Aquifer Characterization through GPR and Borehole Analysis
Eau Claire Municipal Well Field, Wisconsin
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Abstract
Our data collection methodology was three-fold: 1) to collect and analyze data from secondary sources addressing the hydrogeologic aspects of the Eau Claire municipal well field (ECMWF), 2) to collect primary source GPR data on site, and 3) to process the data and assess their viability in characterizing groundwater flow. 1) Initially we contacted the drilling companies responsible for installing the high-capacity wells supplying the ECMWF to acquire drill logs from the bores. Upon analysis the geologic data for Well 21 was determined to be the best available and so we chose its location as our target area. We were also given a tour of the ECMWF and information about the aquifer (e.g. water table depth, water quality, water removal rates); (Greene, 2014). 2) To begin on site data collection, we measured a 150 m transect (R1 and two 50 m transects (C1 and C2) perpendicular to R1 and recorded GPR coordinates at the transects’ endpoints. Using a Topcon laser level and surveying rods we recorded elevation differences every two meters to calibrate our subsurface reflections with the area relief (Jol and Bristow, 2003). Using a pulseEKKO 100 GPR system we first recorded a common midpoint (CMP) centered at the 75 m mark of the R1 transect to determine the subsurface velocity, this technique is necessary to convert our electromagnetic wave travel time measurements to depth. Following the CMP survey data was collected across the R1, C1, and C2 transects using a frequency of 100 MHz with a 0.5 m step size and 1 m antenna separation (Jol and Bristow, 2003). We also collected data along the C2 transect at 50 m with a 1 m step size and 2 m antenna separation and at 200 MHz with a 0.10 m step size and 0.5 m antenna separation to determine the most effective resolution for imaging reflections in the study area (Jol and Bristow, 2003).

Methods
Traditionally, aquifer characterization is conducted by extrapolating stratigraphy between boreholes and producing a fence diagram. However, the point-source nature of boreholes can produce inaccurate models so a better methodology is needed. Ground penetrating radar (GPR) is a geophysical method using electromagnetic signals and provides a non-invasive way to image the subsurface. Our project’s goal is to improve the characterization of the aquifer supplying the Eau Claire municipal well field by correlating borehole data with GPR profiles to produce stratigraphic models at a higher degree of accuracy than traditional methods. Using a pulseEKKO 100 system, GPR data was collected across a 150 m and two 50 m transects to a depth of 12 m using a frequency of 100 MHz with a 0.5 m step size and 1 m antenna separation. The results show two facies representing a migrating sidebar and an expanding floodplain. Borehole data was collected to a depth of 30 m revealing grain size ranging between medium sand to gravel.

Analysis
Subsequent to on site data collection Sensors and Software, Inc.’s EKMark and Lineview software was used to compile elevation, CMP and transmit data to produce the images seen in the results section. The data collected along R1 contained a significant amount of noise (likely emanating from FM radio waves or power lines) as well as many underground obstructions (e.g. pipes) which interferes with our image clarity and hinders interpretation (Jol and Bristow, 2003). Through the western portion of the R1 transect noise decreases and the quality of the image increases. The C1 and C2 transects produces images which can be interpreted and are believed to be representative of the western portion of R1. Prominent reflections from C1 and C2 were geometrically characterized and correlated to interpret sedimentary facies (Jol and Bristow, 2003). C1 and C2 both illustrate a subtle change of sedimentary facies within the mixed sand and gravel not observed in the Well 21 bore log (Jol and Bristow, 2003). Two distinct facies are interpreted; aggrading floodplain deposits, shown as red traces, and braided stream deposits, shown as blue traces (Roberts and Bravard, 1997; Bridge and Lunt, 2006). The green traces in C1 are anomalous and represent an underground obstruction (e.g. pipe) (Jol and Bristow, 2003). A lower facies identified in the Well 21 drill log as a well graded glacial outwash exists below the depth of about twelve meters but could not be imaged with GPR due to signal attenuation caused by fine grained sediments (e.g. silts, clays). The reflections which are interpreted as braided stream deposits and categorized as a middle facies is of interest during a hydrogeologic characterization of the aquifer because it contains adjacent well sorted sedimentary units of varying hydrogeologic properties, the type and spatial extent of these units control how water moves within the upper portions of the aquifer (Slater and Comas, 2009; Bridge and Lunt, 2006).

Study Area

Results

Summary

Acknowledgments

References