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Synopsis of Karst Investigations Conducted in Jefferson and Berkeley Counties, West Virginia, by the U.S. Geological Survey, West Virginia District

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Abstract

The U.S. Geological Survey has been investigating ground-water flow and quality in the karst aquifer system of West Virginia's Eastern Panhandle since the early 1960's. The first study was conducted by Paul P. Bieber in 1961 and primarily described the hydrogeologic setting of the karst aquifer within Jefferson and Berkeley Counties. The study also estimated the potential volume of flow that might be expected from wells drilled within the karst aquifer based on well yield data. Two studies by William A. Hobba (Hobba, W.A., Jr., 1976, and Hobba, W.A., Jr., 1981) in Berkeley and Jefferson Counties concentrated on Cambrian and Ordovician age limestones and dolomites of the Great Valley. Determining the quality of ground water within the karst aquifer system and determining whether agriculture was impacting the quality of ground water within the aquifer were the major objectives of the studies. In 1991 Kozar, Hobba, and Macy investigated whether water-quality problems documented in the 1981 study of Jefferson County had improved or worsened over the ten-year period. Shultz, Hobba, and Kozar (1995) made a similar study in Berkeley County, to address whether temporal changes in ground-water quality had occurred. The later studies, although based on more random criteria for selecting wells, also contained a significant component of research into the effects of agriculture on ground-water quality. A more recent investigation (Mathes, 2000) assessed the effects of septic systems on the occurrence of indicator bacteria in the karst aquifer in Berkeley County. This abstract presents a chronological history of significant findings of these investigations.

Initial investigations by Bieber indicate that large quantities of ground water are available throughout Jefferson and Berkeley Counties. Of 104 wells for which yield data were available, yields ranged from 1 to 630 gallons per minute (gal/min). For wells less than 100 feet in depth, average well yield was found to be less than 20 gal/min. For wells deeper than 150 feet, average well yield was in excess of 60 gal/min. Optimal depths for drilling in the karst aquifer were found to be between 150 and 200 feet. Generally, the quality of ground water available from the karst aquifer was good except many wells produced hard to very hard water.

The first Berkeley County study (Hobba, 1976) found the quality of water available from the karst aquifer generally to be good. Only a few wells had chloride and/or nitrate in excess of drinking-water standards. Eighty to ninety percent of streamflow was found to be attributable to ground-water discharge to streams. On average, 600,000 gallons of water per day per square mile (gal/day/mi^2) were estimated to be available from the karst aquifer and 100,000 gal/day/mi^2 were estimated to be available from shale aquifer within the county.

The first countywide investigation of ground-water quality within Jefferson County documented high concentrations of nitrate in water from a few wells completed within the karst aquifer (Hobba, W.A., Jr., 1981). Of 192 wells sampled and analyzed for nitrate, 27 (14 percent) had concentrations equal to or exceeding the 10 mg/L maximum contaminant level (MCL) drinking water standard. On average, up to 600,000 gal/d/mi^2 of water were estimated to be available from the karst aquifer.

A more comprehensive investigation was made in the second Jefferson County study. The second study included dye tracer tests to determine rates and directions of ground water flow within the karst aquifer. Results of dye tracer tests indicate that ground water moves parallel to bedrock strike at a rate of 70 to 840 feet per day (ft/day) and perpendicular to bedrock strike at a rate of 30 to 235 ft/day (Kozar and others, 1991). Transmissivity was estimated by using streamflow and water-table gradients to be 3,900 and 4,100 feet squared per day (ft^2/day) parallel to strike and 800 and 1,100 ft^2/day perpendicular to strike. Spring discharge data indicate that the Chambersburg Limestone, the Beekmantown Group, and the Connococheague Formation have yields of more than 1,300,000; 290,000; and 175,000 gal/day/mi^2 of water, respectively. Of 62 wells and springs sampled as part of the investigation, water samples from 26 percent of the sites contained nitrate in excess of the MCL. Fecal coliform bacteria were detected in water samples from 53 percent of the sites and fecal streptococcus bacteria were detected in water from 70 percent of the sites.

The second Berkeley County investigation was also more comprehensive than the first. Recharge was estimated to be about 10 inches per year for the karst aquifer (Shultz and others, 1995). Ground-water flow is controlled by geologic structure with bedding planes being major controls on the direction and velocity of ground water flow. Ground-water velocities, based on results of dye tracer tests, ranged from 32 ft/day in the more diffuse portions of the aquifer to 1,879 ft/day in the more conduit-dominated portions of the karst aquifer. The highest mean yield (48 gal/min) was for wells completed in the Beekmantown Group but the highest median yield (20 gal/min) was for wells completed in the Martinsburg Shale Formation. Faults were also found to be important avenues of ground-water flow. Median specific capacity of wells less than 700 ft from a fault was 3.6 gallons per minute per foot of drawdown (gal/min/ft) while wells greater than 700 ft from a fault had median a specific capacity of only .26 gal/min/ft. For wells completed within the karst aquifer, yield generally decreases with depth. The highest median yield (20 to 30 gal/min) generally is for wells less than 150 feet deep. For wells deeper than 150 feet, median yields range from 4.5 gal/min for wells greater than or equal to 400 feet in depth to 15 gal/min for wells between 150 and 199 feet in depth. The quality of water from the karst aquifer in Berkeley County is generally good, but the aquifer is highly susceptible to contamination. Fecal coliform bacteria were detected in water samples from 41 percent and fecal streptococcus bacteria were detected in water samples from 54 percent of wells sampled within the karst aquifer. Nitrate, which was found to be a potential problem in Jefferson County, was detected in concentrations exceeding the MCL in only 3 wells sampled in the karst aquifer within Berkeley County. Bacterial contamination was found to be the primary water-quality problem of concern.

In June of 2000, 50 wells in the karst aquifer of Berkeley County were sampled for total coliform, fecal coliform, and *E. coli* indicator bacteria. The wells were selected to represent areas with differing densities of septic systems within a 5-acre area around the well. A primary objective of the investigation was to assess the impact of septic density on ground-water quality of the karst aquifer. No relation between septic density and indicator bacteria could be determined. A high proportion of wells sampled, however, contained indicator bacteria. Of the 50 wells sampled, 62 percent contained total coliform bacteria, 32 percent contained *E. coli*, and 30 percent contained fecal coliform bacteria. Complicating factors of septic efficiency and/or complexities of the ground-water flow system likely are responsible for the lack of correlation between indicator bacteria and densities of septic systems.

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