FLOW PATTERN IN REGIONAL AQUIFERS AND FLOW RELATIONS BETWEEN THE LOWER COLORADO RIVER VALLEY AND REGIONAL AQUIFERS IN SIX COUNTIES OF SOUTHEASTERN TEXAS

By Dennis G. Woodward

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DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
8011 Cameron Rd.
Austin, TX 78753

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CONTENTS

ILLUSTRATIONS

METRIC CONVERSIONS

For readers preferring to use metric (International System) units rather than inch-pound units, conversion factors and abbreviations for terms are listed below:

Multiply inch-pound units	By	To obtain metric units
acre-foot per acre (acre-ft/acre)	0.00304	cubic hectometer per acre
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.18943	meter per kilometer
gallon per minute (gal/min)	0.06308	liter per second
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level of 1929."

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ABSTRACT

The lower Colorado River discussed in this report consists of the 318-river-mile reach from Mansfield Dam near Austin, Texas, to the Gulf of Mexico. The river is underlain directly or indirectly by six regional aquifers--the Trinity Group, Edwards, Carrizo-Wilcox, Queen City, Sparta, and Gulf Coast; the Trinity Group aquifer is further subdivided into the lower Trinity, middle Trinity, and upper Trinity aquifers. Generalized potentiometric-surface maps of each regional aquifer show the ground-water-flow pattern near the river valley. Each regional aquifer discharges water to the lower Colorado River valley, particularly in the outcrop area of each aquifer. Only the Gulf Coast aquifer in central Wharton County appears to be recharged by water in the river valley. A summary map shows those subreaches of the lower Colorado River that gain water from the aquifers and those subreaches that lose water to the aquifers.

INTRODUCTION

The Lower Colorado River Authority was created by the Texas Legislature in 1934 with the mandate to conserve water resources in 10 central and southeastern counties; responsibilities included flood control, soil and water conservation, pollution control, electric-power generation, and recreation. Many of these responsibilities involve the management of the "Highland Lakes", six reservoirs on the lower Colorado River in central Texas that provide both storage and the regulation of flow in the lower reaches of the river by controlled releases. In 1984, the Authority took the initiative in planning for the water and wastewater-treatment needs throughout the lower Colorado River basin. A study by the U.S. Bureau of Reclamation (1981) states that the rapidly increasing water requirements of the area served by the Highland Lakes will soon exceed the capabilities of the existing facilities. The primary area of water demand served by the existing Authority facilities begins at Mansfield Dam (river mi 318.0) near Austin and ends at the coastal estuary (river mi 22.8). Within this water-demand area are six counties--Travis, Bastrop, Fayette, Colorado, Wharton, and Matagorda.

Water in the lower Colorado River travels about 318 mi from where the river is controlled by Mansfield Dam to where the river discharges into the Gulf of Mexico. Along this reach, surface water is added to the mainstem flow by: (1) Tributary flow, (2) reservoir releases, (3) discharge from wastewater-treatment plants and industrial operations, and (4) return flow from agricultural irrigation. Surface water is diverted from the mainstem flow by: (1) Municipal and domestic diversions, (2) irrigation diversions, (3) industrial activities, and (4) reservoir maintenance. Also along this reach, the lower Colorado River flows either directly on or over six regional aquifers--the Trinity Group, Edwards, Carrizo-Wilcox, Queen City, Sparta, and Gulf Coast aquifers (fig. 1). An alluvial aquifer, which underlies parts of the river, provides an indirect hydraulic connection between the river and the regional aquifers. Along certain subreaches of the lower Colorado River, ground water from the aforementioned regional aquifers flows into the river valley and provides recharge to the lower Colorado River. Along other subreaches, water in the river may seep downward through the river valley and become recharge to the aquifer(s).

A major finding of the U.S. Bureau of Reclamation (1981) study is that conjunctive use of ground water and surface water will be required to support major industrial expansion and population increase in the study area. The exchange of water between the river and the aquifers also will become increasingly important when the Lower Colorado River Authority will have to operate under a River Master Plan, which is scheduled to begin in 1991.

The determination of those subreaches of the lower Colorado River that gain water from aquifers and those subreaches that lose water to aquifers is particularly important for a variety of reasons, such as: (1) Siting of surface-water impoundments, wastewater-treatment discharge points, and facilities processing hazardous material; (2) characterizing the potential movement of either contaminated ground water or river water in areas adjacent to the river valley; (3) evaluating the effects of surface-water diversions on the ground-water system, and of ground-water withdrawals on the surface-water system; and (4) identifying aquifers that are hydraulically connected with the river for use in conjunctive water-use planning.

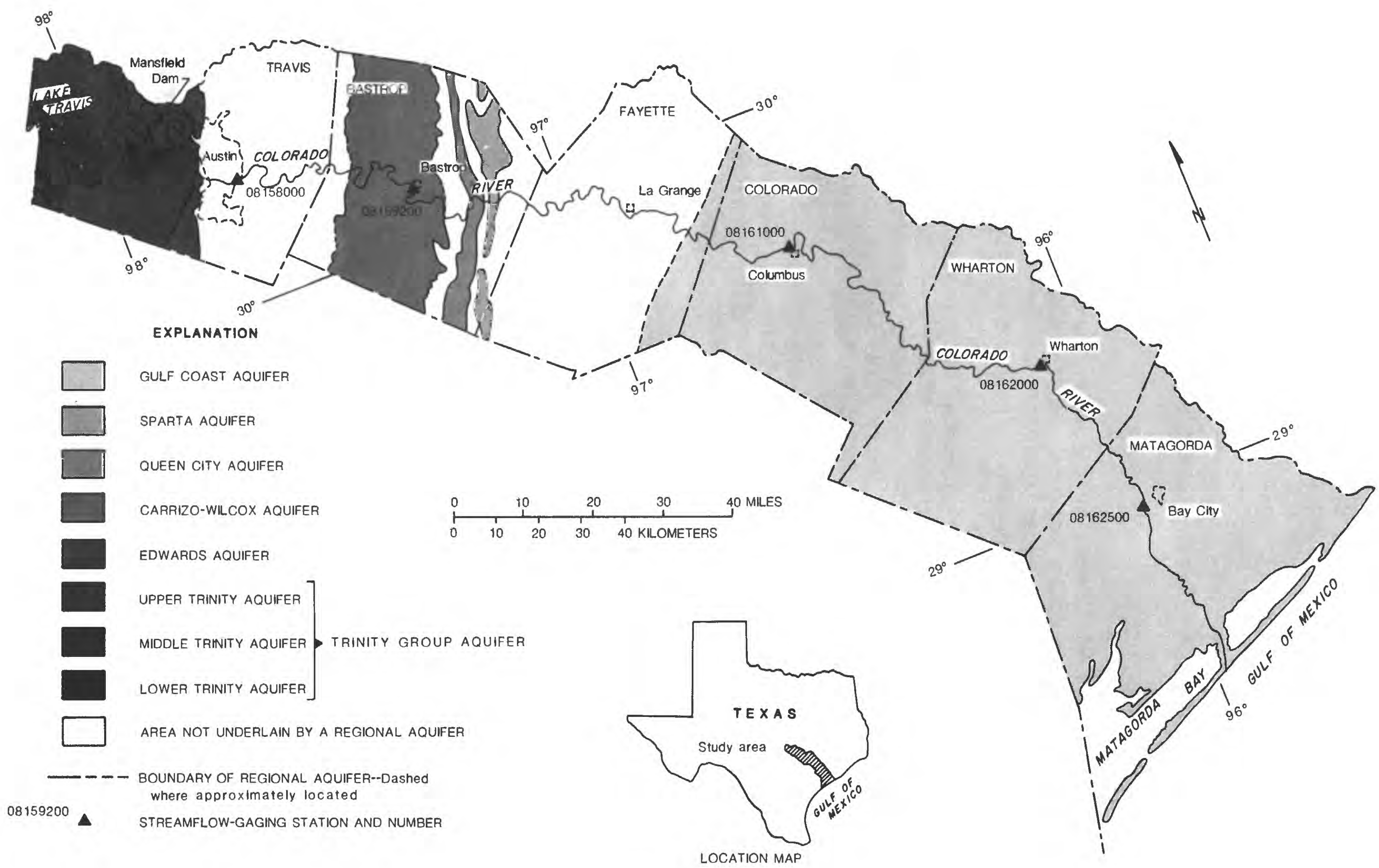


Figure 1.--Location of lower Colorado River valley, regional aquifers, and streamflow-gaging stations.

Purpose and Scope

This report describes the flow pattern of water in regional aquifers near the lower Colorado River, and identifies those subreaches of the lower Colorado River through which water can flow at a significant rate between the river and the underlying regional aquifers. Only those aquifers described by the Texas Department of Water Resources (1984) as a major or a minor aquifer (regional aquifers) are evaluated. Quantification of flow rates between the river and regional aquifers was not attempted.

Approach

The direction of horizontal ground-water movement can be determined by analyzing the pattern of contours representing the potentiometric surface of an aquifer; ground water flows, under isotropic aquifer conditions, in a down-gradient direction perpendicular to the potentiometric contours. Existing water-level data from the files of the U.S. Geological Survey and the Texas Water Development Board were used to prepare potentiometric maps for each regional aquifer. Because contemporaneous water-level data for each aquifer were limited, generalized potentiometric maps were prepared that integrate water levels measured during 1970-85. Water-level hydrographs for observation wells maintained by the Board were created to analyze long-term fluctuations in water levels for each aquifer at different locations and to provide guidance in preparing the generalized potentiometric maps. Hydrographs for all the aquifers, with the exception of the Edwards aquifer, commonly showed fluctuations ranging from less than 10 to about 30 ft; however, water-level fluctuations greater than 50 ft were noted in some wells.

Description of Study Area

The study area, which includes the lower Colorado River valley, consists of Travis, Bastrop, Fayette, Colorado, Wharton, and Matagorda Counties, an area of 6,011 mi^2 in southeastern Texas (fig. 1). Although the population of the six-county study area is primarily urban, the land use and water demand are primarily for agricultural purposes. Historically, the largest volume of water diverted from the lower Colorado River has been used for agricultural irrigation--almost exclusively for rice irrigation in Colorado, Wharton, and Matagorda Counties (fig. 2). Both surface and ground water are used for the rice irrigation; surface water used for irrigation is pumped or diverted directly from the lower Colorado River. Double cropping of hybrid rice has resulted in increased water demand; annual water-use rates for the major rice irrigators averaged 5.88 acre-ft/acre during 1975-77 (U.S. Bureau of Reclamation, 1981).

Within the study area, more than 70 streams are either primary or secondary tributaries to the lower Colorado River; total length of these tributaries is about 775 mi. During normal flow conditions, about 80 percent of those tributaries are intermittent streams (about 625 mi of stream channel) and about 20 percent (about 150 mi of stream channel) are perennial streams (U.S. Bureau of Reclamation, 1981). Some of the larger perennial tributaries are Onion, Buckners, Cummins, Wilbarger, and Cedar Creeks.

Six long-term, continuous streamflow-gaging stations provide hydrologic data to analyze discharge relations along the lower Colorado River (fig. 1).

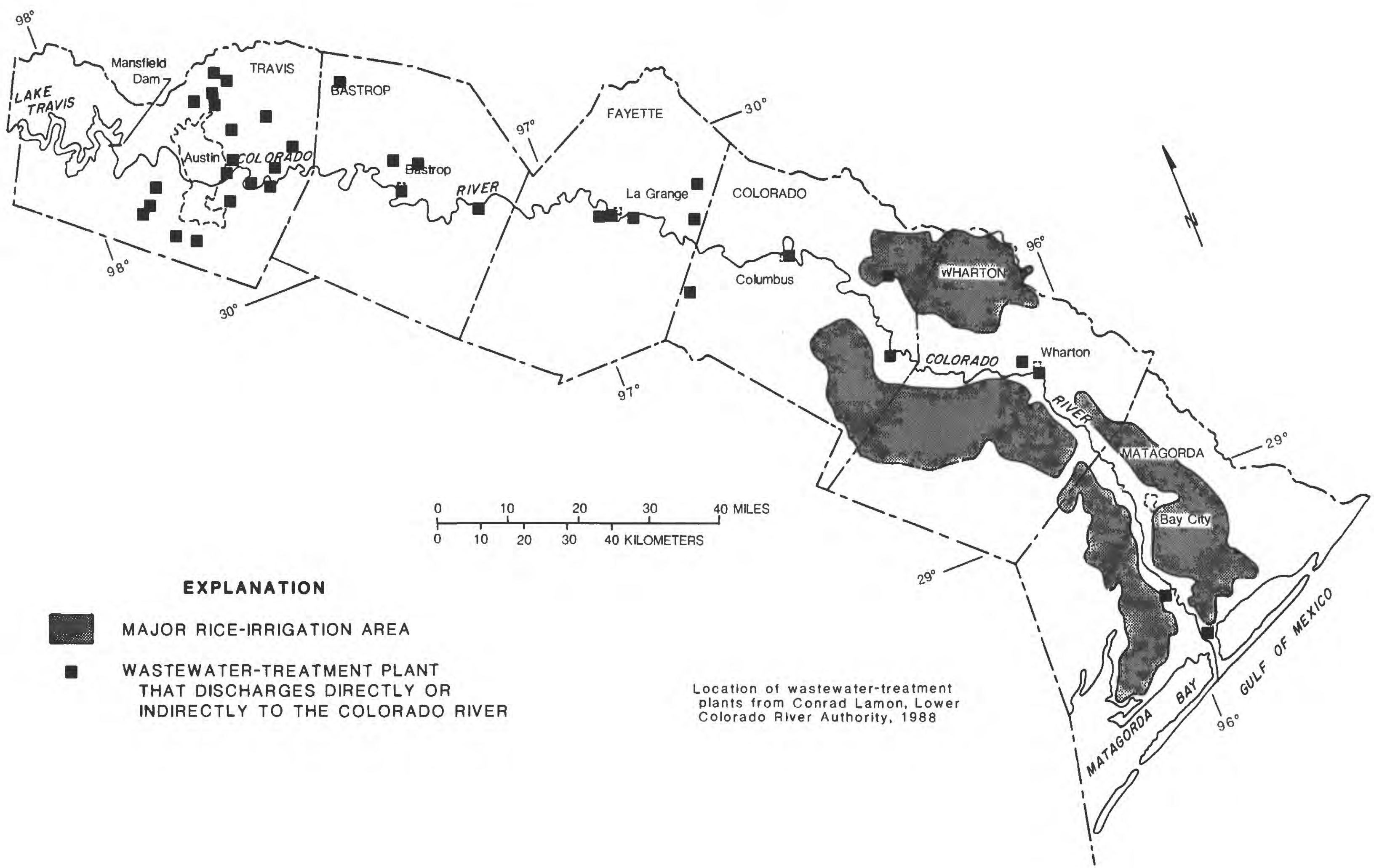


Figure 2.--Location of major rice-irrigation areas and wastewater-treatment plants.

The mean daily discharge from three of these stations was manually smoothed to produce the generalized streamflow hydrographs shown in figure 3. Streamflow in the lower Colorado River is primarily controlled by releases from Lake Travis through Mansfield Dam, located a few miles upstream from Austin; the discharge at station 08154510 during mid-March illustrates the beginning of the release cycle for water year 1985. The releases primarily fulfill the additional water requirements of the rice irrigators in Colorado, Wharton, and Matagorda Counties. Generally, streamflow in the lower Colorado River increases downstream from Mansfield Dam to the Gulf of Mexico; however during the rice-irrigation season, streamflow decreases substantially from Columbus to Bay City (fig. 3), largely as a result of surface-water diversions for irrigation.

The discharge from 37 wastewater-treatment plants directly or indirectly enters the lower Colorado River (fig. 2). In the study area, the largest user of water for municipal purposes is Austin, which is supplied water by the lower Colorado River (actually by Lake Austin and Town Lake, both in-river impoundments near the city). Austin returns 58 percent of its water withdrawals to the lower Colorado River in the form of treated wastewater effluent (U.S. Bureau of Reclamation, 1981).

Water is also added to the flow of the lower Colorado River by return flow from agricultural irrigation. Rice irrigation involves keeping the rice in a "flooded" condition during most of the growing season; however, the rice fields usually are drained and re-flooded once or twice during the growing season. Tuck (1974) estimated that about 30 percent of the water used for rice irrigation in Colorado County returns as surface flow to the drainage system.

DESCRIPTION OF AND FLOW PATTERN IN REGIONAL AQUIFERS

Geologically, the study area is situated on a broad regional homocline that dips toward the Gulf of Mexico (fig. 4); the homocline is interrupted in central Travis County near Austin by the Balcones fault zone and in western Bastrop County by the Luling-Mexia-Talco fault zone. The Balcones fault zone consists of a series of normal, en echelon, down-to-the-coast faults that occur in a zone about 8 mi wide. The net vertical displacement across the fault zone ranges from 600 ft in the northeast to more than 1,000 ft in southwestern Travis County; the Mount Bonnell fault, the major fault in the zone, has a vertical displacement of as much as 600 ft (Brune and Duffin, 1983). The Luling-Mexia-Talco fault zone is approximately parallel to the Balcones fault zone and consists of normal, up-to-the-coast faults. Major fault displacements in each fault zone can affect ground-water flow patterns by diverting flow along the strike of the fault (Maclay and others, 1986).

Because this study is regional in scope, only those aquifers that are considered to be regional aquifers will be discussed in this report. Consequently, only those aquifers listed as major aquifers or minor aquifers in the 1984 Water Plan for Texas (Texas Department of Water Resources, 1984) were investigated--these include the Trinity Group, Edwards, Carrizo-Wilcox, Queen City, Sparta, and Gulf Coast aquifers. Ground water in the study area also is obtained from the Yegua Formation and Jackson Group, both of Eocene age, alluvium, and other units, but these are considered to be not even minor

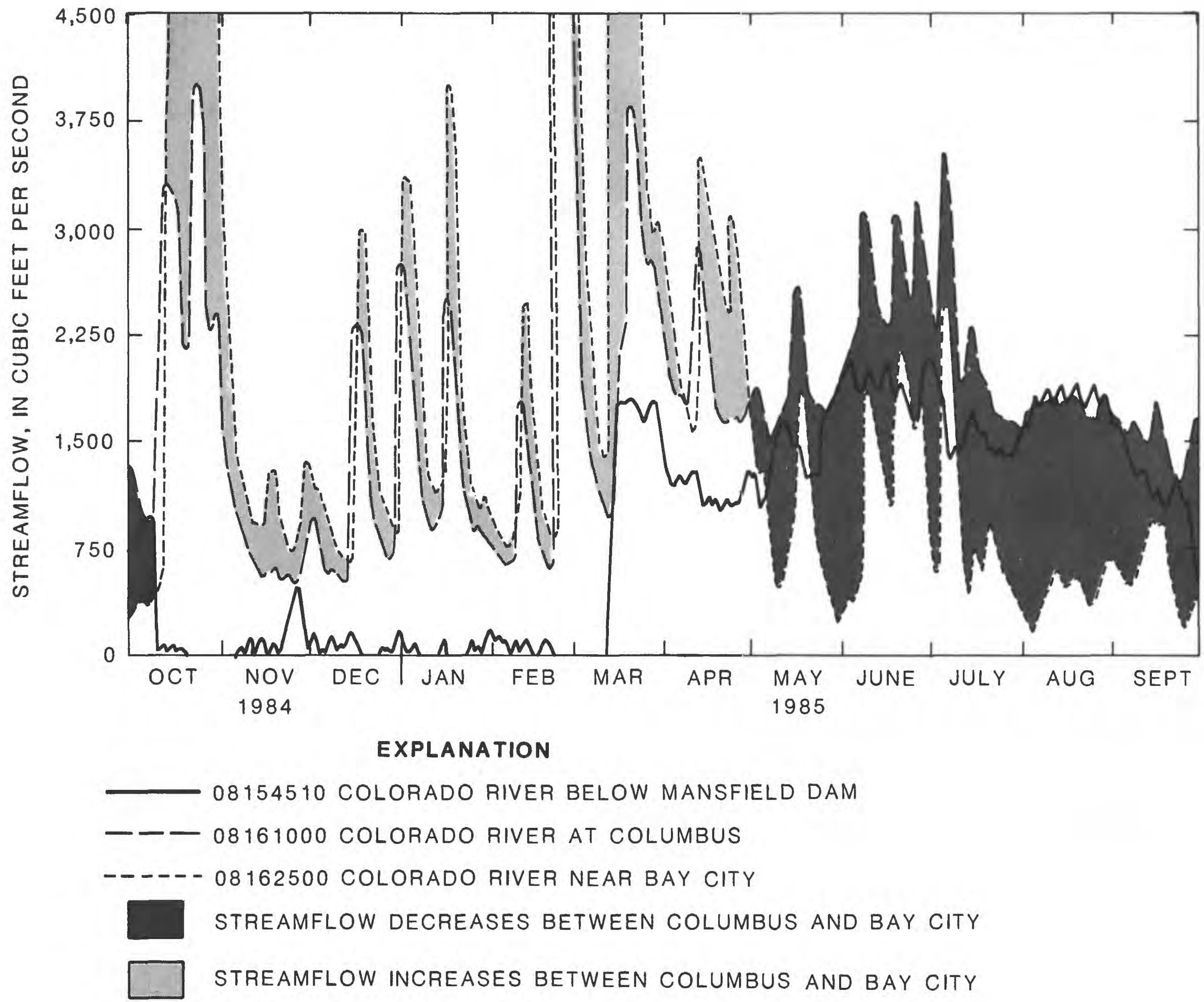


Figure 3.--Generalized streamflow hydrographs of lower Colorado River, water year 1985.

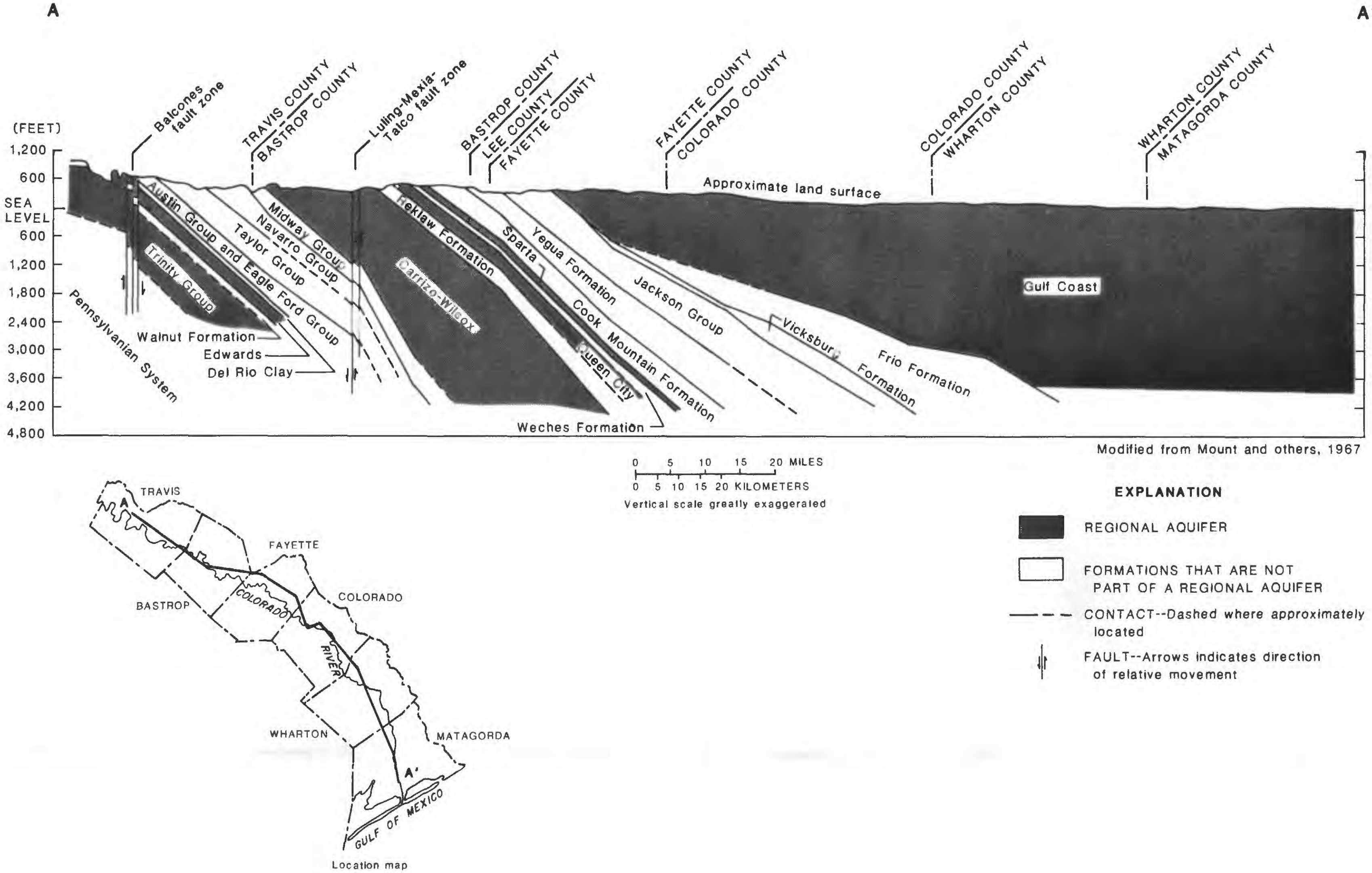


Figure 4.--Hydrogeologic section of study area.

aquifers and, hence, are not discussed. Regional aquifers in the study area will be discussed in ascending order.

Trinity Group Aquifer

The Trinity Group aquifer of Cretaceous age is divided, in ascending order, into the lower, middle, and upper Trinity aquifers. The lower Trinity aquifer consists of the Hosston Sand and Sligo Limestone Members of the Travis Peak Formation (Brune and Duffin, 1983). The Hosston and its surface equivalent, the Sycamore Sand Member of the Travis Peak Formation (Brune and Duffin, 1983), form a wedge of alluvial sediments that vary from conglomerate, sandstone, and claystone in the updip facies to more dolomitic and shaly sediments downdip. Further downdip, the Hosston Sand Member grades into a sandy dolomitic limestone of the Sligo Limestone Member. The lower Trinity aquifer crops out in extreme western Travis County (fig. 5) and has a maximum thickness of about 1,000 ft. Yields of water to wells vary from 10 to about 75 gal/min; however, yields of as much as 200 gal/min have been obtained after acidizing the wells. The water in the aquifer is either fresh or slightly saline in most of Travis County.

Flow in the lower Trinity aquifer is toward the lower Colorado River and major tributaries of the river (fig. 5). The potentiometric contours in figure 5 also indicate flow toward Lake Travis; but at the lake-aquifer interface, the localized flow direction is from the lake to the aquifer. Water-level data for the aquifer in and east of Austin were not sufficient to project the potentiometric surface in that area.

The middle Trinity aquifer consists of the Cow Creek Limestone and Hensell Sand Members of the Travis Peak Formation and the lower member of the Glen Rose Formation. The lower member of the Glen Rose Formation consists of massive limestone and dolomite in the basal part, and limestone, shale, marl, anhydrite, and gypsum in the upper part. The middle Trinity aquifer crops out in western Travis County (fig. 6) and ranges in thickness from about 300 to 500 ft. Most wells yield water at the rate of 10 to 40 gal/min, but rates of as much as 65 gal/min have been obtained. The water in the aquifer is either fresh or slightly saline throughout the western one-half of Travis County.

Flow in the middle Trinity aquifer is toward the lower Colorado River and major tributaries of the river (fig. 6). The potentiometric contours in figure 6 also indicate flow toward Lake Travis; but at the lake-aquifer interface, the localized flow direction is from the lake to the aquifer. In the immediate Austin area north of the lower Colorado River, water in the aquifer discharging to the river has dissolved-solids concentrations greater than 3,000 mg/L (milligrams per liter).

The upper Trinity aquifer is composed of the upper member of the Glen Rose Formation and the overlying Paluxy Formation. The upper member of the Glen Rose Formation consists of shale and marl alternating with thin beds of limestone and dolomite; the Paluxy Formation, about 10 ft thick in the study area, consists of fine grained, quartz sand. The aquifer crops out west of the Mount Bonnell fault in the western one-half of Travis County (fig. 7) and ranges in thickness from about 200 to 600 ft. Wells commonly yield water at a rate of 10 to 25 gal/min.

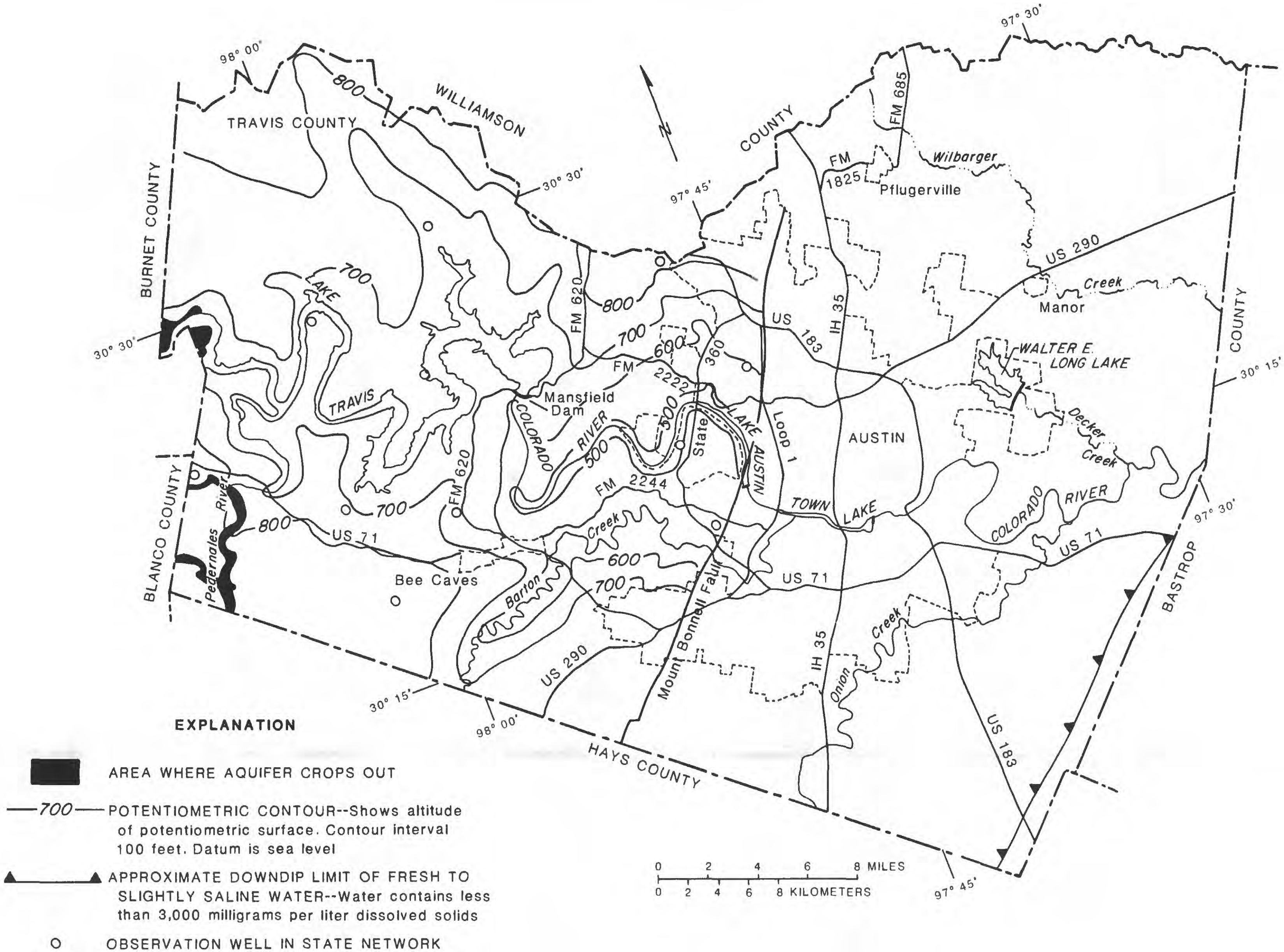


Figure 5.--Generalized potentiometric surface of the lower Trinity aquifer, 1970-85.

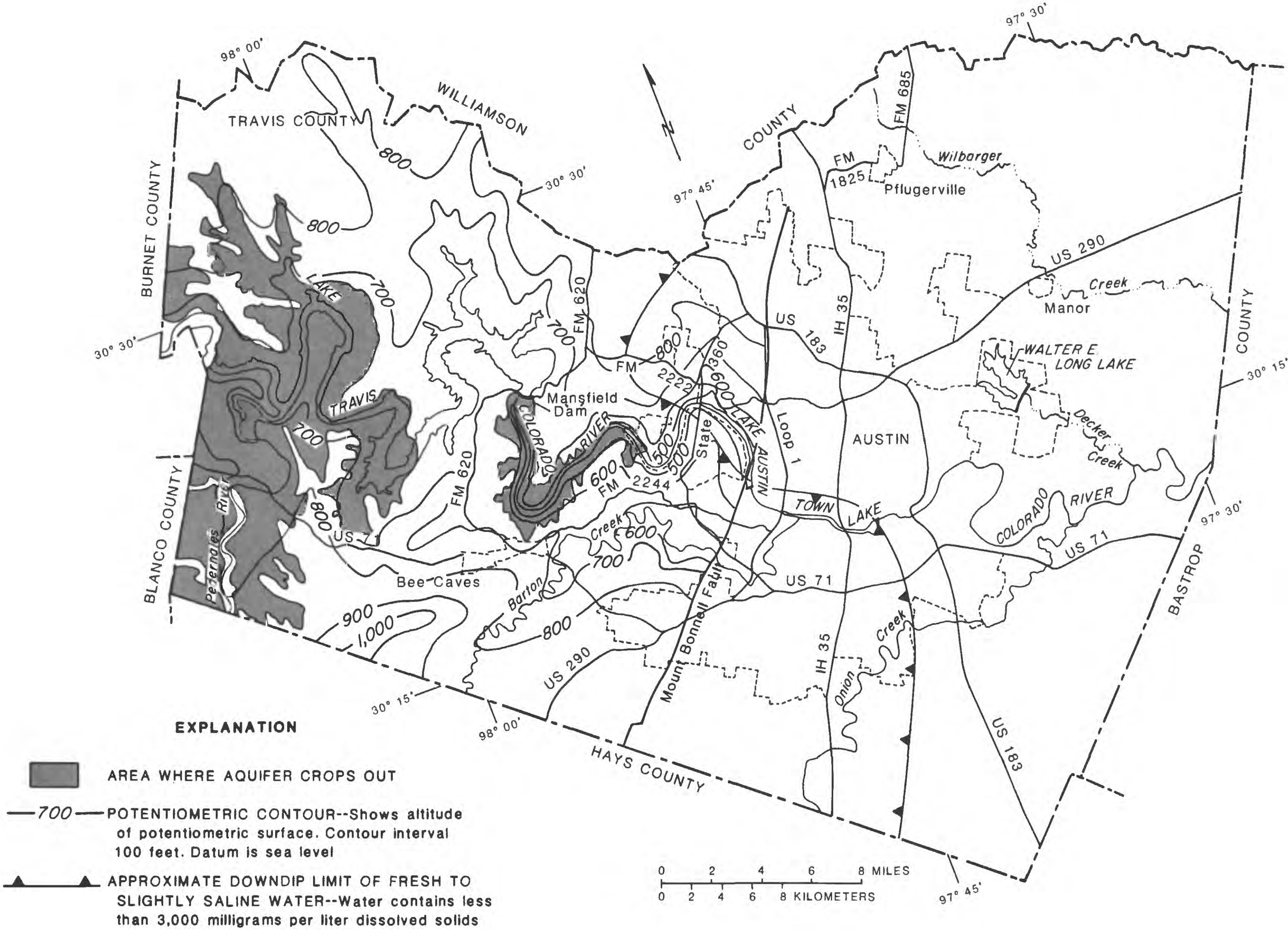
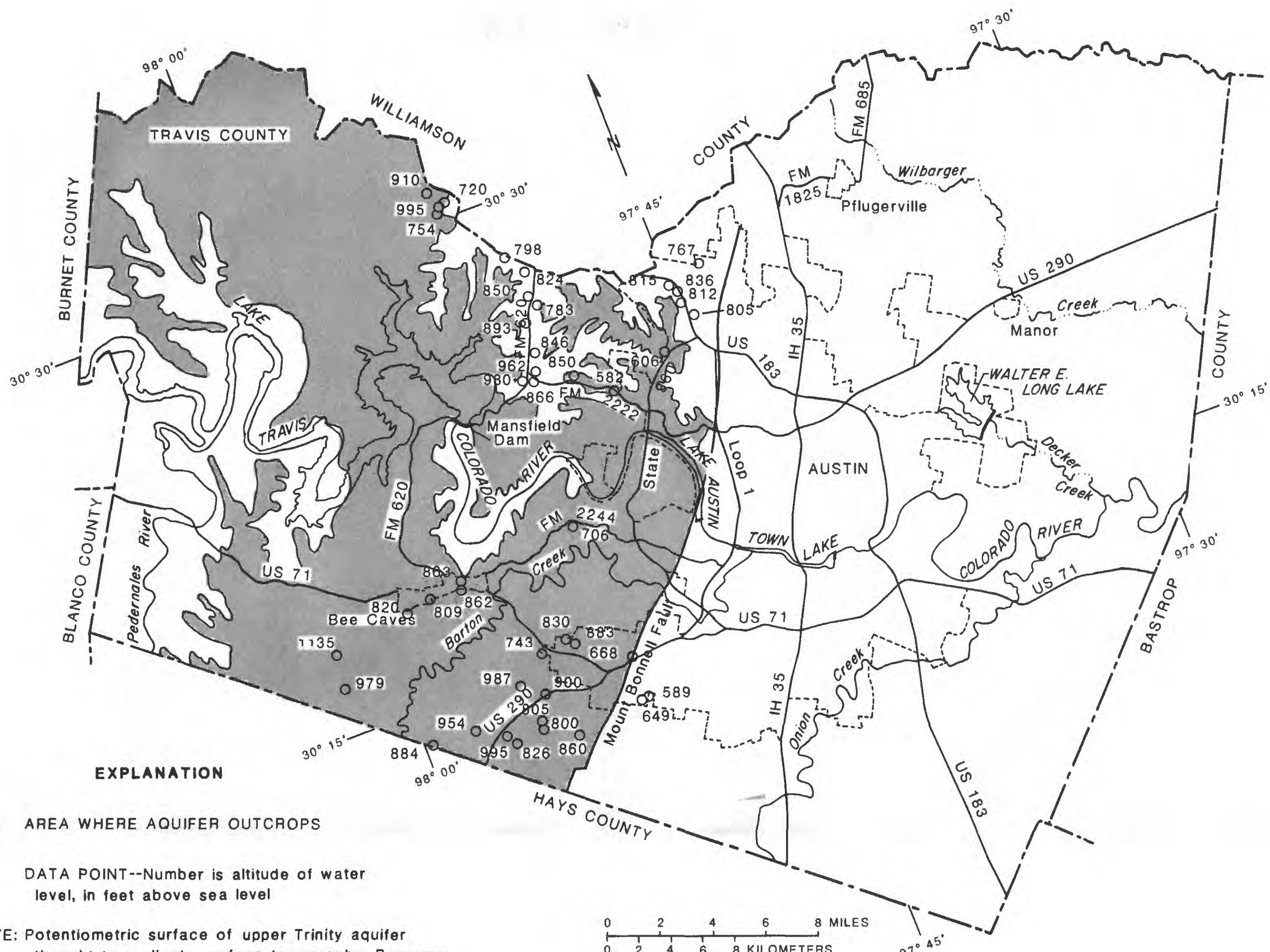


Figure 6.--Generalized potentiometric surface of the middle Trinity aquifer, 1970-85.



EXPLANATION

AREA WHERE AQUIFER OUTCROPS

1135 ○ DATA POINT--Number is altitude of water level, in feet above sea level

NOTE: Potentiometric surface of upper Trinity aquifer thought to replicate surface topography. Because of complex relief in outcrop area, only data points shown with altitude of potentiometric surface.

Figure 7.--Generalized potentiometric surface of the upper Trinity aquifer, 1970-85.

Reliable water-level data for the upper Trinity aquifer in the study area are few. The altitude of the water level measured in wells completed in the upper Trinity aquifer is shown in figure 7. According to Brune and Duffin (1983), movement of water in the outcrop area of the upper Trinity aquifer in Travis County is generally in the same direction as the slope of the land surface.

Edwards Aquifer

The Edwards aquifer consists of the Comanche Peak, the Edwards, and the Georgetown Limestones of Early Cretaceous age, and ranges in thickness from 200 to 450 ft in the subsurface. South of the lower Colorado River, the aquifer crops out within the Balcones fault zone (see fig. 4) east of the Mount Bonnell fault; north of the river, the aquifer mostly crops out west of the Mount Bonnell fault (fig. 8). Solution features--such as honeycombing, sinkholes, and caverns--allow for rapid infiltration of water on the outcrop as well as rapid movement of water within the aquifer. Numerous faults in the outcrop allow many of the solution features to develop (Baker and others, 1986). Yields of water to wells vary considerably from 10 to 300 gal/min; yields of as much as 500 gal/min have been obtained. The freshwater and slightly saline water parts of the Edwards aquifer in the study area occur in the outcrop area and in a zone as much as 8 mi east of the eastern limit of the outcrop area.

The regional direction of flow in the Edwards aquifer in the study area is easterly and toward the lower Colorado River. The Edwards aquifer east of the Mount Bonnell fault is in the Balcones fault zone and is dissected by many faults. Some of these faults are barriers to ground-water flow and deflect the regional flow direction. The potentiometric surface depicted in figure 8 represents the regional flow pattern and does not show the complex localized flow patterns. In the outcrop area south of the river, the aquifer is recharged by Barton, Williamson, and Slaughter Creeks.

Carrizo-Wilcox Aquifer

The Carrizo-Wilcox aquifer in rocks of Paleocene and Eocene age is one of the most extensive aquifers in Texas. The aquifer primarily consists of cross-bedded sand with clay, sandstone, silt, lignite, and gravel of the Paleocene and Eocene Wilcox Group and overlying Eocene Carrizo Sand. The Carrizo-Wilcox aquifer crops out in western Bastrop County (fig. 9) and dips to the southeast beneath younger gulf-coast sediments. The aquifer ranges in thickness from about 1,600 to 4,000 ft. Yields of water to wells vary considerably; they are commonly 500 gal/min, but can be as much as 3,000 gal/min downdip from the outcrop where the aquifer is under artesian conditions. Throughout most of its extent in the study area, the Carrizo-Wilcox aquifer contains fresh to slightly saline water which is acceptable for most public-supply, irrigation, and industrial uses.

Water in the Carrizo-Wilcox aquifer flows toward the lower Colorado River and the major tributaries of the river (fig. 9). Although the aquifer contains freshwater to slightly saline water in extreme eastern Bastrop and western Fayette Counties, few wells in these areas are completed in the Carrizo-Wilcox because potable water in shallower aquifers is available.

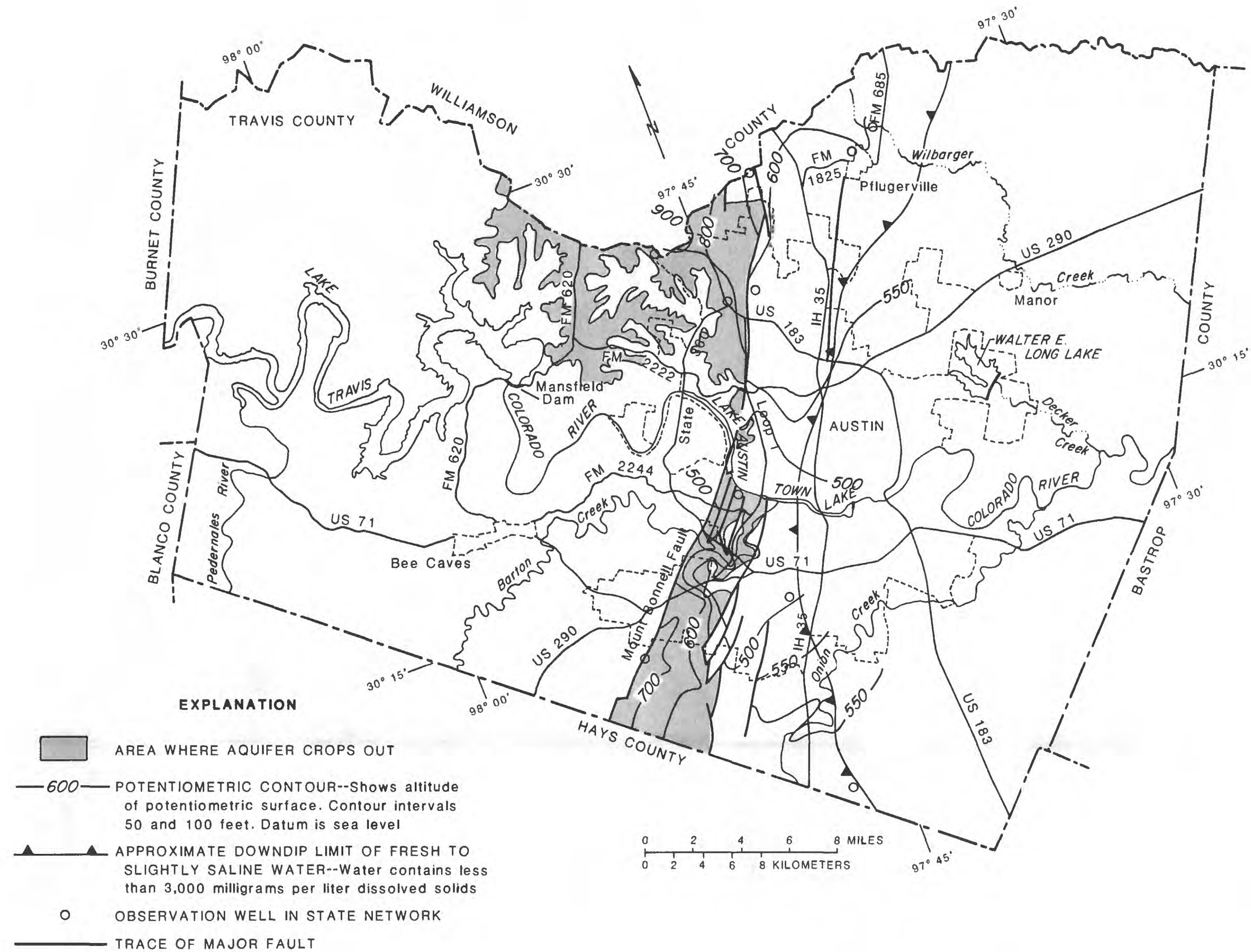


Figure 8.--Generalized potentiometric surface of the Edwards aquifer, 1970-85.

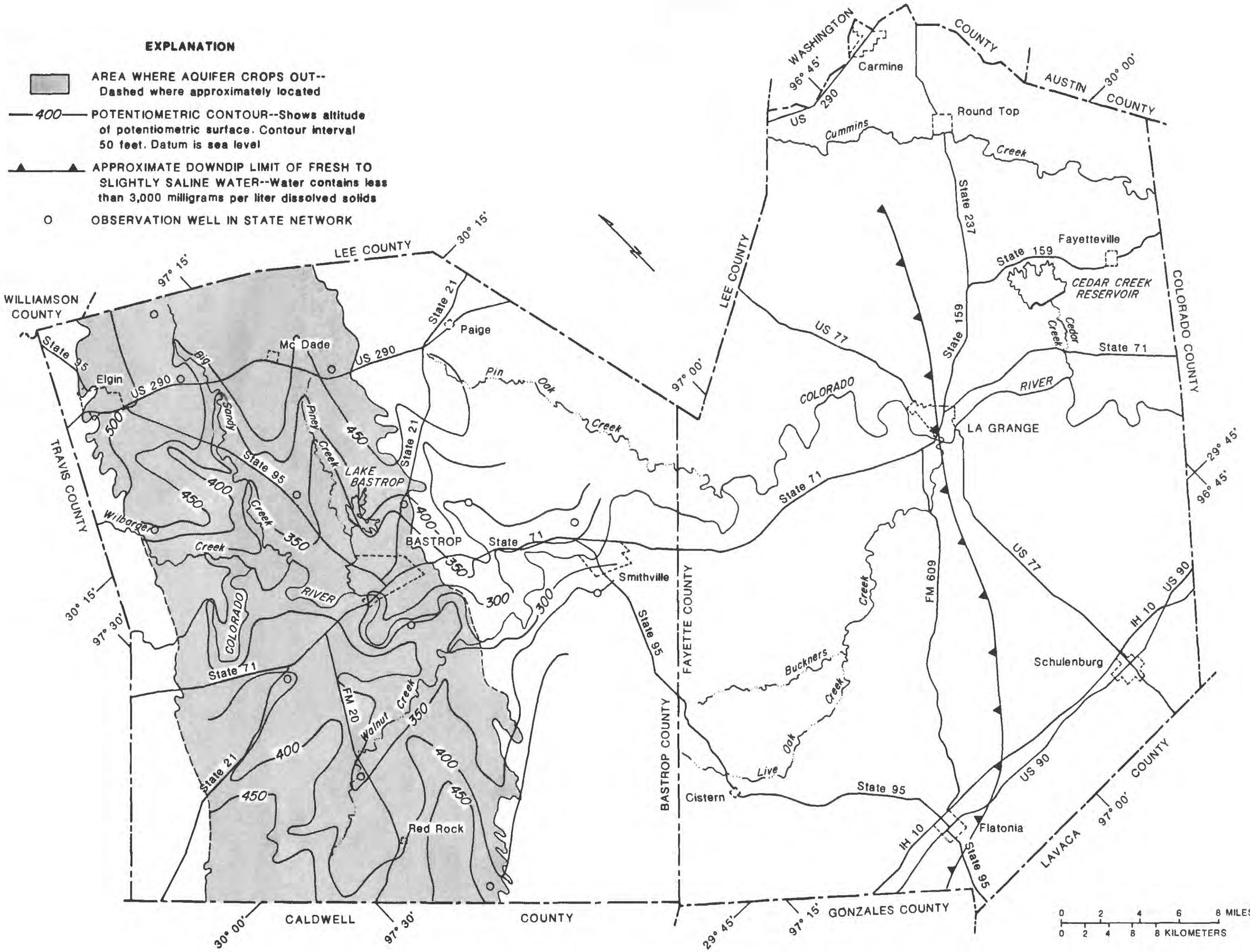


Figure 9.--Generalized potentiometric surface of the Carrizo-Wilcox aquifer, 1970-85.

Hence, the potentiometric surface of the Carrizo-Wilcox aquifer in these areas is speculative and is not shown.

Queen City Aquifer

The Queen City aquifer in rocks of Eocene age crops out in eastern Bastrop County (fig. 10) and dips southeasterly toward the Gulf Coast at about 150 ft/mi. The aquifer principally consists of sand, loosely cemented sandstone, and interbedded clay of the Queen City Sand; aquifer thickness ranges from about 480 to 750 ft in the subsurface of Fayette County. Yields of water from wells completed in the aquifer are rather small with only a few yields exceeding 400 gal/min. Concentrations of dissolved solids are usually small; water containing less than 3,000 mg/L dissolved solids extends to depths of about 2,000 ft below the land surface.

The direction of ground-water flow in the Queen City aquifer is toward the lower Colorado River and a major tributary, Pin Oak Creek (fig. 10). There is a ground-water divide east of Pin Oak Creek which diverts some of the flow easterly into Lee County. The Queen City aquifer contains freshwater and slightly saline water in western Fayette County, but few wells are completed in the aquifer in that area because potable water can be obtained from shallower aquifers.

Sparta Aquifer

The Sparta aquifer, in the Sparta Sand of Eocene age, consists of fine- to medium-grained sand interbedded with a few lignitic shale beds. The aquifer crops out in eastern Bastrop County (fig. 11) and dips southeasterly at about 175 ft/mi. The aquifer ranges in thickness from 0 to about 275 ft in Fayette County. Large-capacity wells, producing mainly from thick sand deposits near the base of the aquifer, generally yield 400 to 500 gal/min. Water produced from the aquifer generally has small concentrations of dissolved solids.

Water in the Sparta aquifer moves easterly and toward the Colorado River and its major tributaries--Pin Oak, Buckners, and Live Oak Creeks (fig. 11). Water-level data for this aquifer are lacking in west-central Fayette County, and consequently, the potentiometric surface in this area is speculative and is not shown.

Gulf Coast Aquifer

The Gulf Coast aquifer is comprised of rocks that range in age from Miocene to Holocene, and, in ascending order, is composed of the Catahoula and Oakville Sandstones, Lagarto Clay, Goliad and Willis Sands, and Lissie and Beaumont Formations, as well as overlying surficial deposits. The aquifer consists of alternating beds of clay, silt, sand, and gravel that are hydraulically connected to form a leaky artesian aquifer (Muller and Price, 1979). The principal water-bearing units are the Goliad Sand (analogous to the Evangeline aquifer), and the Willis and Lissie Formations (analogous to the Chicot aquifer). The aquifer crops out in eastern Fayette County and is exposed at the surface in most of Colorado, Wharton and Matagorda Counties (fig. 12).

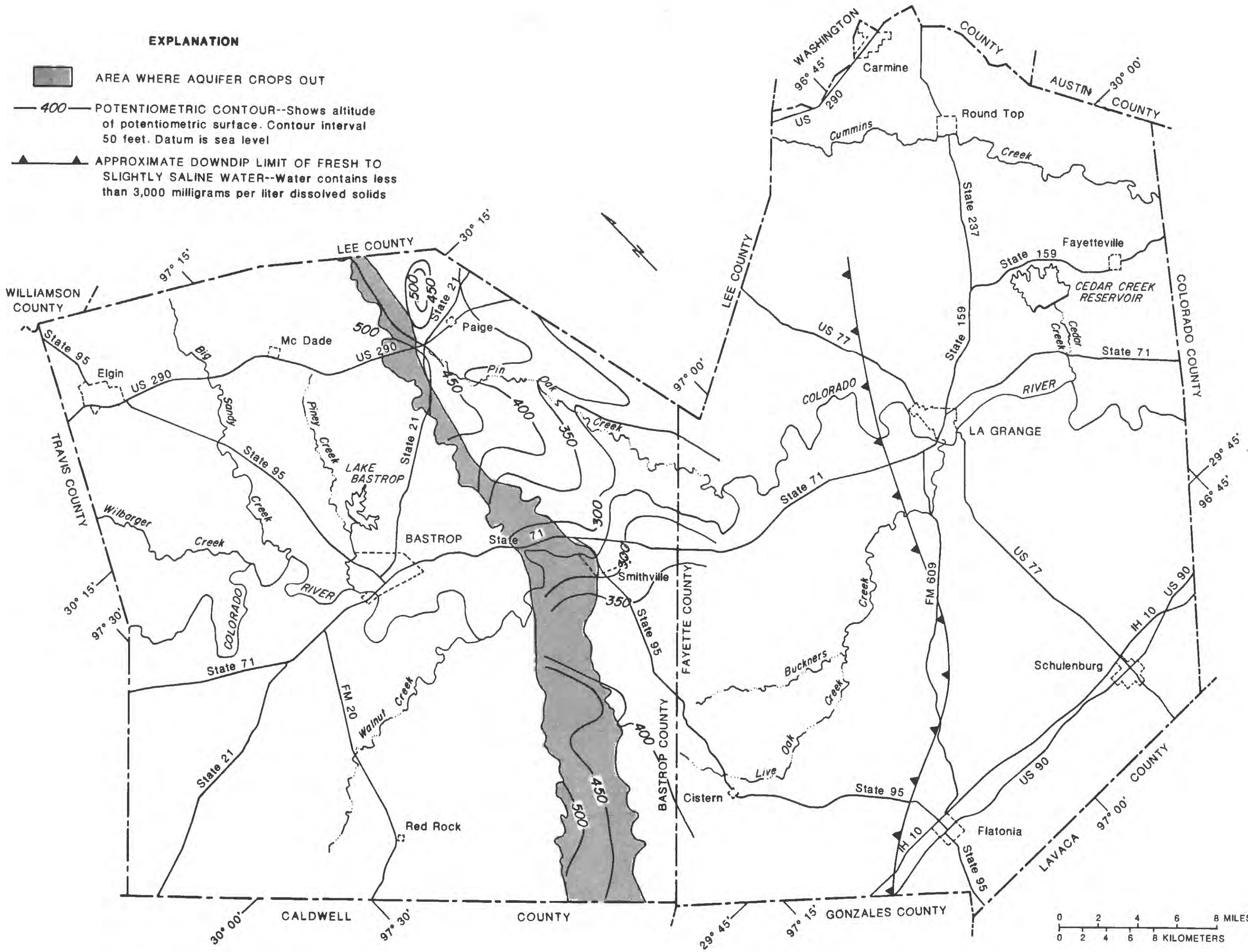


Figure 10.--Generalized potentiometric surface of the Queen City aquifer, 1970-85.

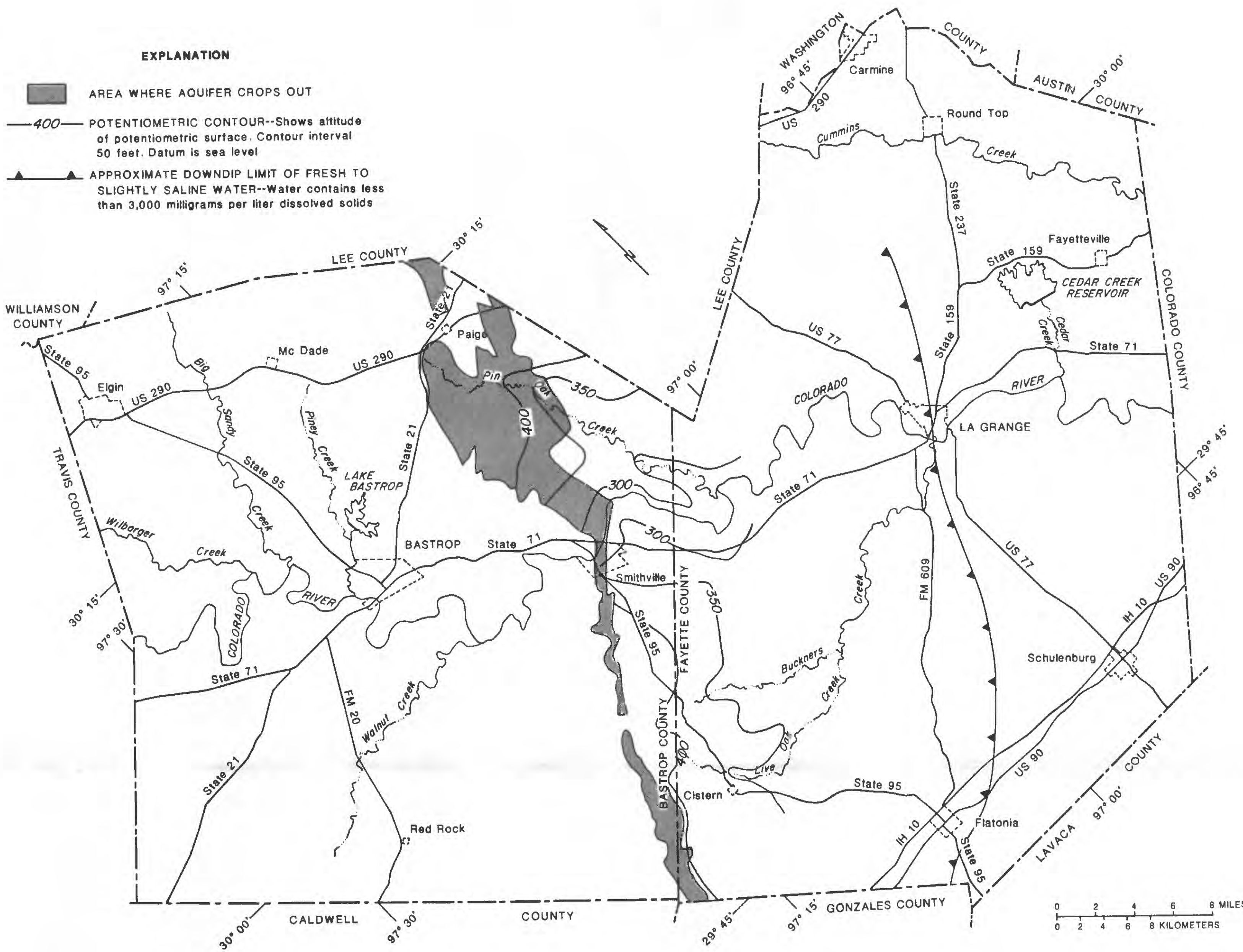


Figure 11.--Generalized potentiometric surface of the Sparta aquifer, 1970-85.

Generally, water in the Gulf Coast aquifer flows southeasterly toward the gulf and toward the lower Colorado River and its major tributaries (fig. 12). However, it appears that the regional ground-water-flow pattern gradually changes from: (1) Flow towards the lower Colorado River in central Colorado County, to (2) flow along and approximately parallel to the river in southern Colorado and northern Wharton Counties, to (3) flow away from the Colorado River in central Wharton County upstream from the city of Wharton, to finally (4) flow back towards the river again in southern Wharton County. Ground-water pumpage from rather closely spaced irrigation wells between the cities of El Campo and Wharton may have created a cone of depression that would cause water to move away from the lower Colorado River valley to the Gulf Coast aquifer. Ground-water divides that occur northeast and southwest of the lower Colorado River in Matagorda and southern Wharton Counties divert flow out of the study area to the northeast and southwest, respectively.

FLOW RELATIONS BETWEEN THE RIVER VALLEY AND REGIONAL AQUIFERS

The flow relations between the river valley and each regional aquifer have been previously discussed and illustrated in figures 5-12. Significant flow relations interpreted to exist between the lower Colorado River and the underlying regional aquifers are summarized in figure 13. Each regional aquifer discharges water to the river valley, particularly in the outcrop area of each aquifer. Only the Gulf Coast aquifer in central Wharton County appears to be recharged by water in the river valley.

Subreaches of the lower Colorado River that receive substantial recharge from underlying regional aquifers are denoted in figure 13. The downstream extent of these subreaches is somewhat speculative because the necessary supportive water-level data are not available.

SUMMARY

The study area, which includes the lower Colorado River valley, consists of Travis, Bastrop, Fayette, Colorado, Wharton, and Matagorda Counties, an area of 6,011 mi^2 in southeastern Texas. Water in the lower Colorado River travels about 318 mi from where the river is controlled by Mansfield Dam to where the river discharges into the Gulf of Mexico. Along this reach, the Colorado River flows either directly on or over six regional aquifers--the Trinity Group, Edwards, Carrizo-Wilcox, Queen City, Sparta, and Gulf Coast aquifers. An alluvial aquifer, which underlies parts of the river, provides an indirect hydraulic connection between the river and the regional aquifers.

Although the population of the six-county study area is primarily urban, the land use and water demand are primarily for agricultural purposes. Historically, the largest volume of water diverted from the lower Colorado River has been used for agricultural irrigation--almost exclusively for rice irrigation in Colorado, Wharton, and Matagorda Counties. Both surface and ground water are used for rice irrigation; surface water used for irrigation is pumped or diverted directly from the lower Colorado River. Double cropping of hybrid rice has resulted in increased water demand.

Streamflow in the lower Colorado River is primarily controlled by releases from Lake Travis through Mansfield Dam, located a few miles upstream from Austin. Most of the releases primarily fulfill the additional water

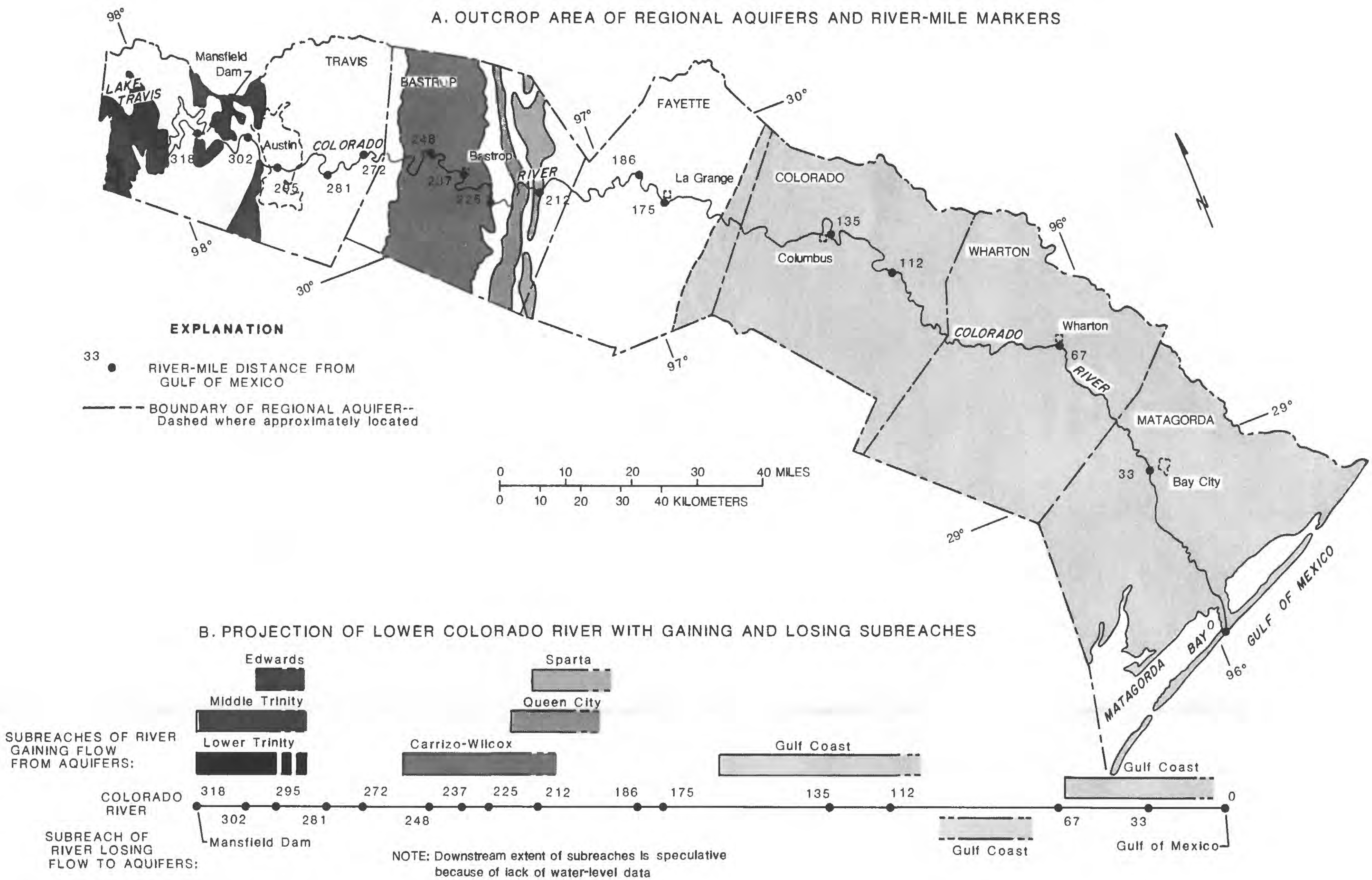


Figure 13.--Flow relations between the river and regional aquifers.

requirements of the major rice irrigators. Generally, streamflow in the lower Colorado River increases downstream from Mansfield Dam to the Gulf of Mexico; however, during the rice-irrigation season, streamflow decreases substantially from Columbus to Bay City, largely as a result of surface-water diversions for irrigation. Water is also added to the flow of the lower Colorado River by return flow from agricultural irrigation.

Geologically, the study area is situated on a broad regional homocline that dips toward the Gulf of Mexico; the homocline is interrupted in central Travis County near Austin by the Balcones fault zone and in western Bastrop County by the Luling-Mexia-Talco fault zone.

This report describes the flow pattern of water in the regional aquifers near the lower Colorado River, and identifies those subreaches of the lower Colorado River through which water can flow at a significant rate between the river and the underlying regional aquifers. Existing water-level data from files of the U.S. Geological Survey and the Texas Water Development Board were used to prepare potentiometric maps for each regional aquifer. Because contemporaneous water-level data for each aquifer were limited, generalized potentiometric maps were prepared that integrate water levels measured during 1970-85. Flow patterns in the aquifers and flow relations between subreaches of the lower Colorado River and regional aquifers are interpreted from these potentiometric maps.

The general direction of flow in the Trinity Group, Edwards, Carrizo-Wilcox, Queen City, and Sparta aquifers is easterly and toward the lower Colorado River and its major tributaries. The general direction of flow in the Gulf Coast aquifer is southeasterly toward the gulf and toward the lower Colorado River and its major tributaries. However, it appears that the regional ground-water-flow pattern gradually changes from: (1) Flow towards the Colorado River in central Colorado County, to (2) flow along and approximately parallel to the river in southern Colorado and northern Wharton Counties, to (3) flow away from the lower Colorado River in central Wharton County upstream from the city of Wharton, to finally (4) flow back towards the river again in southern Wharton County. Ground-water pumpage from rather closely spaced irrigation wells between the cities of El Campo and Wharton may have created a cone of depression that would cause water to move away from the lower Colorado River valley to the Gulf Coast aquifer. Ground-water divides that occur northeast and southwest of the lower Colorado River in Matagorda and southern Wharton Counties divert flow out of the study area to the northeast and southwest, respectively.

Significant flow relations are interpreted to exist between the lower Colorado River and the underlying regional aquifers. Each regional aquifer discharges water to the river valley, particularly in the outcrop area of each aquifer. Only the Gulf Coast aquifer in central Wharton County appears to be recharged by water in the river valley.

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