HOW MUCH WATER IS IN THE PEDERNALES?

Determining the Source of Base Flow to the Pedernales River in Northern Blanco, Hays and Travis Counties

The Meadows Center for Water and the Environment
September 2017

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The Meadows Center for Water and the Environment
Texas State University

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Performing Agency:

Texas State University, and
Meadows Center for Water and the Environment

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LIST OF ACRONYMS

BPGCD: Blanco-Pedernales Groundwater Conservation District

BSEAGD: Barton Springs Edwards Aquifer Conservation District

CFS: Cubic Feet per Second

EL: Ellenburger Aquifer

GAT: Geological Atlas of Texas

GIS: Geographic Information Systems

GPS: Global Positioning System

HTGCD: Hays Trinity Groundwater Conservation District

LCRA: Lower Colorado River Authority

MCWE: The Meadows Center for Water and the Environment

KCC: Cow Creek Aquifer

LT: Lower Trinity Aquifer

MT: Middle Trinity Aquifer

NLCD: National Land Cover Database

NHD: National Hydrological Database

PFSP: Pedernales Falls State Park

STH: State Highway

SWR: State Well Report

TNC: The Nature Conservancy

TPWD: Texas Parks and Wildlife Department

TWC: Texas Water Commission

USH: United States Highway

USGS: United States Geological Survery

EXECUTIVE SUMMARY

The results of this study confirm that the groundwater from the Paleozoic and Cretaceous Aquifers contribute significant base flow to the Pedernales River and Lake Travis in the study area. Approximately half of the inflow into Lake Travis from the Pedernales River originates in the study area, or approximately 12 percent of the total inflow into Lake Travis. Shallow depths to groundwater and apparently high-modeled recharge rates indicate the Paleozoic strata, primarily on the northern side of the river, contribute the majority of the inflow to the river. Future groundwater management actions in this area need to consider the importance of this area to maintaining adequate water supplies.

BACKGROUND AND PURPOSE

The Pedernales River is an important source of water to Lake Travis of the Highland Lakes chain of lakes. Lake Travis supplies the City of Austin and many other downstream municipalities along the Colorado River as the sole source of potable water. Approximately 23 percent of the annual inflow to Lake Travis is from the Pedernales River. Maintaining environmental flows down to the Gulf of Mexico from the Colorado River is dependent on inflows from the Pedernales River.

Stream flow gain/loss studies performed in 1962 and 2016 on the Pedernales River have indicated significant gains to base flow in the main channel along the reach from Johnson City to the confluence of the river with Lake Travis. A synoptic groundwater level measuring event was conducted to determine if groundwater inflows played a significant role contributing to the gains. If so, potential river management actions may be identified to maintain the current level of flow into the river.

STUDY AREA

The study area included an area roughly bounded by Cypress Mill Road, Hammetts Crossing, County Road 2766 and State Highway (STH) 281 on the north, east, south and west, respectively (Figure 1). The reach encompasses approximately 32 miles of river, primarily in Blanco County. The river from headwaters near Harper to Hammetts Crossing is approximately 102 river miles and 119 miles to the confluence with Lake Travis. The scope of the project was to arrange for access to as many wells in the study area as possible and, within a short period of time, obtain groundwater level measurements. State Well Reports (SWR) were obtained, where available, to aid in determining well depths and completion zones.

SCOPE OF PROJECT

Forty-three wells were identified by the team from The Meadows Center for Water and the Environment (The Meadows Center), Blanco-Pedernales Groundwater Conservation District (BPGCD) and the Hays Trinity Groundwater Conservation District (HTGCD) as shown on Figure 1. Most of the wells were visited prior to the synoptic event to evaluate access and site logistics. Water levels were obtained at 42 wells during the period of October 24 – November 1, 2016 (Note: one of the wells had a significant wasp infestation of the well house and was not measured). Depth-to-water measurements were collected using either an electric e-line or sonic water level measurement meter. Well locations were determined by hand-held Global Positioning System (GPS). Well surface elevations were obtained from USGS maps or Google Earth®. River and tributary creek elevations were obtained from Google Earth®. Water elevations were hand-contoured to develop a potentiometric surface map of the study area. Geologic maps, SWRs (where available), water levels, well depths and local knowledge were the primary tools for determining into which aquifer a given well was completed. Well coordinates, ground elevations, depth-to-water and groundwater level elevations are shown on Table 1. Available SWRs are included in Appendix A.

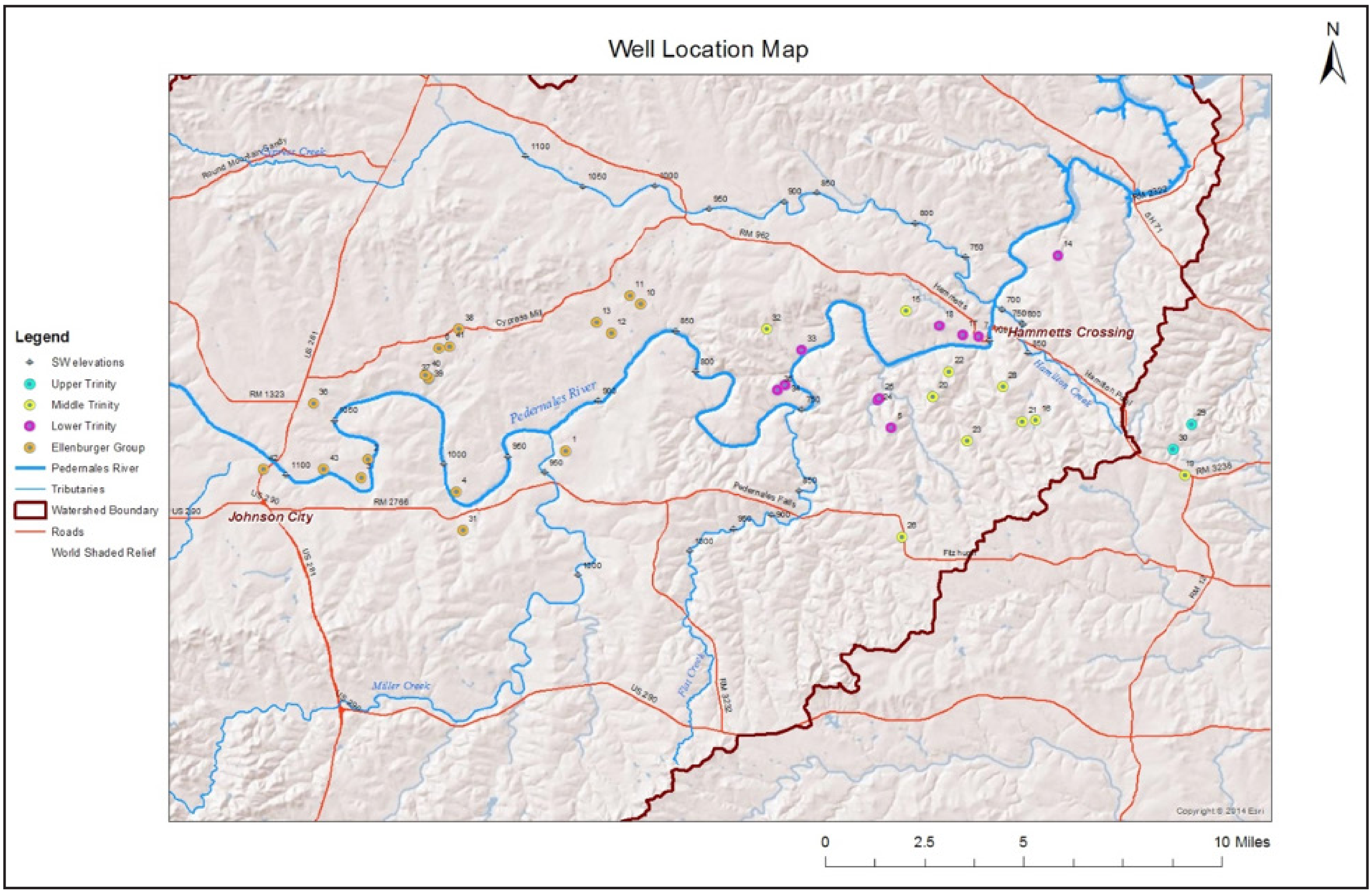

Figure 1. Study Area and Well Locations

RESULTS

The Lower Colorado River Authority (LCRA) monitors inflows from the Pedernales River into Lake Travis. The United States Geological Society (USGS) gauge at Johnson City at STH 281 is the closest upstream gauge to the lake. LCRA uses an inflow runoff factor of 2.030 times the discharge at the USGS gauge to estimate flow into Lake Travis from the Pedernales River. Therefore, the study area reach accounts for approximately one third of the total river and contributes half of the water, either via tributaries or groundwater inflow. Figure 2 illustrates the two major gain/loss studies performed on the Pedernales River in 1962 (Holland and Hughes, 1964) and 2016 (Wierman, et al, 2017). The increase in discharge during the 1962 study across the study area was 15 cubic feet per second (cfs) with tributaries accounting for 7.2 cfs and main channel inflow of 7.8 cfs (total discharge was 30.3 cfs). The increase across the reach during the 2016 study was 28.8 cfs out of a total discharge of 52.8 cfs. Individual tributaries were not quantitatively measured during the 2016 study. Note: dye tests from the 2016 study indicate the large loss measured at river mile 86 that occurs upstream of the Pedernales Falls State Park (PFSP) is the source of water at the major spring at the base of PFSP with the spring flow returning to the river (Brune, 1981) and is likely a local "diversion" of water that returns to an otherwise gaining reach of the river.

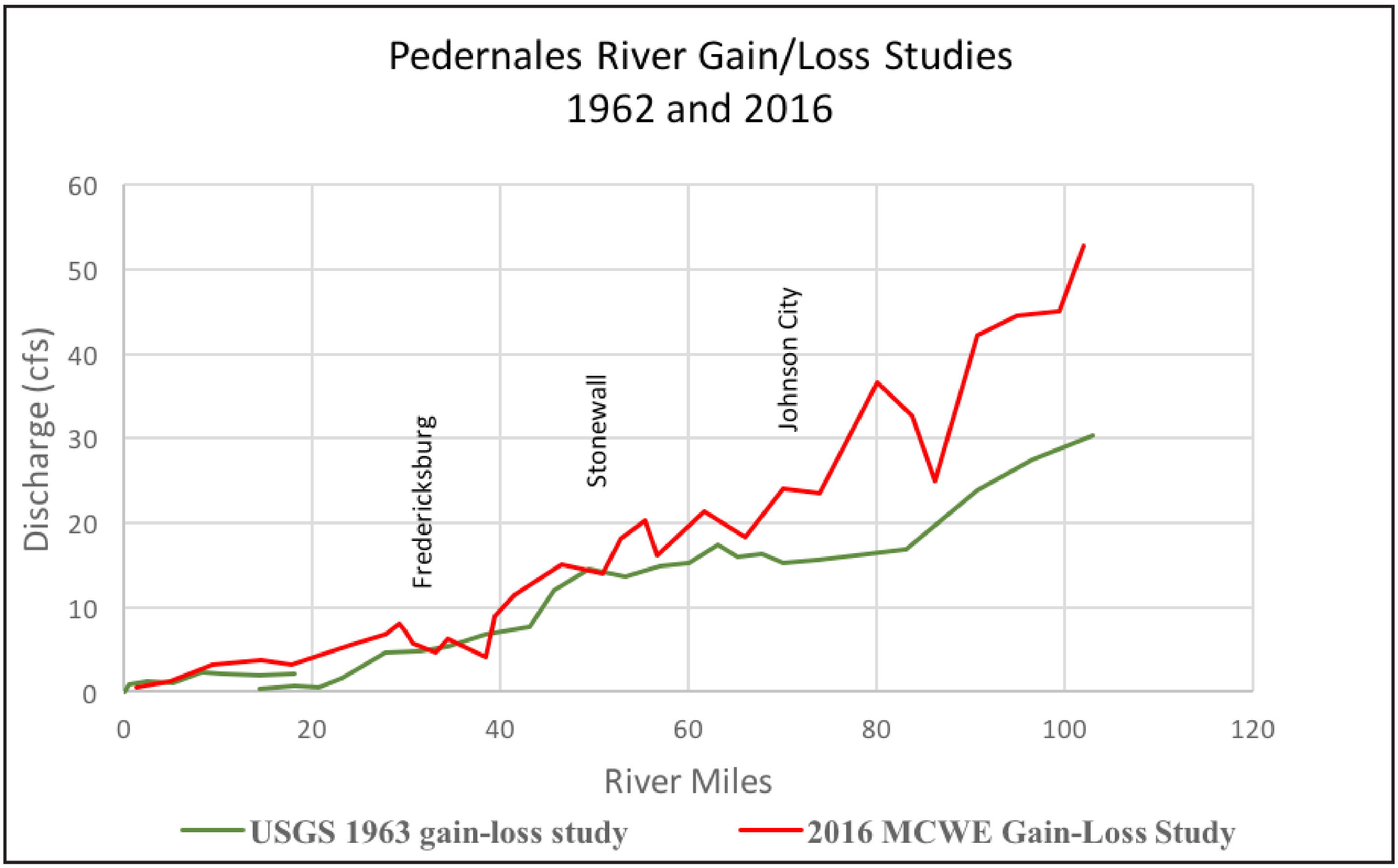

Figure 2. Pedernales River Gain-Loss Studies 1962 and 2016 (from Wierman, et.al., 2017)

USGS maintains a discharge measurement station on the Pedernales River at the bridge on STH 281 in Johnson City. Discharge measured during the synoptic event is shown on Figure 2. Flow ranged between 38 and 40 cfs which is at or slightly below the median daily discharge. As evident from Figure 3, there was no significant precipitation/runoff during the several weeks prior to the synoptic event. At the time of the study, Lake Travis was at its normal full pool elevation of Elev. 681. At this level, water is backed up in the Pedernales River to just downstream of Hammetts Crossing near the confluence with Hamilton and Cypress creeks.

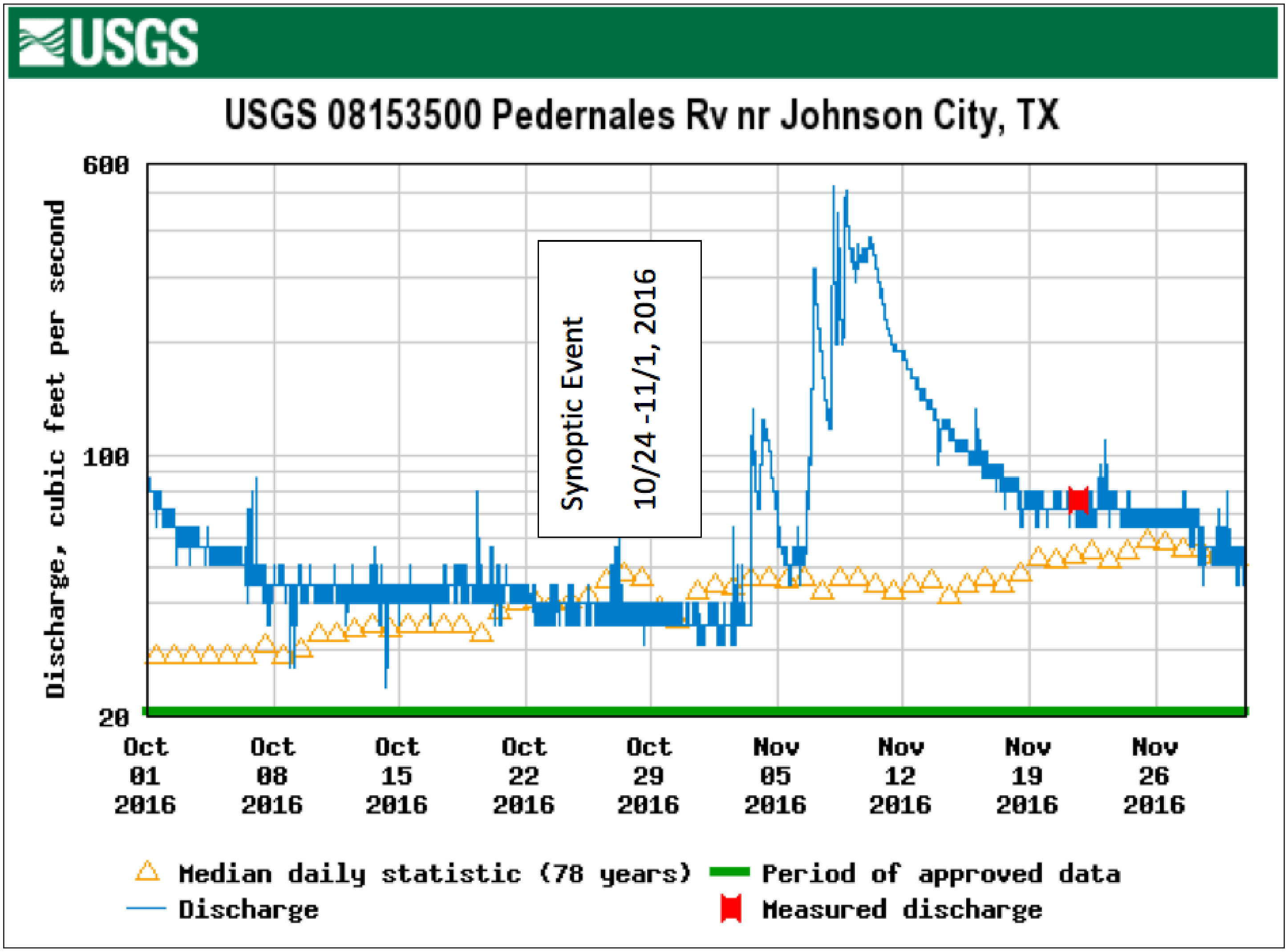

Figure 3. Pedernales River Discharge at State Highway 281 in Johnson City, TX

The geologic units exposed in the study area range in age from Paleozoic to Quaternary (Figures 4 and 5). The reach of the river from Johnson City to PFSP is dominated by the various units of the Ordovician Ellenburger Group. The Ellenburger units are primarily thin to thickly bedded limestones and dolomites. Pennsylvanian Marble Falls limestone crops out along the northern bank of the river upstream of the PFSP and is the geologic unit underlying the falls at the park (Barnes, 1982; Barnes, 1982; and Barnes, 1963). These units generally dip to the southeast at approximately 7 – 10 degrees. Numerous southwest/northeast trending faults have been mapped. The rocks of the Ellenburger, and to a lesser extent the Marble Falls, are the primary sources of groundwater in the area for domestic and agricultural use. The municipal water supply for Johnson City is developed in the Ellenburger.

Along the southern side of the river upstream of PFSP and dominating the entire watershed downstream of the park are the Cretaceous age units of the Trinity Aquifer. The Trinity section, from oldest to youngest, is composed of the Sycamore Sand, Hammett Shale, Cow Creek Limestone, Hensel Sand and the Upper and Lower units of the Glen Rose Limestone (Barnes,1982; Wierman et al, 2010) and lies unconformably on the older Paleozoic strata. The river has deeply incised the entire Trinity section which is exposed in outcrop from PFSP to Hammetts Crossing and in varying degrees in the major tributary valleys. The Lower Glen Rose, Hensel and Cow Creek comprise the Middle Trinity Aquifer. The Cow Creek pinches out in the study area and is not present in the western part of the study area (Figure 6). Similarly, the Sycamore formation, which is exposed in the deeper river and tributary valleys and makes up the Lower Trinity Aquifer, also pinches out against the Paleozoic strata.

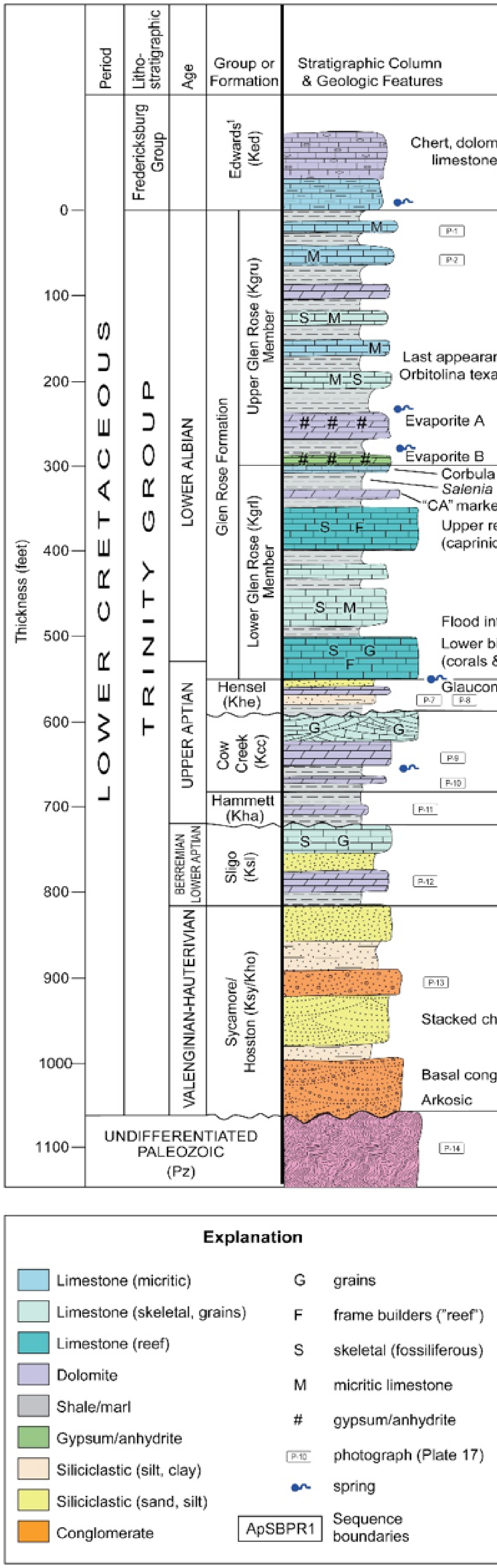

Figure modified from Stricklin; Smith & Lozo, 1971

Stratigraphic notes:
1 - Edwards Group, Kainer Fm, as defined by Rose (1972).
2 - Ages and sequence boundaries from Scott et al. (2007).

Figure 4. Stratigraphic Column – Texas Hill Country (from Wierman, et al, 2010)

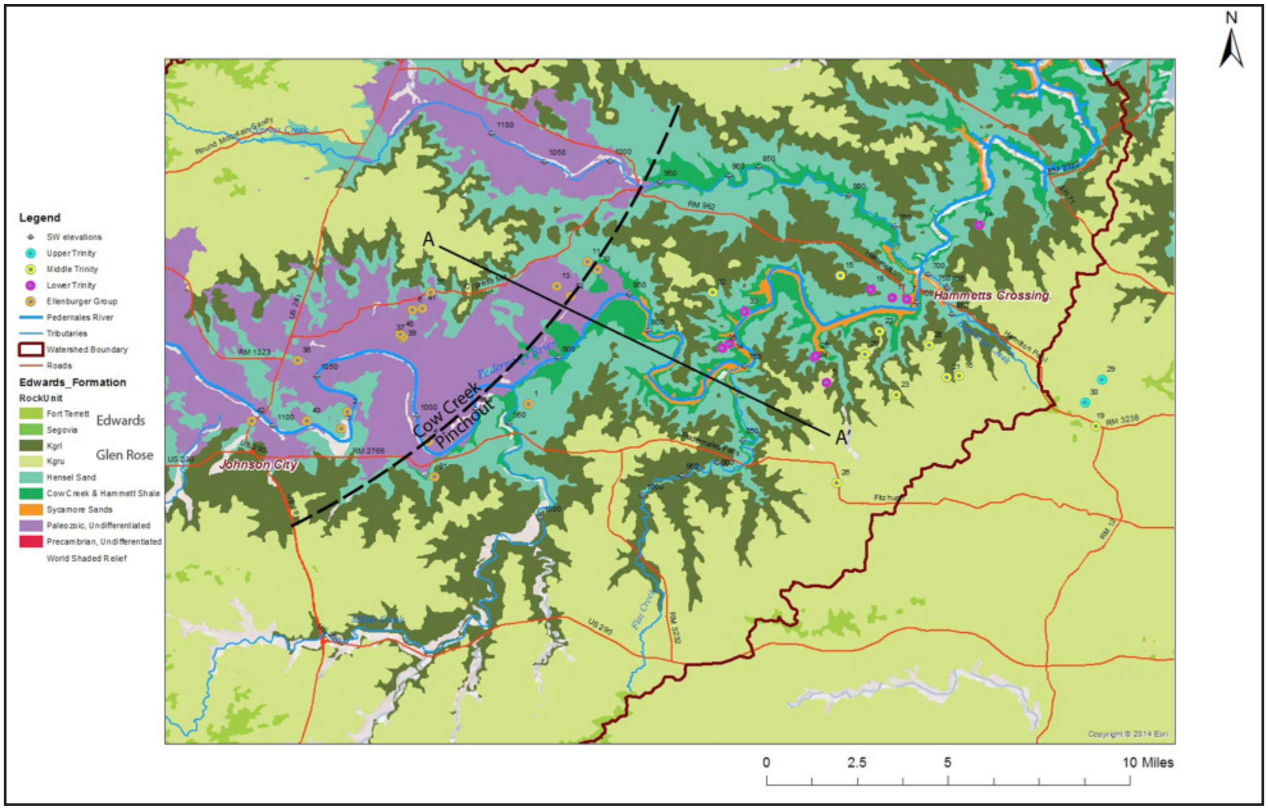

Figure 5. Study Area Geologic Map (from Barnes, 1981)

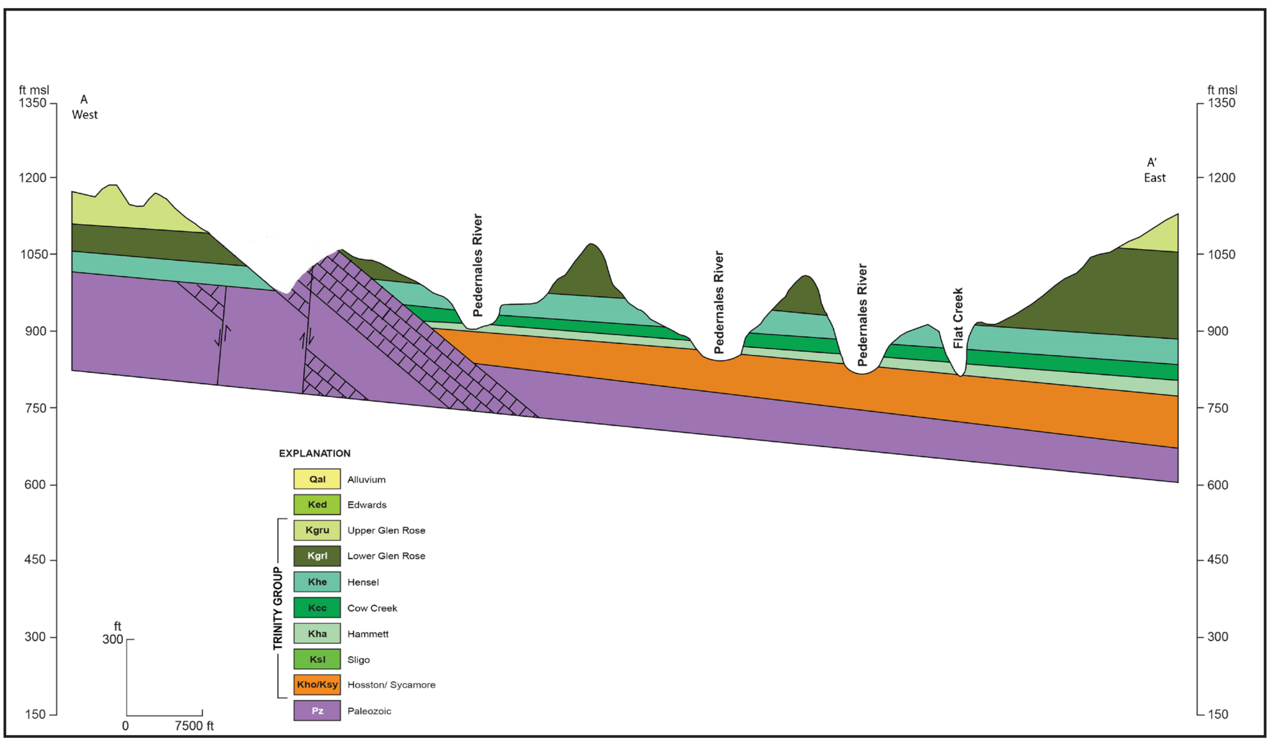

Figure 6. Geologic Cross Section (interpreted from Barnes, 1982)

Regional groundwater flow directions in the Paleozoic strata have not been determined in detail.

Per Bluntzer (1992):

> *Adequate amounts of data are not available to determine accurately the direction or rate of movement of water in the Paleozoic aquifers. However, water in those aquifers probably moves southward and southeastward along the dip of the aquifers. In some areas of Gillespie and Blanco Counties, a significant portion of the recharge probably moves into the Middle Trinity Aquifer and discharges into the Pedernales and its tributaries.*

Regional flow in the Middle Trinity Aquifer has been shown on a series of regional potentiometric surface maps over time as generally west to east across the study area of Blanco County (Hunt, et al, 2010). The regional maps are not of sufficient detail to determine flow directions in the immediate vicinity of the river.

Figure 7 represents a potentiometric surface map of the study area developed during this study. Groundwater elevations range from 1150 ft. mean sea level (MSL) in Johnson City to a low of 804 ft. MSL at Reimers Ranch near Hammetts Crossing. As the river is a rapidly gaining river in the study area (Wierman, 2017), surface water elevations were contoured along with the groundwater elevations to develop the map. Depth to groundwater in the Ellenburger wells on the north side of the river was generally shallow, typically less than 50 ft. below ground surface (bgs) and often less than 20 ft. The SWR for Well 12 drilled in 1961 indicated the well flowed at the surface at times. In October 2016, the depth to water was 12.8 ft. below the top of the well casing. Depth to groundwater in wells completed in the Middle and Lower Trinity aquifers in the eastern study area is considerably deeper than the wells completed in the Ellenburger. Water depths range from 100 – over 200 ft. bgs in the Trinity wells.

As shown in Figure 7, groundwater flow directions are clearly influenced by the river and are indicative of a gaining river. Groundwater flows towards the river in both the Paleozoic and Cretaceous Aquifers. To the north, Cypress Creek may have a similar influence on shallow groundwater with a shallow groundwater divide present between the two watersheds.

Due to the deep incision of the river and main tributaries down into the Cow Creek and Sycamore formations, the Middle Trinity and Lower Trinity aquifers have been eroded and are no longer present or deeply eroded in the study area. Along the river, these aquifers have been dewatered over time and are not productive. Water levels in the two aquifers tend to come together near the river/tributaries with groundwater discharging into the river. The Cow Creek formation pinches out to the northeast as shown on Figure 5. In areas to the southeast of the pinch out, the Cow Creek is a major water producing aquifer. Near the pinch out where the Cow Creek is thinning or absent, groundwater production appears to be from the underlying Sycamore.

Inflow to the main channel of the river from major tributaries was not measured during this study. Tributary input in the study area is derived from groundwater base flow, similar to inflow into the main channel. Major tributaries (Miller Creek and Flat Creek) are deeply incised into the Upper, Middle, and near the river, the Lower Trinity Aquifer and are dewatering the aquifers and providing base flow to the river.

Based on the potentiometric surface map, there appears to be lateral continuity of groundwater flow across both the Paleozoic and Cretaceous Aquifers. Groundwater flow in the eastern part of the study area is primarily contained in the Paleozoic Ellenburger Aquifer. In the central study area along the river in the Trinity Aquifer, the Lower Trinity Hosston formation is the primary source of groundwater due to the thinning of the Cow Creek and the deeply incised river dewatering the Middle Trinity. In the eastern study area, flow is primarily in the Middle Trinity Aquifer.

The groundwater gradient towards the river is generally greater in the Paleozoic Aquifers than the Trinity Aquifers. This may indicate there is more groundwater being discharged to the river from the Paleozoic Aquifers than the Cretaceous Aquifers. This may be the result of relatively high recharge rates in the Paleozoic Aquifers. Modeled simulated recharge developed in the Numerical Model Report: Minor aquifers of the Llano Uplift of Texas (Shi, et al, 2016) indicate high recharge rates associated with area of surficial Ellenburger strata.

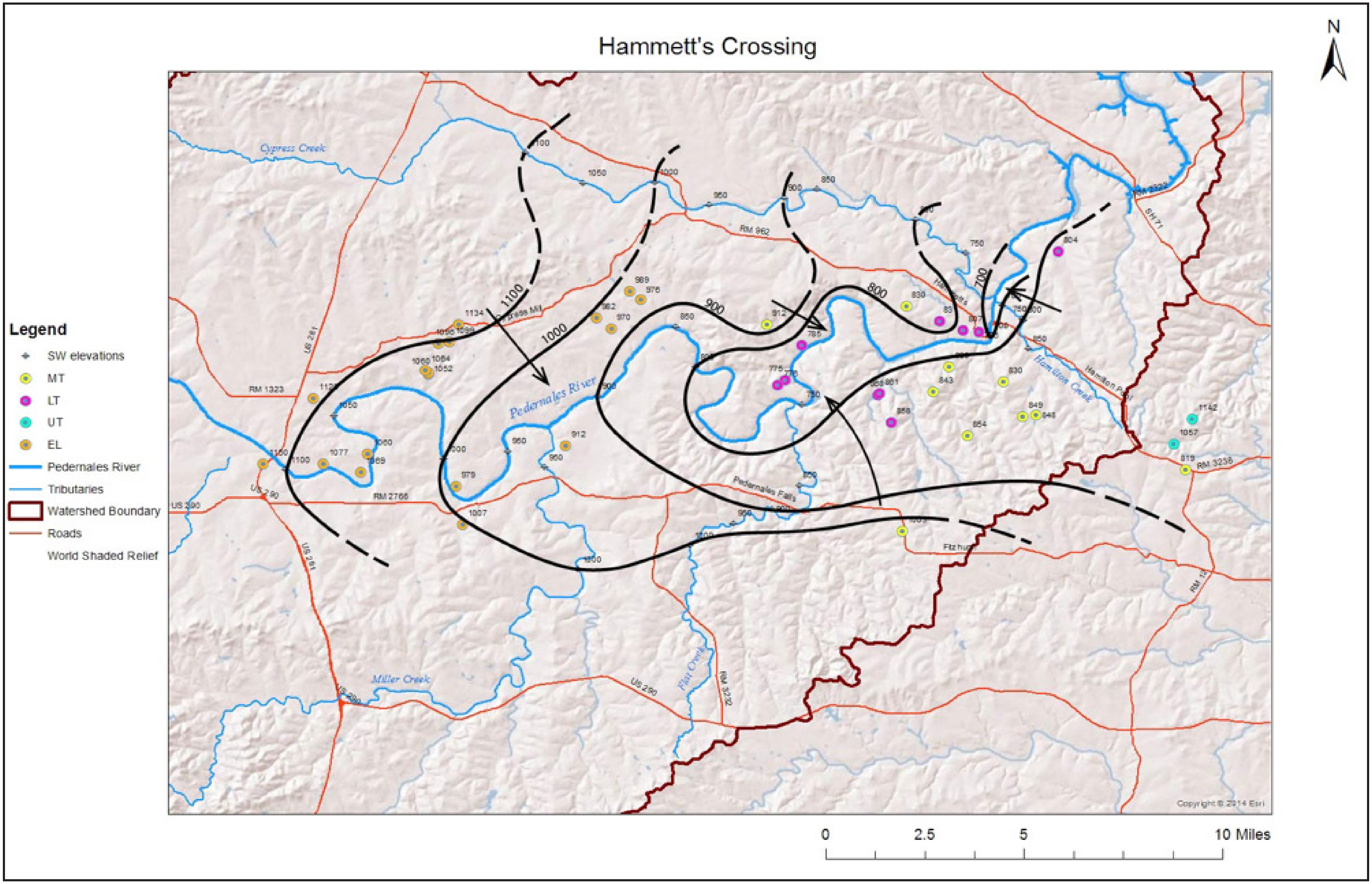

Figure 7. Study Area Potentiometric Surface Map (October 24-November 1, 2016)

CONCLUSIONS

The results of this study confirm that the groundwater from the Paleozoic and Cretaceous Aquifers contribute significant base flow to the Pedernales River and Lake Travis in the study area. Approximately half of the inflow into Lake Travis from the Pedernales River originates in the study area, or approximately 12 percent of the total inflow into Lake Travis. Shallow depths to groundwater and apparently high modeled recharge rates indicate the Paleozoic strata, primarily on the northern side of the river, contribute the majority of the inflow to the river. Future groundwater management actions in this area need to consider the importance of this area to maintaining adequate water supplies.

ACKNOWLEDGEMENTS

The Meadows Center for Water and the Environment would like to thank The Cynthia and George Mitchell Foundation for providing funding for the project.

We also thank the Blanco-Pedernales Groundwater Conservation District and the Hays Trinity Groundwater Conservation District for their help in identifying wells and obtaining water level measurements.

We especially thank all of the landowners that allowed us to enter their property and access their wells. Without cooperation of private landowners, opportunities for us to expand our knowledge of the river would not be possible.

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Table 1. Well List and Water Level Measurements - Hammetts Crossing Groundwater Study

Well #	Latitude	Longitude	Elevation	State Well #	Total Depth	Aquifer	Depth to Water 10/24 - 11/1, 2016	Groundwater Elevation
1	30.29587	-98.29375	1083			MT	171	912
2	30.29278	-98.36588	1105			EL	45.1	1060
3	30.28604	-98.36858	1118			EL	49.1	1069
4	30.28083	-98.33382	1012	128646	180	EL	33.5	979
5	30.30437	-98.17496	1068	427541	265	Kho	209.7	858
6	30.33324	-98.34005	1168			EL	72.1	1096
7	30.33766	-98.14301	840	5747305	110	Kho	43.7	796
8	30.31640	-98.27324	982	34922			not measured	
9	30.34755	-98.27647	1045	78018	320	EL	35.5	1010
10	30.34946	-98.26647	1000	78014	320	EL	23.9	976
11	30.35244	-98.27033	1015	86465	280	EL	26	989
12	30.33894	-98.27705	983	5746301	1000	EL	12.8	970
13	30.34269	-98.28262	1000		20	EL	18.1	982
14	30.36700	-98.11417	834			Kho	30.3	804
15	30.34690	-98.16956	1008	95023	360	MT	178	830
16	30.30726	-98.12220	1075	392395	320	Kcc	227	848
17	30.33827	-98.14889	856		190	Kho	49.1	807
18	30.34151	-98.15745	944		240	Kho	113.2	831
19	30.28695	-98.06761	1242	415430	580	Kcc	423	819
20	30.31578	-98.15964	1082	421894	330	Kcc	238.6	843
21	30.30646	-98.12707	1075	5747602	320	Kcc	225.7	849
22	30.32468	-98.15386	974	416399	205	Kgrl	144.2	830
23	30.29958	-98.14725	1084	378324	340	Kcc	229.9	854

Well #	Latitude	Longitude	Elevation	State Well #	Total Depth	Aquifer	Depth to Water 10/24 - 11/1, 2016	Groundwater Elevation
24	30.31430	-98.17994	887	5747503	81	LT	19.1	868
25	30.31509	-98.17932	885			LT	23.7	861
26	30.26435	-98.17110	1208	358527	360	MT	205.3	1003
27	30.28300	-98.10340	1260	5748705	600		476	784
28	30.31926	-98.13424	1090	5832	350	MT	260.2	830
29	30.30567	-98.06542	1220		503		77.6	1142
30	30.29654	-98.07206	1150		443		93.2	1057
31	30.26682	-98.33137	1092		1092	EL	85.36	1007
32	30.34030	-98.22046	951	5747107	951	MT	38.80	912
33	30.33268	-98.20771	885		885	LT	99.55	785
34	30.31997	-98.21365	916	5747403	916	LT	140.9	775
35	30.31801	-98.21634	945	19431?	945	LT	169.2	776
36	30.31329	-98.38582	1188		1188	EL	63.1	1125
37	30.32218	-98.34384	1065		1065	EL	12.6	1052
38	30.34023	-98.33276	1184		1184	EL	50.2	1134
39	30.32272	-98.34389	1074	48239	1074	EL	14.1	1060
40	30.32361	-98.34483	1080		1080	EL	16.25	1064
41	30.33386	-98.33607	1154	282282	1154	EL	55.2	1099
42	30.28925	-98.40412	1165		1165	EL	15.35	1150
43	30.28926	-98.38206	1122		1122	EL	45.1	1077

Aquifer

EL Ellenburger
LT Lower Trinity
MT Middle Trinity

APPENDIX A

State Well Reports