# *Ground Penetrating Radar survey of Erf 44500*

# *Corner of Quinn and Lawrence Streets*

# *Kimberley*

# *Undertaken on behalf of P&V Pillay Family Trust*

# *23 - 24 January 2015*


By

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## Table of Contents:

## 1. Objective and Terms or Reference (ToR):

Terra Scan was appointed by Mr Tom Pillay to undertake a non-intrusive Ground Penetrating Radar (GPR) survey of Erf 44500 in order to establish the presence or absence of an old (1870's / 1879) cemetery or any other buried manmade structures on the site. Terms of Reference (ToR) for the identification of graves included:

i. A consistent high-density pattern of subsurface disturbance that would reflect rows or row-like patterns of graves situated between 15-20cm (6 -8 inches) apart reflective of the study site forming part of the inferred cemetery 'site proper'.
ii. A lower density pattern of subsurface disturbance that would reflect rows or row-like patters of graves situated in excess of roughly 20cm (8 inches) apart or a random scatter of subsurface disturbance reflective of the study site forming part of the inferred cemetery but closer associated with 'perimeter' burials.
iii. Individual or low density scattered subsurface disturbance that may reflect on Later Iron Age (LIA) burial practice of burial within a homestead yard.
iv. At the time of the GPR scan surface Hutton sand had been removed to a level of 30cm below the contemporary surface and the site sealed with a fine gravel layer of 10-15cm providing for a GPR scan surface level of approximately 15cm below the contemporary surface.
v. Stratigraphy of the site, based on archaeological excavation data from the immediate vicinity included a top Hutton sand level underlain by a '*consolidated calcified sand / calcrete*' member, situated at approximately 60-65cm below the contemporary surface. The said member may be lense like, not continuing across the sub-surface extent of the study site or may be characteristic of the sub-surface geology of the study site.
vi. Previously identified graves in the vicinity of the study site were dug between 10-40+cm into the '*consolidated calcified sand / calcrete*' member.
vii. [A 1940's residential development with confirmed evidence of impact on the western portion of the study site is available from the records of the Sol Plaatje Municipality. The 1980's development of Quinn Street resulted in destruction of the 1940's residences affecting the study site.]

The results of the GPR survey will be used by ArchaeoMaps in the preparation of an Archaeological and Cultural Heritage Impact Assessment (AIA).

## 2. What is Ground Penetrating Radar?

A GPR system is made up of a control unit, antenna, a power source and a trolley cart.

GPR is described by Geophysical Survey Systems, Inc as:

*"The control unit contains the electronics which triggers the pulse of radar energy that the antenna sends into the ground. It also has a built-in computer and hard disk/solid state memory to store data for examination after fieldwork. Some systems, such as the GSSI DF, are controlled by an attached Windows computer with pre-loaded control software. This system allows data processing and interpretation without having to download radar files into another computer.*

*The antenna receives the electrical pulse produced by the control unit, amplifies it and transmits it into the ground or other medium at a particular frequency while the antenna moves across the ground surface. Antenna frequency is*

*one major factor in depth penetration. The higher the frequency of the antenna, the shallower into the ground it will penetrate. A higher frequency antenna will also 'see' smaller targets.*

*GPR works by sending a tiny pulse of energy into a material and recording the strength and the time required for the return of any reflected signal. A series of pulses over a single area make up what is called a scan. Reflections are produced whenever the energy pulse enters into a material with different electrical conduction properties or dielectric permittivity from the material it left. The strength, or amplitude, of the reflection is determined by the contrast in the dielectric constants and conductivities of the two materials. This means that a pulse which moves from dry sand (dielectric of 5) to wet sand (dielectric of 30) will produce a very strong reflection, while moving from dry sand (5) to limestone (7) will produce a relatively weak reflection.*

*While some of the GPR energy pulse is reflected back to the antenna, energy also keeps traveling through the material until it either dissipates (attenuates) or the GPR control unit has closed its time window. The rate of signal attenuation varies widely and is dependent on the properties of the material through which the pulse is passing.*

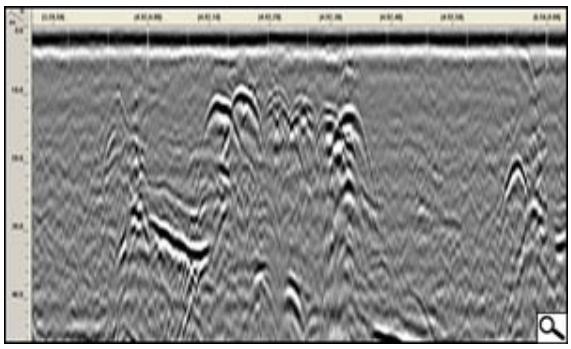
*Materials with a high dielectric will slow the radar wave and it will not be able to penetrate as far. Materials with high conductivity will attenuate the signal rapidly. Water saturation dramatically raises the dielectric of a material, so a survey area should be carefully inspected for signs of water penetration.*

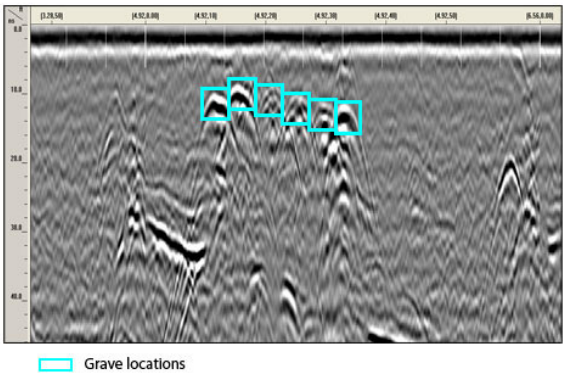
*Metals are considered to be a complete reflector and do not allow any amount of signal to pass through. Materials beneath a metal sheet, fine metal mesh, or pan decking will not be visible.*

*Radar energy is not emitted from the antenna in a straight line. It is emitted in a cone shape. The two-way travel time for energy at the leading edge of the cone is longer than for energy directly beneath the antenna. This is because the leading edge of the cone represents the hypotenuse of a right triangle.*

*Because it takes longer for that energy to be received, it is recorded farther down in the profile. As the antenna is moved over a target, the distance between them decreases until the antenna is over the target and increases as the antenna is moved away. It is for this reason that a single target will appear in a data as a hyperbola, or inverted "U." The target is actually at the peak amplitude of the positive wavelet." (*http://www.geophysical.com/whatisgpr.htm - accessed on 26 January 2015.)

The example linescan radar images below identify several soil anomalies that equate the locations of remains during an archaeology survey. (http://www.geophysical.com/archaeology.htm - accessed on 26 January 2015.)





## 3. Equipment used to scan Erf 44500:

An UtilityScan DF system with cart serial number # 204, antenna serial number # 217 manufactured by Geophysical Survey Systems, Inc. (GSSI) was used for the survey. The DF system incorporates a digital dual-frequency antenna (300 MHz and 800 MHz) and a touchscreen interface that allowed shallow and deep targets to be viewed simultaneously in a single scan. The DF system has a maximum depth range of 5m depending on the soil conditions. The system has a signal floor tracking feature whereby the calculated penetration depth based on the site specific conditions was displayed.

## 4. Survey methodology and data acquisition on Erf 44500:

For practical scanning purposes the site was divided into three survey sections along its length.

**Block one** is situated on the Western side of the site in the area demarcated by datum points Z and Y as indicated in the Google earth image on page 4, the block measures 17m x 40m.

A total of 103 scans were performed across block one. The block was scanned in a grid formation and 54 scans were performed in the South to North and North to South directions, 19 scans were performed in the West to East and East to West direction. A further 30 scans were performed across the anomalies that were detected during the onsite grid scan.

**Block two** is situated in the centre of the site in the area demarcated by datum points Y and X as indicated in the Google earth image on page 4, the block measures 17m x 40m.

A total of 74 scans were performed across block two. The block was scanned in a grid formation and 45 scans were performed in the South to North and North to South directions, 23 scans were performed in the West to East and East to West direction.

**Block three** is situated on the Eastern side of the site in the area demarcated by datum points X and W as indicated on the Google earth image below, the block measures 17m x 36m.

A total of 94 scans were performed across block three. The block was scanned in a grid formation and 64 scans were performed in the South to North and North to South directions, 23 scans were performed in West to East and East to West directions.

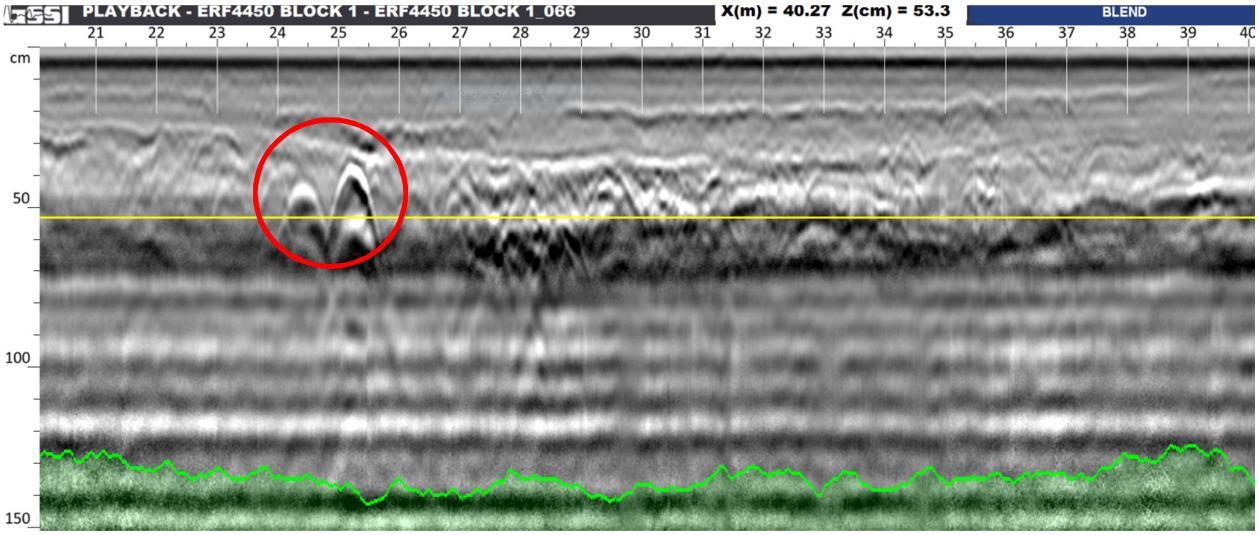
## 5. Site Map. (GPS data recorded and map produced by ArchaeoMaps)


## 6. Site conditions and GPR penetration at Erf 44500:

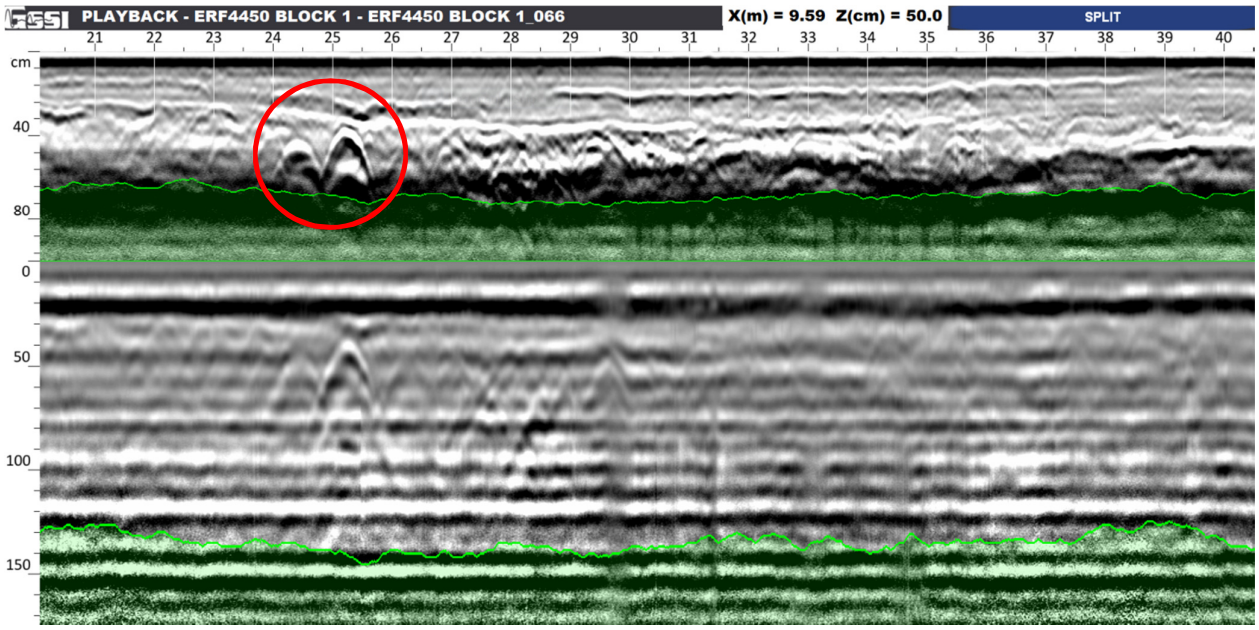
The surface layer of the area in question was disturbed when recent construction activities started on site, subsequently construction was stopped and the current top layer consisting of a soil and limestone mixture was introduced and compacted to seal the area. The working surface was in good condition at the time of the survey.

Penetration with the 800Mhz channel was relatively good up to 500mm as indicated by the signal floor tracking indicator, a change in geology across the entire area is evident at a depth of ± 56 cm. The calculated signal tracker indicated that a penetration depth of ± 1300mm was achieved with the 300Mhz antenna as per the two examples below. The geology change at a 56cm below surface had an adverse effect on the visible image quality between 700mm and 1300mm. It is believed that the dielectric constant and conductivity of the soil changes dramatically at the point of change in geology as described above.

Blended channels



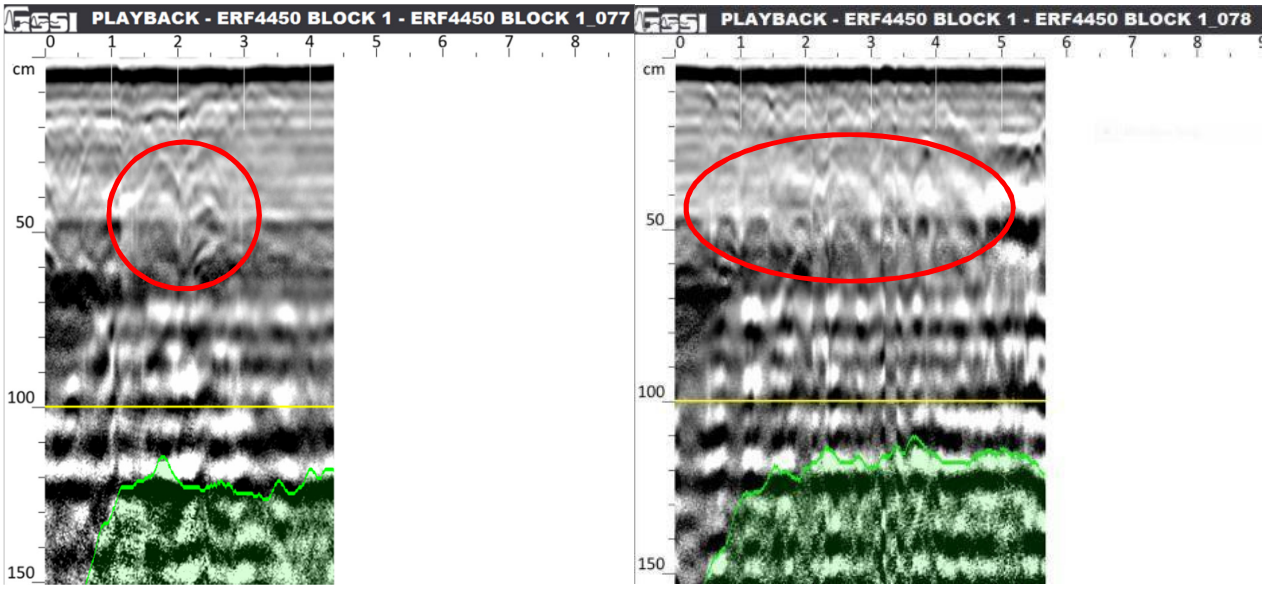

Split channels



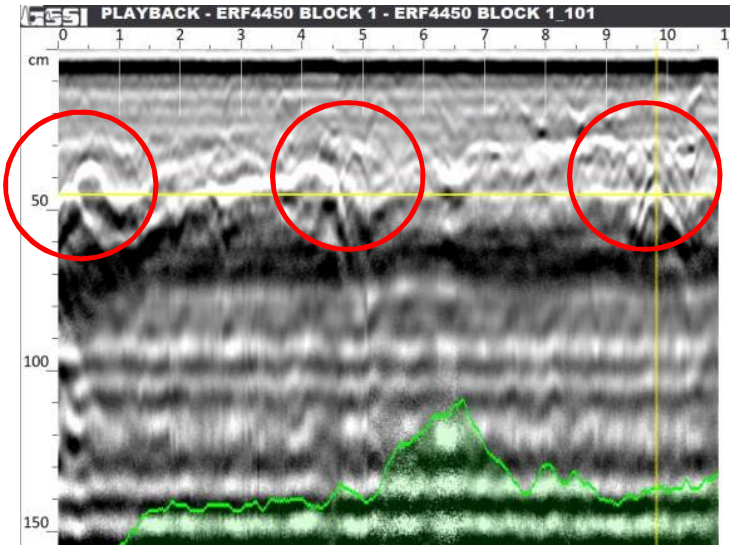

## 7. On-site observations and findings at Erf 44500:

During the on-site survey, several objects were detected at depths varying between 350mm to 500mm below ground surface. The location of these detected objects was recorded and is indicated on the Google earth image, the GPS coordinates of the indicated positions was recorded by ArchaeoMaps. The positioning and shape of the detected objects suggest that the detected objects are of a continuous nature and could represent the remains of old building infrastructure. Document proof exist that the area in question used to be a developed residential area. The findings are illustrated in picture format below.

**General area of marked positions in block one: YB2, YC1, YC2, YD1 and YD2.** During the on-site survey the area between YC1 and YB2, as shown below was identified as an area of interest.

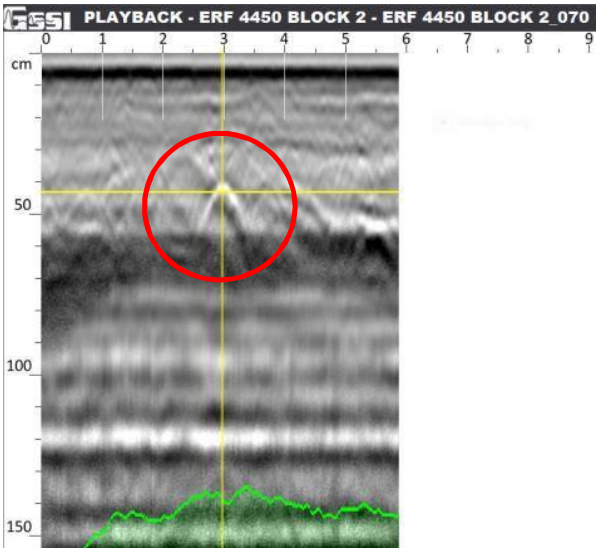



**General area of marked positions in block one: YH1, YH2, YH3, YH4, YH5 and YH6.**




**General area of marked positions in block one: YG1, WE1 and XD1.**

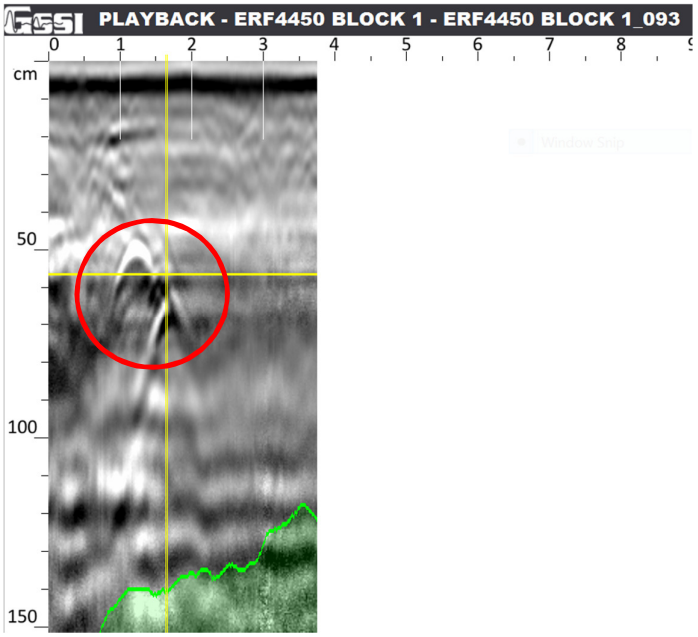
**General area of marked positions in block two: XA1 and XA2.**




NEW APOSTOLIC
CHURCH

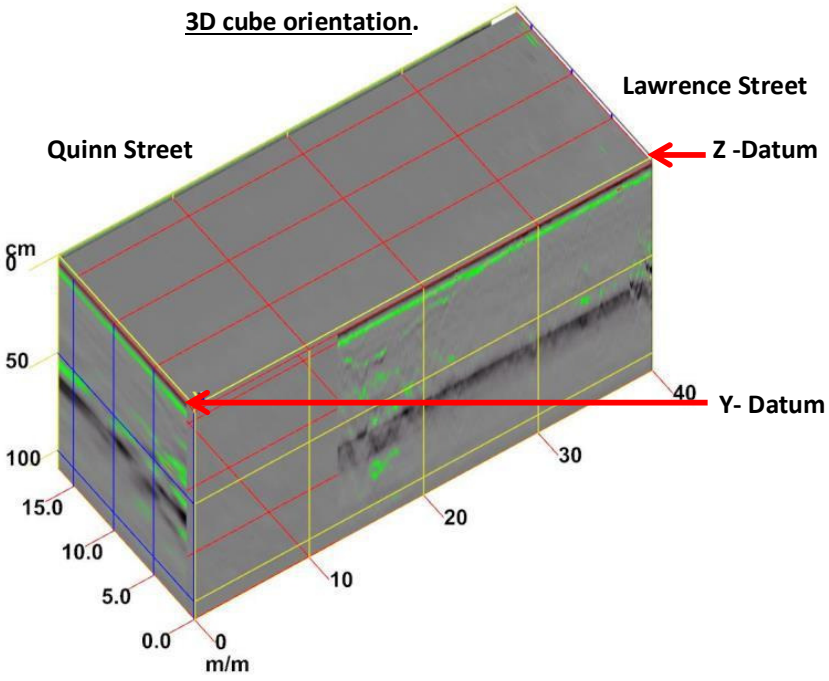
**General area of marked positions in block two: XC1, XC2 and XB1.**

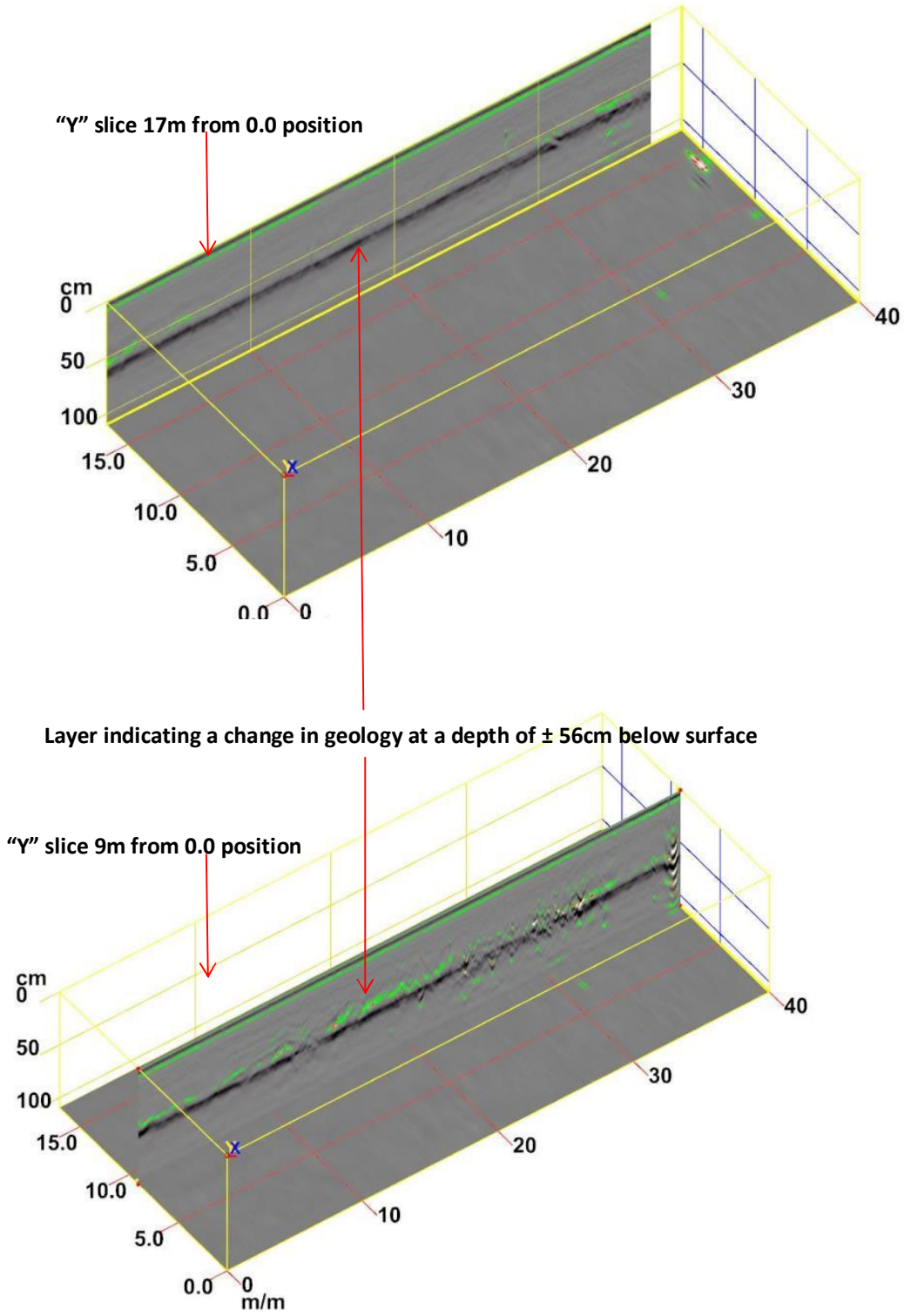

**General area of marked positions in block three: WC2, WC1, WA2 and WB1.**

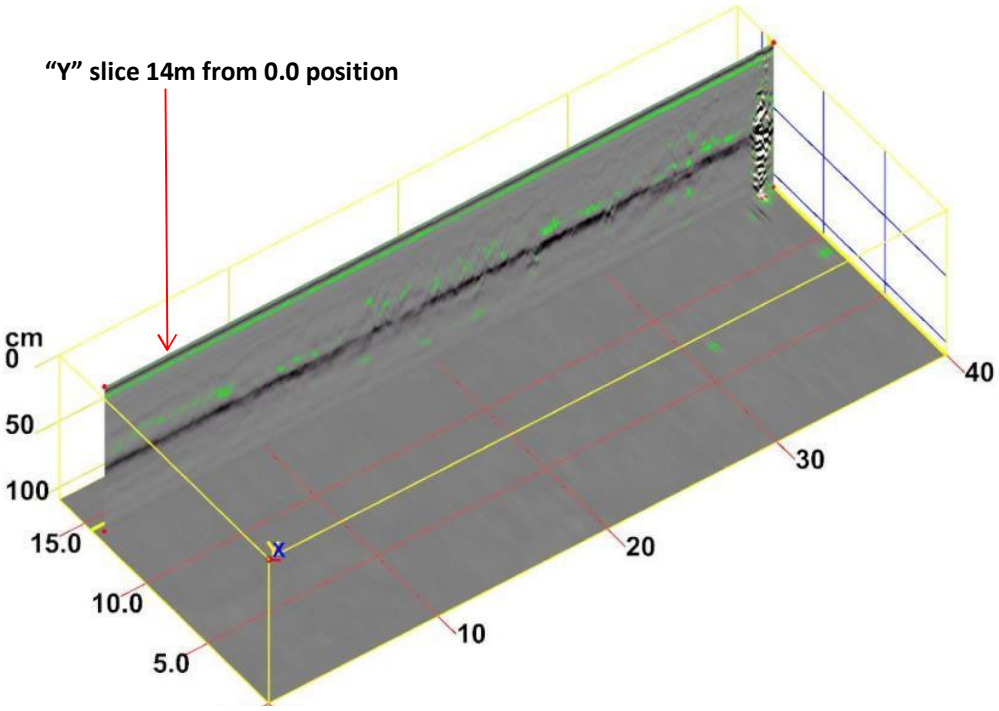


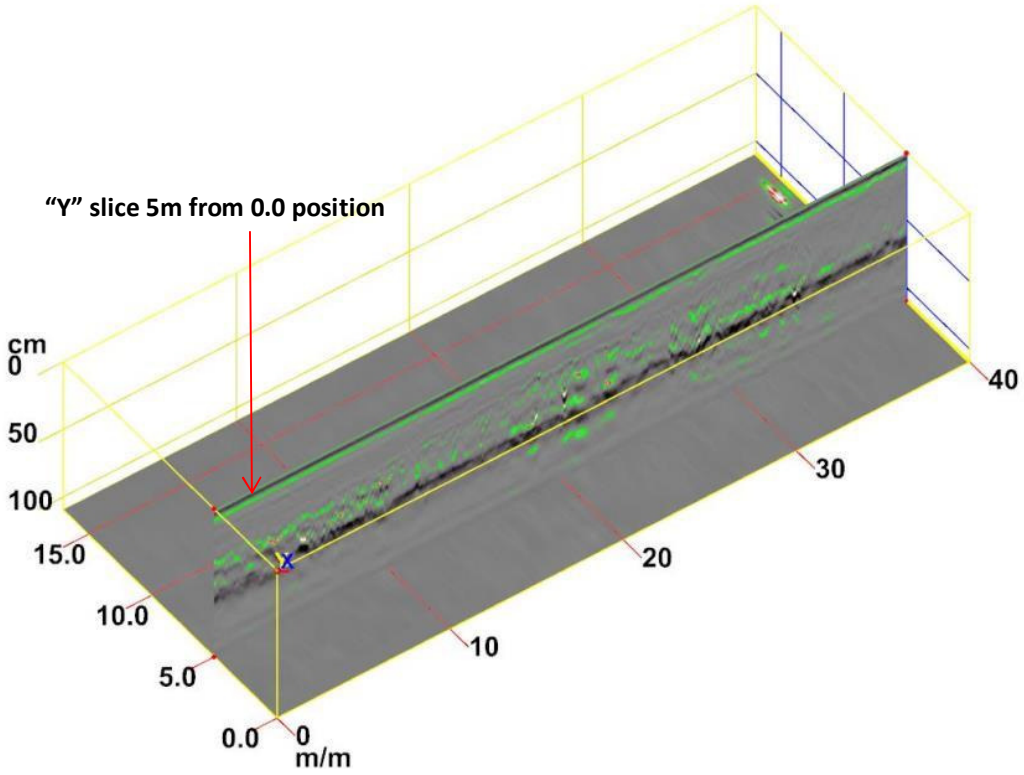
## 8. Off-site data processing and 3D data analysis of data collected at Erf 44500:

Given the majority of the detected objects are concentrated in Block one and in order to further identify possible voids or patterns of ground disturbance the data collected in this area was processed off-site using Radan 7, radar analyses software from GSSI. The processed data was used to build a 3D cube of Block one. The images below represent slices along the X, Y and Z planes of the 3D cube.

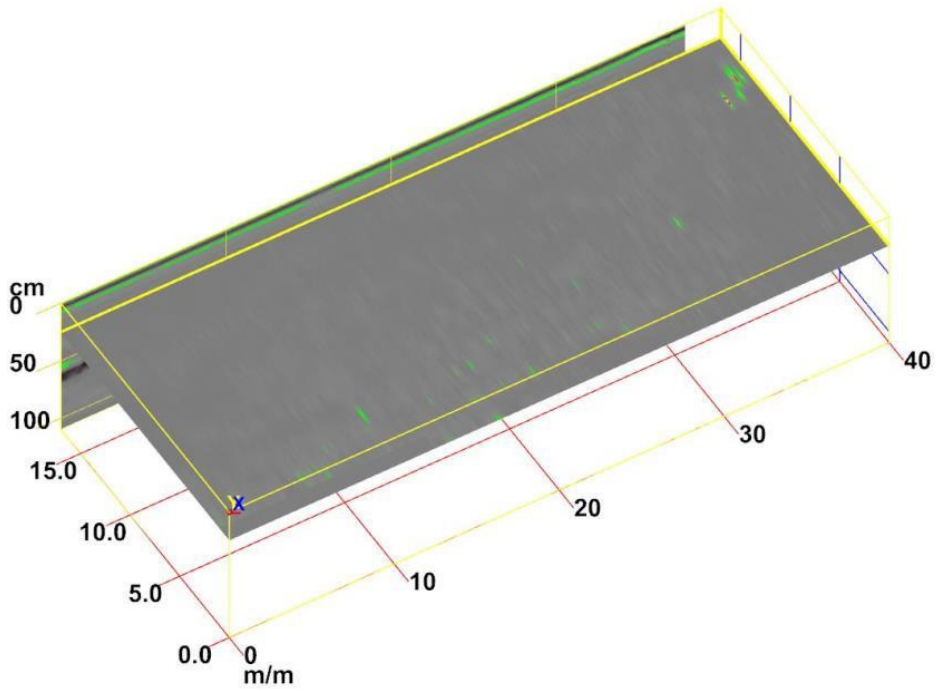



"Y" slice 17m from 0.0 position
cm
0
50
100
15.0
10.0
5.0
0.0
0
10
20
30
40
Layer indicating a change in geology at a depth of ± 56cm below surface
"Y" slice 9m from 0.0 position
cm
0
50
100
15.0
10.0
5.0
0.0
0
m/m
10
20
30
40


"Y" slice 14m from 0.0 position
cm
0
50
100
15.0
10.0
5.0
10
20
30
40

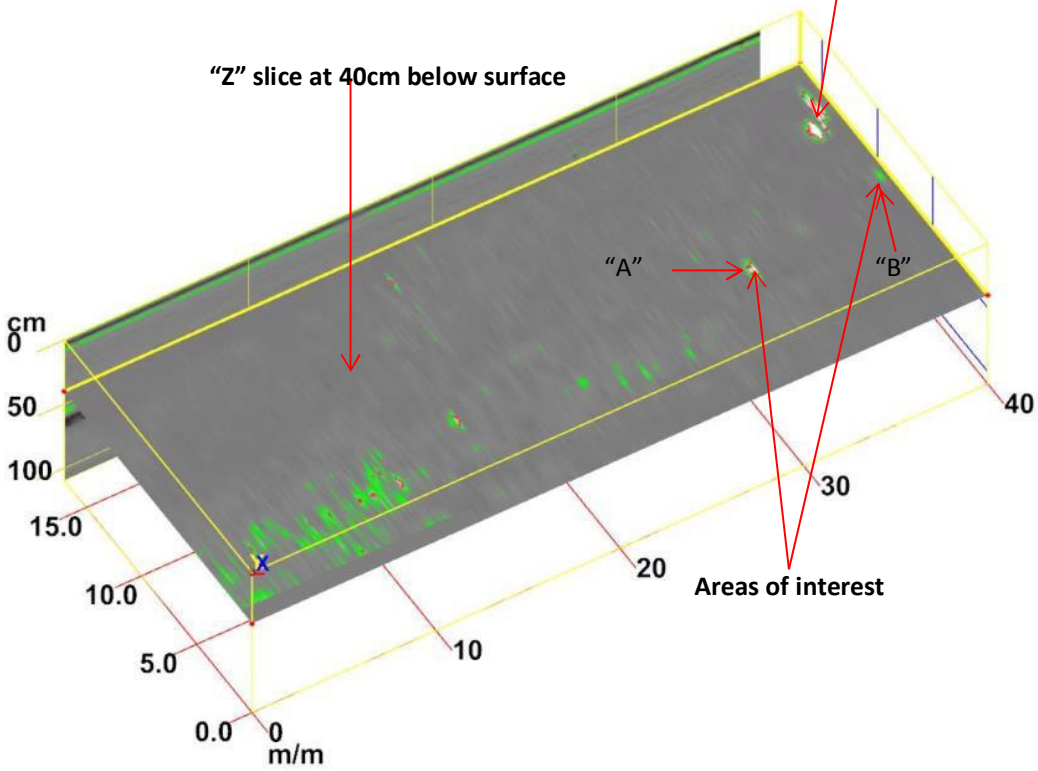

"Y" slice 5m from 0.0 position
cm
0
50
100
15.0
10.0
5.0
0.0
0
m/m
10
20
30
40

**“Z” slice at 25cm below surface**

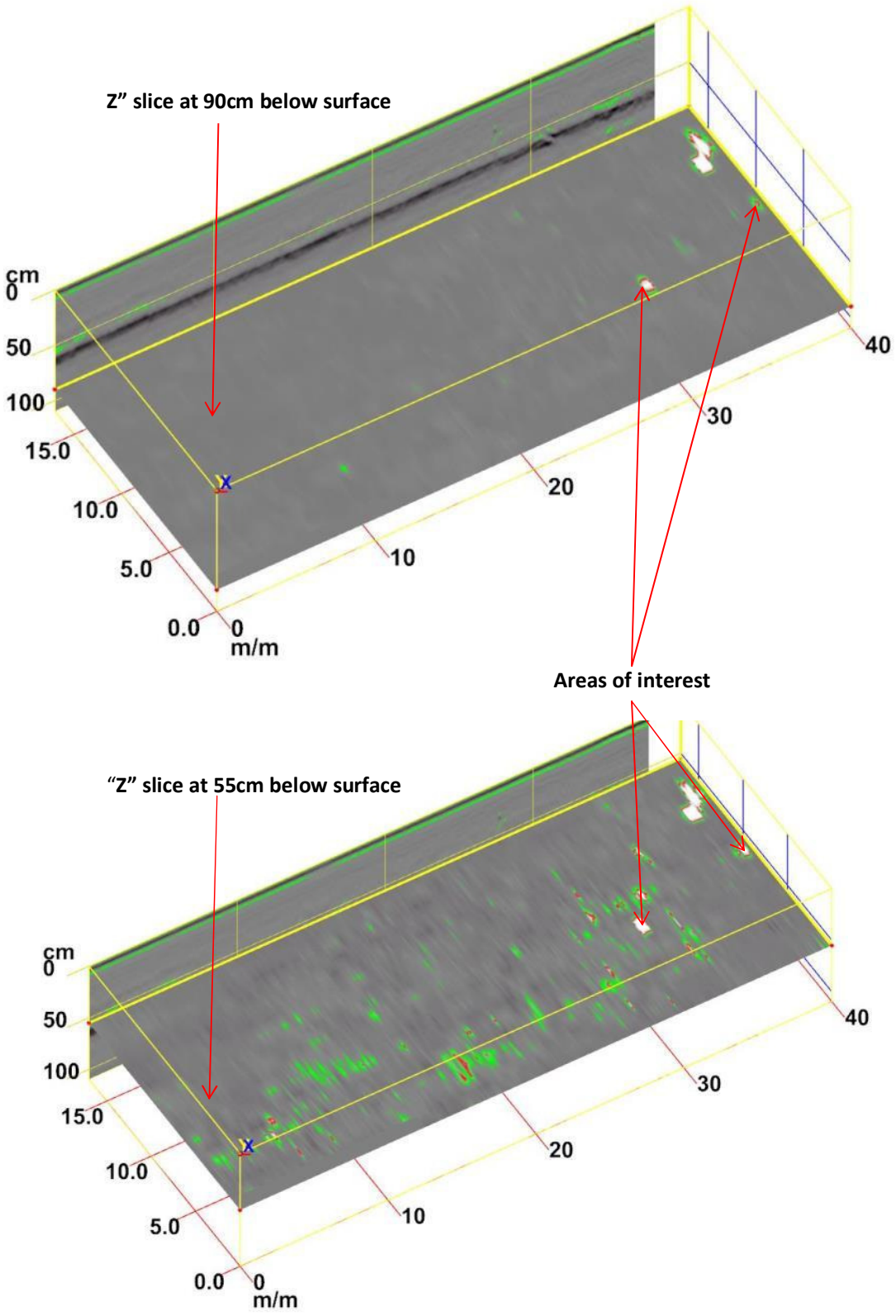



**Telkom & Neotel manholes**

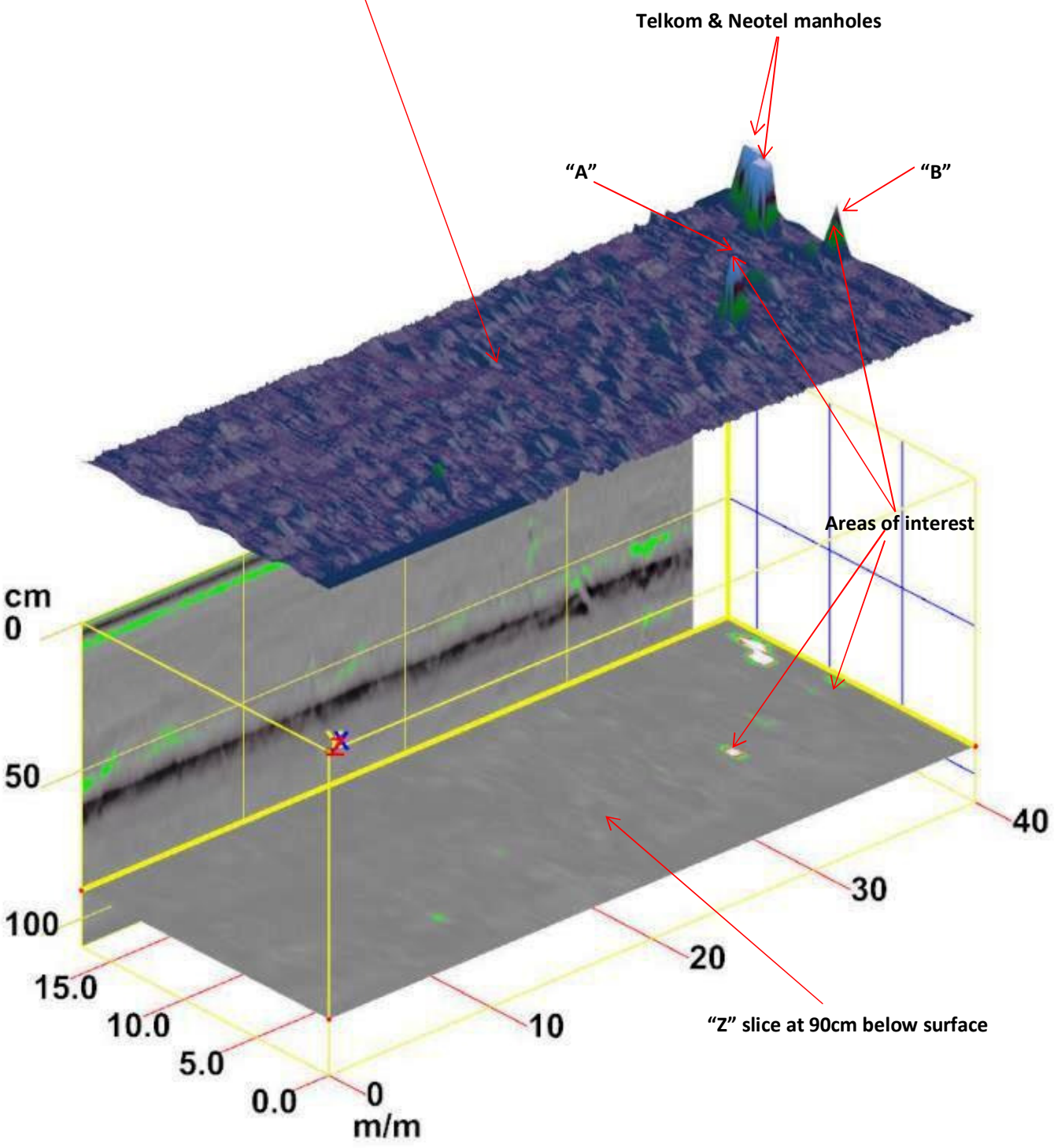
**“Z” slice at 40cm below surface**




**Areas of interest**


Z" slice at 90cm below surface
cm
0
50
100
15.0
10.0
5.0
0.0
0
m/m
10
20
30
40
Areas of interest
"Z" slice at 55cm below surface
cm
0
50
100
15.0
10.0
5.0
0.0
0
m/m
10
20
30
40

**Contoured image of "Z" slice showing anomalies from surface level to 90cm below surface**



## 9. Limitations of results:

It should be noted that GPR and geophysical investigations and the interpretation of data from these investigations are inherently ambiguous. More than one source may have similar variations in the measured property, making it difficult to correctly interpret the results. In other words, the measured geophysical anomaly may have more than one interpretation and different physical sources may produce similar geophysical anomalies.

The depth to anomalies is determined by the velocity of the electromagnetic energy in the soil. In the case of Erf 4450 a dielectric constant of 9 was used for limestone and clay. Variations in the constant as a result of moisture or changes in the medium itself may produce incorrect depths because of an “incorrect” dielectric constant. In this case a change in the dielectric constant of the soil is expected at a depth of approximately 56cm below surface at the point where there is a drastic change in the geology on site. These variations are typically small and should typically not produce errors larger than 10% in depth estimation.

## 10. Conclusion:

The objects detected and marked out during the onsite survey represents linear objects that represents the remains of what is believed to be manmade infrastructure such as building foundations described in the ToR (vii), the ground disturbance that were detected was relatively shallow and on top of the change in geology situated at a depth of ± 56 cm below ground surface, the mentioned change in geology corresponds with the ToR (v) and extends across the sub-surface extent of Erf 44500.

During the onsite survey, no consistent high or lower density patterns of subsurface disturbance were detected that could reflect rows or row-like patterns, or infrequent random scatters of graves as described in the ToR (i, ii, iii & vi), with grave-like disturbance inferred to be variable in size, primarily rectangular in shape, but which may approach 'square shaped' disturbances (double or multiple graves) and which may approach 'oval' shapes. No disturbance other than objects "A" and "B" penetrated the geological member situated at 56cm below ground surface.

The off-site analysis of the GPR data highlighted the presence of two objects of interest marked as "A" and "B" in the 3D image on page 18.

The data suggests that that object "A" is a void measuring 1.5 m x 0.7m situated at approximately 30cm below the surface, it extends down to a depth of 1m below surface. This object seems to have a flat surface area that suggests that it could be an old sewerage pit or other manmade void. Object "A" is situated 9.7m from the Quinn Street sidewalk and 8.9m from the Lawrence Street kerb.

Object "B" is situated on the sidewalk, 0.9m from the Lawrence Street kerb. The object measures 1.2m x 0.6m and is situated at a depth of approximately 48cm below the surface and extends down to a depth of 90cm below the surface. This object represents a similar GPR signature as a void but no flat surface is present in this position.

It is suggested that the two objects of interest mentioned above be further investigated.

Through an analysis of the processed GPR data, no consistent high or lower density patterns of subsurface disturbance were detected that could reflect rows or row-like patterns of graves as described in the ToR (i, ii, iii & vi).

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05 February 2015

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