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SUMMARY OF THE GROUND-WATER AQUIFERS IN THE RIO GRANDE BASIN

By

Richard C. Peckham, Geologist
Ground Water Division

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INTRODUCTION

Ground-water reconnaissance investigations were made in the Rio Grande Basin in 1960 and 1961 as part of a statewide program to determine the order of magnitude of ground-water supplies potentially available from the principal water-bearing formations of the State. The approach to water planning in Texas is by river basins; thus, the ground-water investigations were conducted by river basins so that the result could be integrated with information on surface water by agencies and groups concerned with planning the development of the State's water resources. The investigations were conducted by personnel of the Texas Water Commission and U. S. Geological Survey under a cooperative agreement between the two agencies. Because of the large areal extent of the Rio Grande Basin, it was divided into three parts to facilitate the investigations and the reporting of the results. These three divisions, the Upper Rio Grande Basin, Middle Rio Grande Basin, and the Lower Rio Grande Basin, are shown on Figure 1. Separate manuscript reports have been prepared on each of these divisions and are on file in the Austin office of the Texas Water Commission.

The manuscripts resulting from the various basin investigations are being prepared for publication as funds become available. The basin reports are being published in sequence across the State from east to west. Therefore, the three Rio Grande Basin reports probably will not be published before late 1964 or early 1965. Because of the delay in publishing the Upper, Middle, and Lower Rio Grande Basin reports, this summary on the aquifers has been prepared to make information contained in these reports available at an earlier date. The summary also pulls together data contained in the three independently prepared reports and presents it for the entire Rio Grande Basin.

The total area of the Rio Grande Basin, as considered in this report, covers an area of about 49,000 square miles from El Paso to Brownsville. The Texas part of the basin is quite broad above the mouth of the Devils River and tapers down to a narrow area bordering the river south of the Devils River. Included in the Rio Grande Basin are two large closed basins which do not contribute surface-water runoff to the Rio Grande or its tributaries. These closed basins are considered within the Rio Grande Basin because they do affect the occurrence and availability of ground water in the Rio Grande Basin. One of these basins is located in parts of Hudspeth, Culberson, Jeff Davis and Presidio Counties and covers approximately 4,300 square miles. The other closed basin includes parts of Andrews, Loving, Winkler, Ector, Ward, Crane, and Upton Counties and covers an area of approximately 3,200 square miles. These closed basins are shown on Figures 2 and 3.

The rainfall in the Rio Grande Basin varies from an average of about 8 inches annually at El Paso, to about 14 inches at the mouth of the Pecos River, to about 26 inches in the lower valley. Net evaporation rates average from about 90 inches annually in the Big Bend country, to about 70 inches at the mouth of the Pecos River, to about 35 inches at Brownsville.

PRIMARY AQUIFERS

Practically all of the geologic formations in the Rio Grande Basin yield some water, but relatively few formations yield sufficient quantities of usable water to be considered as principal water-bearing formations. The principal aquifers of the Rio Grande Basin have been classified as primary or secondary according to their importance within the basin. A primary aquifer is defined as an aquifer capable of supplying large quantities of water over a large area of the basin. The Cenozoic alluvial and bolson deposits, and the Edwards Limestone-Trinity sands are classified as primary aquifers. The location of these aquifers is shown on Figure 2.

Cenozoic Alluvial and Bolson Deposits Aquifer

The Cenozoic alluvial and bolson deposits occur in four separate areas of the Rio Grande Basin. The areas are: the El Paso area in western and southern El Paso County and southwestern Hudspeth County; the Salt Basin area in northeastern Hudspeth, western Culberson, and western Jeff Davis Counties; Pecos Valley area in Andrews, Loving, Winkler, Ward, Crane, Reeves, and northern Pecos Counties; and the lower Rio Grande Valley area in southern Starr and Hidalgo Counties, western Cameron County, and the southern part of Willacy County (most of the lower Rio Grande Valley area is outside of the Rio Grande Basin).

El Paso Area

The bolson deposits consist of unconsolidated sand, gravel, clay, and caliche, derived primarily from the weathering and erosion of local rock. The sediments have accumulated in two large basin-like depressions west and east of the Franklin Mountains. The deposits range in thickness from a few feet to more than 4,900 feet. The alluvial deposits occupy a large part of the Rio Grande Valley between Anthony, north of El Paso, and Fort Quitman in Hudspeth County, and mantle the bolson deposits. The alluvial deposits consist of poorly sorted sand, gravel, clay, and silt. The thickness of these sediments is probably not more than 200 feet in the river valley and considerably less in the upland areas. Because of the hydraulic connection between the alluvial and bolson deposits, they are considered as one aquifer.

Ground water in the aquifer generally occurs under water-table conditions and has a gradient of about 4 feet per mile toward the south-southeast except in areas of concentrated withdrawal where cones of depression in the water table have reversed the gradient. In some areas, especially in the Rio Grande Valley, the ground water passes beneath relatively impermeable sediments and occurs under artesian conditions. The depth to the base of fresh water extends down to as much as 1,400 feet below the land surface in the western part of the aquifer. East and southeast of El Paso the base of usable-quality water is much shallower.

Recharge to the bolson deposits is by infiltration of runoff from the mountains, precipitation on the surface, and underflow from New Mexico. Recharge to the shallow alluvium is principally by infiltration of surface water applied to the land surface for irrigation, but also to a lesser extent by upward movement of water from the underlying bolson deposits, seepage from canals, and precipitation on the valley floor. Ground water in the bolson deposits is discharged naturally by upward movement into the shallow alluvium where it is lost by evaporation, drainage flow, and seepage to the Rio Grande. Large quantities of water are discharged from the bolson deposits through wells, and in localized areas pumping has caused water in the alluvium to move into the bolson. Although some water is discharged from the aquifer into the Rio Grande, the ground water does not contribute to the downstream flow of the river, primarily owing to the high evaporation losses in the area.

The depth to water ranges from about 400 feet in the upland areas to about 2 feet in the river valley. Water levels in some areas of the aquifer have declined steadily since 1936, as much as 33 feet in the more heavily pumped areas. Water levels in the alluvium fluctuate chiefly in response to changes in the river level and the availability of surface water for irrigation.

In 1960 the withdrawal of ground water from all sources in the El Paso area was approximately 92,000 acre-feet. Pumpage for municipal purposes accounted for about 56 percent of the water pumped and irrigation accounted for most of the rest. Most of the irrigation occurs in the river valley to supplement surface water supplies from the Elephant Butte Reservoir in New Mexico. Most of the irrigation and public-supply wells have yields greater than 1,000 gpm (gallons per minute). Some of the well yields in the bolson range up to as high as 3,000 gpm; however, the average yield of most wells is from 1,000 to 1,500 gpm. The well yields are lower in the southern end of the aquifer with most wells in southern Hudspeth County producing less than 500 gpm. The specific capacities of wells producing from the aquifer range from 3 to 61 gpm per foot of drawdown and generally average about 20 gpm per foot of drawdown.

The water in the bolson deposits generally contains less than 1,000 ppm (parts per million) dissolved solids. In much of the area, the fresh water in the bolson is overlain by several hundred feet of more saline water, generally ranging from 2,000 to 3,000 ppm dissolved solids. Downstream from El Paso, the ground water in the valley ranges from 1,000 to 6,000 ppm dissolved solids with mineralization generally increasing to the south. The quality of fresh water in some areas of the bolson is slowly deteriorating because of the encroachment of the more highly mineralized water from above and possibly from below the aquifer.

The natural recharge to the bolson sediments in the El Paso area is about 31,000 acre-feet per year. Downstream in the valley, unknown but substantial quantities of recharge enters the alluvium from surface water applied for irrigation. It is estimated that at least 9,000,000 acre-feet of fresh ground water is available from storage in the El Paso area, and an additional large but undetermined amount of more mineralized water is available from storage.

Salt Basin Area

The Cenozoic alluvial and bolson deposits of the Salt Basin extend from the Dell City area on the Texas-New Mexico border in Hudspeth County southward to

Presidio County. The Salt Basin is from 5 to 15 miles in width and is about 130 miles in length. The deposits consist of unconsolidated sand, gravel, clay, and caliche. The deposits range in thickness from 0 to as much as 1,600 feet. Ground water in the aquifer generally occurs under water-table conditions. At the northern end of the aquifer in the Dell City area the water table slopes at a very low gradient to the south, toward the Wild Horse Draw area in west-central Culberson County. At the southern end of the aquifer water moves northward from Jeff Davis County toward the Wild Horse Draw area at a gradient of more than 30 feet per mile. The Salt Basin is without external surface drainage.

Recharge to the alluvial and bolson deposits in the Salt Basin is by infiltration of stream runoff and recirculation of irrigation water and to a lesser extent from precipitation on the land surface. Ground water that is not withdrawn by wells moves generally toward the salt lakes where it is discharged naturally to the atmosphere by evaporation from the water table. In 1959 and 1960 the depths to the water table under the salt lakes were about 3 feet. It is estimated that at least 40,000 acre-feet of ground water is discharged naturally each year by evaporation from the salt lake east of Dell City. Being in a closed basin, none of the ground water in this aquifer reaches the Rio Grande.

In the Wild Horse Draw irrigation area northeast of Van Horn, water levels declined an average of 9 feet from 1953 to 1961. The largest decline in water levels has occurred in the Lobo Flats area of southern Culberson County where the bolson deposits consist of more clay than sand. Since 1951 water levels in the Lobo Flats area have declined from 31 to 73 feet, or an average of 3 to 7 feet per year. Prior to irrigation development in the Wild Horse Draw and Lobo Flats areas ground water was discharged from the aquifer at a salt lake north of Van Horn. The water level declines have caused a reversal in the gradient so that water now moves from the salt lake area toward the irrigation development to the south.

Approximately 36,500 acre-feet of water was pumped from the aquifer in 1960. All but about 500 acre-feet of this pumpage was for irrigation purposes. Most of the ground-water development in the aquifer occurs in the Wild Horse Draw and Lobo Flats areas which have 57 and 53 irrigation wells respectively. In addition, there are approximately 22 wells producing from the aquifer in the Dell City area and 11 wells in Jeff Davis County. The yields of wells in the Wild Horse Draw area range from 600 to 2,450 gpm and have specific capacities ranging from 9.1 to 33.3 gpm per foot of drawdown. In the Lobo Flats area the well yields range from 250 to 900 gpm, and the specific capacities range from 13.9 to 49.0 gpm per foot of drawdown and average about 25 gpm per foot of drawdown.

Most of the water withdrawn from the aquifer in the Wild Horse Draw and Lobo Flats areas is of good quality, satisfactory for most industrial, municipal, domestic, and irrigation uses. In the Lobo Flats area the water is typically low in dissolved solids, chlorides and sulfates. As the water moves northward into the Wild Horse Draw irrigation area there is an increase in the mineralization of the water. The dissolved-solids content of water in 26 wells in the Wild Horse Draw area ranges from 413 ppm near Van Horn to 2,900 ppm near the north end of the area.

The amount of water received by the aquifer each year as recharge is not known. Based on the thickness of the fresh-water-bearing part of the bolson and alluvial deposits that underlie the Wild Horse Draw and Lobo Flats areas, there is estimated to be at least 385,000 acre-feet of fresh water available from storage. This estimate is probably conservative for the entire aquifer.

Pecos Valley Area

The alluvial deposits of the Pecos Valley consist of unconsolidated to partially consolidated sands, silt, gravel, bolders, clay, gypsum, and caliche. The alluvium thickness ranges from 100 to 300 feet over most of the area. There are two troughs where the thickness generally ranges from 600 to 700 feet and in some places is as much as 1,500 feet. The lithology and thickness of the sediments differ widely within short distances, and approximately 50 percent of the total thickness is sand and gravel.

Water in the alluvium is generally under water-table conditions and the water movement is toward the Pecos River. However, because of heavy irrigation pumpage in central Reeves and northwest Pecos Counties, the water-level gradient has been reversed in this area and the water moves toward the areas of pumpage. The hydraulic gradient ranges from about 4 feet per mile in central Ward County to more than 100 feet per mile in the heavily pumped areas.

The aquifer is recharged by infiltration from intermittent streamflow, local precipitation, return irrigation water, and by subsurface flow from the older formations. The Edwards-Trinity aquifer contributes the largest amount of fresh-water recharge to the alluvium through subsurface underflow and from large spring discharges which become recharge to the alluvium. The alluvium also receives some recharge from the Pecos River where large cones of depression caused by heavy pumpage near the river have reversed the water level gradient. This recharge, however, is not entirely desirable as the Pecos River water most of the time is of poorer quality than that of the ground water. Most of the present discharge from the aquifer is through irrigation, industrial, and municipal wells. Water is naturally discharged from the aquifer by evapotranspiration where the water table is close to the surface, and by seeps, springs, and underflow into the Pecos River. The annual discharge of the aquifer is undoubtably much greater than the annual recharge. Although there is some discharge of ground water into the Pecos River there is a net loss of water from the river between the northern and southern boundaries of the aquifer. Most of this loss can be attributed to high evaporation rates and to water losses to the aquifer.

The depths to water in the aquifer range from less than 10 feet to more than 365 feet in the heavily pumped irrigation areas. Water levels declined about 70 feet in the irrigated area of Reeves County from 1949 to 1957. The water-level decline in the Pecos County irrigation area was about 50 feet from 1955 to 1957. Outside of the heavily irrigated areas, water-level declines have been small to moderate.

An estimated 385,000 acre-feet of ground water is pumped annually from the Cenozoic alluvium of the Pecos Valley and about 95 percent of this water is used for irrigation. The yields of irrigation wells generally range between 200 and 2,500 gpm and average about 1,000 gpm.

The quality of water in the aquifer varies with location and depth. Generally, wells penetrating the deeper part of the alluvium will yield water with higher mineral concentrations than the wells producing from the shallower zones. The dissolved-solids content of the water ranges from less than 200 ppm to more than 13,000 ppm. However, most of the water utilized in the area ranges from 1,000 to 4,000 ppm dissolved solids. Wells penetrating the alluvium near the Pecos River generally have a higher dissolved-solids content than wells in the other areas. There has been some increase in the mineral content of water in the aquifer. The increase probably is due to the recirculation of irrigation water and from the movement of water from the Pecos River into the aquifer.

The amount of water the aquifer receives each year as recharge is not known. There is estimated to be on the order 50,000,000 to 60,000,000 acre-feet of ground water available from storage in the aquifer.

Lower Rio Grande Valley Area

The alluvial aquifer of the lower Rio Grande Valley consists of terrace, flood-plain, and delta deposits of the Rio Grande. They are made up of unconsolidated gravel, sand, silt, and clay. The aquifer also includes some clay, silt, sand, and gravel of the Goliad, Lissie, and Beaumont Formations which underlie the alluvium. The aquifer extends along the Rio Grande from below Falcon Dam in Starr County for about 100 miles to Brownsville in Cameron County. In southern Starr County and southwestern Hidalgo County, the aquifer follows a narrow strip along the river 5 to 10 miles wide. From eastern Hidalgo County, it extends northward into Willacy County where its maximum width in Texas is about 28 miles. It also covers the western half of Cameron County. The productive area of the aquifer covers about 950 square miles, most of which lies outside of the Rio Grande Basin in Hidalgo, Cameron, and Willacy Counties. This additional area adjacent to the Rio Grande Basin has been included in this discussion because of its hydrologic connection with the aquifer in the basin. The potential yield of the aquifer in the Rio Grande Basin depends on the amount of water recharged, by the infiltration of precipitation and by seepage from the Rio Grande, and the amount of water withdrawn from the aquifer in the area north of the basin.

Ground water in the upper part of the aquifer generally is under water-table conditions. However, local artesian conditions exist where the water passes under relatively impermeable clays. The maximum thickness of the aquifer is about 700 feet. Its thickness is irregular and is generally less than 500 feet. The best quality of water in the aquifer occurs near the Rio Grande at depths of less than 75 feet in southeastern Starr County, between 50 and 250 feet in southern Hidalgo County, and between 100 and 300 feet in western Cameron County. The hydraulic gradient is to the northeast and east at about 1 to 2.5 feet per mile except in the areas of heavy pumpage where it is steeper.

Recharge to the aquifer is from the percolation of water from the land surface. This water is from precipitation, canals and drains, irrigation return water, and the Rio Grande. Water normally moves from the Rio Grande into the aquifer, except when the river is at its lowest level. Ground water is discharged from the aquifer by pumping wells and by underflow into adjacent formations, evapotranspiration, and seepage into streams and drains and possibly the

Rio Grande when it is at low stage. Most of the ground water discharged before irrigation development started was by transpiration, primarily by mesquite trees. Clearing of a large part of the lower Rio Grande Valley reduced the amount of water discharged by transpiration, and ground-water levels rose until they were near the surface in some localities. Evaporation of water at or near the land surface caused local concentrations of salt to form in the soils which were detrimental to the crops. The shallow water levels made the construction of drains necessary. Water from the aquifer normally does not contribute to the flow of the Rio Grande.

The water levels are near the land surface throughout most of the aquifer. There is direct hydraulic connection between the Rio Grande and the aquifer, and water levels of the aquifer follow the trend of the water level of the Rio Grande although the aquifer levels do not fluctuate as rapidly or as much as the level of the river. Water levels declined about 10 feet between 1954 and 1957 during a period of deficient rainfall. However, the water levels in 1959 following several years of heavy rains were higher than in 1954.

The estimated ground-water withdrawal from the aquifer is approximately 182,500 acre-feet per year. There are about 1,500 irrigation wells, most of which are outside of the Rio Grande Basin, numerous domestic wells, and some industrial and municipal wells obtaining water from the aquifer. Most of the wells range in depth from 100 to 300 feet and have an average yield of about 300 gpm, with several wells reported yielding more than 2,000 gpm.

The aquifer in the lower Rio Grande Valley contains water with less than 3,000 ppm dissolved solids as deep as 700 feet below the land surface in some places. However, the best quality of water occurs above a depth of about 300 feet. The dissolved-solids content of the water increases with depth and also in distance from the river. The dissolved-solids content of water obtained from the aquifer ranges from about 400 to 6,000 ppm. Generally the water in the alluvium contains from 1,000 to 2,000 ppm dissolved solids, and from 1,000 to 3,000 ppm in the underlying Goliad, Lissie, and Beaumont part of the aquifer.

Data are insufficient to permit a quantitative evaluation of the perennial yield of the alluvial aquifer in the lower Rio Grande; however, it is probably large. The perennial yield of the aquifer depends on the amount of water it receives as recharge by infiltration from precipitation, the Rio Grande, the canals and drainageways, and the return water from irrigation. During extended periods of subnormal precipitation, a large amount of water may be pumped from storage in the aquifer. However, as the water levels are lowered, water of inferior quality may move upward and laterally into the aquifer. During periods of normal and above-normal precipitation, water levels will be near the land surface and drainage problems may develop.

Edwards-Trinity Aquifer

The Edwards-Trinity aquifer covers a large area of the middle Rio Grande Basin, extending from southern Reeves County to the middle of Kinney County. The Edwards-Trinity aquifer is composed of water-bearing sands and limestones of the Washita, Fredericksburg, and Trinity Groups. The upper part of the aquifer is made up of the Georgetown, Edwards, and Comanche Peak Formations. The Georgetown Formation is composed of medium to thick-bedded limestone interbedded with marl and clay and ranges in thickness from 0 to 300 feet. The Edwards Formation consists of thick-bedded limestone and has a thickness ranging up to 800 feet in the subsurface. The Comanche Peak Formation consists of thin to medium-bedded, nodular limestone interstratified with marl. The lower part of the aquifer is made up of sands of the Trinity Group which consists of fine to coarse-grained quartz sand. The thickness of the Trinity sands is generally less than 100 feet, although in southern Terrell County it is reported to be as much as 300 feet thick. The sands are absent in the southeastern part of the aquifer.

Water in the Edwards-Trinity aquifer occurs in solution cavities and fractures in the limestone and in the underlying Trinity sands. The ground water occurs under both artesian and water-table conditions and in some areas the aquifer is hydraulically connected with the overlying Cenozoic alluvium aquifer in the Pecos Valley. Regionally, the ground-water movement in the aquifer is to the south and southeast except in the immediate vicinity of stream drainages where the water moves toward the streams. In the Pecos Valley the movement of water is toward the Pecos River. The water-level gradient in the aquifer ranges from about 5 feet per mile in northern Crockett County to approximately 100 feet per mile in southeast Val Verde County.

Recharge to the Edwards-Trinity aquifer is derived from precipitation and runoff, both in its outcrop area and in the area where it is overlain by Cenozoic alluvium. Ground water is discharged artificially by wells penetrating the aquifer and is discharged naturally by springs, seeps, evapotranspiration, and by underflow into the overlying alluvium. Some of the more notable springs discharging large quantities of ground water from the Edwards-Trinity aquifer are: the San Solomon and Phantom Lake springs located near Balmorhea in southern Reeves County discharge approximately 30,000 acre-feet annually (Most of this water is used for irrigation or recharges the alluvium and therefore never reaches the Rio Grande); Leon Springs west of Fort Stockton and Comanche Springs at Fort Stockton had a combined flow of approximately 40,000 acre-feet per year prior to 1946 (However, heavy pumpage from the aquifer in this area has stopped the flow of the springs); numerous seeps and springs along the Pecos River between Girvin and the mouth of the Pecos River contribute approximately 93,000 acre-feet of water annually; Goodenough Springs, located along the Rio Grande between the Pecos and Devils Rivers, yields approximately 100,000 acre-feet annually; numerous small springs and seeps along the Devils River yield approximately 300,000 acre-feet of water annually; San Felipe Springs at Del Rio contributes 55,000 acre-feet annually (However, much of this water is used by the city of Del Rio); Mud Springs and Pinto Springs in Kinney County contribute about 7,000 acre-feet; Los Moras Springs at Brackettville contributes about 15,000 acre-feet annually (However, some of this water is used by the town of Brackettville); and between the western edge of the aquifer in Brewster County and Langtry near the Pecos River junction with the Rio Grande, there is a pick-up in river flow of approximately 160,000 acre-feet which is attributed to springs and seeps along the drainageways of the Rio Grande and its tributaries. There is estimated to be between 700,000 and 800,000 acre-feet of ground water contributed to the flow of the Rio Grande each year from the Edwards-Trinity aquifer, between Brewster and Kinney County.

The water levels in the Edwards-Trinity aquifer range from above the land surface at several springs to as much as 900 feet below the land surface in the southern part of the aquifer. There has not been any large-scale decline of water levels in the Edwards-Trinity aquifer, although the water levels have been lowered sufficiently in the Fort Stockton area to cause the springs in the area to stop flowing.

Approximately 150,000 acre-feet of water is pumped from the aquifer each year with most of the pumpage being for irrigation in the western part of the aquifer. The yields of wells range from a few gallons per minute to as much as 3,000 gpm. The yields of wells producing only from the sands of the aquifer are much smaller than the yields of some of the limestone wells.

The dissolved-solids content of the water in the northwest part of the aquifer ranges from less than 500 ppm to more than 5,000 ppm with most of the wells having between 1,000 and 3,000 ppm. In the southern part of the aquifer, the concentrations of dissolved solids range from less than 200 ppm to about 2,900 ppm with most of the wells having less than 1,000 ppm.

It would not be possible to intercept all of the water now being discharged naturally through seeps and springs from the Edwards-Trinity aquifer. Of the 700,000 to 800,000 acre-feet being discharged annually, it may be possible through well development over the aquifer to intercept on the order of 400,000 to 500,000 acre-feet annually.

SECONDARY AQUIFERS

In addition to the primary aquifers of the Rio Grande Basin there are six secondary aquifers which supply ground water in the basin. The locations of these aquifers are shown on Figure 3. A secondary aquifer is defined as an aquifer capable of supplying large quantities of water in small areas or relatively small quantities of water in large areas of the basin. The Bone Spring and Victorio Peak Limestones, Igneous rocks, Marathon Limestone, Santa Rosa Sandstone, Rustler Formation, and Capitan Reef complex and associated limestones are classified as secondary aquifers.

Bone Spring and Victorio Peak Limestones

The Bone Spring and Victorio Peak Limestones occur in the Dell City area of the Salt Basin, in the northeast corner of Hudspeth County. The Bone Spring and Victorio Peak Limestones crop out in a narrow belt along the west-facing escarpment of the Guadalupe Mountains. They pass beneath the alluvial surface of the Salt Basin and crop out again to the west on the Diablo Plateau. In the Dell City area they are overlain by 5 to 150 feet of alluvial deposits. The Bone Spring Limestone consists of black cherty, dense, fine-textured, thin-bedded limestone and is at least 500 feet thick. The Victorio Peak Limestone is a succession of thick-bedded layers of gray limestone having a total thickness of about 800 feet. Ground water in this aquifer occurs in joints, cracks, and solution caverns of the limestone and in most places is under artesian pressure. The distribution of the openings in the limestone is erratic, making it possible to drill dry holes in the immediate vicinity of wells yielding several thousand gallons per minute. Recharge to the aquifer occurs to the west, and to the north in New Mexico. Prior to 1948 when the large-scale irrigation development started in the Dell City area, water moved toward the southeast and was discharged by upward seepage into the overlying alluvium and out of the basin as underflow. In 1960, approximately 100,000 acre-feet of water was pumped from about 200 wells tapping the aquifer. The irrigation development which has taken place caused a steady water-level decline from 1948 to 1961. Water-level declines during this period ranged from 16 to 21 feet and averaged 18.5 feet. The yields of wells range from 160 to 2,240 gpm. The specific capacities of the wells range from 5.2 to 63.8 gpm per foot of drawdown. The water from the aquifer is generally poor and is generally suited only for irrigation. Chemical analyses of the water show a dissolved-solids content ranging from about 1,000 ppm to about 8,000 ppm. The quality of water has also deteriorated during the period since 1948.

Igneous Rocks

Igneous rocks cover an extensive area in Jeff Davis, Presidio, and the northwestern part of Brewster Counties. The igneous rocks are volcanics, consisting of a succession of solidified lava flows with associated tuffs and unconsolidated sand, gravel, and silt. The maximum thickness of the rocks is not known, but it has been reported in various places to occur as much as 4,000 feet or more in depth. The primary water-producing area of the igneous rocks occurs from Marfa southward along Alamito Creek, covering approximately 80 square miles. The thickness of the water-bearing zone in this area is approximately 700 feet. The water generally occurs under artesian conditions and moves south toward the Rio Grande. Recharge to the aquifer is derived from precipitation, runoff from the mountains, seepage of surface water applied to the land surface for irrigation, and underflow of ground water from other rocks in the area. Recharge is estimated to be about 8,000 acre-feet per year. Discharge from the aquifer primarily is by subsurface flow into the alluvial deposits which cover the Alamito Creek Valley and from wells. Pumpage in 1960 was about 8,300 acre-feet and was primarily used for irrigation. Some of the well yields were as much as 1,000 gpm. Water levels in the Marfa area have generally shown a slight rise during the period 1942 to 1959. Water from the igneous rocks in this area is of good quality, generally containing less than 500 ppm dissolved solids.

Marathon Limestone

The Marathon Limestone contains fresh water in the vicinity of the town of Marathon, in the north-central part of Brewster County. The Marathon limestone crops out in the town of Marathon and has a thickness ranging between 350 to 900 feet. It consists principally of a dark gray, flaggy limestone, gray and green shale, sand, sandstone, and conglomerate. Water occurs under water-table conditions in the vicinity of Marathon in crevices, joints, and cavities in the limestone. Further to the south, the aquifer is buried beneath younger formations and the water occurs under artesian conditions. Most of the ground water in the Marathon area moves toward the south and southeast. Recharge to the aquifer is by precipitation and steam runoff in the outcrop area. Ground water is discharged artificially by wells in the Marathon area and naturally by springs, evapotranspiration, and underflow into other rocks south of the area. The yields of wells in the Marathon Limestone are small and do not exceed 50 gpm, but the largest spring in the area flows about 300 gpm. Water from the Marathon Limestone is generally of good quality and is used primarily for domestic and livestock purposes in the vicinity of Marathon. The dissolved-solids content of the water generally ranges between 500 and 1,000 ppm.

Santa Rosa Sandstone

The Santa Rosa Sandstone extends from eastern Loving County and western Ward County eastward to Reagan County. Santa Rosa Sandstone is composed of reddish-brown and gray sandstone cemented with calcite and silica, and contains some red and green shale. Water in the Santa Rosa occurs both under artesian and water-table conditions, but generally is under artesian pressure. The sandstone ranges from a few feet to more than 300 feet in thickness. Recharge to the aquifer is from infiltration of precipitation on its outcrop and through the overlying alluvium. Ground water is discharged from the aquifer through wells, evapotranspiration, and upward seepage into the overlying beds. Most of the well yields are small, not more than 300 gpm; however, a few wells have reported yields of more than 1,000 gpm. The heaviest concentration of pumpage occurs in central Winkler and northeastern Reeves Counties. The dissolved-solids content of water from the aquifer ranges from 55 to 3,600 ppm, with most of the samples having dissolved-solids concentrations of more than 1,000 ppm. The annual pumpage from the Santa Rosa is approximately 23,000 acre-feet per year, most of it being for irrigation purposes.

Rustler Formation

The Rustler Formation extends over a large area of the Pecos Valley and consists mainly of dolomite, limestone, and anhydrite with a basal sand conglomerate and some shale. The Rustler is about 200 to 500 feet thick and occurs at depths of several hundred to about 1,800 feet in most of the area of use. Water production from the Rustler is from vugular and cavernous zones in the dolomite and limestone. Porosity of the aquifer varies greatly from place to place and the yields of wells vary accordingly, from a few gallons per minute to as much as 1,100 gpm. Generally the more productive zones yield from 500 to 1,000 gpm. Recharge to the Rustler is by precipitation and seepage from streams in its outcrop area in the Rustler Hills of eastern Culberson County. Also, some water may recharge the aquifer from equivalent permian rocks in the southern part of Pecos County. Ground water is discharged from the aquifer by wells, seeps, springs, and vertical leakage upward into the overlying strata. Depths to water range from the land surface at flowing wells to more than 400 feet in the heavily pumped areas. Approximately 9,000 acre-feet of water per year is pumped from the Rustler Formation for irrigation purposes. The dissolved-solids content of the Rustler water ranges from about 2,000 to 6,000 ppm and includes large amounts of sulfate.

Capitan Reef Complex and Associated Limestones

The Capitan Reef complex and associate limestones is productive in a narrow belt trending south-southeast through Winkler, Ward, and Pecos Counties. The aquifer consists of reef limestones and backreef beds of dolomite, limestone, sand, shale, and evaporites. The aquifer is as much as 2,000 feet thick, and depths to the top of the aquifer range from 2,400 to 3,600 feet below the land surface. Recharge to the aquifer is primarily from precipitation in its outcrop areas in the surrounding mountains. Ground water is discharged from the aquifer by wells and upward movement into the overlying formations. Water in the aquifer occurs under artesian conditions and in some cases wells will flow. Well yields are generally large, some as much as 2,000 gpm. Water from the aquifer generally contains high concentrations of dissolved solids, sulfates, and chlorides. The dissolved solids range from about 3,000 to 6,000 ppm and the water is highly corrosive. Approximately 12,600 acre-feet of water from the aquifer each year is used for irrigation purposes. In addition, large quantities of the highly mineralized water is used by the oil industry for water-flooding purposes.

Armstrong, C. A., and McMillion, L. G., 1961, Geology and ground-water resources of Pecos County, Texas: Texas Board Water Engineers* Bull. 6106, v. I and II, 536 p.

Baker, R. C., 1962, Reconnaissance investigation of the ground-water resources of the Lower Rio Grande Basin, Texas: Texas Water Commission [unpublished manuscript report], 42 p.

Baker, R. C., and Dale, O. C., 1961, Ground-water resources of the Lower Rio Grande Valley area, Texas: Texas Board Water Engineers* Bull. 6014, v. I and II, 428 p.

Bennett, R. R., and Sayre, A. N., 1962, Geology and ground-water resources of Kinney County, Texas: Texas Water Commission Bull. 6216, 92 p.

Brown, J. B., Roger, L. T., and Baker, B. B., 1962, Reconnaissance investigation of the ground-water resources of the Middle Rio Grande Basin, Texas: Texas Water Commission [unpublished manuscript report], 83 p.

Cronin, J. G., 1961, A summary of the occurrence and development of ground water in the Southern High Plains of Texas: Texas Board Water Engineers* Bull. 6107, 110 p.

Dale, O. C., 1952, Ground-water resources of Starr County, Texas: Texas Board Water Engineers* Bull. 5209, 50 p.

Dale, O. C., and George, W. O., 1954, Ground-water resources of Cameron County, Texas: Texas Board Water Engineers* Bull. 5403, 66 p.

Davis, M. E., 1961, Ground-water reconnaissance of the Marfa area, Presidio County, Texas: Texas Board Water Engineers* Bull. 6110, 44 p.

Davis, M. E., and Leggat, E. R., 1962, Reconnaissance investigation of the ground-water resources of the Upper Rio Grande Basin, Texas: Texas Water Commission [unpublished manuscript report], 145 p.

De Cook, K. J., 1961, A reconnaissance of the ground-water resources of the Marathon area, Brewster County, Texas: Texas Board Water Engineers* Bull. 6111, 54 p.

Follett, C. R., 1954a, Records of water-level measurements in Loving and Ward Counties, Texas: Texas Board Water Engineers* Bull. 5408, 26 p.

_______1954b, Records of water-level measurements in Reeves County, Texas: Texas Board Water Engineers* Bull. 5414, 31 p.

_______1954c, Records of water-level measurements in Culberson, Hudspeth, and Jeff Davis Counties, Texas: Texas Board Water Engineers* Bull. 5415, 34 p.

_______1954d, Records of water-level measurements in El Paso County, Texas: Texas Board Water Engineers* Bull. 5417, 50 p.

Follett, C. R., 1956a, Records of water-level measurements in Kinney, Uvalde, and Val Verde Counties, Texas, 1929 to March 1956: Texas Board Water Engineers* Bull. 5611, 72 p.

_______1956b, Records of water-level measurements in Dimmit, Maverick, and Zavala Counties, Texas, 1920, 1928 to Sept. 1956: Texas Board Water Engineers* Bull. 5617, 76 p.

Garza, Sergio, and Wesselman, J. B., 1959, Geology and ground-water resources of Winkler County, Texas: Texas Board Water Engineers* Bull. 5916, 216 p.

Hood, J. W., and Knowles, D. B., 1952, Summary of ground-water development in the Pecos area, Reeves and Ward Counties, Texas, 1947-51: Texas Board Water Engineers* Bull. 5202, 13 p.

Hood, J. W., and Scalapino, R. A., 1951, Summary of the development of ground water for irrigation in the Lobo Flats area, Culberson and Jeff Davis Counties, Texas: Texas Board Water Engineers* Bull. 5102, 29 p.

Knowles, D. B., 1952, Ground-water resources of Ector County, Texas: Texas Board Water Engineers* Bull. 5210, 117 p.

Knowles, D. B., and Kennedy, R. A., 1956, Ground-water resources of the Hueco Bolson, northeast of El Paso, Texas: Texas Board Water Engineers* Bull. 5615, 270 p.

Leggat, E. R., 1962, Development of ground water in the El Paso district, Texas, 1955-60, progress report no. 8: Texas Water Commission Bull. 6204, 65 p.

Leggat, E. R., Lowry, M. E., and Hood, J. W., 1962, Ground-water resources of the Lower Mesilla Valley, Texas and New Mexico: Texas Water Commission Bull. 6203, 199 p.

Littleton, R. T., and Audsley, G. L., 1957, Ground-water geology of the Alpine area, Brewster, Jeff Davis, and Presidio Counties, Texas: Texas Board Water Engineers* Bull. 5712, 91 p.

Long, A. T., 1962, Ground-water geology of Edwards County, Texas: Texas Water Commission Bull. 6208, 128 p.

Lonsdale, J. T., and Day, J. R., 1937, Geology and ground-water resources of Webb County, Texas: U. S. Geol. Survey Water-Supply Paper 778, 104 p.

Mason, C. C., 1960, Geology and ground-water resources of Dimmit County, Texas: Texas Board Water Engineers* Bull. 6003, 251 p.

Ogilbee, William, and Wesselman, J. B., 1962, Geology and ground-water resources of Reeves County, Texas: Texas Water Commission Bull. 6214, v. I and II, 461 p.

Outlaws, D. E., and others, 1952, Winter Garden district, Dimmit and Zavala Counties and eastern Maverick County, Texas [Records of Wells]: Texas Board Water Engineers* Bull. 5203, 59 p.

Rayner, F. A., 1959a, Records of water-level measurements in Crockett, Glasscock, Reagan, Upton, and Terrell Counties, Texas, 1937 through 1957: Texas Board Water Engineers* Bull. 5903, 23 p.

_______1959b, Records of water-level measurements in Crane and Midland Counties, Texas, 1937 through 1957: Texas Board Water Engineers* Bull. 5906, 14 p.

Sayre, A. N., and Livingston, Penn, 1945, Ground-water resources of the El Paso area, Texas: U. S. Geol. Survey Water-Supply Paper 919, 196 p.

Scalapino, R. A., 1950, Development of ground water for irrigation in the Dell City area, Hudspeth County, Texas: Texas Board Water Engineers* Bull. 5004, 41 p.

Shafer, G. H., 1956, Ground-water resources of the Crane Sandhills, Crane County, Texas: Texas Board Water Engineers* Bull. 5604, 108 p.

Smith, R. E., 1956, Ground-water resources of the El Paso district, Texas, progress report no. 7: Texas Board Water Engineers* Bull. 5603, 36 p.

Stearman, Jack, 1960a, Water-level measurements in Culberson, Hudspeth, and Jeff Davis Counties, Texas: Texas Board Water Engineers* Bull. 6005, 9 p.

_______1960b, Water levels in observation wells in Cameron, Hidalgo, and Starr Counties, Texas, 1950-1959: Texas Board Water Engineers* Bull. 6008, 9 p.

Sundstrom, R. W., and Hood, J. W., 1952, Results of artificial recharge of the ground-water reservoir at El Paso, Texas: Texas Board Water Engineers* Bull. 5206, 21 p.

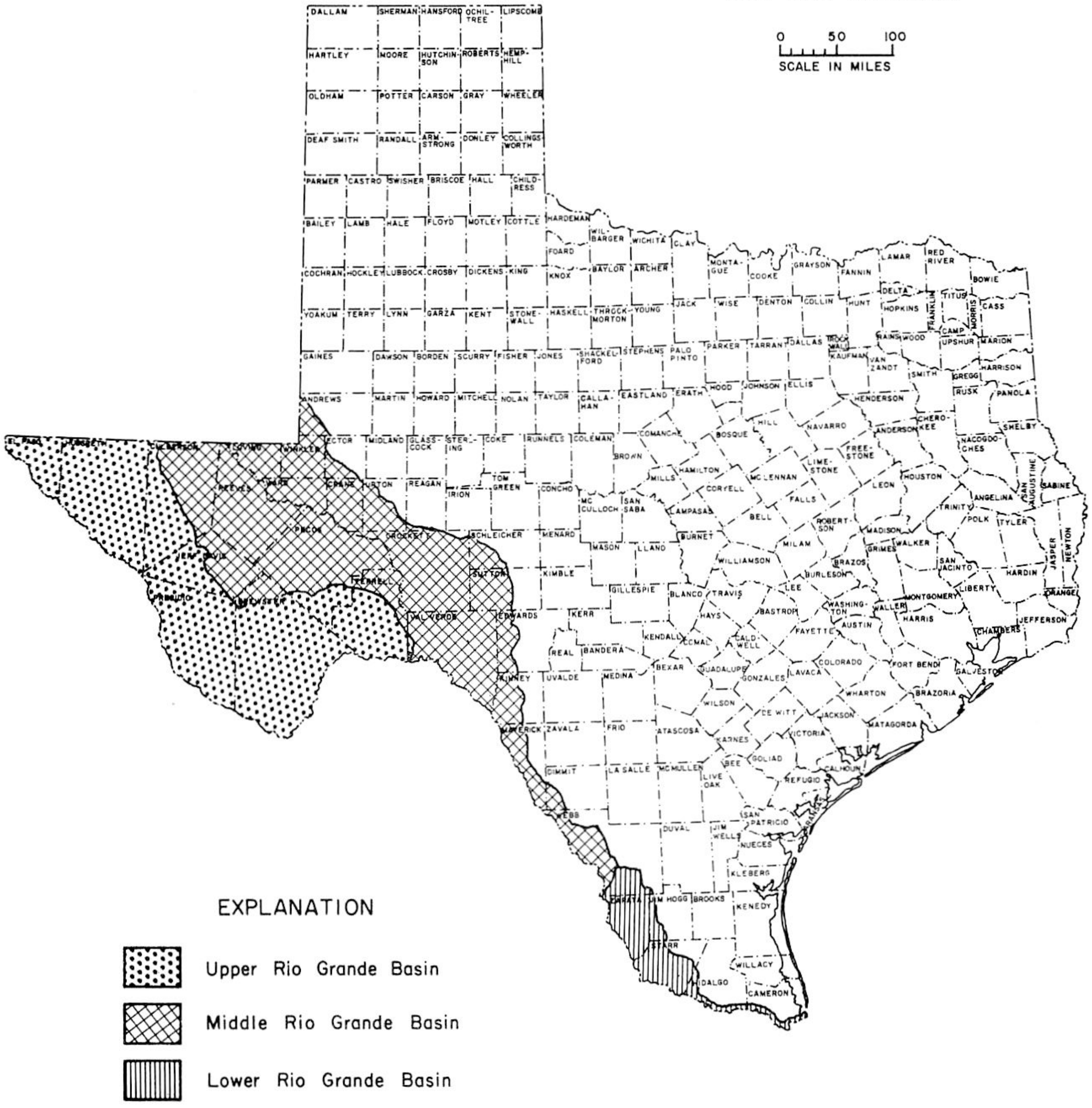
Turner, S. F., Robinson, T. W., and White, W. N., 1948, Geology and ground-water resources of the Winter Garden district, Texas, 1948: U. S. Geol. Survey Water-Supply Paper 1481, 253 p.

* Name of Agency changed to Texas Water Commission January 30, 1962.

Figure I

Map of Texas Showing Location of the Rio Grande Basin

Texas Water Commission



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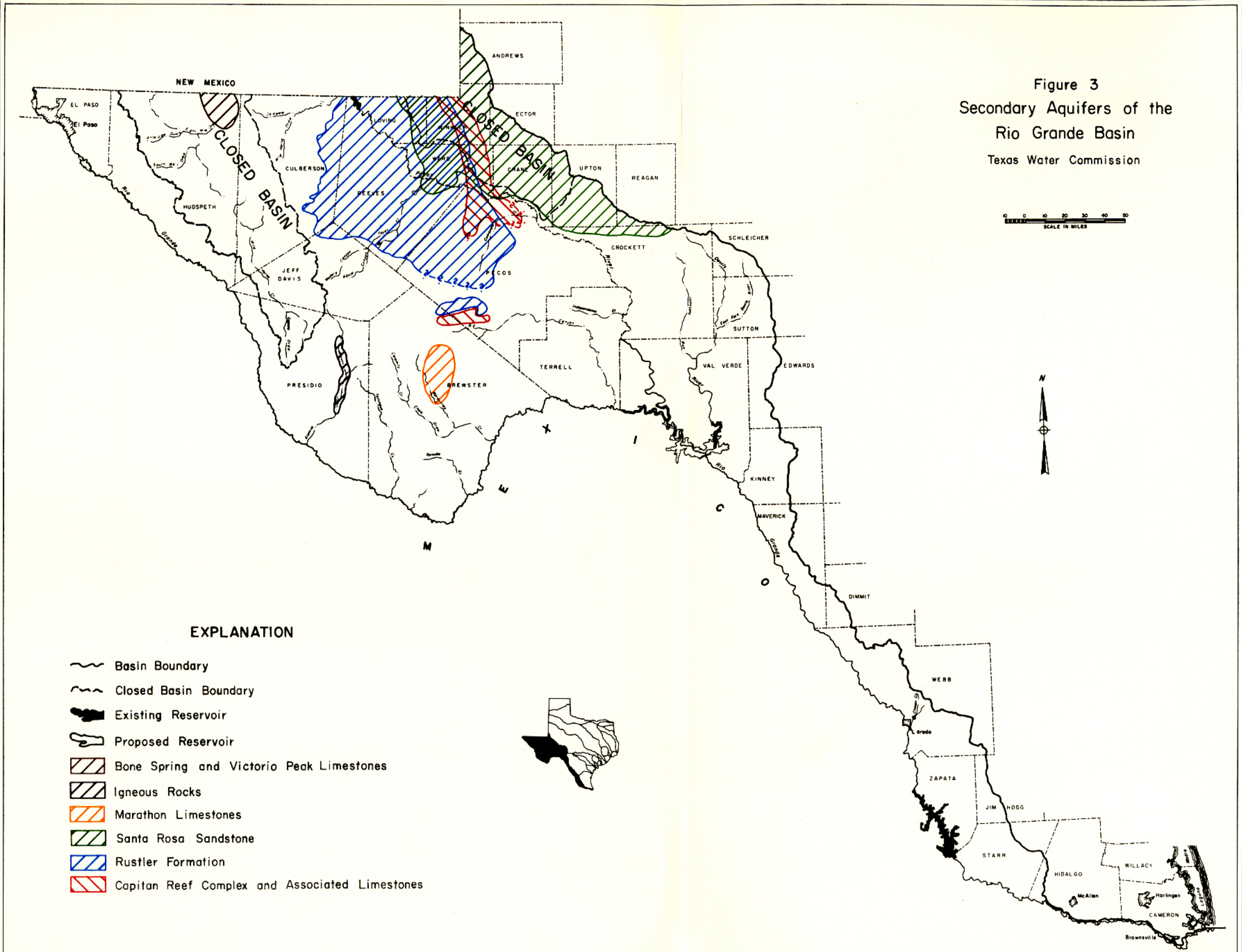

Figure 3
Secondary Aquifers of the Rio Grande Basin
Texas Water Commission
SCALE IN MILES
N
NEW MEXICO
CLOSED BASIN
CLOSED BASIN
M E X I C O
EL PASO
El Paso
HUDSPETH
CULBERSON
LOVING
WINKLER
WARD
REEVES
ANDREWS
ECTOR
CRANE
UPTON
REAGAN
JEFF DAVIS
PECOS
CROCKETT
SCHLEICHER
SUTTON
PRESIDIO
BREWSTER
TERRELL
VAL VERDE
EDWARDS
KINNEY
MAVERICK
DIMMIT
WEBB
Laredo
ZAPATA
JIM HOGG
STARR
HIDALGO
McAllen
WILLACY
Harlingen
CAMERON
Brownsville
EXPLANATION
Basin Boundary
Closed Basin Boundary
Existing Reservoir
Proposed Reservoir
Bone Spring and Victorio Peak Limestones
Igneous Rocks
Marathon Limestones
Santa Rosa Sandstone
Rustler Formation
Capitan Reef Complex and Associated Limestones

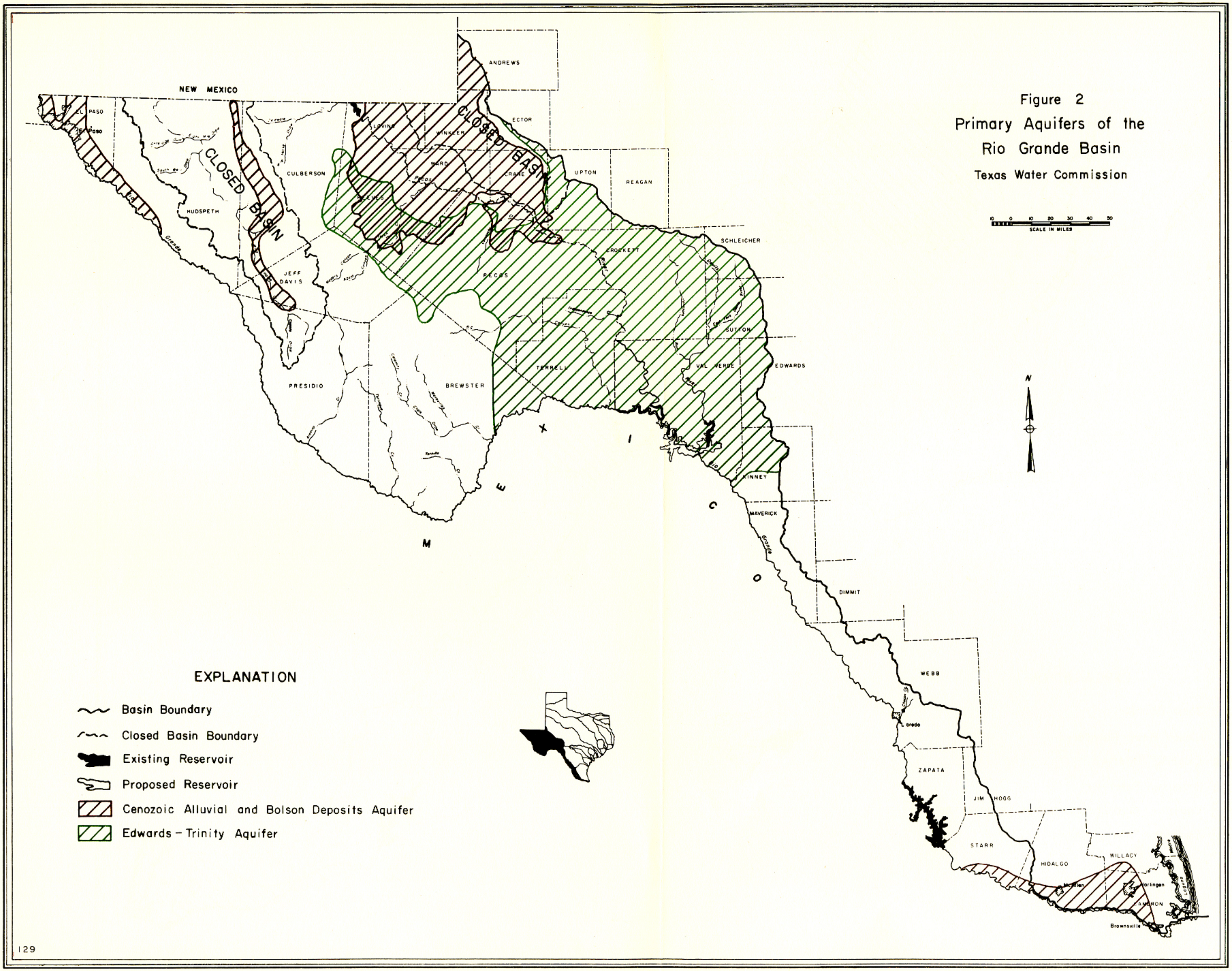

Figure 2
Primary Aquifers of the
Rio Grande Basin
Texas Water Commission