SUBSURFACE VIEWS

CELEBRATING OUR NEWSLETTER ANNIVERSARY

25th Anniversary

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In this issue

Scanning New Ground: European 3-Day GPR Course

Sensors & Software has conducted an annual 3-Day course in Canada since 1998; this course is in its 22nd year. In 2018, for the first time, we conducted a 3-Day course in Europe; in Höhr-Grenzhausen, Germany, the town where our European office is located.

We used the same formula that has worked so successfully in Canada for over two decades: the first day covered GPR theory and case studies, the second day was a complete day of hands-on field work and the last day focused on data processing, interpretation and analysis using the EKKO_Project™ software. For the field day, the students were split into groups and rotated through 4 stations, spending 2 hours at each station.

The students were also introduced to the latest generation of SPIDAR hardware, that allows networking multiple Noggin® or pulseEKKO® GPR systems together into multi-frequency, array and multi-fold systems, including the WARR Machine. A friendly competition developed between the groups, wondering who had collected the most data over the course of the day (see the results on page 2).

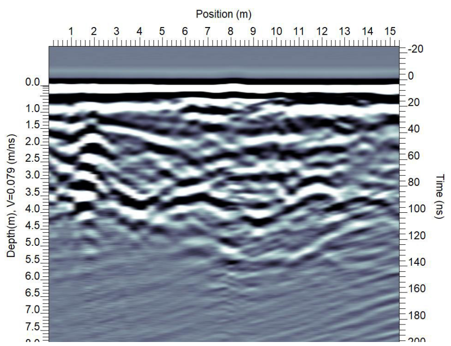
After a great field day, the last day was spent using the EKKO_Project™ software to plot the data in cross-sections, 2D depth slices and 3D volumes to analyze and interpret the data. A favourite feature of the students was the LineView module's ability to launch Google Earth to pinpoint where a subsurface reflection was located; a great way to add context to the GPR data and improve the data interpretation.

We got some great positive feedback from the course, including this comment from one of the students: *"It was well organized, sufficiently dense to be very useful but not overwhelming and moreover I enjoyed it. Well worth the time, money and the travel."*

We are already planning for the 2019 course. If you are interested, see the course details on our website.

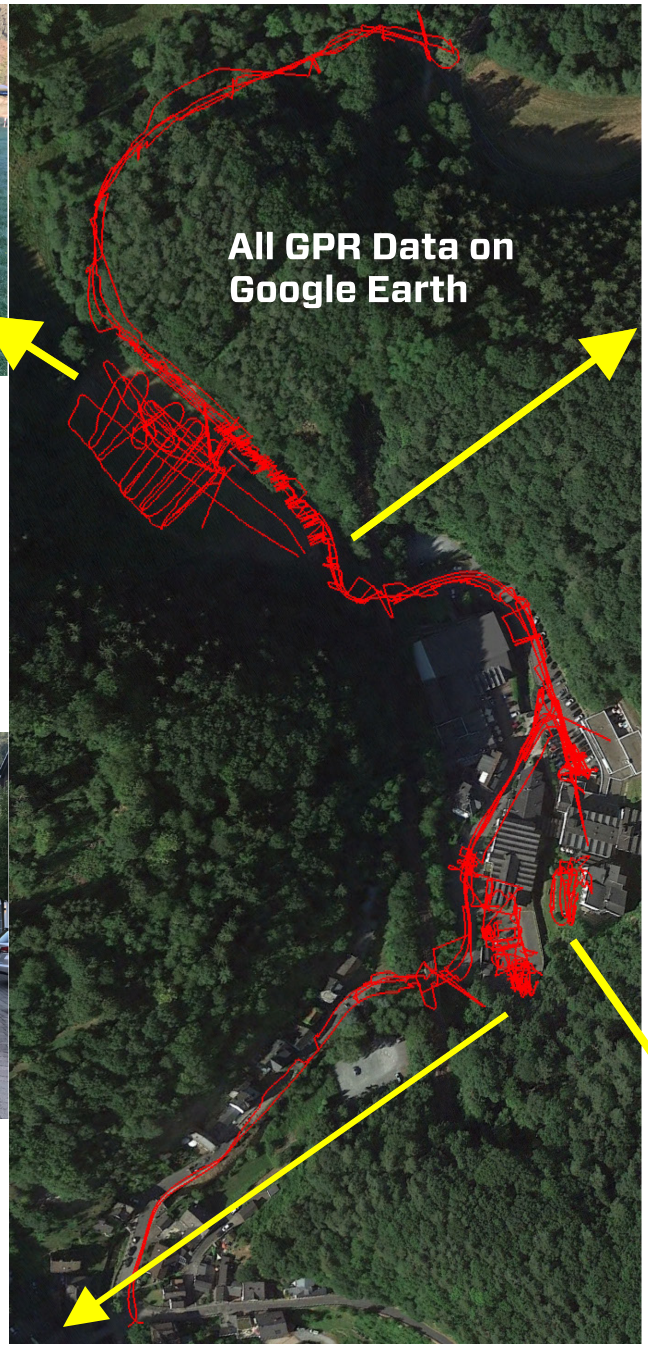
100 MHz Geology Station

A 100 MHz pulseEKKO® PRO system in Full Bistatic and SmartTow configurations for imaging geological structure, featuring the new Ultra Receiver, for deeper sounding.



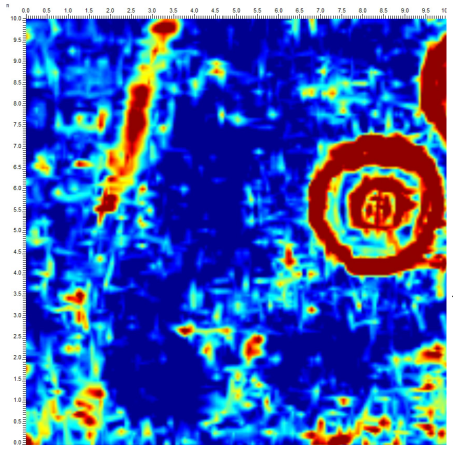
Statistics

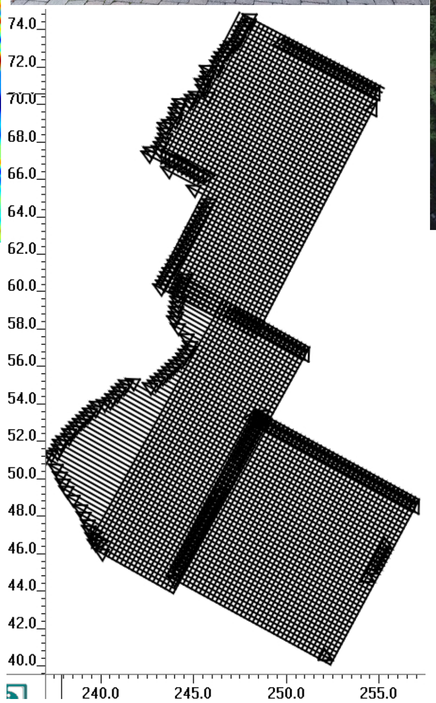
- 19 megabytes
- 1635 meters
- 6539 traces @ 0.25m step size



250 MHz Utility-Locating Station

A Noggin® 250 MHz system in the SmartCart® configuration for utility mapping; Line Scans and Grid Scans were done.





Statistics

- 128 megabytes
- 3680 meters
- 73,611 traces @ 0.05m step size

Overall Statistics

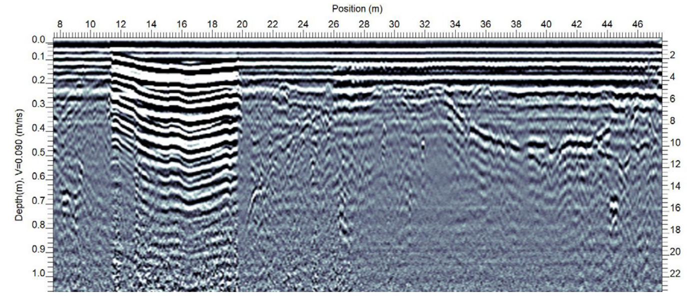
261 megabytes
9510 meters
164,103 traces

1000 MHz Road Survey

A Noggin® 1000 MHz system on the SmartChariot for a high-resolution road survey

Statistics

- 42 megabytes
- 3145 meters
- 31,450 traces @ 0.1m step size

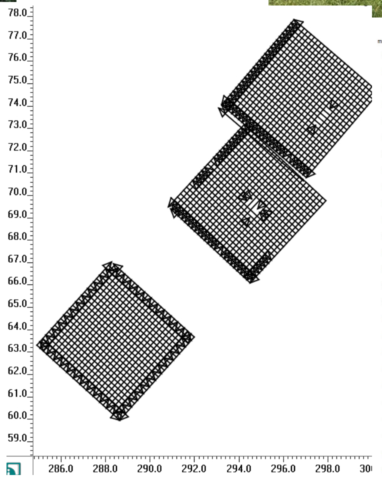


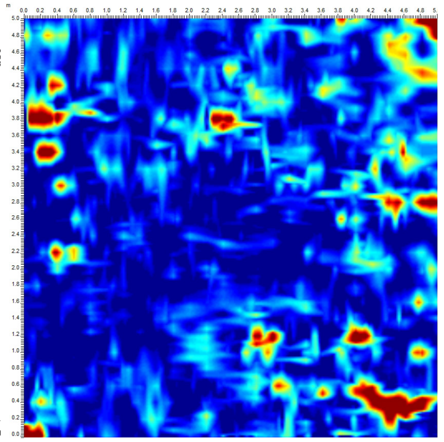
500 MHz Forensics Station

A Noggin® 500 MHz system in the SmartCart® configuration for detailed forensic mapping; a series of 5x5 meter Grid Scans were collected.

Statistics

- 72 megabytes
- 1050 meters
- 52,503 traces @ 0.02m step size





Pipe up about #UsingYourNoggin

Background

A 7-foot diameter fiber-reinforced plastic (FRP) sewer pipe was being installed via a microtunnel boring machine (MTBM) at a depth of approximately 40 feet below the ground surface (Figure 1). After the installation of a 530-foot section of the sewer pipe, areas of surface subsidence (sinkholes) were noted along the trend of the sewer pipe.

Due to the concern that the tunneling work had undermined the area, threatening the integrity of a public roadway, Prism Geoimaging, a full-service geophysical investigations provider in the US, was contracted to image the subsurface in the subsided areas. The goal was to trace the source of the subsidence and indicate where remediation efforts should be focused.

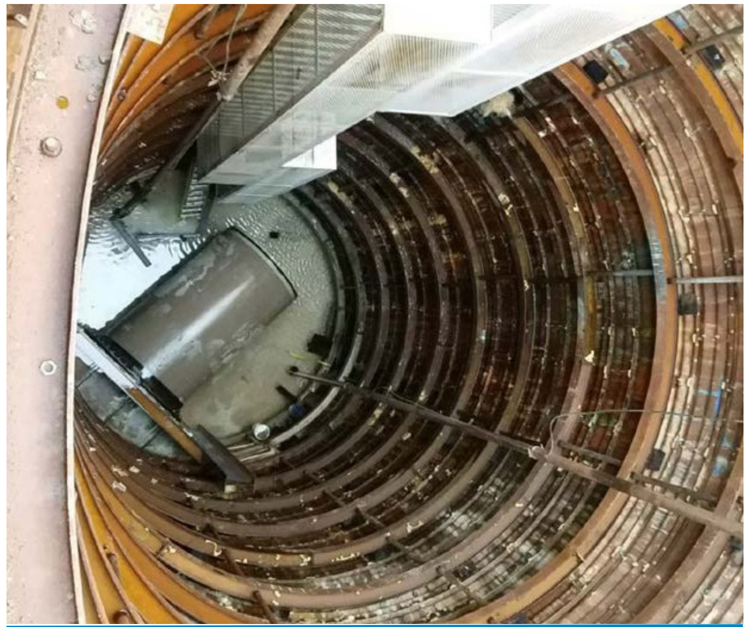


Figure 1: View of the FRP sewer pipe entering the bottom of the installation shaft.

Geophysical Methods

Three separate geophysical methods were used for this project, namely ground penetrating radar (GPR), electrical resistivity tomography (EIT) and seismic refraction imaging. Seismic imaging was successful at tracing the path of the subsidence from the ground surface down to the top of the pipe while GPR was used to scan upwards from the ceiling of the sewer pipe towards the surface; making use of the portable and flexible Noggin® 250 SmartCart® GPR system.

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Collecting the GPR data was accomplished using a custom-fabricated lift cart that held a flipped-upside-down SmartCart® to maintain firm contact between the ceiling and the bottom of the Noggin® 250. Using the odometer wheel for triggering, data was then collected as the cart ran along the entire length of the pipe (Figure 2). For control and comparison purposes, an additional GPR line was collected along the floor of the pipe, scanning downward into the ground and both datasets were then processed and analyzed with Sensors & Software's all-inclusive GPR software solution, EKKO_Project™.

Figure 2: Noggin® 250 SmartCart® being deployed inside of the FTP sewer pipe

Results and Interpretations

The GPR data showed a maximum signal penetration of 6 to 8 feet, both upward and downward (Figure 3). The GPR line below the pipe had a few reflections but no anomalies of note with the most prominent reflections being from the pipe joints (Figure 3, bottom). In contrast, the data from the top of the pipe revealed several strong reflectors with a series of ringing signals appearing close to 8 feet from the top of the pipe; indicative of an air gap between the pipe and the soil. The immediate area above the pipe also has multiple reflections that were consistent with slumped or subsided soil, likely due to the natural depositional bedding being disrupted.

GPR combined with seismic refraction imaging proved most effective in this geophysical investigation with both methods highlighting anomalous areas consistent with the greatest volume of undermined soil; allowing for focused remediation efforts.

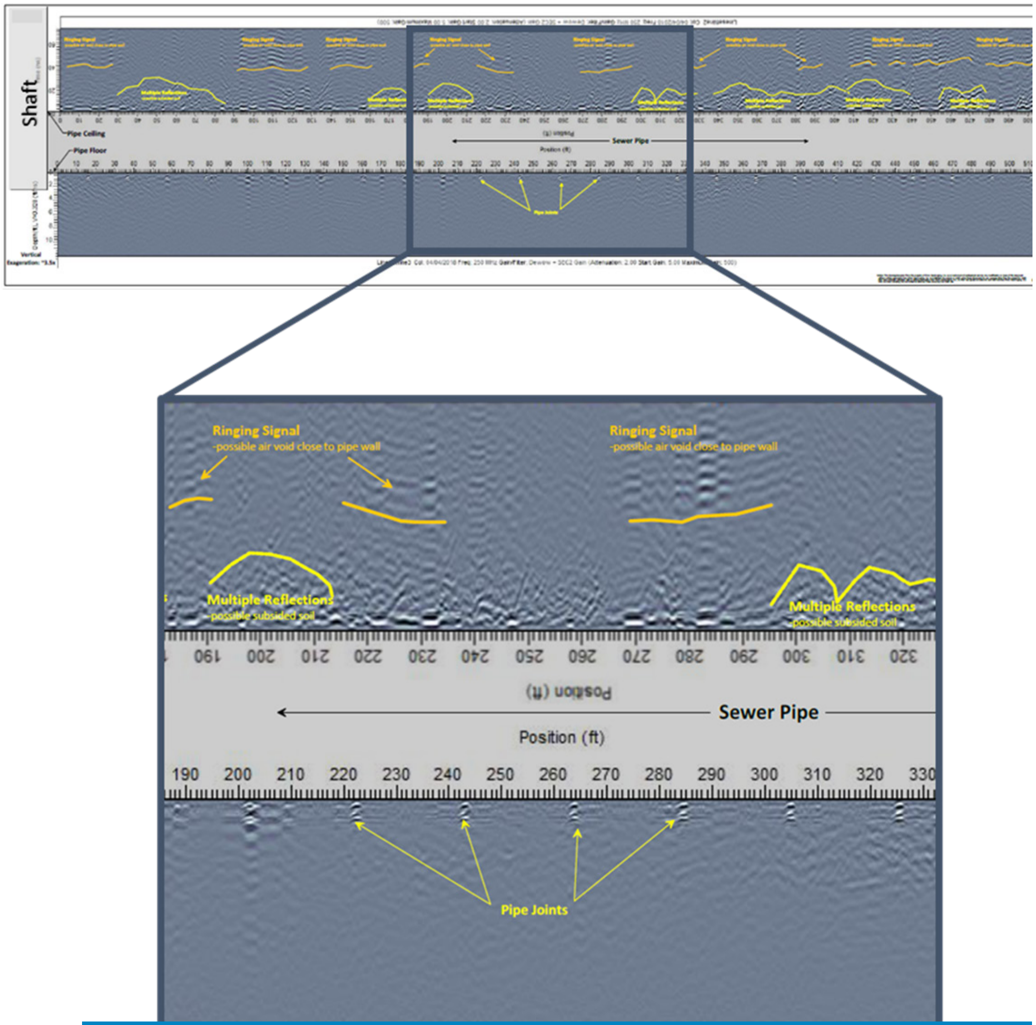

Figure 3: Noggin® GPR data obtained from inside the FRP pipe with a zoomed in section with GPR data interpretations. Observed ringing reflections are from potential voids between the pipe and the ground and areas of possible subsided soil are indicated by multiple reflections close to the top of the pipe. The bottom cross sectional data showed minimal reflections with most prominent ones being from the pipe joints.

Story courtesy of John Vanderlaan of Prism Geoimaging.

Water WARRs

For more than four decades, radio wave velocity and soil water content have been known to be strongly coupled. By measuring radio wave velocity, an indirect measure of the water content of soil can be obtained. Such measurements have the potential to optimize agricultural irrigation.

Ground penetrating radar (GPR) maps the subsurface using radio waves. In the very early days of GPR, the factors controlling wave velocity were not well understood. Pioneering work in the late 1970s established the empirical relationship between water content and GPR velocity. In fact, use of time domain reflectometry (TDR), which is a close cousin to GPR, was used extensively to study controlled soil samples and establish the relationship.

Since that time, TDR devices have become a regular method for measuring the water content of soil. Numerous variations of the TDR approach now exist, and the method is commonly accepted. The TDR technique is limited because it requires a probe to be inserted into the soil; water content measurement is obtained over a limited area, so the method is not readily used to cover large areas. On the other hand, the method is great for monitoring the water content versus time at a localized position.

GPR has always offered the potential for providing a powerful means for rapid area coverage because the technique does not require direct contact with the soil. A GPR device can be moved over the surface quickly and large areas can be mapped. For many years development of GPR to complement discrete TDR measurements has been a goal.

Several GPR-based approaches are possible but all have seen limited success. Each approach can work effectively to obtain water content when a skilled researcher or GPR operator is engaged. Unfortunately, acquiring the desired result using a readily-deployable GPR device with automated data analysis to a water content value has never been achieved.

One of the more effective ways of using GPR for estimating water content has been to use wide angle reflection and refraction (WARR) soundings. These measurements have been complex to carry out with slow data acquisition and have only been limited to small areas. Further, an experienced operator is required to make the measurement and analyze the data.

Recently we have introduced the WARR Machine which is a novel new GPR instrument. This new system enables rapid profiling with virtually continuous acquisition of WARR soundings. The result has opened the door for doing large area soil moisture mapping.

Figure 1: Collecting WARR Machine data at an agricultural test site.

The Forschungszentrum Jülich, a university in Germany, has been pioneering the use of GPR for many soil and ground water applications. Jülich has an extensive capability for examining agricultural problems and is developing several new and advanced applied geophysical methods. Well-controlled test sites enable technology testing for a wide variety of problem areas. Some unique time lapse studies are providing a greatly enhanced understanding of how ground water conditions change during the growing season.

Dr. Jan van der Kruk and his research team are currently pioneering the use of the WARR Machine for soil water content mapping. Research by PhD-candidate Manuela Kaufmann is demonstrating the viability of the new technology. A prototype system deployed at Jülich is shown in Figure 1. This WARR machine configuration unit is towed behind an ATV vehicle and is being developed to allow continuous profiling of field size areas to map variations in soil water content on a regular basis.

An example of a profile across a controlled test field generated the preliminary results shown in Figure 2. Automated and manual data analysis were used to estimate water content from radio wave velocity and compared with a limited number of separate single-channel WARR measurement results. The development of a reliable automated data analysis tool will be key to the successful deployment of this new technology.

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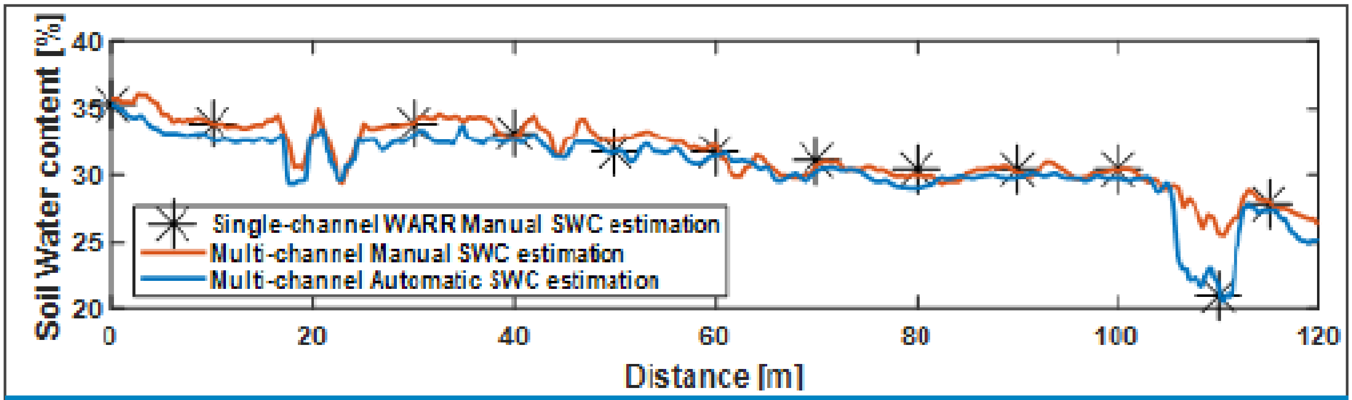

Figure 2: Preliminary Soil Water Content estimations from WARR Machine data.

Upcoming Courses

FREE Webinar The New pulseEKKO Ultra Receiver - February 6, 2019, Mississauga, ON, Canada

GPR for High Resolution Concrete Scanning - February 6, 2019, Mississauga, ON, Canada

Subsurface Utility Locating with GPR course (NULCA-accredited) - March 4, 2019, Mississauga, ON, Canada

Concrete Scanning with GPR course - March 5, 2019 Mississauga, ON, Canada

GPR for the Locating Technician (NULCA accredited) - March 26 2019, Tampa, FL, USA

3-Day GPR course - May 29-31, 2019, Mississauga, ON, Canada

3-Day Europe GPR course - October 9-11, 2019, Europe Höhr-Grenzhausen, Germany

Upcoming Tradeshows

Transportation Research Board (TRB) January 13-17, 2019, Washington, DC, USA

World of Concrete (WOC) January 22-25, 2019, Las Vegas, NV, USA

Canadian Concrete EXPO February 6-7, 2019, Mississauga, ON, Canada

German Geophysical Society (DGG) March 4-7, 2019, Braunschweig, Brunswick, Germany

Forensics Europe Expo March 5-6, 2019, Olympia, London, UK

NASTT's No Dig Show March 17-21, 2019, Chicago, Illinois, USA

Environmental and Engineering Geophysical Society (SAGEEP) March 17-21, 2019, Portland, OR, USA

Excavation Safety 811 (CGA) March 26-28, 2019, Tampa, Florida, USA

Sensors & Software Inc.

1040 Stacey Court
Mississauga, ON
Canada L4W 2X8

+1 905 624 8909
sales@sensoft.ca
www.sensoft.ca

Sensors & Software Europe GmbH

Auf der Haide 8/UG
D-56203 Höhr-Grenzhausen
Germany

Office: +49 (2624) 915 9353
Fax: +49 (2624) 915 8097
europesales@sensoft.ca