Effects of Vista Ridge Pumping on Groundwater and Surface Water in the Lost Pines and Post Oak Savannah Groundwater Conservation Districts

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1.0 Introduction

Abengoa Vista Ridge, LLC is proposing to pump approximately 50,000 acre feet of water per year from the Simsboro and Carrizo aquifers in western Burleson County, Texas. This water would be delivered to San Antonio via the Vista Ridge pipeline. This pumping would affect groundwater levels and the discharge of groundwater to the Colorado and Brazos rivers.

The effects of the Vista Ridge pumping were estimated using the *Central Queen City and Sparta Groundwater Availability Model* (GAM)[1]. The input files used to generate the results presented in this report were provided by the Lost Pines Groundwater Conservation District (LPGCD)[2], or are modifications of LPGCD-provided files. Figure 1 shows the geologic units represented in the GAM.

2.0 Effects of Vista Ridge pumping on groundwater

Pumping would occur in the Simsboro (36,000 ac-ft/yr) and Carrizo (15,000 ac-ft/yr) aquifers[3]. This pumping would reduce hydraulic heads (i.e., water levels or hydraulic pressure) in these aquifers. However, because of leakage[4], hydraulic heads would also be reduced in the Hooper, Calvert Bluff, and Queen City aquifers (figure 1).[5] In other words, Vista Ridge pumping would cause water from these aquifers to be drawn into the Simsboro and/or Carrizo aquifers. The maximum reductions in head (drawdowns) in all five aquifers, as predicted by the model, are given in table 1.[6]

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[1] TWDB 2004; and LPGCD 2013. The GAM is based on the MODFLOW computer code developed by the U.S. Geological Survey (TWDB 2004, page 6-1).

[2] LPGCD 2013.

[3] These pumping values are given in POSGCD, 2015, page 12. The GAM simulated pumping 50,000 acre-feet per year (SAWS, 2014, page 1), beginning in 2020. In the GAM, 35,721 acre-feet per year was pumped from the Simsboro, and 14,283 acre-feet per year from the Carrizo.

[4] Leakage is a common and well-known phenomenon that is discussed in standard hydrology texts (See, for example, Davis and DeWiest 1966, pages 224 – 229; and Freeze and Cherry, 1979, pages 320 – 324.). In figure 1, leakage (cross-formational flow) between geologic units is indicated by double-headed arrows. In a 2009 pump-test conducted in Lee County, it was estimated that 22% of the water pumped from the Simsboro was derived from leakage from adjacent aquifers (Thornhill 2009, page 8).

[5] According to simulations by Huang et al., much of the water pumped from the Simsboro originates as leakage from the underlying Hooper and overlying Calvert Bluff (Huang et al., 2012, pages 9 and 10).

[6] Note: there is evidence that the manner in which faults are represented in the GAM causes the model to over-estimate drawdowns on the side of the fault where pumping takes place, and under-estimate drawdowns on the other side of the fault (Young, S., 2015).

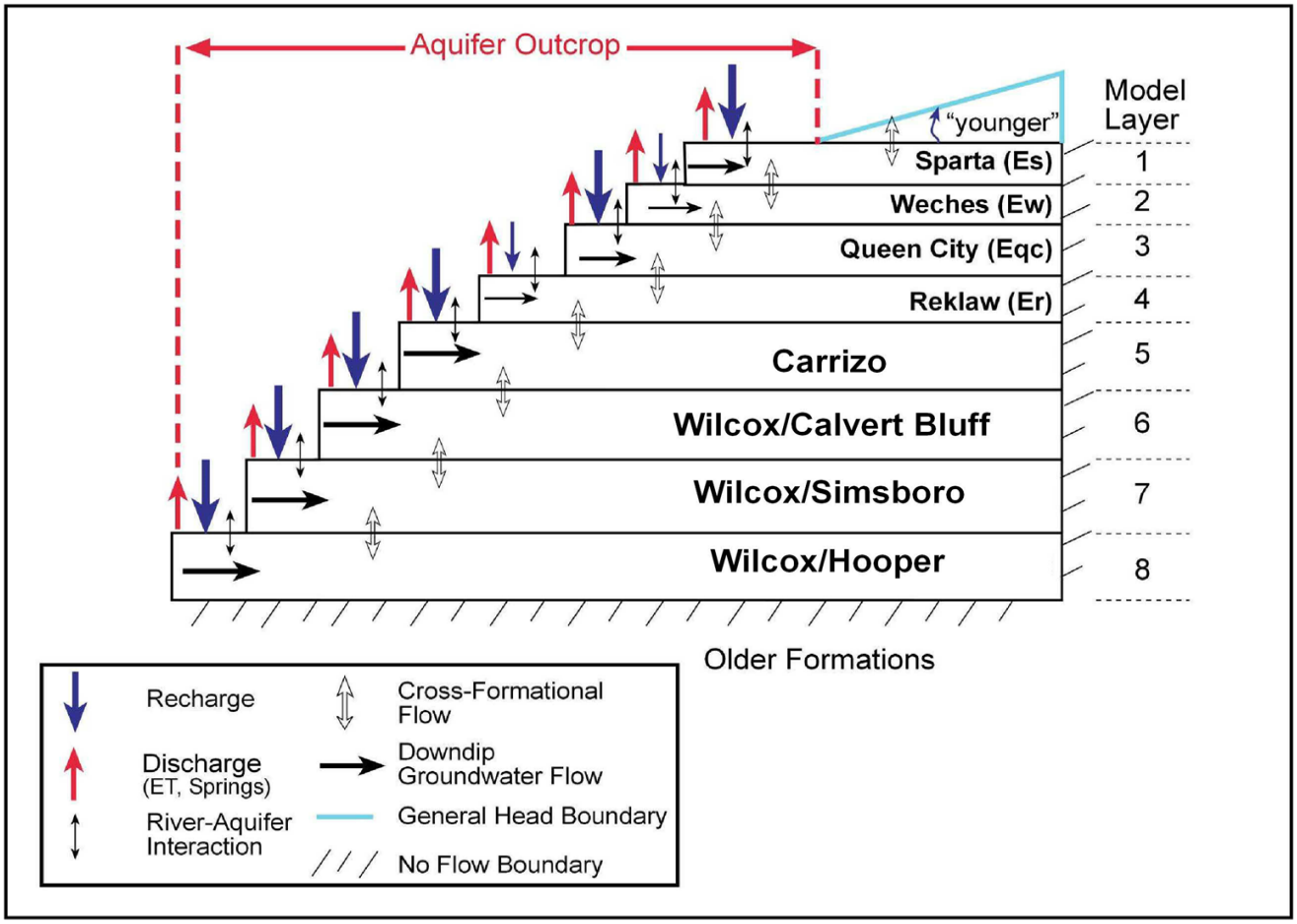

Figure 1
Geologic Units Represented in the GAM
(adapted from TWDB, 2004, figure 5.1)

Table 1
GAM Predictions of Maximum Drawdowns
Due to Vista Ridge Pumping in 2060

Aquifer	**Maximum drawdown (ft)**[7]
Hooper	94
Simsboro	466
Calvert Bluff	99
Carrizo	217
Queen City	29

[7] Drawdowns at Vista Ridge wellfield. Simulated Vista Ridge pumpage from model cells (row, column): (42, 122), (42, 123), (43, 122), and (43, 123).

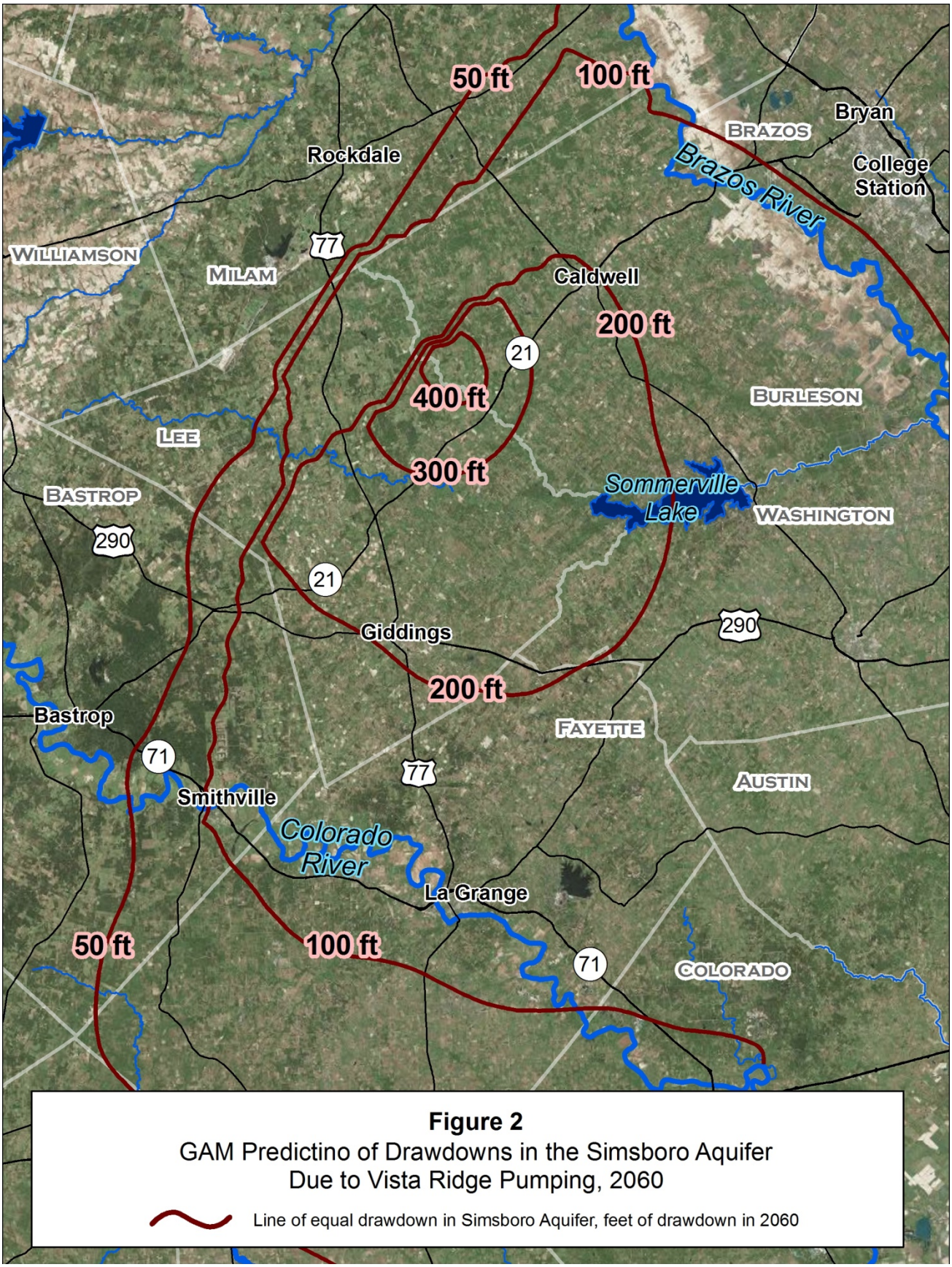

Figure 2
GAM Predictino of Drawdowns in the Simsboro Aquifer
Due to Vista Ridge Pumping, 2060

Line of equal drawdown in Simsboro Aquifer, feet of drawdown in 2060

The drawdowns extend to both the confined and unconfined portions of the Simsboro and Carrizo aquifers. Where the aquifers are confined, drawdowns will reduce water levels in wells that draw water from the aquifers. Where the aquifers are unconfined (recharge areas), drawdowns will dewater portions of the aquifers.

The drawdowns in the Simsboro Aquifer in 2060 are shown in figure 2. Table 2 shows the average 2060 drawdowns in Bastrop, Lee, Burleson, and Milam counties, and in the LPGCD (Bastrop and Lee counties) and the Post Oak Savannah groundwater Conservation District (POSGCD, Burleson and Milam counties).

The drawdowns caused by Vista Ridge pumping would be in addition to the drawdowns caused by baseline pumping.[8]

Table 2
GAM Predictions of Average Drawdowns in the Simsboro Aquifer Due to Vista Ridge Pumping, 2060

County or GCD[9]	Average drawdown (ft)
Bastrop	46
Lee	188
Burleson	179
Milam	39
LPGCD	112
POSGCD	123

As shown in figure 2, pumping in one GCD may affect water levels in an adjacent GCD. There are two projects in the LPGCD that each propose to pump tens of thousands of acre feet annually from the Simsboro Aquifer[10]. These projects would add to future drawdowns in the LPGCD and the POSGCD.

2.1 Simsboro Aquifer DFCs

The LPGCD and the POSGCD have adopted Desired Future Conditions (DFCs) for the aquifers in their districts. The DFCs are average drawdowns that occur between the years

[8] Baseline pumping is an estimate of the amount of past, present, and future pumping (not including proposed projects such as Vista Ridge or End Op and Forestar's projects, see below). Baseline pumping data used to produce the GAM results given in this report are contained in the file Run50.wel. This file was provided by LPGCD. Baseline pumping from the Simsboro in 2000 is approximately 11,300 acre-feet per year in the LPGCD and 12,200 acre-feet per year in the POSGCD. For 2060, baseline pumping is 40,400 acre-feet per year in the LPGCE and 48,500 acre-feet per year in the POSGCD.

[9] GCD: Groundwater Conservation District.

[10] End Op L.P. and the LPGCD have agreed to a settlement framework that, if finalized, would allow End Op to pump 46,000 acre-feet per year (Austin American Statesman, September 10, 2015). Forestar Inc. has been given a permit to pump 12,000 acre-feet per year but is claiming the right to pump 45,000 acre-feet per year (Elgin Courier, March 25, 2014).

2000 and 2060.[11] The DFCs adopted for the Simsboro Aquifer by the LPGCD and the POSGCD are 237 feet and 300 feet, respectively.[12] Table 3 shows the GAM predictions of average drawdowns due to baseline pumping and to baseline plus Vista Ridge pumping.

Table 3
GAM Predictions of Average Drawdowns
In the Simsboro Aquifer from 2000 to 2060

GCD	DFC (ft)	Baseline drawdown (ft)	Baseline plus Vista Ridge drawdown (ft)
LPGCD	237	209	320
POSGCD	300	279	402

3.0 Effects of Vista Ridge pumping on groundwater discharge to the Colorado and Brazos rivers

Groundwater discharge contributes to the flow of both the Colorado and Brazos rivers. In Bastrop County, groundwater discharge to the Colorado is between 22,000 and 36,000 acre-feet per year.[13] During normal times this represents about 2% of flow. However, during times of drought, more than half the flow of the Colorado may be due to groundwater discharge.[14] Most of the discharge to the Colorado River appears to come from the Simsboro Aquifer.[15]

The GAM predicts that groundwater discharges to the Colorado and Brazos rivers will decrease as a result of Vista Ridge pumping. These decreases are shown in figures 3 and 4.[16]

Although the GAM predicts the amount of groundwater discharge to the rivers over time, as well as trends in groundwater discharge, there is reason to believe that 1) the amount of discharge predicted by the GAM is probably not reliable, and 2) the trend predicted by the GAM is probably reliable[17]. The basis for these claims is presented in appendix 1.

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[11] GMA 12, 2010, appendix B, first page.
[12] GMA 12, 2010, appendix B, Table B-1.
[13] 30 to 50 ft^3/s (Saunders, 2009, pages 1 – 3).
[14] Minimum flow measured at Bastrop = 75 ft^3/s = 54,000 acre-feet per year (USGS, 2002, page 261).
[15] Saunders, 2009, page 3.
[16] The results for the Colorado River are for the end of time step ten in stream segments 36, 38, 40, and 46. The results for the Brazos River are for the end of time step ten in stream segments 49, 51, 53, 58, and 60.
[17] According to simulations by Huang et al., groundwater pumping in the region represented by the GAM will continue to reduce the discharge of groundwater to streams. Over 50 years, the percentage of pumped groundwater derived from streams will increase from about 18% to 24% (Huang et al., 2012, page 10 and figure 8).

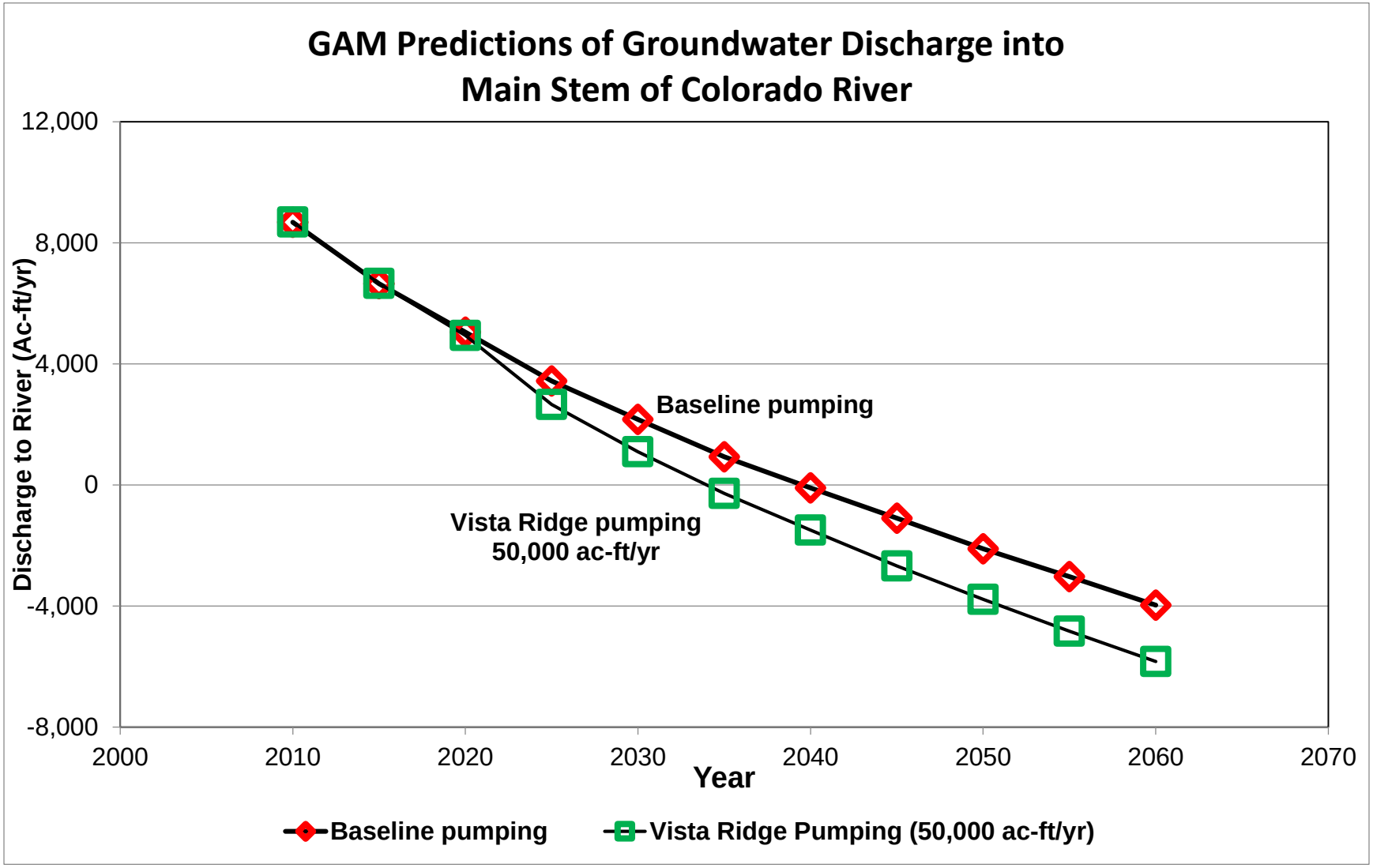

Figure 3
GAM Prediction of Groundwater Discharge to Colorado River

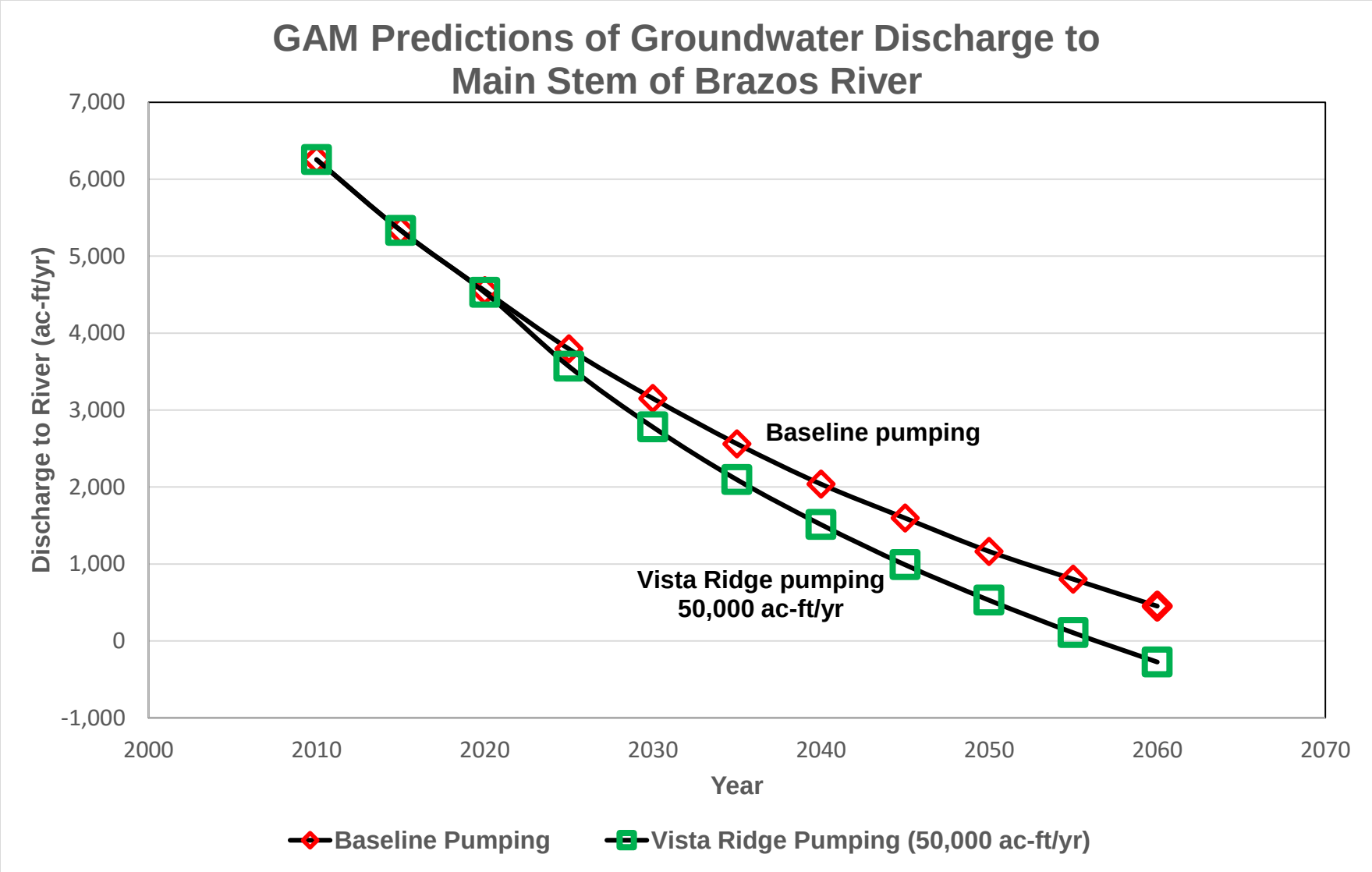

Figure 4
GAM Prediction of Groundwater Discharge to Brazos River

4.0 Conclusions

The Vista Ridge pumping would:

- Reduce hydraulic heads in the Hooper, Simsboro, Calvert Bluff, Carrizo, and Queen City aquifers.
- Where these aquifers are confined, the reduced heads would cause water levels in wells to decline.
- Where these aquifers are unconfined (recharge areas), the reduced heads would cause dewatering of portions of the aquifers.
- Result in the LPGCD and POSGCD exceeding their adopted Simsboro Aquifer DFCs by 2060.
- Reduce groundwater discharge to the Colorado and Brazos rivers, thereby reducing the amount of water flowing in these streams.

5.0 References

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Huang et al., 2012, Yun Huang, Bridget R. Scanlon, Jean-Philippe Nicot, Robert C. Reedy, Alan R. Dutton, Van A. Kelley, Neil E. Deeds, *Sources of groundwater pumpage in a layered aquifer system in the Upper Gulf Coastal Plain, USA,* in Hydrogeology Journal, v. 20, pages 783–796, 13 April, 2012.

Appendix 1

Reliability of GAM Groundwater Discharge Predictions
Amount and Trend of Discharge to Streams

Note: the GAM runs discussed in this appendix are for purposes of illustration. These runs did not simulate Vista Ridge pumping.

The GAM simulates the effects of groundwater pumping on groundwater discharges to streams. There are two questions regarding the simulations. First, can the GAM reliably predict the amount of discharge that will occur? Second, can the GAM reliably predict trends in the discharge?

A1: GAM predictions of amount of discharge

The answer to the first question appears to be no. Groundwater discharges to the Colorado River have been measured for the Carrizo-Wilcox Aquifer[18] in Bastrop County[19]. The measurements ranged from about 22,000 to 42,000 acre-feet per year (table A1).

Table A1
Measured Groundwater Discharge to the Colorado River
From the Carrizo-Wilcox Aquifer in Bastrop County[20]

Year	Discharge (cfs)	Discharge (ac-ft/yr)	Remarks
1918	36	26,060	USGS
1999	59	42,742	LCRA
2005	50	36,200	LCRA
2008	30	21,720	Saunders

However, between the years 2000 to 2010, the GAM predicts groundwater discharges between 8,000 and 12,000 acre-feet per year (figure A1). Clearly, these predictions are unreliable.

[18] The Wilcox Aquifer consist of three parts: the Calvert Bluff, Simsboro, and Hooper aquifers.
[19] Saunders 2009.
[20] Saunders 2009, page 3; and Deeds et al. 2006, page 290.

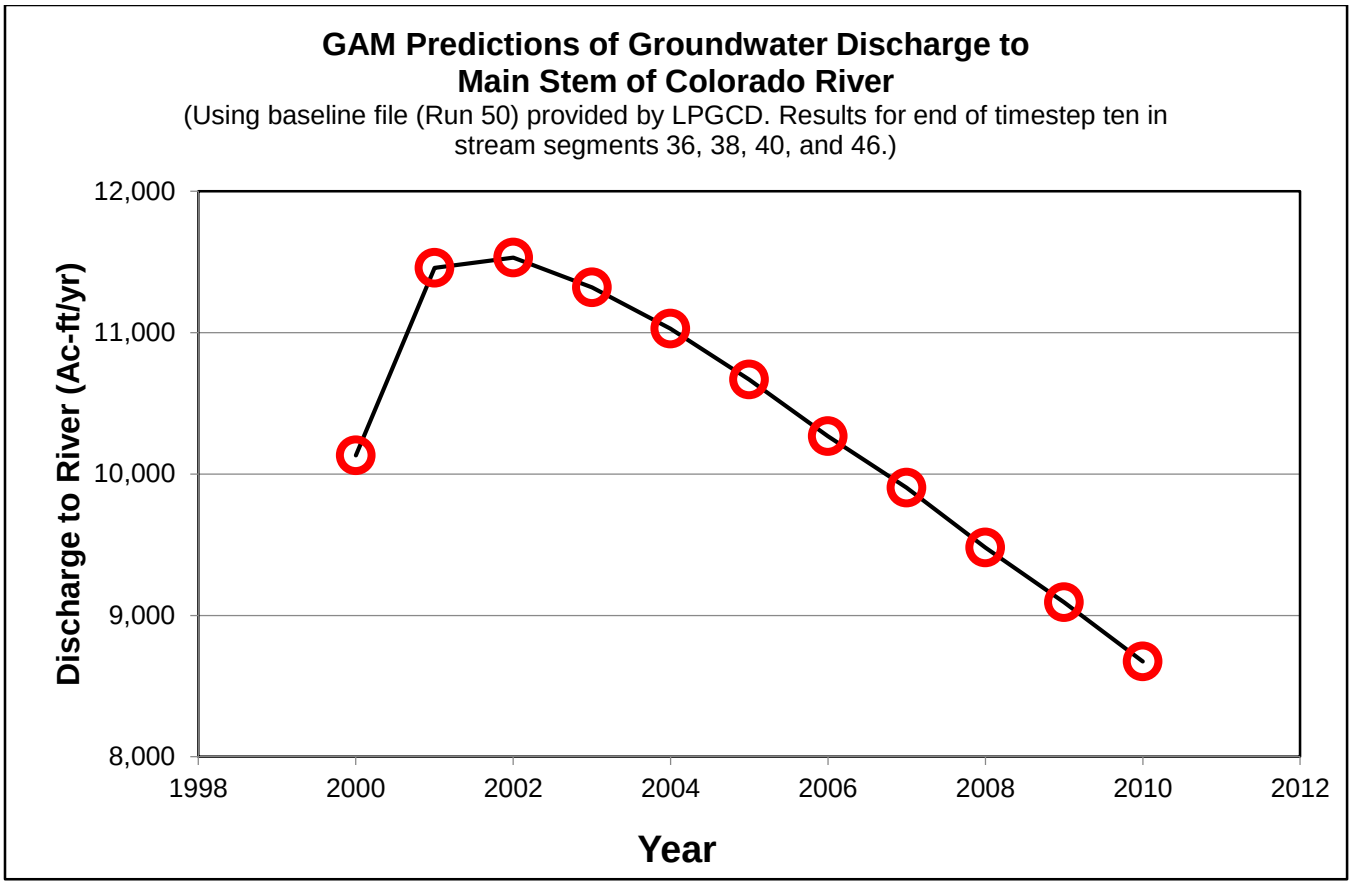

Figure A1
GAM Predicted Discharges to Colorado River

A2: GAM predictions of discharge trends

The answer to the second questions appears to be yes. This is because GAM results are consistent with what groundwater discharges would be expected to do in response to pumping. That is, we would expect the following:

- Pumping rates: higher groundwater pumping rates should result in less discharge to the river.
- Duration of pumping: longer durations should result in less discharge to the river.
- Distance of pumping: pumping closer to the river should have a greater effect than pumping farther from the river.

A2-1: Pumping rates

GAM predictions are consistent with expectations regarding the effect of pumping rates. Figure A2 shows that the GAM predicts less discharge to the river when pumping is

increased by 56,000 acre-feet per year over baseline pumping rates, and more discharge when water is injected at a rate of 56,000 acre-feet per year over baseline rates.

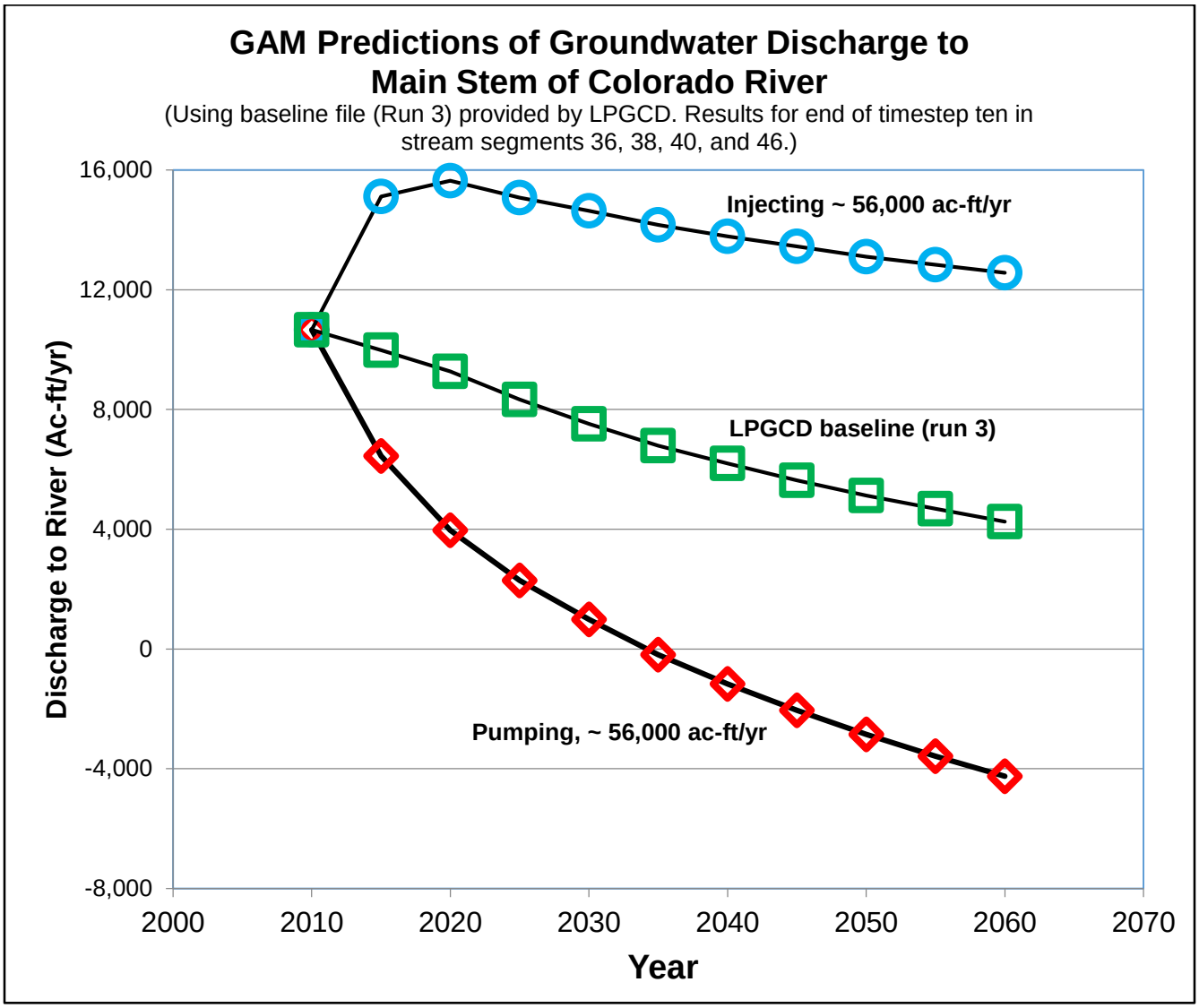

Figure A2
GAM Predicted Effects of Varying Pumping Rates and Pumping Duration

A2-2: Pumping duration

GAM predictions are consistent with expectations regarding the effect of pumping duration. That is, longer pumping times result in less discharge to the river (figures A2 and A3).

A2-3: Distance of Pumping

GAM predictions are consistent with expectations regarding the effect of distance. Figure A3 illustrates the effects of pumping from four wells at a rate of 3400 acre-feet per year over baseline pumping rates. The GAM predicts less discharge for pumping wells that are adjacent to the river, than for pumping wells that are approximately one mile from the river.

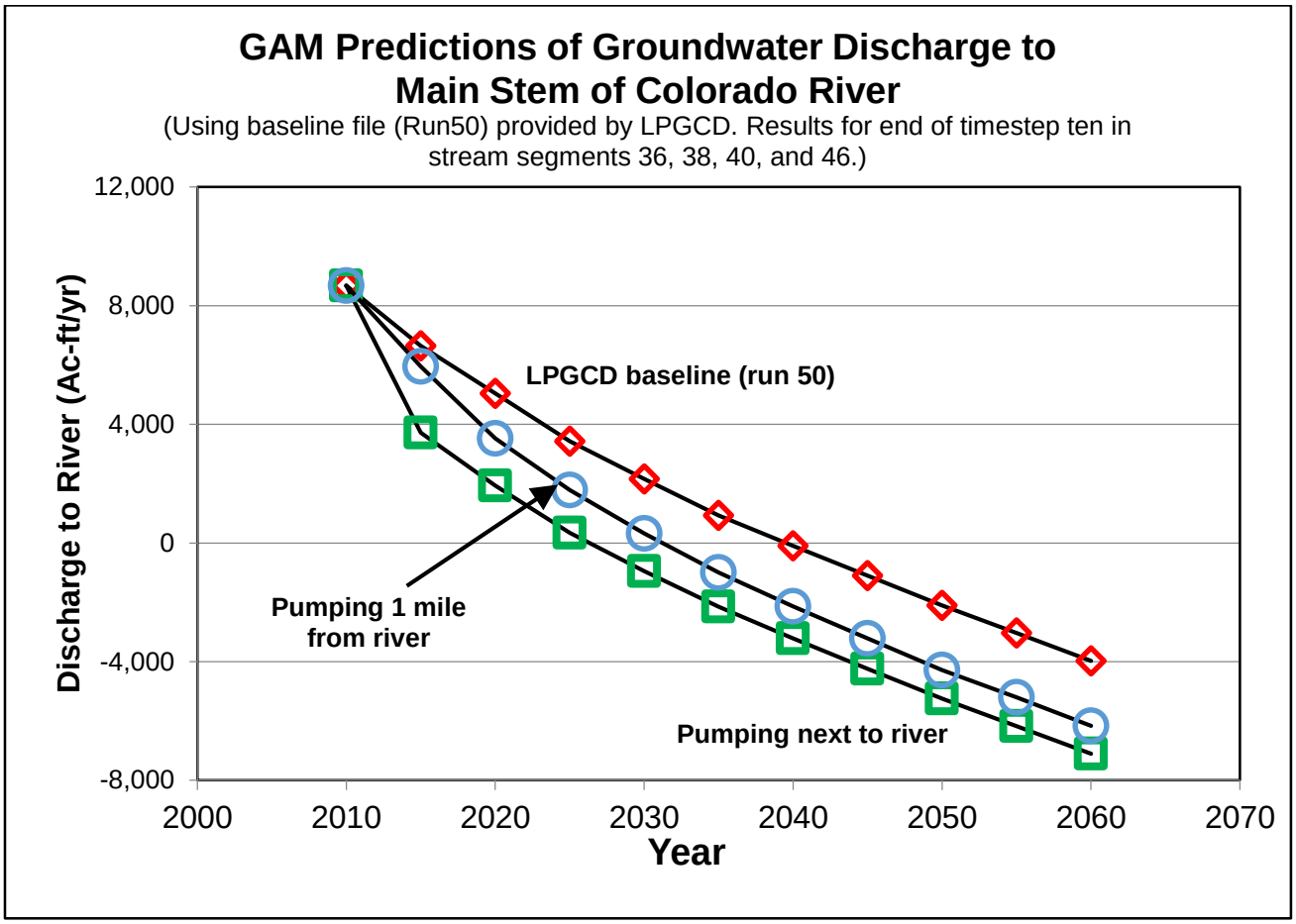

Figure A3
GAM Predicted Effects of Pumping Distance

A-3: Conclusion

The results presented above indicate that the GAM does not reliably predict the effect of pumping on the amount of groundwater discharged to streams. It does, however, reliably predict the trends in groundwater discharge resulting from pumping.