EXECUTIVE SUMMARY

Groundwater is essential to the communities, economy, and natural resources of Kinney County. It supports municipal and domestic water supplies, ranching, agriculture, and numerous springs that have played an important role in the history and development of the county. Among these is Las Moras Springs, one of the largest remaining spring systems in Texas. Historically, mean daily spring discharge has averaged approximately 17.7 cubic feet per second (cfs), although flows vary substantially under changing hydrologic conditions. Recent periods of prolonged drought and reduced spring discharge have renewed interest and desire to better understanding how groundwater moves through the county and the relationships between drought, groundwater pumping, and spring discharge.

The Kinney County Groundwater Conservation District (District), with support of its Board of Directors, has made a significant investment in improving the scientific understanding of groundwater resources in Kinney County. As part of this effort, the District engaged Freese and Nichols, Inc. (FNI) to update the conceptual groundwater flow model for the county. This work brings together more than a century of hydrogeologic research with recent groundwater level measurements, water quality data, and geophysical and lithologic information under a county-wide groundwater framework. By evaluating these data collectively, the study provides a more complete understanding of how groundwater enters, moves through, and leaves the aquifer systems within Kinney County. The resulting conceptual model builds on previous investigations and provides an updated framework for evaluating regional groundwater flow patterns, hydraulic connections, and the geologic conditions that influence groundwater movement.

Hydrogeologic Framework

At the center of Kinney County is the transition between two major aquifer systems, as designated by the Texas Water Development Board (TWDB): the Edwards-Trinity (Plateau) Aquifer and the Edwards (Balcones Fault Zone [BFZ]) Aquifer. Both include the same Cretaceous limestone rocks, although their hydrogeologic characteristics and regional groundwater flow patterns differ. The Austin Chalk also provides groundwater to wells in portions of the county, along with other formations that locally may yield water in the outcrop areas along fractures and other zones of secondary porosity. Recharge occurs through infiltration of precipitation on exposed limestone and through streambeds and other recharge features, particularly along the West Nueces River. Groundwater moves through fractures, faults, and solution enhanced karst openings before discharging through springs, groundwater wells, and subsurface flow toward surrounding areas.

Kinney County has experienced multiple periods of geologic deformation that produced faults, folds, and other structural features. Some of these features may enhance groundwater movement where fractures and faults provide permeable pathways. Others may restrict flow where changes in lithology, structural displacement, or igneous intrusions reduce permeability and hydraulic connectivity. The Kinney County groundwater system reflects the combined influence of regional hydrostratigraphy, geologic structure, and the development of karst and secondary porosity within the limestone.

An important part of this investigation was developing an updated three-dimensional hydrostratigraphic model of Kinney County. The model integrates geophysical logs, lithologic descriptions, mapped geologic contacts, and other subsurface information to characterize the principal geologic formations. Particular attention was given to the Salmon Peak, McKnight, and West Nueces formations of the Edwards and the underlying Glen Rose Formation of the Trinity Group. These formations have different lithologic and hydraulic characteristics that influence groundwater movement and contribute differently to groundwater occurrence across the county. The Salmon Peak Formation contains fractures, faults, and solution enhanced karst openings that provide pathways for groundwater movement. The underlying McKnight Formation includes intervals with different lithologic and hydrochemical characteristics, including evaporite that may influence groundwater chemistry. Groundwater movement within the West Nueces Formation appears more restricted, although localized flow may occur through fractures and other secondary porosity. The Glen Rose Formation represents an additional potential source of groundwater, specifically where wells are completed across both the Edwards and Trinity Groups. These observations are important to the overall understanding of groundwater occurrence in Kinney County, because the Edwards does not necessarily behave as a single, uniform groundwater producing interval. Instead, groundwater movement and the relative contribution from individual units vary geographically and under different hydrologic conditions.

Groundwater Levels and Regional Flow Patterns

Groundwater level maps indicate that groundwater generally moves from recharge areas in northern Kinney County toward discharge areas to the south, southwest, and east. These maps also identify a recurring pattern of groundwater flow divergence in central Kinney County, generally associated with a groundwater divide that corresponds with the Pinto Valley and Grass Valley areas.

Although the approximate divide is identifiable under different hydrologic conditions, its location and hydraulic expression vary among the mapped periods. The recurrence of this regional flow pattern

suggests that the divide is associated with relatively persistent hydrogeologic controls rather than representing a temporary response to an individual event. Importantly, the divide should not be interpreted as a fixed geographic boundary or as a continuous barrier to groundwater flow. Its location and behavior may change with recharge, groundwater levels, pumping, and the connection of permeable pathways between adjacent areas. West of the interpreted divide, groundwater generally moves southward and southwestward through the Pinto Valley area, consistent with regional movement toward Pinto Springs and discharge areas farther southwest, including the Rio Grande. East of the divide groundwater movement is generally directed towards Las Moras Springs and eastward toward Uvalde County. Although these represent the dominant regional flow directions, local groundwater movement may differ because of geologic structure, pumping, or changes in hydraulic gradients.

Evaluation of groundwater level hydrographs also identified differences in groundwater response across Kinney County. These differences were used to characterize several hydrogeologic domains, including an eastern transition zone, a central domain containing the Pinto Valley and Grass Valley response areas, and a western domain. Groundwater levels within these areas respond differently to recharge and pumping, reinforcing that hydraulic conditions are not uniform throughout the county. The boundaries between these response domains are interpretive and represent changes in groundwater behavior rather than hydraulic barriers.

Pinto Valley and Grass Valley Groundwater Pools

A principal finding of this investigation is that groundwater within the Pinto Valley and Grass Valley areas exhibits differences in groundwater level responses, hydrochemical characteristics, and regional flow directions. Collectively, these observations support distinguishing two principal groundwater pools within the Edwards: the Pinto Valley Pool west of the interpreted groundwater divide and the Grass Valley Pool east of the divide.

Within the Pinto Valley Pool, groundwater movement and production appears to involve both the Salmon Peak and McKnight formations. Groundwater levels are generally higher than those observed in Grass Valley, although these differences vary by location and hydrologic conditions. Groundwater chemistry and temperature also suggest that groundwater within Pinto Valley may interact with multiple hydrostratigraphic intervals, including deeper sections of the aquifer. The relative contribution of each formation remains uncertain due to the number of wells completed across multiple units. In contrast, groundwater movement in the Grass Valley Pool appears more strongly associated with the Salmon Peak

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Formation and exhibits a stronger response to rainfall and recharge events. Groundwater level responses in portions of Grass Valley are also closely associated with discharge at Las Moras Springs.

Groundwater chemistry provides another line of evidence for distinguishing the two areas. Differences in groundwater temperature, sulfate concentrations, and specific conductance are consistent with variations in groundwater flow paths, water-rock interactions, and potentially the relative contributions of individual formations. Specifically, elevated sulfate concentrations and specific conductance in some wells may reflect interaction with evaporite bearing intervals of the McKnight Formation or mixing with more mineralized groundwater from a greater depth.

The July 2026 precipitation event provided an additional opportunity to evaluate groundwater level and hydrochemical responses under changing recharge conditions. Observations from monitoring wells indicated differences in the timing and magnitude of groundwater level and specific conductance responses between Pinto Valley and Grass Valley. A more pronounced and immediate increase in specific conductance was observed in Pinto Valley and may reflect increased interaction with mineralized intervals of the McKnight Formation, while Grass Valley demonstrated a delayed and more subdued response in specific conductance, indicating mixing with more saline water over a longer period of time.

Conceptual Western Boundary of the Edwards BFZ Aquifer

Based on the combined groundwater level, hydrochemical, and geologic evidence, the conceptual western boundary of the Edwards BFZ aquifer within Kinney County is interpreted to approximately follow the main axis of the regional groundwater divide between the Pinto Valley and Grass Valley pools.

Under this conceptual framework, the Pinto Valley Pool is interpreted as part of the Edwards-Trinity (Plateau) Aquifer, whereas the Grass Valley Pool remains associated with the Edwards (BFZ) Aquifer. This interpretation reflects differences in dominant regional groundwater flow directions, groundwater level responses, hydrochemical characteristics, and relationships with groundwater discharge areas. It is important to note that this is only a conceptual refinement of the hydrogeologic boundary between the two aquifer systems, and not a formal revision to TWDB designated aquifer boundaries. Additionally, this boundary should not be interpreted as a fixed line separating two hydraulically independent groundwater systems.

Hydraulic Connections Between Groundwater Pools

Groundwater level observations, previous dye-tracing investigations, and the regional geologic framework suggest that hydraulic connections exist between portions of the Pinto Valley and Grass Valley Pools. North of Highway 90, groundwater levels are generally higher in Pinto Valley than in Grass Valley, suggesting that hydraulic gradients may favor groundwater movement from west to east where permeable connections exist. Near Highway 90, geologic mapping, dye-tracing investigations, and potentiometric data suggest that groundwater movement may be locally restricted by structural features, potentially by an igneous intrusion. During periods of relatively high groundwater levels, additional permeable pathways may become saturated, potentially allowing groundwater movement from the Pinto Valley Pool toward the Grass Valley Pool where hydraulic gradients are favorable. South of Highway 90, groundwater exchange may be influenced by structural dip, faults, and local folds. Under lower groundwater level conditions, pumping in the Standart irrigation area may influence local hydraulic gradients and favor groundwater movement toward Standart from portions of the surrounding groundwater system. These possible changes in groundwater movement represent conceptual interpretations rather than demonstrated flow rates or established pathways of continuous exchange.

The Standart irrigation area presents additional uncertainty because some wells are completed across both the Edwards and the Trinity Group. Groundwater level responses and regional geologic relationships suggest potential hydraulic communication between Pinto Valley and portions of Standart. However, the relative contributions of the Edwards Group and Glen Rose Formation to groundwater production remain uncertain. Some wells in the Standart area also exhibit elevated groundwater temperatures, salinity, and sulfate concentrations that may reflect contributions from the McKnight Formation, Glen Rose Formation, or mixing between groundwater from multiple intervals. Differences in well construction and local geologic conditions may also influence these observations. As a result, groundwater levels and chemistry measured in wells completed across multiple formations may not represent conditions within a single hydrostratigraphic unit.

Although the available data support the potential for hydraulic connections between Pinto Valley, Standart, and Grass Valley, they do not establish the magnitude of groundwater exchange or the extent to which groundwater production in one area affects groundwater conditions in another.

Las Moras Springs and Groundwater Discharge

Las Moras Springs is a principal groundwater discharge feature of the Grass Valley Pool and provides base flow to Las Moras Creek. Spring discharge reflects the combined influence of recharge, aquifer storage,

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hydraulic gradients, and groundwater movement through the surrounding hydrogeologic system. Historical records demonstrate substantial variability in spring flow, including periods of reduced or intermittent discharge during prolonged drought.

Groundwater level and spring discharge observations indicate that Las Moras Springs responds to changing aquifer conditions, although groundwater level responses are not uniform throughout Kinney County. During periods of limited recharge, groundwater levels may decline as water continues to discharge through springs, groundwater wells, and subsurface flow pathways. If hydraulic heads decline below the elevations necessary to sustain spring discharge, spring flow may decrease or cease until groundwater level conditions recover. Groundwater pumping can also influence hydraulic heads and groundwater movement. The magnitude and timing of these effects depend on production rates and duration, aquifer properties, hydraulic connectivity, recharge conditions, and the location of pumping wells relative to groundwater discharge features.

In the vicinity of Las Moras Springs, groundwater production by the City of Brackettville and Fort Clark Municipal Utility District may influence local groundwater levels and the hydraulic gradients that support spring discharge. Although these municipal wells account for a relatively small portion of countywide groundwater production, their proximity to the springs and potential hydraulic connectivity may result in effects that differ from those associated with pumping farther away. The magnitude of these potential effects has not been quantified in this investigation.

Groundwater production elsewhere in Kinney County, including Pinto Valley and the Standart irrigation area, may also influence groundwater conditions where hydraulic connections exist. The presence of the regional groundwater divide does not independently demonstrate that groundwater production west of the divide has no potential influence on spring discharge. Similarly, the possibility of groundwater exchange between the pools does not establish that pumping west of the divide produces a measurable reduction in spring flow.

The relative contributions of drought, groundwater pumping, and other hydrogeologic factors to observed changes in Las Moras Springs discharge have not been quantified in this conceptual model. Evaluating these relationships would require additional hydrogeologic investigations and numerical groundwater flow modeling capable of examining groundwater level and spring discharge responses under different recharge and pumping conditions.

Remaining Uncertainties and Future Investigations

Although this investigation improves understanding of groundwater flow in Kinney County, several important uncertainties remain. These include the location and hydraulic behavior of the regional groundwater divide, the magnitude and direction of groundwater exchange between the Pinto Valley and Grass Valley Pools, groundwater movement between the Edwards and the Trinity Group, and the extent to which geologic structures influence regional groundwater flow pathways. Additional uncertainty remains regarding aquifer hydraulic properties, the relative contributions of individual formations to groundwater production, and the relationships between groundwater pumping and spring discharge.

Four principal investigations are recommended to further improve the conceptual groundwater flow model.

First, additional well construction and completion information would improve interpretation of groundwater level and hydrochemical observations, particularly where wells are completed across multiple formations. Many existing wells were constructed several decades ago, and available records are incomplete. Better information regarding well depths, casing, open-hole intervals, and producing formations would better help identify which hydrostratigraphic units are represented by groundwater level and water quality observations.

Second, additional aquifer testing would improve characterization of hydraulic properties within the principal groundwater formations. Information regarding transmissivity, hydraulic conductivity, storage properties, and hydraulic responses to pumping would provide a stronger basis for evaluating groundwater movement and supporting future numerical modeling.

Third, further investigation of the Glen Rose Formation would improve understanding of its contribution to groundwater production and potential interaction with the Edwards. This uncertainty is particularly important in the Standart irrigation area, where some wells are completed across both groups and groundwater chemistry suggests that multiple formations may contribute to production.

Finally, expansion of the groundwater level monitoring network would improve characterization of the regional groundwater divide and the hydraulic relationships between the Pinto Valley and Grass Valley Pools. Additional monitoring locations would be particularly valuable in areas with limited geographic coverage, including the western groundwater level response domain, near Highway 90, and east of the Standart irrigation area. Repeated measurements under different recharge and pumping conditions would help characterize changes in hydraulic gradients and the location and expression of the divide through time.

These investigations should be implemented strategically and incrementally, with priority given to locations and data gaps most likely to influence interpretations of regional groundwater movement and hydraulic connectivity. The resulting information would provide opportunities to test and refine the conceptual model while improving the technical basis for future numerical groundwater flow modeling.

Key Takeaways

The updated conceptual groundwater flow model provides a more detailed understanding of the hydrogeologic framework of Kinney County and the factors that influence groundwater movement within and between its principal groundwater systems. The investigation supports distinguishing the Pinto Valley and Grass Valley Pools based on differences in groundwater level responses, hydrochemical characteristics, and regional flow directions. The combined evidence also supports interpreting the approximate axis of the recurring regional groundwater divide as the conceptual western boundary of the Edwards (BFZ) Aquifer within Kinney County. Although the two pools exhibit distinguishable hydrogeologic characteristics, hydraulic connections may exist between them, and groundwater exchange may vary under different hydrologic conditions. The groundwater divide does not necessarily prevent movement between the pools, nor does the potential for hydraulic exchange establish the magnitude of groundwater movement or the effects of production in one area on groundwater conditions elsewhere.

This investigation was intended to improve the conceptual understanding of groundwater flow rather than quantify the effects of individual groundwater production activities or establish groundwater availability under specific pumping scenarios. The available information does not establish the magnitude of groundwater exchange between the Pinto Valley and Grass Valley Pools or the effects of groundwater production from specific areas on Las Moras Springs.

The updated conceptual model represents an important advancement in understanding the groundwater systems of Kinney County. Although uncertainties remain, the findings provide a stronger foundation for evaluating regional groundwater movement, hydraulic connections, and the factors that influence groundwater levels and spring discharge. The District's investment in this investigation, reflects a commitment to improving the scientific information available for groundwater management. Continued monitoring and future investigations will provide opportunities to refine the conceptual model as additional data become available.

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