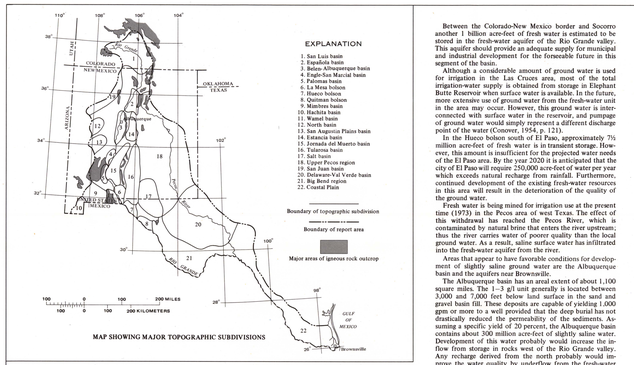
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

HYDROLOGIC INVESTIGATIONS
ATLAS HA-510 (SHEET 1 OF 4)



MAP SHOWING MAJOR TOPOGRAPHIC SUBDIVISIONS

INTRODUCTION

At the present time (1973), the surface-water resources of the Rio Grande drainage basin are fully appropriated and insufficient to meet present needs in most of the basin. Ground-water supplies have been extensively developed for irrigation and for almost all municipalities. In areas of heavy ground-water use, withdrawals often substantially exceed annual recharge; therefore the ground water in storage is being depleted steadily, with accompanying deterioration in quality. Because of the increasing demands for ground water by the 1,250,000 people of the United States part of the basin, fundamental knowledge of both fresh and saline ground-water resources is needed to serve as a guide for future development.

Ground water in the Rio Grande basin can be divided into two major quality types: fresh water which generally is near the surface, and the more deeply buried saline water. Following the standards used by the U.S. Public Health Service (1962), the U.S. Geological Survey has defined saline water as water that contains more than 1,000 mg/l (milligrams per liter, mg/l) can be considered as synonymous with the salinity of the water and terms "salinity" and "dissolved solids" are used interchangeably throughout the report.

The more common chemical constituents present in fresh-water samples are tabulated on Sheet 1; constituents present in saline-water samples are tabulated on Sheets 2 and 3. The few data that were available relating to the minor elements in the ground water of the Rio Grande basin are also tabulated on Sheet 1.

Electric logs of deep exploratory test holes were used as much as possible to facilitate regional correlations of the various rock units and to estimate the relative salinity of the water in the subsurface as shown on Sheet 4. Bottom-hole temperatures were used to extrapolate the temperature of the formation water at various depths; temperatures listed in the tables are considered to be representative of the region and should not be considered as maximum or minimum.

Water unit, as used in this report, refers to the sequence of geologic units which contain water of similar chemical quality. Thus, two or more aquifers may be within a given water unit, as in the Pecos River basin and on the coastal plain. In the middle and upper Rio Grande valley, a single aquifer may contain two or more water units.

Yield figures for a water unit cited in this report are applicable only for properly constructed wells that completely penetrate the water unit under consideration. In general, such wells presently do not exist in the Rio Grande basin. Consequently, the yields are estimated by interpretation of available information. For example, the alluvium and bolson fill deposits in the San Luis Valley of south-central Colorado yield as much as 4,000 gpm (gallons per minute) and at Albuquerque deposits of the same type yield as much as 2,500 gpm. However, Dinwiddie and others (1966, table 10) report that a municipal well at Espanola, midway between the San Luis Valley and Albuquerque, yielded only 250 gpm from these same deposits. Therefore it is assumed that wells at Espanola are capable of greater yields.

The Texas Water Development Board, the Office of the New Mexico State Engineer, and petroleum industry and associated service companies contributed a great deal of information. B. N. Myers, Austin, Tex., and L. A. Hershey, Pueblo, Colo., deserve special mention for their valuable contributions to the study. Most of the maps used in this atlas were modified after Kelly and others, 1970. A. Gene Collins of the Bureau of Mines, Bartlesville, Okla., contributed valuable data on minor elements from brines in the study area.

DISTRIBUTION AND AVAILABILITY OF GROUND-WATER RESOURCES

FRESH-WATER UNIT

Fresh water is present in significant quantities in most of the Rio Grande basin in Colorado and New Mexico, and in parts of west Texas. The fresh water generally occurs at depths of less than 10 feet below land surface where it is present in alluvial deposits. The thickness of the unit is variable; the principal controls on thickness of the fresh-water unit depend upon the thickness of the alluvium and the type of underlying deposits (Kelly and others, 1970, p. 17–23).

The greatest thickness of the fresh-water aquifer is present in the San Luis structural basin of Colorado. Throughout this entire basin the water table generally is less than 12 feet below the land surface. The deepest producing well, which is north of Alamosa, yields water containing 347 mg/l dissolved solids from a depth of 4,200 feet. Estimates indicate that as much as 9,000 feet of sediments may contain fresh water in the San Luis basin (P. A. Emery, oral commun., 1968).

In northern New Mexico the thickness of the fresh-water unit probably is less than that of the bordering San Luis basin; however, thick sequences of lava have restricted extensive exploration for water in that area. Fresh water extends to a depth of 3,500 feet in the Albuquerque basin. From Socorro south to El Paso the valley of the Rio Grande contains approximately 1,000 feet of sediments that generally are saturated with fresh water. The fresh-water aquifer is of negligible extent and thickness in the Pecos River drainage basin and also in the closed basins of south-central New Mexico and west Texas, except in the upper reaches of the Pecos and in the vicinity of the city of Pecos, Tex., where supplies sufficient for irrigation have been developed. Fresh water extends to a depth of 100 to 500 feet in most of the alluvial aquifers downstream from the mouth of the Pecos. North of Laredo, Tex., the Carrizo Sand contains nearly 1,000 feet of fresh water; however, yields from this aquifer in the Rio Grande valley are low.

Most of the fresh-water aquifers in the Rio Grande basin are composed of unconsolidated sand and gravel. Yields from wells in this aquifer range from about 5 gpm to 4,000 gpm. Irrigation wells in the San Luis Valley commonly yield 500 gpm. In New Mexico, most of the wells that obtain fresh water from alluvial or valley-fill deposits yield 25 to 100 gpm, but wells producing 100 to 500 gpm are common. Several of the Albuquerque municipal wells produce more than 1,000 gpm.

Yields as great as 3,000 gpm have been measured in irrigation wells southeast of El Paso. Two large areas in south Texas produce fresh water; most of the production is from alluvium that yields between 200 and 2,500 gpm to wells (Brown and others, 1965, p. M-43). More than 1,000 feet of fresh water occurs in the area north of Laredo to the Brownsville area the yields are variable; the production ranges from 25 to 50 gpm, but where there is sufficient thickness, yields may exceed 1,500 gpm.

Nearly all the fresh water in the Rio Grande basin has a temperature of less than 50°C. The only known exception is in the San Luis Valley where an oil test drilled to a depth of 10,344 feet had a bottom-hole temperature of 113°C. In that well the 50°C isothermal surface is at a depth of about 4,500 feet, or approximately 3,000 feet above sea level.

In general, the regional hydrology of the fresh-water unit is rather simple. Most of the water is derived from precipitation that falls in the highland areas of Colorado and New Mexico. This water moves toward the nearby stream channels and enters the Rio Grande drainage system or is lost by evapotranspiration. Some of this water moves downward to the water table, then laterally through the aquifers; Emery and others (1971, pl. 1) estimate that about 35,000 acre-feet of fresh ground water flows southward from the San Luis basin into New Mexico each year.

Water-level data indicate that the fresh water in the vicinity of Pecos, Tex., is moving toward areas of heavy pumping for irrigation. Originally most of this ground water drained into the Pecos River and was discharged to streamflow and evapotranspiration. The fresh water in the lower Tularosa Basin of the basin flows downdip where the water interfingers with more mineralized water. In general, all the water beneath the coastal plain flows southward and eastward toward the Gulf of Mexico.

SALINE-WATER UNITS

1–3 GRAMS PER LITER SALINE-WATER UNIT

Slightly saline water is not uniformly distributed in the Rio Grande basin. A thick but isolated saline aquifer is present in the San Luis Valley, and another is in the Albuquerque basin. The Tularosa basin contains water of this quality, as does the Rio Grande basin south of Pecos, Tex. Elsewhere 1–3 g/l saline water is present in isolated areas, as in the Hueco bolson which contains an estimated 2 to 3 million acre-feet of this quality water, but in comparison with the size of the Rio Grande basin, these areas are relatively small. In some areas the 1–3 g/l unit is widespread but relatively thin. The top of the 1–3 g/l unit coincides with the base of the fresh water or with the water table in those areas where fresh water is not present.

The Albuquerque basin, extending about 100 miles from the vicinity of Santa Fe to near Socorro, probably contains large quantities of 1–3 g/l saline water. Most of the Rio Grande valley south of Albuquerque, and in general the rest of New Mexico within the basin, is underlain by approximately 500 feet of sediments saturated with 1–3 g/l saline water. The unit is about 1,000 feet thick in the Tularosa basin east of Las Cruces. Nearly all the Pecos and Rio Grande drainage basins in west and south Texas is underlain by slightly saline water. The greatest thickness, about 1,500 feet, is present south of Del Rio; northwest of Brownsville as much as 1,000 feet is present. Although this unit is widely distributed in the lower Pecos River area, in general the thickness does not exceed 500 feet.

Yield from the aquifers containing 1–3 g/l saline water are dependent primarily on the aquifer permeability and secondarily on the thickness. Most sand and gravel aquifers in the Rio Grande valley and in the Tularosa basin are capable of yielding more than 500 gpm to a well. The consolidated rocks in central New Mexico are able to yield about 50 to 100 gpm except where highly fractured limestones will yield more than 500 gpm. Much of the 1–3 g/l saline water in the Pecos and Del Rio, Tex., areas is produced from sandstone and limestone which are capable of yielding more than 500 gpm to a well. Although the yields from individual wells are variable, the significant thickness of the aquifers account for large yields. Farther south, on the coastal plain, nearly all the sand aquifers are capable of yielding from 25 to more than 1,000 gpm, depending on the thickness of the water-quality unit.

Most of the 1–3 g/l saline water has a temperature of less than 50°C. The only major exception is in the San Luis Valley where this unit is deep-seated and has a minimum temperature of approximately 100°C.

3–10 GRAMS PER LITER SALINE-WATER UNIT

Water of 3–10 g/l salinity is widespread throughout much of the Rio Grande basin; however, with few exceptions, the unit is relatively thin because it represents a rather sharp transition zone between the low-salinity water above and highly mineralized water below. Water of 3–10 g/l salinity is found in the deepest part of the San Luis basin and in most of New Mexico south of 36° latitude. In Texas, the unit is thin or absent in most places.

The yield of wells tapping the 3–10 g/l unit is difficult to predict because few pumping-test data are available. In the past, poor water quality has discouraged construction of wells in this zone, and probable yields are based on pumping figures obtained from areas where the same aquifers produce fresh water; the change in rock type and depth of burial have been taken into consideration.

Hale and others (1965, p. 43) report that if a properly constructed well penetrated all the sandstones on the eastern flank of the San Juan basin, such a well would produce 3,500 gpm. It is likely that at least 1,000 gpm could be obtained from a well tapping these rocks northwest of Albuquerque. In the Albuquerque basin the upper part of the 3–10 g/l unit occupies more permeable aquifers than the lower part. Assuming that the deeply buried aquifers (7,000 feet below land surface) at Albuquerque are considerably less permeable than those at shallower depths, properly constructed wells might produce 500 gpm from this unit.

Yield of 1,000 gpm is reported to be rather common from wells that penetrate the San Andres Limestone in the Pecos River valley of southeastern New Mexico (Fiedler and Nye, 1933, p. 227). On the flanks of this basin the yields undoubtedly are in the range of 100 to 500 gpm, similar to those commonly found in the Tularosa basin. Many wells in west Texas that produce 3–10 g/l saline water from limestone and sandstone have yields exceeding 500 gpm. However, in those areas where shale is a principal constituent of the moderately saline aquifers, yields are quite small. Wells that tap the 3–10 g/l unit in the coastal sands of the lower Rio Grande basin generally yield more than 500 gpm except where the sands contain appreciable clay and silt, which restricts well yields to less than 25 gpm.

Nearly all saline water in the 3–10 g/l unit in the Rio Grande basin has temperatures of 50° to 100°C. The temperatures are highest where the unit is deepest. The 100°C isotherm is about 8,000 feet below sea level in the Albuquerque basin and the base of the moderately saline unit is 9,000 feet below sea level. Temperatures are somewhat less than 50°C beneath the coastal plain where the unit is relatively shallow.

10–35 GRAMS PER LITER SALINE-WATER UNIT

Ground water containing 10–35 g/l dissolved solids is limited to that part of the basin south of about 36° latitude. In the north-central part of New Mexico this unit is irregular in distribution and thickness; elsewhere in New Mexico it is relatively uniform. In west Texas the unit is thin to absent but increases abruptly to more than 8,000 feet near the mouth of the Pecos River. Although some localized thinning occurs near the gulf, the unit is more than 8,000 feet thick throughout much of the lower Rio Grande basin.

The yield from wells producing very saline water ranges from less than 25 to more than 500 gpm. Most of the yields from the San Juan-Albuquerque basin are believed to be 500 gpm depending upon the thickness of the unit. As the 10–35 g/l water occupies thick alluvial deposits in the Jornada del Muerto-Estancia basin, as much as 500 gpm may be available to wells. Most of the wells in the upper Pecos region probably would produce approximately 500 gpm from sandstone and limestone, however there probably would be considerable variation in yields throughout the basin. Most of the rocks in the Delaware basin would yield between 100 and 500 gpm from the 10–35 g/l unit but less than 25 gpm would be available to wells near the boundary of this area. Because of the great thickness of the unit south of Del Rio, deep wells probably would yield as much as 500 gpm.

The temperature of most of the 10–35 g/l water is between 100° and 150°C, as in the San Juan-Albuquerque basins and in the lower Rio Grande drainage area south of Del Rio. Where this water-quality unit is present at shallow depths, as in the Tularosa, Roswell, and Delaware basins, the average temperature is less than 50°C.

BRINE UNIT

Water having more than 35 g/l dissolved solids, here termed brine, underlies southeastern and south-central New Mexico and most of the study area in Texas. Although there are local exceptions, in most areas the brine is deeply buried, extremely thick, and extends from the 35 g/l isosaline surface to the basement rocks. The water in this unit ranges from 35 g/l to more than 300 g/l.

The brine unit has a thickness of 22,000 feet in the Delaware basin and a probable thickness of more than 30,000 feet on the coastal plain. This thickness is due in part to the great depth to basement rocks, which are about 26,000 feet in maximum depth in the Delaware basin. The rocks dip southward toward the coastal plain. In general, the top of the brine unit is more than 4,000 feet deep except in the Tularosa and Delaware basins.

Yields of wells producing from the brine unit are extremely difficult to estimate because most of the data on the brine was obtained from low-yielding oil and gas wells. Frequently production is from consolidated rocks and such wells produce less than 25 gpm unless the well was completed in fractured limestone. The Tularosa basin, where the brine occurs at shallow depths, is an exception (McLean, 1970, p. 26). In this basin wells probably could produce more than 500 gpm and would have a temperature of less than 50°C in the shallow part; the more deeply buried brines have temperatures exceeding 150°C.

Parts of New Mexico and Texas are underlain by a thick sequence of evaporites, such as halite, gypsum, and anhydrite which is present at depths of less than 4,000 feet below land surface. Where these evaporites are present, the 35 g/l isosaline surface coincides with the top of these evaporites. Water samples from limestones interbedded with the evaporites contain more than 300 g/l dissolved solids, with sodium and chloride being the principal ions.

Water below the evaporite sequence is much less mineralized, generally not containing less than 100 g/l. Production of this water would be extremely difficult. The base of the evaporite sequence is more than 6,000 feet below land surface locally so that producing wells would have to exceed this depth. Also, permeabilities are low for most of the consolidated rocks from which production would be obtained (Hogan and Sires, 1966, table 1).

CURRENT GROUND-WATER USE AND PROJECTIONS

The fresh-water aquifer underlying the San Luis Valley contains at least 2 billion acre-feet of water in transient storage (Emery and others, 1971, pl. 1). Average annual recharge is about 2½ million acre-feet, much of which is discharged into the Rio Grande or is lost by evapotranspiration. Water in storage is sufficient to maintain the current use for 1,000 years.

Between the Colorado-New Mexico border and Socorro another 1 billion acre-feet of fresh water is estimated to be stored in the fresh-water aquifer of the Rio Grande valley. This aquifer should provide an adequate supply for municipal and industrial development for the foreseable future in this segment of the basin.

Although a considerable amount of ground water is used for irrigation in the Las Cruces area, most of the total irrigation-water supply is obtained from storage in Elephant Butte Reservoir when surface water is available. In the future, more extensive use of ground water from the fresh-water unit in the area may occur. However, this ground water is interconnected with surface water in the reservoir, and pumpage of ground water would simply represent a different discharge point of the water (Conover, 1954, p. 121).

In the Hueco bolson south of El Paso, approximately 7½ million acre-feet of fresh water is in transient storage. However, this amount is insufficient for the projected water needs of the El Paso area. By the year 2020 it is anticipated that the city of El Paso will require 250,000 acre-feet of water per year which exceeds natural recharge from rainfall. Furthermore, continued development of the existing fresh-water resources in this area will result in the deterioration of the quality of the ground water.

Fresh water is being mined for irrigation use at the present time (1973) in the Pecos area of west Texas. The effect of this withdrawal has reached the Pecos River, which is contaminated by natural brine that enters the river upstream; thus the river carries water of poorer quality than the local ground water. As a result, saline surface water has infiltrated into the fresh-water aquifer from the river.

Areas that appear to have favorable conditions for development of slightly saline ground water are the Albuquerque basin and the aquifers near Brownsville.

The Albuquerque basin has an areal extent of about 1,100 square miles. The 1–3 g/l unit generally is located between 3,000 and 7,000 feet below land surface in the sand and gravel basin fill. These deposits are capable of yielding 1,000 gpm or more to a well provided that the deep burial has not drastically reduced the permeability of the sediments. Assuming a specific yield of 20 percent, the Albuquerque basin contains about 300 million acre-feet of slightly saline water. Development of this water probably would increase the inflow from storage in rocks west of the Rio Grande valley. Any recharge derived from the north probably would improve the water quality by underflow from the fresh-water aquifers on the north, although the ultimate source of recharge is from the Rio Grande.

The area northwest of Brownsville is a possible prospect for development because it is underlain by about 1,000 feet of sand capable of yielding large quantities of slightly saline water. According to Baker (1965, p. L-29), the sand generally yields more than 1,000 gpm to individual wells; however, extensive development near the coast might result in an increase of salinity by encroachment of salt water from the Gulf of Mexico.

Throughout the remainder of the Rio Grande basin, the 1–3 g/l saline unit averages less than 500 feet in thickness. Although many areas are capable of producing large quantities of this water, such as the large area southeast of Pecos, Tex., extensive development might result in the upward coning of more highly mineralized water.

Both the Albuquerque basin and the southeast edge of the San Juan basin contain about 5,000 feet of moderately saline water of 3–10 g/l dissolved solids. However, in the Albuquerque basin the unit extends for more than 10 miles beneath the Rio Grande valley, both bolson deposits and consolidated rocks at depths of more than 7,000 feet below land surface contain water of this salinity. Assuming that the specific yield of these combined aquifer types is 10 percent, about 32 million acre-feet of 3–10 g/l water is in transient storage in the Albuquerque basin. It is possible that wells completed at depths of 7,000 to 12,000 feet would yield about 500 gpm. Extensive development of the water from this unit probably would result in deterioration of water quality.

In the San Juan basin, wells less than 7,000 feet deep which penetrate the 3–10 g/l units could be expected to yield as much as 500 gpm from sandstone aquifers. These sandstones dip northwestward and conduct ground water out of the Rio Grande drainage basin. Extensive development undoubtedly would result in the inflow of ground water from outside the study area. Because of the large volume of moderately saline water in the San Juan basin, the water quality probably would not deteriorate and might be freshened by recharge from the San Juan River.

The upper Pecos region contains significant amounts of moderately saline water, most of which is in limestone having yields in excess of 500 gpm. More than 4,000 square miles of the basin is underlain by 1,000 feet or more of this water quality. Near Pecos, Tex., the 3–10 g/l unit occupies more than 2,000 feet of rocks that are extremely variable in lithology. In general, the limestone may be capable of yielding 500 gpm or more to a well, but much of the sequence is composed of low-yielding siltstone and shale and their distribution is not well known. Consequently estimates of yield are not justified by the amount of information currently available.

The Capitan reef complex extends from Carlsbad, N. Mex., to beyond the Pecos River in Texas. The highly permeable reef limestone is capable of yielding large quantities of water, and it acts as a permeable conduit enclosed in less permeable rocks (W. L. Hiss, oral commun., 1971). Preliminary evidence indicates that the reef complex is capable of yielding moderate quantities of 3–10 g/l saline water. In recent years large quantities of petroleum have been produced in the area and various oil companies have initiated water-flooding operations with water obtained from the reef. Extensive development of water resources for municipal supply from the reef might affect the water-flooding operations.

The thick deposits of sand south of Laredo probably represent the only other source of water available to that city. Currently Laredo obtains all of its water from the Rio Grande, where water rights are fully appropriated. Projections to the year 2020 indicate that this city will have to develop another source of municipal water, and development of saline ground water is the only obvious alternative at the present time.

Wells producing from the 3–10 g/l unit southeast of Laredo have average yields greater than 500 gpm; maximum yields of about 2,000 gpm have been reported. Assuming an average specific yield of 10 percent and an average thickness of 800 feet, the lower 1,200 square miles of the basin contains approximately 6 million acre-feet of moderately saline water. Extensive long-term development might result in deterioration of the water quality by upward coning of more saline water.

Three areas in the Rio Grande drainage area are underlain by significant quantities of water having 10–35 g/l dissolved solids—the lower Rio Grande south of Del Rio, the Roswell area, and the Jornada del Muerto-Estancia basin.

Nearly all of the area south of 30° latitude is underlain by more than 8,000 feet of very saline water. This region encompasses more than 6,500 square miles and most of the thick sandstone aquifers probably would yield more than 500 gpm to wells. The upper 1,000 feet of this water-quality unit probably contains several billion acre-feet. The top of the unit is more than 4,000 feet below land surface throughout much of the area which might constitute a deterrent to development of this unit for desalting.

In the upper Pecos area, the 10–35 g/l unit underlies more than 5,000 square miles. The greatest thickness is about 3,000 feet in the northern end of the basin, and the average thickness is more than 2,000 feet. Locally the top of the unit is less than 1,000 feet below the land surface, and therefore it is well suited for desalting operations. A desalting demonstration plant was constructed under the auspices of the Office of Saline Water in Roswell in 1962, but the use for the plant is supplied by wells that produce about 500 gpm each from a depth of less than 600 feet. The water is of average salinity of 18 g/l.

In the Jornada del Muerto-Estancia basin complex the 10–35 g/l unit has an average thickness of 4,000 feet and extends from near land surface to the mountain outcrops. The major aquifer is composed of relatively permeable sediment. Well yields of as much as 500 gpm probably could be obtained from this unit. Extensive development probably would have little effect on the water quality in the Jornada del Muerto-Estancia basins because of the large volume of saline water presently in storage. Any water-quality change that might occur probably would be a reduction in dissolved solids by invasion of the aquifer by less mineralized water from adjoining areas.

The Tularosa basin stands out as a possible prospect for development of brine for municipal or industrial purposes. In this area there is presently a serious shortage of potable water. Brine occurs at depths of less than 200 feet. The bolson fill that contains the brine is capable of yielding more than 500 gpm to a well. Elsewhere in the Rio Grande basin brine could be utilized for the production of minor elements as well as for reprocessing oil and gas fields which have been depleted.

PROBLEMS ASSOCIATED WITH USE OF SALINE GROUND WATER

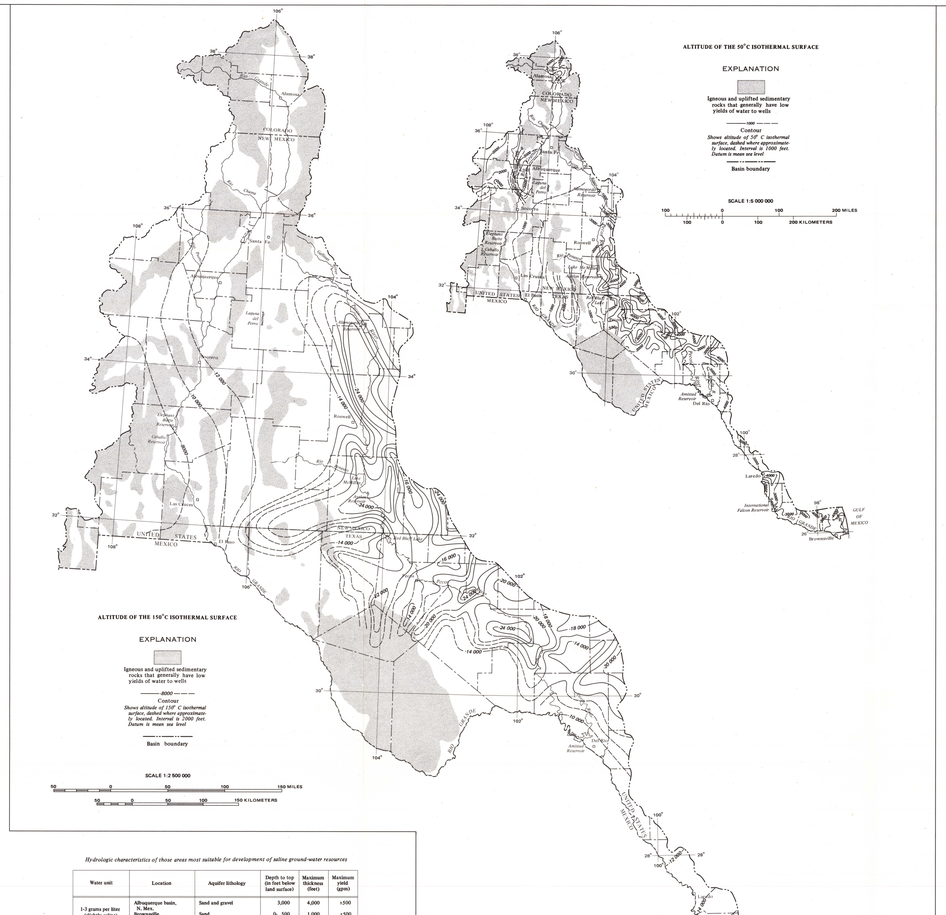
Three major problems are associated with the use of saline ground water in the Rio Grande basin: (1) the effect on the nearby fresh-water aquifers caused by saline-water withdrawal; (2) disposal of the waste products of desalting; and (3) the lack of hydrologic data on which to base predictions of the effects of long-term withdrawal from saline aquifers.

Fresh-water aquifers could be affected both favorably and adversely by removal of saline water from nearby aquifers. Pumping saline water from beneath a fresh-water aquifer might cause upconing of the fresh water toward the pumped area, but might also induce recharge of fresh water by diversion of surface water. Thus, more fresh ground water would be available at the expense of the surface water. This condition could occur in the Rio Grande valley where, by pumping saline ground water, the water table beneath the river would be lowered and inflow of fresh water from streams would be induced from the river. Conversely, in the absence of a source of fresh-water recharge, as in the Tularosa basin, the overlying fresh water would be drawn into the saline-water aquifer where some mixing might occur.

Waste disposal is one of the major problems in desalting. All desalting processes require disposal of waste water which contains the highly concentrated minerals present in the feed water. Therefore, the problems associated with brine disposal may differ at each plant site. In the Rio Grande valley, disposal of the brine could be a major problem if the volume were large and the chemical quality precluded other uses.

Seven areas in the Rio Grande region probably have a good potential for desalting—the Albuquerque basin, the Rio Grande valley near Del Rio, the lower Rio Grande valley, the Jornada del Muerto-Estancia basin, the Tularosa basin, the east edge of the San Juan structural basin, and the Roswell area. The first five of these areas are underlain by saline water that occupies thick sequences of permeable clastics having distinct hydrologic boundaries. The other two areas, the San Juan and Roswell areas, have saline-water aquifers in stratified rocks having indistinct hydrologic boundaries.

In general, data are not available for adequate evaluation of the potential for development of saline aquifers in the Rio Grande drainage basin. Although preliminary data may indicate the suitability of an aquifer for long-term desalting development, as required for the 30-year amortization of a desalting plant, subsequent production could result in hydrologic changes within 5 or 10 years that would force curtailment or cessation of the operation and render the area unsuitable for additional development. Obviously, the selection of sites for desalting must be based on accurate knowledge of the geology and hydrology of the area, and of the probable responses of the aquifers to changes brought about by development.



MAPS SHOWING ALTITUDE OF ISOTHERMAL SURFACES

Hydrologic characteristics of those areas most suitable for development of saline ground-water resources

Water unit	Location	Aquifer lithology	Depth to top (in feet below land surface)	Maximum thickness (feet)	Maximum yield (gpm)
1–3 grams per liter (slightly saline)	Albuquerque basin, N. Mex. Brownsville, Tex.	Sand and gravel	3,000	4,000	+500
		Sand	0– 500	1,000	+500
3–10 grams per liter (moderately saline)	San Juan basin, N. Mex. Roswell basin, N. Mex. Capitan reef complex, N. Mex. and Tex. Texas Brownsville, Texas area	Sandstone	+500	5,000	100–500
		Limestone and sandstone	+500	+1,000	100–500
		Limestone	0–5,000	+1,200	+500
		Sandstone	0–1,000	1,500	+500
10–35 grams per liter (very saline)	Lower Rio Grande valley, Texas	Sandstone	2,000	+8000	100–500
	Roswell basin, N. Mex.	Limestone	500–3,000	3,000	100–500
	Jornada del Muerto-Estancia basin, N. Mex.	Sand and gravel	0– 500	8,000	+500
Greater than 35 grams per liter (brine)	Tularosa basin, N. Mex.	Sand and gravel	0–3,000	7,000	+500

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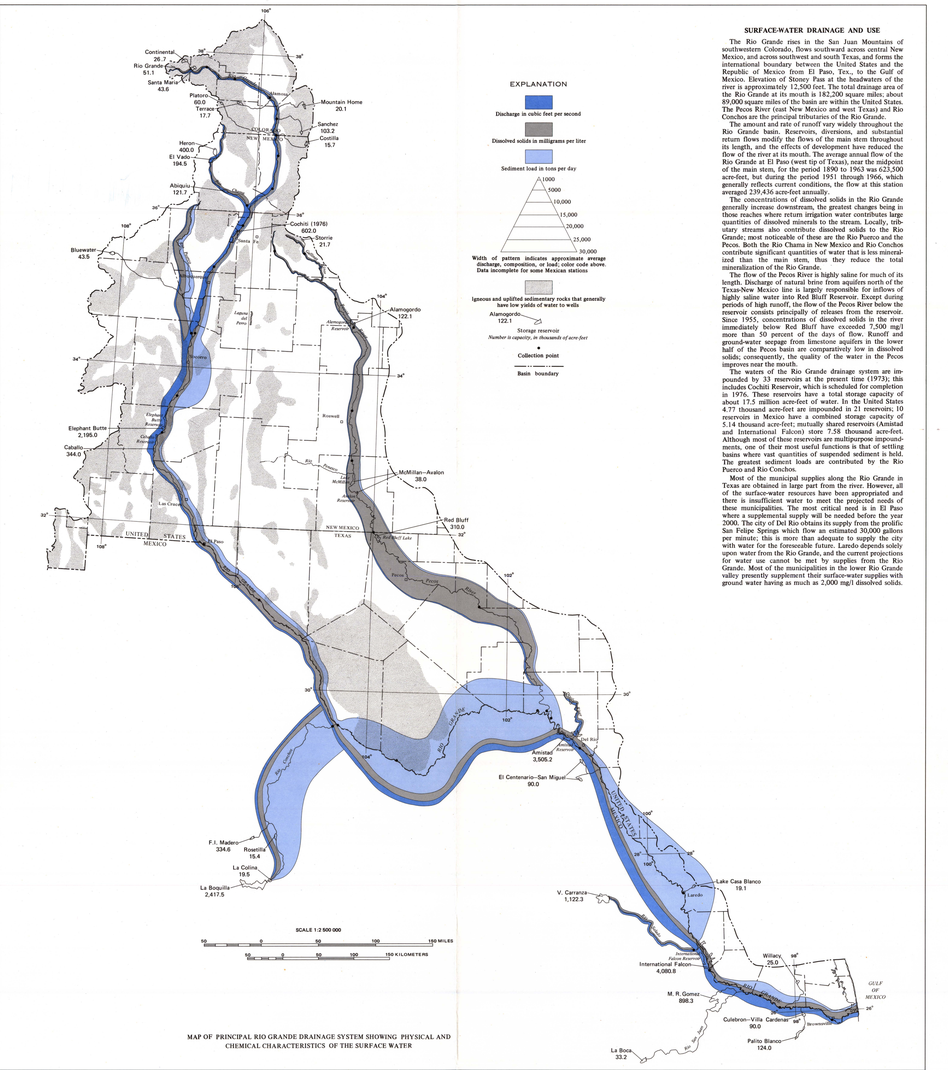
EXPLANATION
Discharge in cubic feet per second
Dissolved solids in milligrams per liter
Sediment load in tons per day
1,000
5,000
10,000
15,000
20,000
25,000
30,000
Width of pattern indicates approximate average discharge, composition, or load; color code above. Data incomplete for some Mexican stations
Igneous and uplifted sedimentary rocks that generally have low yields of