Letter Report

Thoughts on Defining Groundwater Flow Units beneath Browning Ranch Watersheds

Prepared for:

C. L. Browning Ranch, Blanco County, Texas

By:

Alan R. Dutton, Ph.D.

Associate Professor of Hydrogeology

January 2008

Center for Water Research
One UTSA Circle, SB 1.03.04 • San Antonio, TX 78249-0663

UTSA THE UNIVERSITY OF TEXAS AT SAN ANTONIO

CONTENTS

Abstract

Siting permanent surface-water gauging stations precisely at the “formational” or “stratigraphic” contact between the Glen Rose Limestone and the uppermost sand bed of the underlying Hensel Formation solely on the basis of surface geology will be difficult. The formational contact is obscured by colluvium beneath most of the Browning Ranch. The Hensel sand is easily weathered and appears to have been scoured out to some depth (a guess of a few feet) beneath the channels of the Rock Creek and adjacent watersheds, but those incisions have since been filled in with colluvium. The colluvium itself might complicate local baseflow discharge along the channels.

Additional measurements are proposed to directly measure where the amount of baseflow changes along the course of Red Creek, and other drainages, as a basis for siting permanent gauging stations. The location of the “hydrologic contact” between flow units can be defined at least as accurately as the stratigraphic contact that is covered by colluvium. The advantage is that one does not have to assume that flow units are identical to stratigraphic units. Also, flow mapping might show where seeps and springs are concentrated by karst activity such that gauge siting just needs to be between main seepage zones.

Introduction

Two main objectives of this part of the Browning Ranch watershed studies are (1) to better define the contact between the Glen Rose Limestone and the Hensel Sandstone that underlie the watersheds, and (2) to determine the depth of the water table and formational contact across each of the four creek valleys. The objectives were accomplished through observations of where the formational contact crops out and through geophysical sounding of the shallow subsurface.

This report focuses on hydrogeologic observations and inferences pertaining to locating the contact between the Glen Rose and Hensel and revising the conceptual-model framework for locating permanent surface-water gauging stations. Much of this report is an in-progress hypothetical or even speculative narration of the author’s conceptual hydrogeologic model for the area around the Browning Ranch. A second report focuses on mapping the water table and subsurface formational contact.

Hydrogeologic Setting

The C.L. Browning Ranch is located approximately four miles east of Johnson City in Blanco County, Texas. This area is on the eastern edge of the Edwards Plateau and the general area is known as the Texas Hill Country.

The Ranch receives 30 to 32 inches of precipitation annually with typically wet spring and autumn seasons. The climate is classified as semiarid to subtropical. Both droughts and flash floods are common.

Honeycut Creek is the main drainage on the ranch, flowing north to the Pedernales River. It is a perennial stream below the Honeycut Creek Spring. Several ephemeral creeks or channels feed into Honeycut Creek. Four ephemeral creeks feed into

Honeycut Creek from the west (from north to south): Turkey Creek, Red Tail Creek, Rock Creek, and Walnut Creek. Water budget information is needed under pre-treatment conditions to define precipitation, runoff, and recharge in each watershed and account for the amount of baseflow each contributes to Honeycut Creek. The Pedernales River drains into the Colorado River.

The upper watersheds of the Browning Ranch are floored by Cretaceous-age limestone, marl, and sandstone of the Trinity Group. The Glen Rose Limestone caps the upland areas around the perimeter of the range. This rock is resistant to weathering and tends to hold up steep slopes. Below the Glen Rose lies the Hensel Formation. The Hensel sandstone, a thin layer approximately 6- to 9-ft thick at the ranch, is not well cemented and underlies only part of the broad terrace of land between Honeycut Creek and the Glen Rose "upland escarpment." The sandstone layer of the Hensel is underlain by a thicker limestone layer thought to be a Cretaceous-age pedogenic (formed from soil processes) caliche. Erosion of Honeycut Creek valley has cut through the Hensel Formation in the northern part of the ranch and exposed the Cow Creek Limestone. The northernmost part of Honeycut Creek downstream of Honeycut Creek Spring exposes Paleozoic rocks, part of the so-called Llano Uplift aquifer.

The contact between the Cretaceous rocks and the underlying lower Paleozoic rocks is an erosional unconformity. The limestone and sandstone of the Ellenburger Group crop out in the valley and north of the Pedernales River, and occur at depth at the ranch beneath the Trinity Group.

The ranch lies at the northern edge of the Hill Country Trinity Aquifer (Mace and others, 2000). The Glen Rose and Hensel Formations where they are water saturated make up part of the Trinity Aquifer. The local recharge area at the ranch would include the broad upland area underlain by the Glen Rose and the terrace underlain by the sandstone and caliche portions of the Hensel. The general conceptual hydrogeologic model for the ranch is that groundwater moves from recharge to discharge areas along local-scale (e.g., discharge to Rock Creek), intermediate-scale (e.g., discharge to Honeycut Creek), and regional-scale (e.g., discharge to Pedernales River) flow paths:

- The shortest path (10s to 100s of feet) for groundwater to take is from recharge in the upland area to discharge as springs and seeps along the small channels of Turkey, Red Tail, Rock, and Walnut Creeks. This local flow path could be very curving or arcuate but would generally be from west to east with small north and south components directing water to the channel seeps.
- An intermediate-length flow path (100s to few 1000s of feet) would be from the upland recharge areas but with deeper downward circulation and with upward discharge in the lower reaches of Turkey, Red Tail, Rock, and Walnut Creeks, the upper reach of Honeycut Creek, or into the Paleozoic rocks beneath and subjacent to Honeycut Creek. Direction of flow is mainly eastward. Water that has moved cross-formationally into the Paleozoic rocks along Honeycut Creek might flow northward through karst bedding plane fractures to discharge at Honeycut Creek Spring.
- A long regional flow path (several 1000s of feet) would take recharged groundwater downward beneath upland areas into the underlying Paleozoic

rocks and northward to discharge areas as springs and seeps in the bottom lands along the Pedernales River.

Honeycut Creek Spring probably does not capture all of the groundwater flowing in the Paleozoic rocks beneath Honeycut Creek along the intermediate-scale flow path. Some groundwater flow would most likely bypass the spring and move in conduits to discharge farther north closer to the Pedernales River.

These three hypothesized local-, intermediate-, and regional-scale flow paths for groundwater at the Browning Ranch reflect an inferred three-dimensional flow field controlled by the location of recharge beneath the upland areas and the Hensel terrace and location of discharge areas in the watershed's creeks, Honeycut Creek, and the Pedernales River. The effect of karst heterogeneities on short-circuiting these flow paths is only beginning to be understood at the Browning Ranch. Honeycut Creek Spring appears to be a karst-fed spring at a solution-enlarged bedding plane. It is likely that a variety of karst conduits move water vertically and laterally in preferential flow paths on all these inferred scales of flow. The karst features of limestones typically mean that much of the water may be stored in unfractured matrix between karst conduits while the highest flow rates take place within the conduits. Groundwater moves into the matrix from the conduits during recharge events when fluid pressure in the conduits is high, and back out of the matrix into conduits during the recession-flow stage between recharge events, as long as the conduits remain saturated.

Small pools of standing water are found in the channels in the upper reaches of all watersheds throughout the year under normal rainfall conditions. Non-storm related streamflow (i.e., baseflow) is seen along most of the length of stream courses only during the dormant winter season. A large, but still unknown, portion of stream flow in the tributaries falls through the fractured base of creeks before reaching the confluence with Honeycut Creek.

Review of Surficial Geology

Initial hydrogeological inspections at the Browning Ranch in late 2006 suggested the importance of mapping the stratigraphic contact between the Glen Rose Limestone and the Hensel Sandstone for siting surface-water gauging stations. Barnes (1982) shows a broad terrace underlain by Hensel Formation between the Glen Rose "upland escarpment" and Honeycut Creek. The Hensel is known in many locations as a sand-rich formation. The casual first impression of the terrace at Browning Ranch, therefore, was that it would be underlain by the easily weathered Hensel sandstone, which would account for the low topographic profile of the terrace. The early conceptual model of the site specified recharge in the upland Glen Rose limestone, runoff and baseflow to channels, some cross-formational flow into the Hensel, and various gaining and losing reaches of the channel crossing the Hensel terrace. This conceptual model underscored the need to separately gauge and monitor surface water flow at the contacts above and below the Hensel Formation to define the net base-flow contribution to flow from the Glen Rose.

This conceptual model, however, needs to be refined to incorporate the observation that the Hensel Formation at the Browning Ranch includes a thin upper sand and a thick, well-cemented caliche zone. Another hydrologic unit that might need to be taken into account is a black clay and limestone-float colluvium within and lining the floor of the small watershed channels.

Observations include:

- A contact between the Glen Rose limestone (base of Glen Rose) and Hensel sand (top of Hensel) is reported and exposed in a road cut along FM 2766 a few miles west of Browning Ranch (Follett, 1973). The Hensel sand at that location is friable, somewhat arkosic, and clayey. The Hensel sand at that road cut, however, is less than 6-ft thick. Beneath the sand is a well-indurated, hard, and massive limestone. That Hensel limestone is interpreted to be a Cretaceous-age pedogenic (formed from soil processes) caliche (Prochnow, personal communication, November 2007).
- The lower beds of the Glen Rose Limestone are readily recognized across most of the Browning Ranch. No contact of the quality seen on the FM2766 road cut, however, is easily found on the Browning Ranch, as discussed in the following bullet. The limestone that floors the ranch road across Rock Creek is thought to be equivalent to the Hensel caliche seen in the FM 2766 road cut. The Hensel sand on the Browning Ranch must be a bed that is less than 5- to 6-ft thick and occurs between recognizable lower Glen Rose limestone and the massive “caliche” limestone.
- Clean exposures of the thin Hensel sand are hard to find at the Browning Ranch because the sand is easily weathered and has been covered by a veneer of colluvium consisting of limestone flagstone ‘float’ and clay transported from the residual limestone soils. It is especially hard to pinpoint the contact within the channels of Turkey, Red Tail, Rock, and Walnut Creeks because of the history of scour and deposition that has occurred. In the past, significant surface water flow has cut the channels into the bedrock, more deeply in the easily weathered sand than in the limestone. More recently, soil creep, mass wasting, and sedimentation under slow flow conditions have filled in the older incisions in the Hensel sand. Shallow hand-dug excavations in the channel beds, therefore, only show colluvium made up of black clay, carbonate rock fragments, and small caliche nodules.
- Although the Hensel sand is only 5- to 6-ft thick at the Browning Ranch, it underlies a breadth of the terrace owing to the low topographic slope. It is not well exposed at ground surface or in stream channels but is covered by mixed colluvium, soil, and limestone-flagstone float.

To precisely locate the stratigraphic contact will require a number of boreholes drilled by powered flight auger, for example, a two-person post-hole auger. Auger depths of 2 to 3 feet are expected to be sure the colluvium is penetrated and Hensel sand is sampled.

Discussion

These geological observations and inferences suggest a need to (1) refine the conceptual model of local-scale flow systems to account for thin Hensel sand, thick Hensel caliche, and channels locally clogged with colluvium, and (2) use additional data to map hydrological flow units in the watersheds as a basis for siting permanent gauging stations for separating runoff from baseflow.

A transect of streamflow measurements in the small channels of the watersheds can be made, as described in Dutton (2008). This transect should demonstrate whether significant changes take place in rates of groundwater discharge along the length of the channel and where they occur.

The location of the “ hydrological contact” between flow units can be defined at least as accurately as the “stratigraphic contact” obscured by colluvium. The advantage of siting the permanent gauging stations on the basis of direct baseflow-measurements is that one does not have to assume that the flow units exactly match the stratigraphic units. Direct baseflow measurements can also indicate, for example, where (possibly karst-controlled) springs and seeps contribute most of the base flow within the Glen Rose and with in the Hensel. Locating the gauging station anywhere between these main seep areas might suffice if the baseflow contribution of the remaining stretch is negligible in comparison.

References

Barnes, V. E., 1982, Geology of the Pedernales Falls Quadrangle, Blanco County, Texas: Bureau of Economic Geology, The University of Texas at Austin, 1:24,000 Geologic Quadrangle Map.

Dutton, A. R., 2008, Demonstration of instream tracer test technique for estimating flows in small streams: Letter report prepared for C. L. Browning Ranch, Blanco County, Texas, Center for Water Research, The University of Texas at San Antonio, 6 p.

Follett, C. R., 1973, Groundwater resources of Blanco County, Texas: Austin, Texas Water Development Board Report 174, 78 p.