ENVIRONMENTAL CONSULTING

GROUND PENETRATING RADAR GRAVE SCANNING REPORT

Hardekraaltjie Cemetery

June 2024

SEC REFERENCE NUMBER: G19105

PO Box 30134, Tokai, 7966
Telephone: 021 712 5060
Email: info@environmentalconsultants.co.za

Suite 401, Tokai Village Centre, 2 Burchell Road, Tokai, 7945
Email: info@environmentalconsultants.co.za
Directors: Adrian Sillito (Managing) & Diane Sillito

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1. Scope & Summary of Work Completed

Sillito Environmental Consulting (Pty) Ltd (SEC) was requested by Stellenbosch University (SUN) to submit a methodology and cost proposal to conduct a Ground Penetrating Radar survey at the Hardekraaltjie cemetery, located within the Tygerberg Hospital complex in Bellville. The aim of the project was primarily to screen the area for unmarked graves; to identify these; and to create a report of the findings. This would include a CAD drawing of the locations of the identified grave target locations. This was subsequently approved by SUN, and the project was completed.

The site covers an area of approximately 2.33 Hectares and currently comprises of sports fields and a garden area with some trees. This area according to anecdotal information for Stellenbosch Municipality may have been used for informal graves in the past.

Approximately 0.79 Hectares of the target area could not be traversed due to dense vegetation/trees making access problematic and a total area of 1.54 Hectares (15 400 m^2) was actually scanned.

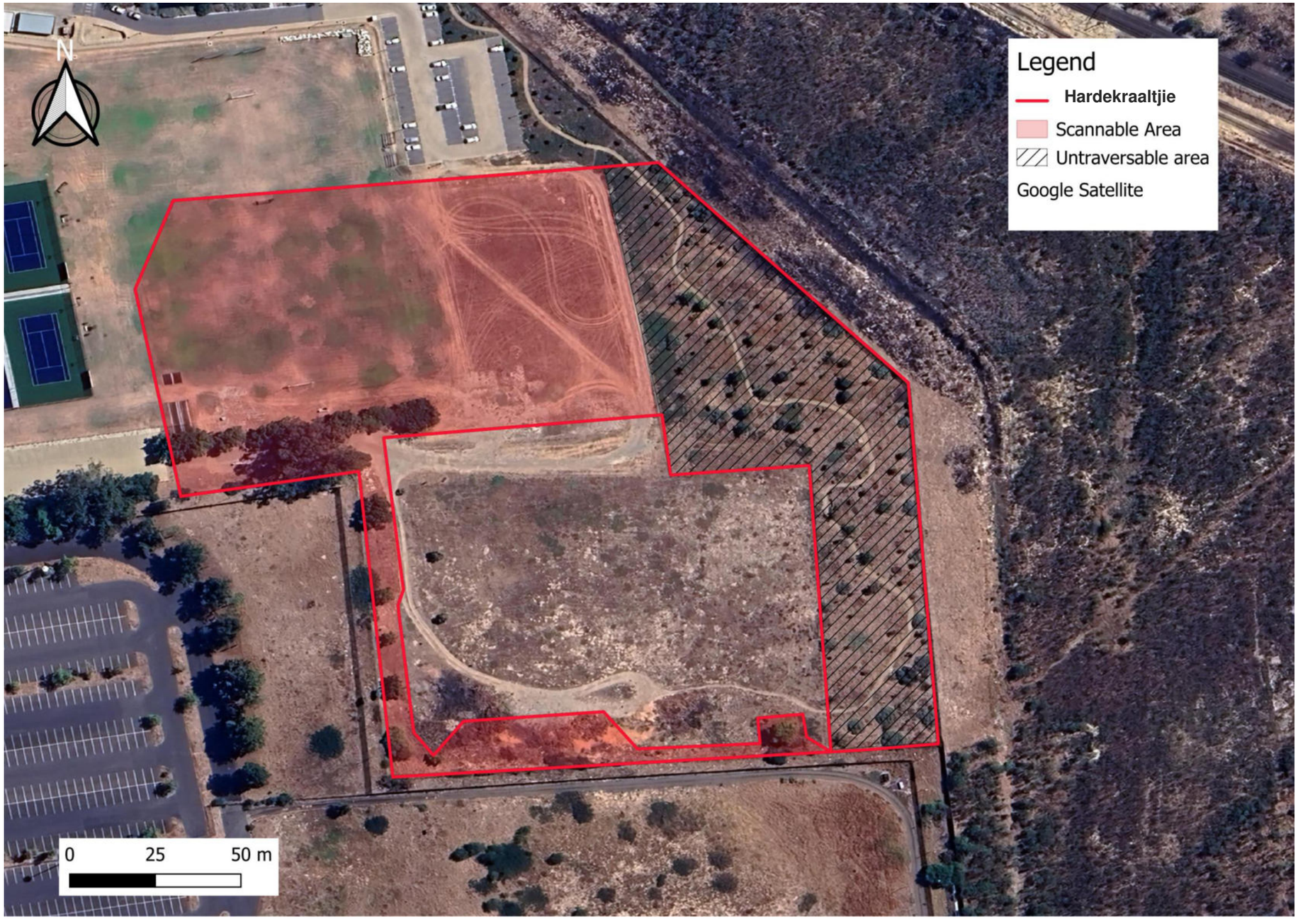
Figure 1 below shows the approximate location and extent of the site scanned in relation to the surrounding area. **Figure 2** below shows the actual scanned area, including the untraversable area.

In terms of a summary of the underground scanning completed, we advise as follows:

1. The total number of scans completed was 690.
2. The total distance scanned was 20 700 metres.
3. The total number of likely grave targets was 52.

Figure 1: Site Locality Map and Scan Extent.

Figure 2: Actual Area Scanned & Untraversable Area.



2. Scanning Methodology

The equipment used in the scan included a Geophysical Survey Systems Incorporated (GSSI) Dual Frequency (DF) type Ground Penetrating Radar (GPR). The DF incorporates a 300 and 800 MHz antenna. This provides a high-resolution scan down to 3 m depth and a lower resolution scan down to 5 m depth. This results in the creation of two radargrams, one for the shallow 800 MHz antenna and one for the deeper 300 MHz scanner. This enhances the quality of the scanning and ensures a double scan of each traverse carried out maximising target identification.

The site was systematically scanned utilising all available information to create a report including the location and depth of grave targets. The work carried out included the following:

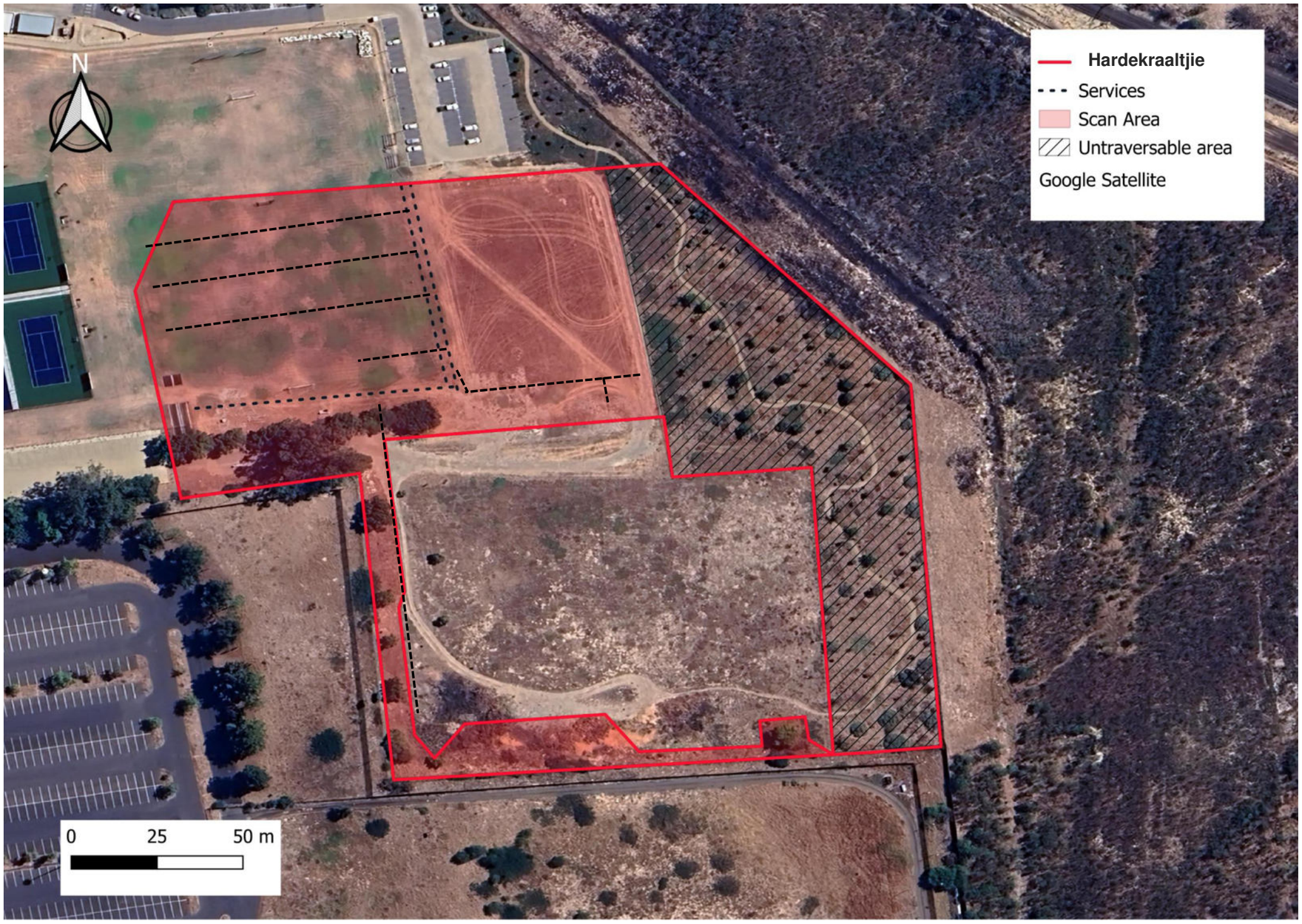
1. Studying available documents and previous reports for the area.
2. Complete Work Clearance Forms where applicable and obtain relevant approvals to access the site.
3. Discussions with site management.
4. A site walkover, noting any restricted areas and areas that cannot be scanned due to obstructions etc.
5. Marking out a grid system with the surveyor for reference point purposes and to improve scan location accuracy.
6. An initial phase of scanning was carried out to locate potential utilities (water mains, sewer, stormwater, electrical cables, etc.) and a Photolog report was created indicating the location depth and type of service detected. Refer to **Appendix A**.
7. The Photolog was used in the field during the detailed grave scanning phase to remove such features from potential target locations and was also used during the radargram interpretation phase.
8. The detailed scanning phase involved GPR traverses across the accessible area of the site at approximately 1.0 m centres in a broadly East-West orientation.
9. All of the radargrams produced were saved and number according to the survey grid pattern and used in the subsequent raw data review phase and for grave target identification.
10. Once scanning had been completed a detailed office-based review of the radargrams was carried out. This involved the field technicians and senior management to determine the location and depth of grave targets.
11. The processing and filtering process identified the best fifteen grave targets, along with their coordinates and these have been presented in **Table 1** below. A full list of all potential grave targets has been summarised in **Table 2** with 52 targets were identified.

12. The best fifteen grave targets are the ones which we have the greatest confidence in and that theses are indeed graves. The remaining 37 targets are still however potential grave targets, but we have a lower confidence level in these.

3. Photolog Report & Sketch Plan

1. The results of the underground utility scanning for the site in the form of a Photolog has been presented in **Appendix A**.
2. A high-level presentation of the services detected have also been included in sketch plan format in **Figure 3** with their approximate locations indicated.

Figure 3: Sketch Plan showing the approximate location of the services detected. (Refer to Appendix A for the Photolog Report)



4. GPR Survey Considerations and Results

4.1. Anomalies

The presence of anomalies on site that may look like grave targets could include the following features:

- Fill comprising large rocks or boulders.
- Dense, non-metal objects such as building rubble.
- Dense, compacted clay layers.

Please note that mole burrows have been identified on the site. However, mole activity is typically located between 0.3m and 0.7m below surface and graves are typically located below 1.5 m depth. The mole activity is typically shallower and will therefore not affect grave target identification.

Great care has been taken to minimise these anomalies, although some may match a grave target and be considered as such.

4.2. Scan Area and Site Boundaries

The boundary shown in red in **Figure 2** is consistent with the boundary provided to SEC as part of the original scope of works.

The unscannable areas are indicated as a black cross-hatched polygon which occurred where the GPR equipment could not traverse it or where there were obstacles in the way, including vegetation and trees.

4.3. Grave Characteristics

Based on SEC's experience to date and from previous grave detection work, graves are generally approximately 1.5 m wide and 2.7 m long and can be found at depths of between 1.5 m and 2.5 m bgl. This would typically be for a formal cemetery (not the current site being scanned). Informal cemeteries are likely to be less rigid in terms of depths, widths, and orientation, so this was also taken into consideration when reviewing the scanning results. Stellenbosch Municipality has advised that the site was likely used for informal graves, so this was factored into the assessment process.

The orientation of these graves could be random and not necessarily the East-West excavations as normally carried out for Christian burials or the Northeast-Southwest excavations for Muslim burials.

As such SEC undertook closely spaced sets of scans at approximately 1.0m centres for the site; with one set of scans orientated broadly to the East - West.

4.4. Radargram Interpretation

Detailed data interpretation was undertaken on each of the radargrams to identify potential targets. Adjacent sets of radargrams were then assessed to check for a similar chainage and depth of the potential target. Where more than one target has been identified on adjacent radargrams it is listed as a potential target. If the target continues for considerably longer than this, then it is likely that it is a service of some type. Fifteen of the best potential targets have been summarised in **Table 1** below.

During the radargram interrogation phase, reference was also made to the underground utility Photolog to exclude services from the potential target identification phase. The full list of potential targets is presented in **Appendix B.**

5. Selected Radargram Results

As previously advised, 15 radargrams were selected to highlight features that were identified as the most likely grave targets at the Hardekraaltjie Cemetery site. **Table 1** below lists the survey coordinates for the 15 targets, scan number as well as the scan distance and the depth of the target and any other related comments.

Figure 4 below shows the grid layout plan and numbering system used, as well as the location of the fifteen best grave targets identified.

Below **Table 1** we have included a single radargram for each of the 15 grave targets. In order to assist with the understanding of the radargrams, **Figure 5** below shows an annotated radargram of an actual grave. This grave example was from a known formal cemetery and not from this site.

Figure 4: GPR Grid Layout Plan and Approximate Location of Grave Targets.

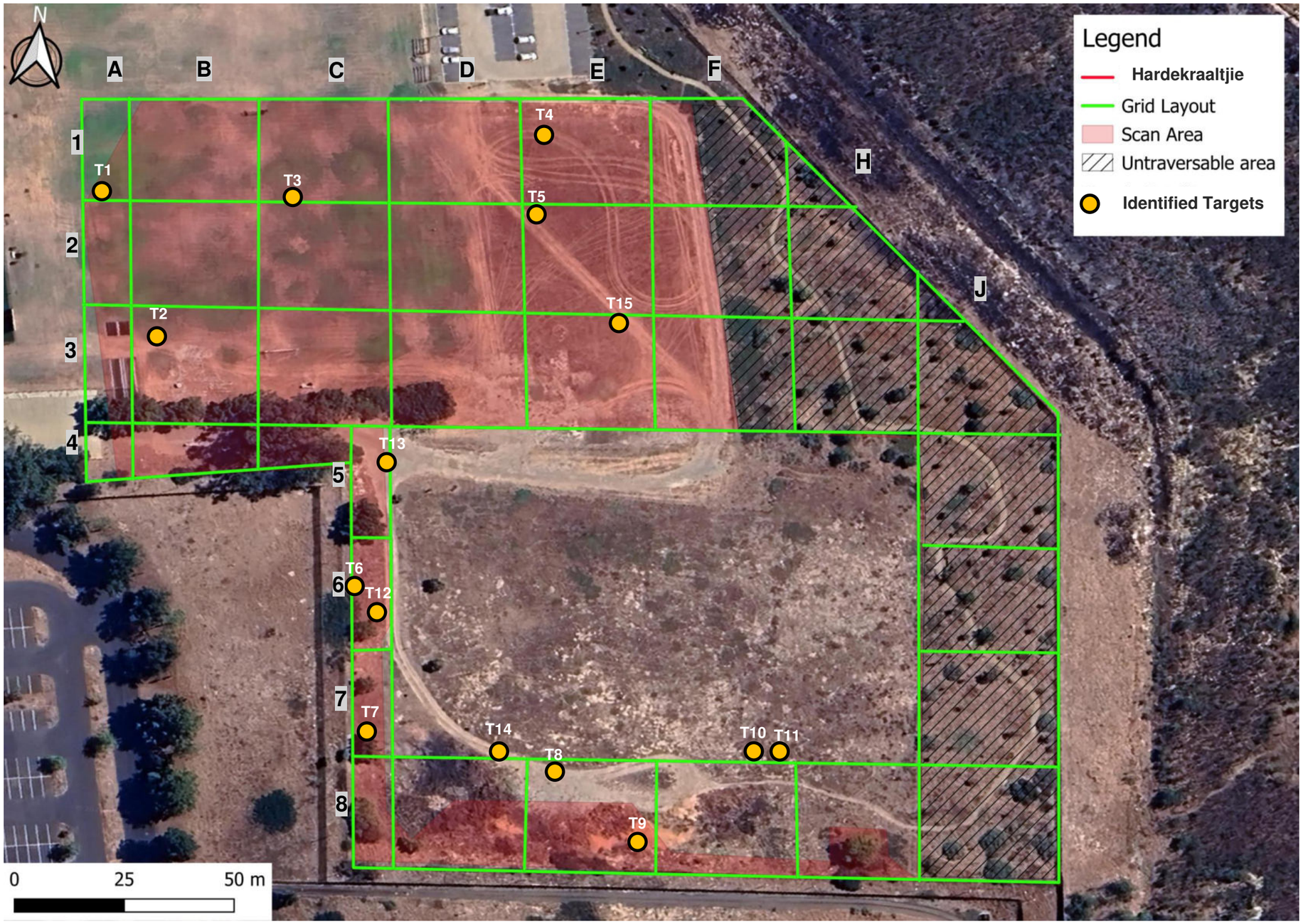
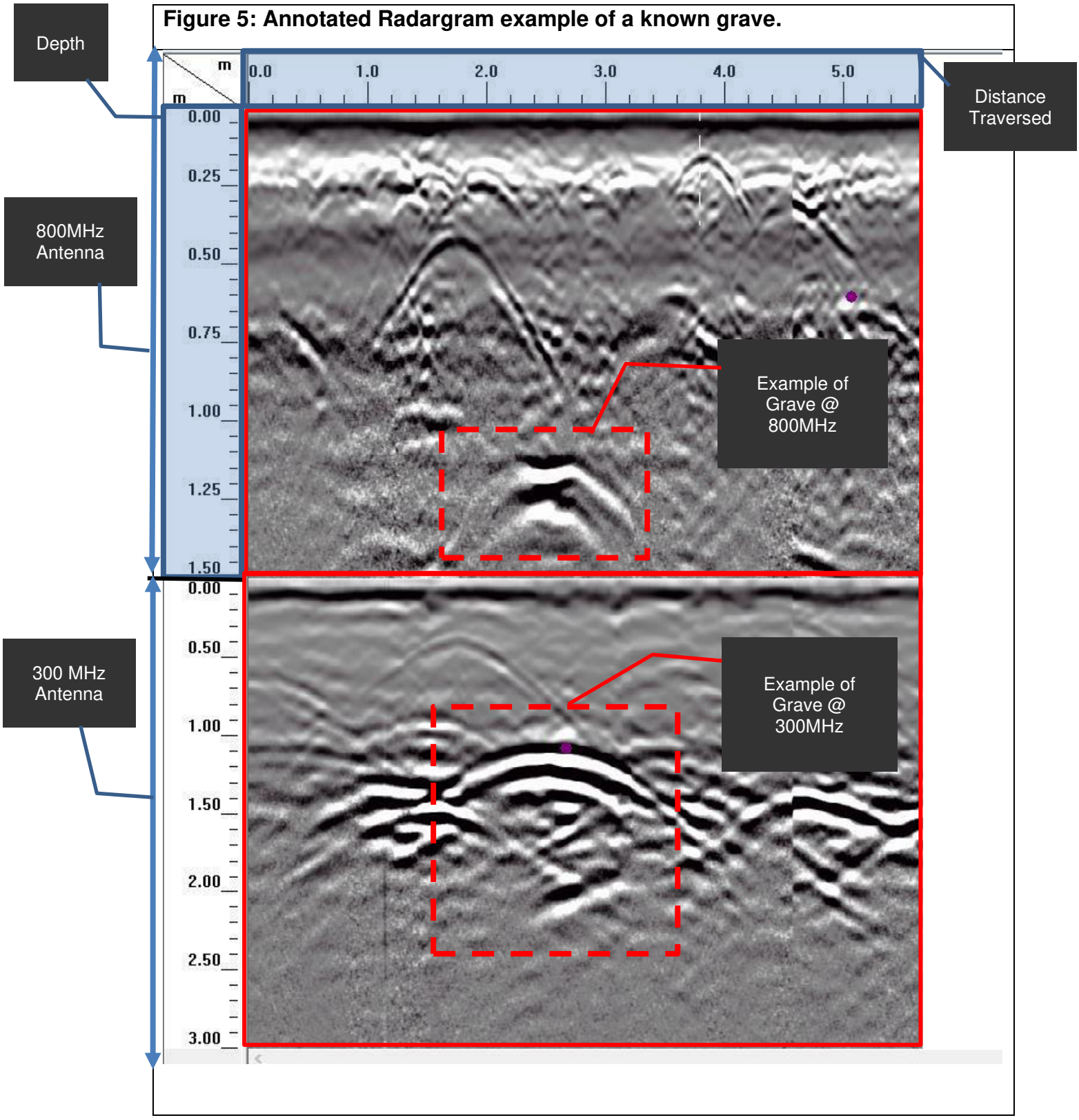


Table 1: Hardekraaltjie Cemetery Likely Target Numbers & Coordinates

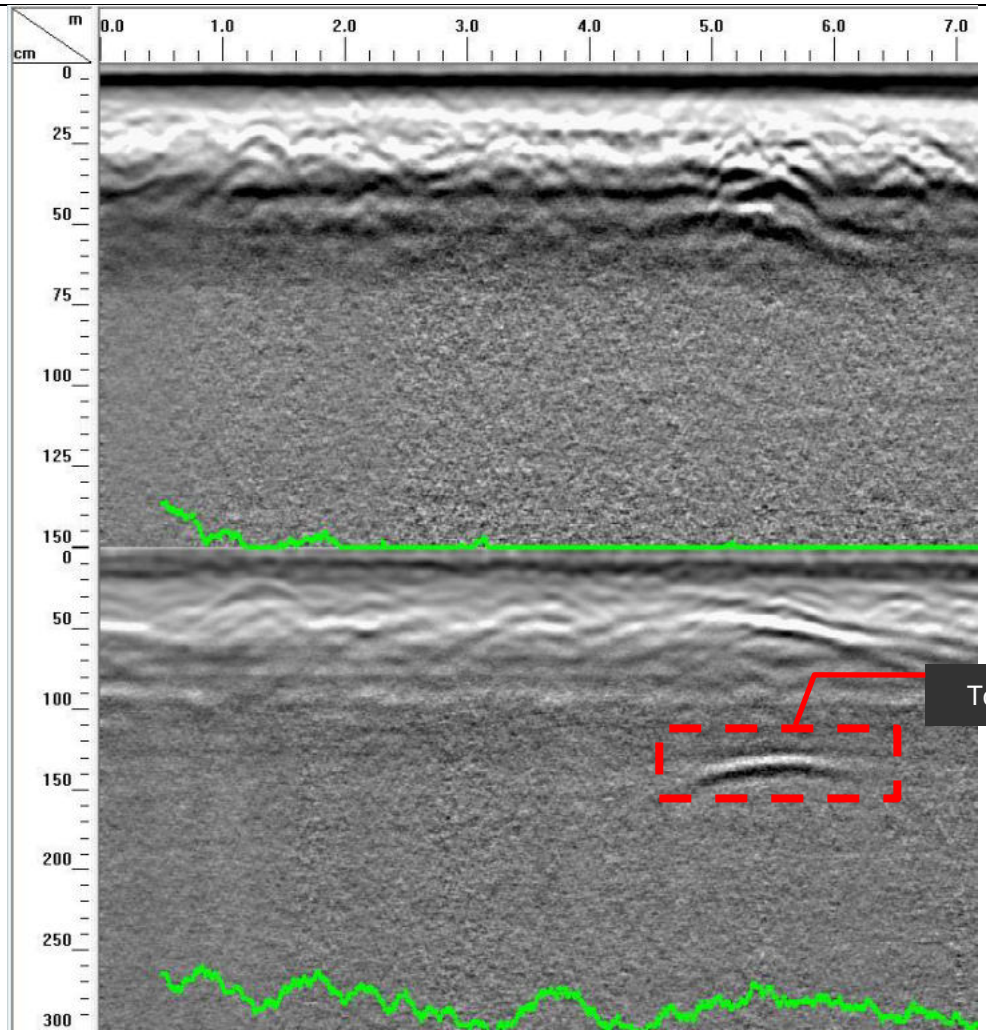
Target Number	Coordinates		Radargram Number	Target Horizontal Distance (m)	Target Vertical Depth Top of Target (m)	Comments
	Y	X				
T1	35484,43	3753485,27	1	4.9 – 6.1m	1.3m	
T2	35468,81	3753530,12	17	6.7 – 7.8m	1.0m	
T3	35445,263	3753481,973	6	5 – 7.2m	1.6m	
T4	35376,171	3753461,102	16	9 – 21m	1.27m	Multiple targets
T5	35374,616	3753480,038	5	14.5 – 16.1m	2.0m	
T6	35416,563	3753574,893	19	0 – 2.36m	1.5m	
T7	35416,655	3753622,067	23	1.3 – 2.5m	2.2m	
T8	35358,144	3753638,214	14	15.1 – 16.7m	2.2m	
T9	35349,365	3753649,517	26	26 – 27.6m	1.3m	
T10	35358,144	3753623,471	2	21 – 23.2m	0.8m	
T11	35322,879	3753623,202	2	24 – 26m	1.0m	
T12	35414,539	3753591,782	23	5.2 – 8m	0.8m	
T13	35414,89	3753550,667	12	9 – 10.1m	1.7m	
T14	35399,772	3753481,153	2	21.3 – 22.8m	1.3m	
T15	35374,616	3753513,521	9	19.4 – 20.6m	1.8m	

Figure 5: Annotated Radargram example of a known grave.

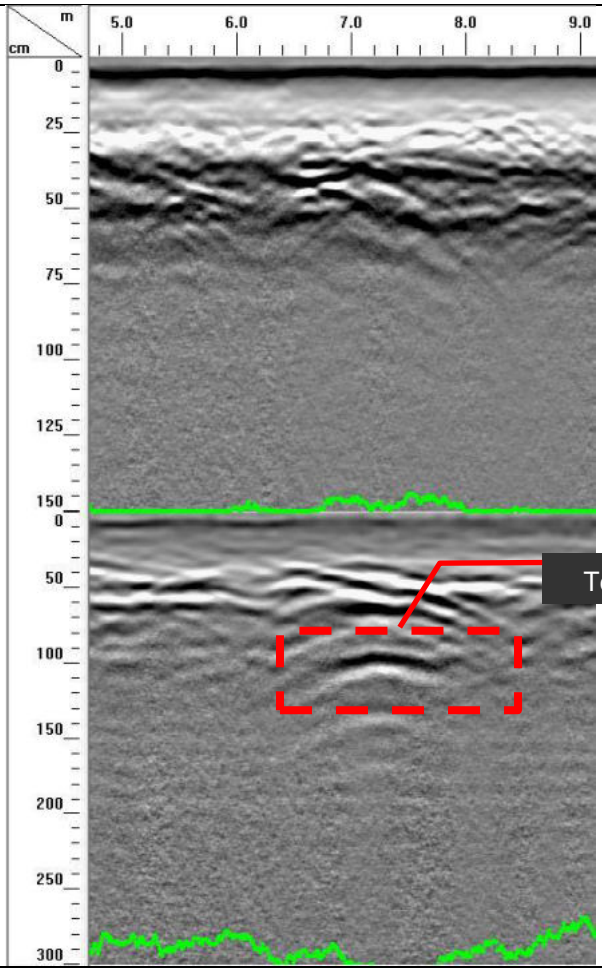


Radargram per Grave Target (Target Number indicated)

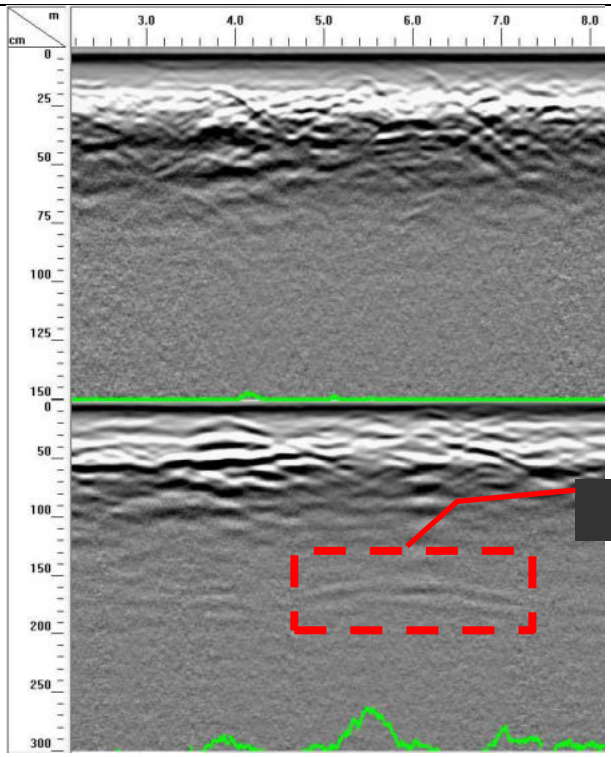
Target number: T1

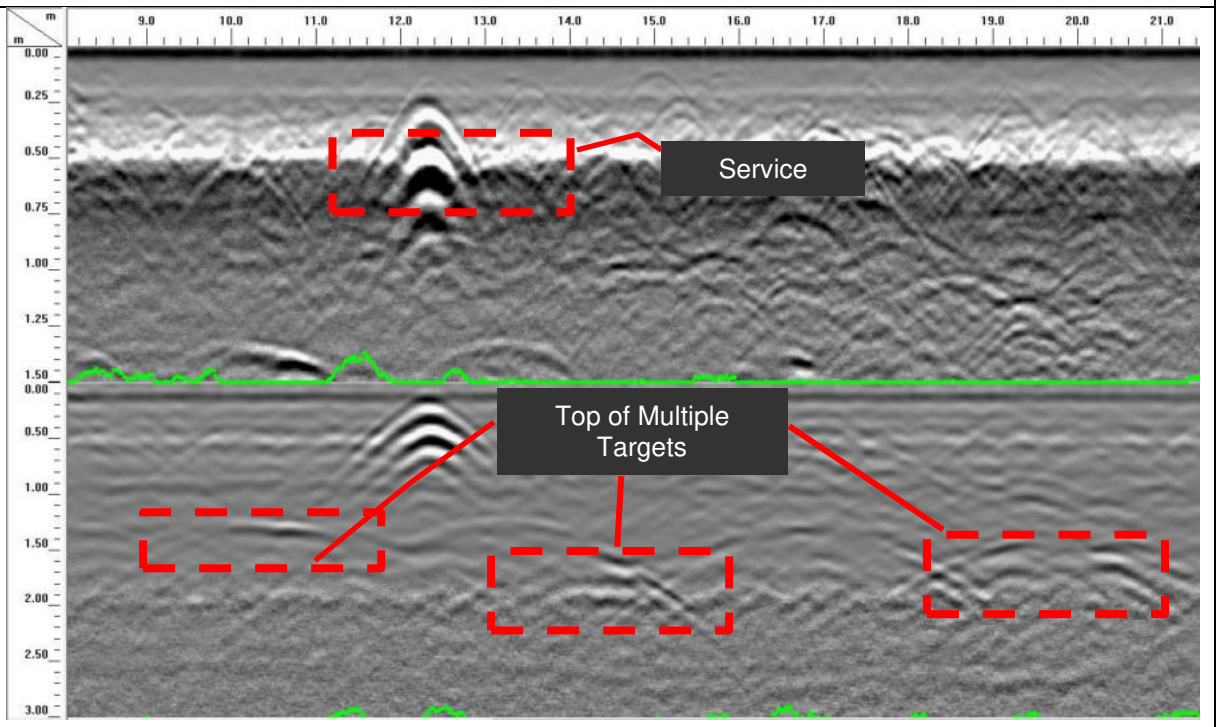
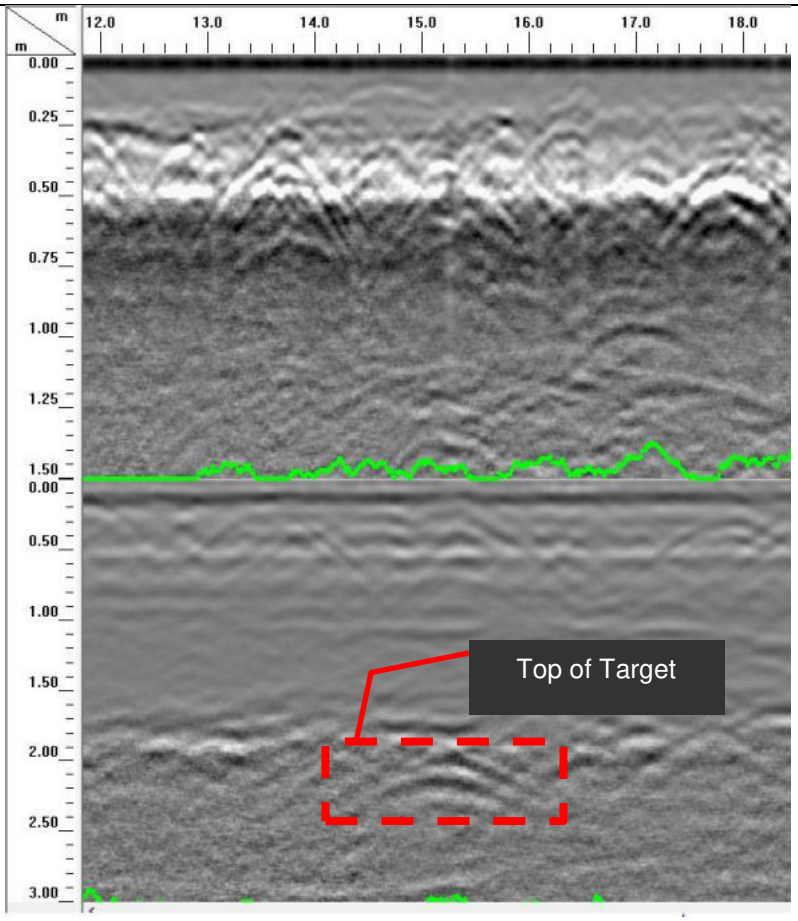


Target number: T2

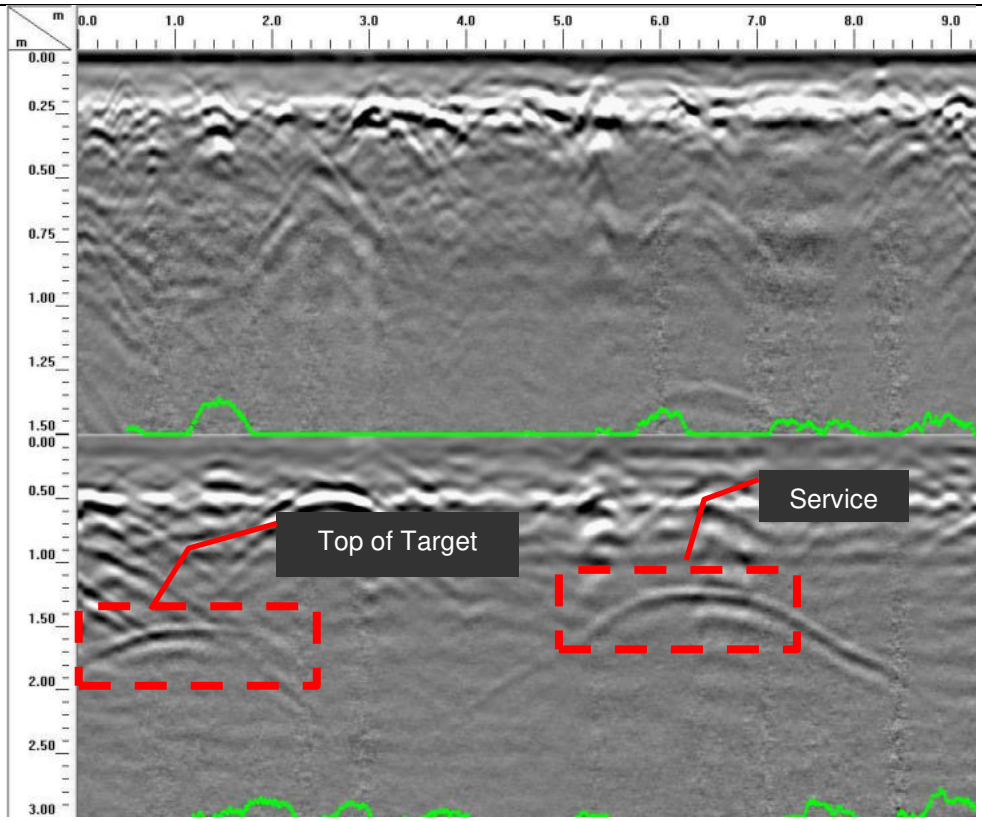


Target number: T3

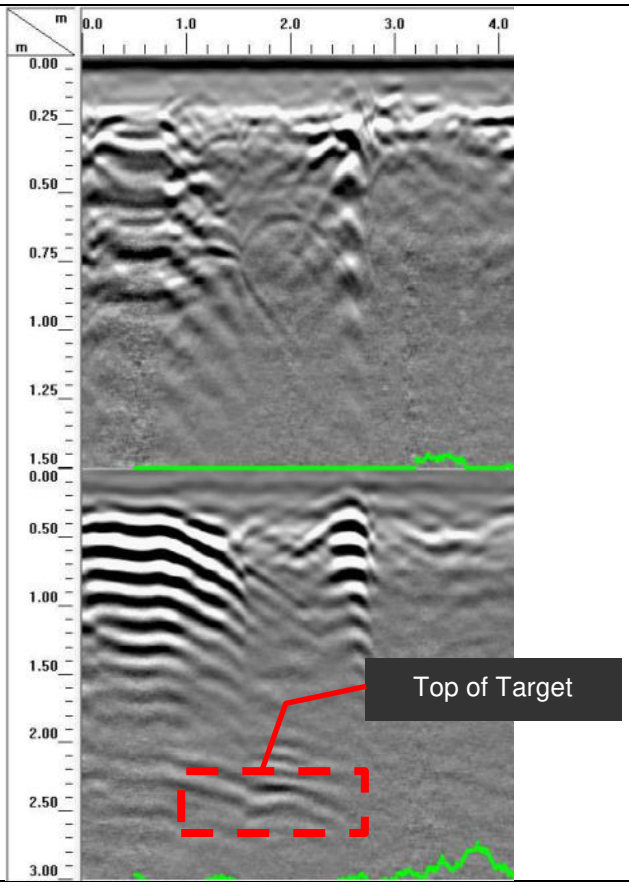


Target number: T4

Target number: T5


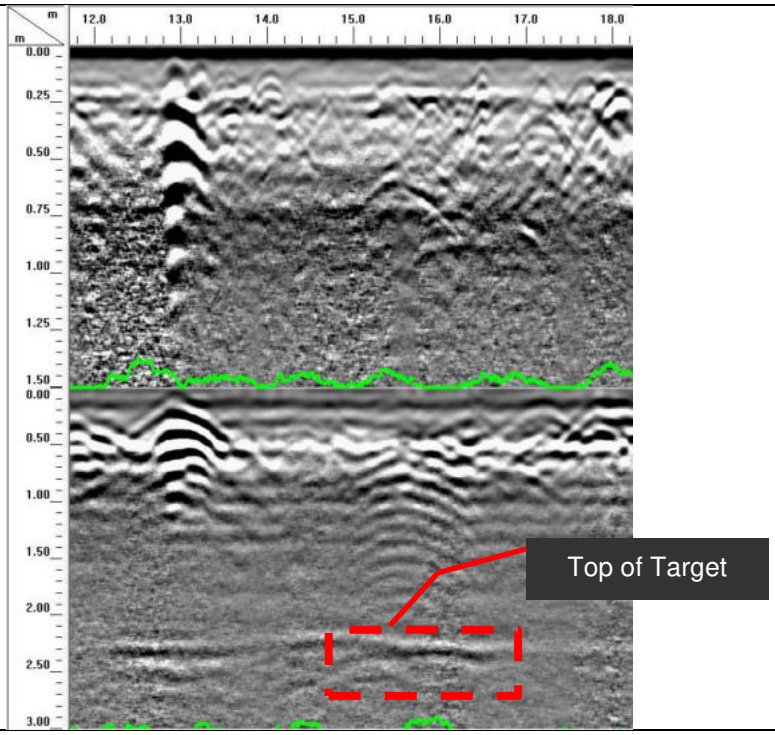
Target number: T6



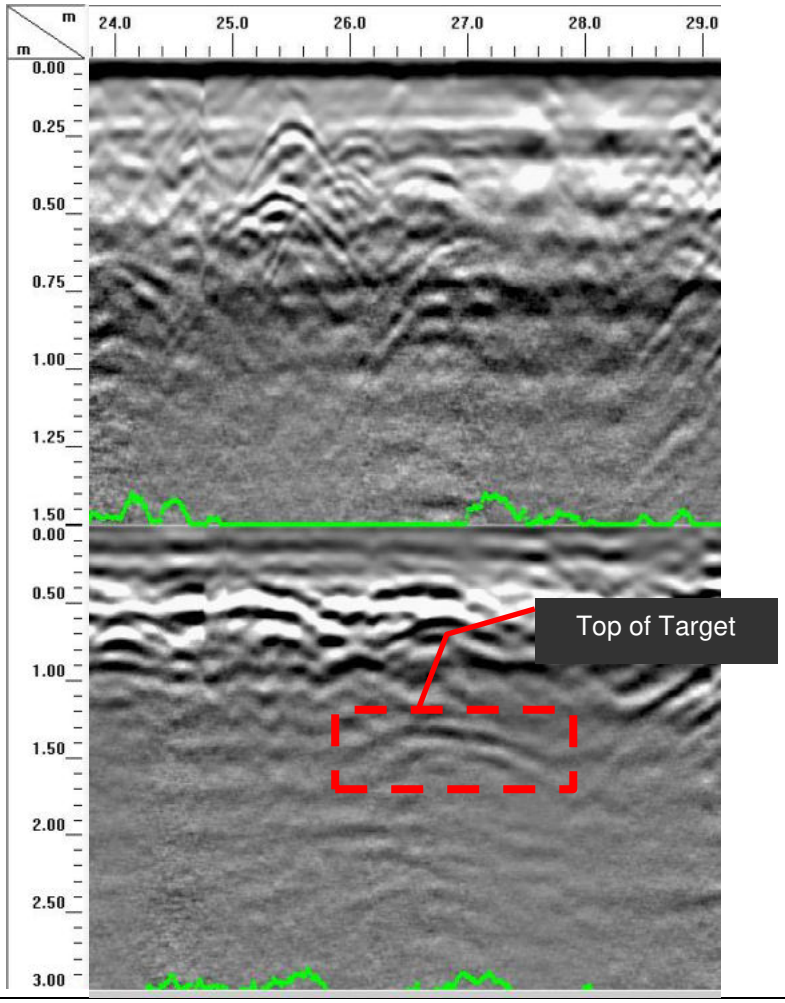
Target number: T7

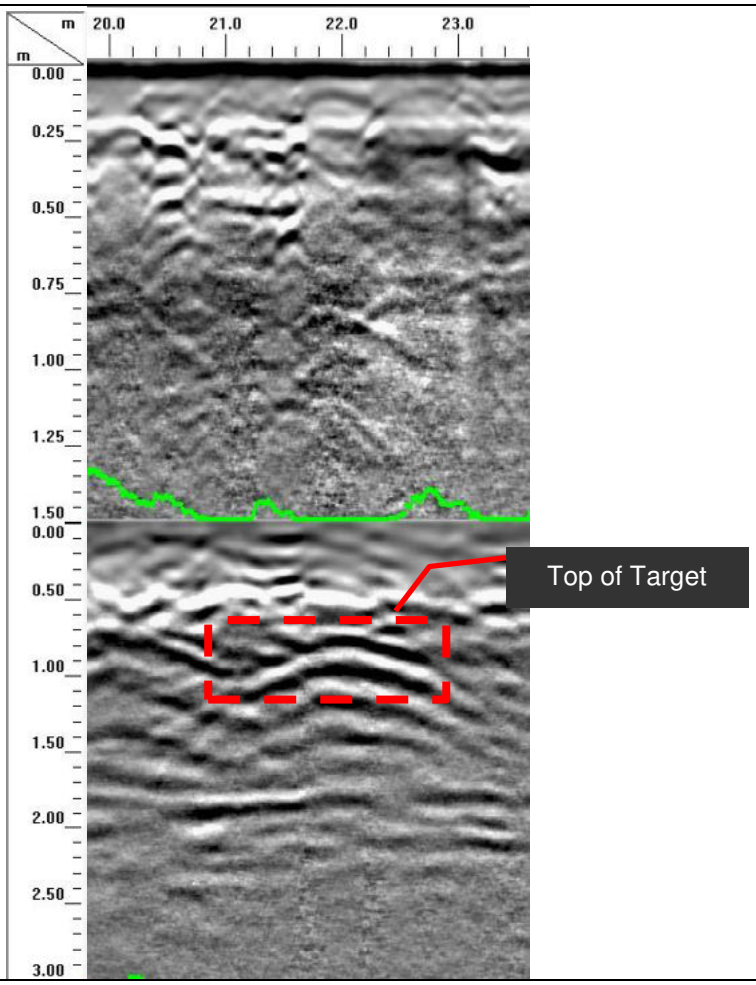
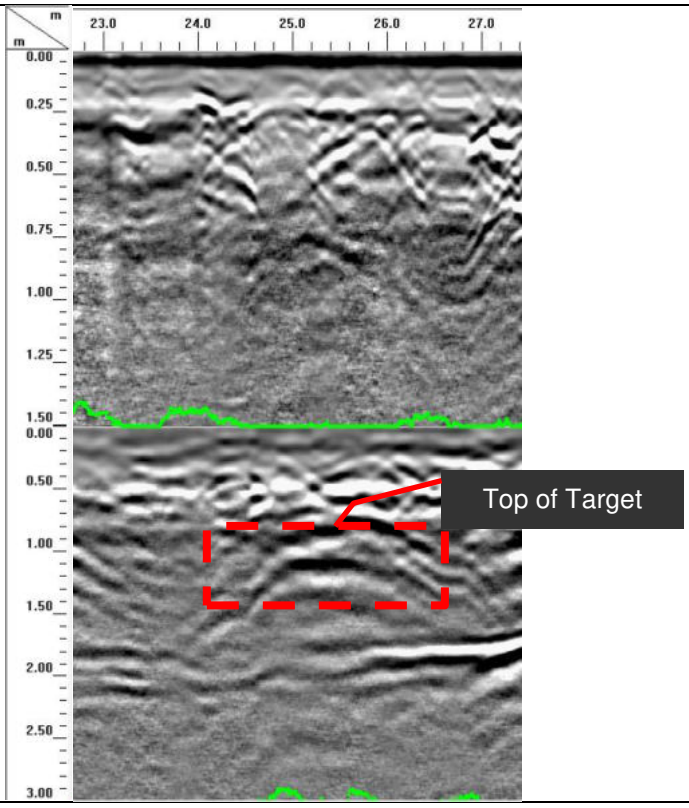


Target number: T8

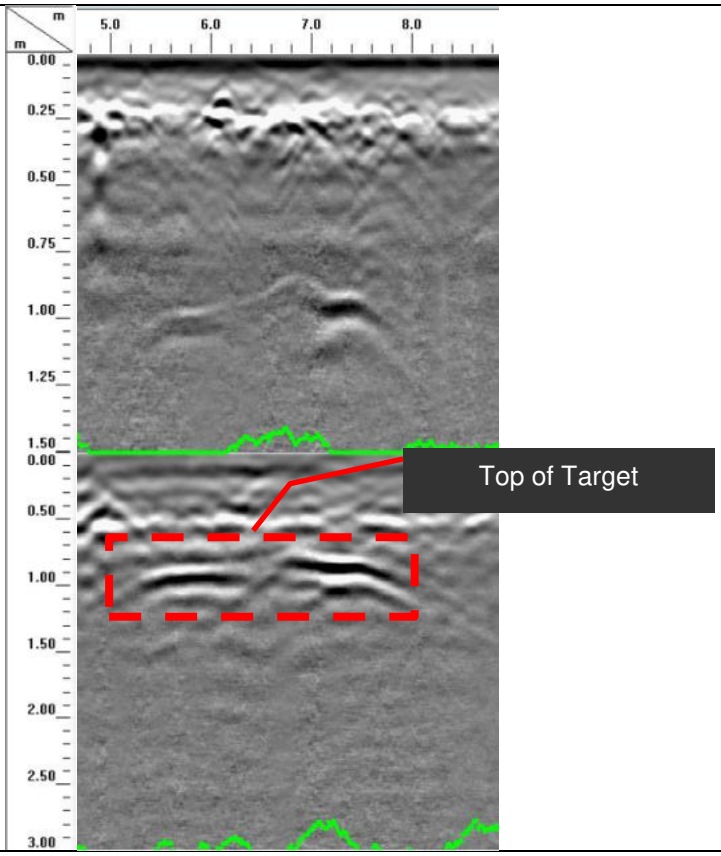


Target number: T9

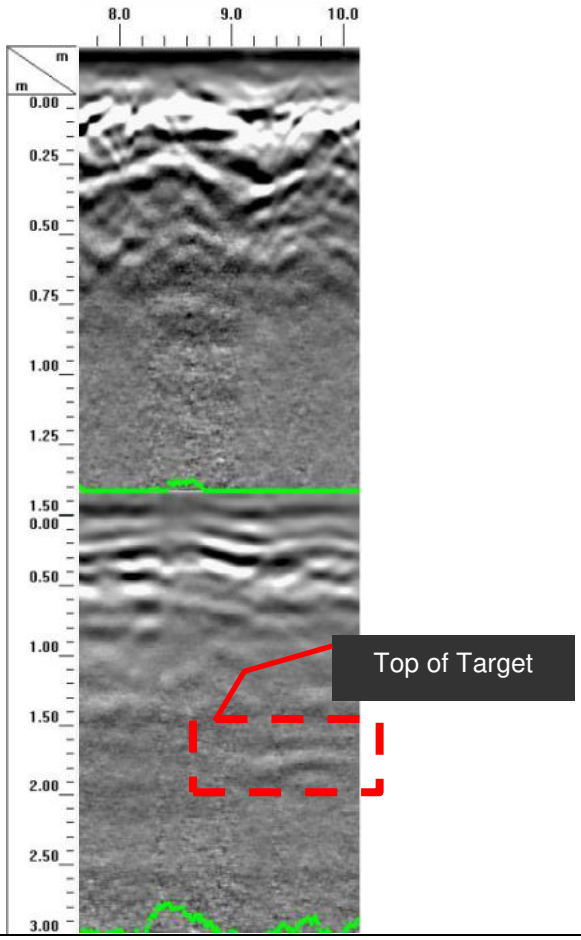


Target number: T10	
	
Target number: T11	
	

Target number: T12



Target number: T13



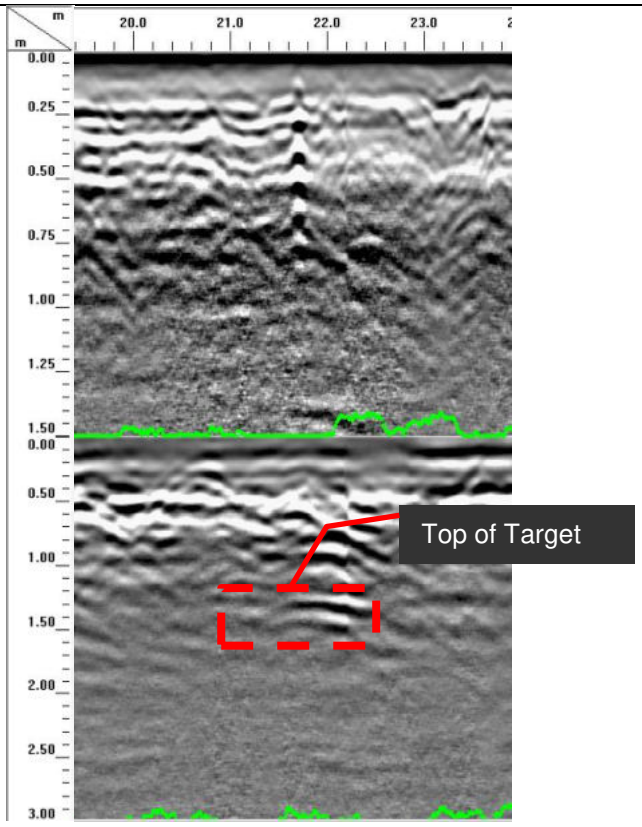
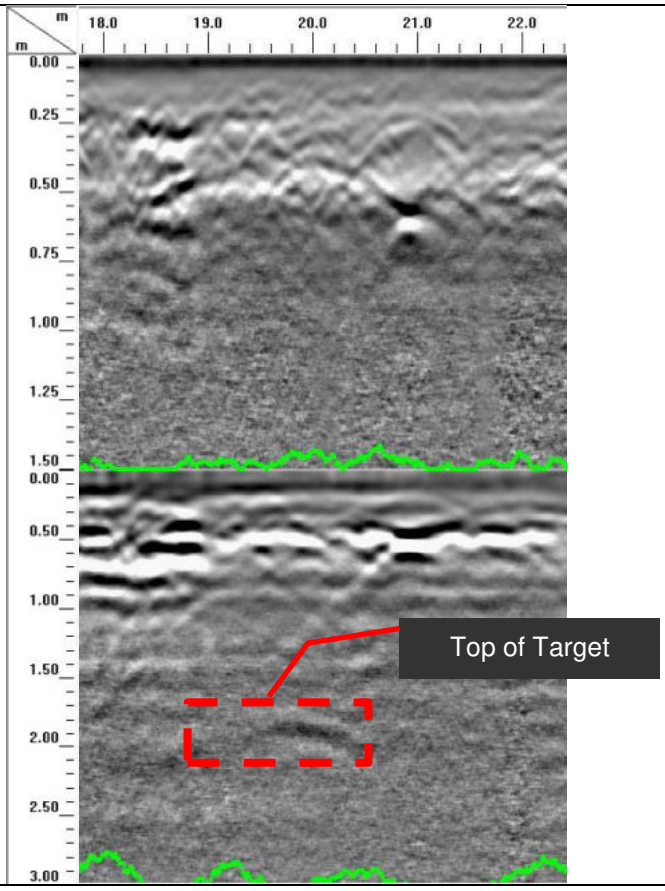
Target number: T14	
	
Target number: T15	
	

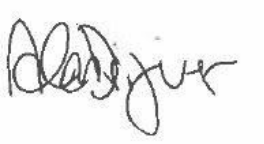
Table 2: Full List of Potential Targets

No	Grid	Scan	Target Centre point	Depth	Y	X
1	A2	1	5.4m	1.3m	35484,43	3753485,27
2	A2	2	3.0m	1.4m	35486,73	3753486,47
3	A2	2	4.7m	1.4m	35485,04	3753486,33
4	A2	4	8.9m	1.4m	35480,69	3753487,97
5	B2	12	21.7m	1.2m	35457,29	3753494,03
6	B2	18	24m	1.3m	35454,50	3753499,81
7	B2	22	20m	1.3m	35458,15	3753504,13
8	B3	17	7.2m	0.97m	35468,81	3753530,12
9	C1	4	18.0m	1.3m	35434,28	3753453,95
10	C2	1	4.70m	1.4m	35445,26	3753481,97
11	C2	6	5.90	1.6m	35443,65	3753486,86
12	C5	12	9.70m	1.7m	35414,89	3753550,67
13	C6	3	4.60m	1.8m	35418,21	3753572,02
14	C6	5	9.80m	1.0m	35412,86	3753573,58
15	C6	6	6.0m	1.5m	35416,56	3753574,89
16	C6	10	4.60m	1.5m	35417,62	3753579,00
17	C6	12	0.60m	2.0m	35421,44	3753581,32
18	C6	19	1.08m	1.5m	35420,38	3753588,26
19	C6	20	0.50m	1.4m	35420,87	3753589,31
20	C6	23	6.60m	0.9m	35414,54	3753591,78
21	C7	23	1.95m	2.1m	35416,66	3753622,07
22	D8	1	21.90m	1.3m	35386,14	3753627,53
23	D8	27	6.70m	1.5m	35399,10	3753654,71
24	D8	27	16.90m	1.5m	35388,94	3753653,85
25	D8	29	7.28m	2.2m	35398,36	3753656,65
26	E8	14	18.90m	2.2m	35358,14	3753638,21
27	E8	15	15.40m	2.3m	35361,55	3753639,50
28	E8	26	26.70m	1.4m	35349,37	3753649,52
29	F8	2	20.0m	0.8m	35328,16	3753623,65
30	F8	2	22.10m	0.8m	35326,07	3753623,47
31	F8	2	25.30m	1.1m	35322,88	3753623,20
32	D2	4	20.10m	1.4m	35399,77	3753481,15
33	E1	3	16.40m	2.1m	35376,17	3753448,06
34	E1	3	22.60m	2.0m	35369,99	3753447,54
35	E1	6	25.00m	1.7m	35367,34	3753450,32
36	E1	14	16.20m	1.5m	35375,44	3753459,03

No	Grid	Scan	Target Centre point	Depth	Y	X
37	E1	14	18.20m	1.5m	35373,45	3753458,87
38	E1	16	15.30m	1.8m	35376,17	3753461,10
39	E2	2	15.90m	1.7m	35374,23	3753477,00
40	E2	2	21.60m	1.6m	35368,55	3753476,52
41	E2	2	23.40m	1.6m	35366,76	3753476,37
42	E2	3	17.80m	2.0m	35372,25	3753477,83
43	E2	4	19.80m	1.6m	35370,18	3753478,66
44	E2	5	15.26m	1.9m	35374,62	3753480,04
45	E2	6	22.26m	1.6m	35367,56	3753480,45
46	E3	2	28.97m	2.1m	35358,69	3753505,79
47	E3	9	3.10m	2.0m	35383,88	3753514,94
48	E3	9	20.0m	1.8m	35367,04	3753513,52
49	F8	4	14.0m	1.4m	35333,97	3753626,14
50	F8	4	22.90m	1.5m	35325,10	3753625,40
51	F8	22	8.40m	1.2m	35338,04	3753644,55
52	F8	25	9.56m	1.4m	35336,63	3753647,44

6. Report Findings and Recommendations

1. Based on the comprehensive scanning carried out at the Hardekraaltjie Cemetery site it is evident that the subject area may have a number of informal graves present based on the results of the Ground Probing Radar scanning.

Fieldwork by:	Report reviewed by:	Report reviewed by:
		
Andrew den Drijver	Adriaan Botha Pr. Sci. Nat Registration Number 123032	Adrian Sillito *Pr. Sci.Nat Registration Number 400046/93*

Appendix A

Photolog report

(Attached separately not part of this report)

Appendix B

CAD Survey Drawing

(Attached Separately not part of this report)

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ENVIRONMENTAL CONSULTING

UNDERGROUND UTILITY SURVEY REPORT

Hardekraaltjie Cemetery Scan

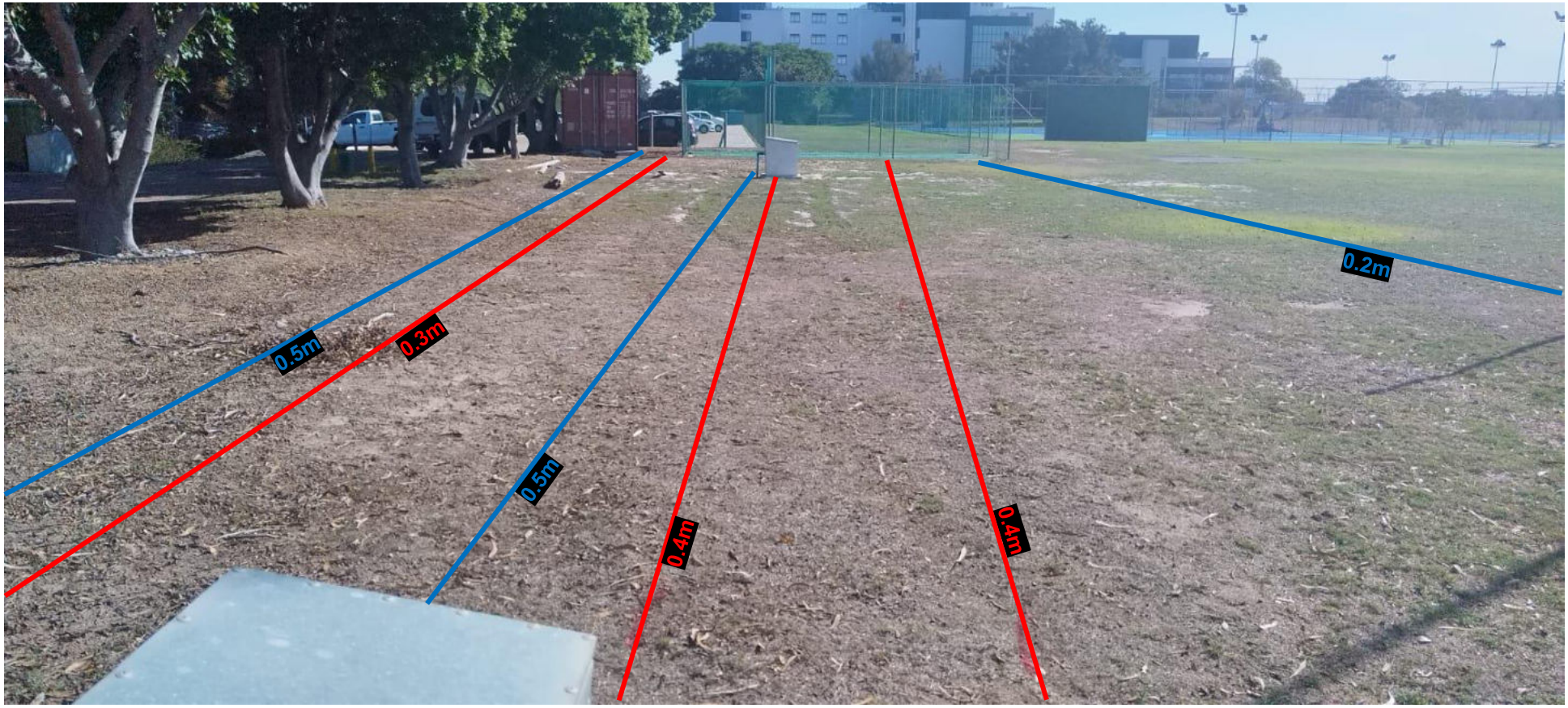
23 April 2024

SEC REFERENCE NUMBER: G19105

PO Box 30134, Tokai, 7966
Telephone: 021 712 5060
Email: info@environmentalconsultants.co.za

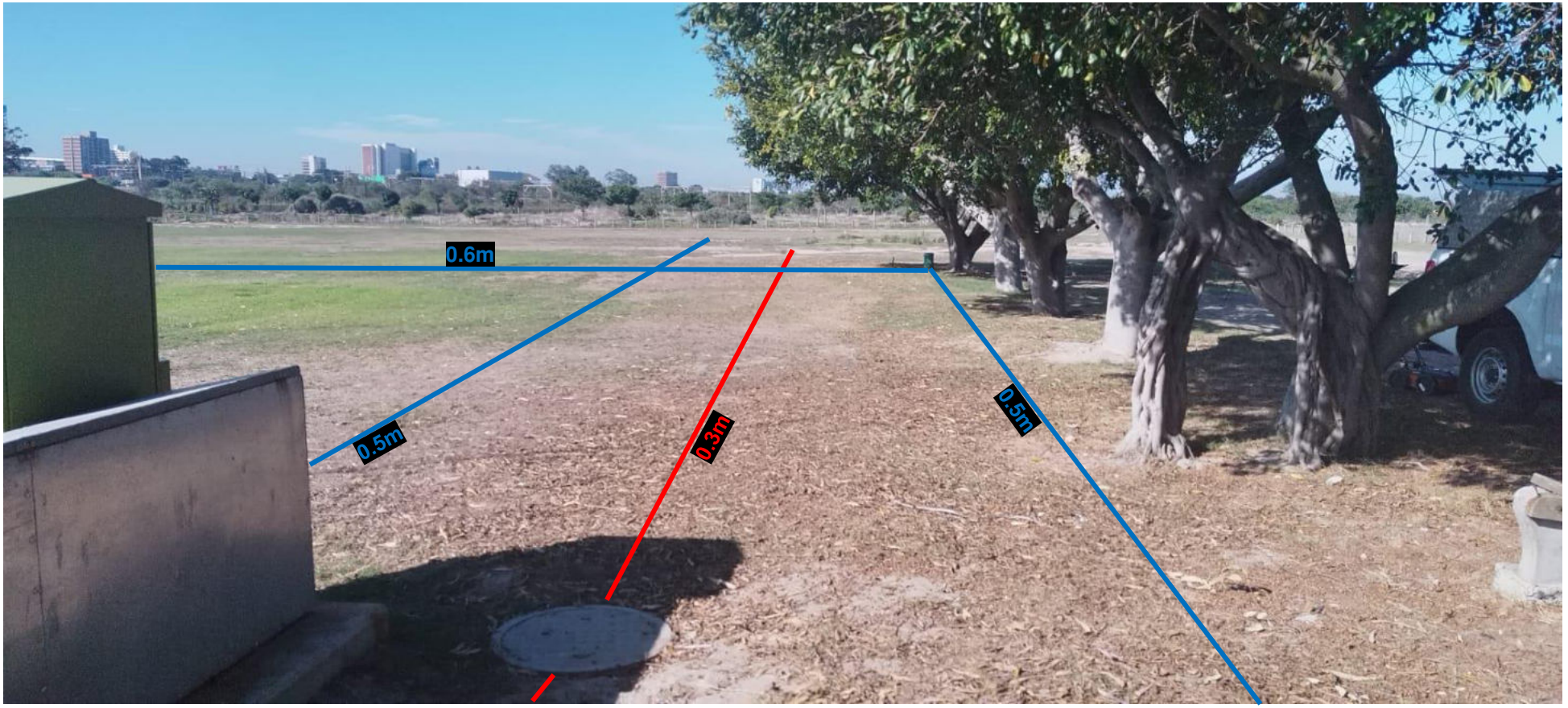
BASELINE MAP: Map showing the extent of the scan and the approximate location of the Photographs.

PHOTOGRAPH 1: Area Scanned Showing Utilities Found and Depths – View Looking West



Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	———	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 2: Area Scanned Showing Utilities Found and Depths – View Looking East



Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 3: Area Scanned Showing Utilities Found and Depths – View Looking West

Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 4: Area Scanned Showing Utilities Found and Depths – View Looking South

Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 5: Area Scanned Showing Utilities Found and Depths – View Looking West

Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

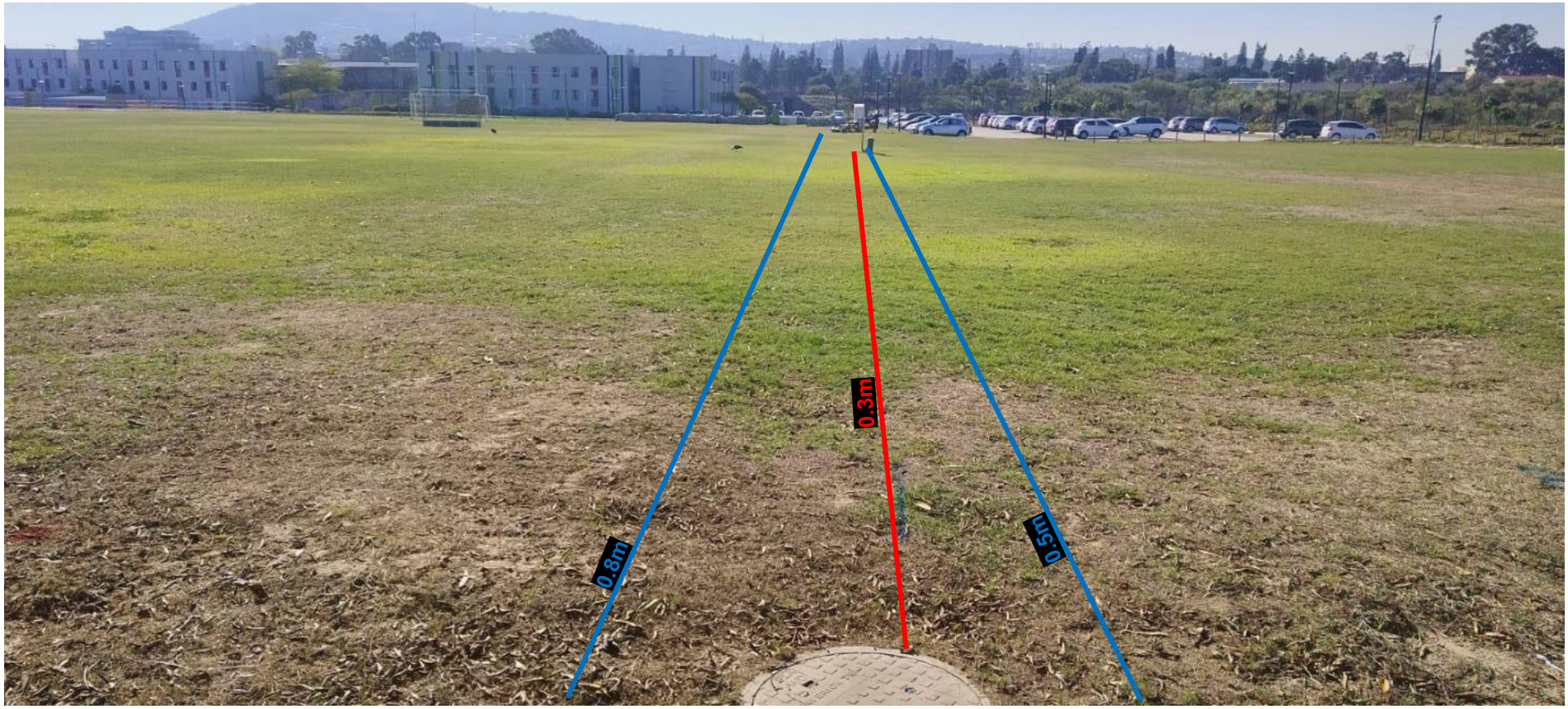
PHOTOGRAPH 6: Area Scanned Showing Utilities Found and Depths – View Looking West

Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 7: Area Scanned Showing Utilities Found and Depths – View Looking East

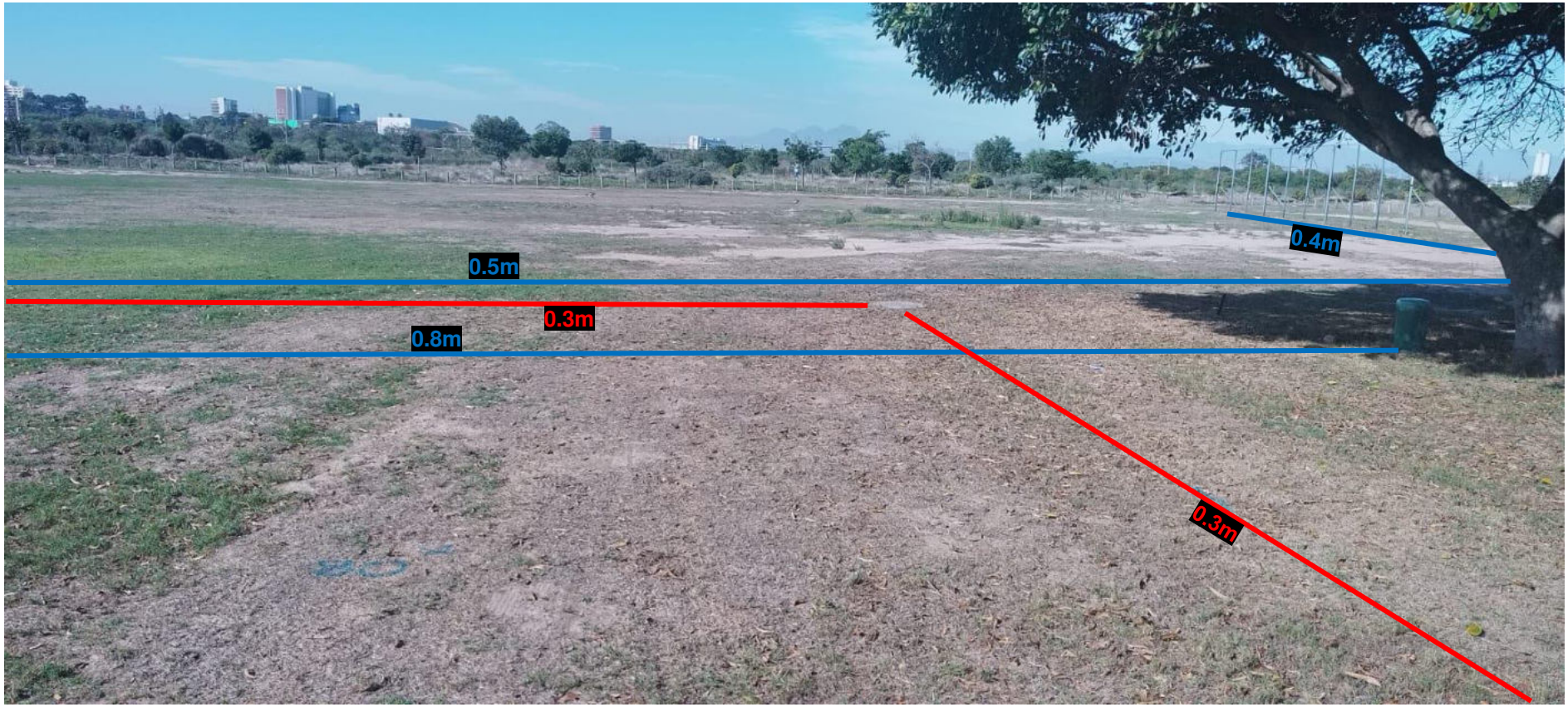
Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 8: Area Scanned Showing Utilities Found and Depths – View Looking North



Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 9: Area Scanned Showing Utilities Found and Depths – View Looking East



Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 10: Area Scanned Showing Utilities Found and Depths – View Looking East

Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 11: Area Scanned Showing Utilities Found and Depths – View Looking East

Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 12: Area Scanned Showing Utilities Found and Depths – View Looking East

Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 13: Area Scanned Showing Utilities Found and Depths – View Looking East

Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 14: Area Scanned Showing Utilities Found and Depths – View Looking East

Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

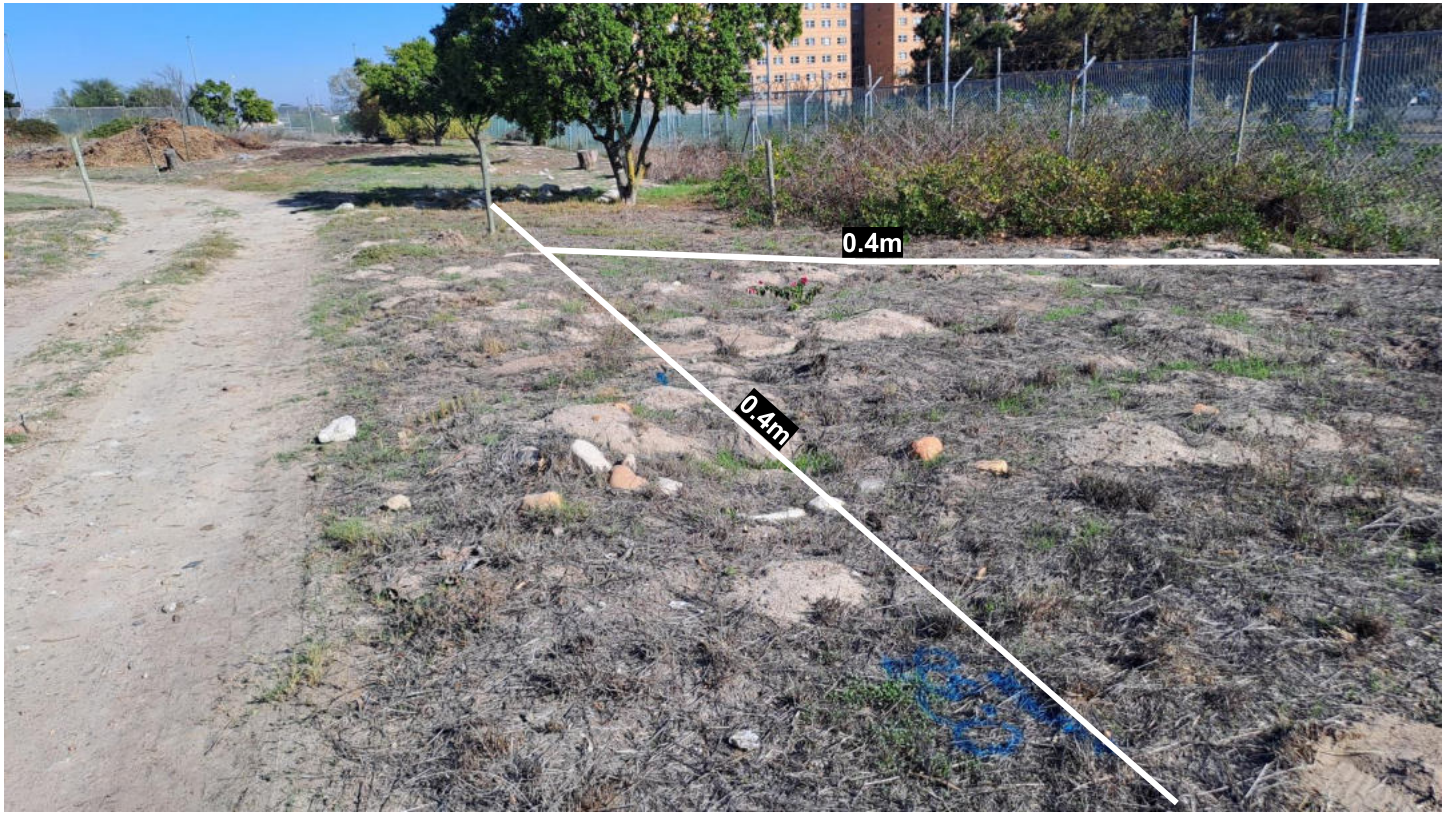
PHOTOGRAPH 15: Area Scanned Showing Utilities Found and Depths – View Looking South – East

Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

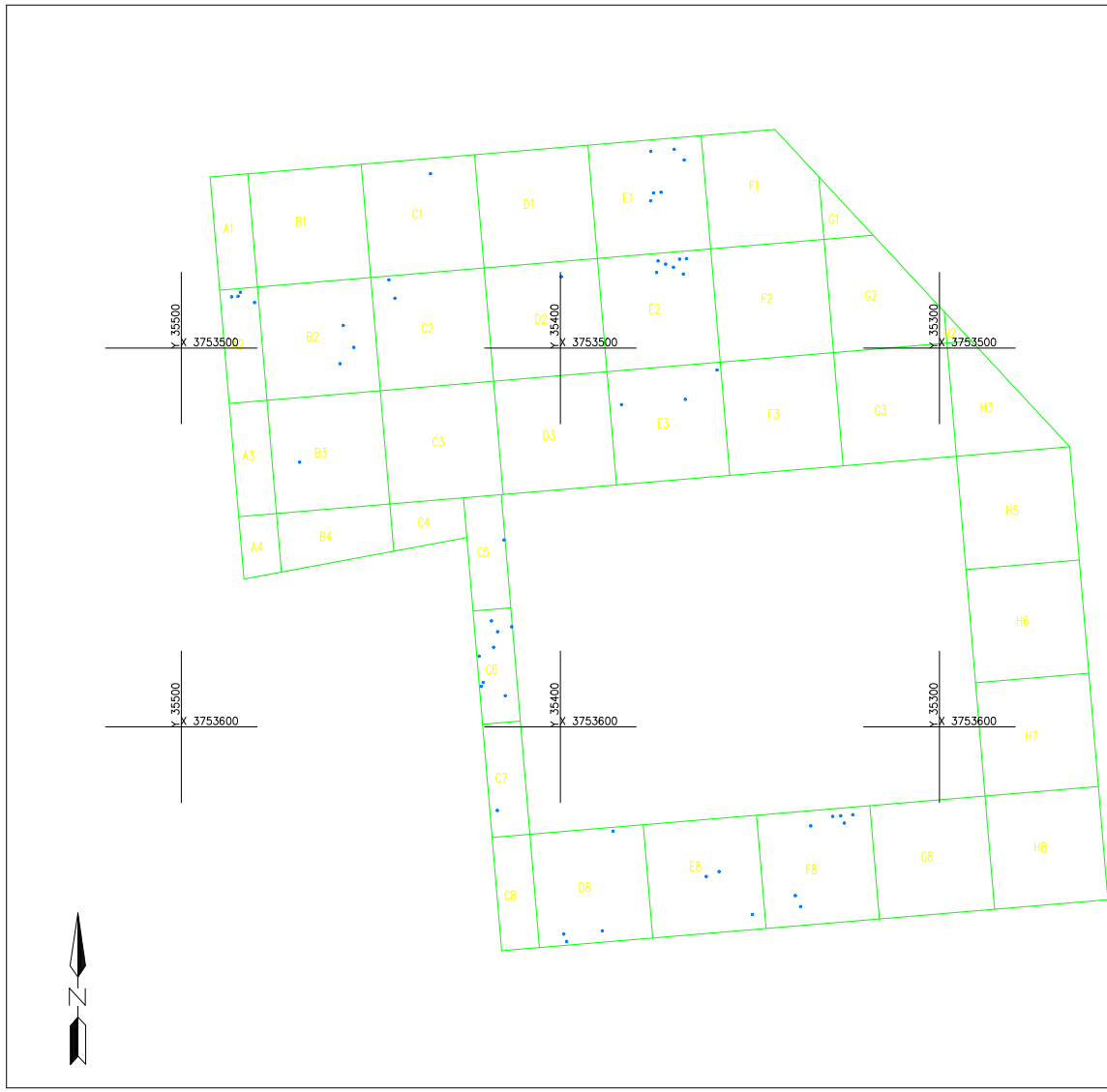
PHOTOGRAPH 16: Area Scanned Showing Utilities Found and Depths – View Looking South

Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		

PHOTOGRAPH 17: Area Scanned Showing Utilities Found and Depths – View Looking South



Line Colours	Legend:	Line Style	Legend:
Red	Live Electrical / Telecom Cables	▬▬▬▬	Utilities detected with GPR/ CAT
Blue	Water		
Green	Fuel Line		
Black	Sewage		
White	Unknown service or target		



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Y 35600 X 3753600
Y 35500 X 3753600
Y 35400 X 3753600
Y 35300 X 3753600
Y 35200 X 3753600
Y 35100 X 3753600

LEGEND

Potential grave position

NOTES:

1 All measurements are in metres
2 Grave positions indicated by Stilto Environmental Consulting

PROJECT:

TOPOGRAPHICAL SURVEY

Hardekraal

Tygerberg Campus

JENNINGS GOULLEE THOMSON

Professionele Landmeters Dorpsuitlegbeplanners
Posbus 840
Howard Place 7450
TEL. (021) 531-2222

Professional Land Surveyors Township Planners
PO Box 840
Howard Place 7450
FAX. (021) 532-2644

SCALE: 1/1000 @ A3 DATUM: WGS

DATE: JUNE 2024

OUR REFERENCE: B7351

THIS PLAN No.: B7351

SURVEYED BY: SM DRAWN BY: SM

N

LEGEND

- Potential grave position
- Previous grave position

NOTES:

1 All measurements are in metres
2 Grave positions indicated by Sillito Environmental Consulting
3 Erf boundaries subject to survey

PROJECT:

TOPOGRAPHICAL SURVEY

Hardekraal

Tygerberg Campus

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SCALE: 1/1000 @ A3 DATUM: WGS

DATE: JUNE 2024

OUR REFERENCE: B7351

THIS PLAN No.: B7351v1

SURVEYED BY: SM DRAWN BY: SM