Draft GAM Task 10-027 (revised)

by William R. Hutchison, Ph.D, P.E., P.G.
Texas Water Development Board
Groundwater Resources Division
(512) 463-5067
February 9, 2011

This document is released for the purpose of interim review under the authority of William R. Hutchison, P.E. 96287, P.G. 286 on February 9, 2011

EXECUTIVE SUMMARY

This GAM Task summarizes the results of seven pumping scenarios using the recently completed groundwater flow model of the Kinney County area. The seven pumping scenarios represent pumping that is higher and lower than historic pumping in order to evaluate changes in spring flow in Las Moras Spring and estimate minimum groundwater elevation in the monitor well that is used by the Kinney County Groundwater Conservation District. The spring flow and minimum groundwater elevation have been adopted by the Kinney County Groundwater Conservation District as their desired future conditions of the aquifer.

Based on this analysis, average spring flow in Las Moras spring will be 23.9 cubic feet per second and median spring flow in Las Moras Spring will be 24.4 cubic feet per second if pumping is about 77,000 acre-feet per year in Kinney County. Minimum groundwater elevation in the monitoring well will be 1,184 feet above mean sea level under this scenario. The minimum groundwater elevation has been revised from an earlier version of the Draft GAM Task report based on input from the Kinney County Groundwater Conservation District regarding the land surface elevation of the monitoring well used in this analysis.

ORIGIN OF TASK:

The Kinney County Groundwater District requested assistance in developing desired future conditions. As a result of this request, TWDB staff developed a groundwater flow model of all the aquifers in Kinney County and surrounding areas. This model is documented in Hutchison and others (2011). This task report summarizes the results of seven scenarios that were presented at the Kinney County Groundwater Conservation District Board meeting of July 27, 2010.

DESCRIPTION OF TASK:

Based on the results of the calibration of the groundwater flow model of Kinney County, historic groundwater pumping from 1950 to 2005 has ranged from about 51,000 acre-feet per year to about 77,000 acre-feet per year (Hutchison and others 2011). In general, pumping increases result in reduced spring flow, and reduced pumping result in increased spring flow. The objective of the simulations run for this task was to quantify the change in spring flow under various scenarios of constant pumping. The information from these simulations has been used by the Kinney County Groundwater Conservation District in establishing the desired future conditions of the aquifer as part of the Joint Planning Process in Groundwater Management Areas 7 and 10. In order to facilitate comparison with historic spring flows, all simulations were run with the recharge and river conditions equivalent to the historic period (1950 to 2005).

METHODS:

Seven pumping scenarios were developed for this task, each with constant pumping. The base case assumed 77,000 acre-feet per year (AF/yr) of pumping, which is equivalent to the highest year of pumping based on the calibrated model for the period 1950 to 2005. Two scenarios included reduced pumping and four scenarios included increased pumping as follows:

Scenario	Kinney County Pumping (AF/yr)
1	38,000
2	57,000
3	77,000
4	96,000
5	115,000
6	134,000
7	153,000

The scenarios consisted of running the model for 56 years, using recharge and river conditions from 1950 to 2005 in order to facilitate comparison with the historic spring flows.

PARAMETERS AND ASSUMPTIONS:

- The recently developed groundwater flow model of the Kinney County area (Hutchison and others, 2011) was used for these simulations.

- The model has four layers: layer 1 represents the Carrizo-Wilcox and associated aquifers, layer 2 represents the upper Cretaceous formations that yield groundwater, layer 3 represents the Edwards (Balcones Fault Zone) Aquifer and the Edwards Group of the Edward-Trinity (Plateau) Aquifer, and layer 4 represents the Trinity Aquifer.

- As further detailed in the model report (Hutchison and others, 2011), model calibration statistics for the entire model domain for groundwater elevation and spring flow are summarized below. Note that groundwater elevation data are expressed in feet above mean sea level (ft MSL), and spring flows are expressed in cubic feet per second (cfs):

Statistic	Groundwater Elevation	Spring Flow
Number of Measurements	1,878	432
Average Residual	4.5 ft	-1.2 cfs
Standard Deviation	58 ft	10 cfs
Range of Measurements	1,581 ft	223 cfs
Standard Deviation divided by Range	0.04	0.04

- Seven different pumping scenarios were used as described above
- Each simulation consisted of 57 stress periods. All model input files were identical to the calibration period in each scenario except for the pumping file, as noted above.
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

RESULTS:

Spring Flow

The results of the simulation include estimating spring flow changes under alternative pumping scenarios. A summary of the results expressed as average spring flow for the three major springs in Kinney County (Las Moras, Mud, and Pinto) as a function of pumping in Kinney County are presented in Figure 1.

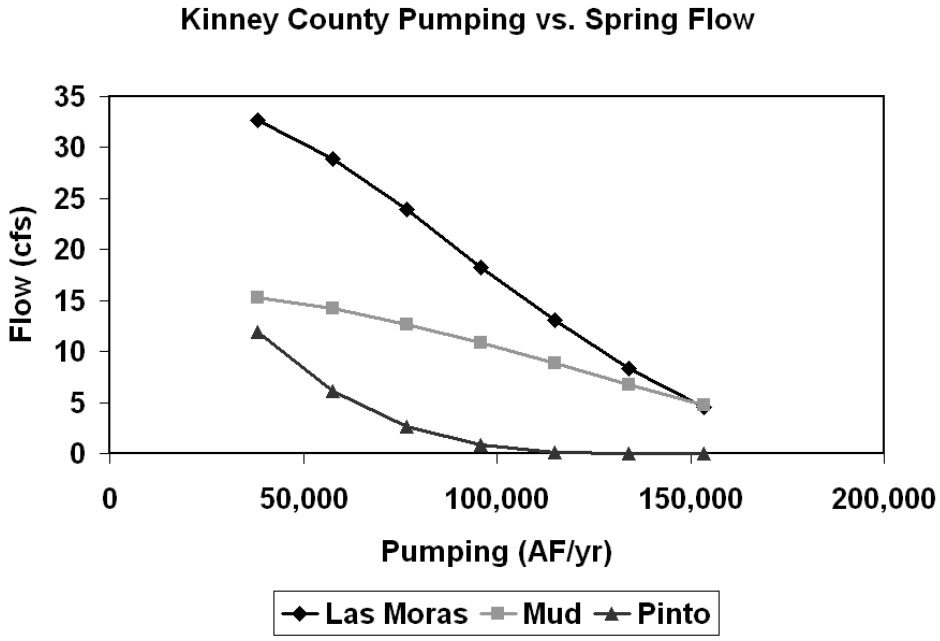

Figure 1. Kinney County Pumping versus Spring Flow for Seven Pumping Scenarios.

Note that as a result of input received from the Kinney County Groundwater Conservation District Board of Directors, Las Moras is the only spring for which a desired future condition will be set due to monitoring constraints. The frequency of various flows in Las Moras spring that are a result of changes in recharge conditions are presented in Table 1.

Table 1. Las Moras Spring Flow Frequency under Seven Alternative Pumping Scenarios
Pumping Totals for Kinney County Only, Frequency Expressed as Percent Occurrence for 56 Year Simulations

Las Moras Spring Flow (cfs)	Scenario 1 (Pumping = 38,000 AF/yr)	Scenario 2 (Pumping = 57,500 AF/yr)	Scenario 3 (Pumping = 77,000 AF/yr)	Scenario 4 (Pumping = 96,000 AF/yr)	Scenario 5 (Pumping = 115,000 AF/yr)	Scenario 6 (Pumping = 134,000 AF/yr)	Scenario 7 (Pumping = 153,000 AF/yr)
0	0	0	0	13	25	45	59
0 to 5	0	0	5	9	14	9	16
5 to 10	0	2	13	9	9	13	5
10 to 15	0	11	7	13	7	9	7
15 to 20	11	9	18	11	18	9	4
20 to 25	13	18	9	14	7	5	2
25 to 30	20	13	16	9	7	4	5
30 to 35	18	20	11	11	5	5	2
35 to 40	16	9	11	7	5	2	0
40 to 45	11	14	7	5	2	0	0
> 50	13	5	4	0	0	0	0

Because the average spring flow and median spring flow of Scenario 3 were adopted as the desired future condition for Kinney County, a graphical summary of Scenario 3 for Las Moras Spring is presented in Figure 2. Note that the average flow and the median flow fall into the group that would occur about 9 percent of the time (20 to 25 cfs). A spring flow between 15 and 20 cfs (slightly below the adopted desired future condition) would occur 18 percent of the time, and flow between 25 and 30 cfs (slightly above the adopted desired future condition) would occur about 16 percent of the time. Thus, Las Moras spring flow would be between 15 and 30 cfs about 43 percent of the time. Note that because the model was run on annual stress periods, these spring flows are representative of end-of-the calendar year conditions. Thus, for comparative purposes, flows collected in December and January should be used to track with the desired future condition.

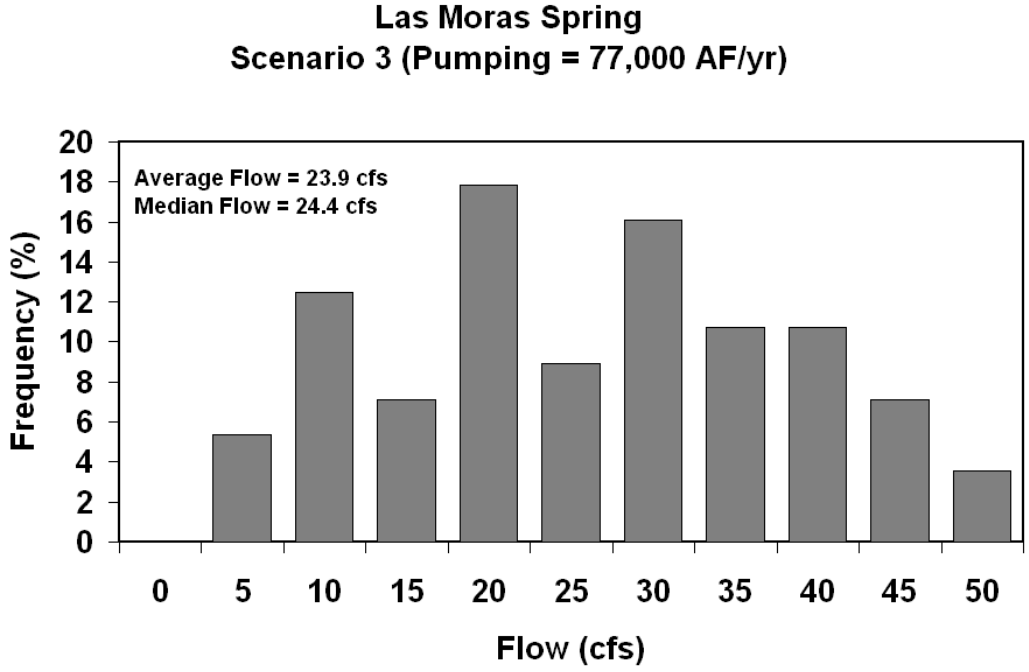

Figure 2. Las Moras Spring Flow Frequency for Scenario 3.

Groundwater Elevations

Groundwater elevation changes due to pumping were evaluated for the monitoring well used by the Kinney County Groundwater Conservation District (Well No. 70-38-902). This well was constructed in 1973 by the Texas Water Development Board. The earlier version of this Draft GAM Task report calculated groundwater elevations using a measuring point elevation of 1,373 ft MSL. However, during review of this document, the Kinney County Groundwater Conservation District informed the Texas Water Development Board in an email dated February 8, 2011, that the measuring point elevation is 1,381.042 ft MSL. Consequently, the hydrograph of measured groundwater elevations presented in Figure 3 have been revised. Note that the minimum groundwater elevation is 1,186, which was measured in January of 1991. The monitoring well has a limited record of data as compared to the calibration period of the model. Moreover, some of the highest levels of groundwater pumping in Kinney County predate the existence of the monitoring well.

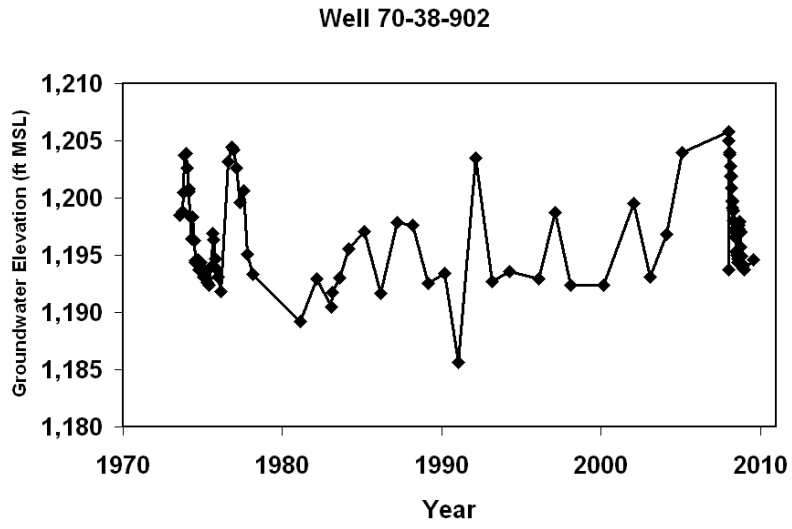

Figure 3. Groundwater elevation measurements in Well 70-38-902.

Because the Kinney County Groundwater Conservation District Board of Directors has adopted a minimum groundwater elevation in this well (1,184 ft MSL) as desired future condition for the Groundwater Management Area 10 portion of Kinney County, an analysis of simulated groundwater levels at the site of this well was completed. Figure 4 presents a comparison of the simulated groundwater elevation estimates with measured groundwater elevations.

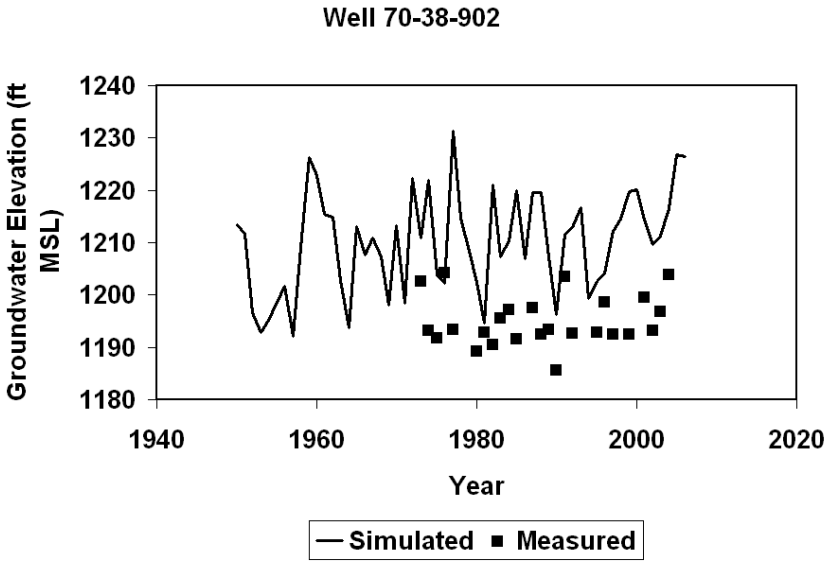

Figure 4. Comparison of simulated groundwater elevations and measured groundwater elevations from winter months.

Note that the general trend is that the simulated groundwater elevations are slightly higher than the measured groundwater elevations. At the end of 1990, the simulated groundwater elevation was estimated to be 1,196 ft MSL, and is comparable to the measured value in January 1991 of 1,186 ft MSL. Note that from 1950 to 2005, there were five years where the simulated groundwater elevation was lower than that simulated in 1990. These estimates are as follows:

- 1957 (4 feet lower than 1990),
- 1953 and 1964 (3 feet lower than 1990),
- 1981 (2 feet lower than 1990), and
- 1954 (1 foot lower than 1990).

The Kinney County Groundwater Conservation District has adopted desired future conditions that are consistent with Scenario 3, and established a minimum groundwater elevation in Well 70-38-902 of 1,184 ft MSL in the Kinney County portion of Groundwater Management Area 10.

Given the nature of the desired future condition, the actual data collected at the well, and the accuracy of the model, it is concluded that the desired future condition expressed by the Kinney County Groundwater Conservation District (minimum groundwater elevation for Well 70-38-902 of 1,184 ft MSL) is consistent with Scenario 3.

REFERENCES:

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, The U.S. Geological Survey modular ground-water model-user guide to modularization concepts and the ground-water flow process: U.S. Geological Survey Open-File Report 00-92, 121 p.

Hutchison, William R., Shi, Jerry, and Jigmond, Marius, 2011. Groundwater Flow Model of the Kinney County Area. Texas Water Development Board Unpublished Report.