GROUNDWATER LEVEL MONITORING RESULTS FOR HTGCD TRANSDUCER WELLS AND WIMBERLEY VALLEY PUBLIC WATER SUPPLY WELLS, HAYS COUNTY, CENTRAL TEXAS

The Meadows Center for Water and the Environment
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GROUNDWATER LEVEL MONITORING RESULTS FOR HTGCD TRANSDUCER WELLS AND WIMBERLEY VALLEY PUBLIC WATER SUPPLY WELLS, HAYS COUNTY, CENTRAL TEXAS

Prepared as part of the Cypress Creek Watershed Protection Project.

Texas State University, and
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EXECUTIVE SUMMARY

The Trinity Aquifer of central Texas is a critical groundwater resource for water supply, ecological, and recreational uses. However, limited continuous water level data exists to characterize the aquifer system. Accordingly, in 2008, the Hays Trinity Groundwater Conservation District (HTGCD) initiated a water level monitoring program across central Hays County that involved installing continuous data recorders. One of the purposes of the program was to determine the relationship between groundwater levels and discharge from Jacob's Well Spring (JWS) and flow in Cypress Creek. Water level monitoring of the Middle Trinity aquifer across the Tom Creek Fault Zone(TCFZ) indicates the zone partially restricts horizontal groundwater movement from the up dip recharge area into the deeply confined down dip units. The karst nature of the surficial Lower Glen Rose (and underlying units) allows for rapid recharge from precipitation events that is transmitted almost instantaneously as discharge from JWS. Response to major precipitation events is more muted in the deeper Middle Trinity aquifer down dip of the TCFZ.

INTRODUCTION AND PURPOSE

The Trinity Aquifer of central Texas is a critical groundwater resource for water supply, ecological, and recreational uses. However, limited continuous water level data exists to characterize the aquifer system. Accordingly, in 2008, the Hays Trinity Groundwater Conservation District (HTGCD) initiated a water level monitoring program across central Hays County that involved installing continuous data recorders (pressure transducers). The primary purpose of the continuous water level monitoring program was to establish a base line of water levels, to track changes going forward, and determine the relationship between groundwater levels and discharge from Jacob's Well Spring (JWS) and flow in Cypress Creek. JWS and flow in Cypress Creek are important ecological and recreational resources as well as major tributaries to the Blanco River and the Edwards Aquifer. They are critical to the ecological and economic health of the area surrounding the town of Wimberley within the Blanco River Watershed, referenced here as the "Wimberley Valley."

Since 2008, eight wells were instrumented with continuous recording pressure transducers within the Wimberley Valley, but concentrated in Cypress Creek watershed that contains JWS. In addition, operators of non-exempt public water supply (PWS) wells provided water level data for the Wimberley Valley. PWS operators report monthly water levels in their wells as required by permit. An inventory of the wells is provided in Table 1 and well locations are shown on Figure 1.

The purpose of this paper is to summarize the water level data data collected to date and characterize its hydrogeologic relationship among the structure, hydrostratigraphy (aquifers), and JWS.

HYDROGEOLOGIC SETTING

The hydrogeologic setting of the Wimberley Valley has been described in numerous recent publications (Wierman, et al., 2010, Wierman, et al., 2008, Watson, et al., 2014, and Hunt et al., 2010. Smith et al., 2015). The geology of the Wimberley Valley is dominantly gently dipping Lower Cretaceous limestone and dolomite strata, which intersection the Balcones Fault Zone in the eastern portion of the study area (Figure 1). The surficial geology is shown on Figure 1 and a generalized geologic cross section is included as Figure 2.

Except where Edwards Formation is present on hilltops, the dominant uppermost unit present in the Blanco watershed is the Glen Rose Formation. The Upper Glen Rose member is composed of relatively thin interbeds of

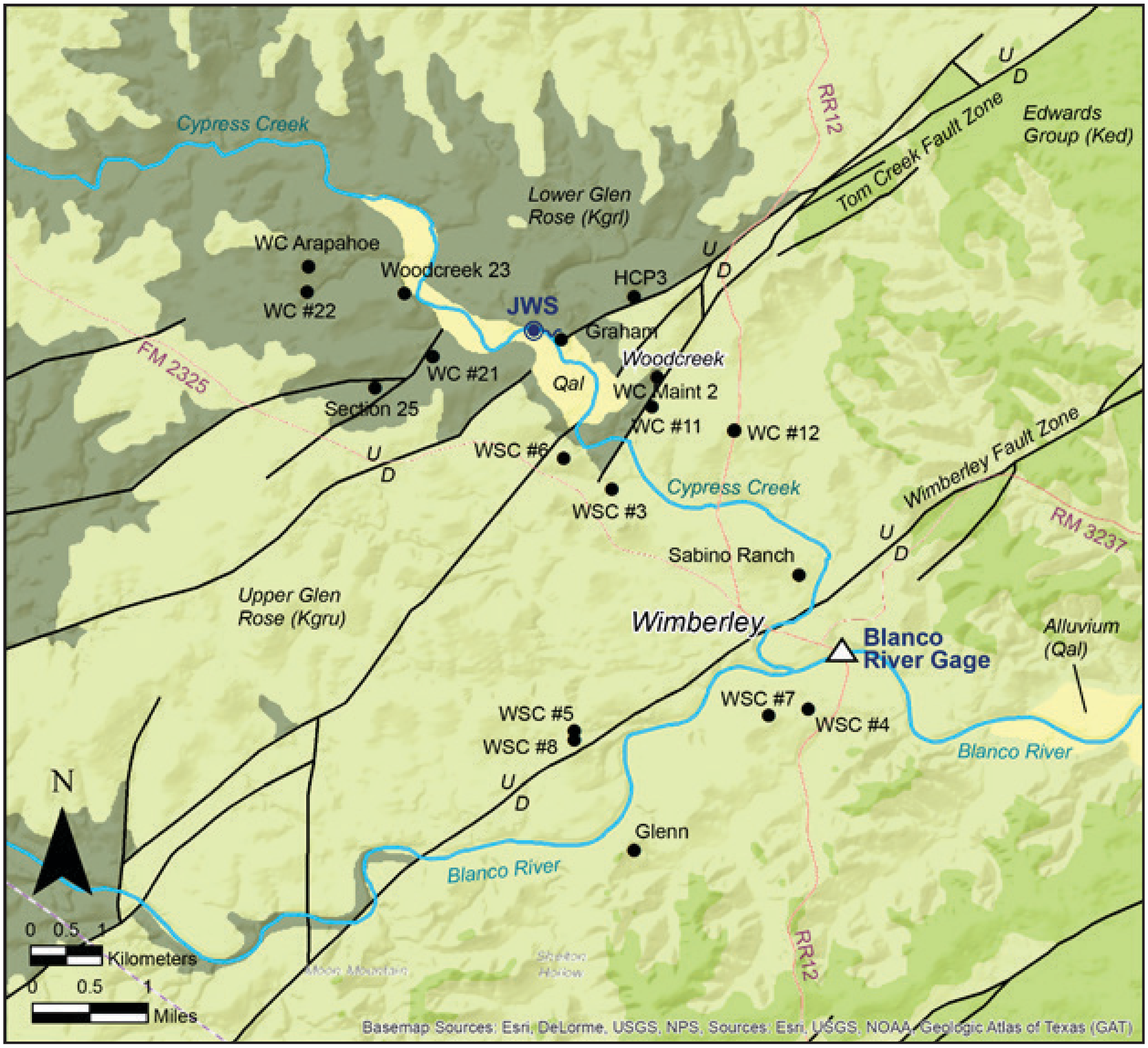

Figure 1. Surficial Geology and Well Location Map

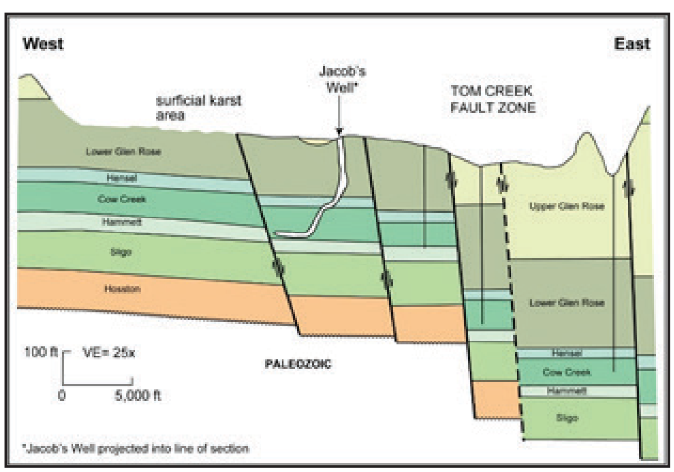

Figure 2. Geologic Cross Section through the Wimberley Valley

dolomite and limestone with varying amounts of clay content. Underlying the Upper Glen Rose member is the Lower Glen Rose member (~200 ft thick), which is thicker bedded and predominately limestone interbedded with bioclastic intervals and localized reef units. Where the Upper Glen Rose has been eroded in the lower parts of the Cypress Creek watershed, the lower Glen rose is the dominant surficial unit (Collins, 2002a; Collins 2002b). The Lower Glen Rose is also the dominant surficial unit upgradient of Tom Creek Fault Zone (TCFZ) within the Blanco River watershed and exhibits extensive karst development.

The Hensel formation (25 ft thick) underlies the Lower Glen Rose member. The Hensel formation is a silty dolomite with small poor exposures at the surface within portions of the incised Blanco River and adjacent river banks upstream from the TCFZ. Underlying the Hensel is the Cow Creek formation which is a calcarenite unit about 75 ft thick. The Cow Creek has a localized exposure within the bed of the Blanco River upstream of the TCFZ near Burnett Ranch. The Cow Creek also has well-developed karst features. The Hammett Shale (50 ft thick) is a clay unit that separates the Cow Creek from the underlying Sligo and Hosston Formations.

The Upper Trinity aquifer is composed of the Upper Glen Rose. However, the Upper Trinity generally consists of shallow perched water tables, where present. The Upper Trinity has many small ephemeral and a few larger perennial springs that provide baseflows to the creeks and rivers. Historically, the Upper Trinity provided very small amounts of water to shallow wells for domestic and livestock purposes (Ashworth, 1983).

The Middle Trinity is the primary water supply for much of the Hill Country, including the Wimberley Valley. The Middle Trinity aquifer is composed of the Lower Glen Rose, Hensel and Cow Creek. Perenial springs such as Pleasant Valley (PVS) and Jacob's Well (JWS) flow from the Middle Trinity and provide base flow to the Blanco River and Cypress Creek, respectively. The Cow Creek unit within the Middle Trinity is the primary source of water for those two large springs, and is also the primary unit targeted for water supply wells in the Wimberley valley. The Cow Creek provides relatively consistent high yield and good water quality to wells.

The Lower Trinity Aquifer is composed of the Sligo and Hosston Formations. It is increasingly targeted for production, but is deeper and generally has less yield and poorer quality than the Middle Trinity. The Hammett shale is an aquitard which separates the Middle and Lower Trinity aquifers.

Groundwater flow in the Middle Trinity Aquifer is generally from the northwest to southeast following the regional dip of the rocks (Watson, et al., 2014). In the vicinity of Jacobs Well, the Middle Trinity is under artesian pressure and groundwater discharges at the well creating base flow to Cypress Creek. With the exception of the Arapahoe well (Lower Trinity), all of the transducer wells in this study and PWS wells are completed in the Middle Trinity.

STRUCTURE

In the eastern part of the Wimberely valley, the strata are intersected by a series of normal faults of the Balcones Fault Zone, which stretches from north of Austin to west of San Antonio. In the vicinity of Wimberley, the TCFZ and Wimberley fault zones are the two major named faults. Vertical displacement across the faults is variable along strike with combined offset ranging from zero to a few hundred feet. The TCFZ is a series of normal faults (down to the east) generally to the east, or down dip from JWS. In the area east of JWS fault displacement has been correlated from geophysical logs (Wierman, et al., 2010) and indicate up to 220 hundred feet of vertical displacement is present (Smith, et al, 2017). This offset may juxtapose Lower Trinity strata on the western upthrown side, with the Middle Trinity Aquifer on the eastern downthrown side. East of the TCFZ the variable offset and enchelon nature of the faults have created relay-ramp structures that provide some lateral continuity of geologic units, and which influence groundwater flow (Hunt et al., 2015).

Based on the study performed by Schumacher and Saller (2008): *The general structural trends of the region are best recognized when presented in a rose diagram. As seen in Figure 3, the most prevalent orientation of jointing was found to be in the direction of the region's minor stress axis (310-330°), and perpendicular to the normal faulting that resulted from the vertical stress (45-60°). This alignment of jointing and the overall low angle dip of bedding to the southeast indicates a dominant flow direction of groundwater in the Middle Trinity aquifer along this axis……..*

The secondary orientation of joints is aligned with the Balcones Fault Zone, and represents the 90° joint set to the minor stress axis. In addition, many of the located minor faults fall into this set, as they are part of the much larger fault zone. Twin minor trends also exist, as 60° conjugates to the existing patterns.

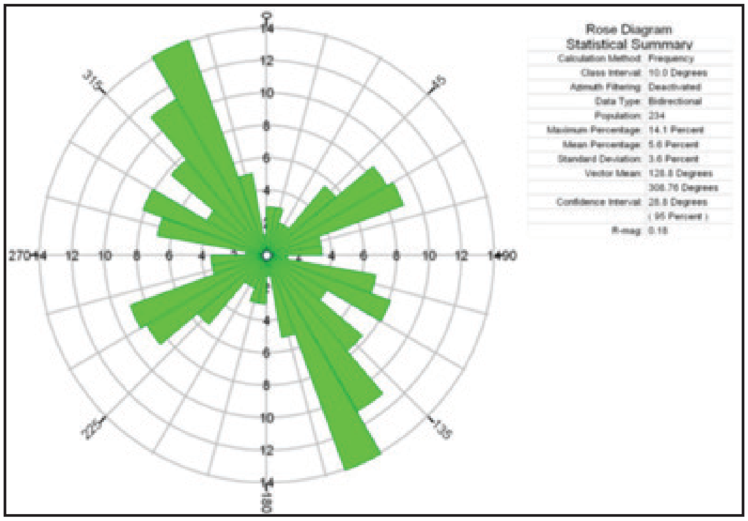

Figure 3. Rose Diagram of Joints and Faults in the Cypress Creek Watershed. (from Schumacher and Saller, 2008).

JACOB'S WELL

JWS a well-known artesian spring of the Hill Country Trinity Aquifer system and is located 5 miles ENE along strike from PVS, the largest documented spring in the Texas Hill Country. Both springs have similar water surface elevations (survey JWS = 922.4 ft-msl and PVS = 921-923 ft-msl), and similar structural and hydrogeologic settings (Hunt et al., 2013).

The opening of Jacob's Well in the bed of Cypress Creek (Figure 4) occurs in the Lower Glen Rose Member of the Middle Trinity Aquifer. The nearly vertical shaft of Jacob's Well (Figure 4) probably follows a former fracture or joint set that has been enlarged by solution activity. Approximately 70 feet below the mouth of the spring is the contact between the Lower Glen Rose and the Hensel formation. There are two large caverns at the contact. The contact between the Hensel and Cow Creek occurs 100 feet below the ground surface. The cave passageway becomes roughly parallel to the horizontal bedding and continues laterally within the Cow Creek. The orientation of the main passage way trends along the minor fracture stress axis, or roughly 310-330°(Figure 5). Divers have mapped in excess of 7,000 feet of cave passages linked to Jacob's Well. Several passages terminate in constrictions that divers cannot proceed beyond; others are continuing to be explored (Wierman, et al., 2010). Some wells are directly completed within the JWS conduit system and produce very high yields of fresh water. For example, pumping from the Woodcreek #21 well directly influence JWS with corresponding decline of springflow (Wierman et al., 2008). Indeed many wells are likely influenced by the JWS conduit system as evidenced in the potentiometric trough created by the high permeability conduit (Watson et al., 2014).

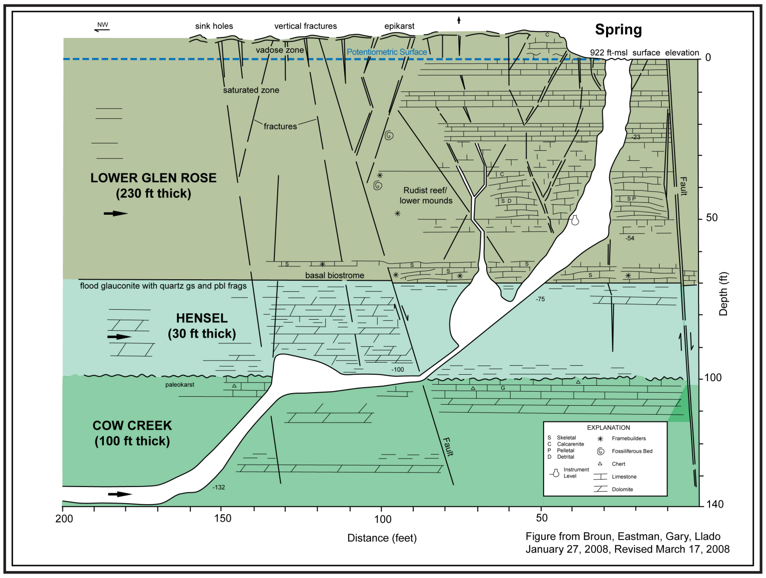

Figure 4. Geologic Cross Section of Jacobs Well Spring

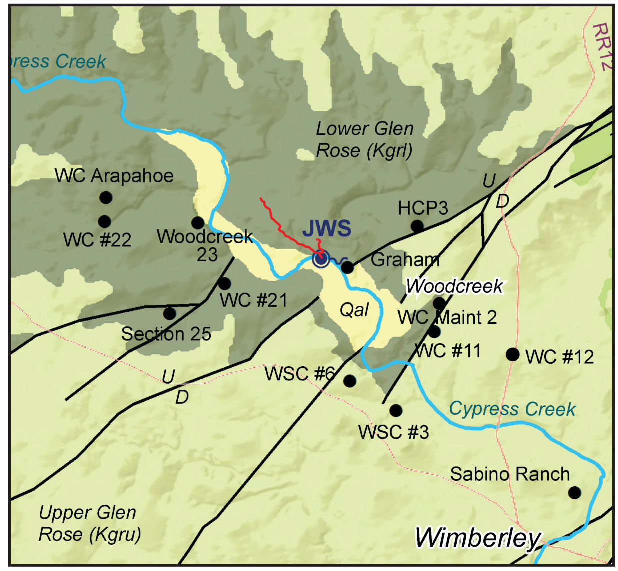

Figure 5. Extent of Explored Jacob's Well Spring (PWS) passageway (red line). Source: David Moore

Springflow from JWS is the primary contributor of baseflow to Cypress Creek. Daily springflow values from JWS since January 2008 through September 2016 has a median value of 2.4 cfs (min = 0, max = 157). Increasing levels of pumping have influenced flows at JWS. JWS has changed from a perennial to an intermittent baseflow spring over the last decade due to droughts and increased groundwater pumping. Data from the 1950s indicate flow occurred during the drought of record, however, the spring ceases flowing during drought conditions (Smith et al., 2015).

PROCEDURES AND DATA

Instruments used to measure water levels continuously were InSitu Level Troll pressure transducers with a range of 100 psi (with reported accuracy and long-term sensor stability of about 0.2 ft.) They are absolute transducers (e.g. non-vented) suspended with a stainless steel cable. No compensations or corrections to the data were made for the relatively minor effects of non-vented instruments or barometric changes. For this study we refer to the wells with these equipment as the "Transducer Wells". The data is recorded every 30 minutes. Monitor well were visited about every three months by HTGCD staff and a manual measurement made with either an eline or calibrated sonic meter. The data is inserted into a spread sheet and the data are converted to a daily groundwater elevation. Temperature was also recorded in several of the transducers but not included in this paper.

The water level data obtained from the PWS wells are collected by PWS staff on a monthly basis using manual methods and reported the HTGCD on a quarterly basis. For this study we refer to these wells and their data as the "PWS Wells."

WATER LEVEL MONITORING RESULTS

Transducer Wells

During major rainfall (recharge) events groundwater levels rise almost instantaneously, as does discharge from JWS, due to the karst nature of the Middle Trinity units (Figure 6). Groundwater elevations in wells up dip and west of the TCFZ indicate very similar levels in the 920 feet to 925 feet range, and fluctuate only a few feet, except during major precipitation events. These potentiometric elevations are very similar, and only slightly higher, than the elevations of JWS and PVS. It appears the opening of Jacobs Well and the karst conduits is a dominant hydrologic feature that controls the heads upgradient of the spring within Cypress Creek. To use an analogy from hydraulics, JWS acts as a “relief valve” for head build up in the Middle Trinity Aquifer and provides relatively consistent base flow to Cypress Creek. Dynamic and large magnitude head changes in wells in the up dip area during major precipitation events and result in very rapid increases in discharge at Jacobs Well. Figure 7 compares groundwater elevations in transducer wells and the discharge from Jacobs Well during the flood of Halloween 2013. After major events, water levels and discharge dissipate quickly. Regional potentiometric maps (Watson, et al., 2014, and Hunt et al., 2009) indicates a regional flow component from the northwest in the Middle Trinity which likely maintains base flow to Jacobs Well between major precipitation events.

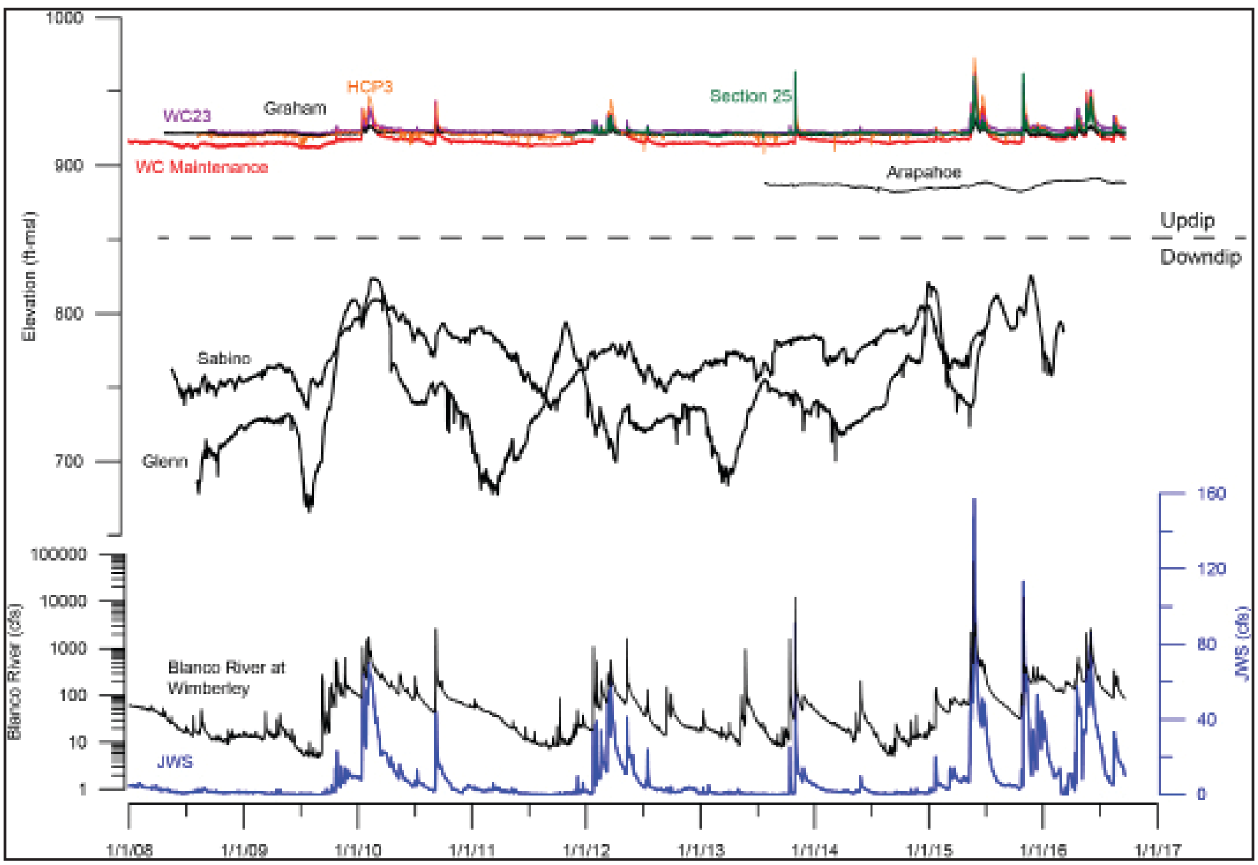

Figure 6. Daily Hydrographs of Transducer Wells and JWS/Blanco River Discharge

Groundwater levels located down dip and east of the TCFZ show a very different behavior to recharge events. Two wells located down dip of the TCFZ, Glenn and Sabino Ranch, have water level elevations up to 200 feet lower than the up dip wells. The difference in water levels indicates the fault is acting as a partial hydrologic barrier, or relatively impermeable restriction to horizontal flow. Due to the amount of displacement across the fault zone (several hundred feet), Upper Glen Rose may be juxtaposed against the Middle Trinity (see Figure 2). Water level trends in down dip wells generally do not mimic the flat trend of water levels in the up dip wells and appear to fluctuate more gradually to wet/drought cycles than individual precipitation events. As evident on Figure 7, there was a somewhat muted response to the Halloween flood in the Glenn and Sabino wells, demonstrating limited vertical hydraulic connection between the upper and lower zones in this area.

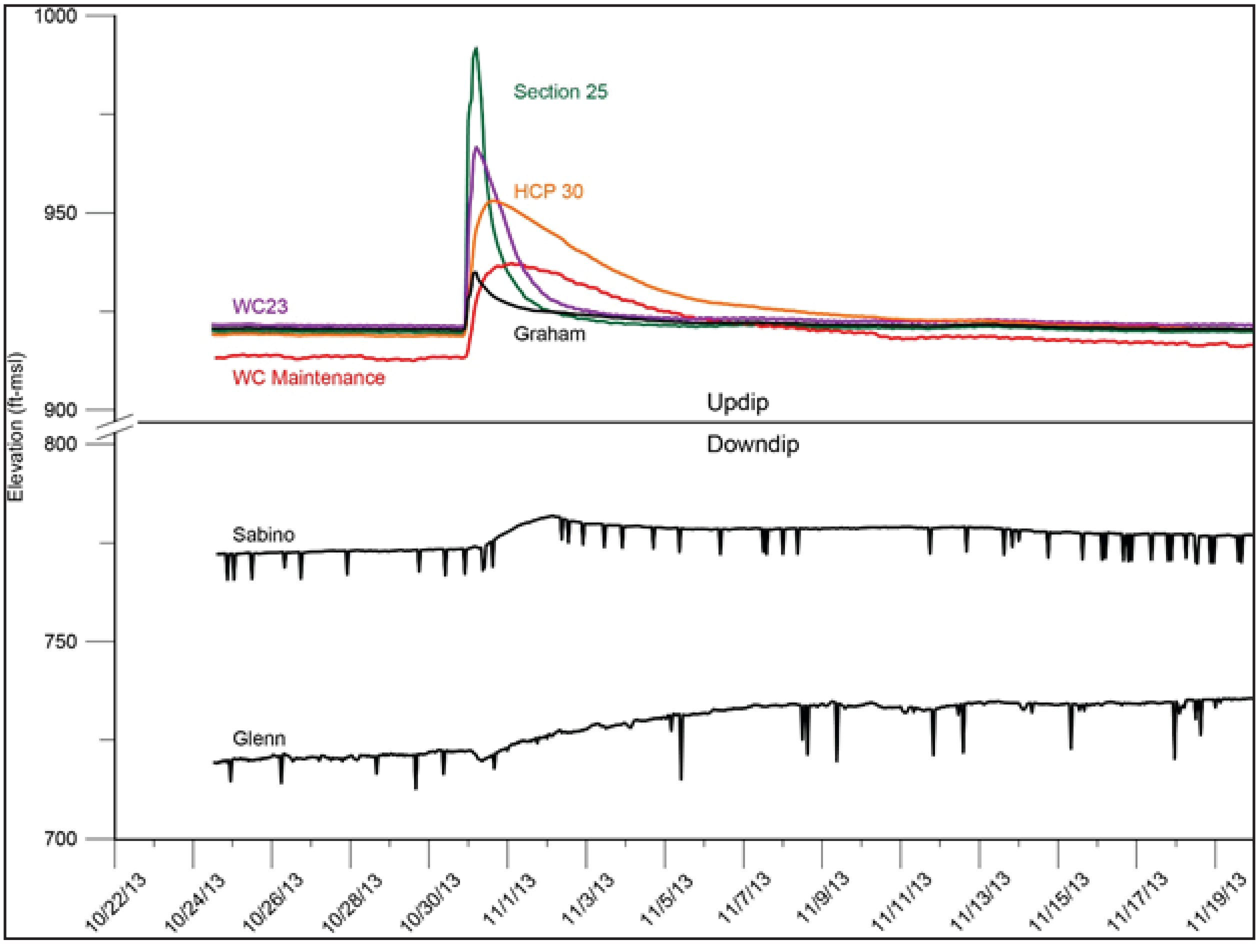

Figure 7. Hydrographs of the Halloween 2013 Flood Event

The difference in water level response between up and down dip wells may be related to recharge and groundwater flow rates. The up dip area is characterized by surficial Lower Glen Rose which is very karstic. Infiltration of precipitation is rapid as evidenced by the rapid water level rises and increased discharge at Jacobs Well (Figure 7). The Middle Trinity aquifer monitored in the down dip wells is significantly deeper within the geologic section resulting a much longer, slower, vertical or lateral recharge pathway. In contrast to the PWS wells (next section), no long-term trends are clearly demonstrated by the two transducer wells down dip of the fault zone.

The Arapahoe well is completed in the Lower Trinity aquifer. Water levels are lower than in the overlying Middle trinity wells up dip of the TCFZ, but significantly higher than the Middle Trinity wells down dip of the fault zone. Over the three year period of record for water level monitoring results for the well indicate little fluctuation in water levels, including during the major flooding events of 2013 and 2015. There appears to be no influence on discharge from JWS from the Lower Trinity aquifer. The Sligo and Hosston are likely juxtaposed against the Middle Trinity units across the TCFZ (Figure 2). Due to the lack of Lower Trinity wells in the area, any hydraulic connection between the Middle and Lower Trinity aquifers across the fault zone has not been documented.

PWS Wells

Groundwater elevations in the PWS wells show a similar trend to the transducer wells (Figure 8). Wells located up dip of the TCFZ tend to maintain water levels close to the level of Jacobs Well and do not significantly fluctuate over time, similar to the up dip transducer wells. Major precipitation events are not as noticeable in the PWS wells (Figure 8) as with the transducer wells (Figures 6 and 7), which is likely due to the data collection frequency and short-term drawdown "noise" from the pumping wells. Another difference is that the long-term water level trend in 5 of the 6 PWS wells on the down dip side of the fault is downward, between three to eleven feet per year.

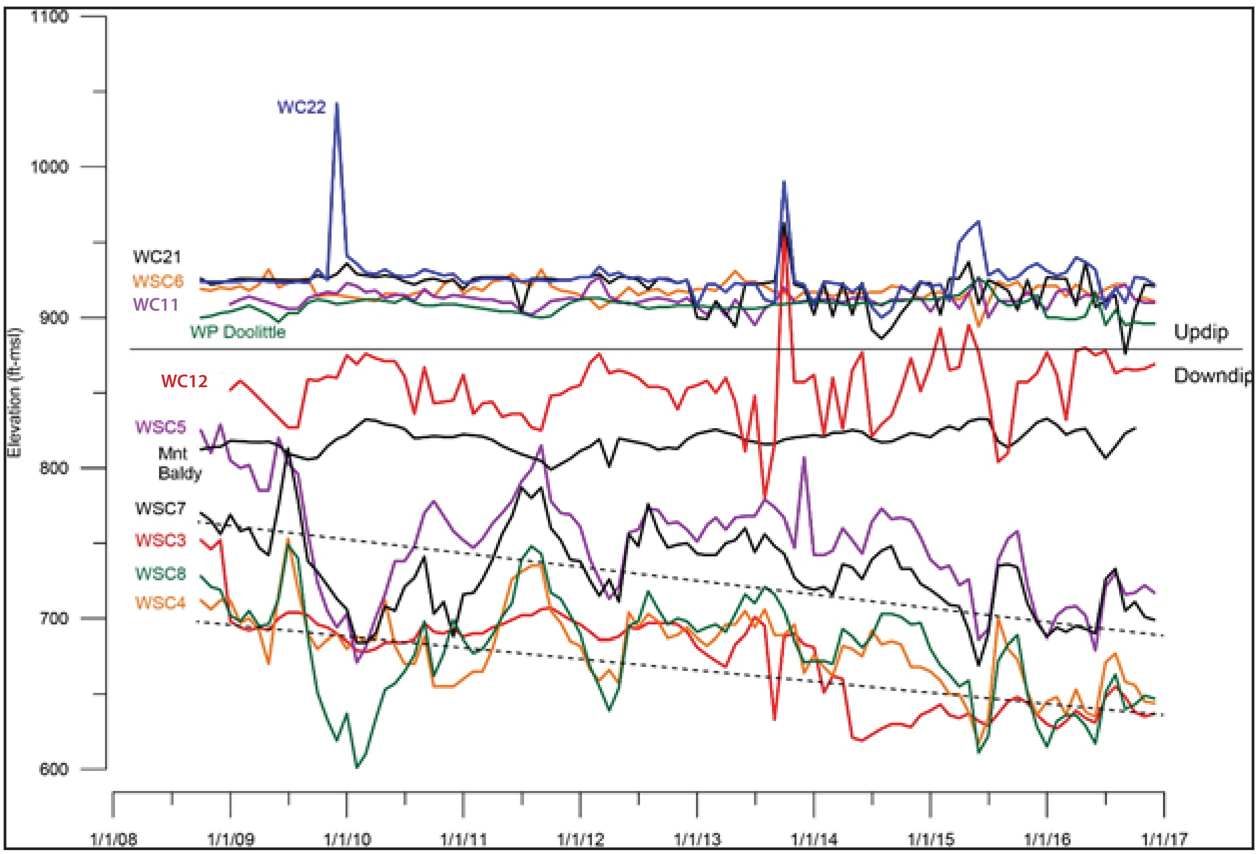

Figure 8. Monthly Hydrographs of PWS wells in the Wimberley Valley with general trend lines

SUMMARY

Water levels in Middle Trinity wells in the vicinity of JWS Spring reflect the influence of stratigraphy, structure and the karst nature of the Cretaceous carbonates that comprise the Middle Trinity Aquifer. The karst nature of the surficial Lower Glen Rose (and underlying units) allows for rapid recharge from precipitation events that is transmitted almost instantaneously as discharge from JWS. Water level monitoring of the Middle Trinity aquifer across the TCFZ indicates the zone partially restricts horizontal groundwater movement from the up dip recharge area into the deeply confined down dip units in the vicinity of Wodcreek. Thus, the data suggest that the TCFZ is a boundary between two different hydrologic systems—the karstic unconfined up-dip area and the deeply confined down-dip area. The head buildup and the karstic nature of units behind the TCFZ results in the discharge from JWS and base flow to Cypress Creek. Response to major precipitation events is more muted in the down dip area.

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Table 1. Well Inventory

Well Name	Latitude	Longitude	Period of Record	Surface Elevation	Well Depth	State Well Report #	Aquifer
Transducer Wells							
WC Arapahoe	30.04252	-98.15575	7/2013 to present	1089.97	680	5763604	Lower Trinity
Glenn	29.96889	-98.11472	8/2008 to present	1073.62	680	6808107	Middle Trinity
Graham	30.03333	-98.12389	4/2008 to present	956.17	153		Middle Trinity
HCP3	30.03872	-98.11468	8/2008 to present	1039.29	310		Middle Trinity
Section 25	30.0272	-98.14732	10-2011 to present	1039.02	300	5763903	Middle Trinity
Woodcreek 23	30.03914	-98.14364	9/2008 to present	1051.89	284	5763908	Middle Trinity
WC Maint 2	30.02853	-98.11175	1/2008 to present	961.61	460?	5764703?	Middle Trinity
Sabino Ranch	30.00361	-98.09389	05/2008 to 07/2015	884.01	760	5764717	Middle Trinity
Public Water Supply Wells							
WC #11	30.02487	-98.11242	2008 to present	970	400	5764702	Middle Trinity
WC #12	30.02181	-98.10213	2009 to present	1010	590	5764711	Middle Trinity
WC #21	30.0312	-98.1401	2010 to present	1000	400	5763907	Middle Trinity
WC #22	30.03933	-98.15595	2011 to present	1040	300	5763906	Middle Trinity
WSC #3	30.01444	-98.1175	2012 to present	930	400	5764707	Middle Trinity
WSC #4	29.98667	-98.09278	2013 to present	890	550	6808102	Middle Trinity
WSC #5	29.98389	-98.12222	2014 to present	990	500	6808103	Middle Trinity
WSC #6	30.01833	-98.12361	2015 to present	1060	620	5764712	Middle Trinity
WSC #7	29.98583	-98.09778	2016 to present	968	580	6808108	Middle Trinity
WSC #8	29.98278	-98.12222	2017 to present	988	615	6808109	Middle Trinity

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