# GAM Run 05-29

**by Ali H Chowdhury, Ph.D., P.G.**
Texas Water Development Board
Groundwater Availability Modeling Section
(512) 936-0834

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## REQUESTOR:

Mr. Neil Hudgins on behalf of the Coastal Bend Groundwater Conservation District and the Coastal Plains Groundwater Conservation District.

## DESCRIPTION OF REQUEST:

Mr. Hudgins requested maps of water levels, water-level changes, and water budgets for Matagorda and Wharton counties using the northern part of the Gulf Coast aquifer Groundwater Availability Model (GAM) developed by the U. S. Geological Survey (Kasmarek and Robinson, 2004, Kasmarek and others, 2005). This run is similar to earlier GAM runs 05-03 and 05-23 (Jones, 2005a, 2005b). GAM runs 05-03 and 05-23 used the central part of the Gulf Coast aquifer GAM developed by the Texas Water Development Board (Chowdhury and others, 2004). The requested water-level maps are for Matagorda and Wharton counties for 1988, 1992, and average water levels for 2005 through 2012, which corresponds to water levels during dry, wet, and predicted conditions. Additionally, Mr. Hudgins requested calculation of total freshwater in storage in the Gulf Coast aquifer in these respective counties.

## METHODS:

Both Matagorda and Wharton counties fall within the overlap areas of the northern and the central parts of the Gulf Coast aquifer GAMs. Simulation results for the overlap areas for the northern and the central part of the Gulf Coast aquifer GAMs were reported by Chowdhury and others (2004) and Kasmarek and Robinson (2004).

We used the historic and predictive models for the northern part of the Gulf Coast aquifer GAM (Kasmarek and Robinson, 2004, Kasmarek and others, 2005) to determine simulated water levels for Matagorda and Wharton counties. The historic portion of the model simulates groundwater flow through the northern part of the Gulf Coast aquifer during the period 1891 through 2000. The predictive portion of the model simulates water levels during the period 2001 through 2050 based on projected pumping.

We extracted water levels from the northern part of the Gulf Coast aquifer GAM for zones representing Matagorda and Wharton counties for 1988, 1992, and the predictive period (2005 through 2012). The water levels reported for 1988 are the average water levels for that year. Similarly, the water levels for the predictive period are the average for the years 2005 through 2012. We calculated water-level changes for the respective counties relative to 1980 water levels.

We assumed that the total freshwater in storage for the unconfined Chicot aquifer is the product of the saturated thickness and specific yield where the saturated thickness is the difference between the water-level elevation and the elevation of the aquifer base. For the confined Evangeline aquifer, we assumed storage to be the product of the total aquifer thickness and specific yield. Specific yields used to calculate storage volumes are 0.05 for the Chicot aquifer and 0.1 for the Evangeline aquifer.

## PARAMETERS AND ASSUMPTIONS:

For detailed discussion on assumptions and limitations of the northern part of the Gulf Coast aquifer GAM, refer to Kasmarek and Robinson (2004) and Kasmarek and others (2005).

Given differences in model construction between the northern part of the Gulf Coast aquifer GAM and the central part of the Gulf Coast aquifer GAM, it is likely that simulation results for the overlap areas will differ. Therefore, which model to use rests entirely on the user to decide which model better addresses their concern or question. If the concern is land subsidence, then the northern part of the Gulf Coast aquifer GAM is the better choice. Similarly, if the concern is surface water-groundwater interaction, then the central part of the Gulf Coast aquifer GAM is more applicable.

The northern part of the Gulf Coast aquifer GAM uses MODFLOW’s General Head Boundary package to simulate recharge and Interbed Storage package to simulate land surface subsidence. The central part of the Gulf Coast aquifer GAM uses MODFLOW’s Recharge package to simulate recharge. The central part of the Gulf Coast aquifer GAM uses recharge datasets developed using precipitation and zones that roughly correlate to geology and soil characteristics of the outcrop (Waterstone, 2003). The Interbed Storage package was not used in the central part of the Gulf Coast aquifer GAM to simulate land surface subsidence. The central part of the Gulf Coast aquifer GAM uses MODFLOW’s Streamflow package that was not used in the northern part of the Gulf Coast aquifer GAM. In the northern part of the Gulf Coast aquifer GAM, streamflow interaction was built into the General Head Boundary package. Model grids for the Evangeline aquifer in the central part of the Gulf Coast aquifer GAM includes the northern half of Matagorda County while the grid in the northern part of the Gulf Coast aquifer GAM includes the all of Matagorda County. In addition, pumping values between the models may differ depending on how each allocated pumpage by model layer. Model grids for the Burkeville Confining System and the Jasper aquifer in the northern part of the Gulf Coast aquifer GAM includes only to a small portion of northwestern Matagorda and Wharton counties. Therefore, we have not reported simulated water levels, water-level changes or water budget results for the Burkeville Confining System and the Jasper aquifer in this GAM run report.

Quality of model calibration can be estimated using root mean square (RMS) error. RMS error evaluates differences between measured and simulated water levels in the wells considered for calibration. The RMS error is 31 feet for the Chicot aquifer, 45 feet for the Evangeline aquifer, and 38 feet for the Jasper aquifer for the calibration year 2000.

## RESULTS:

Simulated water-level elevation maps for the Chicot and the Evangeline aquifers indicate that regional groundwater flow is directed east towards the Gulf of Mexico (Figures 1, 3, 5, 7, 9, and 11). A small cone of depression is observed in the Chicot aquifer in southwestern Wharton and western Matagorda counties for 1988 (Figure 1). This cone of depression is caused by groundwater pumping in the area that disappears as the water levels rise in the Chicot aquifer in 1992 (Figure 3). The cone of depression in western Matagorda County reappear during 2005 to 2012. No cone of depression is observed in the simulated water levels in the Evangeline aquifer during 1988, 1992, or 2005 through 2012 (Figures 7, 9, and 11).

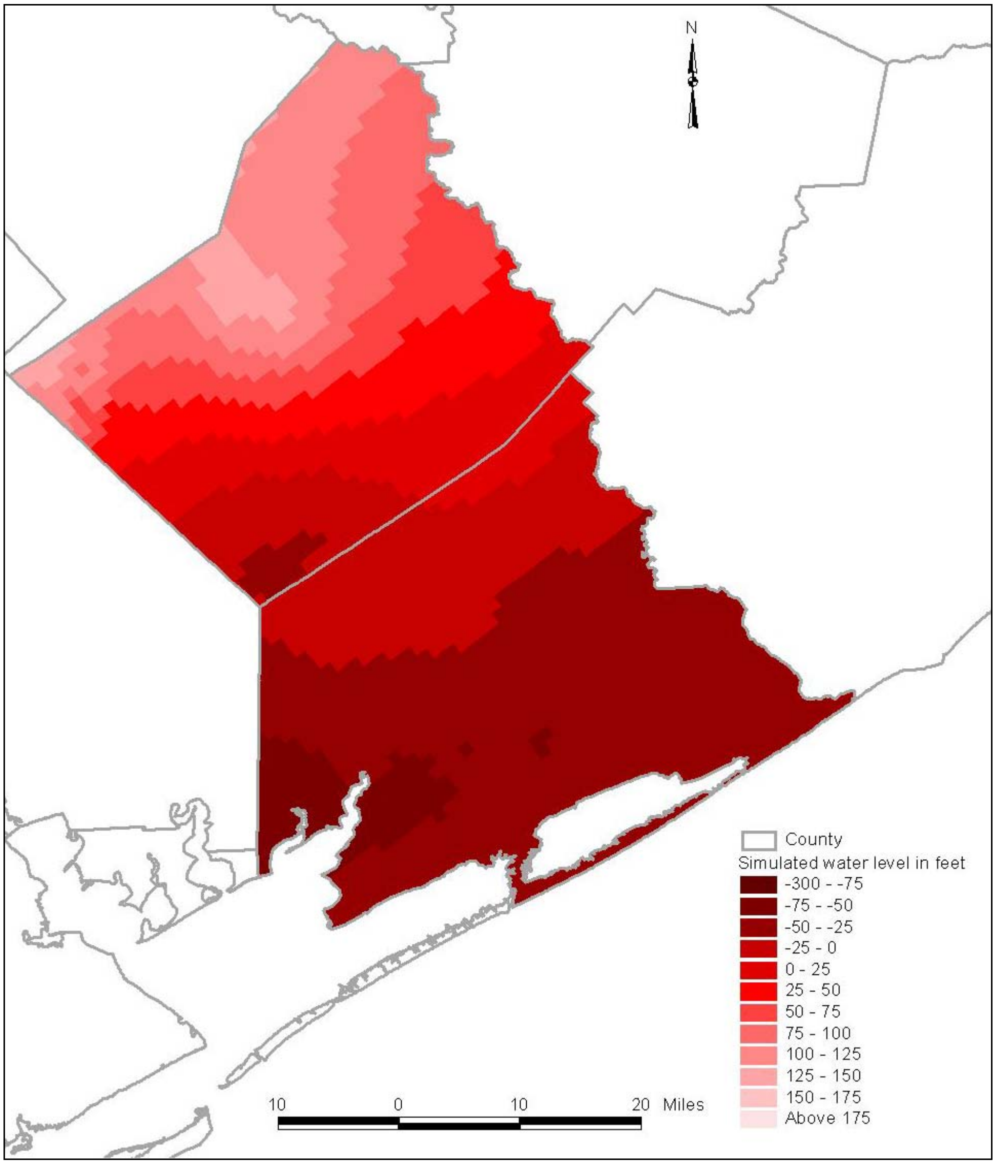


Figure 1. Average simulated water-level elevations map in 1988 for the Chicot aquifer.

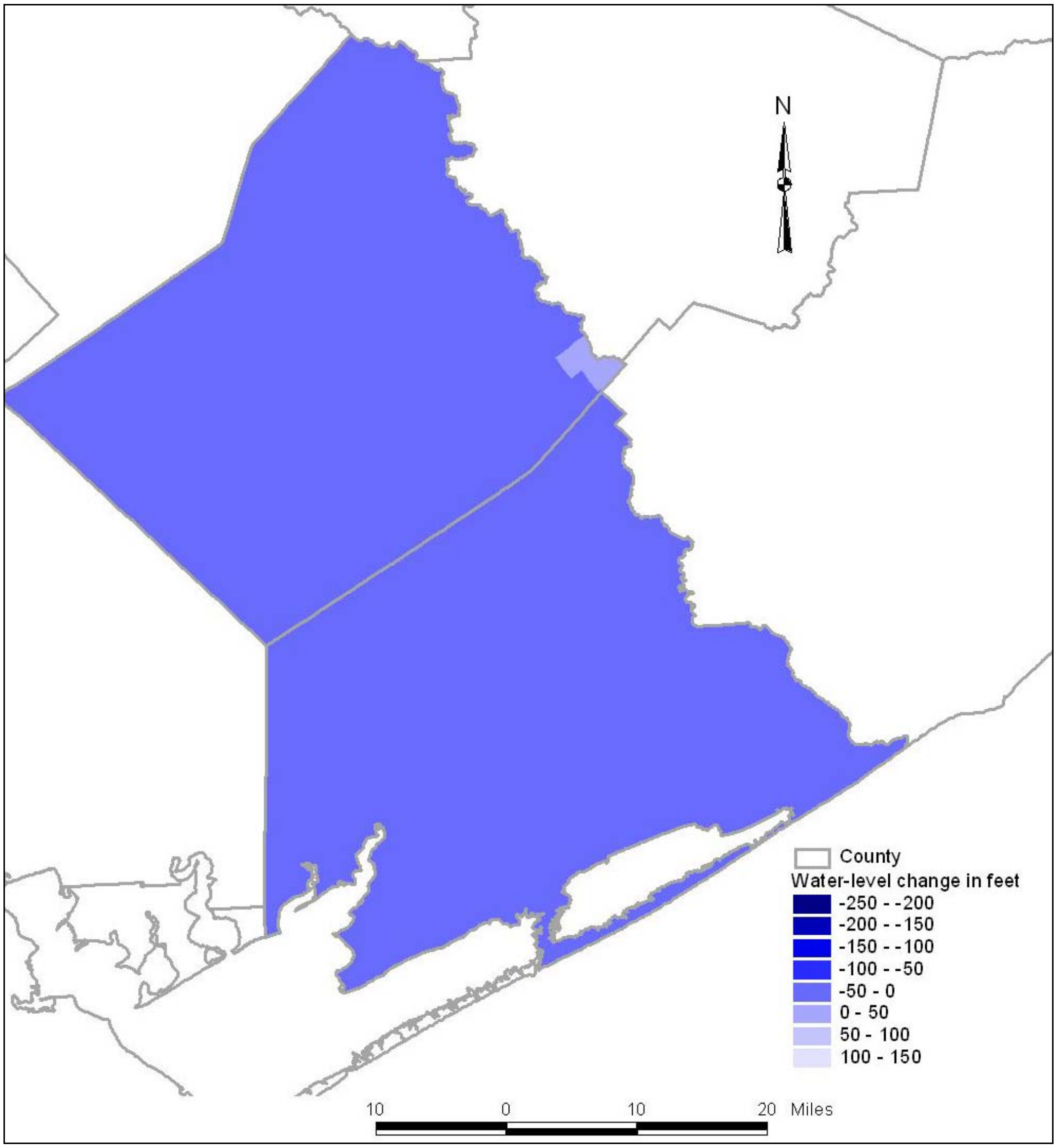


Figure 2. Average water-level changes map for 1988 compared to water levels for 1980 in the Chicot aquifer. Positive values indicate water-levels rise and negative values water-level decline.

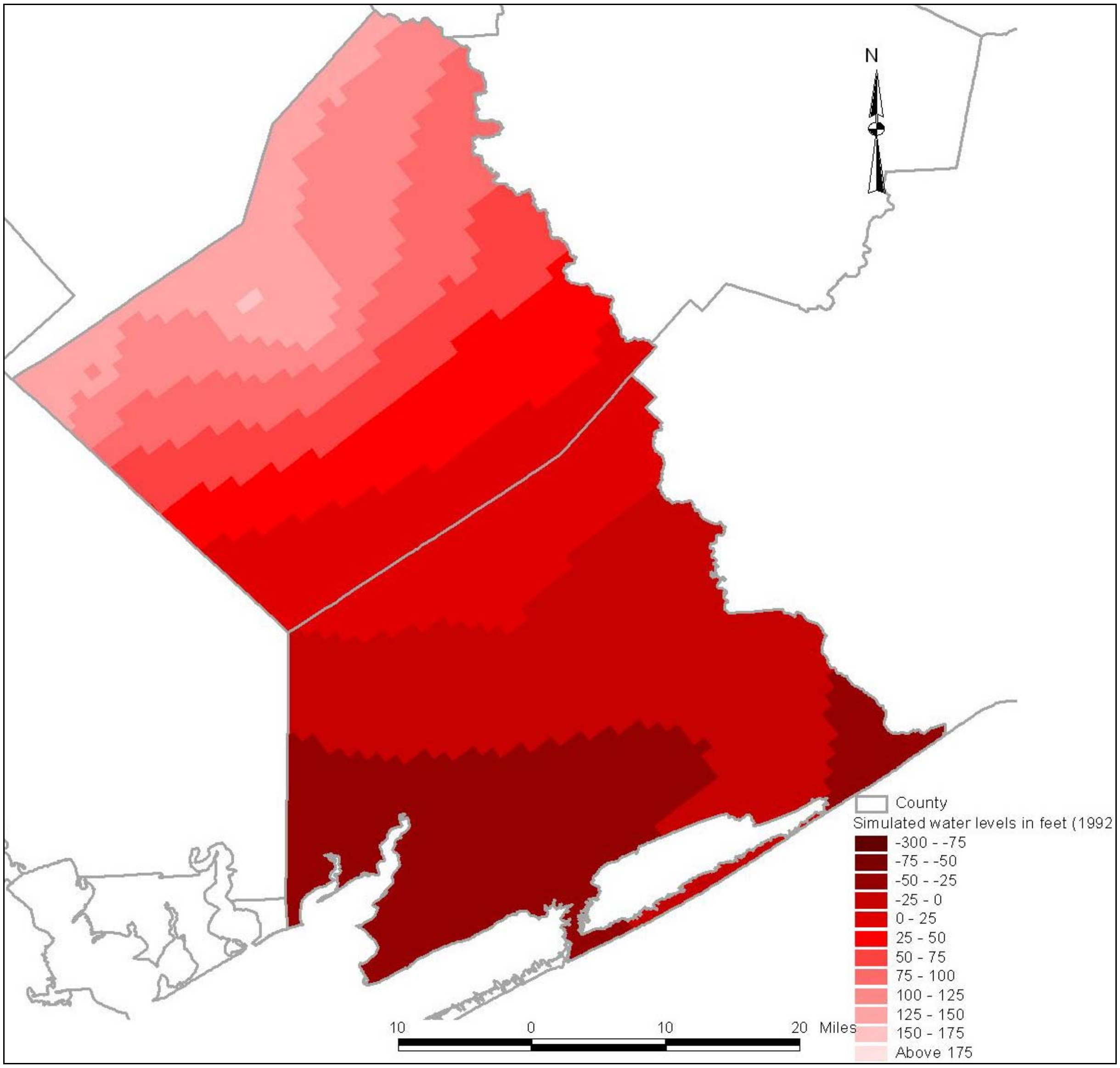


Figure 3. Average simulated water-level elevations map for the Chicot aquifer in 1992.

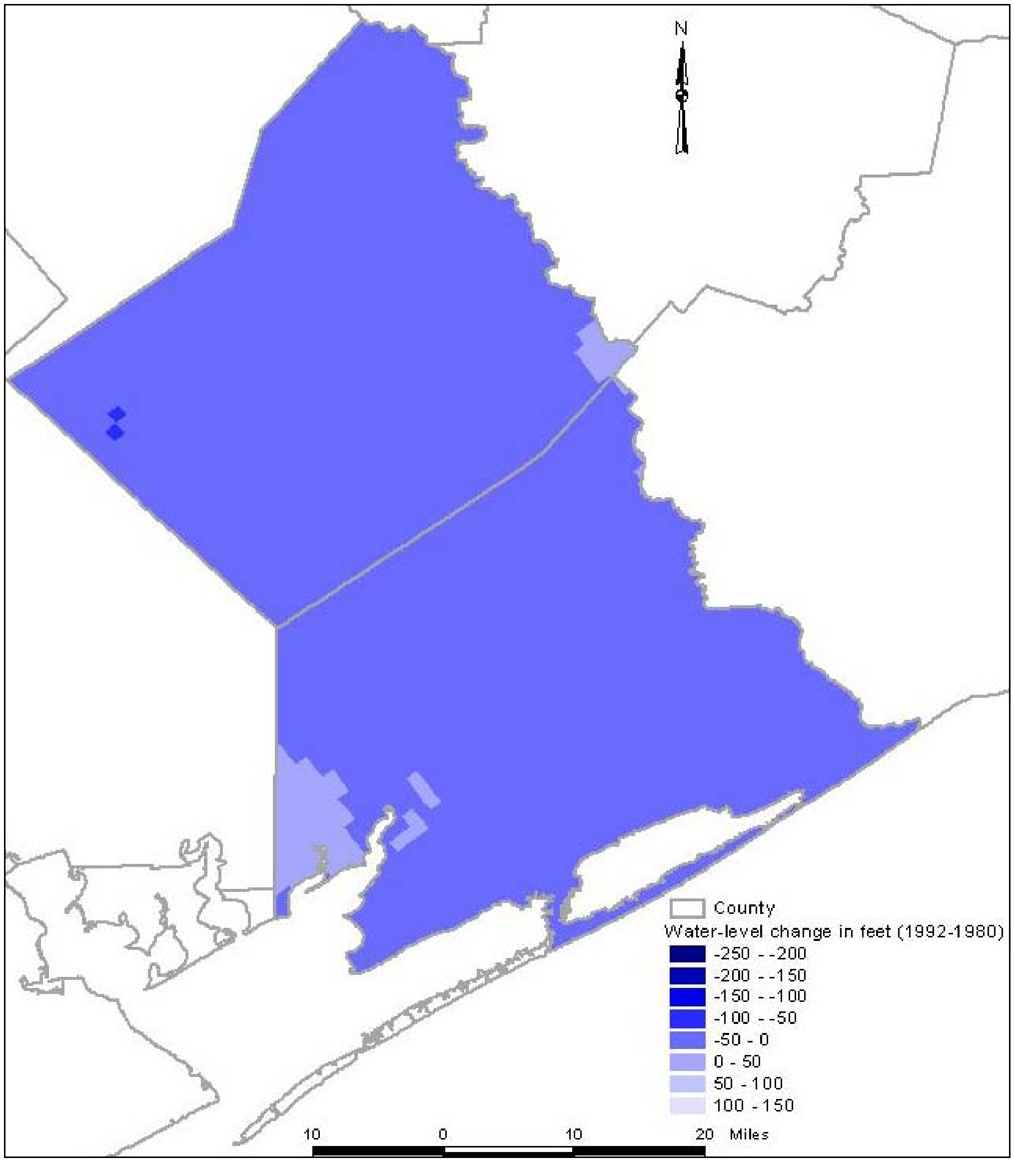


Figure 4. Average water-level changes map for 1992 compared to water levels for 1980 in the Chicot aquifer. Positive values indicate water-levels rise and negative values water-levels decline.

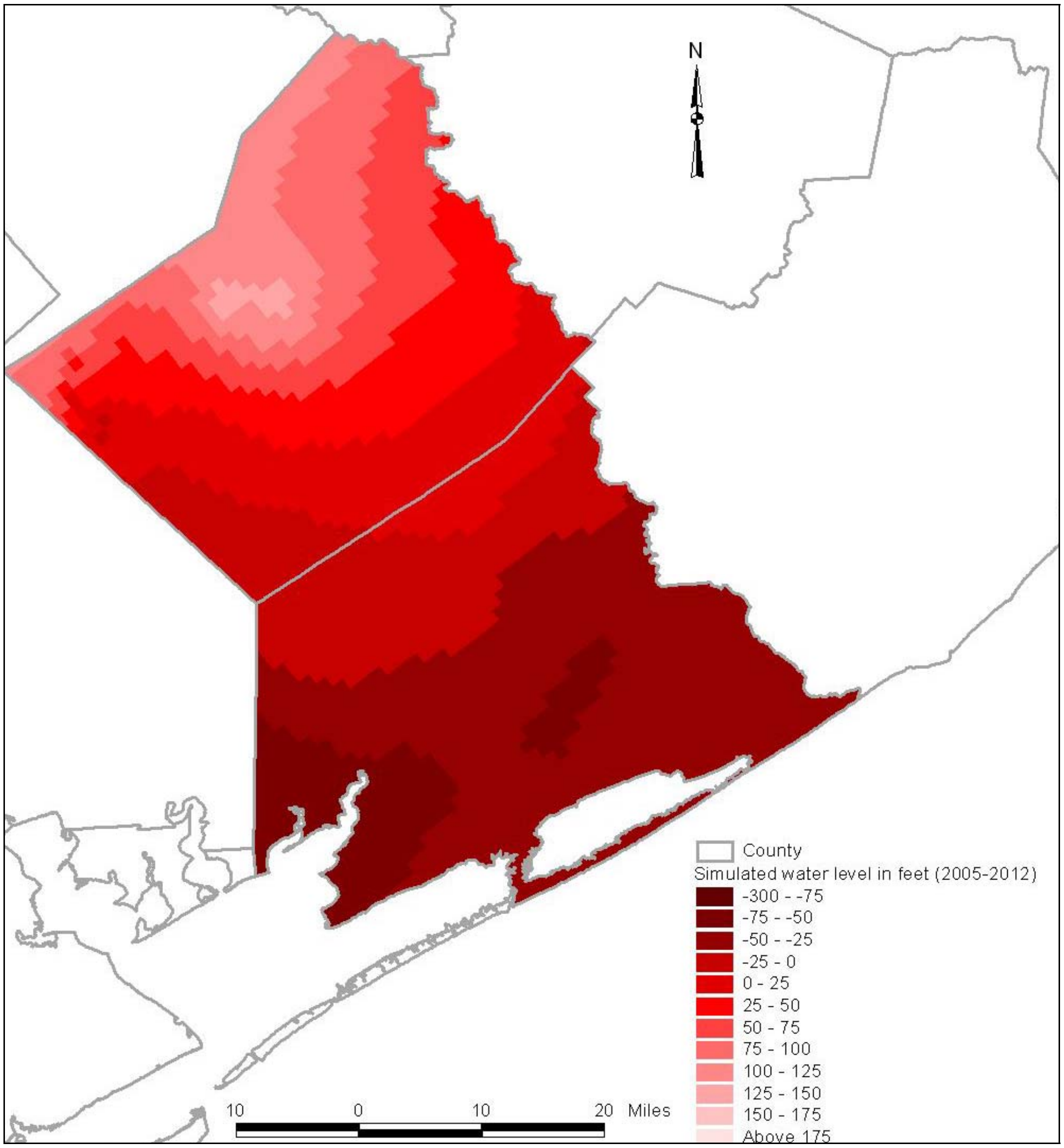


Figure 5. Average simulated water-level elevations map for 2005 through 2012 in the Chicot aquifer.

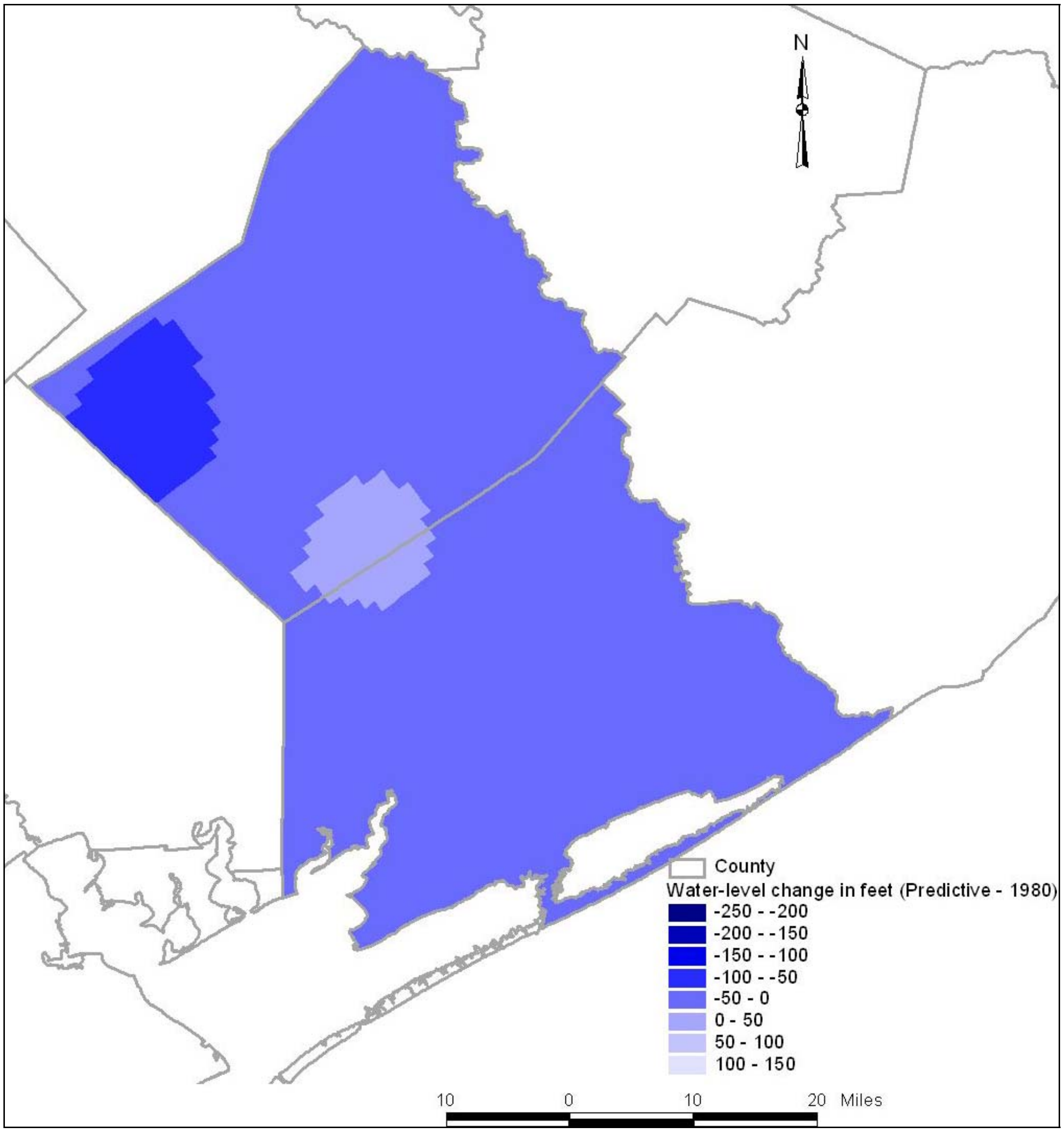


Figure 6. Average water-level changes map for 2005 through 2012 (predictive) compared to water levels for 1980 in the Chicot aquifer. Positive values indicate water-levels rise and negative values water-levels decline.

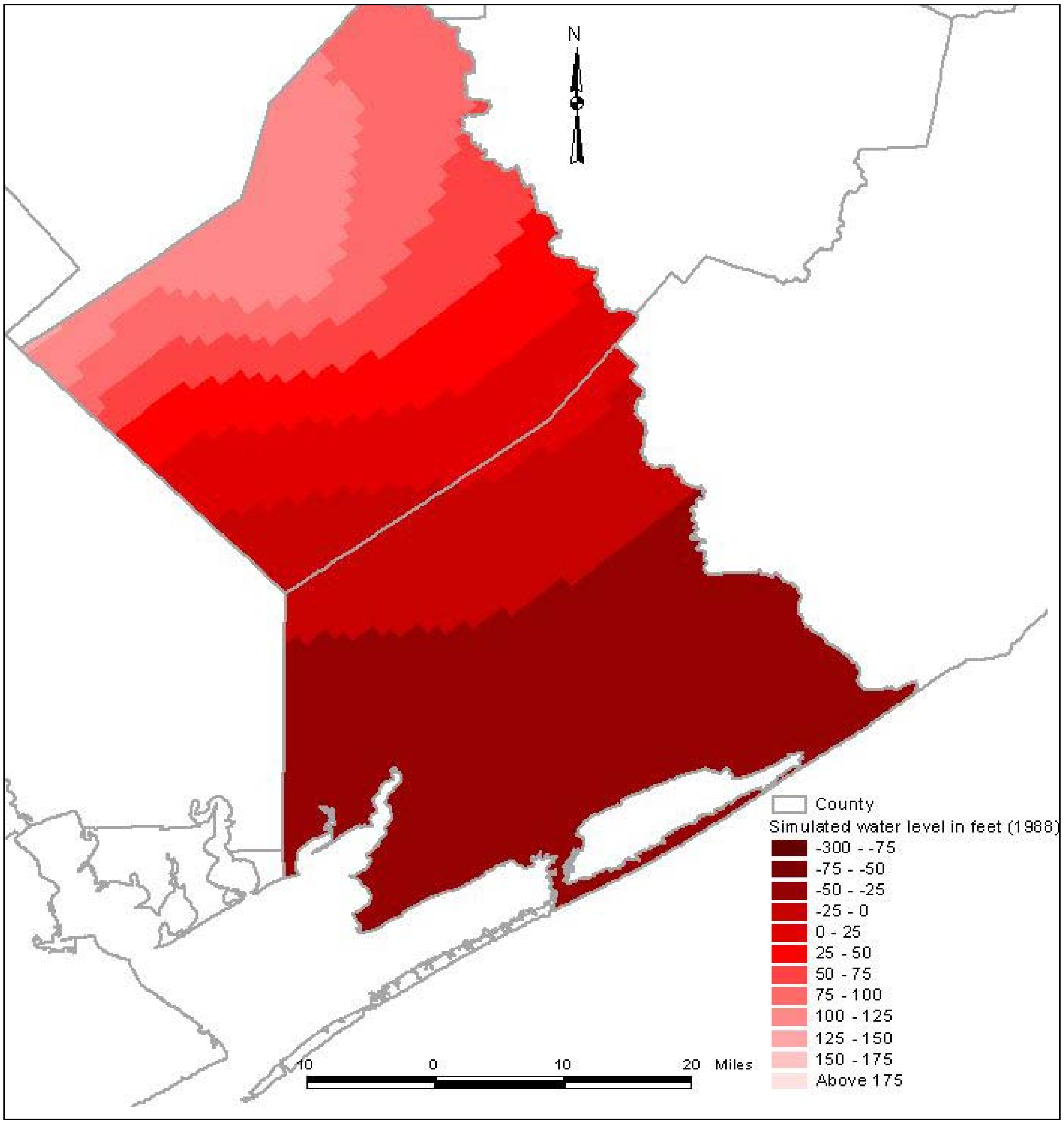


Figure 7. Average simulated water-level elevations map for 1988 in the Evangeline aquifer.

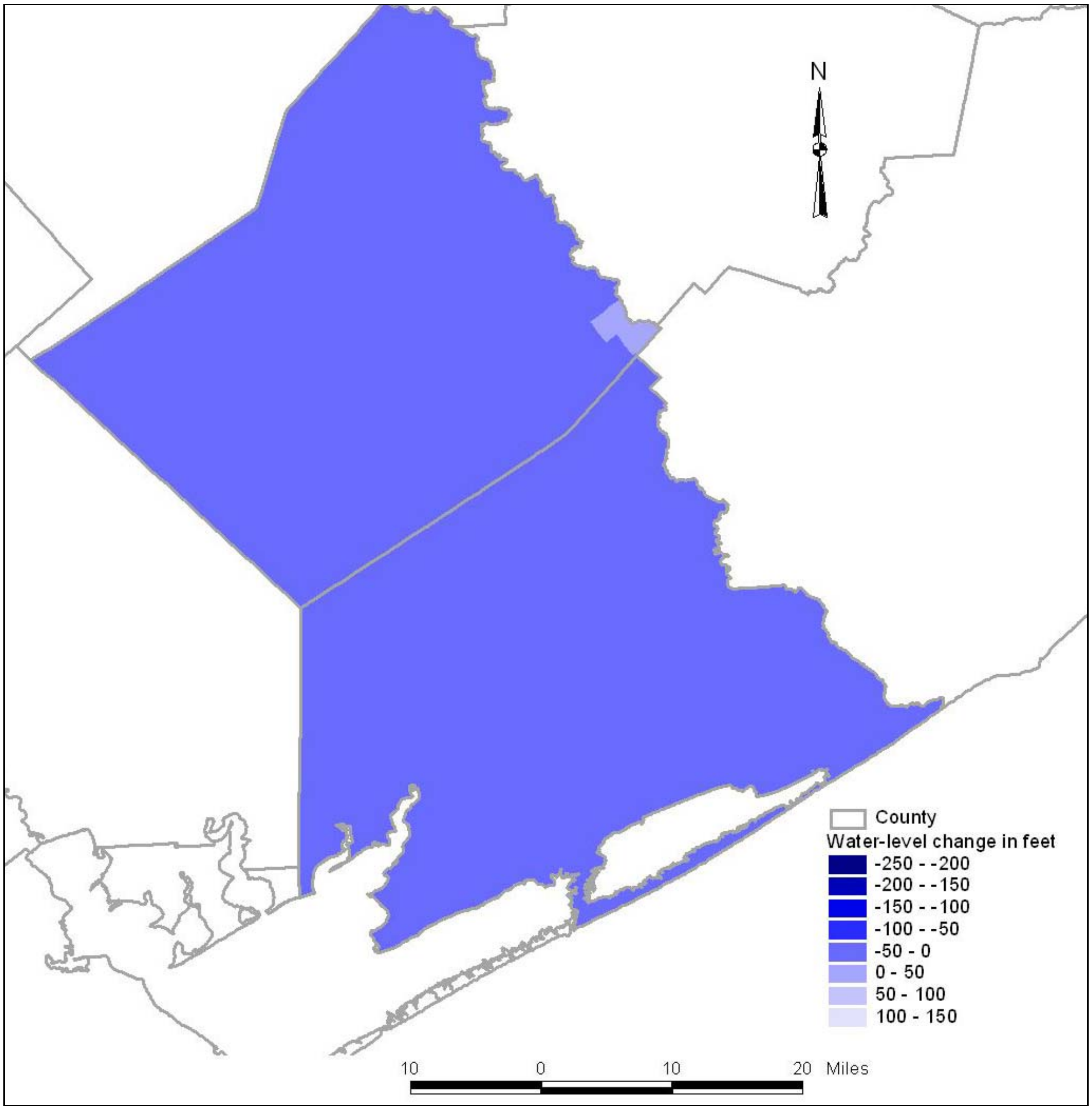


Figure 8. Average water-level changes map for 1988 compared to water levels for 1980 in the Evangeline aquifer. Positive values indicate water-levels rise and negative values water-levels decline.

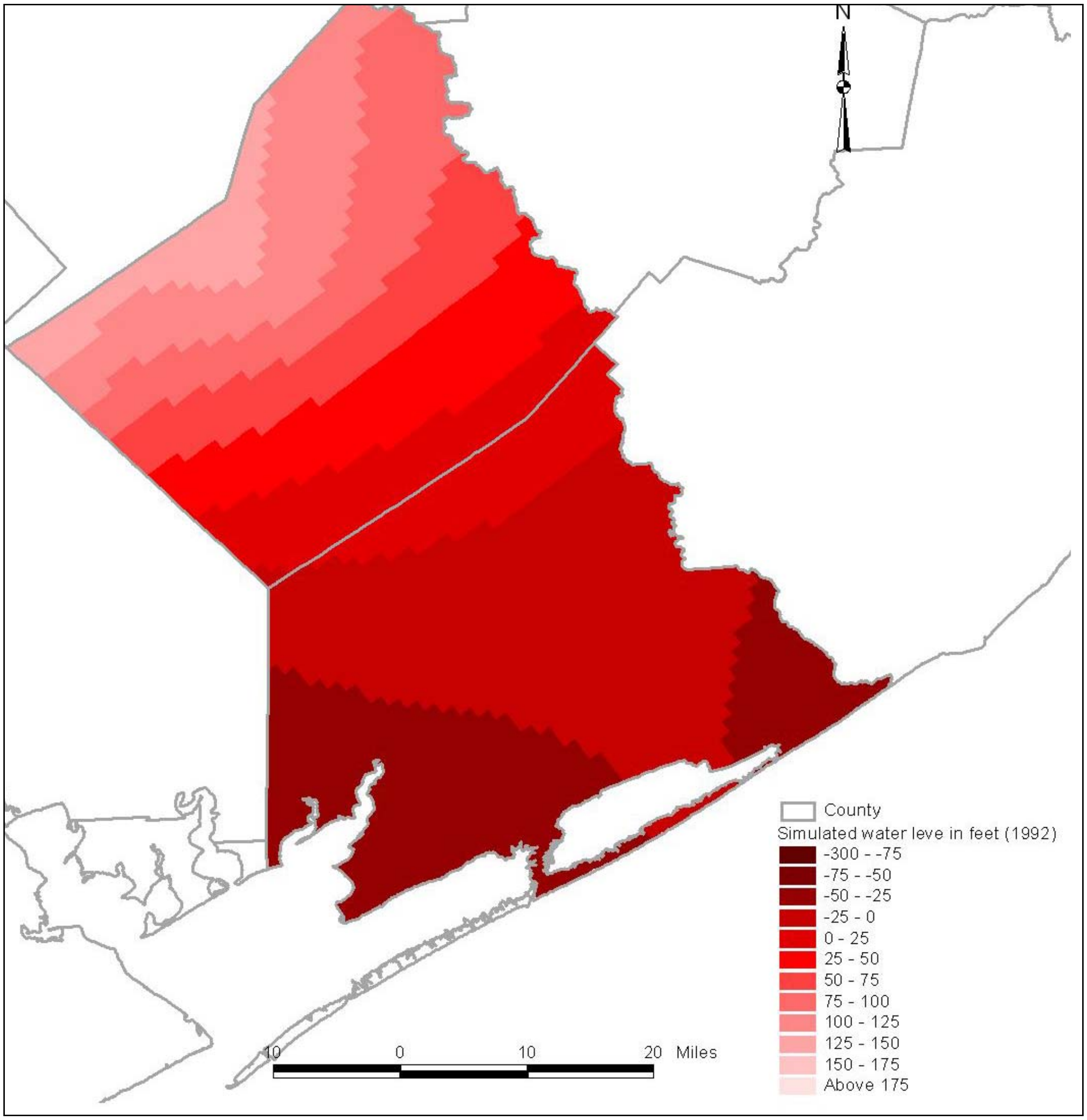


Figure 9. Average simulated water-level elevations map for 1992 in the Evangeline aquifer.

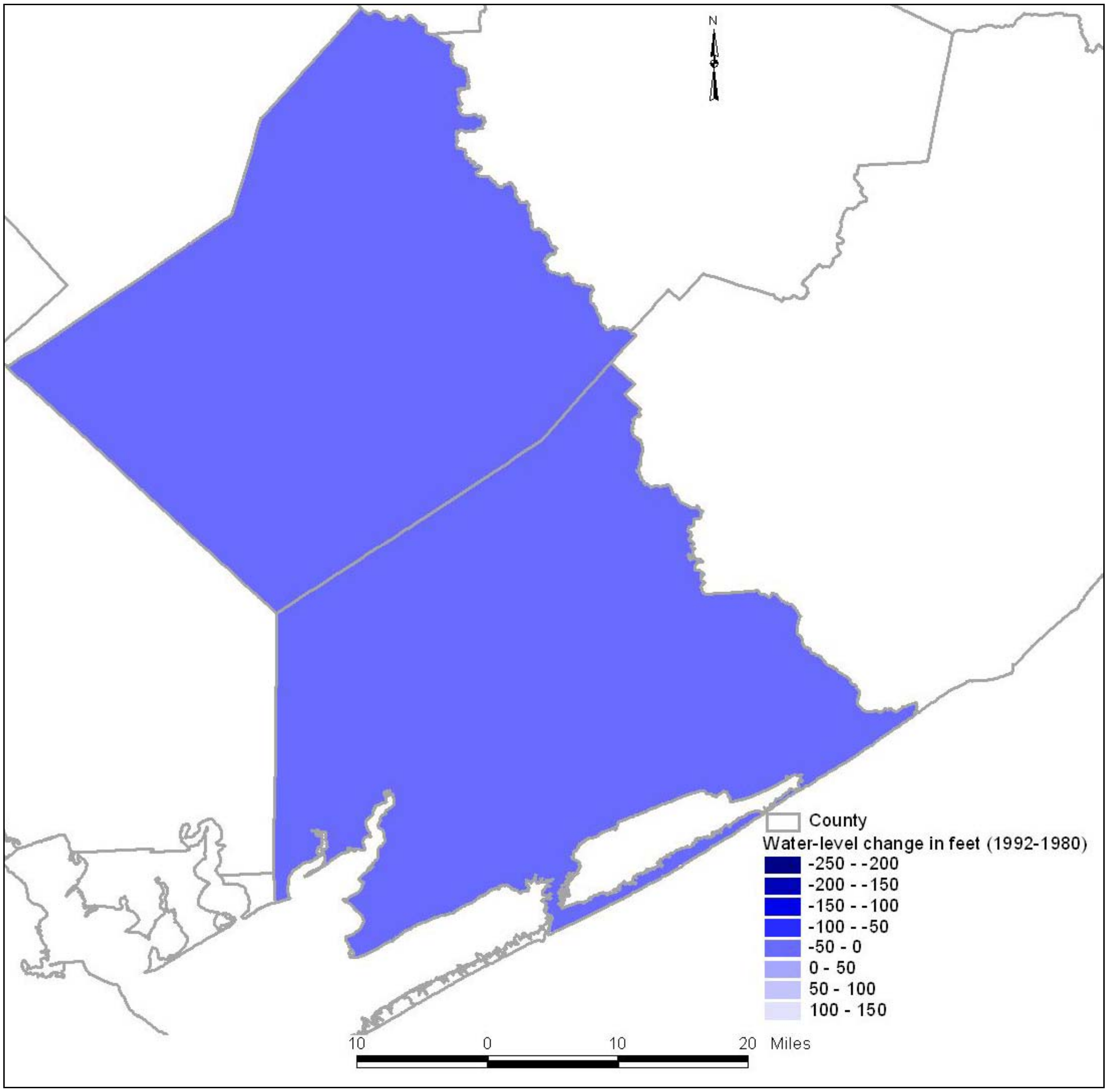


Figure 10. Average water-level changes map for 1992 compared to water levels for 1980 in the Evangeline aquifer. Positive values indicate water-levels rise and negative values water-levels decline.

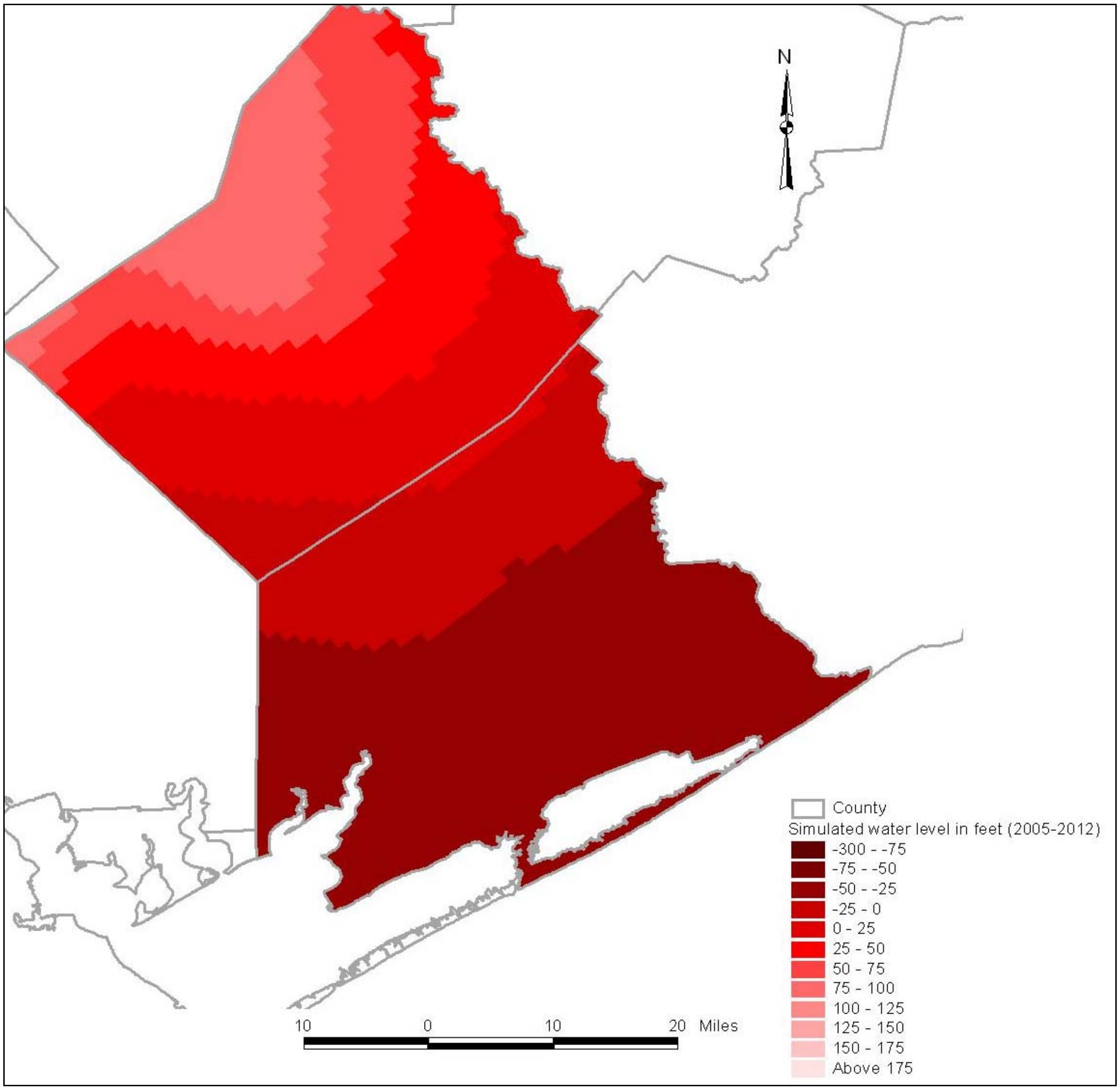


Figure 11. Average simulated water-level elevations map for 2005 through 2012 in the Evangeline aquifer.

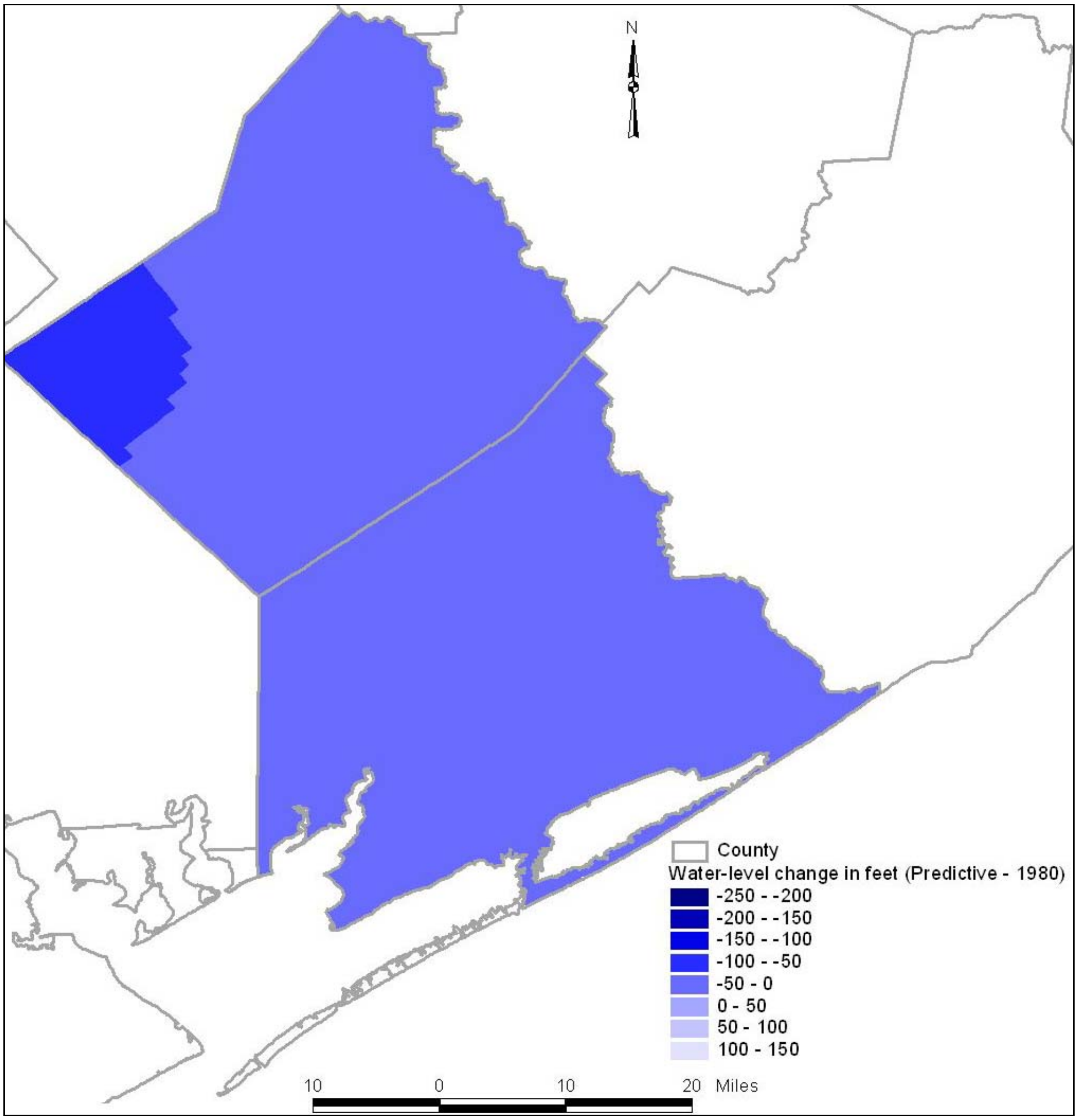


Figure 12 . Average water-level changes map for 2005 through 2012 compared to water levels for 1980 in the Evangeline aquifer. Positive values indicate water-levels rise and negative values water-levels decline.

Maps of water-level changes for the Chicot and the Evangeline aquifers for 1988, 1992 and 2005 to 2012 are presented in Figures 2, 4, 6, 8, 10, and 12. Average water-level changes for Wharton and Matagorda counties are reported in Table 1. This table reports the minimum and maximum water-level changes in 1988, 1992, and 2005 to 2012 compared to simulated water levels in 1980. Water levels in the Chicot and the Evangeline aquifers in Wharton County show more decline compared to Matagorda County (Table 1). This decline is caused by a substantially higher pumpage in Wharton County compared to the adjacent areas.

*Table 1. Water-level changes for 1988, 1992, and the predictive (average 2005 to 2012) period compared to water levels in 1980 in Wharton and Matagorda counties.*

| County | Aquifer | Water-level Change (feet) | | |
|---|---|---|---|---|
| | | 1988-1980 | 1992-1980 | Predictive-1980 |
| Wharton | Chicot | -40 to +6 | -52 to +7 | -88 to +6 |
| | Evangeline | -12 to -3 | -15 to -4 | -29 to -67 |
| Matagorda | Chicot | -22 to -1.3 | -30 to +6.5 | -22 to +3.45 |
| | Evangeline | -14 to -4 | -13 to -1 | -14 to -3 |

## Water Budget

The water budget describes the amount of water that flows through different components of a groundwater flow system. It identifies the amount of water that is derived from recharge, storage, compaction of interbedded clays within the aquifer materials, exchange with different aquifers and confining units, discharge to and from springs and rivers, and withdrawn from the aquifer by pumping. As indicated earlier, in the northern parts of the Gulf Coast GAM, recharge was simulated using MODFLOW's General-Head-Boundary package. The General-Head-Boundary identifies the amount of recharge and groundwater-surface water interaction. All units reported in the water budget are in acre-feet per year.

The water budget tables (Table 2 to Table 13) indicate that a substantial amount of water recharges the aquifer system in Wharton County while recharge is minimal in Matagorda County. The reduction in recharge in Matagorda County is caused by the presence of clayey materials in the Chicot aquifer near the coast that retards infiltration into the aquifer. Groundwater pumping in Wharton County is nearly six times more than in Matagorda County during 1988. Most of the groundwater is pumped from the Chicot aquifer. As pumping decreases and water-levels rise in the aquifers from 1988 to the predictive period, changes in storage in the aquifer decline. Total freshwater storage in the Chicot and the Evangeline aquifers are presented in Table 14.

## Wharton County

*Table 2. Water Budget for 1988, Chicot aquifer.*

| Flow term | In | Out | In-Out |
|---|---|---|---|
| Storage Change | 140,204 | 65,490 | 74,714 |
| Horizontal Exchange | 30,431 | 21,790 | 8,641 |
| Exchange (Evangeline) | 7,881 | 15,627 | -7,746 |
| Wells | 0 | 244,897 | -244,897 |
| Recharge/Groundwater-surfacewater interaction | 147,663 | 63 | 147,600 |
| Interbed Storage | 23,037 | 1,352 | 21,685 |
| Sum | 349,215 | 349,219 | -4 |

## Wharton County (continued)

*Table 3. Water Budget for 1988, Evangeline aquifer*

| Flow term | In | Out | In-Out |
|---|---|---|---|
| Storage Change | 2,039 | 1,691 | 348 |
| Horizontal Exchange | 4,010 | 10,219 | -6,209 |
| Exchange (Chicot) | 15,626 | 7,881 | 7,745 |
| Exchange (Burkeville) | 619 | 414 | 205 |
| Wells | 0 | 4,033 | -4,033 |
| Recharge/Groundwater-surfacewater interaction | 0 | 0 | 0 |
| Interbed Storage | 2,584 | 641 | 1,943 |
| Sum | 24,878 | 24,879 | -1 |

## Matagorda County

*Table 4. Water Budget for 1988, Chicot aquifer.*

| Flow term | In | Out | In-Out |
|---|---|---|---|
| Storage Change | 4,216 | 7,805 | -3,588 |
| Horizontal Exchange | 15,397 | 16,996 | -1,599 |
| Exchange (Evangeline) | 6,276 | 3,039 | 3,237 |
| Wells | 0 | 43,350 | -43,350 |
| Recharge/Groundwater-surfacewater interaction | 29,207 | 0 | 29,207 |
| Interbed Storage | 18,399 | 3,824 | 14,575 |
| Sum | 74,313 | 74,281 | 31 |

*Table 5. Water Budget for 1988, Evangeline aquifer.*

| Flow term | In | Out | In-Out |
|---|---|---|---|
| Storage | 1,584 | 3,084 | -1,500 |
| Constant Head | 0 | 0 | 0 |
| Horizontal Exchange | 6,747 | 4,431 | 2,316 |
| Exchange (Chicot) | 3,039 | 6,276 | -3,237 |
| Exchange (Burkeville) | 0 | 0 | 0 |
| Wells | 0 | 2 | -2 |
| Recharge/Groundwater-surfacewater interaction | 0 | 0 | 0 |
| Interbed Storage | 2,014 | 1,275 | 739 |
| Sum | 14,303 | 14,302 | 1 |

## Wharton County

*Table 6. Water budget for the Chicot aquifer, 1992.*

| Flow term | In | Out | In-Out |
|---|---|---|---|
| Storage Change | 55,818 | 0 | 55,818 |
| Horizontal Exchange | 29,852 | 19,515 | 10,337 |
| Exchange (Evangeline) | 7,130 | 15,538 | -8,408 |
| Wells | 0 | 211,798 | -211,798 |
| Recharge/Groundwater-surfacewater interaction | 153,714 | 23 | 153,691 |
| Interbed Storage | 244 | 0 | 244 |
| Sum | 246,758 | 246,874 | -115 |

*Table 7. Water budget for the Evangeline aquifer, 1992.*

| Flow term | In | Out | In-Out |
|---|---|---|---|
| Storage Change | 414 | 0 | 414 |
| Horizontal Exchange | 3,859 | 10,097 | -6,238 |
| Exchange (Chicot) | 15,538 | 7,130 | 8,408 |
| Exchange (Burkeville) | 244 | 0 | 244 |
| Wells | 0 | 3,277 | -3,277 |
| Recharge/Groundwater-surfacewater interaction | 0 | 0 | 0 |
| Interbed Storage | 425 | 0 | 425 |
| Sum | 20,479 | 20,504 | -25 |

## Matagorda County

*Table 8. Water budget for the Chicot aquifer, 1992.*

| Flow term | In | Out | In-Out |
|---|---|---|---|
| Storage Change | 299 | 83 | 216 |
| Horizontal Exchange | 12,188 | 14,280 | -2,091 |
| Exchange (Evangeline) | 3,795 | 2,164 | 1,631 |
| Wells | 0 | 28,261 | -28,261 |
| Recharge/Groundwater-surfacewater interaction | 28,289 | 0 | 28,289 |
| Interbed Storage | 166 | 139 | 28 |
| Sum | 44,737 | 44,927 | -190 |

## Matagorda County (continued)

*Table 9. Water budget for the Evangeline aquifer, 1992.*

| Flow term | In | Out | In-Out |
|---|---|---|---|
| Storage Change | 158 | 141 | 17 |
| Horizontal Exchange | 5,986 | 4,427 | 1,559 |
| Exchange (Chicot) | 2,164 | 3,795 | -1,631 |
| Exchange (Burkeville) | 0 | 0 | 0 |
| Wells | 0 | 2 | -2 |
| Recharge/Groundwater-surfacewater interaction | 0 | 0 | 0 |
| Interbed Storage | 95 | 72 | 23 |
| Sum | 8,403 | 8,436 | -33 |

## Wharton County

*Table 10. Average water budget for the Chicot aquifer, 2005 through 2012.*

| Flow term | In | Out | In-Out |
|---|---|---|---|
| Storage | 24,147 | 0 | 24,147 |
| Horizontal Exchange | 20,568 | 38,289 | -17,721 |
| Exchange (Evangeline) | 5,061 | 17,975 | -12,914 |
| Wells | 0 | 157,861 | -157,861 |
| Recharge/Groundwater-surfacewater interaction | 163,766 | 3 | 163,762 |
| Interbed Storage | 565 | 0 | 565 |
| Sum | 214,106 | 214,129 | -22 |

*Table 11.* Average *water budget for the Evangeline aquifer, 2005 through 2012.*

| Flow term | In | Out | In-Out |
|---|---|---|---|
| Storage Change | 158 | 0 | 158 |
| Horizontal Exchange | 4,377 | 11,903 | -7,526 |
| Exchange (Chicot) | 17,975 | 5,061 | 12,914 |
| Exchange (Burkeville) | 213 | 0 | 213 |
| Wells | 0 | 5,861 | -5,861 |
| Recharge/Groundwater-surfacewater interaction | 0 | 0 | 0 |
| Interbed Storage | 96 | 0 | 96 |
| Sum | 22,818 | 22,825 | -7 |

## Matagorda County

*Table 12. Average water budget for the Chicot aquifer, 2005 through 2012.*

| Flow term | In | Out | In-Out |
|---|---|---|---|
| Storage Change | 271 | 0 | 271 |
| Horizontal Exchange | 19,828 | 12,714 | 7,114 |
| Exchange (Evangeline) | 4,446 | 3,628 | 818 |
| Wells | 0 | 37,374 | -37,374 |
| Recharge/Groundwater-surfacewater interaction | 28,485 | 0 | 28,485 |
| Interbed Storage | 573 | 0 | 573 |
| Sum | 53,603 | 53,716 | -113 |

*Table 13. Average water budget for the Evangeline aquifer, 2005 through 2012.*

| Flow term | In | Out | In-Out |
|---|---|---|---|
| Storage Change | 296 | 0 | 296 |
| Horizontal Exchange | 6,638 | 5,290 | 1,348 |
| Exchange (Chicot) | 3,628 | 4,446 | -818 |
| Exchange (Burkeville) | 0 | 0 | 0 |
| Wells | 0 | 1,245 | -1,245 |
| Recharge/Groundwater-surfacewater interaction | 0 | 0 | 0 |
| Interbed Storage | 354 | 0 | 354 |
| Sum | 10,916 | 10,981 | -65 |

*Table 14. Total freshwater storage estimates in the Chicot and the Evangeline aquifers in Wharton and Matagorda counties.*

| County | Aquifers | Total Storage (acre-feet) | | |
|---|---|---|---|---|
| | | 1988 | 1992 | 2005 to 2012 |
| Wharton | Chicot | 24,774,791 | 24,218,541 | 24,022,503 |
| | Evangeline | 89,029,973 | 89,029,973 | 89,029,973 |
| Matagorda | Chicot | 36,149,224 | 35,916,302 | 35,782,582 |
| | Evangeline | 134,379,204 | 134,379,204 | 134,379,204 |

## REFERENCES:

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