SOAH DOCKET NO. 952-19-0705

APPLICATION OF LOWER COLORADO RIVER AUTHORITY (LCRA) FOR EIGHT OPERATING AND TRANSPORT PERMITS IN BASTROP COUNTY, TEXAS	**§**	**BEFORE THE STATE OFFICE OF ADMINISTRATIVE HEARINGS**

PRE-FILED DIRECT TESTIMONY

OF

GEORGE RICE

ON BEHALF OF

ENVIRONMENTAL STEWARDSHIP

June 28, 2019

EXHIBIT LIST

Number	Exhibit
100	Direct Testimony of George Rice
101	Resume of George Rice
102	Old v. New GAM, Groundwater Discharge to Main Stem of Colorado River
103	Old v. New GAM, Predictions of Drawdown in Simsboro Aquifer
104	New GAM, Groundwater Discharge to Main Stem of Colorado River
105	New GAM, Groundwater Discharge to Walnut/Cedar Creeks
106	New GAM, Groundwater Discharge to Big Sandy Creek
107	New GAM, Groundwater Discharge to Wilbarger Creek
108	New GAM, Groundwater Discharge to Piney Creek/Lake Bastrop
109	Old v. New GAM, Predictions of Drawdown in Simsboro Aquifer
110	New GAM, Groundwater Discharge to Main Stem of Colorado River, LCRA Pumping Plus Pumping by Vista Ridge, End Op, and Forestar
111	New GAM, Estimates of Simsboro Drawdowns in 2070, LCRA Pumping Plus Pumping by Vista Ridge, End Op, and Forestar

I. INTRODUCTION

Q: Please state your name.

A: George Rice.

Q: Please state your address.

A: My address is 414 East French Place, San Antonio, Texas 78212.

Q: Please describe your occupation.

A: I am a hydrologist.

II. QUALIFICATIONS

Q: Please describe your educational background.

A: I have a BS and MS in Hydrology from the University of Arizona.

Q: Please describe the nature of your professional work.

A: I have been working as a hydrologist since 1979. I work primarily on groundwater supply and groundwater contamination issues. I have been an independent consultant since 1993.

Q: Are you a licensed professional geoscientist in the State of Texas?

A: Yes. My license number is 6144.

Q: How long have you been a licensed professional geoscientist?

A: Since about 2004.

Q: Have you authored any publications?

A: Yes. They include the following:

Rice, G., 1987. *Design of Low Level Radioactive Waste Repositories to Minimize Groundwater Contamination*. Presented to Rocky Mountain Association of Environmental Professionals, Albuquerque, New Mexico.

Rice, G., Brinkman, J., and Muller, D., 1988. *Reliability of Chemical Analyses of Water Samples -- The Experience of the UMTRA Project*. Ground Water Monitoring Review, Vol. VIII, No. 3, pp. 71-75.

Green, R.T., Dodge, F.T., Svedeman, S.J., Manteufel, R.D., Rice, G., Meyer, K.A., Baca, R.G., 1995, *Thermally Driven Moisture Redistribution in Partially Saturated Porous Media*, Prepared for Nuclear Regulatory Commission Contract NRC-02-93-005, Center for Nuclear Waste Regulatory Analyses, San Antonio, Texas.

Rice, G., 2014, *Excursions of Mining Solution at the Kingsville Dome In-situ Leach Uranium Mine*, Volume 9—Austin Geological Society Bulletin—2012-2013.

Q: **Have you prepared any reports that address the aquifers that make up the Carrizo-Wilcox Aquifer?**

A: Yes. I have produced reports for clients regarding the effects of pumping on the aquifers of the Carrizo-Wilcox. These include:

Rice, G., 2001, *Evaluation of HDR/SAWS Modeling of the Carrizo-Wilcox Aquifer in Lee, Bastrop, and Milam Counties, Texas.*

Rice, G., 2013*, Forestar's Proposal to Pump Groundwater from the Simsboro Aquifer*, December 14, 2013.

Rice, G., 2018, *Evaluation of LCRA's Proposal to Pump 25,000 Acre-Feet per Year from the Simsboro Aquifer*, June 5, 2018.

Q: **Do you have experience in modeling of groundwater?**

A: Yes. I have used a number of models to evaluate groundwater flow and groundwater chemistry/contaminant transport. The groundwater flow models include: MODFLOW, TOUGH, and the Groundwater Availability Model for the Central Portion of the Sparta, Queen City, and Carrizo-Wilcox Aquifers (GAM). The groundwater chemistry models include: MINTEQ and PHREEQE.

I have used these models to evaluate a number of groundwater scenarios, including: the transport of groundwater contaminants at Kelly Air Force Base, Texas; the flow of heat and water at the proposed Yucca Mountain nuclear waste repository; the transport of groundwater contaminants at Los Alamos National Laboratory; the effects of pumping on water levels in the Ellenburger-San Saba Aquifer; and the effects of pumping on the aquifers that make up the Carrizo-Wilcox.

Q: Please describe your work experience related to your opinions regarding this LCRA application for groundwater pumping permits.

A: Since about the year 2000, I have been evaluating the effects of pumping on the aquifers that make up the Carrizo-Wilcox. These aquifers are, from bottom to top: the Hooper, the Simsboro, the Calvert Bluff, and the Carrizo. I have evaluated pumping projects proposed by the San Antonio Water System, End Op L.P. (End Op), Forestar Real Estate Group

(Forestar), the Lower Colorado River Authority (LCRA), and Vista Ridge. These projects are in Bastrop, Lee, and Burleson counties.

The particular effects of pumping that I have evaluated are: the reduction in the discharge of groundwater to the Colorado River and its tributaries; and the declines in water levels (drawdowns) in the Hooper, Simsboro, Calvert Bluff, and Carrizo aquifers.

Q: Can you identify what has been marked as Exhibit 101?

A: Yes. This exhibit is a representative resume summarizing my experience in various areas of practice.

Q: Is this a true and accurate copy of your resume?

A: Yes.

ENVIRONMENTAL STEWARDSHIP OFFERS EXHIBIT 101.

Q: What materials have you reviewed in preparation for your testimony?

A: I have reviewed the following documents:

DBS (Daniel B. Stephens & Associates, Inc.), 2018a, Memorandum to Jim Totten, General Manager, Lost Pines Groundwater Conservation District, April 6, 2018.

DBS, 2018b, GAM In-Kind Services, Task 3 - DFC Run Evaluation, Memorandum to Jim Totten, General Manager, Lost Pines Groundwater Conservation District, October 26, 2018.

Deeds et al., 2006, (Neil Deeds, Van Kelley, P.G., Steven C. Young, and Geoffrey P. Saunders, P.G., C.G.W.P.), *Assessment of Shallow Recharge and Groundwater-Surface Water Interactions for the LSWP Study Region, Central Texas Coast*, in: Texas Water Development Board Report 365. *Aquifers of the Gulf Coast of Texas,* February 2006.

Freeze, R.A., and Cherry, J.A., 1979, *Groundwater,* Prentice-Hall.

LCRA (Lower Colorado River Authority), 2018, Lower Colorado River Authority's Application for Groundwater Operating and Transport Permits for Griffith League Ranch, submitted to the Lost Pines Groundwater Conservation District, February 21, 2018.

LPGCD, 2017, (Lost Pines Groundwater Conservation District), *Management Plan*, Revised September 20, 2017.

Rice, G., 2015, *Effects of Vista Ridge Pumping on Groundwater and Surface Water in the Lost Pines and Post Oak Savannah Groundwater Conservation Districts*, September 22, 2015.

Rice, G., 2016, *Supplement, Effects of Vista Ridge Pumping and Additional Pumping by End Op, Forestar, and LCRA on Groundwater and Surface Water in the Lost Pines and Post Oak Savannah Groundwater Conservation Districts*, January 26, 2016.

Rice, G., 2018, *Evaluation of LCRA's Proposal to Pump 25,000 Acre-Feet per Year from the Simsboro Aquifer*, George Rice, June 5, 2018.

Saunders, G.P., 2009, *Low-Flow Gain-Loss Study of the Colorado River in Bastrop County, Texas*. Thornhill (Thornhill Group, Inc.), 2009, *A Report of Results of Drilling and Testing Programs to Verify Ground-Water Supplies in the Simsboro Aquifer – Proposed End Op, LP Well Fields in Bastrop and Lee Counties*, Texas, April 15, 2009.

TWDB (Texas Water Development Board), 2004, *Groundwater Availability Models for the Queen City and Sparta Aquifers*, October 2004.

TWDB, 2017, *Final Report: Field Studies and Updates to the Central Carrizo-Wilcox, Queen City, and Sparta GAM to Improve the Quantification of Surface Water-Groundwater Interaction in the Colorado River Basin*, August 2017.

TWDB, 2018, Final Report: *Groundwater Availability Model for the Central Portion of the Sparta, Queen City, and Carrizo-Wilcox Aquifers*, September 2018.

USGCRP, 2018, (U.S. Global Change Research Program), *Fourth National Climate Assessment, Volume II, Impacts, Risks, and Adaptation in the United States.*

USGS (United States Geological Survey), 1998, Ground Water and Surface Water A Single Resource, U.S. Geological Survey Circular 1139.

USGS, 2019, *USGS Surface-Water Monthly Statistics for the Nation, USGS 08159200 Colorado Rv at Bastrop, TX*, June 23, 2019.

Q: What other research have you done in preparation for your testimony?

A: I have used Groundwater Availability Models (GAMs) to predict the effects of LCRA's proposed pumping on surface water flows and groundwater levels. I used both the old GAM (TWDB, 2004) and the new GAM (TWDB, 2018).

I have included in my testimony predictions produced by the old GAM because it was used to support the development of the Lost Pines Groundwater Conservation District's (LPGCD) Management Plan. However, the new GAM is an improvement on the old, and its predictions are probably more reliable.

Q: What is the difference between the two GAMs?

A: Simulations performed with the old and new GAMs give different results. The new GAM predicts a greater reduction in the flow of the Colorado River (Exhibit 102). The new GAM also predicts less of a decline (drawdown) in water levels in the Simsboro Aquifer (Exhibit 103). But, compared to the old GAM, the new GAM predicts greater water level declines in the Hooper, Calvert Bluff, and Carrizo aquifers.

Pumping files are still being developed for the new GAM. To date, I have used the pumping file provided by the LPGCD in 2018 (DBS, 2018b). An updated pumping file is due to be completed in July. Once available, I intend to use the updated file to produce new GAM predictions. I do not know whether the predictions produced with the updated file will differ significantly from those produced with the current file.

Q: What is Exhibit 102?

A: Exhibit 102 is a figure showing the difference between the old GAM predictions and the new GAM predictions of groundwater discharge to the main stem of the Colorado River.

Q. What is Exhibit 103?

A: Exhibit 103 is a figure showing the difference between the old GAM predictions and the new GAM predictions of water level drawdowns in the Simsboro Aquifer.

Q: Did you prepare Exhibits 102 and 103?

A: Yes, I prepared them based on the GAM simulations I performed.

ENVIRONMENTAL STEWARDSHIP OFFERS EXHIBITS 102 and 103.

Q: Are you familiar with the Griffith League Ranch, the area where the proposed groundwater pumping is to occur?

A: Yes.

Q: How are you familiar with the area?

A: I have examined maps and geologic cross-sections of the area.

III. OPINIONS

Q: Have you developed any opinions regarding the application by LCRA for Operating and Transport Permits in Bastrop County, Texas, for Well Nos. 58-55-5-0032; 58-

55-5-0033; 58-55-4-0016; 58-55-4-0017; 58-55-4-0018; 58-55-4-0019; 58-55-4-0020; and 58-55-4-0021?

A: Yes.

Q: On what subjects have you developed opinions?

A: LCRA is proposing to pump 25,000 acre-feet per year from the Simsboro Aquifer at the Griffith League Ranch. I have developed opinions regarding the effects of LCRA's pumping on the flow of the Colorado River and its tributaries in Bastrop County, and on water levels in wells.

Q: Please summarize your opinions regarding the above-referenced application.

A: LCRA's proposed pumping would reduce the discharge of groundwater to the Colorado River and its tributaries, thereby reducing the amount of water flowing in these streams. It would also reduce water levels in wells that tap the aquifers of the Carrizo-Wilcox.

It should be noted that LCRA's proposed pumping is just one of several large pumping projects that are being proposed in the area. At least three other entities are planning to pump large amounts of water from the Simsboro Aquifer in Bastrop, Lee, and Burleson counties. The combined effects of these pumping projects will be greater than the effects of LCRA's pumping alone.

Q: Ok, let's begin with the first part of your opinion. Can you elaborate on your opinion concerning the effects of LCRA's proposed pumping on flows in the Colorado and its tributaries?

A: Yes. I used the GAMs to predict the effects of LCRA's proposed pumping on the flow of the Colorado River and its tributaries. The portion of the Colorado River that was examined is about 48 river-miles long and is entirely within Bastrop County. The tributaries are also in Bastrop County.

As stated above, LCRA's proposed pumping would reduce flows in the Colorado River and its tributaries. The Colorado is currently a gaining stream. That is, groundwater from the aquifers' discharges into the stream. LCRA's pumping would reduce the amount of groundwater discharging to the Colorado. The GAMs predict that the Colorado will eventually become a losing stream. That is, the flows between the aquifers and the stream would be reversed. Instead of water from the aquifers flowing into the Colorado, water from the Colorado would flow into the aquifers.

Exhibit 102 shows the predictions produced by both GAMS. Groundwater discharge values greater than zero mean that the stream is gaining, values less than zero mean that the stream is losing. The new GAM predicts that LCRA's pumping will cause the

Colorado to become a losing stream shortly after 2050. The old GAM predicts that the Colorado will become losing around 2025.

Q: Please explain the reference to "basin pumping" in Exhibit 102.

A: In this case, baseline pumping is all of the pumping that occurs in the area, except the 25,000 acre-feet per year that LCRA is proposing to pump. Baseline includes the 6,500 acre-feet per year that LCRA currently pumps. All of the GAM simulations include the baseline pumping.

Q: Please explain what the new GAM tells us about the amount of flow in the Colorado River.

A: Two new GAM simulations were performed for the main stem of the Colorado River. The first simulated baseline pumping. The second simulated baseline pumping plus LCRA's proposed pumping.

According to the GAM, the Colorado River is currently a gaining stream. This agrees with field measurements of groundwater discharge to the river, which show that the river gains between 20,000 and 40,000 acre-feet of water per year (Deeds et al, 2006; and Saunders, 2009).

For the simulation of baseline pumping, the GAM predicts that between 2010 and 2070, groundwater discharge to the Colorado River will decrease.

For the simulation that includes LCRA pumping, the GAM predicts a more rapid decrease in groundwater discharge. It also predicts that the Colorado will become a losing stream. By 2070, the GAM predicts that, compared to the effects of baseline pumping, LCRA's pumping will reduce the flow in the Colorado River by approximately 7000 acre-feet per year, or approximately 9.7 cubic feet per second (cfs).

Q: Please describe exhibit 104.

A: Exhibit 104 is a figure I prepared that shows the results of the simulations I just described.

Q: Did you prepare Exhibit 104?

A: Yes, I prepared it based on the GAM simulations I performed.

ENVIRONMENTAL STEWARDSHIP OFFERS EXHIBIT 104.

Q: How does this reduction in flow compare to the flow of the Colorado River at Bastrop?

A: A reduction of 7000 acre-feet per year represents about 0.5 percent of the average annual flow of the Colorado River at Bastrop (USGS, 2019). However, the effect during low flows would be greater. For example, between November 1963 and March 1964, the average flow of the river at Bastrop was about 120 cfs (USGS, 2019). During this period, the reduction in flow would be about eight percent.

The GAM does not incorporate the potential effects of climate change. Climate change will result in hotter weather in Texas (USGCRP, 2018). This would probably cause reductions in recharge, and that would probably result in less groundwater discharge to the river.

Q: Please describe the new GAM's predictions regarding the tributaries to the Colorado River.

A: There are four tributaries: Walnut/Cedar Creeks, Wilbarger Creek, Big Sandy Creek, and Piney Creek/Lake Bastrop. Two new GAM simulations were performed for each tributary. The first simulated baseline pumping. The second simulated baseline pumping plus LCRA's proposed pumping.

For the simulation of baseline conditions, the GAM predicts that groundwater discharge to all the tributaries will decrease. Two of the tributaries, Big Sandy Creek, and Piney Creek Creek/Lake Bastrop, will change from gaining to losing streams.

For the simulation that includes LCRA's pumping, the GAM predicts that all of the tributaries except Walnut/Cedar Creeks will become losing streams.

Q: Please describe Exhibits 105, 106, 107, and 108.

A: These are figures I prepared to depict the results of the simulations I just described, regarding each of the tributaries.

Q: Did you prepare Exhibits 105, 106, 107, and 108?

A: Yes, I prepared them based on the GAM simulations I performed.

ENVIRONMENTAL STEWARDSHIP OFFERS EXHIBITS 105, 106, 107, and 108.

Q: Does the proximity of LCRA's wells affect the amount of reduction in flow into the Colorado River and its tributaries that is predicted by the GAM, as compared to the location of other major pumping projects?

A: Yes. The GAM is sensitive to the distance of pumping from streams. All things being equal, a pumping project that is closer to a stream will have a greater effect on predicted stream flows than a project that is farther.

Q: Is the reduction of streamflow due to pumping of groundwater a well-known phenomenon?

A: Yes. Many professional papers have described the relationship between groundwater pumping and reductions in stream flows. An overview of the subject is contained in the United States Geological Survey paper cited above: *Ground Water and Surface Water, A Single Resource* (1998).

Q: What about your second opinion? Please describe the effects of LCRA's proposed pumping on water levels in wells.

A: I used the old and new GAMs to simulate the effects of LCRA's proposed pumping on water levels in wells. More technically, the GAMs predicted drawdowns, or declines, in hydraulic heads. Hydraulic head can be thought of as the water level in a well.

Q: What did the GAMs predict?

A: The GAMs predicted that water levels in the four aquifers that make up the Carrizo-Wilcox will decline as a result of LCRA's proposed pumping.

Q: Please describe Exhibit 109.

A: Exhibit 109 is essentially the same as Exhibit 103. It is a cross-section showing predicted drawdowns in the Simsboro Aquifer in 2060. The cross-section is centered on the LCRA wellfield and extends about ten miles to the northwest, and ten miles to the southeast of the wellfield.

Q: Did you prepare this Exhibit?

A: Yes, I prepared it based on the GAM simulations I performed, as described above.

ENVIRONMENTAL STEWARDSHIP OFFERS EXHIBIT 109.

Q. Looking at Exhibit 109, what does it tell us about predicted declines in the aquifer?

A: As expected, drawdowns are greatest at the wellfield, and decrease with distance from the wellfield. In general, the old GAM predicted greater drawdowns than the new GAM.

Q: What does the ellipse marked as 'A' in Exhibit 109 show?

A: The ellipse marked as 'A' shows the predicted drawdowns in a Simsboro well about two miles northwest of the wellfield. The new GAM predicts a water level decline of 185 feet. The old GAM predicts a decline of 247 feet.

Q: How might this decline affect the use of the well?

A: There are three possible effects. First, if the well is deep enough and the pump is set deep enough in the well, the use of the well may not be affected at all – other than an increase in the amount of energy required to pump water from greater depths.

Second, if the pump is not set deep enough, the water may drop below the level of the pump. In this case, the pump would have to be lowered.

Finally, if the well is not deep enough, the water may drop below the bottom of the well. In this case, the well would have to be deepened or replaced.

Q: Did the GAM simulations predict drawdowns in the other aquifers of the Carrizo-Wilcox?

A: Yes, the GAMs predicted that the proposed pumping would also cause the following drawdowns at the proposed LCRA wellfield:

In the Hooper Aquifer, the predicted drawdowns are 22 feet (old GAM) and 42 feet (new GAM).

In the Calvert Bluff Aquifer, the predicted drawdowns are 22 feet (old GAM) and 51 feet (new GAM).

In the Carrizo Aquifer, the predicted drawdowns are 1 foot (old GAM) and 10 feet (new GAM).

Q: Why would pumping the Simsboro Aquifer cause drawdowns in the other Carrizo-Wilcox Aquifers?

A: Pumping lowers the hydraulic head (pressure) in the aquifer. If the head in the pumped aquifer becomes lower than the head in adjacent aquifers, water from those aquifers will flow into the pumped aquifer. This causes drawdowns in the adjacent aquifers.

This movement of water between aquifers is called ‘interformational flow’, or ‘leakage’. Leakage is a common and well-known phenomenon that is discussed in standard hydrology texts (*e.g.,* Freeze and Cherry, 1979).

Leakage is often detected during pump-tests. In a 2009 pump-test conducted in Lee County, it was estimated that 22% of the water pumped from the Simsboro Aquifer was derived from leakage from adjacent aquifers (Thornhill, 2009).

Q: Earlier you mentioned other large pumping projects that are being proposed in the area. What are those?

A: Yes, at least three other pumping projects have been proposed in Bastrop, Lee, and Burleson counties. All of these projects would pump from the Carrizo-Wilcox, and the majority of the pumping would be from the Simsboro Aquifer. The projects are: Vista Ridge (50,000 acre-feet per year), End Op (46,000 acre-feet per year), and Forestar (28,800 acre-feet per year).

Q: Have you used the new GAM to predict the effects of these projects?

A: Yes, I used the new GAM to simulate pumping from the three projects mentioned above, plus LCRA's proposed pumping of 25,000 acre-feet per year. It should be noted that at least one other large pumping project may be developed at Alcoa's Sandow Mine. This project is not included in any of the GAM simulations that I performed.

Q: Please describe Exhibit 10.

A: Exhibit 110 shows the new GAM's predictions of groundwater discharge to the Colorado River.

Q: Did you prepare Exhibit 110?

A: Yes.

ENVIRONMENTAL STEWARDSHIP OFFERS EXHIBIT 110.

Q: What does exhibit 110 tell us about prediction of groundwater discharge to the Colorado River?

A: Relative to the reduction due to baseline pumping, the predicted reduction in flow due to LCRA's pumping plus pumping by the other three projects is about 13,000 acre-feet per year. For LCRA's pumping alone, the reduction is about 7000 acre-feet per year. Notice that the baseline pumping alone results in a large reduction in flow. Between 2010 and 2070, baseline pumping results in a 17,000 acre-feet per year reduction in the flow of the Colorado River.

Q: Please describe Exhibit 111.

A: Exhibit 111 shows the new GAM's predictions of drawdowns in the Simsboro Aquifer in 2070.

Q: Did you prepare Exhibit 111?

A: Yes, I prepared it based on the GAM simulations I performed, as described above.

ENVIRONMENTAL STEWARDSHIP OFFERS EXHIBIT 111.

Q: What does Exhibit 111 tell us about predicted drawdowns in the Simsboro Aquifer in 2070?

A: The cross-section is centered on the LCRA wellfield and extends about ten miles to the northwest, and ten miles to the southeast of the wellfield. The drawdowns predicted for the combined pumping by LCRA, Vista Ridge, End Op, and Forestar are 100 to 200 feet greater than the drawdowns predicted for the LCRA pumping alone.

Q: Do you believe the GAM is a reliable method to predict the effects of groundwater pumping on stream flows.

A: To answer that, I'd like to address it in two parts. First, does the GAM reliably predict the trends in discharge? Second, does the GAM reliably predict the amount of groundwater discharged to streams?

Q: Okay, do you believe that the trends in discharge predicted by the GAM are reliable?

A: Yes. The GAM predicts that pumping will cause the discharge of groundwater to streams to decrease with time as shown in Exhibits 102, 104-108, and 110. This is consistent with what groundwater discharges would be expected to do in response to pumping.

I addressed this question several years ago. I examined the response of the old GAM to changes in: pumping rates, pumping duration, and the location of pumping relative to the Colorado River (Rice, 2015). My purpose was to see whether the GAM predictions made sense. For example, would pumping that is closer to the river result in a greater reduction in groundwater discharge than pumping that is farther from the river? In each case, the GAM predictions made sense. These results indicate that the trends predicted by the GAM are reliable.

Q: Second, do you believe that the GAM reliably predicts the amount of groundwater discharged to streams?

A: This question is more difficult to answer. We know that the predictions of the old GAM are not reliable. Between 2000 and 2010, the old GAM predicted that the groundwater discharge to the Colorado River was between about 8,000 and 10,000 acre-feet per year (Exhibit 102). However, between 1999 and 2008, field measurements of groundwater discharge to the river ranged from about 20,000 to 40,000 acre-feet per year. Clearly, the old GAM's predictions were not reliable.

On the other hand, the new GAM predicted that the groundwater discharge to the Colorado River was between about 20,000 and 23,000 acre-feet per year (Exhibit 102). This is within the range of the measured discharge values. This gives us some confidence in the new GAM's predictions, although it does not necessarily mean that the predictions

are reliable. At this time, the predictions produced by the new GAM are the best available.

Q: What could be done to improve the GAM predictions of groundwater discharge to the Colorado River?

A: Field studies have been proposed to measure the exchange of water between aquifers and the Colorado River (TWDB, 2017). The information obtained from these studies could be used to improve the GAM's predictions of groundwater discharge to the Colorado River.

Q: How do the GAM predictions compare with the Desired Future Conditions (DFCs) contained in the LPGCD's Management Plan (LPGCD, 2017)?

A: A DFC has been established for each aquifer in the district. The DFC is the amount of drawdown, averaged across the entire district, that occurs between 2000 and 2070. The DFC for the Simsboro Aquifer is 240 feet.

The old GAM predicts that the average drawdown in the Simsboro Aquifer due to LCRA's pumping alone will be 60 feet. It also predicts that the drawdown due to baseline pumping will be 234 feet. So, the total average drawdown in the Simsboro Aquifer is predicted to be 294 feet. This exceeds the DFC. Note that the old GAM simulations did not go beyond the year 2060.

The new GAM predicts that the average drawdown in the Simsboro Aquifer due to LCRA's pumping alone will be approximately 34 feet. It also predicts that the drawdown due to baseline pumping will be 153 feet. So, the total average drawdown in the Simsboro Aquifer is predicted to be 187 feet. This does not exceed the DFC.

Q: How does LCRA's proposed pumping compare with the Modeled Available Groundwater (MAG) contained in the LPGCD's Management Plan?

A: A MAG is the amount of groundwater production, on an average annual basis, that will achieve a DFC. For the Simsboro Aquifer, the MAGs in 2020 and 2030 are 32,731, and 31,362 acre-feet per year, respectively. The estimated current pumping is between 13,000 and 17,000 acre-feet per year (DBS, 2018a). The sum of LCRA's proposed pumping and the lower estimate of current pumping is 38,000 acre-feet per year. This exceeds the MAGs for 2020 and 2030.

IV. CONCLUSIONS

Q: Please briefly summarize your major conclusions.

A: The GAMs predict that LCRA's proposed pumping would reduce the amount of groundwater that discharges to the Colorado River and its tributaries in Bastrop County, thereby reducing the amount of water flowing in these streams.

The GAMs predict that LCRA's proposed pumping would reduce water levels in wells that tap the Carrizo-Wilcox aquifers. These aquifers are the Hooper, Simsboro, Calvert Bluff, and Carrizo.

The old GAM predicts that LCRA's proposed pumping will cause the Simsboro Aquifer DFC to be exceeded, but the new GAM does not.

LCRA's proposed pumping will result in the MAG being exceeded.

Q: Does this conclude your testimony?

A: Yes, although I reserve the right to supplement this testimony.

EXHIBIT 101

George Rice
Groundwater Hydrologist

414 East French Place
San Antonio, TX 78212
(210) 251-5524
jorje44@yahoo.com

General

More than 20 years experience in groundwater contamination investigations.

Education

M.S. Hydrology, University of Arizona, 1991
B.S. Hydrology, University of Arizona, 1979

Employment History

1993: Consultant
1988 - 1993: The MITRE Corporation, Brooks Air Force Base, Texas
1983 - 1988: SHB Geotechnical Engineers, Inc., Albuquerque, New Mexico
1980 - 1983: University of Arizona, Tucson, Arizona
1979 - 1980: U.S. Forest Service, Gifford Pinchot National Forest, Vancouver, Washington

Experience

- Design and install monitor well networks.
- Design, perform, and analyze aquifer tests.
- Design and install vadose zone monitor networks.
- Design and conduct groundwater sampling programs.
- Apply groundwater flow and contaminant transport models to predict the fate of groundwater contaminants.
- Participate in multidisciplinary teams to select and design hazardous waste disposal sites.
- Conduct third party reviews of environmental documents and field programs.

- Expert Witness.

Representative Projects

UMTRA Project, Arizona, Colorado, New Mexico, Utah, Wyoming. Groundwater contamination caused by uranium mill tailings. Typical contaminants: metals (arsenic, uranium). Worked for SHB Geotechnical Engineers, Inc. Determined extent and character of contamination, developed plans to cleanup tailings and groundwater.

Yucca Mountain Nuclear Waste Repository, Yucca Mountain, Nevada. Worked for Southwest Research Institute and HOME (Healing Ourselves and Mother Earth). Evaluated the potential for groundwater to contact waste canisters, and established background concentrations for radionuclides in aquifer down gradient of the proposed waste repository.

Kelly Air Force Base, San Antonio, Texas. Groundwater contamination caused by discharge of contaminated water, leakage from tanks and lines, and disposal of wastes. Typical contaminants: solvents (TCE, PCE), fuel components (benzene), metals (chromium, thallium). Member of Kelly Air Force Base RAB. Commented on Air Force's plans to cleanup contaminated soils and groundwater.

Pantex Plant, Amarillo, Texas. Groundwater contamination caused by discharge of manufacturing process water and disposal of wastes. Typical contaminants: (TCE, PCE), explosives (RDX), metals (chromium), radionuclides (tritium). Worked for STAND (Serious Texans Against Nuclear Dumping). Evaluated DOE's plans to delineate, cleanup, and monitor contaminated groundwater.

Los Alamos National Laboratory, Los Alamos, New Mexico. Groundwater contamination caused by discharges and disposal of industrial wastes. Typical contaminants: explosives (RDX, perchlorate), metals (chromium), radionuclides (plutonium, tritium). Worked for CCNS (Concerned Citizens for Nuclear Safety) and Los Alamos National Laboratory. Evaluated the potential for laboratory contaminants to reach the Rio Grande, and evaluated disposal options for radioactive wastes.

Kingsville Dome Mine, Kleberg County, Texas. Groundwater contamination caused by in-situ uranium mining. Typical contaminants: metals (molybdenum, uranium). Worked for the Kleberg County URI Citizen Review Board. Evaluated URI's progress in cleaning up contaminated groundwater, and plans for post-cleanup monitoring.

Flint Hills Refinery, Corpus Christi, Texas. Groundwater contamination caused by leakage from refinery. Typical contaminants: fuel components (benzene). Worked with concerned citizens to evaluate the Texas Commission on Environmental Quality's plans to determine the extent of contamination.

Longhorn Army Ammunition Plant, Karnack, Texas. Groundwater contamination caused by discharge of contaminated water, leakage from tanks, and disposal of wastes. Typical contaminants: solvents (TCE, DCE), explosives (RDX, perchlorate), metals (antimony, thallium). Worked for Caddo Lake Institute. Evaluated Army's plans to clean-up contaminated groundwater.

Bibliography

Rice, G., 1987. *Design of Low Level Radioactive Waste Repositories to Minimize Groundwater Contamination*. Presented to Rocky Mountain Association of Environmental Professionals, Albuquerque, New Mexico.

Rice, G., Brinkman, J., and Muller, D., 1988. *Reliability of Chemical Analyses of Water Samples -- The Experience of the UMTRA Project*. Ground Water Monitoring Review, Vol. VIII, No. 3, pp. 71-75.

Casagrande, D., Price, F., Rice, G., Vogel, G., 1989. *Geochemistry Manual*, MITRE Working Paper WP-89W00180. The MITRE Corporation, Civil Systems Division, 7525 Colshire Drive, McLean, Virginia.

Rice, G., Green, R., Pohle, J., 1993, *Reduction in Uncertainty in the Geologic Setting Performance Measure, 10 CFR 60.113(a)(2): Computer Code Selections, Conceptual Models, and Databases*, Prepared for Nuclear Regulatory Commission Contract NRC-02-88-005, Center for Nuclear Waste Regulatory Analyses, San Antonio, Texas.

Rice, G. 1994, *AGUA Report, Contamination of the Edwards Aquifer in Bexar County*.

Green, R., Meyer, K., Rice, G., 1994, *Hydraulic Characterization of Hydrothermally-Altered Nopal Tuff*, Prepared for Nuclear Regulatory Commission Contract NRC-02-93-005, Center for Nuclear Waste Regulatory Analyses, San Antonio, Texas.

Green, R.T., Dodge, F.T., Svedeman, S.J., Manteufel, R.D., Rice, G., Meyer, K.A., Baca, R.G., 1995, *Thermally Driven Moisture Redistribution in Partially Saturated Porous Media*, Prepared for Nuclear Regulatory Commission Contract NRC-02-93-005, Center for Nuclear Waste Regulatory Analyses, San Antonio, Texas.

Rice, G., 1996, *The BFI Tessman Road Landfill: Hydrologic Issues*, Prepared for Larry R. Daves and Associates, San Antonio, Texas.

Rice, G., 1997, *Groundwater and Groundwater Contamination in the Vicinity of Mr. Quintanilla's House, 710 price Avenue, San Antonio, Texas,* Prepared for Tinsman & Houser, San Antonio, Texas.

Rice, G., 2001, *Evaluation of Groundwater Characterization and Modeling at the Pantex Plant,* June 2001. Prepared for Serious Texans Against Nuclear Dumping (STAND).

Rice, G., 2001, *Evaluation of HDR/SAWS Modeling of the Carrizo-Wilcox Aquifer in Lee, Bastrop, and Milam Counties, Texas.*

Rice, G., 2002, *Groundwater Modeling at Pantex, and Recommendations of the Technical Advisory Group,* Prepared for Serious Texans Against Nuclear Dumping (STAND), September 2002.

Rice, G., 2003, *Background Concentrations of Contaminants in the Ogallala Aquifer at Pantex, an Evaluation*, Prepared for Serious Texans Against Nuclear Dumping (STAND), May 2003.

Rice G., and P. Allison, 2004, *Contaminants in The Ogallala Aquifer at the Pantex Plant*, STAND Technical Report 2004-1, May 2004.

Rice, G., 2004, *The Potential for Groundwater Contaminants from Los Alamos National Laboratory to Reach the Rio Grande*, July 2004.

Rice, G., 2006, *Effects of URI's Kingsville Dome Mine on Groundwater Quality*, Prepared for the Kleberg County URI Citizen Review Board, July 2007.

Rice, G., 2012, *Occurrence of Groundwater at the Compact Waste Facility, Waste Control Specialists Facility, Andrews County, Texas*, May 3, 2012.

Rice, G., 2014, *Excursions of Mining Solution at the Kingsville Dome In-situ Leach Uranium Mine*, Volume 9—Austin Geological Society Bulletin—2012-2013.

EXHIBIT 102

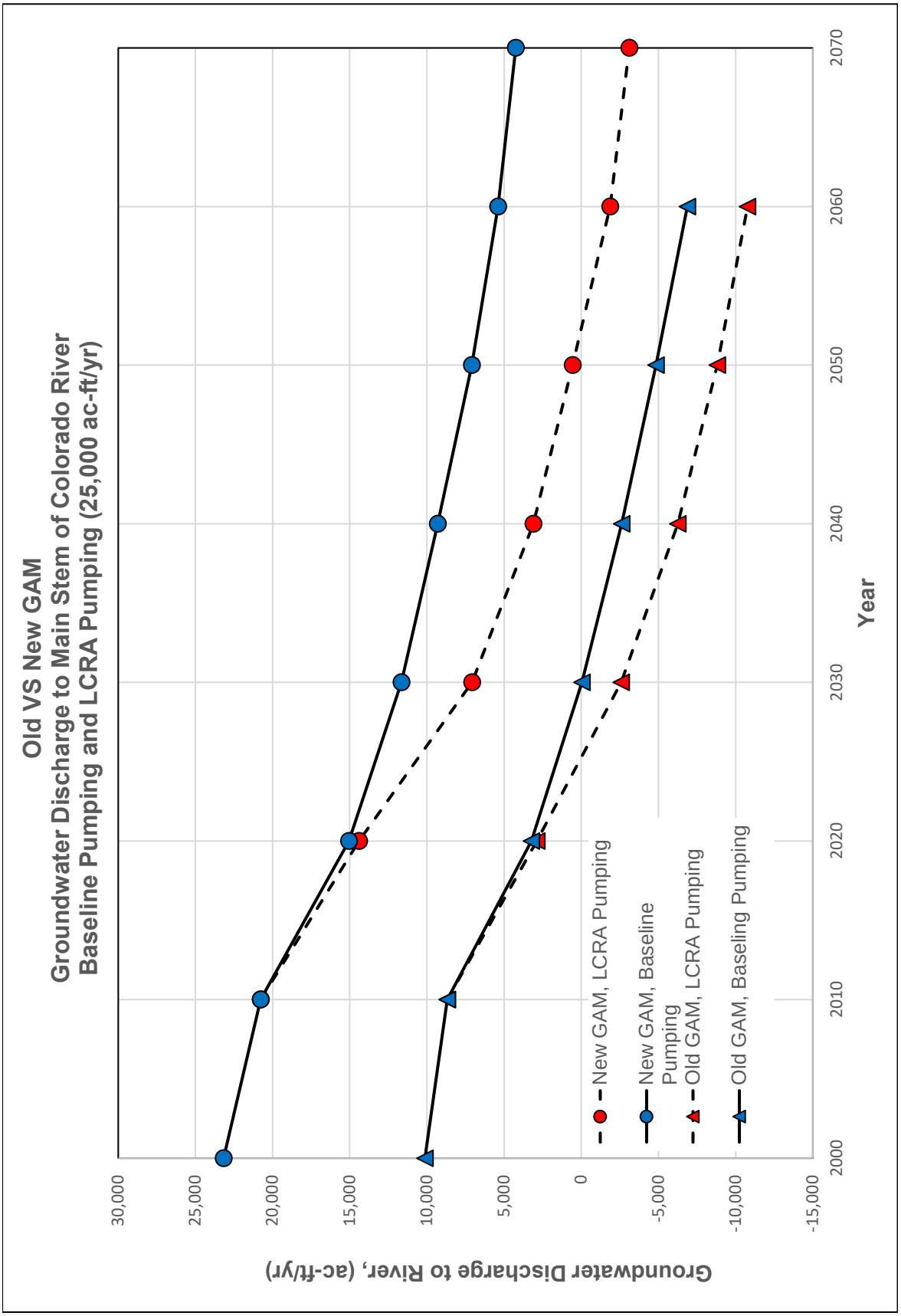

Old VS New GAM
Groundwater Discharge to Main Stem of Colorado River
Baseline Pumping and LCRA Pumping (25,000 ac-ft/yr)
Groundwater Discharge to River, (ac-ft/yr)
30,000
25,000
20,000
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
2000
2010
2020
2030
2040
2050
2060
2070
Year
New GAM, LCRA Pumping
New GAM, Baseline Pumping
Old GAM, LCRA Pumping
Old GAM, Baseling Pumping

EXHIBIT 103

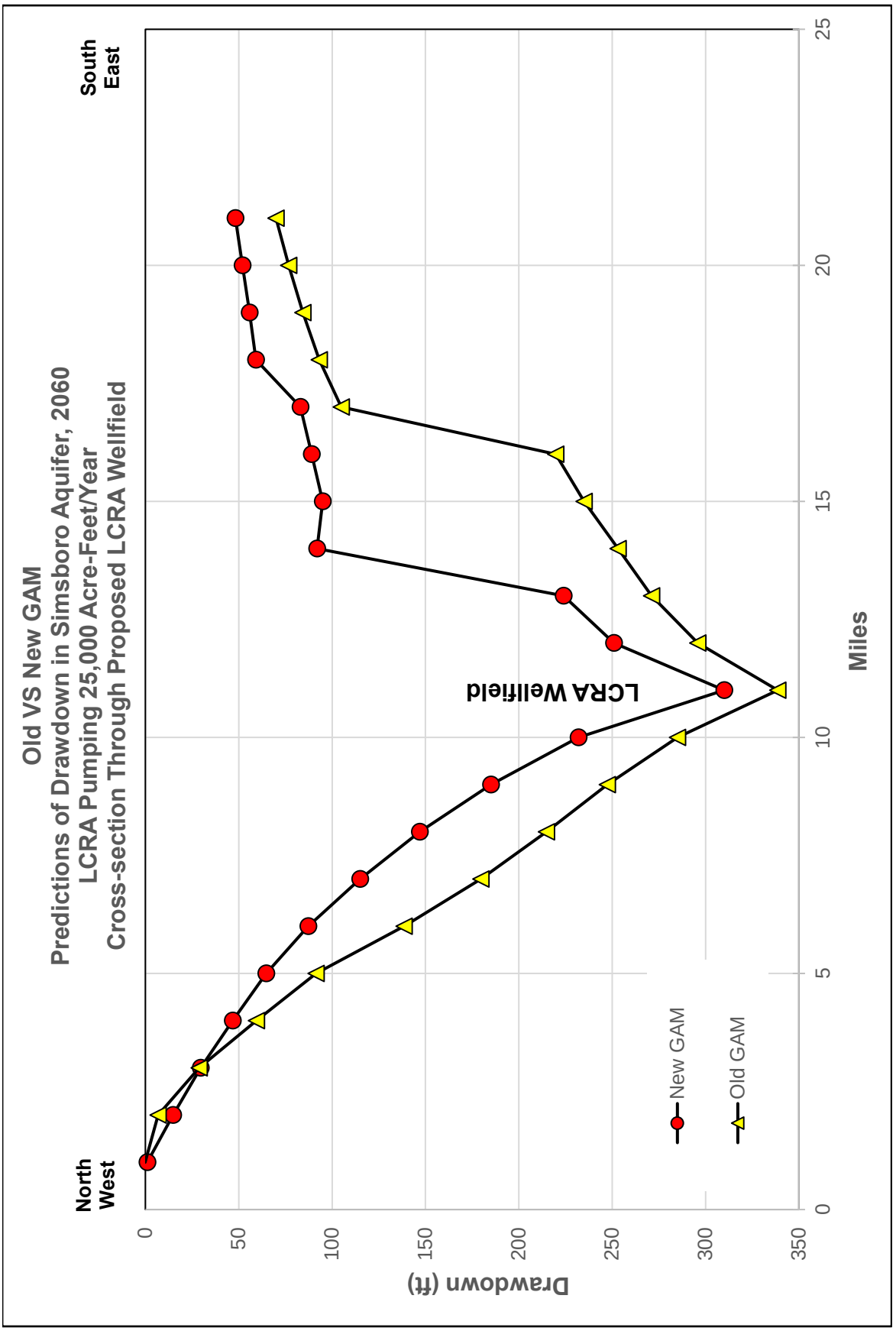

Old VS New GAM
Predictions of Drawdown in Simsboro Aquifer, 2060
LCRA Pumping 25,000 Acre-Feet/Year
Cross-section Through Proposed LCRA Wellfield
North West
South East
LCRA Wellfield
Drawdown (ft)
Miles
0
50
100
150
200
250
300
350
0
5
10
15
20
25
New GAM
Old GAM

EXHIBIT 104

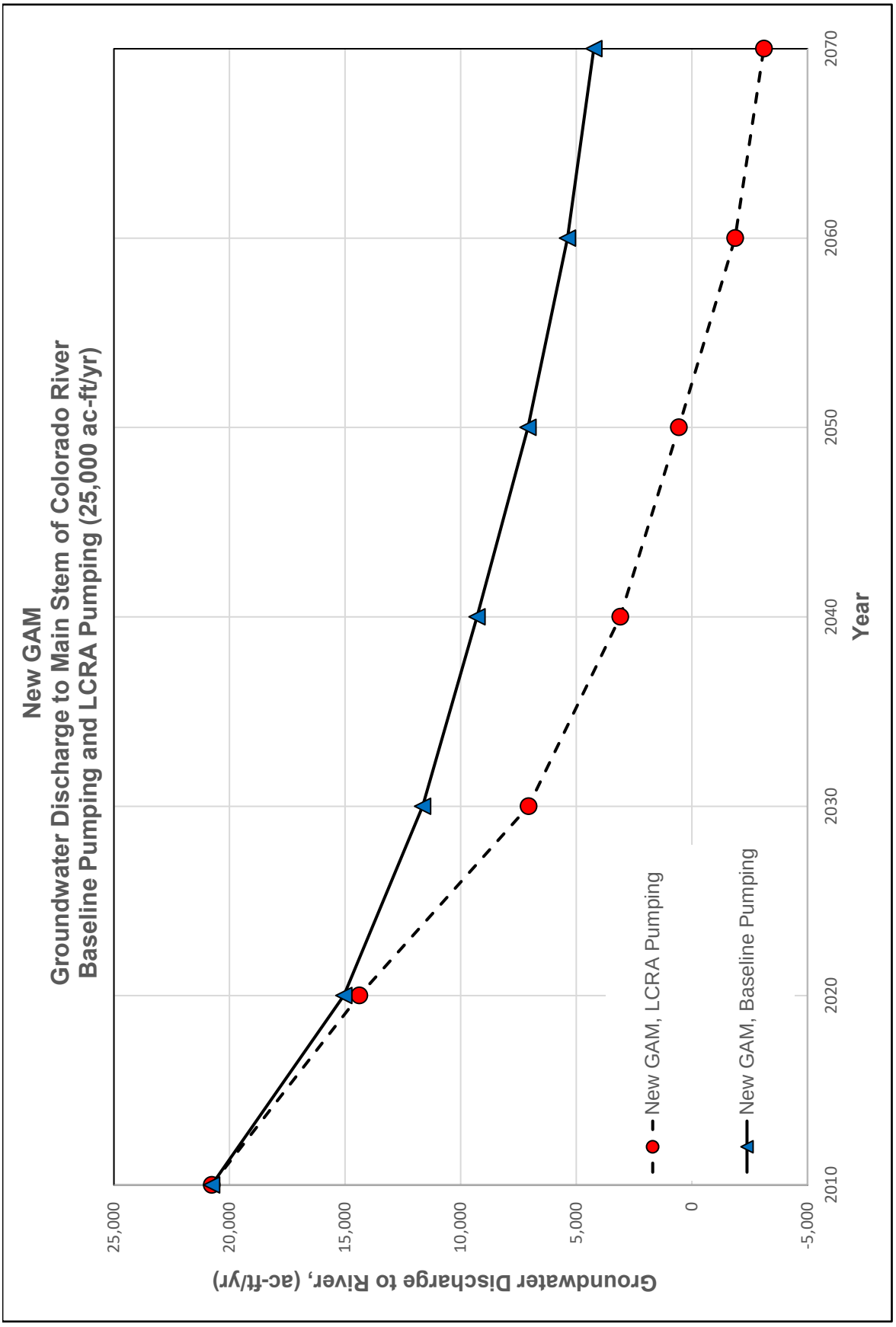

New GAM
Groundwater Discharge to Main Stem of Colorado River
Baseline Pumping and LCRA Pumping (25,000 ac-ft/yr)
Groundwater Discharge to River, (ac-ft/yr)
25,000
20,000
15,000
10,000
5,000
0
-5,000
2010
2020
2030
2040
2050
2060
2070
Year
New GAM, LCRA Pumping
New GAM, Baseline Pumping

EXHIBIT 105

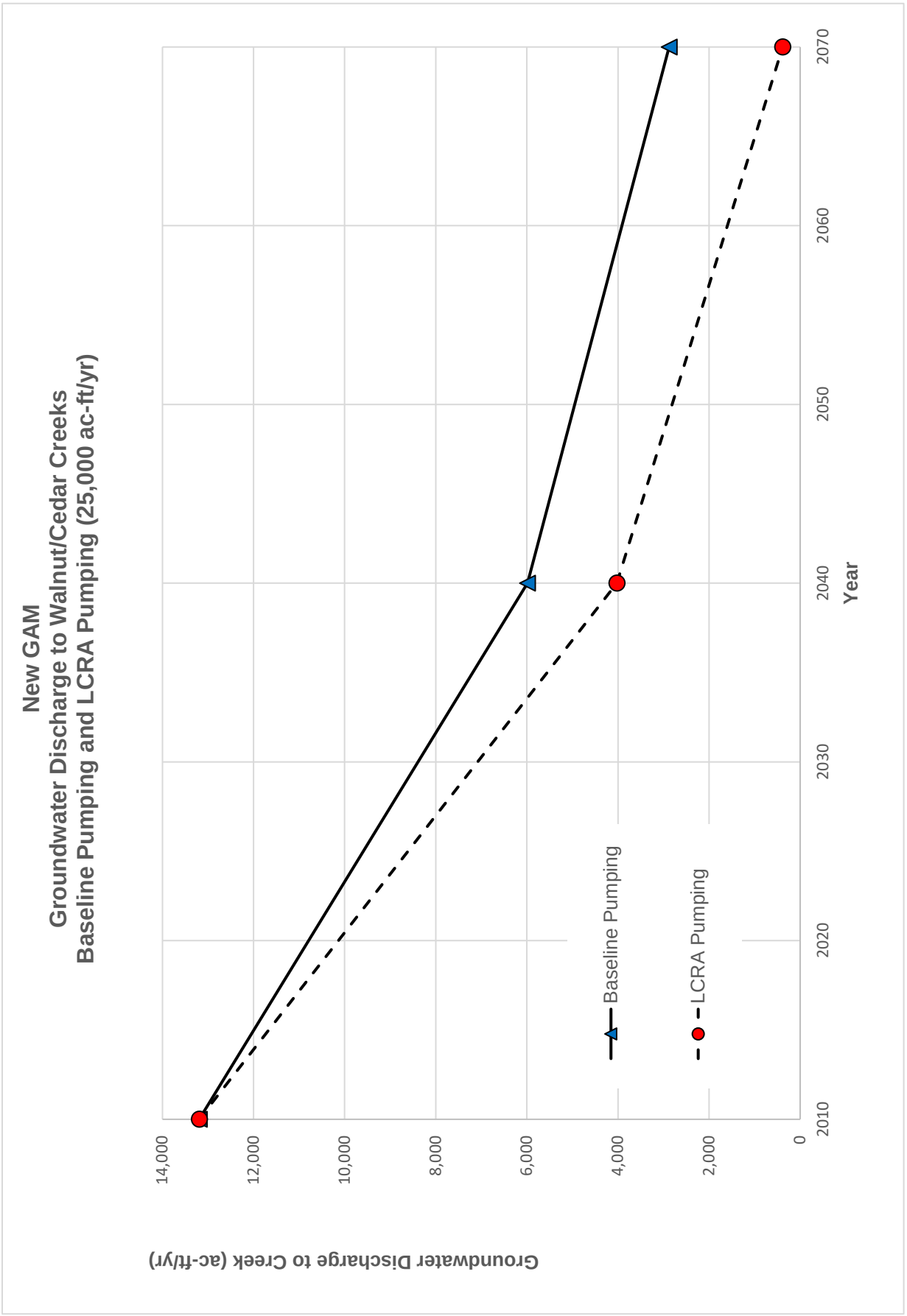

New GAM
Groundwater Discharge to Walnut/Cedar Creeks
Baseline Pumping and LCRA Pumping (25,000 ac-ft/yr)
Groundwater Discharge to Creek (ac-ft/yr)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2010
2020
2030
2040
2050
2060
2070
Year
Baseline Pumping
LCRA Pumping

EXHIBIT 106

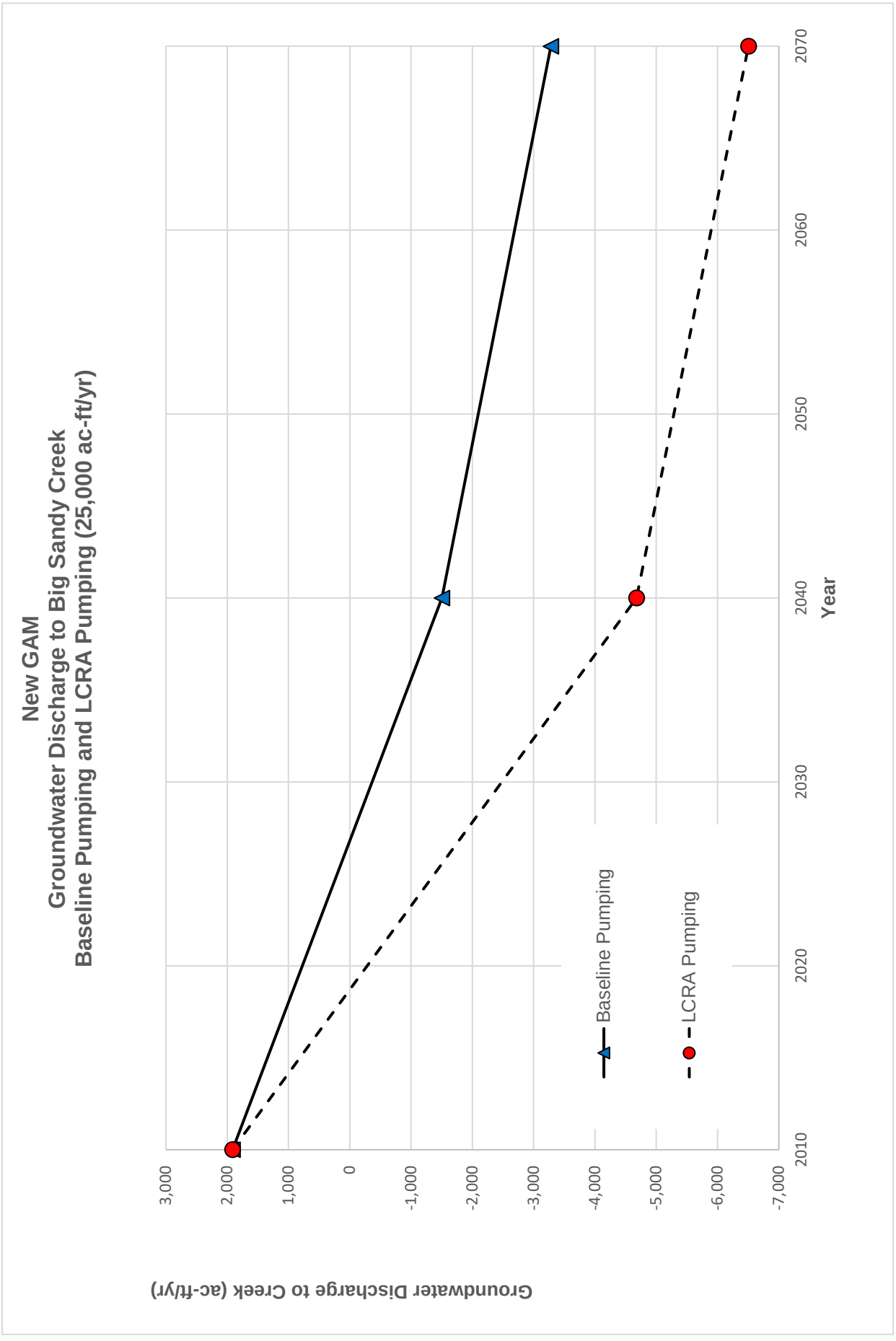

New GAM
Groundwater Discharge to Big Sandy Creek
Baseline Pumping and LCRA Pumping (25,000 ac-ft/yr)
Groundwater Discharge to Creek (ac-ft/yr)
3,000
2,000
1,000
0
-1,000
-2,000
-3,000
-4,000
-5,000
-6,000
-7,000
2010
2020
2030
2040
2050
2060
2070
Year
Baseline Pumping
LCRA Pumping

EXHIBIT 107

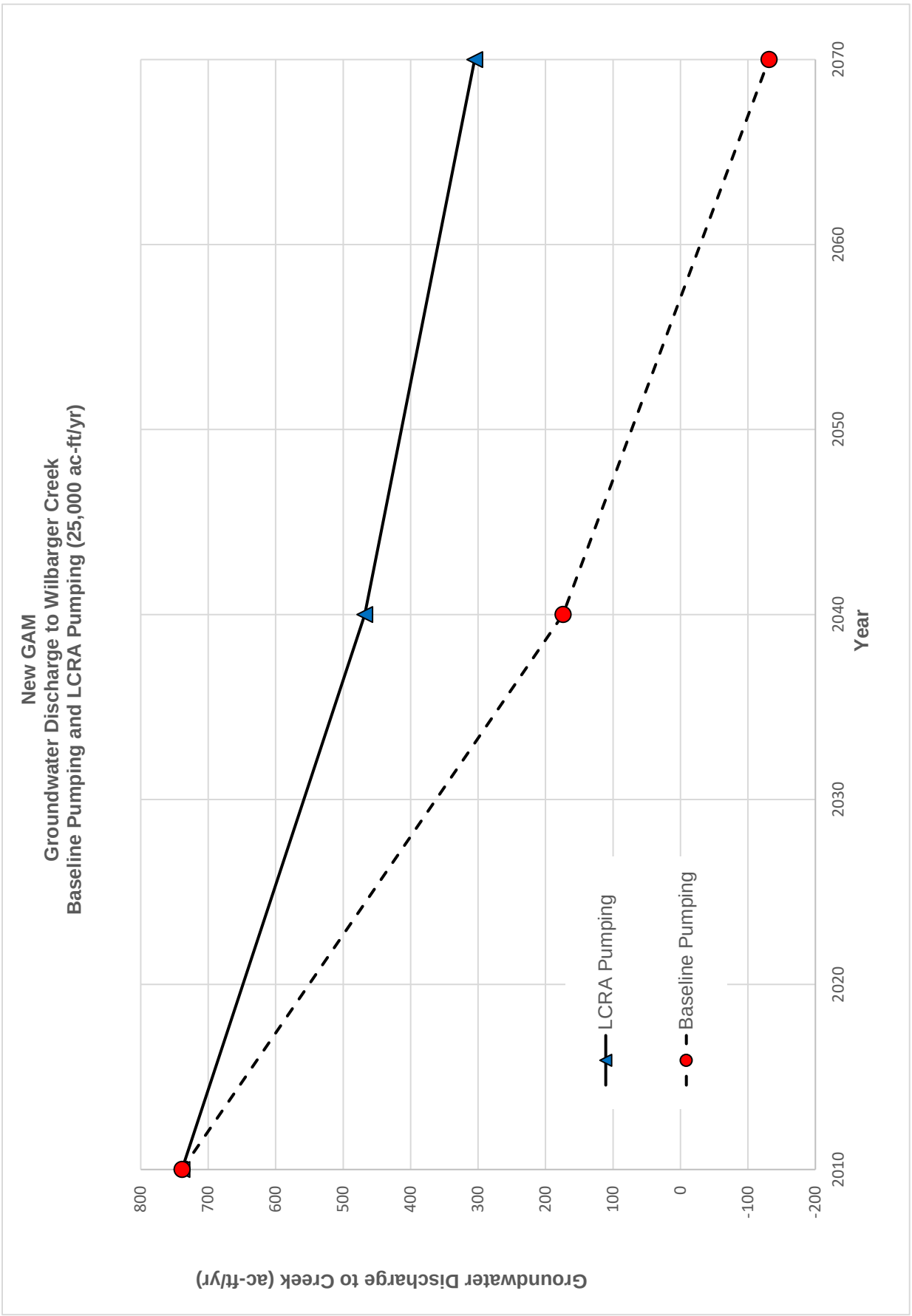

New GAM
Groundwater Discharge to Wilbarger Creek
Baseline Pumping and LCRA Pumping (25,000 ac-ft/yr)
Groundwater Discharge to Creek (ac-ft/yr)
800
700
600
500
400
300
200
100
0
-100
-200
2010
2020
2030
2040
2050
2060
2070
Year
LCRA Pumping
Baseline Pumping

EXHIBIT 108

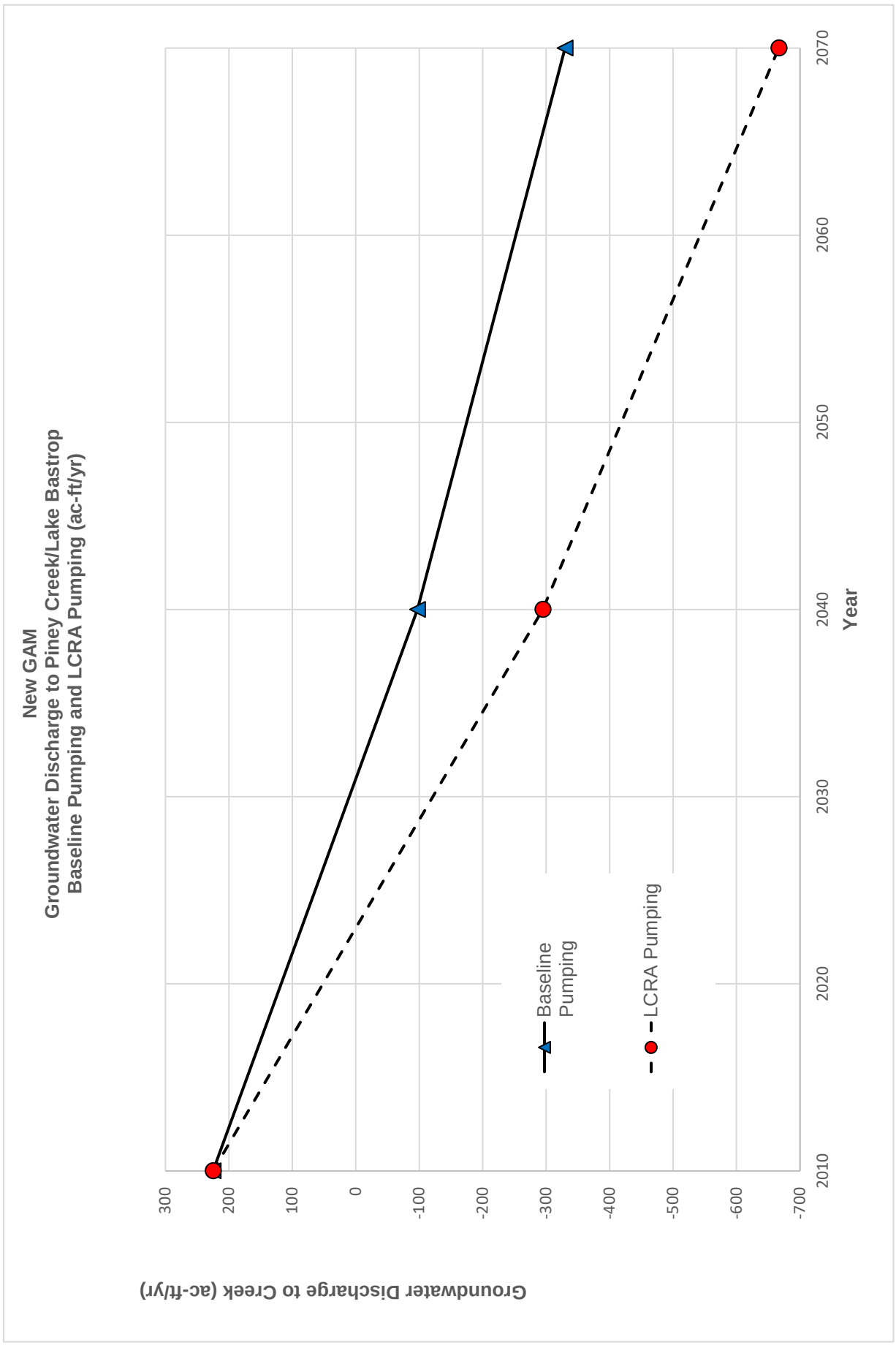

New GAM
Groundwater Discharge to Piney Creek/Lake Bastrop
Baseline Pumping and LCRA Pumping (ac-ft/yr)
Groundwater Discharge to Creek (ac-ft/yr)
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
2010
2020
2030
2040
2050
2060
2070
Year
Baseline Pumping
LCRA Pumping

EXHIBIT 109

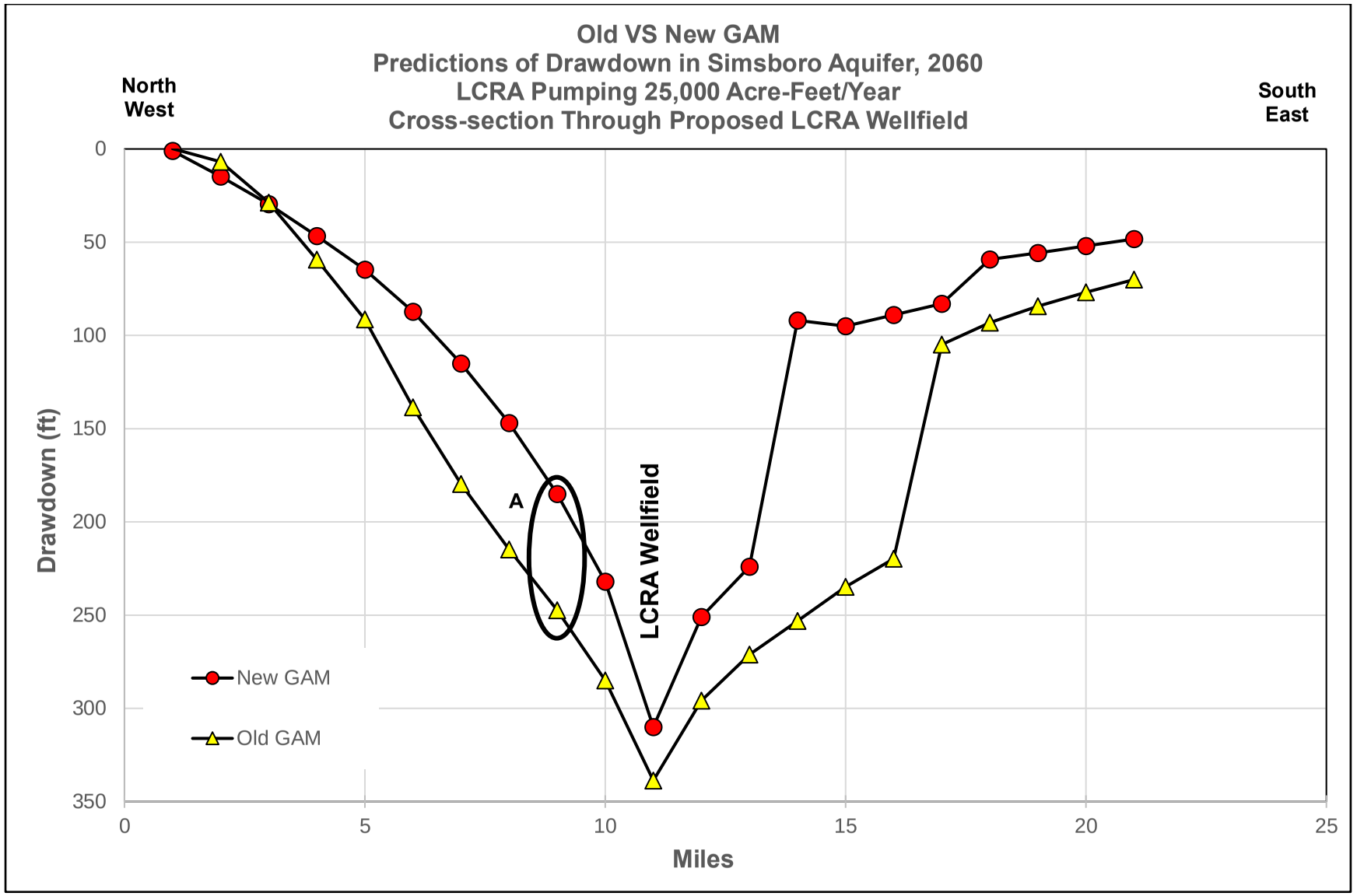

Old VS New GAM
Predictions of Drawdown in Simsboro Aquifer, 2060
LCRA Pumping 25,000 Acre-Feet/Year
Cross-section Through Proposed LCRA Wellfield
North West
South East
Drawdown (ft)
0
50
100
150
200
250
300
350
0
5
10
15
20
25
Miles
A
LCRA Wellfield
New GAM
Old GAM

EXHIBIT 110

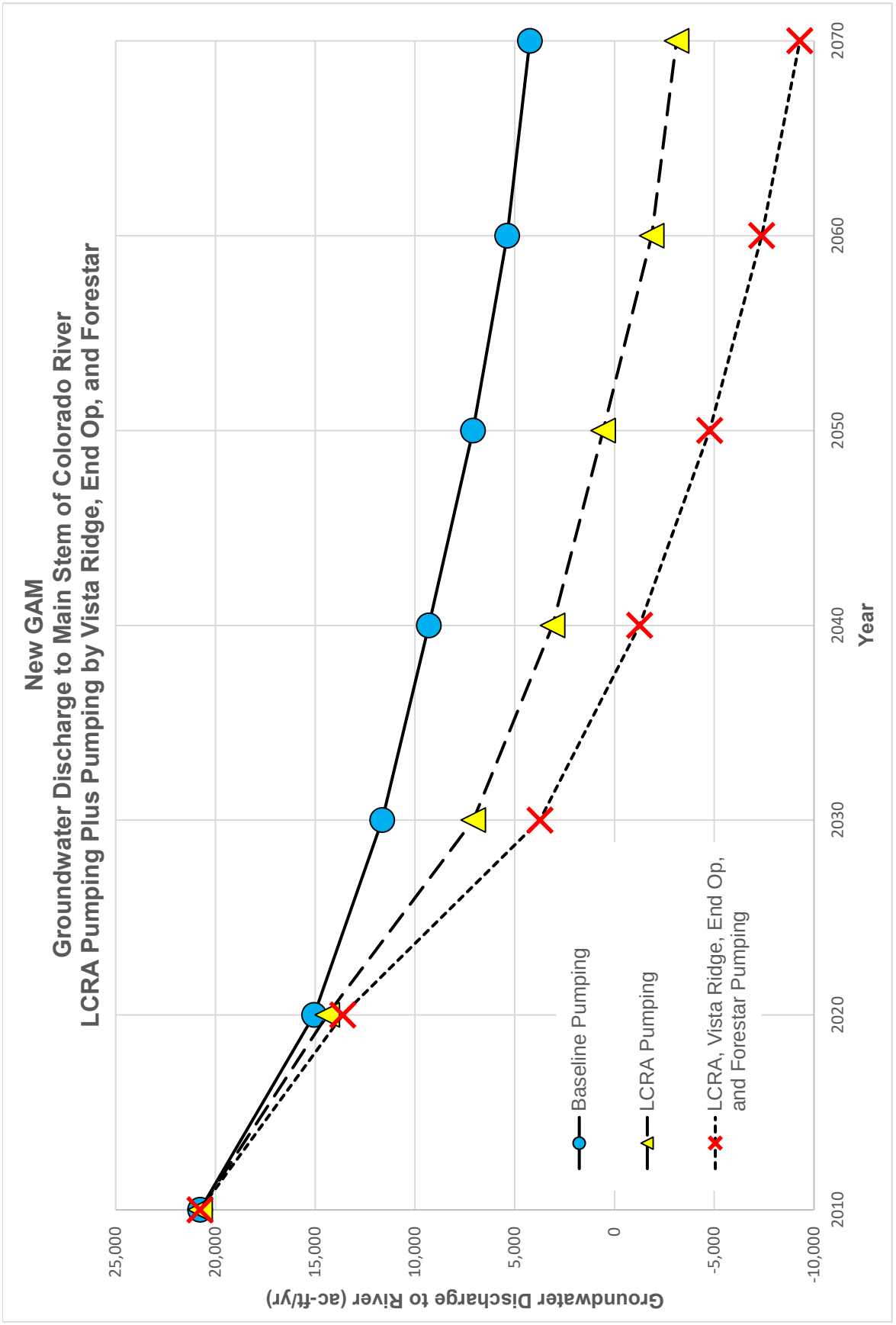
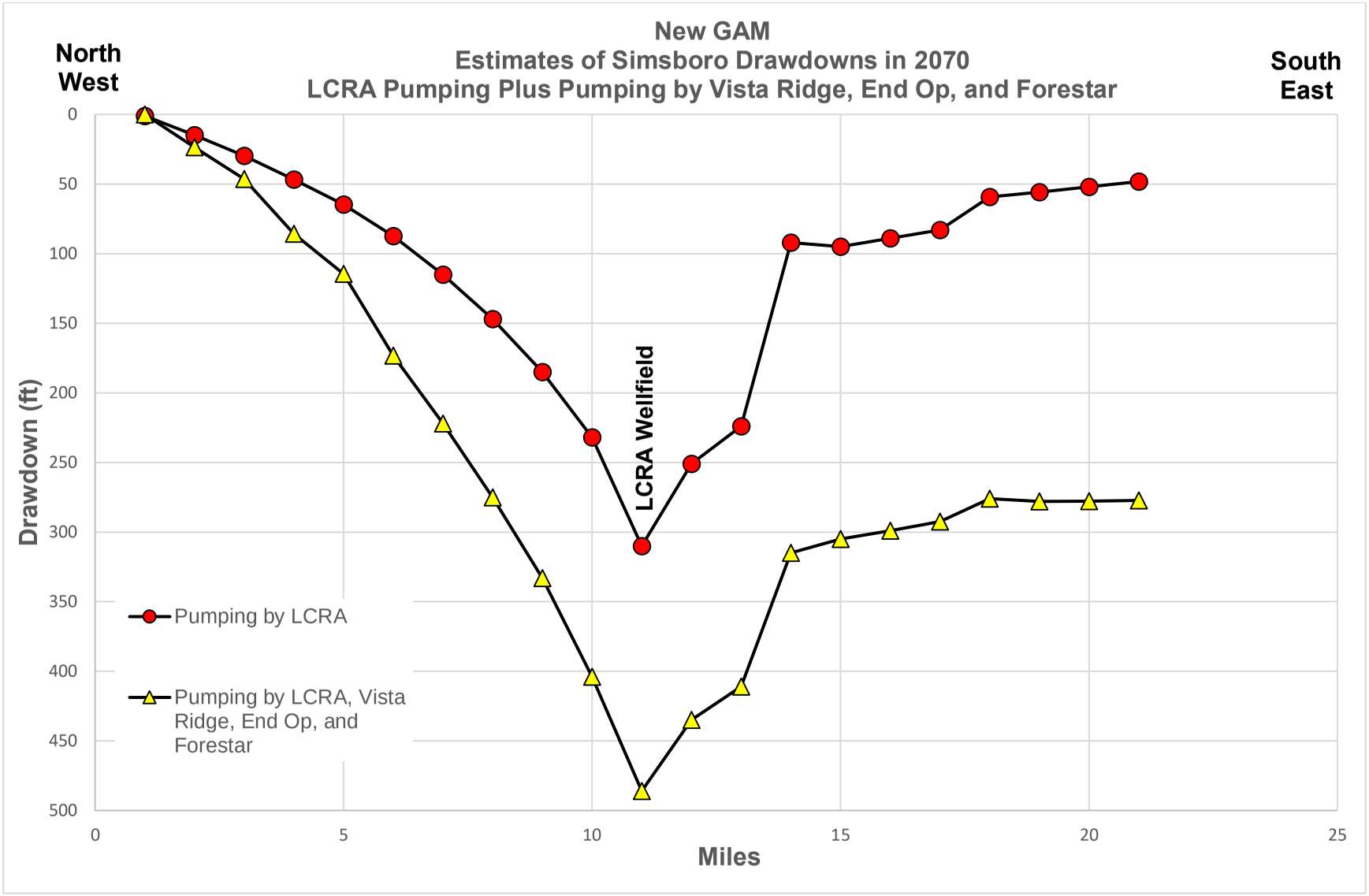

New GAM
Groundwater Discharge to Main Stem of Colorado River
LCRA Pumping Plus Pumping by Vista Ridge, End Op, and Forestar
Groundwater Discharge to River (ac-ft/yr)
25,000
20,000
15,000
10,000
5,000
0
-5,000
-10,000
2010
2020
2030
2040
2050
2060
2070
Year
Baseline Pumping
LCRA Pumping
LCRA, Vista Ridge, End Op, and Forestar Pumping

EXHIBIT 111


New GAM
Estimates of Simsboro Drawdowns in 2070
LCRA Pumping Plus Pumping by Vista Ridge, End Op, and Forestar
North West
South East
Drawdown (ft)
0
50
100
150
200
250
300
350
400
450
500
LCRA Wellfield
Pumping by LCRA
Pumping by LCRA, Vista Ridge, End Op, and Forestar
0
5
10
15
20
25
Miles