HUNTER GEOPHYSICS

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GEOPHYSICAL SURVEY REPORT

SITE NAME	[redacted] Cemetery
SITE CODE	2014/4
CLIENT	[redacted] Shire Council
SURVEYORS	David Hunter, Shannon Hunter
SURVEY DATES	24-25 November, 2014
REPORT SUBMISSION DATE	15 December 2014
REPORT AUTHOR	David Hunter

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Statement of indemnity

The results and interpretation of the geophysical surveys described herein should not be considered an absolute representation of the underlying soil or archaeological features, but instead as a hypothesis yet to be verified. Confirmation of geophysical interpretations is only possible through careful (preferably archaeological) excavation. Every effort is made to ensure that these risks are minimized, but Hunter Geophysics does not guarantee that the interpretations of geophysical data provided herein are accurate.

While Hunter Geophysics aims to produce accurate interpretations of geophysical surveys, numerous unforeseeable issues may arise that may limit the accuracy of interpretations. These may include unforeseen soil or geological conditions, the presence of rabbit or other animal burrowing, the presence of tree/plant root systems, ploughing, site drainage and interference caused by variations in the Earth's magnetosphere and ionosphere, or interference caused by nearby radio transmitters or solar weather.

Of particular importance is the similar appearance of tree roots and rabbit burrowing with unmarked graves. These factors may have influenced the geophysical data described in this report; areas noted in the 'Results' section and associated figures as indicative of such features should be treated as if they were unmarked graves due to this uncertainty.

Other areas of unknown soil disturbance may be noted in the report. These areas generally do not exhibit the same characteristics as unmarked graves; however, it is possible that these areas actually contain multiple burials, at different depths and on different alignments, which may obscure the graves. Therefore, these areas should also be treated as if they were unmarked graves.

Important notice: the precision of the location of detected features within all survey areas is within 0.2 metres.

This survey was specifically designed for the detection of unmarked graves. The location or nature of any other detected buried feature, especially buried utilities, cannot be guaranteed. The client is advised to employ a buried utility/pipe/cable locator should they require the precise mapping of buried utilities (especially prior to any excavation the client may undertake). Hunter Geophysics can provide this service if required under a separate contract.

Hunter Geophysics can also mark-out detected graves using timber stakes, also under a separate contract.

Please contact Hunter Geophysics directly for a quotation for either of these services.

Front cover image: the cemetery's western fence.

Table of contents

Executive summary

An intensive geophysical survey was undertaken by Hunter Geophysics at the [redacted] Cemetery for the purposes of locating unmarked graves. The geophysical investigation has determined the location of numerous unmarked graves.

Introduction

Hunter Geophysics was commissioned by the [redacted] Shire Council to undertake a geophysical survey covering two areas outside the present fence boundary of the [redacted] Cemetery, [redacted], New South Wales.

Aims

The geophysical survey aimed to determine the location of any unmarked graves within any of the areas surveyed at the [redacted] Cemetery.

Geography and topography

The [redacted] Cemetery is located at the southeastern end of the [redacted] Village, on a small peninusula overlooking [redacted] Road and its bridge. Surveyor [redacted] established four survey control points within the cemetery, upon which the positioning of data provided under this project is based. A hole drilled into a headstone near the centre of the cemetery by Mr [redacted] is located at Map Grid of Australia (MGA) zone [redacted] coordinates [redacted] (using the Geodetic Datum of Australia 1994). Elevation data were not provided for the control points; all elevations noted in this report and any data provided under this project are relative to arbitrary control points established by Hunter Geophysics throughout the survey and do not reflect absolute elevations above mean sea level.

The cemetery is situated on a the side of a sandstone hill, with topography highly variable throughout the survey areas.

Figure 1: aerial photograph and map (courtesy of Google, Inc.) showing the [redacted] Cemetery and surrounds.

Site geology

As per the geological map below, the [redacted] Cemetery is located on a Quarternary sandstone deposit.

Site weather conditions

The geophysical survey was conducted during the period 24-25 November 2014. The site experienced heavy rainfall from late afternoon on 23 November into the early morning of 24 November, with intermittent rain continuing throughout 24 November. The site was thoroughly saturated while the survey was performed.

Figure 2: geological map with the [redacted] Cemetery shown at the centre of the figure (New South Wales Government 1995).

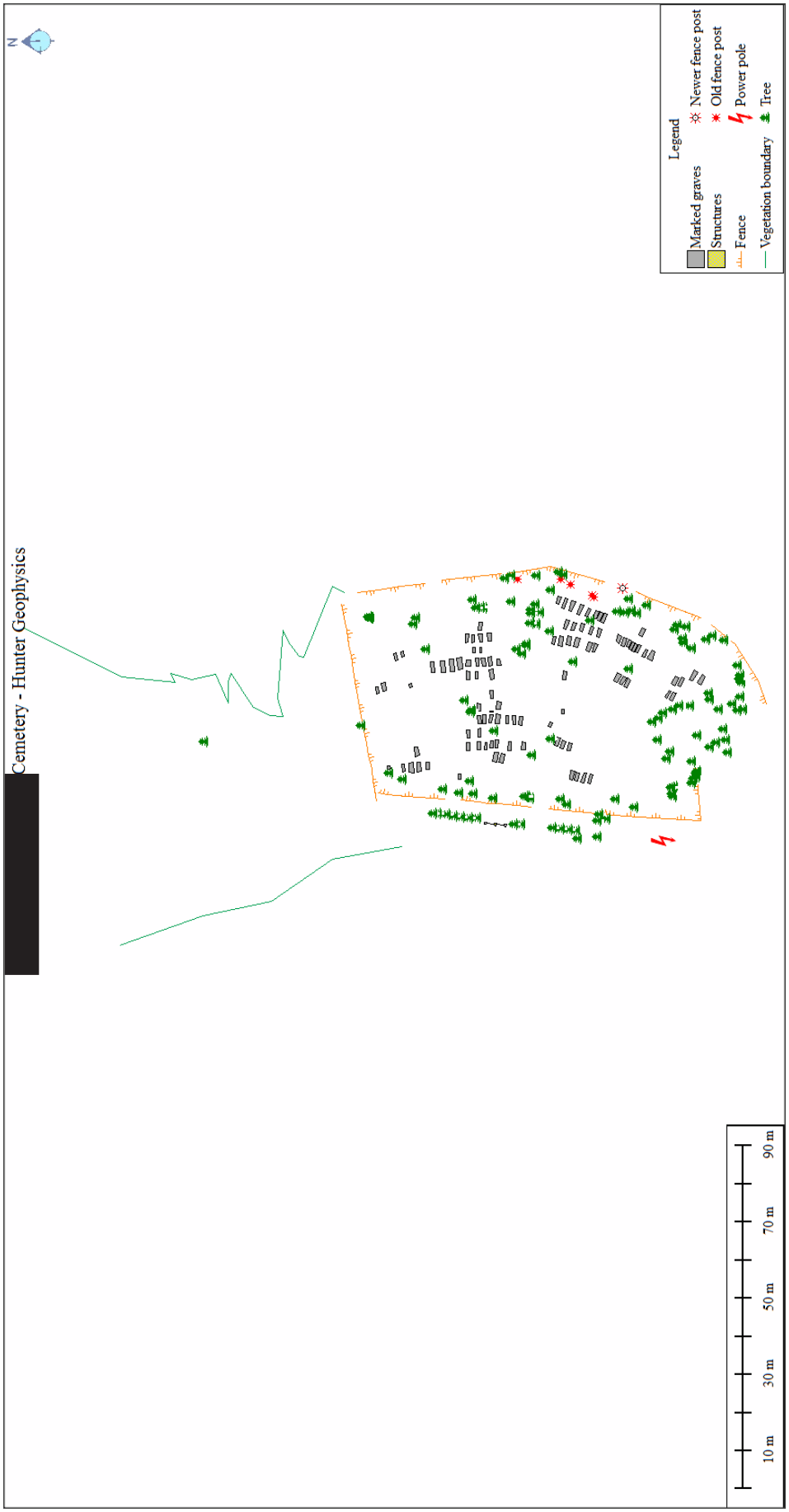

Figure 3: [redacted] Cemetery base map.

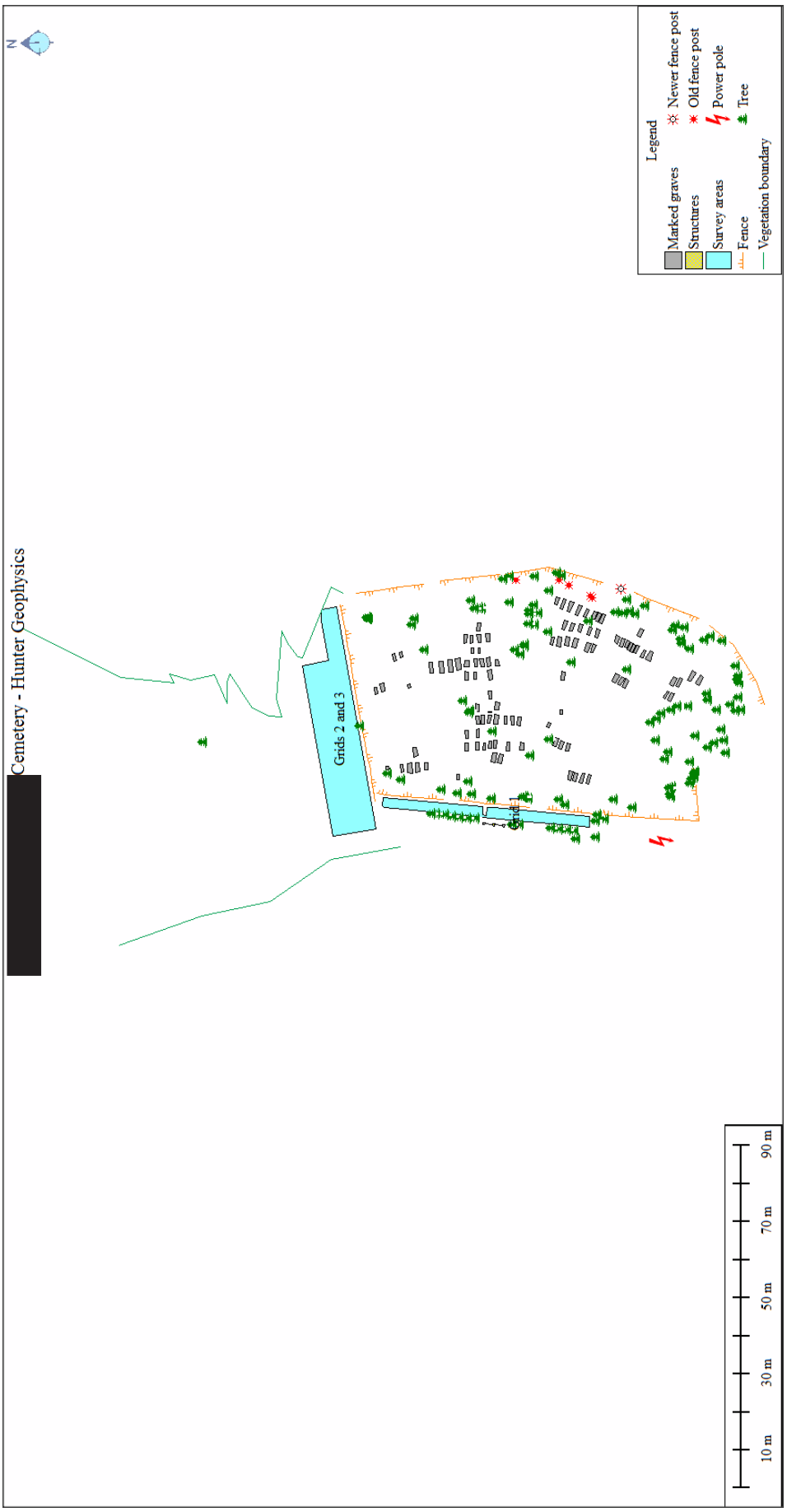

Figure 4: map showing areas covered by the geophysical survey.

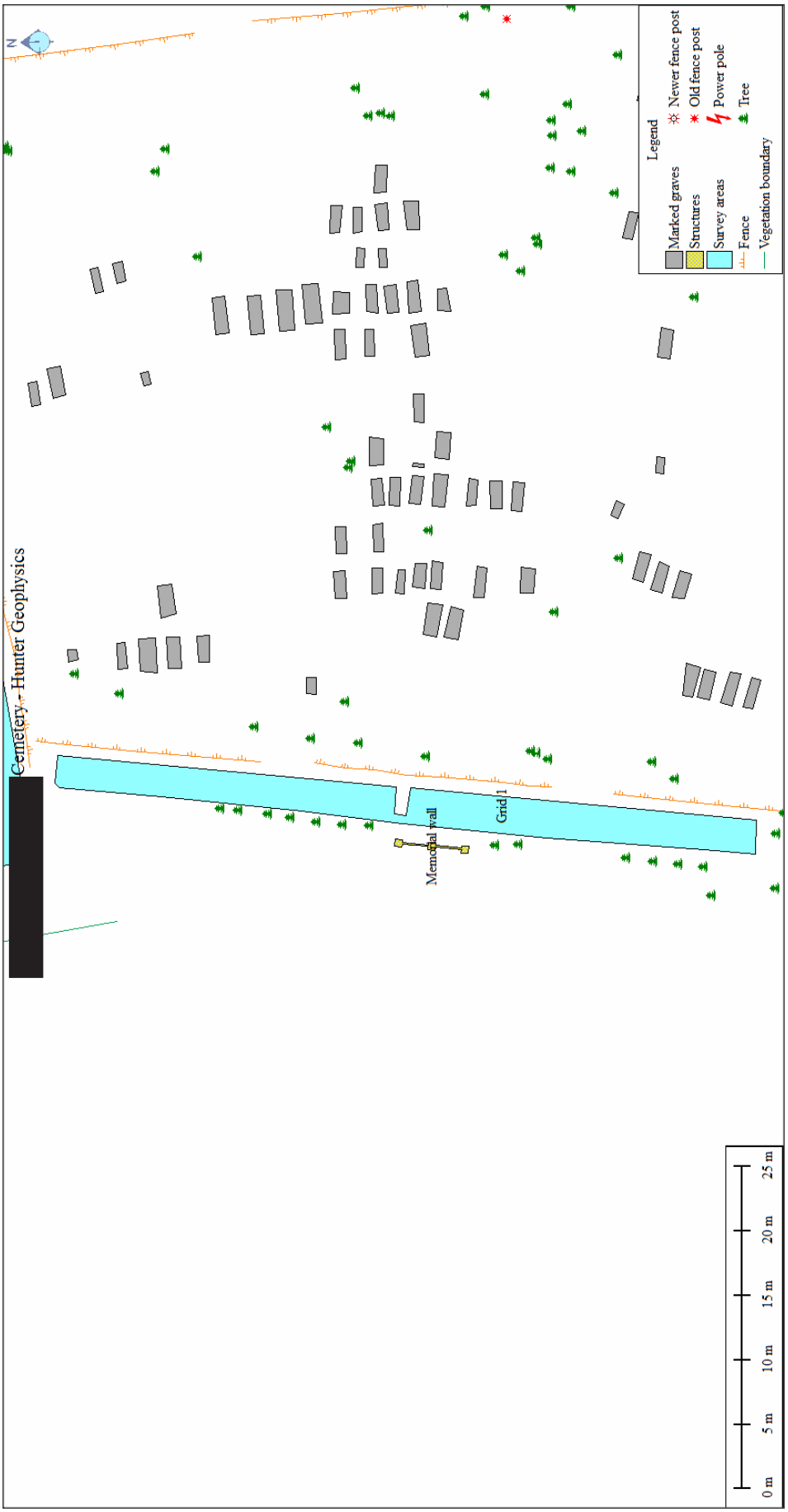

Figure 5: a map showing the location of the western survey area.

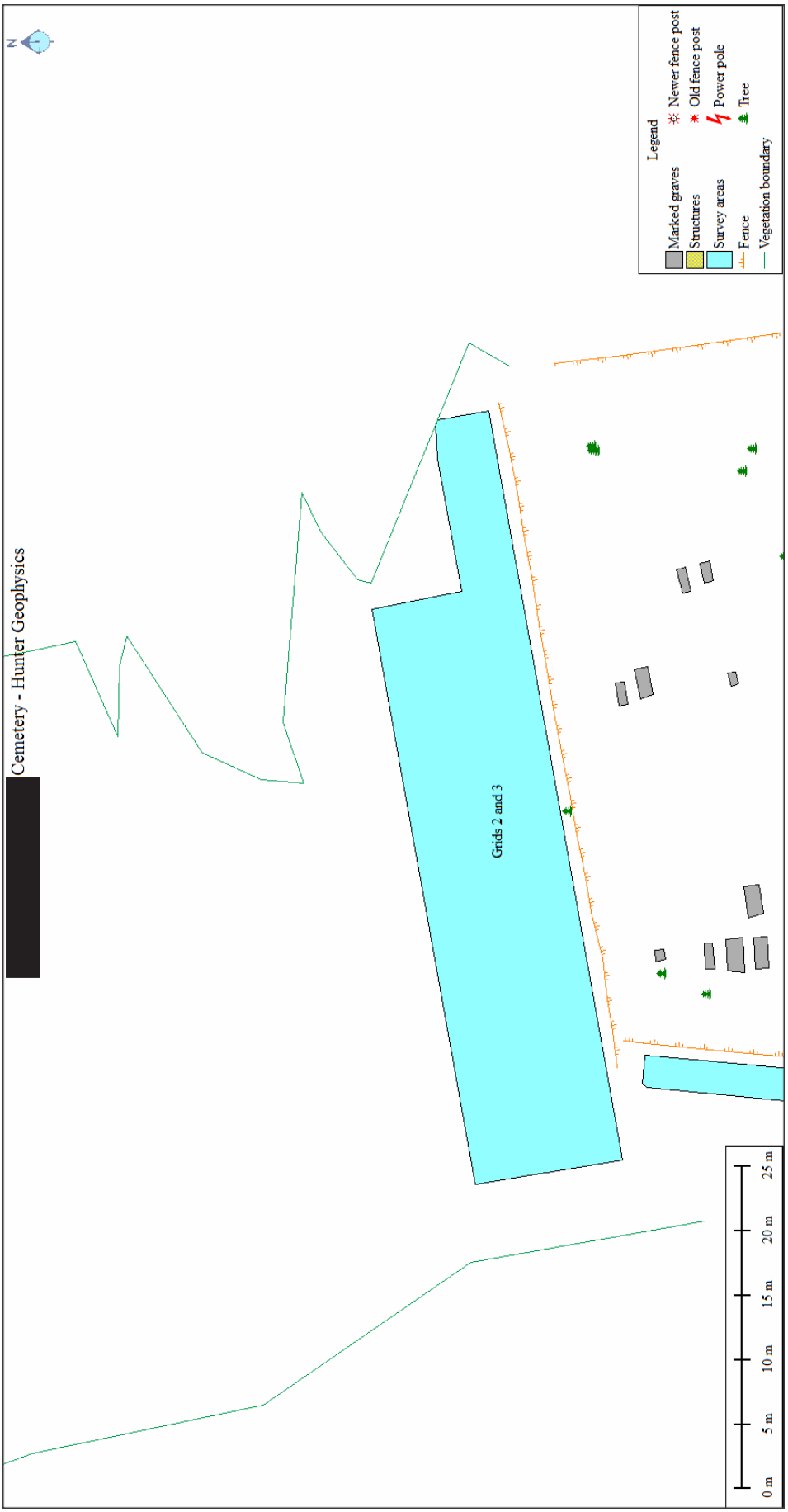

Figure 6: a map showing the location of the northern survey area.

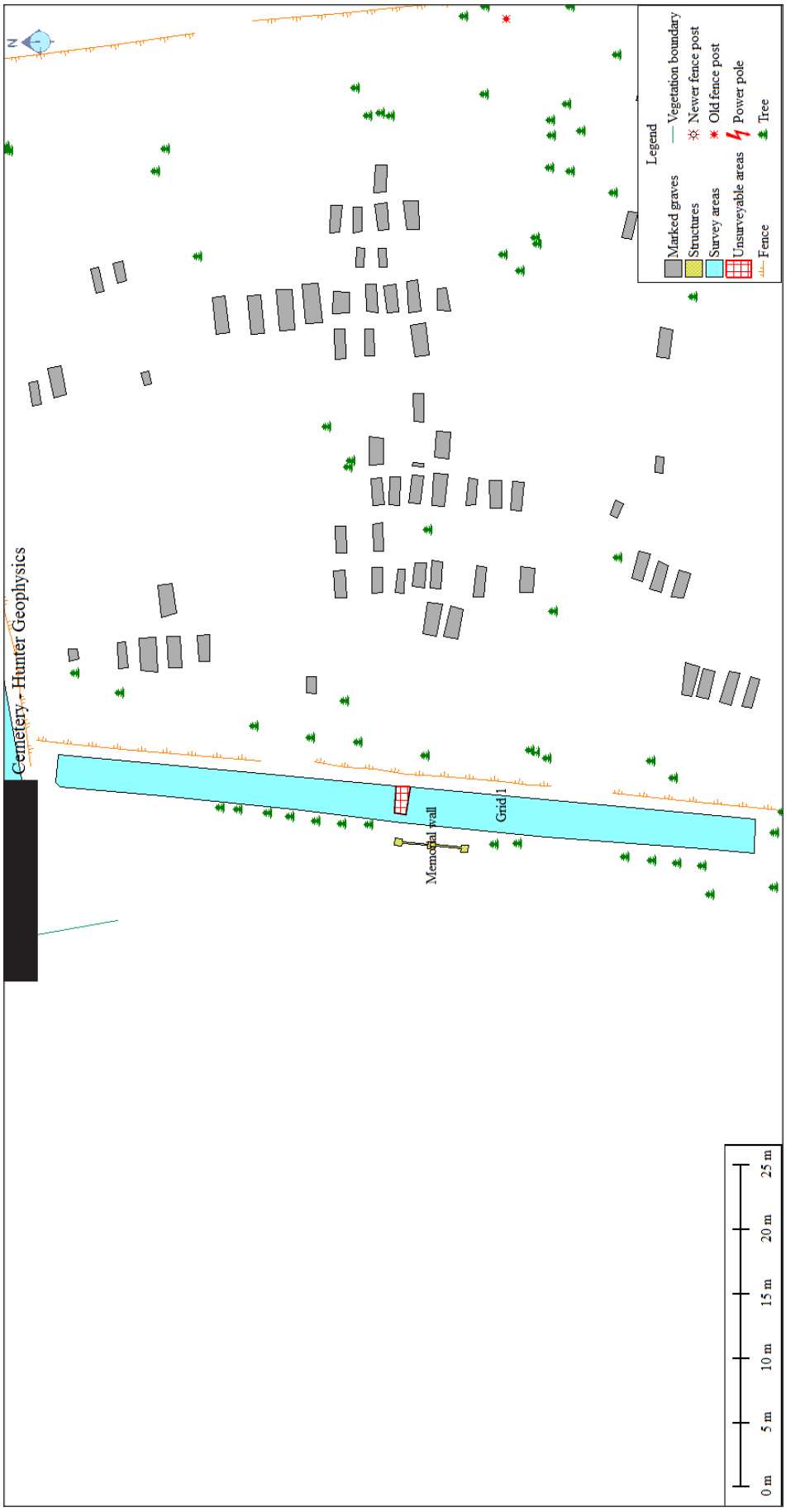

Figure 7: map showing a small area within the western survey area that was not surveyable.

Methodology

Data collection

Upon arrival at the site, the exact location of survey areas was negotiated with the client's representative, [redacted]. Figures 4 to 6 on pages 7 to 9 show the two areas that were covered by the geophysical survey. Due to surface obstacles, a small segment of the western survey area was not surveyed (please refer to Figure 7 on page 10).

Ground-penetrating radar (GPR) data were collected by Hunter Geophysics using a Sensors and Software Noggin Utility SmartCart system and a Noggin antenna with a central transmitting frequency of 250MHz. Survey areas were staked out using a [redacted] robotic total station; the total station was also used to collect geographic data pertaining to each ground-penetrating radar trace (i.e. northing, easting, and relative elevation values were collected for each geophysical measurement) wherever possible.

All survey traverses were staked-out using brick-layers string to ensure complete survey grid coverage. Traverses were spaced at 25cm intervals, with each GPR trace being recorded at 5cm intervals along each traverse. Each GPR trace was recorded with a time-window of 98 nanoseconds, and 245 samples were recorded per trace.

Data were collected automatically by a computer using an odometer wheel calibrated at the beginning of the survey. In this manner, GPR traces are recorded autonomously as the operator pushes the GPR system along the traverse. The data were stored in an internal data logger and downloaded to a computer via the system's memory card.

Data processing

The ground-penetrating radar data were downloaded onto a computer and were arranged into separate folders based on the survey grid number.

The data were processed in the Geophysical Archaeometry Laboratory's GPR-SLICE software. Data processing routines were applied to the raw data in order to remove noise and enhance clarity. The processed radargram data were then sliced horizontally and plotted into XYZ tables.

Image maps ("depth slices") were created from the tables and were used to create a three-dimensional volume of the data, which was then interpreted, using the radargrams and depth slices as an aid. Interpretations were drawn onto the three-dimensional data volume in GPR-SLICE and then exported to DXF files, which were then imported into GIS for inclusion in the site map.

Topographic, antenna roll, and antenna tilt corrections were applied to the geophysical data as required. The specific data processing steps used throughout this project are detailed in the log files accompanying the geophysical data, and are provided on the accompanying USB memory stick. Please refer to page 17 for details.

Reporting, mapping and archiving

The geophysical survey and report follow the recommendations outlined in the English Heritage Guidelines (David 1995) and IFA Paper No. 6 (Gaffney et al. 2002) as a minimum standard. Mapping was performed using a Leica TS15 robotic total station, providing a precision of less than one centimetre in both horizontal and vertical planes. This is of a higher precision than that required by the English Heritage Guidelines and Aboriginal Affairs Victoria requirements (both of which require a half-metre precision as a minimum and are accepted industry standards in their respective jurisdictions).

Due to the very large volume of data collected, all geophysical data is provided in electronic form only (please refer to page 17 for details). Data processing steps are also detailed in the log files accompanying the geophysical data.

Geophysical data, figures and text are archived in-house following the recommendations of the Archaeology Data Service (Schmidt 2001). All data, figures and text are also provided to the client.

Results

Ground-penetrating Radar survey

The ground-penetrating radar survey revealed the location of unmarked graves within the survey areas. A minimum of 40 unmarked graves have been located, along with probable tree roots and other features.

An area immediately outside the northern gate in the western fence has been identified as having vastly different hydrogeological properties to the rest of the site. Given the context of the area, this may indicate that the northern gate has been in use for longer than the southern gate or - at least - has been used more frequently than the southern gate. The change in hydrogeological properties of the soil in this area is likely caused by repeated use of the area as a footpath (i.e. repeated use causing the compaction of the ground surface).

Additionally, other areas of uncertain soil disturbance have been located; these areas are consistent with rabbit burrowing, ‘floating’ boulders within the soil matrix, and plant and tree root systems, as well as the possible stacking of several unmarked graves on top of each other, perhaps in different orientations. Please note that these interpretations are subject to a level of uncertainty as explained on page 2; it is possible that these features may, indeed, be unmarked graves.

The following pages contain maps which show the location of all detected features. An accompanying memory stick contains digital maps and GIS data. Please refer to page 17 for details.

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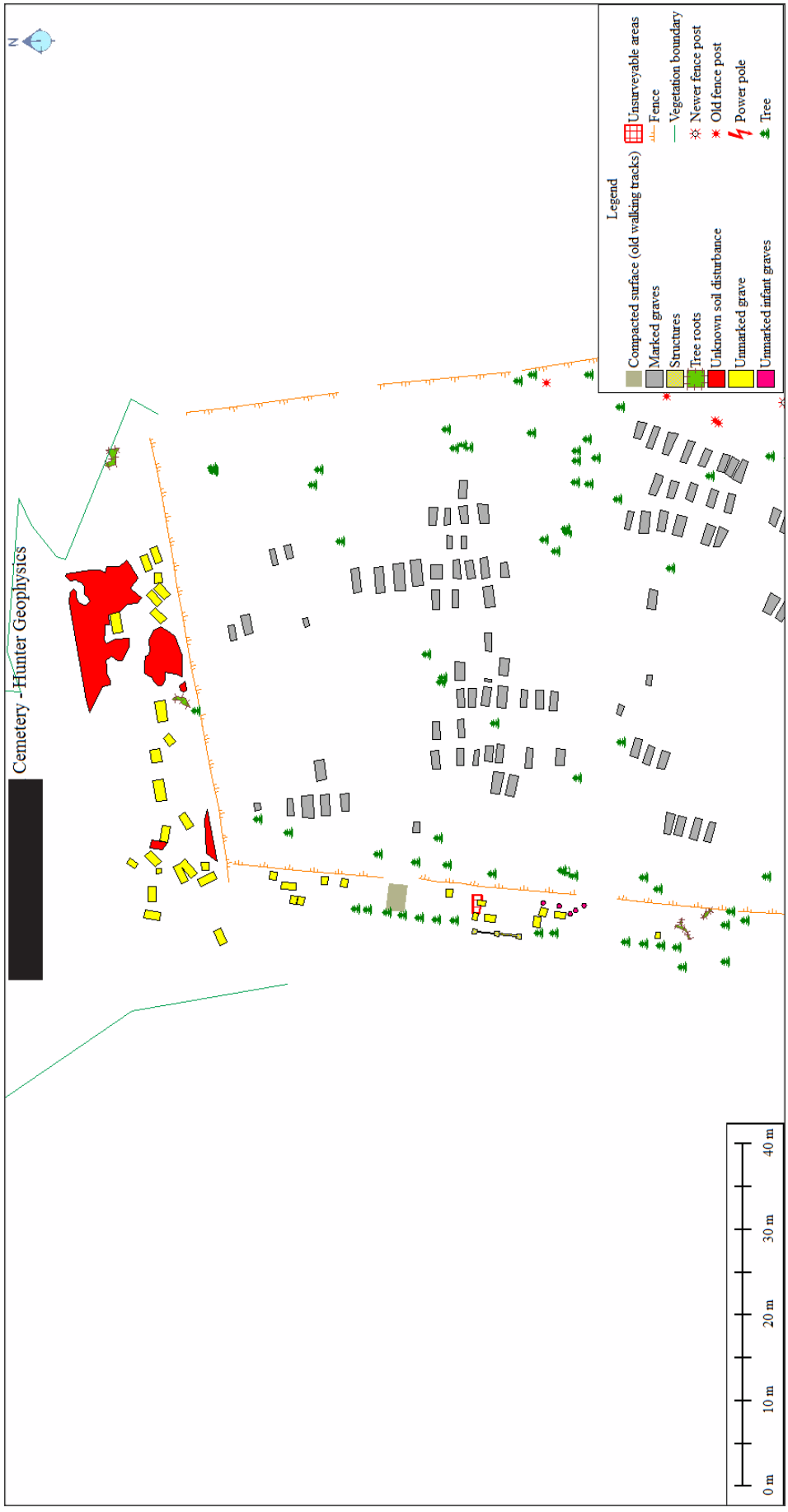

Figure 8: an overview map showing all buried features detected by the performed geophysical survey.

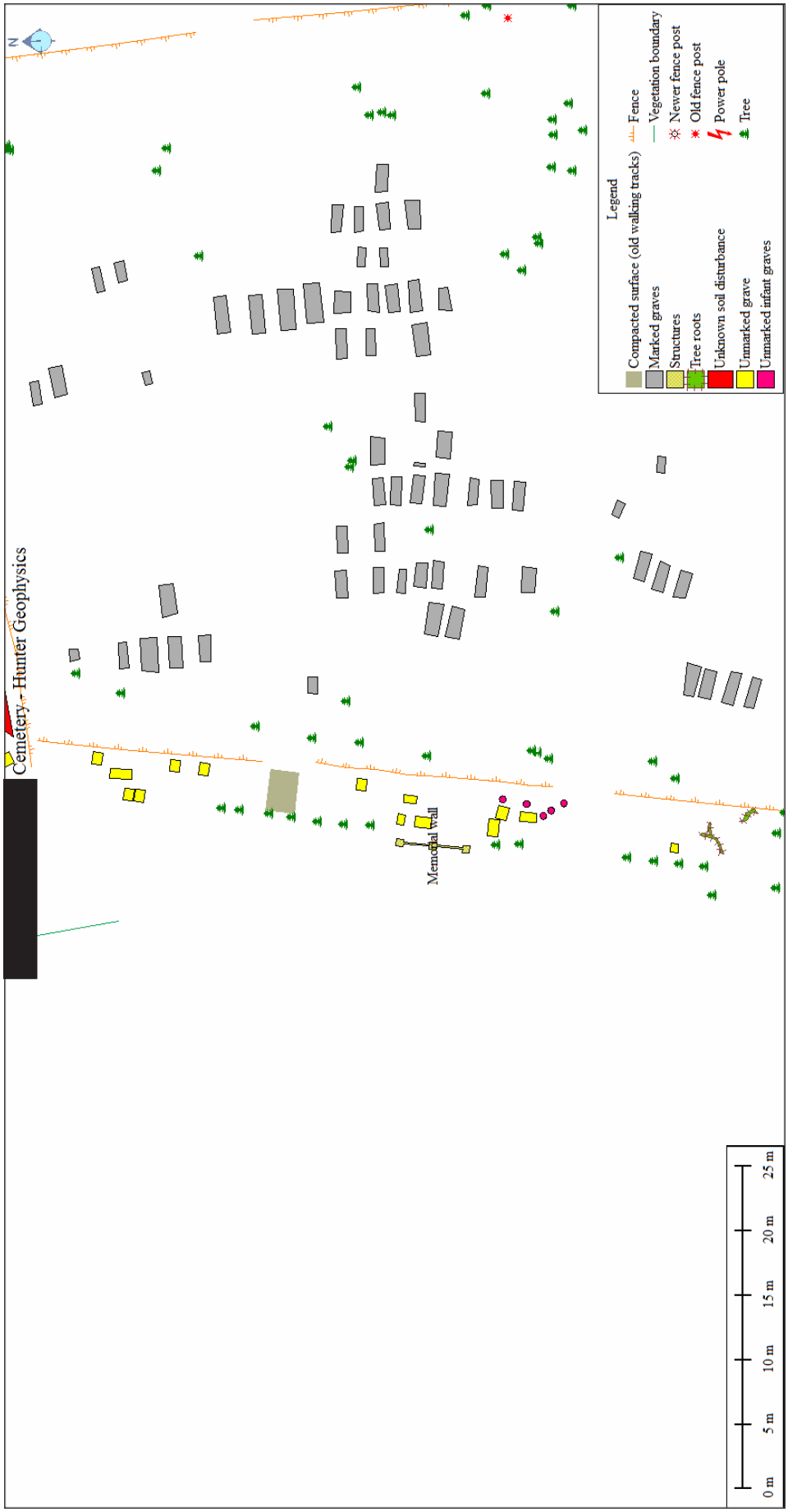

Figure 9: a detailed map showing all buried features detected by the performed geophysical survey in the western survey area.

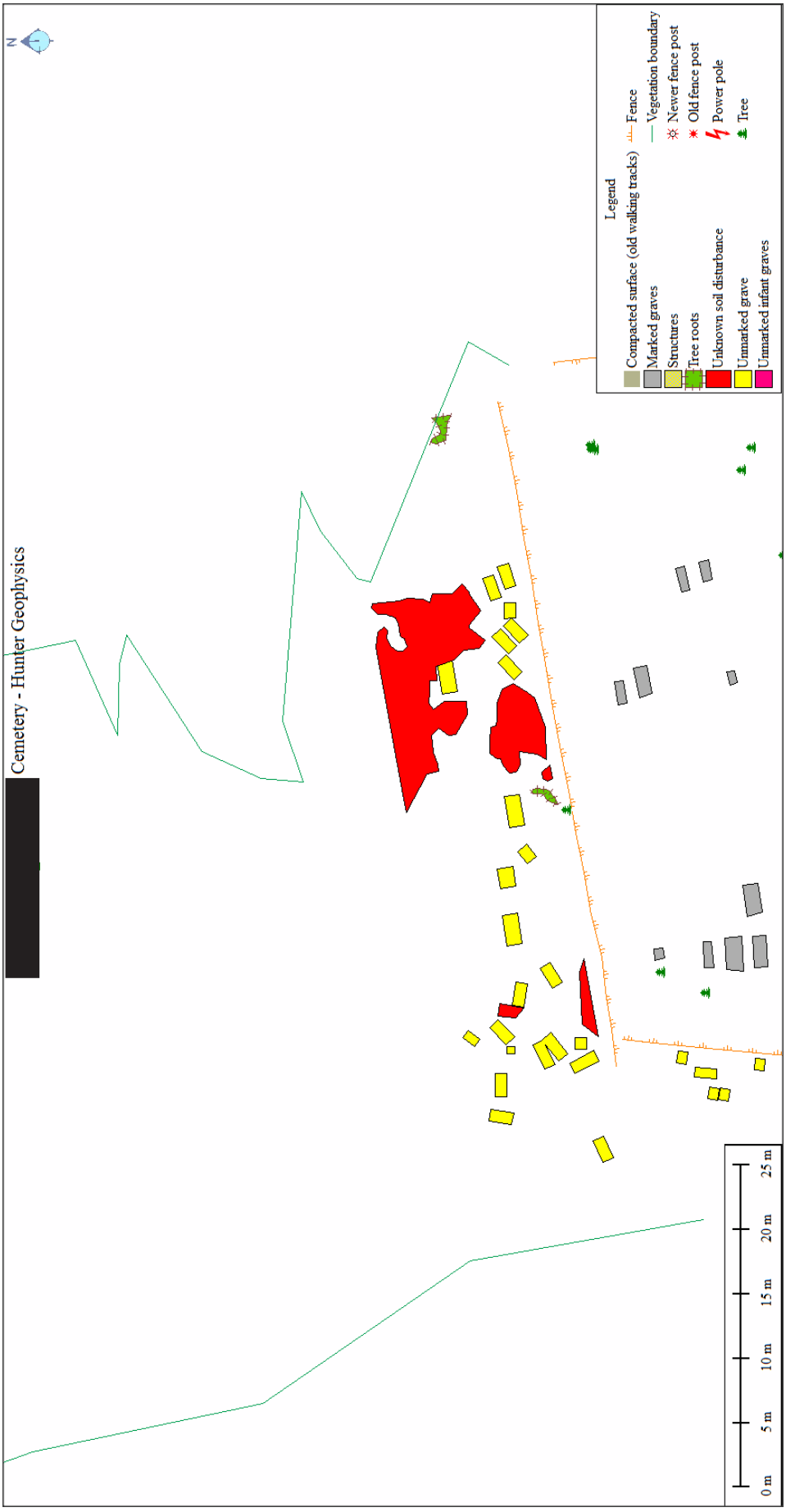

Figure 10: a detailed map showing all buried features detected by the performed geophysical survey in the northern survey area.

Conclusion

Satisfaction of objectives

The geophysical survey undertaken for this project has successfully located the unmarked graves present within the areas searched at the [redacted] Cemetery.

Summary of results

The survey has located at least 40 areas of disturbed soil stratigraphy most likely to be associated with unmarked grave shafts and funerary urn burials and other areas of soil disturbance which may be indicative of unmarked graves or other buried features.

Geophysical research value

[redacted]

Archaeological research value

The geophysical survey detected five small features (most likely unmarked infant burials) just outside the cemetery's western fence. Hunter Geophysics have found this practice to occur "more often than not". It is recommended that surveys of future cemeteries include searches immediately outside cemetery boundaries.

Dissemination

This report was submitted to the [redacted] Shire Council on Monday, 15th December 2014.

Recommendations

Hunter Geophysics recommends the marking out of detected unmarked graves on the ground surface as such will make the results of this survey more readily accessible to those excavating new graves in future. Hunter Geophysics are capable of meeting this recommendation should the client so desire under a separate contract.

Hunter Geophysics also recommends staking out other features detected by this survey and preventing excavations within these areas due to the uncertain nature of these features. Careful archaeological excavation of these uncertain features may also be desirable should the cemetery run out of space for future interments.

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What's on the USB

A Universal Serial Bus v3 (USB) memory stick is included with this report. The following files may be found on the memory stick in digital form:

All figures included in this report.
The report itself in Adobe InDesign v8 format and also in Adobe Portable Document Format (PDF).
Site map file (with a .gmp file extension) for use with Global Mapper v15.1 or later.
All geophysical datasets in their own proprietary digital formats.
XYZ files for each feature detected by the geophysical survey (as requested by surveyor [redacted]).

N.B.: A demonstration version of Global Mapper - which allows viewing of gmp files - is available from the Blue Marble Geographics website at http://www.bluemarblegeo.com/products/global-mapper-download.php.

Should GIS data be required in other formats, please contact Hunter Geophysics directly.

References

DAVID, Andrew, 1995, 'Geophysical Survey in Archaeological Field Evaluation: Research and Professional Services Guidelines', No. 1. English Heritage.

GAFFNEY, Chris, GATER, John. and OVENDEN, Susan, 2002, 'The use of Geophysical Techniques in Archaeological Evaluations', IfA Paper No. 6. Institute for Archaeologists.

NEW SOUTH WALES GOVERNMENT, 'The [redacted] Australia 1:250,000 geological map' (accessed via [redacted] on 11th April 2014), published by the Department of Mineral Resources, 1995.

SCHMIDT, Armin, 2001, 'Geophysical Data in Archaeology: A Guide to Good Practice.' Archaeology Data Service, Oxford, Oxbow.

Acknowledgments

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Shannon Hunter

Report: David Hunter

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