Report 316

Evaluation of Ground-Water Resources in the Lower Rio Grande Valley, Texas

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Texas Water Development Board

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by
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ABSTRACT

In 1985, the Sixty-ninth Texas Legislature enacted House Bill 2, which directed the State water agencies to identify critical ground-water areas within the State of Texas, conduct studies on those areas, and submit the findings along with recommendations on whether a ground-water conservation district should be established in the study area. One area so identified for study is in Cameron, Hidalgo, Starr, and Willacy Counties, collectively known as the Lower Rio Grande Valley. The study area is located at the southern tip of the Texas Gulf Coastal Plain and has a semi-arid climate with low to moderate rainfall and a high rate of evaporation. Agriculture dominates the region's economy.

Water needs for the Lower Rio Grande Valley are provided almost entirely from the Rio Grande via storage in Amistad and Falcon Reservoirs. Surface water accounts for over 97 percent of the total water used in the Valley, with irrigation being the predominant use.

Ground water in the area is produced in small amounts from Eocene-age strata and the Miocene-age Oakville Sandstone in Starr County, and in moderate to large amounts from the Evangeline and Chicot aquifers in Cameron, Hidalgo, and Willacy Counties. Water levels in the study area declined dramatically in the 1950's due to heavy irrigation pumpage and a severe drought. Since the construction of reservoirs on the Rio Grande and the shift to surface-water use, area water levels have been rising steadily.

The chemical quality of ground water over most of the study area is poor and does not meet Texas Department of Health recommended drinking water standards. Dissolved solids usually range from 1,000 to 5,000 milligrams per liter, with sodium, chloride, and sulfate dominating the hydrochemistry. Additionally, high boron and nitrate concentrations appear to be widespread throughout the area. In general, the ground water is unsuitable for irrigation without practicing special agricultural techniques.

In 1985, the total pumpage of ground water in the Lower Rio Grande Valley was 17,268 acre-feet. Total surface-water use was 824,250 acre-feet. Surface water has been and will continue to be the most important source of water supply for the area. Projected total annual water use through the year 2010 does not exceed total water use in the area in 1980. Adequate ground water should be available to meet projected needs through the year 2010.

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INTRODUCTION

Purpose

Recognizing that certain areas of the State were experiencing, or were expected to experience within the next 20 years, critical ground-water problems, the Sixty-ninth Texas Legislature enacted House Bill 2 in 1985. House Bill 2 directed the State water agencies to identify critical ground-water areas, conduct studies of those areas, and submit the findings and recommendations on whether a ground-water conservation district should be established in the respective areas in order to address ground-water problems (Subchapter C, Chapter 52, Texas Water Code).

The study area covered by this report includes Cameron, Hidalgo, Starr, and Willacy Counties, an area collectively referred to as the Lower Rio Grande Valley (Figure 1). In this report, major emphasis is placed on eastern Starr County and all of Cameron, Hidalgo, and Willacy Counties.

Geography

Topography and Drainage

The Lower Rio Grande Valley is the southernmost portion of the Texas Gulf Coast Plain. The most prominent feature of the region is the Rio Grande, which forms the western and southernmost boundaries of the Valley, as well as Texas' border with Mexico.

Most of the Lower Rio Grande Valley forms a broad, flat plain which rises gently from sea level at the Gulf of Mexico in the east to an elevation of approximately 500 feet in western Starr County. The western edge of this plain culminates in a westward-facing escarpment known as the Bordas escarptment. The upland plain consists primarily of unconsolidated sand and clay, while the escarpment is made up of more resistant sandstone and clay.

Drainage in the region is into either the Rio Grande or the Laguna Madre through small coastal streams. The Rio Grande has no large tributaries in the area, but several small intermittent streams drain into the river in Starr County and western Hidalgo County. The Arroyo Colorado floodway is a prominent drainage feature which heads near Mission in southern Hidalgo County, flows east-northeast through western Cameron County to form part of the county line between Cameron and Willacy Counties, and eventually empties into the Laguna Madre.

Much of the drainage in Cameron County empties into the Laguna Madre through former distributary channels of the Rio Grande called resacas. Drainage in northeastern Starr County, northern Hidalgo County, and much of Willacy County is into shallow depressions which form small lakes or ponds; the water dissipates by percolation into the subsurface and by evaporation.

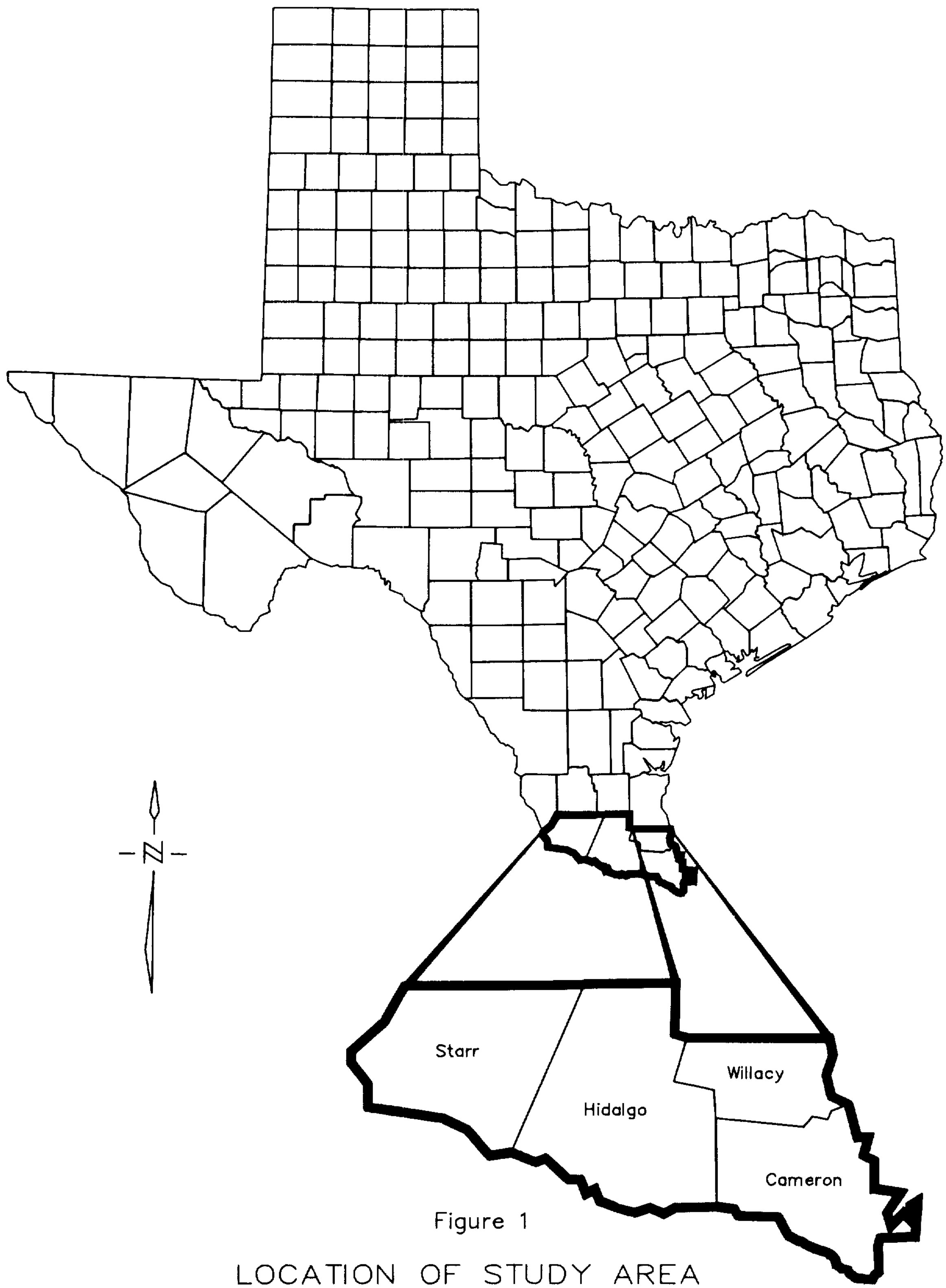


Figure 1

LOCATION OF STUDY AREA

Climate

The climate of the Lower Rio Grande Valley is subtropical and semi-arid. Temperature extremes, either high or low, are very uncommon. The annual average daily low temperature is about 63°F and the daily high temperature averages about 84°F. Summer temperatures usually reach into the mid to upper 90's and winter temperatures can drop into the 20's, though the latter is rare.

The average annual precipitation ranges from about 22 to 26 inches, increasing from west to east across the study area (Figure 2). Most precipitation falls during the spring from April through June, and during the late summer and early fall, from August through October. Spring precipitation is the result of seasonal transition as inflowing warm, moist air from the Gulf of Mexico and the Pacific Ocean generates thunderstorms. The period of late summer to early fall is the hurricane season, during which Atlantic and Gulf storms may move ashore along the Texas or upper Mexican Gulf Coast. These storms can generate tremendous amounts of rainfall over a very short period of time causing extensive flooding due to the flat nature of the terrain.

The average annual gross lake evaporation varies from 81 inches in Starr County to 61 inches in Cameron County. Lake-surface evaporation rates are highest in the summer months (Figure 2).

Economy

The economy of the Lower Rio Grande Valley is primarily agricultural, including both intensive irrigation farming and ranching. In 1985, agriculture generated some $462.5 million for the entire region (Texas Agricultural Statistics Service, 1985). In that same year, approximately 570,000 acres was irrigated, mainly with surface water from the Rio Grande. The area is a leader in the State in the production of citrus fruit, vegetables, and cotton.

Oil and gas production is a secondary, but locally important industry in Hidalgo, Starr, and Willacy Counties. Oil was first discovered in the region in Starr County in 1929. In 1986, 5.9 million barrels of crude oil was produced in the counties of the Lower Rio Grande Valley (Railroad Commission of Texas, 1986).

Tourism is also an important minor industry for Cameron, Hidalgo, and Willacy Counties. Brownsville and McAllen are an important gateway for travel to and from Mexico. In addition, the beach on South Padre Island and numerous state parks attract many visitors. During the fall and winter, the Valley is subject to a large seasonal influx of many retirees from northern states who prefer to winter in south Texas because of the mild climate. Known in the Valley as "winter Texans", these visitors usually arrive in October and return to their home states in April.

Previous Investigations

Numerous ground-water investigations have been conducted on specific areas of the Lower Rio Grande Valley, but only one study has been undertaken covering all four counties of the area. In addition, the area has been included in several regional studies of the Texas Gulf coastal plain and the Rio Grande basin. The results of these studies and investigations were published as reports or bulletins by the Texas Water Development Board or its predecessor agencies.

The principal ground-water study of the Lower Rio Grande Valley was made by the U.S. Geological Society (Baker and Dale, 1961) and published in two volumes as Bulletin 6014 by the Texas Board of Water Engineers. This study covered the geology and ground-water hydrology of the area and addressed the questions of ground-water availability and quality.

Two smaller, more recent ground-water investigations have been conducted by the Texas Department of Water Resources. The first investigation covered ground-water availability and quality in an area northwest of the City of Brownsville in Cameron County (Preston, 1983). The second investigation reported the results of test-hole drilling by the agency near Mission in southwestern Hidalgo County (Molofsky, 1985).

In addition to the above ground-water studies, county reports have been issued for Cameron County (Dale and George, 1954) and Starr County (Dale, 1952). Various basinal and regional reports are also available on the Rio Grande basin and the Texas Gulf coastal plain that include the Lower Rio Grande Valley (Wood, et al., 1963; Baker, 1965; Baker, 1979; Carr, et al., 1985). Geologic mapping of the Lower Rio Grande Valley is best available on the McAllen-Brownsville Geologic Atlas sheet published by the University of Texas Bureau of Economic Geology. Soils surveys published by the Soil Conservation Service of the U.S. Department of Agriculture are available for Cameron, Hidalgo, Starr, and Willacy Counties.

The Texas Water Development Board, in accordance with its legislatively mandated data-collection activities, maintains a network of 49 water-level observation wells in the four counties of the Lower Rio Grande Valley, which are visited annually to obtain water-level measurements. In addition, as part of its water-quality monitoring program, the agency has 774 chemical analyses of water samples collected from 257 wells.

Acknowledgements

This report was prepared under the general supervision of Robert L. Bluntzer, Henry J. Alvarez, and Dr. Tommy Knowles of the Texas Water Development Board.

GEOHYDROLOGY

Geology

Structure

Since the end of the Mesozoic era tens of thousands of feet of eroded material from the North American Continent have been steadily deposited into the Gulf of Mexico basin in series of cross-cutting and overlapping layers of fluvial, lacustrian, and eolian sediments onto a thick progradational deltaic and continental-slope platform (Galloway, 1982). From time to time this basin has subsided in order to accept this tremendous amount of clastic debris. During brief, intermittent periods of Cenozoic history, when the rate of deposition was less than the rate of basinal subsidence, the sea would invade the land surface resulting in the deposition of transgressive marine sequences.

The post-Eocene Texas Gulf Coastal Plain forms a relatively flat surface, which dips gradually gulfward. Further inland, this plain abuts more resistant Cretaceous and Eocene strata, which form low, strike-parallel escarpments (Figure 3). In the study area, Eocene-age strata form the Bordas escarpment in western Starr County.

The Rio Grande and Houston embayments, along with the San Marcos arch, comprise the major structural elements of the post-Eocene Texas Gulf Coastal Plain (Figure 3). Since the Mesozoic, these structures have influenced sedimentation on the coastal plain. Major fault systems, such as the Balcones Fault Zone and the Pearsall-Luling-Mexia Fault Zone, rim the basin, breaking up the upper Cretaceous and Eocene strata. These fault zones also serve as a buffer between the Edwards Plateau of central and western Texas and the Texas Gulf Coastal Plain.

Deposition within the Rio Grande embayment has been fairly steady since the end of the Eocene epoch. Mineralogical studies indicate that the dry climate of the region had become established by the middle of the Tertiary (Galloway, 1977). Paleocaliche horizons abound in the Miocene- through Pleistocene-age strata in the study area, giving further evidence of steady climatic conditions through time.

Stratigraphy

In general, the geologic strata of the Lower Rio Grande Valley decrease in age from west to east across the study area. The oldest strata, which are of Eocene and Miocene age, crop out in western Starr County and dip eastward (Figure 4). The internal depositional framework of these strata, in particular the Miocene formations, mirrors very closely that of the younger Quaternary-age system. These older units are mostly multilateral and multistory fluvial sand bodies flanked by crevasse splays. Also, interbedded with these fluvial bodies are layers of tuffaceous ash derived from vulcanic sources further to the west in what is now northern Mexico and New Mexico.

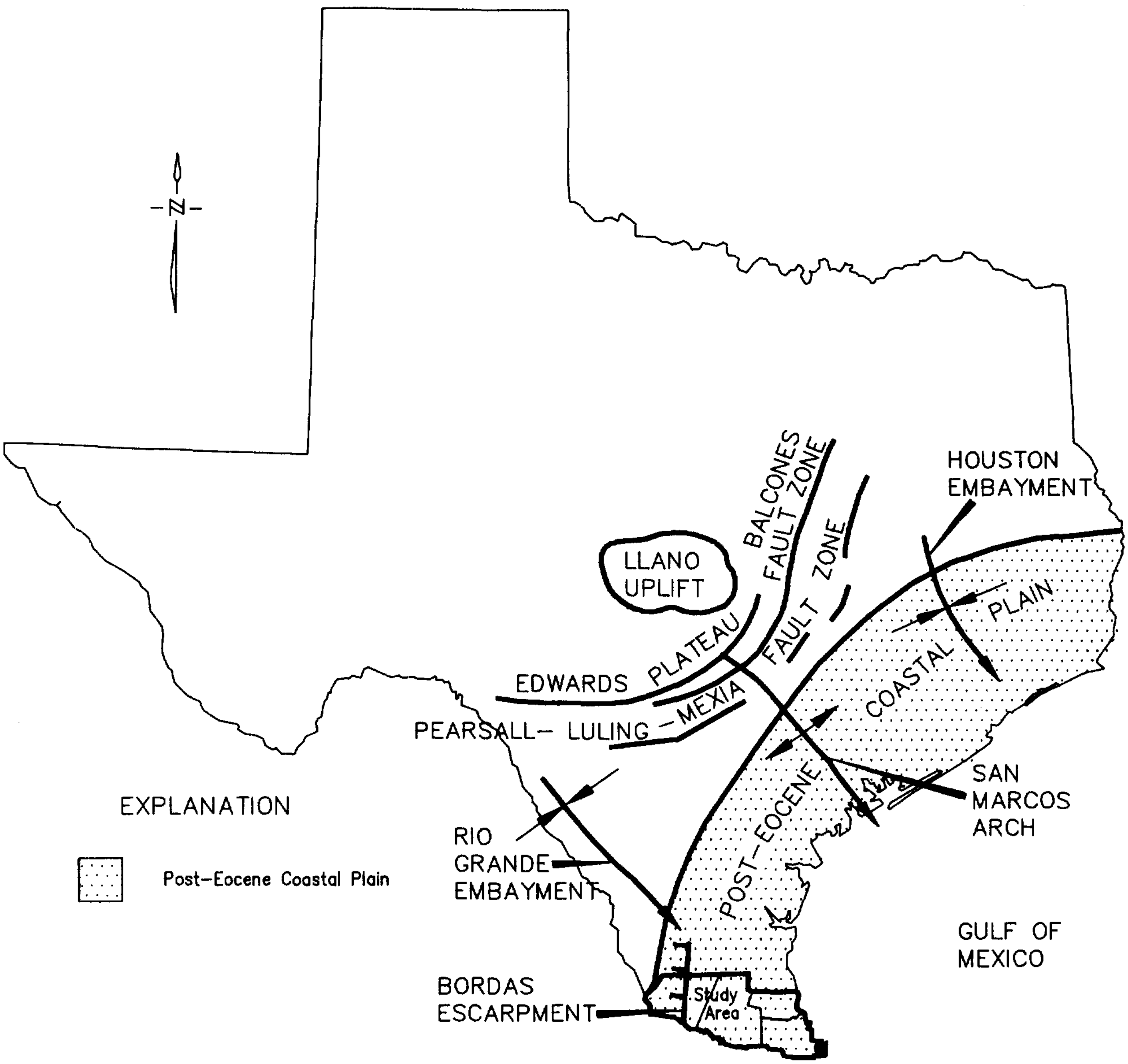


Figure 3

STRUCTURAL AND PHYSIOGRAPHIC REGIONAL SETTING OF THE POST–EOCENE TEXAS GULF COAST PLAIN

Overlying the Eocene- and Miocene-age strata and cropping out in eastern Starr and western Hidalgo County are the sands, clays, sandstones, and marls of the Goliad Formation (Figure 4). The Goliad Formation was deposited by an extrabasinal, bed load type fluvial system as multilateral sand bodies with laterally constricted distributary aprons. Down-dip the Goliad Formation thickens considerably.

Cropping out over most of Cameron and Willacy Counties and parts of Hidalgo County are the Quaternary deposits of Pleistocene and Recent age (Figure 4). Except for the eolian sheet sands in the northern part of the study area, these deposits represent current and recent historical fluvial and deltaic aggradations of the Rio Grande.

The complex depositional framework of interbedded layers and lenses make subsurface identification of specific formations difficult. The lithology changes both horizontally and vertically, sometimes over very short distances.

Source and Occurrence of Ground Water

In general, recharge to the aquifers in the study area is by precipitation on the land surface. Water that does not run off, and is not lost through evapotranspiration, percolates into the subsurface. The degree of subsurface infiltration is determined by the permeability of the soil stratum and underlying beds. The soils of the Lower Rio Grande Valley are characterized by many different types varying in permeability from low, less than 0.06 inch per hour, to high, 6.0 inches per hour (U.S. Soil Conservation Service, 1972, 1977, 1981, 1982).

Recharge can also occur in irrigated areas by infiltration of excess irrigation water. Along the Rio Grande and the numerous unlined floodways and irrigation canals in Cameron County, southern Hidalgo County, and Willacy County, water percolates into the subsurface when the local water table is lower than the streambed.

Collectively, the entire suite of geologic strata in the study area form a large, leaky artesian system in which recharge can occur across formational boundaries where permeable sands are in contact (Muller and Price, 1979). Additionally, uncemented and improperly cased wells can allow ground-water communication between different zones within the well bore.

Several localized sources of ground water have been identified in the Lower Rio Grande Valley by previous workers. Historically, workers with the U.S. Geological Survey recognized and classified four major areas of ground-water production as follows: 1) the Lower Rio Grande ground-water reservoir, 2) the Mercedes-San Sebastion shallow ground-water reservoir, 3) the Linn-Faysville ground-water reservoir, and 4) the Oakville sandstone (Follett, et al., 1949; Baker and Dale, 1961). Later this system of localized ground-water reservoirs was discarded and specific geologic formations were consolidated into recognizable hydrogeologic units (Table 1) using nomenclature extended into the south Texas coastal plain by workers with the Survey (Figure 5)(Baker, 1979; Carr and others, 1985).

Workers with the various State water agencies have historically classified the geologic strata from the Miocene to Recent ages as the Gulf Coast aquifer (Muller and Price, 1979). Additionally, individual water-bearing strata within the Gulf Coast aquifer have usually been identified by their formation name. The exception to this is the designation Lower Rio Grande Valley aquifer, a term used to describe the fluvial and deltaic deposits of the embayment of the Rio Grande in southern Cameron and Hidalgo Counties (Preston, 1983; Molofsky, 1985). This report will use the hydrogeologic units proposed by workers within the U.S. Geological Survey in its description of usable-quality water-bearing strata in the Lower Rio Grande Valley.

In western Starr County, Eocene-age strata provide small quantities of slightly to moderately saline water to rural wells, mostly for domestic and livestock use (Table 1). Water quality in these strata differs considerably across the area and there does not seem to be any pattern or uniformity to the distribution. In many places, water from wells completed in these deposits is so mineralized that it cannot be used for domestic supplies and in some places cannot be used for stock watering.

In northwestern Hildalgo and eastern Starr County Miocene-age strata yield small to moderate quantities of slightly to moderately saline water to area wells (Table 1). In particular, the Oakville Sandstone in northeastern Starr County has been previously identified as an important source of water to ranches and the petroleum industry (Baker and Dale, 1961).

Within the Lower Rio Grande Valley, the Pliocene-age Goliad Formation and Quaternary-age sediments form two major hydrogeologic units (Table 1). The Goliad Formation, and some sands of the underlying upper Miocene, form the Evangeline aquifer. The younger, Quaternary-age deposits that overlie the Goliad Formation comprise the Chicot aquifer. Both the Evangeline and Chicot aquifers yield moderate to large quantities of fresh to moderately saline water to wells in Cameron, Hidalgo, and Willacy Counties.

Figures 6 and 7 show the relationship of the Evangeline and Chicot aquifers in dip sections across the northern and southern portions of the study area. In general, ground-water movement within both these aquifers is down dip, or to the east. This has created a leaky artesian system between the two hydrogeologic units as evidenced by artesian conditions of deep wells completed into the Evangeline aquifer in central Willacy County.

Because of the thick deltaic deposits of the Rio Grande, the Chicot aquifer is more extensive in southern Cameron and Hidalgo Counties than in northern parts of the study area. Electric log data show that the water quality changes both laterally and vertically in the Chicot aquifer. Previous authors have recognized that ground water in the Chicot aquifer deteriorates in quality with distance from the Rio Grande, as well as with depth (Baker and Dale, 1961; Preston, 1983; Molofsky, 1985). In general, the shallowest zones tend to contain highly mineralized water overlying fresh to slightly saline water, while deeper zones tend to yield poorer quality water.

Table 1. - Stratigraphic and Hydrologic Section of the Lower Rio Grande Valley Area

Era	System	Series	Stratigraphic Units	Character of Material	Hydrologic Units	Water-Bearing Characteristics*
Cenozoic	Quaternary	**Recent**	Alluvium	Sand and silt	Chicot Aquifer	Yields moderate to large quantities of fresh to slightly saline water near the Rio Grande in Cameron and Hidalgo Counties.
		Pleistocene	Fluviatile Terrace Deposits	Gravel, and silt, and clay		Yields moderate to large quantities of fresh to moderately saline water.
			Beaumont Formation	Mostly clay with some sand and silt.		
			Lissie Formation	Clay, silt, sand, gravel, and caliche		
	Tertiary	**Pleistocene or Pliocene**	Uvalde Gravel	Chert, occurs as terrace gravel in western Starr County		
		Pliocene	Goliad Formation	Clay, sand, sandstone, marl, caliche, limestone, and conglomerate.	Evangeline Aquifer	Yields moderate to large quantities of fresh to slightly saline water.
		Miocene	Miocene Formations Undifferentiated	Mudstone, clay-stone, sandstone, tuff, and clay.		Yields moderate quantities of slightly to moderately saline water in northwestern Hidalgo and eastern Starr Counties.
		Eocene	Eocene Formations Undifferentiated	Sandstone and clay.		Yields small quantities of slightly to moderately saline water.

* Yields of wells: small = <50 gallons per minute; moderate = 50 to 500 gallons per minute; large = > 500 gallons per minute.
Chemical Quality of Water: fresh = <1,000 milligrams per liter (mg/l); slightly saline = 1,000 to 3,000 mg/l; moderately saline = 3,000 to 10,000 mg/l.

The Evangeline aquifer presents a different picture of water-quality distribution. In western Hidalgo County, the shallow sediments of the Goliad Formation yield slightly saline water to wells. In the north-central area of Hidalgo county, near Faysville and Linn, the thin veneer of the Chicot aquifer and the upper portion of the Evangeline aquifer yield fresh water to area wells. Further east, in central Willacy County, the Evangeline aquifer yields slightly to moderately saline water to irrigation wells as deep as 1,200 feet below the land surface.

Hydraulics

Pumping tests in Starr County (Baker and Dale, 1961; Myers, 1969) on wells completed in the Oakville Sandstone indicated a coefficient of transmissibility of about 6,850 gallons per day per foot (gpd/ft). Average yield for these wells was 120 gallons per minute (gpm).

In Cameron County, pumping tests on wells completed in the Chicot aquifer near the Rio Grande showed an average coefficient of transmissibility of 49,500 gpd/ft and an average yield of 1,200 gpm (Myers, 1969). Discharges as high as 2,900 gpm have also been reported for wells completed in the Chicot aquifer in Cameron County (Baker and Dale, 1961).

Water Levels

Ground water in the Miocene-age strata and the Evangeline aquifer is under water-table conditions where these units crop out at the land surface. Where they deepen and thicken towards the coast, their water is confined by overlying strata and will rise in wells completed in them above the depth at which it is encountered. In the strata of the Chicot aquifer, the water is unconfined and under water-table conditions.

Figure 8 shows the altitude of water levels in the Chicot and Evangeline aquifers in 1988. In general, the water level decreases in altitude towards the coast. In north-central and southeastern Hidalgo County and southwestern Cameron County, irrigation pumpage has left cones of depression in the water-level surface.

Figure 9 shows the water-level rise and decline for wells in the study area from 1970 to 1988, as well as selected hydrographs of area wells. In general, water levels throughout the Lower Rio Grande Valley show a slight rise of a few feet since 1970. The hydrographs show fluctuations in water levels with a trend toward a slightly rising water level. Since ground-water usage is only two percent of total water usage in the Lower Rio Grande Valley, these fluctuations may reflect more the historical rainfall amounts rather than pumpage amounts.

Numerous areas of the Texas Gulf Coastal Plain have experienced problems with land-surface subsidence due to ground-water pumpage and hydrocarbon production. The pumpage of ground water causes the dewatering of montmorillonite clays resulting in their compaction. Investigations by the U.S. Geological Survey on the upper Texas Gulf Coastal Plain have shown a definite relationship of subsidence to ground-water withdrawal (Jorgensen, 1975; Gabrysch, 1977).

In the south Texas Gulf Coast Coastal Plain, particularly the Lower Rio Grande Valley, subsidence problems have not been encountered in spite of heavy pumpage (Texas Water Development Board, 1976). This is probably due to the geochemistry of the South Texas formations, i.e., the presence of illite (non-hydrous, mica-like) clay rather than hydrous montmorillonite clay. Computer simulations of land-surface subsidence for the Texas Gulf Coast through the year 2020 show no appreciable subsidence in any of the counties of the Lower Rio Grande Valley (Muller and Price, 1979).

Water Quality

The ground water of the Lower Rio Grande Valley is characterized by its generally poor quality in relation to the waters of the Rio Grande (Figure 10). Surface water from the Rio Grande usually has a dissolved solids content of from 400 to 750 milligrams per liter (mg/l) and is classified as fresh in quality. Ground water from all the aquifers in the study area generally exceeds 1,000 mg/l dissolved solids (slightly saline) and often exceeds 3,000 mg/l (moderately saline). Additionally, constituents such as chloride and sulfate often exceed the Texas Department of Health recommended drinking water standards.

Ground water in the Evangeline and Chicot aquifers contains high sodium concentrations (Figure 10). Analyses of water from the Chicot aquifer show chloride, bicarbonate, and sulfate in roughly equal proportions. Analyses of water from the Evangeline aquifer show larger amounts of chloride and sulfate in relation to bicarbonate. Analyses of water in an irrigation well in Willacy County (State Well Number 88-26-303) show no major changes from 1971 to 1984 (Figure 11).

Figure 12 shows the chemical quality of water in the Chicot and Evangeline aquifers in the study area. Only two small areas contain fresh-quality ground water (less than 1,000 mg/l dissolved solids): the alluvial and deltaic deposits of the Rio Grande in southern Hidalgo and southwestern Cameron County, and the shallow sediments between Linn and Faysville in north-central Hidalgo County. Outside of these areas, water quality in the Chicot and Evangeline aquifers ranges from slightly to moderately saline.

A large amount of data has been collected by the U.S. Department of Agriculture relative to the classification of water for irrigation use in arid and semiarid areas (U.S. Salinity Laboratory Staff, 1954). Classification of irrigation waters should be used as a broad guideline, as other factors such as soil texture, infiltration rate, farm management practices, drainage conditions, climatic factors, and salt tolerances of different crops also affect the suitability of water for irrigation.

The major characteristics of ground water that are most important in determining its suitability for irrigation use are: 1) total concentration of soluble salts; 2) relative proportion of sodium to the other cations; 3) concentration of boron or other elements that may be toxic; and 4) under some conditions, the bicarbonate concentration as related to the concentration of calcium plus magnesium (U.S. Salinity Laboratory Staff, 1954). The first three characteristics are known respectively as the salinity hazard, the sodium adsorption ratio (alkali hazard), and the boron hazard.

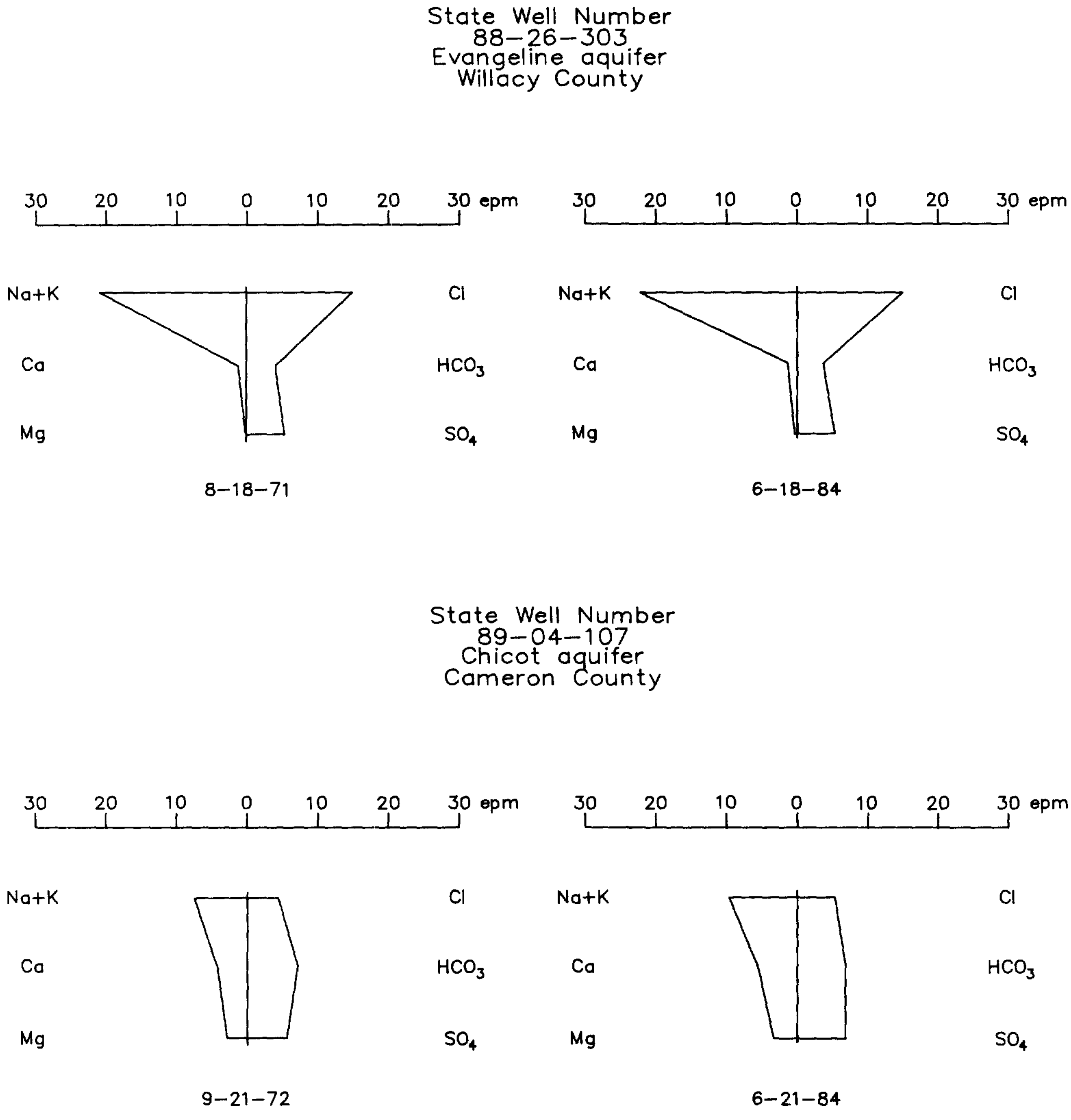


Figure 11

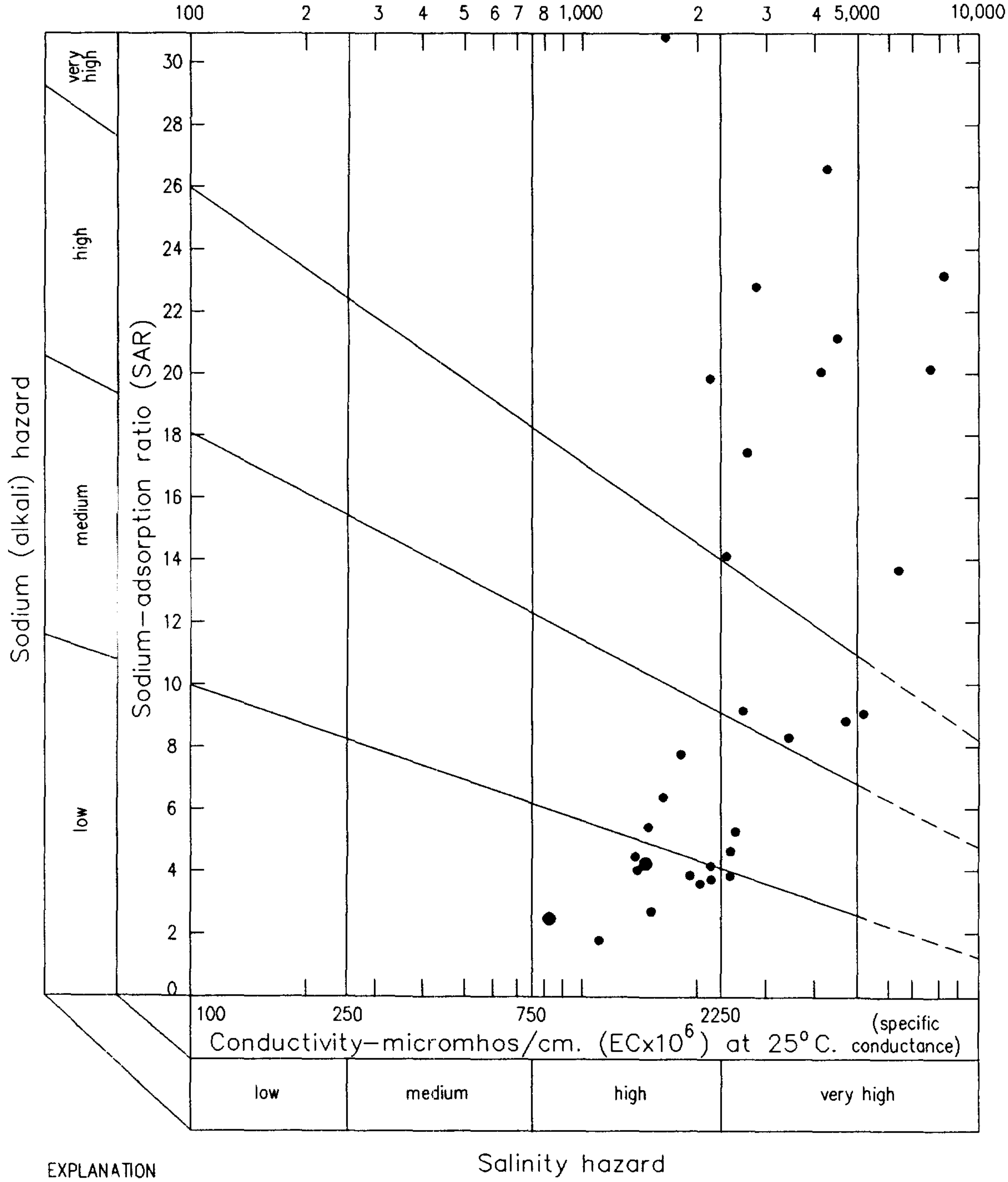
CHEMICAL-QUALITY DIAGRAMS SHOWING THE CHANGE IN THE CONCENTRATION AND RATIO OF CONSTITUENTS IN WATER FROM SELECTED WELLS

High concentrations of soluble salts in irrigation water can cause a buildup of salts in the soil, which can affect the ability of plants to take up moisture and nutrients from the soil. This, in turn, can adversely impact crop yields. The salinity hazard is expressed in terms of specific conductance in micromhos per centimeter at 25°C. Water from a selection of wells completed in aquifers in the Lower Rio Grande Valley has a salinity hazard ranging from high to very high.

The sodium adsorption ratio (SAR), which is used to show the sodium (alkali) hazard, reflects the amount of sodium relative to calcium and magnesium in irrigation water and is a measure of the activity of sodium ions in exchange reactions with the soil. A high SAR in irrigation water can damage sodium sensitive plants, as well as form a hard impermeable crust on the soil that can cause cultivation and drainage problems.

SAR and specific conductivity values of 29 wells in the study area, and of water from the Rio Grande near Hidalgo, have been plotted in order to show the range in quality for irrigation waters from various sources in the Lower Rio Grande Valley (Figure 13). The salinity hazard for ground water ranges from high to very high, and the sodium hazard for ground water ranges from low to very high. The salinity hazard for surface water is high, but the sodium hazard is low. In general, water with less than 5,000 micromhos/cm specific conductance and low to medium sodium hazard (SAR) can successfully be used for irrigation. Water in excess of 5,000 micromhos/cm and a high to very high SAR requires special agricultural practices to grow salt tolerant crops (U.S. Salinity Laboratory Staff, 1954).

Boron, while necessary in small amounts for plant growth, becomes toxic when present in large amounts in irrigation water. Depending on plant sensitivity, the maximum permissible level of boron in irrigation water ranges from 1.0 to 3.0 mg/l (Scofield, 1936). Previous data show localized areas of high boron content in ground water throughout the study area (Baker and Dale, 1961). High boron content does not seem to correlate with the concentration of other minerals that cause poor ground-water quality in the Lower Rio Grande Valley.



EXPLANATION

- Surface Water
- Ground Water

Figure 13

CLASSIFICATION OF IRRIGATION WATERS IN THE LOWER RIO GRANDE VALLEY

(After United States Salinity Laboratory Staff, 1954, p.80)

GROUND-WATER PROBLEMS

Ground-Water Quality

Except for a few small areas of the Lower Rio Grande Valley, ground-water quality is marginal to poor. Ground-water contamination also tends to be localized throughout the study area.

Baker and Dale (1961) identified various areas in the Lower Rio Grande Valley experiencing problems with high boron content in the ground water. High boron levels seem to be widespread in every county in the study area due to natural conditions.

Western Hidalgo County has historically had problems with land surface drainage. To compensate for this, farmers in the Mission area have installed drain well systems since the 1950's to alleviate the problems associated with perched water tables. These wells allow the ground water perched on clay zones to drain into deeper, more permeable strata. While helping with drainage, these wells also serve as conduits for surface contaminants and their water has been found to contain high concentrations of nitrate, dissolved solids, and pesticides (Knape, 1984).

High nitrate levels have also been reported in wells in every county in the Lower Rio Grande Valley, particularly in wells with depths of less than 100 feet (Baker and Dale, 1961). The extent of the high nitrate concentrations, which appear to be localized in widely scattered locations, may suggest (be taken as an indication) that the water is subject to organic contamination, possibly from fertilizer use, although high nitrate levels might also be of natural origin. Water containing more than 44 mg/l nitrate can cause methemoglobinemia ("blue-baby" syndrome) in infants, and there is evidence that human consumption of water with high nitrate can cause intestinal problems resulting in diarrhea.

Wells in Starr, Willacy and northern Hidalgo Counties, which are completed in the Oakville Sandstone and the Evangeline aquifer, can contain levels of sulfate that exceed the Texas Department of Health recommended drinking water limit (300 mg/l). High amounts of sulfate can have a laxative effect on humans, as well as causing an obnoxious mineral taste and odor in drinking water. These sulfate levels appear to be a natural occurrence as a result of formation chemistry.

PROJECTED WATER DEMANDS

Population

Table 2 shows projected population growth for each county in the Lower Rio Grande Valley, as well as their combined total. In 1985, the total population was 655,278. This figure is expected to double by the year 2010 (Figure 14).

Approximately one-third of the study area's population in 1985 was rural, reflecting the agrarian nature of the region. This ratio is not projected to change by the year 2010. Major cities in the area are Brownsville and Harlingen in Cameron County and McAllen in Hidalgo County, which had a combined population in 1985 of 194,321, or approximately 30 percent of the total population of the Lower Rio Grande Valley.

Water Use

Current and projected water use for the Lower Rio Grande Valley is shown on Table 3. The data for 1980 and 1985 are differentiated between surface-water and ground-water use and are based on reported and site-specific computed use. Projected water use for the years 1990, 2000, and 2010 is based on the 1988 Texas Water Development Board Revised High Series projections, but does not differentiate between surface-water and ground-water use.

In 1985, surface-water use accounted for 98 percent of all water use in the study area. In 1980, surface water comprised 99 percent of all water use. Agriculture use comprised some 85 percent of the total water use in 1985 and 92 percent of total water use in 1980. Municipal water use in the Lower Rio Grande Valley is projected to slowly increase through the year 2010. However, because of reduced irrigation, total future water use is not projected to exceed the historical water use for the year 1980. The projection of 1.3 million acre-feet of total water use for 2010 is less than the 1.34 million acre-feet of water used for irrigation in 1980 (Figure 15).

Table 2
Current and Projected Population of Study Area [1]

County	Year	Cities	Rural [2]	Totals
CAMERON	1980	162,348	47,379	209,727
	1985	194,463	55,324	249,787
	1990	228,176	76,661	304,837
	2000	297,033	86,349	383,382
	2010	358,560	97,630	456,190
HIDALGO	1980	205,532	77,697	283,229
	1985	258,345	93,863	352,208
	1900	315,672	113,732	429,404
	2000	435,558	150,212	585,770
	2010	587,115	215,064	802,179
STARR	1980	13,713	13,553	27,266
	1985	15,778	18,675	34,453
	1990	18,695	24,750	43,445
	2000	26,299	32,002	58,301
	2010	34,262	39,370	73,632
WILLACY	1980	11,111	6,384	17,495
	1985	11,957	6,873	18,830
	1990	12,791	7,363	20,154
	2000	14,874	8,962	23,836
	2010	16,852	9,956	26,808
TOTALS	1980	392,704	145,013	537,717
	1985	480,543	174,735	655,278
	1990	575,334	222,506	797,840
	2000	773,764	277,525	1,051,289
	2010	996,789	362,020	1,358,809

1 Population for the years 1980 and 1985 is based on Bureau of Census statistics. Population for the years 1990, 2000, and 2010 is based on 1988 Texas Water Development Board Revised High Series population projection.

2 The term "Rural" includes unincorporated areas and all rural population.

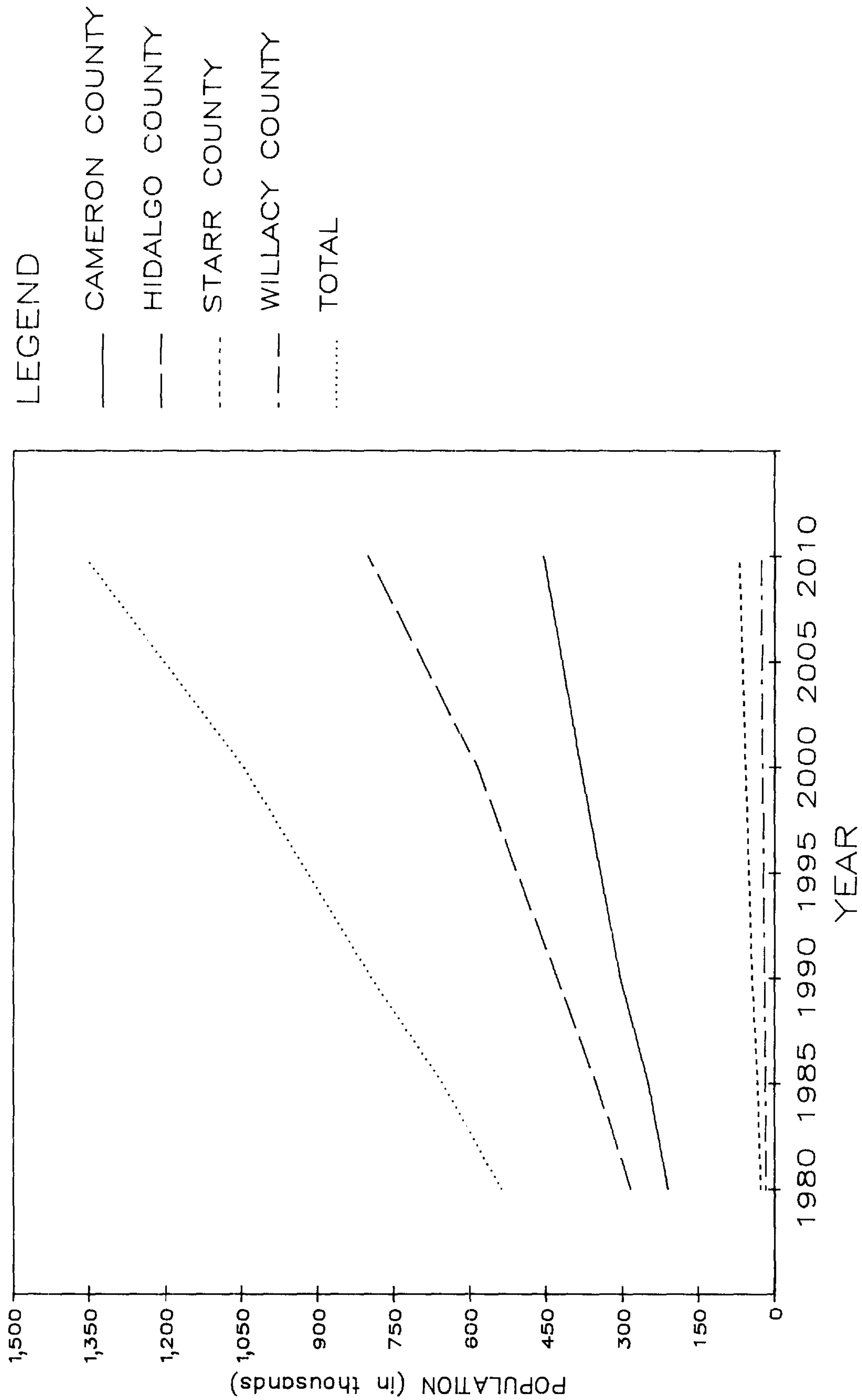


Figure 14

CURRENT AND PROJECTED POPULATION,
LOWER RIO GRANDE VALLEY

TABLE 3.- Current And Projected Water Use By Demand In Study Area [1]
(Units in Acre-Feet)

County	Year	Public Supply [2] Ground	Public Supply [2] Surface	Irrigation Ground	Irrigation Surface	Other [3] Ground	Other [3] Surface	Totals Ground	Totals Surface
Cameron	1980	452	39,522	-0-	495,987	458	5,279	910	540,788
	1985	760	47,922	-0-	225,234	101	4,082	861	277,238
	1990	66,766		327,800		4,308		394,566	
	2000	80,432		318,786		6,335		405,553	
	2010	90,887		312,498		6,674		410,059	
Hidalgo	1980	3,317	45,638	9,000	751,333	607	6,054	12,924	803,025
	1985	3,773	45,669	9,957	418,788	918	5,880	14,648	470,337
	1990	80,776		674,300		7,370		762,446	
	2000	104,969		655,757		9,720		770,446	
	2010	135,745		642,822		10,927		789,494	
Starr	1980	163	4,147	-0-	30,855	514	1,322	677	36,324
	1985	705	5,306	597	22,221	433	1,917	1,735	29,444
	1990	8,237		42,900		2,039		53,176	
	2000	10,619		41,720		2,245		54,584	
	2010	12,797		40,897		2,220		55,914	
Willacy	1980	554	4,597	-0-	63,700	19	208	573	68,505
	1985	1	5,704	-0-	41,292	23	235	24	47,231
	1990	6,162		55,000		252		61,414	
	2000	6,577		53,487		6,298		66,362	
	2010	7,022		52,433		7,608		67,063	
Totals	1980	4,486	93,904	9,000	1,341,875	1,598	12,863	15,084	1,448,642
	1985	5,239	104,601	10,554	707,535	1,475	12,114	17,268	824,250
	1990	161,941		1,045,000		13,969		1,220,910	
	2000	202,597		1,069,750		24,598		1,296,945	
	2010	246,451		1,048,650		27,429		1,322,530	

[1] Water demand for the years of 1980 and 1985 is based on reported and site-specific computed use. Water demands for the years 1990, 2000, and 2010 is based on 1988 Texas Water Development Board Revised High Series projections. Projections do not separte ground-water and surface-water use.

[2] Public Supply includes unincorporated areas and all rural population use.

[3] Other includes all water demand except for public supply and irrigation.

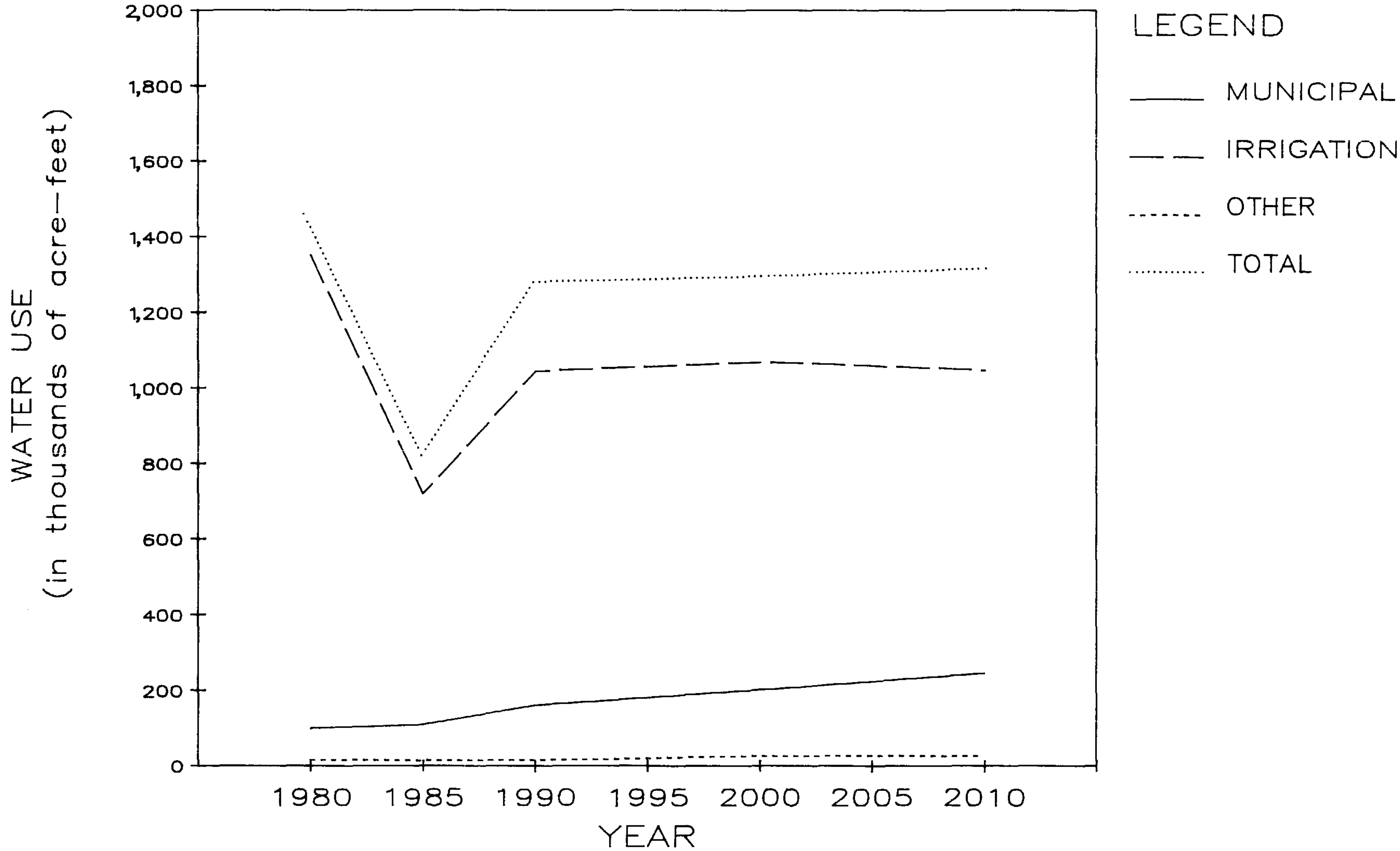


Figure 15

CURRENT AND PROJECTED WATER USE,
LOWER RIO GRANDE VALLEY

AVAILABILITY OF WATER

Current and Projected Availability of Ground Water

Overall ground-water quality is poor to marginal throughout the Lower Rio Grande Valley. Only two areas, the Linn-Faysville area in north-central Hidalgo County and the southern portion of Hidalgo County and the southwestern portion of Cameron County along the Rio Grande, yield appreciable quantities of fresh-quality ground water. For the deposits along the Rio Grande, Baker and Dale (1961), estimated a yield of about 75,000 acre-feet of water for each foot that the water level could be lowered. Not enough data is available for the Linn-Faysville area to accurately determine total storage. Other areas yield ground water with high dissolved solids, high chloride, and high sulfate concentrations which preclude its widespread use for domestic and irrigation supply.

Total ground-water use in 1985 was 17,268 acre-feet from all aquifers in the study area. Irrigation use was 10,554 acre-feet, or 61 percent of the total for 1985. Where available, usable-quality ground-water resources appear to be adequate to meet pumpage demands through the year 2010.

Current and Projected Availability of Surface Water

The overwhelming preponderance of water used in the study area is surface water from the Rio Grande. This water is stored upstream in two international reservoirs: International Falcon Reservoir and International Amistad Reservoir. Water availability from these reservoirs is regulated by the International Boundary and Water Commission under the terms of a 1944 treaty between the United States and Mexico. This treaty called for the equitable distribution of the waters of the Rio Grande and its tributaries between the two nations. Water available to the United States is 56.2 percent of Amistad Reservoir storage and 58.6 percent of Falcon Reservoir storage.

Allocations of water in Texas from reservoirs on the Rio Grande are by water rights whose accounts are overseen by the Rio Grande Watermaster of the Texas Water Commission. The Watermaster maintains accounts for all water rights and is responsible for requesting water supply releases from the International Boundary and Water Commission. The Watermaster also is the overseer for the transfer and use of water rights and charges fees for water supplies and storage. Water cannot be pumped from the Rio Grande into Texas without a water right and permission from the Watermaster. Currently, all water rights on the Texas side of the Rio Grande from Amistad and Falcon Reservoirs are allocated.

Water rights in the Lower Rio Grande Valley are owned by municipalities, irrigation districts, public water supply corporations, and a few private property owners. The original allotment to municipalities was based on the erroneous assumption that their growth would not exceed 50 percent of their 1965 population. In most cases, such growth has already occurred, limiting extension of city services outside of the city corporate limit. Conversion of irrigation water rights to municipal water rights is now occurring.

Water districts, both irrigation and public supply, furnish water to unincorporated areas in the study area. The irrigation districts have built canal systems to carry water to customers located away from the Rio Grande.

Potential for Conjuctive Use of Ground and Surface Water

Current surface-water use, due to a dramatic decrease in irrigation, is far less than the total amount available in storage in Amistad and Falcon Reservoirs. Future expansion of surface-water use is contingent on demand versus reservoir storage capacity and the availability of water rights.

There is significant potential for the use of ground water to extend public drinking water supplies presently dependent on surface water, but only in limited areas of the Lower Rio Grande Valley. Some smaller towns, such as Mercedes in Hidalgo County, currently use a mixture of ground and surface water to extend their public water supply and satisfy demand during periods of peak use. The Brownsville Public Utilities Board is currently working on development of fresh ground-water supplies in southwestern Cameron County near the Rio Grande. In each case, slightly poorer quality ground water is mixed with better quality surface water. Over most of the study area, however, constituents such as chloride and sulfate content exceed Texas Health Department recommended drinking water standards to such a degree that mixing becomes unfeasible.

Potential for Additional Ground-Water Development

Given the poor suitability of ground water in the Lower Rio Grande Valley for irrigation, additional ground-water development could only be used to augment public drinking supplies. This could be accomplished in some areas by mixing ground and surface water to extend supplies, and by treatment of poor quality ground water by such methods as electrodialysis or reverse osmosis.

Increased development of ground water along the Rio Grande in Hidalgo and Cameron County would have an adverse effect. Since this area is primarily recharged by the Rio Grande, removal of large amounts of ground water could result in lowered flows in the river below Landrum in Cameron County (Baker and Dale, 1961; Preston, 1983). Additionally, heavy pumpage could result in lowering the water levels in these deposits, as happened in the 1950's.

Outside of southern Hidalgo and Cameron Counties, very little potential exists for large-scale development of ground-water resources. This is due to both the poor quality of the ground water and the low permeability of many of the water-bearing strata.

Projected Availability Through the Year 2010

Historically, water use in the Lower Rio Grande Valley was at a high in 1980. However, in 1985, total water use was only 57 percent of the 1980 total due to a slumping farm economy (irrigation pumpage down 53 percent). If current projections hold true, water use in the Valley through the year 2010 will not exceed that of 1980. Therefore, available water supplies should be adequate to meet the area's need for the next 20 years.

SUMMARY

The Rio Grande provides 97 to 98 percent of the water used in the Lower Rio Grande Valley. Of this total use, irrigation comprises about 85 percent. Surface-water supplies are limited by water rights and storage capacities at Amistad and Falcon Reservoirs. Since 1954, surface water has provided, and will continue to provide, most of the Valley's water needs.

Ground water in the area is characterized by its generally poor quality, which makes it unsuitable for public water supply and irrigation. Only the deltaic and fluvial deposits of the Rio Grande in southern Hidalgo and Cameron Counties yield large to moderate supplies of fresh water. Total ground-water use for 1985 was 17,268 acre-feet, and area water levels have risen several feet, on average, from 1970 through 1988. Available ground-water resources, where usable, should be adequate to meet increases in pumpage through the year 2010.

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