SUBSURFACE VIEWS

GPR INNOVATIONS
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In this issue

Detecting and Identifying Water Fraud

Every year millions of dollars in water disappears from taxpayer-funded and private water distribution systems around the world. This invisible drain on the economy is a problem that governments and enforcement agencies worldwide have been struggling to deal with for decades.

While some loss to leakage does occur, in some cases fraudsters are paid by unscrupulous home or business owners to tap into water mains and bypass the water meter, resulting in low or no water bills (Figure 1).

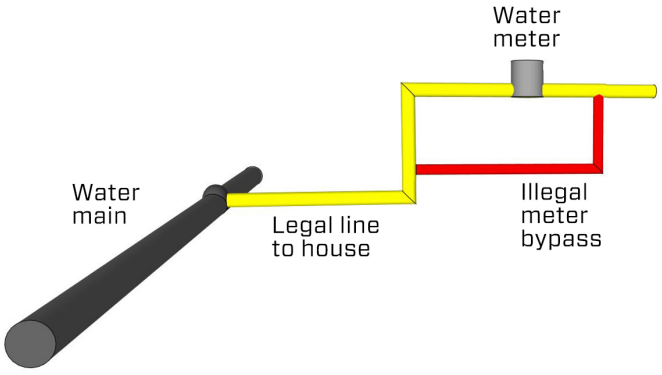

Figure 1: Illegal pipe circumvents the water meter.

Water companies and local governments lose revenue daily to these illegal connections. In addition, these clandestine taps pose a risk to other innocent users of the water network. When the illegal connections are installed into the water mains, they can introduce dirt and other contaminants along with fragments of the foreign pipe material (steel, plastic, etc) into the clean water supply.

Water distributors struggle to detect these illegal connections. The most common indicator of an illegal connection occurs when an occupied residence water usage declines or stops. Depending on how the water metering is monitored, detecting this can take weeks, months, or years. Once discovered, the next step is to determine the nature of the usage drop. If an illegal tap into the water main is used, the tap will usually be underground and not readily visible making locating and disabling a real challenge.

One forward-thinking water company was keen to solve their problem of water theft and they chose to put Sensors & Software's GPR to the test. In southern Europe a mid-sized home in the suburbs had declining water usage. The water company was suspicious since the home was occupied and

they could see from Google Earth images that a large outdoor pool was still operational. The residence was located within a few feet of the sidewalk; a visual inspection did not show any abnormalities in the connection or disturbance on the ground surface.

A Noggin 500 SmartCart, deployed using the fast grid collection capability, allowed the small team to collect a 1.2 x 4-meter grid over the area in front of the house where they suspected the tap might be. A series of hyperbolas were found and marked using the field interpretation capability of the Noggin system (Figure 2). This series of hyperbolic targets ran parallel and was inferred to be the water main. When the grid data was converted to depth slices with the field interpretations superimposed on top, the truth of the situation became increasingly clear.

The depth slice showed the water company that an unknown linear feature ran from the residence and ended at the company's water line. This linear feature snakes up from the bottom of the image and appears to connect to the company's water main (Figure 2) suggesting an illegal tap was present. Also, the cross sections from the grid showed hyperbolic responses from the suspected tap line terminating at the water main location (Figure 3). Though the water company could not verify that the two pipes were connected based on the Noggin data, they had strong evidence that warranted further investigation.

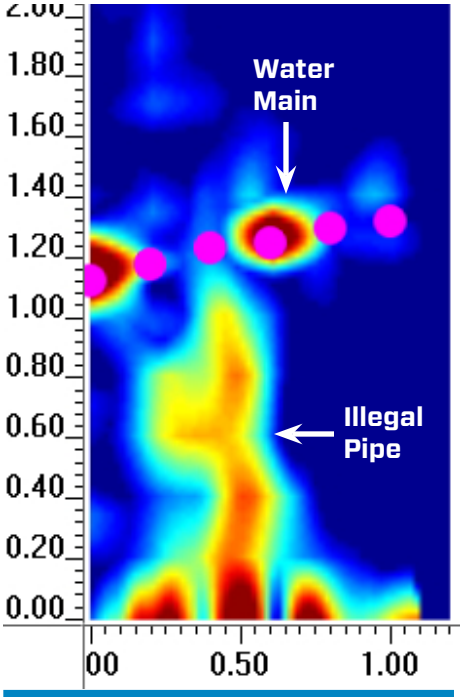

Figure 2: The water main shown by pink dots and the unknown line goes up to it vertically.

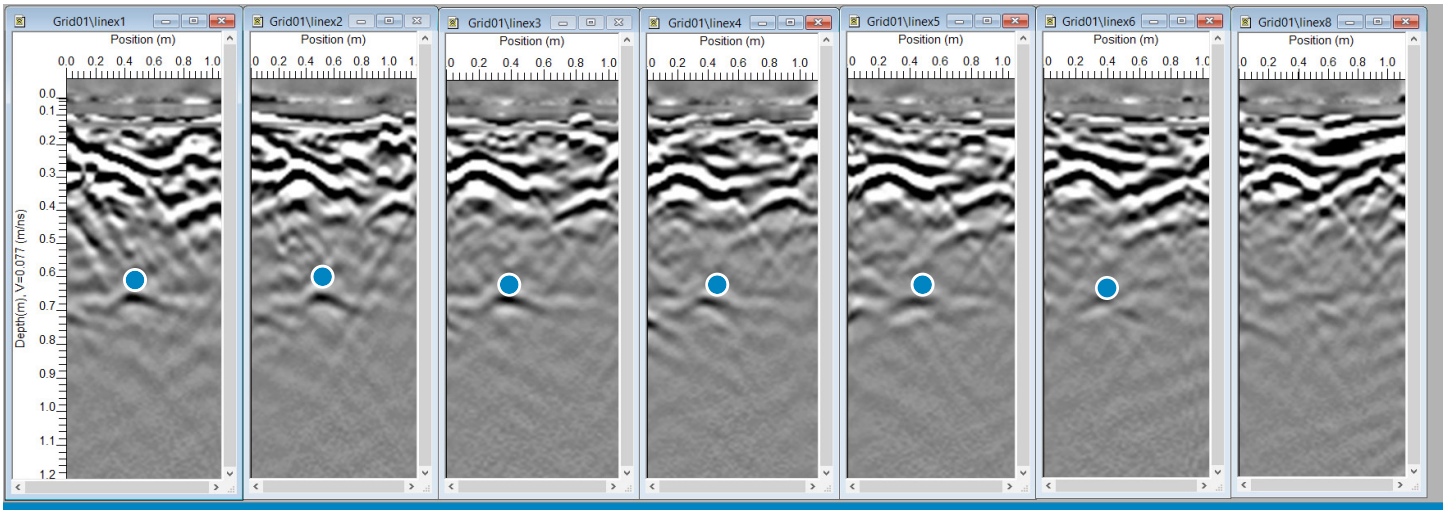

Figure 3: Starting from the left, each cross section shows the unknown, potentially illegal, pipe approaching the water main. After the water main the target disappears as shown in the right most cross section.

A few weeks later the water company went back to the quiet suburb to discover the truth. Using a small excavator and hand tools, they carefully dug up the area that appeared to have an illegal connection; they were not disappointed. The people who installed the connection had tunneled and tapped into the water line (Figure 4); providing the owner with an unlimited supply of free water.

The successful results from this investigation demonstrate that GPR is a useful tool to help stop water fraud. Once the water company suspects that someone has bypassed the water meter, GPR provides a non-intrusive approach to assess the presence of an illegal tap before bringing in a construction crew to excavate for visible proof.

The Noggin 500 GPR system provided the information that the water company needed to catch a fraudulent customer and recover lost revenue.

Figure 4: Tunnel showing the illegal connection tapping the water main.

Noggin helps find and remove bombs from German Airfield

During World War II, bombs were dropped throughout Germany, the UK and other European countries. Many of these bombs failed to detonate and were buried in the ground. Now, more than 70 years later, these hidden threats – unexploded ordnance (UXO) - remain buried underneath urban centers and rural lands. Today, in Germany, it is estimated that there are still 100,000 unexploded and undiscovered bombs lurking in the ground. To ensure safety during construction projects, German legislation requires that the work site must be cleared of unexploded ordnance before the construction can begin.

Mapping magnetic fields over the area is the most common method for UXO detection since buried bombs are iron-rich metallic objects. This method works well in open areas outside of cities, but when working in urban areas with extensive metallic infrastructure (fences, vehicles, pipes, etc.) these other metallic objects create magnetic field disturbances that can mask a buried bomb response.

In these cases, ground penetrating radar (GPR) becomes a useful alternative. GPR is less affected by nearby metallic objects and can be effectively used to pinpoint the position of objects buried in the ground.

GPR also provides an indication of the depth of buried objects, especially important in UXO detection. Once a UXO is detected, it has to be uncovered, defused and removed from the site. Having a precise depth to the UXO allows the removal teams to carefully excavate and remove the hazardous device.

One area that was subject to significant bombing during World War II was the airport in Oberschleissheim, north of Munich. Hundreds of bombs are still suspected to be buried in the airport compound. The company MuN Ortung GmbH was contracted to investigate a 10,000 m^2 area of the airfield and safely remove all UXO (Figure 1).

Figure 1: Aerial image of the airport in Oberschleissheim from 1945, with the UXO survey area overlaid in green.

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As a first step, they scanned the area with their 7-channel magnetometer system, towed behind a vehicle to quickly gather data over the entire survey area. Upon completion of this survey, they collected lines with their Noggin 250 MHz SmartCart GPR system over the anomalies (Figure 2) to confirm the findings and determine the depth to the targets.

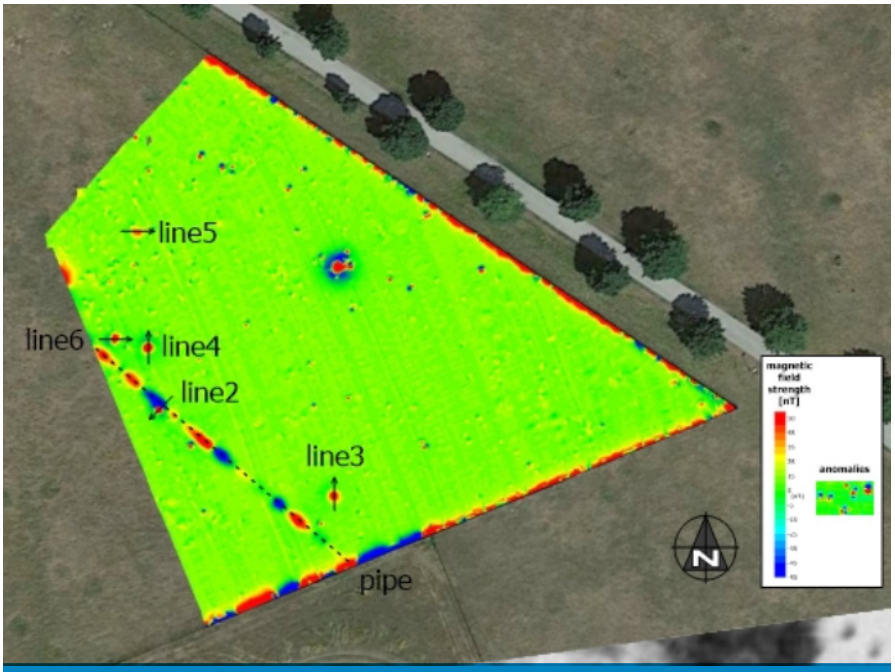

Figure 2: Magnetic survey results indicating point targets of interest. GPR lines (2-6) were collected over the areas of interest to confirm findings and determine depth of the target.

The GPR data clearly shows the hyperbolic response of the buried targets, as well as the expected depth of the target. (Figure 3). Using the additional information from the GPR survey, they carefully began excavating the suspected UXO.

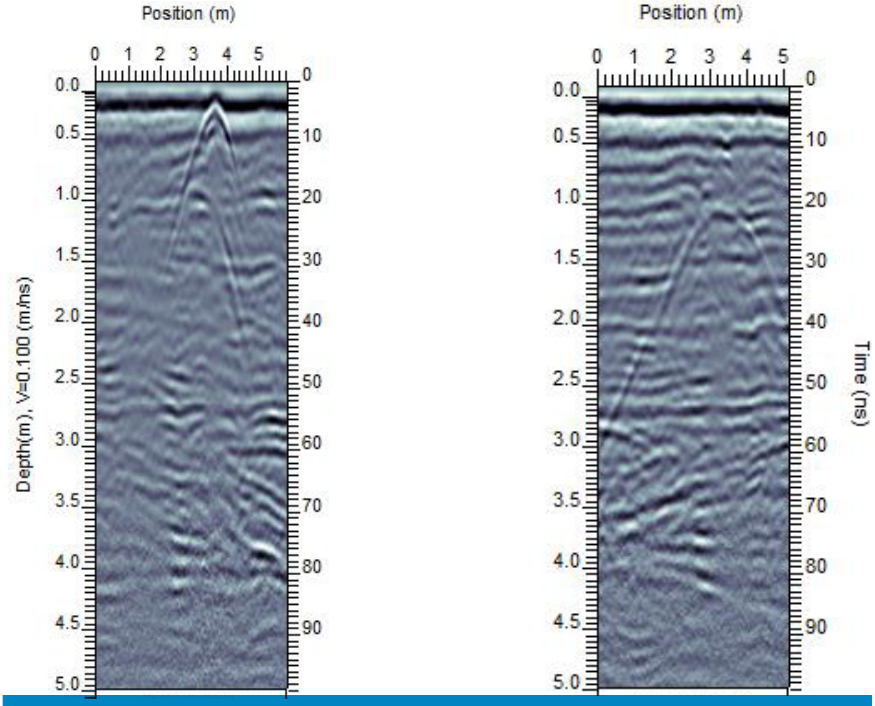

Figure 3: GPR Line 2 (left) was collected across a linear target (likely a utility pipe) and a point target. The GPR line data clearly shows the pipe at 1m depth and the suspected UXO buried just beneath the surface. GPR Line 3 (right) shows a suspected UXO at a slightly deeper depth of 1m.

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At each anomaly, a type GP 150lb T1 (General Purpose) bomb was discovered. (Figure 4). Each bomb was carefully removed, defused, and set aside for disposal.

The UXO survey was successful, and 5 potentially deadly UXO (Figure 5) were safely located and removed thanks to the Noggin GPR system and the expertise of the MuN Ortung team. *Story courtesy of MuN Ortung GmbH*

Figure 4: Excavation revealed a shallow buried bomb corresponding to the target location and depth in the GPR Line 2 data.

Figure 5: A total of 5 type GP 150lb T1 (General Purpose) bombs were located and safely excavated from the airport .

Notes from the Classroom: Student-Led Science using GPR

Sensors & Software supports the use of GPR in educational facilities around the world. We provide materials to assist instructors in teaching the theory behind GPR as well as providing free software licenses for laboratory computer rooms. We also offer GPR systems for field schools and special research projects. Below, Dr. Del Bohnenstiehl describes his experience using GPR to enhance his courses at North Carolina State University.

Over the last ten years North Carolina State University (NCSU) has trained hundreds of Marine and Earth Science majors in Ground Penetrating Radar techniques. The pulseEKKO PRO GPR system and the EKKO_Project software suite make it possible for students to follow the workflow from the field into the laboratory.

This semester the Environmental and Engineering Geophysics class at NCSU took on the challenge of delineating unmarked graves within portions of Raleigh's Oak Grove cemetery—using 250 and 500 MHz antennas deployed on SmartCarts (Figure 1). Data images from the GPR survey are shown in Figure 2. The data images show undisturbed stratigraphy to the left and a series of burials at variable depths to the right.

Projects like this allow students to tackle real-world problems and connect the University with community groups who are actively engaged in efforts to preserve the City's historic cemeteries.

Figure 1: pulseEKKO PRO 250 and 500 MHz systems at Oak Grove Cemetery.

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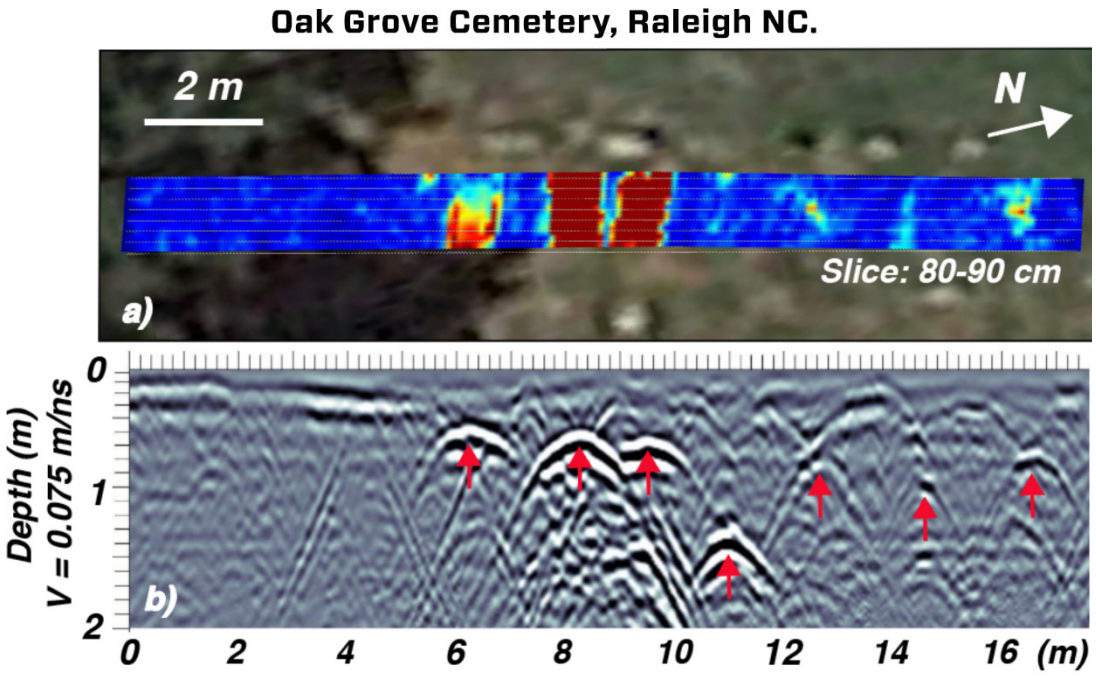

Figure 2: 250 MHz GPR data from Oak Grove Cemetery.

(Top): GPR depth slice map at a depth of 80-90 cm superimposed on the Google Earth image of the cemetery. The three red areas are interpreted as burials as they correspond the hyperbolic responses seen in the GPR line below.

(Bottom) GPR line through the center of the grid. Red markers identify reflections from the tops of burials.

Images were background subtracted and an SEC gain applied.

Upcoming Courses

NEW Sensors & Software's one-day training course is the first GPR course to be accredited by NSF-ISR to meet the Nulca training standards and ensure that the locator demonstrates knowledge, skill and understanding in applying GPR safely and professionally to utility locates.

Subsurface Imaging with GPR course - May 7, 2018. Mississauga, ON, Canada

Concrete Scanning with GPR course - May 8, 2018. Mississauga, ON, Canada

3 Day Ground Penetrating Radar Course - May 30 to June 1, 2018. Mississauga, ON, Canada

Upcoming Tradeshows

IFAT World's Leading Trade Fair for Water, Sewage, Waste and Raw Materials Management
May 14-18, 2018, Messe München, Munich, Germany

17th International Conference on Ground Penetrating Radar
June 18-21, 2018, Hochschule Für Technik Rapperswil, Rapperswil, Switzerland

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