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Brackish Groundwater in the Hill Country Trinity Aquifer, Texas

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ABSTRACT

As part of the Texas Water Development Board (TWDB) Brackish Resources Aquifer Characterization System (BRACS), a study to delineate the extent of brackish groundwater in the Hill Country portion of the Trinity Aquifer in Texas was performed. In this study, we used geophysical well logs, submitted driller's reports, aquifer tests, and measured water quality samples to map the stratigraphy and water quality for six Trinity Group hydrostratigraphic units as well as the Hammett shale aquitard.

We analyzed 1266 geophysical well logs and driller logs to map the stratigraphy of the Trinity Aquifer in all or parts of 24 counties. These logs were used to derive 4079 stratigraphic picks that we interpolated along with select known major faults to generate stratigraphic surfaces.

The stratigraphic surfaces were then used to assign aquifer codes to aquifer tests and measured water quality analyses compiled from various public data sources, such as the TWDB Groundwater Database, public water supply entities, and groundwater conservation districts.

To determine groundwater salinity in downdip portions of the aquifer, we used a variation of the Alger-Harrison resistivity ratio method to make 1487 salinity calculations from geophysical well logs. We then used the calculated salinity values, along with measured water quality samples, to produce salinity maps for each of the six mapped hydrostratigraphic units.

Upon the completion of the project, a report detailing the methodology and results, GIS datasets, and study specific database tables (which include log interpretations) will soon be available at the TWDB website (http://www.twdb.texas.gov/groundwater/bracs/index.asp).

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INTRODUCTION

The Texas Water Development Board (TWDB) is a state agency responsible for working with 16 regional water planning groups in a comprehensive water planning process that projects demand for water 50 years into the future. Based on expected population growth and water supply, water shortages have been identified in the 2022 State Water Plan. Desalinization of brackish groundwater is one strategy available to meet future needs and characterizing the location, quantity, and quality of brackish groundwater makes this resource more accessible for development.

This report reviews the Brackish Resources Aquifer Characterization System (BRACS) study of the Hill Country portion of the Trinity Aquifer and associated downdip portions of the Trinity Group. To simplify terminology for this report, we hereafter refer to these collectively as the Hill Country Trinity Aquifer (HCT). The study area extends roughly 30 miles south and west of the TWDB–designated Hill Country portion of the Trinity Aquifer (George et al., 2011), in order to encompass more of the downdip extent of the Trinity Group.

The HCT occurs across a large portion of Central Texas. The study area covered in this report is approximately 15,500 square miles in size and encompasses all or part of 24 counties. The study area intersects four Regional Water Planning Areas and six Groundwater Management Areas. There are 22 groundwater conservation districts intersecting the study area.

The HCT is a thick sedimentary wedge of calcareous sandstone, shale, limestone, dolomite, and evaporites belonging to the Trinity Group that was deposited upon an eroded shelf of Paleozoic aged rocks. This wedge thickens from zero to 5000 feet in a northwest to southeast direction. The Trinity Group is heavily faulted in the study area by the Balcones and Luling fault zones. These fault zones tend to restrict the downdip flow of groundwater through water-bearing units, and in some portions of the study area may form a boundary between relatively fresh or slightly saline groundwater and the moderate to very saline groundwater in downdip portions of the HCT.

Groundwater within the Trinity Group is present in porous and permeable sandstones, conglomerates, and carbonate rock units that have granular, fracture, and solution porosity. Seven hydrostratigraphic units were defined and mapped for this study Upper Glen Rose limestone, Lower Glen Rose limestone, Hensell sandstone, Cow Creek limestone, Hammett shale, Sligo limestone, and Hosston sandstone. The Hammett shale is considered a non-water bearing unit because of its lithologic composition.

METHODS

Data Sources: More than 65,000 wells have been drilled for water and hydrocarbons over the last 70 years within the study area. Of these, about 24,000 have penetrated the Trinity Group formations and are shown in Figure 1. These well records have been invaluable in mapping the Trinity Group in the subsurface. However, we found that there are very few public records on the water quality and aquifer hydraulic properties of the generally deeper brackish groundwater intervals.

Stratigraphic Framework: The stratigraphic framework and geologic column used for this study is shown in Figure 2. The terminology for mappable geologic units of the Trinity Group varies according to geographic location. We decided to utilize the stratigraphic terminology used to describe the Trinity Group in the subsurface and in outcrops by previous studies in Hays, Travis, Blanco, and Gillespie counties (Wierman, 2010; Hunt et al., 2020).

We used the IHS–Markit Kingdom® geological software to interpret 1266 geophysical well-logs and driller logs. This software uses depth calibrated images of geophysical well logs and provides efficient tools for their visualization and interpretation. We mapped in the subsurface the stratigraphic units primarily based upon geophysical well log characteristics. Driller logs were used when no geophysical log was available or to confirm stratigraphic interpretations. The use of well logs from both water wells and deeper oil and gas wells allowed us to correlate

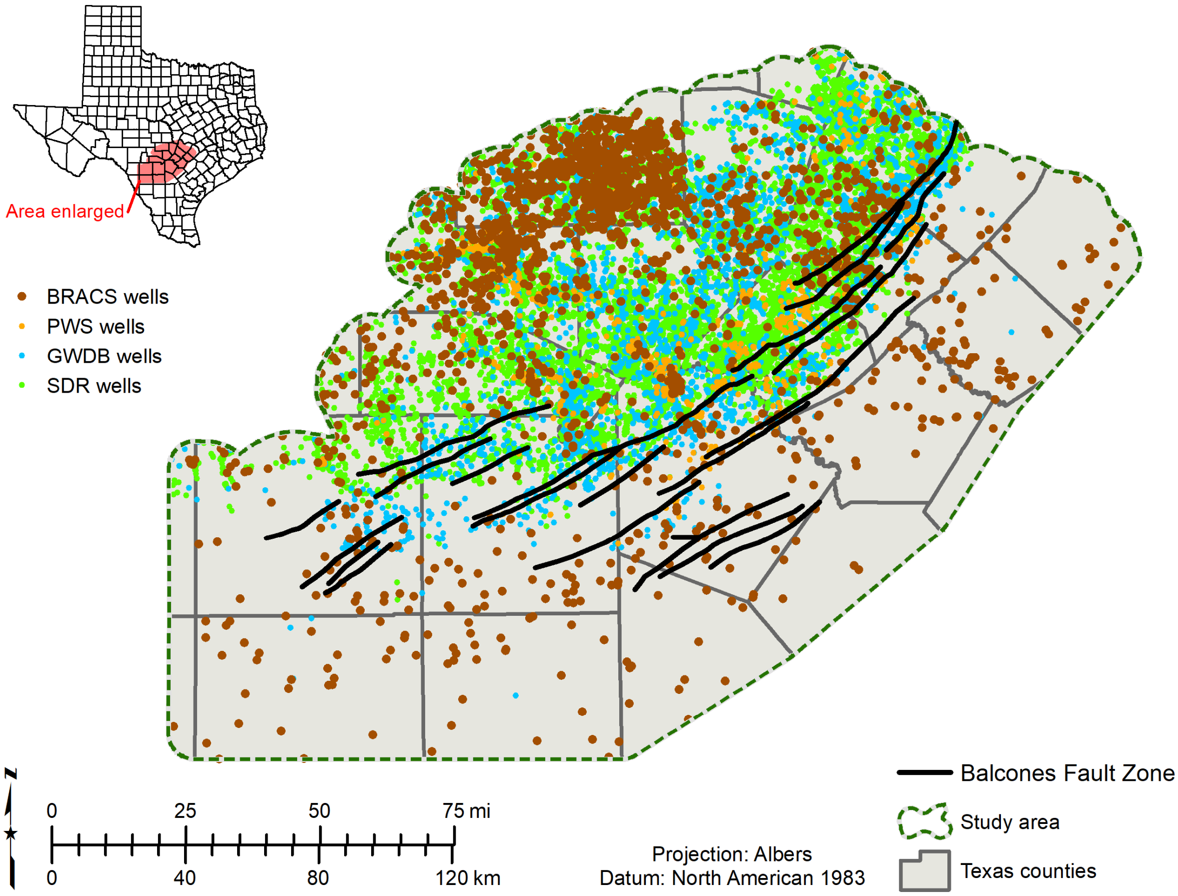

Figure 1. Well control in the Hill Country Trinity Aquifer study area. The well control consists of 23,991 wells; 2130 have been assigned well identification numbers in the TWDB BRACS Database (BRACS); 4670 wells have been assigned state well numbers in the TWDB Groundwater Database (GWDB); 17,763 wells have been assigned tracking numbers in the TWDB Submitted Drillers Report Database (SDR), and 1073 wells have been assigned well identifiers in the Texas Commission on Environmental Quality (TCEQ) Public Water Supply Database (PWS). Many of the wells exist in two or more of the sourced databases.

the hydrostratigraphic units consistently throughout the study area. Figure 3 is an example of the maps generated by the study. Figure 4 and Figure 5 are cross-sectional views of the interpolated surfaces.

Aquifer Determination: An important part of a BRACS study is the accurate assignment of groundwater samples and geophysical well log analyses to the correct hydrostratigraphic unit. We used the geologic surfaces created from the interpreted geophysical logs, driller logs, and surface geologic maps to calculate their intersections with all study area wells. For wells that had reported completion intervals, we determined which HCT hydrostratigraphic unit or units could potentially provide groundwater to the well.

Salinity Class Mapping: Measured water quality analyses were assigned an aquifer code utilizing the aquifer determination process. Calculated total dissolved solids (TDS) values were made using a modified Alger-Harrison methodology (Alger and Harrison, 1989). The Alger-

Age m.y.	Period	Epoch	Group	Formation				Hydrostratigraphic unit	Hydrologic unit
				Northern		Hill Country			
Undifferentiated post Buda formations and sediments									
95	Upper Cretaceous	Cenomanian	Washita	Grayson		Buda Del Rio			
100		Upper Albian		Mainstreet Papaw Weno Denton Fort Worth Duck Creek		Georgetown			
110	Lower Cretaceous	Lower Albian	Fredericksburg	Kiamichi Edwards Comanche Peak Walnut		Kiamichi Edwards Comanche Peak Walnut		Edwards	
			Trinity	Paluxy Glen Rose		Glen Rose		Upper Glen Rose	Upper Trinity
113		Upper Aptian						Lower Glen Rose	Middle Trinity
				Twin Mountains	Hensell	Travis Peak	Hensell (Bexar Shale)	Hensell	
					Pearsall		Cow Creek	Cow Creek	
							Hammett (Pine Island)	Hammett	
125		Lower Aptian					Sligo	Sligo	Lower Trinity
129		Hauterivian-Valanginian			Hosston		Hosston	Hosston	
Pre-Cretaceous									

Figure 2. Stratigraphic column of geological units identified within the Hill Country Trinity Aquifer study area. Hydrologic units from Ashworth (1983). Geological units that produce water from the Hill Country Trinity Aquifer are highlighted.

Harrison method utilizes the ratio of the deep and shallow resistivity measurements from an electric log, which should be equivalent to the ratio of the resistivity of the formation water to that of the mud filtrate. If more than one calculation was performed for a hydrostratigraphic unit in a well, we used the average of the calculated values in determining the appropriate salinity class.

The combined datasets of total dissolved solids (TDS) from the measured water quality samples and calculated water salinities from geophysical well logs were used to map groundwater salinity. We used all samples for which the aquifer determination process was able to uniquely associate a single hydrostratigraphic unit of the HCT. With this data, we generated salinity class maps for each hydrostratigraphic unit as shown in Figure 6.

The salinity zones are considered to exist in three dimensions delimited above and below by the corresponding stratigraphic surfaces. Our analysis treats the salinity of the groundwater to be constant within a salinity zone. This is a significant simplification as the range for very saline groundwater (10,000 to 35,000 mg/l of TDS) demonstrates. It would also be expected that thick hydrostratigraphic units such as the Hosston sandstone could contain groundwater of varying salinity between the top of the unit and the base of the unit at a specific location.

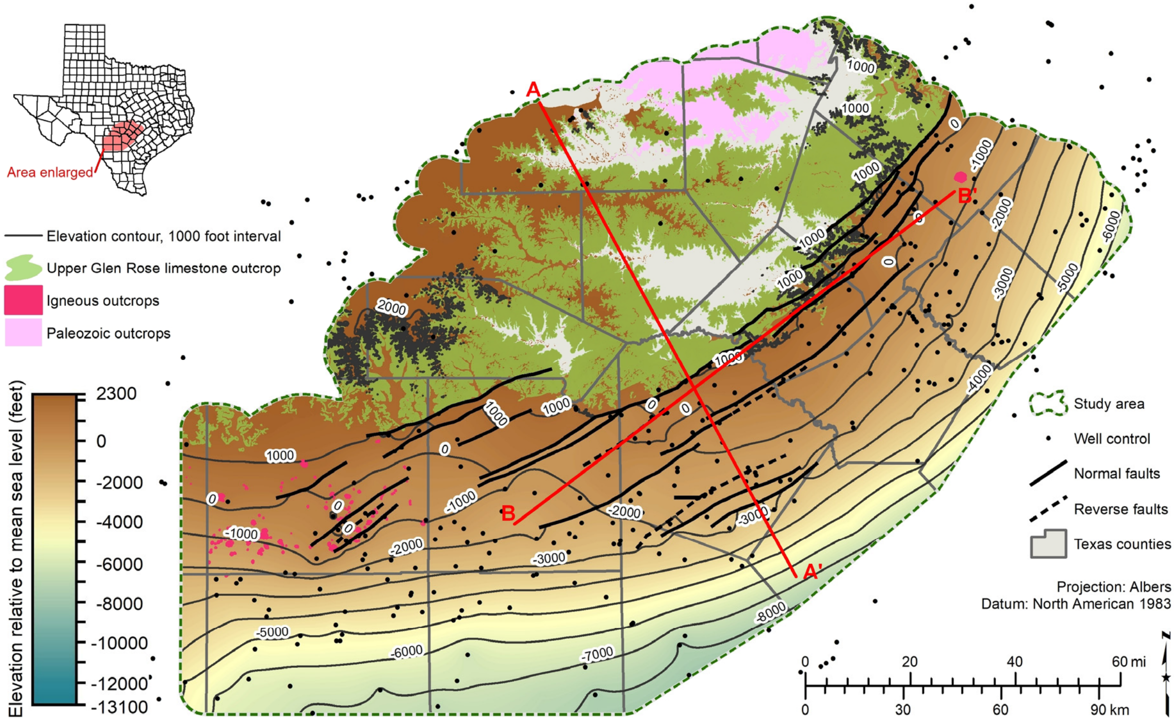

Figure 3. Upper Glen Rose limestone structure map (elevation datum is mean sea level, feet). Location of cross-section lines shown in red.

Groundwater Volumes: In-place groundwater volumes were calculated for the six water-bearing hydrostratigraphic units defined for the HCT. We used the stratigraphic surfaces, salinity zones, aquifer properties, and static water level surfaces to calculate groundwater volumes. The primary purpose of these in-place volumes is to provide some form of quantitative volumetric measurement for the brackish groundwater resources of HCT.

RESULTS

Overall, our calculations determined that for the HCT within the study area (Fig. 7) there are approximately 26.2 million acre-feet of fresh groundwater (TDS less than 1000 mg/l), 25.7 million acre-feet of slightly saline groundwater (TDS between 1000 and 3000 mg/l), 34.4 million acre-feet of moderately saline groundwater (TDS between 3000 and 10,000 mg/l), and 41.6 million acre-feet of very saline groundwater (TDS between 10,000 and 35,000 mg/l). We realize that not all brackish groundwater can be produced or economically developed; however, these estimates and detailed mapping provide users a beneficial tool to evaluate potential sites for brackish groundwater well fields. Because these volumes do not consider the effects of land surface subsidence, degradation of water quality, or any changes to surface water–groundwater interaction that may result from extracting groundwater from the aquifer, these volumes should not be used for joint groundwater planning or evaluation of achieving adopted desired future conditions,

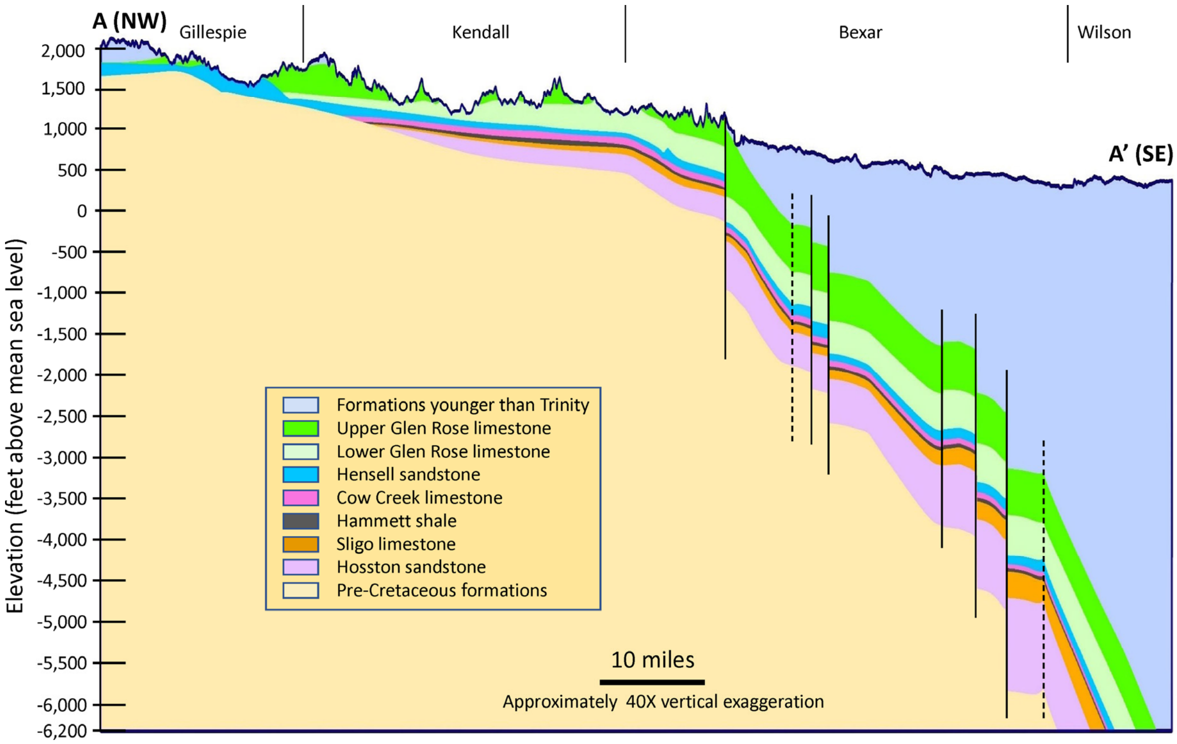

Figure 4. Cross-section A–A'. Refer to Figure 3 for cross-section location.

SUMMARY AND CONCLUSIONS

This study is intended to provide a researched technical evaluation of the brackish groundwater resource of the HCT. In general, fresh and slightly saline groundwater is present in the shallower up dip northern portions of the study area, in which the average depths to fresh water in the HCT ranges from 45 feet for the Upper Glen Rose limestone to 708 feet for the Hosston sandstone. The average depth to slightly saline groundwater ranges from 297 feet for the Upper Glen Rose limestone to 1,419 feet for the Hosston sandstone. The average depth to moderately saline groundwater ranges from 2257 feet for the Upper Glen Rose limestone to 3897 feet for the Hosston sandstone. The average depth to very saline groundwater ranges from 5732 feet for the Upper Glen Rose limestone to 7643 feet for the Hosston sandstone. It should be noted that fresh and slightly saline groundwater in the eastern half of the study area does not extend beyond the Balcones Fault Zone for all the HCT water bearing units.

Publicly available study deliverables include a detailed report, geographic information system (GIS) map files, BRACS database and data dictionary, and water well and geophysical well log files.

Finally, information contained in this report is not intended to serve as a substitute for site specific studies that are required to evaluate local aquifer characteristics and groundwater conditions for a desalination plant. Well-field scale data collection using test and monitor wells is strongly recommended to evaluate the brackish groundwater resource. Collection and evaluation of additional well control in a prospective site area is essential in understanding potential target zones for groundwater development.

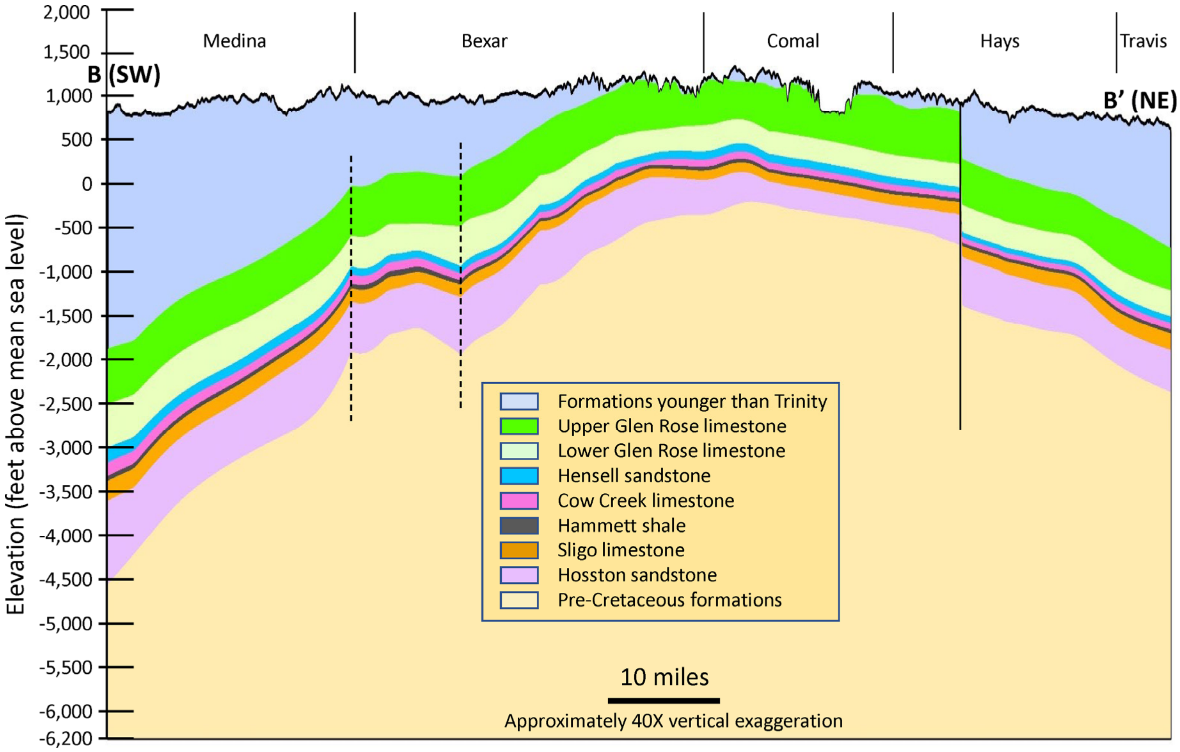

Figure 5. Cross-section B–B'. Refer to Figure 3 for cross-section location.

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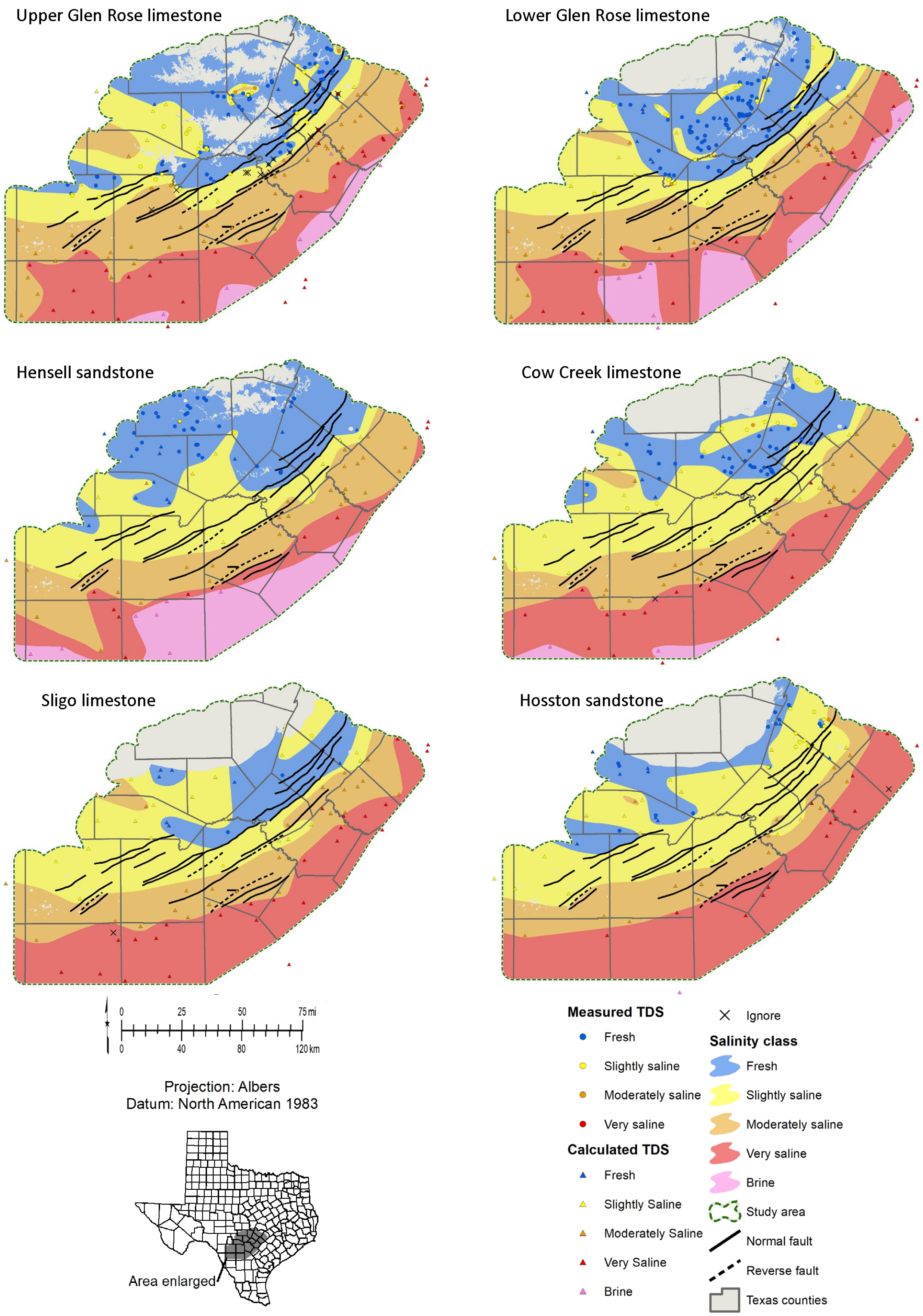

Figure 6. Salinity classes and well control for the six hydrostratigraphic units of the Hill Country Trinity Aquifer.

Hydrostratigraphic unit	Volume (acre-feet)				
	Fresh	Slightly Saline	Moderately Saline	Very Saline	Total
Upper Glen Rose limestone	5,530,304	10,336,358	17,977,443	16,185,301	50,029,406
Lower Glen Rose limestone	11,331,490	7,894,516	6,930,421	7,425,026	33,581,453
Hensell sandstone	1,141,257	1,418,834	2,545,598	1,726,180	6,831,869
Cow Creek limestone	7,489,403	1,417,710	1,103,829	1,972,350	11,983,292
Sligo limestone	237,826	819,872	1,489,536	3,604,435	6,151,669
Hosston sandstone	441,327	3,843,017	4,305,021	10,696,842	19,286,207
Total	26,171,607	25,730,307	34,351,848	41,610,134	127,863,896

Figure 7. The volumes of fresh, slightly saline, moderately saline, very saline, and total groundwater volumes in the Hill Country Trinity Aquifer.

Wierman, D. A., A. S. Broun, and B. B. Hunt, 2010, Hydrogeologic atlas of the Hill Country Trinity Aquifer Blanco, Hays, and Travis counties, Central Texas: Hay-Trinity Groundwater Conservation District, Austin, Texas, 19 p. + 17 plates.

NOTES