DRAFT TECHNICAL MEMORANDUM

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TO:	Kinney County Groundwater Conservation District, Board of Directors
FROM:	Vince Clause, PG Freese and Nichols, Inc.
SUBJECT:	Draft Findings on Desired Future Conditions in GMA-7
PROJECT:	KGD25636 – FY26 Hydrogeological Consulting Services
DATE:	December 12, 2025

DRAFT

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F-50655

1.00 INTRODUCTION

Freese and Nichols, Inc. (FNI) has prepared this draft technical memorandum on behalf of the Kinney County Groundwater Conservation District (KCGCD) to support continued use of the best available science in the joint planning process for Desired Future Conditions (DFCs). The purpose of this draft technical memorandum is to provide the Kinney County Groundwater Conservation District (KCGCD) Board of Directors with relevant data and analysis to help guide discussion as the Board determines its preferred approach for calculating Modeled Available Groundwater (MAG) in GMA 7. This document is intended as a preliminary summary of selected data and findings and is not a substitute for the comprehensive technical report that will be provided in January. All data and analyses presented herein should be regarded as draft and are subject to revision.

This work was completed under FY26 Hydrogeological Consulting Services, Task 2: Support Desired Future Conditions Joint Planning, authorized on August 23, 2025, under the Master Services Agreement between KCGCD and FNI.

2.00 BACKGROUND

DFC FORMULATION FOR KINNEY COUNTY

For the GMA 7 portion of Kinney County, the DFC for the Edwards-Trinity (Plateau) Aquifer is expressed in terms of Las Moras Spring discharge as simulated in Scenario 3 of the Texas Water Development Board's (TWDB) Draft Groundwater Availability Model (GAM) Task 10-027, (revised; Hutchison, 2011), which is based on the Groundwater Flow Model of the Kinney County Area (Hutchison and others, 2011). Under this framework, the aquifer system is simulated over 56-annual stress periods with a constant annual withdrawal of 77,000 acre-feet per year from the Edwards Trinity (Plateau) Aquifer.

From this predictive simulation, TWDB reported average and median end-of-year simulated Las Moras Spring discharge which were subsequently adopted as the DFC for Kinney County, as follows:

- Average simulated end-of-year spring flow: 23.9 cubic feet per second (cfs)
- Median simulated end-of-year-spring flow: 24.4 cfs

Key takeaways from this DFC formulation are provided below.

1. **The stated DFC is a statistical indicator, not a hard cap on minimum spring flow.** Within the Scenario 3 results, end-of-year Las Moras Spring flow is between 5 and 20 cfs about 38 percent of the time and greater than 25 cfs about 49 percent of the time over the 56-year simulation. This frequency distribution indicates that Las Moras flows are expected to vary significantly from year to year. Therefore, the adopted DFC reflects a typical modeled spring discharge under the Scenario 3 assumptions and not a minimum instantaneous or annual flow requirement to be met every year.
2. **The DFC is tied explicitly to annual end-of-year conditions in the model.** Because the Kinney County model uses annual stress periods and reports spring discharge as end-of-year values, the DFC should be evaluated against end-of-year spring flow conditions. Comparing daily, seasonal, or other non-end-of-year measurements directly to the DFC statistics is not consistent with the model's temporal resolution and initial interpretation of the DFC. Both Draft GAM Task 10-027 and the KCGCD Management Plan (KCGCD, 2023, "Management Plan") emphasize that end-of-year flows are the appropriate basis for comparison and that direct use of daily, seasonal, or instantaneous measurements as if they were equivalent is not appropriate.

GMA 7 DFC RESOLUTION LANGUAGE AND SUBSEQUENT INTERPRETATIONS

The founding joint-planning action for Kinney County's GMA 7 DFC is documented in GMA 7 Resolution 07-29-10-9 (GMA 7, 2010), which explicitly links the DFC to Scenario 3 of Draft GAM Task 10-027 (revised). For Kinney County, the resolution states:

> "In Kinney County, that drawdown which is consistent with maintaining, at Los Moras Springs [sic], an annual average flow of 23.9 cfs and a median flow of 24.4 cfs based on Scenario 3 of the Texas Water Development Board's flow model presented on July 27, 2010…"

During the 2016 planning cycle, GMA 7 elected to reaffirm the same spring-flow based DFC for Kinney County, while extending the planning horizon to 2070. The April 21, 2016 proposed DFCs document (Groundwater Management Area 7, 2016; reproduced in Hutchison, 2018) includes the following Kinney County DFC declaration:

> "Total net drawdown in Kinney County in 2070, as compared with 2010 aquifer levels, shall be consistent with maintenance of annual average flow of 23.9 cfs and an annual median flow of 24.4 cfs at Las Moras Springs (Reference: Groundwater Flow Model of the Kinney County Area by W.R. Hutchison, Ph.D., P.E., P.G., Jerry Shi, Ph.D. and Marious Jigmond, TWDB, dated August 26, 2011)."

When the DFCs were formally adopted and later documented in the GMA 7 Explanatory Report (Hutchison, 2018; restated in Hutchison, 2021), the Kinney County DFC appears as:

> "Total net drawdown in Kinney County in 2070, as compared with 2010 aquifer levels, shall be consistent with maintenance of an annual average flow of 23.9 cfs and an annual median flow of 23.9 cfs at Las Moras Springs (Reference: Groundwater Flow Model of the Kinney County Area by W.R. Hutchison, Ph.D., P.E., P.G., Jerry Shi, Ph. D and Marious Jigmond, TWDB, dated August 26, 2011)."

Between the 2010 resolution and later GMA 7 actions, the average spring-flow target remained the same at 23.9 cfs, however the median value shifted from 24.4 cfs in the original 2010 resolution and 2016 proposed DFC document to 23.9 in the final DFC language adopted in 2018 and remained at 23.9 in the 2021 Explanatory Report (Hutchison, 2021).

The wording of the DFC also evolved in a meaningful way that affects how the DFC is interpreted. The 2010 resolution explicitly references Scenario 3 of GAM Task 10-027. In contrast, the 2016 and 2021 resolutions reference the TWDB GAM for Kinney County but do not name Scenario 3 in the DFC statement itself, even though the Explanatory Report explicitly notes that the DFC is based on Scenario 3. The Explanatory Report also notes that GMA 7 and KCGCD "voted to keep the same DFC based on the 2010 analysis despite issues that have been identified with the model," acknowledging both model limitations and the original Scenario 3 analysis.

Although the streamlined DFC wording in summary tables and subsequent planning documents may improve readability, it may also obscure the direct linkage between (1) the predictive scenario and its limitations in the TWDB GAM and (2) the end-of-year spring-flow statistics used to define the Kinney County DFC. For the remainder of this memorandum, that explicit linkage is maintained to provide a clearer technical basis for revisiting the way the associated MAG is calculated and communicated.

KCGCD MANAGEMENT PLAN AND IMPLEMENTATION OF THE DFC

The KCGCD Management Plan confirms that the GMA 7 DFC for Kinney County is expressed as an average and median Las Moras Spring flow based on Scenario 3 of TWDB Draft GAM Task 10-027. The Plan reiterates that the average flow of 23.9 cfs and median flow of 24.4 cfs were calculated from a 56-year simulation under a constant pumping assumption and emphasizes that the simulated spring flow values are end-of-year results. The Plan also states that comparing any single measured spring-flow value directly to the long-term average "for purposes of demonstrating consistency with the desired future condition would be inappropriate."

Spring flow data from the United States Geological Survey (USGS) gauge at Las Moras Spring serves as the primary basis for evaluating DFC compliance on a year-to-year basis. To move from simulated results to an observable metric, the Plan establishes an empirical model that relates annual precipitation to end-of-year spring flow. Figures 5 through 8 in the Plan illustrate how this empirical relationship is used to evaluate recent end-of-year observations based on established relationships within a broader historical context.

Under this approach, the Management Plan does not define a single pass/fail threshold for DFC compliance. Instead, it establishes an envelope of expected end-of-year spring flows for a given annual precipitation and commits the District to annual documentation and interpretation of whether observed spring flow is broadly consistent with that envelope. This approach recognizes key limitations of the modeling on which the DFC is based (e.g. temporal resolution and statistical nature of the DFC) and formalizes a practical evaluation tool for tracking whether groundwater conditions in Kinney County remain consistent with the DFC adopted for the Edwards-Trinity (Plateau) Aquifer in GMA 7.

The stated objective for this approach is to "assess annually the end-of-year Las Moras Spring flow and annual precipitation to evaluate consistency with the desired future condition" (KCGCD, 2023, p. 20). This evaluation tool is formalized as a DFC Performance Standard that:

> "each year, data on annual precipitation from Quad 807 and end-of-year Las Moras Spring flow will be collected. The results will be reported as an agenda item at the first Board meeting after the annual precipitation data are available from TWDB, and final (not provisional) Las Moras Springs flow data are available from the USGS." (KCGCD, 2023, p. 20)

3.00 GROUNDWATER PUMPING

Groundwater pumping volumes were provided to FNI by EcoKai as annual totals by permitted well for the period of 2003 to 2024. Using this record, we prepared summary statistics (Table 1 and Table 2) and a general trend analysis (Figure 1). The distribution of total annual pumping is bimodal, indicating distinct low and high pumping periods over time.

The median total annual pumping for the full period of record is 5,135 acre-feet per year, which is comparable to the median during the 2011 drought interval (2009 to 2015) of 4,761 acre-feet per year. In contrast, recent pumping volumes during 2020 to 2024 are substantially greater with a median of 9,715 acre-feet per year, indicating a marked increase in groundwater production relative to historical conditions.

To provide additional clarity, source aquifers have been assigned to each well. The resulting distribution of pumping by aquifer and year is illustrated in Figure 2, which highlights the temporal evolution of production among the Edwards-Trinity (Plateau), Austin Chalk and other aquifers. Figure 3 provides the same data but illustrates it as percent of total annual pumping by aquifer.

Table 1 – Summary statistics for total annual permitted groundwater pumping volumes (acre-feet per year) across Kinney County.

	Period of record (2003 to 2024)	Drought with baseline pumping (2009 to 2015)	Drought with increased pumping (2020 to 2025)
Count	22	6	5
Standard deviation	2,343	462	911
Minimum	3,043	3,981	8,265
Median	5,135	4,761	9,715
Mean	6,120	4,716	9,464
Maximum	10,608	5,330	10,608

Table 2 – Summary statistics for total annual permitted groundwater pumping volumes (acre-feet per year) across Kinney County and by GMA.

	Total Pumping (2003 to 2024)	GMA 7 Pumping (2003 to 2024)	GMA 10 Pumping (2003 to 2024)
Count	22	22	22
Standard deviation	2,343	2,262	393
Minimum	3,043	2,999	12
Median	5,135	4,773	245
Mean	6,120	5,748	372
Maximum	10,608	10,089	1,376

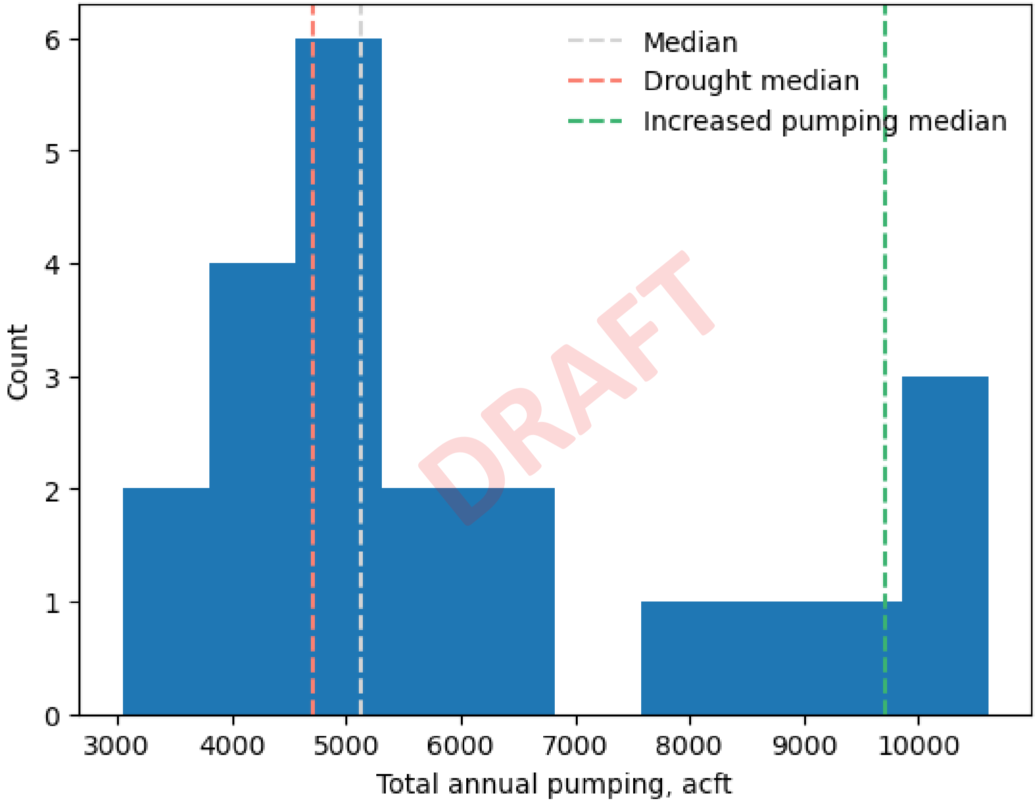

Figure 1 – Distribution of total annual groundwater pumping volumes (acre-feet per year) in Kinney County. Drought median is in reference to 2011 drought (2009 to 2015), while increased pumping median is in reference to 2020 to 2025 period.

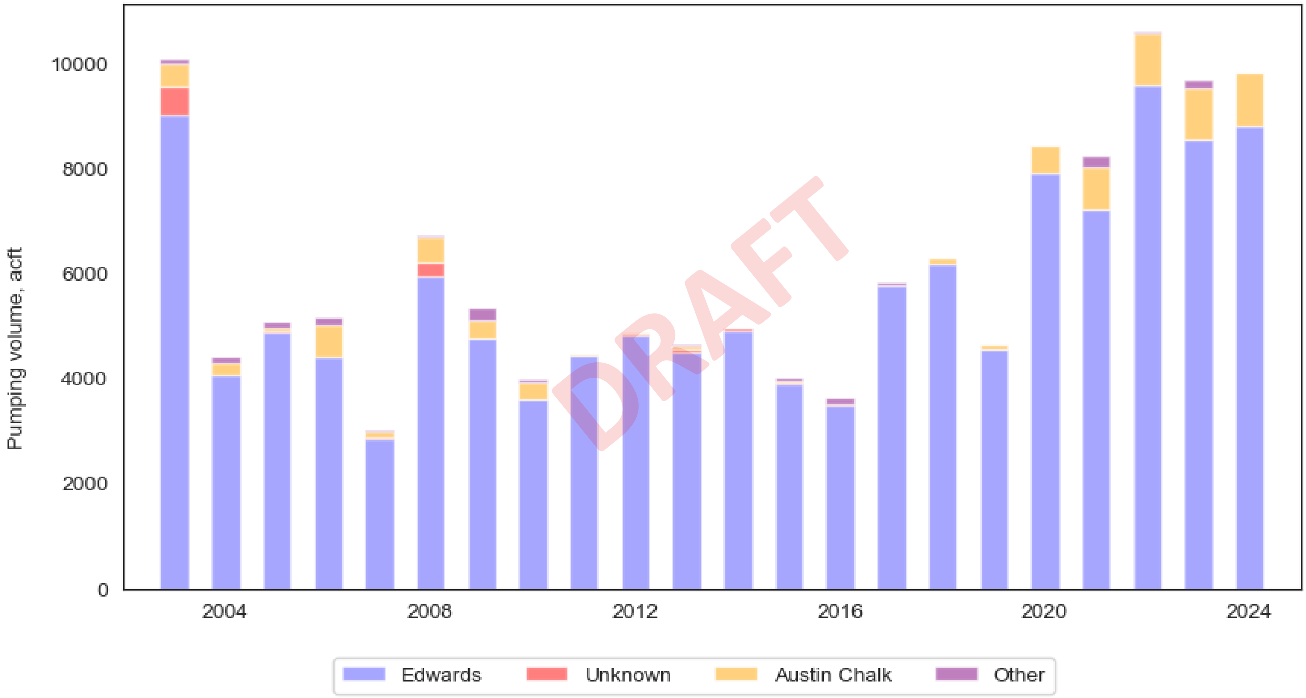

Figure 2 – Annual groundwater (acre-feet per year) pumping by aquifer.

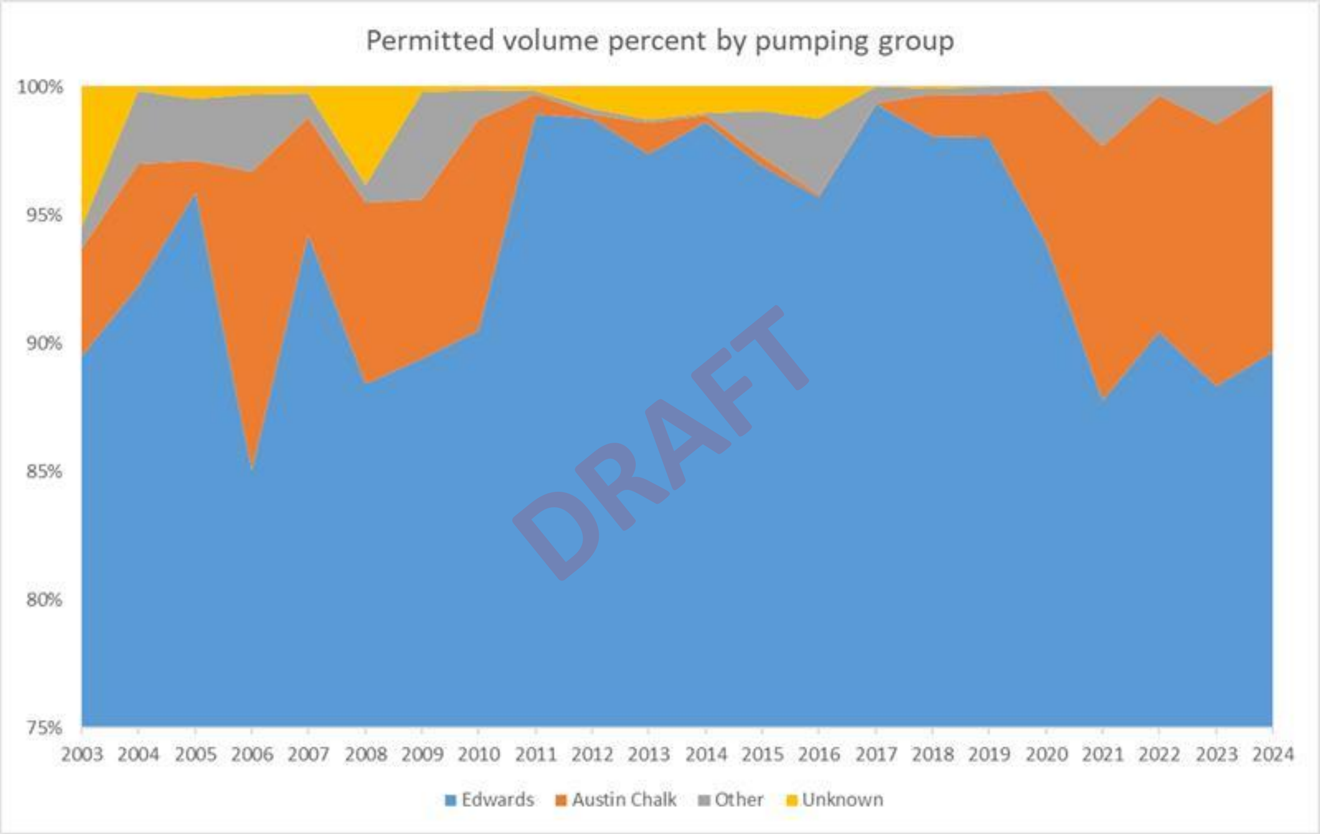

Figure 3 – Annual groundwater pumping volume percent by aquifer.

4.00 PRECIPITATION

The primary source of precipitation data used in this analysis is the TWDB Quad 807 dataset, which reports monthly precipitation (in inches) over a 1-degree by 1-degree grid cell for the period 1940 to present (TWDB, 2025). Summary statistics for the Quad-807 dataset are presented in Table 3 for three intervals: the full period of record, the 2011 drought period (approximated as 2009-2015), and recent drought period with increased pumping (2020-2025).

Table 3. Summary Statistics for Monthly Precipitation (Quad 807, inches)

	Period of record (1940 to Present)	Drought with baseline pumping (2009 to 2015)	Drought with increased pumping (2020 to 2025)
Count	1,026	73	66
Standard deviation	1.75	2.49	1.45
Minimum	-	-	0.01
Median	1.61	1.00	1.05
Mean	2.01	2.00	1.51
Maximum	16.23	10.00	7.58

The distribution of monthly precipitation totals in Figure 4 is right-skewed, with a long tail toward higher rainfall events. This skewness is reflected in the full period of record summary statistics, where the mean monthly precipitation (2.01 in.) exceeds the median (1.61 in.), highlighting the influence of relatively less frequent but large storm events on the long-term average. Figure 4 also marks the median monthly precipitation during the 2009-2015 drought interval and the 2020-2025 drought with increased pumping. Although the median precipitation in these two sub-periods is similar (1.0 to 1.05 inches), the mean precipitation from 2020-2025 (1.51 in.) is notably lower than both the long-term mean (2.01 in.) and mean during the 2009-2015 drought period (2.0 in.). The maximum monthly rainfall during 2020-2025 (7.58 in.) is also substantially lower than the maximum observed over the full record and during the 2009-2015 drought interval.

Figure 5 presents this same data in a different form, showing the number of consecutive months below the long-term median alongside quarterly precipitation totals. This chart allows a direct visual comparison between the 2009-2015 drought and the 2020-2025 drought periods. The 2009-2015 drought is characterized by longer runs of below median precipitation, but with overall higher rainfall totals than the 2020 to 2025 period, which is notably marked by overall lower cumulative rainfall and fewer large precipitation events.

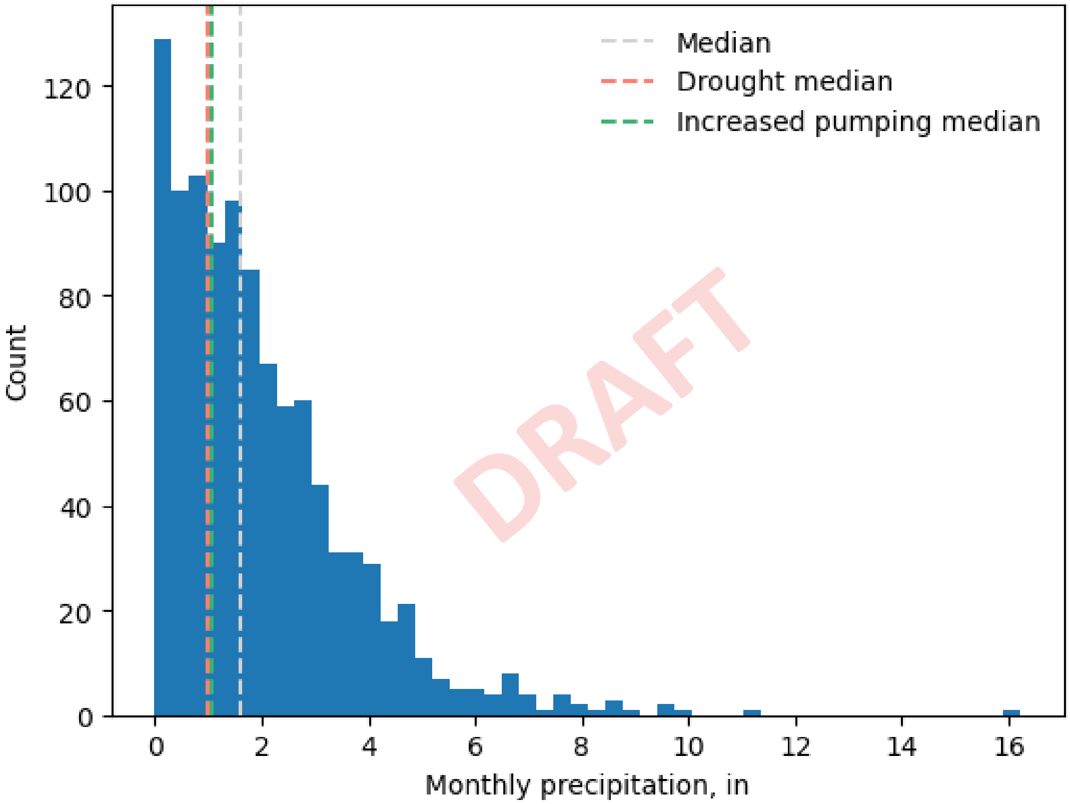

Figure 4 – Distribution of monthly rainfall totals from Quad-807. Drought median is in reference to 2011 drought (2009 to 2015), while increased pumping median is in reference to 2020 to 2025 period.

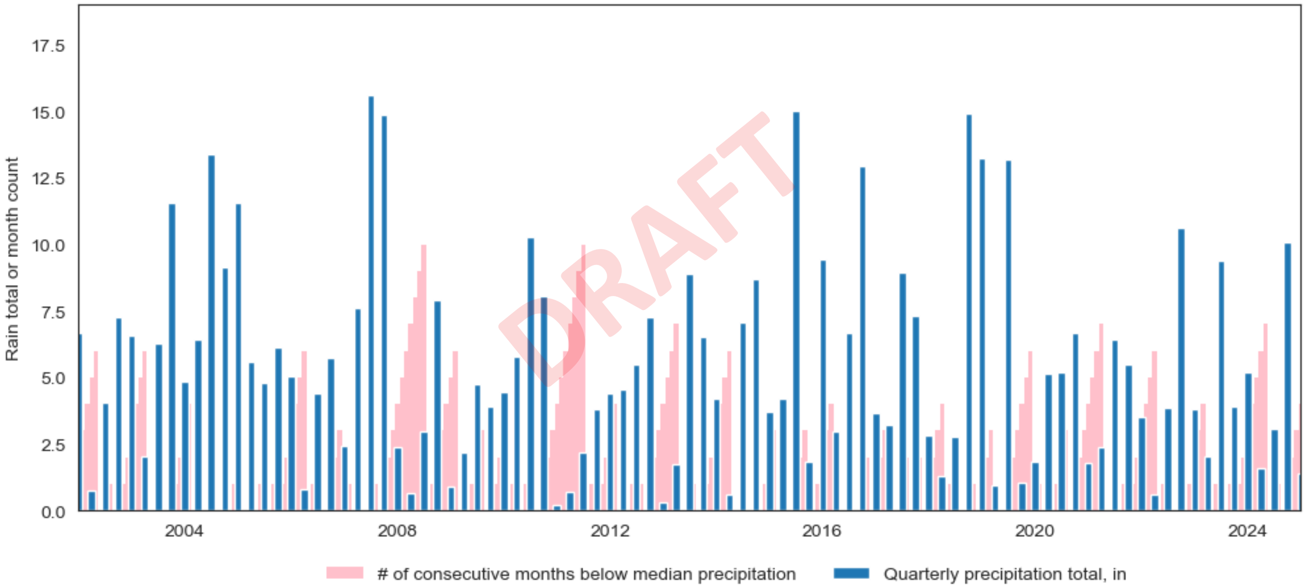

Figure 5 – Quarterly precipitation totals and number of consecutive months below median precipitation.

5.00 LAS MORAS SPRING DISCHARGE

Spring discharge data for Las Moras Spring were obtained from multiple sources and harmonized into a single dataset (2003 to 2025 presented in Figure 6; Bennett and Sayre, 1962; LBG-Guyton Associates, 2009; USGS, 2025a and 2025b). Bennett and Sayre (1962) report daily spring discharge sporadically at Las Moras from Dec. 23, 1895, to Sept. 25, 1956. For this analysis, those daily measurements are interpreted as mean daily discharge. LBG-Guyton Associates (2009) reported spring flow as mean cfs-days per month for the period February 1965 through March 2004. We converted these monthly values to estimated daily discharge by dividing the reported cfs days per month by the number of days in the month and reported the value only at the end of the month.

The USGS has operated two spring gauges at Las Moras (2025a and 2025b). The “old” gauge (active 2003 to 2014) reports mean daily discharge, and the “new” gauge (2014 to present) reports 15-minute mean discharge. We resampled the “new” gauge data to obtain a mean daily discharge value.

Prior to 2003, daily mean discharge values are reported with varying temporal resolution. From 1895 to 1965, the record is sporadic in time. From 1965 to 2003, mean discharge is reported at month end. From 2003 to present, a continuous daily record is available except from August 27,2014 to October 1, 2014 when the USGS gauge was replaced and upgraded. For purposes of this analysis and to maintain consistency across data processing environments, we consider our period of record to be 1900 to present.

Summary statistics for daily mean discharge at Las Moras Spring over the period of record, the 2009 to 2015 drought period, and a recent period of increased groundwater pumping (2020 to 2025) are presented in Table 4. Based on available documentation, we assume the DFC for Kinney County GCD is currently assessed against the mean daily discharge on Dec. 31. To align with the DFC, we also prepared summary statistics for all the available reported values for Dec. 31 of a given year (Table 5).

The distribution of daily mean discharge for the full period of record is bimodal (Figure 7). One peak occurs between approximately 0 and 10 cfs and a second with a shallower peak between 30 and 50 cfs. This right skew in the distribution suggests that we have relatively frequent low to moderate flows and intermittent high-flows. As a result of this right-skew in distribution, the mean spring flow exceeds the median spring flow, an observation that is not consistent with the Scenario 3 GAM results.

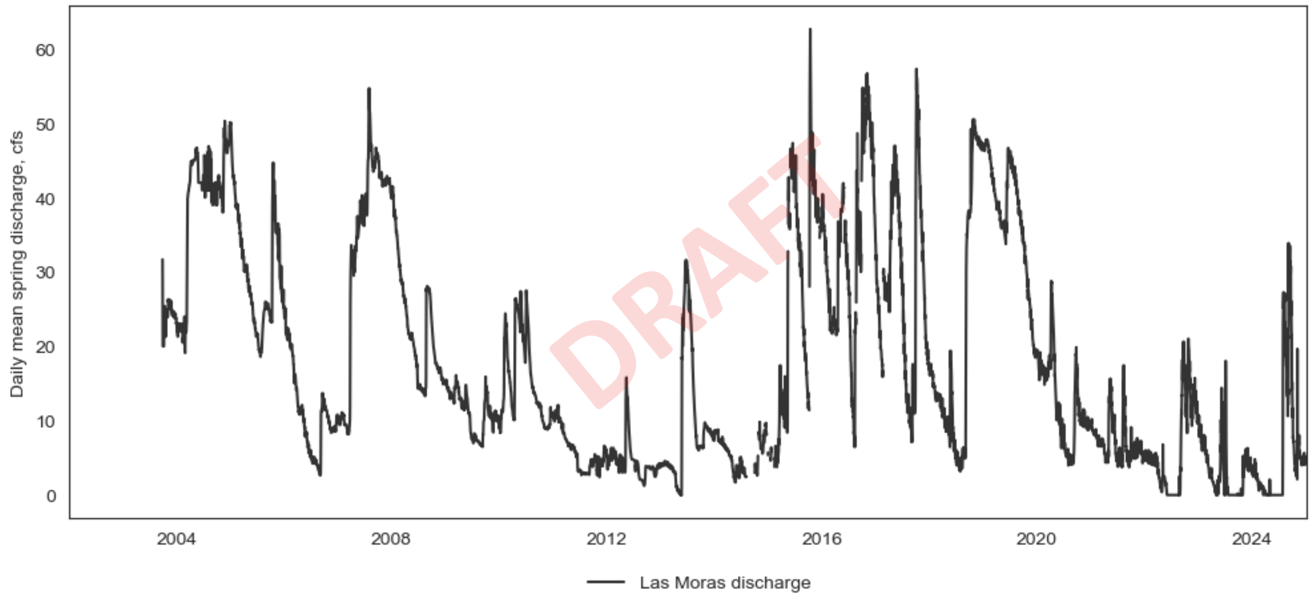

Figure 6 – Las Moras Spring discharge, 2003 to 2025.

Table 4. Summary statistics of mean daily discharge at Las Moras Springs. Discharge reported in cubic feet per second.

	Period of record (1900 to 2025)	Drought (2009 to 2015)	Increased pumping (2020 to 2025)
Count	8,544	2,127	2,112
Standard deviation	14.47	7.33	6.24
Minimum	-	-	-
Median	12.50	5.07	7.23
Mean	17.62	7.04	8.91
Maximum	62.66	40.70	31.60

Table 5. Summary statistics of mean daily discharge on Dec. 31 for Las Moras Springs. Discharge values are reported in cubic feet per second.

	Period of record (1900 to 2025)	Drought (2009 to 2015)	Increased pumping (2020 to 2025)
Count	60	6	5
Standard deviation	12.99	2.61	3.08
Minimum	2.91	4.12	2.91
Median	16.34	6.49	5.61
Mean	20.67	7.12	6.62
Maximum	49.80	11.00	9.92

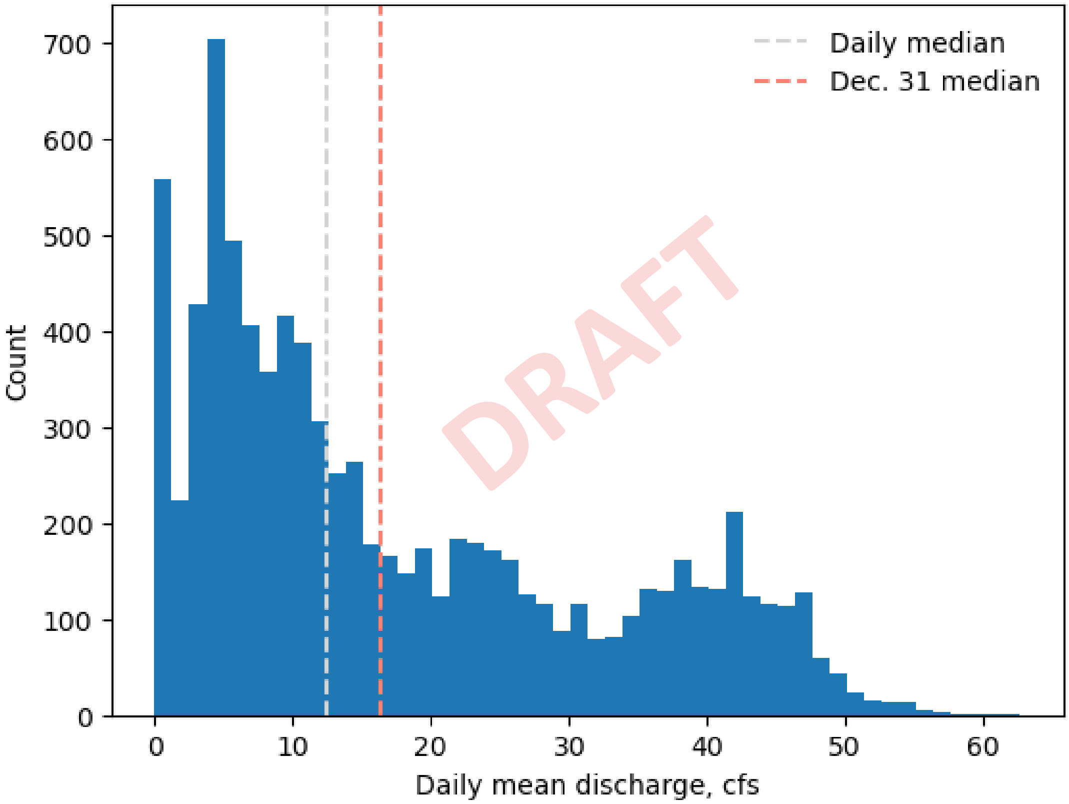

Figure 7 – Distribution of daily mean discharge at Las Moras Springs for the period of record.

6.00 PUMPING RECORD OVERLAY

A simple overlay of Las Moras Spring discharge, rainfall, and pumping by aquifer is provided in Figure 8 below. This information is provided as a visual summary for data presented with the previous sections.

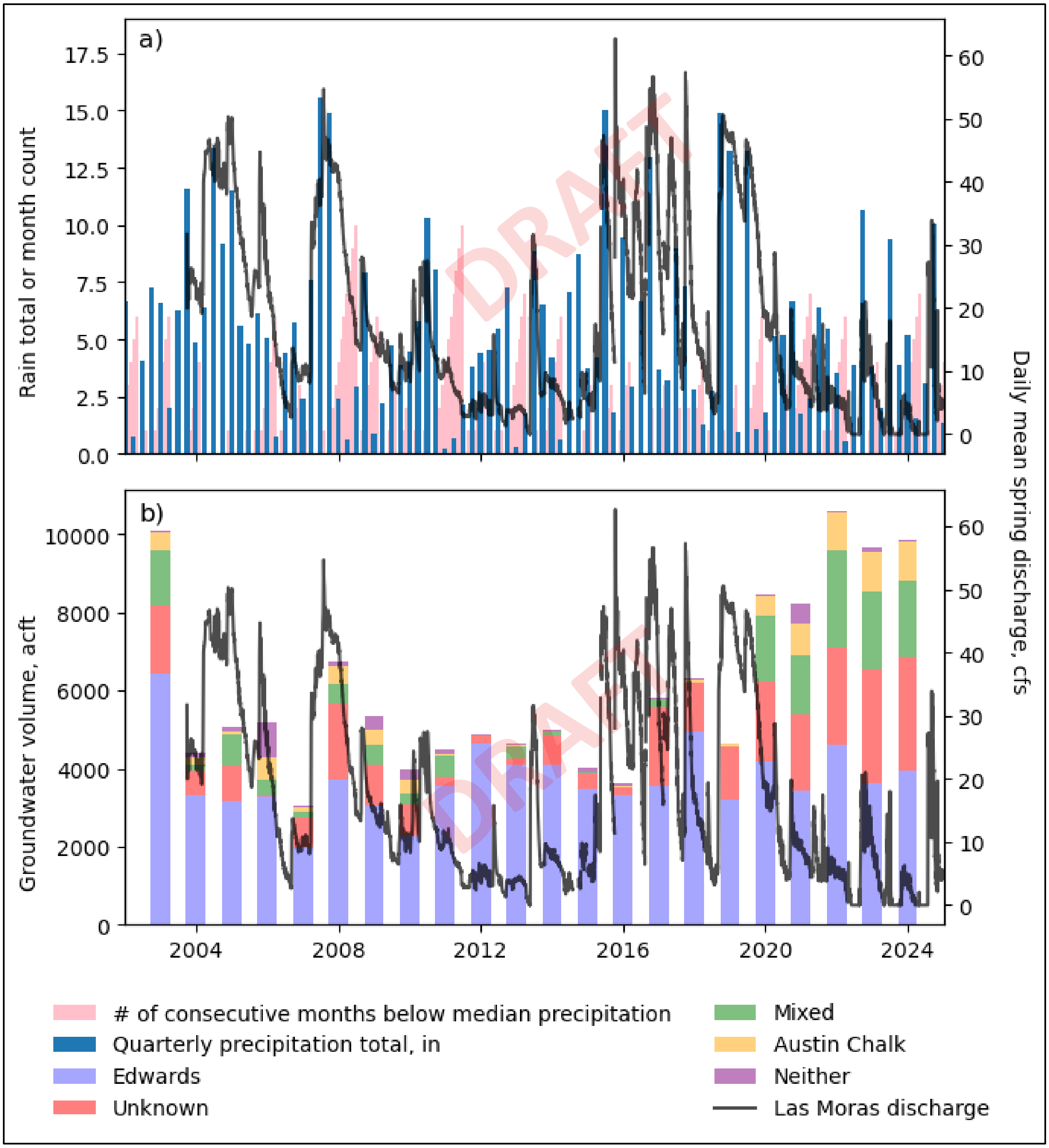

Figure 8 - Groundwater pumping volumes, precipitation, and discharge at Las Moras during the period of record for groundwater pumping volumes. A) Quarterly precipitation totals in inches, daily mean discharge at Las Moras measured in cubic feet per second, and the number of consecutive months below median precipitation (1.61 inches). B) Groundwater pumping volumes by aquifer and daily mean discharge at Las Moras.

7.00 REGRESSION AND CONDITIONAL PROBABILITY ANALYSIS

To estimate a groundwater pumping volume that on average, would be consistent with the GMA 7 DFC, we evaluated the relationships among groundwater pumping, precipitation, and Las Moras Spring flow. A primary challenge in this analysis is the limited length and completeness of the groundwater pumping record, which constrains the robustness of any predictive model.

REGRESSION ANALYSIS

Our initial approach was to develop a relatively simple multivariate regression model. Three different input configurations were tested, each using variations of annual precipitation and annual pumping as predictors. The resulting models produced R^2 values between approximately 0.3 and 0.5, which was only marginally satisfactory for this type of analysis. We then tested the model predictions to observed spring discharge (Figure 9). Although each model captured the general shape of spring discharge, all overestimated spring flow during the 2009-2015 drought. Because the DFC is tied directly to spring flow, this tendency to overpredict discharge under drought conditions is not viewed as acceptable for DFC-based pumping estimates.

CONDITIONAL PROBABILITY ANALYSIS

Given the limitations of the multivariate regression and the available data, we adopted an alternative approach focused on pairwise relationships with stronger apparent correlations. Specifically, precipitation and Las Moras Spring discharge ($R^2 = 0.7175$), as these variables exhibit a stronger relationship than pumping and discharge ($R^2 = 0.10$). We then used this relationship to (1) quantify the precipitation and spring flow relationship, and then (2) used that relationship within a probabilistic framework to explore a range of groundwater pumping volumes that would be broadly consistent with the DFC.

Because the DFC is currently evaluated using mean daily spring flow at Las Moras on December 31, we plotted December 31 mean daily discharge against annual Quad 807 precipitation (**Figure *10***) for the overlapping period of record. We then performed a simple linear regression between these two variables, which yielded a satisfactory R^2 value (Equation 1; $R^2 = 0.7175$):

Equation 1. Linear regression of annual Quad 807 precipitation and Las Moras mean daily discharge on Dec. 31 (from 2003 to 2024).

$$Q_{\text{Dec 31}}\ (\text{cfs}) = -16.09167 + (1.5453 \times P_{\text{annual}})$$
$$R^2 = 0.7175$$

$Q_{\text{Dec 31}}$ is the mean daily Las Moras Spring discharge on December 31 (cfs)
P_{annual} is the annual precipitation from Quad 807 (inches).

This regression provides a better statistical fit than any of the multivariate regression models and forms the basis for the subsequent probabilistic analysis of pumping scenarios relative to the DFC.

From past data and observations, the most likely annual pumping volume that occurred given a specific annual precipitation value (the conditional probability) was assessed. The contemporaneous annual precipitation and annual pumping data from 2003 to 2024 was organized into five bins with a precipitation based width of 10-inches. In each of the precipitation bins, we calculated the average pumping volume, the 25th percentile, and the 75th percentile. From these three values the average annual pumping volume that occurred given a precipitation value and the band of most likely pumping values (25th to 75th percentiles) that occurred given a precipitation value were graphed as bands of conditional probabilities (Figure 11). This conditional probability approach is similar to the current approach used to assess the DFC (assess an envelope of values to account for actual variability), but the input data is based on real, although limited, observations.

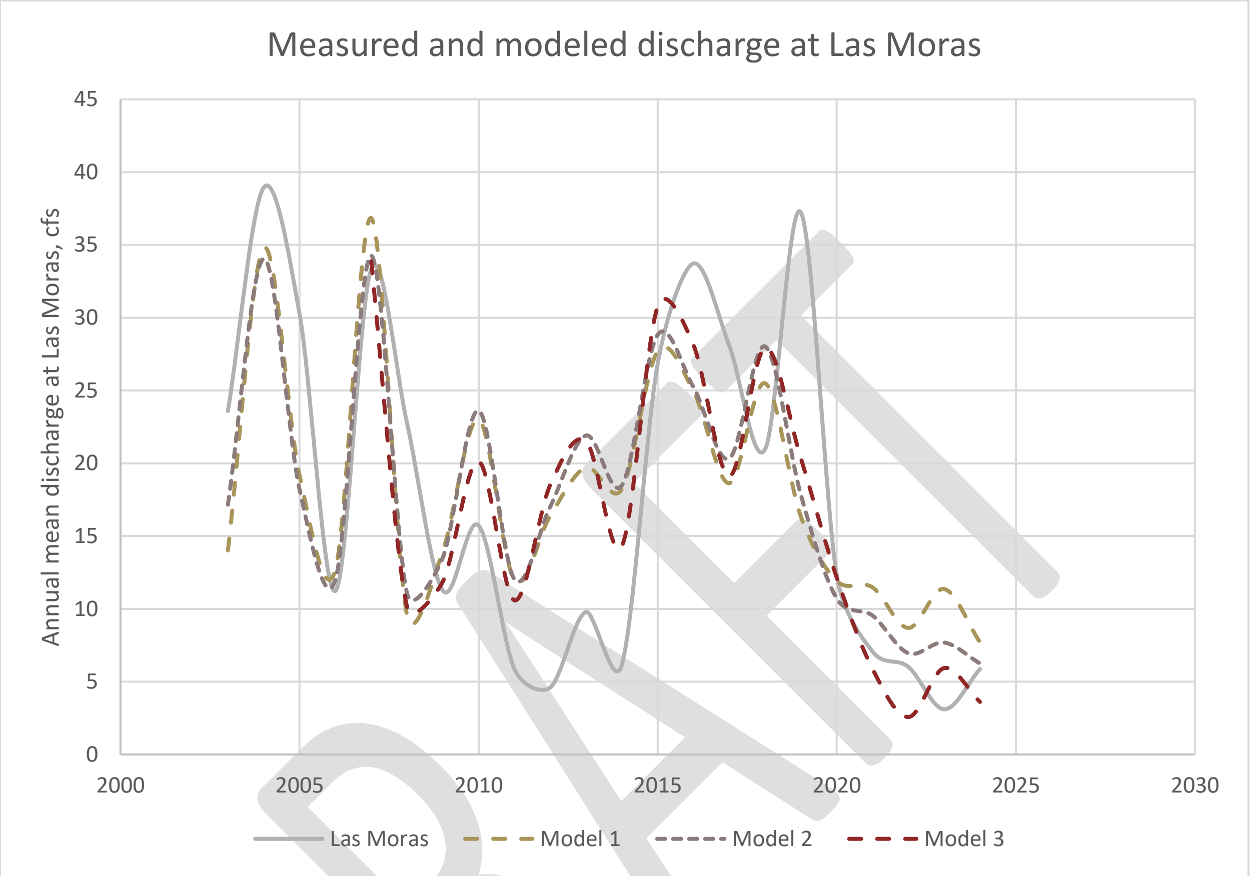

Figure 9 – Multivariate regression model predictions compared with actual Las Moras Spring flow. R2 for the models is between 0.3 and 0.5.

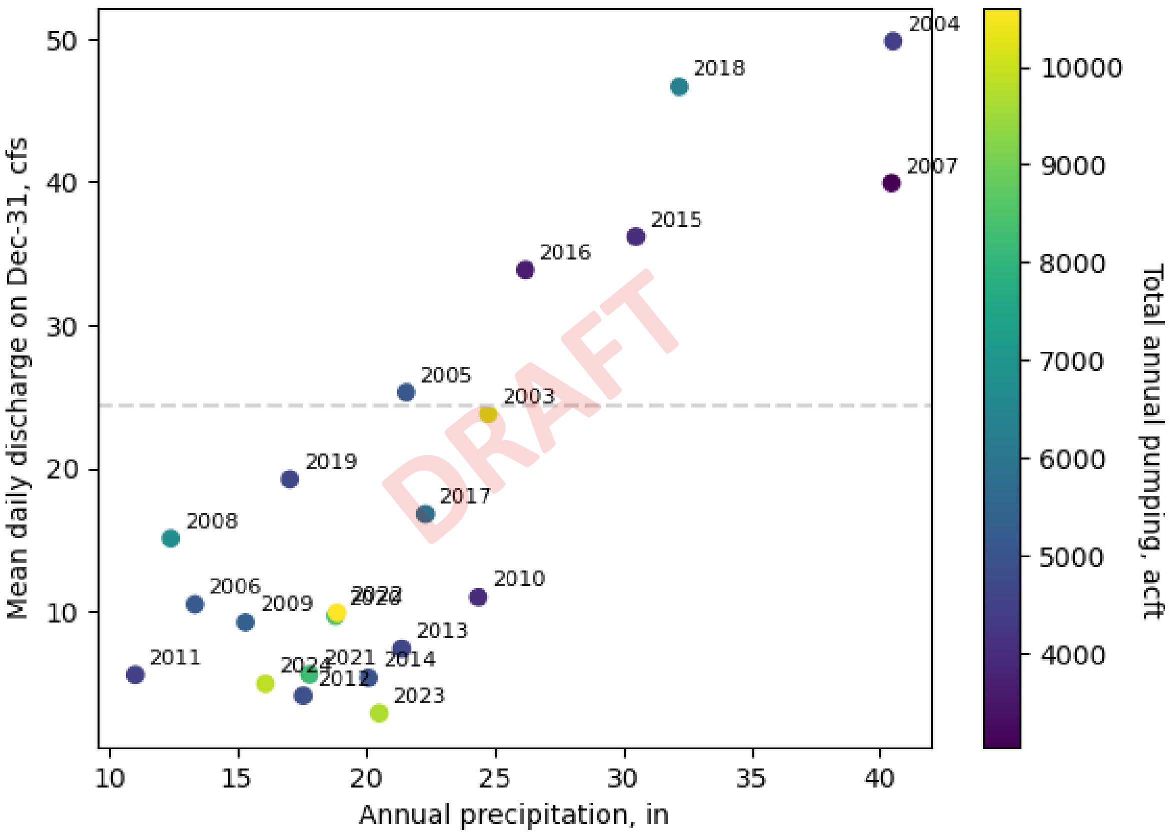

Figure 10 - Annual precipitation, mean daily discharge on December 31, and total annual pumping. The DFC discharge of 24.4 cfs is plotted as a dashed line on the graph.

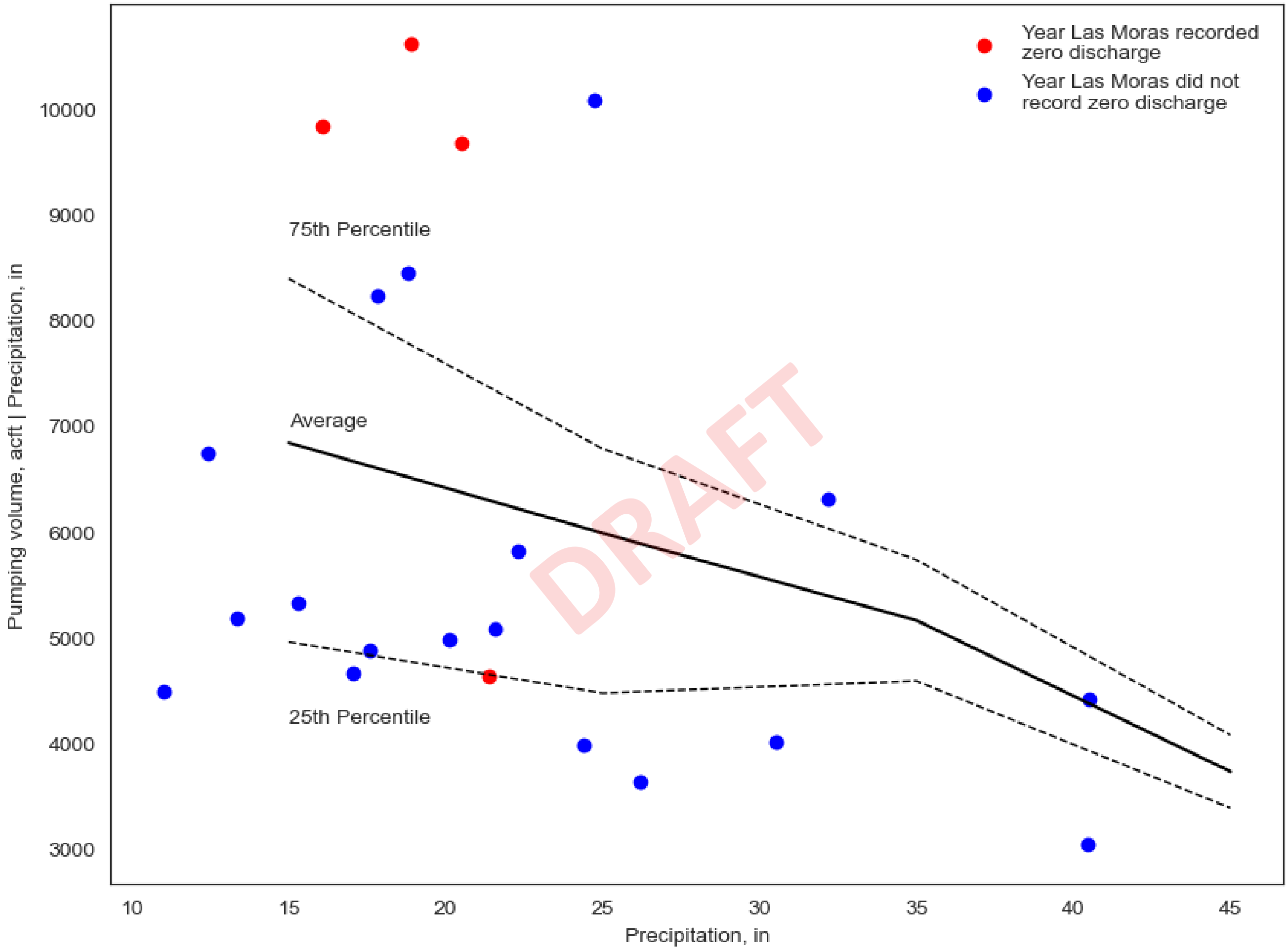

Figure 11. Conditional probability of annual pumping volume given a specific annual precipitation total.

8.00 RECOMMENDATIONS

To support a revised and more transparent approach to calculating the MAG for Kinney County within GMA 7, two technical recommendations are provided below. The first is to consider designating the Edwards-Trinity (Plateau) in Kinney County as non-relevant for joint planning purposes. This option ultimately removes the need to force a spring-flow based DFC into a MAG under a conceptual model that is not directly controlled by pumping. If the Board wishes to keep the aquifer as relevant, the second is to replace the existing GAM framework with a statistical analysis that links MAG to measurable variables (e.g. pumping and long-term spring flow statistics). Either path forward would improve overall technical defensibility, reduce ambiguity in how the DFC is interpreted and applied, and provide a clearer basis for communicating groundwater availability.

1. Consider the Edwards-Trinity (Plateau) Aquifer in Kinney County as Non-Relevant for Joint Planning in GMA 7

The current GMA 7 DFC for Kinney County is expressed as average and median Las Moras Spring flows derived from Scenario 3 of TWDB Draft GAM Task 10-027. Both, the Scenario 3 analysis and the empirical framework in the KCGCD Management Plan indicate that Las Moras Spring flow correlates strongly to variations in recharge (i.e. rainfall), rather than with changes in pumping. The regression analysis presented in this technical memorandum further reinforces this point as spring flow exhibits a much stronger statistical relationship with precipitation ($R^2 = 0.72$) rather than pumping and spring flow ($R^2 = 0.10$). This contrast in R^2 values demonstrates that Las Moras Spring flow is more sensitive to climate variability than to changes in groundwater pumping. There is insufficient evidence that policy-level changes in pumping are likely to generate a meaningful change in the DFC.

Based on review of available technical information, it is reasonable for KCGCD and GMA 7 to consider classifying the Edwards-Trinity (Plateau) as non-relevant for joint planning purposes under 31 TAC §356.31, which allows districts to classify a portion of a relevant aquifer as non-relevant "if the districts determine that aquifer characteristics, groundwater demands, and current groundwater uses do not warrant adoption of a desired future condition." This recommendation is grounded in (1) a strong correlation climate-driven variability and Las Moras Spring flow, and (2) the relatively small and localized role that Edwards-Trinity (Plateau) groundwater in Kinney County plays in the broader regional water supply planning. This classification would apply only to joint planning under Chapter 36 and would not diminish KCGCD's authority or intent to manage, monitor, and permit groundwater production locally.

From a joint planning perspective, the dominant driver of Las Moras Spring flow is rainfall, which is outside the control of the GCD or GMA and limits the usefulness of a DFC that is framed in terms of long-term statistical spring-flow metrics. Furthermore, while groundwater is important locally, pumping in Kinney County represents a relatively small volume at the regional scale and has a minimal impact on adjacent areas. Collectively, these factors support the conclusion that the Edwards-Trinty (Plateau) Aquifer in Kinney County does not warrant a GMA-level DFC and can be considered as non-relevant for joint planning purposes under 31 TAC §356.31.

2. Replace the Existing GAM Framework with a Statistical Analysis that Aligns with the Existing DFC

Using the conditional probability approach outlined in Section 7.00, Equation 1 can be solved for an annual precipitation total that meets the DFC, which is 26.2 inches. An analytical MAG suggestion is the average annual pumping volume given an annual precipitation total of 26.2 inches, which can be estimated from Figure 12 and is approximately 6,200 acre-feet per year.

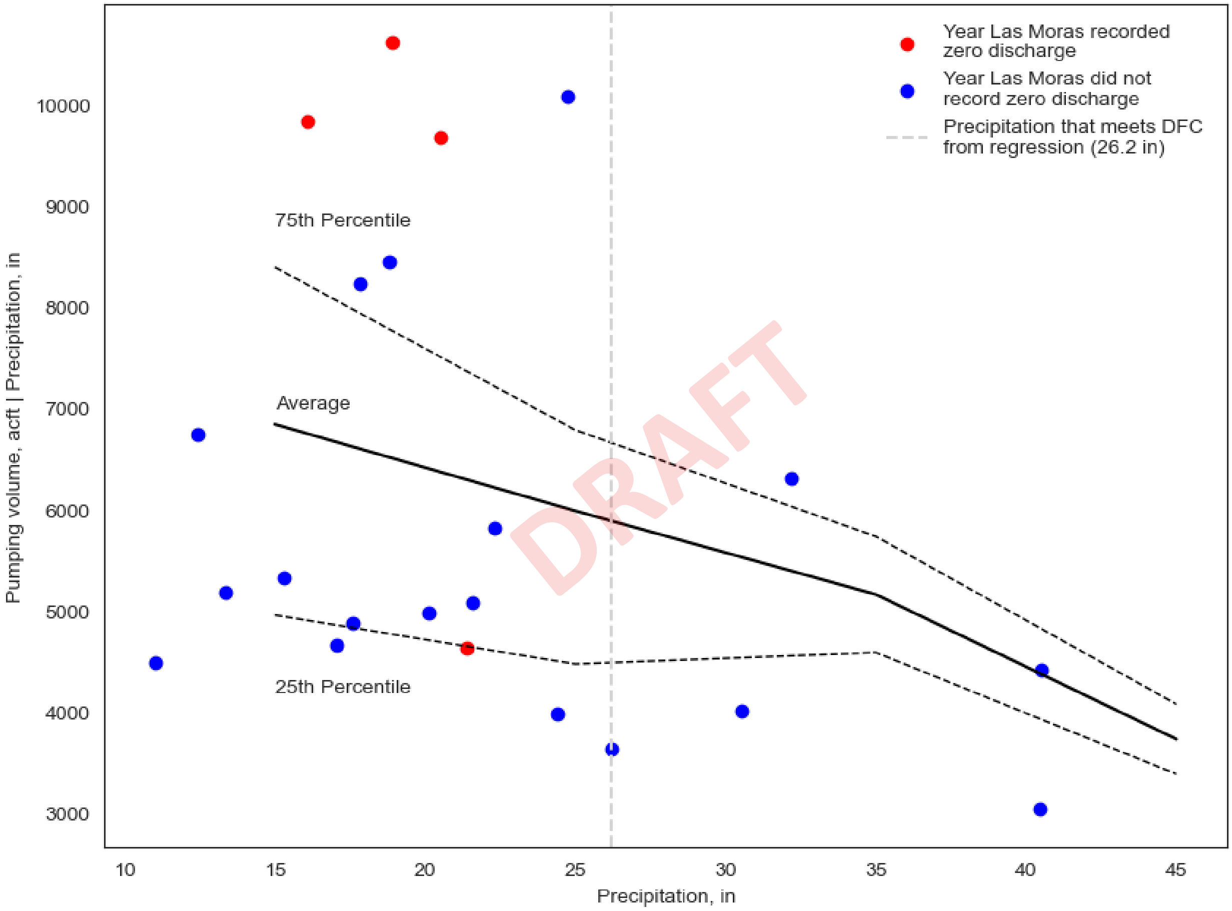

Figure 12. Annual pumping volume given an annual precipitation from 2003 to 2024.

9.00 REFERENCES

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