

Section 13

Sub-Regional Upper Floridan Aquifer Modeling for South-Central Georgia and the Eastern Coastal Plain Area Sustainable Yield Assessment

13.1 Groundwater Modeling Approach for Sustainable Yield Assessment

Consistent with Section 11 of this report, two criteria were used to evaluate sustainable yield in the Upper Floridan Aquifer in south-central Georgia and the eastern Coastal Plain area. These criteria were groundwater level drawdown and reduction of groundwater contributions to stream baseflow. Reasonable metrics, which have been applied elsewhere, for these two criteria are no more than 30 feet of groundwater level drawdown in the targeted aquifer and no more than a 40 percent reduction of groundwater contributions to stream baseflow.

As discussed in Section 11.3, groundwater modeling simulations were performed under a steady-state condition in order to evaluate whether the groundwater withdrawals from the aquifers are sustainable and to estimate the ultimate groundwater level drawdown and reduction of groundwater contributions to stream baseflow due to increased pumping once the aquifer has reached a new equilibrium. Therefore, a steady-state sub-regional Upper Floridan Aquifer model was developed based on the calibrated sub-regional transient Upper Floridan Aquifer model discussed in Section 8. For the south-central Georgia and the eastern Coastal Plain area, the steady-state model was used to: (1) estimate Upper Floridan Aquifer sustainable yields and (2) evaluate the potential effects on the groundwater and surface water systems (rivers and streams) due to simulated increased pumping from the Upper Floridan Aquifer sustainable yields.

Groundwater flow modeling simulations were performed using the steady-state sub-regional Upper Floridan Aquifer model. These simulations were conducted to estimate the range of sustainable yields that could occur from existing and simulated new wells in the Upper Floridan Aquifer in the south-central Georgia and the eastern Coastal Plain area without creating unacceptable impacts to the environment.

For this analysis, two simulation scenarios were performed with simulated pumping from the Upper Floridan Aquifer in south-central Georgia and the eastern Coastal Plain area increasing until either the groundwater level drawdown criteria of 30 feet was exceeded over a large area or reduction of groundwater contributions to stream baseflow exceeded 40 percent. These simulations were designed to estimate an upper and lower bound to sustainable yield and are described below.

- **Simulation 1:** Pumping from the Upper Floridan Aquifer in south-central Georgia and the eastern Coastal Plain was uniformly increased in the existing wells (lower end of sustainable yield range); and
- **Simulation 2:** Pumping from the Upper Floridan Aquifer was non-uniformly increased in existing wells in south-central Georgia and the eastern Coastal Plain. For the existing wells, pumping from the existing large user wells in the Upper Floridan Aquifer was capped and pumping from the remaining existing wells was uniformly increased (upper end of sustainable yield range).

Simulated new wells were not included in the sustainable yield modeling for the Upper Floridan aquifer in south-central Georgia and the eastern Coastal Plain. In these simulations, pumping from both underlying and overlying aquifers was maintained at the baseline pumping rates.

13.2 Groundwater Modeling Results for Upper Floridan Aquifer Sustainable Yield Assessment for South Central Georgia and the Eastern Coastal Plain

Groundwater modeling results for the Upper Floridan Aquifer sustainable yield assessment in south central Georgia and the eastern Coastal Plain are presented in **Table 13-1**. Rather than discuss the results of each simulation, the range of sustainable yields for the Upper Floridan Aquifer in the south-central Georgia and the eastern Coastal Plain will be discussed in this section.

The existing permitted pumping rate from the Upper Floridan Aquifer in the eastern Coastal Plain of Georgia is approximately 146 mgd (Table 13-1). Uniformly increasing pumping from the existing wells in the Upper Floridan Aquifer in south-central Georgia and the eastern Coastal Plain and maintaining baseline pumping from other aquifers (Simulation 1) represents the low end of the range of sustainable yields, whereas non-uniformly increasing pumping from the existing wells within south-central Georgia and the eastern Coastal Plain (Simulation 2) represents the high end of the range of sustainable yields.

As indicated in Table 13-1, if pumping is uniformly increased in the existing wells in the Upper Floridan Aquifer in south-central Georgia and the eastern Coastal Plain, the total withdrawals can be increased by up to approximately 83 percent. Baseline pumping from the Upper Floridan Aquifer in the eastern Coastal Plain and south-central Georgia can be increased from 475 mgd to 868 mgd resulting in an increased withdrawal of 393 mgd. This pumping scenario results in exceedance of the 30-foot groundwater level drawdown criterion and a corresponding reduction of groundwater contributions to stream baseflow of approximately 31 percent.

Table 13-1 Summary of the Sustainable Yields in the Upper Floridan Aquifer in South-Central Georgia and the Eastern Coastal Plain under Different Withdrawal Conditions for an Average Rainfall Year using the Steady-State Upper Floridan Aquifer Sub-Regional Groundwater Model

Pumping Conditions and Potential Impacts	Existing Pumping Conditions (Baseline)			Increased Pumping from Existing Wells within South-Central Georgia and the Eastern Coastal Plain							
	South-Central Georgia	Eastern Coastal Plain	Total	Pumping Uniformly Increased (Simulation 1)				Non-uniform Pumping Increase ¹ (Simulation 2)			
				South-Central Georgia	Eastern Coastal Plain	Total	(% Increase) ⁴	South-Central Georgia	Eastern Coastal Plain	Total	(% Increase) ⁴
No. of Existing Pumping Wells	4,391	1,327	5,718	4,391	1,327	5,718	-	4,391	1,327	5,718	-
No. of Simulated New Pumping Wells	-	-	-	0	0	0	-	0	0	0	-
Upper Floridan Aquifer pumping (mgd)	329	146	475	625	243	868	-	768	214	982	-
Total pumping from all aquifers in the model domain (mgd)	1,019	836	1,855	-	-	1,558	-	-	-	1,672	-
Additional withdrawals from the Upper Floridan Aquifer (mgd)	0	0	0	296	97	393	83%	439	68	507	107%
Simulated groundwater level drawdown (ft) ²	-	-	-	-	-	30	-	-	-	30	-
Simulated river baseflow reduction (mgd) ³	-	-	-	-	-	31%	-	-	-	40%	-

¹ Pumping from existing wells is increased uniformly except for existing large users, which are capped at existing pumping rates.

² Simulated groundwater level drawdown was calculated by subtracting the groundwater elevations for each simulation from the corresponding values in the baseline condition.

³ The baseflow reduction was estimated for the streams in rivers in the outcrop area from a model-wide water budget for each simulation.

⁴ % increase is the increase in total additional withdrawals divided by the total existing withdrawals from the Upper Floridan Aquifer.

If pumping is non-uniformly increased from the existing wells in south-central Georgia and the eastern Coastal Plain, total pumping withdrawals could be increased further. As indicated in Table 13-1, total withdrawals can be increased by up to approximately 107 percent, resulting in exceedance of the 30-foot groundwater level drawdown criterion and an exceedance of the baseflow reduction criterion of 40 percent. For this scenario, baseline pumping from the Upper Floridan Aquifer can be increased from a total of 475 mgd to 982 mgd, resulting in an increased withdrawal of approximately 507 mgd. This upper end of the range of the sustainable yield may have been higher if simulated new wells had been included in the simulations.

The groundwater modeling results show that capping existing large user wells and increasing pumping from the remaining existing wells in south-central Georgia and the eastern Coastal Plain results in the highest estimate of sustainable yield.

A relatively good connection of rivers and their tributaries to the Upper Floridan Aquifer in the outcrop area provides significant quantities of water (approximately 507 mgd) when pumping from existing large user wells is capped at existing rates and pumping is increased in the remaining existing wells.

13.3 Potential Impacts on Groundwater Levels Due to Increased Groundwater Withdrawals in Upper Floridan Aquifer for South Central Georgia and the Eastern Coastal Plain

Groundwater modeling results showing potential impacts due to increased groundwater withdrawals in the Upper Floridan Aquifer in south-central Georgia and the eastern Coastal Plain are presented in the form of groundwater level drawdown contours. The simulated groundwater elevations and groundwater level drawdown contours for the low end of sustainable yield range (Simulation 1) and high end of sustainable yield range (Simulation 2) are presented in this section.

13.3.1 Baseline Condition

For comparison, the groundwater elevations in the Upper Floridan Aquifer (Layer 2) through the Upper Atkinson Aquifer (Layer 7) under existing baseline conditions are presented on **Figures 13-1** through **13-6**. As shown on Figure 13-1, the direction of regional groundwater flow in the Upper Floridan Aquifer north of the eastern Coastal Plain is primarily from northwest to southeast toward the Gulf Trough, whereas the direction of regional groundwater flow in the Upper Floridan Aquifer south of the eastern Coastal Plain is primarily from west to east toward the Atlantic Ocean. North of the Gulf Trough, there are potentiometric highs in the Upper Floridan Aquifer between the major rivers (Alapaha, Ocmulgee, and Altamaha Rivers) with flow toward the rivers. Figures 13-2 through 13-6 indicate that the prevailing groundwater flow directions in the Claiborne-Gordon-Lower Floridan Aquifers and the Cretaceous Aquifer System within the eastern Coastal Plain area occur from northwest to southeast toward the Atlantic Ocean.

13.3.2 Potential Impacts with Lower End of the Range of Sustainable Yield

Figures 13-7 through 13-12 show the groundwater elevations for Layers 2 through 7 for uniformly increased pumping from existing wells in the Upper Floridan Aquifer in south-central Georgia and the eastern Coastal Plain (Simulation 1) areas. As indicated on Figure 13-7, increasing pumping in south-central Georgia and the eastern Coastal Plain does not alter the regional groundwater flow directions from existing baseline conditions. The hydraulic gradients have become steeper around the major rivers and the Gulf Trough due to increased pumping from the existing wells (approximately 393 mgd).

The groundwater level drawdown for Layers 2 through 7 under uniformly increased pumping from the existing wells in the Upper Floridan Aquifer in south-central Georgia and the eastern Coastal Plain (Simulation 1) are shown on **Figures 13-13 through 13-18**, respectively. As shown on Figure 13-13, groundwater level drawdown in the potentiometric surface of the Upper Floridan Aquifer has increased in the vicinity of major rivers and near the Gulf Trough due to increased pumping from the existing wells (approximately 393 mgd). As indicated on Figures 13-14 through 13-18, groundwater level drawdown extends from the Claiborne-Gordon-Lower Floridan Aquifers (Layer 3) to the Upper Atkinson Aquifer (Layer 7) due to this pumping increase. The magnitude of drawdown is reduced in each underlying aquifer.

Some simulated drawdowns may have been locally greater than 30 feet in the vicinity of pumping wells, which did not exceed the sustainable yield criterion that drawdowns not exceed 30 feet between pumping wells. The criterion of no more than 40 percent of groundwater contributions to baseflow was not exceeded in the simulations of the lower end of the range of sustainable yield.

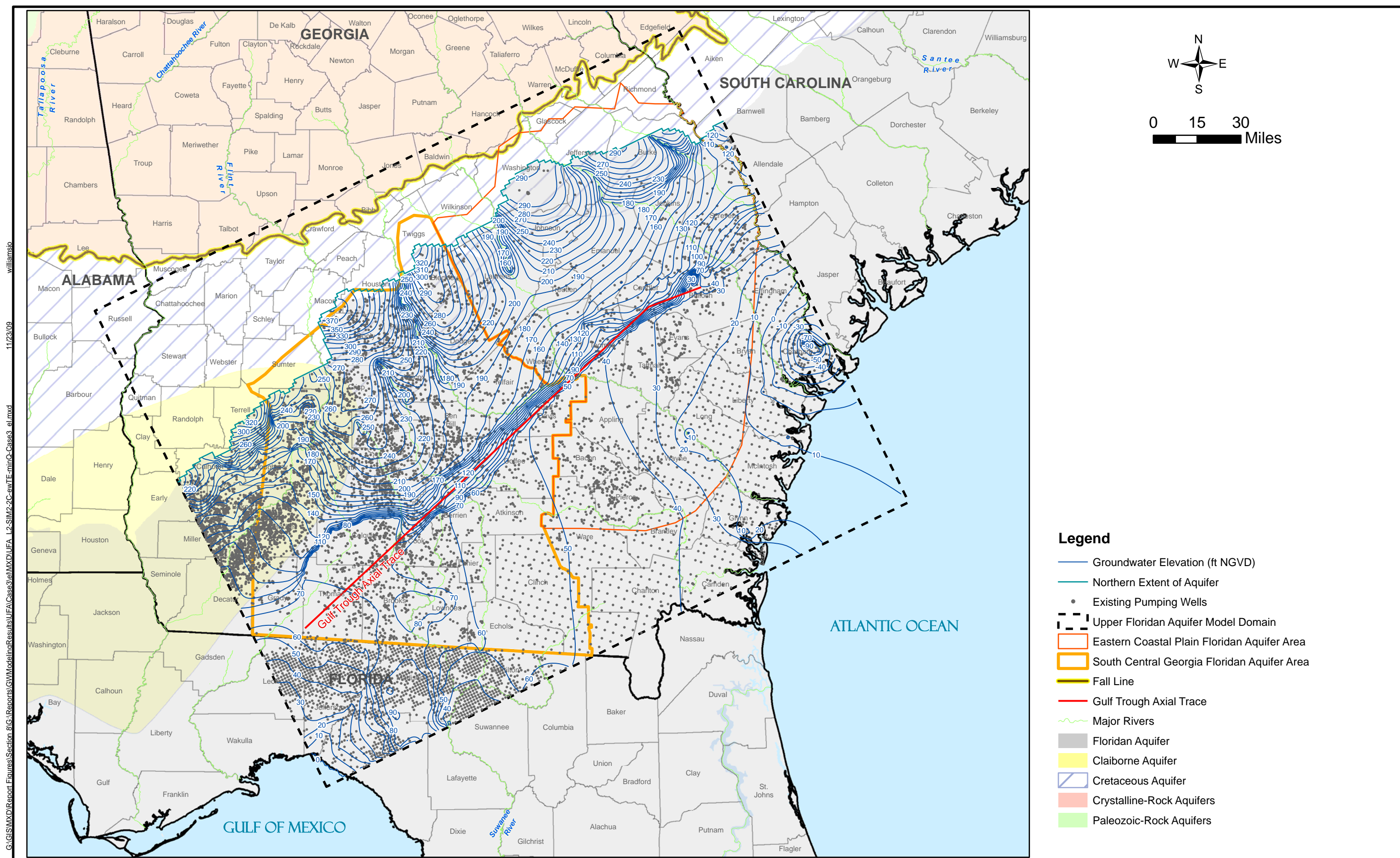
13.3.3 Potential Impacts with the Upper End of the Range of Sustainable Yield

Figures 13-19 through 13-24 show the groundwater elevations in Layers 2 through 7 for non-uniformly increased pumping from the Upper Floridan Aquifer in south-central Georgia and the eastern Coastal Plain (Simulation 2). As shown on Figures 13-19 and 13-20, increased pumping in south-central Georgia and the eastern Coastal Plain does not alter the regional groundwater flow directions in the Upper Floridan Aquifer (Layer 2) or the Claiborne-Gordon Aquifers (Layer 3) from existing baseline conditions. The hydraulic gradients have become even steeper around the major rivers and the Gulf Trough due to increased pumping from the existing wells (approximately 507 mgd).

The groundwater level drawdown for Layers 2 through 7 due to non-uniformly increased pumping from the existing wells in the Upper Floridan Aquifer in south-central Georgia and the eastern Coastal Plain (Simulation 2) are shown on **Figures 13-25 through 13-30**, respectively. As shown on Figure 13-25, groundwater

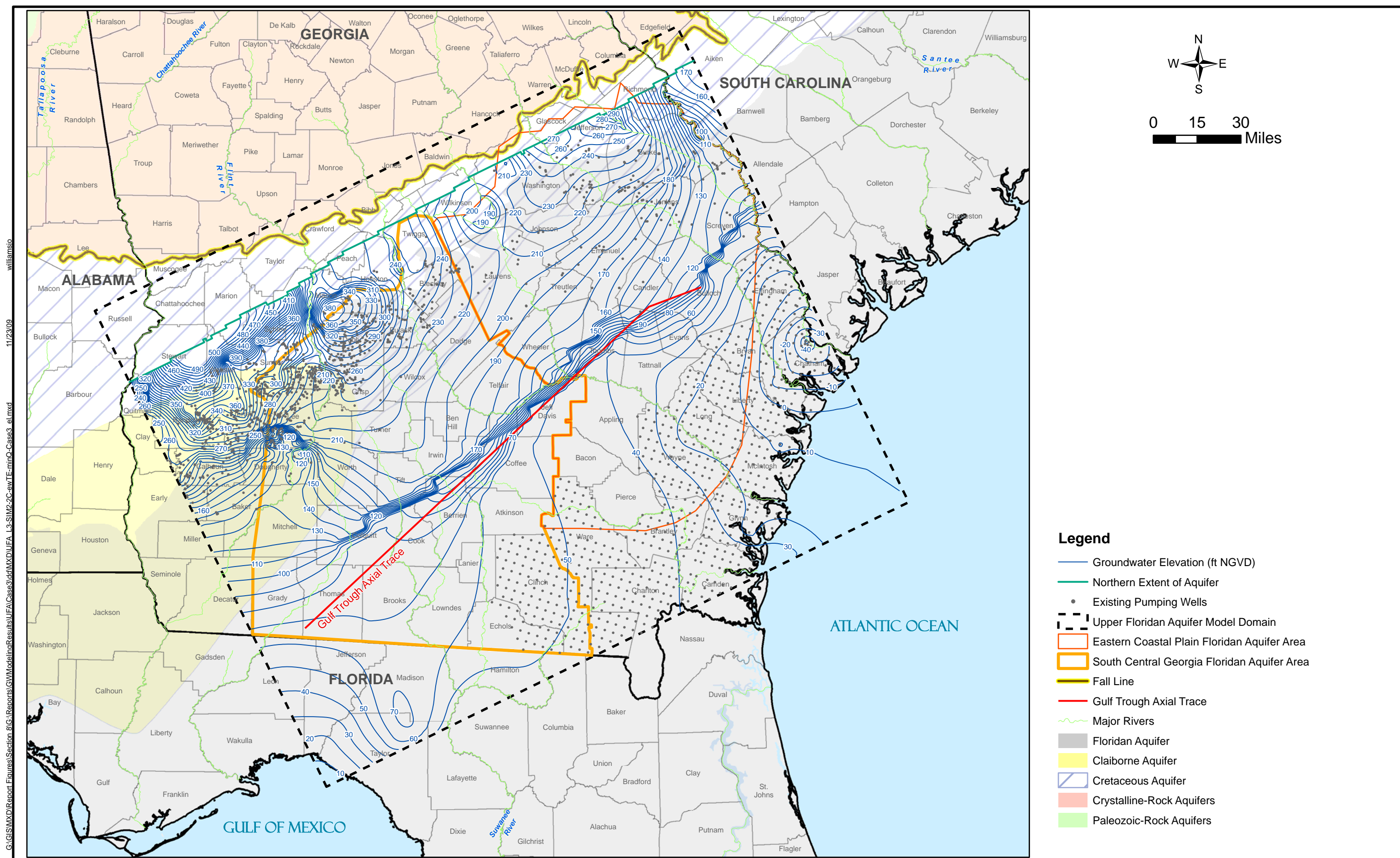
level drawdown in the potentiometric surface of the Upper Floridan Aquifer has increased further in the vicinity of major rivers and near the Gulf Trough due to increased pumping from the existing wells (approximately 507 mgd). Groundwater level drawdown in the potentiometric surface of the Upper Floridan Aquifer (Layer 2) approaches 30 feet in areas north of the Gulf Trough and approximately 1 to 15 feet south of the trough. As shown on Figure 13-26, drawdown approaches 30 feet in the Claiborne-Gordon-Lower Floridan Aquifers (Layer 3) near the Gulf Trough in Irwin and Ben Hill counties, and near rivers in Dooly County. As shown on Figures 13-27 through 13-30, drawdown due to increasing pumping in the Upper Floridan Aquifer ranges from approximately 1 to 17 feet in the Clayton-Dublin Aquifers (Layer 4), 1 to 11 feet in the Providence Aquifer (Upper Cretaceous Aquifer - Layer 5), and 1 to 2 feet in the Eutaw-Midville and Upper Atkinson Aquifers (Lower Cretaceous Aquifer - Layers 6 and 7), respectively.

Some simulated drawdowns may have been locally greater than 30 feet in the vicinity of pumping wells, which did not exceed the sustainable yield criterion that drawdowns not exceed 30 feet between pumping wells. The criterion of no more than 40 percent of groundwater contributions to baseflow was reached in the simulations of the upper end of the range of sustainable yield.



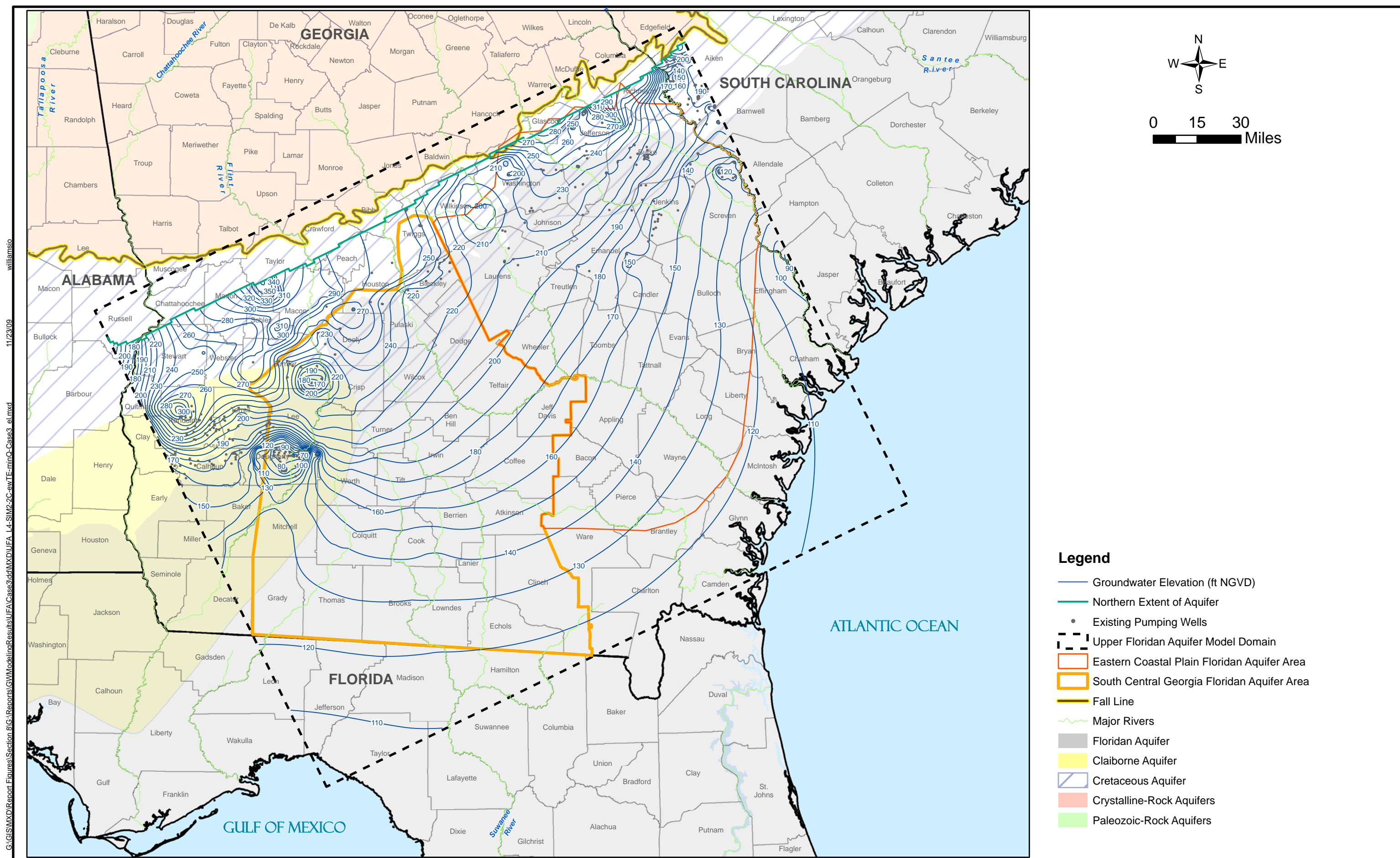
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Simulated Groundwater Elevations in Upper Floridan Aquifer (Layer 2)
At Current Pumping Conditions Using Sub-Regional Upper Floridan Aquifer Model



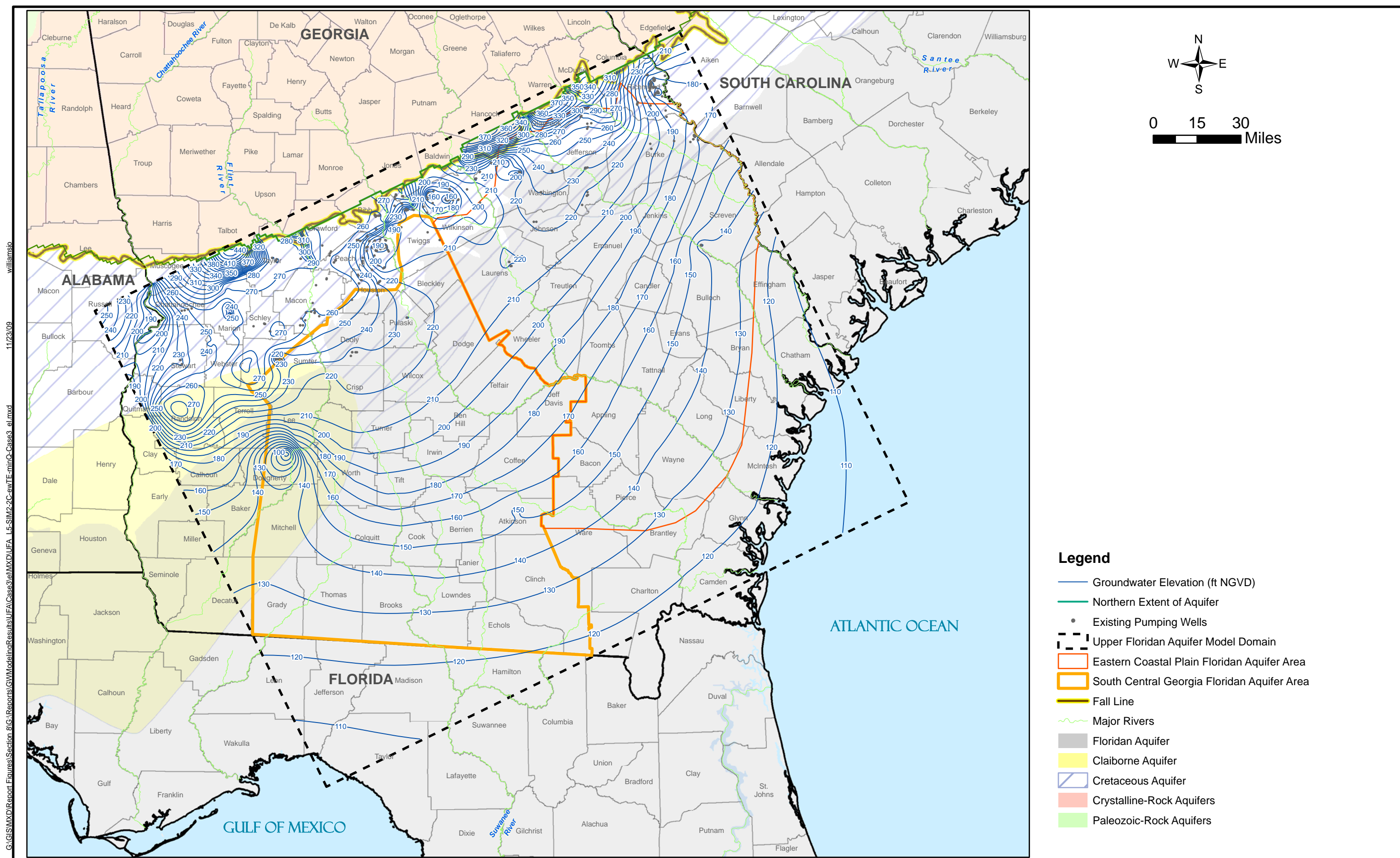
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CDM **Figure 13-2**
Simulated Groundwater Elevation in Claiborne/Gordon/Lower Floridan Aquifers (Layer 3)
At Current Pumping Conditions Using Sub-Regional Upper Floridan Aquifer Model



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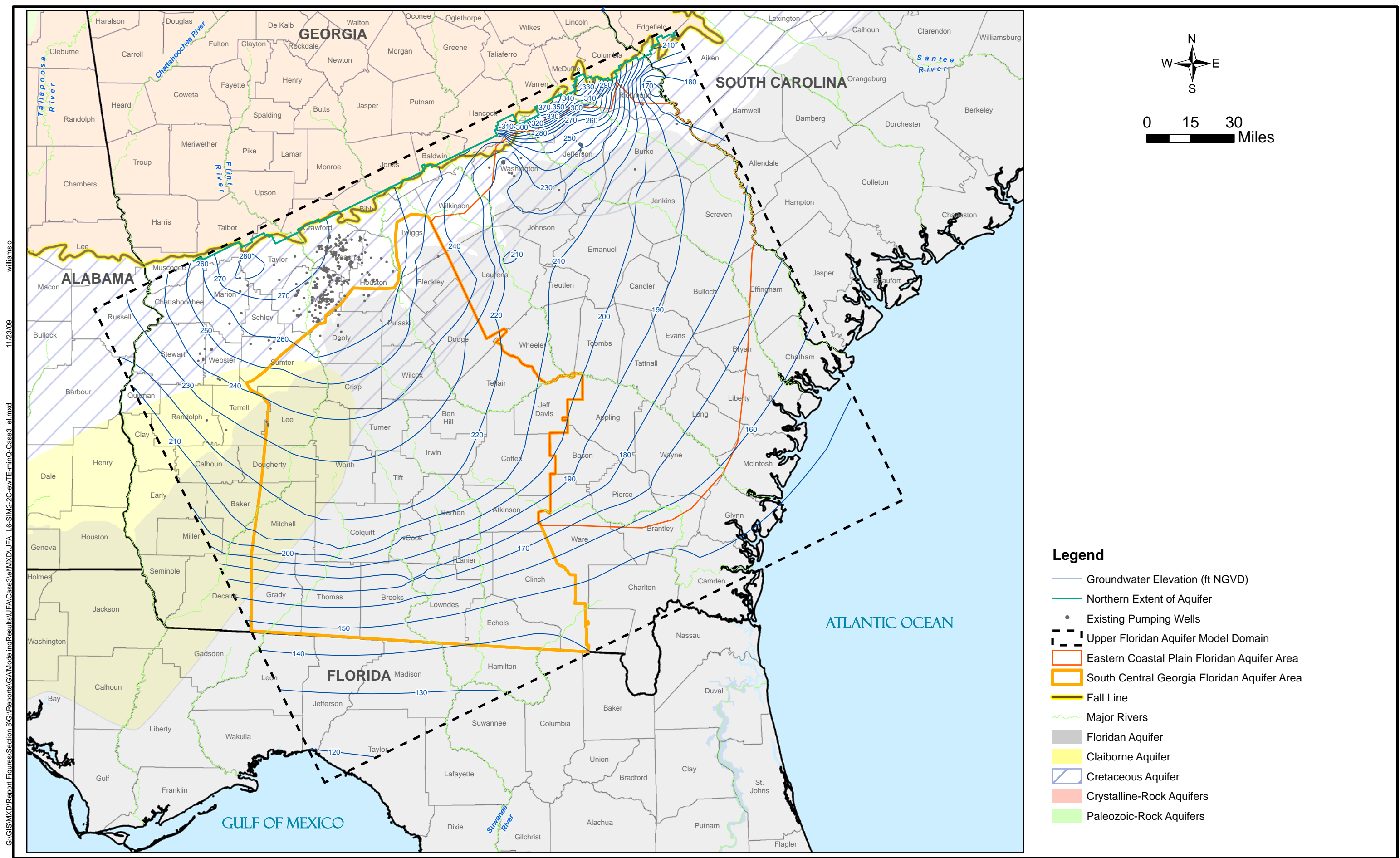
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Simulated Groundwater Elevation in Clayton-Dublin Aquifers (Layer 4)
At Current Pumping Conditions Using Sub-Regional Upper Floridan Aquifer Model



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Figure 13-4
Simulated Groundwater Elevation in Providence Sand-Peedee-Dublin Aquifers (Layer 5)
At Current Pumping Conditions Using Sub-Regional Upper Floridan Aquifer Model



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Figure 13-5

Simulated Groundwater Elevation in Eutaw-Midville Aquifer (Layer 6)

At Current Pumping Conditions Using Sub-Regional Upper Floridan Aquifer Model

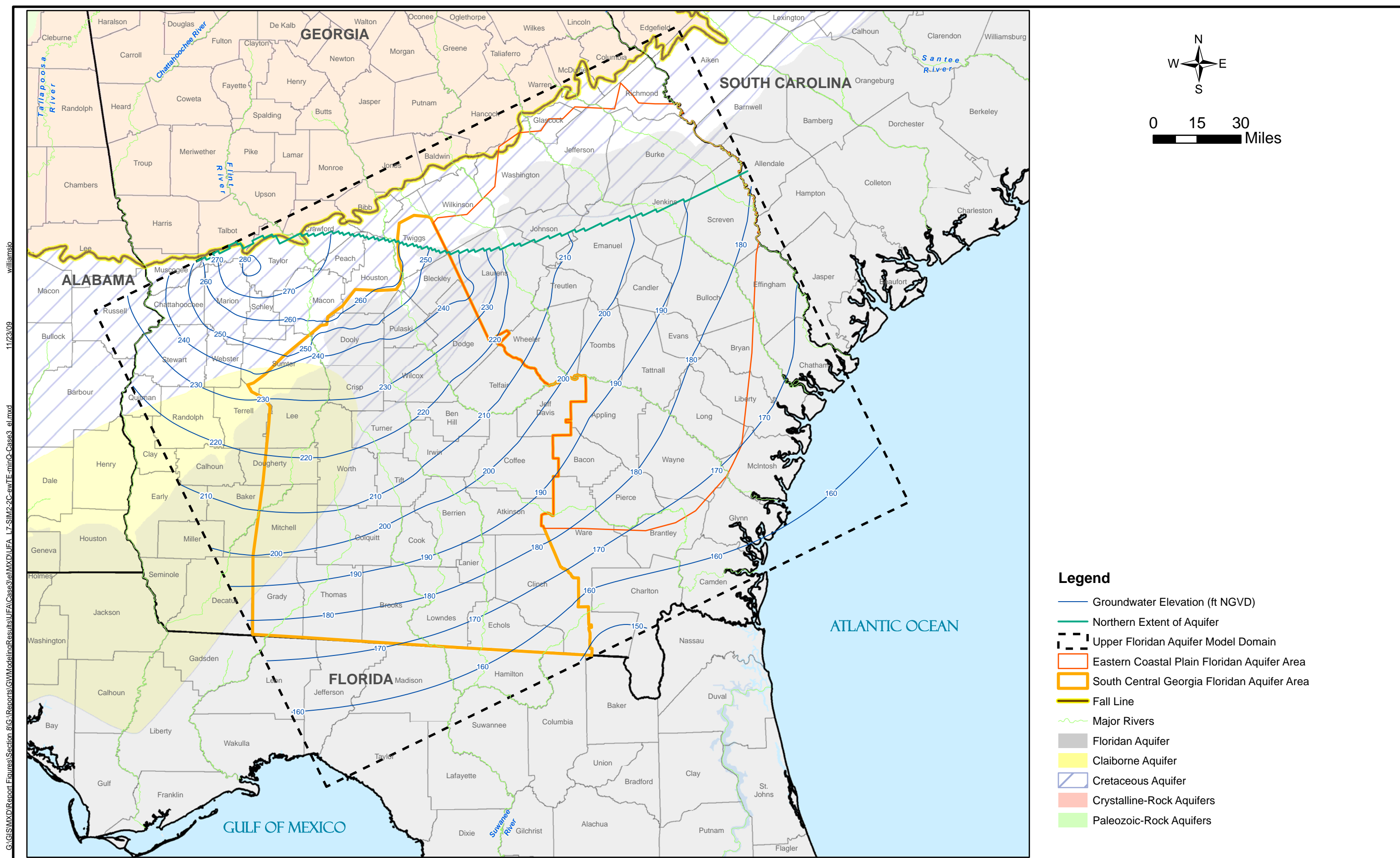


Figure 13-6
Simulated Groundwater Elevation in Upper Atkinson-Upper Tuscaloosa Aquifers (Layer 7)
At Current Pumping Conditions Using Sub-Regional Upper Floridan Aquifer Model

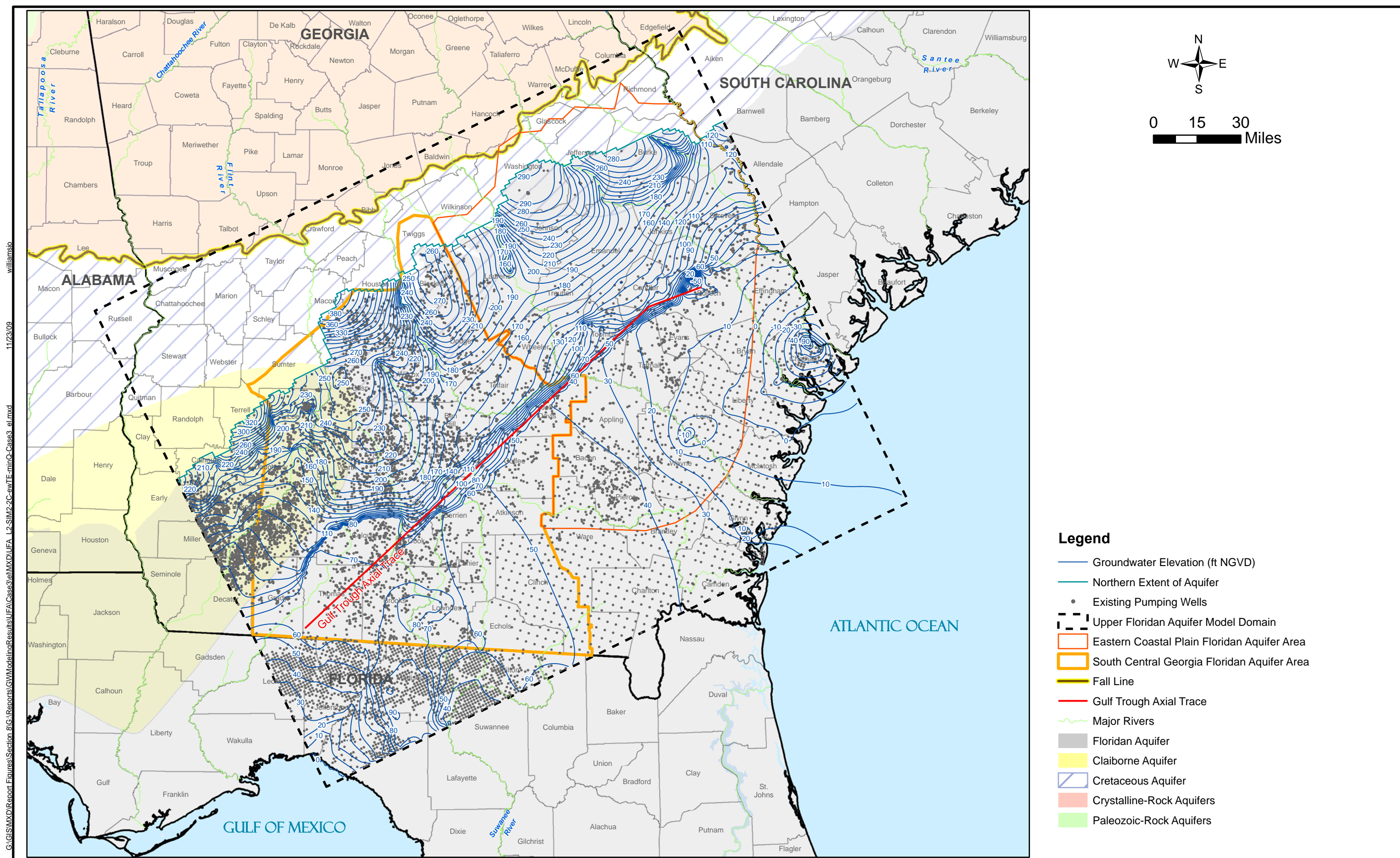
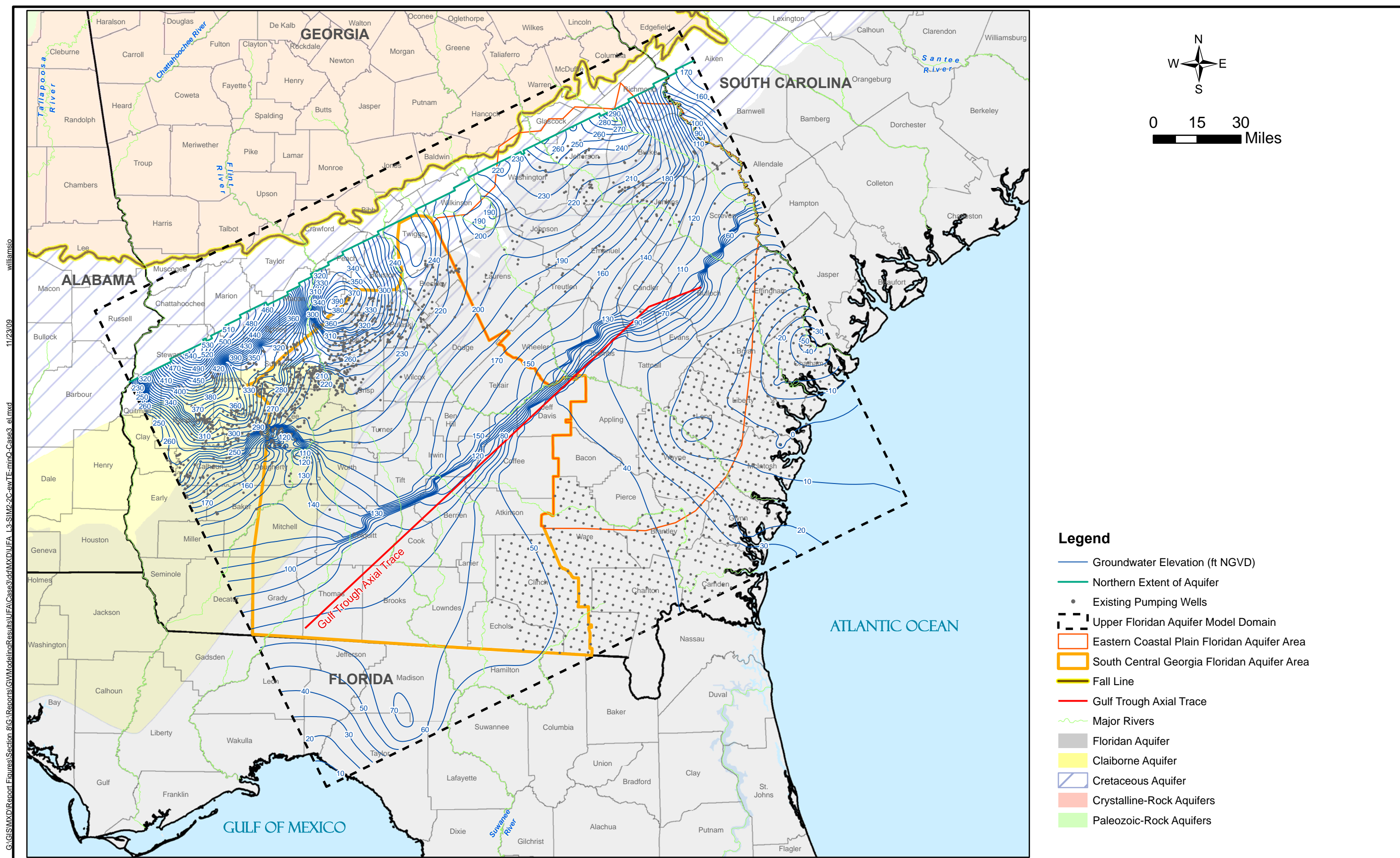


Figure 13-7
Simulated Groundwater Elevations in Upper Floridan Aquifer (Layer 2)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 393$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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CDM **Figure 13-8**
Simulated Groundwater Elevation in Claiborne/Gordon/Lower Floridan Aquifers (Layer 3)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 393$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

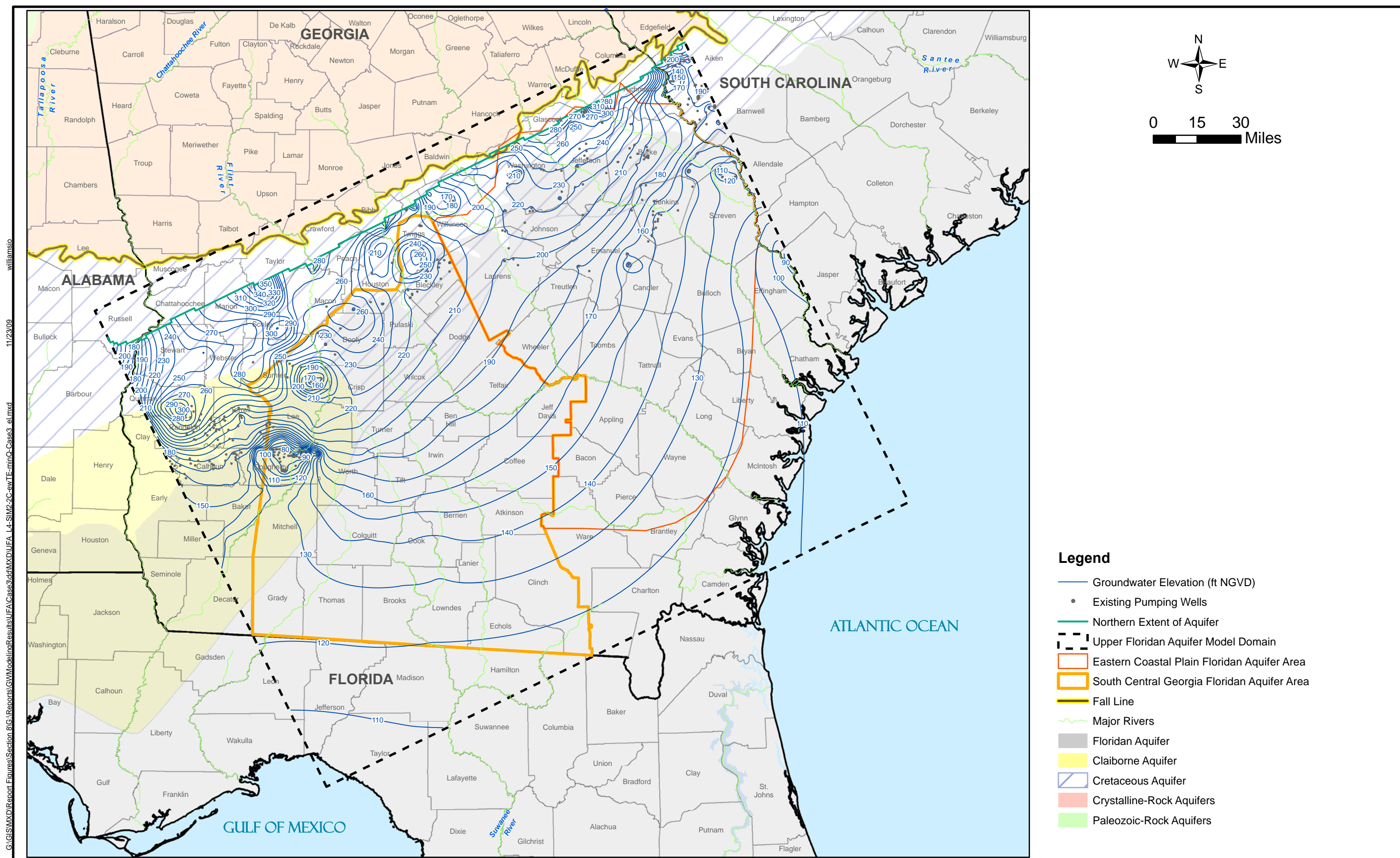


Figure 13-9
Simulated Groundwater Elevation in Clayton-Dublin Aquifers (Layer 4)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 393$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

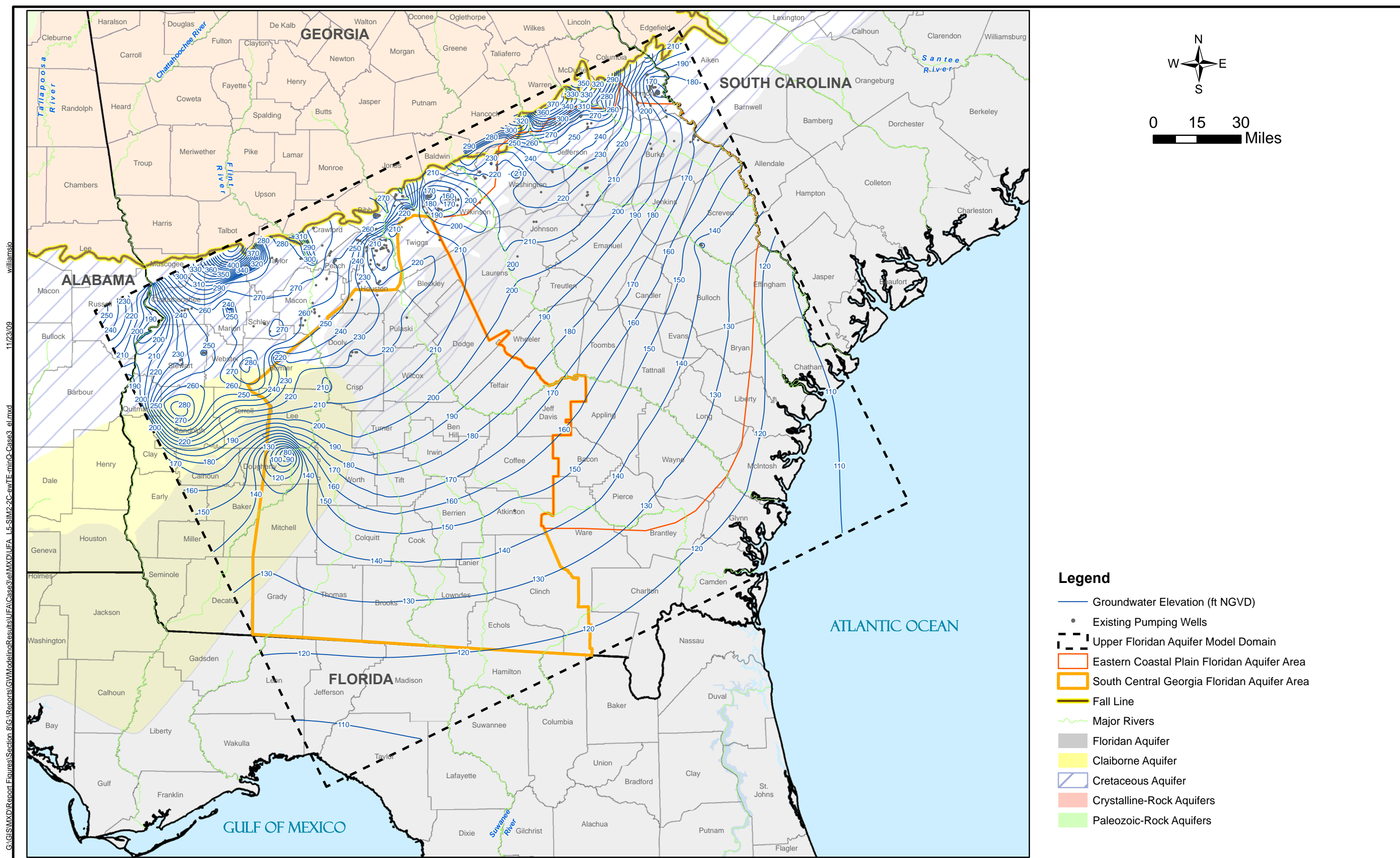
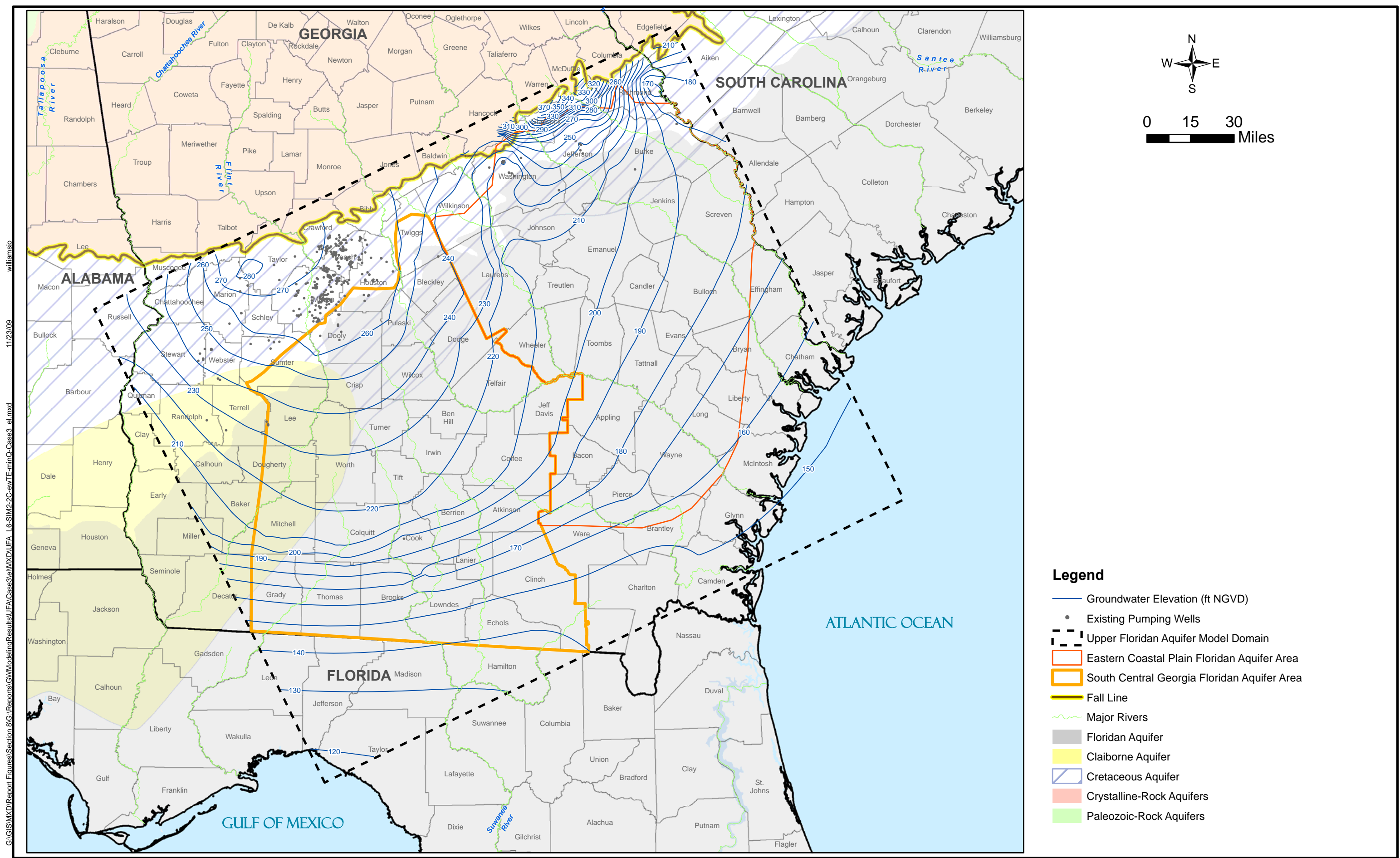
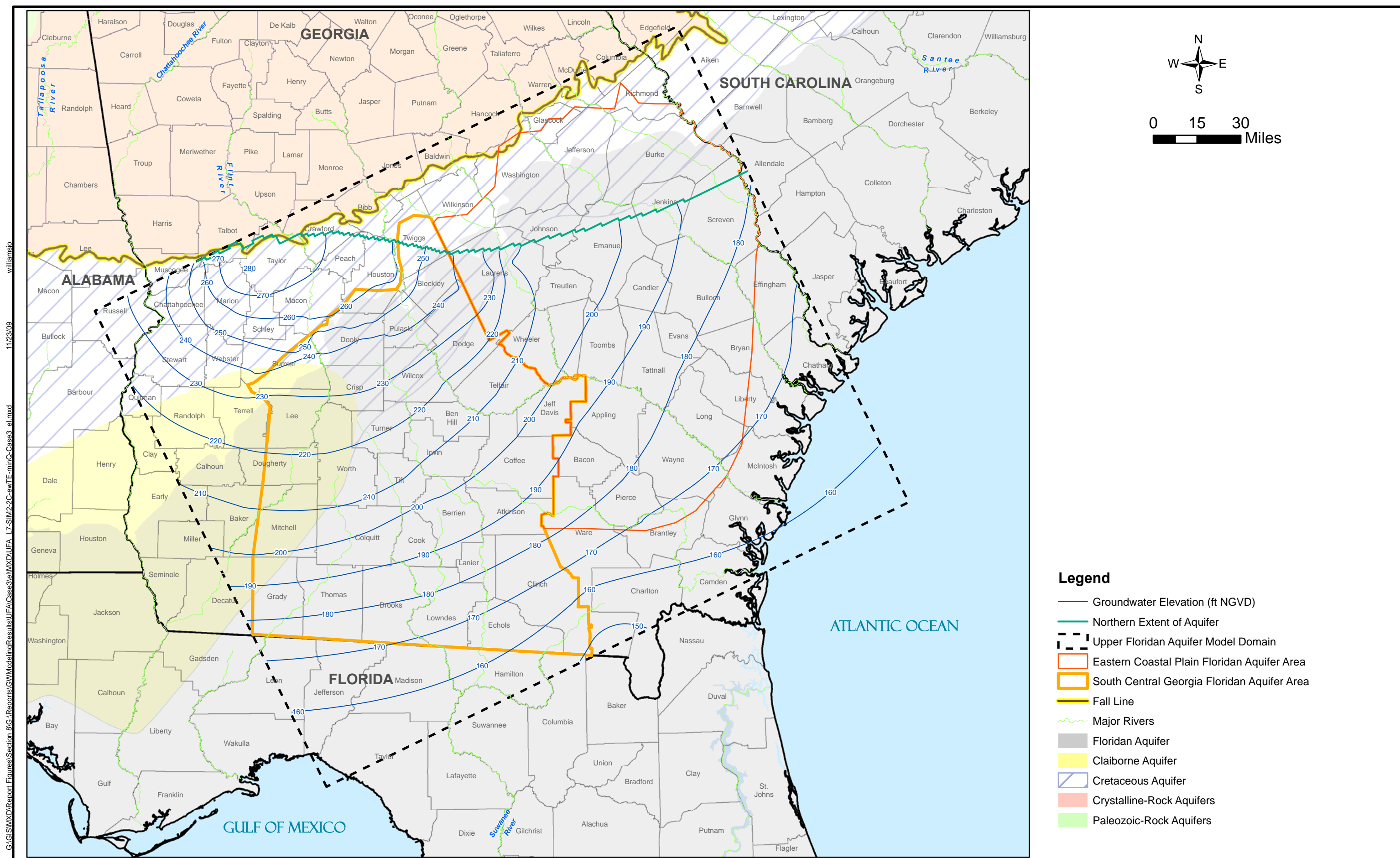


Figure 13-10
Simulated Groundwater Elevation in Providence Sand-Peedee-Dublin Aquifers (Layer 5)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 393$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



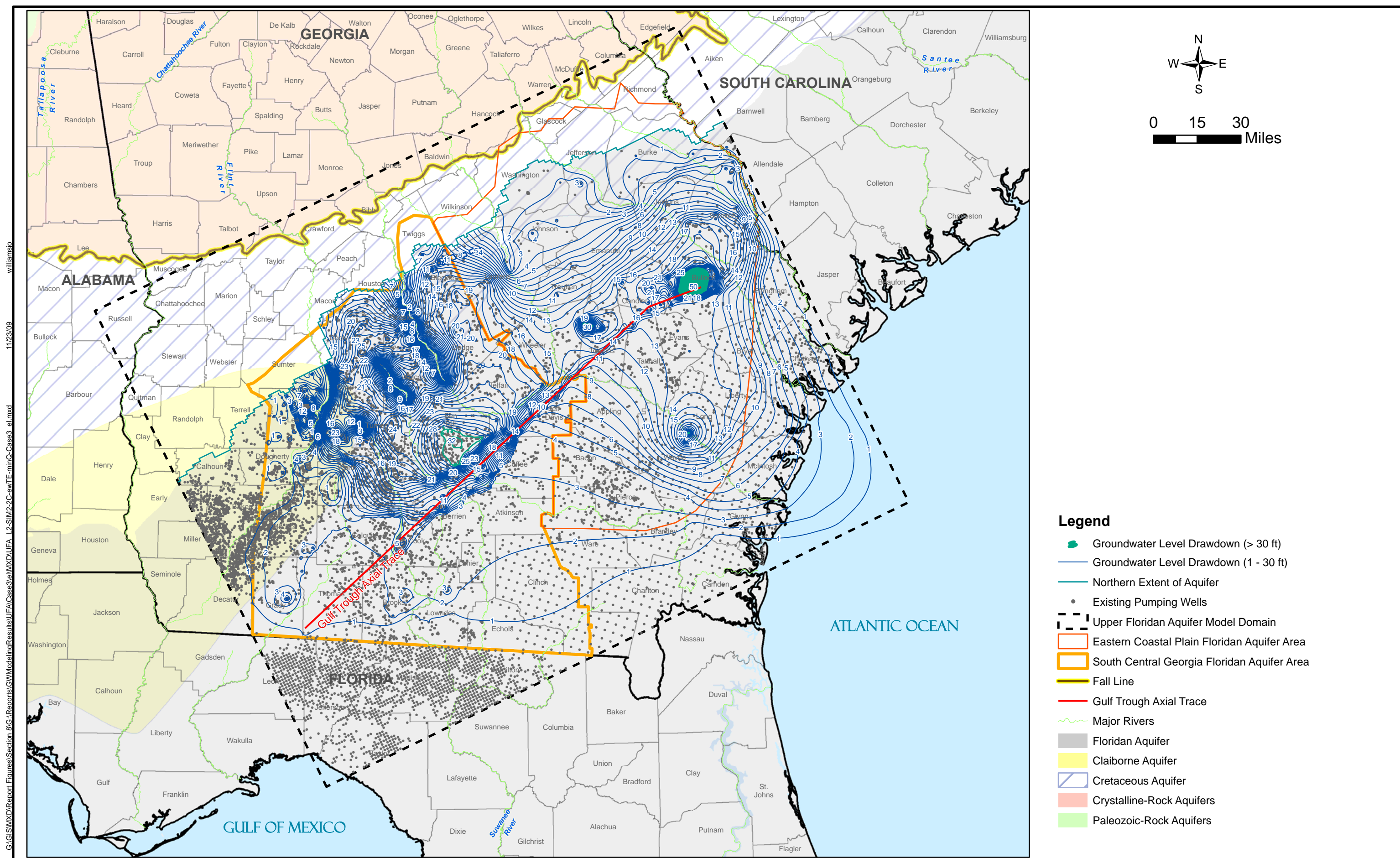
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Figure 13-11
Simulated Groundwater Elevation in Eutaw-Midville Aquifer (Layer 6)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 393$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



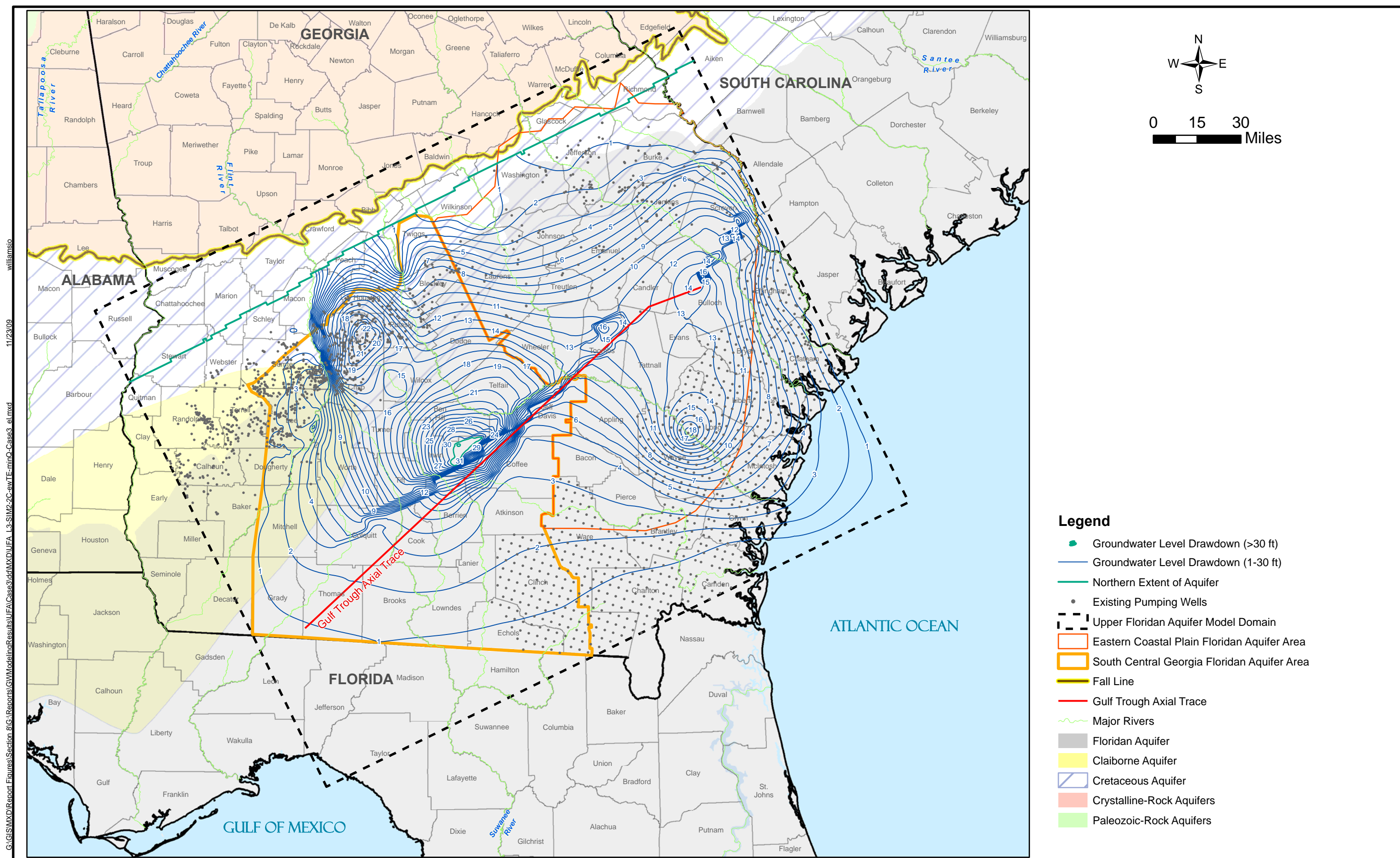
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CDM **Figure 13-12**
Simulated Groundwater Elevation in Upper Atkinson-Upper Tuscaloosa Aquifers (Layer 7)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 393$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



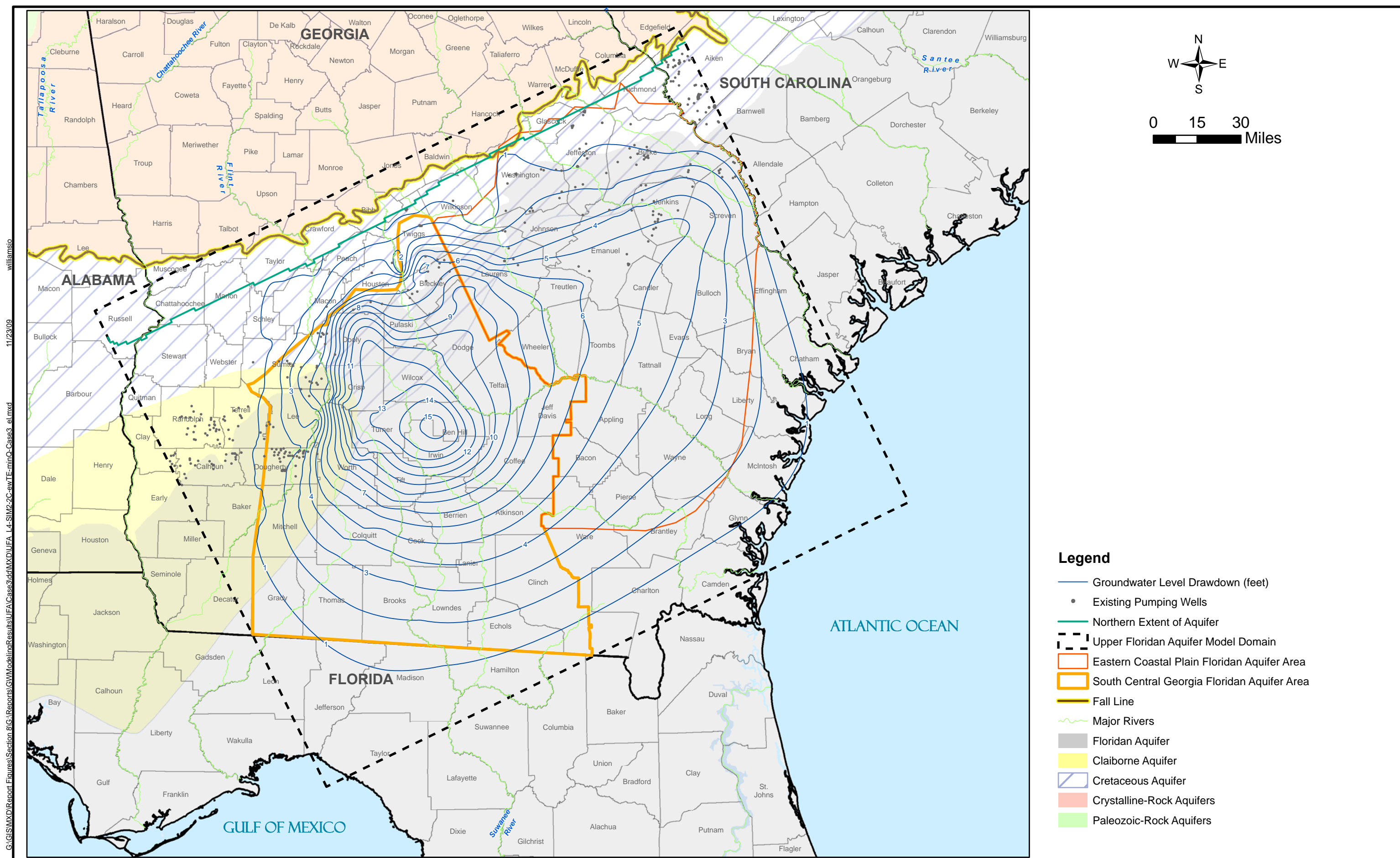
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CDM **Figure 13-13**
Simulated Groundwater Level Drawdown in Upper Floridan Aquifer (Layer 2)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 393$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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CDM **Figure 13-14**
Simulated Groundwater Level Drawdown in Claiborne/Gordon/Lower Floridan Aquifers (Layer 3)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 393$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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CDM **Figure 13-15**
Simulated Groundwater Level Drawdown in Clayton-Dublin Aquifers (Layer 4)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 393$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

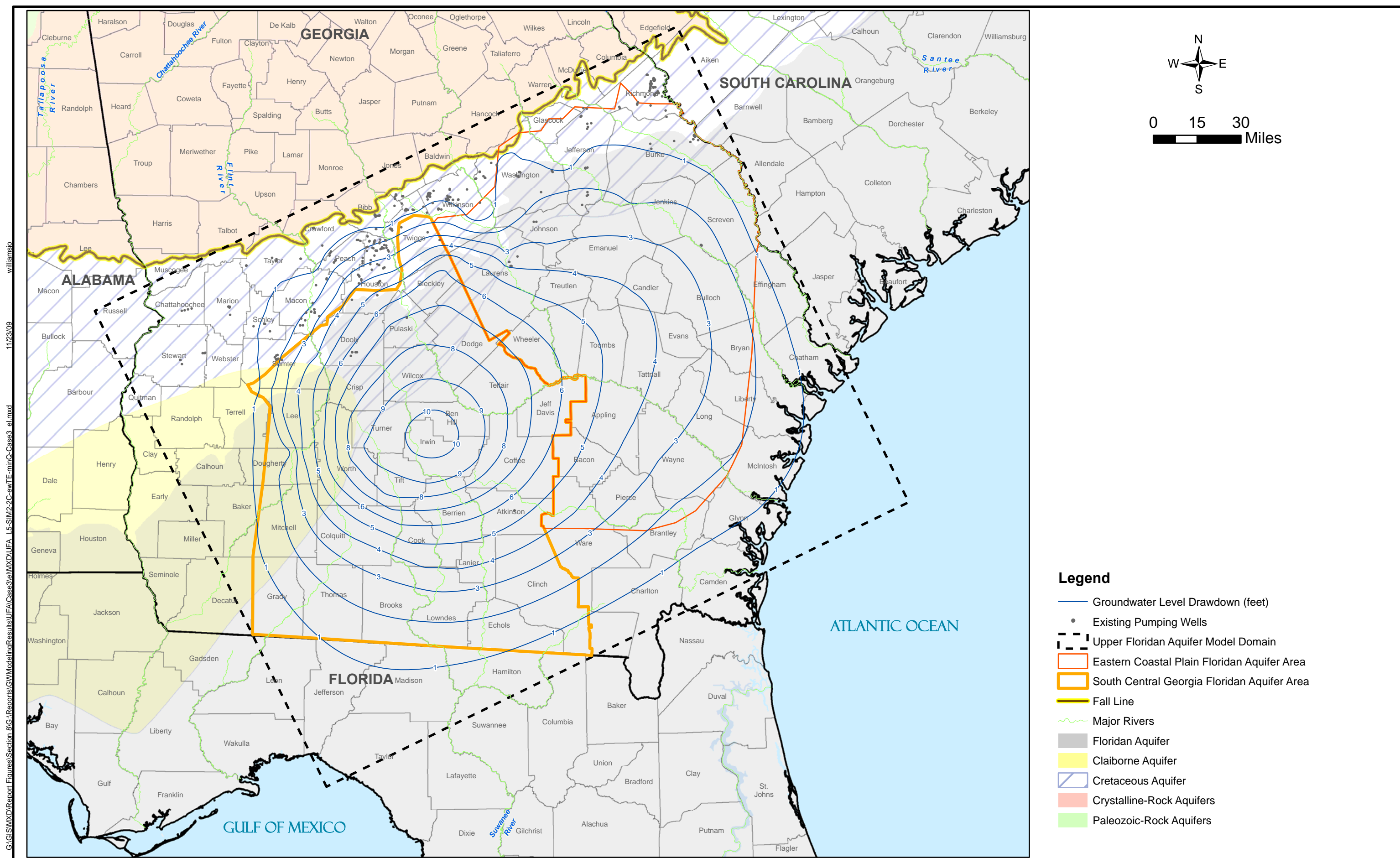
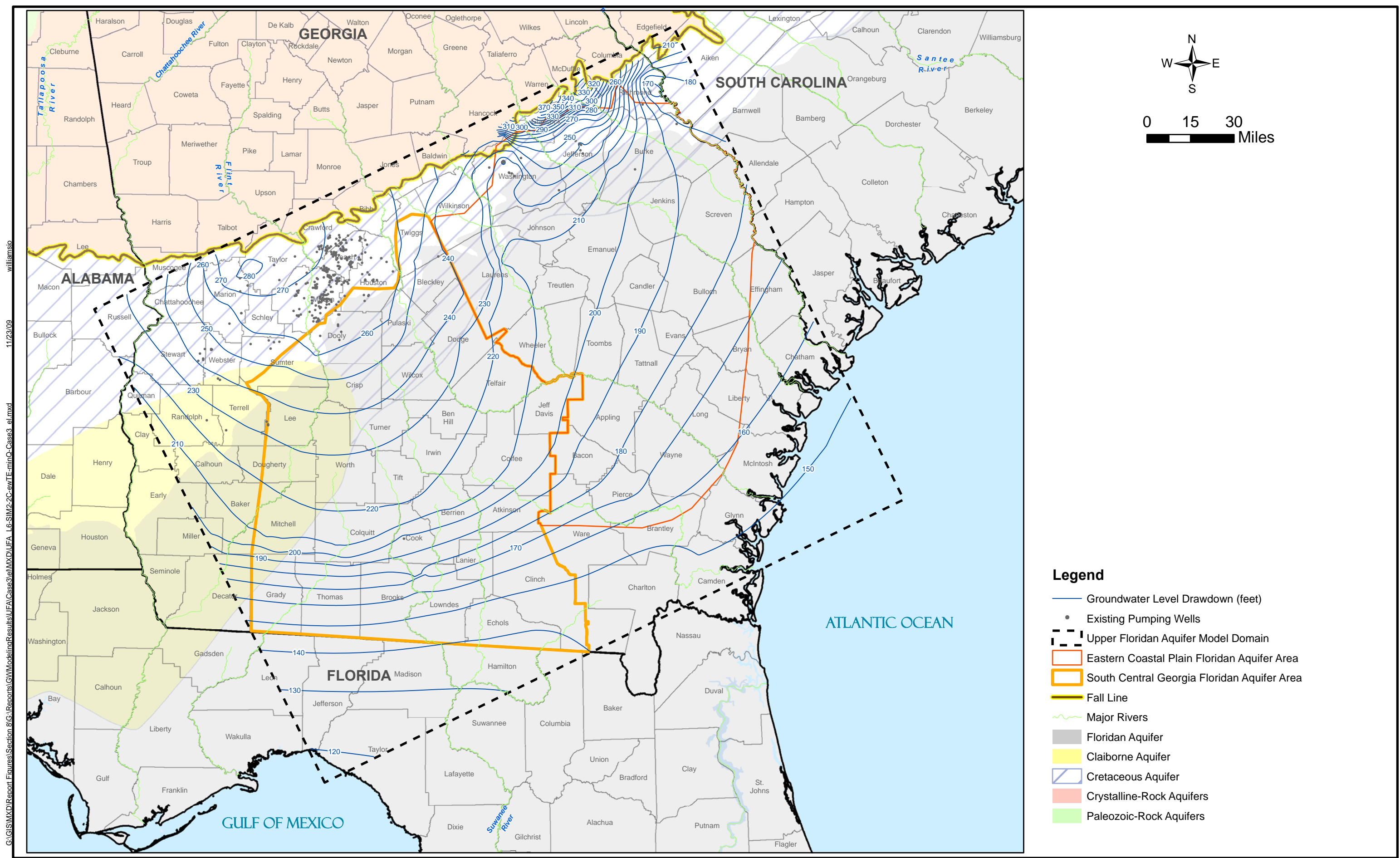
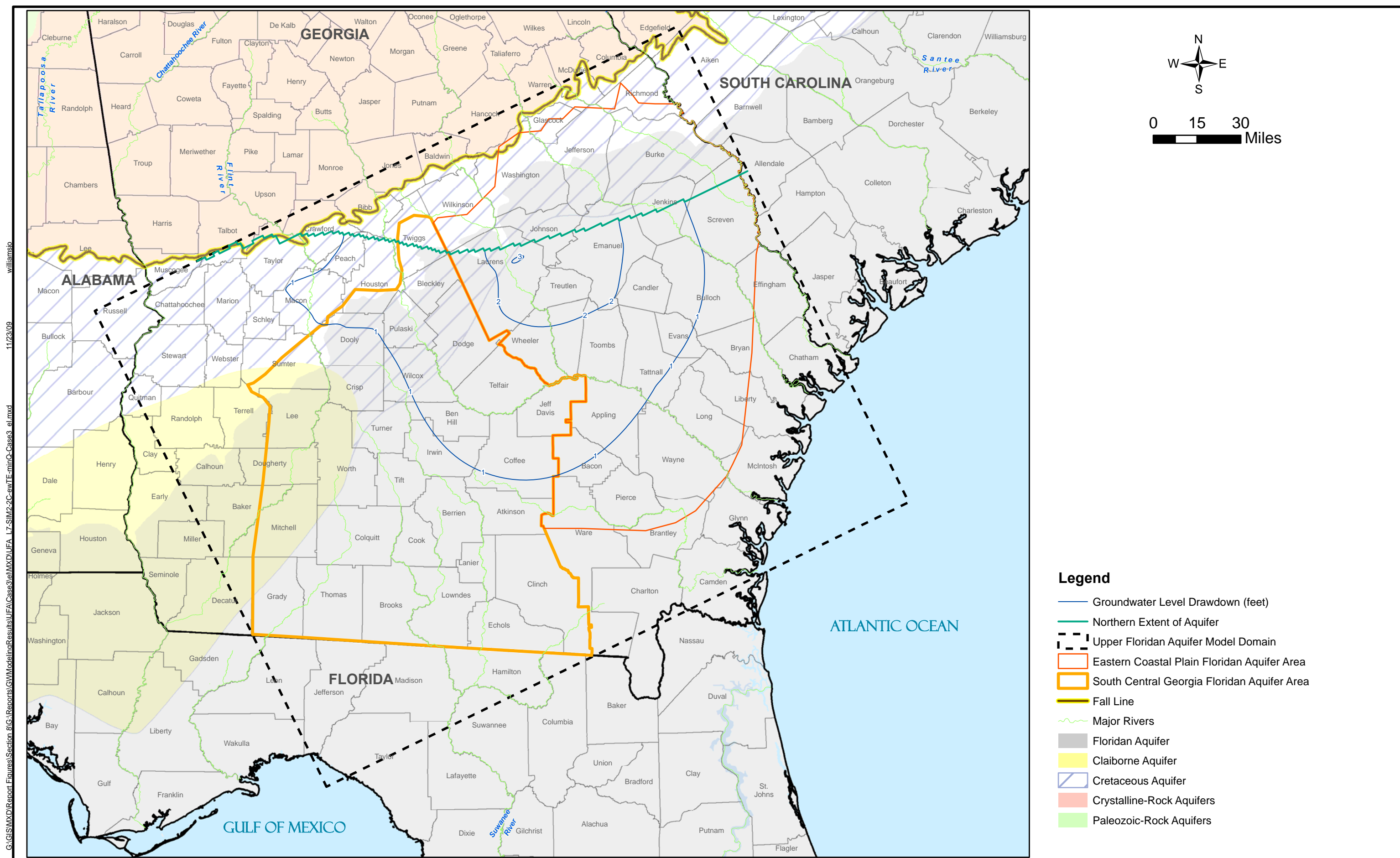


Figure 13-16
Simulated Groundwater Level Drawdown in Providence Sand-Peedee-Dublin Aquifers (Layer 5)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 393$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

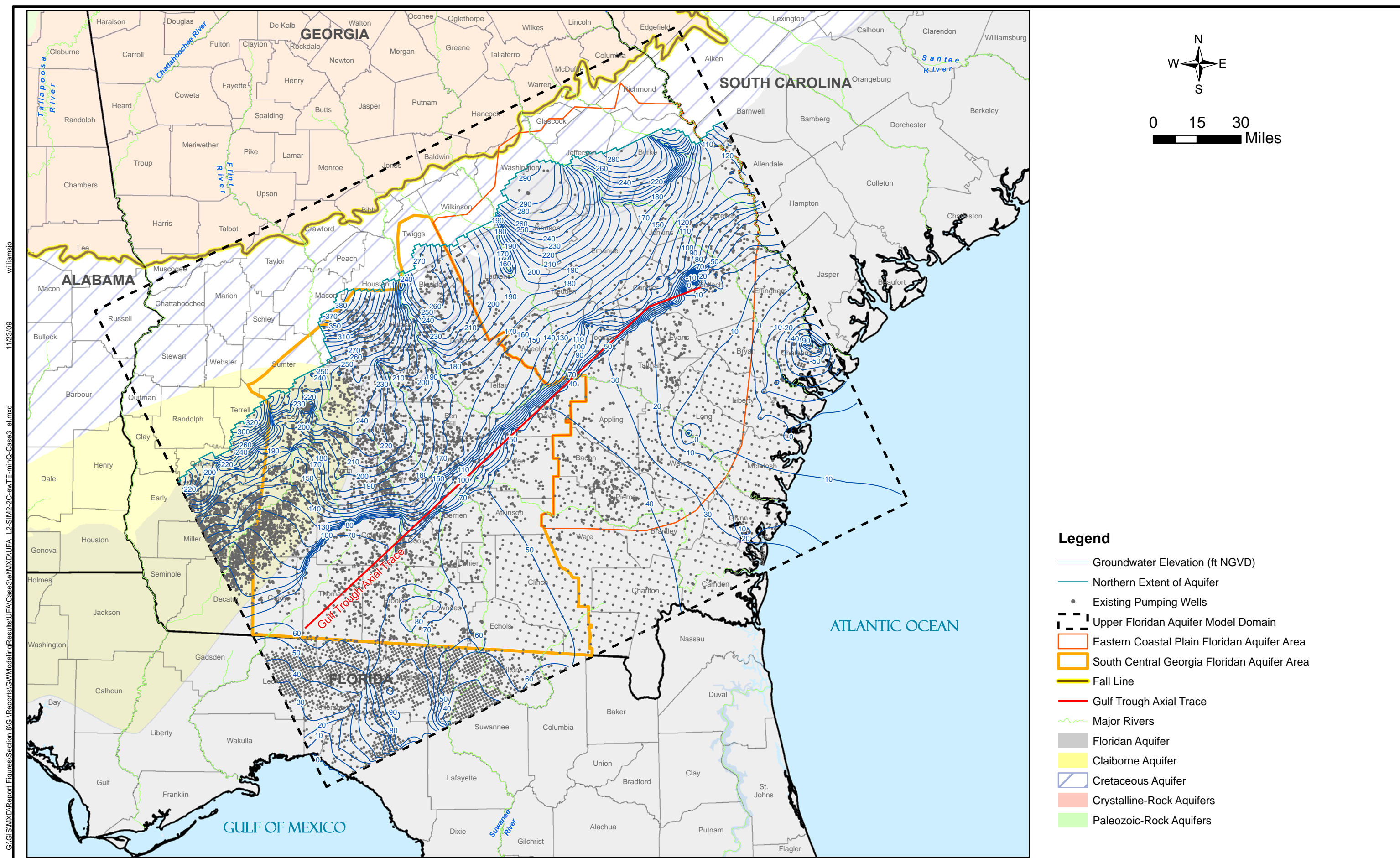


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CDM **Figure 13-17**
Simulated Groundwater Level Drawdown in Eutaw-Midville Aquifer (Layer 6)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 393$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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CDM **Figure 13-19**
Simulated Groundwater Elevations in Upper Floridan Aquifer (Layer 2)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

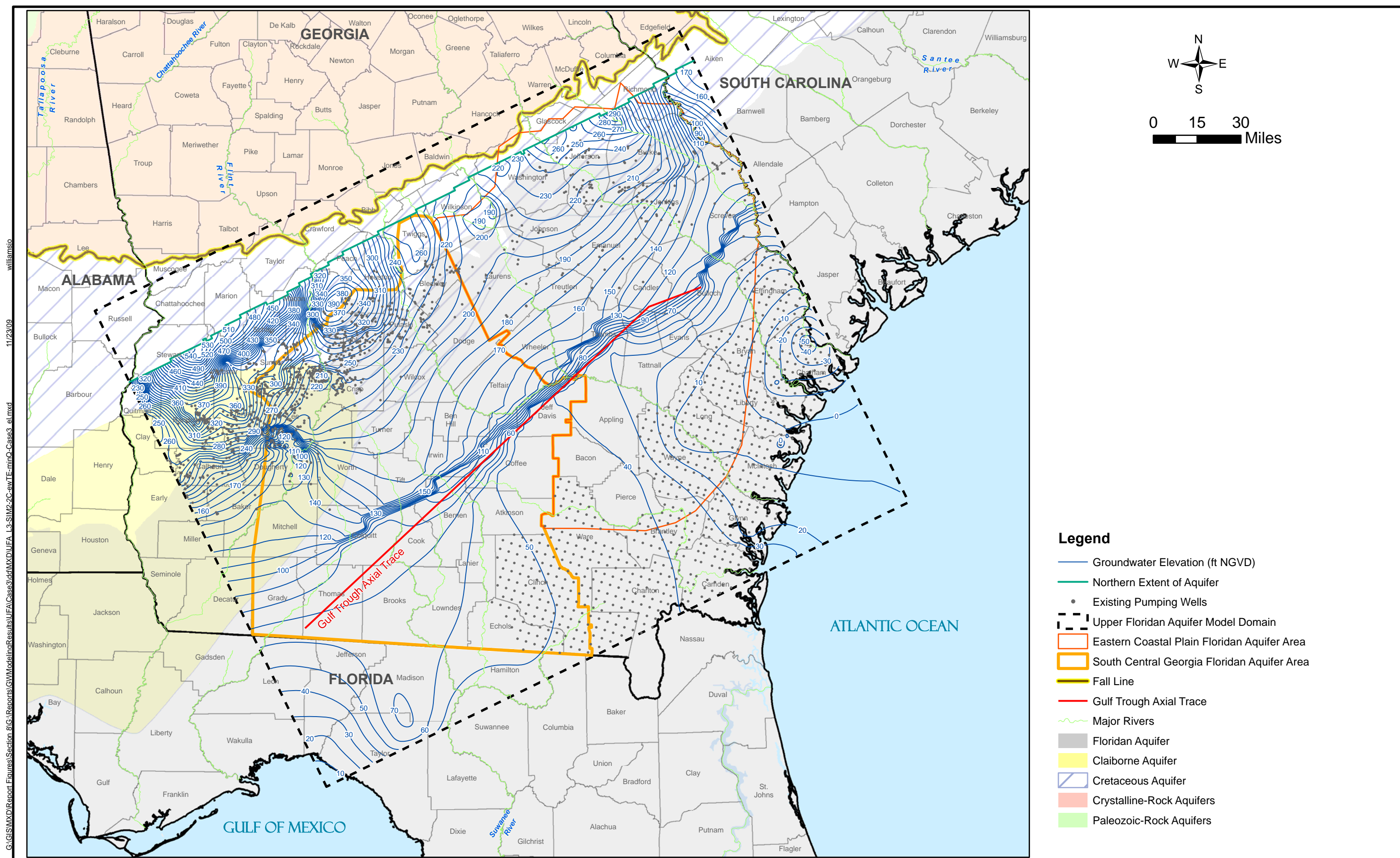


Figure 13-20
Simulated Groundwater Elevation in Claiborne/Gordon/Lower Floridan Aquifers (Layer 3)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

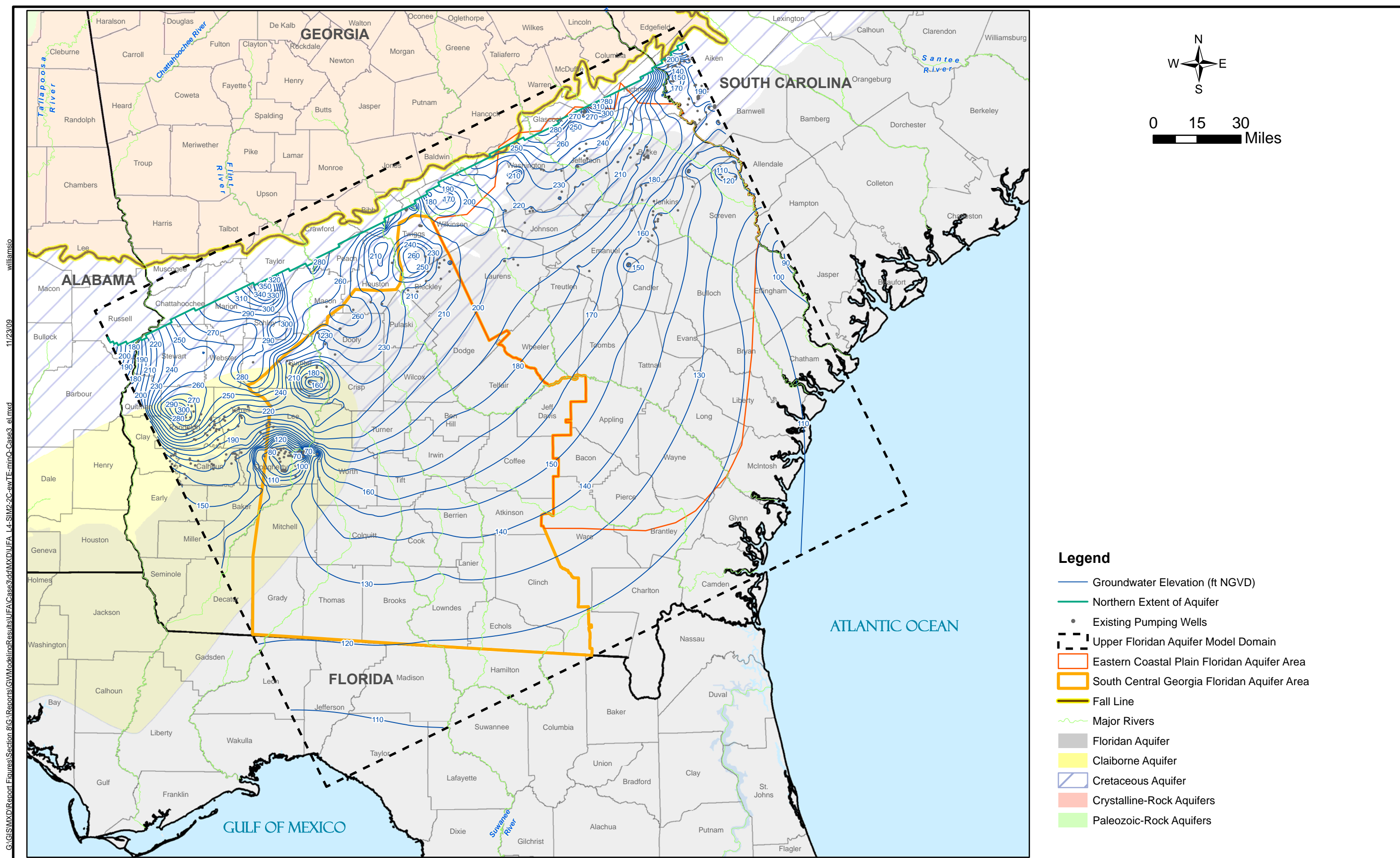
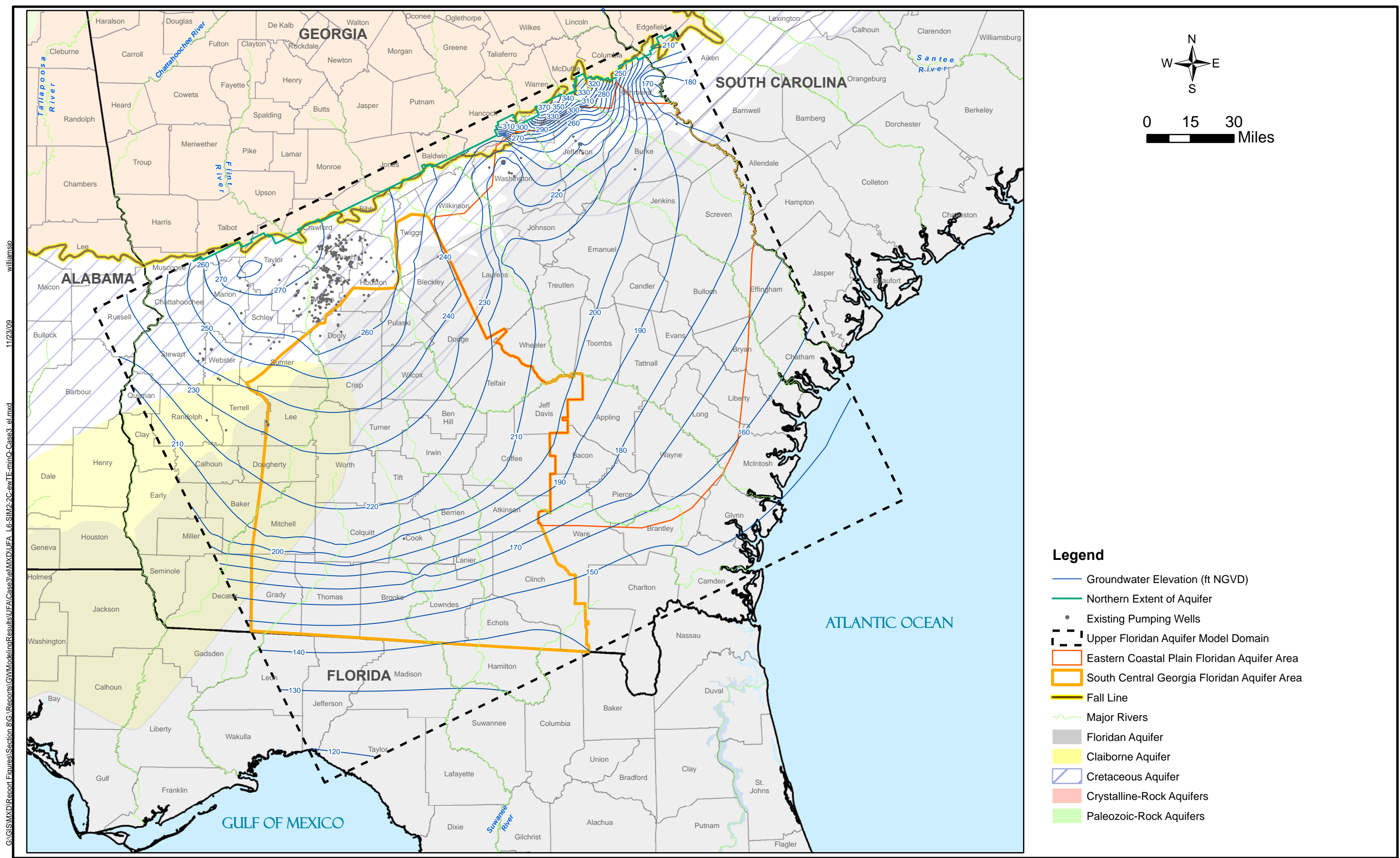


Figure 13-21
Simulated Groundwater Elevation in Clayton-Dublin Aquifers (Layer 4)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

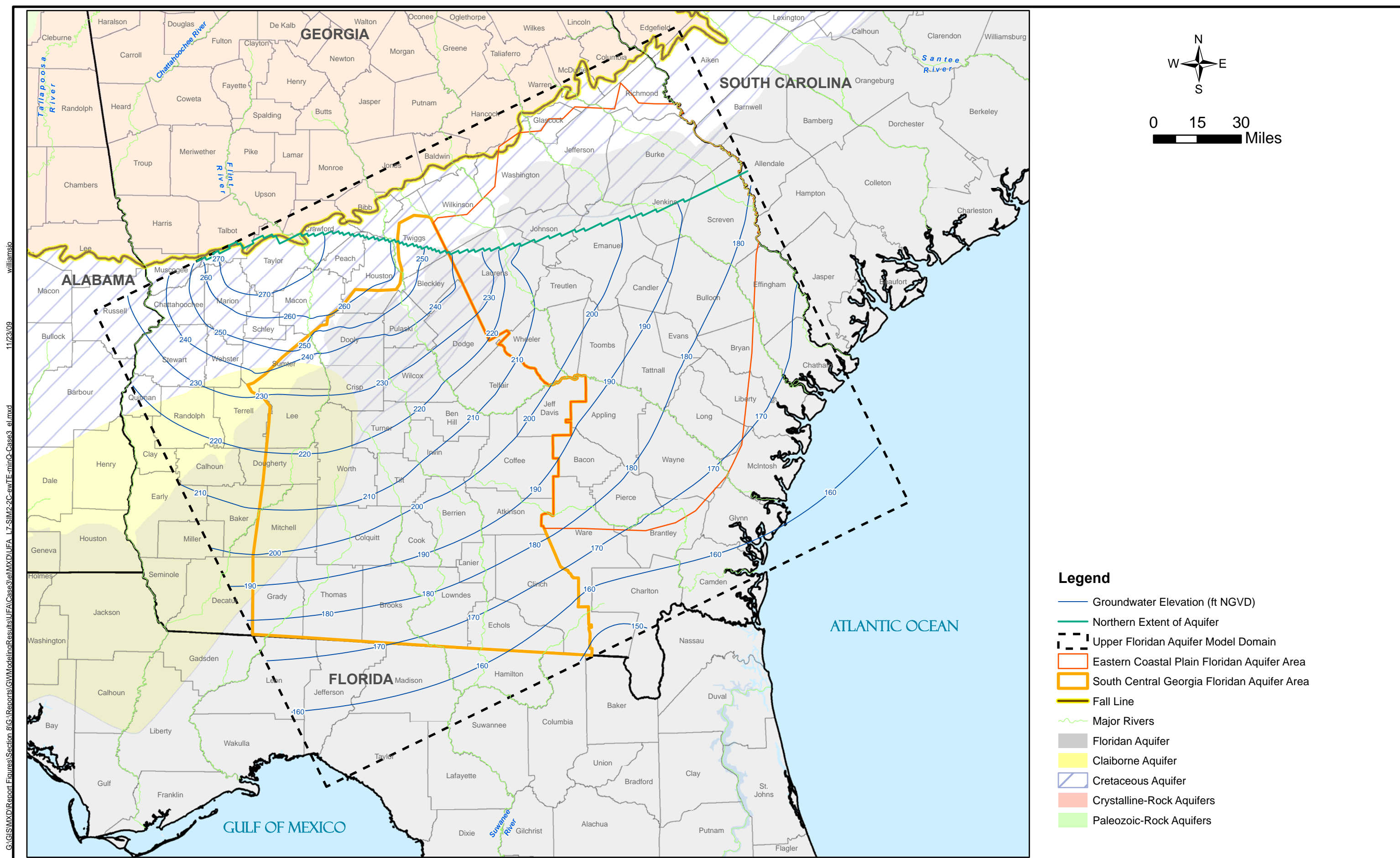


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Figure 13-23

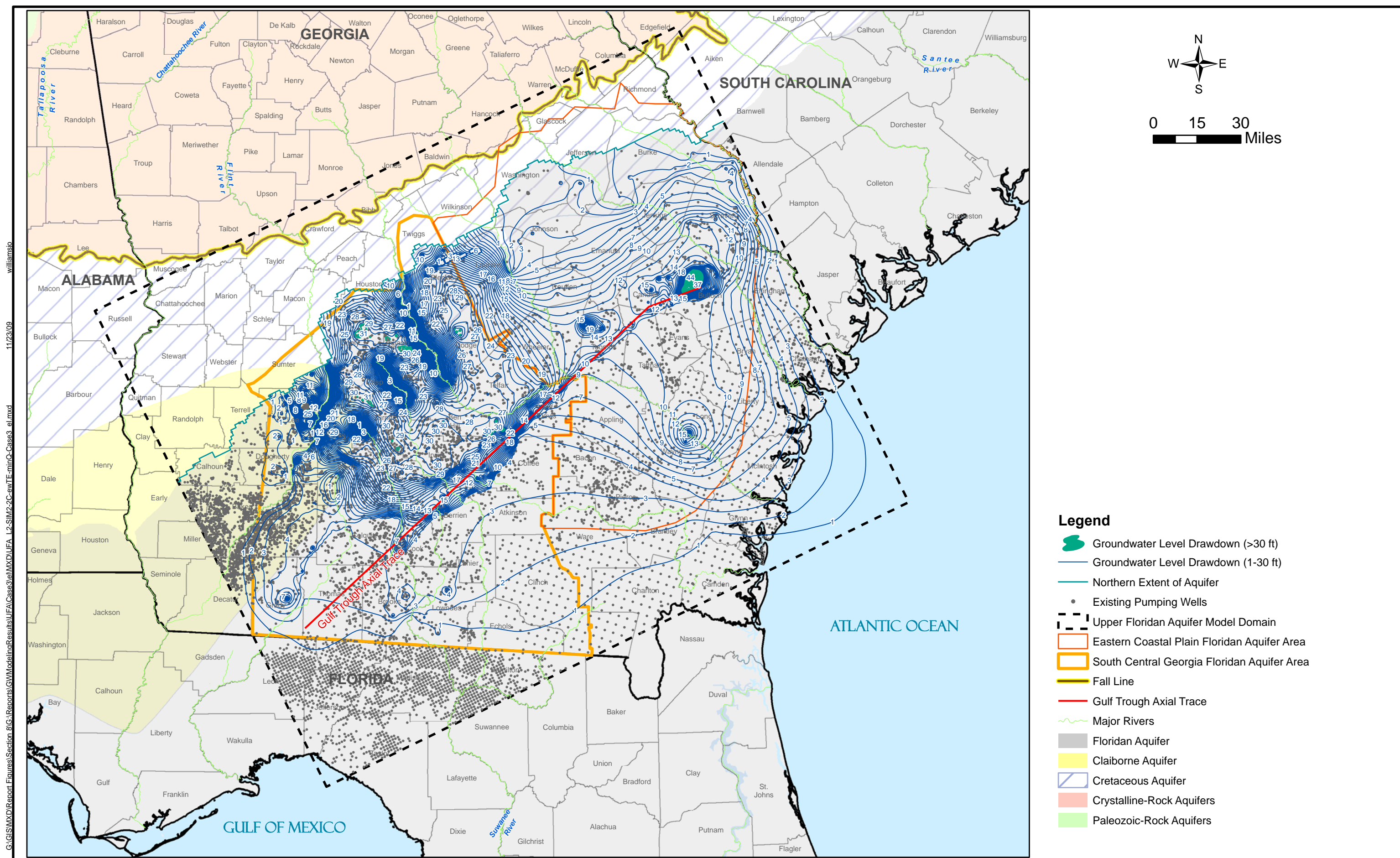
Simulated Groundwater Elevation in Eutaw-Midville Aquifer (Layer 6)

Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



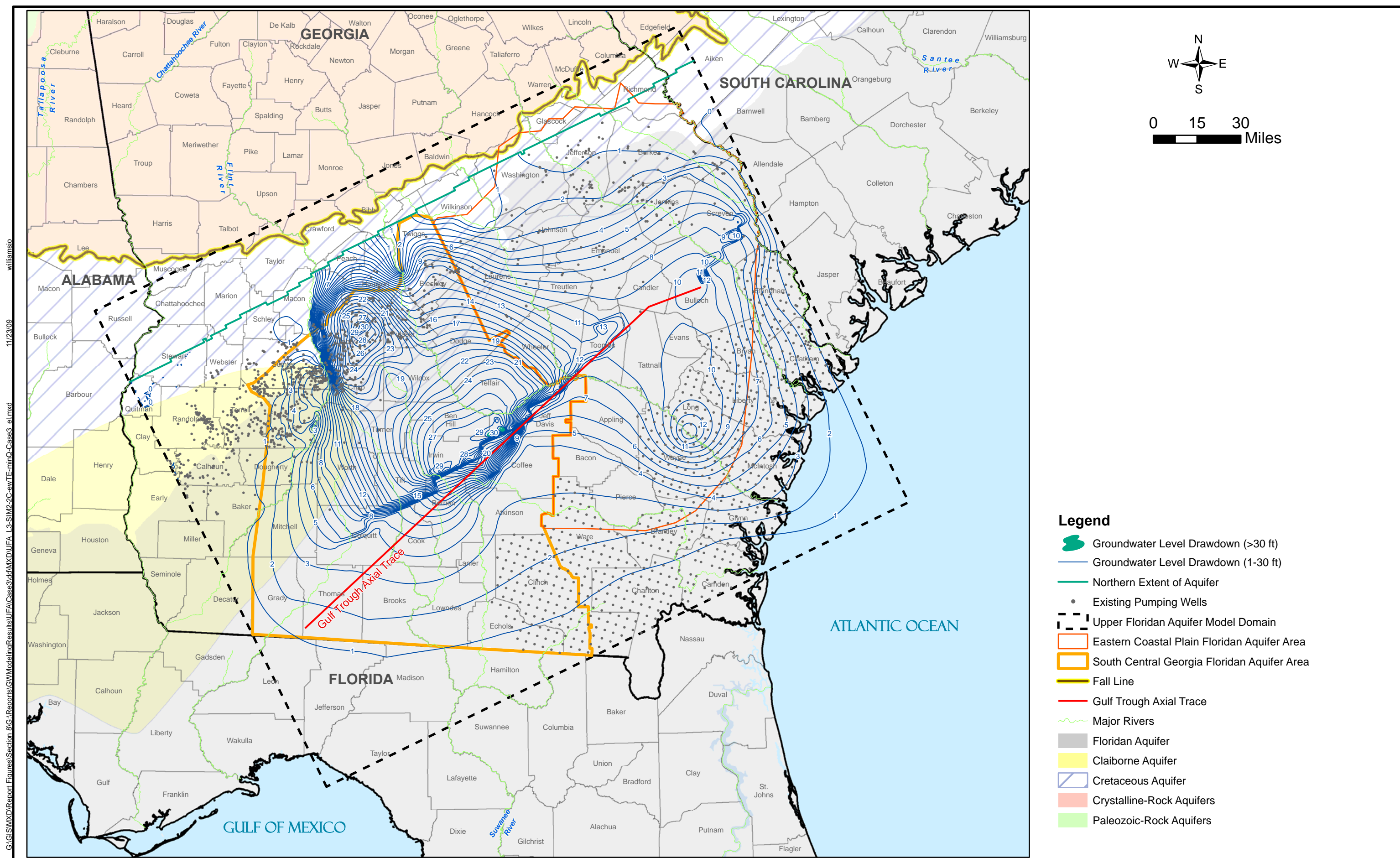
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CDM **Figure 13-24**
Simulated Groundwater Elevation in Upper Atkinson-Upper Tuscaloosa Aquifers (Layer 7)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



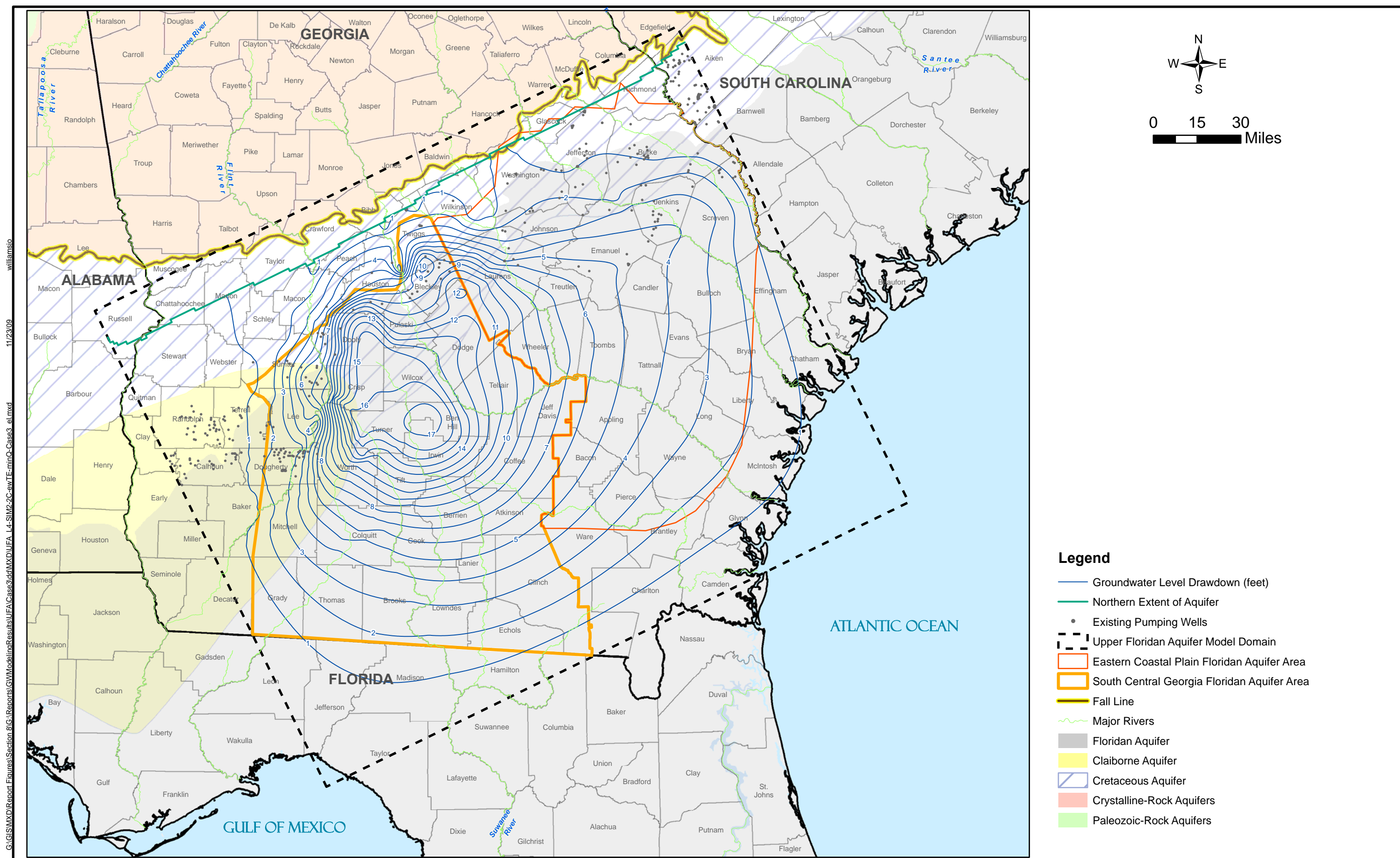
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CDM **Figure 13-25**
Simulated Groundwater Level Drawdown in Upper Floridan Aquifer (Layer 2)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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CDM **Figure 13-26**
Simulated Groundwater Level Drawdown in Claiborne/Gordon/Lower Floridan Aquifers (Layer 3)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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Figure 13-27

Simulated Groundwater Level Drawdown in Clayton-Dublin Aquifers (Layer 4)

Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

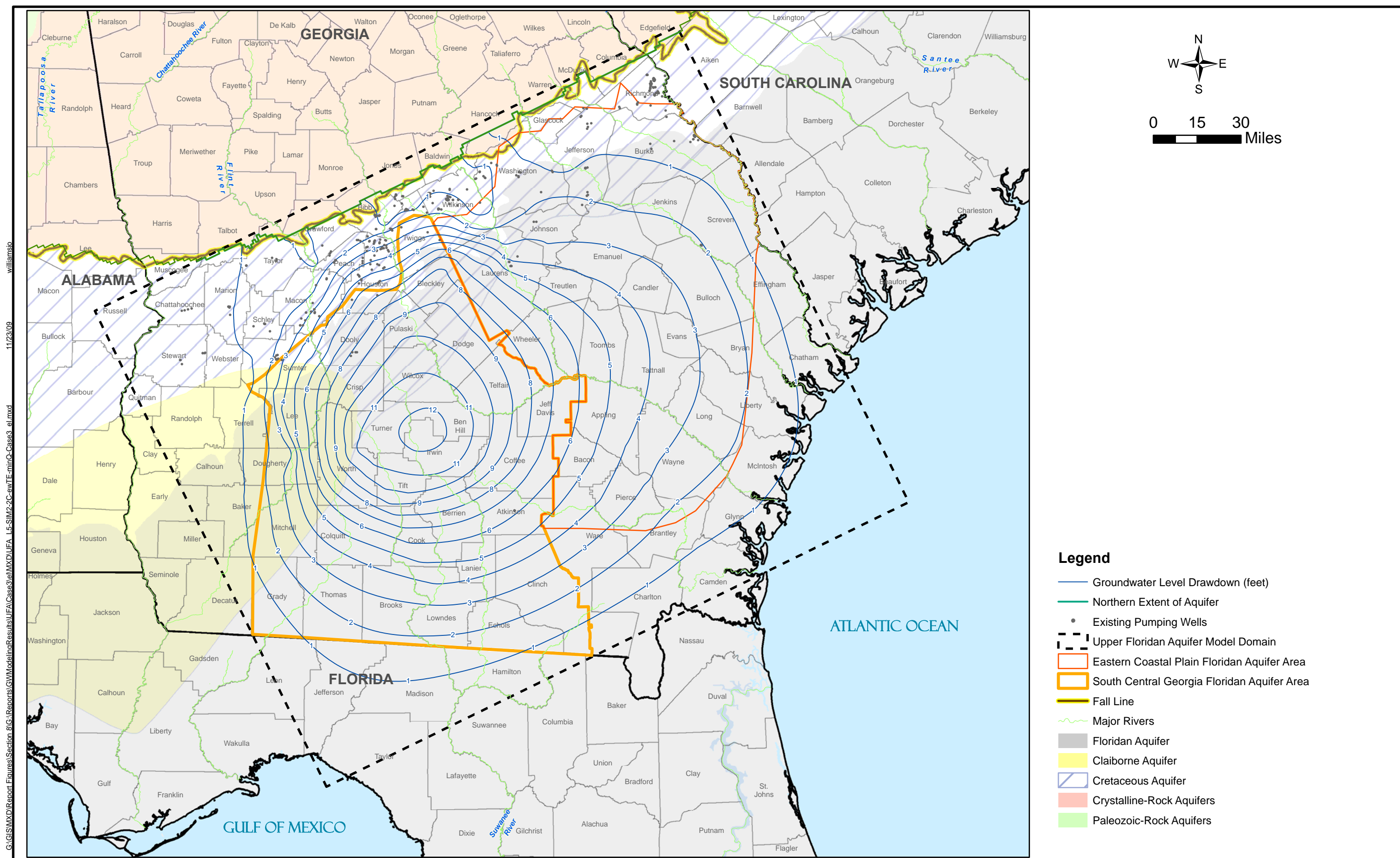
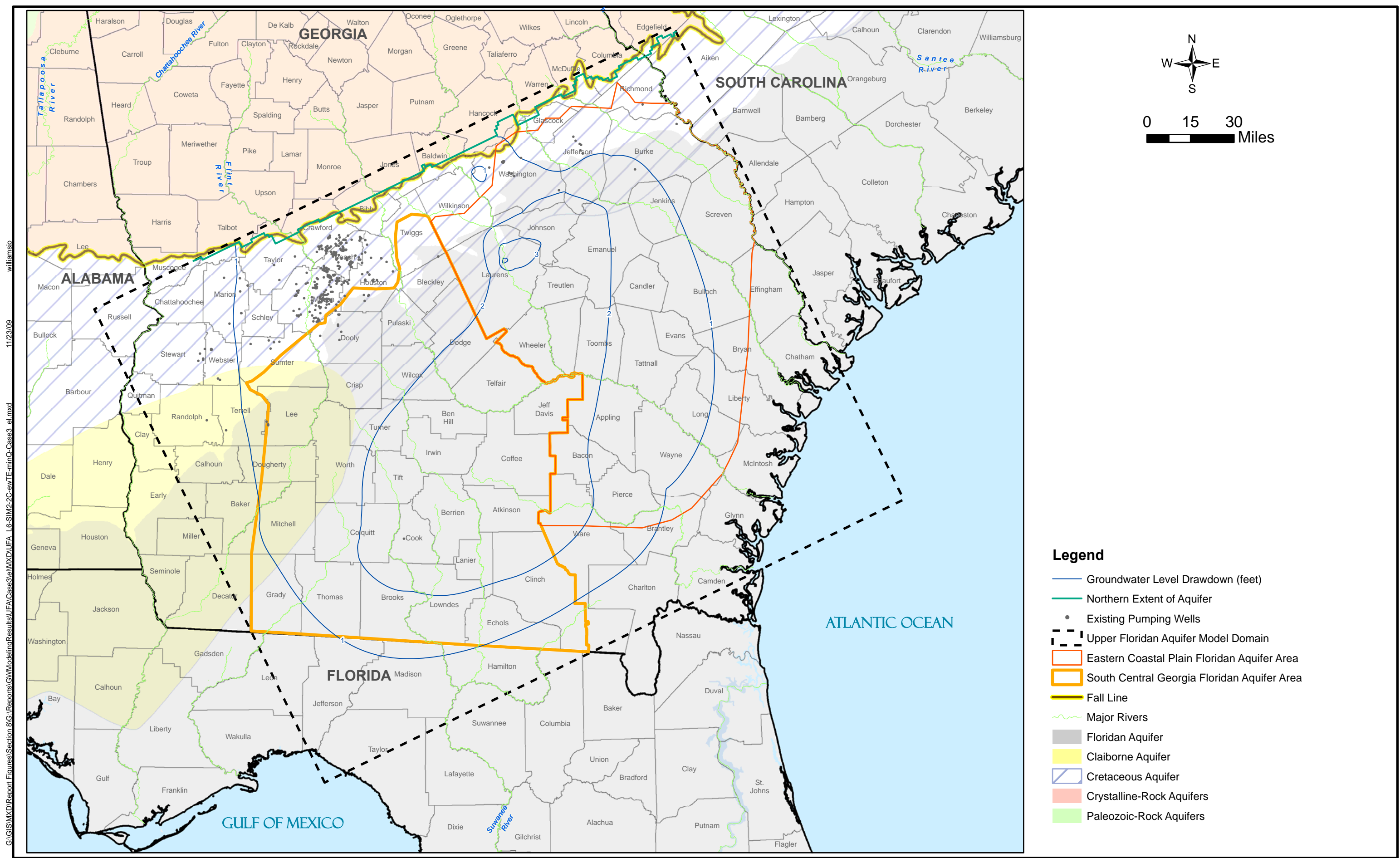
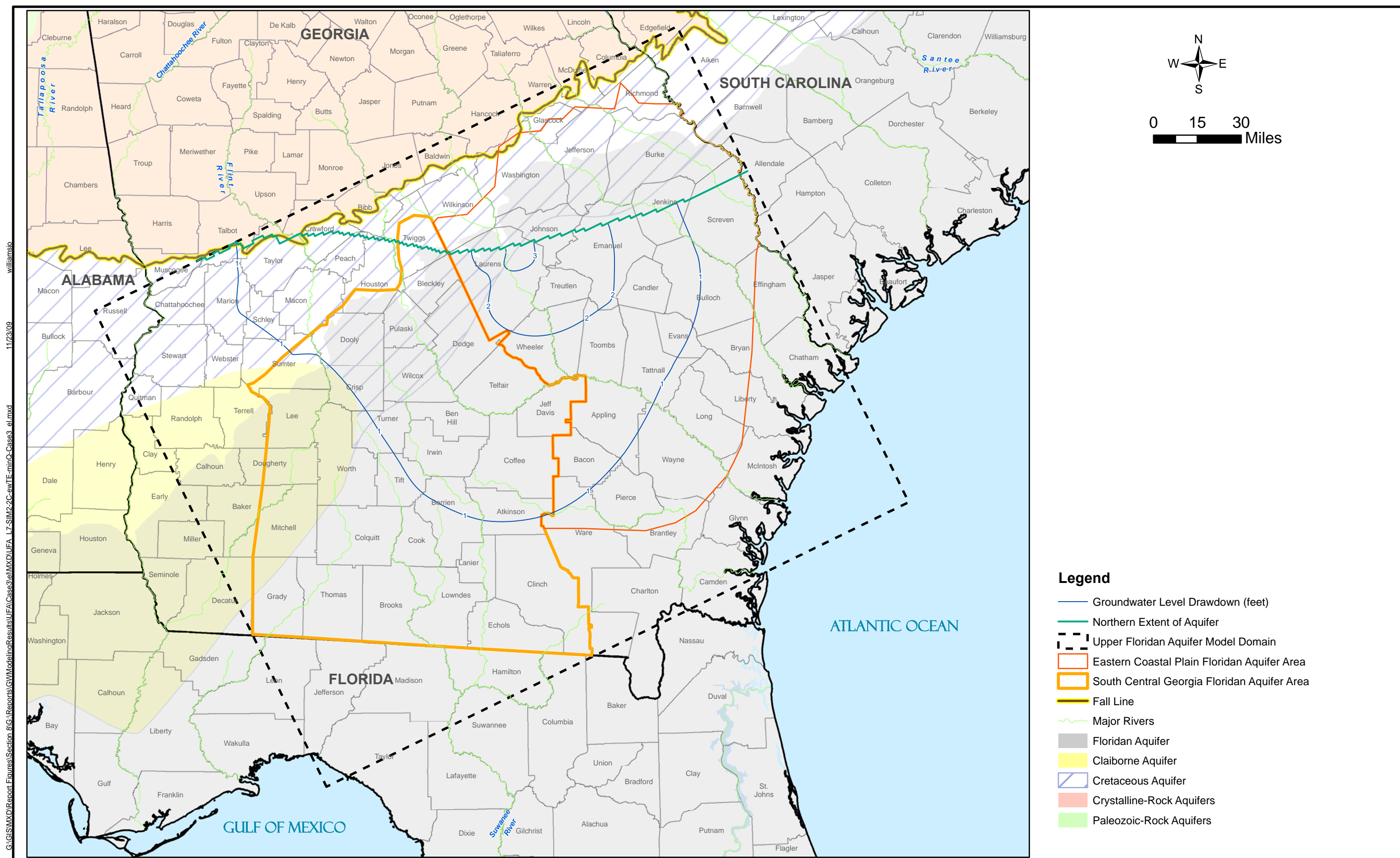


Figure 13-28
Simulated Groundwater Level Drawdown in Providence Sand-Peedee-Dublin Aquifers (Layer 5)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q= 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



CDM **Figure 13-29**

Simulated Groundwater Level Drawdown in Eutaw-Midville Aquifer (Layer 6)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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