2D Multi-Frequency GPR Systems - Another Selection in the Multitool Approach for Utility Locating

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Utility locate professionals of today are equipped with a series of tools to accomplish their objectives, whether marking out utilities with paint on the ground or surveying these same marks to create a detailed SUE deliverable in CAD, or other drawing, to survey grade. Today's short list almost always includes an EM locator and ground penetrating radar (GPR).

For decades now, EM locators have proven the need for a range of frequencies to accommodate differing locate scenarios, such as lower frequency systems for longer distance induction, and higher frequencies for shorter range and higher distortion/resolution. Today, many GPR manufacturers also offer a multi-frequency or dual channel GPR system for the locate professional. Necessity is the mother of invention as they say, and just as with EM locators, there is a reason. Central to the development and proliferation of dual frequency (dual f) systems, one must ask if these systems really have an edge over single frequency systems? Is the additional frequency the extra tool analogous to those neatly folded in a multi-tool? It is not obvious what value or function some of these have if one ever unfolds all of them! The simple answer for a dual f GPR is yes, they do have an edge, but as with a multi-tool, choosing which one of the tools in the handle works best for the task at hand is a matter of knowing how the tool works.

The Right Frequency for the Job

A fundamental understanding of GPR wave propagation and how the frequency governs the resolution and the capacity of that wave to travel through the ground is the key. Lower f GPR waves generally penetrate deeper in a given earth medium than do higher f waves. However, the caveat with GPR is that with these lower frequencies the ability to resolve smaller targets is diminished.

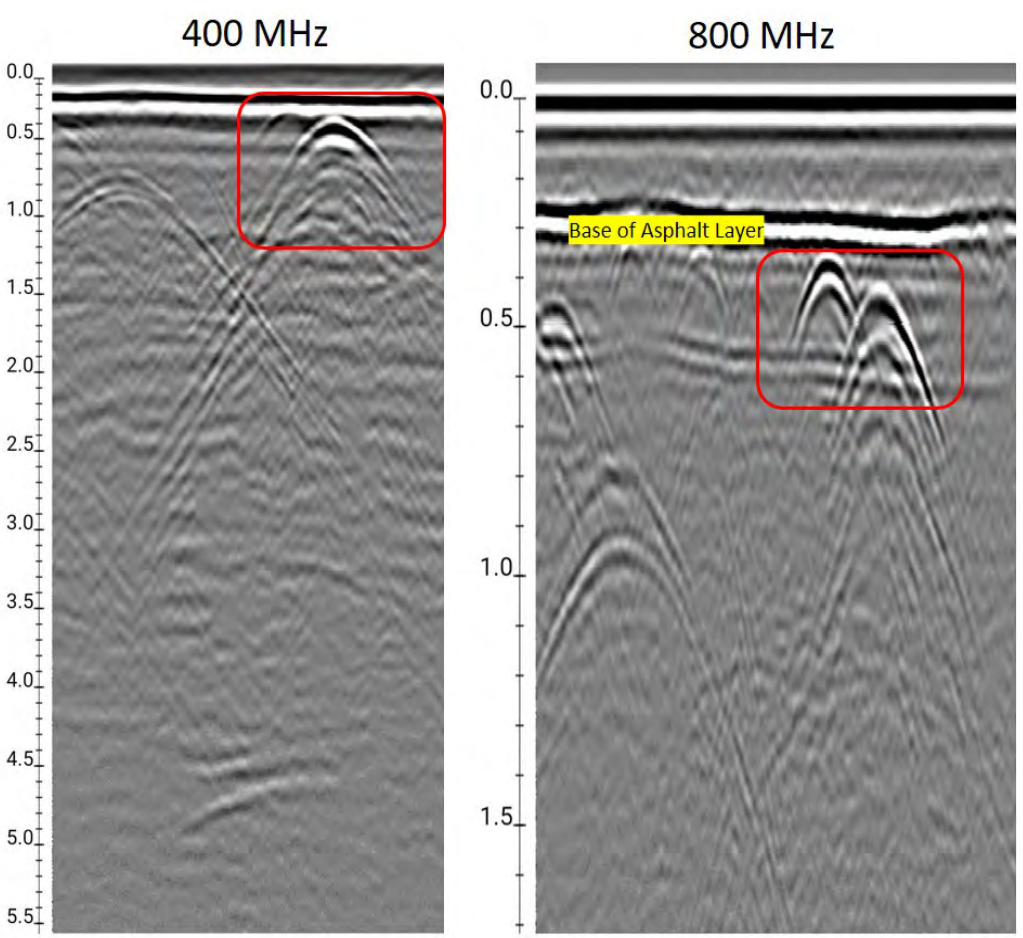

Figure 1: Comparison of depth penetration and resolution over same target area. Vertical depth scale in meters. Useable data to five meters at 400 MHz and up to two meters at 800 MHz. Note target utility couplet not nearly as resolvable at 400 MHz and in the near field/surface.

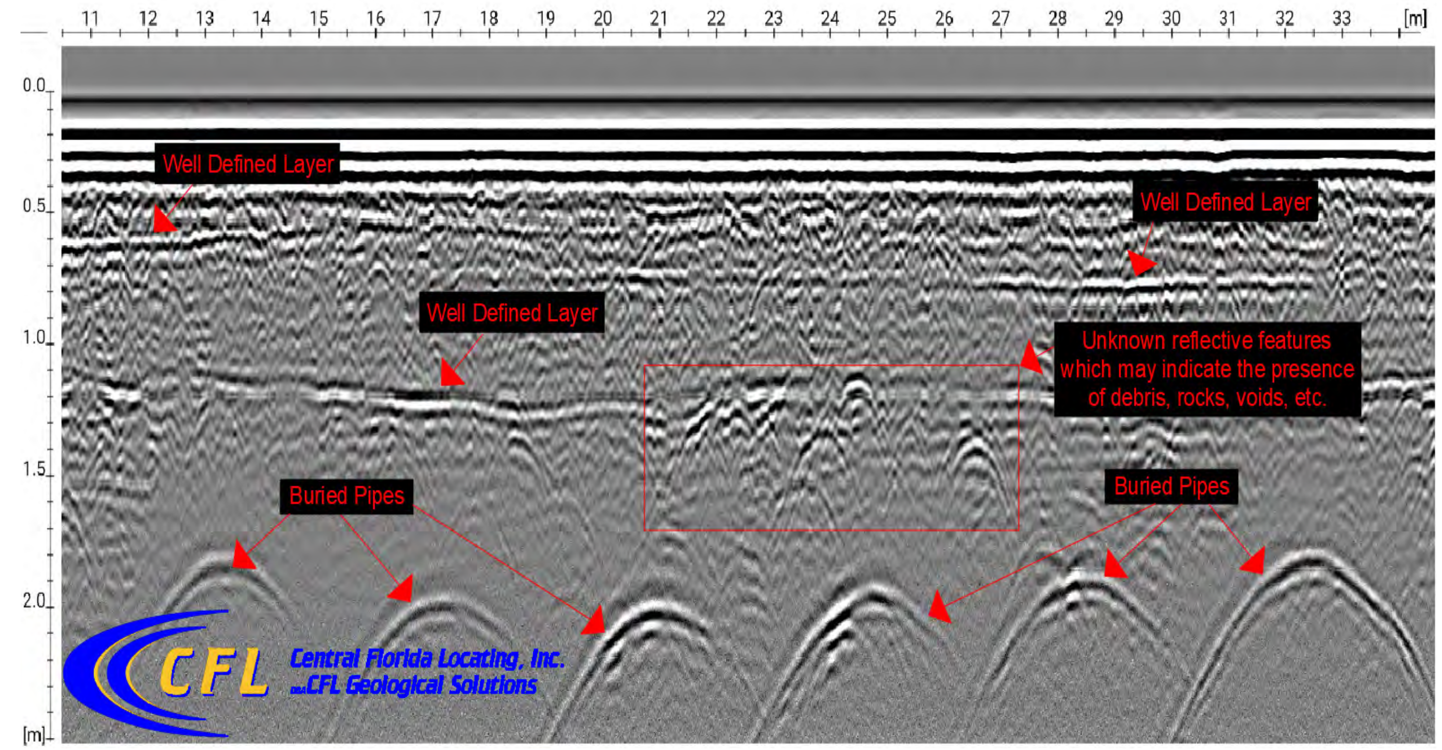

Figure 2: Interpreted 800 MHz data set over culvert bridge system

Conversely, resolution is higher at the higher frequencies, but depth penetration may be limited. It is these basic principles that are the practical rational to have a GPR system with dual f antennas.

Many articles and technical journals have established that conductive soils are the bane of GPR, and in some cases, the method is simply ineffective as a tool. With any GPR training program this concept is front and center as the key component to success or not with GPR utility locate systems. If GPR penetration is severely impacted, it may be best to "fold" it back into the truck. However, in the proper soils, the utility locate industry has learned that GPR is a powerful non-invasive technique to locate utilities that cannot be detected by an EM tool. Doubling down on this fact, in the proper soils, having a range of antenna frequencies from low to relatively high, it gets even more interesting. For example, utilities such as direct buried fiber or very shallow plastic conduits with perhaps a fiber line installed, are simply not resolvable with the classic mid-range GPR antenna from 200-400 MHz. However, once the frequency approaches the range of 600-800 Mhz, odds are these utilities can be resolved (Figure 1).

Most modern-day systems are designed with the latest in digital technology that are pushing depth penetration to new levels. In years past, conventional wisdom dictated that at around 500 MHz in ideal soil conditions, a GPR system was capable of resolving targets to about 12-feet. At 800 MHz, this was around 1.5-feet in ideal soils. Today, systems have more than doubled these performance figures. This is in part due to newer digital sampling technology that is the new industry standard allowing GPR return signals to be "stacked" or repeated over a target at a greater capacity to create a composite signal from many pulses—greatly suppressing noise. These technical advances make the inclusion of a higher frequency antenna even more viable, whereas in the past, one could argue the additional high frequency value was much more limited.

A GPR Case Study

A perfect example of this paradigm shift in effective depth penetration is evident in a recent utility investigation conducted by Central Florida Locating (CFL), a premier utility location and geological consulting firm headquartered in Bushnell, Florida. Using a dual f ImpulseRadar system with a 400 MHz and 800 MHz system, CFL was able to clearly resolve a series of large culvert pipes under a roadway that effectively create a bridge between two canals. The client not only wanted to locate these structures under the roadway, but ascertain if there were any potential voids undermining the road around the pipes. Previous attempts to invasively probe down to the pipes were thwarted by an impenetrable layer that was not known to exist. Locating the culverts was not an issue with the 400 MHz frequency, as would be expected, but the shocker was that the 800 MHz data clearly identified the series of culvert pipes as well at 1.5 meters (5 feet) (Figure 2)! This is a perfect example of the increased depth window these newer systems are achieving, while at the same time resolving the historically non locatable smaller buried assets.

According to Morgan Rickerson (GIT), Geologist and SUE Manager at CFL, the performance of the higher frequency antenna was a complete surprise, as a decade of experience had historically proven otherwise with the older higher frequency systems. Morgan further elaborated that "the higher frequency component and very high resolution of the antenna allowed CFL to render an opinion on the potential for voids under the roadway surrounding the pipes. This additional resolution was instrumental in providing the client with added value." It should be noted that interpreting GPR data beyond a utility investigation should be conducted under the supervision of a licensed geologist or professional engineer.

Conclusion

As with any technology, the continual evolution and refinement of GPR systems will be needed for the most comprehensive and accurate depiction of utilities underground. This need is illustrated weekly, if not daily, in terms of utility strikes that hopefully, someday, will be a thing of the past. Beyond 2D systems, there are rapid advancements in 3D GPR imaging systems. In fact, the ASCE SUE standard 38-02, Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data, is under a major revision for release in 2020 to incorporate the depiction of 3D utility information, a topic best relegated for another time.

There are simple truths and one is clear: there will always be a soil type that will preclude any success with GPR for a target that is simply too deep, and in soil too conductive, for even the most advanced system to resolve. This is why a multi-tool approach will always be the ideal solution, utilizing what is available in the truck and within the technology itself. However, dual f GPR systems are proving to be a tool everyone can recognize in the multitool kit for utility locators.