Hydrogeologic Framework of the Red River Alluvial Aquifer and Carrizo-Wilcox Aquifer in Northwestern Louisiana

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
Water Resources Technical Report No. 82

STATE OF LOUISIANA
DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

In cooperation with the
U.S. GEOLOGICAL SURVEY

2023

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Cover photograph: Aerial view of the Mississippi River, West Baton Rouge Parish, Louisiana (photograph by Angela L. Collier, U.S. Geological Survey, 2017)

STATE OF LOUISIANA

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

OFFICE OF PUBLIC WORKS, HURRICANE FLOOD PROTECTION AND

INTERMODAL TRANSPORTATION WATER RESOURCES PROGRAMS

In cooperation with the

U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

WATER RESOURCES

TECHNICAL REPORT NO. 82

HYDROGEOLOGIC FRAMEWORK OF THE RED RIVER ALLUVIAL AQUIFER AND CARRIZO-WILCOX AQUIFER IN NORTHWESTERN LOUISIANA

By

Phillip D. Hays, Anna M. Nottmeier, Robert B. Fendick, Jr., William J. Daugherty, and Kayla Carter

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Conversion Factors

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Supplemental Information

Concentrations of chemical constituents in water are given in milligrams per liter (mg/L)

Abbreviations

DOTD	Louisiana Department of Transportation and Development
ohm m	ohm meter
NGVD 29	National Geodetic Vertical Datum of 1929
SMCL	Secondary Maximum Contaminant Level
USGS	U.S. Geological Survey

Acknowledgments

The authors would like to thank everyone who helped produce this report. Special recognition is given to personnel of the Water Resources Programs, Louisiana Department of Transportation and Development, for their support and assistance in the creation and publication of this report. Thanks are also extended to the Louisiana Department of Natural Resources for providing access to their collection of petroleum test-well geophysical logs, and to Louisiana water-well drillers and loggers for collecting lithologic and geophysical logs. The work by Robert B. Fendick, Jr., William J. Daugherty, and Kayla Carter was done while they were serving as employees with the U.S. Geological Survey.

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Abstract

Groundwater in northwestern Louisiana is a valuable resource needed for expanding public-supply needs as well as possible energy development needs arising from Haynesville Formation natural-gas production. The Red River alluvial and the Carrizo-Wilcox aquifers are two of the most important and heavily pumped aquifers in northwestern Louisiana; however, little documentation of the regional hydrogeologic framework is available. The U.S. Geological Survey and the Louisiana Department of Transportation and Development have consolidated information from, and built upon, previous studies of the Red River alluvial and the Carrizo-Wilcox aquifers to characterize and document the regional hydrogeologic framework of northwestern Louisiana.

The study area has been tectonically modified and includes abundant structural features such as salt domes and areally extensive faulting in addition to minor folding related to these features, all of which impact the sedimentological and hydraulic characteristics of the freshwater-bearing strata. The hydrogeologic framework of northwestern Louisiana comprises a sequence of structurally modified, complexly interbedded, varyingly interconnected, clayey, sandy, and gravelly alluvial sediments. The important freshwater hydrogeologic units include the Quaternary Red River alluvial and upland terrace aquifers, and the underlying Tertiary Sparta, Cane River, and Carrizo-Wilcox aquifers. The Midway confining unit underlies the Carrizo-Wilcox aquifer throughout the study area. No freshwater is present in or below the Midway Group.

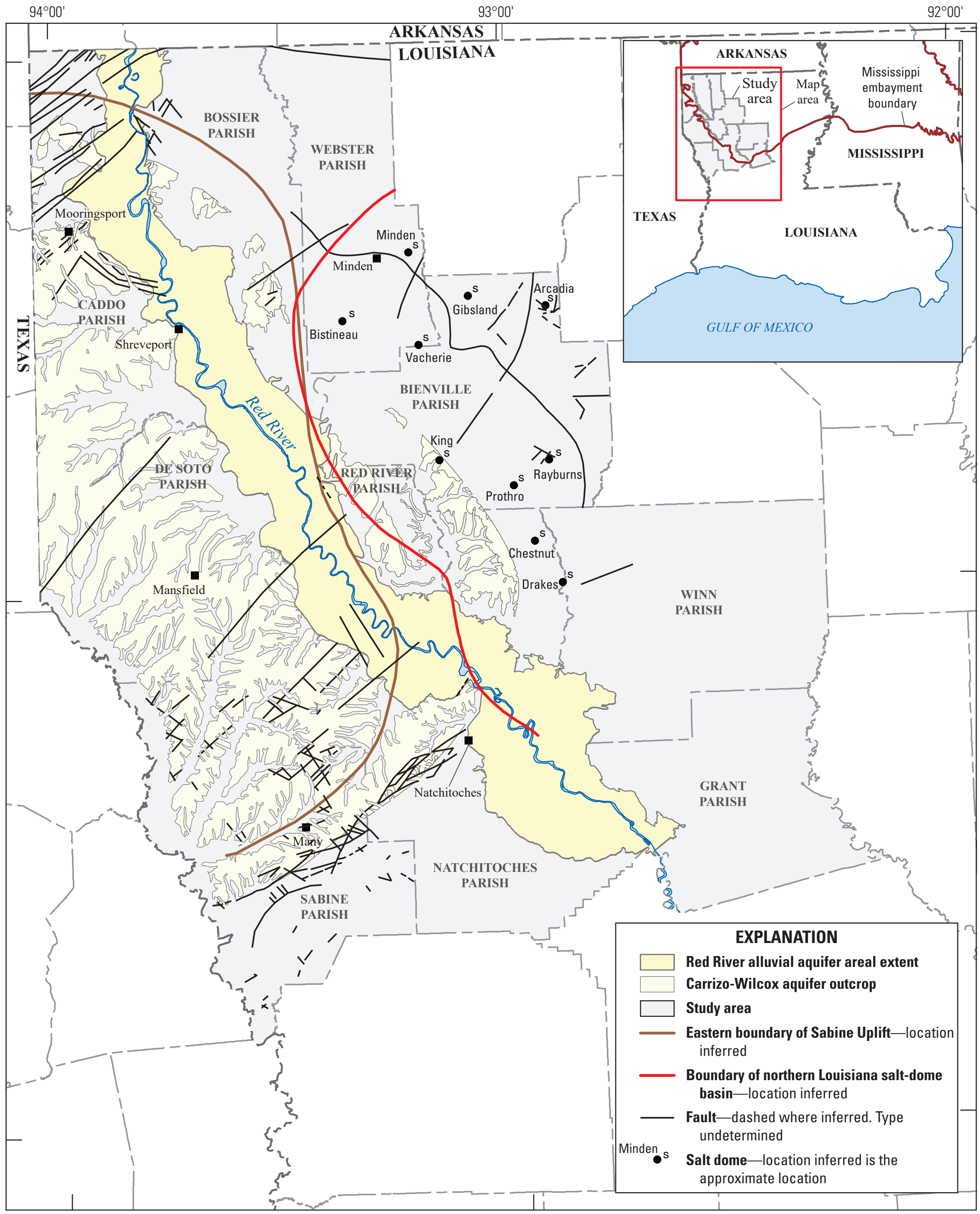
Tertiary-age formations exposed at land surface in the study area have been incised by the Red River and are hydraulically connected to the Quaternary Red River alluvium in the Red River valley. In 2010, 7.73 million gallons per day (Mgal/d) of water were withdrawn from the Red River alluvial aquifer in the study area, representing an increase of 2.00 Mgal/d, or about 35 percent, over 2005 withdrawal rates.

The Tertiary Carrizo Sand and Wilcox Group crop out across much of the study area. The two units are hydraulically connected and function as a single hydrologic unit referred to as the Carrizo-Wilcox aquifer. In 2010, 19.33 Mgal/d of water were withdrawn from the Carrizo-Wilcox aquifer in the study area, representing an increase of nearly 1.8 Mgal/d, or about 10 percent, over 2005 withdrawal rates. Any expansion in energy development, as well as water needs of an increasing population, could result in an increased demand on groundwater in northwestern Louisiana.

Introduction

Groundwater is a valuable resource in northwestern Louisiana (fig. 1), providing for drinking water, industrial, agricultural, and other needs. The Red River alluvial and Carrizo-Wilcox aquifers are two of the most important aquifers in northwestern Louisiana. In 2010, a combined total of about 27.1 million gallons per day (Mgal/d) of groundwater were pumped from the Red River alluvial aquifer (7.73 Mgal/d) and the Carrizo-Wilcox aquifer (19.33 Mgal/d) in the study area (fig. 1 and table 1; Sargent, 2007, 2011). From 2005 to 2010, withdrawals of water from the Red River alluvial aquifer increased by 2.00 Mgal/d, or about 35 percent. More than half of the increase occurred in Caddo Parish, in conjunction with hydraulic fracturing and development of the Haynesville Formation (Sargent, 2011). Water withdrawals from the Carrizo-Wilcox aquifer increased by 1.77 Mgal/d, or about 10 percent, from 2005 to 2010. Most of this increase occurred in Caddo and De Soto Parishes in conjunction with gas production and hydraulic fracturing of the Haynesville Formation (Sargent, 2011). Any expansion in energy development in conjunction with increased water demands from population growth will likely lead to increased future demands on groundwater in northwestern Louisiana.

Documentation of the regional hydrogeologic framework of northwestern Louisiana is sparse. Local studies by Newcome and others (1963), Newcome and Page (1962), Page and May (1964), Page and others (1963), Page and Preé (1964), and Ryals and Hosman (1980) each provide limited information about the nomenclature, location, and characteristics of selected aquifers across small-scale areas, typically one or two parishes. Broad, regional studies have compiled general data but offer very little local



Base from U.S. Geological Survey, digital data, 1:2,000,000, 1998
U.S. Department of Commerce, digital data, 1:1,000,000,000, 2016
Albers Equal-Area Conic projection
Standard parallels 29°50' N. and 45°50' N.
Central meridian 96°00' W.
North American Datum of 1983

0 10 20 MILES
0 10 20 KILOMETERS

Geologic and fault data modified from Gulf Coast Association of Geological Societies and American Association of Petroleum, 1972; McCulloh, 2001; Stoeser and others, 2005; Salt dome data, and Sabine uplift data modified from Ryals, 1982b

Figure 1. Location of the study area, principal aquifers, and selected structural features in northwestern Louisiana.

Table 1. Groundwater withdrawals, in millions of gallons per day, from the Red River alluvial aquifer and the Carrizo-Wilcox aquifer in the study area, 2005 and 2010 (Sargent, 2007, 2011).

[--, aquifer is absent]

Parish	Red River alluvial aquifer		Carrizo-Wilcox aquifer	
	2005	2010	2005	2010
Bienville	--	--	1.01	0.99
Bossier	0.50	0.24	2.46	2.39
Caddo	1.97	3.09	5.22	6.78
De Soto	0.04	0.15	3.25	4.11
Natchitoches	2.65	2.99	1.23	1.03
Red River	0.57	1.26	0.99	1.19
Sabine	--	--	1.87	1.81
Webster	--	--	1.53	1.03
Total	**5.73**	**7.73**	**17.56**	**19.33**

information (Payne, 1975). Detailed regional maps and hydrogeologic sections showing the areal and vertical stratigraphic extents, interconnections, spatial relations, and freshwater extents of the named aquifers across the study area are needed to provide better understanding and planning and management tools for groundwater resources. In response to this need, the U.S. Geological Survey (USGS) and the Louisiana Department of Transportation and Development (DOTD) began a study in 2009 to consolidate information from and build upon previous studies of the Red River alluvial and the Carrizo-Wilcox aquifers to characterize the regional hydrogeologic framework of northwestern Louisiana. The geospatial datasets of the hydrogeologic framework are available from Hays and others (2021).

Description of Study Area

The Carrizo-Wilcox aquifer system and the Red River alluvial aquifer are important sources of water in northwestern Louisiana across an area of about 6,850 square miles (mi^2) in Bossier, Caddo, De Soto, Red River, Bienville, Natchitoches, Sabine, Webster, Winn, and Grant Parishes (fig. 1). Land-surface altitudes are generally higher to the north and decrease toward the Red River valley and to the south and range in altitude from a high of 534 feet (ft) above the North American Vertical Datum of 1988 (NAVD 88) in northeastern Bienville Parish to a low of about 30 ft above NAVD 88 in Winn Parish. Within the Red River valley, local topographic relief is minor; a few isolated monadnocks (knobs or ridges), which generally rise less than 20 ft above surrounding terrain, constitute the most notable topographic features (Newcome, 1960). Altitudes in the Red River valley range from about 260 ft above NAVD 88 in Caddo Parish to about 60 ft above NAVD 88 in Natchitoches Parish. Natural levees and backswamps (poorly drained areas laying behind a stream's natural levee where fine sediments tend to accumulate) are characteristic geomorphologic features of the nearstream areas, and many oxbow lakes remain from abandoned meanders of the Red River. The Red River alluvium generally crops out within the northwest-southeast trending Red River valley. The Carrizo Sand and Wilcox Group crop out extensively across the study area where not overlain by the Red River alluvium and other younger units.

Methods of Study

Data from previous reports, geophysical logs, and drillers' lithologic logs were used to characterize the hydrogeologic framework of the Red River alluvial and Carrizo-Wilcox aquifers in northwestern Louisiana and delineate the spatial extents of specific aquifer units and confining layers. Most of the interpretations presented in this report are drawn from geophysical logs from petroleum test wells and water wells, and from drillers' lithologic logs from water wells. The authors generated log picks from these data sources. The logs used for the study were assimilated by, and archived at, the Louisiana Department of Natural Resources and are made available by that agency's Geological Oil and Gas Division, Well Log Management Section (http://www.dnr.louisiana.gov/index.cfm?md=pagebuilder&tmp=home&pid=154).

Previously published structural contour maps showing the base of the Red River alluvial aquifer and top and bottom of the Carrizo-Wilcox aquifer, as well as isopach maps showing aquifer thickness (Ryals, 1984), were used to guide and support log interpretations. Geophysical and drillers' log data were obtained from the USGS, the DOTD, and the Louisiana Department of Natural Resources. The depth and thickness of sand and clay units primarily were determined using single-point resistance, spontaneous-potential, short-normal resistivity, and medium-induction resistivity geophysical logs, in addition to drillers' lithologic logs. For consistency, altitudes originally referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29) were converted to NAVD 88 using 10-meter digital elevation data (U.S. Geological Survey, 2017). The occurrence and location of freshwater in sand primarily was determined using long-normal resistivity or deep-induction resistivity logs. A long-normal or deep-induction resistivity value of 20 ohm meters (ohm m) was used to indicate an estimated chloride concentration of 250 milligrams per liter (mg/L), so sands having resistivity values greater or less than 20 ohm m were classified as bearing freshwater or saltwater, respectively.

Hydrogeologic cross sections were constructed to represent aquifers and confining units on a regional to local scale; the level of detail included in these sections depended on data availability. The more local-scale hydrogeologic sections depict individual sand and clay lenses within aquifers and confining units. Generally, sand and clay lenses less than 20 ft thick were excluded from the sections.

Fault locations and displacement shown on structural maps in this report are based on information obtained from previous reports (Gulf Coast Association of Geological Societies and American Association of Petroleum Geologists, 1972; McCulloh, 2001; Newcome and others, 1963; Newcome and Page, 1962; Page and May, 1964; Rapp, 1996; Ryals, 1984). Data were extrapolated and assumptions were applied to areas where fault data were limited. Notable changes in water quality at multiple depths between adjacent geophysical logs were interpreted to coincide with fault locations, as is consistent with observations for areas having specific fault information confirming the presence of faults. Individual bed dips were assumed to be similar to dips in adjacent wells. The least complex correlations across faults were assumed and adopted as being most probable.

For the purposes of this report, an aquifer is defined as a lithologic unit consisting of material ranging from fine sand to gravel that is sufficiently permeable to conduct groundwater and yield economically substantial quantities of water to wells (Bates and Jackson, 1984). A clay or confining unit is defined as a lithologic unit composed of relatively impermeable material ranging from solid clay to sandy and silty clay that impedes groundwater flow. The term "freshwater" refers to water that has a chloride concentration of 250 mg/L or less, which coincides with the U.S. Environmental Protection Agency's Secondary Maximum Contaminant Level (SMCL) for drinking water (U.S. Environmental Protection Agency, 2012). The SMCLs are nonenforceable Federal guidelines regarding cosmetic effects (such as tooth or skin discoloration) or aesthetic effects (such as taste, odor, or color) of drinking water. At high concentrations or values, health implications, as well as aesthetic degradation, might exist (U.S. Environmental Protection Agency, 1992).

Structural Setting, Hydrogeologic Framework, and Hydrogeology

The study area lies on the southwestern margin of the Mississippi embayment, a south-plunging regional syncline with the axis trending southward, roughly parallel to the Mississippi River. Downwarping and rifting at the foreland area of the Ouachita orogenic belt formed the embayment, which served as a basin for subsequent sedimentation, including Jurassic, Cretaceous, Tertiary, and Quaternary deposits up to 18,000 ft thick (Cushing and others, 1964; Hosman and others, 1968; Hosman, 1996). Sediments deposited during the Tertiary and Quaternary periods compose the principal aquifers within the Mississippi embayment, including the Quaternary Red River alluvial and Tertiary Carrizo-Wilcox aquifers (fig. 2). The study area has been tectonically modified and includes abundant structural features such as salt domes, areally extensive faulting, and minor folding related to these features (fig. 1). These features have exerted strong control on the deposition and hydraulic characteristics of the freshwater-bearing strata. Locally, the Sabine Uplift is a primary structural feature that affects the hydrogeologic units of the study area (fig. 1). The topographically highest part of the Sabine Uplift is located in the northwestern part of the study area near Mooringsport in western Caddo Parish. The dome imparts an easterly dip component to the generally southerly regional dip of the Tertiary beds in the western part of the study area, and the Carrizo-Wilcox interval thins considerably over the dome (Page and May, 1964). Another major structural feature is a depression, located in the east-central part of the study area, that defines the northern Louisiana salt-dome basin (fig. 1). The locations of salt domes (Beckman and Williamson, 1990) are shown on figure 1. Faulting has had a strong degree of control on the altitude, thickness, and sedimentology of aquifer formations and the distribution of fresh groundwater. Selected faults in the study area (Snead and McCulloh, 1984) are shown on figure 1.

Era	System	Series	Stratigraphic unit		Hydrogeologic unit
Cenozoic	Quaternary	Holocene	Red River alluvium/Quaternary alluvium		Red River alluvial aquifer or surficial confining unit
			Terrace deposits		Upland terrace aquifer or surficial confining unit
		Pleistocene	Unassigned Pleistocene deposits		
	Tertiary	Pliocene	Fleming Formation	Blounts Creek Member	Pliocene-Miocene confining units
		Miocene		Castor Creek Member	
				Williamson Creek Member Dough Hills Member Carnahan Bayou Member	
				Lena Member	
		Oligocene	Catahoula Formation		Catahoula aquifer
			Vicksburg Group, undifferentiated		Vicksburg-Jackson confining unit
		Eocene	Jackson Group, undifferentiated		
			Claiborne Group	Cockfield Formation	Cockfield aquifer or surficial confining unit
				Cook Mountain Formation	Cook Mountain aquifer or confining unit
				Sparta Sand	Sparta aquifer or surficial confining unit
				Cane River Formation	Cane River aquifer or confining unit
				Carrizo Formation	Carrizo-Wilcox aquifer or surficial confining unit
		Paleocene	Wilcox Group, undifferentiated		
			Midway Group, undifferentiated		Midway confining unit

Figure 2. Generalized correlation of stratigraphic units and hydrogeologic units in the study area (modified from Stuart and others, 1994; Lovelace and Lovelace, 1995).

The hydrogeologic framework of northwestern Louisiana consists of a sequence of structurally modified, complexly interbedded, varyingly interconnected, clayey, sandy, and gravelly alluvial sediments. Sand and rarer gravel intervals constitute the aquifers in the study area (Ryals, 1982a, b).

The freshwater hydrogeologic units underlying the study area include the Red River alluvial aquifer and the upland terrace aquifer, both composed of sediments of Quaternary age, and the underlying Sparta, Cane River, and Carrizo-Wilcox aquifers, all composed of sediments of Tertiary age (fig. 2). The Red River alluvial and Carrizo-Wilcox aquifers are the only freshwater units treated in detail in this report, because the others are not important, spatially extensive aquifers and crop out or subcrop only in the southern part of the study area.

The Midway confining unit underlies the Carrizo-Wilcox aquifer throughout the study area and is composed predominantly of marine clay and shale but includes minor sand and limestone beds (Cushing and others, 1964). Neither the Midway Group, nor any strata below, contain freshwater within the study area, but the Midway Group serves as an effective stratigraphic marker bed (Page and May, 1964).

Red River Alluvial Aquifer

The Red River alluvium lies unconformably on the eroded surface of Tertiary sediments (Newcome, 1960) and is notable for increased grain size with depth. The total thickness of the alluvial sequence ranges from about 50 to 200 ft in the study area (Whitfield, 1980). Tertiary-age formations that are exposed at land surface in the study area and compose the Carrizo-Wilcox aquifer have been incised by the Red River and are hydraulically connected to the alluvium in the Red River valley (fig. 3). A map showing the altitude of the base of the Red River alluvial aquifer is provided in figure 3 and shows the important structural modifications notable at that horizon within the aquifer system.

The alluvium of the Red River and its tributaries consists of clay and silt in recent, near-surface layers, grading to coarse sand and gravel at the base. The clay and silt layers are Holocene in age and range in thickness from a few feet to more than 50 ft. The underlying, coarser-grained (sand and gravel) section of the alluvium is termed the Red River alluvial aquifer and is of Pleistocene age. The basal sand and gravel units of the Red River alluvial aquifer range up to a maximum thickness of about 90 ft in Red River Parish (fig. 4). Hydrogeologic sections *A–A′* through *G–G′* showing the Red River alluvium and Red River alluvial aquifer are provided in figures 5–11.

The Red River alluvial aquifer is primarily recharged by precipitation that infiltrates the silty soil of the flood plain. Recharge from streams can occur when the head differential allows movement into the aquifer. Upward leakage from underlying deposits of Tertiary age is a minor source of recharge to the alluvial aquifer. Discharge from the aquifer is by leakage into the Red River, pumping from wells, and down-gradient flow (Hosman and others, 1968; Ryals, 1982b; Stuart and others, 1994).

Across much of the study area, chloride concentrations in the Red River alluvial aquifer are relatively low and do not pose a problem for most uses (Whitfield, 1980). Chloride concentrations typically are less than 20 mg/L in the upper part of the aquifer and less than 50 mg/L in the lower part of the aquifer. In several localized areas (fig. 4), chloride concentrations may exceed 250 mg/L because of thinning or hydraulic conductivity differences in the Midway confining unit, groundwater pumping, vertical movement along fault lines, and migration of saltwater from salt domes (Whitfield, 1980).

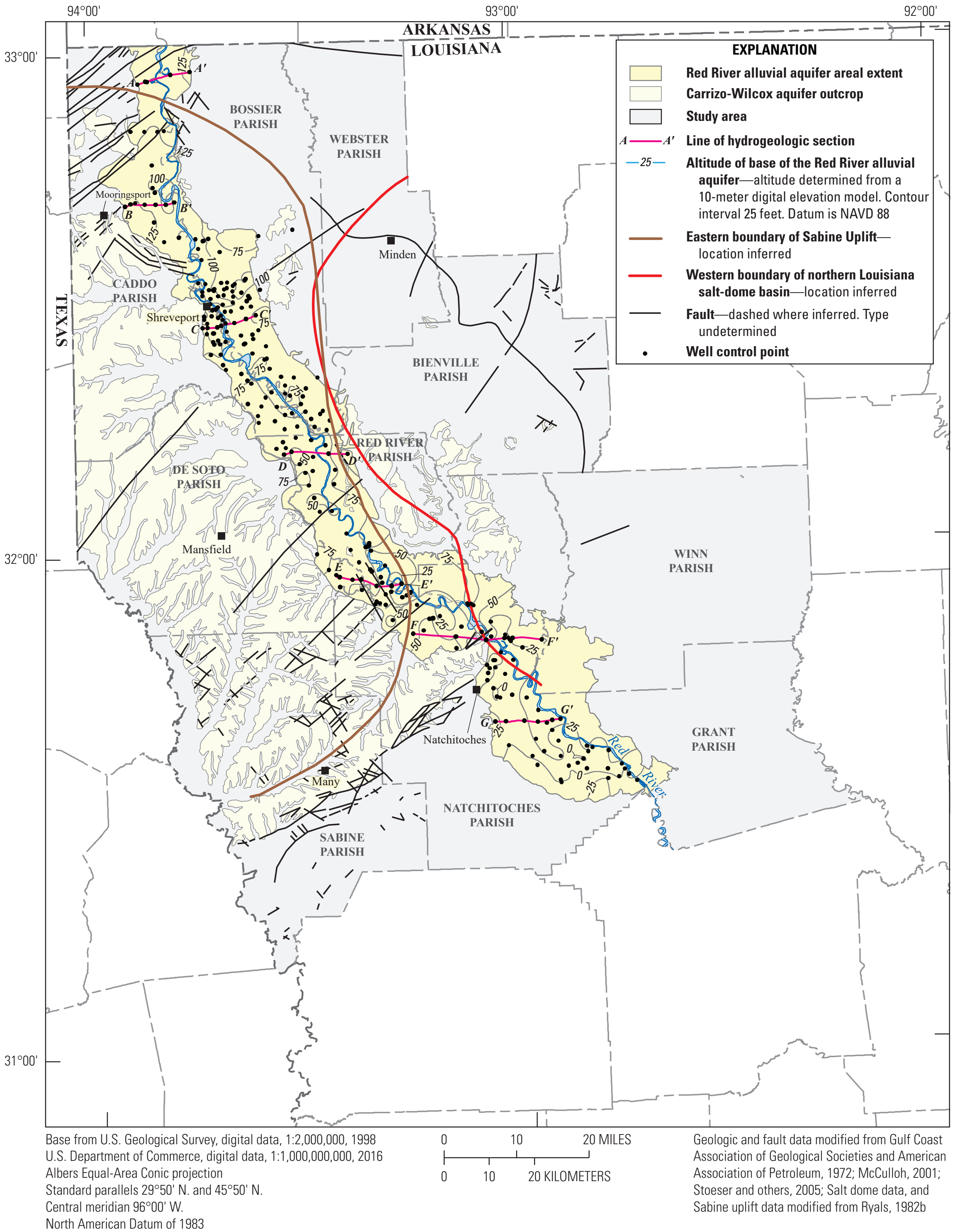


Figure 3. Altitude of the base of the Red River alluvial aquifer, extent of principal aquifers, and lines of hydrogeologic sections *A–A′* through *G–G′* in the Red River valley in northwestern Louisiana.

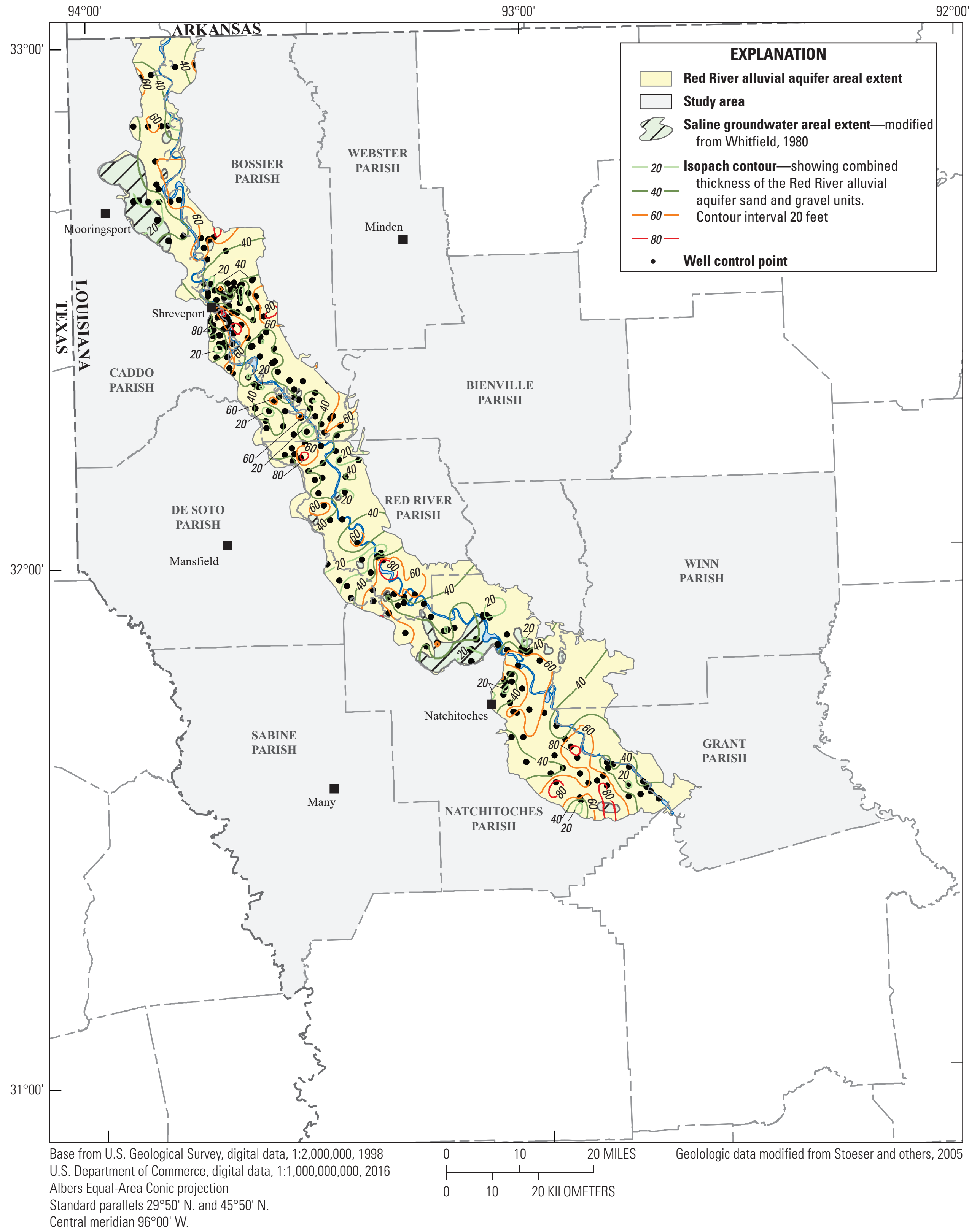


Figure 4. Combined thickness of the sand and gravel unit and areas of saltwater in the Red River alluvial aquifer in northwestern Louisiana.

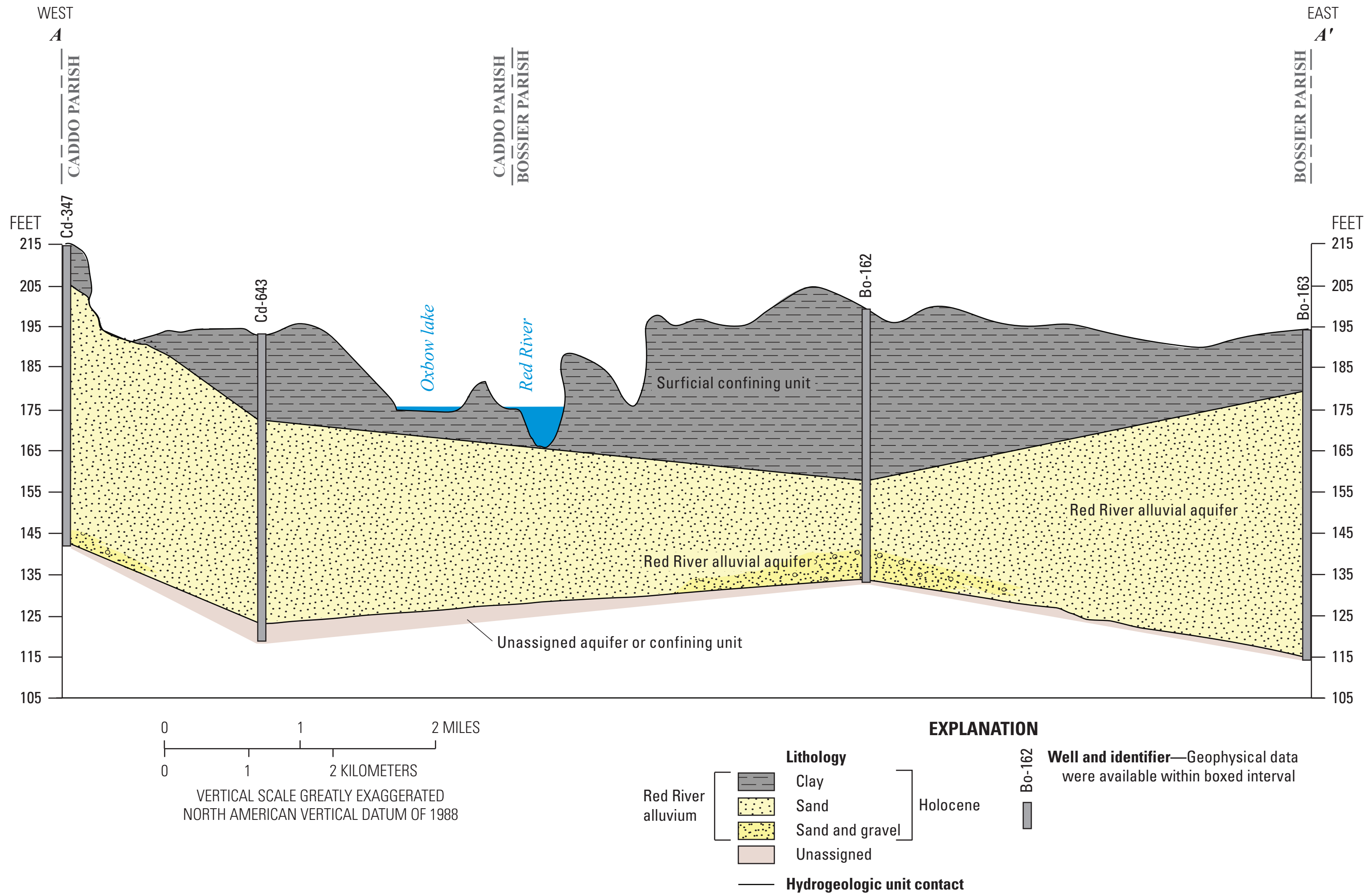


Figure 5. Hydrogeologic cross section *A–A′* of the Red River alluvial aquifer in northwestern Louisiana.

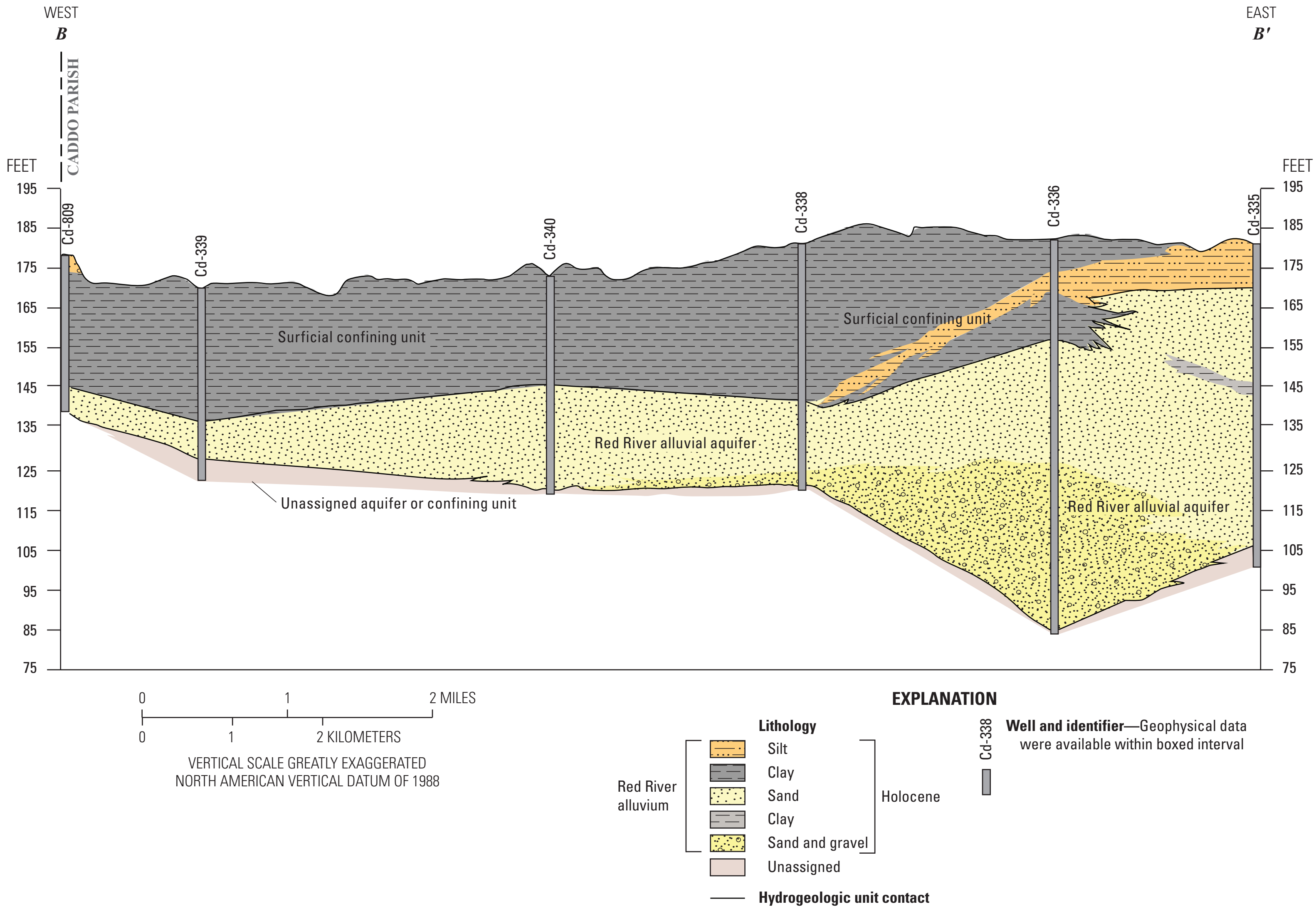


Figure 6. Hydrogeologic cross section *B–B′* of the Red River alluvial aquifer in northwestern Louisiana.

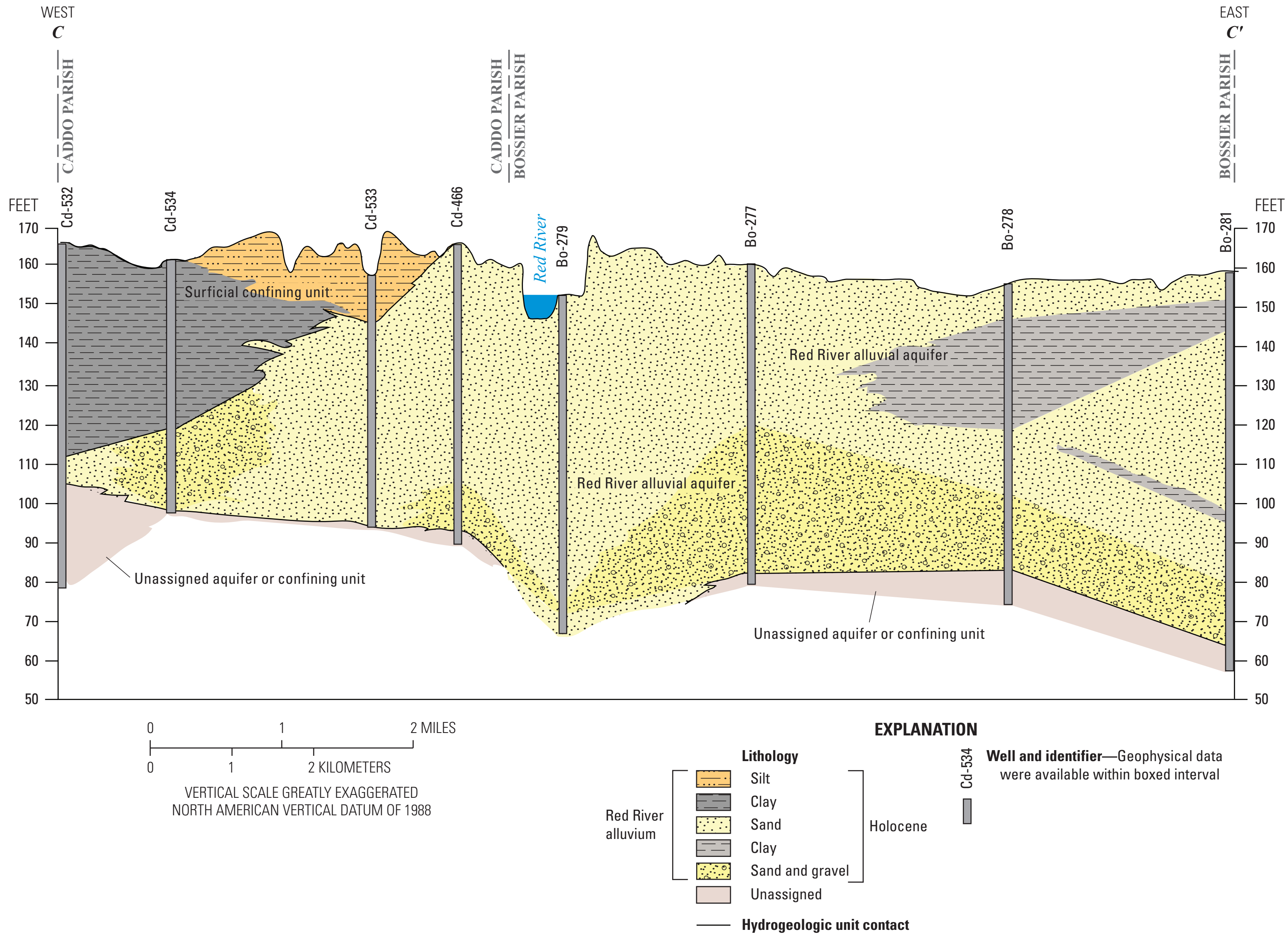


Figure 7. Hydrogeologic cross section *C–C′* of the Red River alluvial aquifer in northwestern Louisiana.

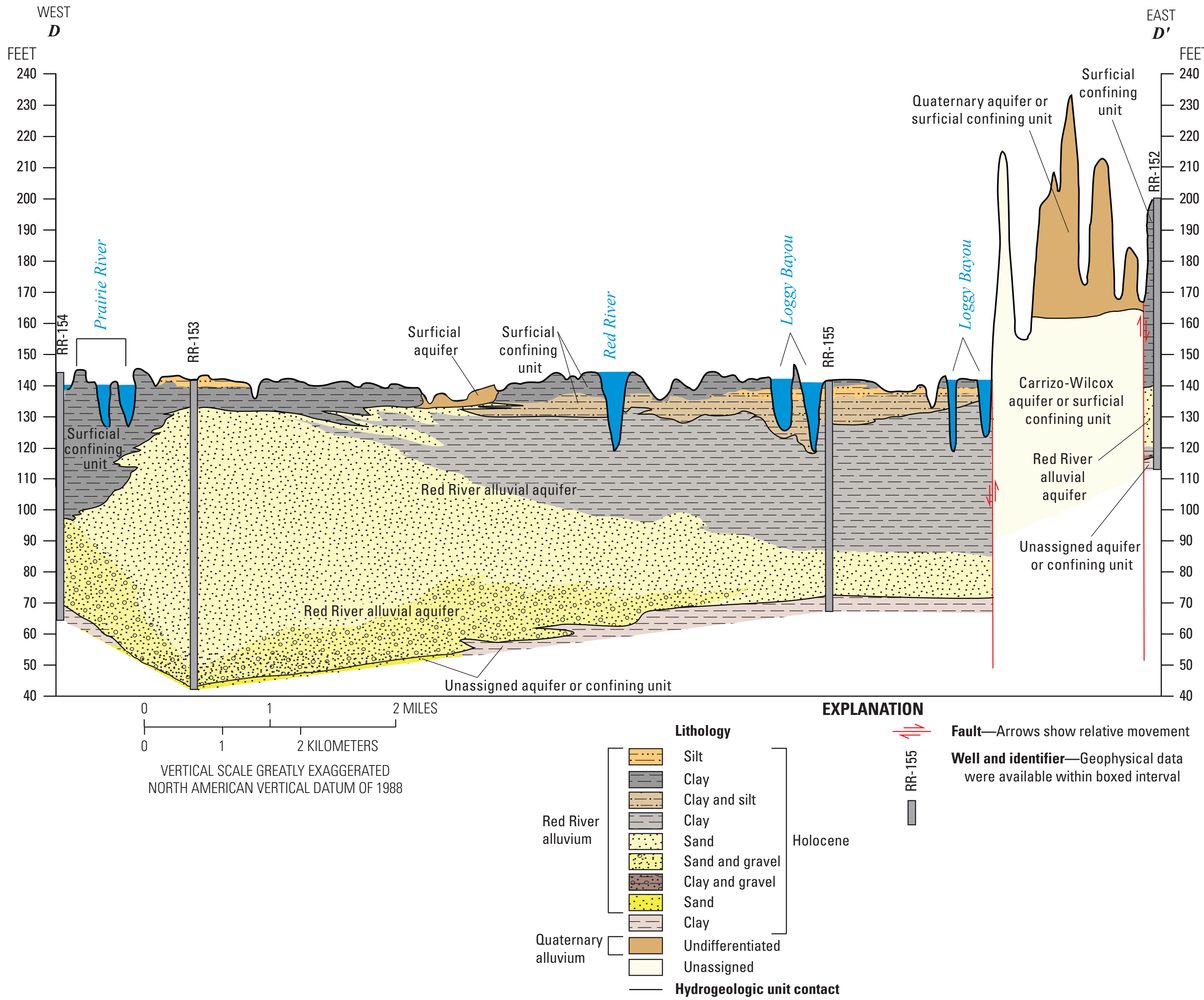


Figure 8. Hydrogeologic cross section *D–D′* of the Red River alluvial aquifer in northwestern Louisiana.

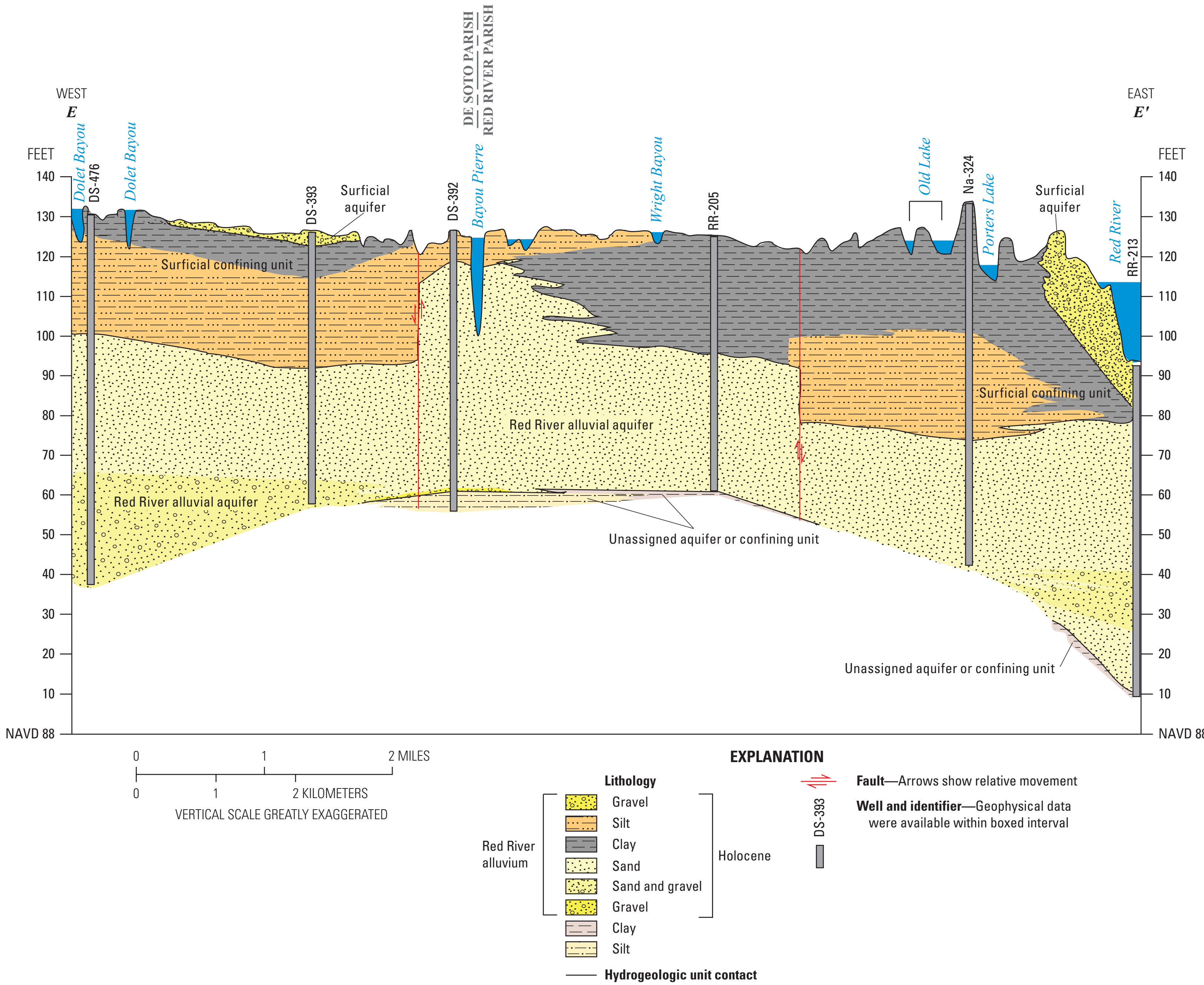


Figure 9. Hydrogeologic cross section *E–E′* of the Red River alluvial aquifer in northwestern Louisiana.

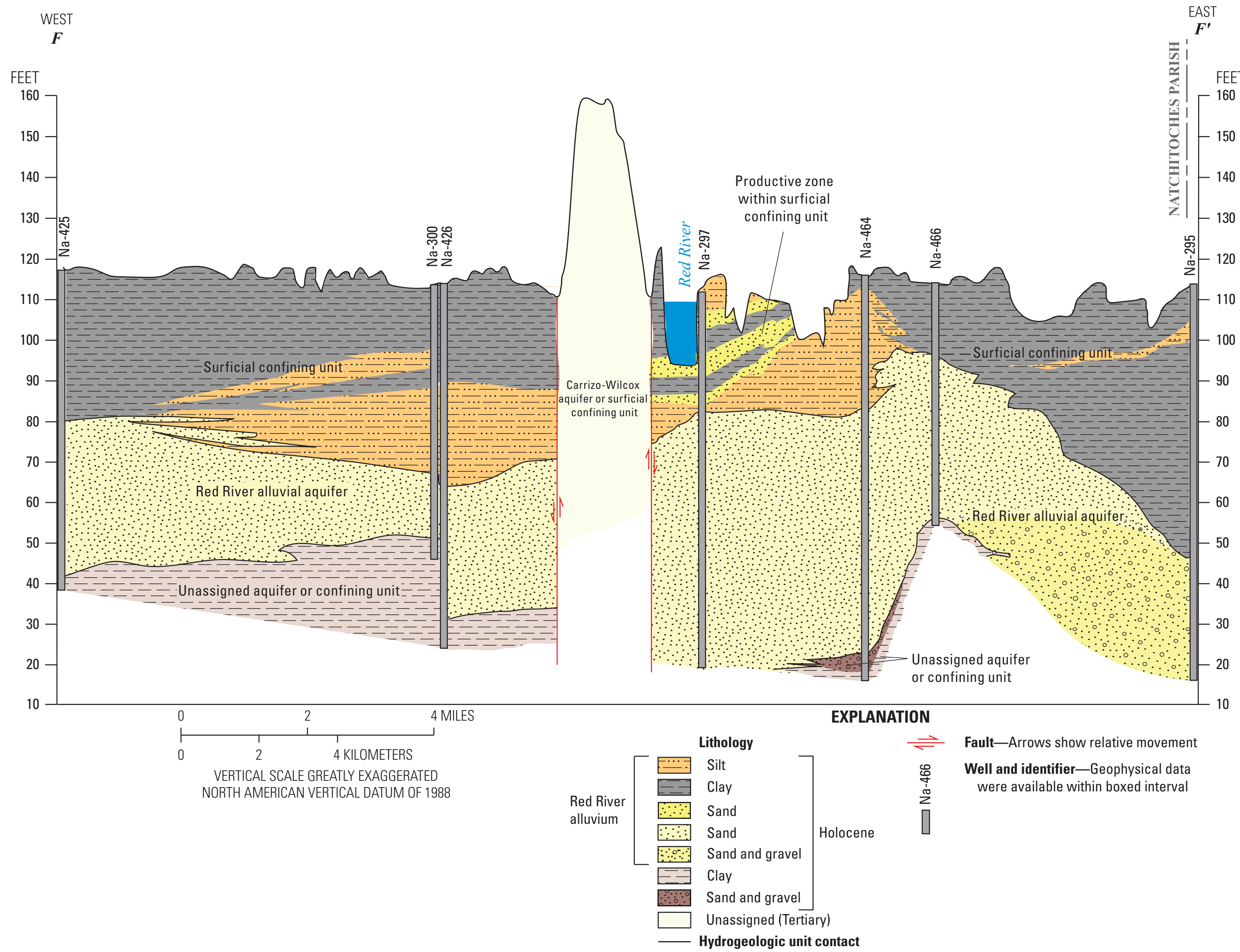


Figure 10. Hydrogeologic cross section *F–F′* of the Red River alluvial aquifer in northwestern Louisiana.

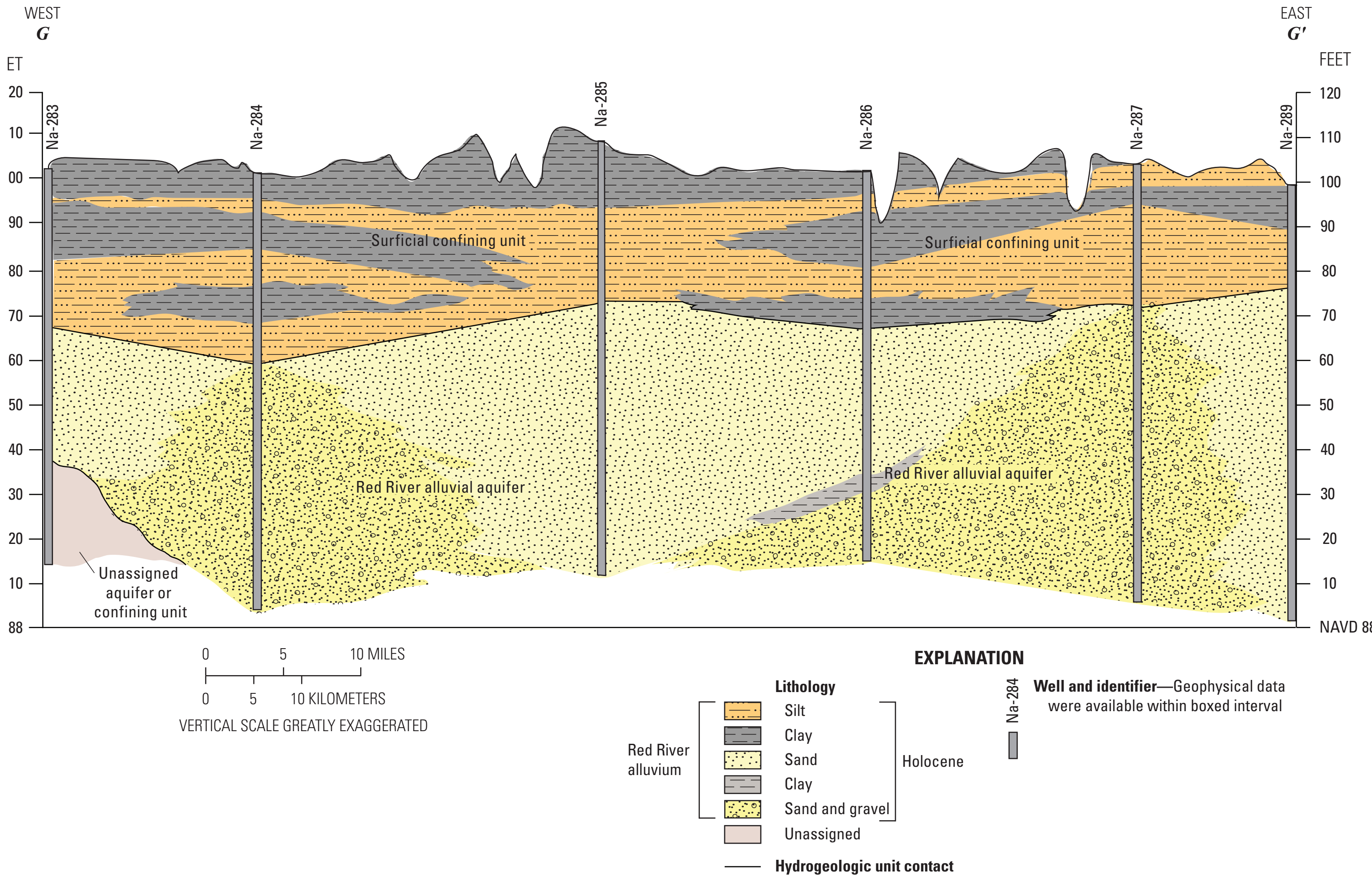


Figure 11. Hydrogeologic cross section *G–G′* of the Red River alluvial aquifer in northwestern Louisiana.

Carrizo-Wilcox Aquifer

The Tertiary Carrizo Sand, the lowermost formation of the Claiborne Group, is a discontinuous, massive sand that lies unconformably on the eroded surface of the Wilcox Group (fig. 2). The Carrizo Sand and Wilcox Group are hydraulically connected, and the two function as a single hydrologic unit, referred to as the Carrizo-Wilcox aquifer (Ryals, 1982a, b). Hydrogeologic sections shown in figures 12–18 illustrate the general characteristics including regional dip and variable thickness of the Carrizo-Wilcox aquifer in northwestern Louisiana. Hydrogeologic sections shown in figures 19–23 illustrate more detailed sedimentologic characteristics including the complexity and variability of the sand and shale beds.

The Tertiary Wilcox Group consists of complexly interbedded clay, silt, and sand and contains varying amounts of lignite (Hosman, 1978). The sands are generally fine and have low hydraulic conductivities. Sand content varies but is generally less than 50 percent (Hosman, 1978). The sand beds are highly variable in thickness and areal extent but are a source of freshwater throughout most of the study area. Only the thickest sand beds can be traced and correlated across any appreciable distance (approximately 2 miles or more). Abundant clay intervals are interspersed with the sands, making correlation over long distances difficult and correlations of the sand beds rather generalized (Newcome and others, 1963).

The Carrizo Sand is absent across most of the study area with the exception of Bossier Parish, where it is an important source of freshwater (Hosman, 1978). The Carrizo Sand consists of generally light-colored, fine to medium sand. The thickness of the Carrizo Sand is usually between 50 to 100 ft where it is present (Hosman, 1978), but it ranges up to 150 ft. (Page and May, 1964).

The Carrizo-Wilcox aquifer crops out at land surface across much of the study area (fig. 24). Rainfall infiltrates the exposed sands and moves down dip to the east and southeast. Within the general outcrop area, the Carrizo-Wilcox aquifer may subcrop below terrace deposits of Red River alluvium, from which the aquifer also receives recharge by leakage (Hosman and others, 1968; Ryals, 1982b; Stuart and others, 1994). Outside of the outcrop area, the Carrizo-Wilcox aquifer is generally overlain by the Cane River aquifer or confining unit.

The Carrizo-Wilcox aquifer generally dips and thickens toward the south (figs. 25–27). The top of the Carrizo-Wilcox aquifer ranges in altitude from about 250 ft above NAVD 88 in the westernmost part of the study area to more than 3,000 ft below NAVD 88 in southeastern Natchitoches Parish (fig. 25). The base of the Carrizo-Wilcox aquifer ranges from about 0 ft (NAVD 88) in Caddo, Bossier, Red River, and De Soto Parishes to more than 7,000 ft below NAVD 88 in southern Natchitoches Parish (fig. 26). The thickness of the Carrizo-Wilcox aquifer ranges from less than 100 ft in the northwestern part of the study area near Mooringsport, Caddo Parish, to more than 3,600 ft in the southern part of the study area (Sabine and Natchitoches Parishes) (fig. 27).

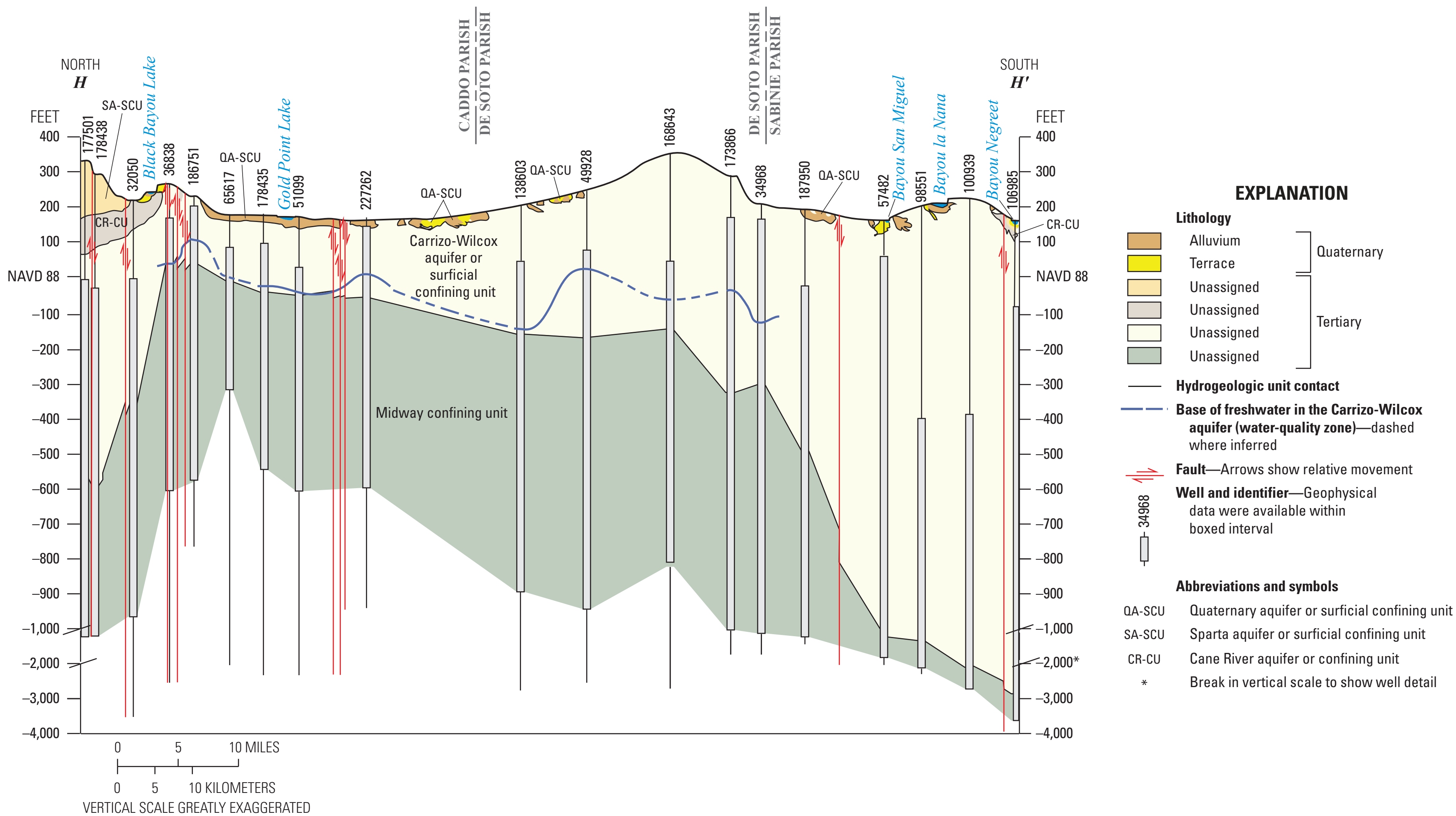


Figure 12. Hydrogeologic cross section *H–H′* and base of freshwater water-quality zone in northwestern Louisiana.

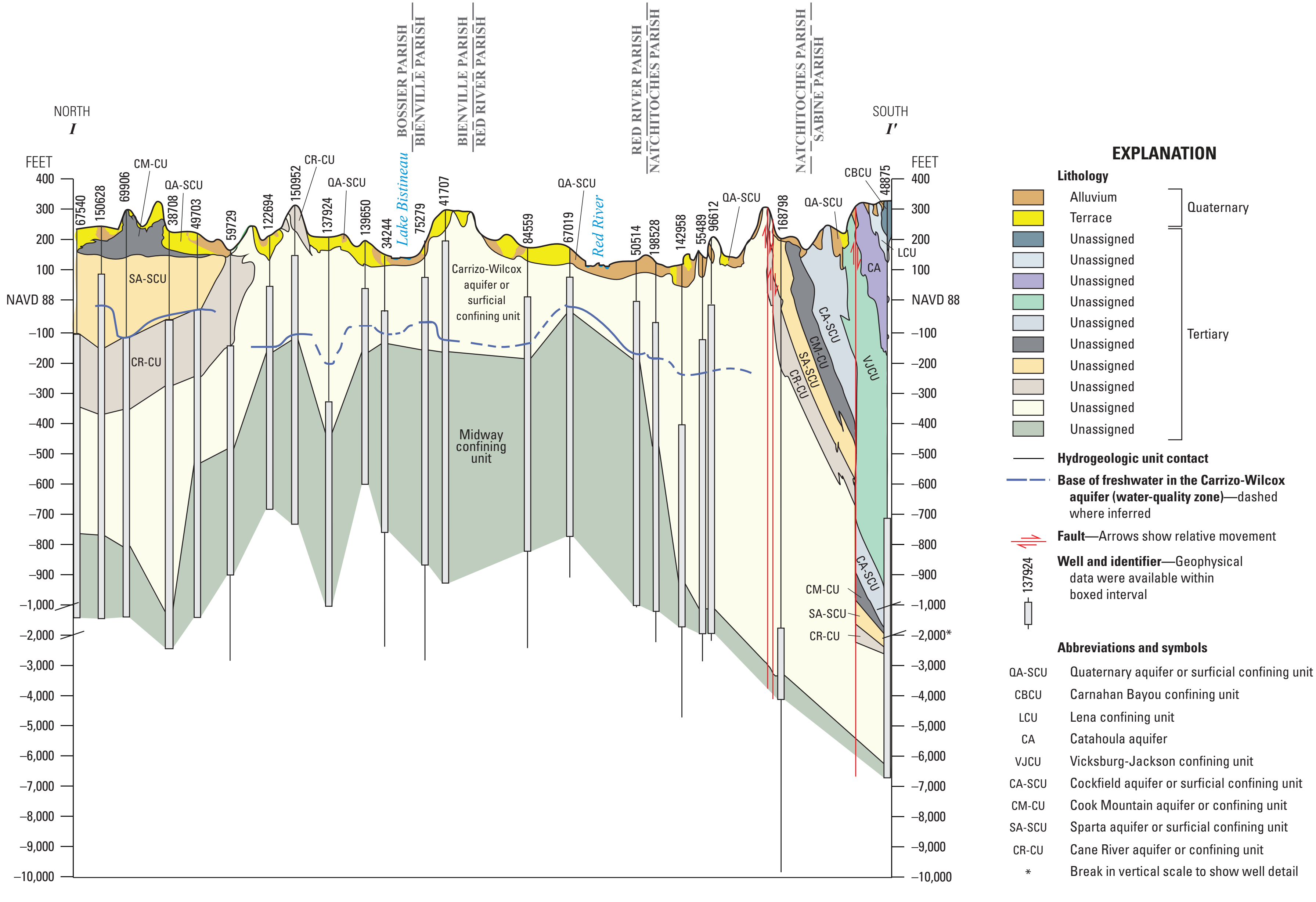


Figure 13. Hydrogeologic cross section *I–I′* and base of freshwater water-quality zone in northwestern Louisiana.

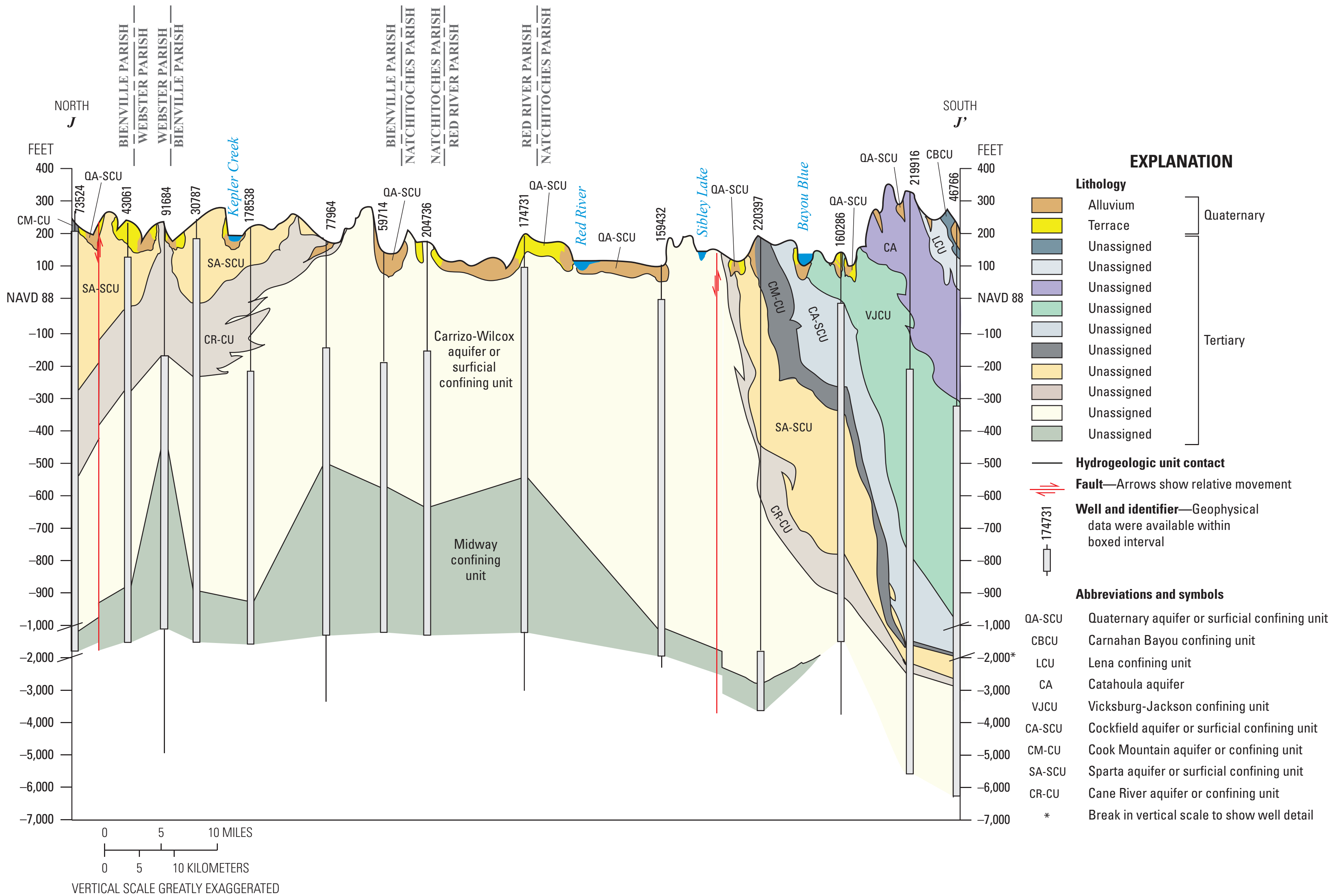


Figure 14. Hydrogeologic cross section *J–J'* and base of freshwater water-quality zone in northwestern Louisiana.

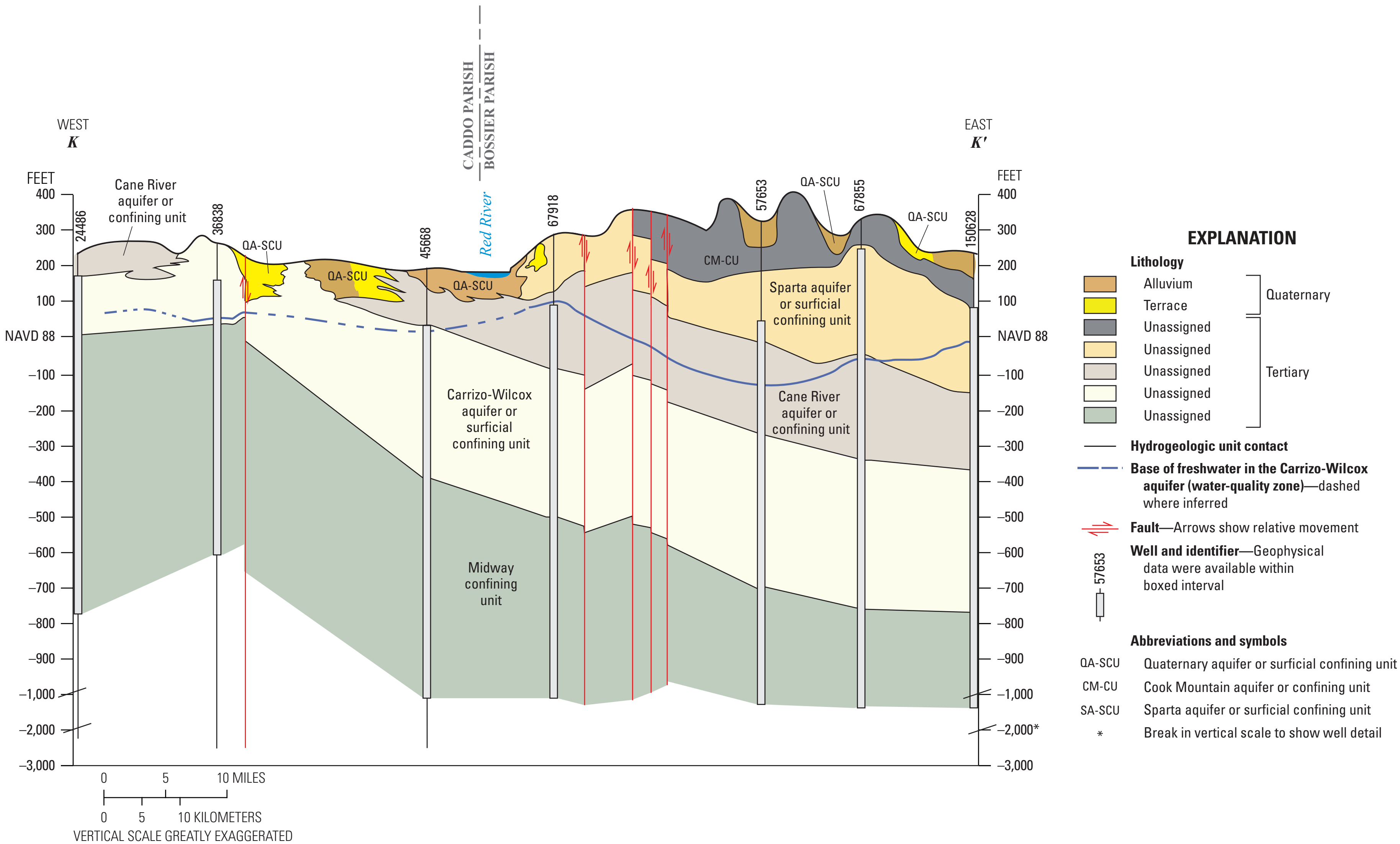


Figure 15. Hydrogeologic cross section *K–K′* and base of freshwater water-quality zone in northwestern Louisiana.

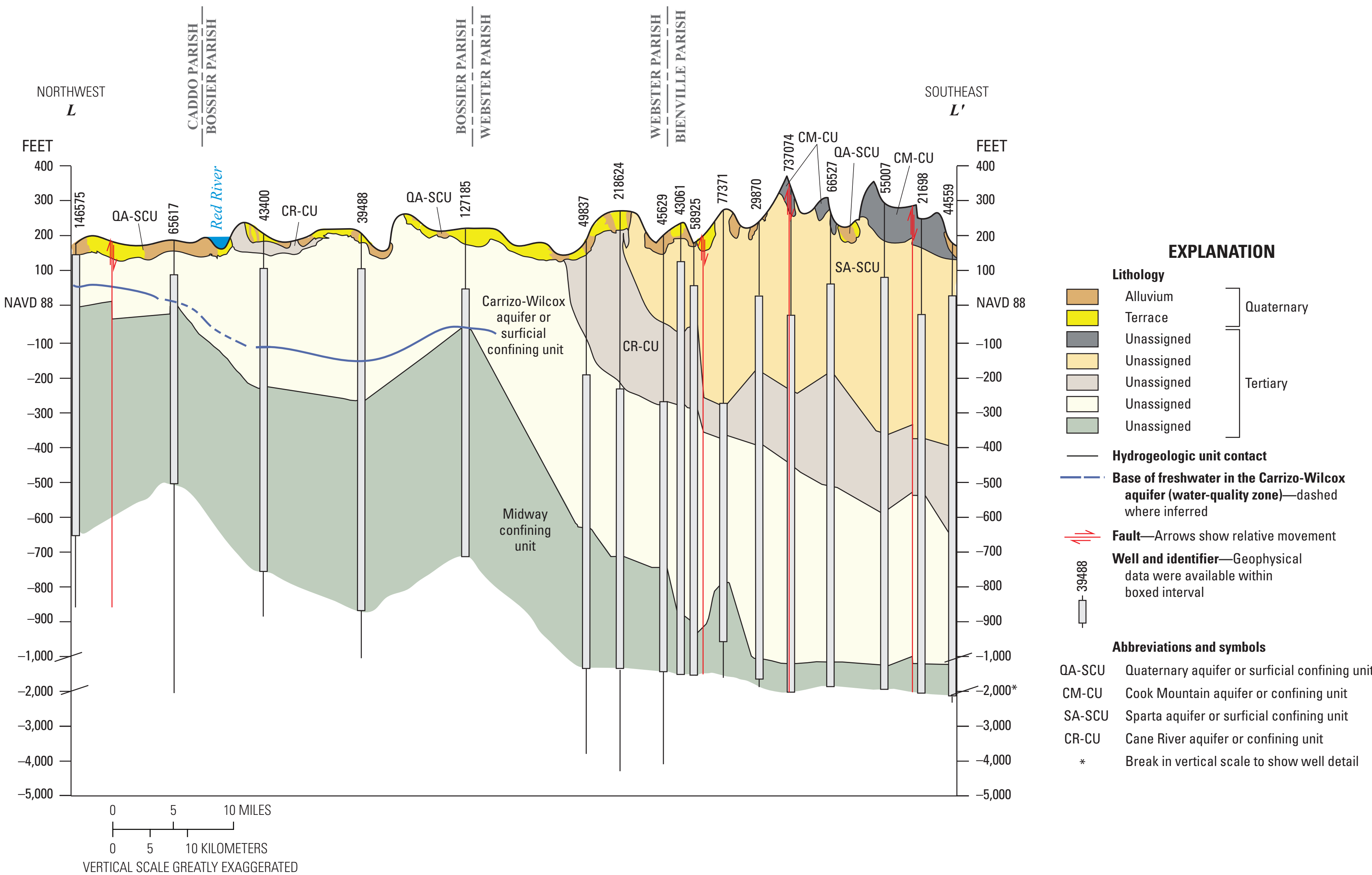


Figure 16. Hydrogeologic cross section *L–L′* and base of freshwater water-quality zone in northwestern Louisiana.

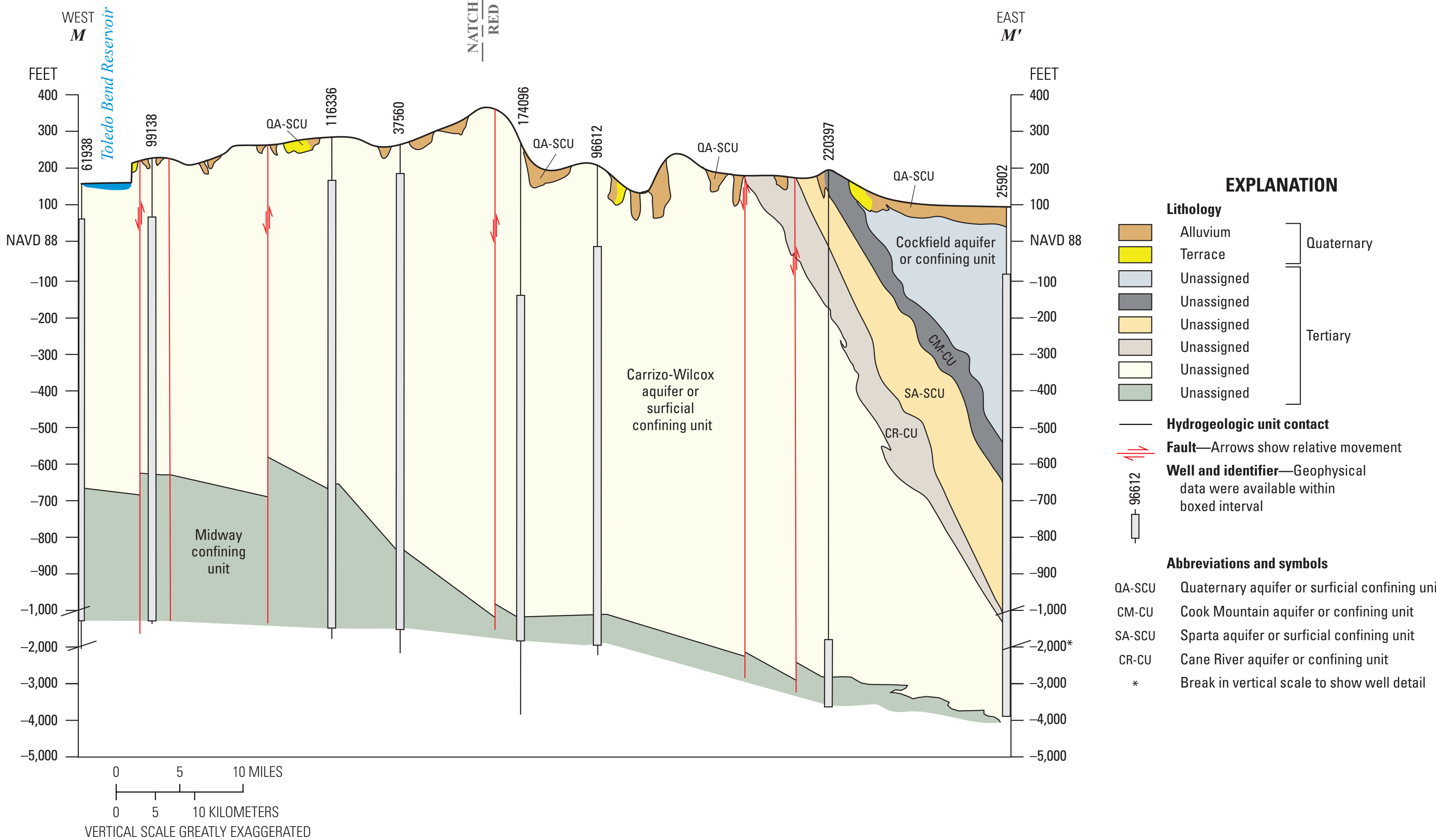


Figure 17. Hydrogeologic cross section *M–M′* and base of freshwater water-quality zone in northwestern Louisiana.

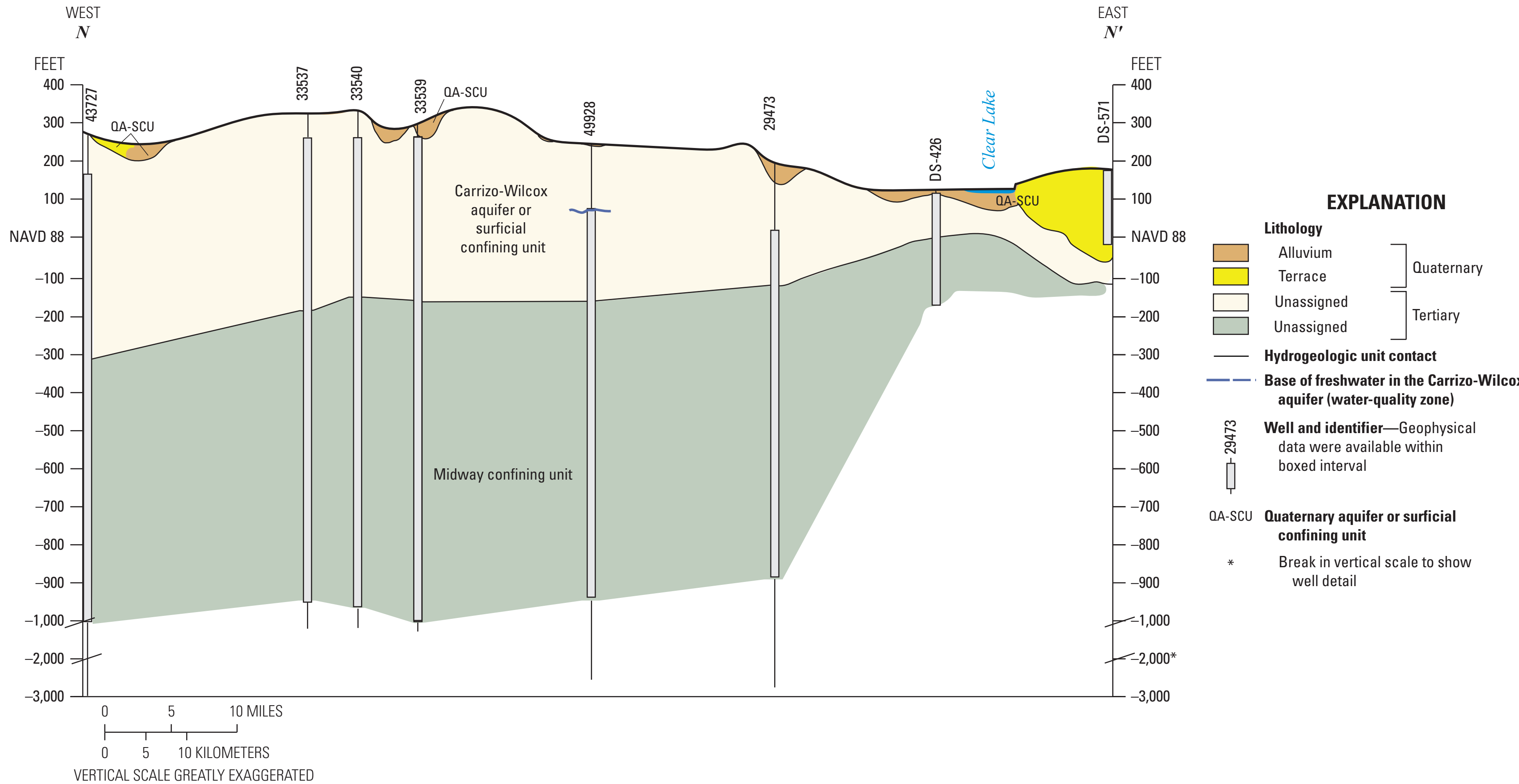


Figure 18. Hydrogeologic cross section *N–N′* and base of freshwater water-quality zone in northwestern Louisiana.

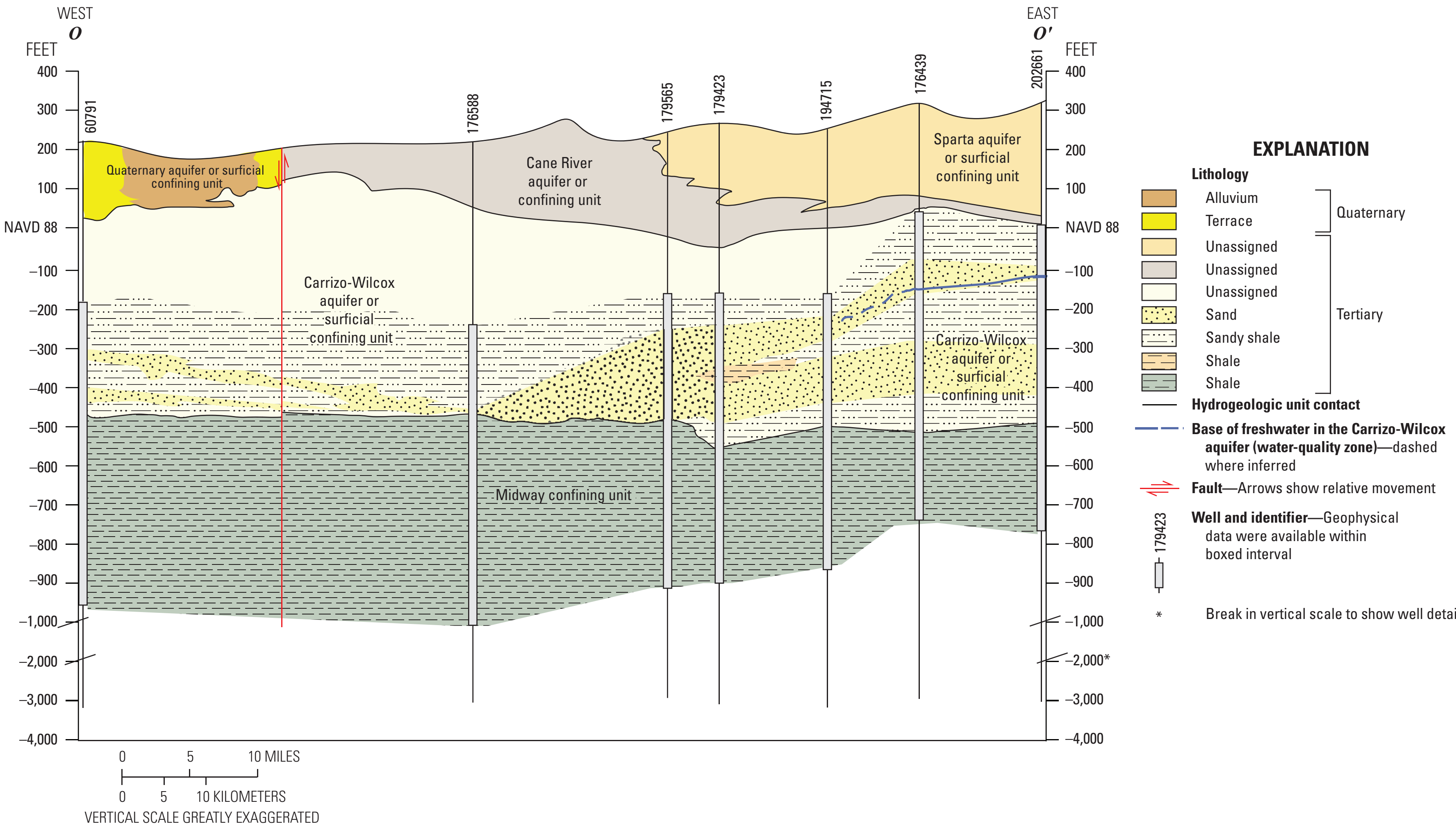


Figure 19. Hydrogeologic cross section *O–O′* and base of freshwater water-quality zone in northwestern Louisiana.

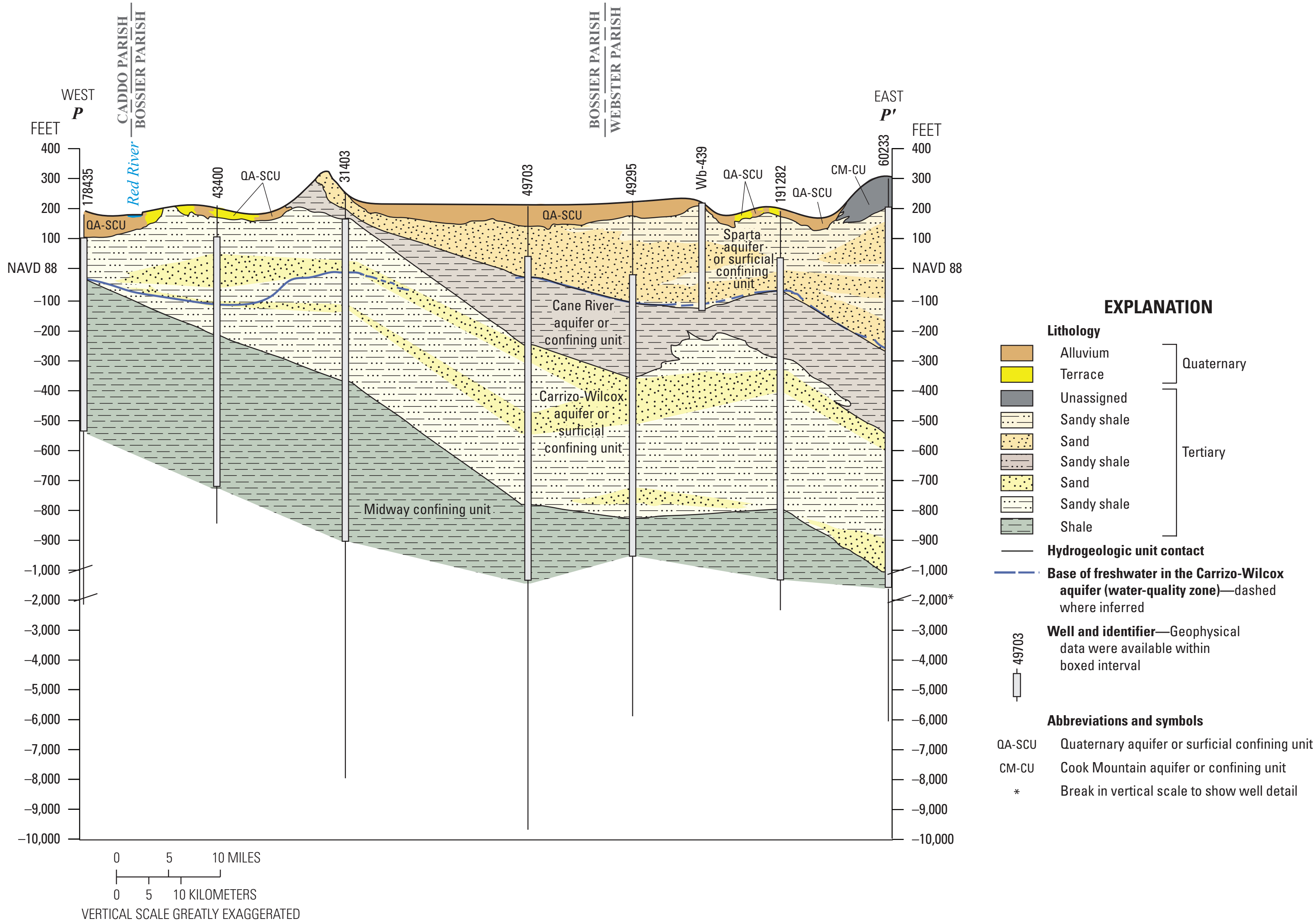


Figure 20. Hydrogeologic cross section *P–P′* and base of freshwater water-quality zone in northwestern Louisiana.

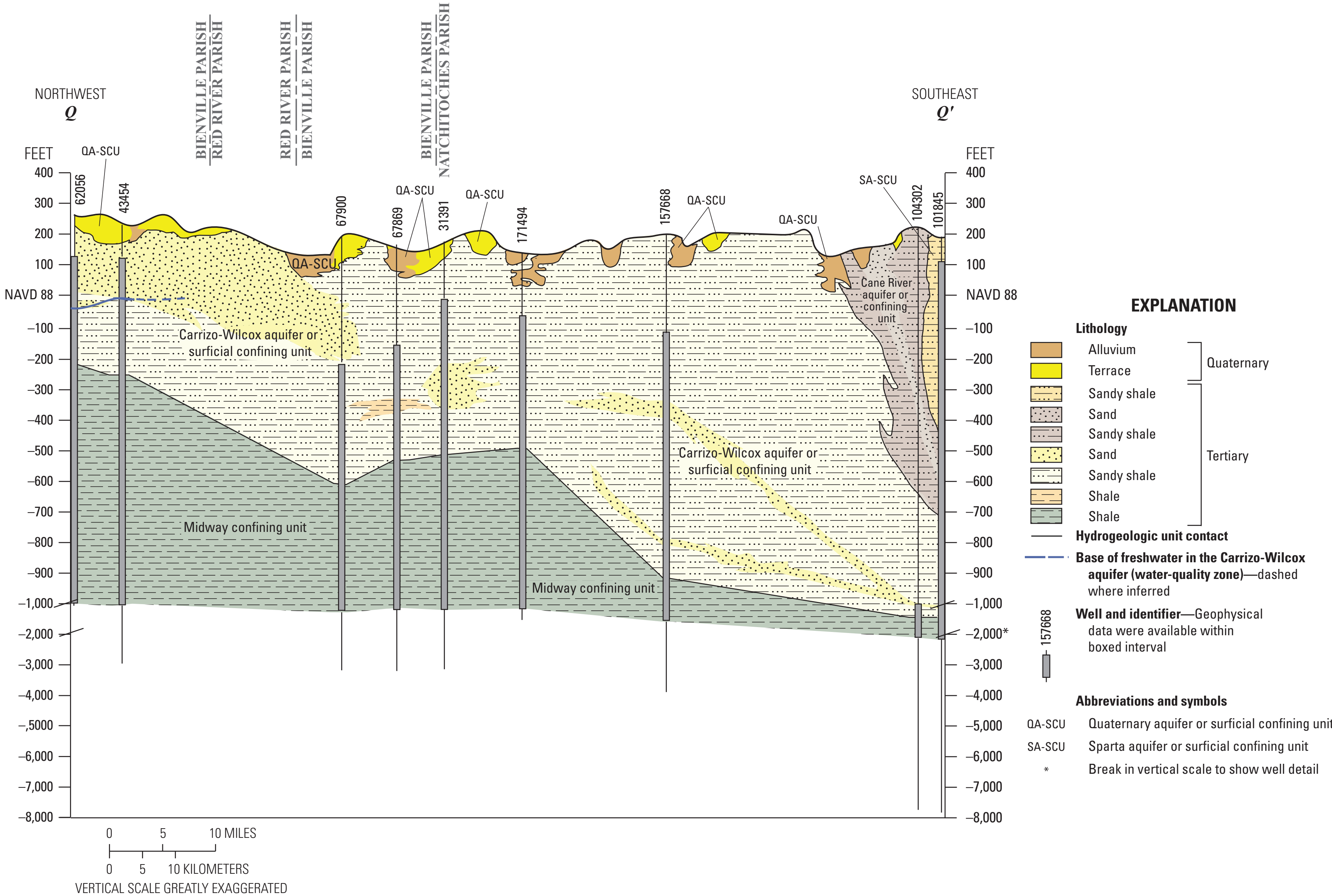


Figure 21. Hydrogeologic cross section *Q–Q′* and base of freshwater water-quality zone in northwestern Louisiana.

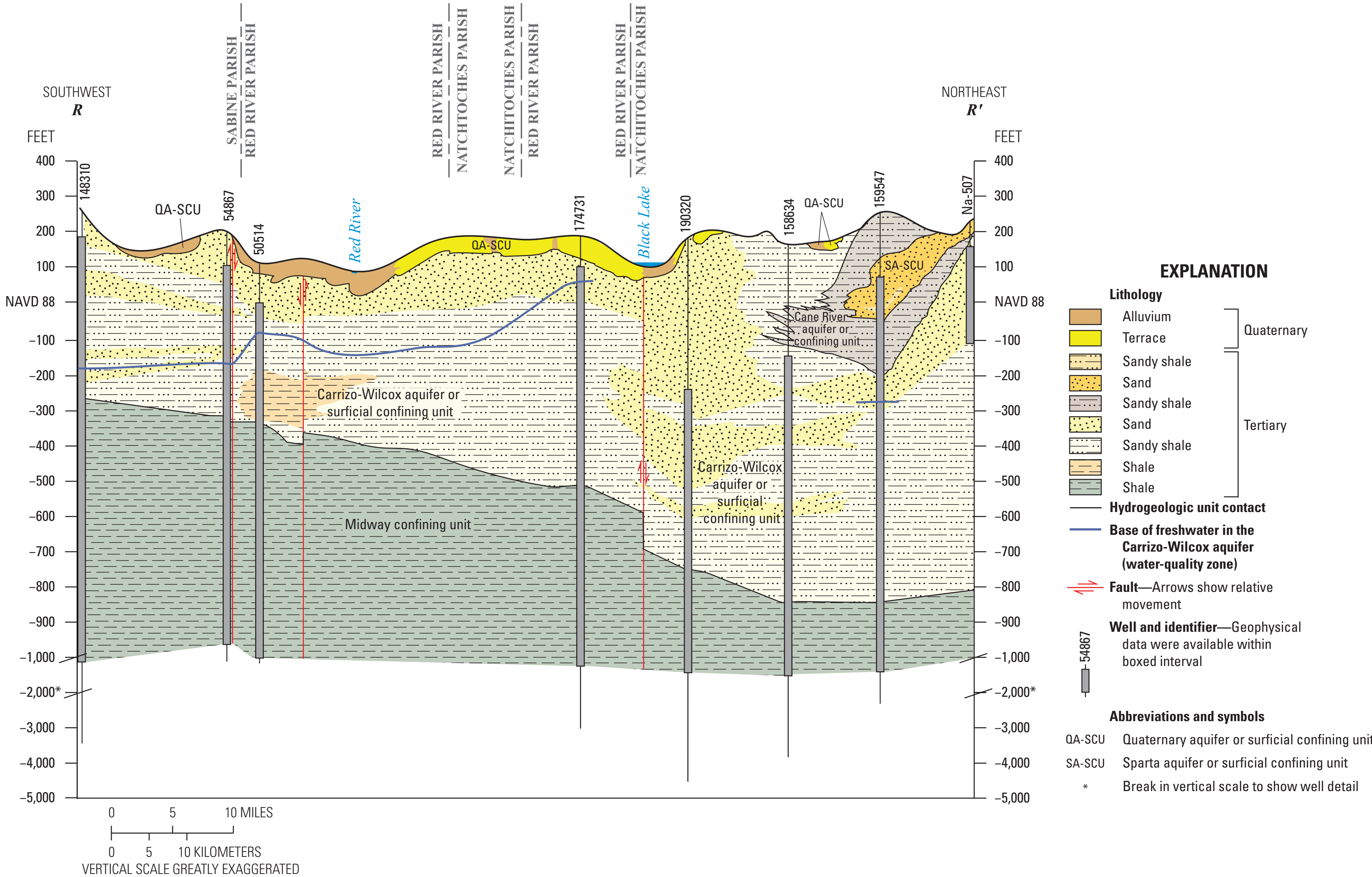


Figure 22. Hydrogeologic cross section *R*–*R′* and base of freshwater water-quality zone in northwestern Louisiana.

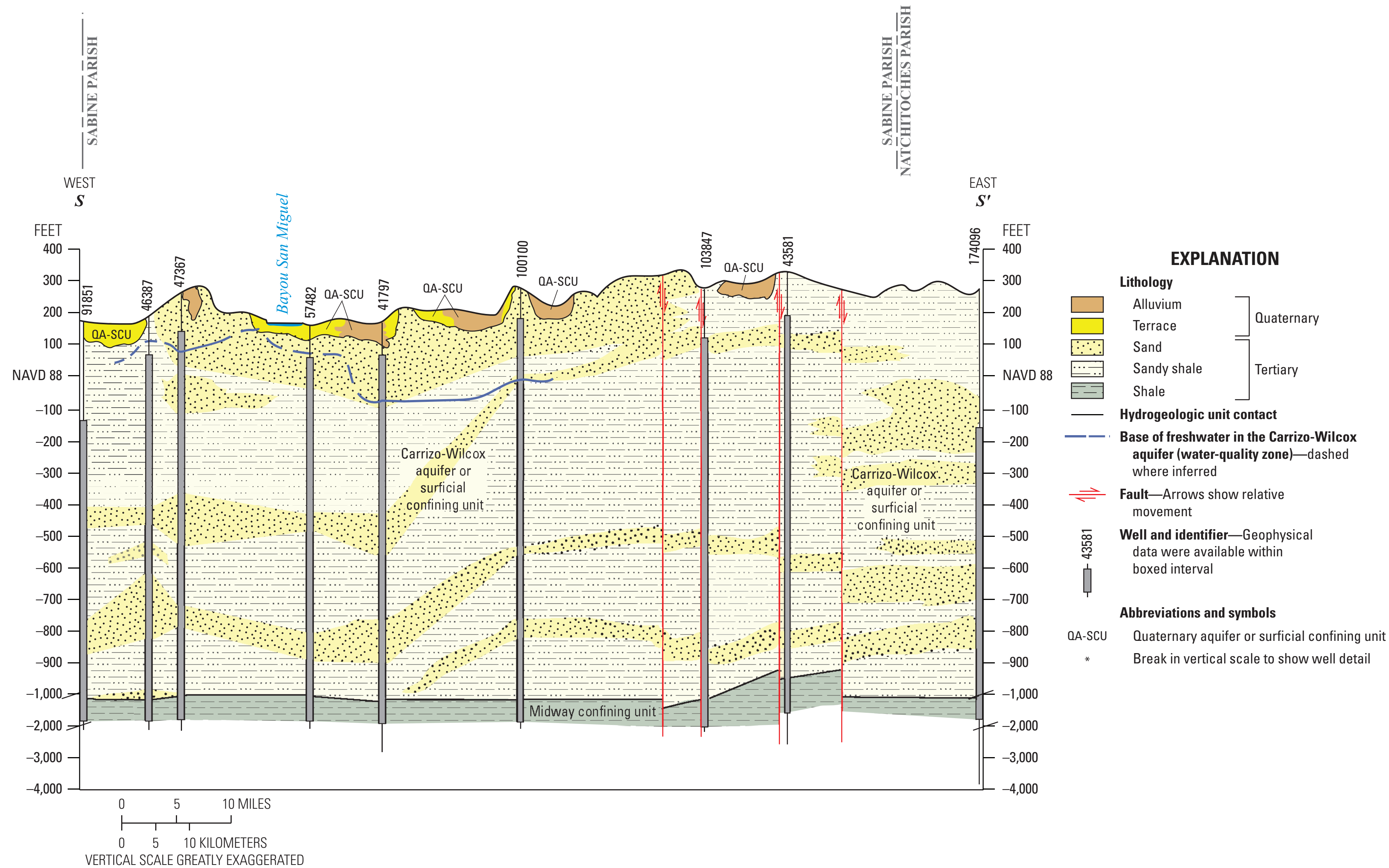


Figure 23. Hydrogeologic cross section *S–S′* and base of freshwater water-quality zone in northwestern Louisiana.

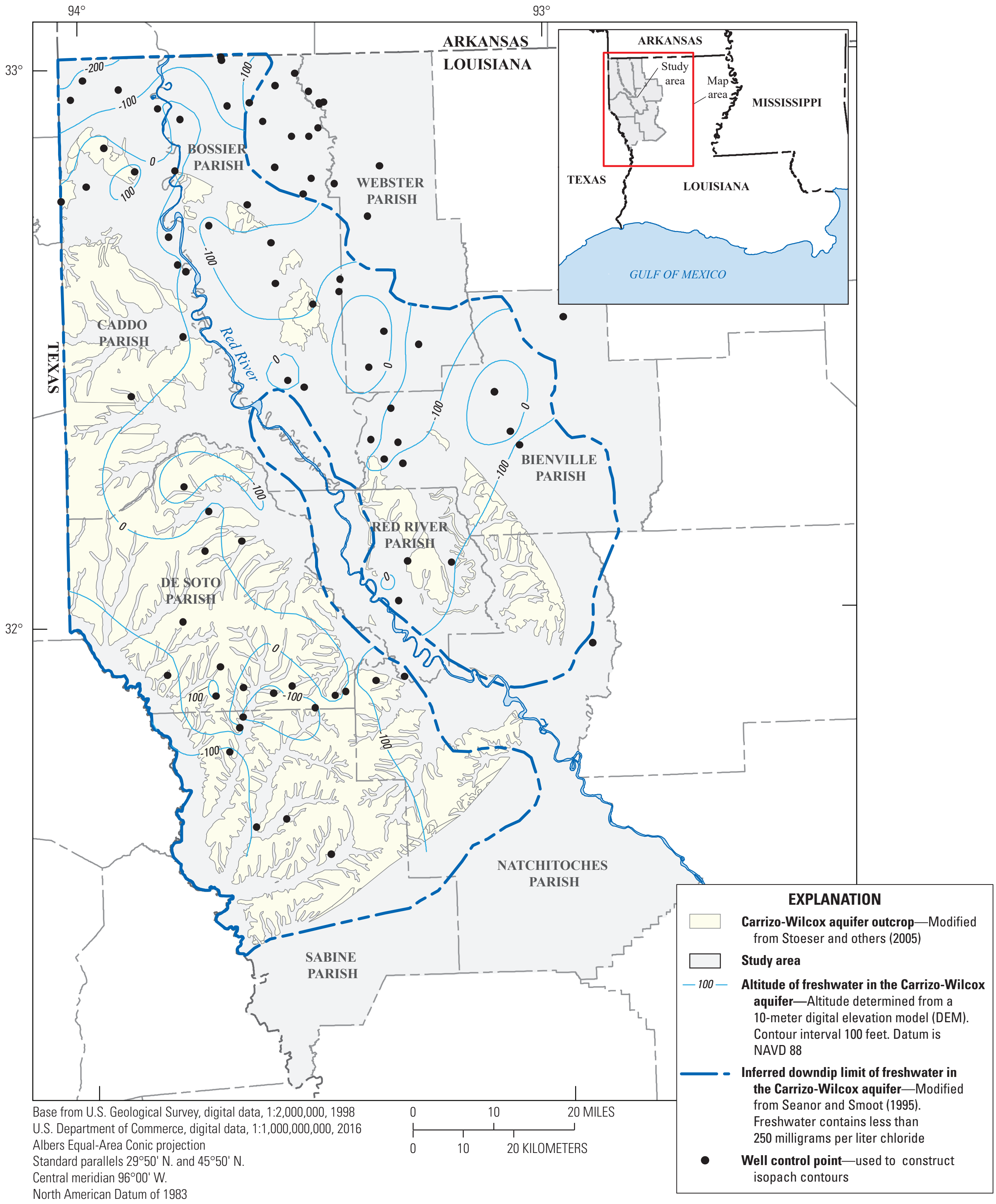


Figure 24. Outcrop area and altitude of the base of freshwater in the Carrizo-Wilcox aquifer in northwestern Louisiana.

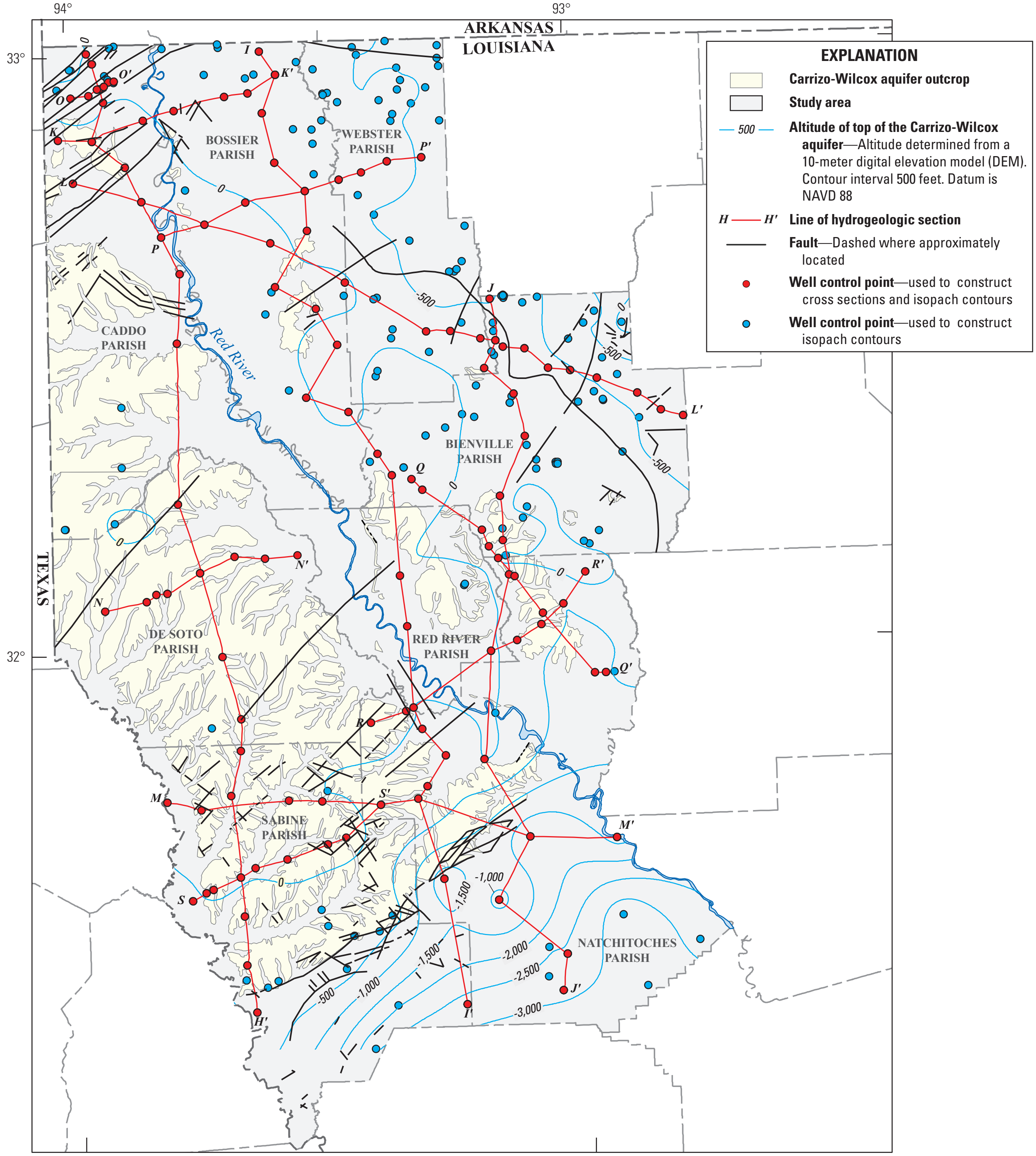


Figure 25. Outcrop area and altitude of the top of the Carrizo-Wilcox aquifer and lines of hydrogeologic cross sections *H–H′* through *S–S′* in northwestern Louisiana.

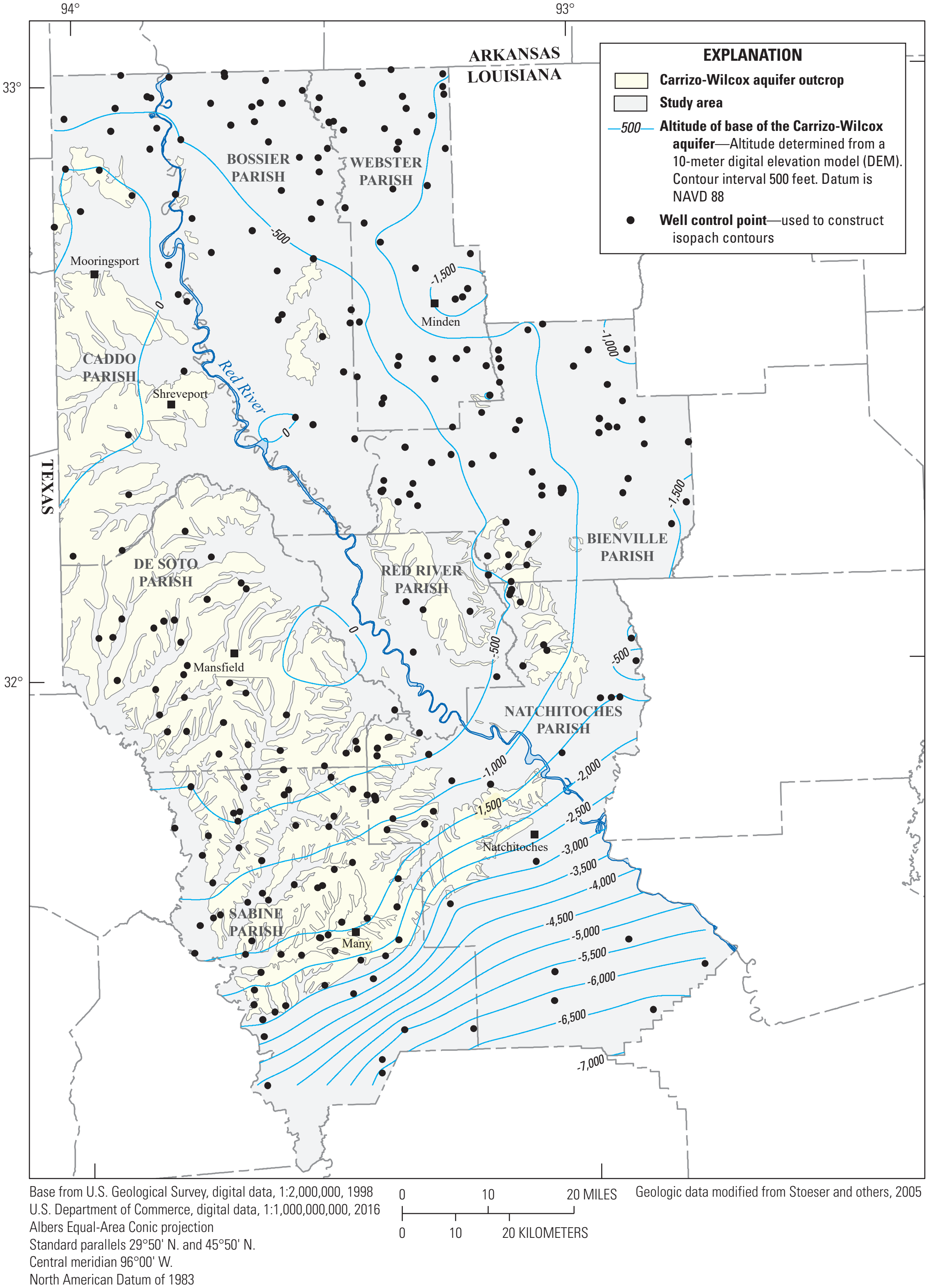


Figure 26. Outcrop area and altitude of the base of the Carrizo-Wilcox aquifer in northwestern Louisiana.

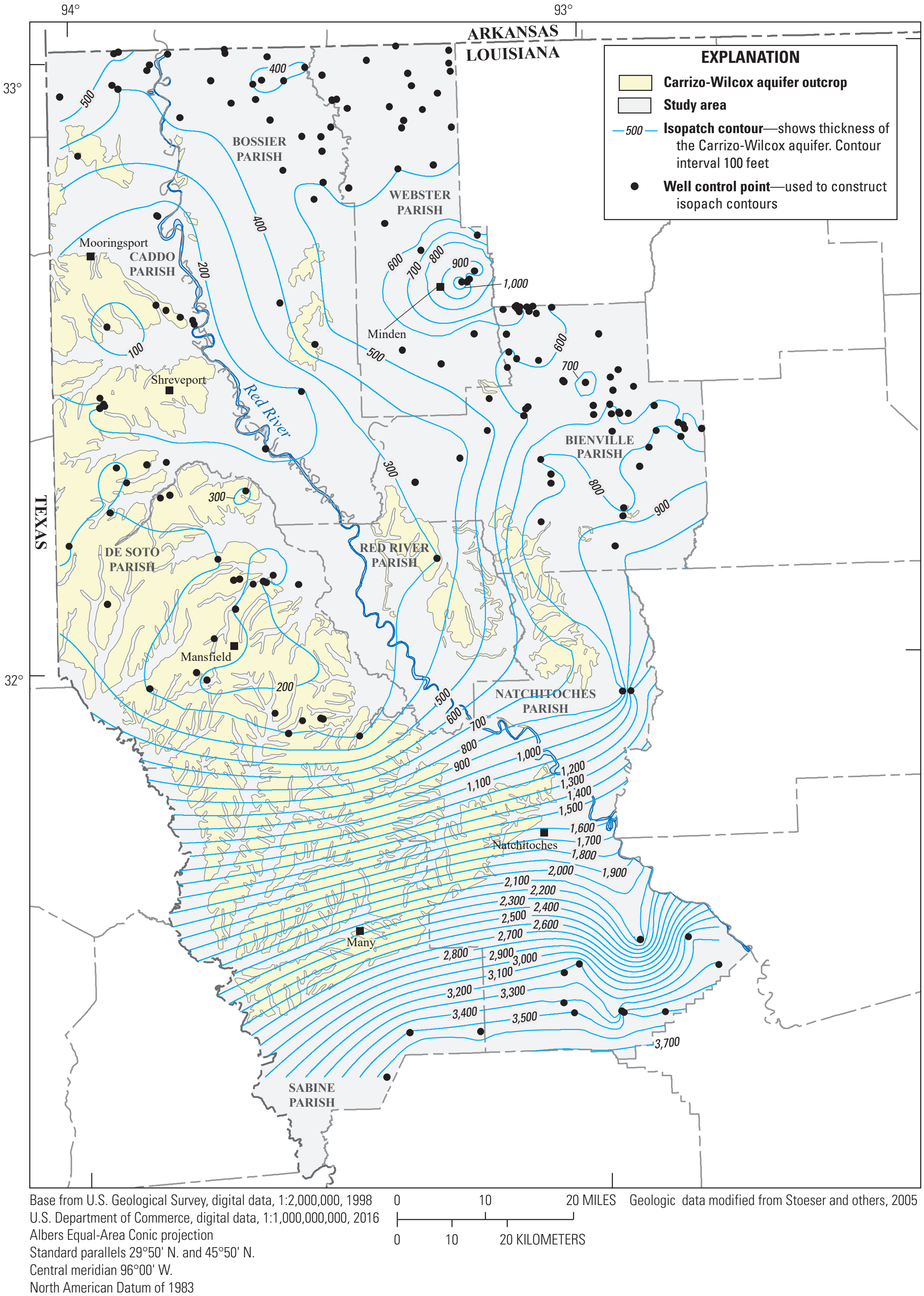


Figure 27. Thickness of the Carrizo-Wilcox aquifer and outcrop area in northwestern Louisiana.

Summary

Groundwater is a valuable resource in northwestern Louisiana, and any expansion in energy development in conjunction with increased water demands from population growth could result in increased future demands on groundwater. The Red River alluvial and the Carrizo-Wilcox aquifers are two of the most important and heavily pumped aquifers in northwestern Louisiana; however, little documentation of the regional hydrogeologic framework is available.

The hydrogeology of the study area has been tectonically modified and includes abundant structural features such as salt domes, areally extensive faulting, and minor folding related to these features. The Sabine Uplift is a primary structural feature that affects the hydrogeologic units of the study area and imparts an easterly dip component to the generally southerly regional dip of the Tertiary-age units in the western part of the study area. Another major structural feature is a depression, located in the east-central part of the study area, that defines the northern Louisiana salt-dome basin. Faulting in the study area provides a strong control on the altitude and thickness of aquifer formations and the distribution of fresh groundwater.

The hydrogeologic framework of northwestern Louisiana consists of a sequence of structurally modified, complexly interbedded, varyingly interconnected, clayey, sandy, and gravelly alluvial sediments. The freshwater hydrogeologic units underlying the study area include the Red River alluvial aquifer and the upland terrace aquifer, composed of sediments of Quaternary age, and the Sparta, Cane River, and Carrizo-Wilcox aquifers, composed of underlying sediments of Tertiary age. Although deposits of the Midway Group consist primarily of clay and yield no freshwater in the study area, this unit has hydrogeologic importance because it serves as both a basal confining unit and a stratigraphic marker bed.

The Red River alluvium, of Quaternary age, lies unconformably on the eroded surface of Tertiary sediments. The alluvium of the Red River and its tributaries consists of clay and silt in recent, near-surface layers, grading to coarse sand and gravel at the base. The underlying, coarser-grained (sand and gravel) section of the alluvium composes the Red River alluvial aquifer. The basal sand and gravel units of the Red River alluvial aquifer range up to a maximum thickness of about 90 ft. Across much of the study area, chloride concentrations are relatively low in the Red River alluvial aquifer and do not pose a problem for most uses.

The Carrizo Sand and Wilcox Group, both of Tertiary age, crop out in the study area. The Carrizo Sand and Wilcox Group are hydraulically connected, forming a single hydrologic unit called the Carrizo-Wilcox aquifer. The altitude of the top of the aquifer ranges from about 250 ft above the North American Vertical Datum of 1988 (NAVD 88) in the westernmost part of the study area to more than 3,000 ft below NAVD 88 in southeastern Natchitoches Parish. The base of the Carrizo-Wilcox aquifer ranges from about 0 ft NAVD 88 in Caddo, Bossier, Red River, and De Soto Parishes to more than 7,000 ft below NAVD 88 in southeastern Natchitoches Parish. The thickness of the Carrizo-Wilcox aquifer ranges from less than 100 ft in the northwestern part of the study area near Mooringsport, Caddo Parish, to more than 3,600 ft in the southern part of the study area.

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