AVAILABILITY AND QUALITY OF GROUND WATER IN THE PECOS RIVER BASIN

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INTRODUCTION

The ground-water regimen of the Pecos River basin can be divided into five segments, each of which constitutes a separate ground-water unit. The occurrence of ground water in each unit, the differences in the chemical quality of water in the various aquifers, and the development of ground water in each unit is related to the drainage system of the Pecos River. Geological factors guide the movement of ground water within and between the ground-water units; however, the Pecos River is the unifying hydrologic feature. The five ground-water units are outlined in figure 1. Hydrologic conditions within each ground-water unit within the Pecos River basin will be discussed in downstream order -- that is, from north to south along the Pecos River. General data on water use, chemical quality of water, potential yield of wells, source of recharge, and status of aquifer development are shown in table 1 for all principal aquifers along the Pecos River.

UNIT 1 - HEADWATERS OF PECOS RIVER TO ANTON CHICO

In the segment, or reach, of the Pecos River from its headwaters to Anton Chico, nearly all the base flow of the river and its upper tributaries comes from ground water discharged by the Magdalena Group (Griggs and Hendrickson, 1951). Rocks of the Magdalena Group overlie crystalline bedrock and form the first aquifer above the geologic basement. Hydrologic information and related data on the Magdalena Group and other aquifers in this reach of the Pecos River are described in table 1.

In this reach of the Pecos River a constant supply of fresh water is discharged into the river from aquifers. Owing to the availability of this fresh water, plus the fact that wells in this area are generally of low yield (fig. 2), surface water is the major source of water for irrigation in Unit 1 (fig. 3). Ground water, however, is an attractive source of supply for needs other than irrigation because of its shallow depth and general low salinity (figs. 4 and 5). Data are not available on the volume of ground water pumped in Unit 1; probably the volume is quite small.

UNIT 2 - ANTON CHICO TO ALAMOGORDO RESERVOIR

This reach of the Pecos River basin is similar to Unit 1 above Anton Chico except that the aquifers are in geologically younger rocks. Because the older aquifers lie at increasing depths southward, they are not within practical drilling depth in this reach of the basin.

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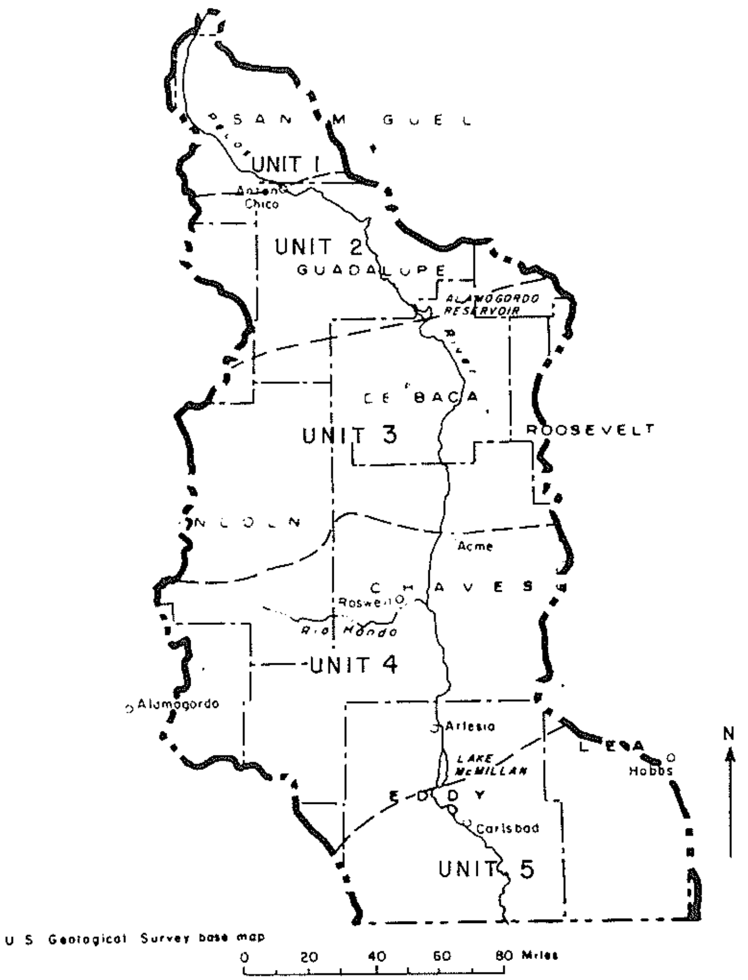
Table 1.--PRINCIPAL AQUIFERS IN THE PECOS RIVER BASIN

System	Geologic source	Headwaters of Pecos River to Anton Chico	Anton Chico to Alamogordo Reservoir	Alamogordo Reservoir to Acme	Acme to Lake McMillan	Lake McMillan to State line	Water use	Water quality	Potential yield (Gallons per minute)	Source of recharge	Aquifer development
Quaternary	Alluvium	X	X	X	X	X	Industrial, irrigation, stock, domestic.	Water is hard, but low in dissolved solids.	From 4 to 2,000.	Surface-water flow over outcrops, return irrigation, ground-water flow from other aquifers, and direct precipitation upon outcrops.	Overdeveloped in most areas.
Tertiary	Ogallala Formation	X	X				Domestic, stock.	Water quality varies widely but in general is fair.	Less than 1 to more than 1,600.	Small amounts of recharge from direct precipitation on outcrops.	In the Pecos River basin the formation covers only a small area and is not strongly developed.
Cretaceous	Mesaverde Formation				X		Stock.	Poor quality water, with bicarbonate and sulfate as the most dominant constituents.	From 5 to 20.	Direct precipitation on outcrops.	Poor quality of water limits its use and consequently the aquifer is not strongly developed.
	Mancos Shale				X		Unsatisfactory for all uses.	Poor quality water, highly mineralized.	From 6 to 75.	Unknown, probably the recharge is negligible.	Very little development because of poor quality water.
	Greenhorn Limestone		X				Stock, domestic.	High in sodium bicarbonate, fair to poor quality.	Less than 1.	Direct precipitation, flow from other aquifers. (Water occurs in fractures in the limestone.)	Owing to low yield, aquifer has not been widely developed.
	Graneros Shale						Stock.	Water is of poor quality, has a fluoride content greater than 3, a hydrogen-sulfide odor, disagreeable taste, and cloudy appearance.	Less than 1 to greater than 10.	Upward leakage from underlying Dakota Sandstone.	Because of poor quality of water and low yield there has been very little development.
	Dakota Sandstone	X			X		Domestic, stock.	Water is generally of good quality except where water flows into the formation from adjacent aquifers.	Between 1 and 125.	Streamflow over outcrops, direct precipitation on outcrops, flow of ground water from adjacent aquifers.	Despite low yield the aquifer has been extensively developed.
Jurassic	Morrison Formation	X	X				Domestic, stock.	Water is hard and is of poor to fair quality.	From 1 to 3.	Direct precipitation, surface-water flow over outcrops.	Despite low yield and poor quality the aquifer has some development.
	Entrada Sandstone	X	X				Domestic, stock.	Good quality, soft water with sodium bicarbonate as the main chemical constituent.	Less than 1 to more than 50.	Small amounts of recharge by flow of surface streams over outcrops.	Present use of water from the Entrada is such that the aquifer is not overdeveloped; however, limited recharge indicates the aquifer could be overdeveloped if subjected to more intense pumping.
Triassic	Chinle Formation		X		X		Domestic, stock.	Fair to poor quality of moderately hard water.	Less than 1 to more than 50.	Surface-water flow over outcrops, direct precipitation on outcrops.	Widely developed for stock and domestic use.
	Santa Rosa Sandstone		X	X	X		Stock and domestic.	Water ranges from fair to poor quality with sodium bicarbonate in amounts detectable by tasting.	From 1 to more than 750. (Locally under artesian pressure.)	Surface-water flow over outcrops, direct precipitation on outcrops.	Do.
Permian	Rustler Formation (Ochoa Series)				-	X	Stock.	Water is of poor quality. Some saturated brine.	From 1 to 10. As much as 600 at Malaga Bend 20 miles south of Carlsbad.	Direct precipitation on outcrops, lateral and vertical leakage from subjacent and superjacent rocks.	Because of poor quality water, the aquifer is not strongly developed.
	Castile Formation (Ochoa Series)					X	Stock and domestic.	High in sulfate and of poor quality.	From 1 to 10.	Direct precipitation on outcrops, surface-water flow over outcrops.	Not strongly developed because of poor quality and low yield.
	Tansill Formation					X	Stock, domestic, irrigation.	Fair quality, potable water high in bicarbonate.	2,500 to 3,000.	Leakage from Lake Avalon, streamflow over outcrops, direct precipitation on outcrops.	Strongly developed.
	Yates Formation (Artesia Group)				X	X	Stock, domestic.	Fair to poor quality, high in chloride and sulfate.	Up to 2,000.	Streamflow over outcrops, direct precipitation on outcrops.	Not strongly developed because of poor quality in most areas but possible good quality of water in outcrop areas west of the Pecos River.
	Seven Rivers Formation (Artesia Group)				X	X	All uses -- irrigation, industrial, municipal.	Water is hard but of good quality in most areas.	From 10 to more than 1,000.	Surface-water flow over outcrops, direct precipitation, return irrigation, vertical and lateral leakage from superjacent and subjacent aquifers.	Overdeveloped in Acme to Lake McMillan area, but underdeveloped in some areas south of Lake McMillan.
	Queen and Grayburg Formations (Artesia Group)			X	X	X	Irrigation, domestic, stock.	Water is of good quality in general, but locally contains high amounts of chloride and sulfate.	10 to 2,000.	Surface-water flow over outcrops, direct precipitation on outcrops vertical and lateral leakage from subjacent and superjacent aquifers.	Strongly over-developed in Acme-Lake McMillan area.
	Capitan Limestone					X	All uses -- industrial, irrigation, domestic, stock.	Good quality water in most places, but water is saline from Carlsbad eastward.	Up to 2,500.	Direct precipitation on outcrops, surface-water flow over outcrops	Fully developed.
	San Andres Limestone	X	X	X	X		All uses -- irrigation, industrial, municipal.	Water is generally of good quality but contains hydrogen sulfide in the deeper part of the aquifer and locally has high amounts of chloride.	From 1 to more than 9,000.	Surface-water flow over outcrops, direct precipitation on outcrops vertical and lateral flow from subjacent and superjacent aquifers.	Strongly overdeveloped in the Acme-Lake McMillan area.
	Glorieta Sandstone	X			X		Domestic, stock.	Water is of good quality in most places except under the Roswell Basin where it has a high chloride content.	From 2 to 700.	Direct precipitation on outcrops, vertical and lateral flow from subjacent and superjacent aquifers.	Small development.
	Yeso Formation	X			X		Domestic, stock.	Poor to fair quality. In some locations the chloride content is too high for most uses.	From 1 to 125.	Direct precipitation on outcrops, vertical and lateral flow from subjacent and superjacent aquifers.	Because of low yield and variable quality of water, aquifer is not strongly developed.
Pennsylvanian and Permian	Sangre de Cristo Formation	X					Domestic, stock.	Fair to good quality water of variable hardness.	From 1 to 15.	Surface-water flow over outcrops, direct precipitation.	Because of its low yield the aquifer is developed for stock and domestic use.
	Magdalena Group	X					Irrigation, domestic, stock, industrial (railroad).	Good quality water, but locally has a high fluoride content.	Up to 100.	Direct precipitation on outcrop.	Not strongly developed.
Precambrian	Metamorphic and igneous rocks	X					Stock, domestic.	Fair quality water.	About 1.	Direct precipitation on outcrops. Water occurs in fractures in the Precambrian rocks.	Precambrian rocks are not strongly developed as an aquifer because of the low yields obtainable.

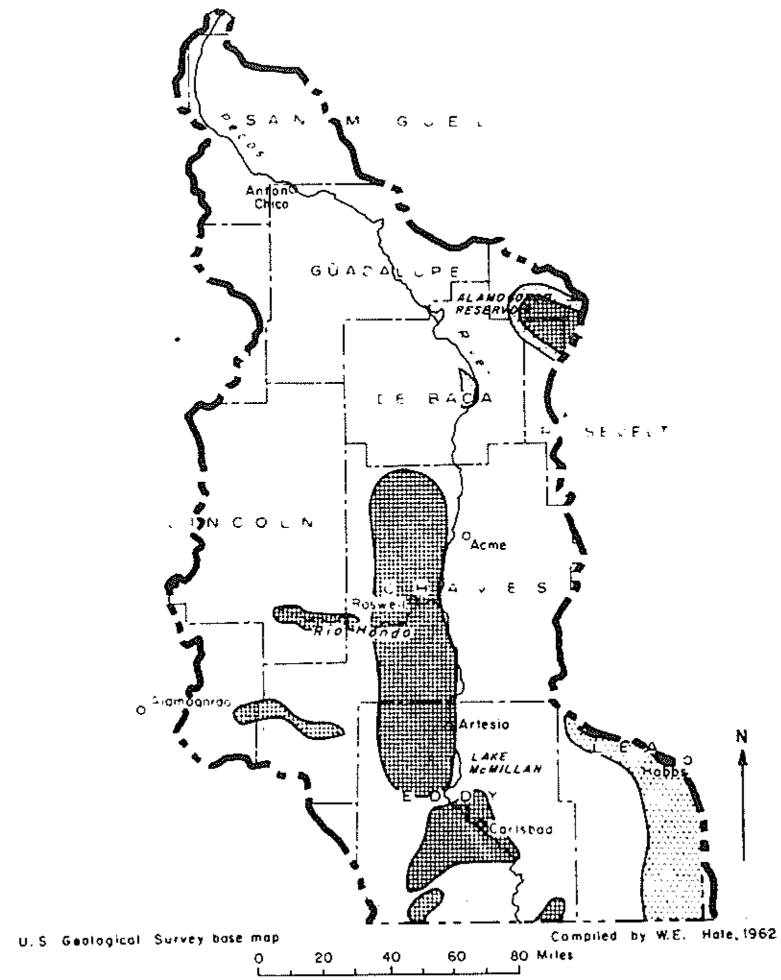


EXPLANATION

Boundary between ground-water units

Unit 1. Headwaters of Pecos River to Anton Chico
Unit 2. Anton Chico to Alamogordo Reservoir
Unit 3. Alamogordo Reservoir to Acme
Unit 4. Acme to Lake McMillan
Unit 5. Lake McMillan to State line

Figure 1.--Principal ground-water units



EXPLANATION

Less than 100 gpm, or areas for which data are inadequate for appraisal

100-300 gpm

More than 300 gpm

Figure 2.--Potential yield of wells

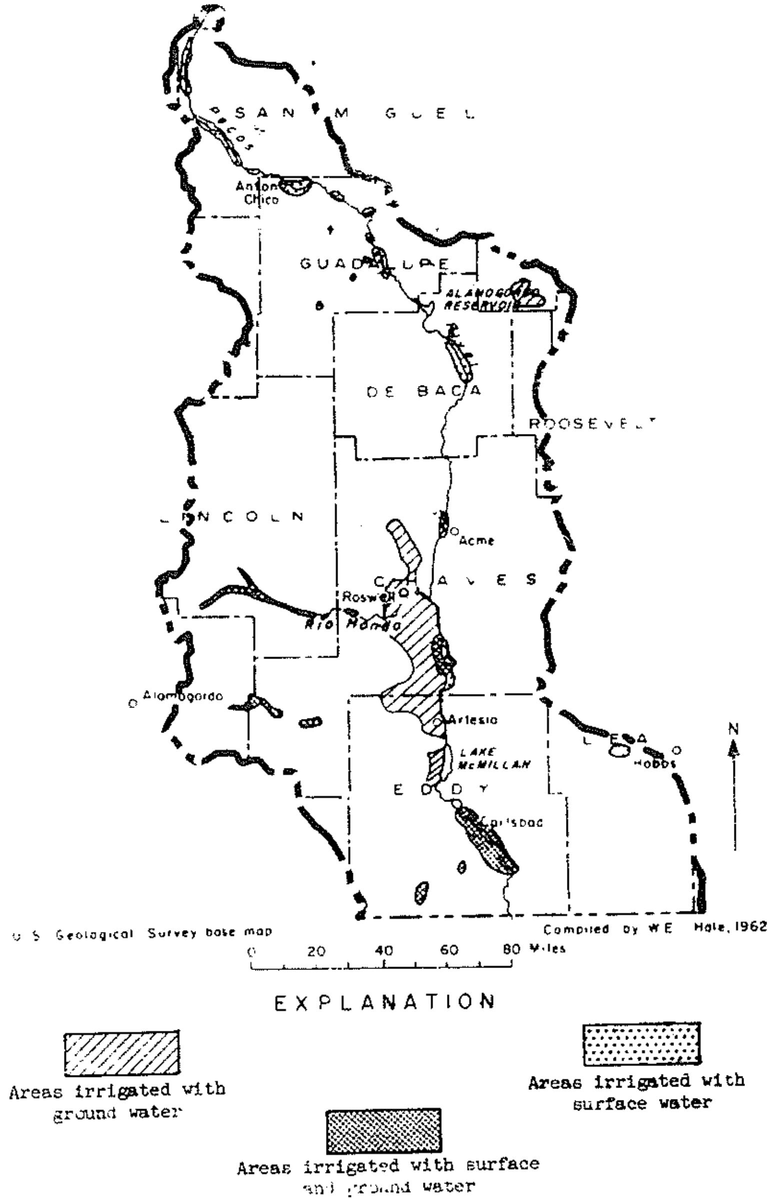


Figure 3.--Areas irrigated by ground water or surface water

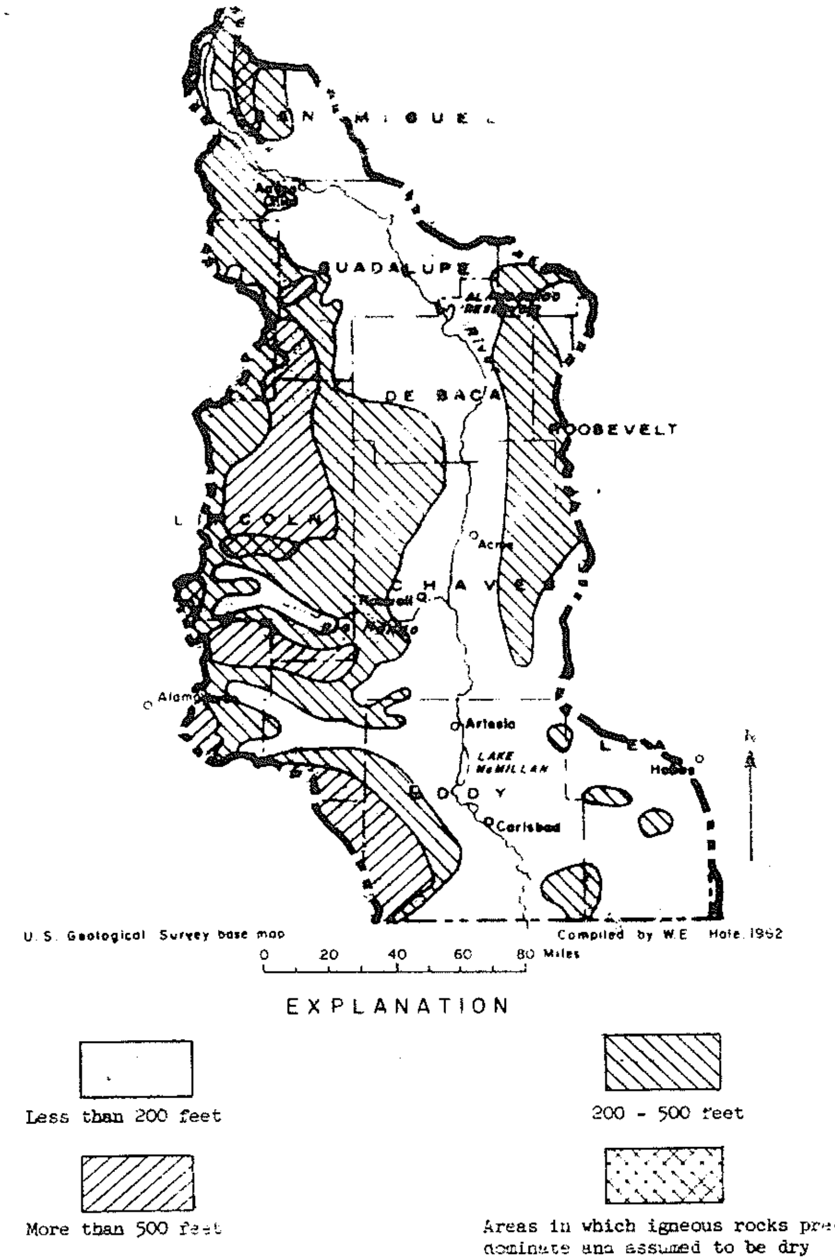


Figure 4.--Depth to ground water below land surface

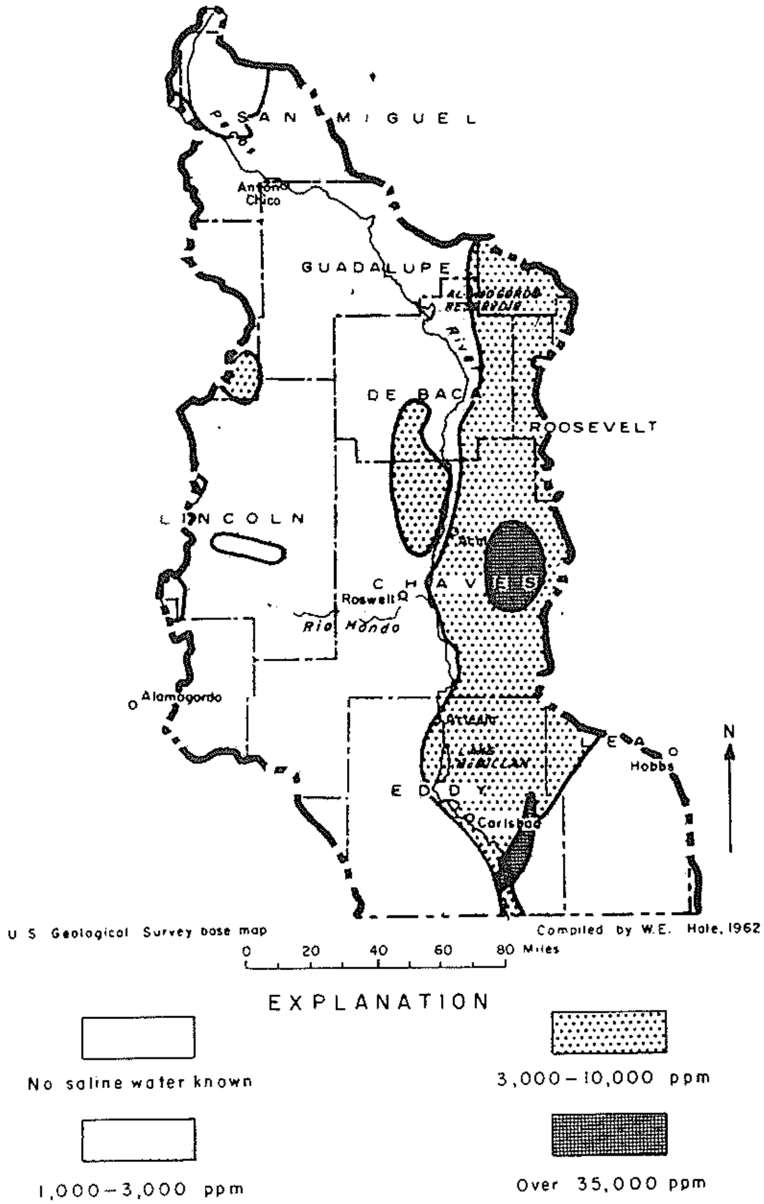


Figure 5.--Salinity of grcund water

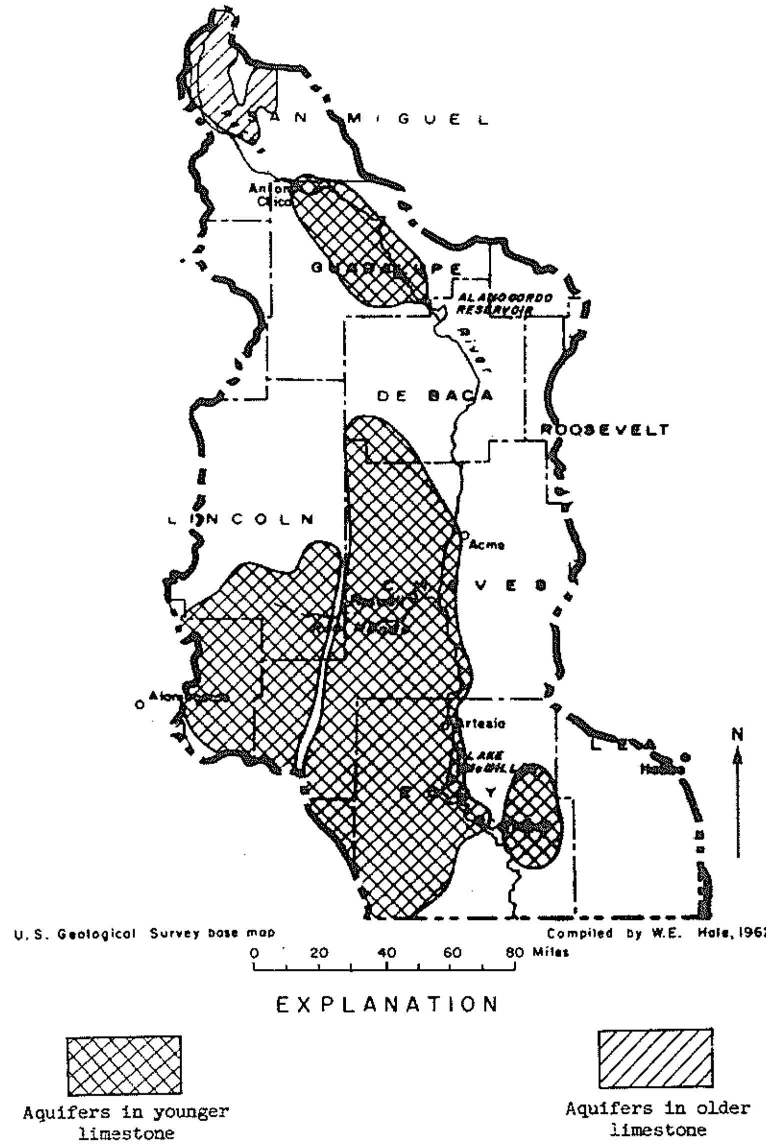


Figure 6.--Limestone aquifers

The potential yield of wells in Unit 2 (fig. 2) and the depth to ground water (fig. 4) is about the same as in the Unit 1 to the north, even though, generally, different aquifers are involved (table 1). However, the overall salinity of the ground water is as high as the most saline ground water in Unit 1 to the north (fig. 5).

The volume of water pumped from Unit 2 is probably fairly small, although it is larger than the volume pumped from Unit 1.

UNIT 3 - ALAMOGORDO RESERVOIR TO ACME

The northernmost usage of ground water for irrigation along the Pecos River is south of Fort Sumner in Unit 3 of the basin (fig. 3). In this area, ground water is pumped from alluvium and used to irrigate fields along the alluvial plain of the Pecos River (table 1 and fig. 8). The potential yield of these wells ranges from 100 to 300 gpm (gallons per minute) (fig. 2). Water levels in the alluvium reflect the elevation of the surface water in the Pecos River and indicate a ground-water gradient roughly parallel to the gradient of the river (written communication, E. C. Chavez, N. Mex. State Engr. Office, 1959). Wells yielding ground water for irrigation in the south Fort Sumner area seldom penetrate to depths greater than 200 feet where beds of clay and silt underlie the loose sand and gravel of the alluvium.

Other aquifers in Unit 3 are listed in table 1 and outlined on figures 6 and 7. These aquifers are developed only for the small volumes of water needed for stock and domestic use. The depth to water in Unit 3 increases to the west (fig. 4), where in some areas of northeastern Lincoln County ground-water levels are more than 1,000 feet below the land surface.

The northernmost large bodies of saline ground water along the Pecos River lie in Unit 3 (fig. 5). The salinity of ground water in all aquifers is such that the water is not suitable for stock or domestic use in much of the area east of the Pecos River. The only non-saline ground water east of the Pecos River in Unit 3 is contained in alluvium, which receives recharge from surface drainageways.

Data are not available on the volume of water pumped from Unit 3, but the volume is undoubtedly greater than that from either Units 1 or 2. Most of the ground-water pumpage is in the irrigated area south of Fort Sumner and in a small area of irrigation in southern De Baca County.

UNIT 4 - ACME TO LAKE McMILLAN

This is the largestand most important unit along the Pecos River, as it encompasses the large ground-water system of the Roswell area. The discharge of ground water from the Roswell area contributes a large

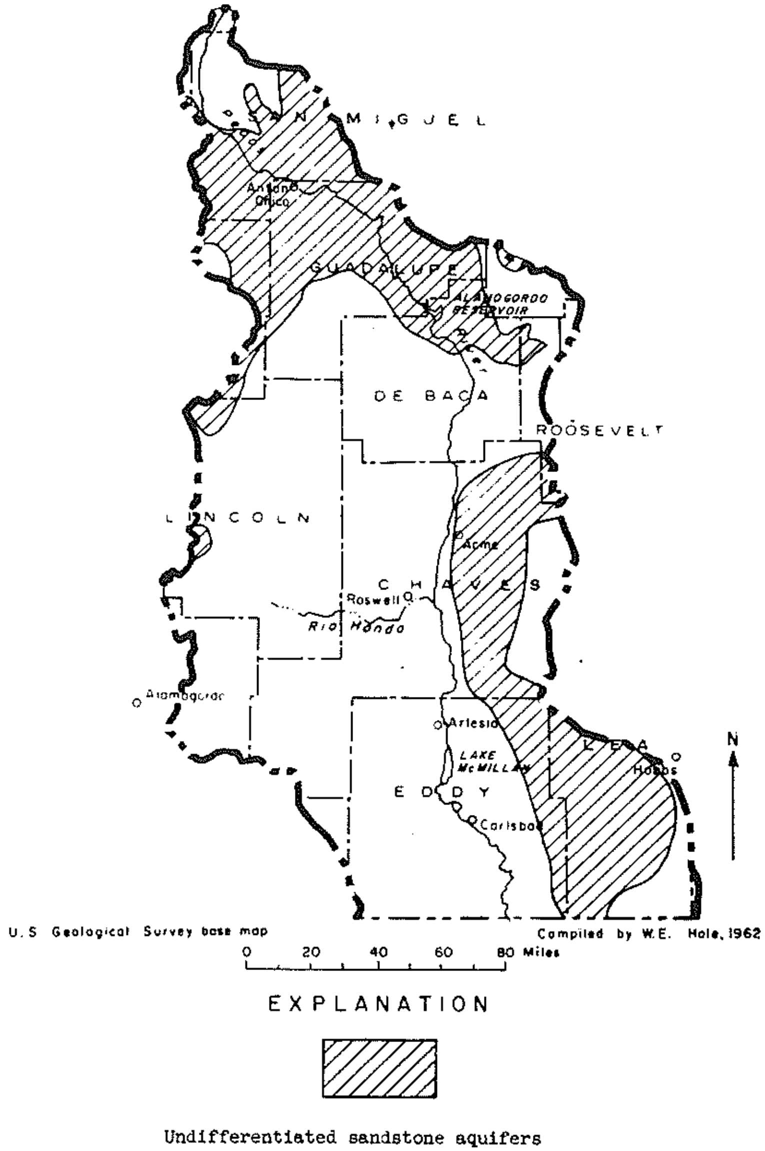


Figure 7.--Sandstone aquifers

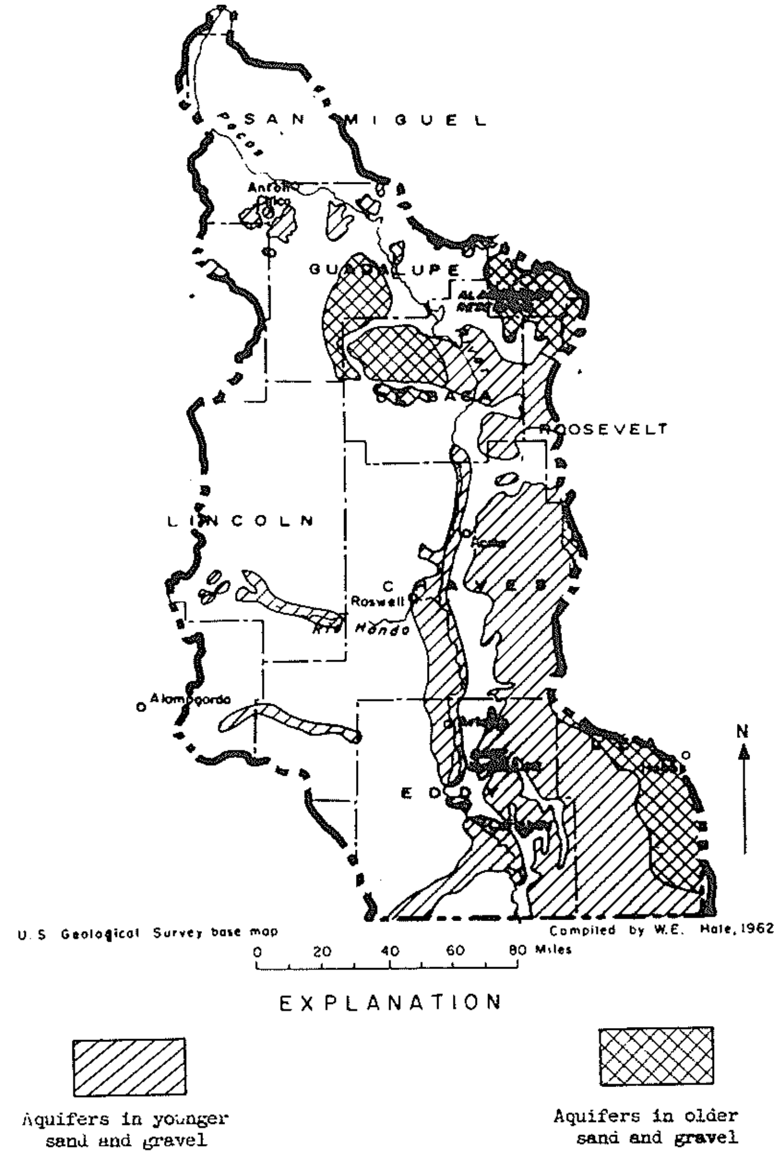


Figure 8.--Sand and gravel aquifers

part of the base flow of the Pecos River along this reach. In recent years, however, decline of ground-water levels due to pumping from both the shallow and artesian aquifers and to extended drought have decreased the volume of ground-water discharge to the river.

Geologic formations composing the shallow and artesian aquifers are given in table 1. The San Andres Limestone which underlies most of the area is the principal aquifer and is the limestone aquifer shown in figure 6. Overlying the San Andres Limestone are the Grayburg and Queen Formations, which do not transmit water as readily as the San Andres Limestone, and which together serve as a confining bed causing the artesian pressures so notable in the Roswell area. Overlying the aquitard is a shallow aquifer in the Seven Rivers Formation and alluvium (fig. 8).

Prior to ground-water development in the Roswell area, water from the San Andres Limestone leaked upward through the aquitard into the shallow aquifer, from which the water discharged into the Pecos River. Large-scale pumping of water from the artesian aquifer, the aquitard, and the shallow aquifer has lowered water levels in the area by the amounts shown in figures 9 and 10. As a consequence, leakage from the artesian to the shallow aquifer has decreased until, at present, ground water leaks from the shallow to the artesian aquifer during most of the year. The net result of the decreased leakage and reversal in the direction of leakage has been a decrease in the volume of gain by the Pecos River.

The quality of the ground water in the Acme-Lake McMillan reach of the basin has deteriorated because of pumping, mainly near the city of Roswell (fig. 5) where water in the artesian aquifer has become more saline, and where the rate of quality deterioration seems to be increasing (Hood and others, 1960). Test wells are presently being drilled to obtain more quantitative information on the ground-water hydrology of the area and to determine the method by which the fresh water is being contaminated.

The potential yield of wells that tap aquifers in Unit 4 is very high (fig. 2). Several wells developed in the artesian aquifer near Roswell have been tested at rates as much as 9,225 gpm. An area-wide average yield of artesian wells is 2,000 to 3,000 gpm. Wells drilled into the shallow aquifer have an average yield of about 1,000 gpm; wells producing from the confining bed have an average yield of 200 to 300 gpm.

Probably due to severe drought, pumpage from Unit 4 has been increasing steadily despite a decrease in irrigated acreage. The volume of ground water pumped from Unit 4 was 499,100 acre-feet in 1964, of which 206,400 acre-feet was pumped from the shallow aquifer and 292,700 acre-feet was pumped from the artesian aquifer.

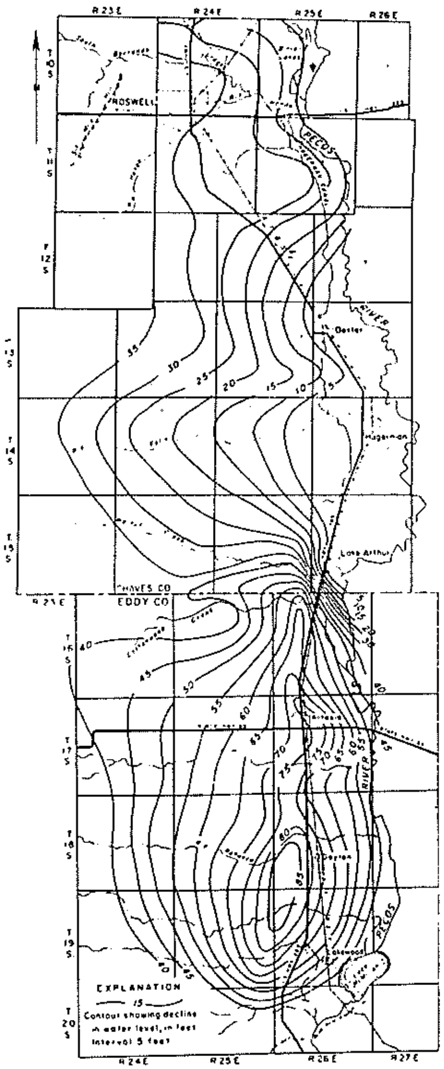


Figure 9.--Decline of piezometric level in the artesian aquifer in the Roswell area, 1944-61.

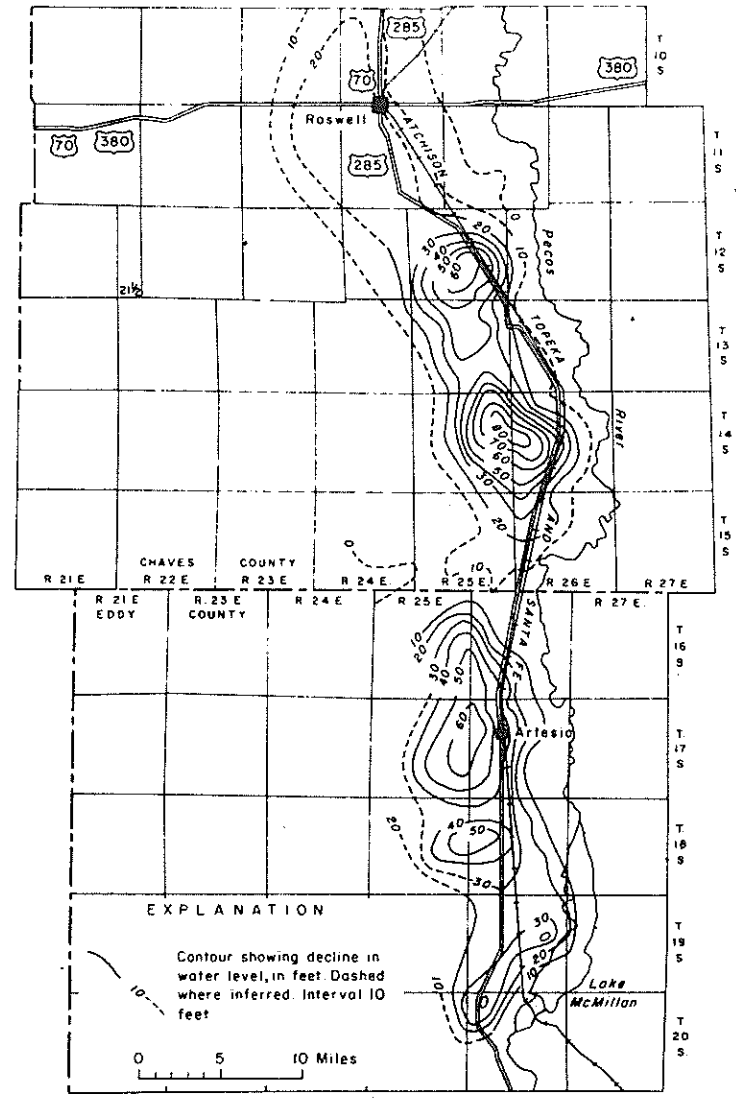


Figure 10.--Decline of ground-water level in the Roswell area 1938-60.

UNIT 5 - LAKE McMILLAN TO STATE LINE

The ground-water unit defined by this reach of the Pecos River is the most complex of all ground-water units associated with the Pecos River and hydrologically may be broken into six zones. The first zone begins near Lake McMillan where both shallow and artesian ground water is discharged out of the Roswell area through the Queen and Seven Rivers Formations. Water also leaks from storage in Lake McMillan and recharges the Seven Rivers Formation and the alluvium south of the lake. Consequently, in an area extending southward one-third the distance from Lake McMillan to Carlsbad, a highly permeable aquifer has developed in the Seven Rivers Formation. Wells drilled into these aquifers should yield a few thousand gallons per minute. (Written communication, E. R. Cox, U. S. Geol. Survey, 1965). Ground water discharged through Major Johnson Springs, about 3½ miles downstream from Lake McMillan, originates from this area of potentially high ground-water yield.

A second ground-water zone extends northward from Carlsbad one-third the distance to Lake McMillan. Here, ground water is obtained from the Tansill and Yates Formations and from the Capitan Limestone, all of which are usually referred to as the limestone aquifer. Wells drilled in this zone have high yields of relatively fresh water. Recharge to the limestone aquifer is from water moving from the southwest through solution openings in the Capitan Limestone. Some additional recharge leaks to this ground-water reservoir from surface water stored north of Carlsbad in Lake Avalon. A third zone lies between zones 1 and 2, and in this zone wells obtain small quantities of water from the Tansill and Yates Formations. In general, this third zone is an area of very low ground-water yield.

A fourth ground-water zone is in alluvium along the Pecos River, extending from Carlsbad to about half-way to the State line. Water in this ground-water zone originates as precipitation on the alluvium, flood water flowing through nearby arroyos, and return flow from irrigation with surface water. Ground water in this zone that is not intercepted by pumping discharges into the Pecos River. Ground-water gradients in the aquifer reflect the elevation of surface water in the Pecos River. A fifth ground-water zone lies south and west of Carlsbad where alluvium along a surface drainage forms a ground-water reservoir. The ground water is not hydraulically connected to the alluvial aquifer south of Carlsbad, but discharges through springs into the surface-water drainage and eventually reaches the Pecos River. A sixth ground-water zone extends northward one-half the distance from the State line to Carlsbad. Yields of wells are very low in this zone and most of the water is for domestic and stock use.

Quality of water in Unit 5 varies widely. Fresh water occurs in the limestone aquifer in the Guadalupe Mountains and saline water occurs near the Pecos River in the same aquifer and in the alluvial aquifer. In general, ground water near the Pecos River reflects the quality of the water in the river, except near the Malaga Bend of the Pecos River, about 20 miles south of Carlsbad, where a body of highly saline ground water exists (fig. 5).

Wells in Unit 5 yield as much as 3,500 gpm from the alluvium and as much as 2,550 gpm from the limestone aquifer. Wells in the low-yield zones yield from less than 1 to more than 50 gpm; most wells produce less than 10 gpm.

Ground-water pumpage from Unit 5 amounted to 79,000 acre-feet in 1964. Ground water pumped from the limestone aquifer accounted for 17,000 acre-feet of the total, and was pumped for municipal use (7,500 acre-feet), industrial use (3,500 acre-feet), and irrigation (6,000 acre-feet). All water pumped from the alluvium (62,000 acre-feet) was used for irrigation.

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