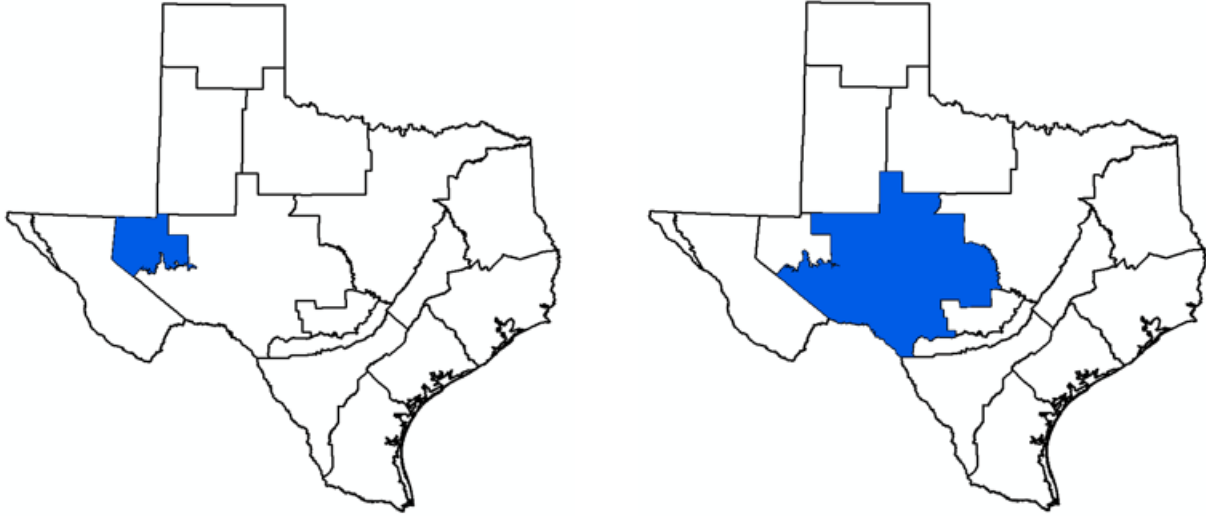


*Draft Report*

**Documentation for Update of  
Alternative Groundwater Availability Model of  
Edwards-Trinity (Plateau) and Pecos Valley Aquifers**



**Prepared for:**

Groundwater Management Area 3  
Groundwater Management Area 7

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**April 16, 2026**

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# **1.0 Introduction**

## **1.1 Background**

The desired future conditions (DFCs) for the Edwards-Trinity (Plateau) and Pecos Valley aquifers in GMA 3 adopted in 2021 were developed based on simulations using the Alternative GAM of the Edward-Trinity (Plateau) and Pecos Valley aquifers. The Alternative GAM is documented in Hutchison and others (2011). The development of the DFCs in 2021 is documented in Hutchison (2021). Specifically, the DFCs were from Scenario 11 as documented in GMA 3 Technical Memorandum 16-01. These DFCs were the same as the DFCs adopted in 2016. The DFCs used 2010 as the baseline year.

## **1.2 Reeves County Issues and GMA 3 Discussion**

In an email dated April 7, 2025, James Beach (consultant to Reeves County GCD) acknowledged that the TWDB update to the GAM was delayed, and that GMA 3 would have to rely on the Alternative GAM for this round of joint planning. He noted that the alternative GAM does not accurately simulate drawdown in Reeves County. Mr. Beach recommended that the pumping for the upcoming simulation be increased to yield a higher drawdown (379,500 AF/yr instead of 189,744 AF/yr).

This issue was discussed further at the May 21, 2025 GMA 3 meeting. This included a brief review of the development of the Alternative GAM in 2009 and 2010. At the time of the development of the Alternative GAM, there were limited data from Reeves County and no GCD in Reeves County. It was also noted that in 2010, some storativity values were modified in Crane, Ward, and Winkler counties to address some issues after release of the Alternative GAM during the first round of joint planning.

Historic pumping and the pumping used in the simulation that was the basis for the desired future condition were reviewed and presented at the May 21, 2025 GMA 3 meeting. The comparison of recent pumping suggested that modifying the simulated pumping may improve the drawdown comparison, but the simulated pumping would likely be overestimated.

The discussion at the May 21, 2025 GMA 3 meeting then focused on a comparison of actual and simulated drawdown and GAM parameters. Of note was the comparison of transmissivity estimates in the Alternative GAM with estimated transmissivity from 30 specific capacity tests in Reeves County that were available from the TWDB groundwater database. A comparison of the estimates from the specific capacity tests yielded lower transmissivity estimates that those used in the Alternative GAM.

As a result of the discussion at this GMA 3 meeting, work began to adjust Alternative GAM parameters in Reeves County. This effort would evaluate the effect of the changes on both overall model calibration and on effects to post-2010 drawdown comparisons. The work was delayed until a similar analysis could be completed for the rest of GMA 3 and GMA 7 to evaluate the need to expand the scope of the update to the Alternative GAM.

### **1.3 HB 2078 Analysis**

In response to the new requirements of HB 2078, Hutchison (2025) completed a comparison of actual drawdown and simulated drawdown using the simulation that formed the basis for the desired future conditions in GMA 3. The comparison showed that the desired future condition is being achieved in Crane, Loving, Ward, and Winkler counties. However, in the GMA 3 portion of Pecos County and in Reeves County, the actual drawdown from 2011 to 2024 is greater than the simulated drawdown.

Thus, the scope to the updated Alternative GAM was extended to the GMA 3 portion of Pecos County in addition to Reeves County.

A similar comparative analysis of actual and simulated drawdown was also completed in GMA 7. Three counties (Coke, Real, and Terrell) had actual drawdown greater than simulated drawdown. However, the relatively simple approach used to address the identified problem in the GMA 3 portion of Pecos County and Reeves County were not effective in resolving the issues in GMA 7 (Hutchison, 2026).

### **1.4 Model Files**

All files associated with this update can be accessed at:

[https://drive.google.com/drive/folders/17VE2X\\_4SpAMoayIyY2420ve-FVFKa7hc?usp=sharing](https://drive.google.com/drive/folders/17VE2X_4SpAMoayIyY2420ve-FVFKa7hc?usp=sharing)

### **1.5 Conclusion and Recommendation**

Based on the evaluation of the recent groundwater elevation data from 2011 to 2025 and comparing the actual drawdown and the simulated drawdown from that period, the Alternative GAM does not perform well in the GMA 3 portion of Pecos County and in Reeves County.

As developed in this report, a reduction in hydraulic conductivity (specifically 20 percent of the values used in the Alternative GAM) is recommended to improve model performance. This change does not negatively impact overall model calibration.

This recommended change results in a distribution in Reeves County transmissivity that is similar to the distribution of transmissivity from 30 specific capacity tests in Reeves County. In addition, a comparison of actual and simulated average drawdown values in Reeves County demonstrates that the lower hydraulic values result in simulated drawdowns that track well with the actual drawdowns.

## 2.0 Adjustments to Hydraulic Conductivity

Based on analysis presented at the May 21, 2025 GMA 3 meeting, the update focused on modifying hydraulic conductivity in the Alternative GAM. Pertinent to this discussion, the Alternative GAM used MODFLOW-2000, which requires cell-by-cell specification of top elevation, bottom elevation, hydraulic conductivity, specific storage, and initial head. Useful calculated parameters used in this analysis include transmissivity and storativity.

### 2.1 Alternative GAM Transmissivity in Reeves County

As noted above, the initial parameter comparison presented at the May 21, 2025 GMA 3 meeting focused on transmissivity and storativity.

Figure 1 presents the distribution of transmissivity in Reeves County from the Alternative GAM. This calculated value used the cell top elevation and cell bottom elevation to calculate aquifer thickness if the initial head was above the top of the cell. If the initial head was below the top of the cell, the thickness was calculated as the initial head minus the cell bottom elevation. If the initial head was below the bottom of the cell, cell thickness was specified as 10 feet.

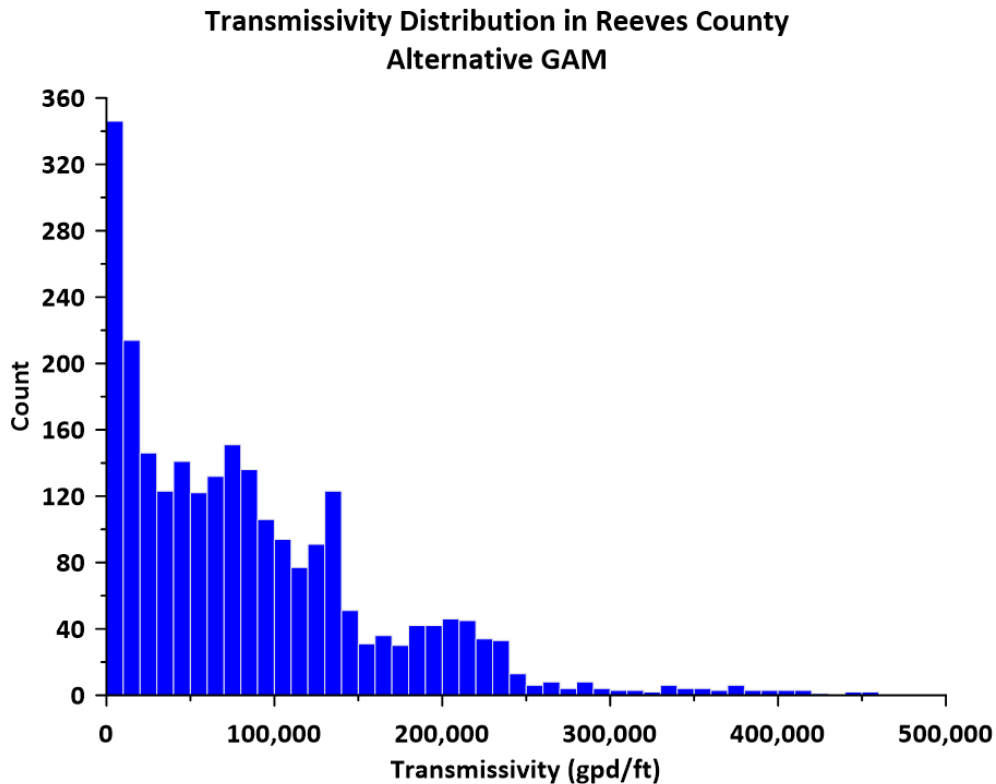
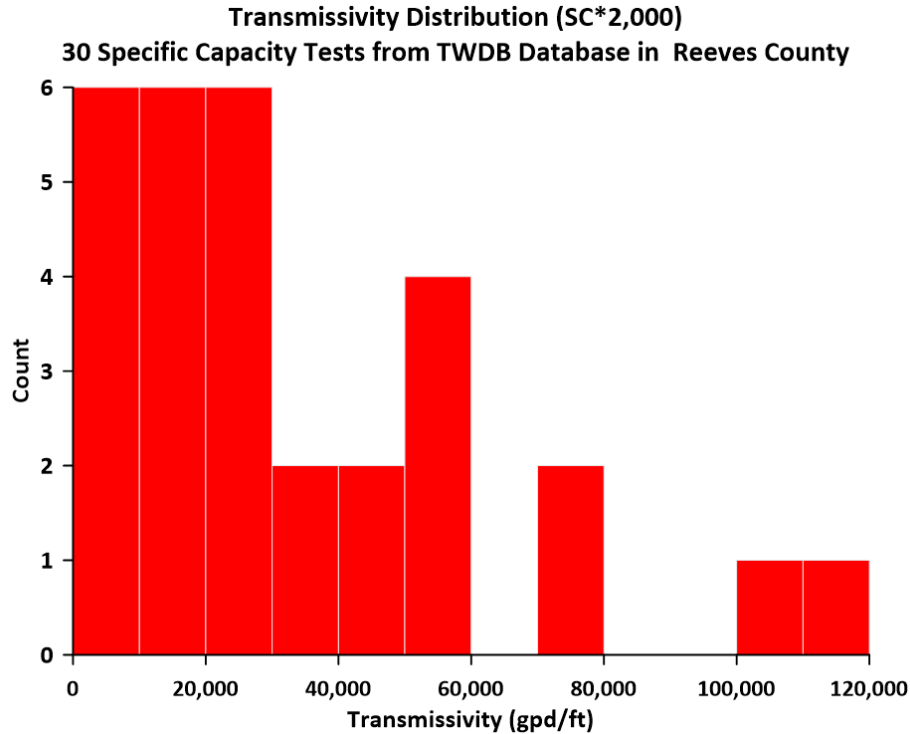


Figure 1. Transmissivity Distribution in Reeves County – Alternative GAM

Figure 2 presents the distribution of transmissivity estimates from 30 specific capacity tests in Reeves County. The test results were downloaded from the TWDB groundwater database. For purposes of this analysis, transmissivity was calculated as specific capacity times 2,000. This is generally a first approximation calculation but is sufficient for purposes of comparison with the estimates in the Alternative GAM.



**Figure 2. Transmissivity Distribution in Reeves County – Specific Capacity Tests**

Please note that the estimates from the specific capacity data are considerably lower than the estimates used in the Alternative GAM.

## 2.2 Alternative Hydraulic Conductivity Values

The Fortran program *AdjustKx.exe* was developed to write 9 alternative hydraulic conductivity files. The program:

- Reads the grid file for the Alternative GAM (to identify the county attribute of the cell)
- Reads the hydraulic conductivity file for the Alternative GAM (*hcx.dat*), which represents the baseline scenario
- Fills the hydraulic conductivity array in the GMA 3 portion of Pecos County and Reeves County for 9 alternatives
  - Alternative 1 = 0.1\*Baseline
  - Alternative 2 = 0.2\*Baseline
  - Alternative 3 = 0.3\*Baseline
  - Alternative 4 = 0.4\*Baseline
  - Alternative 5 = 0.5\*Baseline

- Alternative 6 = 0.6\*Baseline
- Alternative 7 = 0.7\*Baseline
- Alternative 8 = 0.8\*Baseline
- Alternative 9 = 0.9\*Baseline
- Writes the hydraulic conductivity files for the 9 alternatives (*hcxn.dat*, where *n* = alternative number).
- Writes comparison files cell-by-cell hydraulic conductivity values for each alternative (one file for the GMA 3 portion of Pecos County and one file for Reeves County).

### 3.0 Calibration Simulations

The calibration simulations included the baseline (current Alternative GAM as Scenario 10) and nine scenarios with alternative hydraulic conductivity values for the GMA 3 portion of Pecos County and for Reeves County.

#### 3.1 Simulation File Names

Table 1 presents the names of input files that were unchanged from the current Alternative GAM.

**Table 1. Calibration Simulations - Unchanged Input Files**

<b>Package</b>	<b>Unit Number</b>	<b>File Name</b>
BAS6	1	etppv4.bas
DIS	29	etppv4.dis
LPF	11	etppv4.lpf
WEL	12	etppv4.wel
DRN	13	etppv4.drn
RIV	14	etppv4.riv
GHB	17	etppv4.ghb
RCH	18	etppv4.rch
OC	22	etppv4.oc
GMG	19	etppv4.gmg
DATA	71	top.dat
DATA	72	bot.dat
DATA	60	ib.dat
DATA	62	anis.dat
DATA	63	hcz.dat
DATA	64	ss.dat

Table 2 presents the names of scenario-specific input and output file names.

**Table 2. Calibration Simulations - Scenario-Specific File Names**

Scenario Number	Scenario Description	Input Files		Output Files	
		NAM File	Hydraulic Conductivity File	LST File	HDS File
10	Baseline (Current Alternative GAM)	etppv4.nam	hcx.dat	etppv4.lst	etppv4.hds
9	Baseline Hydraulic Conductivity*0.9	etppv4Scen9.nam	hcx9.dat	etppv4Scen9.lst	etppv4Scen9.hds
8	Baseline Hydraulic Conductivity*0.8	etppv4Scen8.nam	hcx8.dat	etppv4Scen8.lst	etppv4Scen8.hds
7	Baseline Hydraulic Conductivity*0.7	etppv4Scen7.nam	hcx7.dat	etppv4Scen7.lst	etppv4Scen7.hds
6	Baseline Hydraulic Conductivity*0.6	etppv4Scen6.nam	hcx6.dat	etppv4Scen6.lst	etppv4Scen6.hds
5	Baseline Hydraulic Conductivity*0.5	etppv4Scen5.nam	hcx5.dat	etppv4Scen5.lst	etppv4Scen5.hds
4	Baseline Hydraulic Conductivity*0.4	etppv4Scen4.nam	hcx4.dat	etppv4Scen4.lst	etppv4Scen4.hds
3	Baseline Hydraulic Conductivity*0.3	etppv4Scen3.nam	hcx3.dat	etppv4Scen3.lst	etppv4Scen3.hds
2	Baseline Hydraulic Conductivity*0.2	etppv4Scen2.nam	hcx2.dat	etppv4Scen2.lst	etppv4Scen2.hds
1	Baseline Hydraulic Conductivity*0.1	etppv4Scen1.nam	hcx1.dat	etppv4Scen1.lst	etppv4Scen1.hds

### 3.2 Calibration Check Data

Data to evaluate changes to model calibration were downloaded from the TWDB Groundwater Database and processed with the Fortran program named *CalData.exe*. In this program, the model grid file and a list of 9,028 wells are read. The actual data are then read and assigned a model row and column.

The raw data from October to March are then processed to find a single end-of-year value using the following preference:

1. December (current year)
2. January (following year)
3. November (current year)
4. February (following year)
5. October (current year)
6. March (following year)

Data from April to September were not used in this effort.

Two output files are written:

- *annualgwecal.dat* are data from 1930 to 2005 (for assessment of historic calibration)
- *annualgwepost.dat* are data from 2006 to 2025 (for HB 2078 analysis)

### 3.3 Post-Processing

Results of the simulations were processed with the Fortran program named *gethds.exe*. This program:

- Reads the hds file from each of the 10 scenarios
- Reads the actual heads (*annualgwecal.dat* described above)
- Writes a file for each simulation that includes actual head, simulated head and residual (simulated head minus actual head)
- Writes a file with the final stress period heads for use as initial conditions for predictive simulations. These files are named *predshedN.dat*, where *N* is the simulation number (1 to 9).

The files containing the comparison of actual head, simulated head and residual were imported into the Excel spreadsheet named *Calibration Summary.xlsx* for further processing.

### 3.4 Calibration Statistics

Calibration statistics for the 10 scenarios (baseline plus 9 alternative hydraulic conductivity values for the GMA 3 portion of Pecos County and for Reeves County) are summarized in Table 3.

Please note that the scaled calibration statistics (scaled residual standard deviation and scaled absolute residual mean) are all less than 0.1, which suggests that any of these simulations would be considered adequately calibrated.

**Table 3. Calibration Simulations - Calibration Statistics**

Scenario Number	Scenario Description	Residual Mean	Absolute Residual Mean	Residual Standard Deviation	Sum of Squared Residuals	Root Mean Square Error	Minimum Residual	Maximum Residual	Number of Data Points	Range in Actual Heads	Scaled Residual Standard Deviation	Scaled Absolute Residual Mean	Scaled Root Mean Square Error	Scaled Residual Mean
10	Baseline (Current Alternative GAM)	-0.75	50.20	73.30	1.05E+08	73.30	-499.72	372.31	19,572	2,657	0.0276	0.0189	0.0276	-0.0003
9	Baseline Hydraulic Conductivity*0.9	-1.12	49.88	72.65	1.03E+08	72.66	-499.72	373.04	19,572	2,657	0.0273	0.0188	0.0273	-0.0004
8	Baseline Hydraulic Conductivity*0.8	-1.68	49.59	72.09	1.02E+08	72.10	-499.72	373.81	19,572	2,657	0.0271	0.0187	0.0271	-0.0006
7	Baseline Hydraulic Conductivity*0.7	-2.48	49.39	71.69	1.01E+08	71.73	-499.72	374.65	19,572	2,657	0.0270	0.0186	0.0270	-0.0009
6	Baseline Hydraulic Conductivity*0.6	-3.62	49.40	71.63	1.01E+08	71.72	-499.72	375.58	19,572	2,657	0.0270	0.0186	0.0270	-0.0014
5	Baseline Hydraulic Conductivity*0.5	-5.54	49.82	72.27	1.03E+08	72.48	-499.72	376.61	19,572	2,657	0.0272	0.0187	0.0273	-0.0021
4	Baseline Hydraulic Conductivity*0.4	-8.89	51.25	74.40	1.10E+08	74.93	-499.72	377.79	19,572	2,657	0.0280	0.0193	0.0282	-0.0033
3	Baseline Hydraulic Conductivity*0.3	-20.91	60.65	92.54	1.76E+08	94.87	-515.22	391.20	19,572	2,657	0.0348	0.0228	0.0357	-0.0079
2	Baseline Hydraulic Conductivity*0.2	-15.58	59.52	92.59	1.73E+08	93.89	-514.83	612.83	19,572	2,657	0.0348	0.0224	0.0353	-0.0059
1	Baseline Hydraulic Conductivity*0.1	-34.11	75.27	124.92	3.28E+08	129.50	-720.02	414.16	19,572	2,657	0.0470	0.0283	0.0487	-0.0128

## 4.0 Predictive Simulations

### 4.1 Simulation File Names

Table 4 presents the names of input files that were unchanged from the current Alternative GAM.

**Table 4. Predictive Simulations - Unchanged Input Files**

Package	Unit Number	File Name
BAS6	1	pred.bas
DIS	29	pred.dis
LPF	11	etppv4.lpf
WEL	12	pred.wel
DRN	13	etppv4.drn
RIV	14	etppv4.riv
GHB	17	etppv4.ghb
RCH	18	pred.rch
OC	22	etppv4.oc
GMG	19	etppv4.gmg
DATA	71	top.dat
DATA	72	bot.dat
DATA	60	ib.dat
DATA	62	anis.dat
DATA	63	hcz.dat
DATA	64	ss.dat

The files that are read each stress period (WEL, DRN, RIV, GHB, RCH, and OC) were updated to include 10 additional stress periods to extend the simulations to the year 2080. This was completed for use in future predictive simulations.

Table 5 presents the names of scenario-specific input and output file names.

**Table 5. Predictive Simulations - Scenario-Specific File Names**

Scenario Number	Scenario Description	Input Files			Output Files	
		NAM File	Initial Heads	Hydraulic Conductivity File	LST File	HDS File
10	Baseline (Current Alternative GAM)	etppv4.nam	predshed.dat	hcx.dat	pred1.lst	predhds
9	Baseline Hydraulic Conductivity*0.9	etppv4Scen9.nam	predshed9.dat	hcx9.dat	pred9.lst	pred9.hds
8	Baseline Hydraulic Conductivity*0.8	etppv4Scen8.nam	predshed8.dat	hcx8.dat	pred8.lst	pred8.hds
7	Baseline Hydraulic Conductivity*0.7	etppv4Scen7.nam	predshed7.dat	hcx7.dat	pred7.lst	pred7.hds
6	Baseline Hydraulic Conductivity*0.6	etppv4Scen6.nam	predshed6.dat	hcx6.dat	pred6.lst	pred6.hds
5	Baseline Hydraulic Conductivity*0.5	etppv4Scen5.nam	predshed5.dat	hcx5.dat	pred5.lst	pred5.hds
4	Baseline Hydraulic Conductivity*0.4	etppv4Scen4.nam	predshed4.dat	hcx4.dat	pred4.lst	pred4.hds
3	Baseline Hydraulic Conductivity*0.3	etppv4Scen3.nam	predshed3.dat	hcx3.dat	pred3.lst	pred3.hds
2	Baseline Hydraulic Conductivity*0.2	etppv4Scen2.nam	predshed2.dat	hcx2.dat	pred2.lst	pred2.hds
1	Baseline Hydraulic Conductivity*0.1	etppv4Scen1.nam	predshed1.dat	hcx1.dat	pred1.lst	pred1.hds

## 4.2 Post Processing

The Fortran program named *gethds.exe* was written to process the results of the simulations. The program:

- Reads the hds files for each simulation
- Reads the actual heads and drawdown used in Hutchison (2025)
- Writes the file *GMA3Scen.dat* that includes:
  - Attributes of each data point (well name, county name, model row, model column, year of measurement)
  - Actual baseline (2010) groundwater elevation
  - Groundwater elevation for the specified year
  - Measured (actual) drawdown
  - The simulated groundwater elevation for each scenario in 2010 (the baseline for simulated drawdown calculations)
  - The simulated groundwater elevation for each scenario for the specified year

This file was then imported into an Excel spreadsheet *PredResults10ScenariosGMA3Kx.xlsx*. The tab named *GMA3Scen.dat* contains the data from the post-processor. Additional columns were added to process the groundwater elevation data to simulated drawdown. The tab named *Avg Results* includes the county averages for GMA 3 (average simulated drawdown and average

differences between simulated and actual drawdown). The information in this tab are summarized in Table 6.

**Table 6. Summary of Predictive Simulation Drawdown Comparison**

County	Number of Readings	Actual Drawdown (ft)	Average Simulated Drawdown (ft - 2010 Baseline)										
			Scen 10	Scen 9	Scen 8	Scen 7	Scen 6	Scen 5	Scen 4	Scen 3	Scen 2	Scen 1	
Crane	24	-2.68	4.32	4.27	4.28	4.27	4.27	4.27	4.27	4.28	4.27	4.27	4.27
Loving	33	-3.78	1.01	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.02	1.02	1.03
Pecos	139	20.57	2.73	5.31	5.75	6.22	6.76	7.40	8.27	9.62	12.42	20.97	
Reeves	310	11.27	1.25	2.57	2.78	3.05	3.50	4.12	5.06	6.78	10.10	17.65	
Ward	78	-3.25	9.64	9.94	9.94	9.94	9.95	9.96	9.98	10.00	10.03	10.06	
Winkler	103	2.11	27.55	27.68	27.68	27.68	27.68	27.68	27.68	27.68	27.68	27.68	27.68

County	Number of Readings	Actual Drawdown (ft)	Average Difference in Drawdown (ft - Simulated minus Actual)										
			Scen 10	Scen 9	Scen 8	Scen 7	Scen 6	Scen 5	Scen 4	Scen 3	Scen 2	Scen 1	
Crane	24	-2.68	7.00	6.96	6.96	6.96	6.96	6.96	6.96	6.96	6.96	6.96	6.96
Loving	33	-3.78	4.79	4.78	4.78	4.78	4.78	4.79	4.79	4.79	4.80	4.81	4.81
Pecos	139	20.57	-17.84	-15.26	-14.82	-14.35	-13.81	-13.17	-12.30	-10.95	-8.15	0.40	
Reeves	310	11.27	-10.02	-8.70	-8.48	-8.22	-7.76	-7.15	-6.20	-4.49	-1.17	6.38	
Ward	78	-3.25	12.89	13.19	13.19	13.20	13.21	13.22	13.23	13.26	13.29	13.31	
Winkler	103	2.11	25.43	25.57	25.56	25.56	25.56	25.56	25.56	25.57	25.56	25.56	25.56

Please recall that hydraulic conductivity was adjusted only in the GMA 3 portion of Pecos County and in Reeves County. No other parameters were adjusted and the results for Crane, Loving, Ward, and Winkler counties demonstrate that the adjustments result in no significant changes to the unadjusted counties.

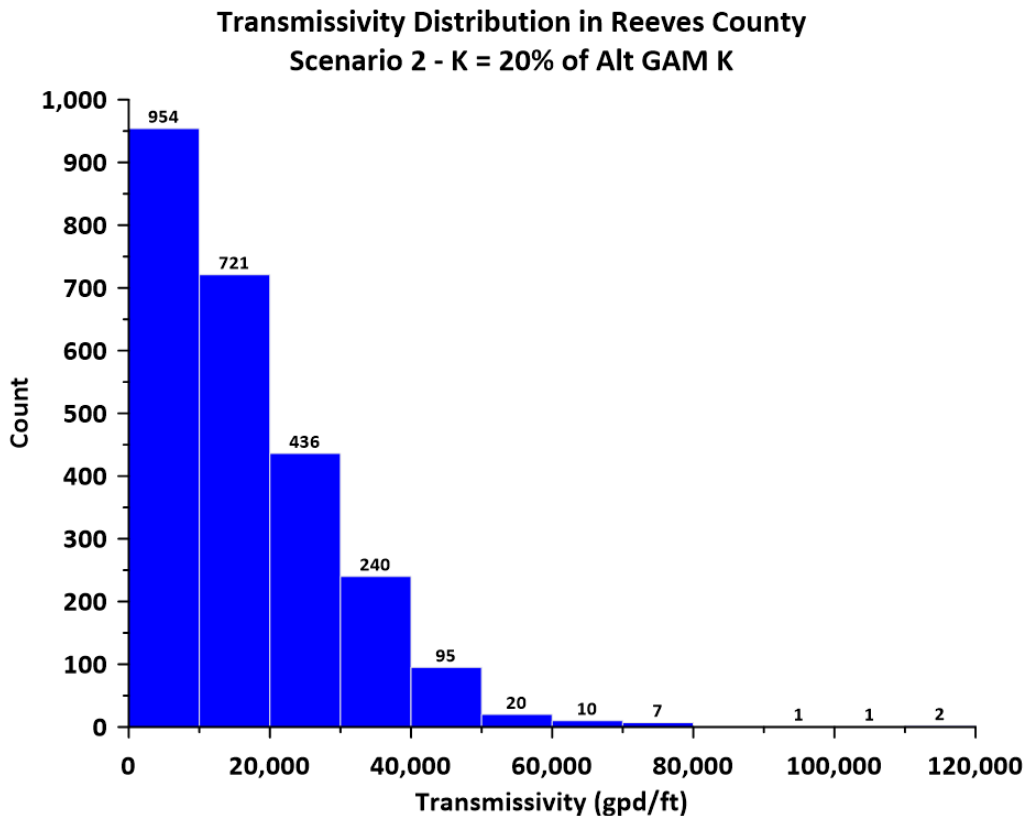
In the GMA 3 portion of Pecos County and in Reeves County, it can be seen that as hydraulic conductivity is reduced (from the current Alternative GAM in Scenario 10 to the lowest simulated values in Scenario 1) the differences in simulated and actual drawdown decreases (yellow highlighted cells).

## 5.0 Discussion of Results

Based on the results of the calibration simulations and the predictive simulations, lowering the hydraulic conductivity in the GMA 3 portion of Pecos County and in Reeves County improves the comparison of actual and simulated drawdown from 2011 to 2024 without compromising the overall calibration of the model. As developed below, it is recommended that the parameters associated with Scenario 2 (hydraulic conductivity is 20 percent of the Alternative GAM hydraulic conductivity in the GMA 3 portion of Pecos County and in Reeves County) should be used in the updated Alternative GAM.

### 5.1 Transmissivity Distribution in Reeves County

Please recall that the transmissivity distribution of 30 wells in Reeves County (based on specific capacity tests) was presented. The distribution of transmissivity for the current Alternative GAM was also presented. Figure 3 presents the transmissivity distribution in Reeves County under Scenario 2 (hydraulic conductivity is 20 percent of the Alternative GAM hydraulic conductivity).



**Figure 3. Transmissivity Distribution in Reeves County – Scenario 2**

Please note that the distribution from Scenario 2 is similar to the distribution of the transmissivity estimated from the specific capacity tests

## 5.2 Average Drawdown in Reeves County

Figure 4 presents a hydrograph of average actual drawdown and average simulated drawdown for Reeves County. Please note that the black line represents the average actual drawdown, the blue line represents the average simulated drawdown from the current Alternative GAM, and the red line represents the average simulated drawdown from Scenario 2. The black numbers above the blue line are the number and annual readings that were averaged.

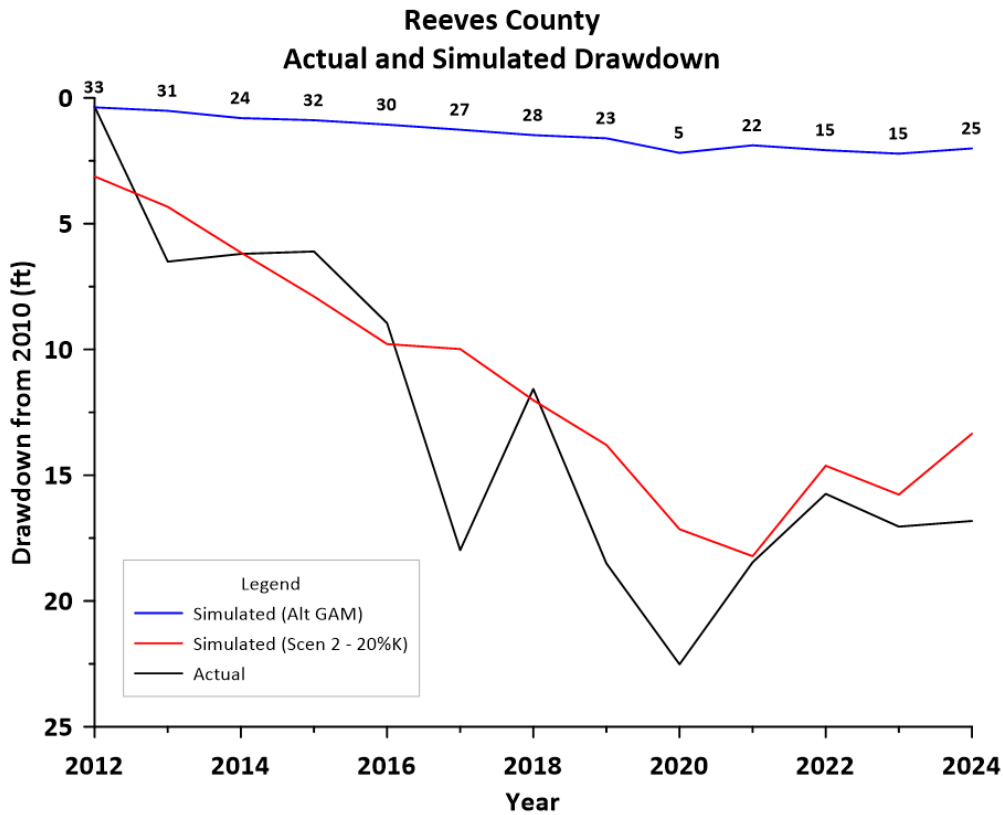
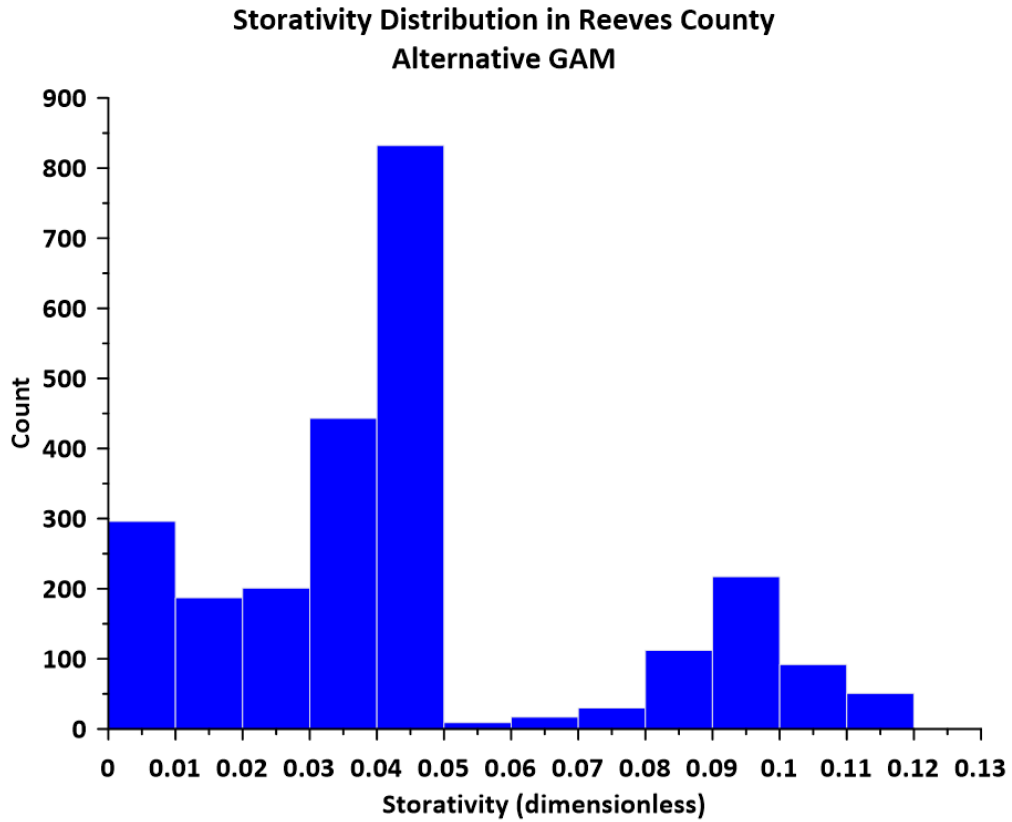


Figure 4. Average Drawdown Comparison - Reeves County

Based on this evaluation, the simulated drawdown in Scenario 2 tracks the actual drawdown except for a few years that may be related to drought conditions.

## 5.3 Storativity

When comparing drawdown estimates, the storativity that is specified is often an important parameter. Figure 5 presents the distribution of storativity used in the current Alternative GAM in Reeves County.



**Figure 5. Storativity Distribution in Reeves County - Alternative GAM**

Qualitatively, this distribution appears reasonable. Unlike the available estimates for transmissivity, there are no available data to base a modification, so it is recommended that these values from the Alternative GAM remain unchanged.

## **X.0 References**

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