GAM Run 07-11

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EXECUTIVE SUMMARY:

We ran the groundwater availability model for the southern part of the Gulf Coast Aquifer for a 60-year predictive simulation using a baseline pumpage (modified slightly from 1999 pumpage initially used in the model) along with average recharge rates, evapotranspiration rates, and initial streamflows. The results of this model run indicate small (mostly less than 6 feet) drawdowns in both the Chicot and Evangeline aquifers within Groundwater Management Area 16. The Jasper Aquifer was not evaluated for the southern part of the Gulf Coast Aquifer groundwater availability model because pumpage is not included in the model from this aquifer.

REQUESTOR:

Mr. Mike Mahoney from the Evergreen Underground Water Conservation District (on behalf of Groundwater Management Area 16).

DESCRIPTION OF REQUEST:

Mr. Mahoney asked us to run a baseline model simulation using the southern part of the Gulf Coast Aquifer groundwater availability model. This baseline model run would be a 60-year simulation using initial water levels from the end of the historic calibration model run and average recharge. Each year of the model runs would use a modified baseline pumpage which was based on the 1999 estimated historic pumpage.

METHODS:

Recharge rates, evapotranspiration rates, and initial streamflows were averaged for the historic calibration-verification runs, representing 1981 to 1999. These averages were then used for each year of the 60-year predictive simulation along with the baseline pumpage. Resulting water levels and drawdowns were then evaluated and are described in the results section below.

PARAMETERS AND ASSUMPTIONS:

The groundwater availability model for the southern part of the Gulf Coast Aquifer was used for this simulation. The parameters and assumptions for this model are described below:

- We used Version 2.01 of the groundwater availability model for the southern part of the Gulf Coast Aquifer.

- See Chowdhury and Mace (2003) and Chowdhury and Mace (in review) for assumptions and limitations of the groundwater availability model for the southern part of the Gulf Coast Aquifer.

- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) in the entire model for 2000 is 17.4 feet (Chowdhury and Mace, in review).

- The model includes four layers representing: the Chicot Aquifer (Layer 1), the Evangeline Aquifer (Layer 2), the Burkeville Confining Unit (Layer 3), and the Jasper Aquifer (Layer 4).

- Recharge and evapotranspiration rates, and initial streamflows are averages from the 1981 to 1999 calibration and verification time period.

- Pumpage used for each year of the 60-year predictive simulation was a baseline pumpage based on the 1999 estimated historic pumpage from the transient calibration-verification run. Historic pumpage included in the transient calibration-verification model run is shown in Appendix A. Modifications that were done to the 1999 estimated pumpage in order to create the new baseline pumpage are shown in Table 1 below. Only pumpage in Jim Hogg County was changed from the 1999 estimated pumpage in the modified baseline pumpage input data set. Pumpage was uniformly decreased in this county to create the revised pumpage.

Table 1. 1999 estimated pumpage from the calibration-verification run of the groundwater availability model and the requested baseline pumpage used in this model simulation. Pumpage is reported in acre-feet per year. Pumpage in Jim Hogg, Brooks, and Kenedy counties represents only the pumpage located in the active portion of the model.

County	1999 pumpage	Requested baseline pumpage	Change
Brooks	389	389	0
Cameron	2,832	2,832	0
Hidalgo	20,325	20,325	0
Jim Hogg	99	38	-61
Kenedy	199	199	0
Starr	394	394	0
Willacy	28	28	0

RESULTS:

Included in the results are estimates of the water budgets after running the model for 60 years. The components of the water budget are described below.

- Wells—water produced from wells in each aquifer. This component is always shown as "Outflow" from the water budget, because all wells included in the model produce (rather than inject) water. Wells are modeled in the model using the MODFLOW Well package.

- Recharge—simulates areally distributed recharge due to precipitation falling on the outcrop areas of aquifers. Recharge is always shown as "Inflow" into the water budget.

- Vertical Leakage (Upward or Downward)—describes the vertical flow, or leakage, between two aquifers. This flow is controlled by the water levels in each aquifer and aquifer properties of each aquifer that define the amount of leakage that can occur. "Inflow" to an aquifer from an overlying or underlying aquifer will always equal the "Outflow" from the other aquifer.

- Storage—water stored in the aquifer. The storage component that is included in "Inflow" is water that is removed from storage in the aquifer (that is, water levels decline). The storage component that is included in "Outflow" is water that is added back into storage in the aquifer (that is, water levels increase). This component of the budget is often seen as water both going into and out of the aquifer because this is a regional budget, and water levels will decline in some areas (water is being removed from storage) and will rise in others (water is being added to storage).

- Lateral flow—describes lateral flow within an aquifer between a county and adjacent counties.

- Evapotranspiration—water that flows out of an aquifer due to direct evaporation and plant transpiration. This component of the budget will always be shown as "Outflow". Evapotranspiration is modeled in the model using the MODFLOW Evapotranspiration (EVT) package.

- Rivers and Streams—water that flows between streams and rivers and an aquifer. The direction and amount of flow depends on the water level in the stream or river and the aquifer. In areas where water levels in the stream or river are above the water level in the aquifer, water flows into the aquifer and is shown as "Inflow" in the budget. In areas where water levels in the aquifer are above the water level in the stream or river, water flows out of the aquifer and into the stream and is shown as "Outflow" in the budget. Rivers and streams are modeled in the model for the southern part of the Gulf Coast Aquifer using the MODFLOW River package

The results of model run are described for only the Chicot Aquifer (layer 1 in the model) and the Evangeline Aquifer (layer 2). The Jasper Aquifer (layer 4) is not discussed because there is no pumpage from this aquifer in the model and the Burkeville Confining Unit (layer 3) is not discussed because this is not a major source of water in the region. There also is no pumpage from this layer in the model.

Initial water levels (which are from the end of the transient calibration run-- the end of 1999) for the Chicot and Evangeline aquifers are shown in Figures 1 and 2, respectively. These figures show the starting water levels for this 60-year predictive model run. These figures all show that water levels decrease in elevation as groundwater flows downdip towards the coast.

Water levels at the end of the 60-year predictive simulation for the Chicot and Evangeline aquifers are shown in Figures 3 and 4, respectively. Water levels at the end of the 60-year runs are very similar to initial water levels (Figures 1 and 2). Because differences between initial water levels and water levels after 60 years of pumpage are difficult to discern in these figures, drawdown (differences in water elevation) maps were also made.

Drawdowns over the 60-year predictive simulation for the Chicot and Evangeline aquifers are shown in Figures 5 and 6, respectively. These figures indicate that drawdowns throughout most of the model area in the Chicot Aquifer (Figure 5) are small (less than 4 feet). In parts of the Chicot aquifer in Jim Hogg, Brooks, and northern Hidalgo counties the drawdown is higher, and this is presumably in response to drawdowns in the Evangeline Aquifer because there is no pumpage in the Chicot in this area. In the Evangeline Aquifer (Figure 6) the drawdowns are also very small (generally less than 2 feet). In the Evangeline Aquifer, slightly higher drawdown in Starr, Brooks, and northern Hidalgo counties are observed. This may be related to the underlying geology in this area of the model which may slightly restrict groundwater flow. It should be noted that the model contains no pumpage from the Evangeline Aquifer in Cameron, southern Willacy, and southern Hidalgo counties, and therefore drawdowns are very small in these areas.

Water budgets are provided in Table 2. The budgets from this baseline run can be compared to future model runs to provide detail on the impact of future pumpage scenarios on these water budget components.

While the differences in water levels in southern part of the Gulf Coast Aquifer models is within the margin of error of the calibration, the trend in increasing and decreasing water levels is important to note.

REFERENCES:

Chowdhury, A. H., and Mace, R. E., 2003, A groundwater availability model of the Gulf Coast Aquifer in the Lower Rio Grande Valley, Texas; Numerical simulations through 2050; Texas Water Development Board draft report, 176 p.

Chowdhury, A. H. and Mace R. E., in review, Groundwater Availability Model of the Gulf Coast Aquifer in the Lower Rio Grande Valley of Texas, Texas Water Development Board Report, 119 p.

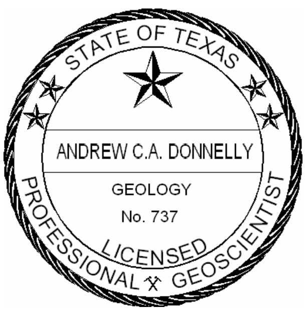

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Table 2. Water budgets for each county at the end of the 60-year predictive model run using a revised baseline pumpage (in acre-feet per year).

	Brooks		Cameron		Hidalgo		Jim Hogg		Kenedy		Starr		Willacy		Non-Texas	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Chicot																
Storage	7	0	0	0	7	0	3	0	4	0	2	0	1	0	0	0
River	0	0	28,041	16,366	19,484	6,927	0	0	0	0	0	0	1,853	2,410	0	0
Well	0	0	0	2,279	0	16,788	0	0	0	0	0	0	0	19	0	0
Constant Head	0	0	0	16,849	0	0	0	0	0	14,207	0	0	0	9,300	0	1,956
Recharge	1,165	0	7,514	0	4,047	0	196	0	7,965	0	108	0	4,580	0	0	0
ET	0	224	0	0	0	210	0	38	0	1,708	0	20	0	349	0	0
Lateral Inflow	711	2,328	7,059	8,777	852	5,454	0	818	5,750	1,107	390	467	9,287	6,123	1,025	0
Vertical Leakage Downward	968	298	2,341	685	5,398	409	659	2	3,368	65	43	55	2,487	7	931	0
Evangeline																
Storage	5	0	0	0	6	0	11	0	1	0	18	0	1	0	0	0
River	0	0	0	0	3,445	338	0	0	0	0	0	339	0	0	0	0
Well	0	389	0	527	0	2,083	0	37	0	199	0	394	0	9	0	0
Constant Head	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recharge	1,860	0	0	0	5,164	0	2,241	0	281	0	3,374	0	417	0	115	0
ET	0	32	0	0	0	66	0	115	0	0	0	8	0	38	0	0
Vertical Leakage Upward	298	968	685	2,341	409	5,398	2	659	65	3,368	55	43	7	2,487	0	931
Lateral Inflow	1,369	2,309	3,524	1,438	4,226	5,955	23	1,702	3,300	379	471	3,925	3,580	1,575	805	14
Vertical Leakage Downward	167	0	97	0	590	1	506	270	299	0	945	153	104	0	26	0

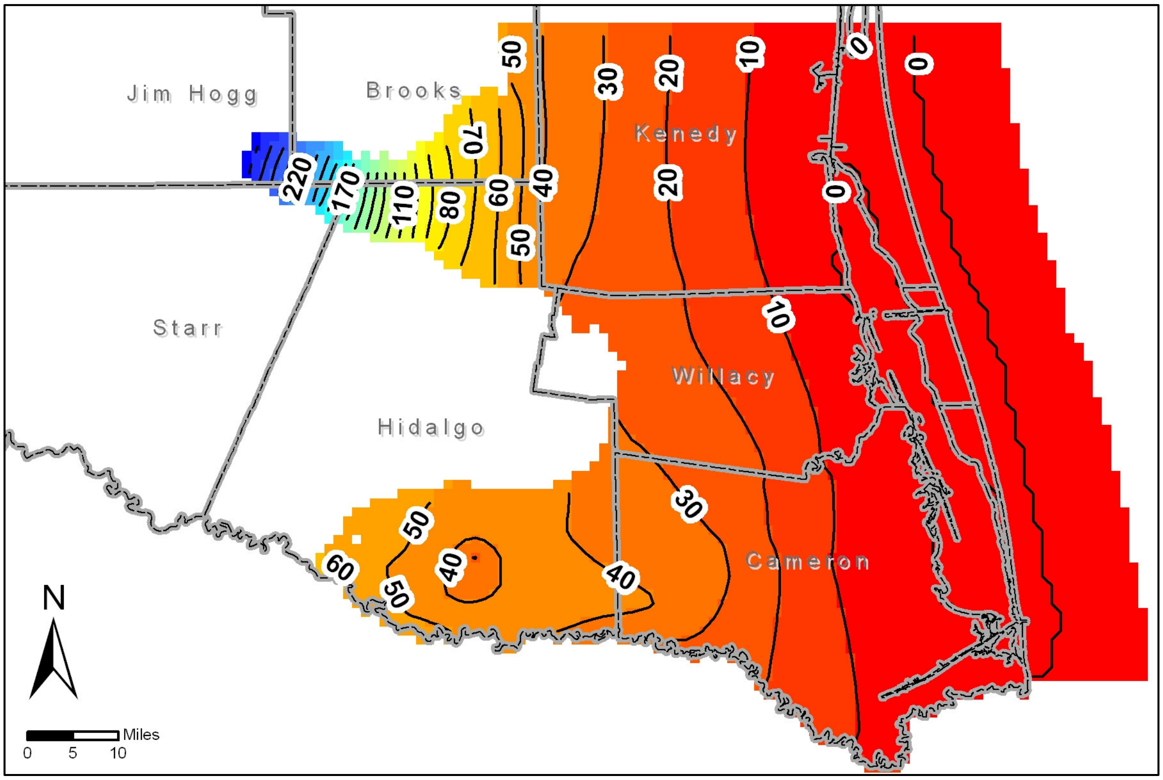

Figure 1. Initial water level elevations for the predictive model run in the Chicot Aquifer from the southern part of the Gulf Coast groundwater availability model. Water level elevations are in feet above mean sea level. Contour interval is 10 feet.

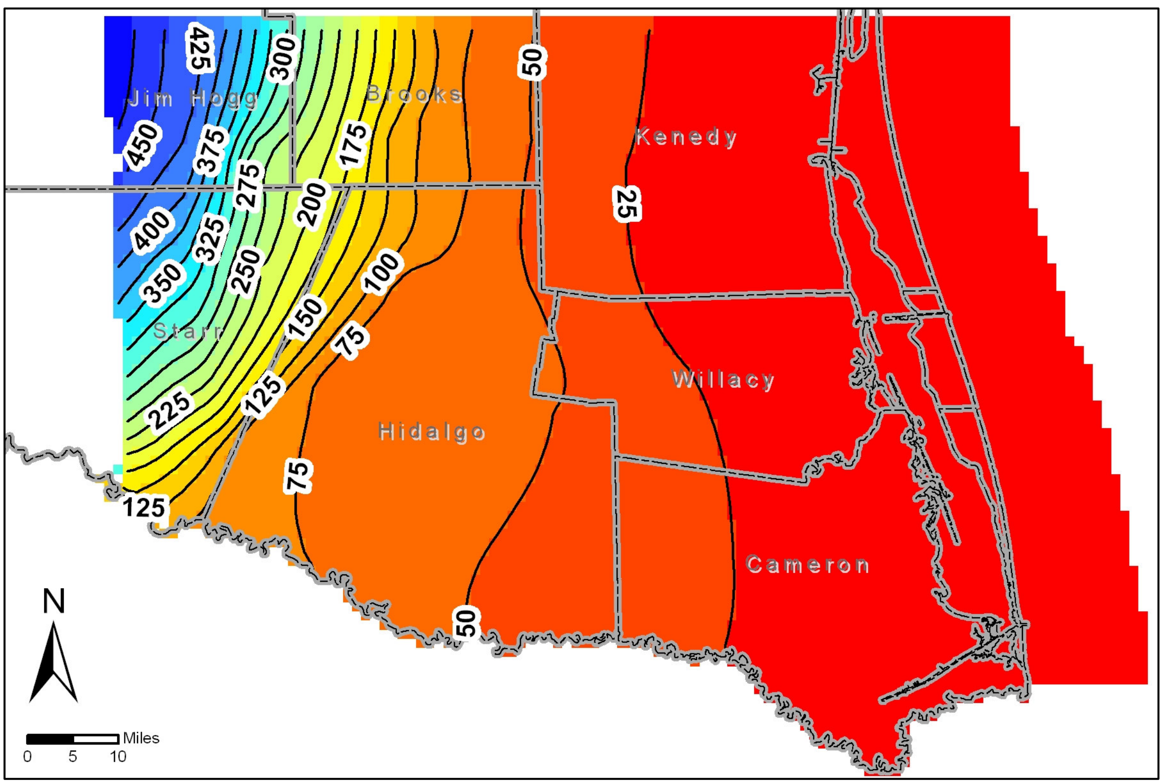

Figure 2. Initial water level elevations for the predictive model run in the Evangeline Aquifer from the southern part of the Gulf Coast groundwater availability model. Water level elevations are in feet above mean sea level. Contour interval is 25 feet.

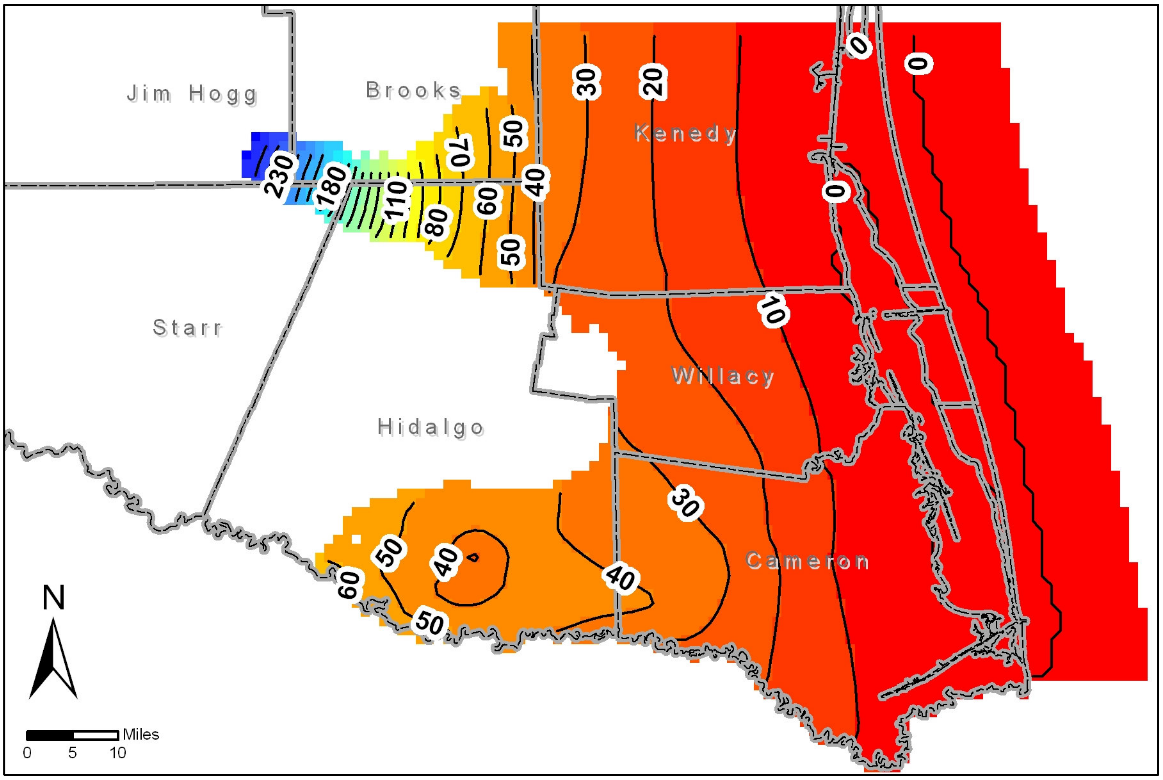

Figure 3. Water level elevations after 60 years using 1999 pumpage in the Chicot Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 10 feet.

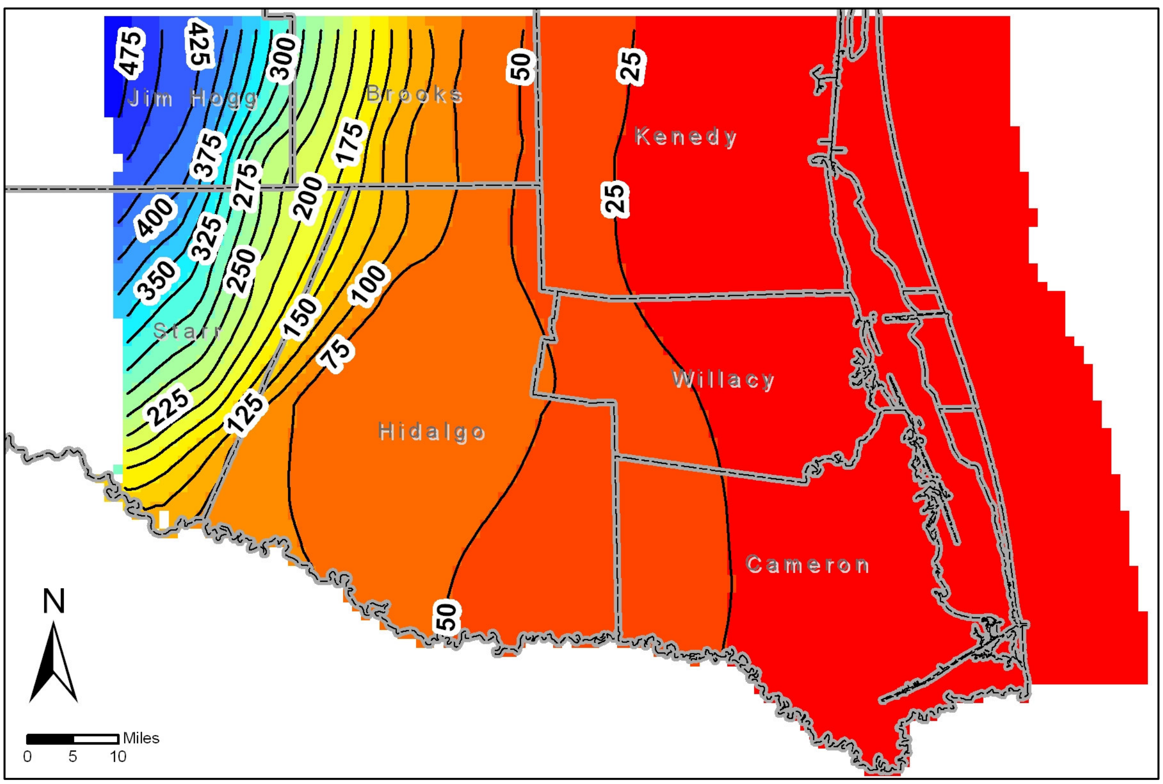

Figure 4. Water level elevations after 60 years using 1999 pumpage in the Evangeline Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 25 feet.

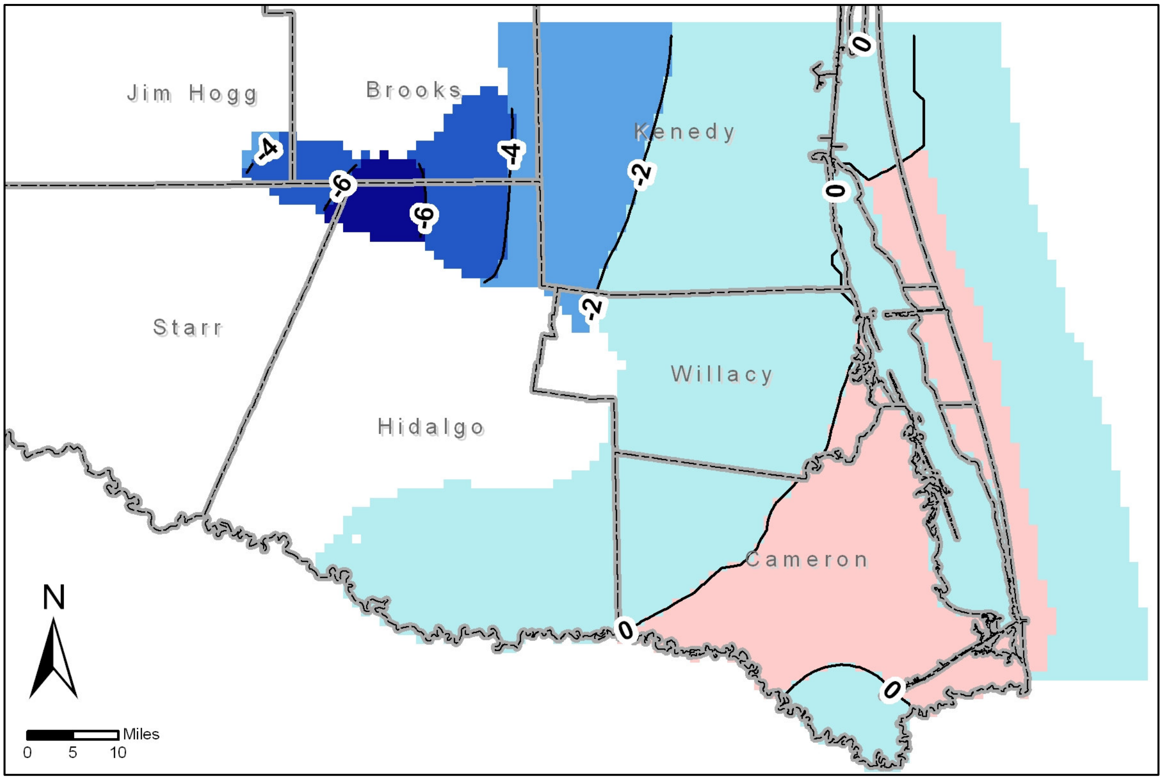

Figure 5. Water level changes (in feet) after 60 years using baseline pumpage in the Chicot Aquifer. Contour interval is 2 feet. Areas of decreasing water levels (drawdown) are shown in red. Areas of increasing water levels (recovery) are shown in blue.

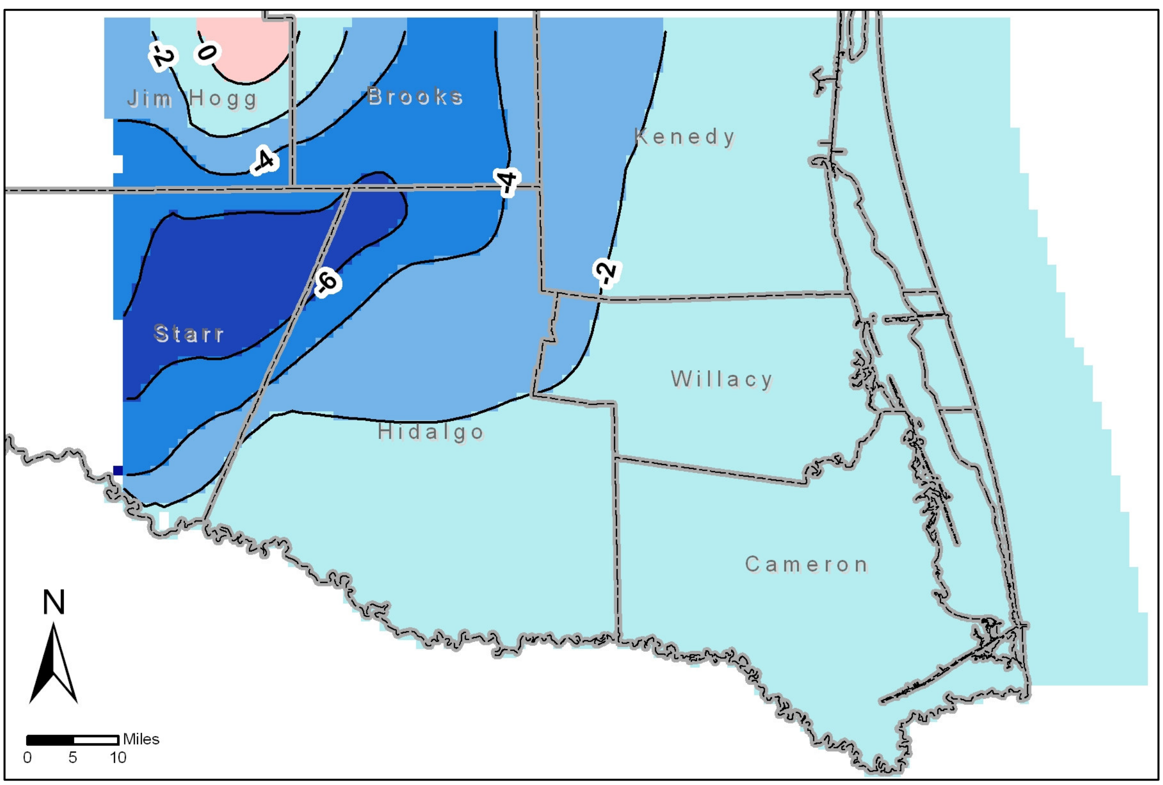

Figure 6. Water level changes (in feet) after 60 years using baseline pumpage in the Evangeline Aquifer. Contour interval is 2 feet. Areas of decreasing water levels (drawdown) are shown in red. Areas of increasing water levels (recovery) are shown in blue.

Appendix A

Summary of Historic Pumpage in the Groundwater Availability Model for the Southern Part of the Gulf Coast Aquifer

Table A-1. Summary of estimated historic pumpage included in the groundwater availability model for the southern part of the Gulf Coast Aquifer (in acre-feet per year).

Year	Total	Brooks	Cameron	Hidalgo	Jim Hogg	Kenedy	Starr	Willacy
1980	13,982	393	954	11,007	39	634	387	568
1981	15,167	386	1,206	12,082	38	600	440	416
1982	14,704	378	1,467	11,506	38	565	457	293
1983	15,224	362	1,825	11,826	38	531	473	169
1984	15,501	332	2,037	12,047	37	496	506	46
1985	14,374	375	977	12,045	35	414	502	27
1986	17,168	483	1,501	14,196	33	430	506	20
1987	16,477	318	1,735	13,230	43	491	641	19
1988	16,893	444	1,466	13,793	42	517	613	19
1989	18,026	224	2,310	14,588	32	504	347	21
1990	27,425	244	2,295	23,940	45	497	383	21
1991	33,697	380	2,249	23,437	40	507	7,050	34
1992	18,903	323	2,281	12,589	53	333	3,293	30
1993	19,423	235	1,911	16,448	51	404	317	58
1994	23,360	267	2,357	20,016	44	326	325	25
1995	22,263	266	2,335	19,051	41	301	243	26
1996	20,257	265	3,066	16,128	47	334	386	31
1997	18,683	268	3,606	14,211	38	292	233	35
1998	25,114	389	3,650	20,148	129	245	519	33
1999	24,288	389	2,838	20,341	99	199	394	28

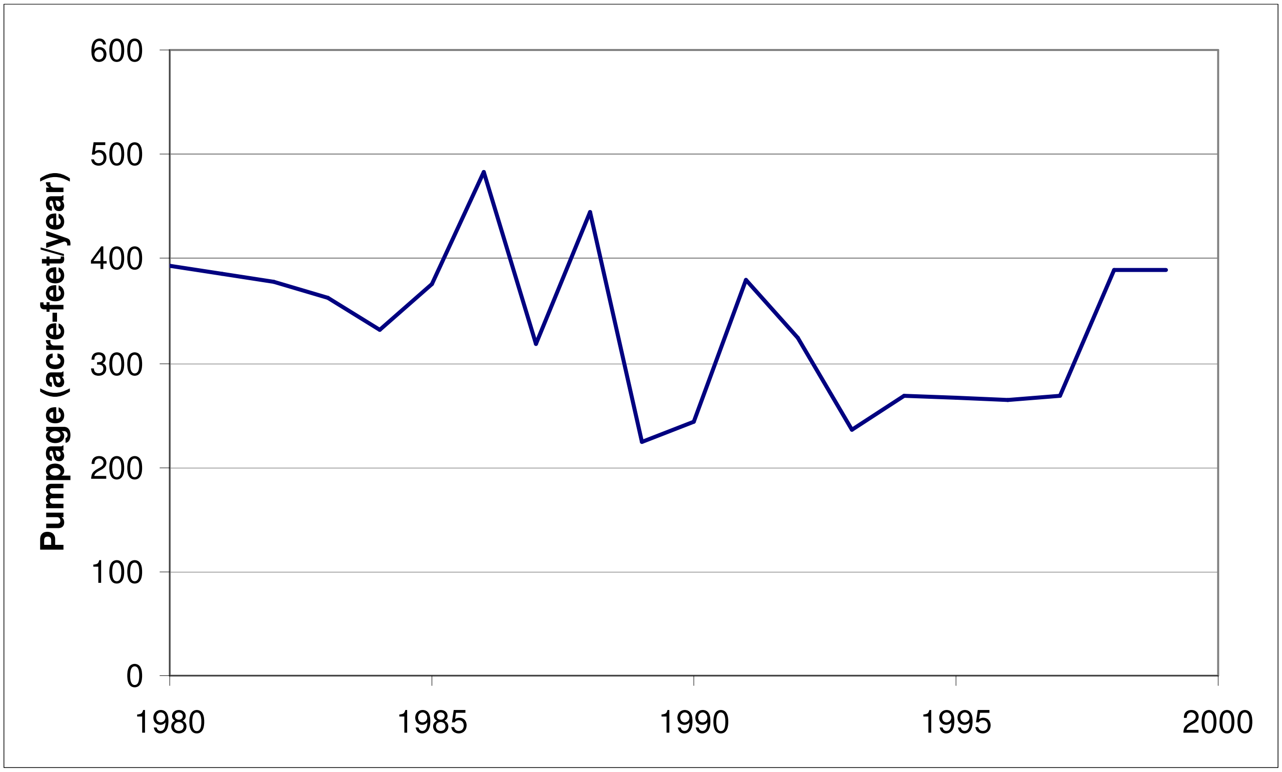

Figure A-1- Pumpage in Brooks County included in the groundwater availability model for the southern part of the Gulf Coast Aquifer.

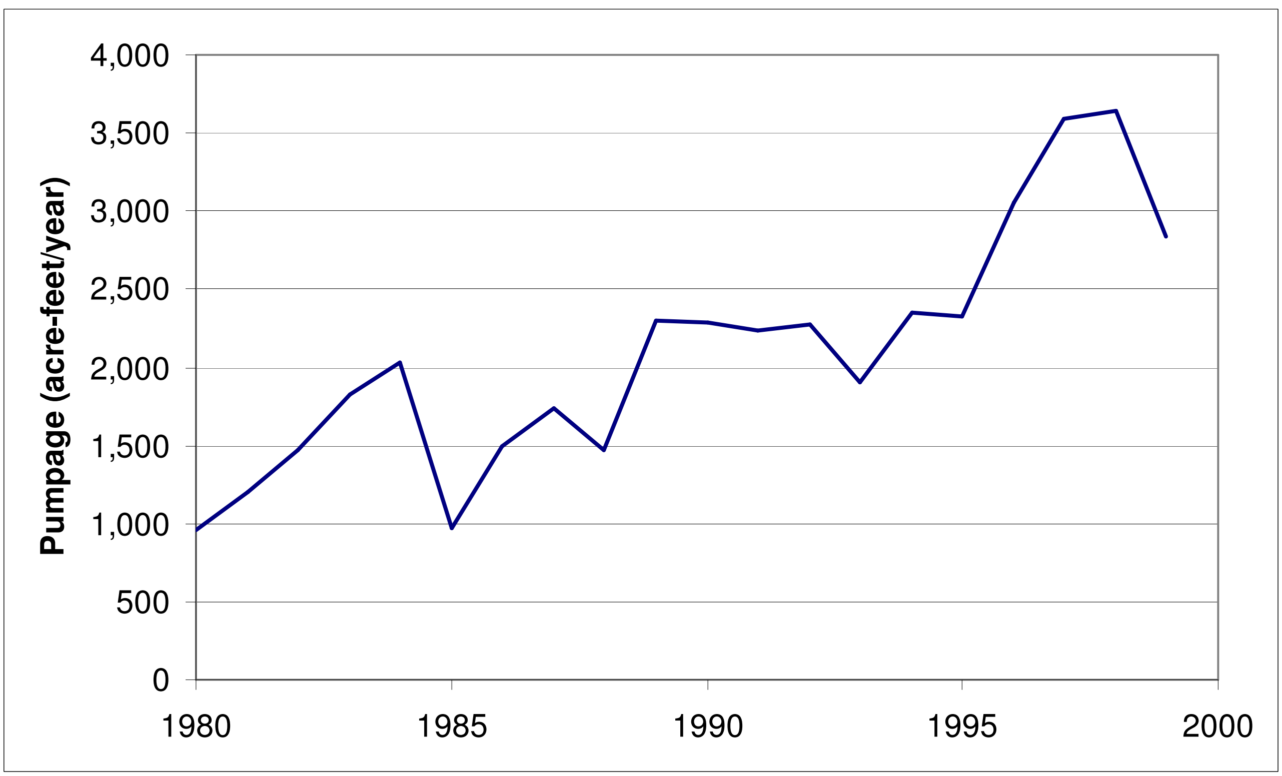

Figure A-2- Pumpage in Cameron County included in the groundwater availability model for the southern part of the Gulf Coast Aquifer.

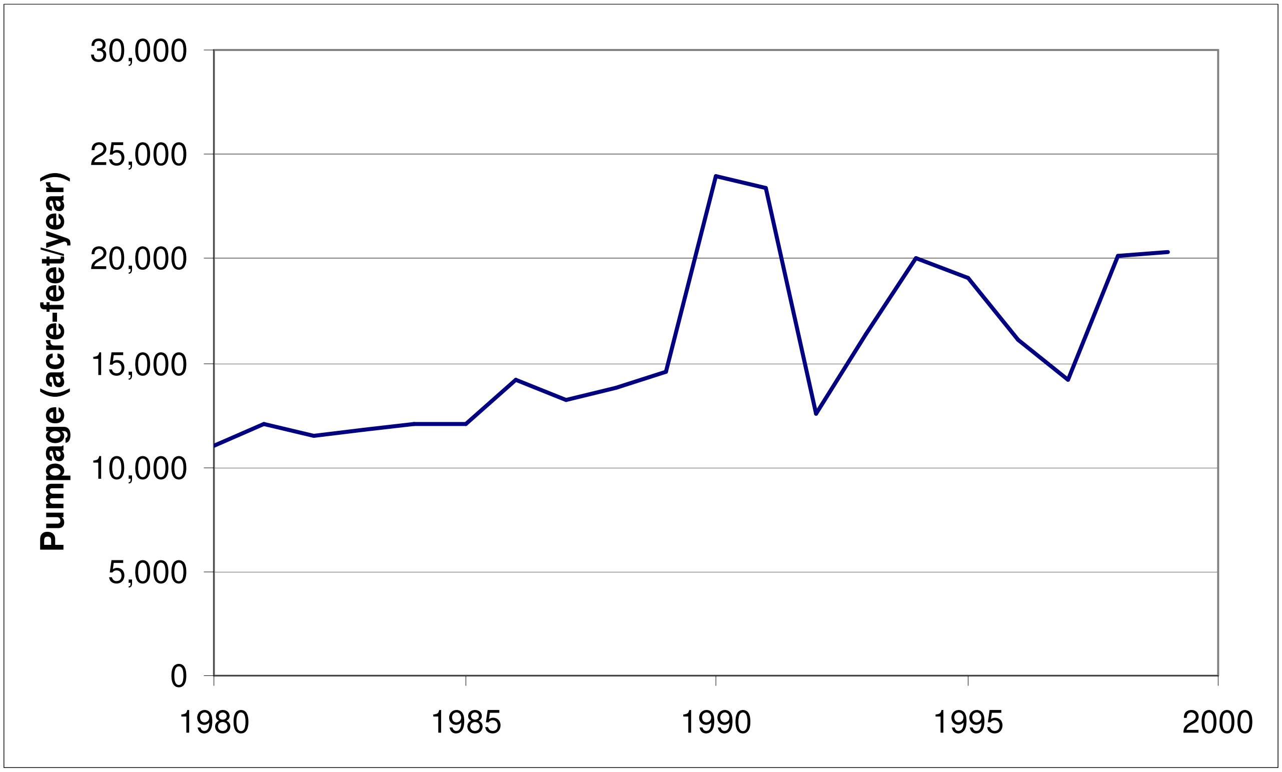

Figure A-3- Pumpage in Hidalgo County included in the groundwater availability model for the southern part of the Gulf Coast Aquifer.

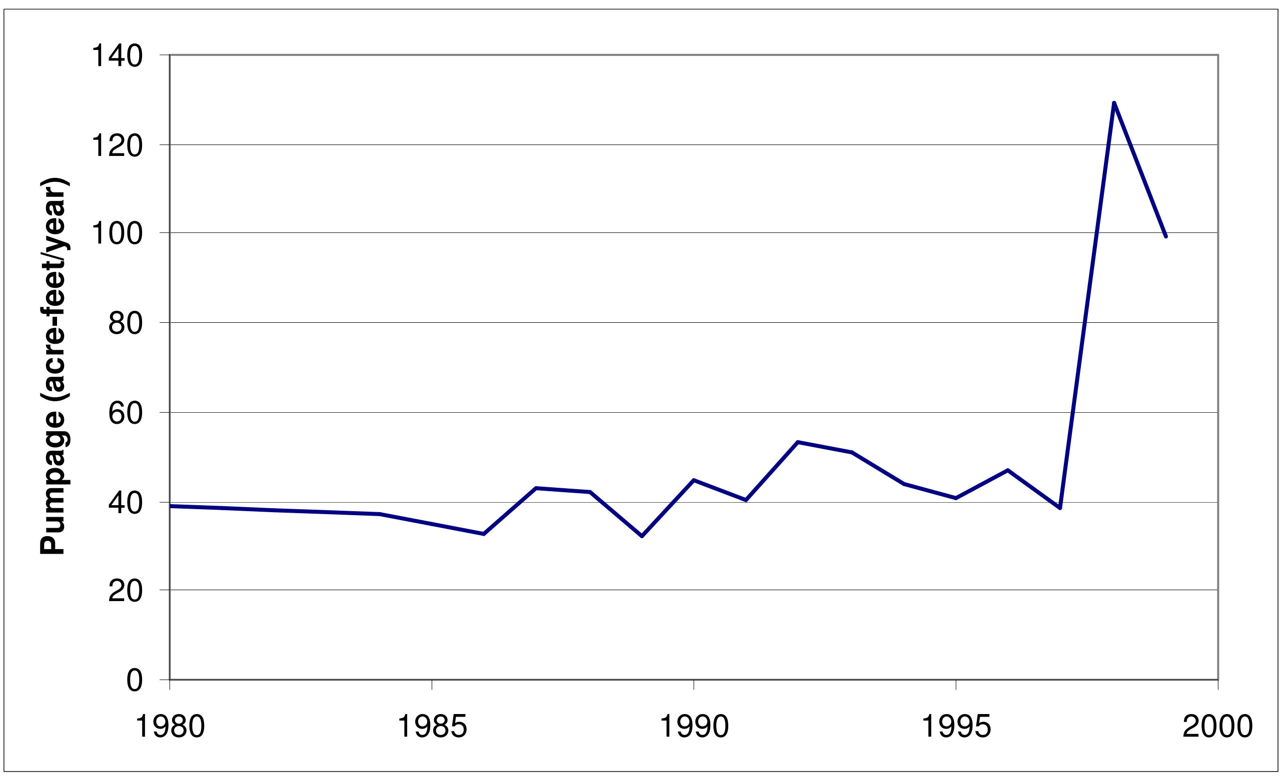

Figure A-4- Pumpage in Jim Hogg County included in the groundwater availability model for the southern part of the Gulf Coast Aquifer.

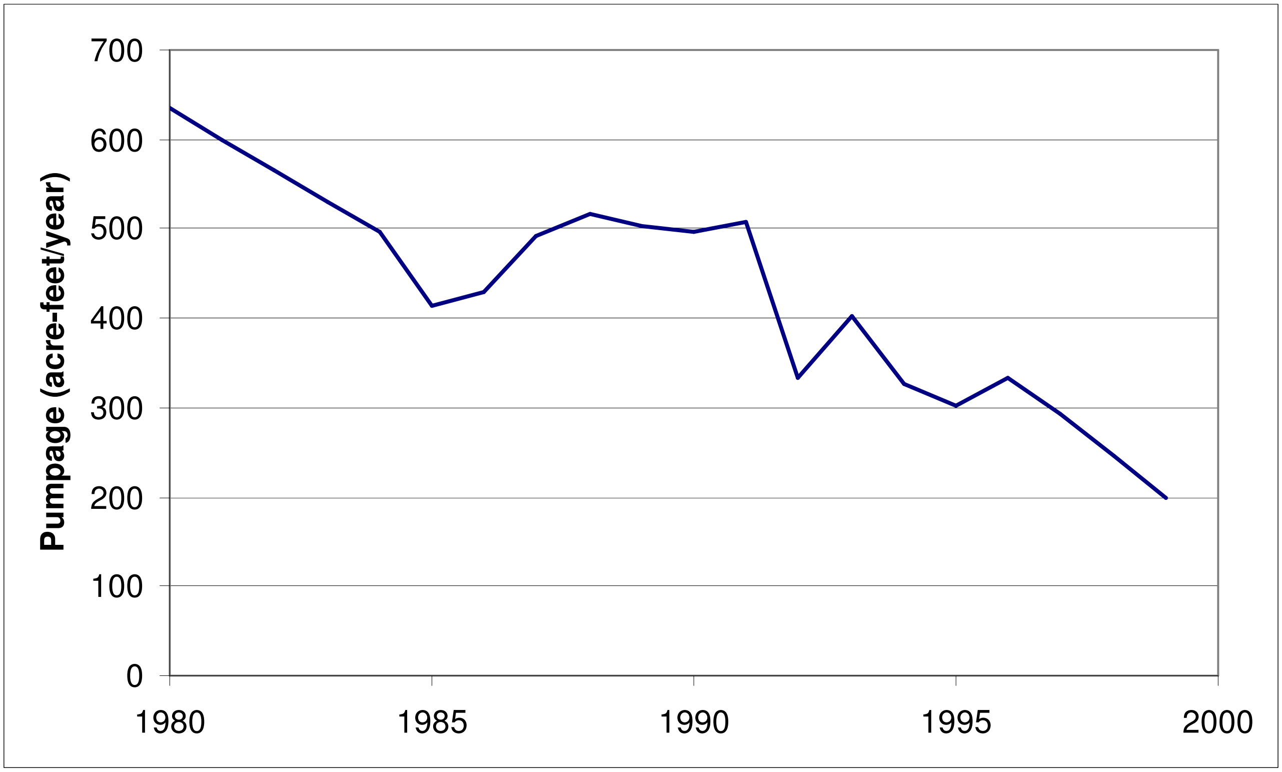

Figure A-5- Pumpage in Kenedy County included in the groundwater availability model for the southern part of the Gulf Coast Aquifer.

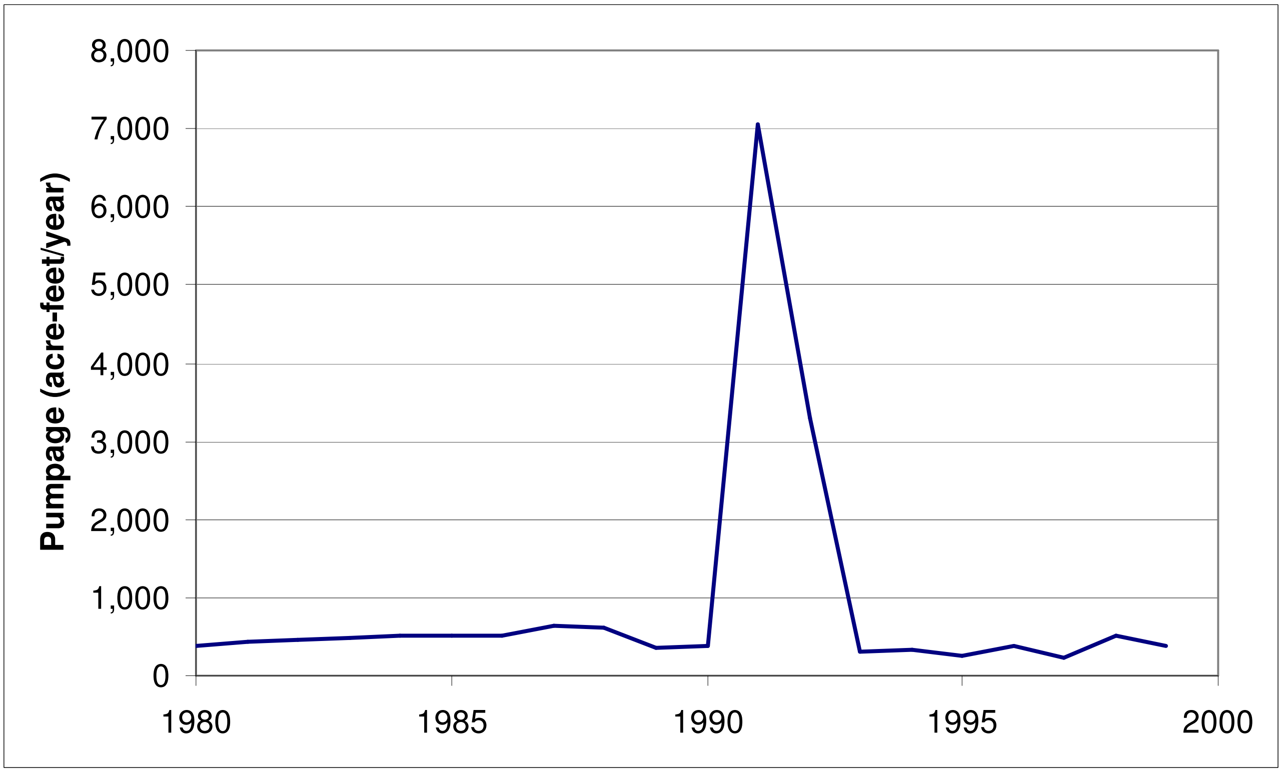

Figure A-6- Pumpage in Starr County included in the groundwater availability model for the southern part of the Gulf Coast Aquifer.

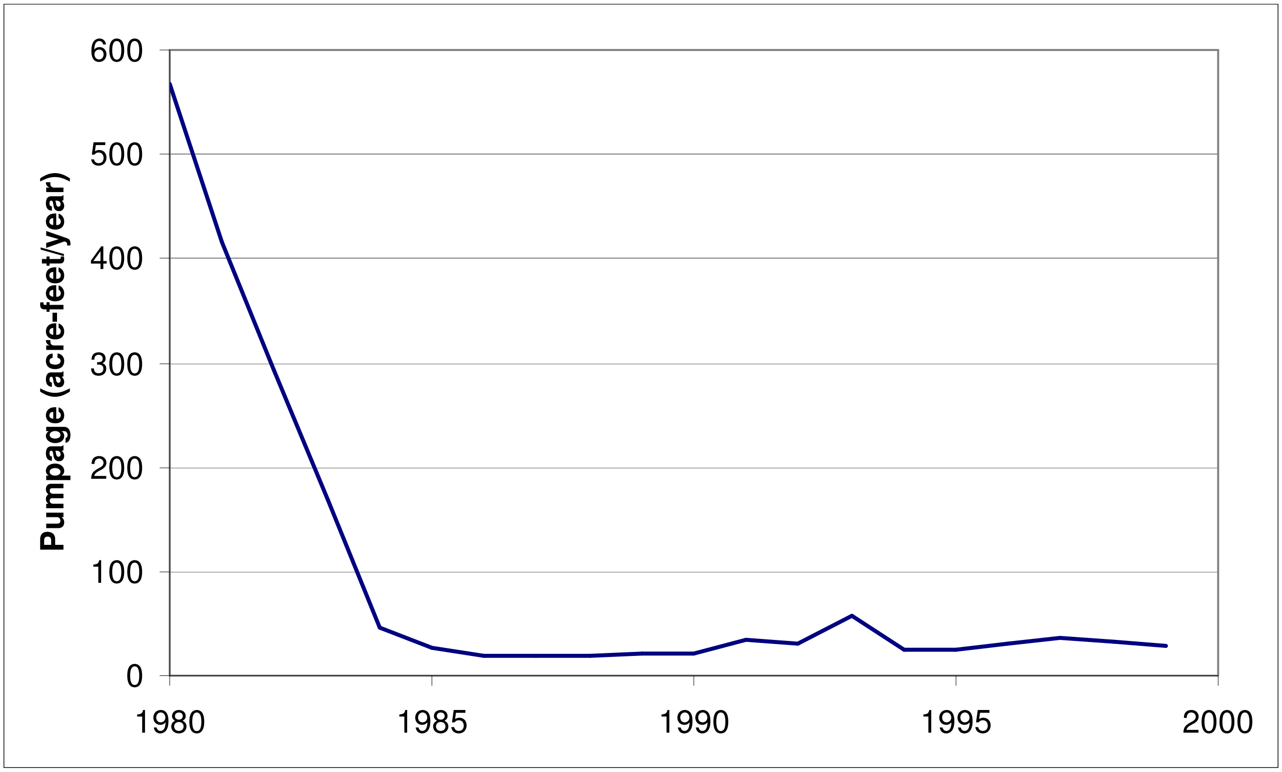

Figure A-7- Pumpage in Willacy County included in the groundwater availability model for the southern part of the Gulf Coast Aquifer.