GPR FOR BURIED UTILITY LOCATING

A utility products case study

By Greg Johnston

A key part of project planning is knowing exactly what lies beneath the surface at a site. This case study demonstrates a common use of GPR.

Introduction

Ground Penetrating Radar (GPR) use radio waves to non-destructively locate objects and subsurface structures in materials like soil, rock, concrete, asphalt, wood and water.

Sensors & Software Inc. is a GPR manufacturer that is recognized worldwide for its commitment to technical excellence, continuous innovation and responsive customer service. You will find their products in use for numerous applications by engineers, miners, archaeologists, geologists, as well as military, security and law enforcement personnel.

A major application area for GPR is the detection and mapping of buried utilities. In the following we address the field methodology and related GPR instrumentation characteristics.

Why Use GPR for Utility Locating?

The tools and methods of locating buried utilities are quite diverse. The most common approach is energizing metal pipes and cables with electric currents and using a magnetic-field sensor to detect the current. Provided the target can be exposed for connection or current can be induced, sufficient current flows on the target, and the detector is sufficiently sensitive to detect the magnetic field created by the current, then this technique works well and is very cost effective.

When access is difficult, electrical current does not flow (i.e. non-metallic element or broken connection), or external noise makes detection impossible, GPR provides an alternative. GPR provides its own source of energy, detects both metallic and non-metallic objects, as well as disturbed soil conditions and other buried structures.

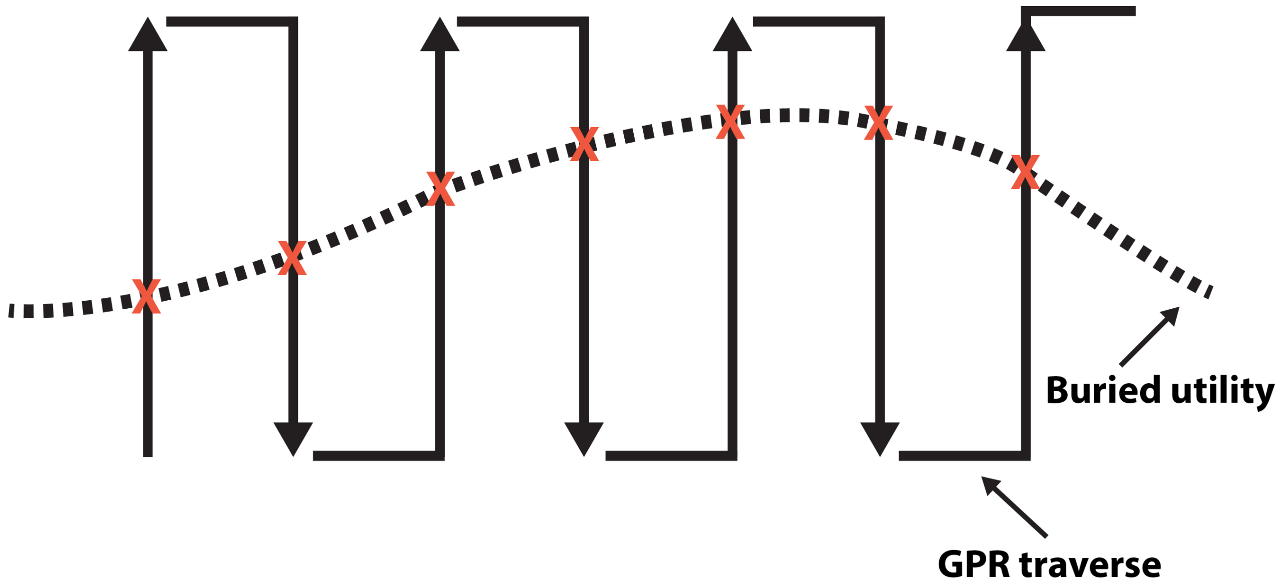

Figure 1

GPR is not without its limitations. GPR radio wave signals are absorbed by the ground with some soils (clays, saline) greatly limiting exploration depth. GPR effectiveness is thus site-specific and varies greatly from place to place.

Other direct approaches for utility detection are to trench, hand dig, or vacuum excavate to expose features. A priori knowledge and accurate as-built drawings are needed to be effective with these techniques. Often these are either not available or not sufficiently accurate.

The common sense approach for locating is to use all of the tools available. Understanding where and when a particular approach is most cost effective comes from experience, business practice and local construction techniques.

Methodology for Using GPR to Locate Buried Utilities

GPR is deployed in two ways for utility locating. The most common is locate and mark as you go. The second is more powerful; mapping the area to create subsurface images or depth slices.

The first method works well in favorable soils and uncluttered settings. The mapping approach provides separation of targets by their spatial continuity and is especially useful in complex conditions. Both approaches are described below.

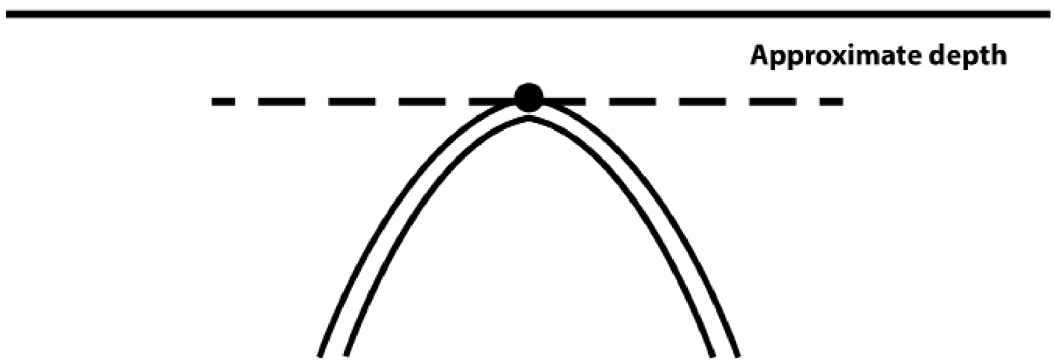

Figure 2

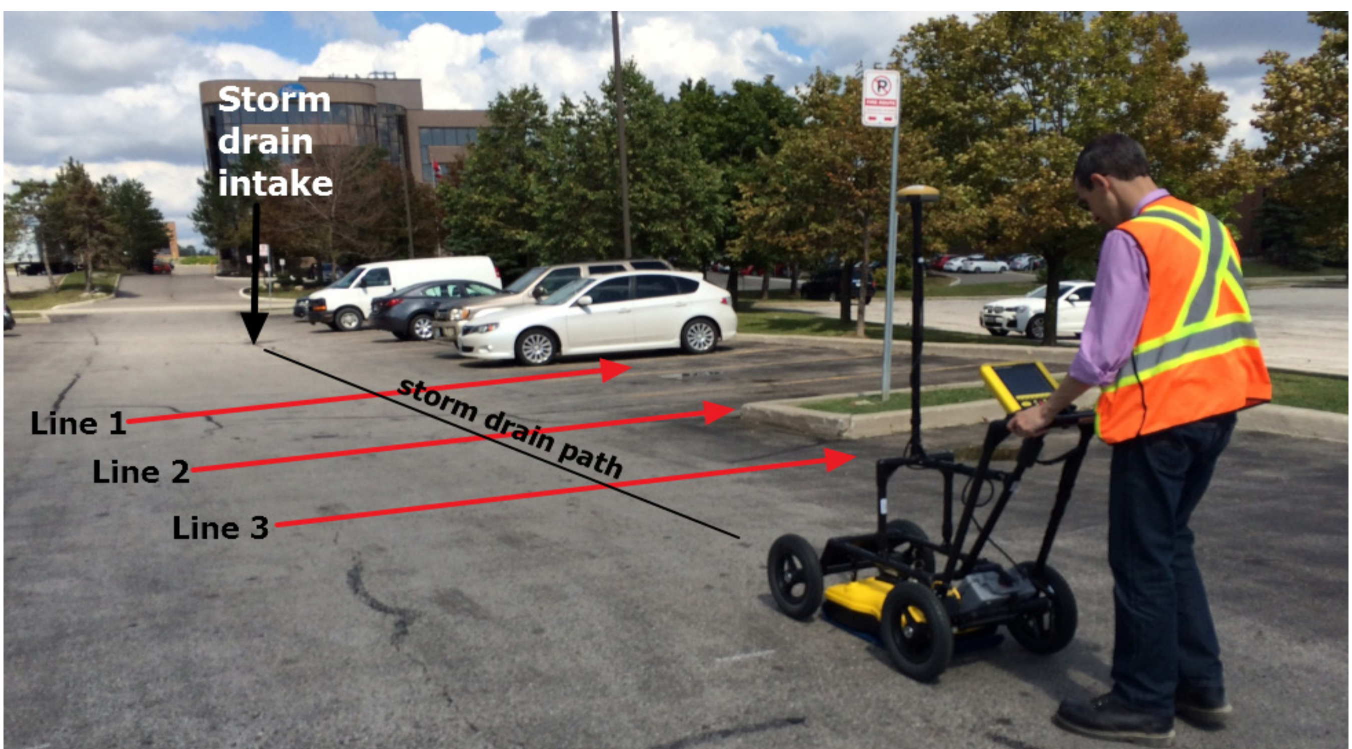

Figure 3

Locate & Mark

Locate and mark is the most common way of using GPR to track utilities. It is very similar to the use of traditional current tracking utility detectors. The GPR sensor is moved along sweeps perpendicular to the anticipated utility axis (see Figure 1). When the GPR unit crosses the utility, the image shows a hyperbolic shape (inverted V) such as shown in Figure 2. The apex or top of the hyperbola is the position of the utility. The distance to the top of the hyperbola is an estimate of depth.

By moving the GPR back and forth and marking the ground where the top of the hyperbola is observed, the alignment of the subsurface utility can be traced out as the X's in Figure 1 indicate.

For example, a concrete storm sewer alignment was located under asphalt in Figure 3. The locations of the 3 perpendicular survey lines are indicated on the photograph in Figure 3 and data images are shown in Figure 4. The inverted V visible on each transect, clearly identifies the alignment of the pipe.

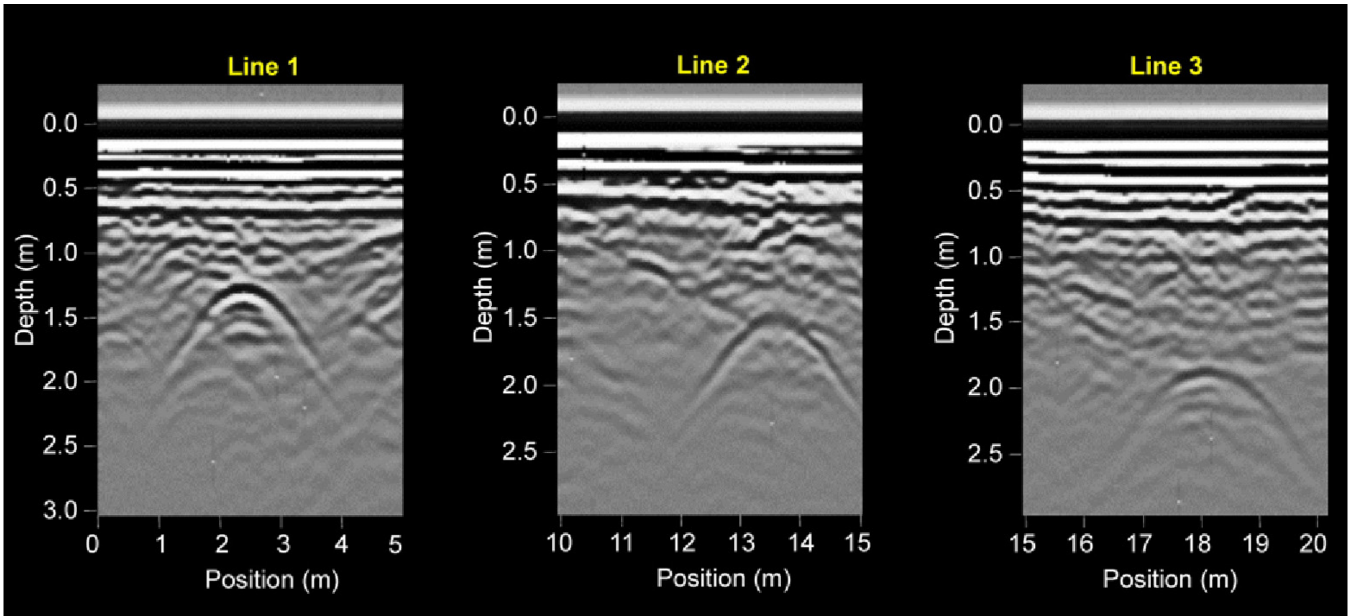

Figure 4

Notice in Figure 4 that as the pipe gets deeper, the strength of the hyperbolic response on the GPR transect gets weaker. This is a result of the GPR signal being attenuated as it travels deeper into the subsurface. In all soils the GPR signal will be completely absorbed eventually and only the ambient radio noise in the area will be detected by the GPR receiver. To see the deepest possible target with a GPR, it is important to have a quiet, highly sensitive system. Figure 5 shows the response from a concrete asbestos pipe that is subtle but visible.

Mapping

In some situations, the ground conditions are complicated and/or there is no a priori knowledge of what is buried. Mapping provides a powerful way of addressing these changing conditions.

In a mapping survey, data are collected over an area in a controlled fashion to cover 100 percent of the area.

Most often, data are acquired in a rectilinear grid of lines to obtain complete area coverage, as depicted in Figure 6. While individual traverses may enable some features to be marked, the primary focus is to acquire and record the data to enable a computer-generated map of the area.

For example, a grid survey was carried out in an area underlain with large boulders. The GPR response is cluttered and complex, making uniquely identifying a buried utility very difficult when looking at a single traverse.

By merging all the data to create a volume image, slice maps at different depths make long linear features readily visible. The results for the grid area are shown in Figure 7. The figure shows depth slices at 0.5 m and 1.1 m for the grid survey. The linear feature near the bottom of the 0.5 m depth slice is a buried electrical power cable feeding the light standards. The feature near the top of the slice is a water sprinkler line. The diagonal feature in the 1.1 m slice is a concrete storm drain.

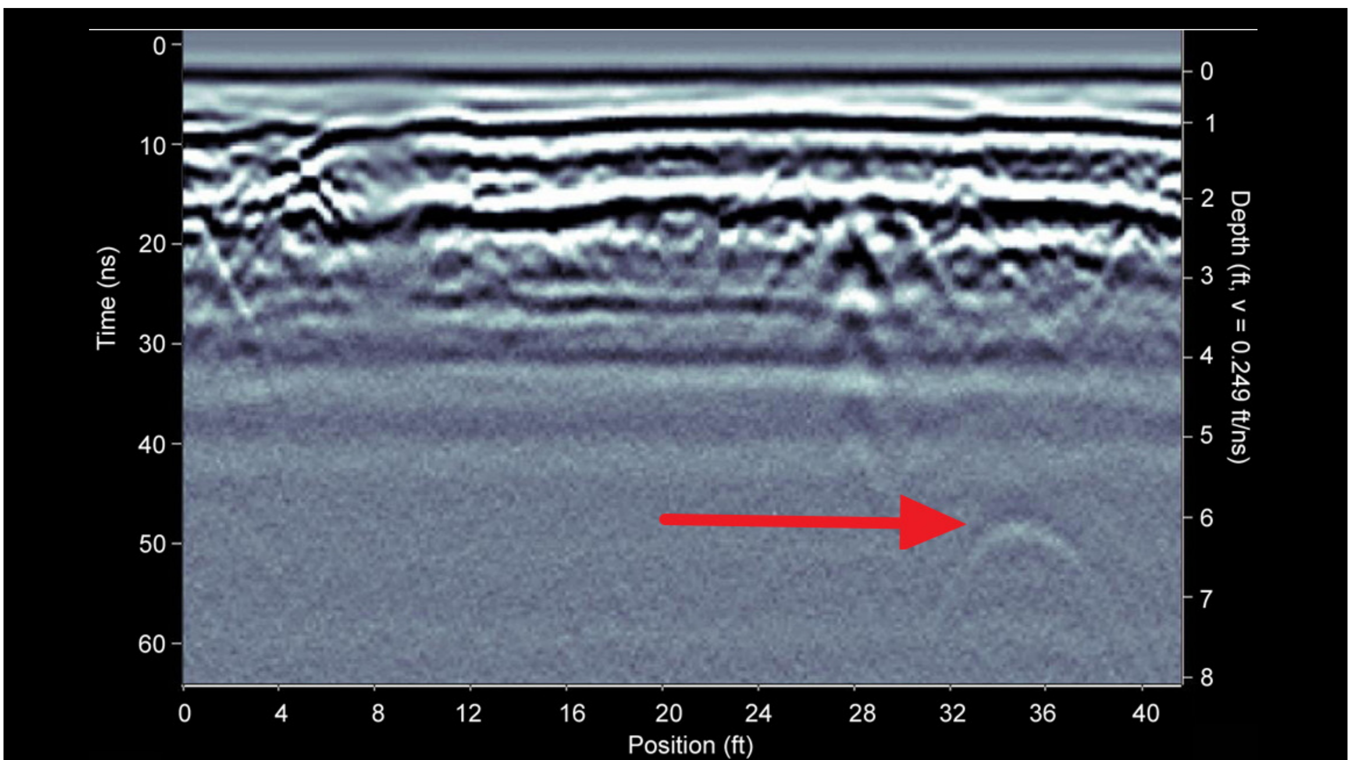

Figure 5

The human eye is very powerful at identifying the connected linear features. Computer animation makes it even more so.

Instrumentation

GPR systems that operate in the 100 to 500 MHz frequency range offer the best compromise between spatial resolution and exploration depth. These frequencies dictate a sensor size that is best deployed on a cart. In order to maximize system sensitivity and minimize interference, carts should be constructed of non-metallic materials.

The LMX200 system (Figure 3) provides an excellent example of a GPR system optimized for utility locating. The collapsible cart is constructed of tough non-metallic fibreglass components, has large diameter wheels and highly visible data display. The system is designed for easy shipping and storage. Set up time from arrival on site to the start of data collection takes only one or two minutes.

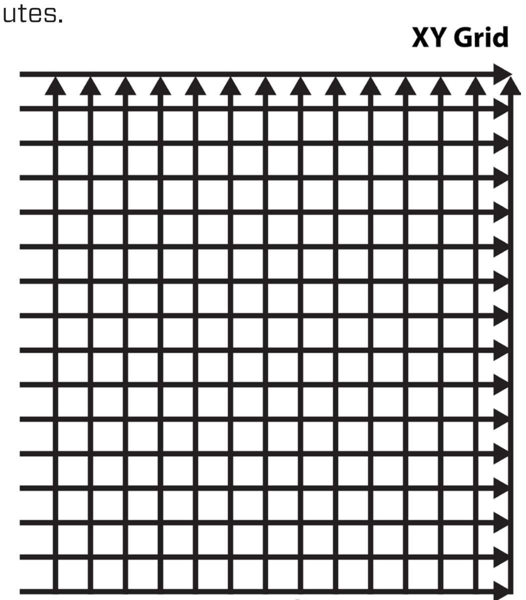

Figure 6

The Display Unit is a rugged field computer for data recording and display. Weatherproof, visible in all lighting conditions including bright sunlight, the Display Unit is designed for rough field conditions and works over a wide temperature range.

The integrated Display Unit, battery and wheel odometer make controlled surveys easy. A full day of surveying requires just one rechargeable gel cell battery. GPS positioning is designed into the LMX200 system.

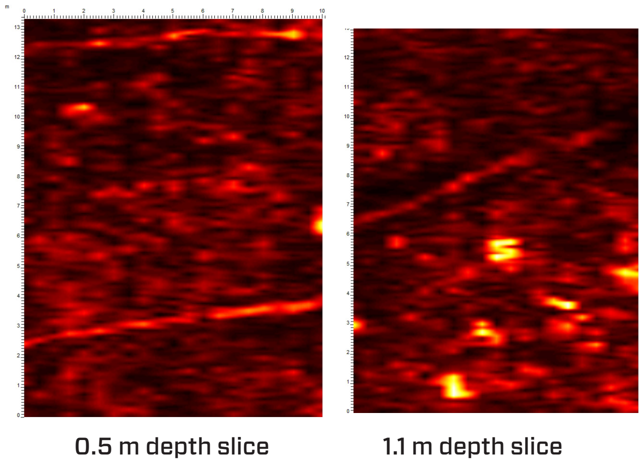

Figure 7

The Display unit's intelligent, user-friendly Smart System firmware makes operation simple and straightforward, whether in Locate and mark mode or conducting a grid survey to image a complex area. During data acquisition, the back-up arrow provides pinpoint accuracy of the exact location of a target.

For grid surveys, the operator is guided at each step of the acquisition by the unique ergonomic interactive control program to ensure complete imaging. Sensors & Software's Easy Grid field kit makes conducting surveys easy.

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