I. PROJECT SUMMARY

Project Title: Time Domain Electromagnetic Induction Survey of Eastern Waukesha County and Selected Locations
Project Number UW-WRI # 00-HDG-8
Principal Investigators:
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Period of Contract: July 1, 1999 to June 30, 2000

A. Background/Need

The sandstone aquifer is the major source of municipal and industrial water in Waukesha County. The aquifer has been heavily exploited over the last century, creating a regional cone of depression that is over 500 feet deep and currently centered on eastern Waukesha County. Over the last ten to fifteen years, total dissolved solids (TDS) levels have risen significantly in several of the higher capacity municipal wells in Waukesha County. TDS levels in at least two municipal wells have risen to over 1,000 ppm. A new municipal sandstone well, in the City of Brookfield, unexpectedly encountered high TDS water (2,200 ppm), causing substantial additional expense to the water utility. While high TDS water is certainly present within portions of the sandstone aquifer, the spatial distribution of this water is poorly defined. The location and depth of high TDS water in the sandstone aquifer must be understood before the cause of the problem and potential solutions can be identified.

B. Objectives

The goal of this study was to map the distribution of high TDS water in the sandstone aquifer in Waukesha and Milwaukee Counties. Direct water sampling through packer tests in existing wells or dedicated monitoring wells was prohibitively expensive. Geophysical methods offered the only practical method of mapping zones of high TDS water in the aquifer. A secondary goal of the study was to map the base of the aquifer.

C. Methods

A geophysical survey consisting of 69 Time Domain Electromagnetic Induction (TEM) soundings was conducted in Waukesha and Milwaukee Counties using a Geonics EM57 system. The layout of the soundings was optimized to measure the electrical resistivity of the sandstone aquifer at depths of about 500 to 2,000 feet. The data were interpreted using the TEMIX two-dimensional modeling software by Interpex. Ltd.

D. Results and Discussion

The TEM data yielded two distinct patterns, depending on the location of the sounding relative to the Waukesha fault. Most soundings on the up-thrown (northwest) side of the fault show a trend toward rising resistivity with depth,

indicating high resistivity basement rock. Most soundings on the down-thrown (southeast) side of the fault indicate a highly conductive electrical half space at depth, suggesting high salinity ground water in the lower portion of the sandstone aquifer.

Modeling data from the up-thrown side of the fault produced reasonable agreement between the interpreted depth of the high resistivity half space and the known elevations of Precambrian basement rock. Down hole water sampling, conducted in a Village of Sussex municipal well for a different study, indicated no significant change in water salinity for the sandstone aquifer. A few soundings in west-central Waukesha County indicated shallower basement rock than expected with some apparent pockets of elevated TDS ground water adjacent to the apparent Precambrian highs.

Modeling data from the down-thrown side of the fault produced estimates of the depth to elevated TDS water that were generally shallower than expected. Geophysical well logs, obtained by the USGS in Waukesha Well No. 5, indicated TDS rising from about 300 ppm at 1,200 feet to over 2,000 ppm at 1,600 feet. The TEM interpreted depth to the top of the high conductivity zone in the Waukesha area is between about 700 and 1,000 feet, and the interpreted resistivity value indicates substantially higher TDS levels. This disparity in the interpreted data is probably true for the other soundings on the down-thrown side of the fault. The cause of the disparity is unknown but could be caused by supression of the fresh water layer between two conductors.

E. Conclusions

The results of the TEM survey strongly suggest the presence of the high TDS water in the lower portion of the Mount Simon unit of the sandstone aquifer. High TDS water appears to be migrating upward in response to heavy pumpage in eastern Waukesha County. The top of the saline water interface appears to be high near heavily pumped wells and near deeper wells, which are likely to penetrate thin shale units in the upper few hundred feet of the Mount Simon sandstone that act as a weak confining unit. This observation is supported by strong correlations between elevated TDS, total depth, and annual pumpage observed in the Waukesha Water Utility well field. The TEM data also suggests that isolated mounds may be present on the Precambrian surface in western Waukesha County with potential zones of elevated TDS ground water adjacent to the mounds.

F. Implications

The data suggest that poor water quality could be minimized by drilling shallower sandstone wells and pumping less, with the development of other wells to offset the loss in capacity. The deeper portions of the sandstone aquifer appear to by generally separated form the upper fresh water zone. For the purposes of modeling the hydraulic response of the sandstone aquifer, the top of the saline water zone at depth may be the practical base of the aquifer.

The Precambrian surface and Waukesha fault may be more complex then initially anticipated.

G. Related Publications

Jansen, J., Taylor, R.W., and Powell, T., 2000, A regional TEM Survey to Map Saline Water in the Cambrian-Ordovician Sandstone Aquifer of Southeastern Wisconsin, accepted for publication, Proceedings of the Environmental and Engineering Geophysical Society.

Key Words: Sandstone aquifer, TDS levels, Water quality, TEM surveys

Funding: UWS-WRI with a donation of 12 soundings and other data from the Waukesha Water Utility