REGIONAL EFFECT OF PUMPING GROUND WATER FROM DEEP FRACTURE SYSTEMS IN THE CONYERS AREA, ROCKDALE COUNTY, GEORGIA

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Abstract. A 72-hour aquifer test was conducted to investigate the yield and interconnectivity of deep fracture systems in the City of Conyers, Rockdale County, Georgia. Wells tapping the deep fracture systems in the underlying igneous and metamorphic crystalline rock have yields ranging from 100 to 350 gallons per minute and can be pumped on a continuous basis. During the test, drawdown in excess of 30 feet was observed at distances as much as 6,200 feet from a pumped well and in observation wells located in two separate topographic basins. The regional effect of pumping is substantial and indicates that wells tapping deep subhorizontal fracture systems can reverse the natural (unstressed) hydraulic gradient and produce large influence areas around the pumped well. Wells tapping into the same (or similar) zones may interfere with each other, even across large distances, causing decreased well yield. Understanding the hydrologic characteristics of subhorizontal systems is critical in managing the water resource in these types of geologic settings.

INTRODUCTION

During 2005, the U. S. Geological Survey (USGS), in cooperation with Rockdale County Board of Commissioners, completed ground-water resource investigations covering Rockdale County, including focused studies in the City of Conyers area (Fig. 1). Historically, the City of Conyers operated one of the higher-yielding well systems in the Atlanta region. In that system, ground water was produced from several high-yield wells, including 13DD55 (120 gallons per minutes [gal/min]), 13DD69 (172 gal/min), 13DD56 (243 gal/min), and 14DD63 (125 gal/min) (Cressler and others, 1983). Although the well system was highly dependable, the depths, yield, and interconnectivity of deep water-bearing fracture zones were poorly understood. Detailed investigations were undertaken to increase the understanding of these productive fracture systems in the underlying igneous and metamorphic rock.

Williams and Burton (2005) and Williams and Cressler (2006) identified many different types of water-bearing fracture zones in the Conyers area—including joints, stress-relief fractures, parallel partings, and dissolution features associated with pegmatites and veins.

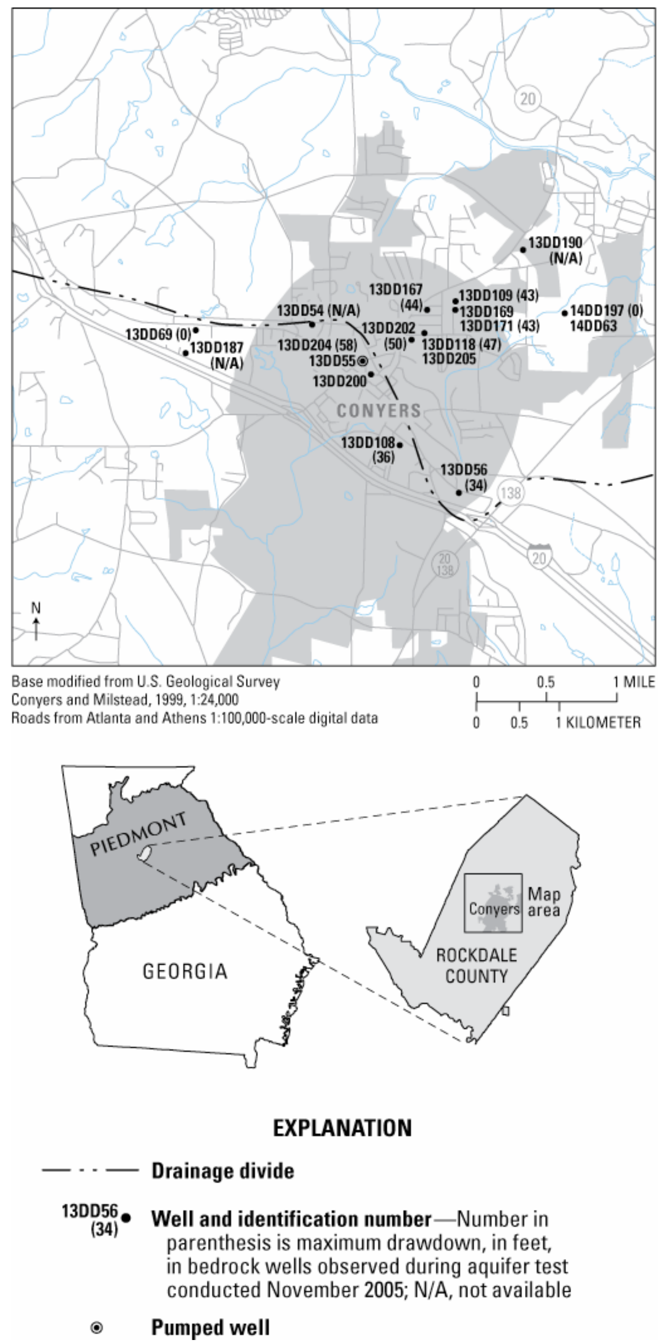

Figure 1. Wells in the Conyers area, Rockdale County, Georgia.

The highest yielding water-bearing fracture zones were, however, identified almost exclusively along subhorizontal lithologic and/or thrust fault contacts below massive, poorly foliated granite gneiss (Williams and Burton, 2005; Williams and Cressler, 2006). Differential weathering along the permeable contacts likely produced the interconnected water-bearing zones across the area; these zones consist of foliation-parallel partings, voids, and other openings ranging from fractions of an inch to several inches in aperture. Permeable contacts are common in the Atlanta region and their significance with respect to water supply is believed to be important in the City of Lawrenceville (Chapman and others, 1999) and as well as many other areas (Cressler and others, 1983).

This paper describes the results of a 72-hour aquifer test conducted in the City of Conyers and the regional effect of pumping from deep permeable fracture systems. Water levels in 10 drilled (bedrock) wells and 3 bored (regolith) wells were monitored before, during, and after the aquifer test to determine the response to pumping at various distances and directions from the pumped well.

REGIONAL EFFECT OF PUMPING GROUND WATER FROM DEEP FRACTURE SYSTEMS

To investigate the yield and interconnectivity of the deep fracture systems in the Conyers area, a 72-hour aquifer test was conducted during November 14–17, 2005. A new test well (13DD204) was drilled adjacent to an old (now abandoned) municipal well (13DD55) (Fig. 1). Historically, well 13DD55 reportedly sustained a pumping rate of 120 gal/min for 11 years under continuous pumping (Cressler and others, 1983).

Test well 13DD204 was drilled to a total depth of 462 feet (ft) and remained essentially dry until penetrating high-yielding fractures near the bottom of the well. An attempt was made to drill the well to 550 ft (total depth of 13DD55); however, the large volume of water produced from the deep fractures "drowned out" the pneumatic hammer, effectively preventing deeper drilling beyond 462 feet.

During the aquifer test, well 13DD204 was pumped for 72 hours at an average rate of 200 gal/min, with a maximum drawdown of 60 ft (Fig. 2). Drawdown response

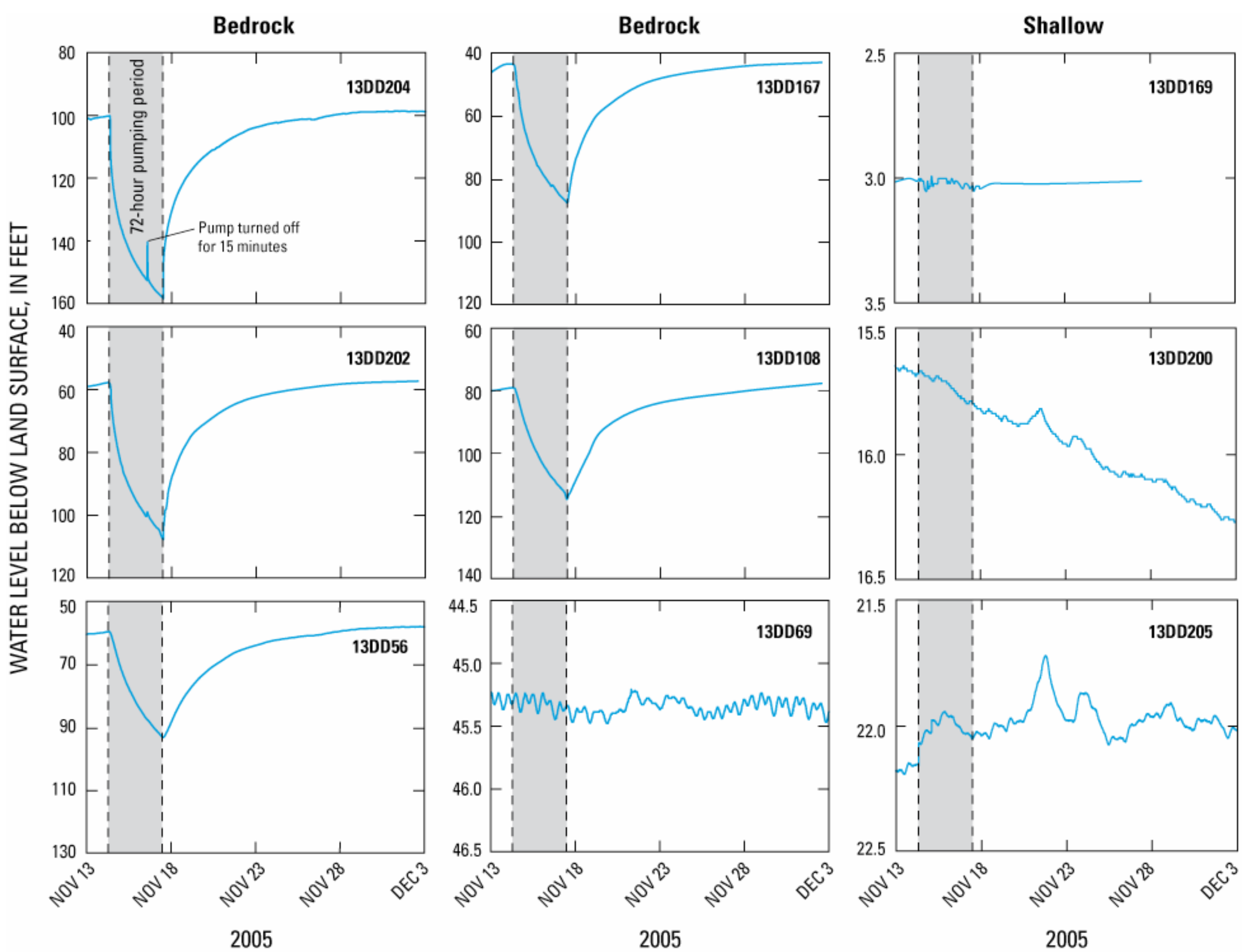

Figure 2. Drawdown and recovery in selected wells during aquifer test of well 13DD204, in the Conyers area, Rockdale County, Georgia, November 13–December 3, 2005.

was areally extensive, and propagated beyond surface-water drainage divides at distances as much as 6,200 ft from the pumped well (Fig. 1). Drawdown in observation wells ranged from 34 ft at well 13DD56 (located 6,200 ft southeast of the pumped well) to 50 ft at well 13DD202 (located 1,900 ft northeast of the pumped well). No drawdown response was observed in wells 13DD69 and 14DD197 located at distances greater than 6,500 ft from the pumped well. A slight directional preference is indicated by greater drawdown in a northeasterly and southeasterly direction (Fig. 1). Water levels did not stabilize during the test, indicating that the aquifer system did not reach equilibrium with sources of recharge supplying the deep water-bearing fracture zones.

After pump shutdown, the water level in the pumped well (13DD204) recovered about 80 percent in 3 days, but took more than 9 days to recover fully. A similar recovery response was observed in wells 13DD167, 13DD202, and 13DD56 (Fig. 2). The slow recovery in the pumped well and observation wells, indicates a slow recharge rate to the water-bearing zones supplying the well. Recovery was slower in well 13DD108, which took 4 days to recover 80 percent and took more than 12 days to recover fully. The delayed response in the wells indicates that the deep bedrock fracture system is not well connected to recharge sources. Recharge into the deep system probably occurs through vertical leakage along steep joints and fractures identified in the area (Khallouf and Prowell, 2003; Tucker and Williams, 2005) or along compositional layering from outcrop areas (Williams, 2003).

Water levels were monitored in three shallow wells (13DD169, 13DD200, and 13DD205) to determine the interconnectivity of the deep bedrock system to the shallow water-table zone in the weathered regolith. Despite the substantial drawdown in the deep bedrock system, no detectable drawdown was observed in the shallow regolith wells during the aquifer test (Fig. 2). For example, well 13DD200 is located 585 ft southeast of the pumped well, and showed no response to pumping (Fig. 2), although the hydrograph for this well does indicate a seasonal downward trend that is not related to pumping. The lack of response in the shallow regolith well indicates that the shallow regolith and bedrock zones are hydraulically separated in the Conyers area.

CONCLUSIONS

The depths, yield, and interconnectivity of deep water-bearing fracture zones are not commonly understood in crystalline-rock settings. Based on the aquifer test conducted in the Conyers area, water-supply wells tapping deep subhorizontal fracture systems are capable of quickly reversing the natural hydraulic gradient and can produce large influence areas around the pumped well. Drawdown in excess of 30 ft was observed at distances as much as 6,200 ft away from pumped well during the 72-hour aquifer test. When water is pumped from these horizontal or low-angle fracture networks, drawdown quickly expands out from the well until sources of recharge are intercepted to sustain the pumping rate. The regional effect of pumping indicates that ground-water flow in deep fracture systems may not necessarily follow surface-water basin divides, particularly during extensive pumping cycles. Wells tapping into the same (or similar) zones may interfere with each other, even across large distances, causing decreased well yield during extended pumping. Understanding the hydrologic characteristics of these systems is critical in managing the water resource.

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