Soil below the water table may not be saturated: how much air is entrapped and what are the implications for seismic determination of depth to water table?

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The zone below the water table is not necessarily saturated, especially following rapid rises in water table, common in alluvial tropical regions. Degree of saturation in this critical zone determines the nature and extent of redox- and diffusion-related processes. Incomplete saturation below the water table means that typical two-layer seismic refraction methods, widely used for determining water table depth, are not accurate under conditions of rapidly fluctuating water table. In this work we a) measured the degree of saturation below the water table, and b) modified the seismic refraction method to enable accurate determination of depth to water table under fluctuating conditions. Degree of saturation was determined by measuring volumetric soil water content (by time domain reflectometry) and total porosity (from bulk density) to 2-m depth in a riparian area during several cycles of flooding and draining. At 0.1-1.0 m depth, air entrapped below the water table represented a mean of 14% of bulk soil volume. Nearby, 60 seismic refraction surveys were conducted at 15 locations to estimate depth to water table (1-9 m), verified in piezometers. Using the conventional two-layer approach, only 28% of predictions were within 1 m of the measured water table. A new three-layer approach, integrating forward and reverse velocities, moisture conditions, aquifer texture categories, and an averaging algorithm, gave depth predictions between 0.38 m above and 0.13 m below the water table with 99% confidence. Using the new method it was also possible to determine the largest historical depth to water table.