Effective GPR surveying techniques

In the first of a two-part article, Brian Jones offers tips and best practices for getting the most from your site investigations

Ground-penetrating radar (GPR) is one of the most accurate non-destructive testing (NDT) methods available. To get the most from GPR surveying, it is absolutely essential to understand how GPR tools work and follow best practices when conducting surveys. The key areas to be aware of include:

- Target characteristics
- Survey design
- Correct antenna selection
- Best practices for setting up the system
- Practical tips to guarantee success in the field

Know your target characteristics

Before taking a single step in the field, investigators must determine the characteristics of the target they are looking for and the surrounding material they are imaging through.

Ground penetrating radar travels at different velocities, depending upon the material it is traveling through. For example, radar travels fastest through air, at about the speed of light – and slowest when traveling through water, about one-ninth the speed of light. Radar velocity for all other materials will vary somewhere between air and water.

The value assigned to the GPR velocity through a material is called its dielectric. For example, air has a dielectric of 1 and water has a dielectric of 81, so all other materials have a value somewhere between 1 and 81. We use the dielectric value to calculate the radar velocity.

GPR equipment is looking for differences in the dielectric of the material, so surveying may be more difficult when two materials have electrical properties that are too similar. Users must assess whether there is enough difference between the target they are looking for and the target's host material.

When scanning concrete, operators may be looking for electrical and telecom conduits. These can be tougher to locate than metallic reinforcing steel, due to the slight variation in dielectric from the concrete and these targets (especially if housed in PVC pipe). A tip for overcoming this issue is turning the antenna 90 degrees from its normal orientation.

Getting a better sense

Collecting data in this way may pick up different information, better allowing the operator to see plastic conduits, and give a better sense of concrete thickness. The same technique can work in utility locating and other layer mapping applications. In other words, if a GPR surveyor cannot see the pipe they think should be there, try turning the antenna 90 degrees. Or, scan in one direction, turn around, and come back in the other direction.

Electrical conductivity of the surrounding material affects how deep surveyors can see. Since GPR emits electromagnetic energy, it is subject to attenuation (natural absorption) as it moves through a material. If the energy is moving through a resistive (low conductivity) material such as very dry sand,

Photo: Courtesy Geophysical Survey Systems Inc

Boundary	Dielectric Constrast	Reflection Strength
Sand – Soil	Medium	Medium
Soil – Damp Sand	Low	Weak
Clay – Air	High, phase reversal	Strong
Dry Sand – Granite	None	No Reflection
Soil – Metal	High	Strong
Soil – Water	High	Strong
Soil – Empty PVC	Low to Medium, phase refersal	Weak

The strength of a reflection is proportional to the dialectric contrast between the target and the host materials. The greater the contrast, the brighter the reflection

ice, or dry concrete, the signal can penetrate a great deal of material. If a material is conductive (clay soil, wet concrete), GPR energy gets absorbed before it has had the chance to go very far into the material.

GPR is best for inspecting materials with low electrical conductivity, like concrete, sand, wood, and asphalt. On the other hand, if the project involves locating a sewer line or an underground storage tank that is down 8-10 feet in wet, clay-filled soil, GPR might not be the appropriate tool for the job.

Choosing the best survey design

After determining the target's electrical characteristics, as well as the size, type and orientation of utility lines, post tension cables, and objects of limited dimensions, including tanks and graves, investigators can design the survey.

If very high confidence is necessary, the survey design should be based on a bi-directional grid, with spacing between the lines equal to the smallest dimension of the targets. Where this is not possible due to obstructions, time, or budget constraints, the survey design should include a large overview grid, which would be followed by one or more smaller focused grids.

If looking for cylindrical objects like an old oil tank or buried drums, investigators should choose a bi-directional grid; these targets may look flat when scanned in one direction, so they can be easily missed or mistaken for a soil layer. Using a bi-directional grid would identify a cylindrical target if the surveyor sees a flat layer in one direction and a hyperbola/arch in the other direction.

For planar objects, including mapping the depth to bedrock, water table, or soil layers, the grid spacing would be determined mainly by the size of the area and allotted time, but one might also consider if there are any odd geologic features that need to be captured. These are typically larger features, and the undulating surface is a layer that can be seen by scanning in just one direction.

In our next issue, Brian Jones addresses the pros and cons of 2D and 3D scanning, target dimensions and boundaries, antenna selection, system setup, and hints and tips to guarantee a successful survey

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