UNIVERSITY OF ALBERTA

Geophysics Field School, University of Alberta

Ground Penetrating Radar
Looking for Engineering Structures

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Introduction

The main goals are to Develop and increase our understanding of Ground penetrating radar method to image the subsurface. From learning how to properly set up equipment to developing more efficient ways to collect data in the field. We will also gain a deeper understanding of the theory behind GPR and how it is applied to the real world. We will develop more intuitive ways to processing data and will also get to put our interpreting skills to use.

The survey was conducted from Monday, August 22nd to Friday August, 26th in Dorothy, AB. The conditions under which the data was collected were a mixture of hot and dry days with cold and rainy days to even thunderstorms. The equipment used was a RAMAC GPR.

Theory

Ground Penetrating Radar - (GPR)[1] is a non-destructive geophysical method that uses electromagnetic radiation in the microwave band. This method very much like seismic reflection, detects the reflected signals from subsurface geological structures or interfaces. A transmitter sends EM energy into the ground that when it encounters a region of different permittivities, the energy may be reflected, refracted or scattered back to the surface. In the surface, an antenna can record the return signal variations.

This method faces a depth/resolution trade off[2]. While higher frequency allows for better resolution, it will also result in shallower depth of investigation. Thus, Ground penetrating radar is a near surface exploration technique.

Field Experiment

The RAMAC GPR is composed of a Transmitter and Receiver (TX & RX), Antennas and a wooden frame that keeps the TX-RX at a constant separation. Recording the data was very straight forward; once the appropriate frequency and measurement offset were selected we could start taking measurements at the profile of interest[3].

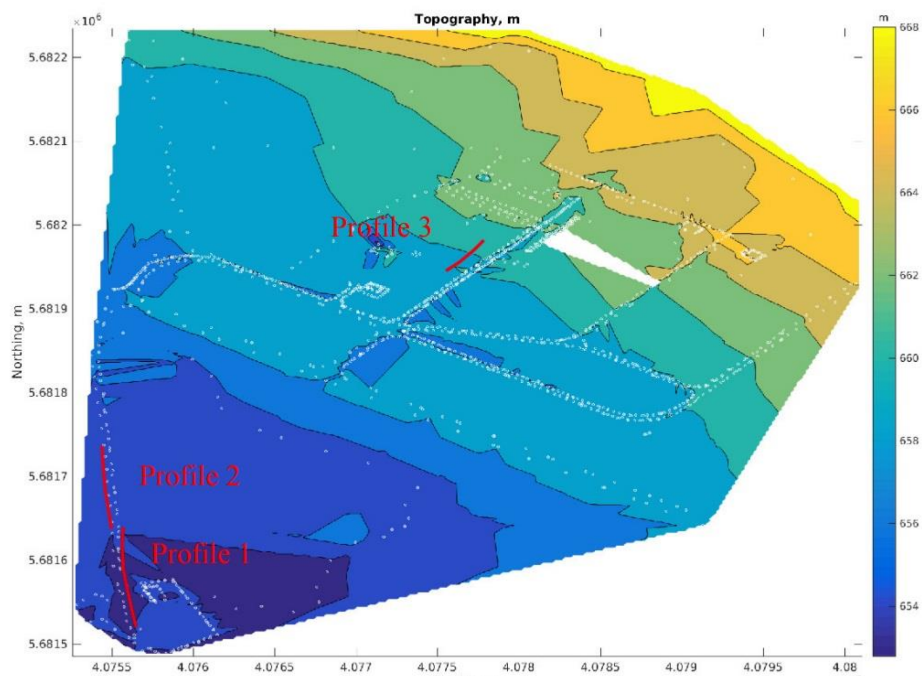

Figure 3.1 Location of GPR profiles.

Results

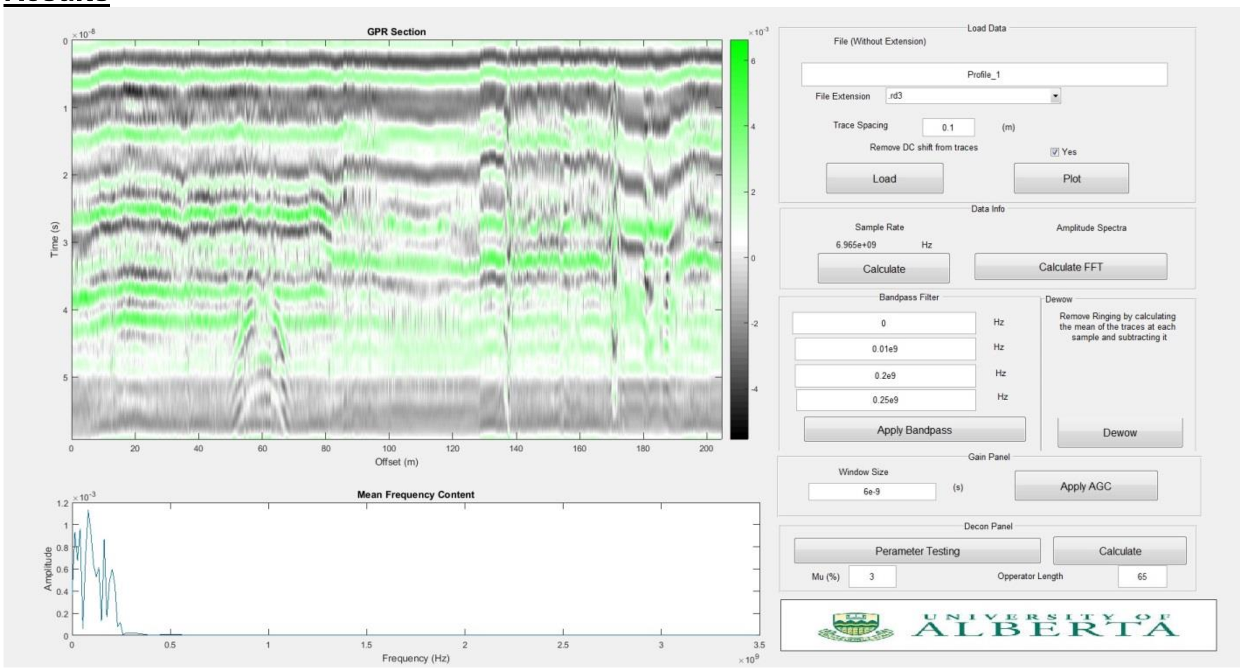

Figure 3.2 Profile_1 with operator length of 65, window size of 6e-9, band pass (0.01e9-0.2e9) and mu = 3

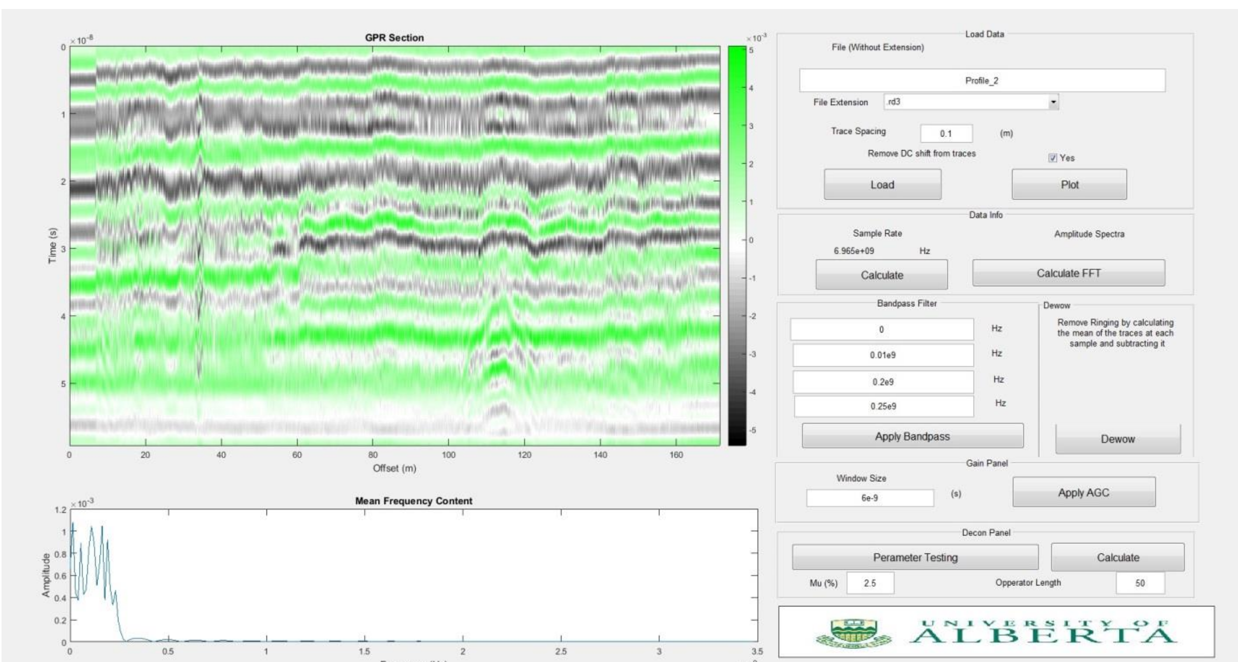

Figure 3.3 Profile_2 with operator length of 50, window size of 6e-9, band pass (0.01e9-0.2e9) and mu = 2.5

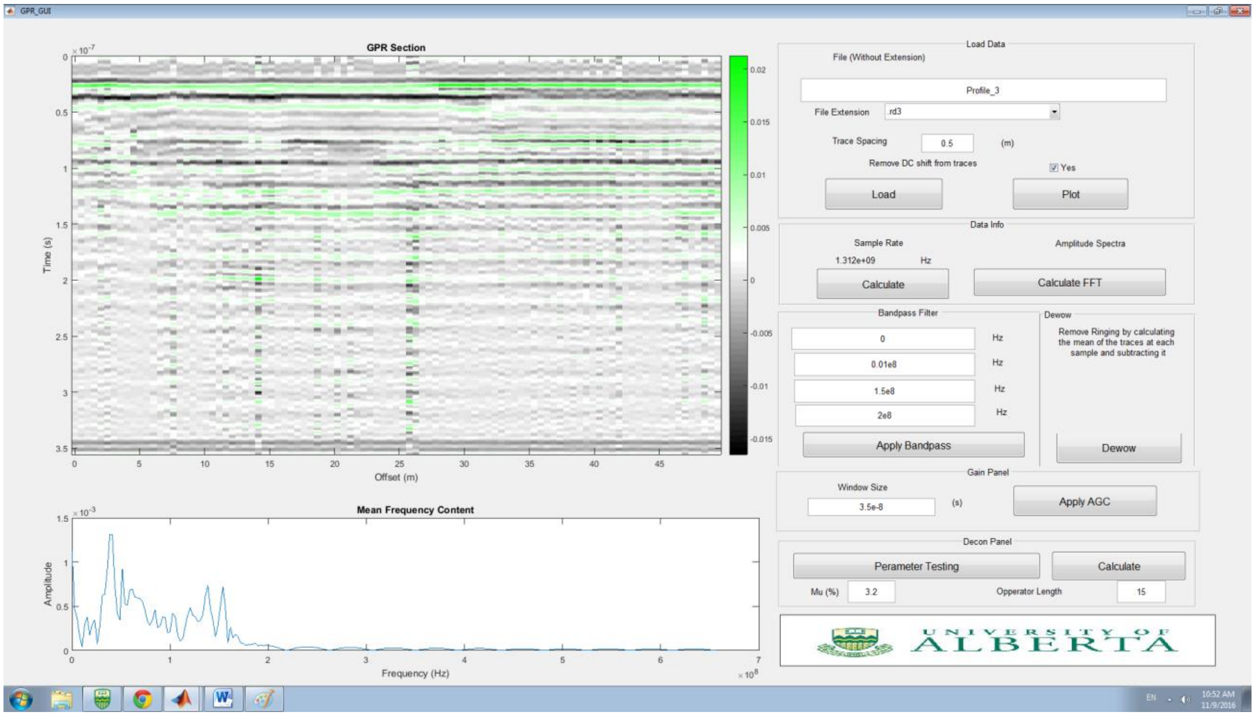

Figure 3.4 Profile_3 with operator length of 15, window size of 3.5e-8, band pass (0.1e8-1.5e8) and mu = 3.2

<u>Interpretation & Discussion</u>

Q1. What's most significant difference between these two frequency spectrums? Could you explain how the DC removal affects the waveform and frequency spectrum? Do you notice any differences in the raw image (pay close attention to the color scale)?

- The most significant differences between these two frequency spectrums are that the amplitude for 0 Hz gets 'reset' to zero. While the unchecked 'remove DC shift from traces" has a nonzero value for the zero frequency. The DC removal assigns a zero value to the white color in the color bar, it shifts the color scale up or down accordingly, thus making the waveform brighter or dimmer.

Q2. Process the other two profiles. You may have to adjust a few parameters, e.g., corner frequencies, mu value, to get a clear image. Make sure you justify the decisions you make in the processing stage.

- See Figures 3.3 and 3.4 in <u>Results</u> for the plots.
- Corner frequencies are adjusted based on the mean frequency content. We want to set the corners such that we see the frequencies we are interested in. The mu value is the permittivity of the conducting medium; this should be almost identical for all there but can also be slightly different in order to obtain a clearer image. The number of lags if set such that we get a "Mexican hat" wavelet.

Q3. In the three profiles provided, you need to identify and mark 1) the direct wave and 2) a reflected wave which could be regarded as a point reflector.

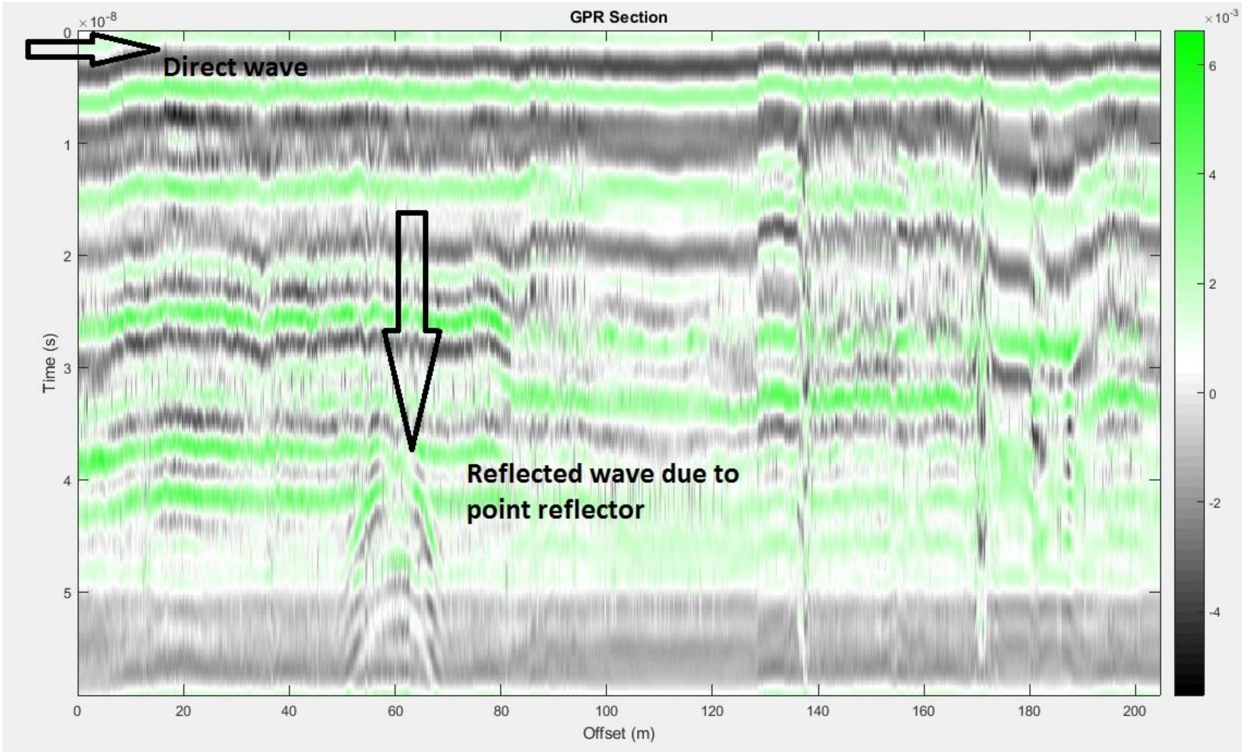

Figure 3.5 Profile 1 displays both the direct wave and reflected wave from a point reflector. This is a high resolution survey since the section is displayed clearly. The trace spacing is 10 cm and sampling frequency of 50 MHZ.

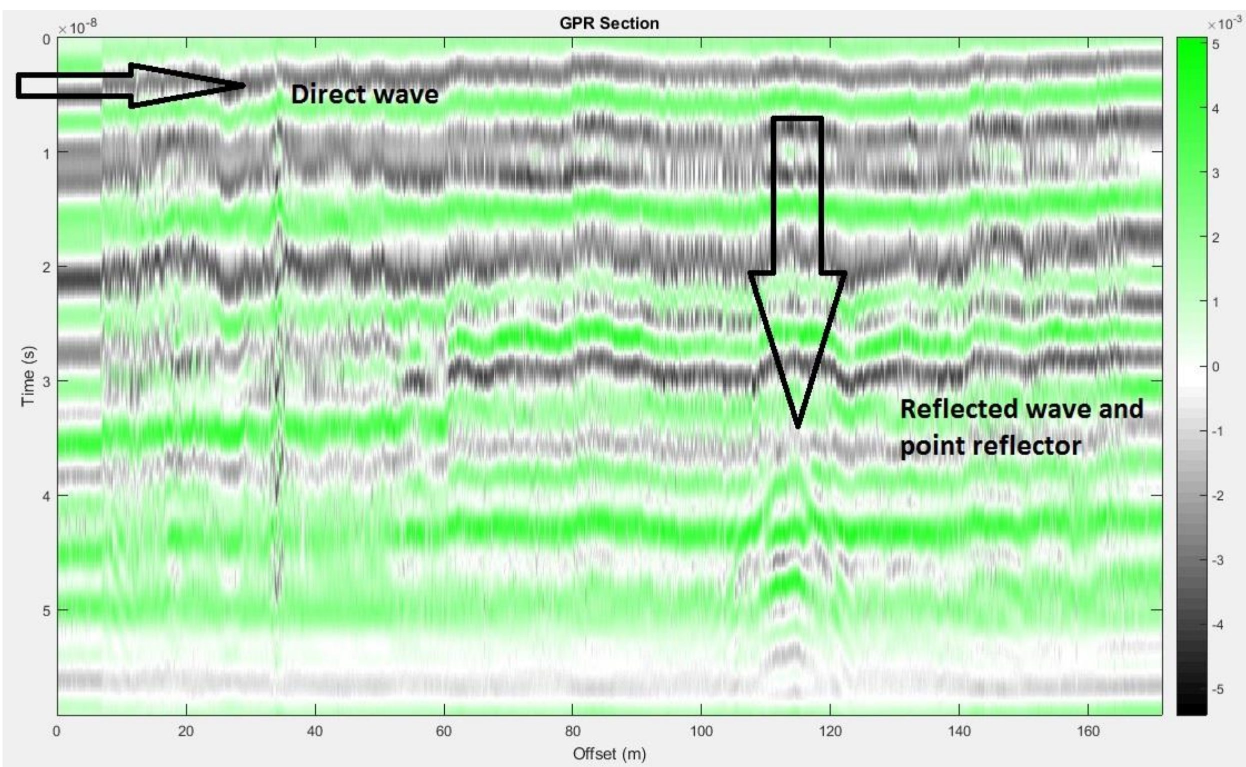

Figure 3.6 Profile 2 exhibits features similar to Profile 1 with both direct wave and point reflector displayed in the cross section. This profile has same spacing and frequency as profile 1.

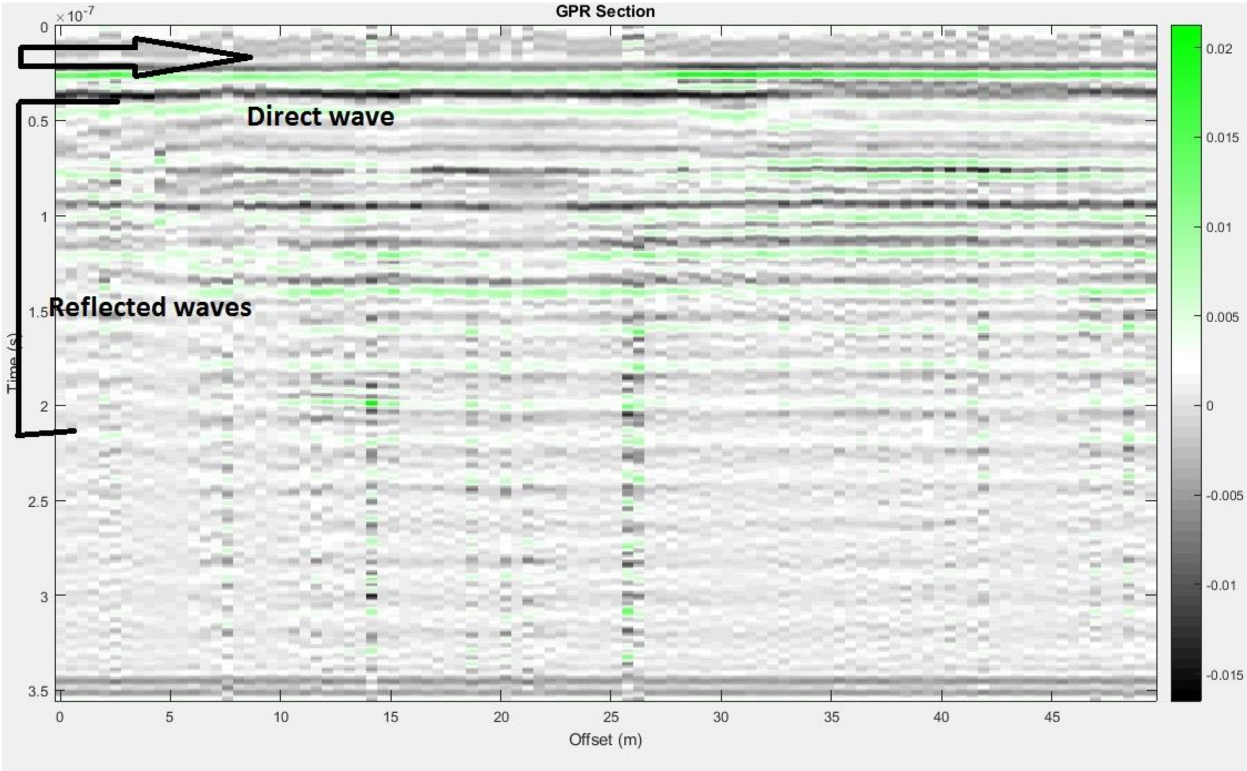

Figure 3.7 Profile 3 is a very low resolution profile with a trace spacing of 0.5 meters. We are not able to obtain much information out of this profile but one can still identify the direct wave and the reflected waves.

Q4. Take an educated guess as to the velocity of the subsurface (in m/ns); calculate an approximate depth to the reflector. Demonstrate / illustrate your analysis procedure.

- Recall[5] $v = {}^{C}\!/\!_{\sqrt{\varepsilon_r}}$ where C is the speed of light and the denominator is the square root of the permittivity of the conducting medium, clay in this case. Assuming C = $3\text{x}10^8$ and the permittivity of clay is 25 F/m, the velocity of propagation of the signal is ~0.06 m/ns[4].
- The depth to the reflector can be found using basic physics (2d = v*t) where the factor of two represents two way travel time. The time at which the reflection occurs is ~4e-8 s (from figure 3.5) therefore; the depth to the reflector is ~1.2 meters.

Q5. Analyze the waveform features and calculate the burial depth of the reflector if it exists.

- The waveform indicated by the point reflector has a parabolic shape since energy is being scattered from there. Again from Q4. The burial depth of the reflector is ~1.2 meters.

Q6. Select one of the three profiles and form an interpretation for the subsurface anomaly. What do you think is causing the reflection?

- Profile1: There are two interesting features here, the first occurs at an offset of ~60 m which could potentially represent a pipe since it is decently deep and only occurs at one spot. The second feature occurs at ~135m and could potentially represent cables since it has a very distinct cylindrical shape and it is a shallow feature.

Conclusion

We were able to identify a few features in our cross sections (Figure 3.2) by conducting GPR survey along three profiles (Figure 3.1). Based on a few assumptions such as the permittivity of clay[4] we were able to calculate with reasonable accuracy both the velocity of propagation of our source (~0.06m/ns) and the depth to burial for any given feature.

The results (Figure 3.5 and Figure 3.6) show that there might be a pipe buried at about 1.2 meters close to Linda's house and also a few cables might be running close to the surface as well. This can be supported by profile 1 and 2; however profile 3 is not very useful given its resolution. The survey showed to excel at mapping conductors in the near subsurface due the shallow propagation of a high frequency signal.

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References

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