Prepared in cooperation with the Tennessee Valley Authority

Effects of Groundwater Withdrawals Associated with Combined-Cycle Combustion Turbine Plants in West Tennessee and Northern Mississippi

Scientific Investigations Report 2012–5072

U.S. Department of the Interior
U.S. Geological Survey

Photographs. Front cover: Gleason combustion turbine plant, Weakley County, Tennessee; title page: Southaven combined-cycle plant, Desoto County, Mississippi. Photographs courtesy of Tennessee Valley Authority.

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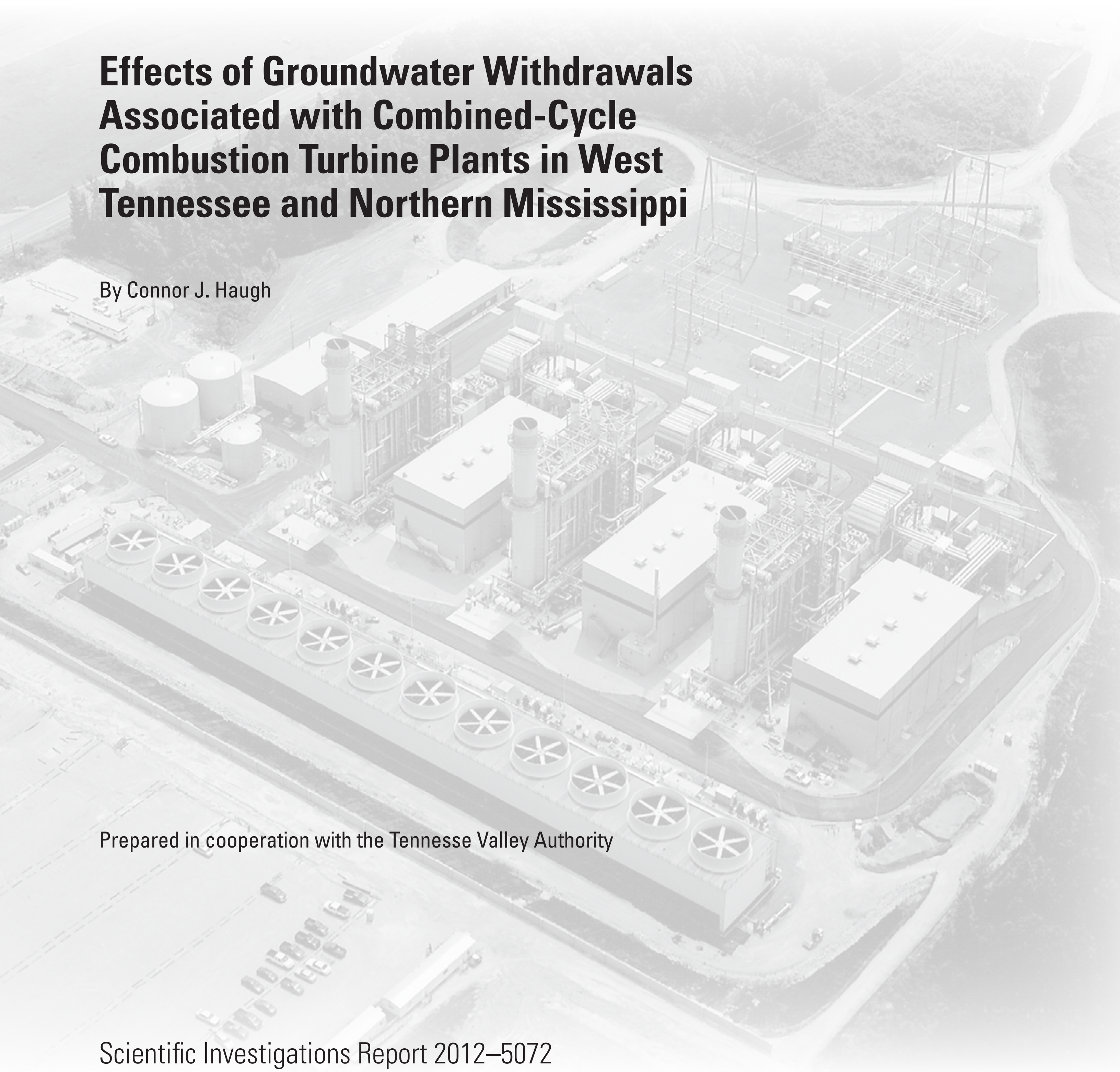

By Connor J. Haugh

Prepared in cooperation with the Tennesse Valley Authority

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U.S. Department of the Interior
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U.S. Department of the Interior
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U.S. Geological Survey
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Effects of Groundwater Withdrawals Associated with Combined-Cycle Combustion Turbine Plants in West Tennessee and Northern Mississippi

By Connor J. Haugh

Abstract

The Mississippi Embayment Regional Aquifer Study groundwater-flow model was used to simulate the potential effects on future groundwater withdrawals at five powerplant sites—Gleason, Weakley County, Tennessee; Tenaska, Haywood County, Tennessee; Jackson, Madison County, Tennessee; Southaven, DeSoto County, Mississippi; and Magnolia, Benton County, Mississippi. The scenario used in the simulation consisted of a 30-year average water-use period followed by a 30-day peak water-demand period. Effects of the powerplants on the aquifer system were evaluated by comparing the difference in simulated water levels in the aquifers at the end of the scenario (30 years plus 30 days) with and without the combined-cycle-plant withdrawals. Simulated potentiometric surface declines in source aquifers at potential combined-cycle-plant sites ranged from 56 feet in the upper Wilcox aquifer at the Magnolia site to 20 feet in the Memphis aquifer at the Tenaska site. The affected areas in the source aquifers at the sites delineated by the 4-foot potentiometric surface-decline contour ranged from 11,362 acres at Jackson to 535,143 acres at Southaven. The extent of areas affected by potentiometric surface declines was similar at the Gleason and Magnolia sites. The affected area at the Tenaska site was smaller than the affected areas at the other sites, most likely as a result of lower withdrawal rates and greater aquifer thickness. The extent of effect was smallest at the Jackson site, where the nearby Middle Fork Forked Deer River may act as a recharge boundary. Additionally, the Jackson site lies in the Memphis aquifer outcrop area where model-simulated recharge rates are higher than in areas where the Memphis aquifer underlies less permeable deposits.

The potentiometric surface decline in aquifers overlying or underlying a source aquifer was generally 2 feet or less at all the sites except Gleason. At the Gleason site, withdrawals from the Memphis aquifer resulted in declines of as much as 9 feet in the underlying Fort Pillow aquifer. The simulated potentiometric surface change occurring in the Fort Pillow aquifer appears to be the result of leakage through the Flour Island Formation separating the Memphis and Fort Pillow aquifers where this confining unit is thin, sandy, or absent.

Introduction

As demand for electrical power increases, so does the need for water to operate electrical generation facilities. To meet rising electrical demands, the Tennessee Valley Authority (TVA) is considering the use of existing combined-cycle plants in West Tennessee and northern Mississippi and the conversion of simple-cycle plants to combined-cycle operation. The plants use groundwater for emission control and for cooling. Simple-cycle plants can use as much as about 300 gallons per minute (gal/min) of water, and combined-cycle plants can use as much as 4,000 gal/min, depending on plant megawatt capacity. Depending on location, local groundwater conditions, and the aquifers used by the plants, the use of groundwater for the combined-cycle plants could affect groundwater levels in nearby domestic and municipal wells. Given these considerations, the effects of groundwater withdrawals at combined-cycle turbine plants on the aquifers and on groundwater levels are being evaluated.

In 2008, the U.S. Geological Survey (USGS), in cooperation with TVA, began an investigation to define the potential effects of groundwater withdrawals associated with combined-cycle-turbine-plant operation on the Mississippi embayment aquifer system in West Tennessee and northern Mississippi. In these areas, groundwater is the sole source of water for municipal and industrial supply. The primary sources of groundwater are the Memphis and Fort Pillow aquifers, which are the two principal aquifers of the Mississippi embayment aquifer system in West Tennessee (Parks and Carmichael, 1989, 1990). Self-supplied domestic groundwater typically is produced from shallow zones including the terrace deposits or Cockfield aquifer, which constitute the “water-table” aquifer(s) at many locations. The Mississippi Embayment Regional Aquifer Study (MERAS) was recently completed as part of the Groundwater Resources Program of the USGS to assess groundwater availability within the Mississippi embayment. The MERAS groundwater-flow model was the primary tool used in the assessment of groundwater availability (Clark and Hart, 2009).

Purpose and Scope

This report presents an analysis of the potential effects of groundwater withdrawals at the following five sites: Gleason, Weakley County, Tennessee; Tenaska, Haywood County, Tennessee; Jackson, Madison County, Tennessee; Southaven, DeSoto County, Mississippi; and Magnolia, Benton County, Mississippi (fig. 1). The effects of groundwater withdrawals at plant sites, in conjunction with existing withdrawals, were analyzed using the MERAS regional groundwater-flow model (Clark and Hart, 2009). Local grid refinement (LGR; Mehl and Hill, 2005) was added to the MERAS model for a more detailed analysis at two of the sites. Water-use estimates for the plant sites were provided by TVA. Water-use trends and population-growth projections were used to estimate future water demands from existing withdrawals.

Approach

The effects of groundwater withdrawals were simulated for the locations of five prospective combined-cycle plants for a 30-year period of average water use followed by a 30-day period of peak water use. Groundwater withdrawals at each of the sites were simulated using the MERAS groundwater-flow model beginning in 2007. Water use by the combined-cycle combustion plants was assumed to be constant over the 30-year period. Projections of future water-supply withdrawals were estimated assuming a linear growth of 2 percent per year. Six stress periods of 5 years each plus a 30-day stress period were used for model simulations. At the end of the 30-year simulation period, an additional short-term stress period of 30 days followed using the projected 30-day peak water withdrawals at the plant sites. Effects of the powerplants on the aquifer system were evaluated by comparing the difference in simulated water levels in the aquifers at the end of the scenario (30 years plus 30 days) with and without the combined-cycle-plant withdrawals.

The grid-cell size of the MERAS flow model is 1 square mile (mi^2) [1 mile (mi) by 1 mi]. A more detailed local evaluation was simulated for the Gleason and Tenaska sites using a refined model grid generated with the LGR package (Mehl and Hill, 2005). The grid-cell size of the local models is 0.04 mi^2 (0.2 mi by 0.2 mi).

Study Area

The simulated sites in West Tennessee and northern Mississippi lie in the gently rolling terrain of the Gulf Coastal Plain Physiographic Province (Fenneman, 1938). Land-surface altitudes range from about 200 feet (ft) near the Mississippi River to more than 500 ft in the upland hills in the eastern part of the study area. Average annual precipitation ranges from about 50 to 54 inches and is uniformly distributed throughout the year. The mean annual temperature is about 59 degrees Fahrenheit (^{o}F). Mean summer temperature is about 79 ^{o}F, and mean winter temperature is about 40 ^{o}F (National Oceanic and Atmospheric Administration, 2002).

Regional aquifers in the area are part of the Mississippi embayment aquifer system. The regional aquifers are formed by deposits of Tertiary age that make up the Claiborne and Wilcox Groups (table 1). In Tennessee, the aquifer system includes, in descending order, the following units: the Cockfield Formation (Cockfield or upper Claiborne aquifer) of the Claiborne Group, the Memphis Sand (Memphis or middle and lower Claiborne aquifer) of the Claiborne Group, and the Fort Pillow Sand (Fort Pillow aquifer) of the Wilcox Group. In northern Mississippi, the aquifer system includes, in descending order, the Cockfield Formation (Cockfield aquifer), the Sparta Sand (Sparta aquifer) of the Claiborne Group, and underlying sands of the Claiborne and Wilcox Groups that make up the lower Claiborne–upper Wilcox aquifer and the lower Wilcox aquifer (Hosman and Weiss, 1991).

Regional Model

The MERAS model covers 97,000 mi^2 and consists of 13 model layers with grid cells of 1 mi^2. The model code used for the MERAS model is MODFLOW 2005 (Harbaugh, 2005). Model layers correspond to aquifers and confining units from land surface down to the top of the Midway Group. In Tennessee these layers include the following aquifers: the fluvial deposits aquifer, the Cockfield aquifer, the Memphis aquifer, and the Fort Pillow aquifer. The MERAS model simulations span more than 130 years from 1870 to 2007 and incorporate the most current water-use data available (Clark and Hart, 2009).

Water-Use Trends

Groundwater use for the next 30 years was estimated on the basis of historic trends and population-growth projections. Nationwide, withdrawals for irrigation increased from 1950 to 1980 but have stabilized since 1985. This stabilization in irrigation withdrawals can be attributed to climate, crop type, advances in irrigation efficiency, and higher energy costs (Hutson and others, 2004). Groundwater use for public supply in Tennessee for the 30-year period from 1970 through 2000 increased at an average annual rate of 2.4 percent. During this time, the average annual rate of growth of groundwater withdrawal for public supply slowed, with average annual rates of 2.8 percent from 1970 to 1980, 2.5 percent from 1980 to 1990, and 1.9 percent from 1990 to 2000 (Webbers, 2003). Future groundwater withdrawals for public supply also were estimated using population projections (University of Tennessee, 2003). Population projections for 5-year increments for the period 2010 to 2040 for each municipality in West Tennessee were multiplied by the current per capita water use of each public water-supply system to estimate future groundwater

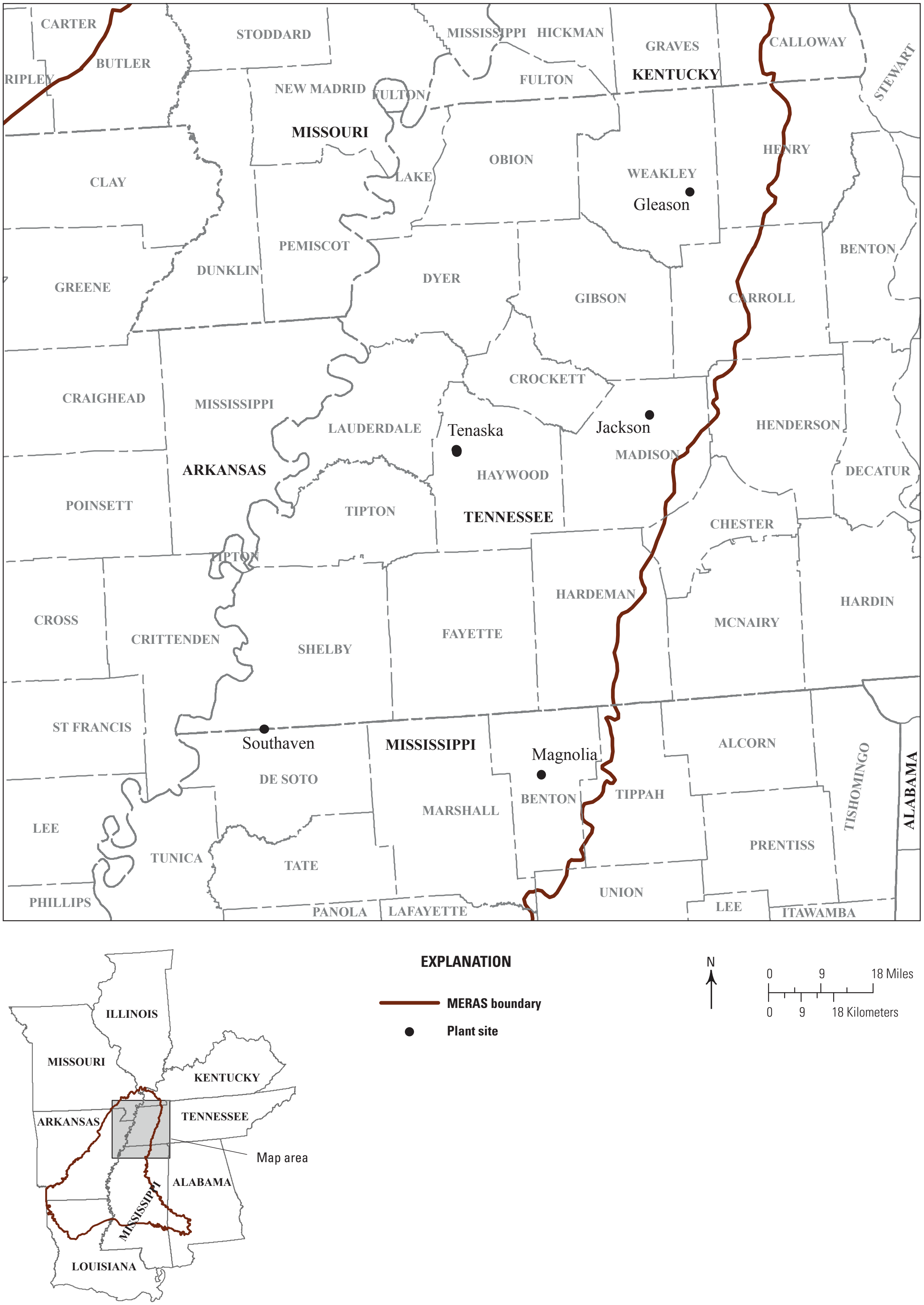


Figure 1. Locations of potential combined-cycle turbine plants in Tennessee and Mississippi.

Table 1. Generalized correlation chart of units of Tertiary age of the Claiborne and Wilcox Groups in Tennessee and northern Mississippi.

[Fm, Formation]

System	Series	Group	Tennessee	Northern Mississippi	Regional hydrogeologic unit
Tertiary	Eocene	Claiborne	Cockfield Fm (Cockfield aquifer)	Cockfield Fm (Cockfield aquifer)	Upper Claiborne aquifer
			Cook Mountain Fm	Cook Mountain Fm	Middle Claiborne confining unit
			Memphis Sand (Memphis aquifer)	Sparta Sand (Sparta aquifer)	Middle Claiborne aquifer
				Zilpha Clay	Lower Claiborne confining unit
				Lower sands in the Claiborne Group	Lower Claiborne-Upper Wilcox aquifer
		Wilcox	Flour Island Fm	Upper sands in the Wilcox Group	
	Paleocene		Fort Pillow Sand (Fort Pillow aquifer)	Lower sands in the Wilcox Group	Middle Wilcox aquifer
			Old Breastworks Fm		Lower Wilcox aquifer
		Midway	Porters Creek Clay	Porters Creek Clay	Midway confining unit
			Clayton Fm	Clayton Fm	

Modified from Hosman and Weiss, 1991.

demand. The average annual rate of growth for all public groundwater supplies in West Tennessee was 0.7 percent with most individual public-supply systems ranging from 0 to 1.2 percent. Combining the two approaches, withdrawals for public groundwater use were assumed to increase at an average annual rate of 2 percent. Groundwater withdrawals for irrigation were assumed to remain constant at 2007 levels.

Effects of Groundwater Withdrawals

The effects of groundwater withdrawals associated with the operation of combined-cycle turbine plants were evaluated by comparing simulations with and without pumping at the five plant sites (table 2). The differences in water levels between these two simulations were contoured to provide an overall measure of effects (figs. 2 and 3; table 3).

Table 2. Annual average and 30-day maximum water demand at proposed combined-cycle turbine plants.

[gal/min, gallons per minute]

Plant	Source aquifer	Number of wells	Annual average water demand (gal/min)	30-day maximum water demand (gal/min)
Gleason	Memphis	4	2,460	3,473
Tenaska	Memphis	5	1,643	2,315
Jackson	Memphis	—	2,460	3,473
Southaven	Lower Wilcox	6	2,460	3,473
Magnolia	Upper Wilcox	12	1,968	2,778
	Lower Wilcox	3	492	695

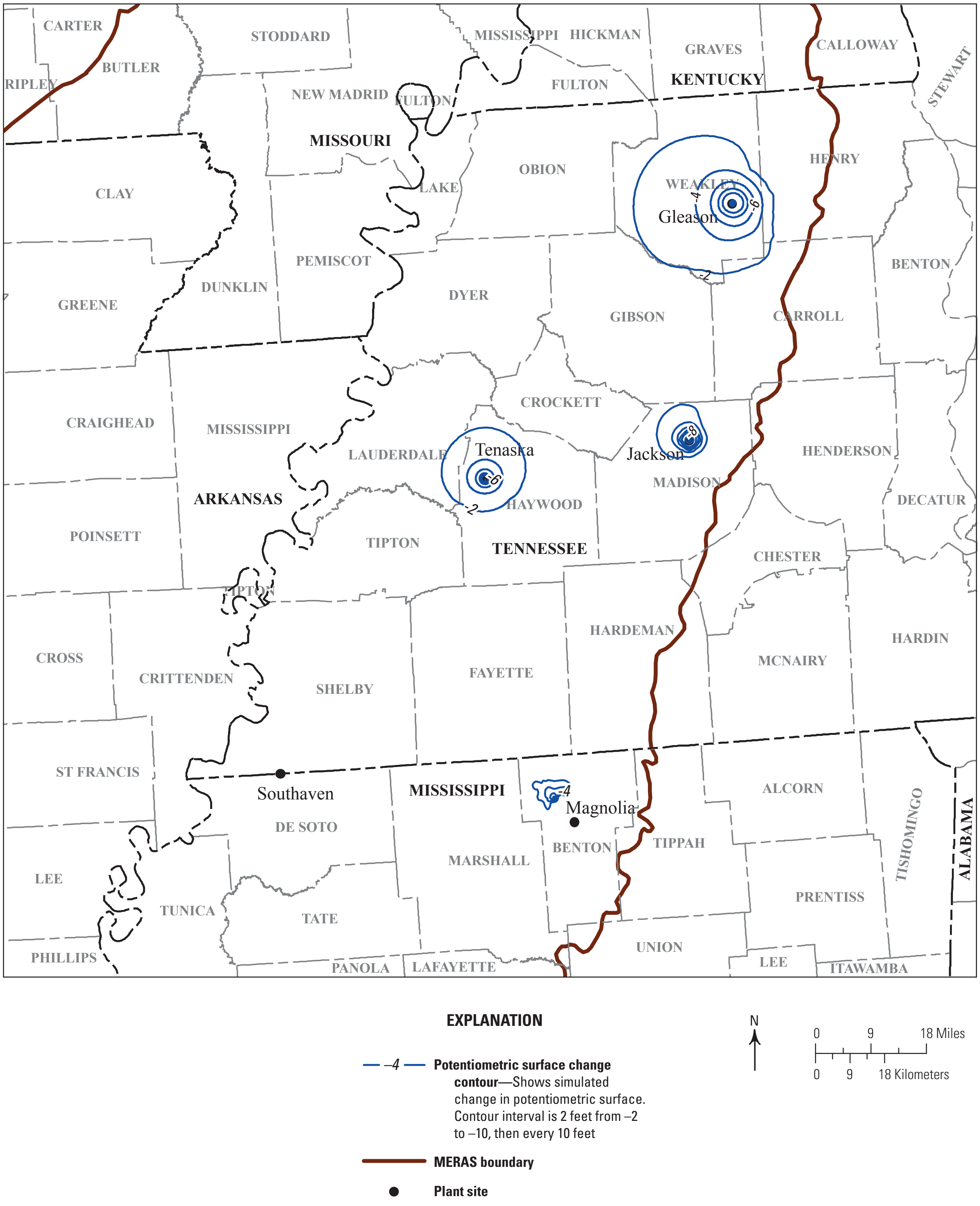
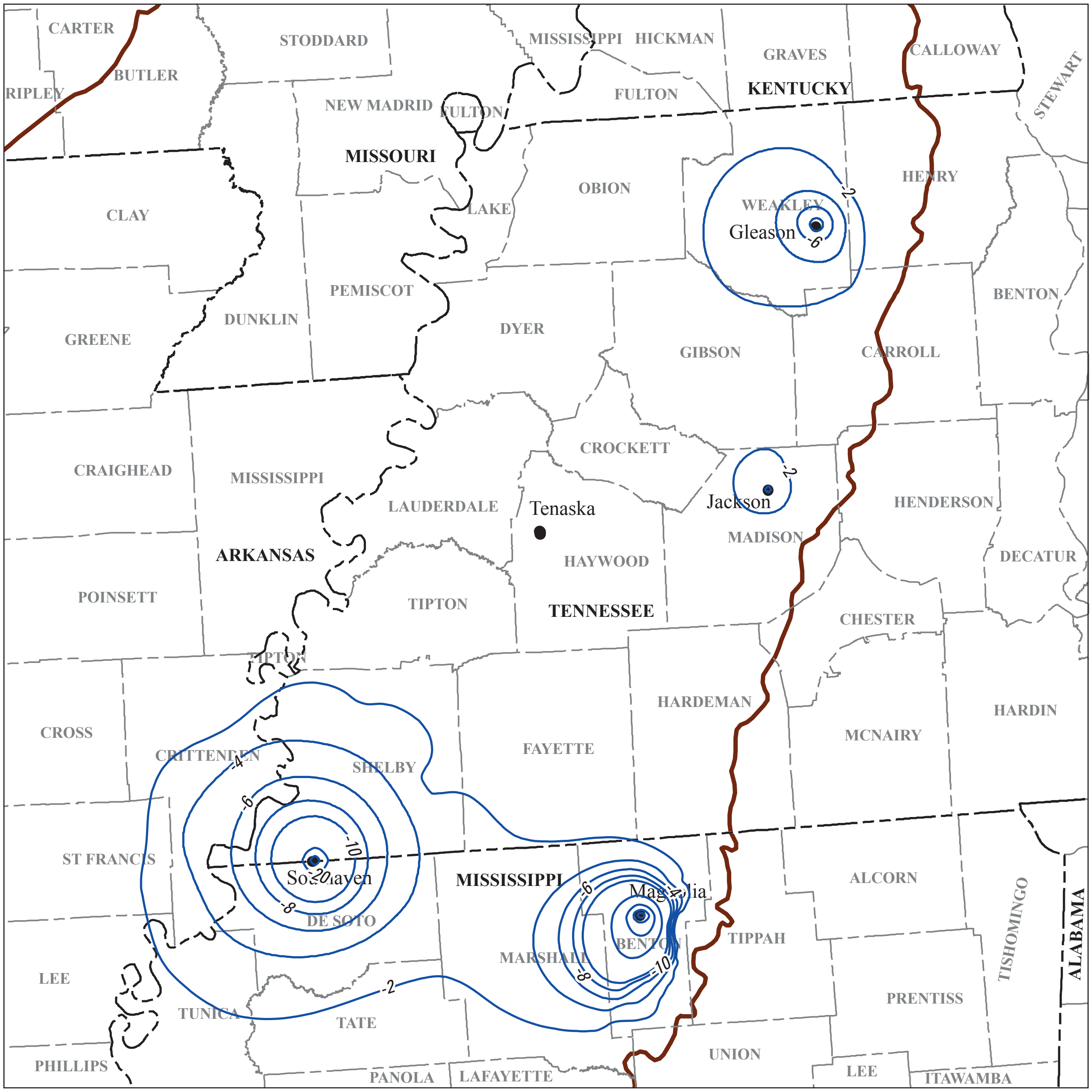


Figure 2. Simulated potentiometric surface change in the Memphis/Sparta aquifer from combined-cycle-plant withdrawals at proposed combined-cycle turbine plants.



EXPLANATION

—−10— **Potentiometric surface change contour**—Shows simulated change in potentiometric surface. Contour interval is 2 feet from –2 to –10, then every 10 feet

MERAS boundary

● **Plant site**

N

0 9 18 Miles

0 9 18 Kilometers

Figure 3. Simulated potentiometric surface change in the Lower Wilcox/Fort Pillow aquifer from combined-cycle-plant withdrawals at proposed combined-cycle turbine plants.

Gleason

The Gleason site (fig. 1) is estimated to have an annual average groundwater withdrawal of 2,460 gal/min and a 30-day maximum water withdrawal of 3,473 gal/min (table 2). For the simulation, four wells at the site pumped water from the Memphis aquifer (table 3). To obtain more detailed resolution in the simulation, local grid refinement was used at the Gleason site (fig. 4). At the end of the TVA withdrawal scenario, the simulated potentiometric surfaces at the plant site in the model cell containing well G5 declined by 40 ft in the Memphis aquifer (fig. 5) and 9 ft in the Fort Pillow aquifer (fig. 6). The simulated changes in the Fort Pillow aquifer appear to be the result of leakage through the Flour Island Formation, which separates the Memphis and Fort Pillow aquifers where the confining unit is thin, sandy, or absent.

Table 3. Annual average and 30-day maximum water demand by well at the Gleason site.

[gal/min, gallons per minute]

G-1	Memphis	516	1,000
G-2	Memphis	48	473
G-3	Memphis	896	1,000
G-5	Memphis	1,000	1,000

Tenaska

The Tenaska site (fig. 1) is estimated to have an annual average water withdrawal of 1,643 gal/min and a 30-day maximum water withdrawal of 2,315 gal/min (table 2). For the simulation, five wells at the site pumped water from the Memphis aquifer (table 4). To obtain more detailed resolution in the simulation, local grid refinement was used at the Tenaska site (fig. 7). At the end of the TVA withdrawal scenario, simulated potentiometric surfaces at the plant site in the model cell containing well T4 declined by 20 ft in the Memphis aquifer (fig. 8), about 1 ft in the Cockfield aquifer, and 2 ft in the Fort Pillow aquifer.

Jackson

The Jackson site (fig. 1) is estimated to have an annual average water withdrawal of 2,460 gal/min and a 30-day maximum water withdrawal of 3,473 gal/min (table 2). For the simulation, wells at the site pumped water from the Memphis aquifer. At the end of the TVA withdrawal scenario, simulated potentiometric surfaces in the 1-mi^2 model cell located at the plant site declined by 35 ft in the Memphis aquifer (fig. 9) and 4 ft in the Fort Pillow aquifer (fig. 10). The areal extent of the decline at the Jackson site appears to be limited by a nearby recharge boundary at the Middle Fork Forked Deer River, which may provide a source of water to the aquifer. Additionally, the Jackson site lies in the Memphis aquifer outcrop where model-simulated recharge rates are higher than in areas where the Memphis aquifer underlies less permeable deposits.

Table 4. Annual average and 30-day maximum water demand by well at the Tenaska site.

[gal/min, gallons per minute]

Well	Source aquifer	Annual average water demand (gal/min)	30-day maximum water demand (gal/min)
T-1	Memphis	538	758
T-2	Memphis	0	0
T-3	Memphis	373	526
T-4	Memphis	690	972
T-5	Memphis	42	59

Southaven

The Southaven site (fig. 1) is estimated to have an annual average water withdrawal of 2,460 gal/min and a 30-day maximum water withdrawal of 3,473 gal/min (table 2). For the simulation, six wells at the site pumped water from the lower Wilcox aquifer (Fort Pillow aquifer equivalent). At the end of the TVA withdrawal scenario, simulated potentiometric surfaces in the 1-mi^2 model cell located at the plant site declined by 38 ft in the lower Wilcox aquifer (fig. 11) and about 1 ft in the overlying Memphis aquifer.

Magnolia

The Magnolia site (fig. 1) is estimated to have an annual average water withdrawal of 2,460 gal/min and a 30-day maximum water withdrawal of 3,473 gal/min (table 2). For the simulation at this site, 12 wells pumped water from the upper Wilcox aquifer and 3 wells from the lower Wilcox aquifer. Pumping was apportioned between the two aquifers on the basis of the number of wells in each aquifer. At the end of the TVA withdrawal scenario, simulated potentiometric surfaces in the 1-mi^2 model cell located at the plant site declined by 56 ft in the upper Wilcox aquifer (fig. 12) and 51 ft in the lower Wilcox aquifer (fig. 13). The spatial extent of change in both aquifers is constrained to the south and east by the boundary of the aquifers.

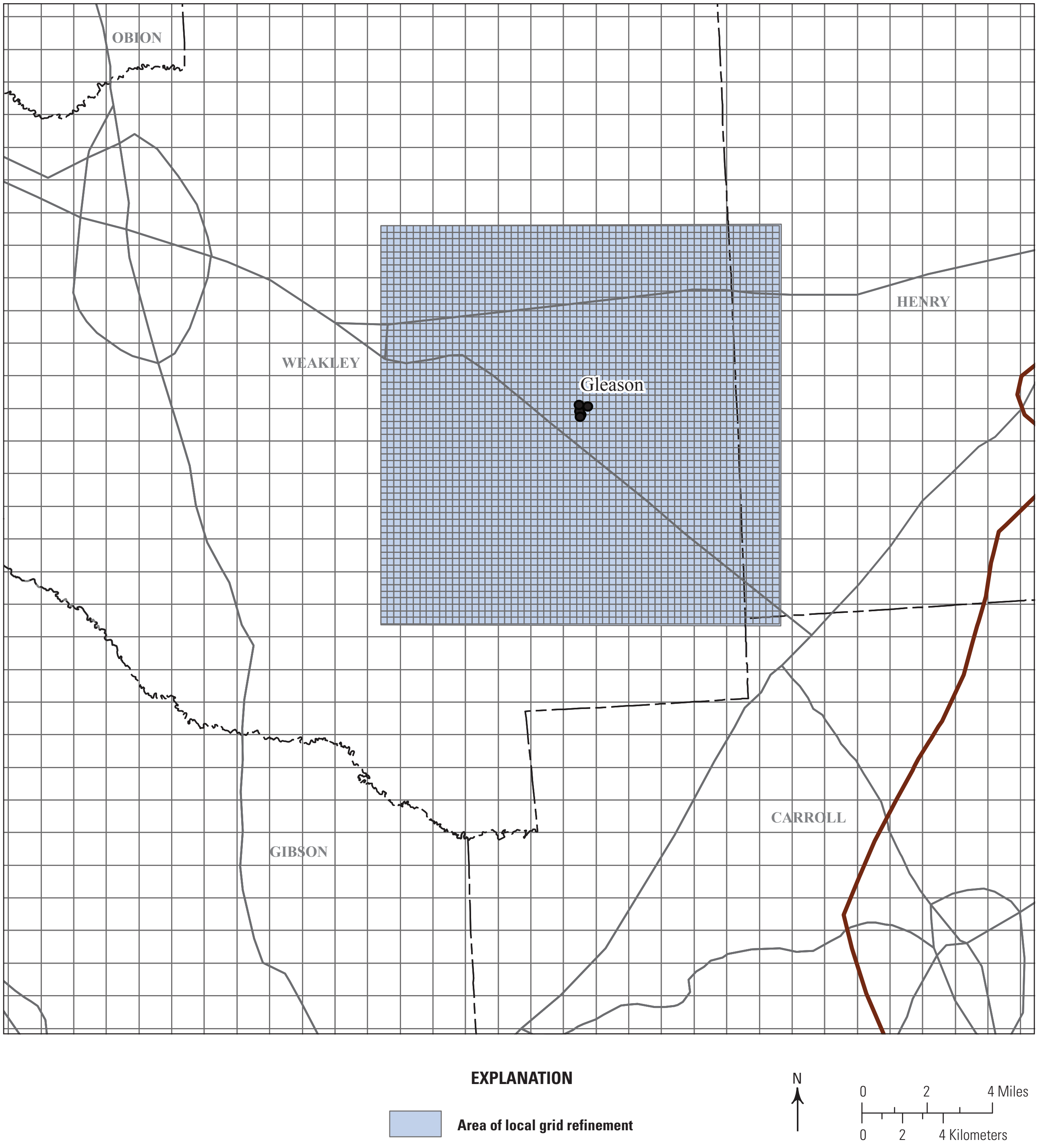


Figure 4. Local grid refinement area at the Gleason site, Weakley County, Tennessee.

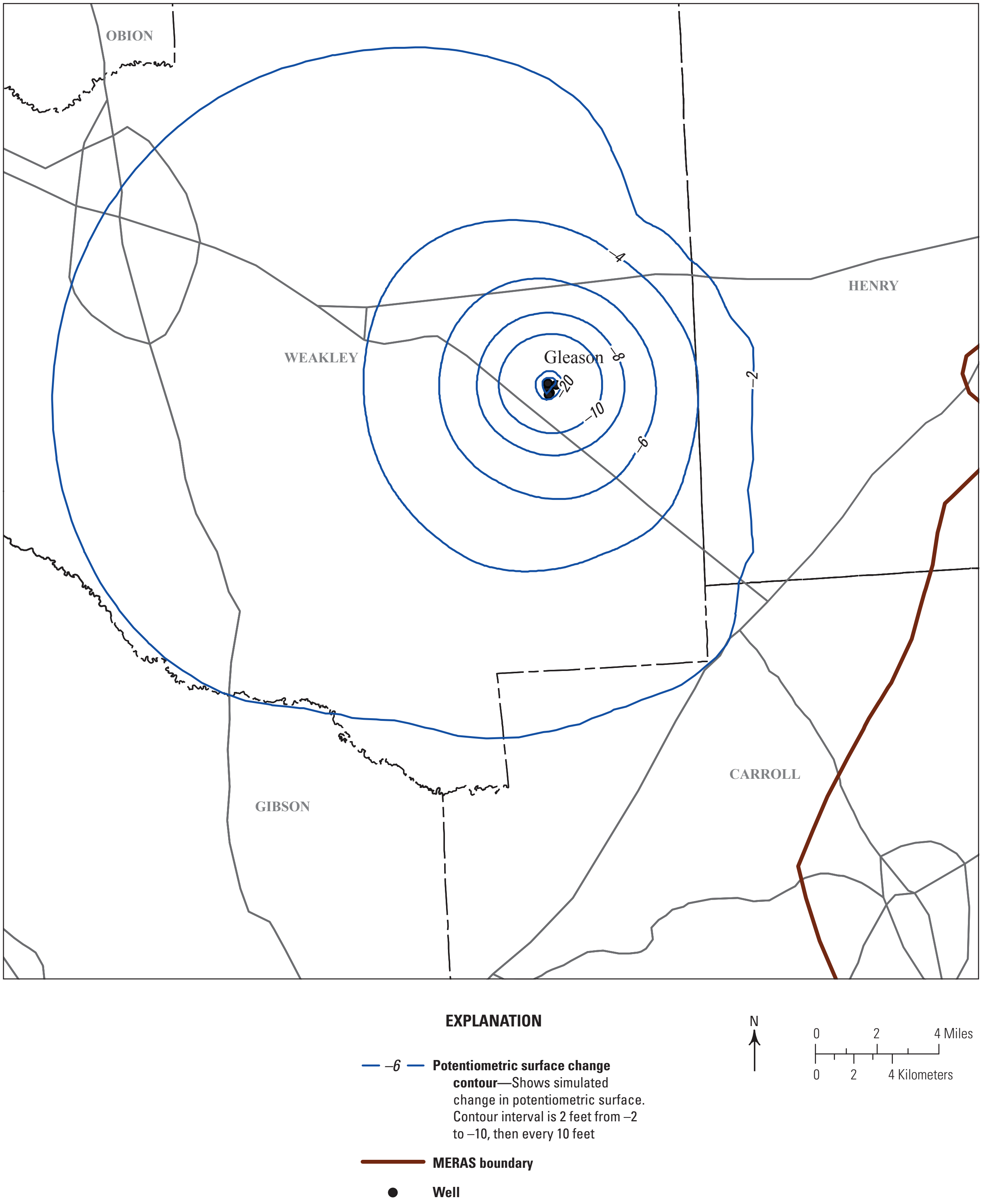


Figure 5. Simulated potentiometric surface change in the Memphis aquifer from combined-cycle-plant withdrawals at the Gleason site, Weakley County, Tennessee.

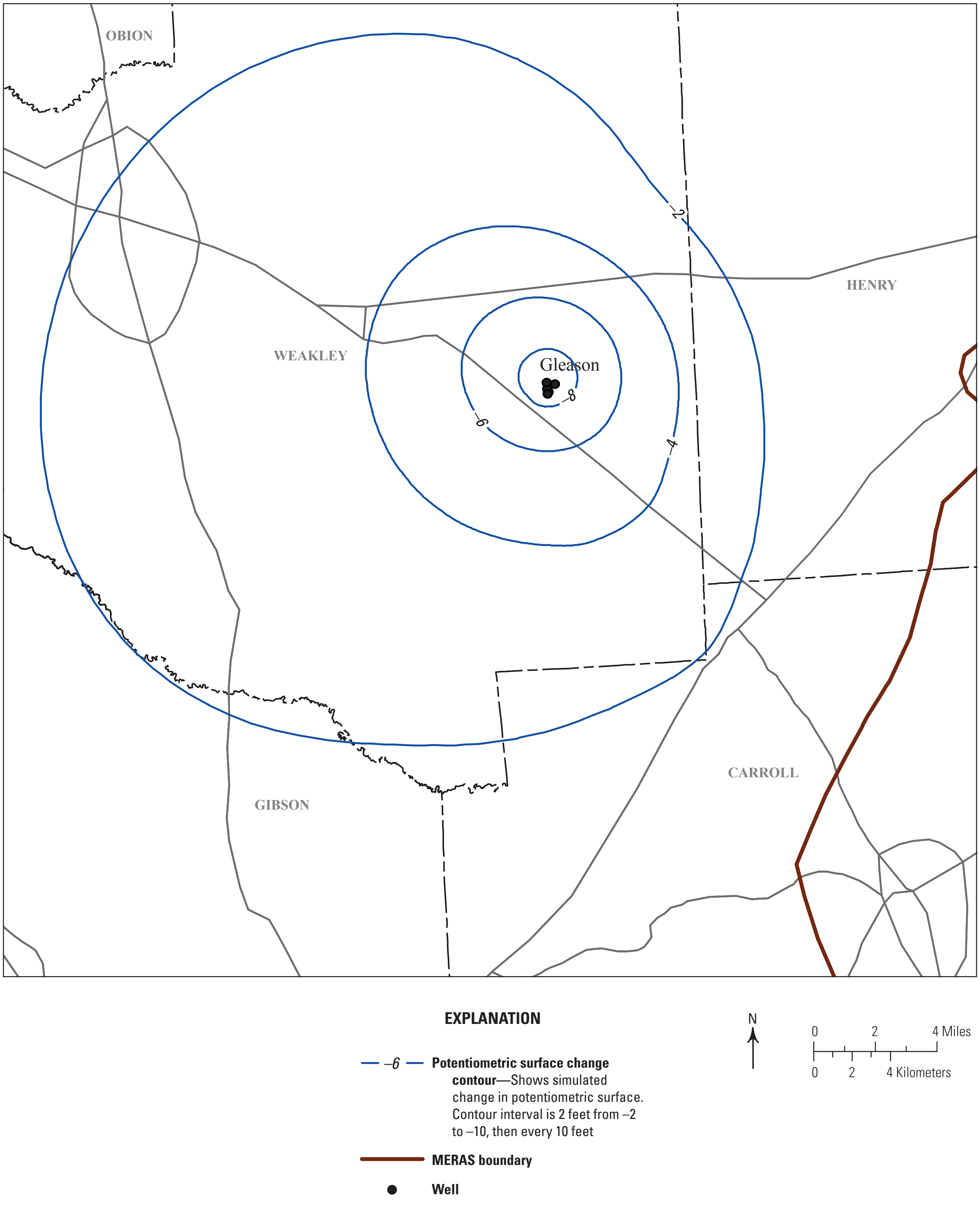


Figure 6. Simulated potentiometric surface change in the Fort Pillow aquifer from combined-cycle-plant withdrawals at the Gleason site, Weakley County, Tennessee.

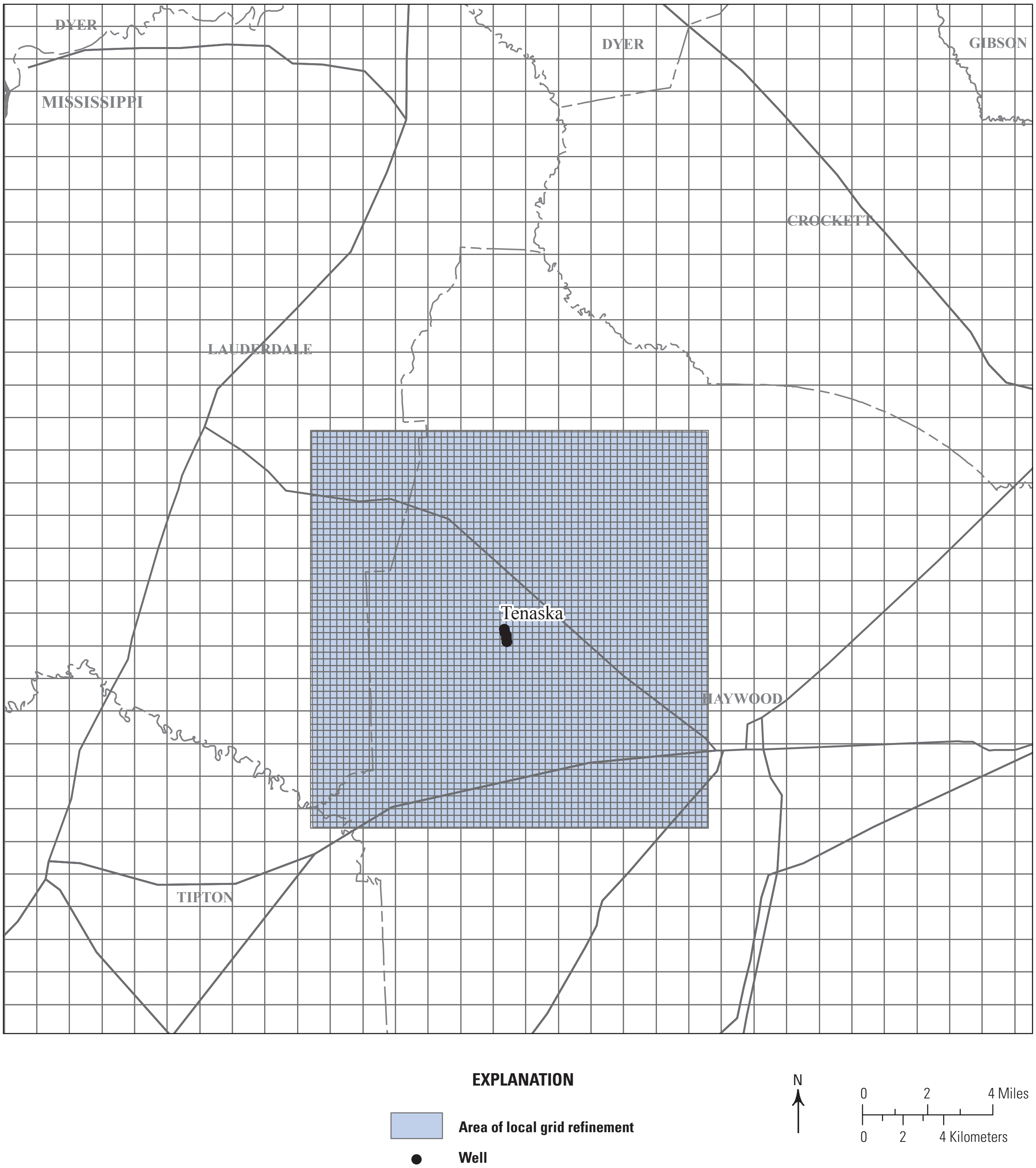


Figure 7. Local grid refinement area at the Tenaska site, Haywood County, Tennessee.

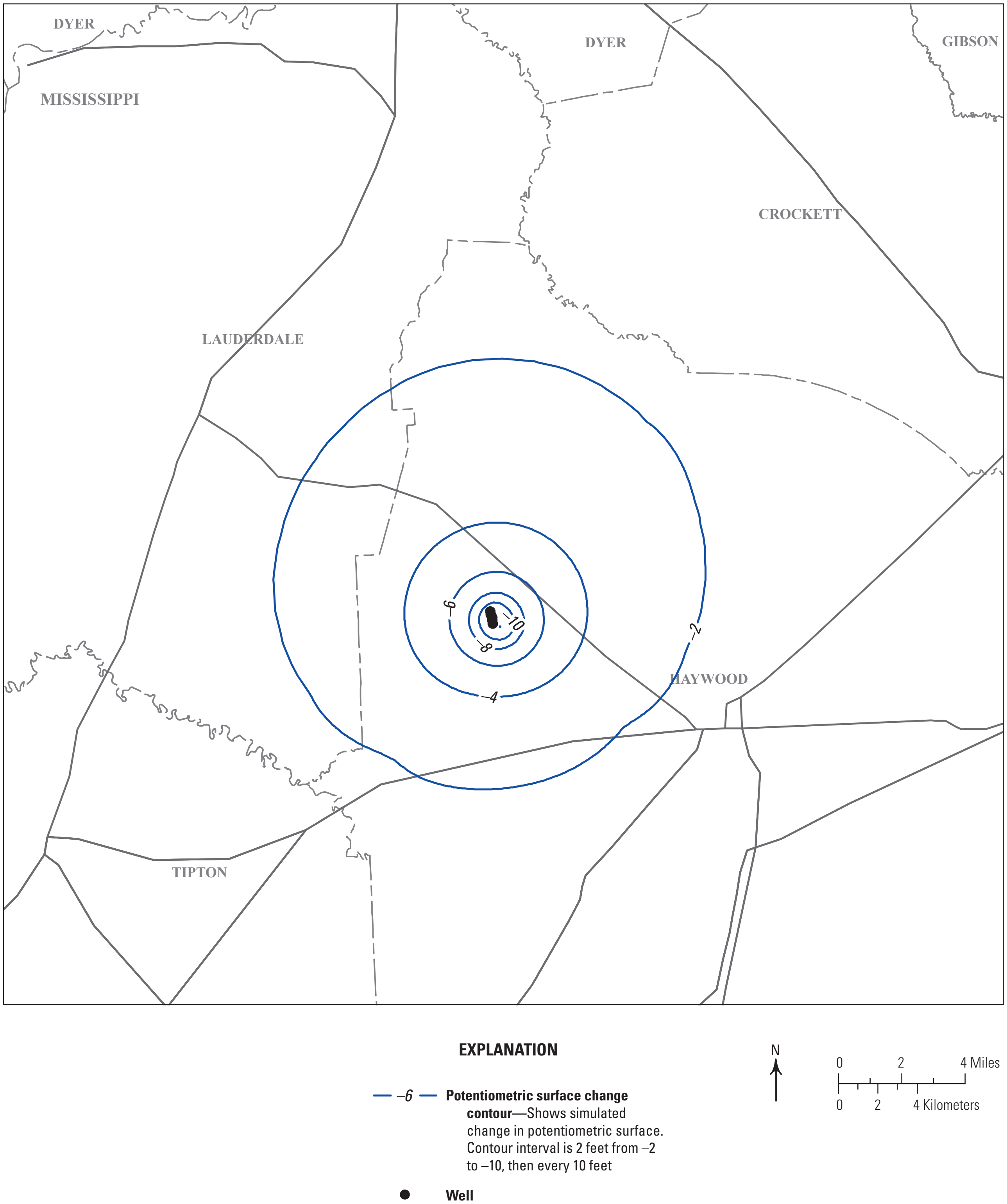


Figure 8. Simulated potentiometric surface change in the Memphis aquifer from combined-cycle-plant withdrawals at the Tenaska site, Haywood County, Tennessee.

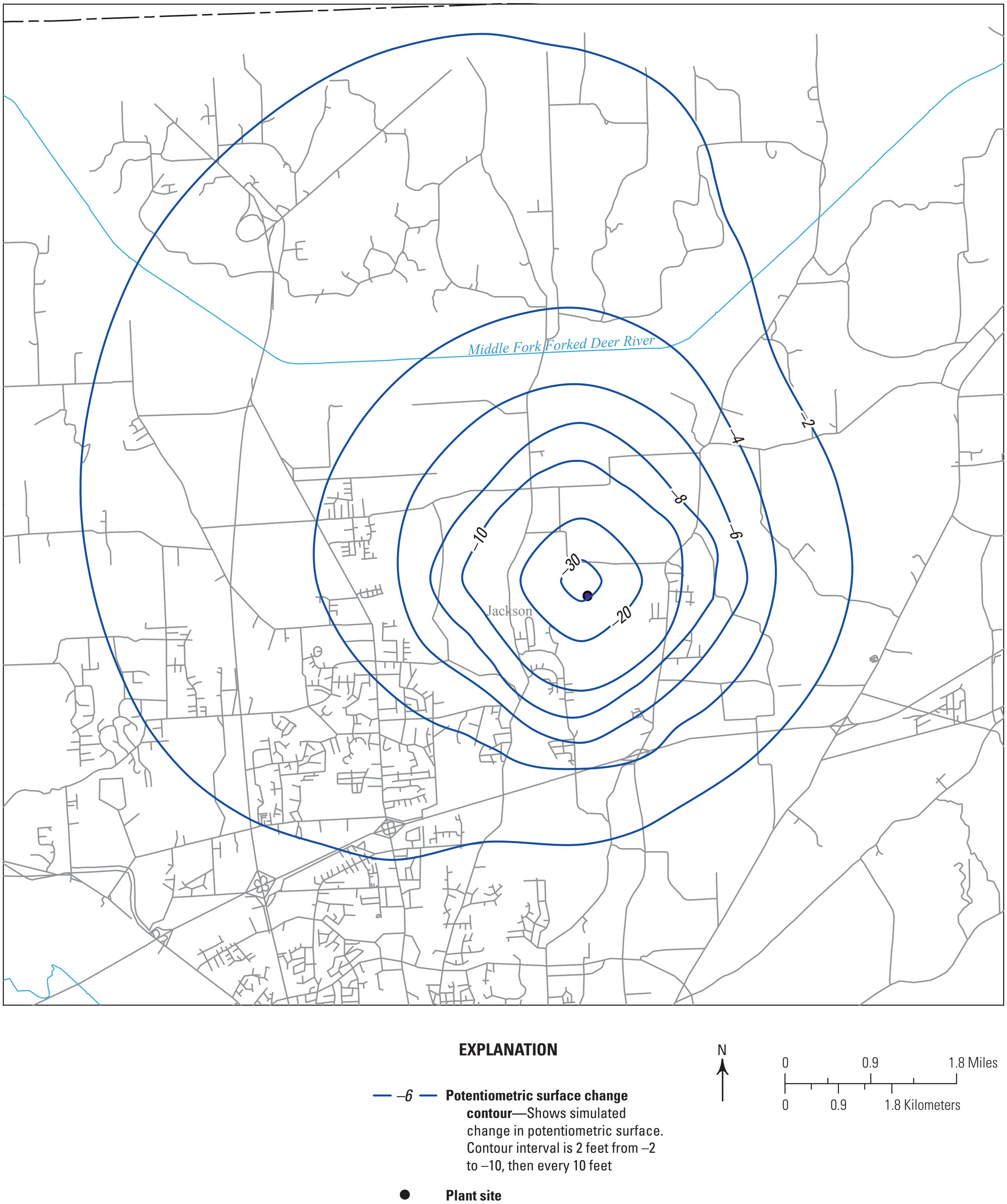


Figure 9. Simulated potentiometric surface change in the Memphis aquifer from combined-cycle-plant withdrawals at the Jackson site, Madison County, Tennessee.

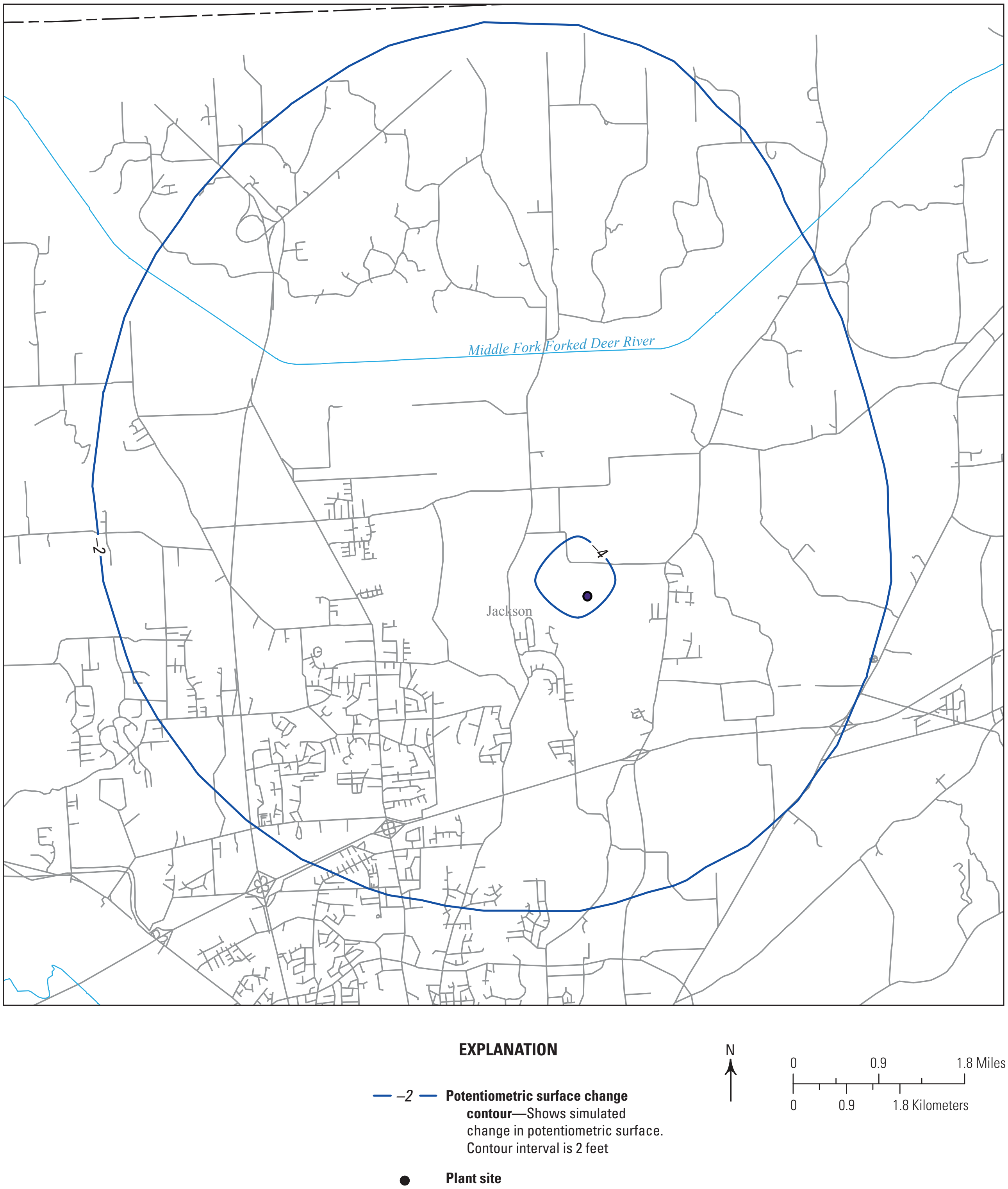


Figure 10. Simulated potentiometric surface change in the Fort Pillow aquifer from combined-cycle-plant withdrawals at the Jackson site, Madison County, Tennessee.

EXPLANATION

— –2 — **Potentiometric surface change contour**—Shows simulated change in potentiometric surface. Contour interval is 2 feet from –2 to –10, then every 10 feet

● **Plant site**

N

0 5 Miles

0 5 Kilometers

Figure 11. Simulated potentiometric surface change in the Lower Wilcox/Fort Pillow aquifer from combined-cycle-plant withdrawals at the Southaven site, DeSoto County, Mississippi.

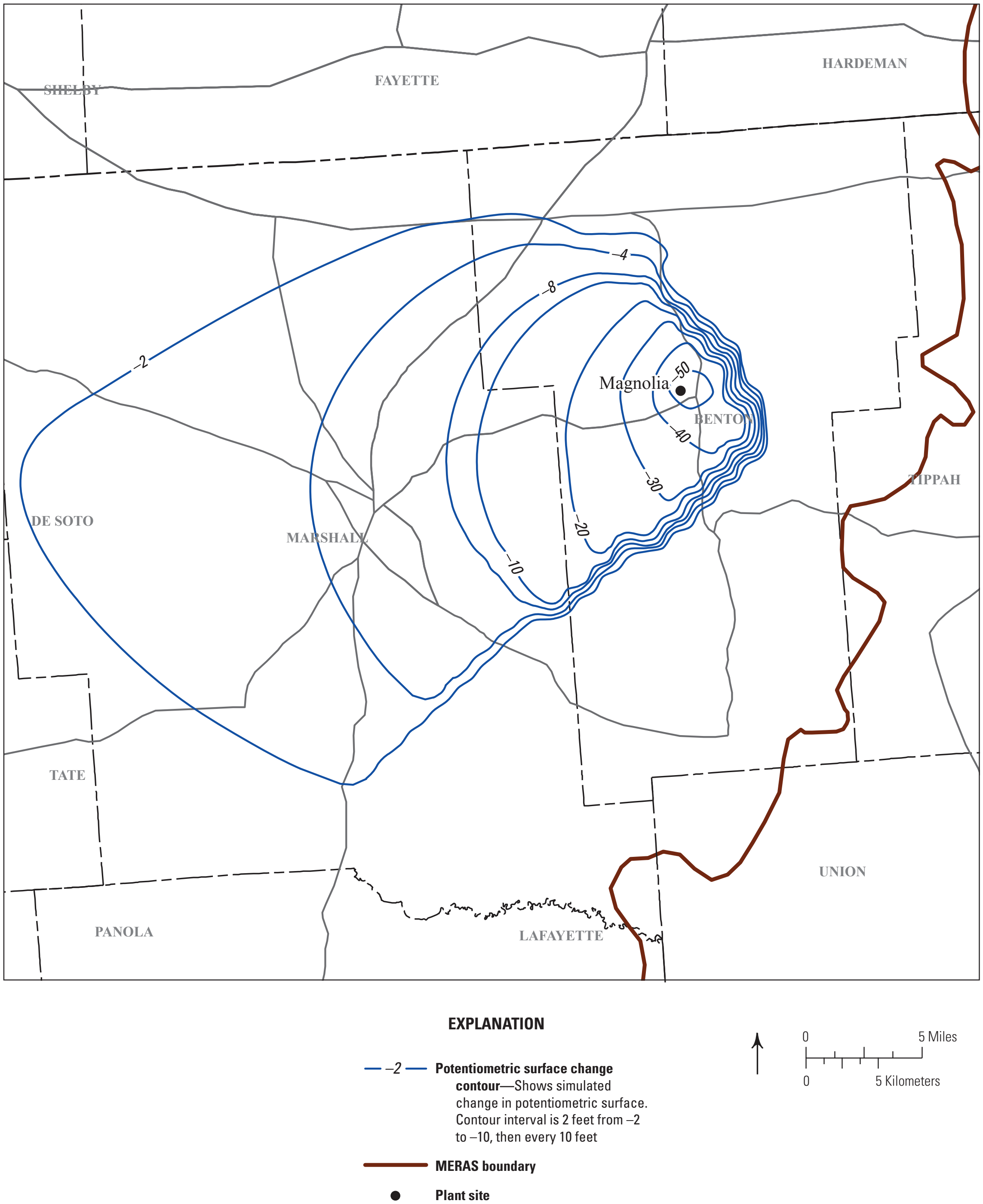


Figure 12. Simulated potentiometric surface change in the Upper Wilcox aquifer from combined-cycle-plant withdrawals at the Magnolia site, Benton County, Mississippi.

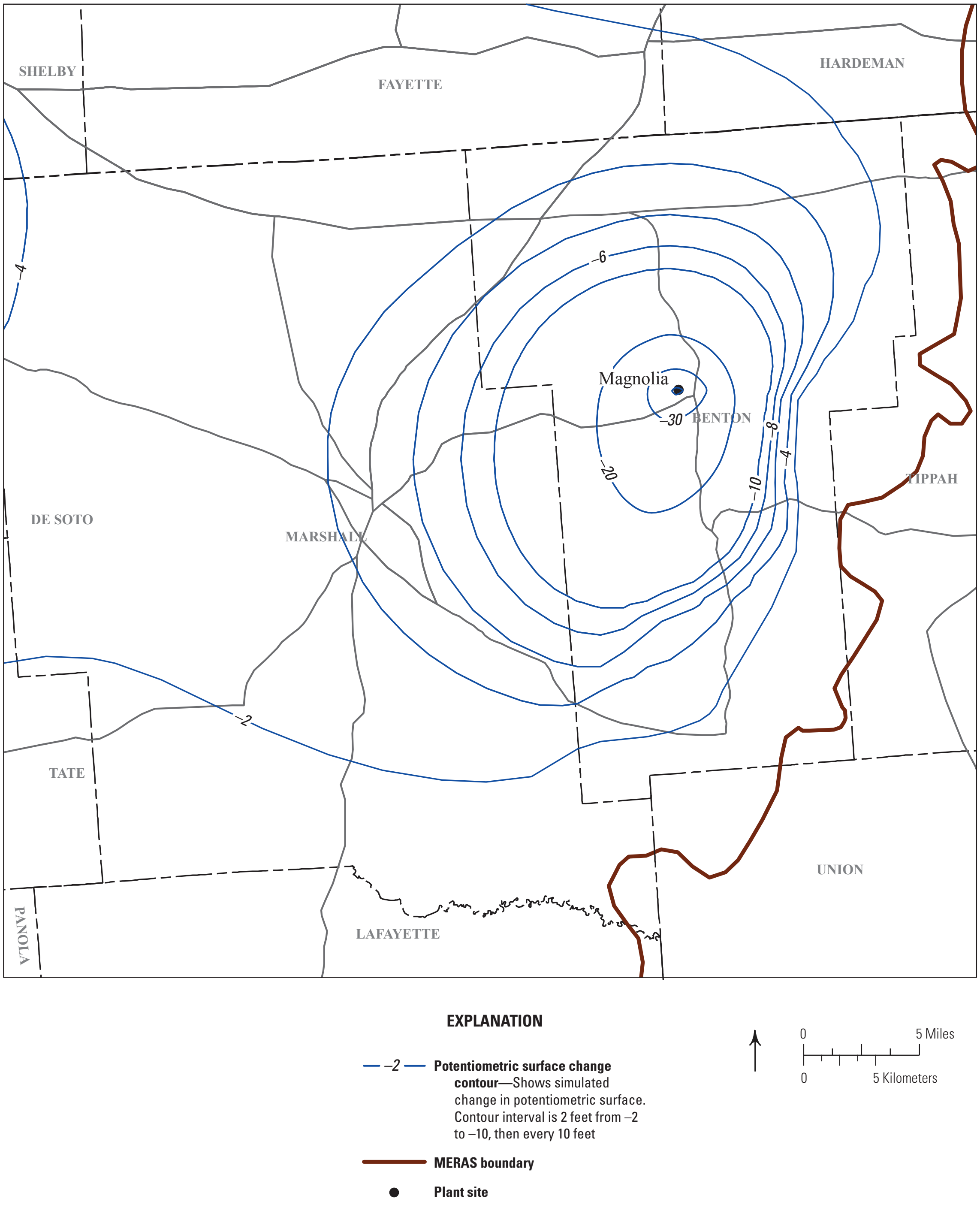


Figure 13. Simulated potentiometric surface change in the Lower Wilcox aquifer from combined-cycle-plant withdrawals at the Magnolia site, Benton County, Mississippi.

Discussion of Results

Simulated potentiometric surface declines in source aquifers attributed to plant withdrawals at potential combined-cycle-plant sites ranged from a maximum of 56 ft in the upper Wilcox aquifer at the Magnolia site to a minimum of 20 ft in the Memphis aquifer at the Tenaska site (table 5). The areas encompassed by the 4 ft potentiometric surface-decline contour (affected area) ranged from a minimum of 11,362 acres at Jackson to a maximum of 535,143 acres at Southaven. The magnitude of change at these sites and the spatial extent of affected areas vary with the transmissivity and storativity of the aquifers, the degree of confinement above and below the aquifers, the modeled withdrawal rates, and the effects of nearby boundary conditions. The overall extents of affected areas are similar at the Gleason and Magnolia sites. The more limited extent of effect at the Tenaska site is most likely a result of the relatively low withdrawal rates and greater aquifer thickness at Tenaska. The spatial extent of effect was least at the Jackson site where the presence of the Middle Fork Forked Deer River nearby may act as a recharge boundary. Additionally, the Jackson site lies in the Memphis aquifer outcrop where modeled recharge rates are higher than in areas where the Memphis aquifer underlies less permeable deposits.

The simulated potentiometric surface in aquifers overlying or underlying source aquifers generally declined less than 2 ft at all the sites except Gleason. At the Gleason site, withdrawals from the Memphis aquifer resulted in a decline of about 9 ft in the underlying Fort Pillow aquifer—perhaps the result of leakage through the Flour Island Formation separating the Memphis and Fort Pillow aquifers where this confining unit is thin, sandy, or absent.

Simulated declines in potentiometric surfaces from TVA withdrawals were similar in magnitude and extent to larger patterns of decline associated with all users over the simulation period. Simulated declines in the Cockfield aquifer from all groundwater use ranged from less than 10 ft to about 70 ft with the largest declines occurring in Shelby County, Tenn. (fig. 14). Simulated declines in the Memphis/Sparta aquifer from all groundwater use ranged from less than 10 ft to about 80 ft with the largest declines occurring in Shelby County, Tenn. (fig. 15). Simulated potentiometric surface declines in the Fort Pillow/lower Wilcox aquifer from all groundwater use ranged from less than 10 ft to about 90 ft with the largest declines occurring in Crittenden County, Ark. (fig. 16).

Model Limitations

Models are simplifications of natural systems. Factors that affect how well a model represents a given natural system include the model scale; the accuracy and availability of hydraulic property data; the accuracy of pumping, water level, and streamflow data; and appropriately defined boundary conditions. The MERAS model, used for the analysis presented in this report, is consistent with the conceptual model and hydrologic data of the MERAS study area. The MERAS model uses a grid-cell size of 1 mi^2. The local grid refinement used in the Tenaska and Gleason areas use a grid-cell size of 0.04 mi^2. A model will not provide an accurate prediction on a scale smaller than the grid resolution. The hydraulic-conductivity zones used in the model represent large-scale variation in hydraulic properties; the actual spatial variations of hydraulic properties of the aquifer system occur on a much smaller scale and are poorly defined. Further discussion of the limitations of the MERAS model are reported by Clark and Hart (2009, p. 56).

Table 5. Summary of simulated potentiometric surface changes resulting from groundwater withdrawals at potential combined-cycle-plant sites.

[TVA, Tennessee Valley Authority]

	Simulated potentiometric surface change from the TVA withdrawal scenario at potential combined-cycle-plant sites (in feet)		
	Memphis Sand	Upper Wilcox	Fort Pillow/ lower Wilcox
Gleason	–40	—	–9
Tenaska	–20	—	–2
Jackson	–35	—	–4
Southaven	–1	—	–38
Magnolia	—	–56	–51

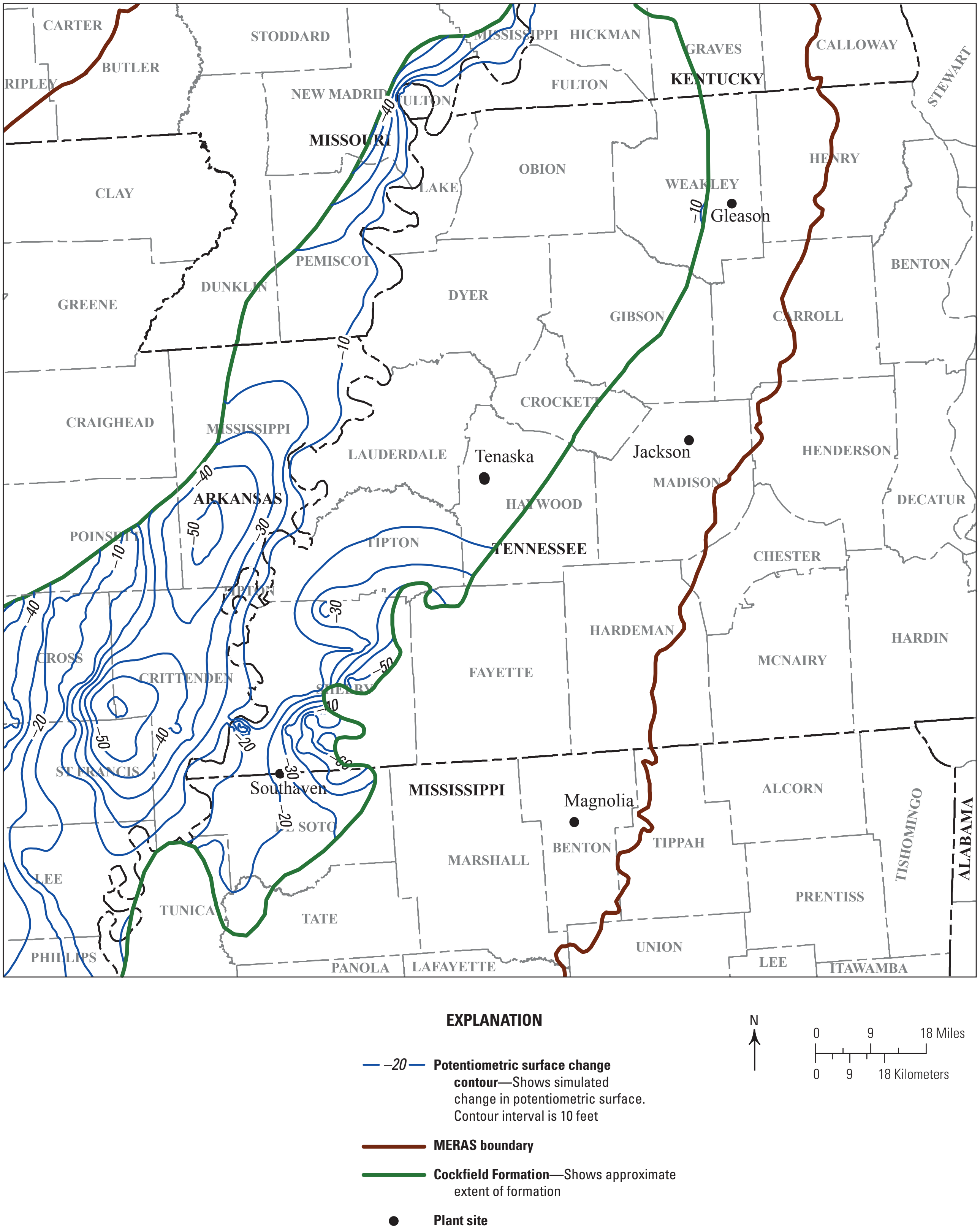


Figure 14. Simulated potentiometric surface change in the Cockfield aquifer from withdrawals by all users at the end of the combined-cycle-plant withdrawal scenario.

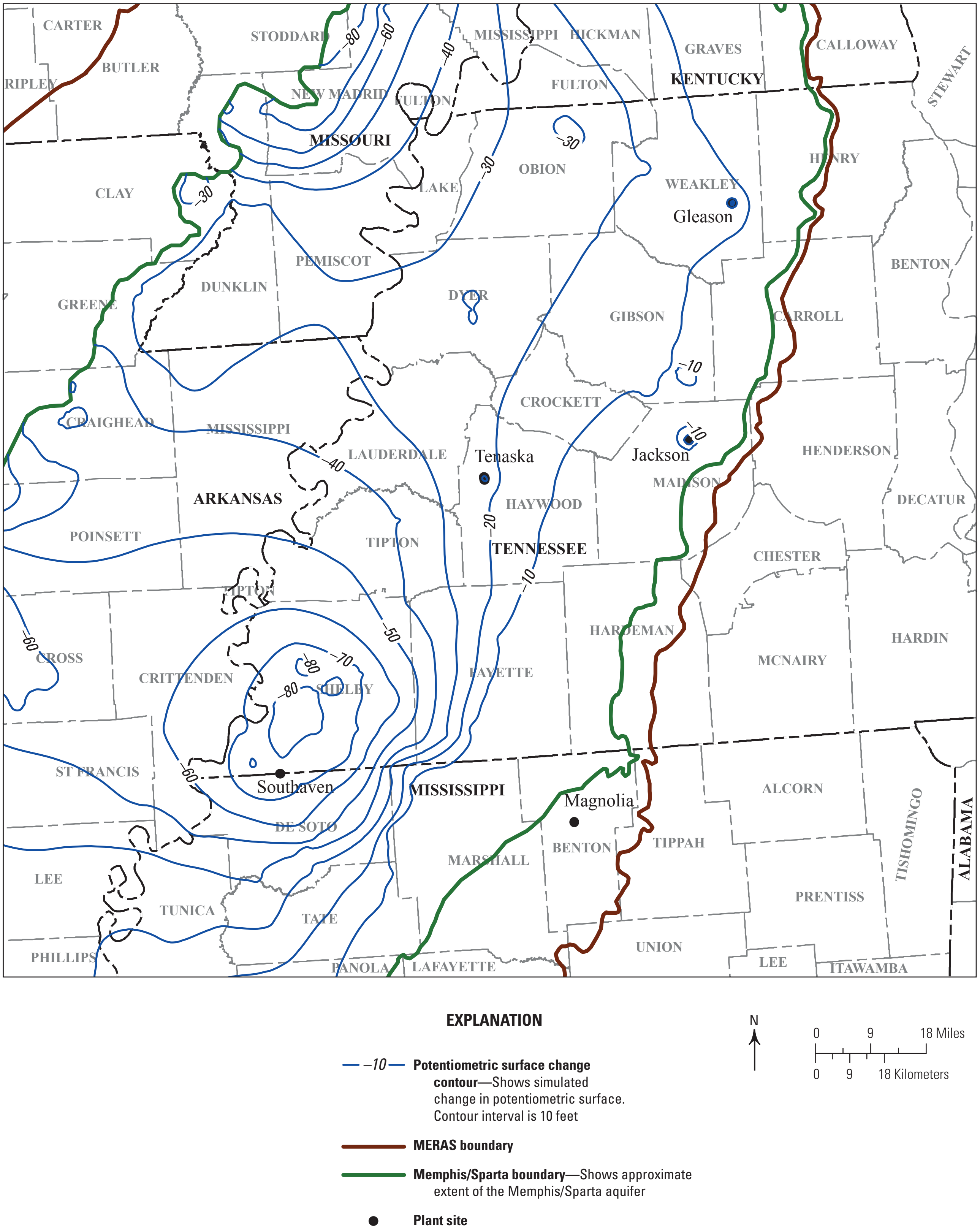
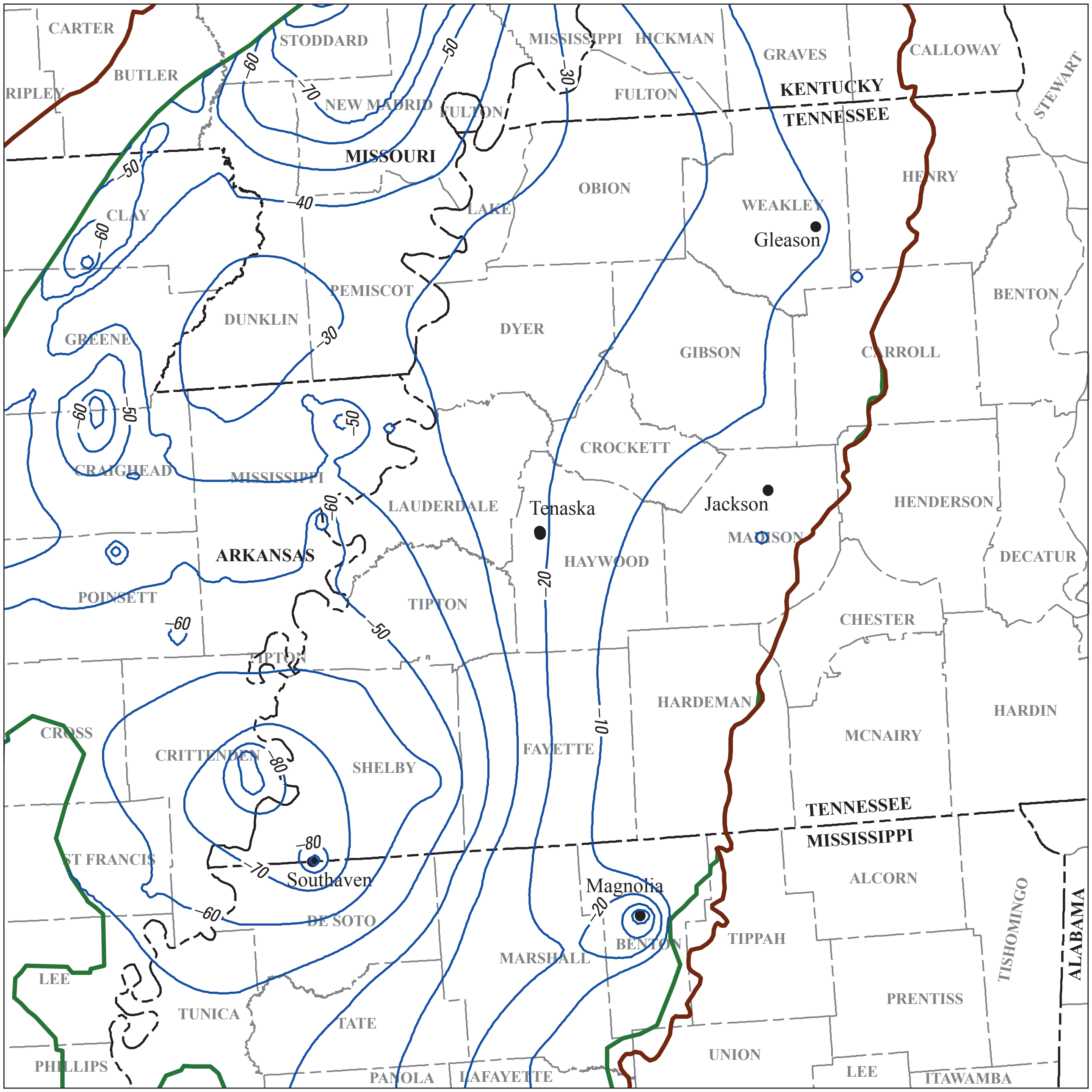


Figure 15. Simulated potentiometric surface change in the Memphis/Sparta aquifer from withdrawals by all users at the end of the combined-cycle-plant withdrawal scenario.



EXPLANATION

—20— **Potentiometric surface change contour**—Shows simulated change in potentiometric surface. Contour interval is 10 feet

MERAS boundary

Fort Pillow/Lower Wilcox extent—Shows approximate extent of the Fort Pillow/Upper Wilcox aquifer

● **Plant site**

N

0 9 18 Miles

0 9 18 Kilometers

Figure 16. Simulated potentiometric surface change in the Fort Pillow/Lower Wilcox aquifer from withdrawals by all users at the end of the combined-cycle-plant withdrawal scenario.

Summary

Increases in population have brought about corresponding increases in demand for electric power. The Tennessee Valley Authority is considering the use of one or more existing combined-cycle plants in West Tennessee and northern Mississippi and the potential conversion of simple-cycle plants to combined-cycle operation. The combined-cycle plants, depending on electrical generation capacity, may require relatively large amounts of water for operation. Given these considerations, the effects of groundwater withdrawals at combined-cycle turbine plants on the aquifers and on groundwater levels are being evaluated.

The potential effects of increased groundwater withdrawals were simulated using the MERAS regional groundwater-flow model at five sites: Gleason, Weakley County, Tennessee; Tenaska, Haywood County, Tennessee; Jackson, Madison County, Tennessee; Southaven, DeSoto County, Mississippi; and Magnolia, Benton County, Mississippi. The scenario evaluated consisted of a 30-year average water-use period followed by a 30-day peak water-demand period. Projections of future water use by public utilities were estimated assuming a linear growth in demand of 2 percent per year. Effects of the powerplants on the aquifer system were evaluated by comparing the difference in simulated water levels in the aquifers at the end of the scenario (30 years plus 30 days) with and without the combined-cycle-plant withdrawals.

Simulated declines in the potentiometric surface in source aquifers at potential combined-cycle-plant sites ranged from 56 ft in the upper Wilcox aquifer at the Magnolia site to 20 ft in the Memphis aquifer at the Tenaska site. The spatial extent of declines as delineated by the minus 4-ft potentiometric surface change contour ranged from 11,362 acres at Jackson to 535,143 acres at Southaven.

The simulated potentiometric surface declines in aquifers overlying or underlying source aquifers generally were less than 2 ft at all the sites except Gleason. At the Gleason site, withdrawals from the Memphis aquifer result in potentiometric surface declines of about 9 ft in the underlying Fort Pillow aquifer. Overall, declines in potentiometric surfaces resulting from combined-cycle powerplants would not appear to be unusual compared to those associated with other projected uses in the region.

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