STATE OF LOUISIANA
DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
OFFICE OF PUBLIC WORKS

WATER RESOURCES
TECHNICAL REPORT
NO. 34

SIMULATION OF GROUND-WATER MOVEMENT IN THE "1,500- AND 1,700-FOOT" AQUIFER OF THE BATON ROUGE AREA, LOUISIANA

Prepared by
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
In cooperation with
LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
OFFICE OF PUBLIC WORKS

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FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) OF METRIC UNITS

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
foot (ft)	0.3048	meter (m)
foot per day (ft/d)	0.3048	meter per day (m/d)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
square foot per day (ft^2/d)	0.0929	square meter per day (m^2/d)
gallon per day per foot [(gal/d)/ft]	0.01242	square meter per day (m^2/d)
mile (mi)	1.609	kilometer (km)
million gallons per day (Mgal/d)	3,785	cubic meter per day (m^3/d)
square mile (mi^2)	2.59	square kilometer (km^2)

To convert temperature in degrees Celsius (°C) to degrees Fahrenheit (°F), multiply by 9/5 and add 32.

SIMULATION OF GROUND-WATER MOVEMENT IN THE "1,500- and 1,700-FOOT" AQUIFER OF THE BATON ROUGE AREA, LOUISIANA

By Thomas L. Huntzinger, Charles D. Whiteman, Jr., and Darwin D. Knochenmus

ABSTRACT

Before 1920, very little water was withdrawn from the "1,500- and 1,700-foot" aquifer of the Baton Rouge area. Since then, the "1,500- and 1,700-foot" aquifer has become a major source of water (17 million gallons per day in 1979) for public supply in East Baton Rouge Parish. This ground-water development has caused a decline of 175 feet or more in the potentiometric surface in the area near the major pumping center.

For simulation purposes, the units of the Baton Rouge aquifer system, considered in this study, consist of three layers: the "1,500-foot" and "1,700-foot" aquifers, treated together as a single layer--the "1,500- and 1,700-foot" aquifer; the overlying "1,200-foot" aquifer; and the underlying "2,000-foot" aquifer with the intervening confining beds. The first test simulation, with pumping continued at the 1978-79 average rate for 30 years, indicated a maximum increase in drawdown of about 25 feet. The second test simulation, with a 30-percent increase in pumping from the 1978-79 rate (increased 5 percent every 6-year period for 30 years), indicated an increased drawdown of about 50 feet. The third test simulation, with a stepped decrease of 30 percent in pumping over 30 years, indicated that drawdowns stabilized at the 1979 level near the cone of depression. The test simulations also indicated that water levels in wells in the aquifer south of the Baton Rouge fault are little affected by changes in pumping rates.

The water budgets for the test simulations indicate that leakage contributes more than 40 percent of the water withdrawn, approximately 55 percent comes from storage, and less than 5 percent is supplied from constant-head sources in the recharge area. However, withdrawals from the "1,500- and 1,700-foot" aquifer are small relative to the total pumpage from the aquifers simulated; therefore, water budgets show very little change as to the source of water from one simulation to another.

Potential water-quality problems exist both spatially and temporally. As a result of the development of the cone of depression, saltwater encroachment is occurring in the "1,500- and 1,700-foot" aquifer.

INTRODUCTION

Development of the ground-water resources of the Baton Rouge area has lowered the potentiometric surfaces of all aquifers down to and including the "2,800-foot" aquifer. With increasing pumpage from the aquifers since the early 1900's, local and State agencies have sought means to effectively manage the water resources for an orderly development.

In 1975, the U.S. Geological Survey began a cooperative program with the Louisiana Department of Transportation and Development, Office of Public Works, and the Capital Area Groundwater Conservation Commission to study the various individual aquifers in the project area, which includes East Baton Rouge, West Baton Rouge, Pointe Coupee, East Feliciana, and West Feliciana Parishes (figs. 1 and 2). Several studies are planned; this report provides results of the study of the "1,500- and 1,700-foot" aquifer, the second in the series of studies. The purpose of the investigation is to define the movement of water and to describe the effect on the potentiometric surfaces of the aquifer of various pumping schemes.

It was determined that the best approach for such an investigation would be to simulate the aquifers by use of a mathematical model. The complexity of the aquifer system in terms of its multisands, aquifer interconnections, variable thickness of beds, and variable hydraulic conductivities indicated that a three-dimensional model should be developed for each aquifer or combination of aquifers. The largest potentiometric-surface declines were in the "2,000-foot" aquifer; therefore, it was selected as the first aquifer to be modeled. The results obtained from the model of the "2,000-foot" aquifer were described by Torak and Whiteman (1982).

The purpose of mathematically modeling the aquifers is to enable the local water managers to determine the potential effect on water levels in a particular aquifer (or adjacent aquifers) of proposed changes in pumping rates and well locations. A secondary purpose is to increase the understanding of the aquifer system by operating the model with variations in the hydrologic conditions to determine the impact on water levels.

This report gives an overview and summary of the geohydrologic setting, describes the aquifer system and its processes, and shows the water-level changes that would occur in the "1,500- and 1,700-foot" aquifer from proposed changes to ground-water pumpage. The model is based on geohydrology as described by Meyer and Turcan (1955), Morgan (1961, 1963), Rollo (1969), and Whiteman (1979).

GEOHYDROLOGIC FRAMEWORK

The geologic sequence underlying the five-parish project area in southeastern Louisiana consists of a complex series of alternating and lenticular beds of sand or clay. To illustrate this complex sequence and show the relationships of the beds, two generalized geohydrologic cross sections through the Baton Rouge area are shown on plate 1; section locations are shown in figure 2. Most of the information for drawing the

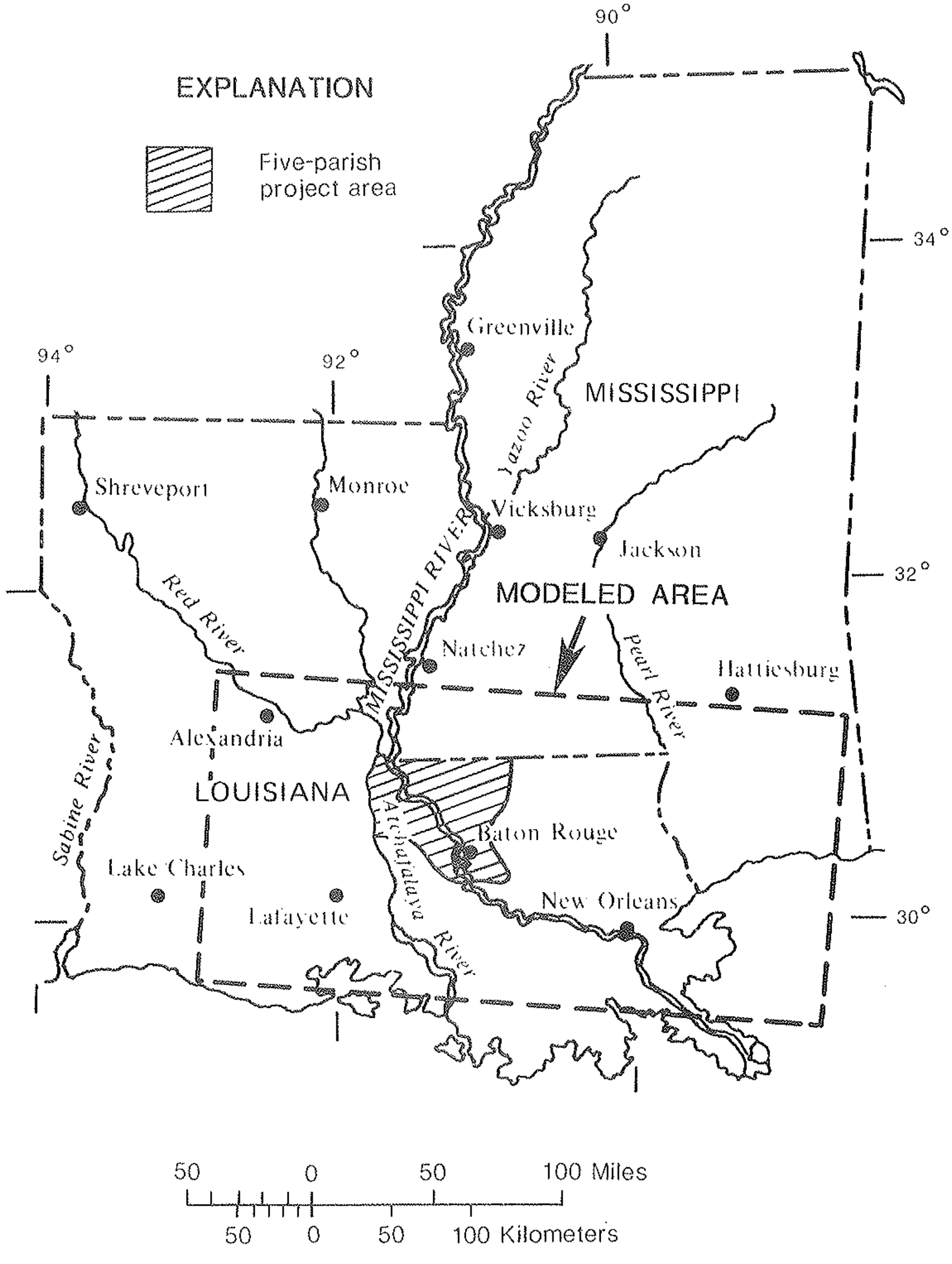


Figure 1.--Five-parish project area and modeled area.

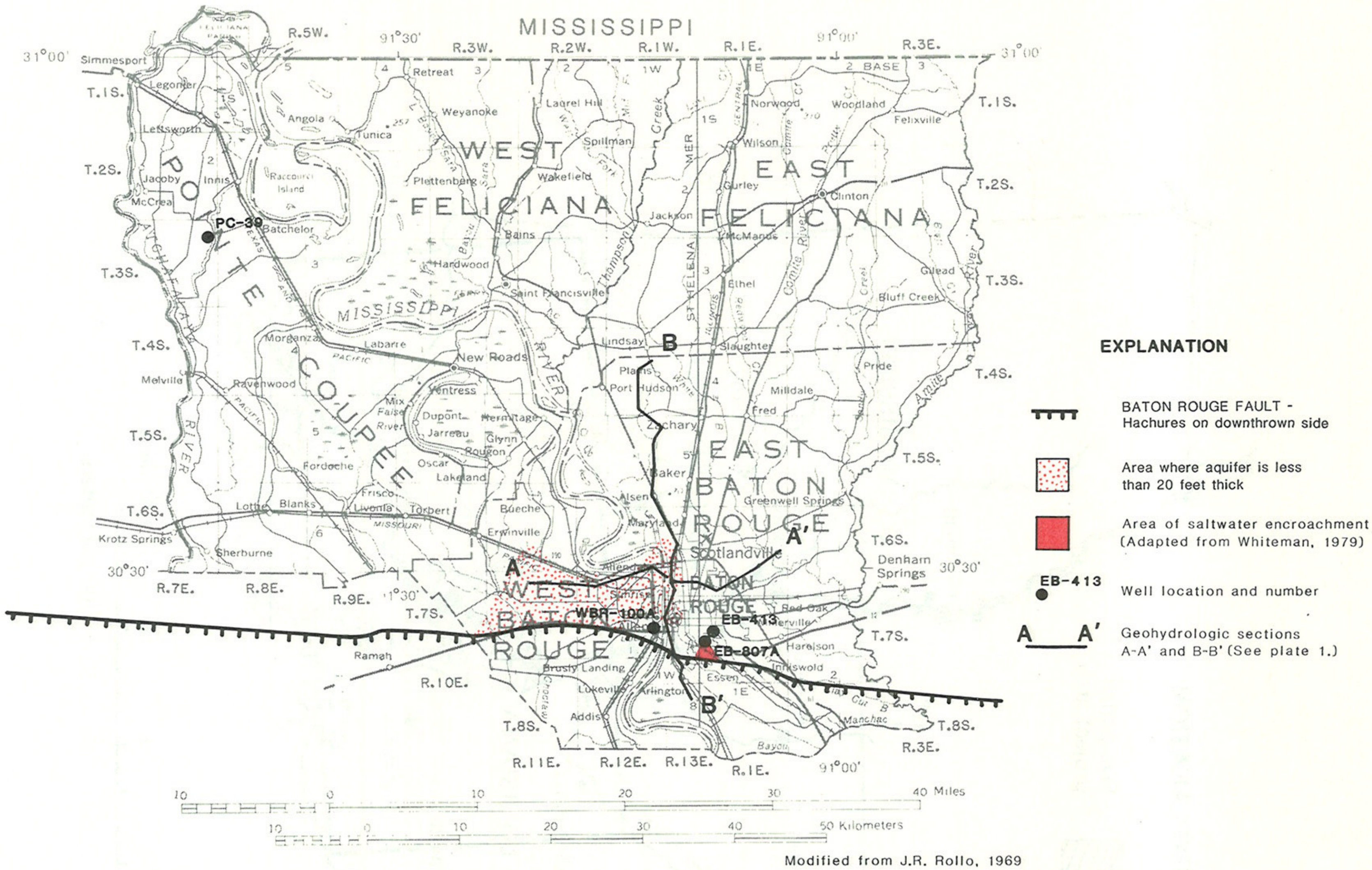


Figure 2.--Five-parish project area showing location of the Baton Rouge fault, area where "1,500- and 1,700-foot" aquifer is thin or missing, geohydrologic sections, and selected wells.

sections and describing the geohydrology is from the Baton Rouge area, where ground water has been highly developed and much aquifer information is available.

The general configuration of the aquifer system is one of massive sand beds separated by major clay layers. The sand beds respond, in general, as single hydrologic units--even though the sands in places are discontinuous and may be interrupted by or contain local clay layers. In other places, two sands may converge to form one bed (pl. 1). The sand beds were identified as aquifers and named for their depth below land surface in the Baton Rouge area by Meyer and Turcan (1955). Although originally both the geologic and the hydrologic units were referred to as "sands," in this report, the hydrologic units will be referred to as "aquifers."

Eleven such aquifers have been named in the Baton Rouge area; shallow aquifers, "400-foot," "600-foot," "800-foot," "1,000-foot," "1,200-foot," "1,500-foot," "1,700-foot," "2,000-foot," "2,400-foot," and "2,800-foot" aquifers. The Mississippi River alluvium is a component of the shallow aquifers, and evidence given by Meyer and Turcan (1955) indicates the alluvium and the "400-foot" aquifer converge into one unit west of the Mississippi River. The aquifers making up the freshwater part of the geologic section extend to a maximum depth of about 3,100 ft below land surface in the Baton Rouge area. The aggregation of all the aquifers constitutes the Southern Hills aquifer system (Buono, 1983) that extends from the uppermost sand to the "2,800-foot" aquifer. The "1,500-foot" and the "1,700-foot" aquifers are hydrologically related and have been developed together with many wells completed in both aquifers. In this report, they will be treated as a single unit--the "1,500- and 1,700-foot" aquifer.

The sand beds and clay layers dip south to southeast (Morgan, 1963) at an average of about 50 ft/mi, which makes each successively deeper aquifer approach the surface farther to the north and farther from Baton Rouge. The recharge area for the "1,500- and 1,700-foot" aquifer occurs where the sand beds approach the land surface in the vicinity of the Mississippi-Louisiana State line (approximately 31°N latitude).

The major clay layers between aquifers vary in thickness from several hundred feet to non-existent, sometimes resulting in a merging of separate aquifers into one. Even though the clay layers cause the aquifers to respond separately, there is some interaction between aquifers by leakage from one aquifer to another through the clay layers. Vertical-hydraulic conductivity through the pure clays is probably about 2.0×10^{-10} ft/s (Whiteman, 1980). Because the confining beds contain considerable silty and sandy material, the resulting overall vertical-hydraulic conductivity is about 5×10^{-9} ft/s.

The relationships of the aquifers in the Baton Rouge area are depicted on plate 1. The "1,500-foot" aquifer is absent in part of north Baton Rouge and the "1,700-foot" aquifer is missing in places in West Baton Rouge Parish (Morgan, 1961). The "1,500-foot" and "1,700-foot" aquifers have maximum thicknesses of 300 and 240 ft, respectively, and average about 100 and 75 ft in thickness, respectively.

The material composing the "1,500- and 1,700-foot" aquifer is primarily medium-grained sand. Characteristics of the "1,500- and 1,700-foot" aquifer and other aquifers in the system are presented in table 1. The rate of flow through the entire thickness of an aquifer is called the aquifer transmissivity. Values of transmissivity for the "1,500- and 1,700-foot" aquifer have been computed from aquifer tests and geologic-log analysis and range from 0.05 to 0.14 ft^2/s [32,000 to 90,000 (gal/d)/ft] (Morgan, 1961). Morgan (1963) also states that storage coefficients for this aquifer range from 1×10^{-4} to 1×10^{-3}.

Table 1.--Characteristics of individual aquifers of the Southern Hills aquifer system in the five-parish project area

Aquifers	Lithologic description	Thickness (feet)	Transmissivity (square foot per second)	Storage coefficient
"400- and 600-foot" aquifer.	Fine sand to pea gravel-	75--400	0.02-0.30	0.0001-0.0025
"800-foot" aquifer---	Fine to medium sand-----	50--150	.04	.0001- .001
"1,000-foot" aquifer-	Fine to coarse sand-----	40-- 90	.11	.0001
"1,200-foot" aquifer-	Fine to medium sand-----	40--100	.12- .20	.0002- .0008
"1,500- and 1,700-foot" aquifer.	Fine to medium sand-----	20--300	.05- .14	.0001- .001
"2,000-foot" aquifer-	Medium sand--------------	100--300	.25- .45	.0006- .0008
"2,400-foot" aquifer-	Fine to medium sand-----	50--250	.15	.0001
"2,800-foot" aquifer-	Fine to coarse sand-----	50--350	.20	.0001

More extensive information on the hydraulic properties of aquifers near Baton Rouge may be obtained from previous studies by Meyer and Turcan (1955), Morgan (1961, 1963), Morgan and Winner (1964), Winner and others (1968) and Rollo (1969). Aquifer properties for the outlying areas are described by Jones and others (1954) and Whitfield (1975) to the west; and Winner (1963), Nyman and Fayard (1978), and Case (1979) to the east. Studies by Brown and Guyton (1943) and Brown (1944) describe the hydraulic properties of the recharge area.

A fault that partially restricts flow is part of the "Baton Rouge fault zone" (Cardwell and others, 1967) that extends from south-central Louisiana eastward through Baton Rouge. (See fig. 2.) Approximately 300 ft or more of vertical displacement has occurred below a depth of about 1,000 ft, causing the "1,500- and 1,700-foot" aquifer south of the fault to become hydraulically connected to the "2,000-foot" aquifer to the north. In the same manner, the "1,200-foot" and the "2,000-foot" aquifers south of the fault are connected to the "1,500- and 1,700-foot" and "2,400-foot" aquifers, respectively, north of the fault. Results of model studies by Torak and Whiteman (1982) indicate hydraulic conductivity representative of the area adjacent to the fault to be about 3.0 X 10^{-7} to 4.0 X 10^{-7} ft/s.

The "1,500- and 1,700-foot" aquifer and the "1,200-foot" aquifer contain saltwater south of the Baton Rouge fault. As a result of the development of the cone of depression north of the fault and realignment of flow lines, saltwater encroachment is occurring north of the fault (Whiteman, 1979) and potential water-quality problems exist. Water-quality characteristics of the "1,500- and 1,700-foot" aquifer have been thoroughly described by Meyer and Turcan (1955), Morgan (1961), Rollo (1969), and Whiteman (1979). In general, except where saltwater occurs in the aquifer, the water is soft and low in dissolved solids. Chlorographs show that saltwater has reached well EB-807A, about 1 mi north of the Baton Rouge fault, but has not yet reached well EB-413 (fig. 3), less than 1 mi farther to the northeast (fig. 2).

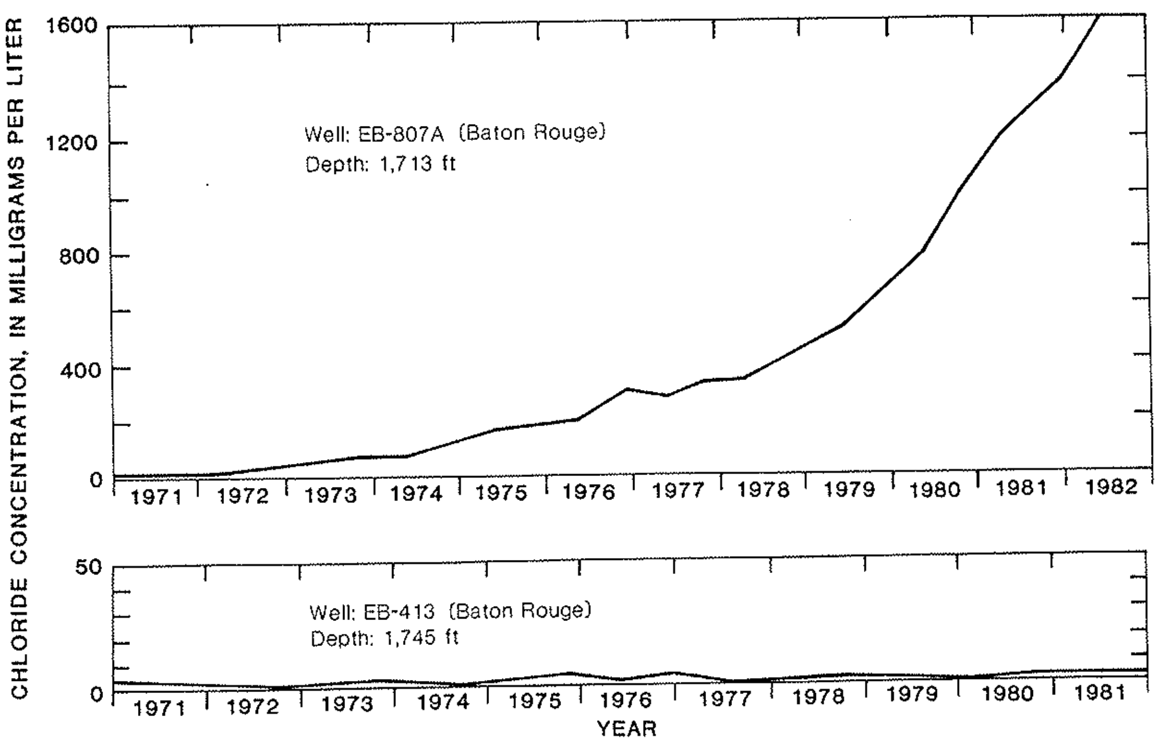


Figure 3.--Chloride concentrations in water from wells in the "1,500- and 1,700-foot" aquifer in the project area.

GROUND-WATER FLOW SYSTEM

Water enters the "1,500- and 1,700-foot" aquifer from rainwater infiltrating and percolating through the surficial sands in southern Mississippi and the northern part of the study area (fig. 2). After water enters the aquifer, it moves downdip along the hydraulic gradient to the south and Baton Rouge (fig. 4). As the water moves down gradient in the undeveloped section of the aquifer north of Baton Rouge, additional water is recharged into the "1,500- and 1,700-foot" aquifer from the "1,200-foot" aquifer above and discharged out of the "1,500- and 1,700-foot" aquifer into the "2,000-foot" aquifer below. The magnitude of these recharge and discharge rates is dependent upon the hydraulic head differences between the aquifers and the vertical-hydraulic conductivity of the intervening clay layers.

Prior to development of the "1,500- and 1,700-foot" aquifer, water flowed south to the vicinity of the Baton Rouge fault (fig. 1), which acts as a barrier to ground-water flow (Whiteman, 1979). The water then moved upward and discharged into the "1,200-foot" aquifer. Water also moved upward from the "2,000-foot" aquifer into the "1,500- and 1,700-foot" aquifer prior to development because of the head difference between the aquifers at the fault. Some water also moved south across the fault and downdips into that part of the aquifer containing saltwater.

The "1,500- and 1,700-foot" aquifer extends eastward beyond the Louisiana-Mississippi State line at the Pearl River. Here, water in the aquifer flows to the southeast toward the Pearl River valley. The aquifers extend into western Louisiana, but for this study, the major emphasis is east of the Atchafalaya River basin. Along the east side of the Atchafalaya River basin, the flow is southwest and west toward the basin.

Under the current pumping conditions, water flows into the "1,500- and 1,700-foot" aquifer from overlying aquifers. Water is released to the "1,500- and 1,700-foot" aquifer from storage in the confining layers and from leakage through the confining layers from the above aquifers. Water flows out of the "1,500- and 1,700-foot" aquifer through the lower confining layer to the "2,000-foot" aquifer.

Before 1920, very little water was withdrawn from the "1,500- and 1,700-foot" aquifer (Torak and Whiteman, 1982). Since then, the "1,500- and 1,700-foot" aquifer has become a major source of water (17 Mgal/d in 1979) for public supply in East Baton Rouge Parish (Whiteman, 1979). More than half of the pumpage is concentrated in two adjacent well fields. The resulting cone of depression has altered the flow paths in the aquifer by inducing flow from all directions. Northern movement has an impact on water quality because it induces movement of saltwater across the Baton Rouge fault toward the well fields.

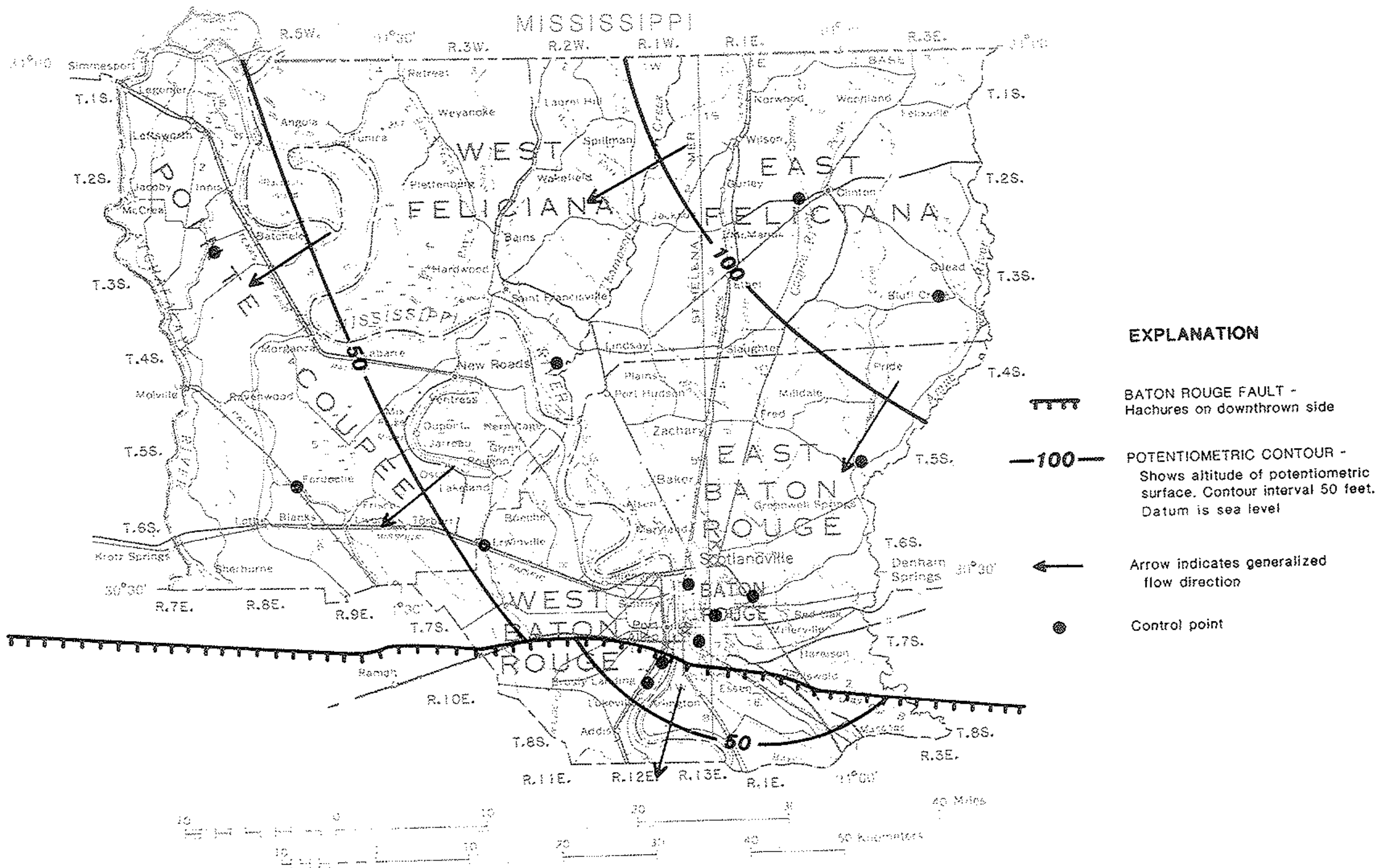


Figure 4.--Five-parish project area showing generalized potentiometric surface and flow pattern of the "1,500- and 1,700-foot" aquifer, 1930-50.

Water-level trends in wells in the "1,500- and 1,700-foot" aquifer are shown in figure 5. (See fig. 2 for location of wells.) Well PC-39, located northwest of East Baton Rouge Parish, is away from the influence of the Baton Rouge pumping. The hydrograph indicates that water levels have not changed other than for seasonal fluctuations. For comparison, note the declining water levels in well EB-807A and in well WBR-100A, both in the Baton Rouge area.

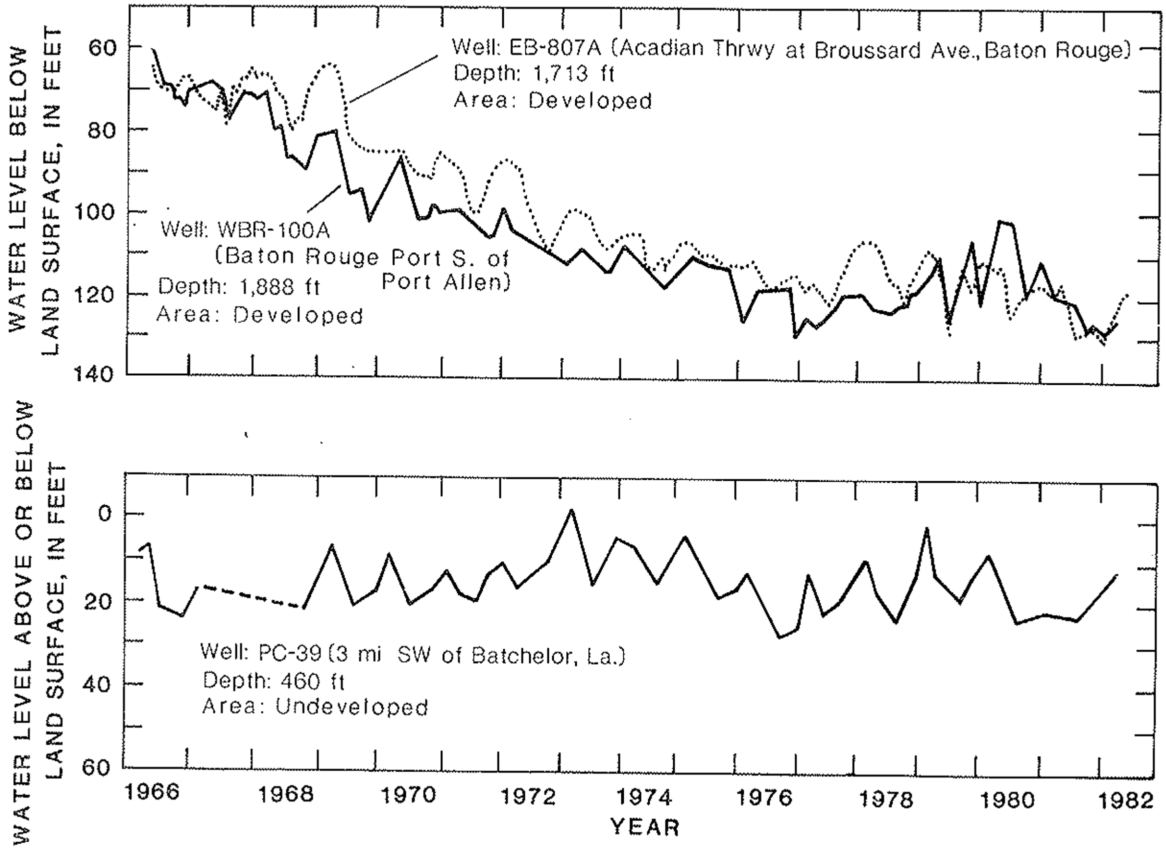


Figure 5.--Hydrographs of water levels in selected wells in the "1,500- and 1,700-foot" aquifer in the project area.

AQUIFER SIMULATION

The response of the "1,500- and 1,700-foot" aquifer to pumping stresses is demonstrated by using a digital model to compute water-level changes that would result from particular projected pumping schedules. Comparison of maps of the computed drawdown and hydrographs at selected locations resulting from projected pumping shows the spatial and temporal distribution of the aquifer response to projected pumping stress. Generalized water budgets of the aquifer system indicate the movement of water within the system in response to projected stress. The ability of the model to simulate the effects of alternate pumping stresses is directly related to the ability of the model to simulate past responses to pumpage.

Alternative Pumping Schedules Tested

Projections of water-level drawdown using the calibrated model are dependent upon the changes in pumping schedules and the length of the projection period. Three alternative pumping schedules were used to make 30-year projections (to the year 2009) of water-level drawdown. One alternative was to maintain the 2-year average (1978-79) pumping rates for 30 years using three 10-year periods. The second alternative was to increase the pumping rates 5 percent for each of six 5-year periods. The third alternative was to decrease the pumping rates 5 percent for each of six 5-year periods. All pumping-rate changes were made for the "1,500- and 1,700-foot" aquifer, and pumpage from the overlying and underlying aquifers was kept at the 1978-79 rates.

Response to Alternative Pumping Schedules

Simulation of the three pumping schedules produced a range of responses based on the relative magnitude and distribution of pumping. Drawdown for past pumping (1920-79) is shown on plate 3, which indicates a maximum drawdown of about 195 ft. Computed water levels at selected wells (location on plate 2) used in calibration, and projection of water levels for an additional 30 years (1980-2009) for the three tested pumping rates are shown in figures 6 through 11.

Results of simulated pumping at the 1978-79 rates show that the drawdown would increase a maximum of about 25 ft near Baton Rouge (to a total drawdown of about 220 ft) and would increase by about 5 ft near the model boundaries north of the Baton Rouge fault and about 15 ft near the southern boundary of the model, after 30 years (pls. 4 and 5).

Simulated responses to a 30-percent total increase in pumping indicate maximum increased drawdowns of nearly 50 ft near the center of the present cone of depression (to a total drawdown of about 245 ft) at Baton Rouge and about 5 ft near the model boundaries north of the fault and about 20 ft near the southern boundary of the model, after 30 years (pls. 6 and 7).

Simulated responses to a 30-percent decrease in pumping show the system responding to a reversal of the past trend. Water levels remain nearly constant in the center of the cone of depression. Additional drawdown of more than 15 ft occurs on the flanks of the cone in East Baton Rouge, West Baton Rouge, and western Livingston Parishes after 30 years, but drawdowns would be about 10 ft less than those projected with the 1978-79 pumping rates. In Pointe Coupee, St. Helena, and East and West Feliciana Parishes, the drawdowns are similar to those for the 1978-79 pumping rates. The resulting flatter gradient toward the pumping center than currently exists is a natural response to decreased pumping (pls. 8 and 9).

The model computations indicate that water levels, in the aquifer south of the Baton Rouge fault, are not greatly affected by changes in pumpage in the range investigated in this study. In all of the simulations, maximum additional drawdown south of the fault was centered along the fault southwest of Port Allen. Maximum additional drawdown varied about 4 ft for the simulations, from slightly over 18 ft with both continued pumping at 1978-79 rates and 30 years of decreasing pumpage to about 22 ft with 30 years of increasing pumpage.

The time distribution of the drawdowns, shown by the hydrographs in figures 6 through 11, indicates steady trends in water-level change throughout the simulation periods in response to the gradual changes in pumping stress that were imposed.

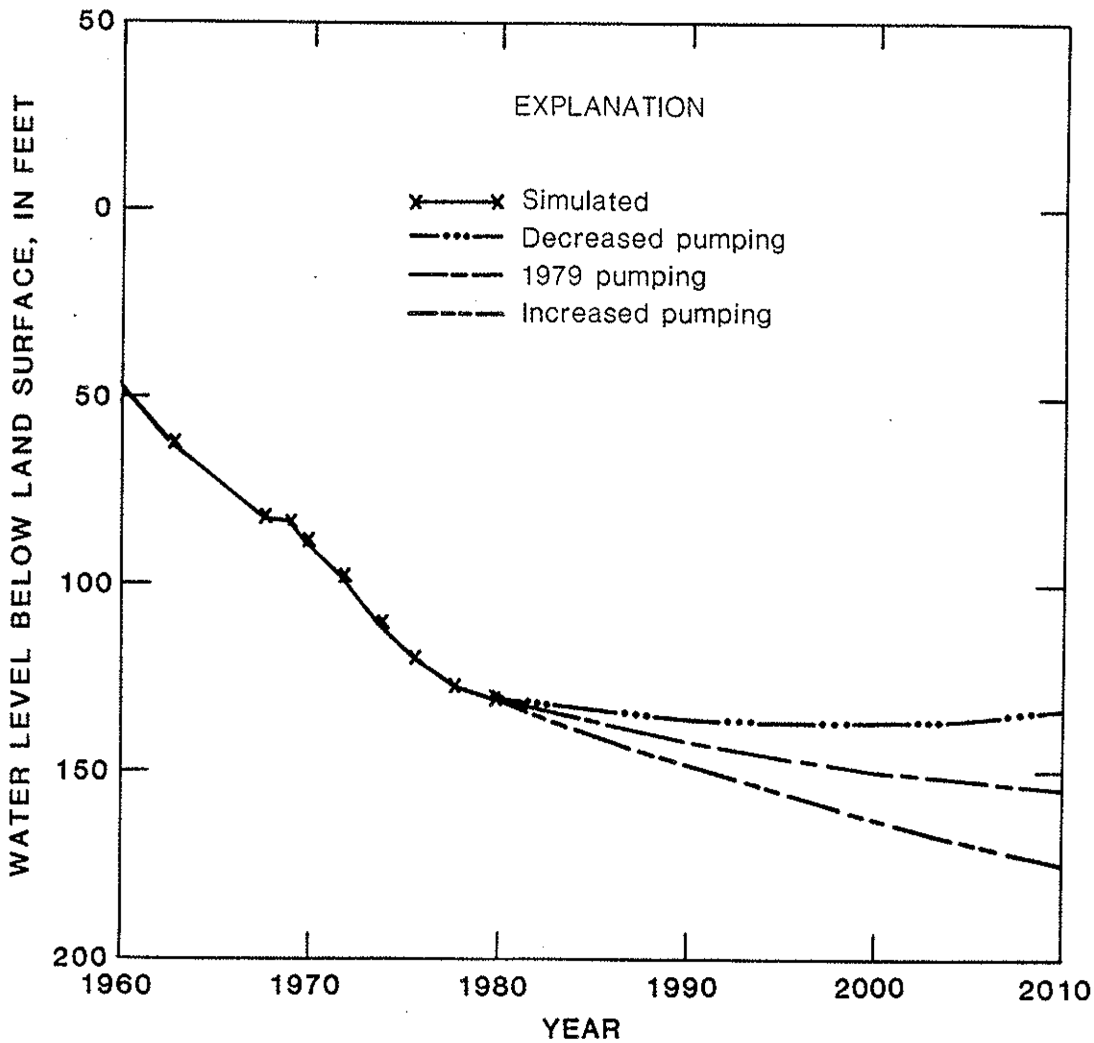


Figure 6.--Computed hydrographs for the "1,500- and 1,700-foot" aquifer for model node 12,18 for projected pumping stresses.

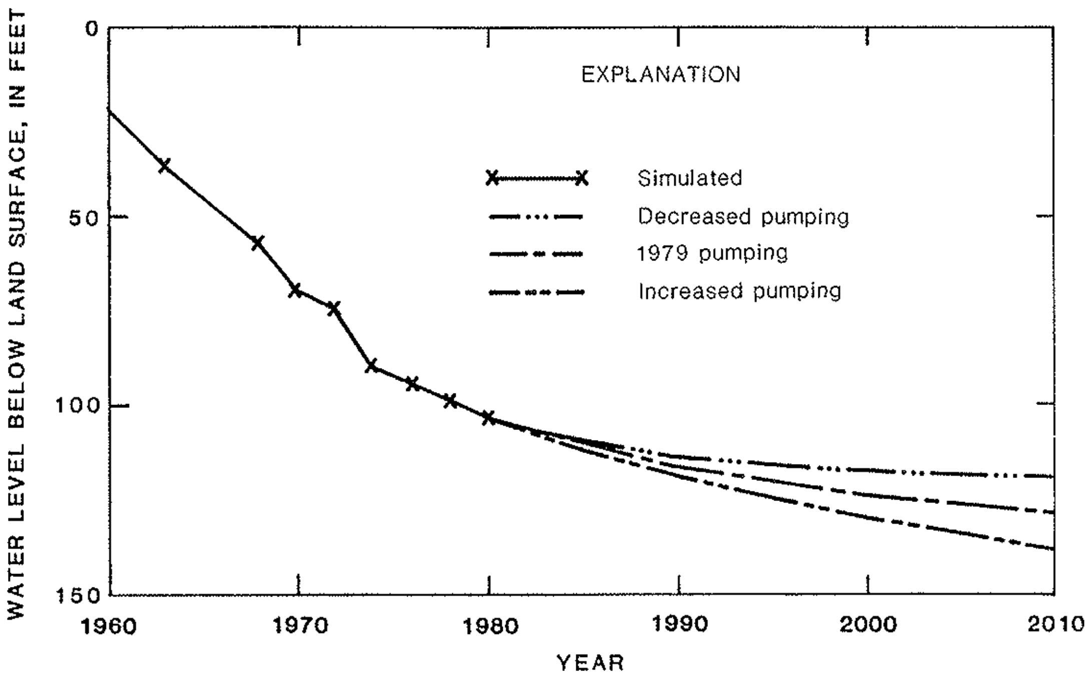


Figure 7.--Computed hydrographs for the "1,500- and 1,700-foot" aquifer for model node 9,14 for projected pumping stresses.

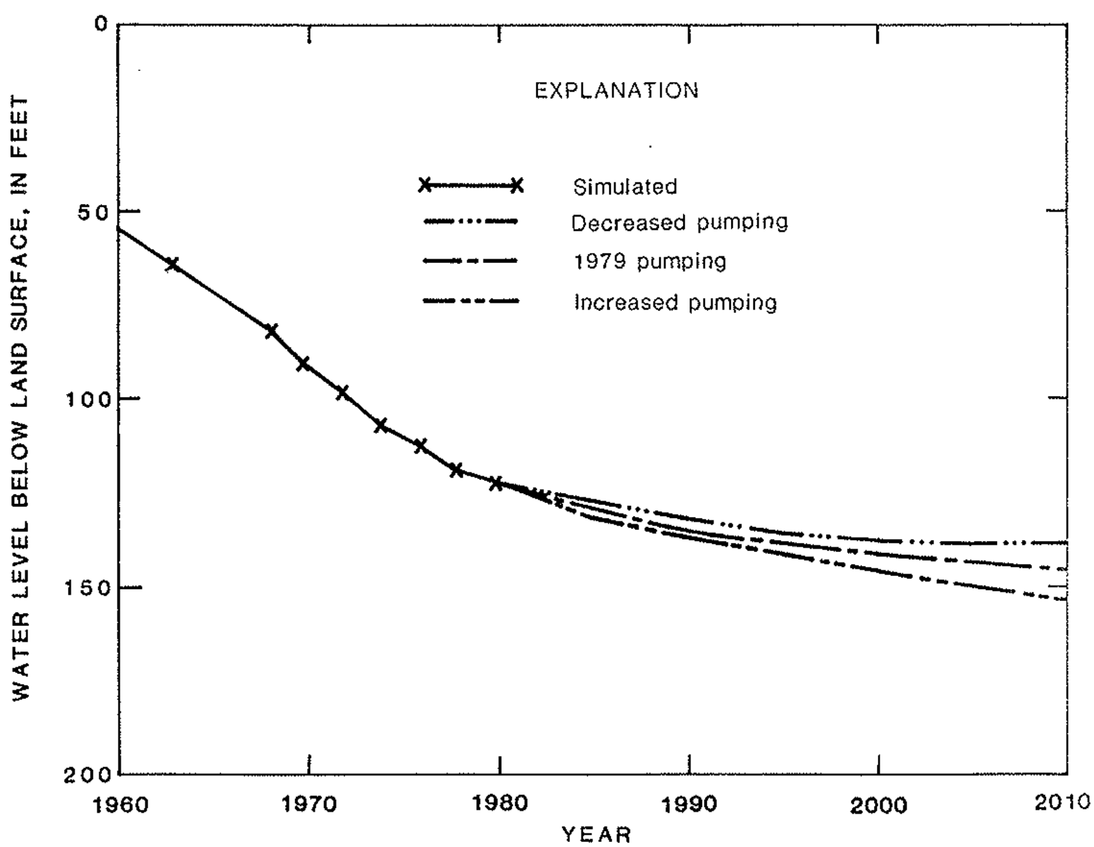


Figure 8.--Computed hydrographs for the "1,500- and 1,700-foot" aquifer for model node 8,17 for projected pumping stresses.

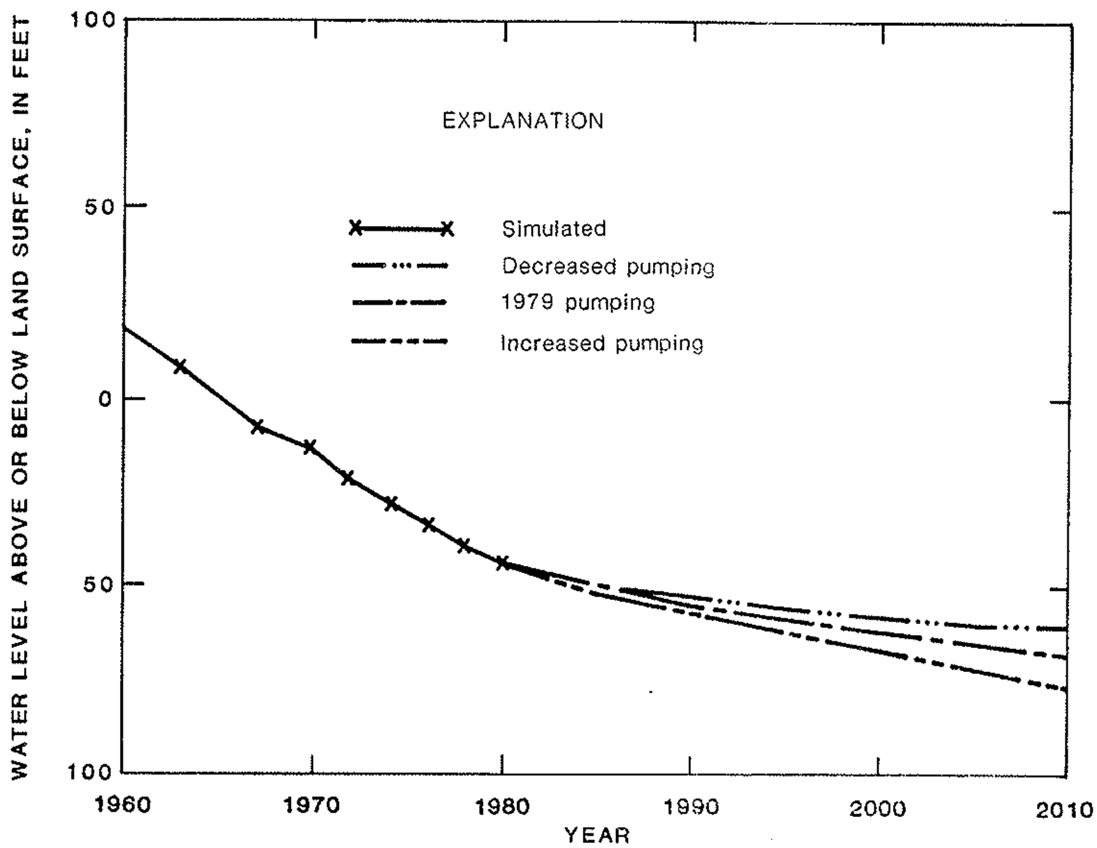


Figure 9.--Computed hydrographs for the "1,500- and 1,700-foot" aquifer for model node 9,23 for projected pumping stresses.

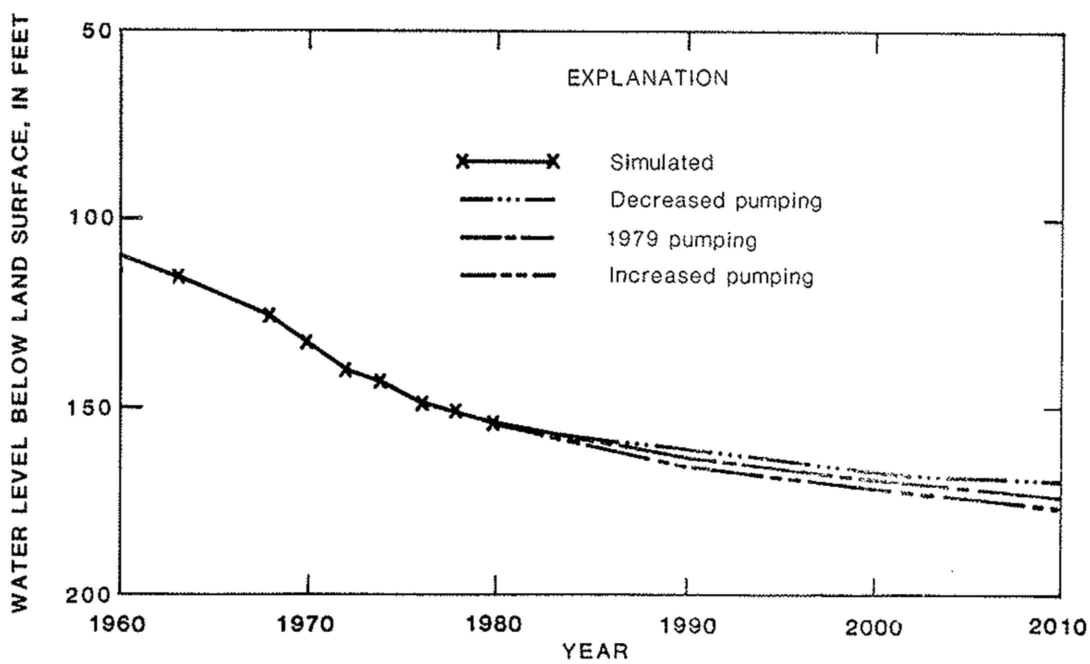


Figure 10.--Computed hydrographs for the "1,500- and 1,700-foot" aquifer for model node 6,16 for projected pumping stresses.

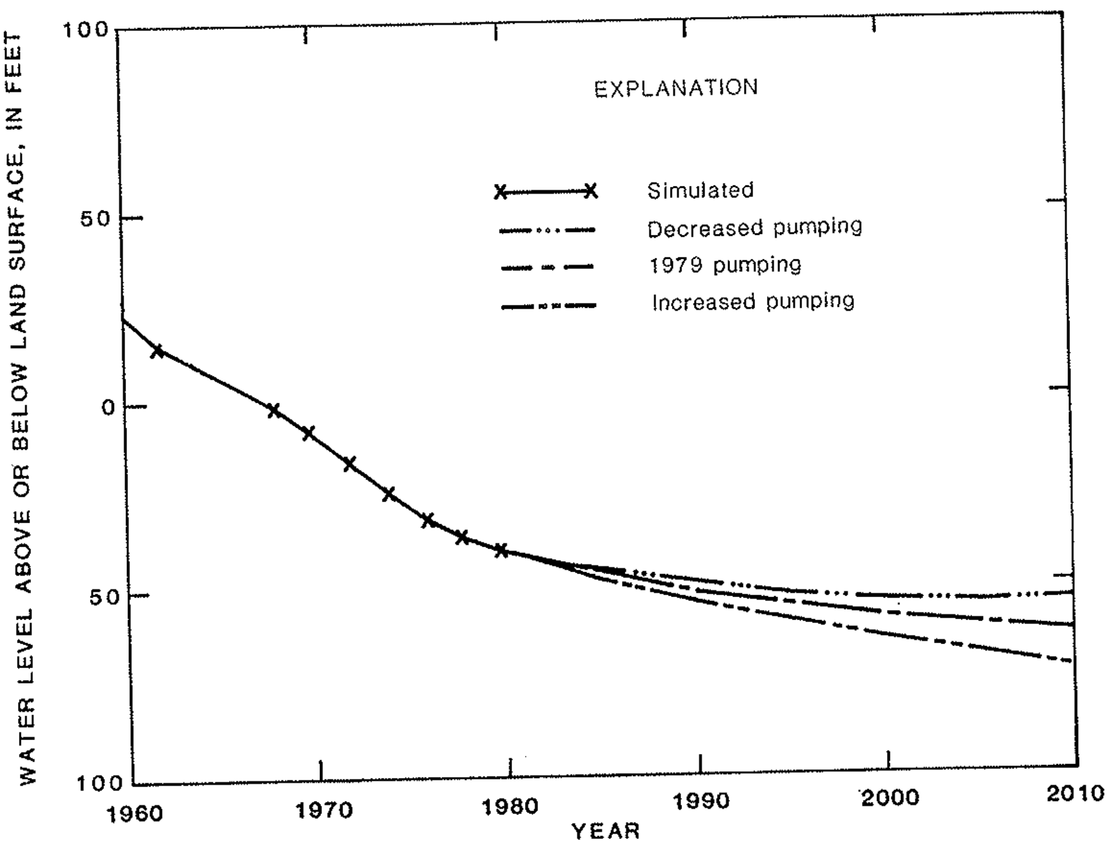


Figure 11.--Computed hydrographs for the "1,500- and 1,700-foot" aquifer for model node 10,23 for projected pumping stresses.

Water Budgets

An accounting of the movement of water through the aquifers included in the model indicates the overall ability of these aquifers to satisfy the pumping demands. Water-budget summaries provided by the model simulations are for the three-aquifer system, which includes the underlying "2,000-foot," the "1,500- and 1,700-foot," and the overlying "1,200-foot" aquifers.

The water budget for each model simulation is shown in table 2. Pumpage changes imposed on the "1,500- and 1,700-foot" aquifer are small relative to the total pumpage for all of the aquifers included in the model. Therefore, water budgets show very little change from one simulation to another. The budget for the period 1920-79 shows that leakage contributes approximately 40 percent of the water withdrawn and more than 55 percent comes from storage. Less than 5 percent of the water is supplied from constant-head sources in the recharge area.

Table 2.--Water budgets from model simulations including the "1,200-foot," "1,500- and 1,700-foot," and "2,000-foot" aquifers

[Total volume for simulation period in million gallons]

Sources	Historical[1]	Alternatives One[2]	Alternatives Two[3]	Alternatives Three[4]
Discharge by pumpage---	945,000	1,997,000	2,031,000	1,963,000
Aquifer storage--------	526,000	1,383,000	1,403,000	1,362,000
Constant-head sources--	35,000	47,000	47,000	47,000
Leakage inflow---------	384,000	567,000	581,000	554,000
Total sources--------	945,000	1,997,000	2,031,000	1,963,000

[1] Simulation based on actual pumping, 1920-79.
[2] Simulation based on actual pumping, 1920-79; continued pumping at 1978-79 rate for 30 additional years.
[3] Simulation based on actual pumping, 1920-79; increased pumping rate for 30 additional years.
[4] Simulation based on actual pumping, 1920-79; decreased pumping rate for 30 additional years.

Leakage is a major source of water to the individual aquifers in the system, and water movement from each aquifer is of interest. The model computes leakage rates through the confining layers and transient leakage rates from storage in the confining layers. Leakage rates are shown in table 3 and indicate significant changes in flow rates in response to

Table 3.--Leakage rates for the final time step of simulation period for the confining layers adjacent to the "1,500- and 1,700-foot" aquifer

[Rates given in million gallons per day]

Leakage components	Historical[1] Underlying layer	Historical[1] Overlying layer	Alternative One[2] Underlying layer	Alternative One[2] Overlying layer	Alternative Two[3] Underlying layer	Alternative Two[3] Overlying layer	Alternative Three[4] Underlying layer	Alternative Three[4] Overlying layer
Steady leakage inflow----	0.00	14.00	0.00	33.76	0.00	36.39	0.00	31.49
Transient leakage inflow-	.00	14.07	.00	7.34	.00	8.12	.00	6.49
Steady leakage outflow---	28.96	.00	40.92	.00	39.66	.00	42.35	.00
Total inflow rate--------	.00	28.07	.00	41.10	.00	44.51	.00	37.98
Total outflow rate-------	28.96	.00	40.92	.00	39.66	.00	42.35	.00
Net inflow rate--------	-0.89		-0.18		4.85		-4.37	

[1] Simulation based on actual pumping, 1920-79.
[2] Simulation based on actual pumping, 1920-79; continued pumping at 1978-79 rate for 30 additional years.
[3] Simulation based on actual pumping, 1920-79; increased pumping rate for 30 additional years.
[4] Simulation based on actual pumping, 1920-79; decreased pumping rate for 30 additional years.

changes in pumpage. Pumpage from the "1,500- and 1,700-foot" aquifer does not reverse the overall movement of water through the aquifers but may intercept water as it passes from one aquifer into another. It has been documented by Torak and Whiteman (1982) that pumpage from the underlying "2,000-foot" aquifer is pulling water from the "1,500- and 1,700-foot" aquifer. This pumpage from the "2,000-foot" aquifer results in a net outflow or loss from the "1,500- and 1,700-foot" aquifer when the pumpage is decreased or maintained at the 1978-79 rates. Increased pumpage from the "1,500- and 1,700-foot" aquifer will intercept more water flowing through the system and result in a small net inflow to the "1,500- and 1,700-foot" aquifer and decrease the amount of leakage to the "2,000-foot" aquifer.

MODEL DEVELOPMENT

Digital-modeling techniques were used to provide quantitative information about the aquifer and to project aquifer responses to alternative pumping stresses. Aquifer and confining-bed properties and the location of natural recharge and discharge areas were put into the model at discrete sites (nodes) to represent the aquifer's ability to store and transmit water. The model was calibrated by imposing historic pumping stresses and comparing drawdowns from field observations with those from model computations. Alternative pumping stresses were then imposed on the system, and the calibrated model projected drawdowns and a water budget for the aquifer.

Design

A three-dimensional ground-water flow model was used to simulate the "1,500- and 1,700-foot" aquifer and to account for its hydrologic relation to the underlying "2,000-foot" aquifer and overlying "1,200-foot" aquifer. A layered conceptualization of the aquifers was developed for modeling purposes. Three aquifer layers representing the "2,000-foot," "1,500- and 1,700-foot," and "1,200-foot" aquifers, respectively, and two layers representing clay confining beds above and below the "1,500- and 1,700-foot" aquifer were included in the model formulation. (See fig. 12.) The two confining layers were allowed to "leak" or to permit water to move vertically through them into the adjacent aquifers. Water was not allowed to move through the underlying or overlying boundaries. The model, documented by Trescott (1975) and Trescott and others (1976), uses a strongly implicit numerical method for solution of the flow equations and can accommodate variable grid (node) spacing and irregular boundaries. Alterations to the model code were made to compute transient leakage from storage in the adjacent confining beds (Torak and Whiteman, 1982).

Grid

The finite-difference grid used for the model was based on the hydrogeologic characteristics of the aquifer and the degree of detail needed in the model results. The active area of the rectangular grid, about 120 mi by 270 mi, represents about 32,000 mi^2. Grid orientation parallels the trend of the Baton Rouge fault and the regional dip of the aquifer (pl. 2). The area of the grid blocks increases from 1.0 mi^2 near the pumping centers to at least 12 mi^2 near the model boundaries.

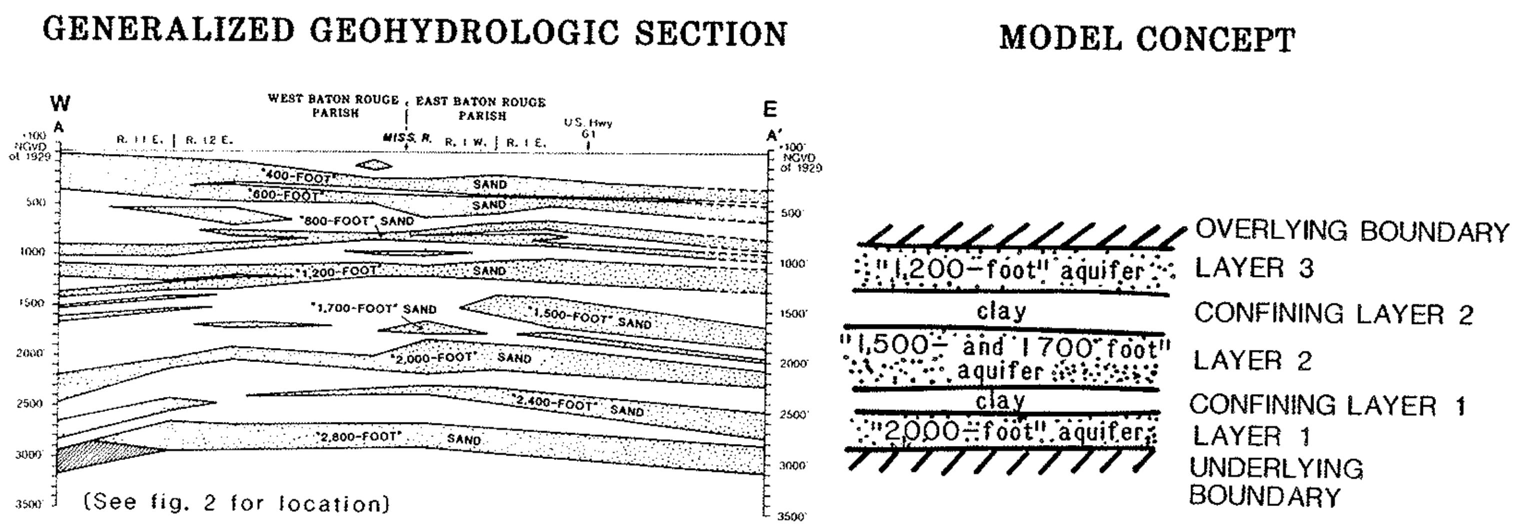


Figure 12.--Conceptual diagram of model design.

The largest active grid block, in the southeastern corner of the area, is 18 mi by 54 mi. The grid orientation and the block-size dimensions are the same as those used by Torak and Whiteman (1982) in the model of the "2,000-foot" aquifer.

Boundary and Initial Conditions

Preliminary model simulations indicated that boundaries to the east and west were a sufficient distance from the pumping center not to affect the computed drawdowns in the pumping center. Flow lines in the aquifer were essentially parallel to the model boundaries; therefore, no-flow boundaries were used. A no-flow boundary also was established at the southern edge of the model. No significant change in drawdown at the pumping centers was computed when constant-head boundaries were substituted for the no-flow boundaries, except to the south. Drawdown differences resulting from the two types of boundaries were significant south of the Baton Rouge fault (being much less with the constant-head boundary), but were less than 2 ft on the north side. Because of the presence of saltwater south of the fault, there is no significant pumpage now and none is anticipated in the future; therefore, the boundary effects south of the fault are not considered to be a problem in this analysis.

The northern boundary is located in the recharge area where water-table conditions exist and stream levels control the head in the aquifer system. A constant-head boundary was used in this area. Boundary nodes were assigned water levels that were comparable with stream levels.

The year 1920 was selected to start model simulations of the "1,500- and 1,700-foot" aquifer because there was insignificant pumping before 1920. There was a minor amount (0.73 ft^3/s or 0.5 Mgal/d) of pumpage at only two locations in 1920--a low enough rate that a steady-state head distribution was not seriously affected. However, because historic water-level data were inadequate to construct a steady-state head map at the onset, the model was developed on the concept of superposition where drawdowns were computed from an arbitrary initial head of zero.

Aquifer Properties

Data defining aquifer properties for the model near Baton Rouge were obtained from previous studies. Hydraulic conductivity and thickness data obtained from these sources were used to compute initial values of transmissivity at each node. Results of a study of the hydraulic conductivity across the Baton Rouge fault by Torak and Whiteman (1982) were used to obtain transmissivities for nodes at the fault. Initial values of storage coefficients from published sources also were used.

The initial values of transmissivity and storage were adjusted in the calibration of the model. Final calibrated values of transmissivity for the "1,500- and 1,700-foot" aquifer ranged from 0.015 ft^2/s for nodes northwest of the Baton Rouge industrial district to more than 0.4 ft^2/s for nodes adjacent to the fault. Transmissivity values ranged from 0.02 to 0.25 ft^2/s and 0.005 to 0.305 ft^2/s for the "1,200-foot" and "2,000-foot" aquifers, respectively. A final calibrated storage coefficient of 5×10^{-4} was used for the "1,500- and 1,700-foot" aquifer, except near the recharge area where storage coefficients are variable and characteristic of water table aquifers. Storage coefficients were 5×10^{-4} and 1×10^{-3} for the "1,200-foot" and "2,000-foot" aquifers, respectively, except in the recharge areas where they are varied.

Leakage

It is stated in earlier sections of this report that leakage from and through the confining layers is significant. The study by Torak and Whiteman (1982) gives an areal distribution of vertical conductance of the confining layer underlying the "1,500- and 1,700-foot" aquifer. Torak's conductance distribution was used for the lower confining layer in the model. A typical value of vertical-hydraulic conductivity for the lower confining layer (5×10^{-9} ft/s) was used for all nodes in the upper confining layer. Areal distribution of conductance in the upper confining layer was accounted for in the initial assignment of confining layer thicknesses by adjusting the thicknesses for the amount of silt and sand in the confining layer.

Pumpage

Data available in the files of the U.S. Geological Survey were used to estimate total pumpage within each grid block. Pumpage data before 1940 were sparse for all of the modeled area. Since 1940, pumpage data for the Baton Rouge area are reasonably complete and detailed, but pumpage data for much of the outlying modeled area remain fragmentary. Fortunately, the model is relatively insensitive to changes in the early pumping periods, so even large percentage errors in the pre-1940 pumpage would have little effect on calculated current and future water-level response.

Calibration

The digital model was calibrated to ensure that it was accurately simulating the physical system. There were not enough water-level data for 1920 to establish an initial steady-state surface so the transient-model calibration was started from an arbitary "zero" initial surface. Drawdown comparisons between the computed model values and the observed values for selected wells were made to determine the model accuracy. Drawdowns from the calibrated model and observed water levels were then used to estimate constant-head water levels for input into a steady-state version of the model to calculate water levels representative of predevelopment conditions across the area.

Model Pumping Periods

The model permits the total simulation period to be subdivided into shorter time periods based on changes in pumpage or the need for water-level data at particular times. The model was calibrated for the period 1920-67 so water-level data available for 1967 (Rollo, 1969) could be used to check the model calibration. The period 1968-79 was used as a final check of the model calibration. The calibration period was subdivided into 10 pumping periods of 2 to 10 years each. The period used as a final check uses six pumping periods of 2 years each (table 4).

Table 4.--Time distribution of pumping from each aquifer included in the model

[Average pumping in million gallons per day for each aquifer. Values in parentheses are in cubic feet per second]

Time period	"2,000-foot" aquifer		"1,500- and 1,700-foot" aquifer		"1,200-foot" aquifer	
1920-29	4.072	(6.30)	0.472	(0.73)	0.485	(0.75)
1930-39	4.647	(7.19)	1.609	(2.49)	.801	(1.24)
1940-41	18.679	(28.90)	3.264	(5.05)	.465	(.72)
1942-43	27.649	(42.78)	3.949	(6.11)	.918	(1.42)
1944-45	27.068	(41.88)	3.787	(5.86)	.918	(1.42)
1946-47	27.914	(43.19)	6.075	(9.40)	.336	(.52)
1948-52	25.174	(38.95)	9.481	(14.67)	1.499	(2.32)
1953-57	30.332	(46.93)	9.216	(14.26)	12.235	(18.93)
1958-62	35.198	(54.46)	11.304	(17.49)	17.909	(27.71)
1963-67	37.861	(58.58)	12.487	(19.32)	20.973	(32.45)
1968-69	49.650	(76.82)	12.028	(18.61)	25.129	(38.88)
1970-71	52.041	(80.52)	12.487	(19.32)	20.973	(32.45)
1972-73	57.445	(88.88)	15.033	(23.26)	21.509	(33.28)
1974-75	55.279	(85.53)	16.281	(25.19)	21.923	(33.92)
1976-77	53.160	(82.25)	17.664	(27.33)	22.899	(35.43)
1978-79	55.609	(86.04)	17.903	(27.70)	22.537	(34.87)

Selection of Values of Aquifer and Confining Bed Properties

The model was run with the initial values of aquifer and confining bed properties selected from available information described previously in this report for the period 1920-67. Observed drawdowns in about 30 wells for the period 1920-67 were compared with the computed drawdowns for the grid blocks in which the wells were located. Adjustments were made to the model input values by trial and error for each model simulation until the computed and observed drawdowns compared within acceptable limits. Drawdowns for the period 1968-79 were computed by the model and compared to observed drawdowns as a check of the final values selected.

Thicknesses of confining layers and aquifers and the pumpage were not varied in the calibration process because they were considered reliable. The hydraulic conductivities and storage coefficients of the aquifers and confining layers were allowed to vary uniformly over the modeled area.

Drawdown Comparisons and Error Analysis

Drawdowns computed by the model were compared to measured drawdowns in the calibration process. Observed drawdowns at selected wells with a significant period of record were compared to the drawdowns computed corresponding period by the model for the grid block in which the wells were located. Periods of record prior to 1940 were avoided, when possible, because water-level and pumpage data before then were limited.

Data included in table 5 represent the available drawdown information that is complete enough to use for comparison with model results. Absolute differences in East Baton Rouge Parish averaged 4.8 ft and ranged from -11.6 to +8.6 ft, with two-thirds of the values falling between -3.0 and +5.5 ft. Absolute and percentage differences in the other parishes are greater than in East Baton Rouge Parish. Absolute differences ranged from -15.6 to +10.8 ft; two-thirds of the values fell between -7.4 and +9.3 ft. Drawdowns computed by the model represent average values for each grid block. These values were compared to drawdowns at specific wells within the given grid block, which generally will not be equal to the average drawdown. This source of error is included in the differences given in table 5.

A final comparative analysis is shown in a plot of the observed versus the modeled drawdowns (fig. 13) for each well listed in table 5. If the model and observations were perfect, all the points would plot on a diagonal line at 45 degrees from the horizontal. The points fall near the line and are distributed evenly about the line at all values of drawdown, indicating the model does simulate the observed drawdowns.

Table 5.--Drawdown comparisons for selected observation wells in the "1,500- and 1,700-foot" aquifer

Well No.[1]	Grid[2] location	Comparison period	Number of years	Drawdown (feet)		Difference	
				observed	computed	feet	percent
EB-94	14,18	1945-61	17	74.0	82.6	+8.6	12
EB-168	12,18	1967-79	13	49.7	47.5	-2.2	4
EB-303	9,23	1945-51	7	11.3	8.3	-3.0	27
EB-312	12,19	1948-53	6	31.2	19.6	-11.6	37
EB-585	9,14	1958-67	10	36.6	38.4	+1.8	5
EB-652	10,19	1967-79	13	46.3	45.4	-.9	2
EB-782B	16,18	1967-79	13	48.7	50.2	+1.5	3
EB-804A	17,22	1967-79	13	44.5	47.6	+3.1	7
EB-807A	16,18	1967-79	13	43.9	50.2	+6.3	14
EB-918	16,19	1973-79	7	13.8	19.1	+5.3	38
EB-971	7,17	1961-67	7	23.5	15.6	-7.9	34
Ev-691	6, 3	1967-79	13	2.8	2.3	-.5	18
Li-16	10,25	1939-47	9	21.7	6.1	-15.6	72
Li-49	10,23	1949-65	17	59.5	52.1	-7.4	12
PC-39	6, 6	1967-79	13	2.7	12.0	+9.3	340
PC-154	9,10	1973-79	7	13.9	15.4	+1.5	11
Ta-258	12,26	1952-69	18	14.9	18.5	+3.6	24
Ta-440	4,26	1975-79	5	2.4	1.1	-1.3	54
WBR-100A	15,15	1967-79	13	35.1	45.9	+10.8	31

[1] Number corresponds to identification numbers on plate 2.
[2] Numbers correspond to row and column in model grid on plate 2.

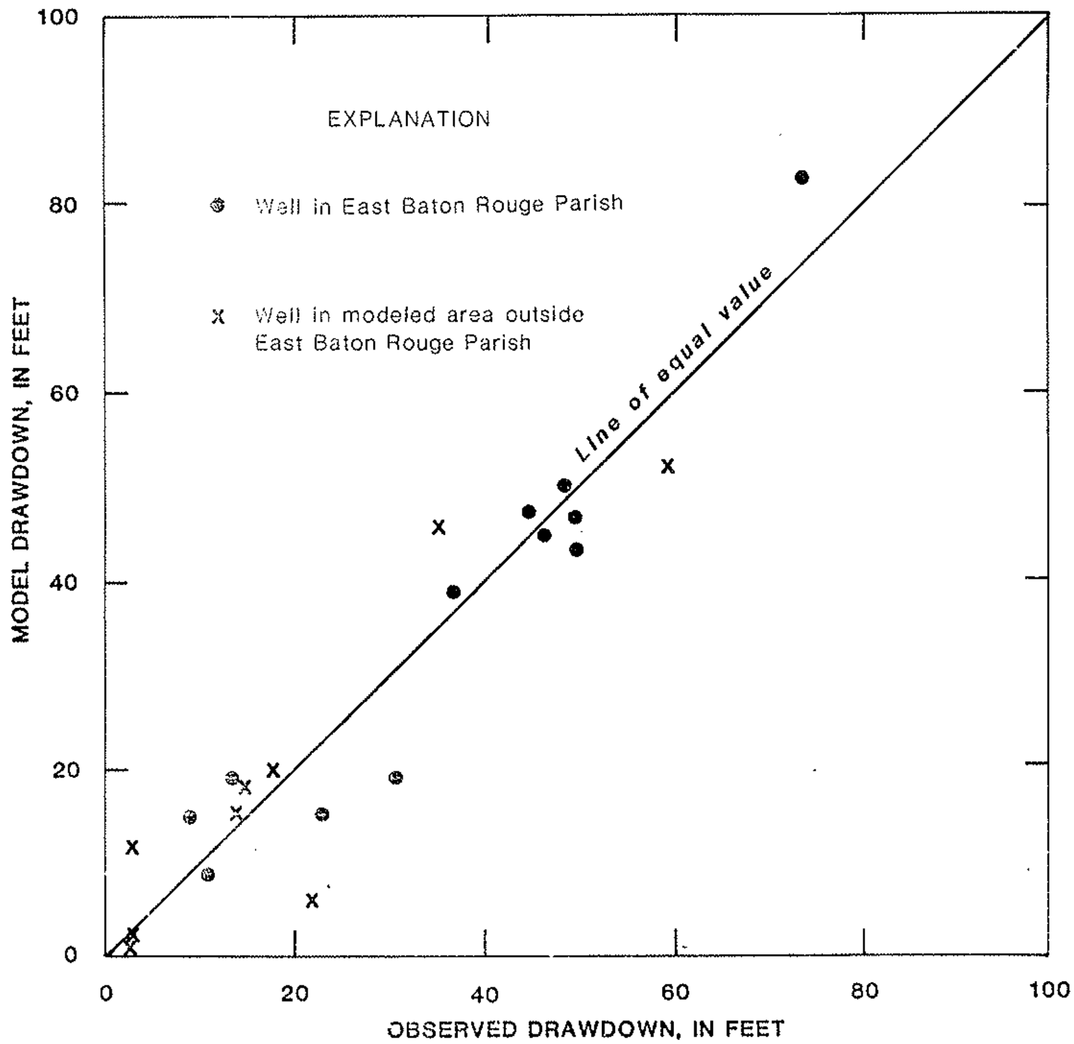


Figure 13.--Model calculated versus observed drawdown in selected observation wells.

The calibration results indicate model-calculated drawdowns of 100 ft or more can be expected to be within 5 percent of observed values two-thirds of the time, which translates to an accuracy of 5 to 10 ft in East Baton Rouge Parish. Calculated drawdown in outlying areas can have larger errors of as much as 15 ft because of larger grid sizes.

Model Response to Changes of Aquifer and Confining Bed Properties

The hydraulic properties of each aquifer and confining bed are entered into the model as matrices. Values assumed to be constant across the area, such as specific storage of the confining beds, can be entered as a single number which the model will assign to each node in the layer. Properties known to change across the area, such as aquifer transmissivity, are entered by assigning each node of the model a value representing that grid block. The model permits each value in the resulting matrix to be multiplied by a constant parameter coefficient. Changing the value of the parameter coefficient gives a uniform percentage change in the hydraulic property across the area without affecting the areal variability.

A general indication of the model's relative response to changes in the hydraulic properties of the aquifers and confining beds is demonstrated by comparing simulated water levels resulting from a range of coefficient multipliers for each property while holding the remaining properties constant. The model properties tested were as follows: (1) transmissivity of the "1,500- and 1,700-foot" aquifer, (2) hydraulic conductivity of the upper confining clay, (3) hydraulic conductivity of the lower confining clay, (4) storage coefficient of the "1,500- and 1,700-foot" aquifer, and (5) specific storage of the confining clays. Pumpage was not tested because it was the best known data used in the model and was not varied in the calibration process.

Three types of analysis were used to demonstrate model responses to changes in hydraulic properties: hydrograph comparison at selected grid blocks, drawdown comparison along selected model rows and columns, and mapping of the difference values between the calibrated drawdown and the drawdowns resulting from property changes. Computed hydrographs for selected grid blocks containing observation wells are shown in figures 14 through 18. The locations where drawdown comparisons were made were selected within the cone of depression (well EB-168), in areas away from the cone of depression (wells Li-49, EB-971, and PC-39), and near the Baton Rouge fault (well EB-782B). Drawdown comparisons are shown in figures 19 through 21 for selected sections through the modeled area taken along column 18 and along row 14 through the cone of depression and along column 23 in the outlying area of the model.

The differences between the drawdowns computed by the calibrated model and the drawdowns resulting from each property change have been mapped. Analysis of the results indicates that drawdowns or water levels are more sensitive to changes in some properties than to others. Changes in the transmissivity of the "1,500- and 1,700-foot" aquifer result in the largest impact on water levels or drawdowns. When the transmissivity was multiplied by two, the drawdown was 60 to 70 ft less or the water levels were 60 to 70 ft higher than the values from the calibrated model near the center of the cone of depression (fig. 22). The values were less than 10 ft different than the calibrated values near the boundaries. Conversely,

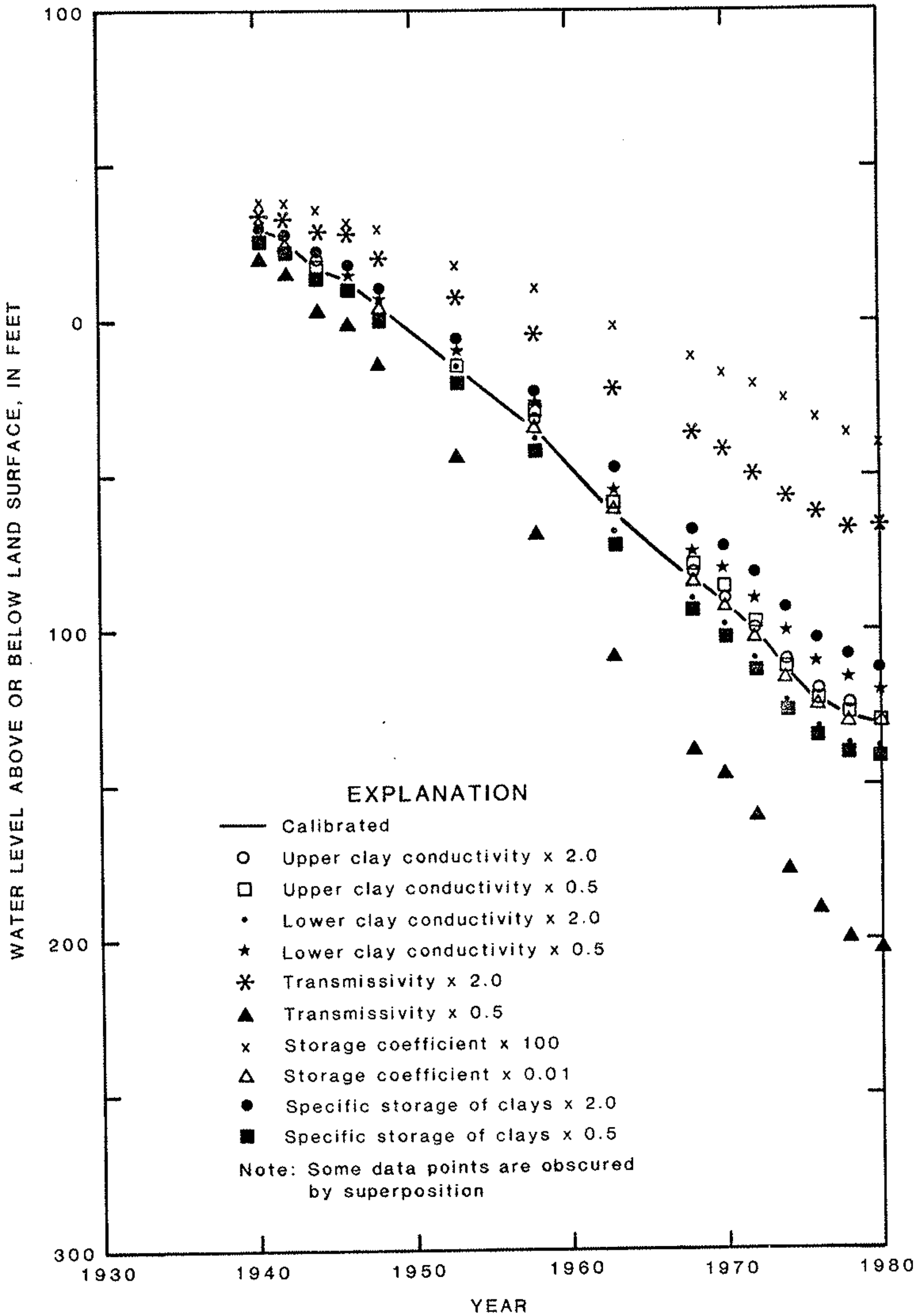


Figure 14.--Computed hydrograph showing the effect on water levels in the "1,500- and 1,700-foot" aquifer of changing selected aquifer and confining bed properties model node 12,18.

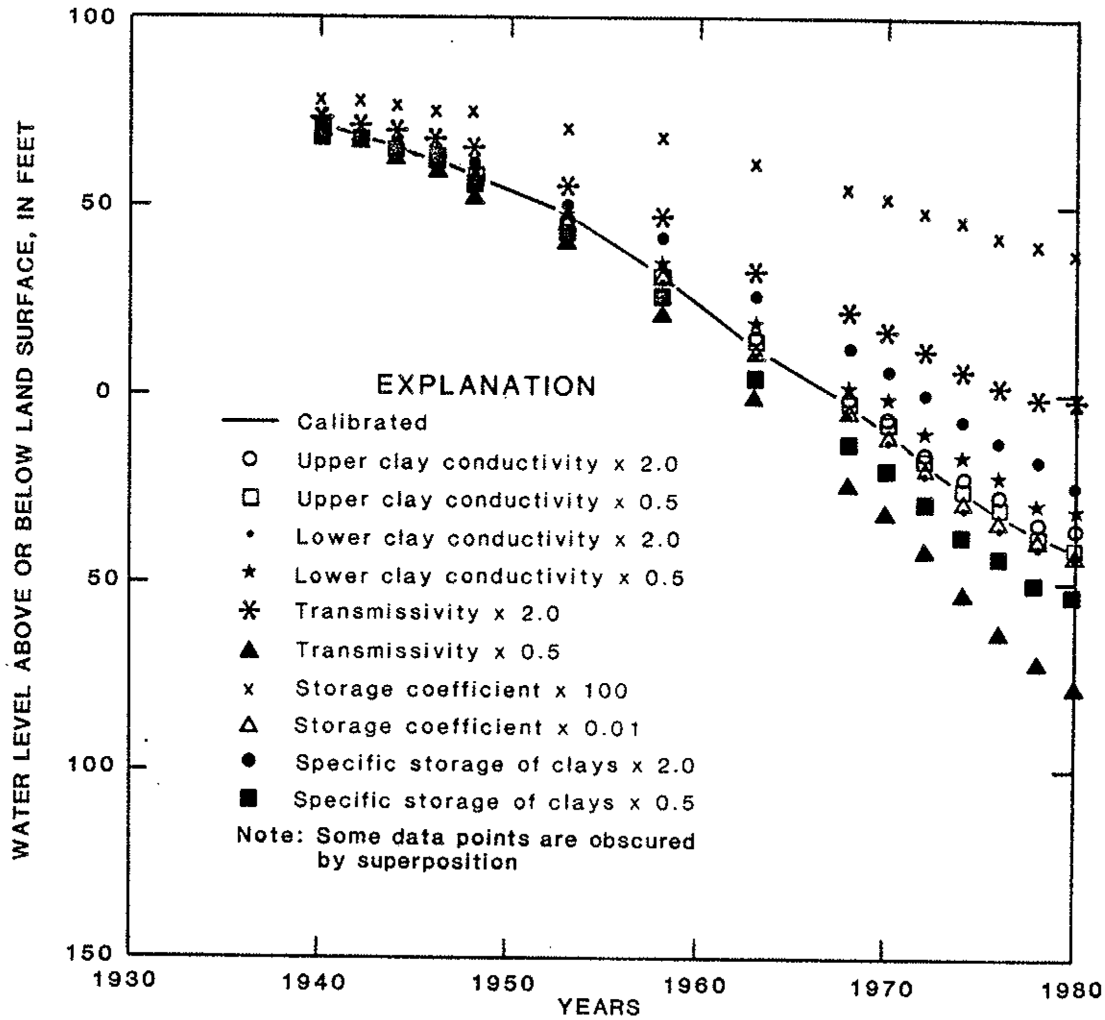


Figure 15.--Computed hydrograph showing the effect on water levels in the "1,500- and 1,700-foot" aquifer of changing selected aquifer and confining bed properties model node 10,23.

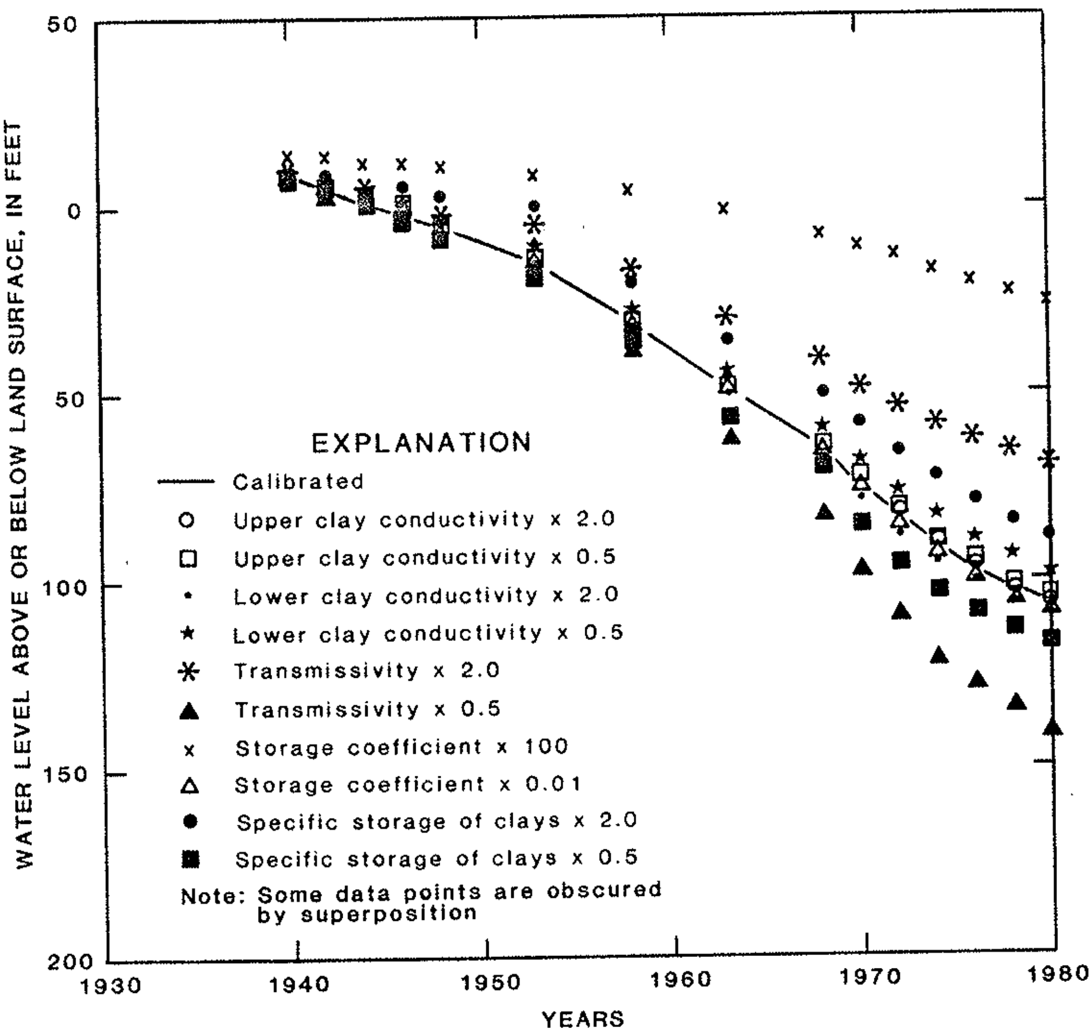


Figure 16.--Computed hydrograph showing the effect on water levels in the "1,500- and 1,700-foot" aquifer of changing selected aquifer and confining bed properties model node 8,17.

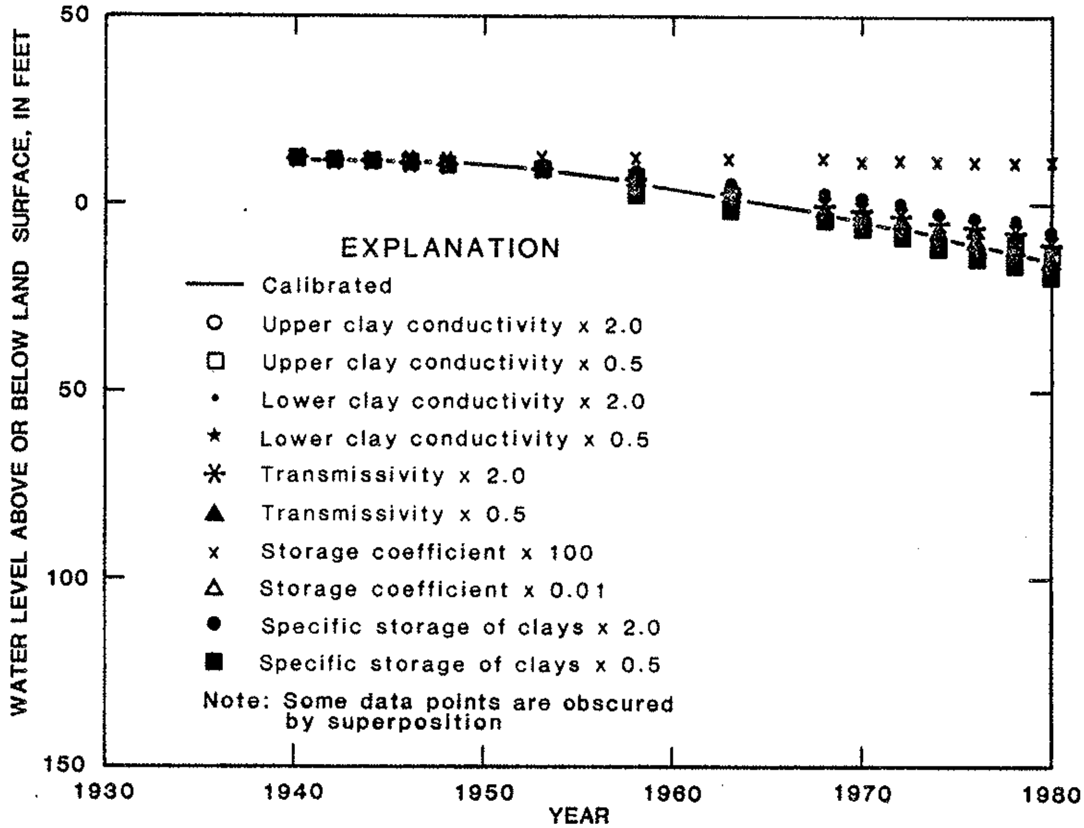


Figure 17.--Computed hydrograph showing the effect on water levels in the "1,500- and 1,700-foot" aquifer of changing selected aquifer and confining bed properties model node 6,6.

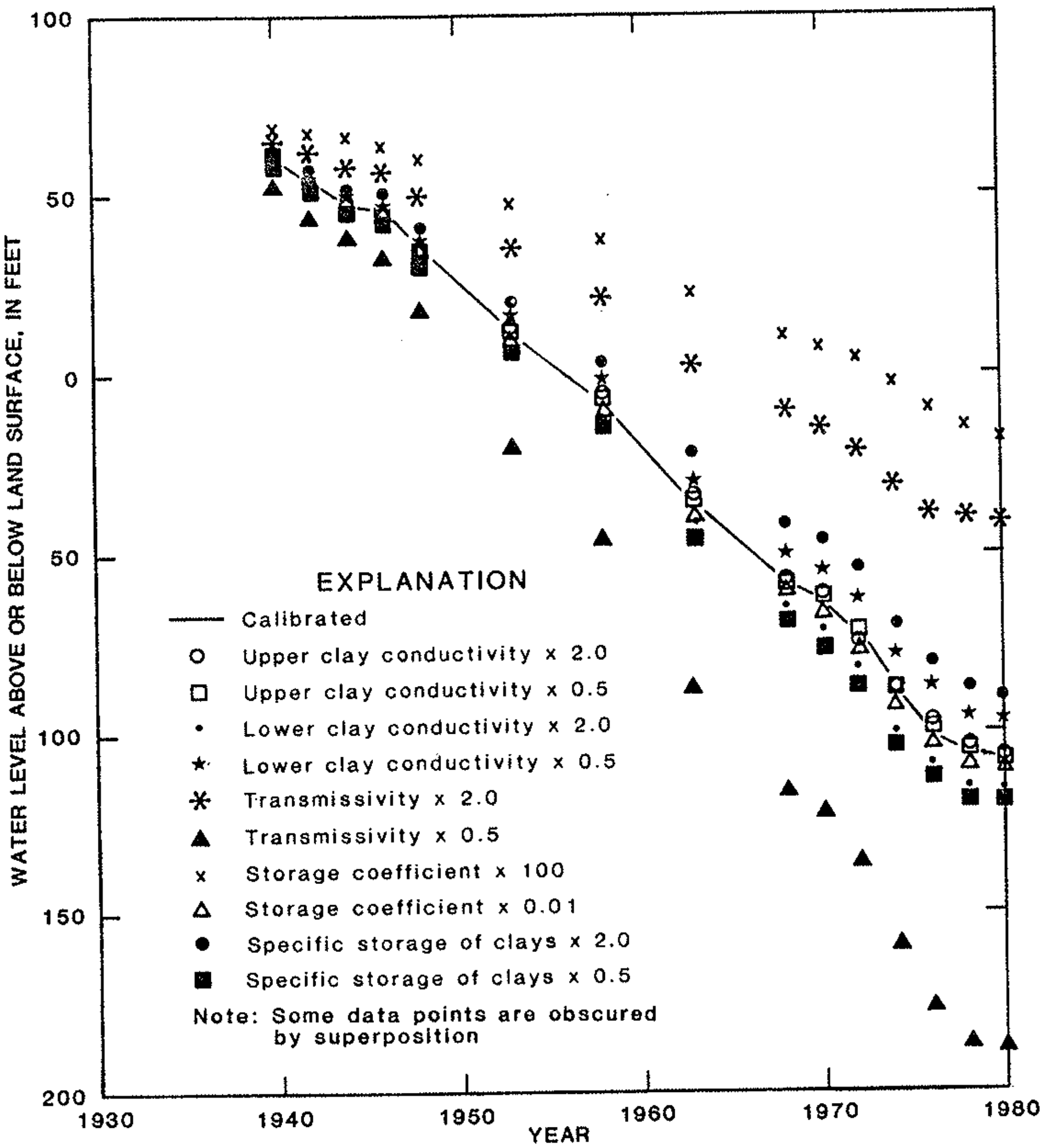
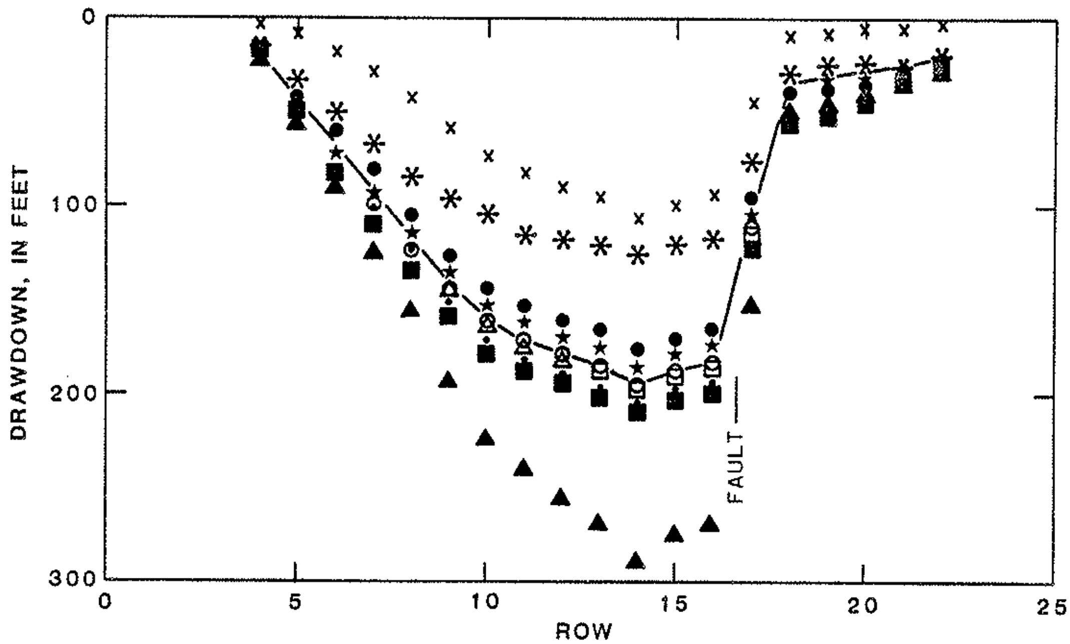


Figure 18.--Computed hydrograph showing the effect on water levels in the "1,500- and 1,700-foot" aquifer of changing selected aquifer and confining bed properties model node 16,18.



EXPLANATION

- Calibrated
- ○ Upper clay conductivity x 2.0
- □ Upper clay conductivity x 0.5
- • Lower clay conductivity x 2.0
- ★ Lower clay conductivity x 0.5
- ✳ Transmissivity x 2.0
- ▲ Transmissivity x 0.5
- x Storage coefficient x 100
- △ Storage coefficient x 0.01
- ● Specific storage of clays x 2.0
- ■ Specific storage of clays x 0.5

Note: Some data points are obscured by superposition

Figure 19.--Computed drawdown in "1,500- and 1,700-foot" aquifer resulting from changes in aquifer and confining bed properties for model column 18.

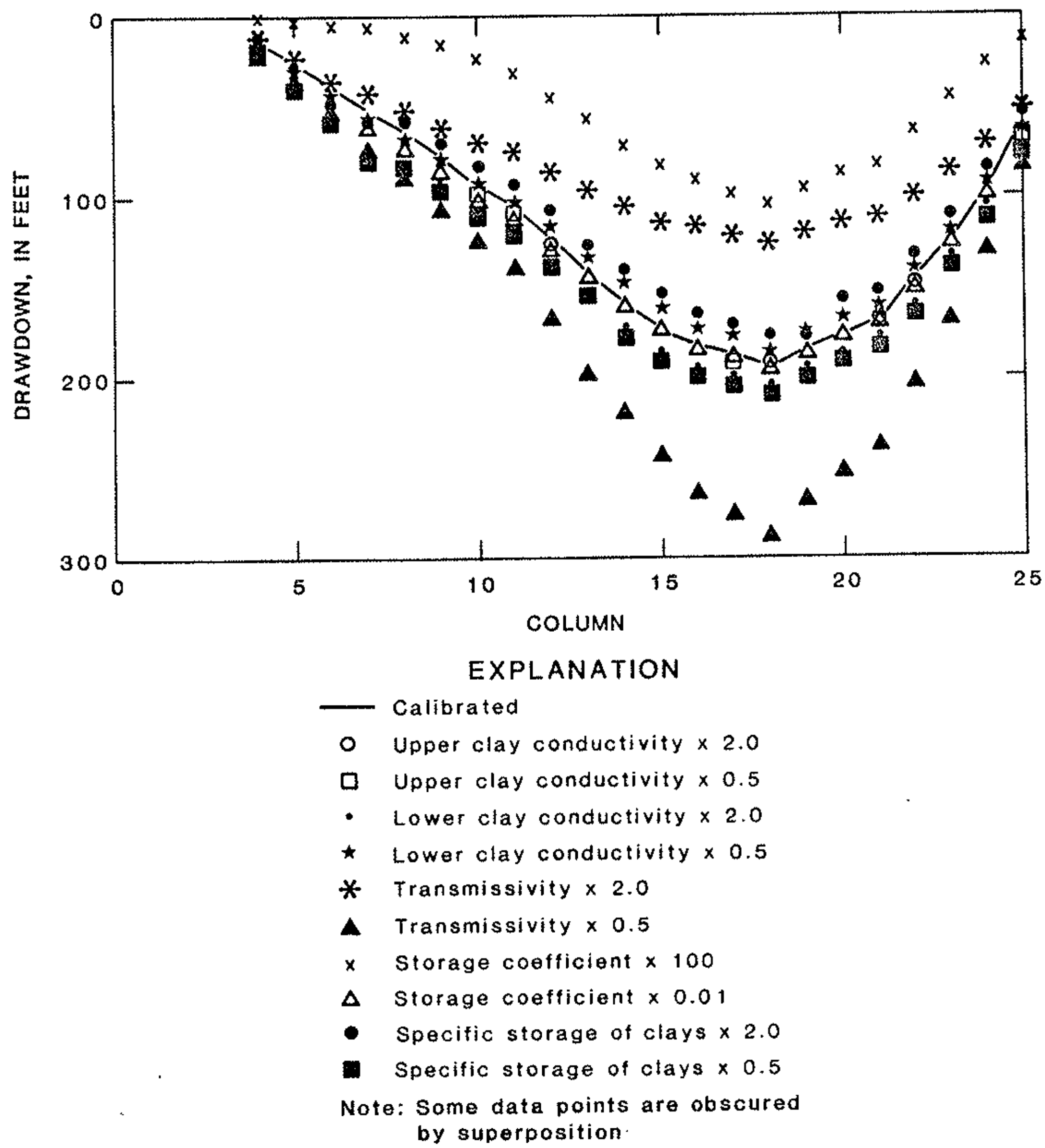


Figure 20.--Computed drawdown in "1,500- and 1,700-foot" aquifer resulting from changes in aquifer and confining bed properties for model row 14.

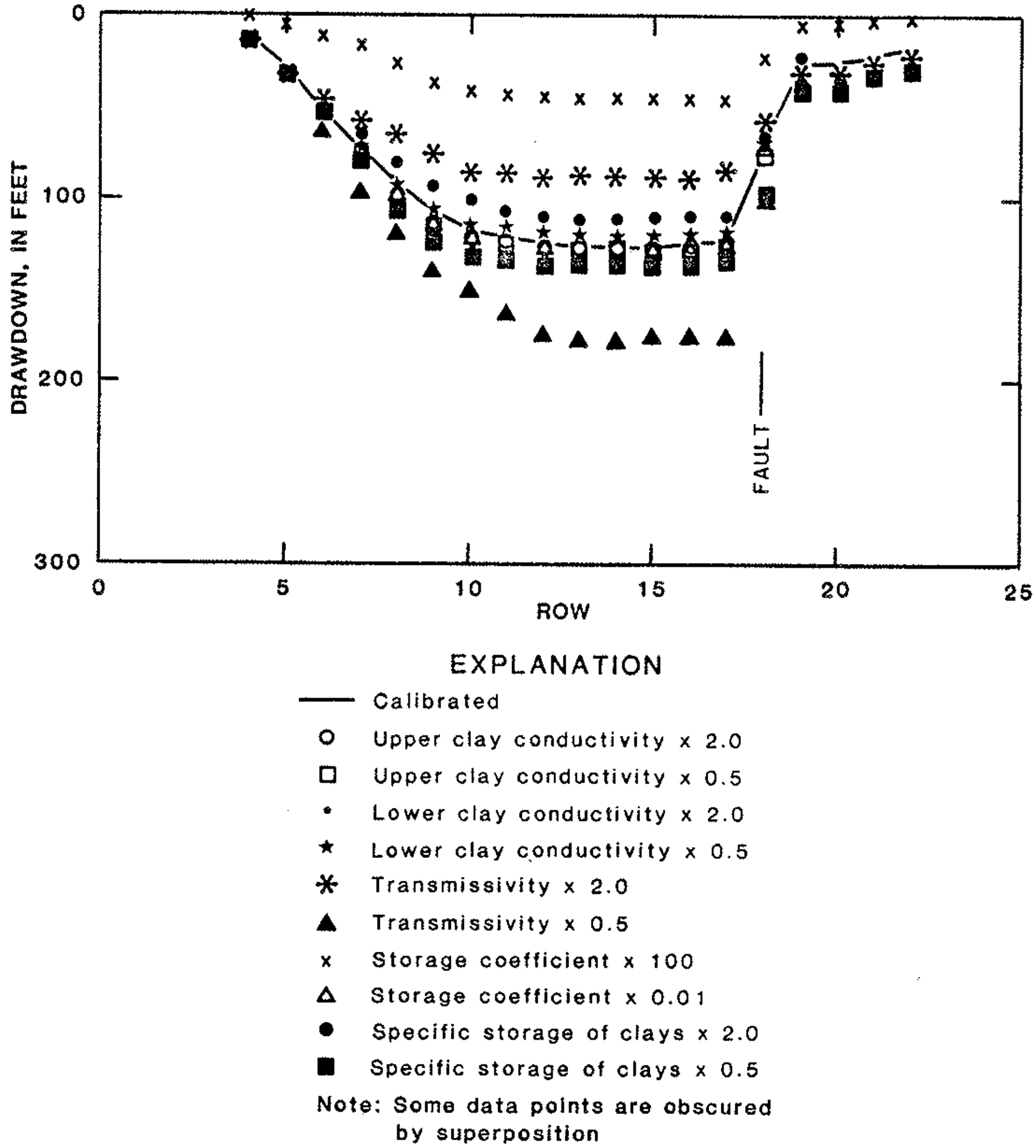


Figure 21.--Computed drawdown in "1,500- and 1,700-foot" aquifer resulting from changes in aquifer and confining bed properties for model column 23.

when the transmissivities were multiplied by 0.5, the increase in drawdown or decline of water levels was about the same magnitude (fig. 23). The magnitude of the differences generally follows the spatial distribution of the magnitudes of the drawdowns from the calibrated model throughout the modeled area, including the area near the Baton Rouge fault. The fault decreases the impacts of changes on the south side of the fault. The model's high sensitivity to changes in transmissivity indicates that uncertainty in estimating transmissivity has the potential for introducing the largest errors in model results.

Because water levels in the "1,200-foot" aquifer and the "1,500- and 1,700-foot" aquifer are similar, the model is relatively insensitive to changes in the hydraulic conductivity of the intervening clay layer. Figure 24 shows that halving the hydraulic conductivity of the confining layer causes increased drawdown of less than 3 ft over most of the central part of the modeled area. The largest increase in drawdown, 3 to 5 ft, is in a recharge area where the decreased hydraulic conductivity causes reduced recharge from above. Doubling (X 2.0) the hydraulic conductivity of the overlying clay layer allows some increase in recharge from above and decreases drawdown over most of the central part of the model by less than 3 ft (fig. 25).

Water levels in the "1,500- and 1,700-foot" aquifer are relatively sensitive to changes in hydraulic conductivity of the clay between the "1,500- and 1,700-foot" aquifer and the "2,000-foot" aquifer because of the large downward gradient across this layer near the pumping centers. When hydraulic conductivity of the lower layer is halved (X 0.5), downward leakage of water to the "2,000-foot" aquifer is decreased and drawdown decreases across the central part of the modeled area, with decreases of more than 10 ft at Baton Rouge (fig. 26). Conversely, when the hydraulic conductivity is doubled (X 2.0), increased downward leakage of water to the "2,000-foot" aquifer produces increased drawdown across the modeled area with a maximum increase of more than 12 ft west of Baton Rouge (fig. 27).

As with many artesian systems, changes in storage coefficients of the aquifers have little effect on water levels or drawdowns unless the storage coefficient changes are relatively large--one or two orders of magnitude. Projected water levels are raised about 90 ft near the cone of depression by multiplying the storage coefficients by a factor of 100 (X 100) (fig. 28). Decreasing the storage coefficient of the aquifers by a factor of 100 (X 0.01) (fig. 29) lowers water levels about 3 to 4 ft near the pumping centers and by about 8 to 10 ft in outlying areas.

Changing the calibrated values of specific storage of the confining layers by a factor of 0.5 results in an increase in drawdown of 10 to 15 ft in the cone of depression and up to 18 ft west of the pumping centers (fig. 30). Multiplying specific storage by two (X 2.0) results in a decrease in drawdown in the cone of depression of 18 ft (fig. 31). Decreasing specific storage of the confining layers reduces leakage of water from the clays and forces the cone of depression to expand. Increases in specific storage of clays make more water available to the aquifer from leakage and decreases the magnitude of the cone of depression.

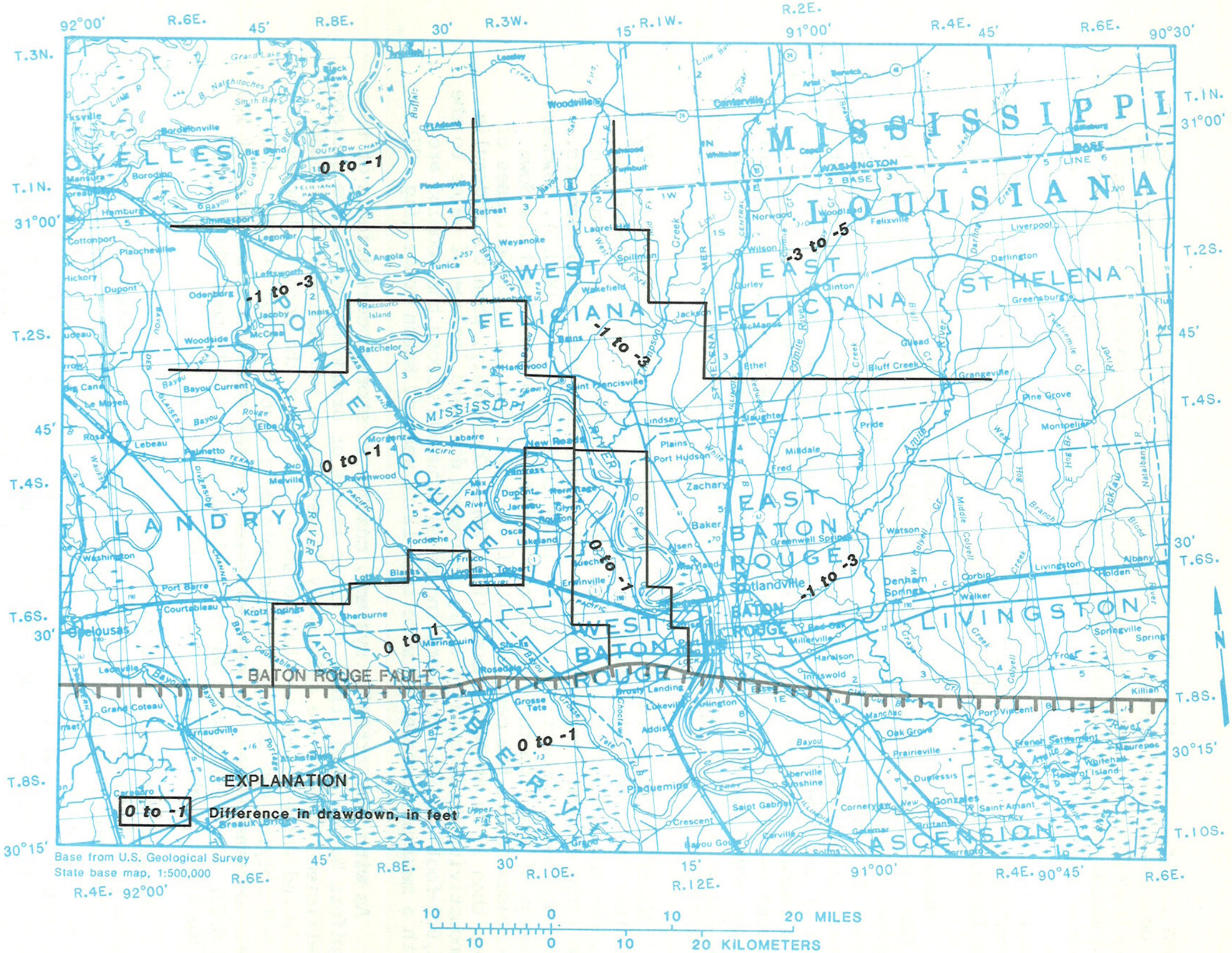


Figure 22.--Difference between the drawdown computed by the calibrated model and the drawdown computed by the model with transmissivity X 2.0 in the "1,500- and 1,700-foot" aquifer.

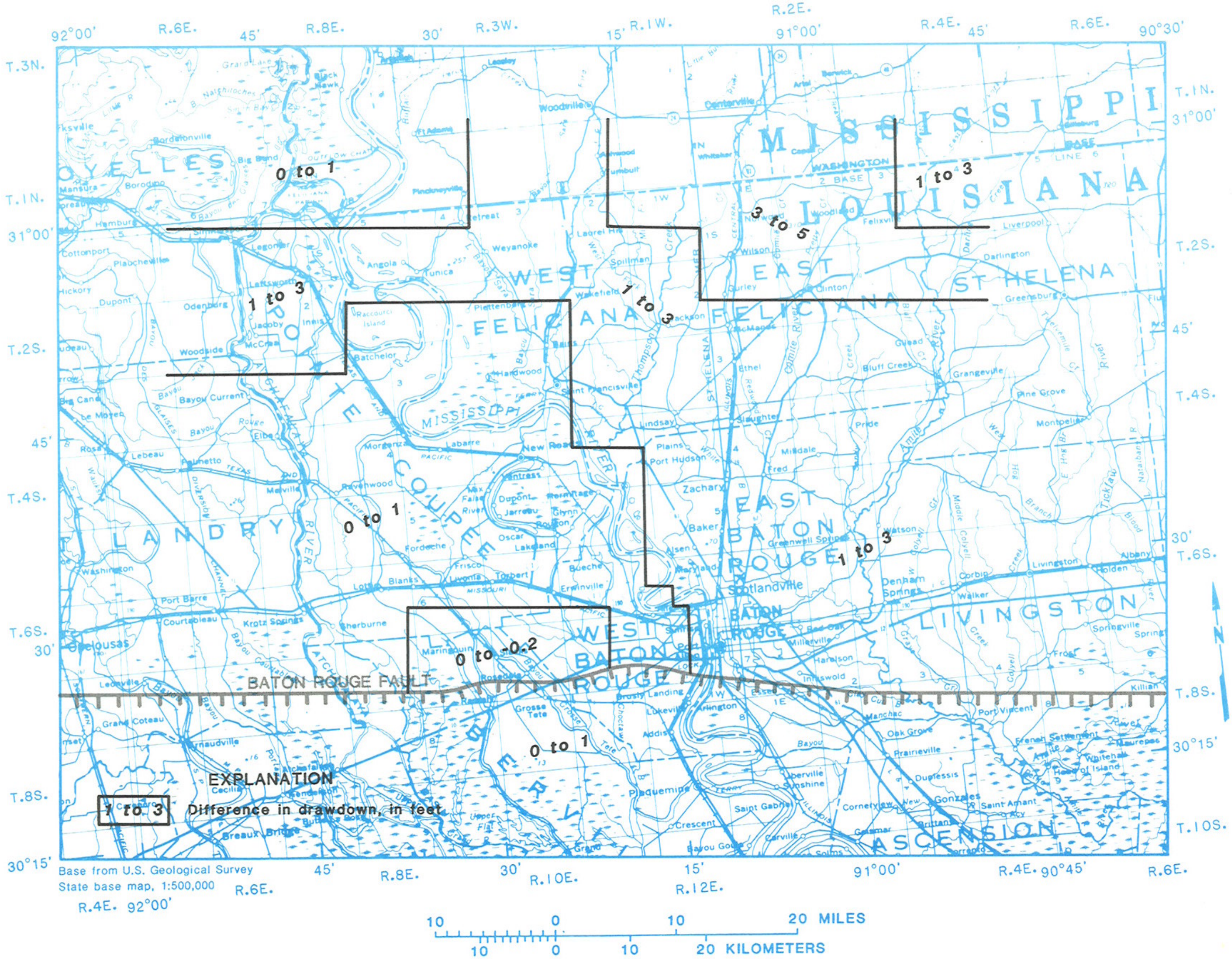


Figure 23.--Difference between the drawdown computed by the calibrated model and the drawdown computed by the model with transmissivity X 0.5 in the "1,500- and 1,700-foot" aquifer.

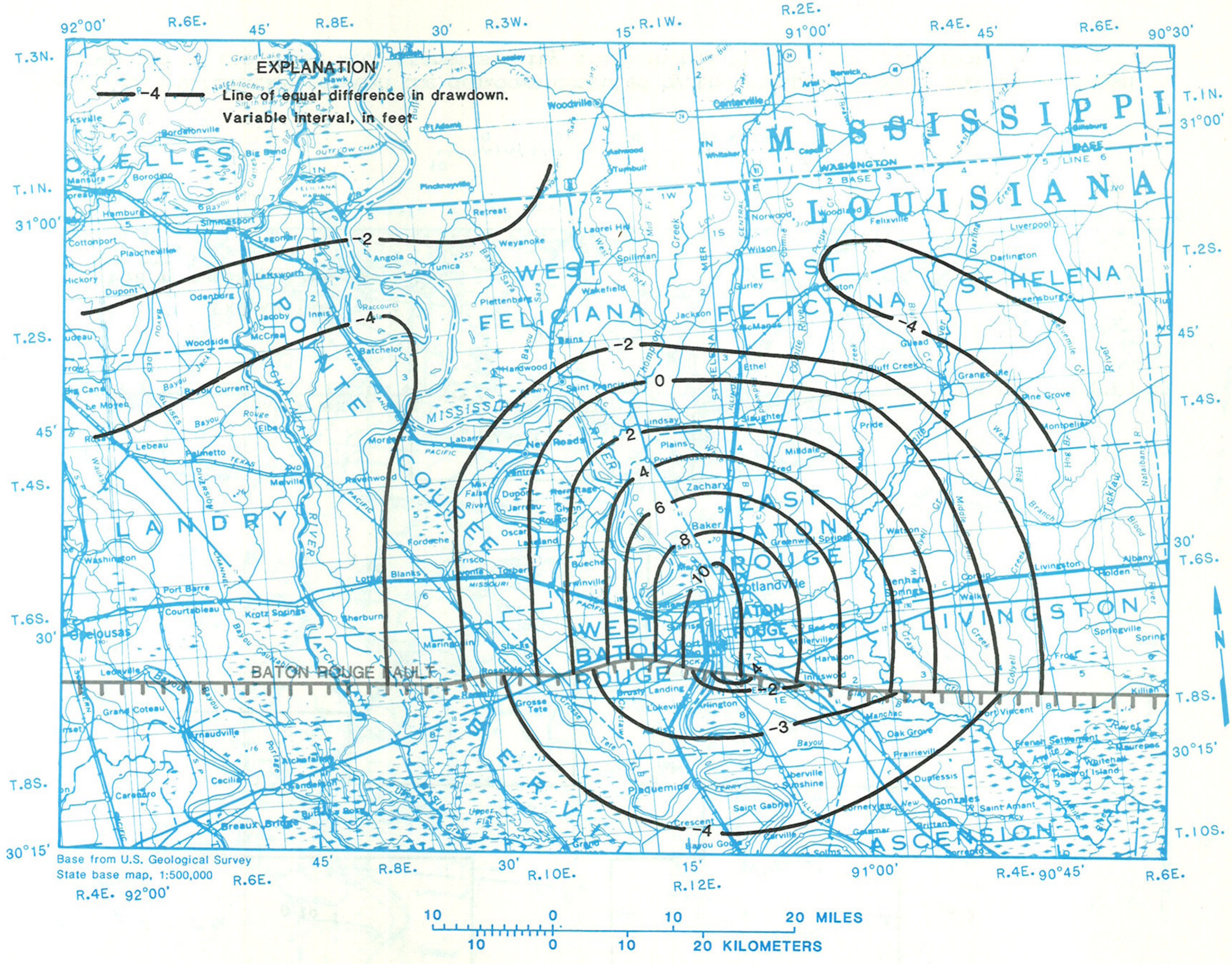


Figure 24.--Difference between the drawdown computed by the calibrated model and the drawdown computed by the model with overlying clay conductivity X 0.5.

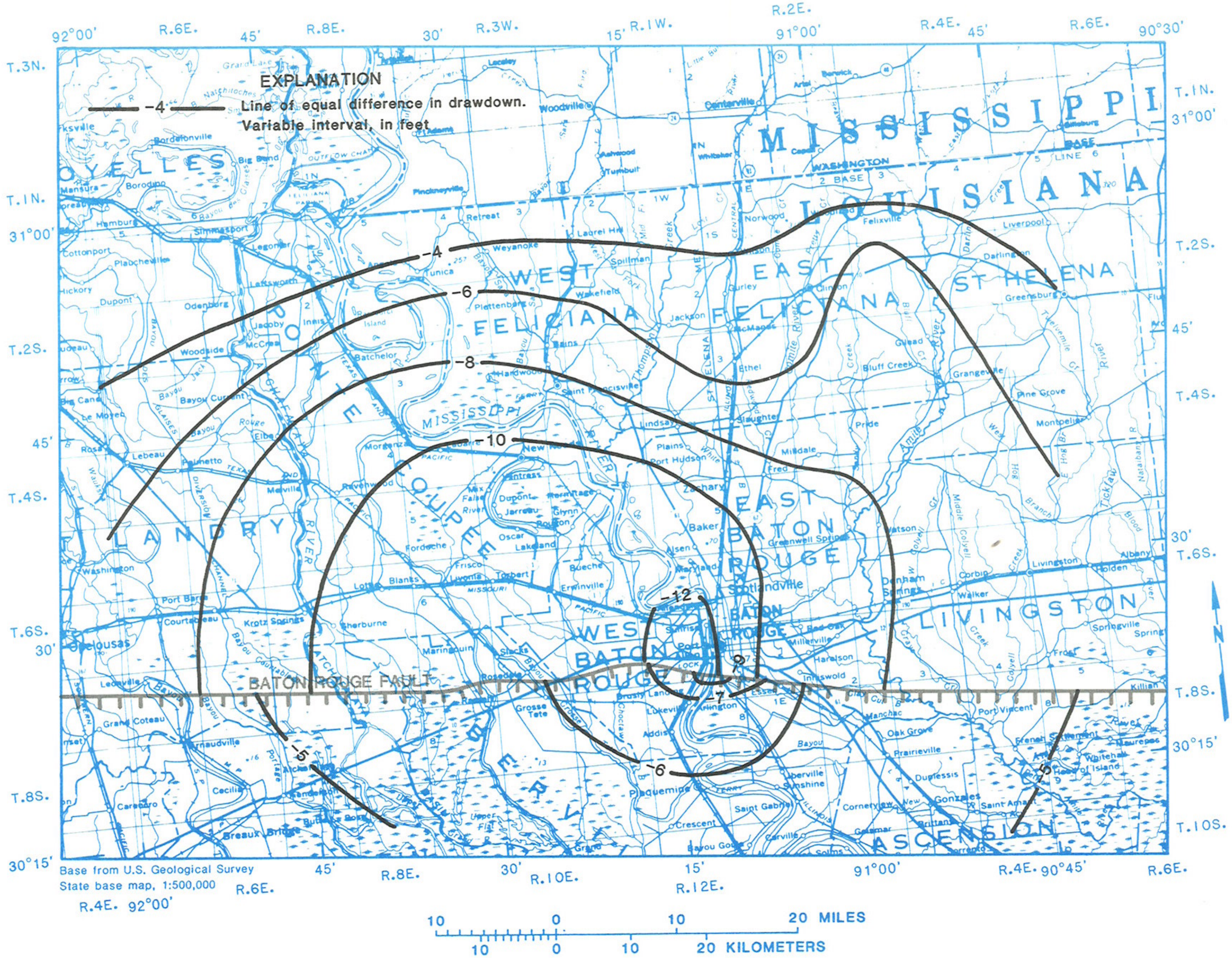


Figure 25.--Difference between the drawdown computed by the calibrated model and the drawdown computed by the model with overlying clay conductivity X 2.0.

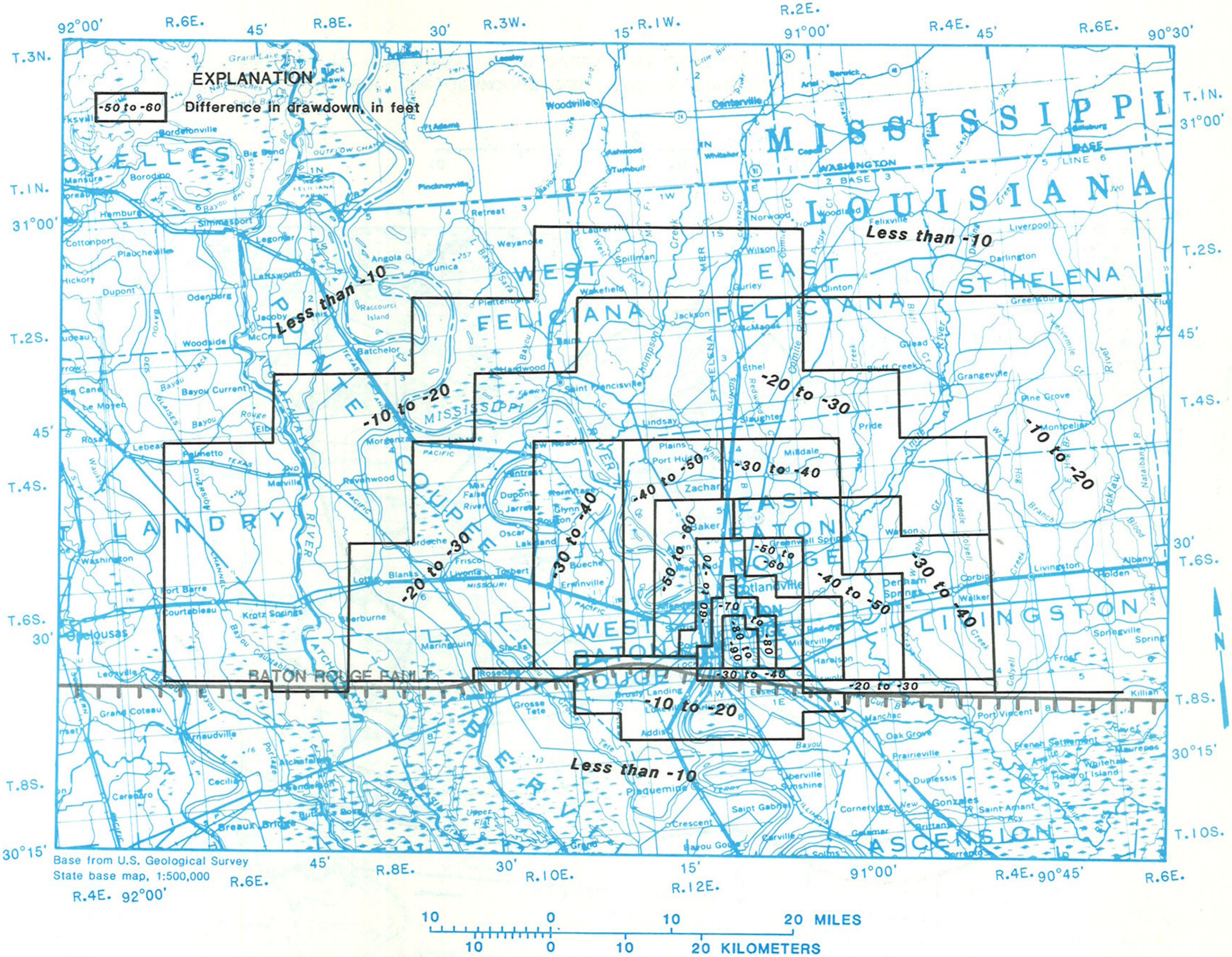


Figure 26.--Difference between the drawdown computed by the calibrated model and the drawdown computed by the model with underlying clay conductivity X 0.5.

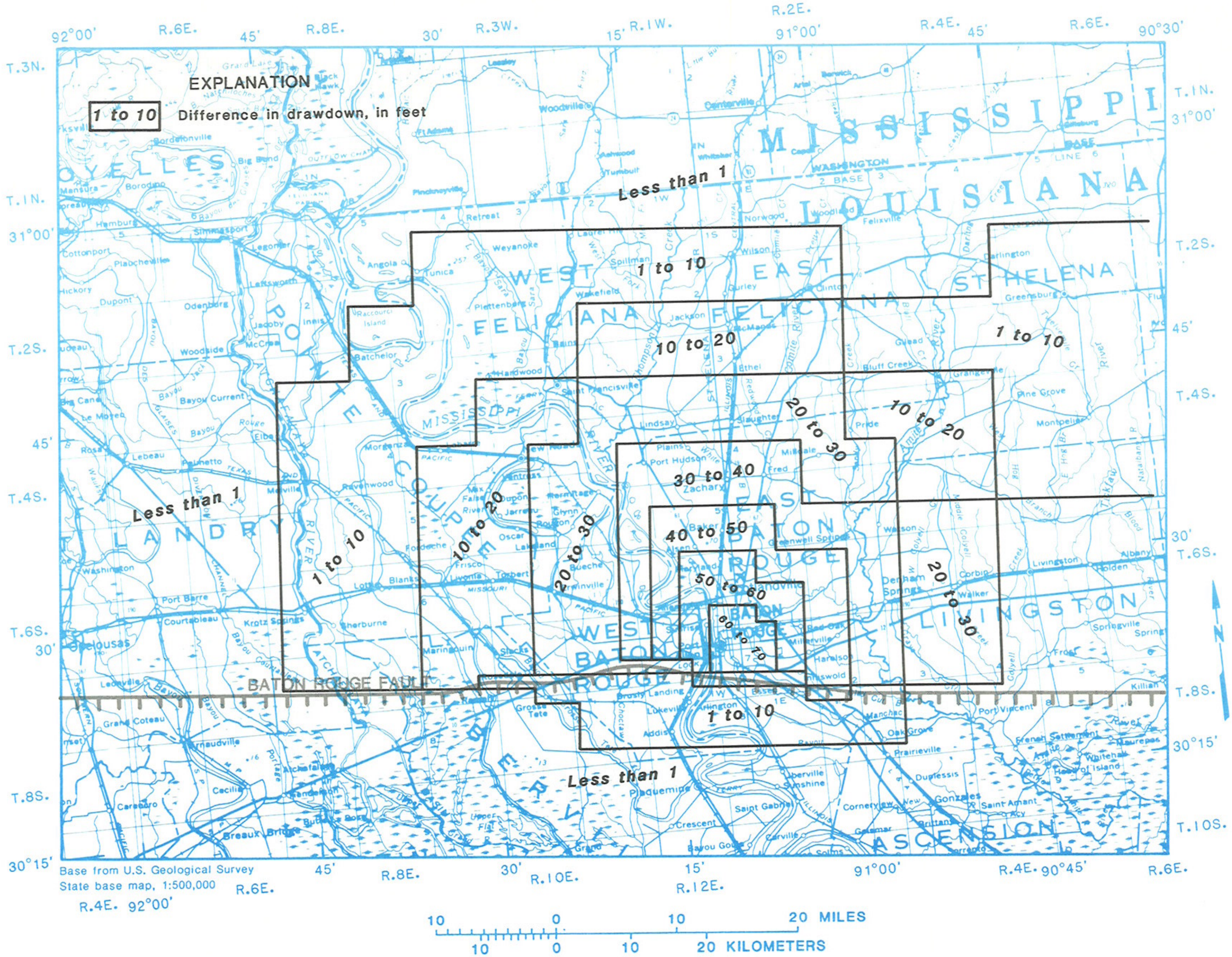


Figure 27.--Difference between the drawdown computed by the calibrated model and the drawdown computed by the model with underlying clay conductivity X 2.0.

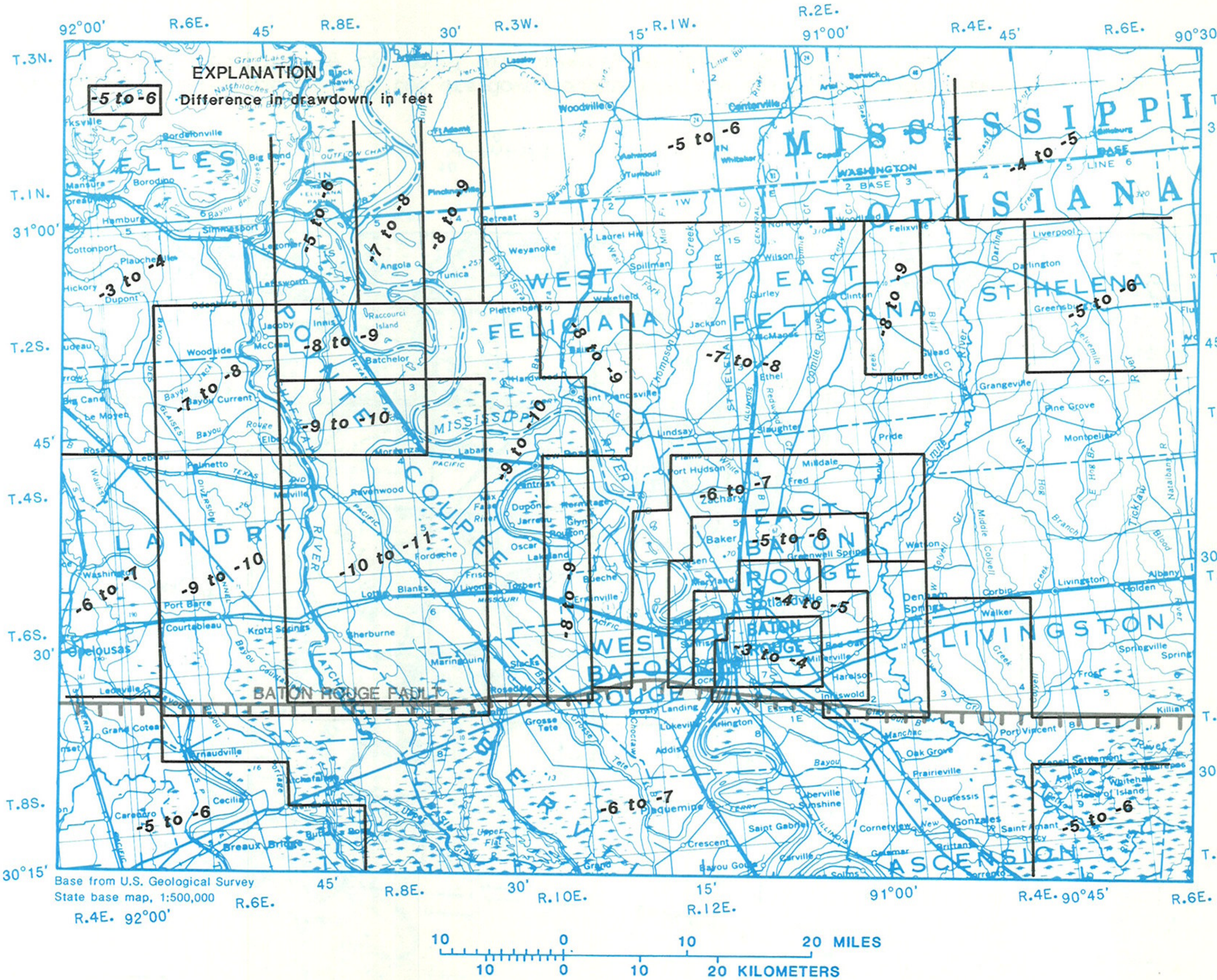


Figure 28.--Difference between the drawdown computed by the calibrated model and the drawdown computed by the model with storage coefficient X 100 in the "1,500- and 1,700-foot" aquifer.

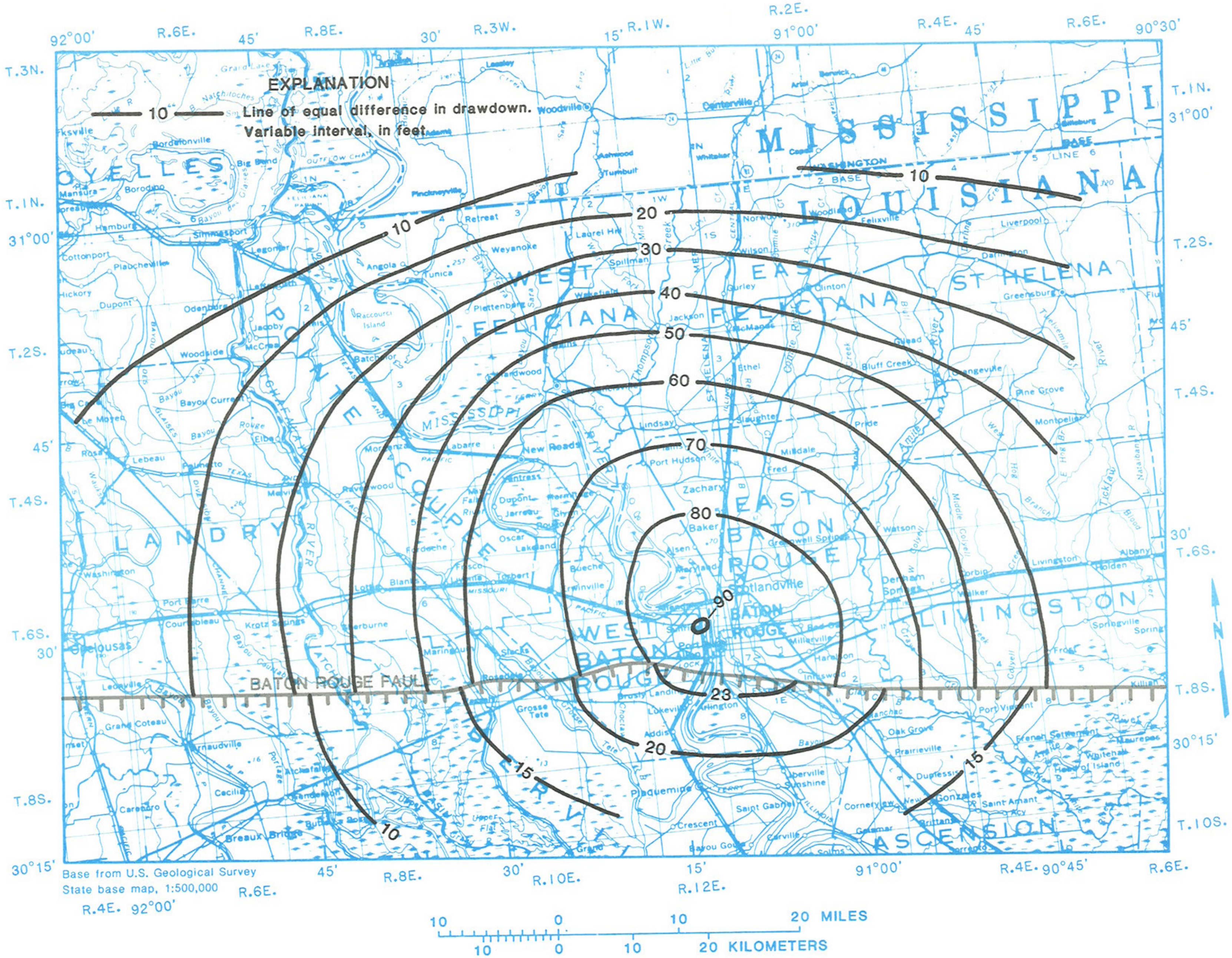


Figure 29.--Difference between the drawdown computed by the calibrated model and the drawdown computed by the model with storage coefficient X 0.01 in the "1,500- and 1,700-foot" aquifer.

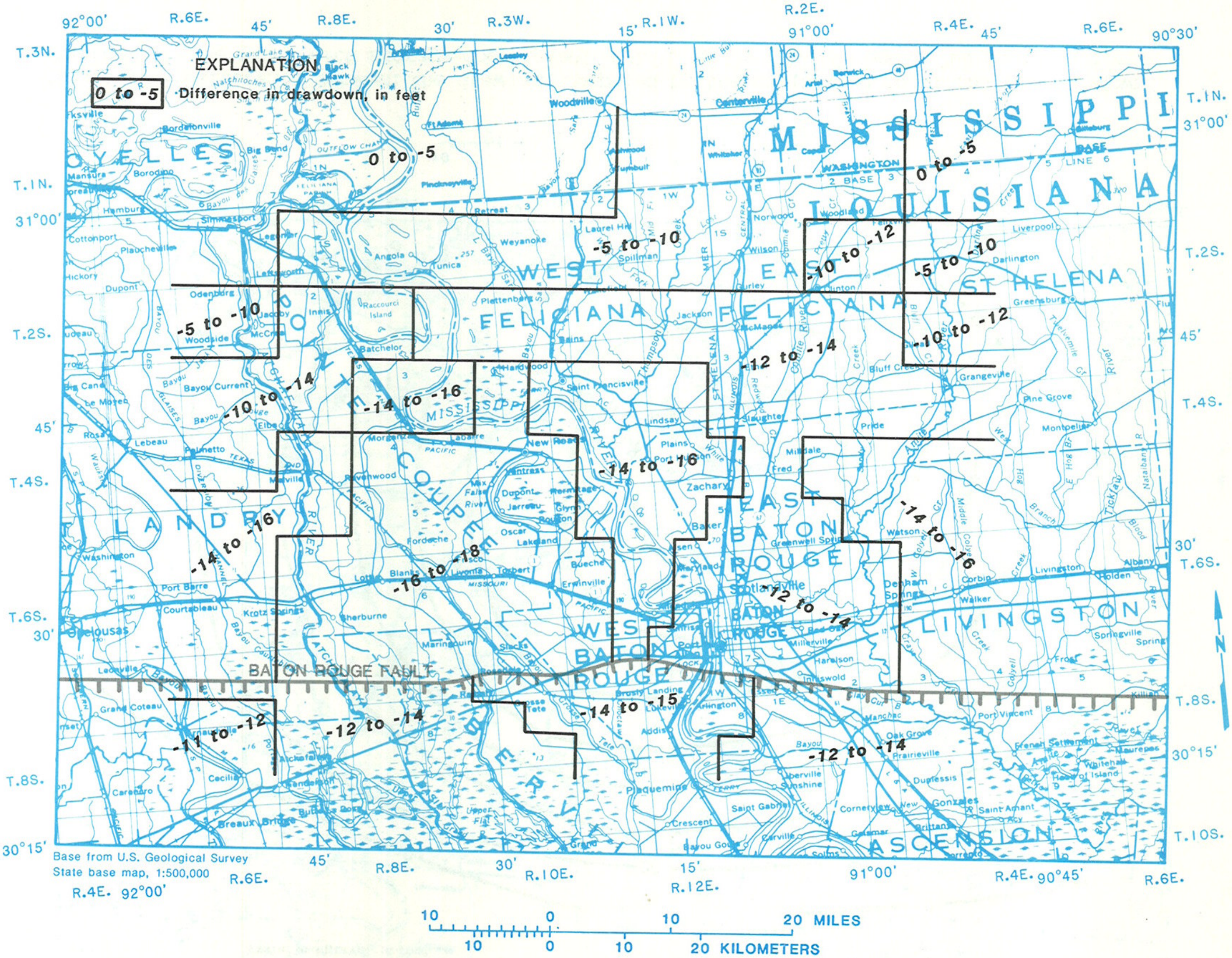


Figure 30.--Difference between the drawdown computed by the calibrated model and the drawdown computed by the model with specific storage of the clays X 0.5, in feet.

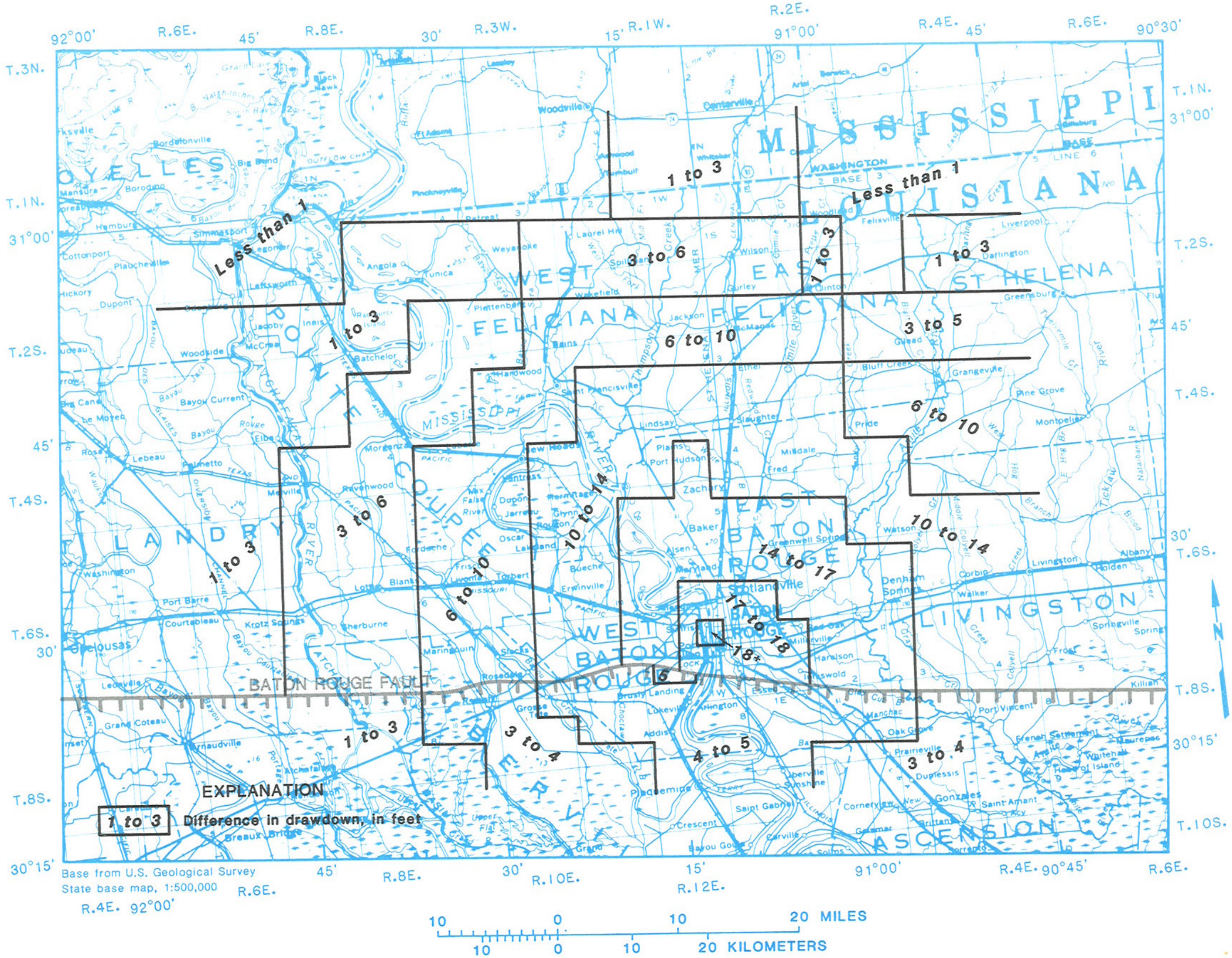


Figure 31.--Difference between the drawdown computed by the calibrated model and the drawdown computed by the model with specific storage of the clays X 2.0, in feet.

Establishment of a Steady-State Potentiometric Surface

After the model was calibrated, a steady-state version was used to define the pre-pumping water-level surface of the "1,500- and 1,700-foot" aquifer. The drawdowns computed by the calibrated model at selected model nodes for a given year were added to measured water-level elevations in wells in these nodes for the same year. (See table 6.) When the model was run to steady-state conditions using the calculated values as known water levels, the model computed water-level values for all nodes between the given values.

The resulting steady-state surface (pl. 10), considered to be representative of conditions prior to 1920, shows a ridge sloping from a high in Mississippi southward to the Baton Rouge fault near Lake Maurepas. General gradients are away from this high toward the Pearl River to the east and the Mississippi River valley to the west. The contours indicate a head difference across the Baton Rouge fault ranging from more than 40 ft near Lake Maurepas to less than 5 ft near the eastern and western boundaries of the model.

Table 6.--Computation of steady-state water levels for selected wells

Well No.[1]	Grid node location[2]	Altitude of land-surface datum (feet)	Measured water level from land-surface datum (feet)		Altitude of water level (feet)	Model drawdown (feet)		Steady-state water level (feet)
EB-168	12,18	56	-130	(1979)	-74	180	(1979)	106
EB-652	10,19	68	-130	(1979)	-62	158	(1979)	120
EB-782B	16,18	28	-108	(1979)	-80	185	(1979)	105
EB-804A	17,22	46	-93	(1979)	-47	147	(1979)	100
EB-807A	16,18	32	-117	(1979)	-85	185	(1979)	100
EB-917	16,19	50	-125	(1979)	-75	184	(1979)	109
EB-918	16,19	40	-118	(1979)	-78	184	(1979)	106
EB-94	14,18	57	+7	(1945)	+64	34	(1945)	98
EB-971	7,18	131	-88	(1967)	+43	63	(1967)	146
EF-27	6,16	225	-127	(1967)	+98	46	(1967)	144
Ev-691	6,3	50	-13	(1975)	+37	4	(1975)	41
Li-49	10,23	51	+14	(1962)	+65	67	(1962)	132
PC-154	9,10	36	-59	(1979)	-23	101	(1979)	78
PC-39	6,6	41	-15	(1979)	+26	29	(1979)	55
Ta-258	12,26	22	+95	(1969)	+117	28	(1969)	145
Wa-15	5,27	105	+30	(1979)	+135	9	(1979)	144
WBR-100A	15,15	29	-115	(1979)	-86	171	(1979)	85

[1] Number corresponds to identification numbers on plate 2.
[2] Numbers correspond to row and column in model grid on plate 2.

Hydrograph Comparisons

Water-level hydrographs were computed from the model output for nodes that corresponded to locations of wells with sufficient water-level records to develop comparisons. Drawdowns calculated by the model for the end of each pumping period were subtracted from the computed steady-state surface to obtain water levels comparable with observed water levels. Hydrograph comparisons of the observed with the calculated water levels are shown in figures 32 through 37 for the selected wells. Well locations are shown on plate 2.

The model accurately reflects the trends in observed water levels but does not duplicate individual observations. The model values represent averages for the nodes, but the observation wells may reflect local effects. The model does not reflect the annual fluctuations shown in the observed hydrographs.

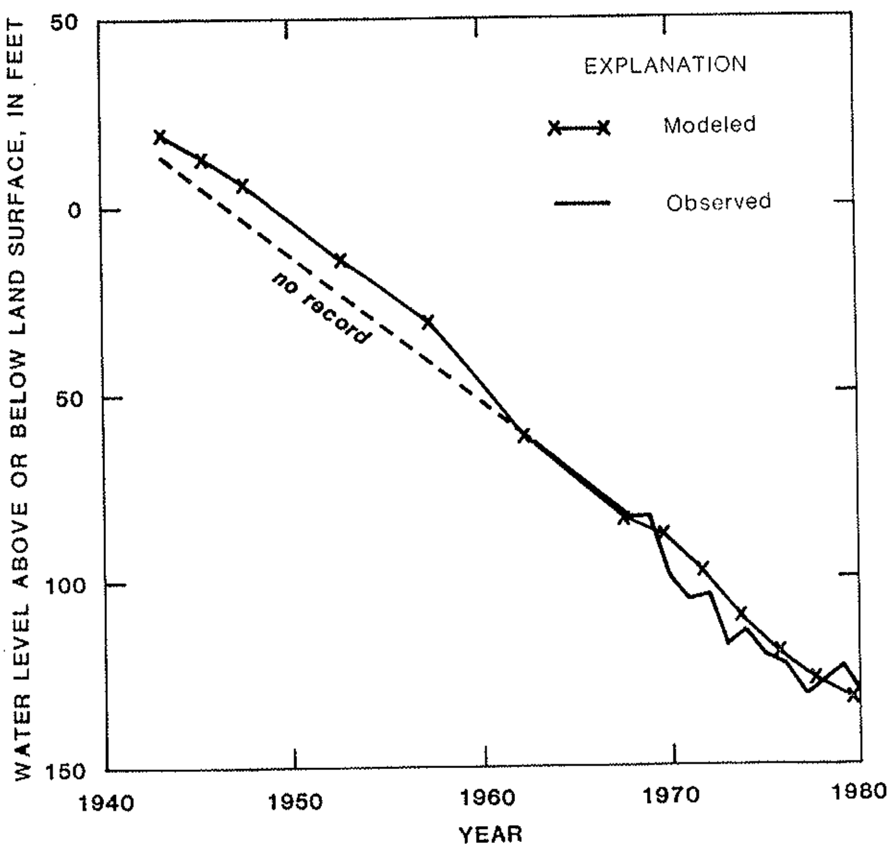


Figure 32.--Hydrographs of the "1,500- and 1,700-foot" aquifer for well EB-168 and model node 12,18.

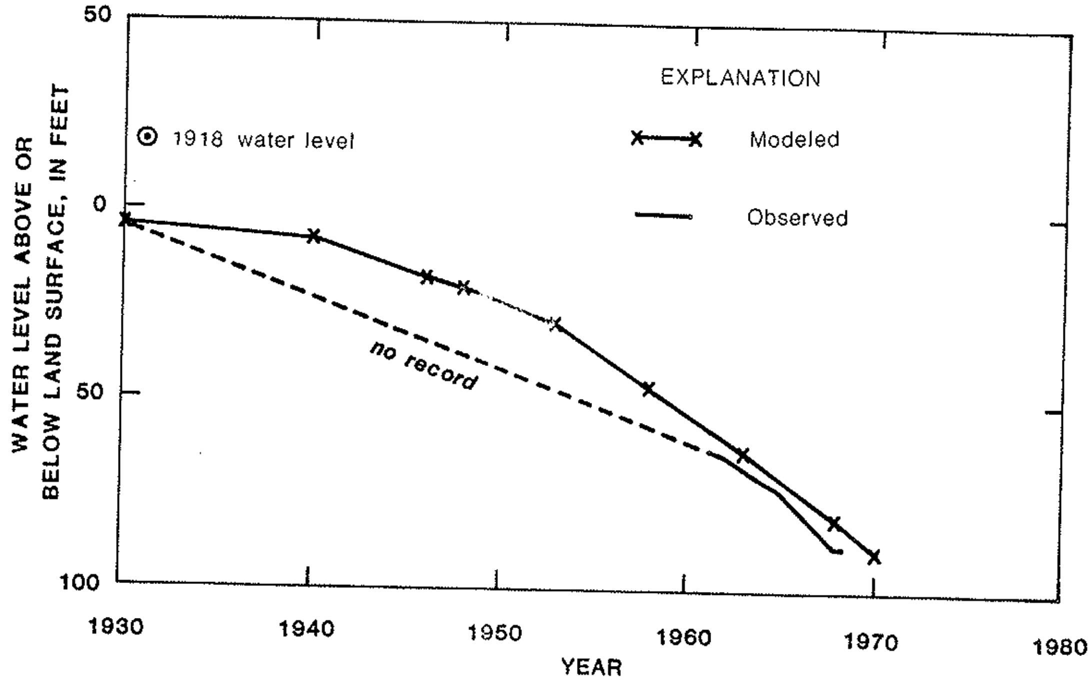


Figure 33.--Hydrographs of the "1,500- and 1,700-foot" aquifer for well EB-971 and model node 8,17.

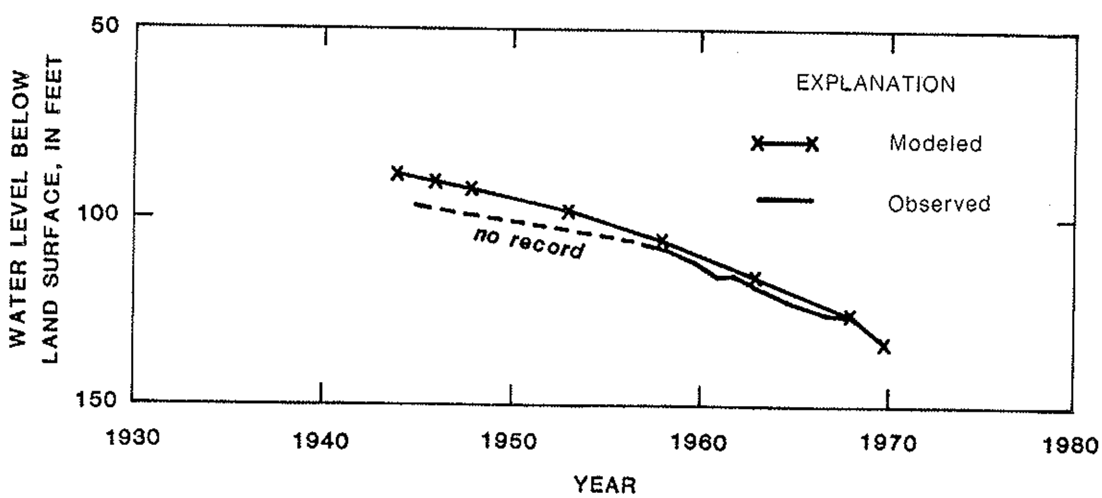


Figure 34.--Hydrographs of the "1,500- and 1,700-foot" aquifer for well EF-27 and model node 6,16.

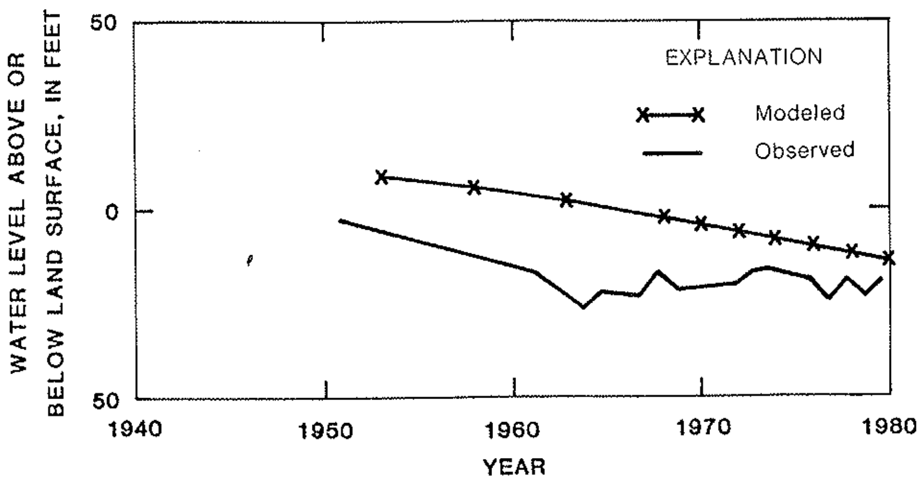


Figure 35.--Hydrographs of the "1,500- and 1,700-foot" aquifer for well PC-39 and model node 6,6.

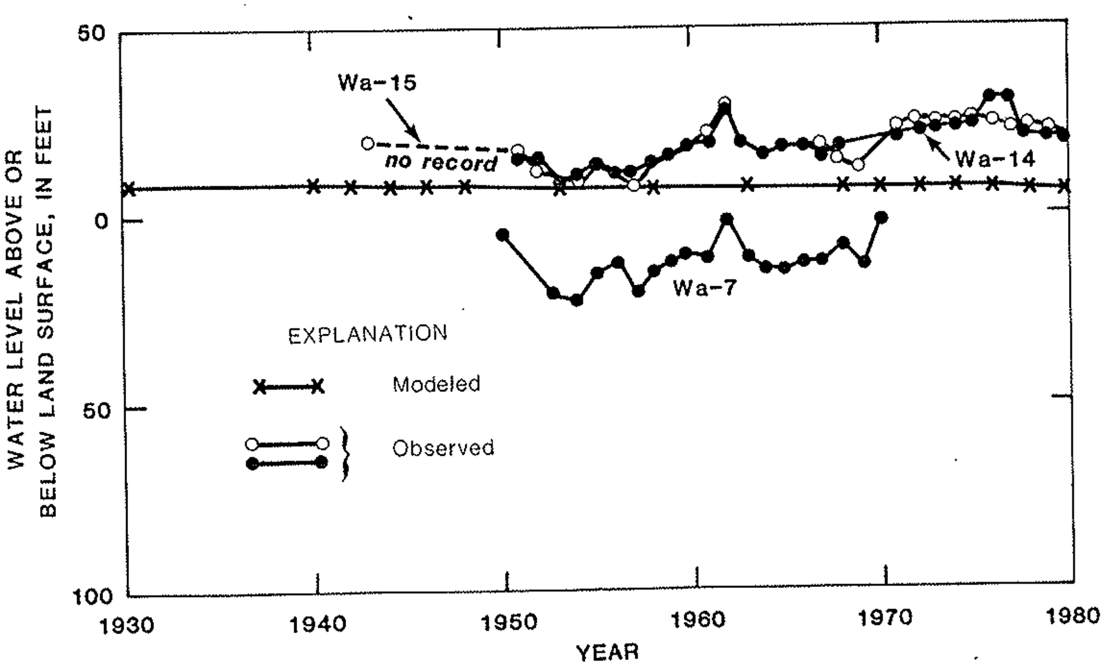


Figure 36.--Hydrographs of the "1,500- and 1,700-foot" aquifer for wells Wa-7, Wa-14, and Wa-15 and model node 5,28.

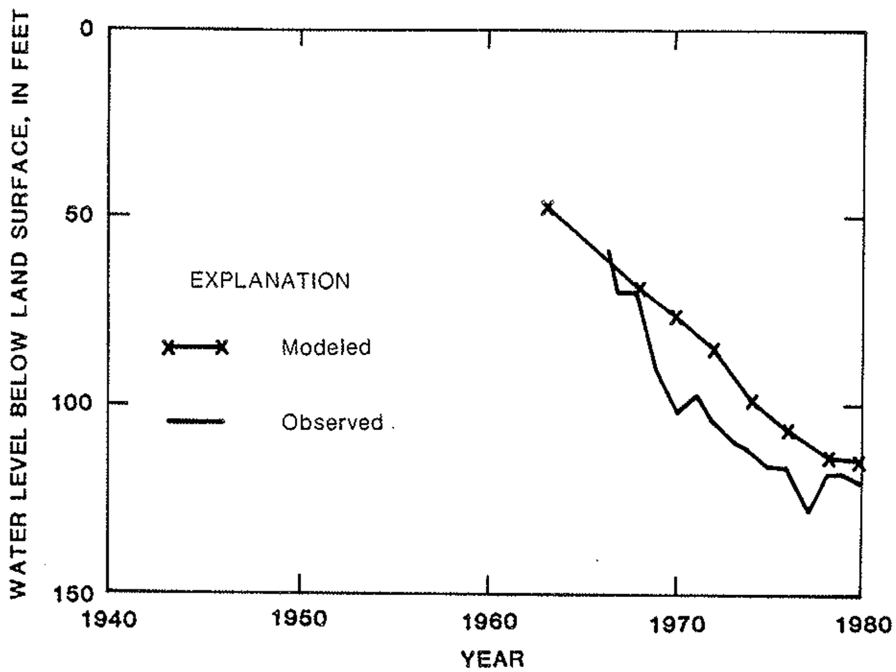


Figure 37.--Hydrographs of the "1,500- and 1,700-foot" aquifer for well WBR-100A and model node 15,15.

SUMMARY

The study area is underlain by a series of alternating layers of clay and water-bearing sand. The major sand beds form aquifers that are named based on their depth below land surface in the Baton Rouge area. This study addressed specifically the "1,500- and 1,700-foot" aquifer and its interaction with the adjacent "1,200-foot" and "2,000-foot" aquifers through the "leaky" clays that form confining layers.

A three-dimensional finite-difference model was used to simulate the aquifer. Boundaries of the model were located far enough away from the study area to ensure that truncation of the model at the boundaries did not significantly affect computations in the study area. Constant-head boundaries in the recharge area to the north were made comparable with stream levels. No-flow boundaries were used on the west, south, and east sides of the modeled area.

Model computations of transient conditions were initiated as of 1920, when approximately steady-state condition prevailed. The concept of superposition was used in the transient computations because very little water-level data were available for 1920. The model calibration was based on comparison of computed and observed drawdowns between about 1945 and 1967, a period when adequate water-level and pumpage records were available. Calibration results indicate transmissivity values of the "1,500- and 1,700-foot" aquifer were about 0.015 ft^2/s in the area northwest of Baton Rouge and about 0.4 ft^2/s near the Baton Rouge fault. Storage coefficients of the aquifer were variable in the recharge area but consistent at 5×10^{-4} throughout the remainder of the study area. The typical value of vertical-hydraulic conductivity of the confining clays was 5×10^{-9} ft/s. Absolute differences between the observed and computed drawdowns averaged 4.8 ft near the pumping centers, where drawdowns exceed 100 ft. The differences between observed and computed drawdowns in the outlying areas ranged between -15.6 and +10.8 ft, where model grid blocks were very large and drawdowns typically were less than 30 ft.

Computed drawdowns of the potentiometric surface of the "1,500- and 1,700-foot" aquifer are most sensitive to the aquifer hydraulic conductivity and least sensitive to storage coefficient. Multiplying the aquifer hydraulic conductivity by two resulted in the drawdown decreasing by 60 to 70 ft near the cone of depression. Multiplying the hydraulic conductivities by 0.5 resulted in increased drawdowns of the same magnitude. Multiplying storage coefficients by 0.5 and by 2.0 had no significant impact, but multiplying by 100 resulted in a decrease in drawdown of 90 ft near the cone of depression.

A steady-state potentiometric surface was computed by the model using observed water levels in wells as control points. The resulting steady-state surface indicates general water-level gradients sloping away from a high in southern Mississippi.

Model simulations were made to project system responses to alternative pumping stresses. Three alternative pumping stresses were imposed on the "1,500- and 1,700-foot" aquifer and projected for 30 years beyond 1978-79 conditions. The pumping stresses were as follows: (1) continue pumping at 1978-79 rates, (2) increase pumping by 30 percent (5 percent for each of six 5-year periods), and (3) decrease pumping by 30 percent (5 percent for each of six 5-year periods).

Continued pumping at the 1978-79 rate resulted in an increased drawdown of about 25 ft near the pumping center. Increased pumping produced increased drawdowns of nearly 50 ft near the present cone of depression and about 5 ft near the boundaries north of the Baton Rouge fault. Decreased pumping produced insignificant changes in drawdown near the cone of depression but additional drawdowns of more than 15 ft on the flanks of the cone. Water levels in the aquifer south of the Baton Rouge fault declined approximately 20 ft in each case and were not greatly affected by changes in pumping rate.

Changes in pumpage from the "1,500- and 1,700-foot" aquifer are small compared to pumpage from the entire aquifer system that was modeled. Therefore, water budgets calculated by the model do not vary significantly between simulations. However, the water budget for the 1920-79 period does show that leakage through the confining beds contributes more than 40 percent of the water withdrawn and that more than 55 percent comes from storage. Less than 5 percent is supplied from constant-head sources in the recharge area.

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