Shah, S.D., Houston, N.A., and Braun, C.L., 2007, Hydrogeologic Characterization of the Brazos River Alluvium Aquifer, Bosque County to Fort Bend County, Texas

Introduction

The Brazos River alluvium aquifer underlies the Brazos River in Texas from Bosque County to Fort Bend County. The aquifer, one of 21 minor aquifers in the State (Texas Water Development Board, 2007), supplies water for irrigation, domestic, stock, and commercial use. The Brazos River alluvium aquifer likely will become more important in the future as demand for water increases statewide. A thorough understanding of the hydrogeology of the alluvium aquifer will be the foundation for future studies in the area.

During October 2006–April 2007, the U.S. Geological Survey (USGS), in cooperation with the Texas Water Development Board (TWDB), conducted a study to delineate the altitude of the top, altitude of the base, and thickness of the Brazos River alluvium aquifer, and to compile and summarize available hydraulic property (specific capacity, transmissivity, and hydraulic conductivity) data. A digital elevation model (DEM) was used as the altitude of the top of the aquifer. The altitude of the base of the aquifer was generated using data from wells (drillers' logs and borehole geophysical logs). The study area encompasses the Brazos River alluvium aquifer in parts of Bosque, Hill, McLennan, Falls, Robertson, Milam, Brazos, Burleson, Grimes, Washington, Waller, Austin, and Fort Bend Counties (fig. 1) and a 1.5–mile-wide lateral buffer adjacent to the aquifer. The results of this study will be used by TWDB for input into a ground-water availability model (GAM) (Texas Water Development Board, 2006a).

Purpose and Scope

The purpose of this report is to describe the hydrogeologic characteristics of the Brazos River alluvium aquifer. Hydrogeologic characterization primarily refers to presentation of maps of altitudes of the top and base, thickness, and areal distribution of hydraulic properties of the Brazos River alluvium aquifer. The report also presents summary statistics of the hydraulic properties. The data used to generate the maps and summary statistics are in Shah and Houston (2007).

Previous Studies

Several previous studies involving all or parts of the Brazos River alluvium aquifer study area have been published. Cronin and Wilson (1967) completed the first comprehensive study of the Brazos river alluvium from Bosque County to Fort Bend County. That report describes the extent and thickness of the aquifer, the amounts and distribution of withdrawals and recharge, and the quantity and quality of ground water available. It also includes descriptions of the hydrologic relations between the alluvium and the underlying bedrock and ground-water/surface-water interaction in the Brazos River alluvium aquifer. Cronin and Wilson (1967) obtained hydrogeologic data from test holes drilled as a part of the study. From 1937 to 1943, nine reports were published documenting inventoried water wells in the following counties: Austin (May, 1938), Burleson (Clark, 1937a), Fort Bend (Elledge, 1937, and Livingston and Turner, 1939), Grimes (Turner, 1939), Milam (Clark, 1937b), Robertson (Davis, 1942), Waller (Turner and Livingston, 1939), and Washington (Follet, 1943). Cronin and Follet (1963) published the first reconnaissance investigation of the ground-water resources of the entire Brazos River Basin in 69 counties from the New Mexico-Texas boundary to the Gulf Coast, including the 13 counties of this report. Additionally, Fluellen and Goines (1952) reported on the water resources of Waller County, and Hughes and Magee (1962) summarized the ground-water withdrawals of irrigation wells in the aquifer.

More recently, Naftel and others (1976) documented well drillers' logs, water-level measurements, and chemical analyses of ground water in Brazoria, Fort Bend, and Waller Counties. Harlan (1990) assessed the hydrogeology of the Brazos River alluvium aquifer from Waco to Marlin, Tex. Wrobleski (1996) characterized the Brazos River alluvium aquifer at a hydrogeologic field site in Burleson County using aquifer-test data to estimate hydraulic conductivity. HDR Engineering, Inc. (2001), developed a ground-water-flow model for the Brazos River combined with a conjunctive-use analysis to quantify the amount of surface and ground water along the Brazos River.

Brief Description of Brazos River Alluvium Aquifer

The Brazos River alluvium aquifer is as wide as 7 miles and extends along 350 river miles from southern Bosque County to eastern Fort Bend County (Ashworth and Hopkins, 1995, p. 35) (fig. 1). Alluvial sediments in the study area occur in floodplain and terrace deposits of the Brazos River (Cronin and Wilson, 1967). The Brazos River alluvium aquifer for this report comprises floodplain alluvium that consists of fine to coarse sand, gravel, silt, and clay. The adjacent terrace alluvium is not an appreciable source of water and thus not considered part of the aquifer. Cronin and Wilson (1967) describe the composition of the floodplain alluvium as varying from place to place, with beds or lenses of sand and gravel that pinch out or grade laterally into vertically finer or coarser material. In general, the finer material is in the upper part of the aquifer, and the coarser material is in the lower part. The aquifer is under water-table conditions in most places and is used mainly for irrigation (HDR Engineering, Inc., 2001). The water table generally slopes toward the Brazos River, indicating that the river is a gaining stream in most places. Recharge to the aquifer occurs primarily from rainfall on the aquifer and subsequent downward leakage to the saturated zone, which (in the late 1960s) ranged from less than 10 to nearly 50 feet below land surface (Cronin and Wilson, 1967, p. 2). Discharge from the aquifer occurs primarily through evapotranspiration, discharge to the Brazos River, and withdrawals from wells. Some wells can yield as much as 1,000 gallons per minute, but the majority of wells yield from 250 to 500 gallons per minute (Ashworth and Hopkins, 1995, p. 35).

The Brazos River alluvium aquifer in the study area is underlain by marine sedimentary rocks, the geologic units of which (Shah and Houston, 2007) crop out in bands roughly parallel to the coast. Many of the geologic units, either individually or in groups, compose major and minor aquifers in the study area (fig. 1). The aquifers dip gently (gradients slightly greater than the land-surface gradient) from their outcrops toward the coast.

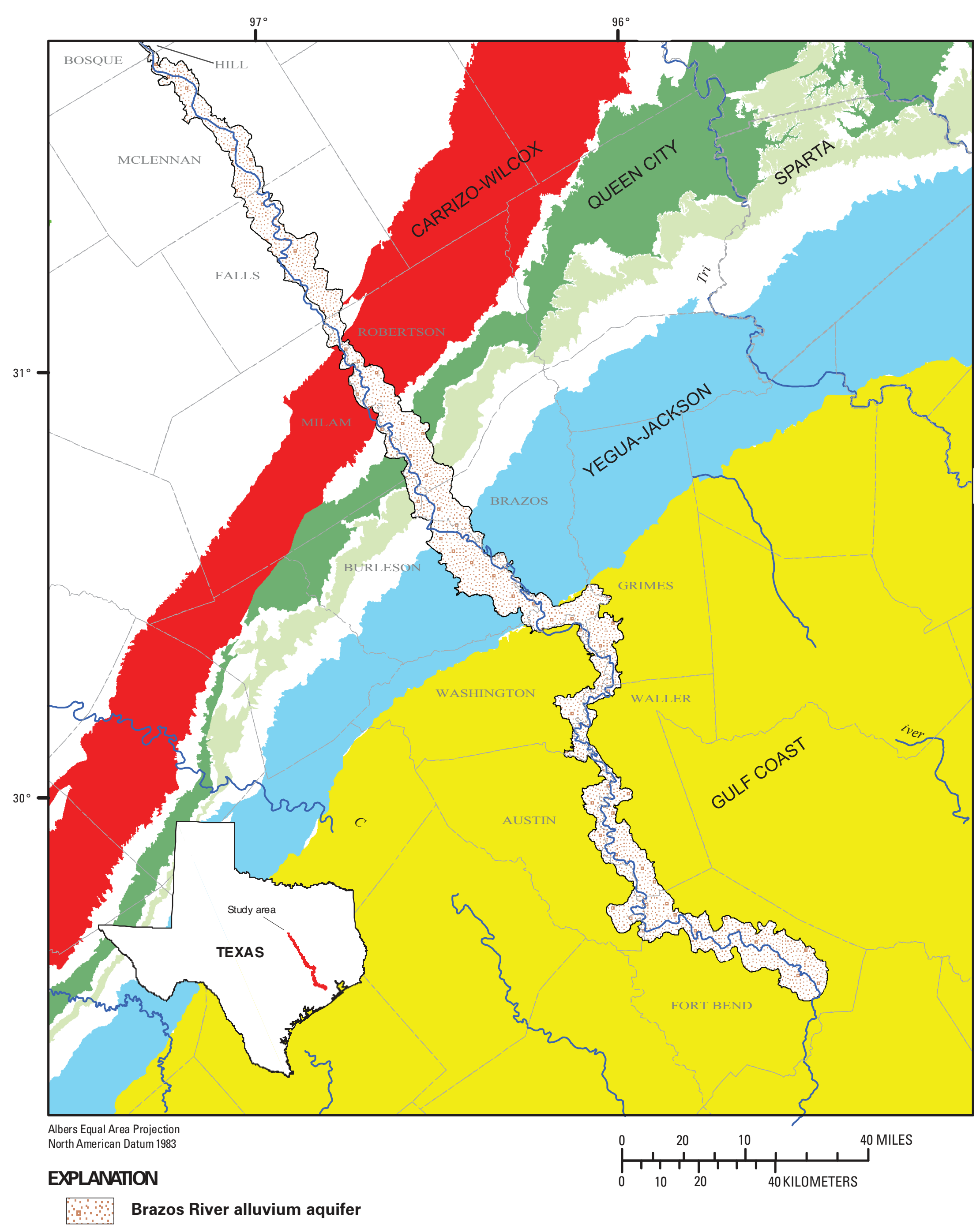

Figure 1. Brazos River alluvium aquifer, Bosque County to Fort Bend County, Texas, and underlying aquifers (outcrops only) (modified from Texas Water Development Board, 2007).

Methods of Hydrogeologic Characterization

Geologic and hydrogeologic information on the Brazos River alluvium aquifer from published reports by the TWDB, Texas Commission on Environmental Quality, various universities, and ground-water conservation districts incorporated into a TWDB GAM-formatted geodatabase (Shah and Houston, 2007) was used for the hydrogeologic characterization of this report.

Altitude of the Top of the Brazos River Alluvium Aquifer

A USGS 30-meter (98-foot) DEM resampled to 0.125 mile was used as the top of the Brazos River alluvium aquifer for the study area. The DEM is a digital file consisting of terrain altitudes for land-surface positions at regularly spaced horizontal intervals from which an accurate depiction of surface topography can be generated. The DEMs for each individual county were obtained from the USGS Seamless Data Distribution System (SDDS) (U.S. Geological Survey, 2007). The SDDS provides DEMs with a resolution of 1 arc-second (about 30 meters) for the United States. The DEMs for each county then were merged to create a single DEM for the Brazos River alluvium aquifer study area.

Altitude of the Base of the Brazos River Alluvium Aquifer

The contact between the alluvium and the underlying rocks at well sites based on lithologic or geologic units was picked from drillers' or geophysical logs or published geologic sections. Many areas lacked sufficient log data (control points) to create a continuous surface for the altitude of the base. For these areas, depth data from wells known to be completed in the Brazos River alluvium aquifer without an associated drillers' or geophysical log were used as control points. Using the log control points and well-depth control points, a surface was generated using the topo-to-raster method in the geographic information system (GIS) software ArcGIS 9.2 (ESRI, 2007). Topo-to-raster is a spline interpolation method specifically designed for the creation of altitude surfaces. The method honors the data without altering the data values and also accepts contours as input (ESRI, 2007).

Despite the use of well-depth control points to supplement the log control points, data gaps exist in parts of the study area. For example, for wells in some areas drillers could not or did not distinguish the alluvium from the underlying unit where both units were of similar lithology, which precluded identification of the base of the aquifer in places. Data gaps also occur in areas where the alluvium is too thin to yield adequate amounts of water, and therefore no wells exist in those areas.

After generating a preliminary raster surface for the base, contours then were generated at 10-foot intervals using GIS software. The preliminary surface, contours generated from the surface, and the input control points were assessed to identify discrepancies, particularly in areas where both log and well-depth control points were used. For log control points, the base pick for each well was compared with picks for nearby wells. If the altitude was unrealistically high or low relative to altitudes from nearby wells, the log was re-examined to determine whether a pick more consistent with the nearby picks might be reasonable. In areas where there was substantial difference in altitude between log control points and well-depth control points, altitudes from log picks were used preferentially over those from well depths; well-depth control points were discarded if there was a difference of more than 5 feet. After assessment and revision, the process thus described was repeated several times. Contours generated from ArcMap (about 500 arces) then were evaluated and modified manually where necessary. The final surface representing the altitude of the base was generated using both points and contours concurrently and the topo-to-raster interpolator. For the final map, a total of 1,364 control points were used: 386 from drillers' logs, 13 from geophysical logs, 955 from well depths, and 10 from geologic sections.

Thickness of the Brazos River Alluvium Aquifer

The thickness of the Brazos River alluvium aquifer was created by subtracting the raster surface of the base of the aquifer from the raster surface of the top of the aquifer using the raster calculator in Spatial Analyst in ArcGIS 9.2 (ESRI, 2007). Subtraction of the raster surfaces in a GIS can provide an objective and unbiased rendition of differences between the two surfaces. Thicknesses in areas where the number of control points for one surface differ substantially from the other surface should be used with caution.

Hydraulic Properties

Two-hundred fifty-six of 358 specific capacity values (Shah and Houston, 2007) were obtained from specific capacity or aquifer tests done by the USGS in 1963 and 1964. The other 102 values were obtained from the online TWDB groundwater database Well-Site Remarks Table (Texas Water Development Board, 2006b).

Two-hundred fifty-eight of 371 transmissivity values (Shah and Houston, 2007) were obtained from the specific capacity or aquifer tests done by the USGS in 1963 and 1964, four were obtained from published reports, and seven were computed from hydraulic conductivity values (Wrobleski, 1996). One-hundred two transmissivity values were computed from the 102 TWDB specific capacity values noted above using an empirical equation for unconfined aquifers developed from the modified nonequilibrium (Jacob) equation (Driscoll, 1986, p. 1,021). The modified nonequilibrium equation is

$$Q/s = T/264(\log[0.3Tt/r^2S]),$$

where Q is the yield of the well in gallons per minute, s is the drawdown in the well in feet, T is the transmissivity of the aquifer in foot squared per day, t is time, and S is the storage coefficient of the aquifer. The empirical equation is

$$Q/s = T/1500.$$

This equation is derived by assuming "typical" values for the variables in the modified nonequilibrium equation. T is assumed to be 30,000 feet squared per day, t is assumed to be 1 day, r is assumed to be 0.5 foot, and S is assumed to be 0.075. The empirical equation was used because few wells with specific capacity data had values for all of the variables necessary to apply the modified nonequilibrium equation.

Base from U.S. Geological Survey
Digital data, 1:100,000
Universal Tranverse Mercator projection
Zone 15

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Information regarding water resources in Texas is available at http://tx.usgs.gov/