Determining Hydrogeology at CEER Using Seismic Refraction Tomography

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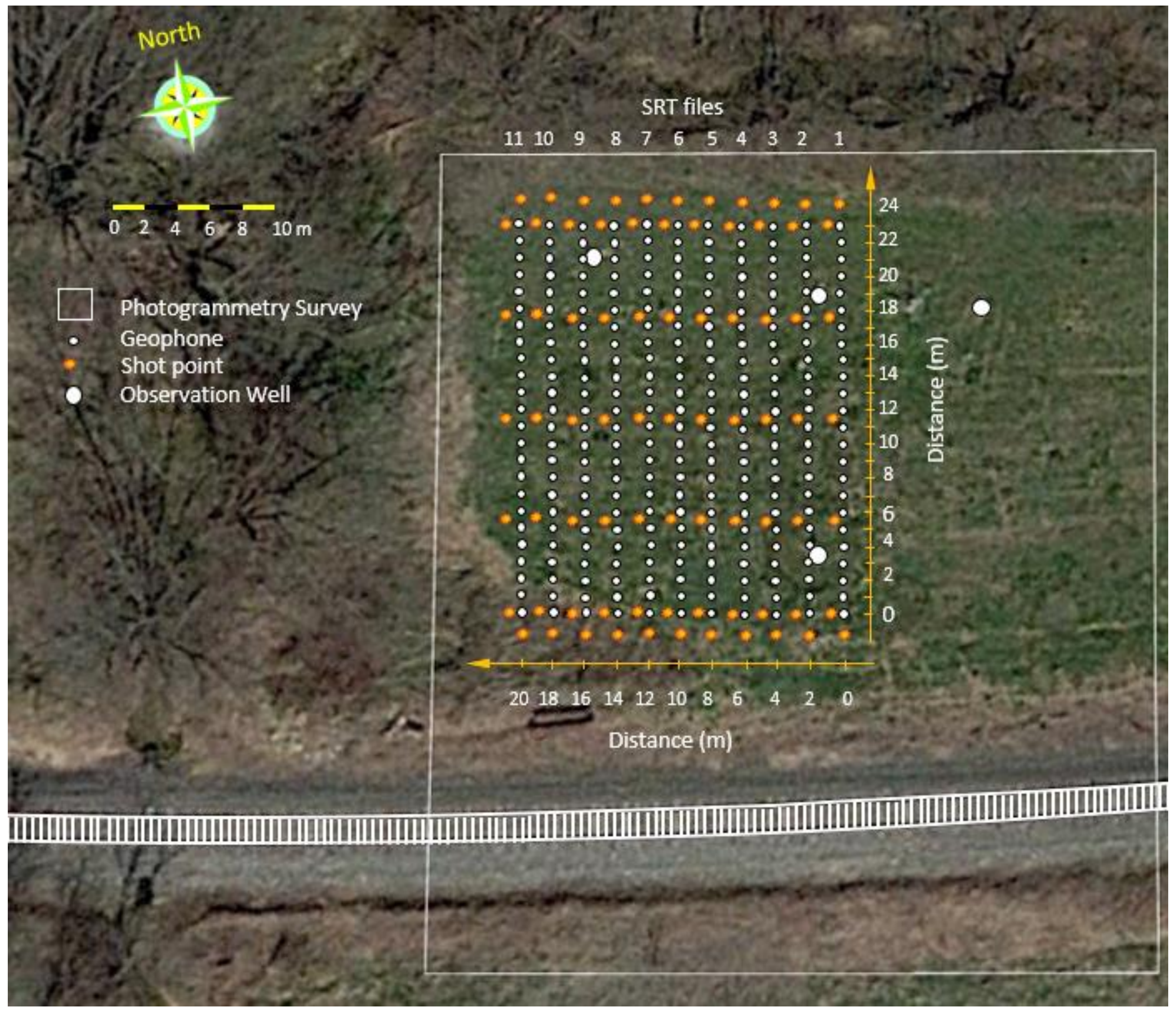
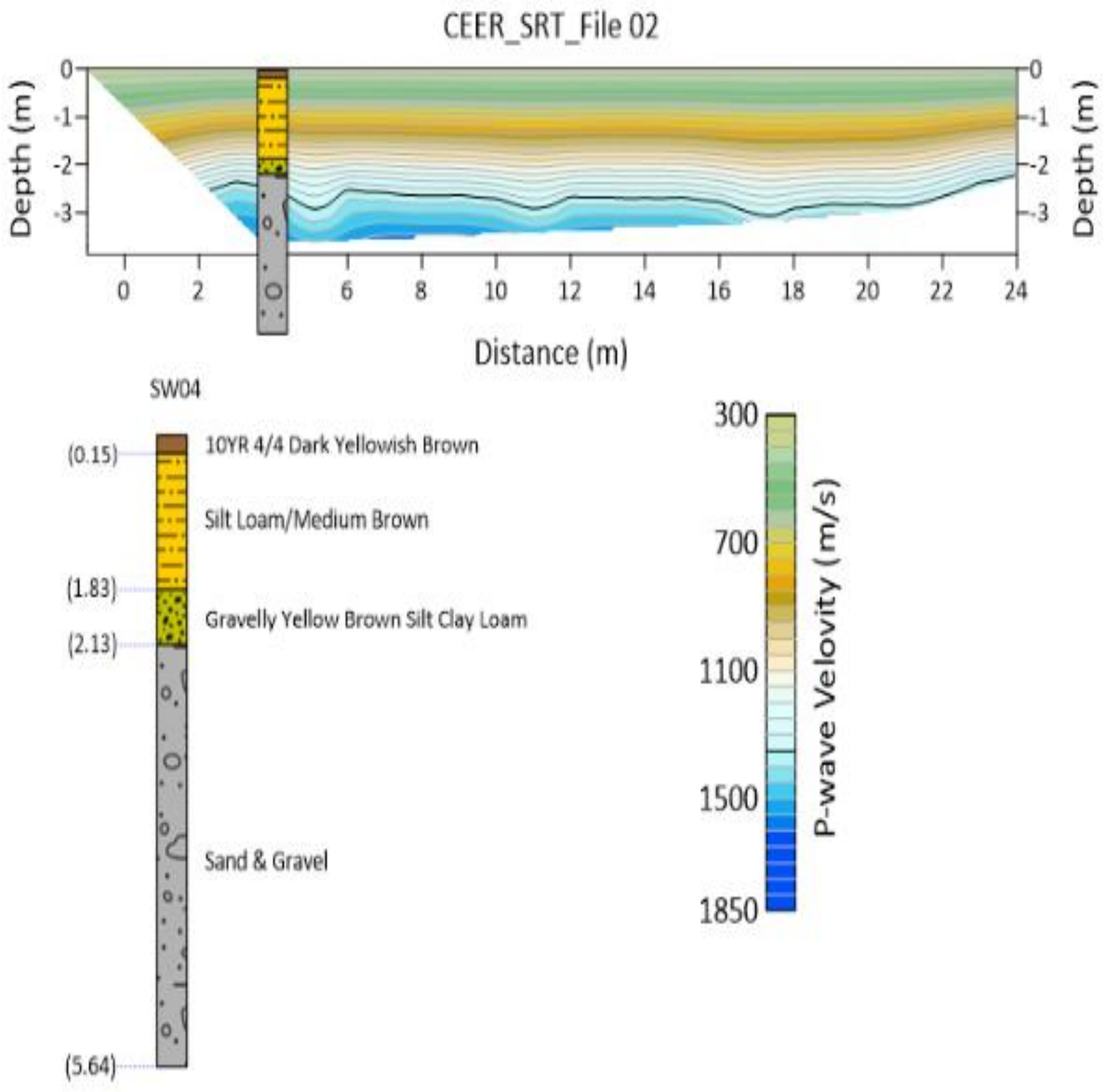
Introduction

A technique used to determine what type of geology is lying in the subsurface is seismic refraction tomography, or SRT. SRT consists of using a seismograph to measure the time it takes for a P-wave to travel from an energy source (e.g. dynamite, air gun, or a sledgehammer strike) to a geophone located a distance away. A P-wave is a seismic body that shakes the ground back and forth as it travels along any direction. The geophones are sensitive devices that measure the arrival time of the P-wave to the seismometer. Once all of the data is collected, a velocity can be determined based on how long it took the P-wave to arrive to where the geophones are located. Each type of subsurface material has its own velocity, so depending on the velocity, the subsurface material can be determined. (Grelle and Guadnagno, 2009)

Methods

The site of this survey was at Susquehanna University's Center for Environmental Education and Research (CEER). Within the 20x23 m^2 field there are three observation wells. The SRT surveys were performed with a SmartSeis seismometer. Eleven SRT survey lines, 24 meters each were used to cover the field. Each survey transect was made with 24 geophones spaced by 0.5 m and the 11 survey lines were spaced by 2 m. A sledgehammer strike on a metal plate was how the energy source was generated for the seismic survey. Seven strikes were used for each survey at -1m, 0m, 5.5m, 12m, 17.5m, 23m, and 24m. The strike triggers a P-wave that travels through the ground and is picked up by all of the geophones which send the data to the SmartSeis data logger. The SmartSeis displays the signal, and if the graph displayed is acceptable, the metal plate is moved to the next shot location and the process is repeated.





Results

Eleven files were plotted and the layers, determined by their velocities, were color coded and could be seen on each of the plots. The top-most layer was determined to be a soil colored 10YR 4/4 Dark Yellowish Brown, the next layer was a silt loam colored medium brown, the following layer was a gravelly silt clay loam. And finally the bottom layer was a mixture of sand and gravel where the groundwater was flowing. The velocities of each layer increased from top to bottom until it finally reached the groundwater where the velocity of the P-wave is at its fastest. As shown in the bottom picture, the plot is only one of the eleven files. Each file has a similar plot and the four distinct layers can be seen on each of the eleven plots at about the same depths. Because of the observation wells, the groundwater can be seen better in some plots compared to others. The picture shown on the left shows file 02, which includes an observation well and is why the groundwater can clearly be seen in the plot. If all of the plots are looked at, it can be seen that the top layer never extends past a depth of about one meter. The second layer ranges from a meter to 2 or 2.5 meters. The gravelly silt clay loam layer ranges anywhere from 2 to 3 meters and lastly, the sand and gravel layer that holds the groundwater has a large range depending on which file it is. In file 06 the layer begins at 2.5 meters and in other layers it doesn't start until nearly 4 meters. There was a limit on how deep the geophones could pick up readings, so the maximum depth is about 4 meters, but the sand a gravel layer most likely extends further down than what can be seen on the plots.

References

Grelle G., Guadagno F. 2009. Seismic Refraction Methodology for Groundwater Level Determination: "Water seismic index". Journal of Applied Geophysics, 68 (3), 301-320.