The Geology of the Cypress Creek Watershed, Wimberley Area, Texas

Alex S. Broun[1], Leslie Llado[1], Douglas A. Wierman[1,2], Andrew H. Backus[1]

[1] *Hays Trinity Groundwater Conservation District,* [2] *Environmental Resources Management*

Abstract

Jacob's Well is an artesian spring that provides the majority of flow to Cypress Creek in Wimberley, Texas. Flows were significantly reduced during the 2005 to 2006 drought and the well ceased to flow in 2000. Because of the importance of the spring to the community, the River Systems Institute at Texas State University awarded a grant to the Hays Trinity Groundwater Conservation District to study the hydrogeology of the Cypress Creek Watershed. The initial phase of the project characterizes the Trinity Group stratigraphy and the hydrogeologic framework of the watershed and the spring. Cuttings samples and geophysical logs were collected from local water wells and analyzed for lithostratigraphic data. Logs were correlated and the resulting stratigraphic and structural interpretation was tied to outcrop observations. Three structural cross sections were built across the study area, including one at Jacob's Well. The sections depict the geology and karstic nature of the faulted and fractured Trinity Group and its relationship to the Balcones Fault Zone. Ongoing studies will gather and analyze water quality and hydraulic gradient data to determine the source of recharge to Jacob's Well and establish metrics to protect spring flow.

Introduction

Cypress Creek, located in the Wimberley, Texas, area, is a major contributor to the aesthetics and quality of life of the residents of the Wimberley Valley. It is also an important economic engine in the area that drives the local tourist economy. Jacob's Well, a karst spring located in Cypress Creek, provides the majority of flow in Cypress Creek and has been described as the "heart and soul" of the Hill Country. Other than a minimal number of individual residential rainwater harvesting systems, the Wimberley Valley is totally dependent on groundwater for its potable water. With the continued rapid growth and development of the Wimberley Valley, and several hot, dry Texas summers, there are ever increasing demands being placed on the groundwater resources of the community. Flows from Jacob's Well were significantly reduced during the drought of 2005 to 2006, and the well ceased to flow in 2000 for the first time in recorded history.

In recognition of the importance of Cypress Creek and Jacob's Well to the Wimberley Valley community, the Hays Trinity Groundwater Conservation District was awarded a grant from the River Systems Institute of Texas State University to study the hydrogeology of the Cypress Creek Watershed (Figure 1) and Jacob's Well. This paper presents the results of the initial phase of the project, which aims to characterize the local stratigraphy and hydrogeologic framework of the watershed and the spring. Ongoing studies are underway to gather and analyze water quality and hydraulic gradient data to determine the source of recharge to Jacob's Well and identify factors to protect spring flow. This work is also part of a larger project by Texas State University to develop a model to predict the impact of future development within the watershed on water quality and availability in Cypress Creek.

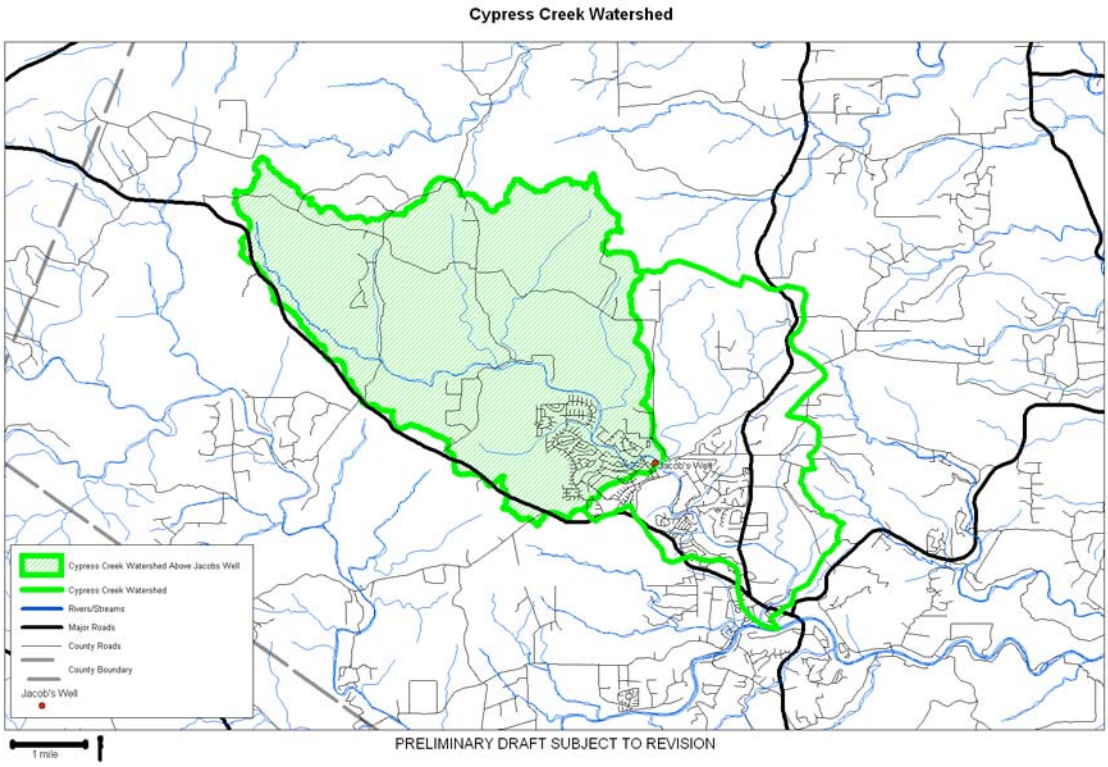

Figure 1. Cypress Creek Watershed

Regional Geologic Setting

The Trinity Group in western Hays County is Lower Cretaceous in age, extending from the Neocomian to the Albo-Aptian. There are producing aquifers in the Upper (Upper Glen Rose), Middle (Lower Glen Rose, Hensel, Cow Creek) and Lower (Sligo, Hosston) Trinity that supply groundwater to local residents. The geologic section that is approximately 1,000 feet thick consists of the wedge-edge of a shallow-water, carbonate shelf which "onlapped" the thrusted Paleozoic rocks of the buried Ouachita Mountains. The Llano Uplift and highlands to the west and northwest provided a provenance for a coarse-clastic sedimentary base (Hosston) that shoals upwards in a series of carbonate-dominated sequences. Tectonic movement during Early Miocene time resulted in a series of northeast-southwest striking, en-echelon, normal faults that

cut the Lower Cretaceous sedimentary rocks and drop the section by as much as 1,200 feet to the south-southeast (Balcones Fault System). The younger Edwards section has been stripped off over most of the western portion of Hays County but is preserved in the down-dropped fault blocks to the east-southeast (Edwards recharge zone).

Methodology

To better understand the hydrogeologic framework of the local aquifer systems several geologic cross sections were created to illustrate the vertical relationship between the area aquifers, faults and Jacob's Well (Figure 2). The project was done using readily available (inexpensive) data and is the first step in understanding the hydrogeologic framework that influences the aquifer system.

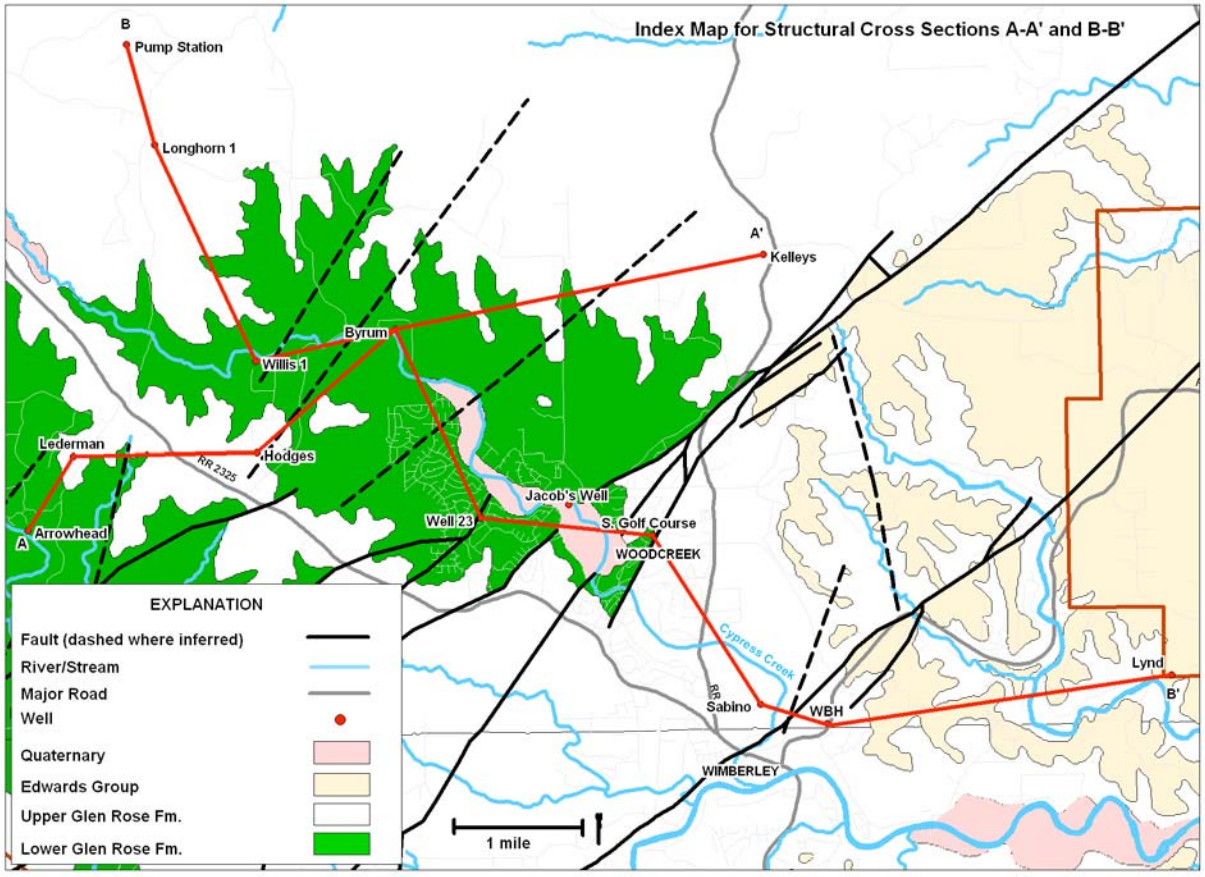

Figure 2. Index map for cross sections A to A' and B to B'

Basic exploration geology methods were applied for mapping and evaluating groundwater resources (look at the rocks!). Cuttings samples and geophysical logs (natural gamma) from Hays County water wells were collected and analyzed for lithostratigraphic data and unit tops. Geophysical logs and rock cuttings are archived at the Hays-Trinity Groundwater Conservation District's offices. The logs were correlated and the resulting stratigraphic and structural

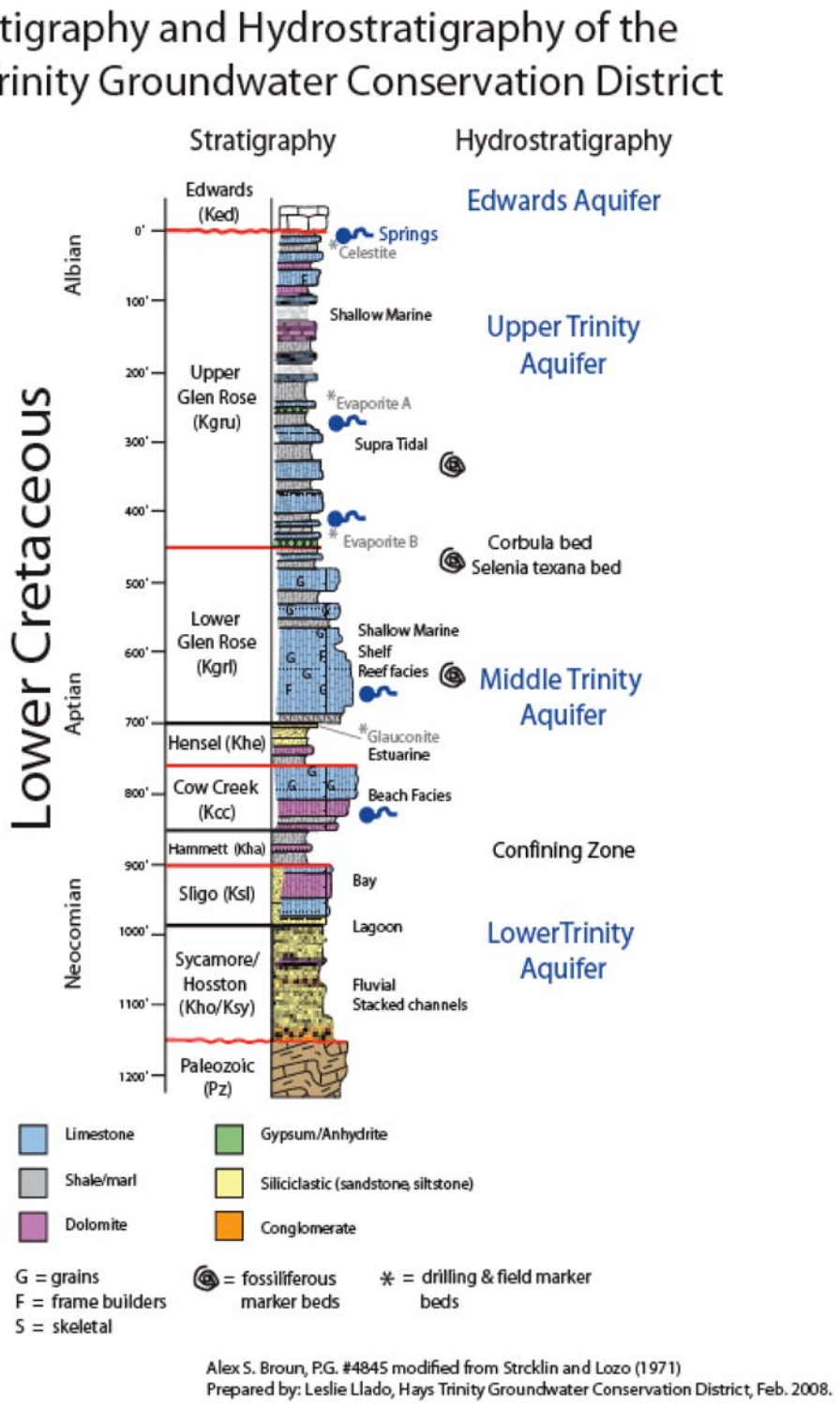

Figure 3. **Stratigraphy and hydrostratigraphy of the Hays-Trinity Groundwater Conservation District.**

interpretation was tied to the outcrop and available literature (Figure 3). Using the interpreted data, a series of three structural cross sections were built, including a profile through Jacob's Well. Local divers contributed invaluable information on the structure of Jacob's Well. Data are continuing to be developed on the groundwater flow regimes in the watershed.

Structural Cross Section A to A'

This roughly southwest-northeast cross section is a strike-line parallel to the structural strike and the major faults of the Cypress Creek Drainage (Figure 4). It is constructed perpendicular to Cypress Creek and intersects section B to B' at the Dry Cypress Well. The line of section stays high to the Tom Creek Fault System. Downcutting from the Blanco River exposes the Lower Glen Rose carbonate section just below the Arrowhead Point Well. Upstream and off the line of section both the Hensel and the Cow Creek crop out in the riverbed and along the bank on the high side (hanging wall) of a normal fault. The cross section cuts the axis of a gentle, southeast plunging nose (Cow Creek structure map, Broun and others, 2007) near Ranch Road 2325 and the Rough Hollow fracture zone. The apparent structural dip is generally flat to the northeast approaching Kelley's Well No.1. The Trinity Group lithology and structural style is similar to that described along cross section B to B'. The deepest erosion is at the Blanco River and along the cut of Cypress Creek where the upper reef/mound facies of the Lower Glen Rose is exposed.

Structural Cross Section B to B'

The section profile is constructed down structural dip from northwest to southeast, and generally follows the course of Cypress Creek (Figure 5). The creek valley cuts through the Upper Glen Rose Formation and exposes the Lower Glen Rose soluble carbonate section. Karstic features are evident as sink holes, caves, Jacob's Well, the dry Cypress Creek bed, and surface joint sets providing conduits for groundwater recharge. Seeps of water from the base of limestone cliffs lining the creek bed are common. Structural dips are gentle, less than 2 degrees to the southeast. Normal faults, sympathetic to the major northeast-southwest trending Balcones Fault Zone, cut the section in the Cypress Creek Valley. The Tom Creek and the Wimberley Fault Systems, at the western edge of the Balcones Fault Zone, drop the Lower Cretaceous interval by 350 to 400 feet to the southeast. Joint sets perpendicular to the strike of the fault systems are structural controls for surface streams and pathways for aquifer recharge.

The Lower Glen Rose Formation is identified in the subsurface and in surface outcrop by an upper and a lower rudistid reef/mound buildup. Reef-core and skeletal–detrital reef margin facies provide porous and permeable zones for local, shallow aquifers. The upper reef is an excellent aquifer in the Wimberley Valley fault block. The Hensel Formation (mudstone, dolomite and siltstone), depending on local lithologic variation, may act as a confining unit to the Cow Creek and as a soluble conduit for groundwater transmission. Cow Creek grain limestone and porous, vuggy dolomite are the primary aquifer lithologies for the Middle Trinity in the upper Cypress Creek area. A large, open conduit (about 8 to 12 inches in diameter) can be observed in the Aqua Texas Well No. 23 videotape within the Cow Creek. This interval corresponds to the main

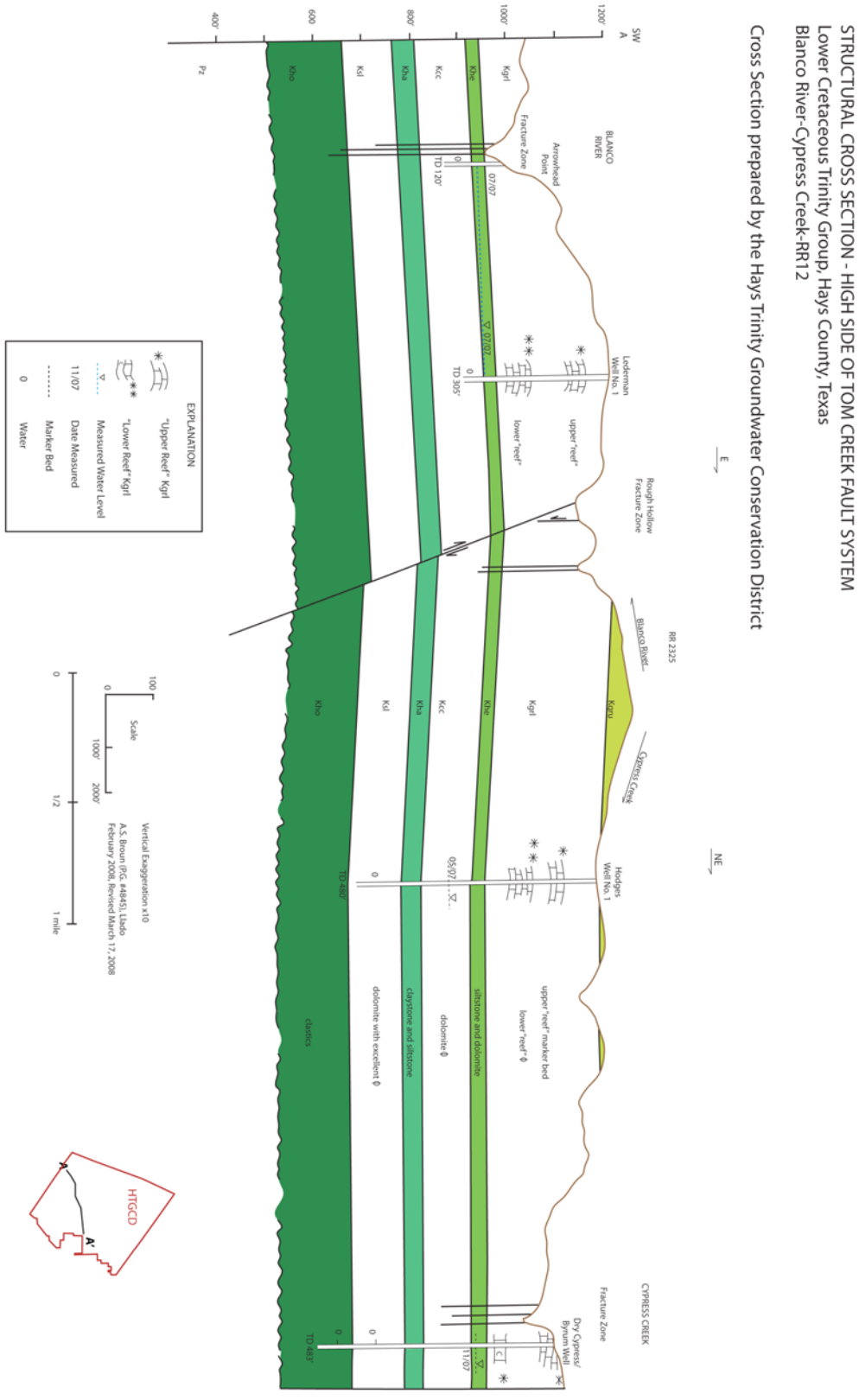

Figure 4. **Structural cross section A to A', high side of the Tom Creek Fault, Lower Cretaceous Trinity Group, Hays County, Texas, Blanco River-Cypress Creek-Ranch Road 12.**

Figure 5a. **Structural Cross Section B to B', Part 1—Cypress Creek Drainage, Lower Cretaceous Trinity Group, Hays County, Texas, South Onion Creek-Cypress Creek-Jacob's Well-Lynd Well.**

Figure 5b. **Structural cross section B to B', Part 2—Cypress Creek Drainage, Lower Cretaceous Trinity Group, Hays County, Texas, South Onion Creek-Cypress Creek-Jacob's Well-Lynd Well.**

cavern passageway elevation in Jacob's Well. Both the underlying Sligo and Hosston (Lower Trinity) contain aquifers along the line of cross section. The porous, vuggy dolomite in the middle Sligo produces at the Dry Cypress/Byrum Well. Interpreted channel sands contain water at several locations in the Hosston. Cross section Ato A' intersects section B to B' at the Dry Cypress/Byrum Well.

Jacob's Well Profile

The northwest–southeast profile depicts the subsurface stratigraphy and karstic nature of Jacob's Well as extrapolated from interpreted geophysical logs in nearby well locations (Figure 6). Particularly useful were the Aqua Texas Well No. 23 and South Golf Course wells (see cross section B to B') and observations and videos from cave divers. The volunteer cave divers have provided invaluable data on the internal structure of the well.

The opening of the spring in the bed of Cypress Creek occurs in the Lower Glen Rose unit of the Middle Trinity Aquifer. The nearly vertical shaft of Jacob's Well probably follows a former fracture or joint set that has been enlarged by solution. Approximately 70 feet below the mouth of the spring is the contact between the Lower Glen Rose and Hensel formations. There are two large caverns at the contact. At 100 feet is the contact between the Hensel and the Cow Creek. The passageway becomes roughly parallel to the horizontal bedding and continues several thousand feet in a paleokarst zone of the Cow Creek. Several smaller tunnels branch off the main shaft. At the current time the divers have mapped in excess of 5,000 feet of passages linked to Jacob's Well. Several passages terminate in constrictions that divers can't proceed beyond; others are still in the process of being fully explored.

Conclusions

Vertical joint sets associated with structural movement along the Balcones Fault Zone shatter the Jacob's Well/Cypress Creek area, providing surficial recharge pathways to subsurface aquifers. The outcropping, soluble Lower Glen Rose carbonate section is the lithologic media for karst development. The porous rudistid reef unit and other skeletal-grain carbonates become selective zones for recent surficial sinkhole and cave development. The normal recharge zone for Jacob's Well is the Cypress Creek drainage basin, with the basin dropping from an altitude of 1,350 to 1,400 feet in the west to 922 feet at Jacob's Well to the east. Karst terrain coupled with fractured, porous Middle Trinity carbonates collect the groundwater in a maze of interconnected conduits and faults. Interstitial water storage provides continuous baseflow of groundwater to Jacob's Well even in dry weather.

The formation contact between the Lower Glen Rose and the underlying dolomite and shale of the Hensel Formation serves as a preferred pathway of flow where conduits develop that may collect and transport groundwater from the Cypress Creek Basin. The contact between the Hensel and underlying Cow Creek may perform a similar function, with the Hensel locally acting as a groundwater confining unit for the lower Cow Creek. Large amounts of groundwater probably move laterally and down gradient through openings in the porous paleokarst Cow Creek carbonates. The porous Cow Creek dolomite, above the underlying Hammett, develops conduits or subsurface passages for groundwater flow. Restricted by the major Tom Creek Fault

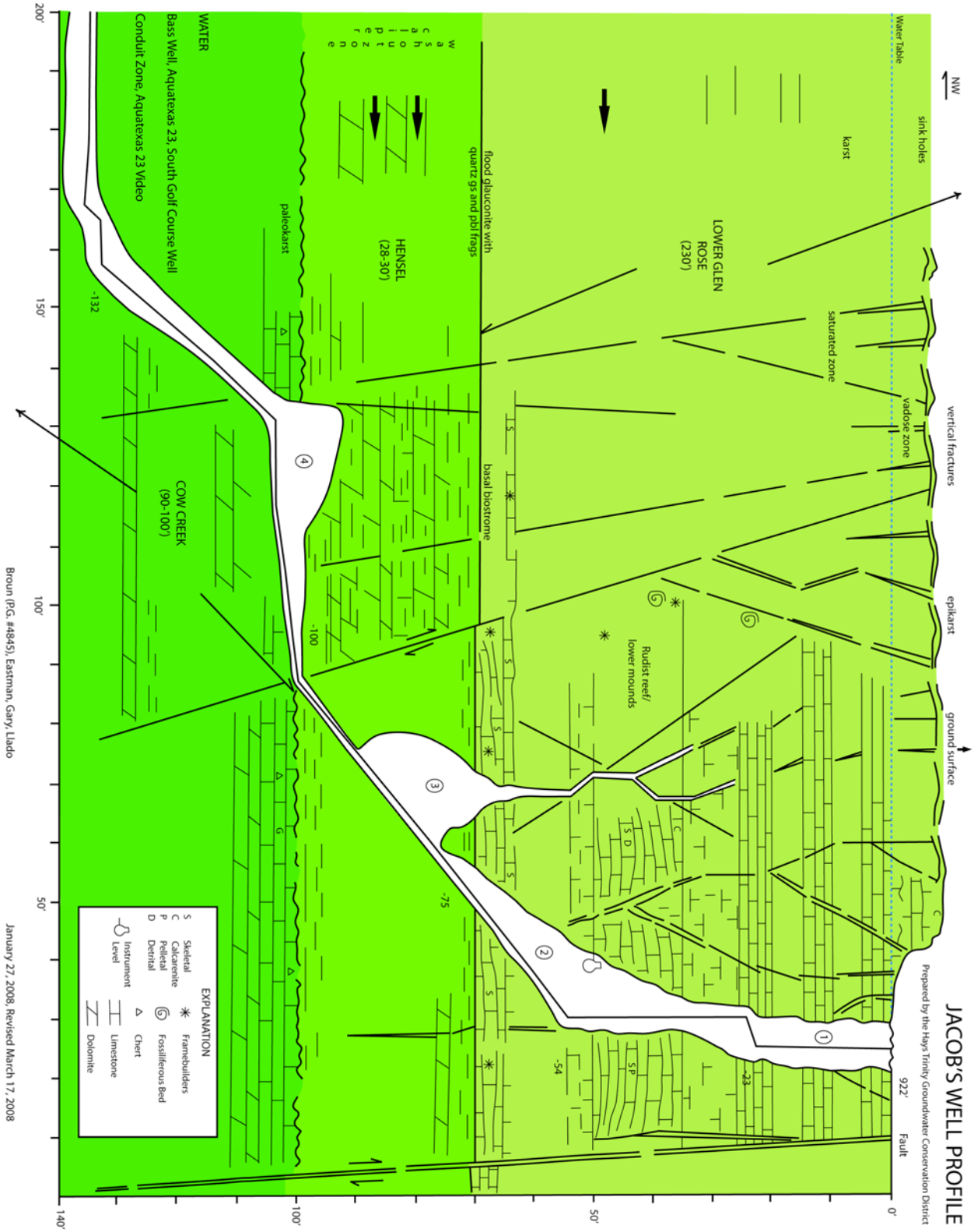

Figure 6. Profile of subsurface stratigraphy of Jacob's Well.

system to the east of the well, which drops relatively impermeable Upper Glen Rose in juxtaposition with the Hensel and Cow Creek members of the Middle Trinity Aquifer, pressure builds and the groundwater moves up fractures and exits as the artesian spring at Jacob's Well. The shattered rocks along the fault trace act as a hydraulic barrier in some zones and as a conduit in others.

Regional fault systems, such as the Tom Creek fault system, may act as a conduit to for the transport water from the Blanco River to Jacob's Well during storm events. Elevated water levels during storm events in the Blanco River may cause groundwater to move over and through the low relief structure that separates the Blanco River and Cypress Creek basins and spills into the "Jacob's Well low" abutting the major fault system.

Selected References Used for Study

Barker, R.A., and Ardis, A. F., 1996, Hydrogeologic framework of the Edwards-Trinity aquifer system, West-Central TX: U.S. Geological Survey Professional Paper 1421-B.

Broun and others, 2007, Geologic analysis of the Trinity Group Aquifer in Western Hays County: Austin Geological Society Guidebook 28.

Collins, E.W., Growth corridor along the Edwards Aquifer, South-Central Texas: The University of Texas at Austin, Bureau of Economic Geology, Map No. 39.

Collins, E.W., Geological Societies Transactions, Vol. XLV.

Collins, E.W., Balcones Fault Zone, Central Texas: Bureau of Economic Geology.

Eastman, R., Jacob's Well Video.

Grimshaw, T.W., 1970, Geology of the Wimberley area, Hays and Comal counties, Texas: Masters Thesis, The University of Texas at Austin.

Kerans, C., and others, 2003, Cretaceous buildups and paleokarst systems, Lake Medina area, South Texas: Field Trip Guidebook, South Texas Geological Society and Gulf Coast Section of SEPM.

Milanovic, P.T., 2004, Water resources engineering in karst: CRC Press.

Palmer, A.N., 2007, Cave Geology: Cave Books.

Perkins, B.F., and others, 1974, Aspects of Trinity Division geology—Geosciences and Man: The School of Geoscience, Louisiana State University.

Stricklin, F.L., Smith, C.I., and Lozo, F.E., 1971, Stratigraphy of Lower Cretaceous Trinity deposits of Central Texas: Bureau of Economic Geology Report of Investigations, No. 71.

Stricklin, F.L., and Smith, C.I., 1973, Environmental reconstruction of a carbonate beach complex—Cow Creek (Lower Cretaceous) Formation of Central Texas: Geological Society of America Bulletin, v. 84.

Acknowledgments

The authors thank the Rivers System Institute at Texas State University, Hays Trinity Groundwater Conservation District Board and Staff, Marcus Gary (Zara Environmental, formerly with U.S. Geological Survey, and cave diver), Robin Gary and Ryan Eastman (cave divers), San Marcos Area Recovery Team, Dan and Kathy Misiaszek, U.S. Geological Survey, Texas Commission on Environmental Quality, Wimberley Valley Watershed Association, Brian Hunt and the Barton Springs-Edwards Aquifer Conservation District, local drilling contractors, and local water supply companies.