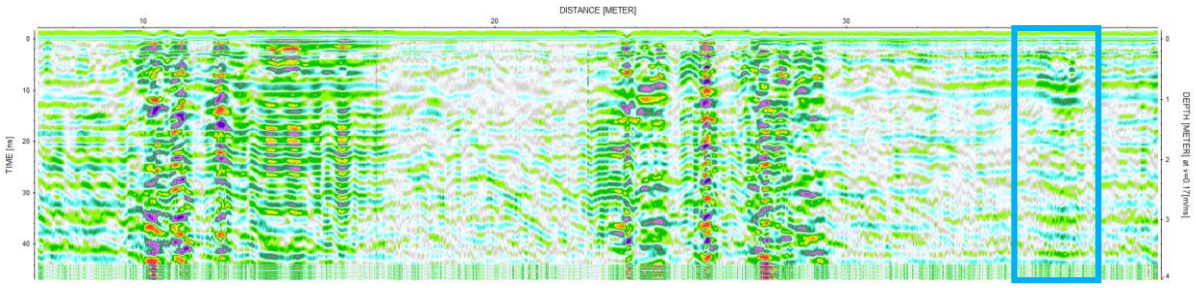

Figure 6: Anomaly near Hawke Street, near church building.

5.3 Rectory Front Yard

The front yard of the rectory was surveyed. The data showed no signs of human disturbance apart from one service running through the yard. This service aligns with the telecommunications pit in the driveway, but also appears to run towards the water meter. Another linear anomaly on the north west of this site seemed too straight to be a tree root, and lines up well with a tap on the corner of the rectory building. There is a chance however that this anomaly is a tree root.

5.4 Small Area Beside Tree

The area behind the rectory and beside the lane was surveyed in April 2019. The scope of that survey was up to the tree adjacent to the lane. 11 lines were surveyed there on this visit to fill in the gap in the area between the tree and the lane. A large number of tree roots were discovered, but nothing else of note.

5.5 Vacant Area

An area of clear ground in the western area of the site was surveyed. This area had a number of paths and remnants of fire pits in it. The GPR data showed that the trees have an extensive root system, but no other significant anomalies were detected.

6 CONCLUSIONS

Approximately 1400 m^2 of the Huskisson Anglican Church property was surveyed using Ground penetrating radar. A number of services were detected, tree roots were found in abundance.

Two anomalies of note were found. Under the site of the metal shed a small, shallow but high amplitude anomaly was detected. Another anomaly was detected near the Hawke Street boundary, to the south – towards the church. This anomaly was larger, deeper and weaker than the first. It is our recommendation that these anomalies be investigated further with ground truthing to determine their cause.

For and on behalf of

GBG Australia

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Geophysicist

APPENDIX A. Drawings

- GBGA2304-01 – Site Overview
- GBGA2304-02 – Metal Shed & Small Area Beside Tree
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