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# Same Aquifer, but Different Source of Water: Contrasting the Middle Trinity Aquifer in Central Texas

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## ABSTRACT

The Cretaceous Middle Trinity (MT) Aquifer is an important groundwater resource for water-supply, economic, and environmental needs of the Texas Hill Country. However, pumping of groundwater resources is producing unacceptable consequences and is thus not achieving a sustainable yield (Alley and Leake, 2004). This talk describes the hydrogeology of the MT Aquifer in adjacent areas of Central Texas (Wimberley in central Hays County, and Bee Caves in southwestern Travis County). Although these areas have a similar geologic and structural setting, the regional hydrogeologic evaluations (Wierman et al., 2010; Hunt et al. 2020) reveal starkly different properties between these two adjacent areas. The results of pumping and other factors for these areas illustrates the classic concept of Theis (1940) that water discharged from wells is balanced by a loss of water somewhere—either from storage (water-level depletion) or capture (decreased springflow).

In the Wimberley area, the MT is the primary groundwater supply and contains high-yield wells, fresh and isotopically young groundwater, numerous significant karst features, and large springs. Impacts from pumping include capture of spring flow and localized water-level depletion. Groundwater availability is limited by drought, springflow decline, and localized well interference. Groundwater management could implement sustainable yield concepts that protect spring flow, water levels, and thus availability. However, if pumping and declining water level and spring flow trends continue, achieving sustainability will not be possible.

In contrast, in the Bee Caves area, the MT is a secondary groundwater supply and contains low-yield wells, brackish and isotopically old groundwater, and is undergoing regional water-level depletion (mining) with parts

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of the MT being entirely unsaturated. Groundwater availability is limited by aquifer properties, well interference, and saturated thickness. Groundwater management will likely involve managed aquifer depletion (MAD) concepts rather than sustainable yield.

With this understanding, groundwater-management agencies can develop targeted policies and strategies to conserve the resource and move the groundwater resources closer to sustainability or increased resiliency.

## INTRODUCTION

The Cretaceous Middle Trinity (MT) Aquifer is an important groundwater resource for water supply, economic, and environmental needs of the Texas Hill Country. The Hill Country Priority Groundwater Management Area was designated in 1990 in response to existing and projected groundwater availability issues within the Trinity aquifers. Rapid growth and demand for water has further strained limited resources.

However, the hydrogeology of the MT Aquifer in adjacent areas of Central Texas (Wimberley in central Hays County, and Bee Caves in southwestern Travis Count; Fig. 1) responds differently to the stress of drought and pumping.

### Hydrogeologic Concepts

A fundamental concept in hydrogeology was illuminated by Theis (1940) that is the essence of quantitative hydrogeology (Bredehoeft and Alley, 2014) and bears on the source of water to wells, and therefore the different aquifer responses to pumping in this study. In that paper he stated that, "All water discharged by wells is balanced by a loss of water somewhere" (Theis, 1940). Theis goes on to define the source of water to wells as either (1) storage—from the aquifer matrix or (2) capture—groundwater capture is increased recharge but is dominated by a decrease in natural discharge.

Storage depletion and capture are variable in space and time. However, if capture is constrained (not able to induce recharge) then equilibrium may never be reached and depletion will continue. Pumping is not sustainable if capture is constrained (Konikow and Leake, 2014).

Time to reach equilibrium is a function of boundary conditions and hydrogeologic properties. Groundwater movement is nearly always substantially slower than the propagation of hydraulic stresses through most types of aquifers, particularly those that are the source of most large-scale groundwater withdrawals (Barlow and Leake, 2012).

### Groundwater Management Concepts

Groundwater sustainability is an important concept in the management of groundwater and is often the motivation for a given hydrogeologic study. Sustainable yield is defined as the use of groundwater indefinitely without unacceptable consequences (Alley and Leake, 2004).

While the concept of sustainability involves scientific reasoning and analyses, the results are derived from subjective considerations of what is a negative or unacceptable consequence. Sustainable yield is a form of commons governance, so the terms of use is defined by the community (Alley and Leake, 2004). An example of the sustainable yield for the Barton Springs segment of the Edwards Aquifer is described in Hunt et al. (2019).

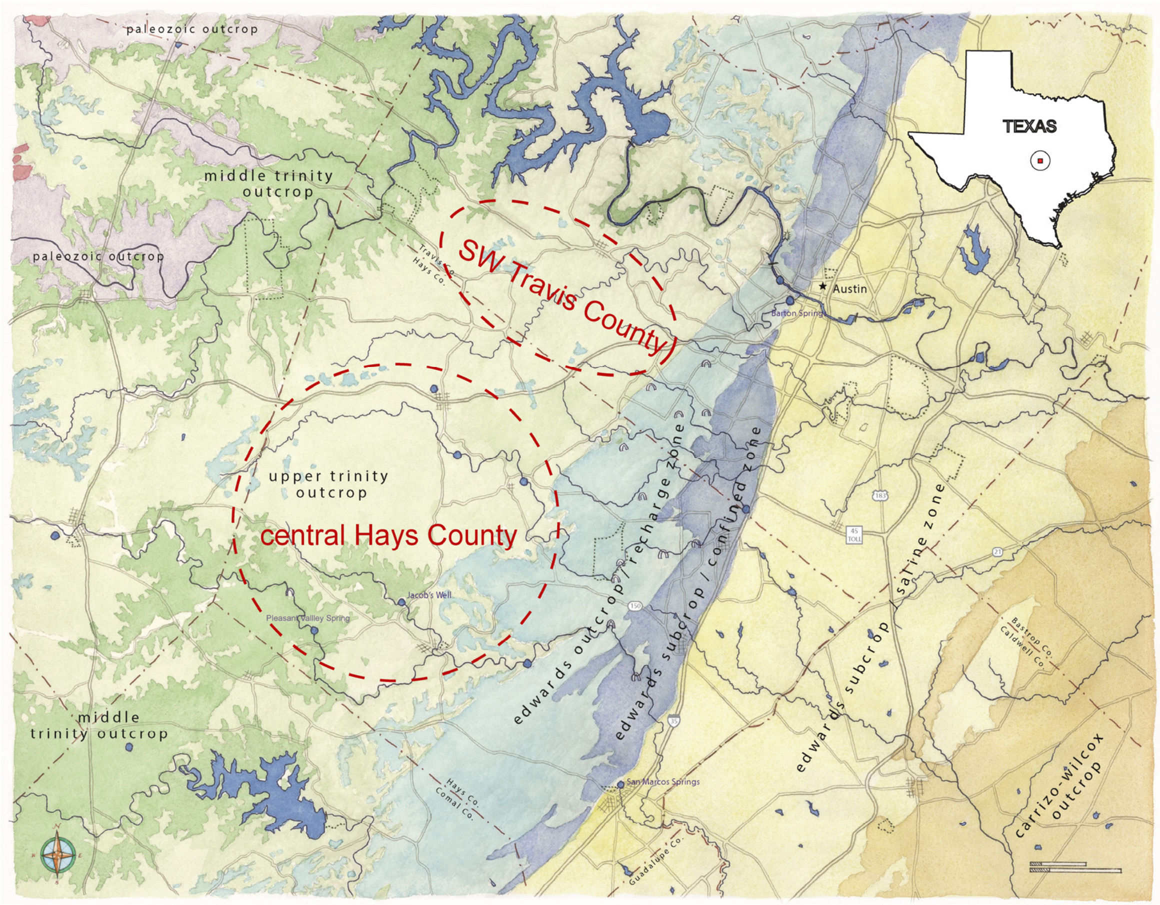


Figure 1. Map of study area (modified after BSEACD, 2017).

## METHODS

Geologic and hydrogeologic data from recent regional studies (Wierman et al., 2010; Gary et al., 2019; Hunt et al. 2020) were used to characterize the study area. Methods and data included: aquifer framework (geologic and stratigraphic data), groundwater flow and aquifer parameters (aquifer tests, potentiometric maps, dye tracing), hydrograph analyses, and pumping estimation (Cockrell et al., 2020). Limited numerical and analytical modeling was also performed and described in Hunt and Smith (2020). Data from those studies were used to synthesize and develop regional conceptual models of the aquifers in the study area.

## RESULTS

The integration of geologic and hydrogeologic data was synthesized into conceptual models of the aquifers in the study area shown in Figures 2 and 3.

In southwestern Travis County, the MT Aquifer water levels are near the bottom of the aquifer reflecting a low-yielding and depleted aquifer. In this area, the groundwater is relatively old (low values of $^{14}C$ and tritium reflecting premodern water older than 1950, or mixing between

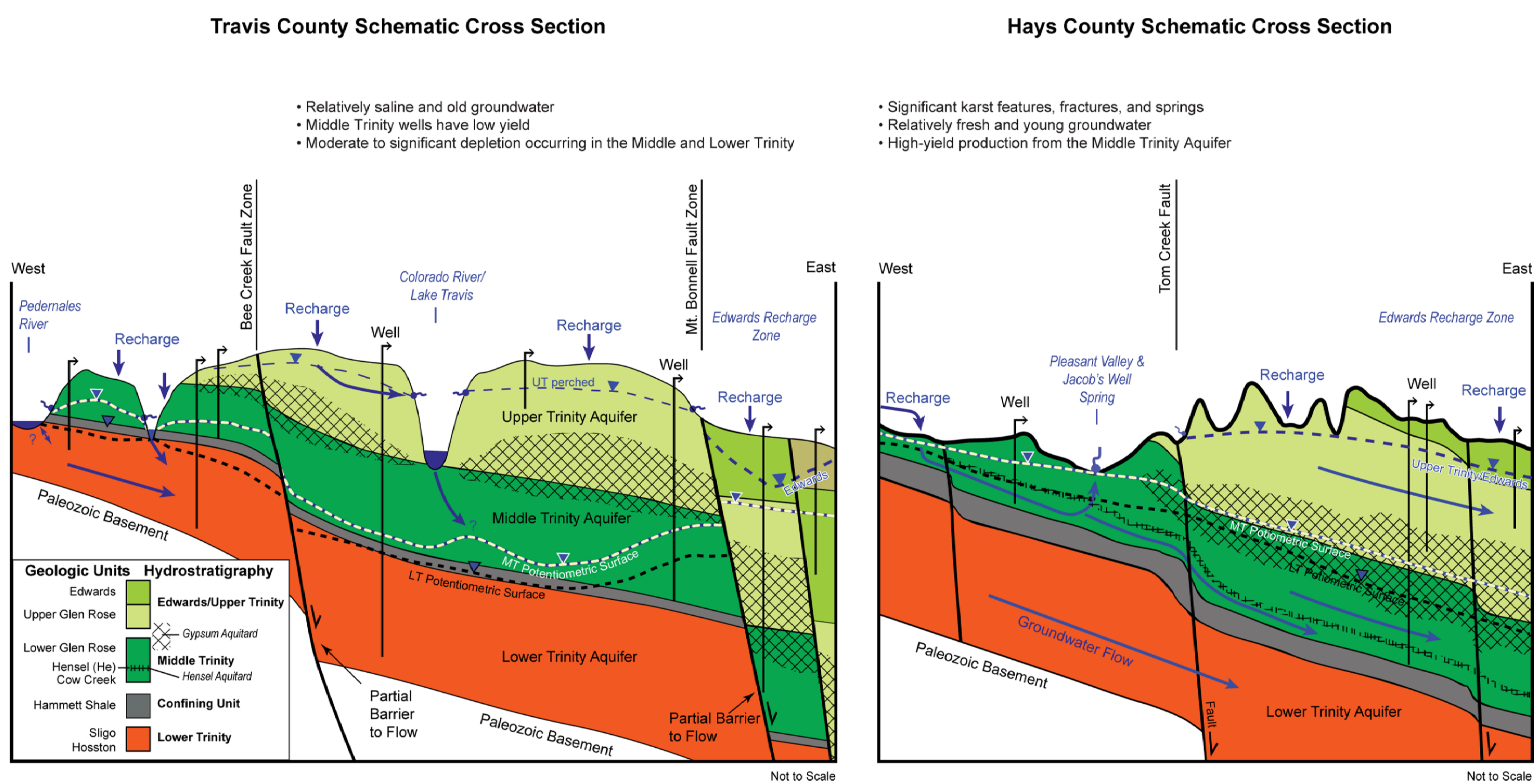


Figure 2. Schematic cross sections of the area (modified after Hunt et al., 2020).

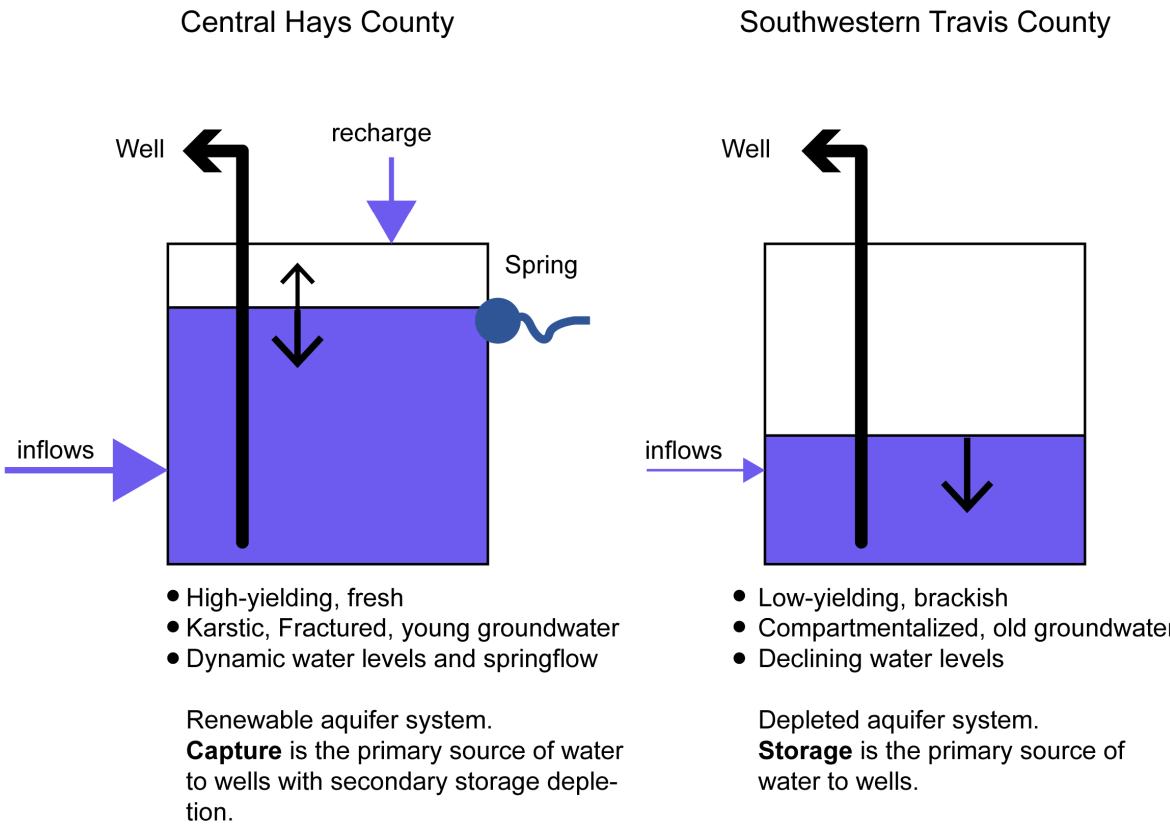


Figure 3. Schematic diagram and summary contrasting the Middle Trinity Aquifer in adjacent areas of Central Texas.

modern and premodern waters) and brackish, indicating distal recharge and little surface-groundwater interaction. Overall, the aquifer appears compartmentalized due to faulting and the low permeability aquifer matrix.

In contrast, the central Hays County area has more dynamic water levels and overall reflects a relatively saturated high-yielding aquifer. This area has significant fracture and karstic recharge, locally rapid groundwater flow, and fresh and young groundwater sustaining spring flow.

## SUMMARY AND CONCLUSIONS

Although these areas have a similar geologic and structural setting, the regional hydrogeologic evaluations (Wierman et al., 2010; Hunt et al. 2020) reveal starkly different properties between these two adjacent areas. The results of pumping and other factors for these areas illustrates the classic concept of Theis (1940) that water discharged from wells is balanced by a loss of water somewhere—either from storage (water-level depletion) or capture (decreased spring flow).

Figure 3 summarizes the overall hydrogeologic differences with the same aquifer and describes the different source of water for each respective area. It should be noted that these diagrams and conceptual models are end-member representations and conceptualizations of the broader system.

With this understanding, groundwater-management agencies can develop targeted policies and strategies to conserve the resource and move the groundwater resources closer to sustainability or increased resiliency. With the understanding that these two segments of the MT are undergoing depletion (albeit at different rates and extent), management of the groundwater resources should acknowledge that any additional pumping will accelerate the decline in water levels and springflow in Hays County.

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## NOTES