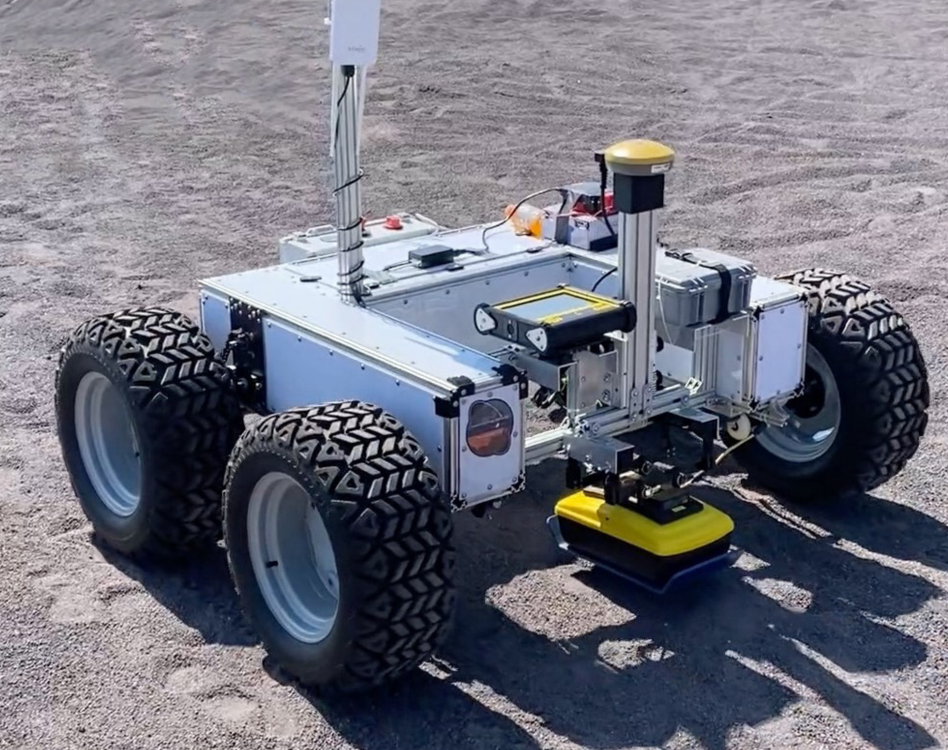

SUBSURFACE VIEWS

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Sensors & Software loves to share customer stories in our newsletter! We find that customer stories are always popular with our newsletter readers. This newsletter contains one article kindly provided to us from our customers. The details and descriptions are those of the authors and Sensors & Software has not made any edits except for typographical errors. If you have a GPR topic of interest to share, please contact us and submit your suggestions.

In this issue

SPIDAR® SDK - GPR under your control!

SPIDAR® SDK (Software Development Kit) is a new product now available from Sensors & Software. It is designed for customers who would like a GPR system that they can control with their own data acquisition software.

SPIDAR® SDK allows users to control a NOGGIN® or pulseEKKO® GPR system, opening a world of new product possibilities. Add GPR to your platform and create a system that can image the subsurface with GPR as it works. Add value to your robot, excavator, mining machine, or any other equipment. Create a new imaging device that solves a problem in your industry and introduce it to the world! There are endless opportunities for adding GPR to your platform and augmenting its capabilities with the ability to image the subsurface (**Figure 1**).

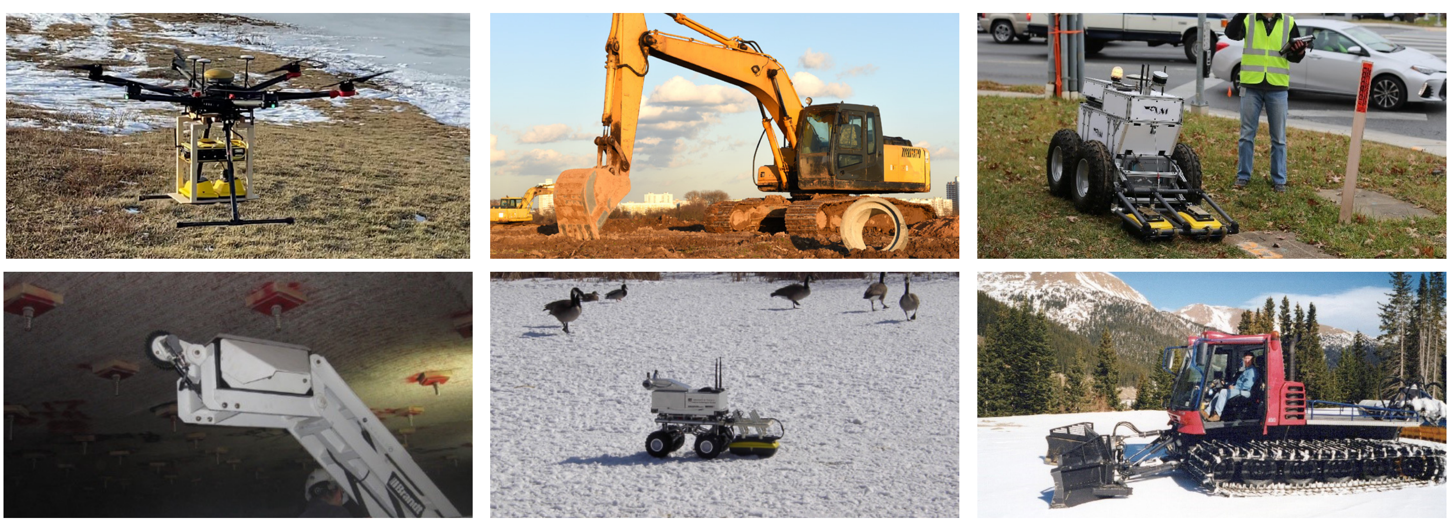

Figure 1: Various equipment that Sensors & Software GPRs have been added to over the years. The SPIDAR® SDK makes integrating GPR with your system easier than ever.

continued on page 2

The SPIDAR® SDK gives customers the software commands to control a single NOGGIN® system (**Figure 2**) or a single pulseEKKO® Transmitter-Receiver pair (**Figure 3**). These systems have a range of antenna frequencies for deep penetration, shallow, high resolution, or anything in between.

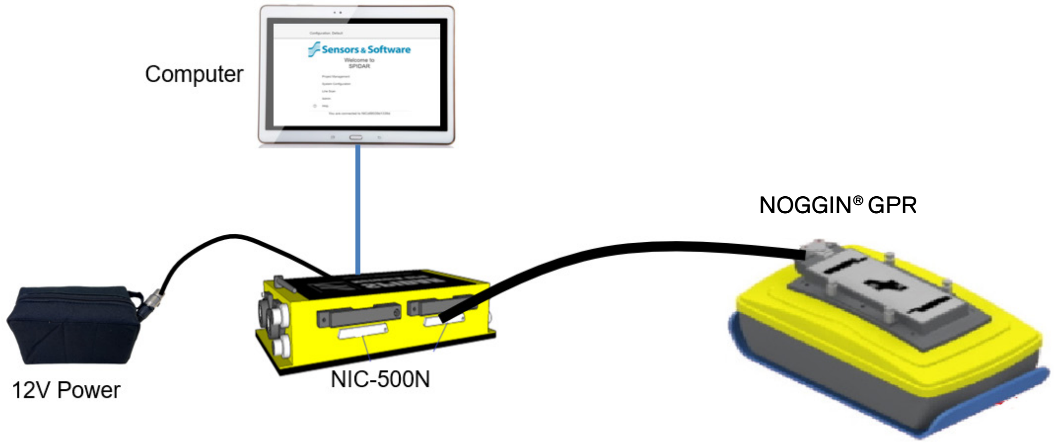

Figure 2: A SPIDAR® SDK system with a NOGGIN® 500 MHz GPR system. NOGGIN® systems are available with center frequencies of 100, 250, 500 and 1000 MHz.

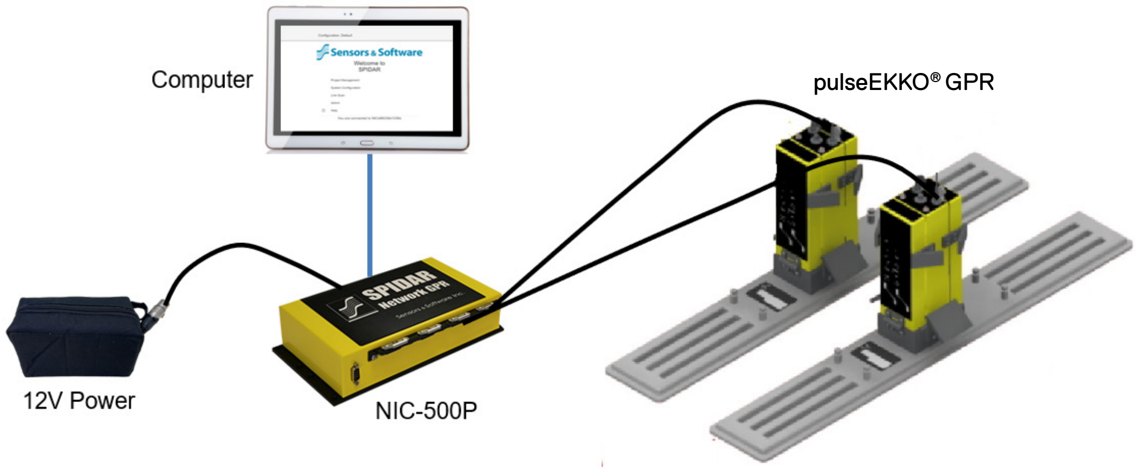

Figure 3: A SPIDAR® SDK system with a pulseEKKO® 100 MHz GPR system. pulseEKKO® systems have antennas with center frequencies of 12.5, 25, 50, 100, 200, 250, 500 and 1000 MHz.

With SPIDAR® SDK activated, the standard SPIDAR® hardware, a NIC-500, has an additional mode called "SDK", which allows it to listen and respond to the commands that your software sends to it. Develop your own software to control the data acquisition with the GPR. Here is a list of some of the commands available to control a GPR system:

1. Power up the GPR
2. Set up GPR survey parameters:
    a. Antenna center frequency
    b. Time sampling interval
    c. Number of points per trace (related to time window and depth of investigation)
    d. Number of stacks
    e. Trigger mode
3. Start data collection
4. Stop data collection
5. Check for errors
6. Set date and time
7. Extract date and time

SPIDAR® SDK includes a sample data acquisition program, written in Python, to get you up and started quickly. However, users can code their data acquisition program in any programming language that supports basic networking.

As well, the computer/tablet running the SPIDAR® data acquisition program can use any operating system: Windows, Linux, Raspberry Pi or Mac, providing it supports networking and has a web browser for the one-time setup of SPIDAR® SDK mode.

We see one of the common uses of SPIDAR® SDK being the development of multi-sensor systems, with GPR being one of several data streams. When other instruments are acquiring data in parallel with the GPR, the best method to correlate the data streams is to use the data collection time stamps. The time stamp of when a GPR trace was collected can be extracted at any time during data collection and correlated with the time stamps from other devices, for example, a GPS.

SPIDAR® SDK is not for everyone because it does require good computer programming skills, but for those interested in adding GPR to an existing product or creating a whole new product, it just might be the key to a game-changing product innovation.

For more information about SPIDAR® SDK, go to www.sensoft.ca/products/SPIDAR-SDK or contact us.

Cover photo of moon-rover prototype courtesy of Michigan Technological University

GPR survey maps voids under a dam spillway

A spillway is "a structure used to provide the controlled release of water from a dam or levee downstream, typically into the riverbed of the dammed river itself" (Wikipedia, see **Figure 1**). These structures endure various degrees of wear and tear from water flow and therefore, must be periodically inspected for structural integrity and safety.

Figure 1: Photo of a spillway, part of a dam or levee structure.

KGS Group, headquartered in Manitoba, Canada, provides spillway inspections, among other engineering inspection services. A recent inspection project completed for a dam owner in Manitoba involved an investigation of a spillway to assess the condition of the structure after record flooding earlier in the year. The goal of the inspection was to look for issues that could affect the performance and safety of the structure, and to identify which issues needed to be addressed as part of a rehabilitation plan.

As part of this investigation, a GPR survey of the spillway chute was completed to identify potential voids; areas where there may have been a loss of granular material in the drainage blanket below the spillway concrete slab (see **Figure 2**).

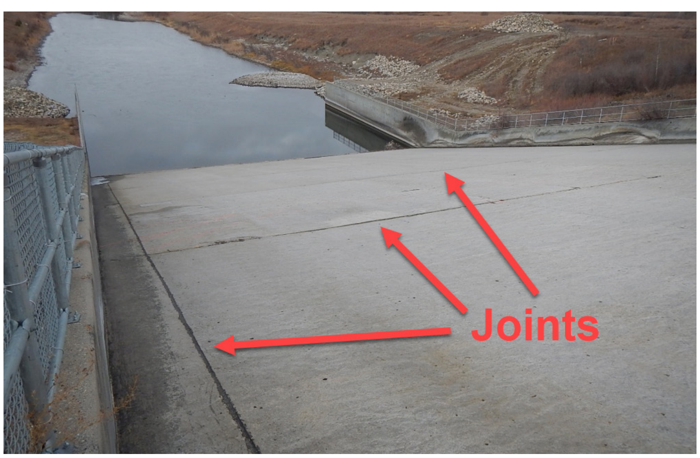

Figure 2: The spillway slope. The joints visible in the concrete slab are areas where water can infiltrate and wash away the supporting granular material.

The GPR data was collected on the spillway slope with a NOGGIN® 500 GPR system with external GPS for positioning (**Figure 3**).

Figure 3: NOGGIN® 500 SmartCart used for the spillway inspection survey. An external GPS was added to position the GPR data.

A grid, approximately 30 metres x 70 metres (2100 square metres), was collected in both the X and Y directions across the spillway. A total of about 2,500 metres of data with a sample every 2 centimeters were collected, for a total of 125,000 unique sample points on the spillway. An external GPS was used for positioning; the paths of the GPR survey lines are shown in **Figure 4**.

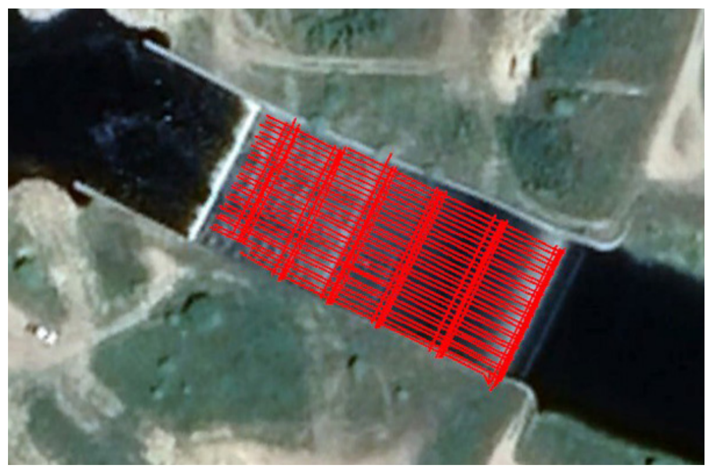

Figure 4: Google Earth image showing the location of the NIGGIN® 500 GPR lines on the spillway.

The data were processed into depth slices using the EKKO_Project™ SliceView-Lines module. The depth slice at 35-40 cm, well under the concrete slab, shows high amplitude reflections, mostly located near and along the concrete joints (**Figure 5**).

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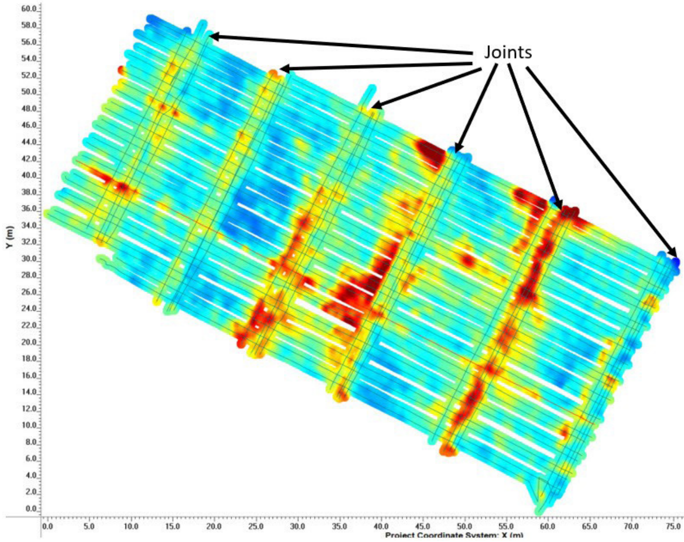


Figure 5: Depth slice at 35-40 cm below the surface of the concrete slab shows high amplitude, red reflectors. Some are likely associated with the structure of the joints (see Figure 2), but others, away from the joints, are interpreted as possible voids under the slab.

The cause for some of these responses is thought to be the structure of the joints, which differs at the joints compared to the middle of the concrete slabs (**Figure 6**). Other high amplitude reflections, away from the joints were analyzed in more detail to try and understand what is causing them. **Figure 6** shows a cross-section with a high amplitude response that was interpreted as a possible void under the concrete slab. Voids in spillways are commonly formed by water infiltrating under the concrete and washing away the granular materials.

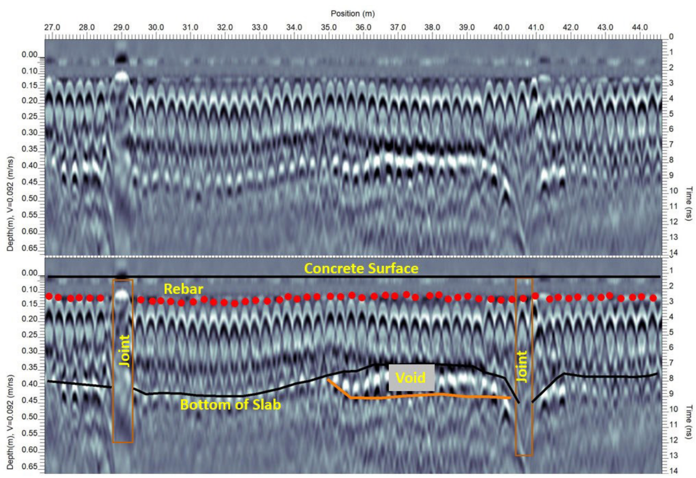


Figure 6: GPR line crossing a concrete slab and 2 joints shows the structure of the slabs; raw data (top) and interpreted data (bottom). At a depth of 35 to 40 cm and from horizontal positions 35 to 40 metres, adjacent to a joint, high amplitude responses are visible, indicating a change in reflectivity at the bottom of the concrete slab. This type of response is consistent with a void. Areas like this became targets for cores to validate the interpretation.

Based on the GPR depth slices and cross-sections, 10 locations across the spillway were identified for the geotechnical coring program and visual inspection. The day of the coring, the Noggin 500 system was used again, this time to collect smaller grids around each proposed coring location to avoid coring through the steel rebar in the concrete slab (**Figure 7**).

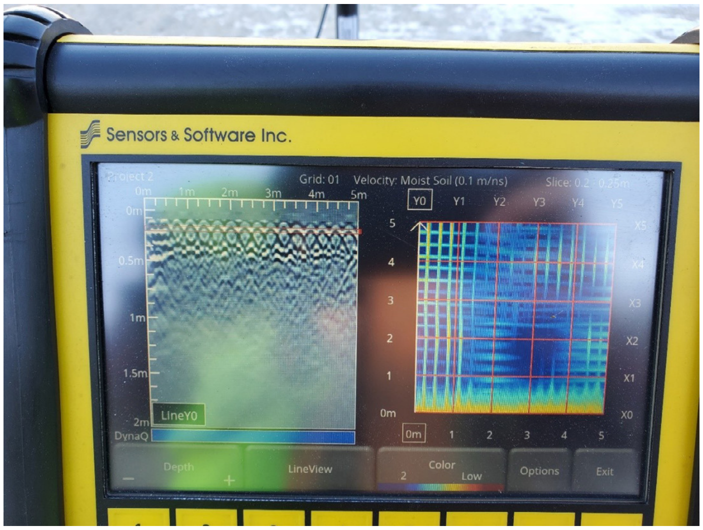


Figure 7: Smaller grids were collected at each coring location to map the rebar, so they could be avoided when coring the concrete slab.

Most cores were to check the structure of the joints but two were drilled specifically on high amplitude GPR responses (**Figure 8**).

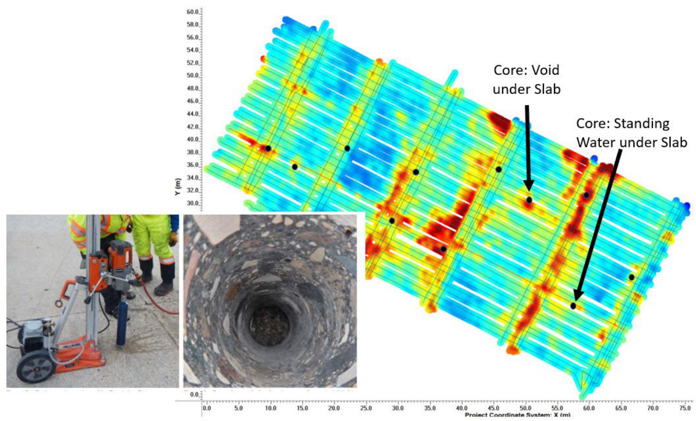


Figure 8: Same image as Figure 5 but showing the locations of 10 cores (black dots). The results from the 2 cores, drilled specifically on high amplitude GPR responses, are indicated.

The GPR survey on the spillway proved to be very successful. The two cores drilled on GPR anomalies were both confirmed to be problem areas beneath the spillway slab:

1. One 5 cm void that looked to be approximately 5 metres wide will need to be remediated, and
2. An area of standing water, due to an ice layer, means the drainage blanket under the slab will need to be improved.

Currently, KGS Group is still in the detailed design phase of the project and will be developing a remediation plan and measures to protect against further and future void formations.

Story courtesy of Jonathan McInnis, KGS Group, Winnipeg, Canada.

TIPS: Locating radiant heating tubes

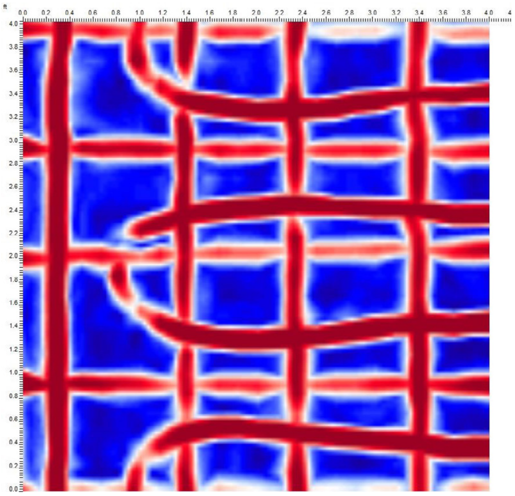
In colder environments, concrete floors may contain in-floor heating tubes (**Figure 1**). A closed system will circulate hot water through these tubes, which will warm the concrete, and subsequently the air above it, either for comfort or to prevent ice formation (on driveways).

Figure 1: Radiant tubing layout before concrete is poured.

When coring in these areas, it's important to scan the area with GPR, to ensure these tubes are not damaged during coring. This article provides 5 tips to help you locate and differentiate heating tubes from other embedded objects:

1. Fill 'em up - Most modern tubes are 1/2" diameter, constructed using PEX, or cross-linked polyethylene, material. From GPR theory, we know that small, air-filled, non-metallic conduits are hard to locate, due to the weak reflection they produce. We can greatly increase our chances of seeing these tubes by ensuring they are filled with liquid (or turning the system on), thereby increasing the reflectivity of the tubes to the GPR signal.
2. Look for the curvature – in-floor heating tubes are laid out in such a way that there are lots of curves and bends, especially near the walls. When doing a scan, if you can see the curvature, you know these are in-floor heating tubes. **Figure 2** shows these tubes, laid over rebar.

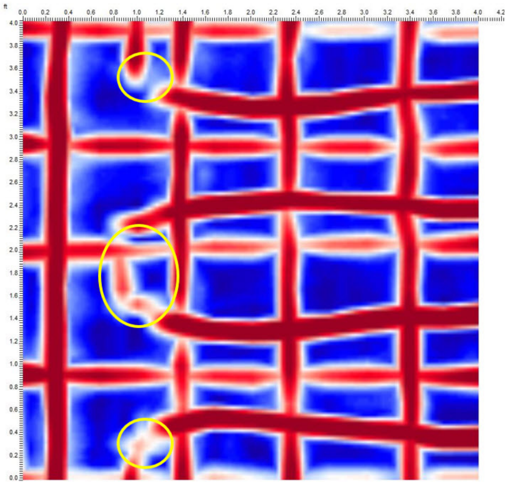
Figure 2



Sometimes during placement of the heating tubes in the concrete, some sections, most often near the curved ends, will "float up" in the wet concrete. These sections appear in shallower depth slices before the rest of the tubes are visible in the deeper depth slices.

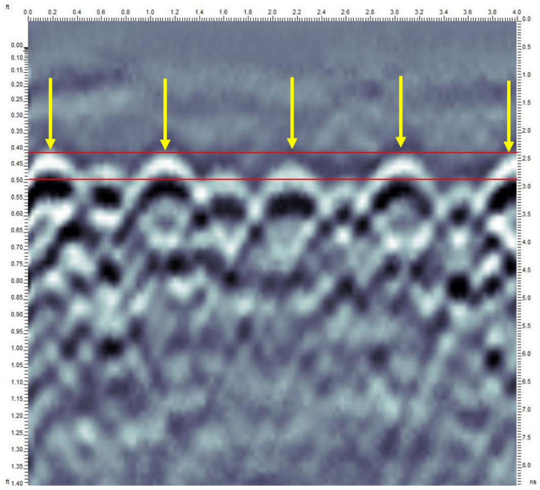
3. Collect a high-resolution grid – closely spaced lines will spatially sample the subsurface more, allowing you to see the curvature better. In Conquest, this is referred to as a high-resolution grid. The depth slice in **Figure 2** (lines collected 2 inches apart) shows the curvature better than the depth slice in **Figure 3** (lines collected 4 inches apart). Note the circles in the image below, highlighting these differences. Collecting a high-resolution grid will help you to differentiate the heating tubes from the rebar.

Figure 3



4. Compare depth on the line scans – heating tubes can be placed above or below the rebar, or even sometimes placed between rebar and wire mesh. Looking at a line scan will reveal this depth difference. For example, in **Figure 4**, the depth slices determined the curved heating tubes were above the rebar; the hyperbolas indicated by the yellow arrows are the heating tubes. The other hyperbolas in between them are the rebar.

Figure 4



5. Collect large grids – if time and space permit, it's always better to collect larger size grids. The larger coverage area will provide the big picture and allow you to see how things are laid out. Objects that overlap in some places may deviate in others, and this will be more noticeable in a larger grid.

Ensure you use the tips above to safely and accurately locate tubes prior to cutting or coring.

Data courtesy of Craig Campbell, G3Tech.

Upcoming Events

SAGEEP 2022 - March 20-24, 2022, Denver, Colorado, USA

SAGEEP is an internationally recognized leading conference on the practical application of shallow geophysics to the challenges faced in engineering and environmental projects.

Sensors & Software will be exhibiting our products and presenting a talk at SAGEEP.

To learn more about SAGEEP 2022, please visit https://www.eegs.org/sageep-2022

Upcoming Courses & Workshops

Virtual Course - Using EKKO_Project™ GPR Analysis Software

February 1, 2022	9:00 am – 1:00 pm Eastern Time (UTC-5)	EKKO_Project™ Core
February 15, 2022	9:00 am – 1:00 pm Eastern Time (UTC-5)	EKKO_Project™ Examine
March 1, 2022	9:00 am – 1:00 pm Eastern Time (UTC-5)	EKKO_Project™ 3D Reveal

Attend this online, live, instructor-led GPR course. Students will be required to have EKKO_Project™ installed on their computer and will be assigned tasks throughout the course.

Click here to learn more about the course and Register.

Workshop - Combining EM Locators and GPR for a Complete Locate

March 2, 2022. Live in Phoenix during Damage Prevention Week

This workshop combines theory and hands-on time with the equipment. The following topics will be covered:
Overview of EM
Overview of GPR
Importance of combining technologies
Benefits & Pitfalls
Hands-on data collection
Case studies

Click here to learn more about the workshop and Register.

On-Demand Training

Pre-recorded webinars and EKKO_Project tutorial webinars are at: www.sensoft.ca/georadar/webinars

Interactive courses are available via our online learning platform: www.SensoftU.com

SENSORS & SOFTWARE
from RADIODETECTION

1040 Stacey Court
Mississauga, ON
Canada L4W 2X8

+1 905 624 8909
+1 800 267 6013
www.sensoft.ca