GAM Run 07-34

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Groundwater Availability Modeling Section
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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 pumpage specified by the members of Groundwater Management Area 16, along with average recharge rates, evapotranspiration rates, and initial streamflows. The results of this model run indicate very large drawdowns in both the Chicot and Evangeline aquifers within Groundwater Management Area 16 in response to the specified pumpage. 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. Scotty Bledsoe from the Live Oak Underground Water Conservation District (on behalf of Groundwater Management Area 16).

DESCRIPTION OF REQUEST:

Mr. Bledsoe asked us to run a model simulation using the groundwater availability model for the southern part of the Gulf Coast Aquifer. 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 pumpage specified by the members of Groundwater Management Area 16.

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 specified 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 (2007) 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 15.3 feet (Chowdhury and Mace, 2007).

- 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 is shown in Table 1 below. The methodology for the addition of pumpage was identical to that done for GAM Run 07-28 (Donnelly, 2007b). Pumpage was added to the baseline pumpage from GAM Run 07-11 (Donnelly, 2007a) in specific areas in certain counties, areas for additional pumpage in the Chicot Aquifer in Kenedy and Willacy counties are shown in Figure 1, and for additional pumpage in the Evangeline Aquifer in Brooks, Hidalgo, Kenedy, and Willacy counties in Figure 2. In these specified areas, pumpage was only added to the shaded areas shown in the figures, and no additional pumpage was added within each of those counties in the non-shaded areas. In counties that don't have specific areas shown in Figures 1 or 2, pumpage was added to all active cells in the county. Pumpage was uniformly distributed to create the specified pumpage totals.

Table 1. Summary of pumpage used in this model run.

County	Total pumpage (acre-feet/year)	Chicot pumpage (acre-feet/year)	Evangeline pumpage (acre-feet/year)
Brooks	25,669	2,500	23,169
Cameron	89,653	89,126	528
Hidalgo	32,920	18,243	14,677
Jim Hogg	4,880	0	4,880
Kenedy	25,700	2,500	23,200
Starr	7,600	0	7,600
Willacy	24,153	7,519	16,634

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. 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 Burkeville Confining Unit 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 3 and 4, respectively. These figures show the starting water levels for this 60-year predictive model run, and 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 using the specified pumpage for the Chicot and Evangeline aquifers are shown in Figures 5 and 6, respectively. Water level changes over the 60-year predictive simulation for the Chicot and Evangeline aquifers are shown in Figures 7 and 8, respectively. These figures indicate that water level declines throughout most of the model area in the Chicot Aquifer (Figure 7) are largely due to the increase in pumpage. Large portions of the Chicot Aquifer area have gone dry during the model run (shown in black in Figure 7). Water level declines in western Kenedy County are up to 160 feet, and in Hidalgo County declines are up to 25 feet. Water level declines decrease significantly towards the coast due to the presence of constant-head cells in the groundwater model used to represent the Gulf of Mexico and Laguna Madre. This is probably not an accurate representation of drawdowns in this area because the constant-head cells in the groundwater flow model will not allow water levels to change in those cells, and they will impact adjacent cells as well. The presence of these constant-head cells forces the model to simulate a reversal in gradient in the Chicot Aquifer that may or may not accurately reflect what would occur in the aquifer with the pumpage included in the model.

In the Evangeline Aquifer (Figure 8) the water level declines are also very large. A large cone of depression can be observed in Brooks County where an approximately 23,000 acre-feet per year of additional pumpage was placed in a relatively restricted area shown in Figure 2. Water level declines in excess of 550 feet are seen in this area, and all areas in the model show significant decline using the specified pumpage totals. 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 generally less than 50 feet in this model run.

As noted above, the results indicate a large number of cells going dry in the Chicot Aquifer during the model simulation. Dry cells occur when the water level in a cell falls below the bottom of the cell. When this occurs the cell is deactivated. If high pumpage is the primary factor for a cell going dry, the model is saying that the pumping may be too great for the aquifer in this area. In the groundwater availability model for the southern part of the Gulf Coast Aquifer, when the model deactivates a cell, that cell is inactive for the rest of the simulation, and it is important to identify why a cell went dry and address the causes. In reality, the aquifer will probably not go dry because pumping will become uneconomical before the aquifer actually is fully dewatered in any particular area.

However, the model is suggesting that these areas may experience water supply problems sometime in the 60-year simulation period if pumpage is increased to the level supplied by Groundwater Management Area 16.

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.

REFERENCES:

Chowdhury, A. H. and Mace R. E., 2007, Groundwater Resource Evaluation and Availability Model of the Gulf Coast Aquifer in the Lower Rio Grande Valley of Texas, Texas Water Development Board Report 368, 119 p.

Donnelly, A. C. A., 2007a, GAM07-11 Final Report, Texas Water Development Board GAM Run Report, April 19, 2007, 15 pp.

Donnelly, A. C. A., 2007b, GAM07-28 Final Report, Texas Water Development Board GAM Run Report, September 13, 2007, 10 pp.

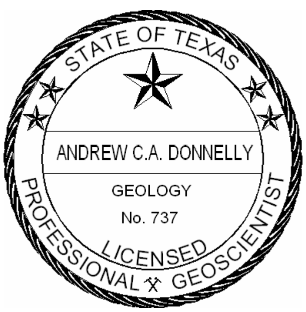

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Table 2. Water budgets for each county at the end of the 60-year predictive model run using the specified pumpage (in acre-feet per year).

	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	2	0	3	0	24	0	--	--	106	0	--	--	15	0	0	0
Rivers	0	0	83,443	5,985	29,601	5,374	--	--	0	0	--	--	5,904	384	0	0
Wells	0	141	0	89,126	2	16,594	--	--	0	2,500	--	--	0	7,519	0	0
Gulf of Mexico (Constant Head)	0	0	12,034	1,302	0	0	--	--	21,771	17	--	--	3,698	1,253	2,698	39
Recharge	67	0	7,514	0	3,189	0	--	--	7,965	0	--	--	4,535	0	0	0
Evapotranspiration	0	0	0	0	0	0	--	--	0	536	--	--	0	101	0	0
Lateral Inflow	554	0	10,467	14,063	2,077	12,924	--	--	8,284	2,366	--	--	14,729	11,532	43	1,807
Vertical Leakage Downward	0	483	1,182	4,167	0	0	--	--	0	32,705	--	--	12	8,105	19	914
Evangeline																
Storage	311	0	7	0	128	0	421	0	77	0	389	4	14	0	1	0
Rivers	0	0	0	0	10,424	0	0	0	0	0	585	18	0	0	0	0
Wells	0	23,169	0	528	0	14,677	0	4,880	0	23,200	0	7,486	0	16,634	0	0
Recharge	2,957	0	0	0	6,023	0	2,436	0	281	0	3,451	0	462	0	115	0
Evapotranspiration	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
Vertical Leakage Upward	483	0	4,167	1,182	7,256	717	0	0	32,705	0	0	0	8,105	12	914	19
Lateral Inflow	17,642	111	1,409	4,038	1,632	11,330	22	804	3,039	14,031	628	726	9,823	2,112	76	1,120
Vertical Leakage Downward	1,889	0	164	0	1,282	20	2,804	0	1,129	0	3,292	107	354	0	34	0

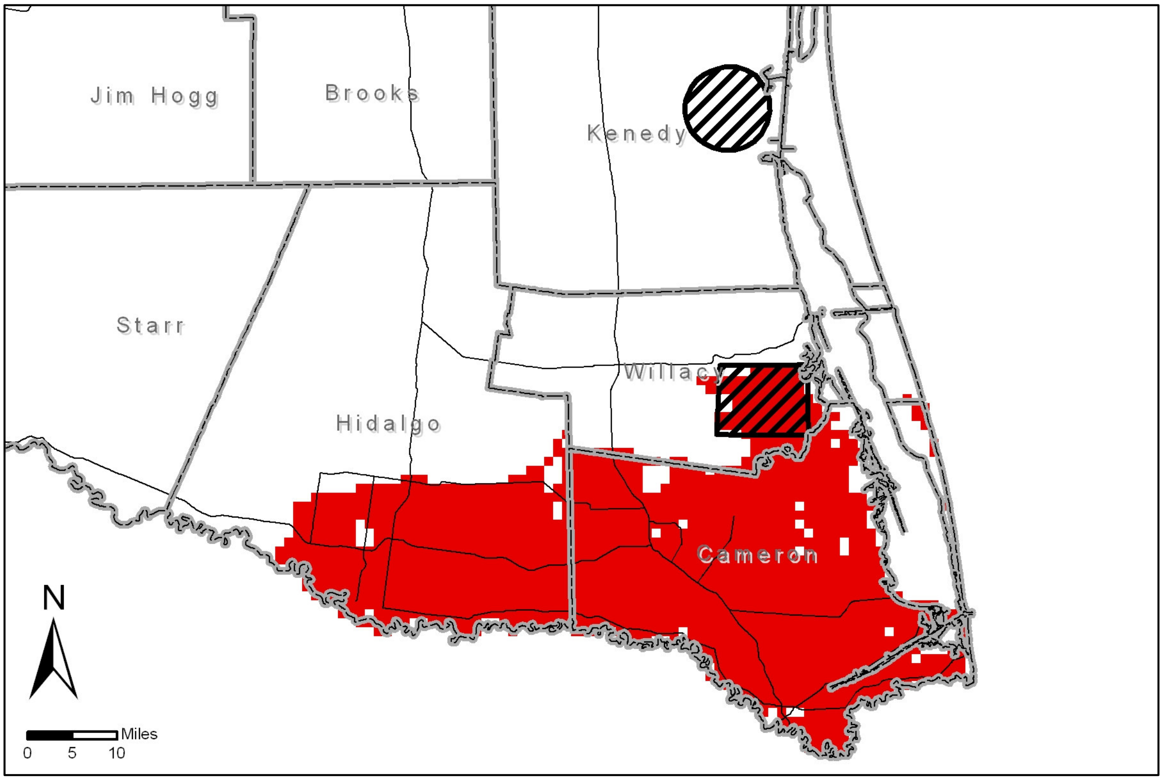

Figure 1. Specific areas in the Chicot Aquifer where additional pumpage was added in Kenedy and Willacy counties. Pumpage present in the baseline pumpage data set is shown in red. Additional pumpage in other counties was added uniformly to all active cells in each county.

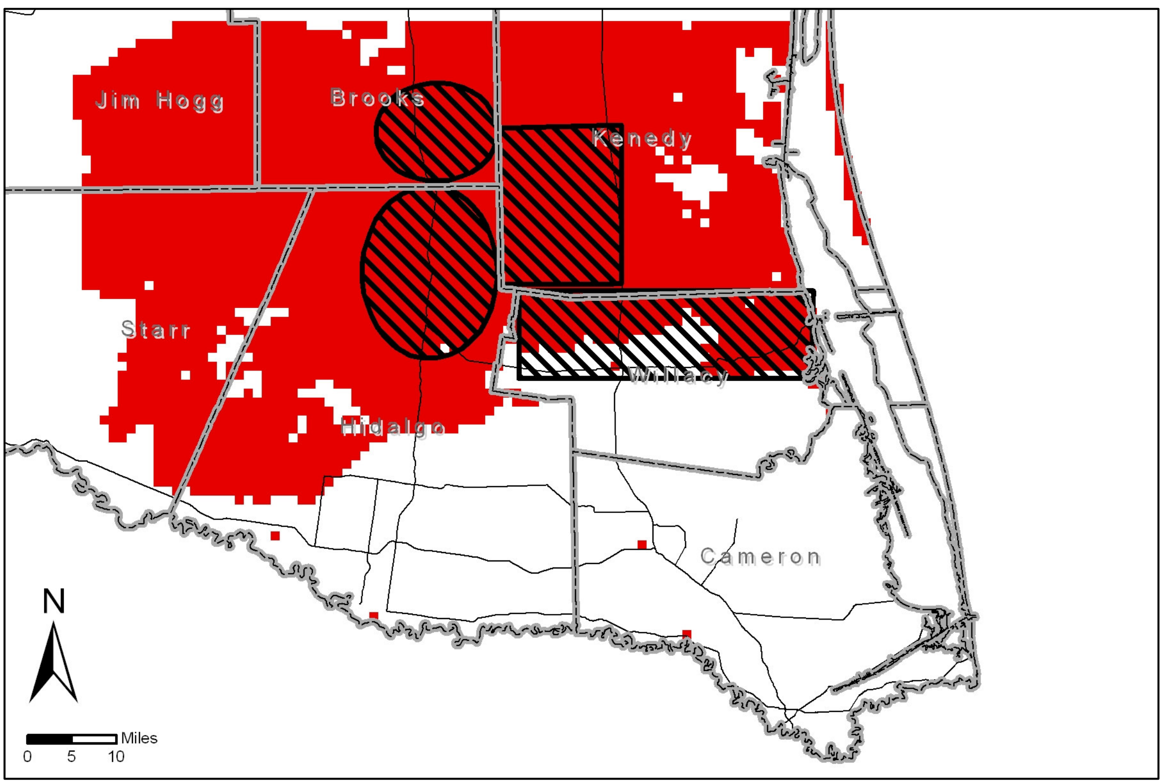

Figure 2. Specific areas in the Evangeline Aquifer where additional pumpage was added in Brooks, Hidalgo, Kenedy, and Willacy counties. Pumpage present in the baseline pumpage data set is shown in red. Additional pumpage in other counties was added uniformly to all active cells in each county.

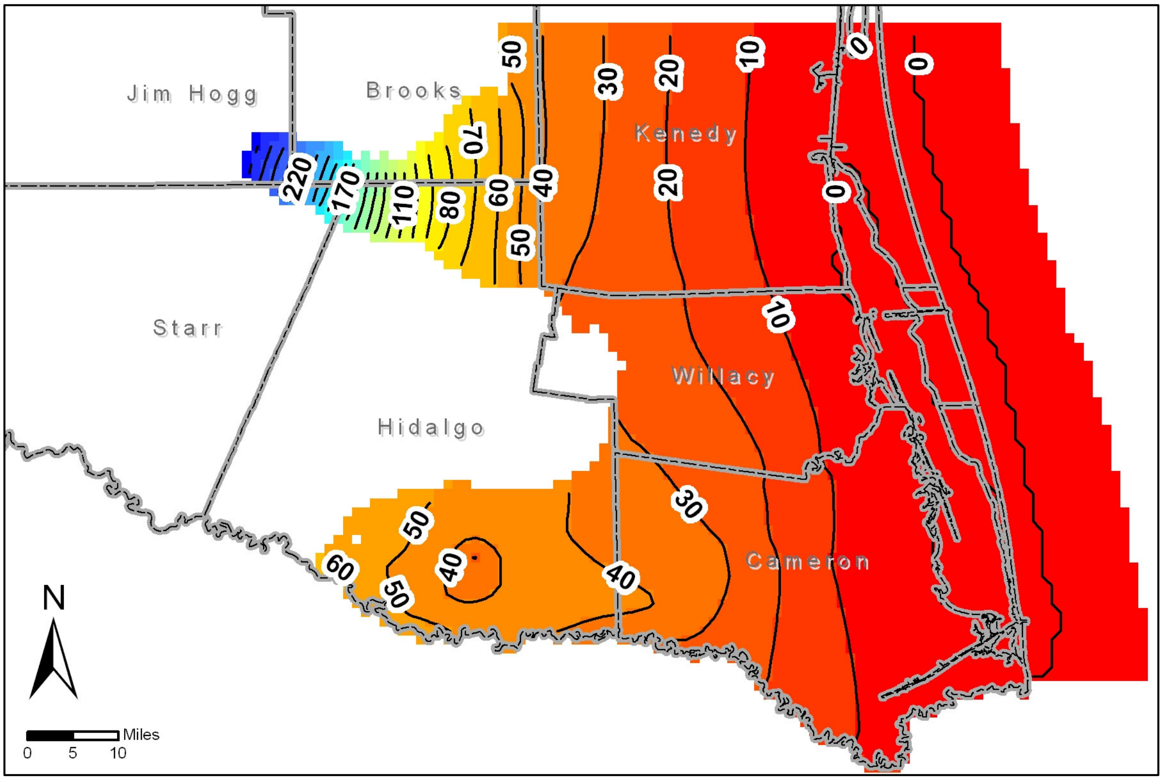

Figure 3. Initial water level elevations for the predictive model run in the Chicot Aquifer from the southern part of the Gulf Coast groundwater availability model. Water level elevations are in feet above mean sea level. Contour interval is 10 feet.

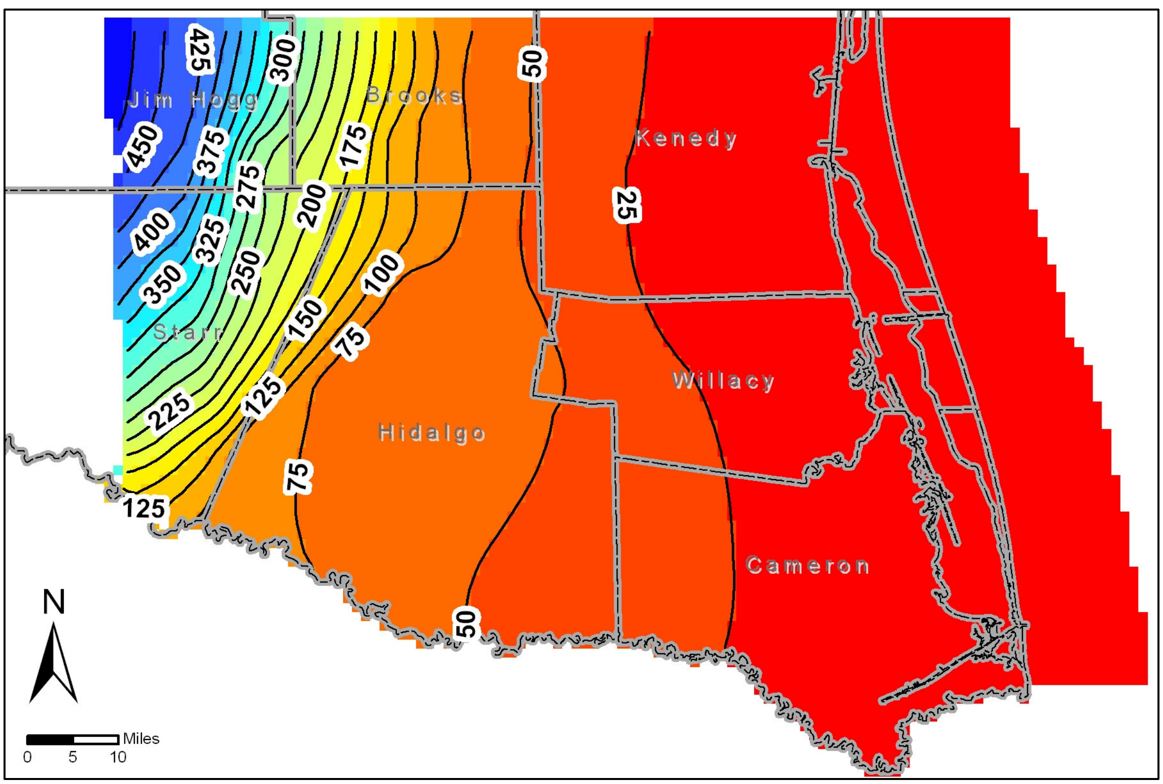

Figure 4. Initial water level elevations for the predictive model run in the Evangeline Aquifer from the southern part of the Gulf Coast groundwater availability model. Water level elevations are in feet above mean sea level. Contour interval is 25 feet.

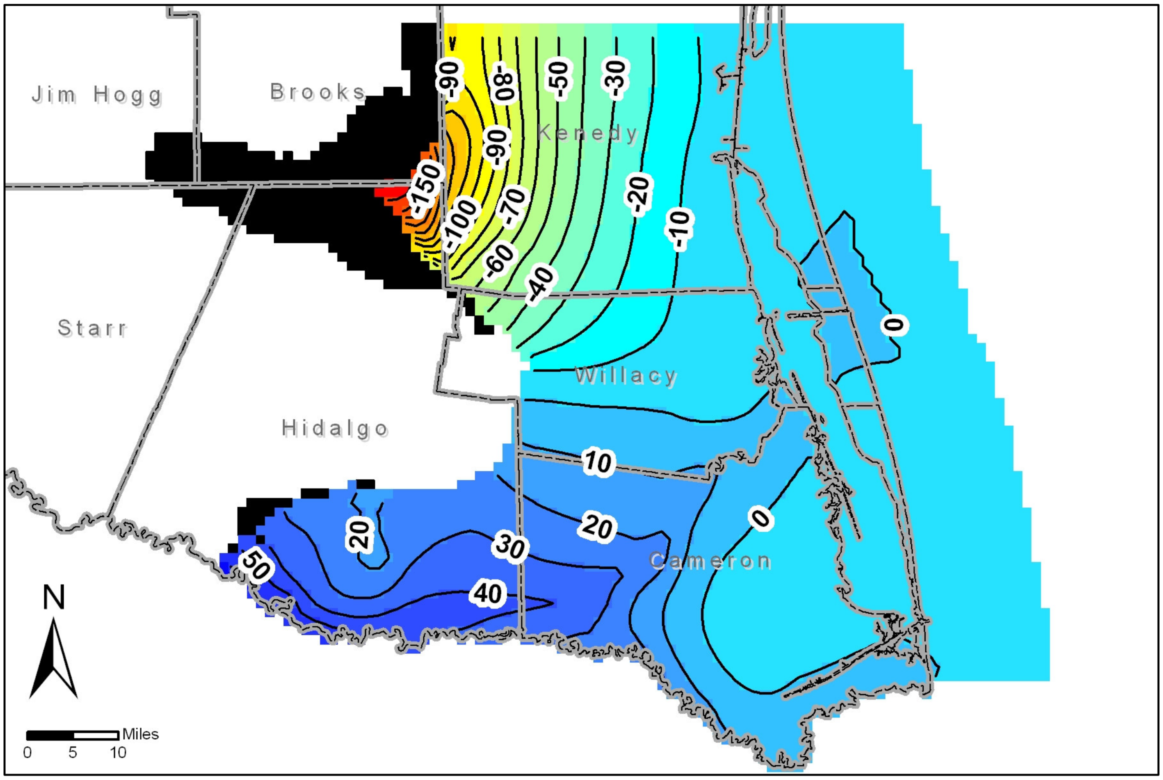

Figure 5. Water level elevations after 60 years using the specified pumpage in the Chicot Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 10 feet. Dry cells are shown in black.

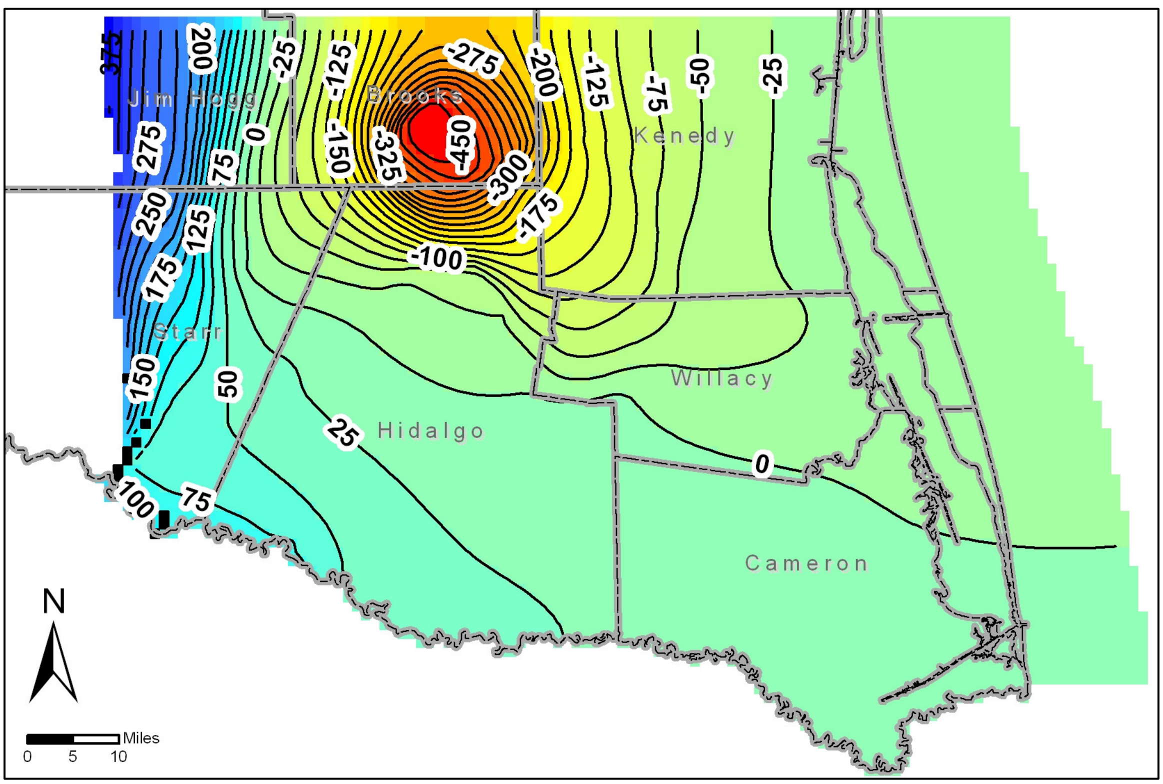

Figure 6. Water level elevations after 60 years using the specified pumpage in the Evangeline Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. Dry cells are shown in black.

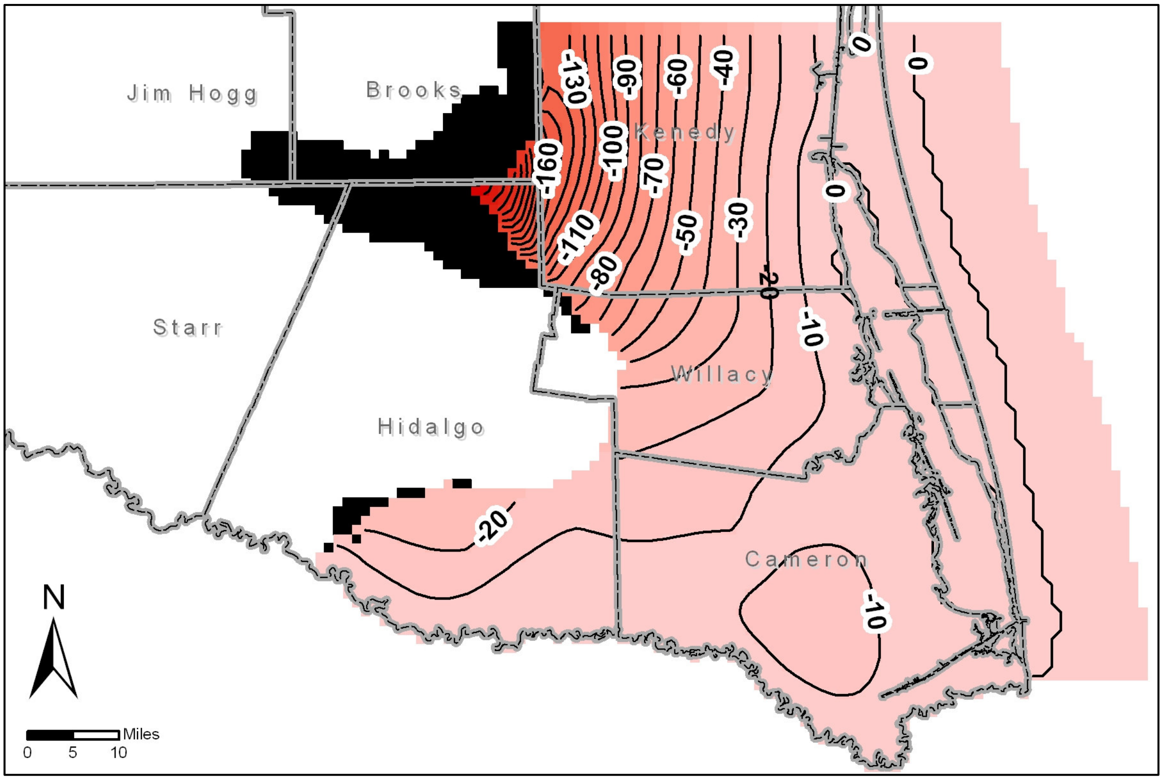

Figure 7. Water level changes (in feet) after 60 years using the specified pumpage in the Chicot Aquifer. Contour interval is 10 feet. Areas of decreasing water levels (drawdown) are shown in red. Dry cells are shown in black.

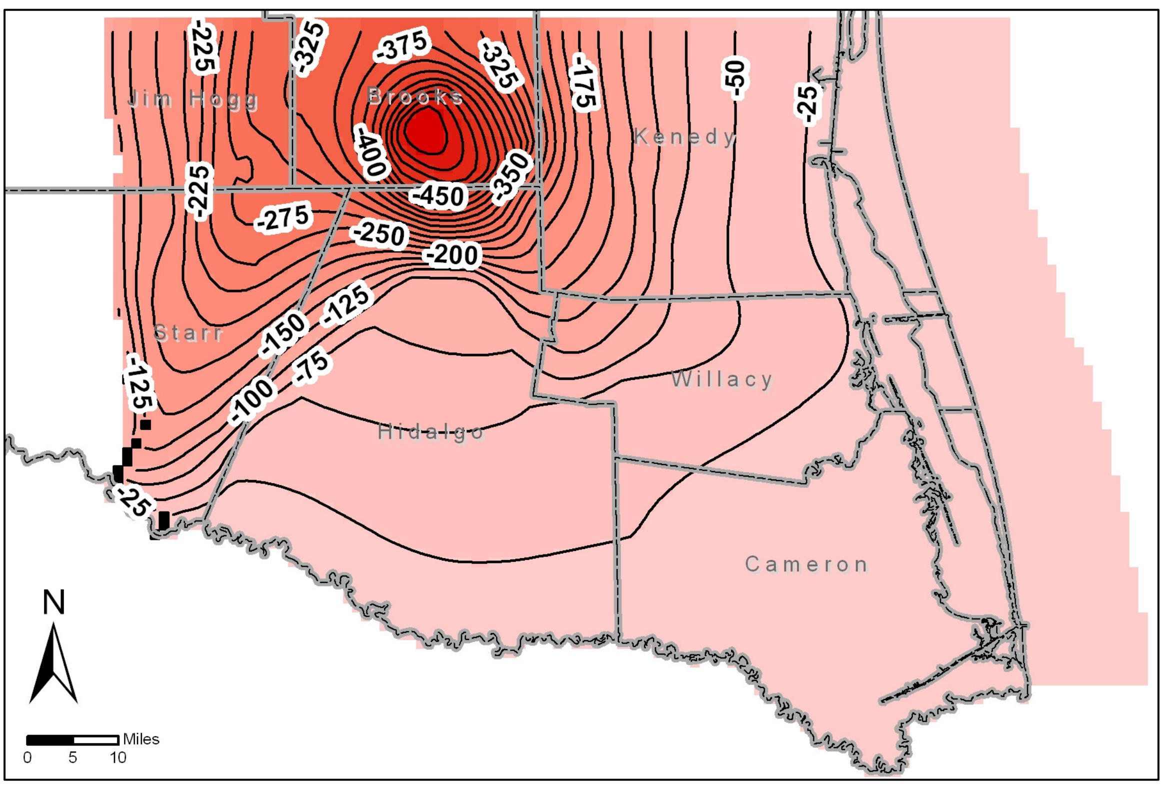

Figure 8. Water level changes (in feet) after 60 years using the specified pumpage in the Evangeline Aquifer. Contour interval is 25 feet. Areas of decreasing water levels (drawdown) are shown in red. Dry cells are shown in black.