Optimal GPR Antenna Selection

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It is common knowledge to anyone practicing Ground Penetrating Radar (GPR) technology that lower center frequency antennas mean higher penetration and lower resolution. In the same way it is correct to say that higher center frequency antennas mean lower penetration and higher resolution. This is without any doubt an axiom that provides us with a rule of thumb on what to use and what not to use for our surveys. The question I am trying to explore in this particular application is quite different: *what is the actual threshold for choosing between a higher or a lower frequency antenna?*

Answering to this question is neither straight forward or easy, but I'll try to explain it with a simple example of cons and pros of using one or the other type of antenna. For this experiment I used two antennas manufactured by Geoscanners AB, a GCB-200 with a center frequency of 200MHz and a GCB-500 with a center frequency of 500MHz. I will have to go into a lot of details for both of the antennas because they are very relevant to the conclusions we are going to reach later on, so please, be patient.

The power spectrum for each antenna is presented in figures 1 and 2 respectfully so you can better understand the concepts explained below.

The GCB-200 has a -10dB bandwidth starting at 121MHz and up to 357MHz giving us 239MHz as the -10dB center frequency and a 98% bandwidth at the -10dB levels. Penetration of six meters or more can be expected in moderate conditions with this antenna. The transmitted pulse duration for the antenna we used was 4.8ns and the relative dielectric permittivity of the media we surveyed is 6. With this figures we can easily calculate that the expected vertical resolution should be around 30 cm.

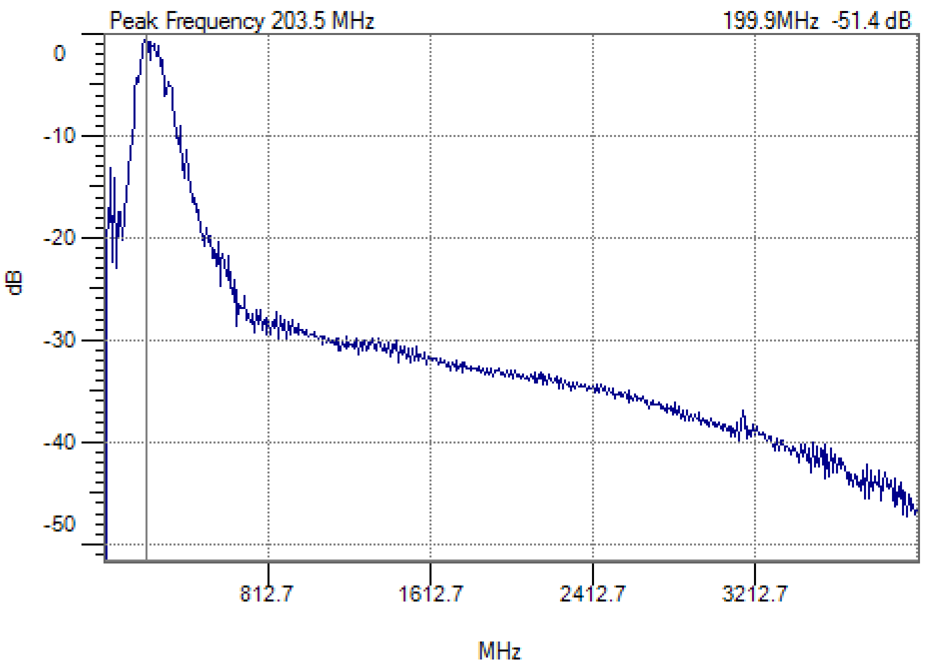

Fig. 1 Power spectrum of the GCB-200 ground coupled antenna.

The GCB-500 has a -10dB bandwidth starting at 266MHz and up to 729MHz giving us 497.5MHz as the -10dB center frequency and 93% bandwidth at the -10dB levels. This antenna was designed for penetrations between 2.5 and 3 meters in moderate conditions. The transmitted pulse duration for the particular antenna we used in this survey was 2.1ns and as said before the relative dielectric permittivity for the site was equal to 6. Putting all this data into a well known equation for the vertical resolution , we can calculate that the vertical resolution for this antenna should be around 13 cm or roughly a little more than the double resolution that can be obtained with the GCB-200.

Fig.2 Power Spectrum of the GCB-500 ground coupled antenna.

We now have a clear picture of the antennas we are going to be using and their properties. In both cases we used an Akula 9000B ground penetrating radar control unit mounted on an U-Explorer utility survey kit equipped with standard accessories. Both measurements were done during the same evening and it didn't rain in the time between the two surveys. This means that the conditions were equal and the results were not affected in any way by environmental changes.

The targets for the survey are as follows:

1. The bottom of the base of the road, approximately at 60cm below the road surface.
2. A large tunnel under the road, approximately 1 meter below the surface.
3. Water accumulation on the lower sides of the tunnel, approximately 3.5 meters below the surface.

It is obvious that the choice of the targets is no coincidence and that we have one shallow target, a medium depth target and finally one relatively deep target. This is where it all sums up, if we would need to survey only the target number one then of course the antenna of choice would have been the GCB-500 without any doubt. If on the other hand we wanted to detect the water accumulation on the sides of the tunnel then only the GCB-200 would have worked because the required depth is out of reach for the GCB-500 as explained above. But, what about the medium depth target, the large tunnel? Here the answer is that both antennas are good for the job, it doesn't really matter which one you choose the target is within range for both and the resolutions are sufficient to effectively detect it.

All this sounds terrific and fairly easy to grasp, but do the results confirm the conclusions we have just reached? The figures 3 and 4 show the results of both surveys. As was expected the tunnel under the road is clearly visible and unmistakeably detected with both antennas. The base of the road can be more or less “guessed” in the data collected with the GCB-200, but putting the right depth to it will prove a challenge for everyone who is not interpreting GPR data on a constant basis. The water accumulation on the sides of the tunnel is completely out of reach for the GCB-500, but it is clearly visible in the data collected with the GCB-200.

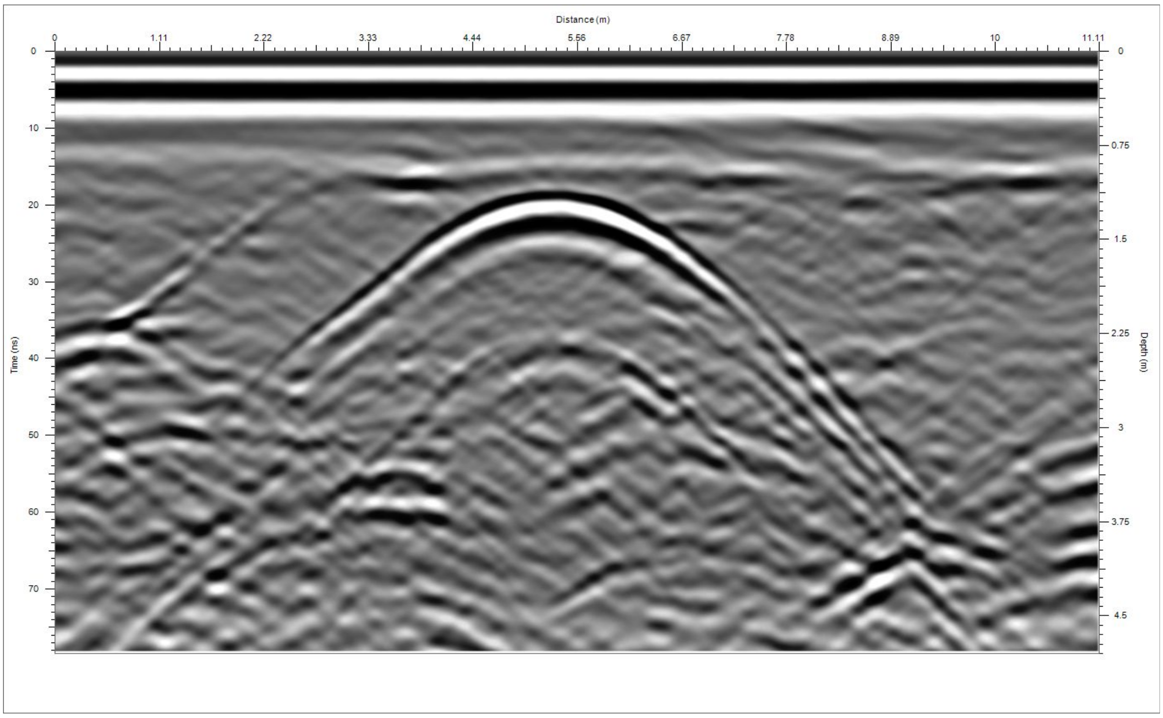

Fig. 3 GCB-200 data showing the tunnel and the water on the sides of the tunnel.

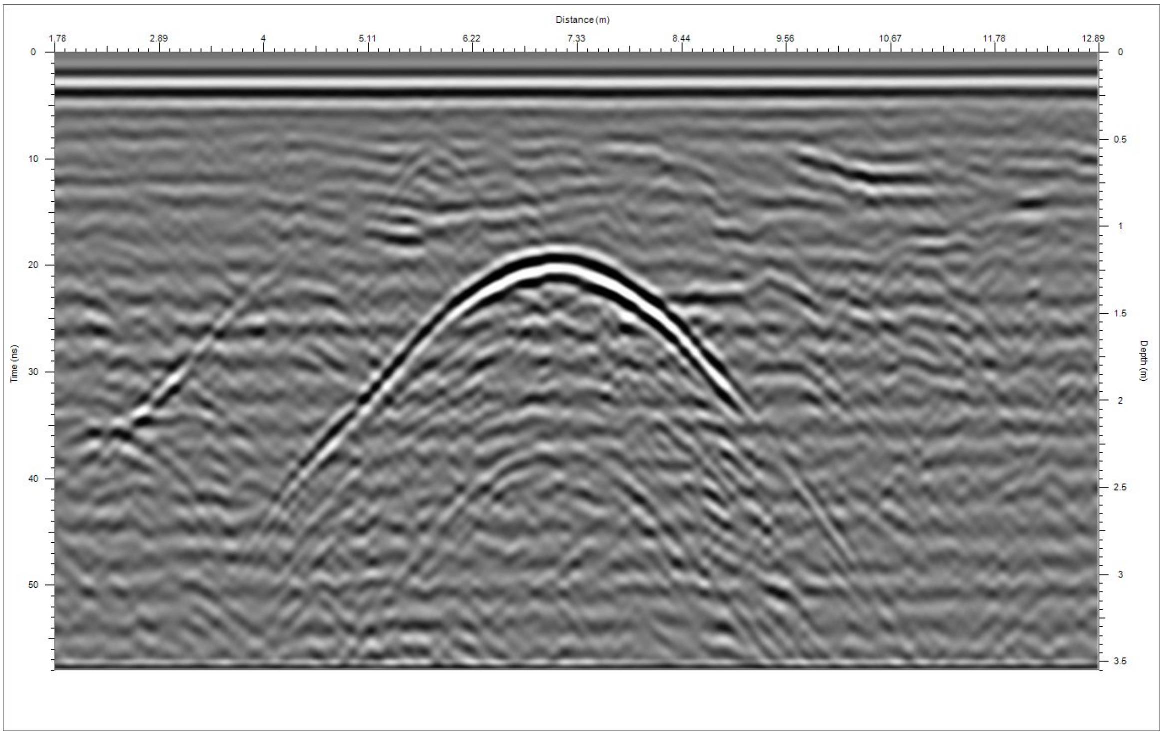

Fig. 4 GCB-500 data showing the tunnel and the base of the road with layers in it.

The conclusion to make for this first survey is that for medium depth targets with relatively large size the choice of the antenna was not critical and either one of them would have done the job equally well. This means that for large targets buried 1 to 1.5 meters from the surface like many UST (Underground Storage Tanks) the GCB-200 with 200MHz center frequency and the GCB-500 with 500MHz center frequency are both adequate devices. In this particular case there is no well defined threshold and when buying your equipment on a tight budget select the antenna that will serve the second criteria best, that is penetration depth or shallow resolution. To put it in other words, *the threshold for selecting your antenna is completely defined by your type of applications and the available budget for purchasing the equipment*.

Fig. 5 Composite picture showing the survey area and the GCB-500 data superimposed.

References:

1. GPR Antenna Resolution - http://www.geoscanners.com/pdf/antres.pdf