Pavement Thickness Data from PicoR-Ice

PicoR-Ice can be used to obtain continuous thickness records of road pavement thicknesses. It is also well adapted to gather and calculate ice thicknesses for safe operations on frozen lakes and ice roads.

Demonstration data acquisition:

Canatec Environmental Limited conducted a five-part data acquisition run over existing roads and parking areas. The purpose of the data acquisition runs were:

1. Test a new vehicle mounting for the PicoR-Ice GPR antenna module.
2. Acquire data under uncontrolled field conditions.

System Set-up:

The mounting was non-metallic and so not likely to interfere with the electromagnetic pulses emitted by the PicoR-Ice transmit-receive antenna module. This custom mounting attached to a standard manufacturer's trailer hitch (Figure 1). The Picor-Ice antenna module was attached to the mounting using hardware supplied by the PicoR-Ice supplier as part of the standard system package (Figure 2). The system's standard 4.5 m USB cable was connected to the antenna module and run through a rear window opening of the survey vehicle to connect to the control microcomputer in the forward passenger seat.

A third-party Geographical Positioning System (GPS) receiver was temporarily fixed to the vehicle's roof on the forward passenger side of the vehicle (Figure 3). The GPS receiver USB cable was run through the passenger side window to connect to the control microcomputer.

Figure 1: Location of auto manufacturer's trailer hitch (left) and detail (right).

Figure 2: PicoR-Ice antenna mounting installed with the antenna module.

Figure 3: Global Positioning System (GPS) receiver location.

Data Collection:

With the PicoR-Ice antenna and the third-party GPS receiver connected to the control computer, a short circuit was driven to obtain pavement thickness data. The circuit was organized into five segments, shown in Figure 4 and Figure 5.

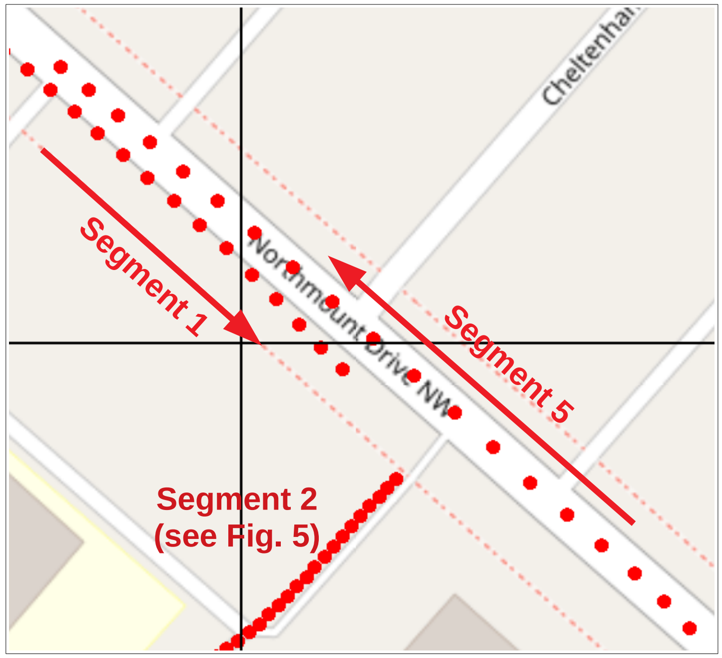

Figure 4: Locations of sample segments 1 and 5 on a public roadway. Map was generated by PicoR-Ice.

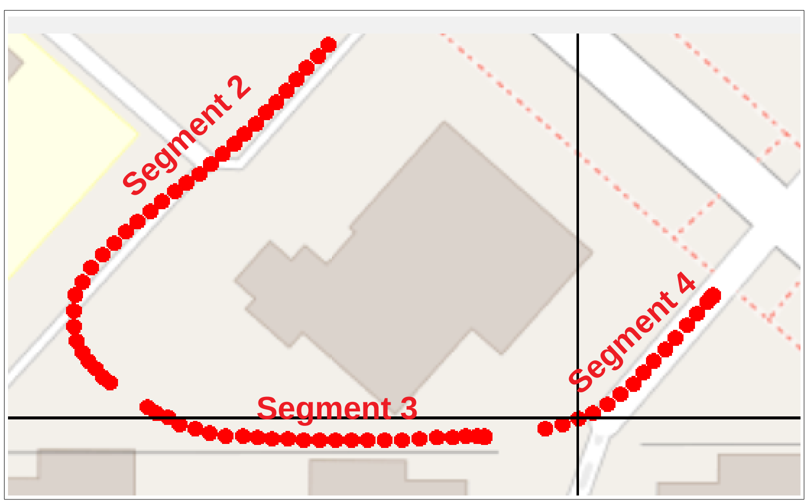

Figure 5: Locations of sample segments 2, 3, and 4 over private parking lot and access roads.

The data acquisition exercise was conducted by a two-person team, i.e. the vehicle driver and the PicoR-Ice operator. The driver maintained a vehicle speed of less than 40 km/h during data access.

The PicoR-Ice operator activated and de-activated the antenna module so as to obtain separate data files for each of the five segments. He also monitored the radar return pattern as it displayed on the control computer and added reference marks at points of interest. For real-time monitoring, PicoR-Ice settings were adjusted to interpret and measure the surface layer material as asphalt. In a full scale survey, a physical measurement of local asphalt thickness would be taken and used as a calibration standard in setting the system parameters at the start of survey.

Computer-Assisted Data Interpretation:

Two distinct qualities of the PicoR-Ice system must be appreciated and always kept in mind. They are:

1. The data that are acquired
2. The user's interpretation of the acquired data.

The data that are acquired by the PicoR-Ice transmit-receive antenna module are the microsecond reflection times of electromagnetic energy transmitted at a frequency of 1,700 MHz. These data do not directly represent asphalt, concrete, ice, snow, or any other material. PicoR-Ice does not "sniff out" designated materials.

The pattern of radar energy returns, skilfully interpreted, can indicate the presence of specific materials. PicoR-Ice software has different algorithms to aid in the identification and interpretation of a selection of materials (asphalt, concrete, ice, snow). Each material has its own electromagnetic qualities that influence the reflection of incoming electromagnetic energy. The PicoR-Ice algorithms perform instant calculations on the incoming data to help the operator interpret the locations of various materials underfoot.

The various settings that the operator may apply to the PicoR-Ice system to aid viewing and real-time interpretation do not in any way alter the source data. The source data can be read through the PicoR-Ice control software any time after acquisition – at home, in the office, in the laboratory – for later re-analysis and interpretation.

Interpretation of Segment 2 Data:

Segment 2 was chosen for presentation because it showed an anomaly which the operator tagged during the survey. Following is a sequence of PicoR-Ice radargams that illustrate how information can be extracted. The target material was the asphalt surface layer in a parking lot.

The survey vehicle was driven down the centre of the parking lot and over a storm drain opening (Figure 6).

Figures 7, 8, 9, 10, 11, 12, and 13 are annotated illustrations of the radargram data of Segment 2.

Figure 6: View of Segment 2 route through a parking lot.

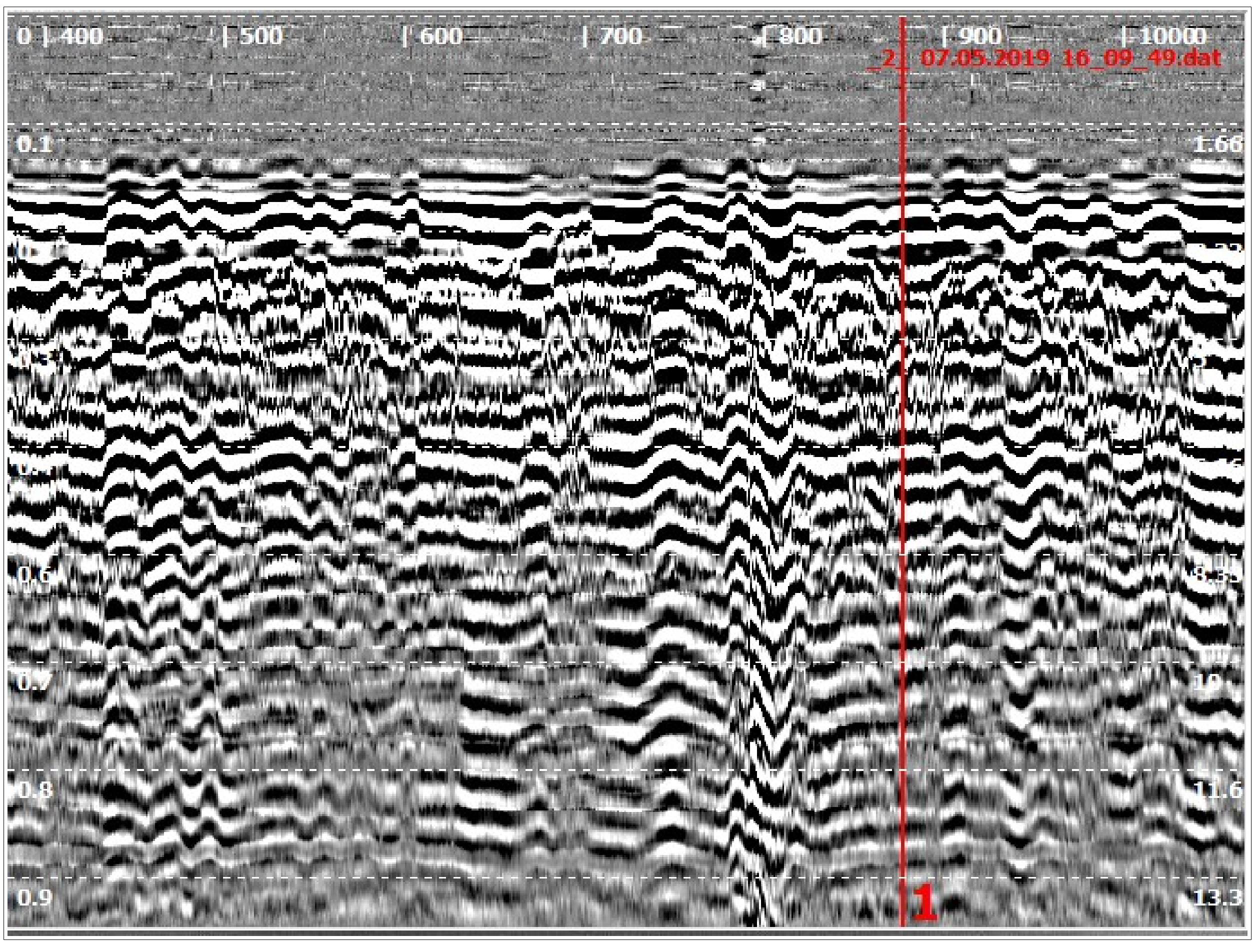

Figure 7: Raw PicoR-Ice radargram over a part of Segment 2.

Figure 7 (preceding) shows the pattern of radar returns over part of the Segment 2. Limited interpretation is possible from this display. More distinction among the underfoot layers of material can be made by varying the display contrast, as in Figure 8 (following). Contrast can be altered both during a survey and in post analysis.

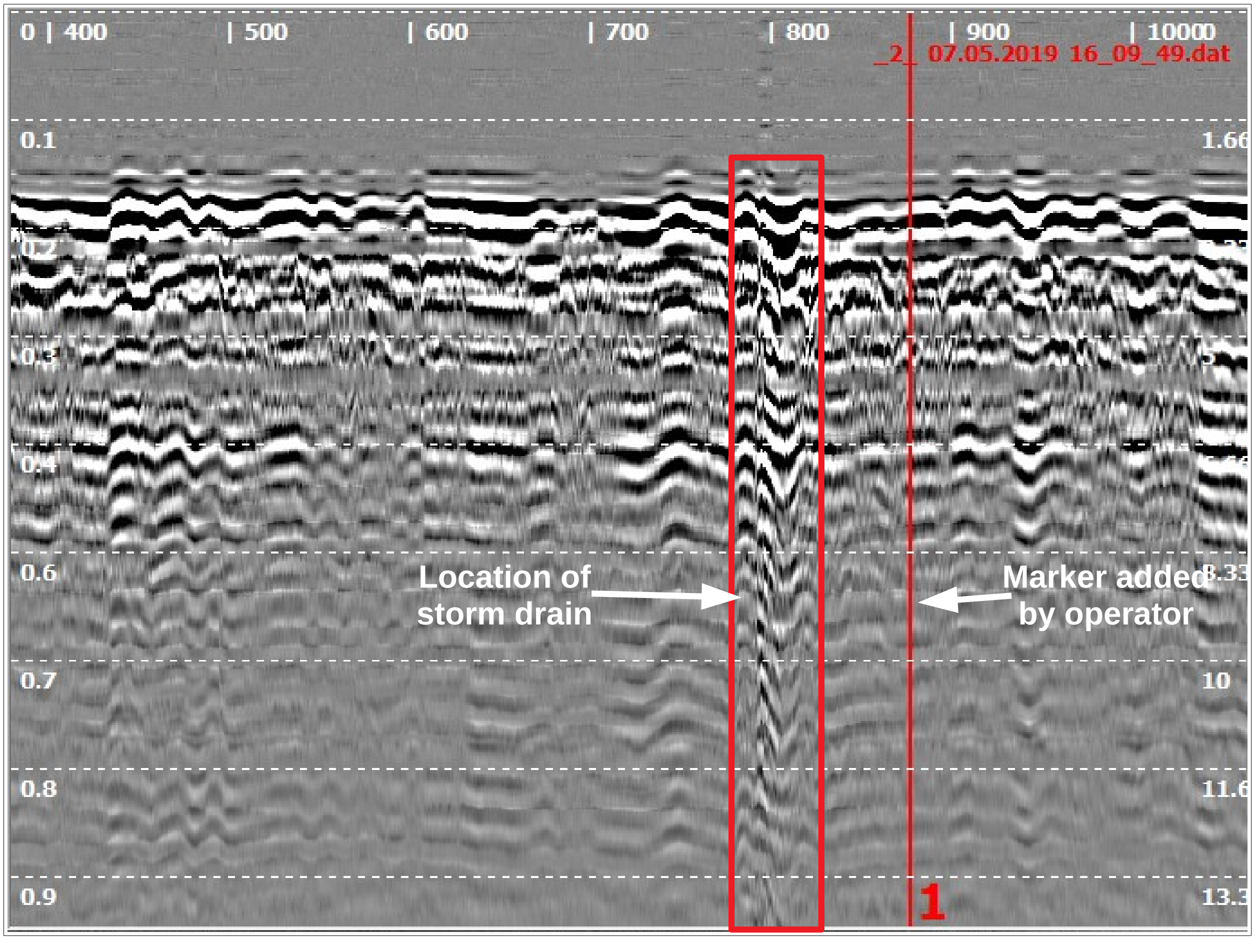

Figure 8: Contrast adjustment made to the raw radargram data display.

Adjustment of the contrast more clearly highlights the location of the storm drain in the parking lot. As the vehicle passed over the drain, the operator added a marker to the data file as a reminder that something of interest had just been passed.

During the actual survey of Segment 2, the PicoR-Ice algorithm for interpretation of materials from a moving vehicle was selected and run. The target material selected was asphalt. The systems default values for various system parameters were selected. Figure 9 displays the output when using default parameters for asphalt detection and measurement.

The algorithm places green lines on the radargram locations for the estimated upper and lower boundaries of the asphalt layer. Based on the default parameters, the algorithm calculates a thickness value (in cm) between the two lines. The algorithm is an aid to interpretation. The operator should be able to see where in the zebra-stripe pattern the boundaries tend to fall.

Default settings, however, can still result in ambiguities and false returns.

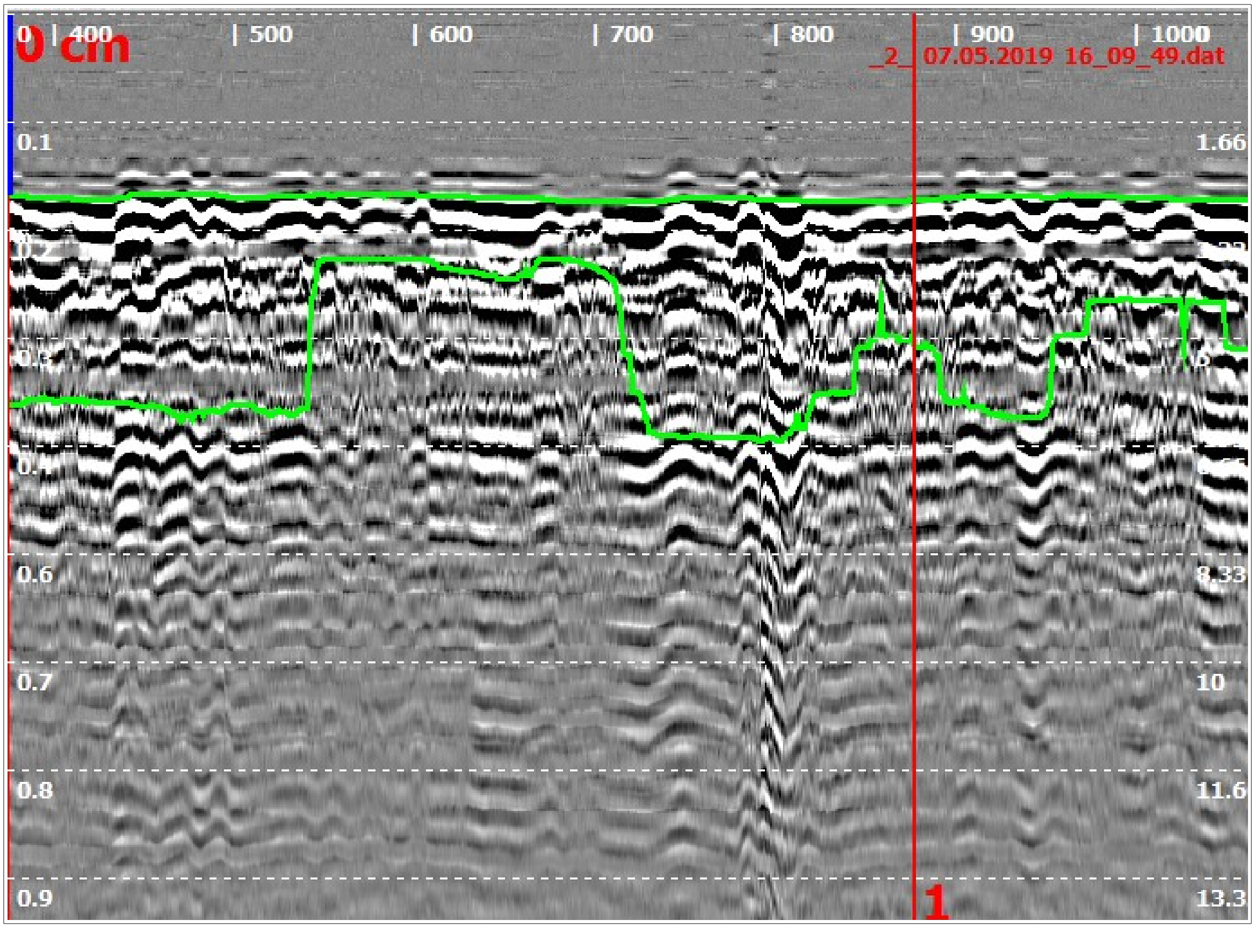

Figure 9: Output from algorithm used to place upper and lower asphalt boundaries; default settings used.

In Figure 9, the upper boundary of the asphalt layer, at the road surface, is clearly defined. However, use of default settings results in ambiguity as to which grouping of patterns represents the true lower boundary.

The PicoR-Ice algorithm calculates a change in material, in part, on the basis of magnitude of change in the return signal. The operator can vary this criterion for material interpretation. In the Segment 2 data, such an adjustment was made and the result is displayed in Figure 10. The adjusted display makes it clearer where the asphalt layer lies. The operator must still make the final judgement of where the material thickness limit lies.

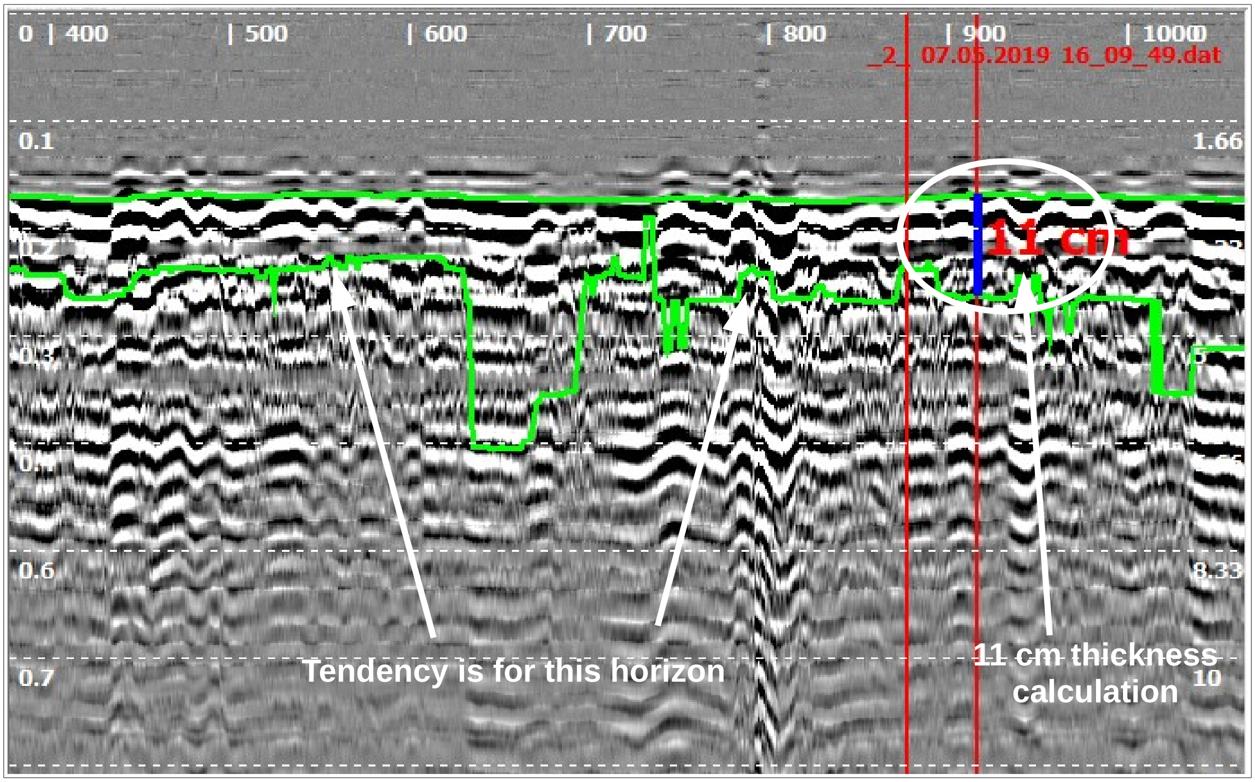

Figure 10: Altering sensitivity of algorithm to changes in material.

For purposes of determining point thickness values and display of data, the operator has the option of smoothing the upper and lower limit lines, based on the assisting algorithm and the operator's own experience in the interpretation of radar data. A smoothed version of the display of Figure 10 is shown in Figure 11.

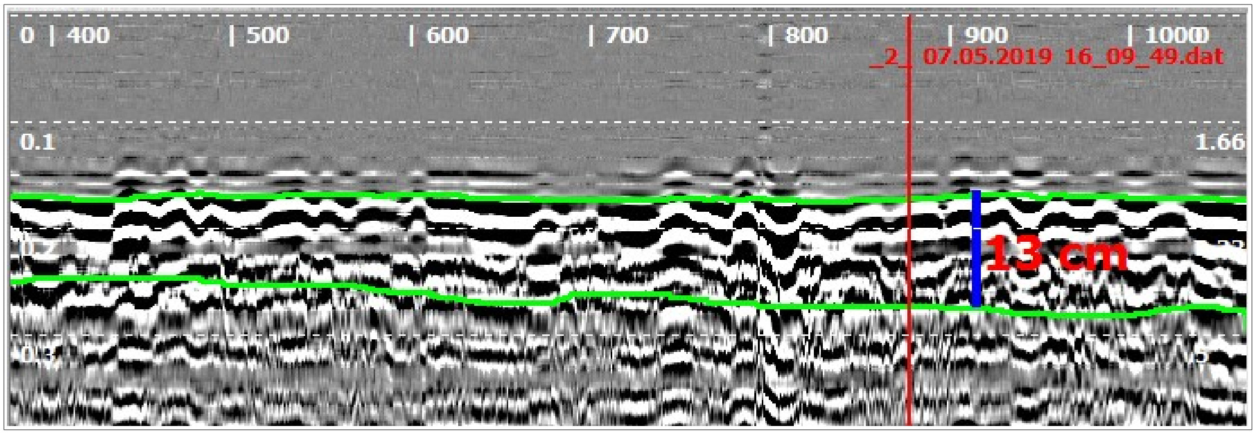

Figure 11: Final placement of asphalt boundaries by the operator with help from the PicoR-Ice algorithm.

The output samples thus far are based on the assumption that the default value for the dielectric properties of asphalt are correct for the particular asphalt mix encountered in Segment 2. In other words, the PicoR-Ice system has not been calibrated against an actual measured thickness of the local asphalt.

In Figure 11, a calculated thickness of 13 cm is shown. But, what if we had a physical measurement of 11 cm for asphalt at that point? The PicoR-Ice algorithm would need to be calibrated to this standard. Canatec offers an add-on calibration tool to aid in the fast correction of material dielectric values. Using the hypothetical measured thickness of 11 cm, the PicoR-Ice system would be calibrated and the output of Figure 12 would result.

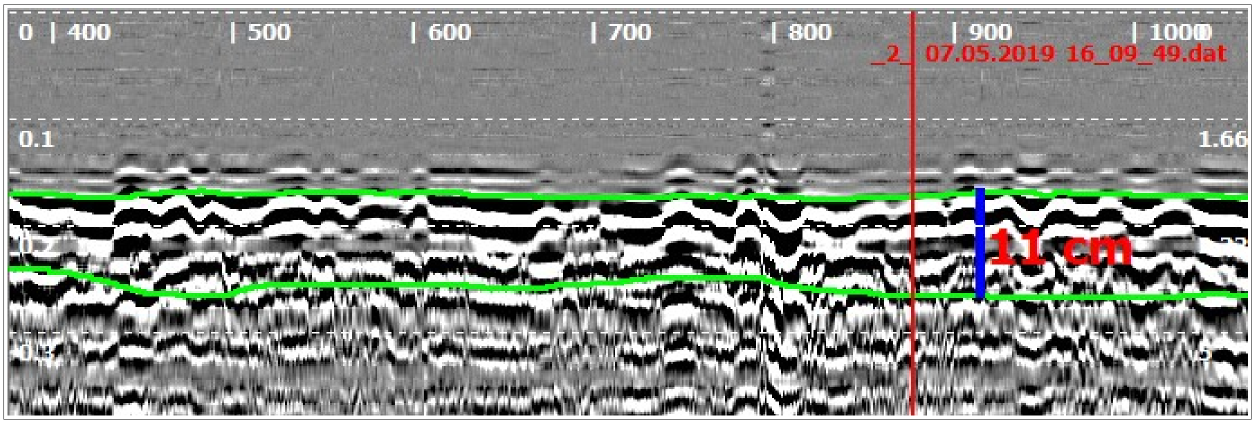

Figure 12: Operator-interpreted asphalt thickness, aided by algorithm and calibrated against a measured thickness.

Finally, PicoR-Ice allows the operator to seek out more than two material boundaries. Figure 13 shows the result of adding a third interface line to the Segment 2 data.

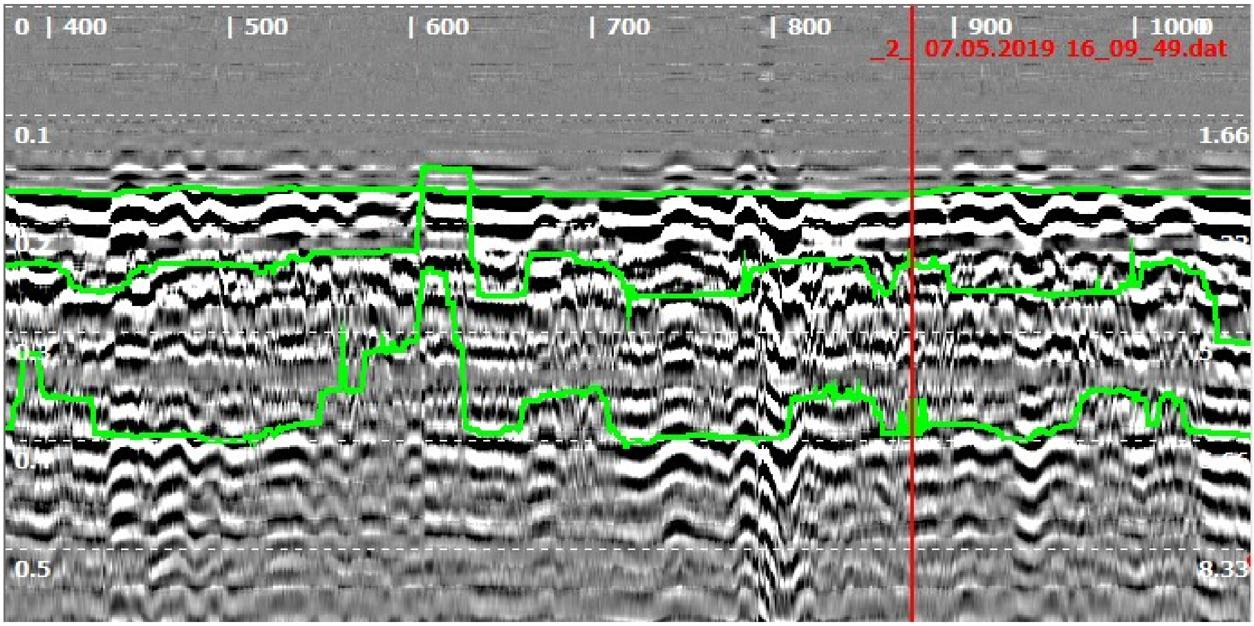

Figure 13: Adjusted and calibrated Segment 2 data with three interface lines (not smoothed).

The third horizon in Figure 13 likely indicates the profile of the prepared road bed beneath the asphalt surfacing.