SUMMARY OF GEOHYDROLOGY AND SIMULATED EFFECTS OF GROUND-WATER WITHDRAWALS ON THE MIOCENE AQUIFER SYSTEM IN THE MISSISSIPPI GULF COAST AREA

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Industrial municipal, and domestic water users along the Mississippi Gulf Coast withdraw about 60 Mgal/d (million gallons per day) from aquifers in sediments of Miocene and Pliocene age, which will be referred to as the Miocene aquifer system in this paper. Intensive development of these aquifers, primarily within a belt a few miles wide along the coast, has significantly altered the natural ground-water flow system. Water levels in some aquifers in sediments of Miocene age have declined about 2 feet per year since 1940, and water-level declines exceed 100 feet in large areas along the coast.

The potentiometric surfaces in many of the confined aquifers in sediments of Miocene age along the coast are now well below sea level (more than 80 feet in some heavily pumped areas). This has prompted much concern for the ability of the aquifers to meet the growing demand for water and the potential for contamination of the freshwater aquifers by saltwater intrusion. Chloride concentrations in a few wells in the Pascagoula and Biloxi areas have increased in recent years and the freshwater-saltwater interface in some aquifers may be close to some municipal and industrial well fields.

Concern over these potential ground-water problems led the U.S. Geological Survey and the Bureau of Land and Water Resources of the Mississippi Department of Natural Resources to begin an investigation of the Miocene aquifer system in 1984. That investigation was completed in 1987. The report documenting the findings of the investigation is titled "Geohydrology and simulated effects of withdrawals on the Miocene aquifer system in the Mississippi Gulf Coast area," by D.M. Sumner, B.E. Wasson, and Stephen J. Kalkhoff. The report has been released as U.S..S. Geological Survey Water-Resources Investigations Report 87-4172. Copies of the report are available for inspection in the offices of the Geological Survey and the Bureau of Land and Water Resources in Jackson, Mississippi. The principal findings of the investigation are summarized in this paper.

The objective of this investigation was to gain an understanding of the ground-water system along the Gulf Coast (fig. 1)--a task made more difficult by the complex nature of the geology. The Miocene and Pliocene sediments that make up the Miocene aquifer system consist of interbedded and lenticular sands and clays. These sediments crop out in southern Mississippi and dip to the south and southwest. They do not fit the concept of layered geology but do exhibit large vertical variations in head and locally respond to stresses as separate aquifers. An analysis of well data along the Gulf Coast indicated that an aquifer system with eight layers having surfaces based primarily on the dip or slope of the base of the mappable Miocene deposits would best represent the vertical heads in the Miocene aquifer system.

The layering system and the relation between the eight hydrologic layers used in this investigation and the geologic units in southern Mississippi are given in table 1. The report presenting the results of the investigation describes the response of water levels in each of the hydrologic layers to estimated future ground-water withdrawals. However, in this paper only layers 3, 4, 5, and 6, which are the principal sources of ground water for municipal and industrial water supplies in the Pascagoula, Biloxi, and Gulfport areas, are discussed.

Recharge to the Miocene aquifer system primarily is from the surficial aquifer system, which is recharged by precipitation. Water in the Miocene aquifer system generally moves to the south and southeast along the bedding planes toward the Mississippi Gulf Coast, where the water is either withdrawn by wells, discharges to the Gulf, or gradually percolates upward through the overlying deposits. The downdip location of the freshwater-saltwater interface, though not well defined in all areas, probably is relatively close to major pumping centers near Pascagoula and the Biloxi Bay area in some layers. The interfaces probably were static prior to development, but drawdowns caused by large ground-water withdrawals in some areas have resulted in the gradual movement of saltwater toward the pumping centers.

Most of the water in the Miocene aquifer system in the area is a sodium bicarbonate type. In the northern third of the study area, water is fresh to the base of the Miocene sediments. Water from some aquifers in the Pascagoula-Moss Point area and in the Biloxi-Ocean Springs area is marginally fresh because of the proximity of the freshwater-saltwater interface and (or) the upward leakage of saline water from deeper aquifers.

The effects of an expected 1.5 percent annual increase in ground-water withdrawals from 1985 through the year 2005 were evaluated by means of a quasi three-dimensional numerical model of the ground-water flow system. An eight-layer model incorporating available geohydrologic data was developed and calibrated by adjusting hydraulic parameters until a reasonable match between computed and measured water levels in 1940, 1960, 1965, 1977, 1982, and 1985 was obtained. The calibration-derived parameter values ranged from 5 ft/d (oldest layer) to 40 ft/d (youngest layer) for horizontal hydraulic conductivity of aquifer material, 1×10^{-4} ft/d for vertical hydraulic conductivity of confining material, and 1×10^{-5} ft-1 (per foot) for specific storage of confining material. A sensitivity analysis indicated that the simulated water levels were relatively sensitive to changes in vertical and horizontal hydraulic conductivity and to storage in the areas heavily stressed by pumping. The computed water levels were much less sensitive to changes in these hydraulic parameters in areas more remote from the pumping centers.

The results of model projections indicate that water-level declines generally would be largest in the Biloxi-Gulfport area (fig. 1). Layer 4, which corresponds to the 900-foot sand at Gulfport, is expected to have additional water-level declines of 135 feet by the year 2005. In the Biloxi-Gulfport area, additional declines of 100 feet in layer 5(600-foot sand) and 50 feet in layer 3 (1,200-foot sand) are also projected. In the Pascagoula area, model projections of additional water-level declines are 40 feet in layer 6 (400-foot sand) and 30 feet in layer 4 (800-foot sand). In much of the western part of the coastal area and in areas more than 10 miles north of the coast, projected declines by the year 2005 generally are less than 20 feet in all layers.

The potential for saltwater encroachment into freshwater aquifers was evaluated on the basis of analytically estimated ground-water velocities and estimates of the present (1985) location of the freshwater-saltwater interfaces. This information is summarized in table 2. The most serious threats of saltwater encroachment are in layers 4, 5, and 6 (the 800-, 600-, and 400-foot sands) in the Pascagoula area. Available data indicate that the base of layer 4 currently is salty in the southern edge of Pascagoula, and that the top of the layer contains saltwater about half a mile farther south. Chloride concentrations in water from some wells suggest that the saltwater front in layer 5 is at the southern edge of the well field in the southeastern part of Pascagoula. Interpretation of available chloride data indicates that in layer 6 the saltwater front may be 2 or 3 miles southeast of downtown Pascagoula but less than a mile southeast of the Bayou Casotte industrial complex. If the estimated locations of the saltwater fronts are accurate, saltwater could contaminate the southern most wells in layers 4 and 5 in Pascagoula in less than 10 years. In layer 6, the downdip saltwater front could reach the southern most wells in the Bayou Casotte industrial complex in less than a decade but may take several decades to reach the southern most municipal-supply wells in Pascagoula. Chloride concentrations in some wells suggest, however, that parts of layer 6 beneath the flood plains of the Pascagoula and Escatawpa Rivers, north of Pascagoula and Moss Point, have been contaminated by saltwater from the tidal reaches of these streams.

A potential problem with saltwater moving into freshwater sands also exists in layer 3 (1,200-foot sand) in the eastern part of Biloxi. Water in this aquifer is salty in the Pascagoula area, along the coast between Pascagoula and Biloxi, and in the area of Biloxi Bay. Available chloride data suggest that layer 5 (the 600-foot sand) may be safe from saltwater intrusion for several decades. West of Gulfport the fresh-water section is relatively thick, and except in the southwest corner of Hancock County, the saltwater front is several miles offshore. Most active wells in this area are screened above the base of freshwater, and saltwater contamination of these sands is not expected to be a problem by 2005.

Table 1.--Geologic units, major aquifers, and hydrologic layering of the Miocene aquifer system in south Mississippi

System	Series	Group	Geologic unit	Major aquifer or aquifer system	Hydrologic layers: Layer number	Hydrologic layers: Depth of base of layer at Pascagoula, in feet
Quaternary	Holocene and Pleistocene		Undifferentiated alluvium and terrace deposits	Surficial aquifer system--includes those parts of aquifers that are less than about 200 feet below land surface		
	Pleistocene		Loess			
			Terrace deposits, undifferentiated		8	(not present)
	Pliocene		Citronelle Formation	Miocene aquifer system	7	180
					6	450
			Graham Ferry Formation		5	650
	Miocene				4	950
			Pascagoula Formation		3	1350
			Hattiesburg Formation		2	2050
			Catahoula Sandstone		1	3500
Tertiary			Paynes Hammock Sand			
			Chickasawhay Sandstone			
	Oligocene	Vicksburg	Bucatunna Formation			
			Byram Formation			
			Glendon Formation			
			Marianna Formation	Oligocene aquifer system		
			Mint Spring Formation			
			Forest Hill Formation			
	Eocene	Jackson	Yazoo Clay			
			Moodys Branch Formation			
		Claiborne	Cockfield Formation	Cockfield aquifer		
			Cook Mountain Formation			
			Sparta Sand	Sparta aquifer system		
			Zilpha Clay			

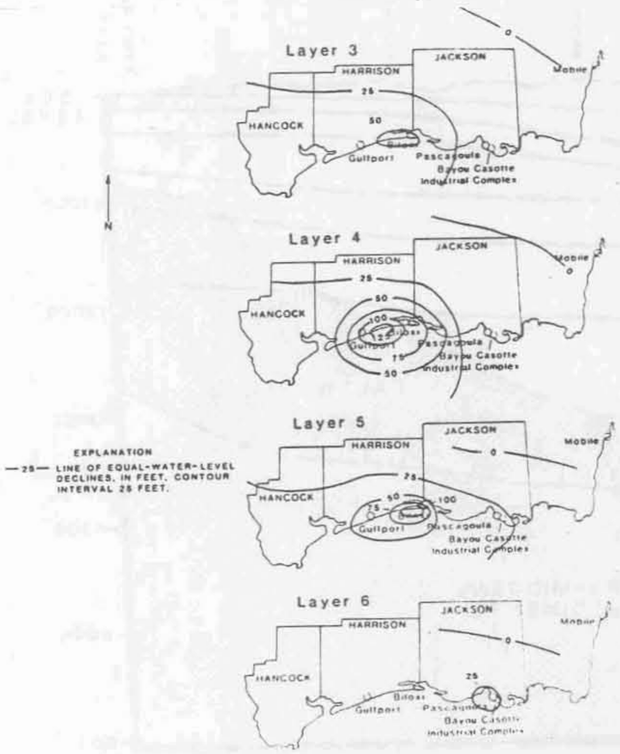

Figure 1.--Estimated water-level declines in layers 3-6 1985 to 2005

Table 2.--Saltwater Encroachment

MODEL LAYER	ESTIMATED DISTANCE FROM SALTWATER INTERFACE, IN MILES	ESTIMATED TIME BEFORE SALTWATER REACHES WELLS[1]
PASCAGOULA (southern edge of well field)		
4 (800' sand)	1/2	less than 10 years
5 (600' sand)	0	less than 10 years
6 (400' sand)	2-3	greater than 20 years
BAYOU CASOTTE INDUSTRIAL COMPLEX (southern edge)		
6 (400' sand)	less than 1	less than 10 years
BILOXI (eastern edge of well field)		
3 (1200' sand)	0	0[2]
4 (800' sand)	?	?[3]
5 (600' sand)	greater than 3	?[4]

[1]Analysis based on theoretical rate of fresh ground-water movement and model-projected water levels in the year 2005. Saltwater-freshwater density differences not considered.

[2]Wells nearest Biloxi Bay currently have saltwater problems.

[3]Some saltwater problems near Biloxi Bay but less severe than in layer 3.

[4]No immediate problems.