# Geophysical logging summary for Madison Water Utility well #14

This memo documents the findings of geophysical logging conducted by the Wisconsin Geological and Natural History Survey (WGNHS) at the request of the Madison Water Utility (MWU) at MWU well #14. Two sets of logs were collected from MWU well #14. The first set was collected under ambient (not pumped) conditions on Feb. 7, 2017. The second set was collect while the well was being pumped (stressed conditions) on Feb. 14, 2017.

**AMBIENT CONDITIONS (Figure 1)** The gamma log corroborates the geologic log that was prepared for the well from the drill cuttings (circa 1960). It shows primarily sandstone from the base of the well casing at 117ft. below grade to approximately 230ft. The Eau Claire Shale (an aquitard) is present from 230ft. to about 270ft. Below the shale, sandstone is present to the bottom of the well which was encountered at 551ft. (The well was originally drilled to 715ft.).

The static flow log indicates that there is inflow of water entering the well near 230ft. The inflow diverges with about 100 gallons per minute flowing up the well and abruptly out of the well at the bottom of the casing. A similar volume flows down the well and gradually leaves the well between 290ft. and about 500ft.

The caliper log and well video show a number of fractures and/or bedding planes intersect the well. A few of these features appear to significantly impact the water quality within the well. At the depths of these features: 117ft. (the bottom of the casing), 150ft. and 230ft., there are corresponding changes in the conductivity and to a lesser degree the temperature of the water. These measurable variation in temperature and conductivity supports the flow log which indicates the fractures at the bottom of the casing (117ft.) and the one near 230 ft. play a significant role in the hydraulics of this well. The values of conductivity and temperature are less informative than the changes of those values under ambient conditions. Additionally, the conductivity calibration was poor.

**STRESSED CONDITIONS (Figure 2)** MWU retained a subcontractor (Municipal Well and Pump) to install a high-capacity temporary pump in the well. The pump was set at 65 ft. and a 4" ID conduit was installed to 75ft. to allow the geophysical tools to pass the pump intake without becoming entangled. The pump was run at approximately 1550 gallons per minute (gpm) for about 30 minutes prior to and during the collection of the stressed data.

The stressed flow log indicates that at the when pumped at 1550 gpm most of the water comes from two fractures; 117ft. and 230ft. This is shown as the two leftward jogs in the borehole flow log at those depths. The maximum flow rate is seen inside the casing between 117ft. and the bottom of the conduit at 75ft. This represents the flow up the well toward the pump. The log also indicates very little if any flow from below 230ft. The slight wiggles in the data at 117ft and 230ft. are thought to be related to turbulence associated with the high flows at those two locations

Similar to the ambient conditions test, both the temperature and the conductivity show changes at 117ft. 150ft. and 230ft. The now properly calibrated conductivity log shows some important additional details. The conductivity is at its highest at the base of the casing (117ft.), suggesting that when pumped, the most conductive water enters the well at the base of the casing. The fractures at 150ft. and 230ft. both produce water with higher relative conductivity than the rest of the well.

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