GEOHYDROLOGY

The regional hydrology of the Rio Grande drainage basin is controlled primarily by the geologic structure and secondarily by the stratigraphy and lithology of the rock units. The Rio Grande traverses four distinct regions and a number of smaller subdivisions, each of which has different hydrologic characteristics. The diverse and complex geology of these areas precludes a detailed description of geologic history; however, the sections shown on sheet 4 illustrate the major geologic features and the relationship of the water-quality units to these features.

The upper basin area encompasses about one-third of the total drainage area of the Rio Grande. This area is characterized by deep, block-faulted structural basins flanked by igneous-cored mountains. The structural basins contain clastic sediments which exceed 20,000 feet in thickness in Colorado but become progressively thinner in the basins to the south. The high permeability of the clastics in these basins facilitates ground-water movement, thus well yields are quite high and the water is less highly mineralized than in more consolidated rocks.

Most of the wells in these structural basins yield fresh to slightly saline water; the few exceptions to this are in those areas of interior drainage or heavy irrigation where evapotranspiration has caused deterioration of the water quality at shallow depths. In these areas the underlying aquifers yield water of better quality than those near the surface. The general direction of water movement is toward the south; however, intrusive rocks and structural features locally modify the direction of flow.

The Pecos River drainage basin and the Big Bend region of west Texas constitute the middle basin area of the Rio Grande. This region is characterized by well lithified Paleozoic rocks which generally are flat lying or dip gently toward the east and south. Limestone is the major lithology. Throughout most of this area fresh water is present in the thin alluvial deposits of the river valleys; elsewhere the water ranges in quality from slightly saline to brine. In general the water becomes more saline with depth. The yield from wells is unpredictable because most of the water is obtained from fractures and solution cavities in limestone.

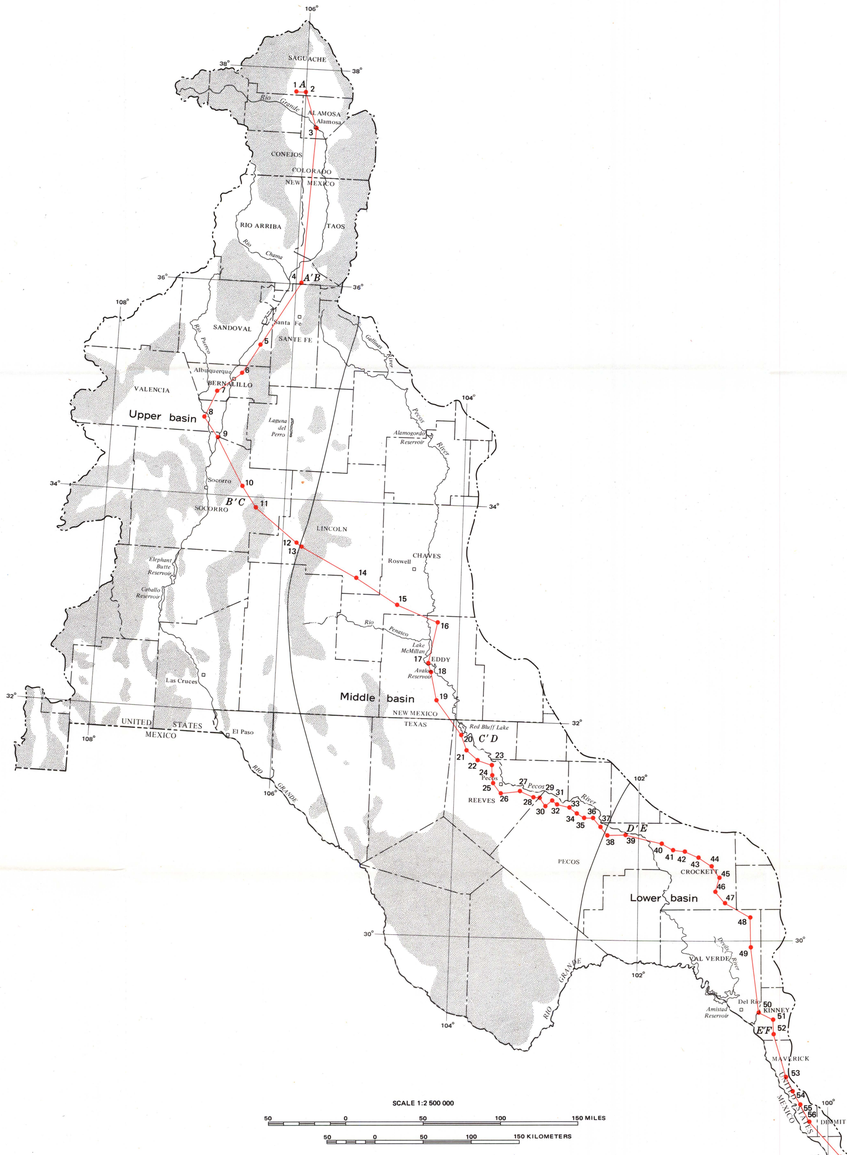
Several hydrologic anomalies occur in the middle basin region. The Capitan reef forms the axis of the Guadalupe Mountains in southeastern New Mexico and extends beneath the surface in an arcuate belt through part of west Texas. Owing to the high permeability of these biohermal deposits, precipitation which falls in the Guadalupe Mountains moves downdip through the reef and can be pumped from beneath more highly mineralized water. Brines exceeding 300,000 mg/l have been produced from shallow depths near the New Mexico-Texas border. In this area the Salado-Castile evaporite sequence has had a pronounced influence on water quality. The distribution of these evaporites is shown on a map on sheet 1.

The surface-water divide that forms the east margin of the middle basin is not a ground-water divide. Consequently the principal direction of ground-water flow is eastward, and with the exception of the water which enters the Pecos River or its tributaries, much of the ground water is lost from the Rio Grande basin.

The lower basin region extends from the lower reaches of the Pecos River to the vicinity of Laredo, Tex. This area structurally is similar to the middle basin, however, the rocks generally are Mesozoic in age and the ground water is less highly mineralized. The alluvial aquifers in the stream channels contain minor amounts of fresh water, and a number of large springs in the region produce fresh water. The major aquifers in the region are limestone and marl of Cretaceous age which generally yield fresh water to wells at shallow depths and slightly to moderately saline water to deeper wells. This area also is the major recharge area of the Edwards Limestone, which is part of the Fredericksburg-Washita Group undifferentiated, one of the most important aquifers in south-central Texas.

As in the middle basin, the surface-water divide does not represent a ground-water divide, therefore most of the ground water moves south and east out of the Rio Grande basin.

Downstream from Webb County, Texas, the Rio Grande traverses the coastal plain. This area is geologically distinct from the other areas of the basin because most of the sediments are poorly lithified marine sands and clays that dip toward the Gulf of Mexico. Most of the clastics in this sequence are fine grained and poorly sorted, consequently the yields to wells are low and the water quality ranges from slightly saline to brine. Generally, fresh water is present only in small quantities and at very shallow depth. One exception is the Carrizo Sand (section *F*–*F'*), a well-sorted sand that produces fresh water in sufficient quantities to support large-scale irrigation near its outcrop. The flow of ground water is downdip and parallel to the Rio Grande throughout most of the coastal plain.



SCALE 1:2 500 000

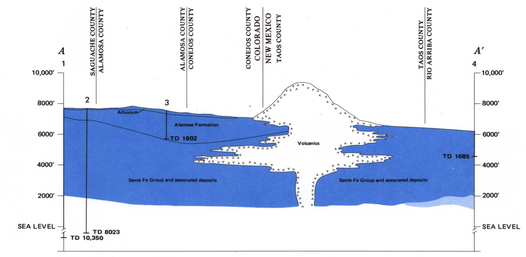
50 0 50 100 150 MILES

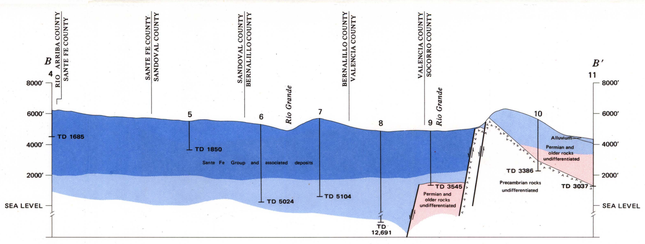
50 0 50 100 150 KILOMETERS

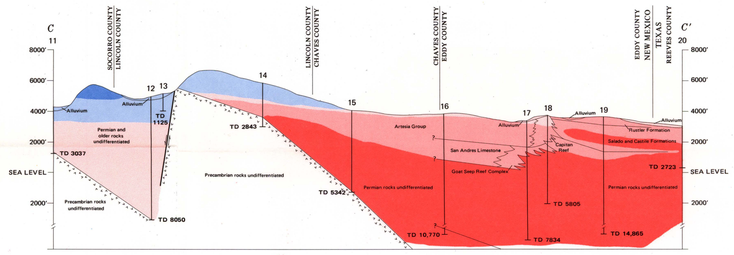
MAP SHOWING LOCATION OF WELLS, BASINS, AND SECTIONS

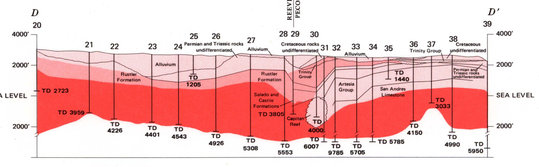
EXPLANATION

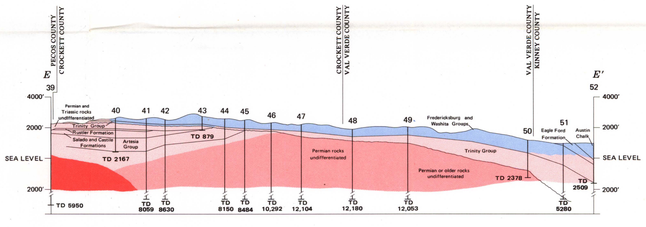
- Fresh water unit (1 gram per liter)
- Slightly saline water unit (1-3 grams per liter)
- Moderately saline water unit (3-10 grams per liter)
- Very saline water unit (10-35 grams per liter)
- Brine water unit (35 grams per liter)
- Igneous and uplifted sedimentary rocks that generally have low yields of water to wells
- Crystalline rocks
- Geologic contact, approximately located
- Unconformity
- Fault — *Arrows show direction of apparent movement*
- Basin boundary
- Boundary of major subdivisions
- 5 — Collection point — *Number corresponds with wells used in sections*
- TD 1802 — Total depth to well

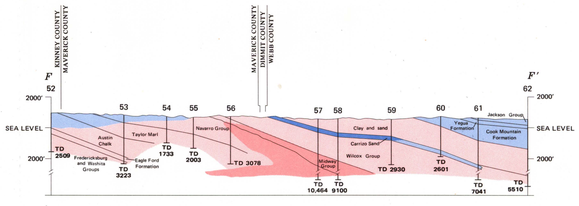


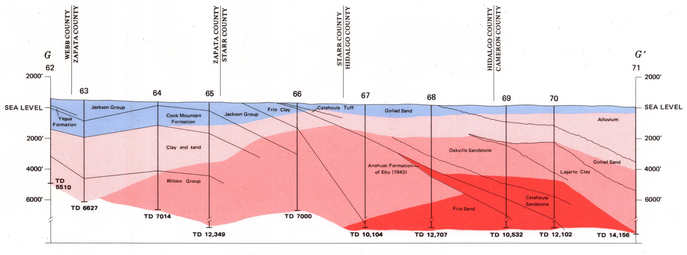












VERTICAL EXAGGERATION APPROXIMATELY X 25

DIAGRAMMATIC SECTIONS SHOWING THE RELATIONSHIP OF WATER UNITS TO PRINCIPAL GEOLOGIC UNITS

The tabular data are applicable to the geologic units only in the vicinity of the cross sections shown on this plate unless stated in the tables. In most cases the water quality and yields of a particular geologic unit vary greatly throughout the areal extent of the unit. For example, the San Andres Limestone shown on the cross section is characterized by moderately saline water and brine. However, near the outcrop belt, this unit produces moderate to large quantities of fresh to slightly saline ground water. More detailed information on the hydrologic characteristics of the major aquifers can be found on sheet 1.

Upper basin

System	Unit	Characteristics
Quaternary	Alluvium	Yields 500 to 1,000 gallons per minute of fresh water along stream channels; these deposits serve as important sources of recharge to underlying aquifers. Predominantly sand and gravel, locally silt, clay, and dune sand. Maximum thickness is 1,000+ feet.
Quaternary and Tertiary	Alamosa Formation	Yields 500 to 1,000 gallons per minute of fresh water; a major source of irrigation water in the San Luis Valley of Colorado. Predominantly gravel and sand, minor amounts of silt and clay. Maximum thickness is 2,000+ feet.
	Santa Fe Group	Yields 500 to 1,000 gallons per minute of fresh to moderately saline water; this is the major source of ground water in the Rio Grande basin. Yields exceeding 2,000 gallons per minute reported. Predominantly sand and gravel with silt, clay, and volcanics present. Maximum thickness is 10,000+ feet.
Tertiary	Volcanics	Generally do not yield water to wells, however highly fractured lava flows locally yield small quantities of fresh water. Thickness unknown; individual flows seldom exceed 10 feet. These rocks are contemporaneous with Santa Fe Group.
Cretaceous		Yields small quantities of moderately to very saline water. Not shown on section, these rocks were identified in the bottom of Humble No. 1 Santa Fe well (8) shown in section *B*–*B'*.
Permian and older		Yields as much as 500 gallons per minute of slightly to moderately saline water to wells; small quantities of fresh water occur locally near the outcrops. Permian rocks consist primarily of well-lithified sandstone, shale, and limestone; Pennsylvanian and Mississippian rocks are predominantly massive limestone which yields small to moderate quantities of fresh water near the outcrops. Numerous springs discharge from these rocks in mountainous areas.
Precambrian		Generally does not yield water to wells except where the rocks are deeply weathered or fractured near the surface. Water quality depends upon depth of water-yielding zones. Numerous springs discharge from these rocks in the mountainous areas.

Middle basin

System	Unit	Characteristics
Quaternary	Alluvium	Yields 500 to 1,000 gallons per minute of fresh to slightly saline water in stream valleys; these deposits serve as important sources of recharge to underlying aquifers. Predominantly sands and gravels, locally silt, clay, and dune sand. Maximum thickness is 1,500+ feet.
Tertiary	Ogallala Formation	Yields 500 to 1,000 gallons per minute of fresh to slightly saline water east of the Pecos River. Most important aquifer in eastern New Mexico and northwestern Texas where it supplies most of the water used for irrigation. Consists of sand, gravel, silt, and clay. Maximum thickness is 1,000+ feet.
Cretaceous	Cretaceous undifferentiated	Yields as much as 1,000 gallons per minute of moderately saline water. Primarily limestone and shale. Maximum thickness is 200+ feet.
	Trinity Group	Yields small quantities of fresh to moderately saline water. Fresh water present near stream channels; quality greatly deteriorates with depth. Primarily sandstone and shale with minor amounts of interbedded limestone. Maximum thickness is 5,000+ feet.
Triassic and Permian		Generally does not yield water to wells in west Texas and southeastern New Mexico. Consists primarily of variegated sandstone and shale containing moderately to very saline water. Locally the Santa Rosa Sandstone yields as much as 1,000 gallons per minute of slightly saline water in eastern New Mexico.
Permian	Rustler Formation	Yields about 500 gallons per minute of moderately to very saline water; quality usually deteriorates with depth. Primarily limestone and dolomite with minor amounts of anhydrite, sand, and shale. Maximum thickness is 500+ feet.
	Salado and Castile Formations	Not known to yield water to wells; brine generally is produced from strata adjacent to these units. Predominantly halite with associated deposits of anhydrite, sybrite, and shale. Maximum thickness is 4,000+ feet.
	Capitan and Goat Seep Limestones	Yields 500 to 1,000 gallons per minute of fresh to very saline water. This arcuate deposit of biohermal limestone conducts fresh water from the outcrops in New Mexico and Texas into the subsurface where it mixes with more highly mineralized water. This is one of the major producers of water used for representing oil and gas fields in the vicinity of the reef complex. Maximum thickness is 3,500+ feet.
	Artesia Group	Yields as much as 1,000 gallons per minute of moderately to very saline water. Stratigraphically equivalent to the Capitan and Goat Seep reef complex. These deposits consist of thin-bedded sandstone, limestone, shale, and evaporites. Greatest yield is from fractured limestone near outcrops. Maximum thickness is 2,000+ feet.
	San Andres Limestone	Yields 500 to 1,000 gallons per minute of moderately saline water to brine. Primarily limestone and dolomite with minor amounts of shale; some thin evaporites reported in eastern New Mexico. Greatest yield is from outcrop belt where water is present in fractures and solution cavities. This unit produces moderately saline water for a desalting plant at Roswell, New Mexico. Maximum thickness is 1,200+ feet.
	Permian undifferentiated	Generally does not yield significant quantities of water to wells. Primarily alternating sand, shale, and limestone which contain small quantities of brine.
Ordovician and Cambrian		Generally do not yield significant quantities of water to wells. Most oil tests produce brine from these units which is less highly mineralized than water from the overlying deposits. Springs of fresh water flow from these deposits in the mountainous areas of west Texas. Primarily massive limestones. Maximum thickness exceeds 3,000 feet.
Precambrian		Generally does not yield water to wells except where the rocks are deeply weathered or fractured near the surface. Water quality depends upon depth of water-yielding zone.

Lower basin

System	Unit	Characteristics
Quaternary	Alluvium	Yields 500 to 1,000 gallons per minute of fresh to slightly saline water in stream valleys; fresh water limited to very shallow wells. These deposits are an important source of recharge to underlying aquifers. Consists primarily of sand and gravel, as well as silt, clay, and dune sands; some caliche present. Maximum thickness is 1,500+ feet.
Cretaceous	Navarro Group	Yields small amounts of moderately saline water with greatest yields from sandstones within the group. Consists primarily of limestone, shale, and minor amounts of sandstone. Maximum thickness is 1,500+ feet.
	Taylor Marl	Yields as much as 500 gallons per minute of water from upper part of the unit. Slightly saline water produced near outcrop, elsewhere moderately to very saline water is present. Limestone and shale predominate. Maximum thickness is 1,000+ feet.
	Austin Chalk	Yields as much as 500 gallons per minute of slightly to moderately saline water. Major yields are from the fractures and solution cavities, thus the yields to wells are quite variable. Primarily massive limestone. Maximum thickness is 1,200+ feet.
	Eagle Ford Formation	Yields small amounts of slightly saline water from fractures in limestone; water quality deteriorates downdip. Primarily thin-bedded limestone. Maximum thickness is 300 feet.
	Washita and Fredericksburg Groups	Yields as much as 1,000 gallons per minute of slightly saline water. Major yield is from fractures and solution openings in limestones, thus yields to wells are quite variable. Springs are known to yield more than 2,000 gallons per minute. Rio Grande basin is important recharge area for this aquifer which is one of the most important in central Texas. Primarily thin-bedded to massive limestone with minor shale units. Maximum thickness is 1,500+ feet.
	Trinity Group	Yields 500 to 1,000 gallons per minute of moderately saline water to wells throughout much of the region. Upper "Trinity sand" is most productive part of the unit; underlying Glen Rose Limestone produces small quantities of water. Maximum thickness of group is 1,200+ feet.
Permian and older		Yields small quantities of very saline water. Primarily thin-bedded limestone and shales, minor amount of sandstone. Brine commonly associated with gypsiferous deposits. Lower Paleozoic rocks are primarily massive limestone that is not known to produce water to wells in this region. Most Paleozoic rocks are known to contain hydrocarbons in this region.

Coastal plain

System	Series	Unit	Characteristics
Quaternary	Holocene and Pleistocene	Alluvium	Yields 500 to 1,000 gallons per minute of fresh to moderately saline water in the Rio Grande flood plain and in the southern part of the coastal plain, especially in Hidalgo County and western half of Cameron County. Fresh water generally absent except near streams. Clay, sand, and gravel predominate. Maximum thickness is 3,500+ feet.
Tertiary	Pliocene	Goliad Sand	Yields as much as 500 gallons per minute of slightly to very saline water. Locally as much as 500 gallons per minute are available where gravels are present; formation is predominantly sand and clay. Fresh water generally absent except near streams. Maximum thickness is 1,500+ feet.
	Miocene(?)	Lagarto Clay	Generally does not yield water to wells except where fractures contain small quantities of very saline water. Primarily clay and sandy clay. Maximum thickness is 2,000+ feet.
	Miocene	Oakville Sandstone	Yields as much as 500 gallons per minute of slightly to very saline water except from the lower part of the Catahoula where brine is present. Yields generally decrease with depth. The Oakville consists primarily of sandstone with some silt and clay, Catahoula is primarily volcanic tuff, some fine clastics. Maximum thickness is 3,000+ feet.
		Catahoula Tuff	
	Oligocene	Anahuac Formation of Eby (1943)	Generally does not yield water to wells except where fractures contain small quantities of brine. Primarily marine shale which thickens toward the coast. Maximum thickness is greater than 2,000+ feet.
	Oligocene(?)	Frio Clay	Yields small quantities of slightly saline water near the surface but deeper wells generally are not productive. Primarily silt and clay; sands become more abundant in the subsurface. Maximum thickness is greater than 4,000 feet.
	Eocene	Jackson Group	Yields small quantities of fresh to slightly saline water in Zapata County; moderately to very saline water found elsewhere. Fresh water limited to very shallow wells and those near streams. Primarily clay, silt, and sand. Maximum thickness is greater than 5,000 feet.
		Claiborne Group: Yegua Formation	Yields small amounts of slightly saline water. Primarily interbedded sand and clay; maximum thickness is 300+ feet.
		Claiborne Group: Cook Mountain Formation	Yields small amounts of slightly to moderately saline water from basal sand deposits; predominantly marl and clay, some gypsum present. Maximum thickness is 1,500+ feet.
		Claiborne Group: Clay and sand	Yields small amounts of moderately saline water except near the surface where slightly saline water is found locally. Predominantly clay with minor amounts of sand. Maximum thickness is 1,000+ feet.
		Claiborne Group: Carrizo Sand	Yields 500 to 1,000 gallons per minute of fresh to slightly saline water. This is the major source of irrigation water near the outcrop belt. Predominantly medium to coarse sand with minor amounts of clay. Maximum thickness is approximately 250 feet.
		Wilcox Group	Yields small quantities of moderately saline water; slightly saline water present locally near the surface. Primarily silt and clay, minor amounts of fine sand. Maximum thickness is 3,000+ feet.
	Paleocene	Midway Group	Generally does not yield water to wells except where fractures contain small quantities of very saline water. Primarily shale with minor amounts of fine sand. Maximum thickness is 1,000+ feet.

GEOLOGIC UNITS AND THEIR WATER-BEARING PROPERTIES ALONG LINES OF SECTIONS

RECONNAISSANCE INVESTIGATION OF GROUND WATER IN THE RIO GRANDE DRAINAGE BASIN

WITH SPECIAL EMPHASIS ON SALINE GROUND-WATER RESOURCES

By
T. E. Kelly

1974

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