HUNTER GEOPHYSICS

Specialists in unmarked grave detection and shallow sub-surface geophysics

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GEOPHYSICAL SURVEY REPORT

SITE NAME	[redacted] Cemetery
HUNTER GEOPHYSICS SITE CODE	2014/8
CLIENT	[redacted]
SURVEYORS	David Hunter, Shannon Hunter
SURVEY DATES	8-10 November, 2014
REPORT SUBMISSION DATE	5th January, 2015
REPORT AUTHOR	David Hunter
HERITAGE VICTORIA ARCHAEOLOGY REPORT NUMBER	[redacted]

Copyright notice

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 are expected to 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 are 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.

Please note that the interpretations of geophysical data in areas subjected to the "scanning" method (the locations of which are noted in the GIS data in the accompanying USB memory stick) may be erroneous due to the experimental nature of this method. Hunter Geophysics cannot guarantee that all unmarked graves in these areas have been detected; archaeological test excavations of these areas is recommended.

Front cover image: monument section in the eastern area of the cemetery, looking south from the entrance gate.

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 were commissioned by the [redacted] to undertake a geophysical survey covering the majority of the [redacted] Cemetery, [town], Victoria.

Aims

The geophysical survey was requested to determine the location of any unmarked graves within specifed survey areas at the [redacted] Cemetery.

Geography and topography

The [redacted] Cemetery is located southwest of the intersection of [redacted]. The cemetery is situated on a volcanic plain; topographic corrections of geophysical data were not required.

Site geology

Please refer to the geological map on page 5. The [redacted] Cemetery is located on the Newer Quarternary Volcanics, a basalt plain formed during the Quarternary era. The site features a clay soil derived from the basalt bedrock. The client advised that 'floating' basalt boulders were observed within the soil matrix during excavation of graves in the past.

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

Site weather conditions

The geophysical survey was conducted on 8-10 November, 2014. The Bureau of Meteorology records the following weather data for [redacted], a nearby town considered indicative of weather at the site:

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)
8th November	15.5	36.0	0
9th November	11.5	[data missing, ~23deg]	0.6
10th November	11	20.2	0

While no mosaic errors are expected to occur in geophysical data, survey areas were processed and interpreted individually rather than as a whole in order to prevent any degradation in data due to variations in soil moisture due to weather.

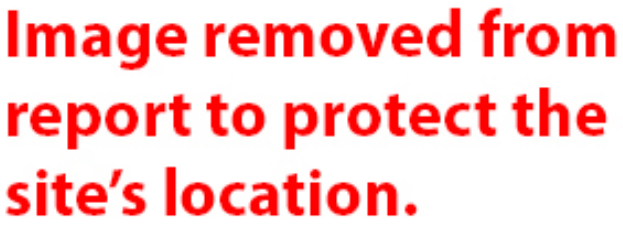

Figure 2: geological map with the approximate location of the site circled in black.

Geological map © State of Victoria, Department of Environment and Primary Industries 1997. Reproduced with permission.

Methodology

Data collection

The client requested specific areas to be covered by the geophysical survey (as seen in figure 3); some areas were not surveyable. Figures 5, 7, and 9 show the areas that were actually covered by the geophysical survey.

A series of trees, large tree stumps, and shrubs were present in an area to the north of Grid 2/3, rendering the area unsurveyable. However, even if the area was cleared, a survey in this area would have been ineffective; the high density of tree roots below the ground, coupled with the severe topographic effect of ripping out tree roots and stumps, would have prevented the successful collection of geophysical data in this area. The same applies for a small area within Grid 8. Areas within grids 12 and 13 were unsurveyable due to the presence of nearby tree canopy and unusually tall headstones, which prevented the successful operation of GPS/GNSS equipment in these areas.

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 Topcon GR-3 RTK GNSS receiver and/or a Leica TS-15 robotic total station; both the RTK GNSS receiver and the robotic total station were used to collect geographic data pertaining to each ground-penetrating radar trace (i.e. latitude, longitude and elevation values were collected for each geophysical measurement) where sufficient satellite coverage or line-of-sight was 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.

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 surveyor pushes the GPR system along the traverse. The data were stored in an internal data logger and downloaded to a field computer via the system's memory card.

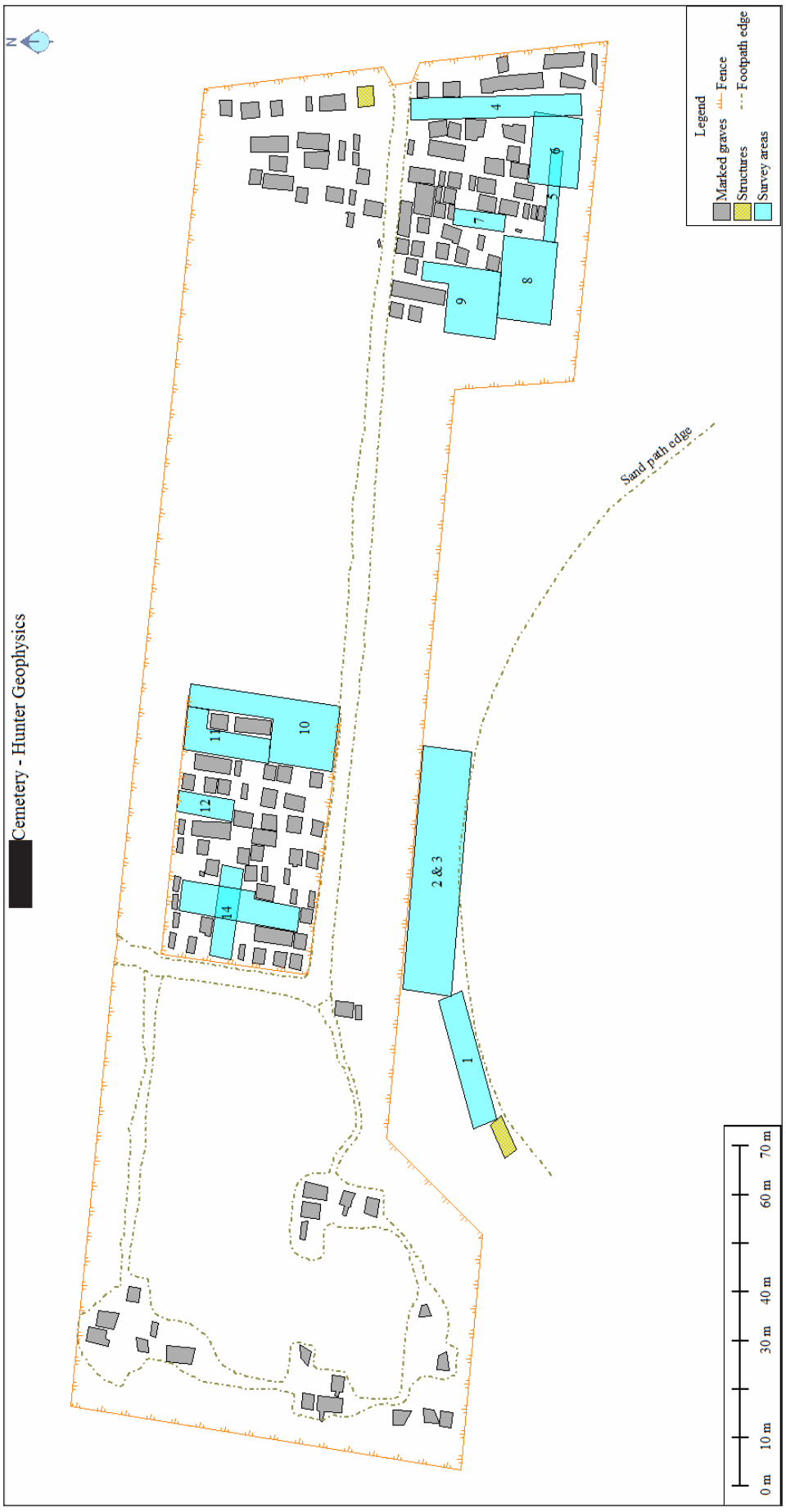

Figure 3: site map showing the location of all survey grids (in blue).

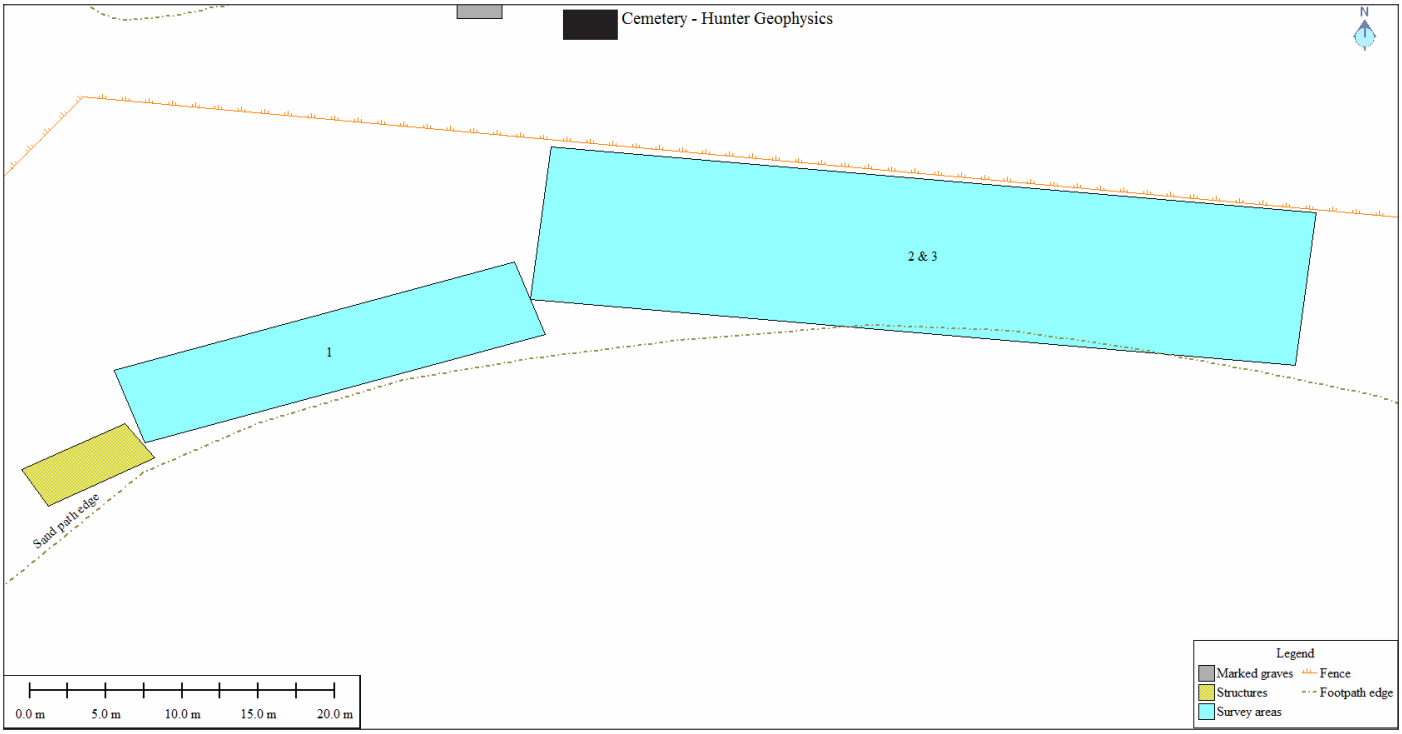

Figure 4: map showing the location of survey grids 1, 2, and 3.

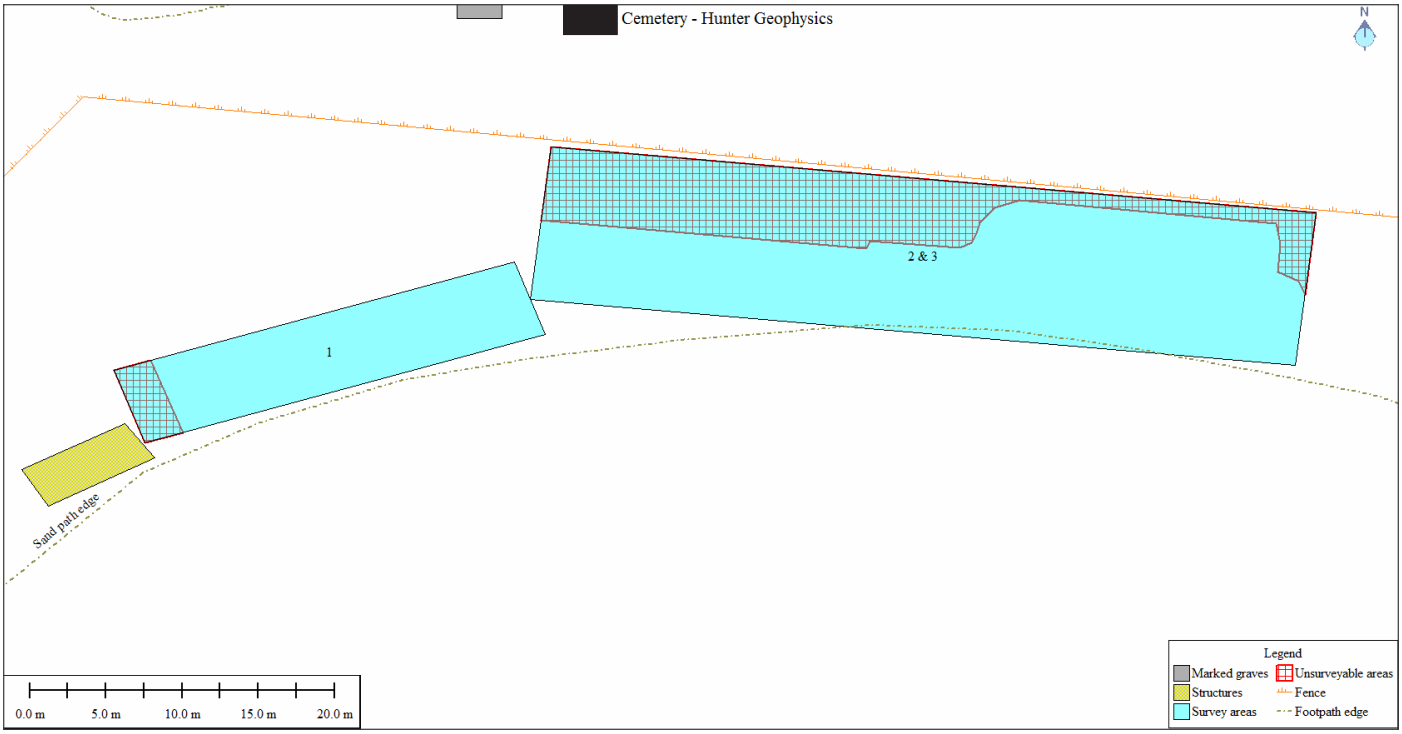

Figure 5: map showing unsurveyable areas within survey grids 1, 2, and 3.

Figure 6: map showing the location of survey grids 4 to 9.

Figure 7: map showing unsurveyable areas within survey grids 4 to 9.

Figure 8: map showing the location of survey grids 10 to 14.

Figure 9: map showing unsurveyable areas within survey grids 10 to 14.

Data processing

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

Please refer to figures 3, 4, 6, and 8 on the previous pages, or to the GIS data on the accompanying USB memory stick (refer to page page 18), for a map showing where each survey grid was located.

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.

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 Topcon GR-3 real-time kinematic global navigation satellite system (RTK GNSS), or a Leica TS-15 robotic total station, providing a precision of less than one centimetre in the horizontal plane, and less than two centimetres in the vertical plane. 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).

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 and are submitted to Heritage Victoria for archival.

Results

Ground-penetrating Radar survey

The ground-penetrating radar survey revealed the location of unmarked graves within the survey areas. A minimum of 110 unmarked graves have been located. 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 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 for use by the client's surveyors. Please refer to page page 18 for details.

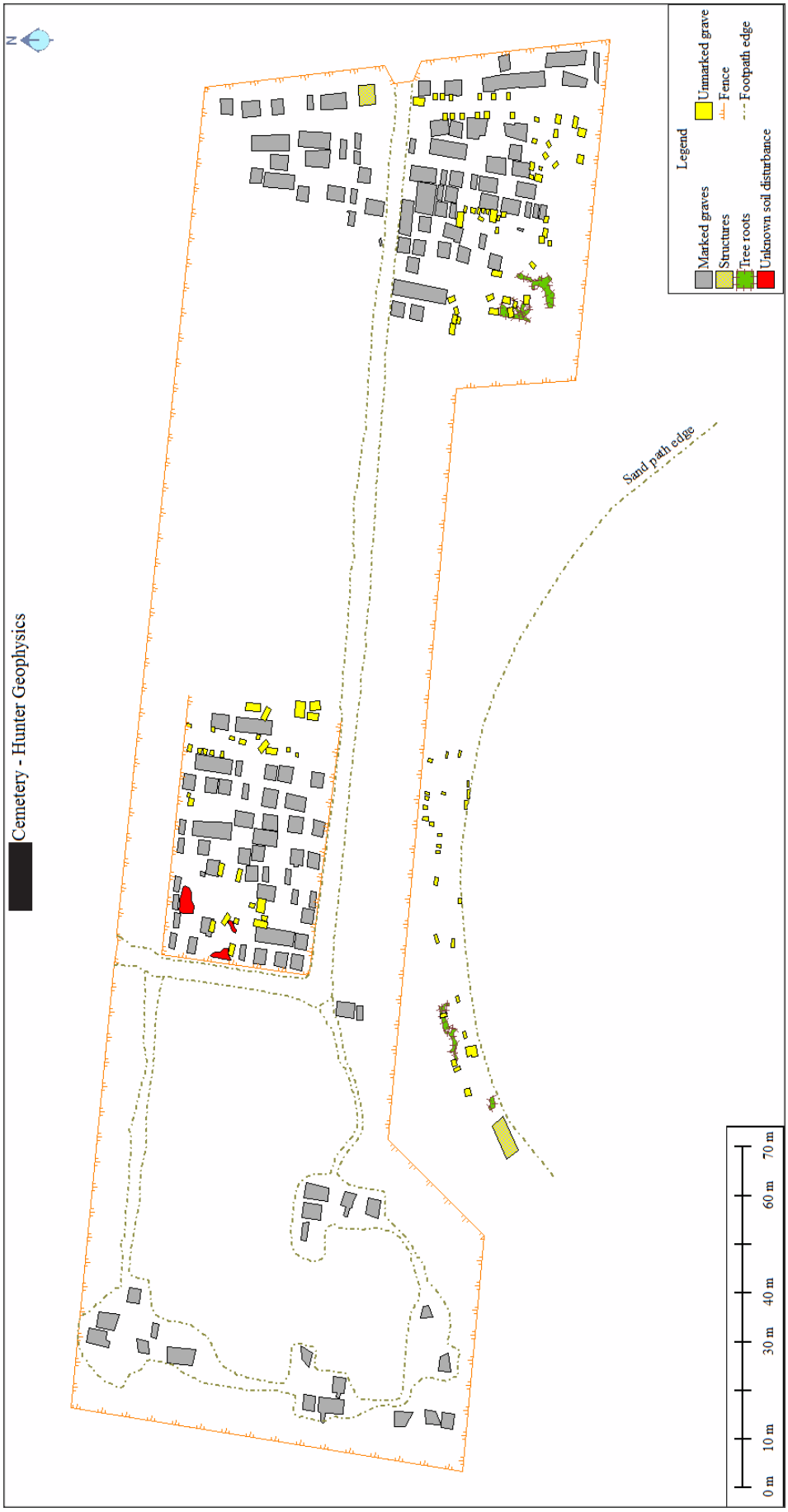

Figure 10: map showing all detected features.

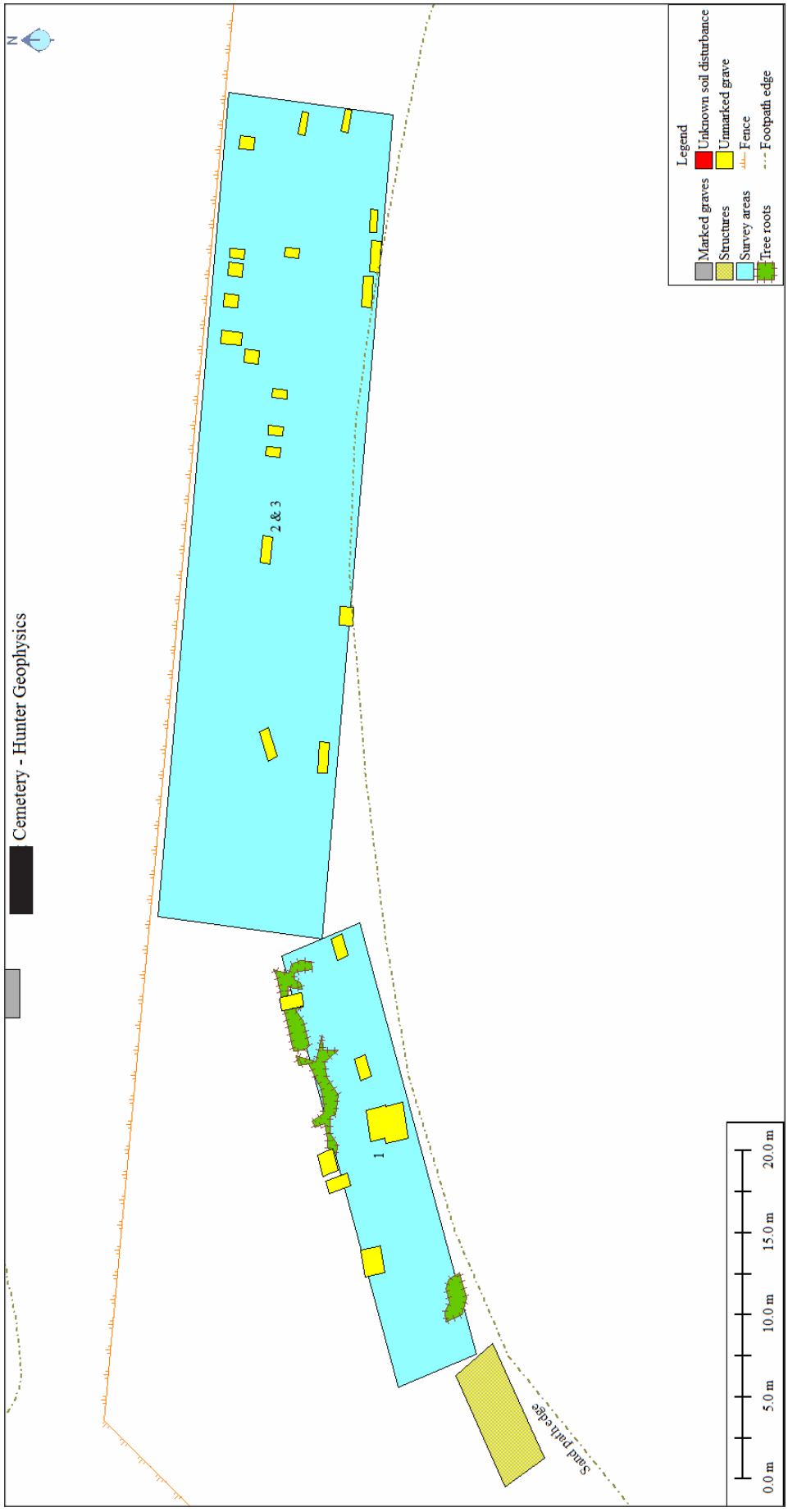

Figure 11: map showing all detected features within survey grids 1, 2, and 3.

Figure 12: map showing all detected features within survey grids 4 to 9.

Figure 13: map showing all detected features within survey grids 10 to 14.

Acknowledgments

Fieldwork: David Hunter
Shannon Hunter

Report: David Hunter

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 (as defined in figure 3 on page 7).

Summary of results

The survey has located at least 110 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]

Dissemination

This report was submitted to the [redacted] in January 2015.

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.

Based on earlier surveys by Hunter Geophysics at other cemeteries (refer to Hunter Geophysics report codes 2014/2, 2014/4 and 2014/7), and due to the detection of unmarked graves outside the cemetery fence at the [redacted] Cemetery, it is recommended that areas outside the cemetery boundary - such as the nature strip on [redacted] Road and [redacted] Street, and the cricket oval to the south of the cemetery - be subjected to intensive geophysical surveys as well, in order to ensure those areas do not contain unmarked graves.

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.
ESRI shapefiles for each feature detected by the geophysical survey.

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

BUREAU OF METEOROLOGY, 2014, '[redacted], Victoria - November 2014 Daily Weather Observations' (accessed via [redacted URL] on 29th December 2014).

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.

GEOLOGICAL SURVEY OF VICTORIA, '1:250,000 Geological Map Series: [redacted], Australia - [redacted]' (accessed via [redacted URL] on 16th February 2012), 2nd edition, published by the Department of Natural Resources and Environment, May 1997. Copyright currently held by the Department of Environment and Primary Industries.

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

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