Report 324

# Evaluation of Ground-Water Resources in El Paso County, Texas

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By

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# ABSTRACT

The evaluation of the ground-water resources of El Paso County is in response to the 1985 passage of House Bill 2 by the Sixty-ninth Texas legislature, which called for the identification and study of areas in the State that are experiencing, or expected to experience within the next 20 years, critical underground water problems. This study in El Paso County was conducted to address problems of overdraft and quality deterioration with respect to the Hueco bolson, Mesilla bolson, and the Rio Grande alluvium aquifers.

Water for irrigation use is obtained primarily from the Rio Grande. However, during years of inadequate surface-water supply, shallow wells in the Rio Grande alluvium are pumped to augment the diversions. Other water use in the county is dependent primarily on pumpage from the Hueco and Mesilla bolson aquifers. Public supply represents 76 percent of the 1985 ground-water use, 91 percent of which was supplied to the City of El Paso.

The amount of fresh ground water available on a perennial basis from the Hueco and Mesilla bolson aquifers within El Paso County is approximately 6,000 and 18,000 acre-feet, respectively, which is the average annual effective recharge to the aquifers. Annual withdrawal by pumpage (107,078 acre-feet in 1985) exceeds this available quantity, thus resulting in areas of water-level decline.

Pumpage in excess of recharge, especially in the vicinity of municipal well fields, has resulted in significant water-level declines in the Hueco bolson aquifer of as much as 150 feet. Recent declines in excess of 50 feet have occurred during the 10-year period prior to 1989 in the City of El Paso metro area and have resulted in minor local land-surface subsidence. Less severe water-level declines have occurred in the Mesilla bolson in the lower Mesilla Valley.

Increasing dissolved-solids concentrations in fresh-water zones of both the Hueco and Mesilla bolsons are attributed mainly to downward leakage of brackish water from shallow zones and possibly upconing of brackish water from below. Analyses of water samples from wells completed in the Hueco bolson show an average annual increase in dissolved solids of about 10 milligrams per liter in the United States and about 30 milligrams per liter in Ciudad Juarez. Dissolved-solid concentrations have also increased in ground water produced from the intermediate zone of the Mesilla bolson at an average rate of about 9 milligrams per liter per year.

Approximately 9.7 million acre-feet of theoretically recoverable fresh water was calculated to occur in Hueco bolson deposits on the Texas side in 1989. The Mesilla bolson deposits and Rio Grande alluvium together contain about 560,000 acre-feet of fresh water in storage under the Texas part of the lower Mesilla Valley.

The total annual water requirement for El Paso County is expected to increase as a result of a rapidly growing population by about 63,000 acre-feet or 22 percent from 1985 to the year 2010. Public supply and rural use combined is projected to increase in response to the expected population growth by 74 percent during this period, while irrigation use is projected to decline by about 12 percent. Current ground-water availability is probably not sufficient to sustain this projected demand beyond the middle of the next century.

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# INTRODUCTION

In 1985, the Sixty-ninth Texas Legislature recognized that certain areas of the State were experiencing or were expected to experience, within the next 20 years, critical ground-water problems. House Bill 2 was enacted which, in part, directed the Texas Department of Water Resources to identify the critical ground-water areas, conduct studies in those areas, and submit its findings and recommendations on whether a ground-water conservation district should be established in the respective areas to address the ground-water problems (Subchapter C, Chapter 52, Texas Water Code). This study in El Paso County was conducted to address the problems of overdraft and quality deterioration with respect to the Hueco bolson, Mesilla bolson, and the Rio Grande alluvium aquifers.

Numerous reports have been written concerning the ground-water resources of the El Paso area. For a more detailed description of the geology and hydrology of the area, a partial list of studies is included in the Selected References section of this report. The following discussion on the hydrogeology and ground-water availability of the area draws liberally from the following reports:

Alvarez and Buckner, 1980
Gates and others, 1978
Leggat and others, 1962
W.R. Meyer, 1976
Meyer and Gordon, 1972
U.S. Bureau of Reclamation, 1973
D.E. White, 1983
D.W. Wilkins, 1986
Wilson and others, 1981

Special appreciation is extended to Tom Cliett, ground-water consultant for the El Paso Water Utilities, and Don White, geologist with the U.S. Geological Survey in El Paso, for providing current ground-water use and availability data in the study area and for conducting a critical review of this report.

## GEOGRAPHIC SETTING

This study of El Paso County, located in the far western tip of Texas (Figure 1), addresses aquifers that primarily occur in basin-fill (bolson) deposits which extend northward into New Mexico and westward into the Republic of Mexico. The Mesilla bolson occupies a basin that extends from Las Cruces, New Mexico, southward into Mexico (Figure 2). On the surface, this area is characterized by a broad, nearly level plain called La Mesa and an incised river valley of the Rio Grande known as the Mesilla Valley which traverses the east side of the basin and is bordered on the east by the Franklin and Organ Mountains. In the El Paso area, the lower Mesilla Valley extends south from the New Mexico-Texas state line at Anthony to the "El Paso del Norte," the narrow gap between the southern end of the Franklin Mountains and the northern end of the Sierra de Juarez in Mexico.

East of the Franklin Mountains, the Hueco bolson extends northward into New Mexico where it merges with the Tularosa Basin and southeastward to about Fort Quitman where it lies between several mountain ranges in Texas and Mexico (Figure 2). South of the City of El Paso, the El Paso-Juarez Valley of the Rio Grande occupies the southwestern edge of the bolson.

The City of El Paso and its counterpart across the Rio Grande, Ciudad Juarez, are the primary population centers in the area. Other cities and military installations include Anthony, Canutillo, Clint, Fabens, and Fort Bliss. Agriculture, industry, military installations, and tourism have the greatest influence on the local economy. Local industries include smelting and refining of nonferrous metals, petrochemical refineries, garment manufactures, food processing plants, and numerous other light manufacturing activities. Twin plants located on opposite sides of the international border take advantage of the availability of the cheap labor force in Mexico.

Topographically, El Paso County includes an irrigated valley along the Rio Grande; semiarid bench land east of the river, locally referred to as "the mesa"; and two small mountain ranges, the Franklins in the northwestern part of the county and the Huecos in the eastern part.

The arid to semi-arid desert climate in the El Paso area is characterized by an abundance of sunshine throughout the year, low humidity, an average annual rainfall of about eight inches, and a high evaporation rate. The average annual gross lake evaporation is about 80 inches which is 10 times the average annual rainfall.

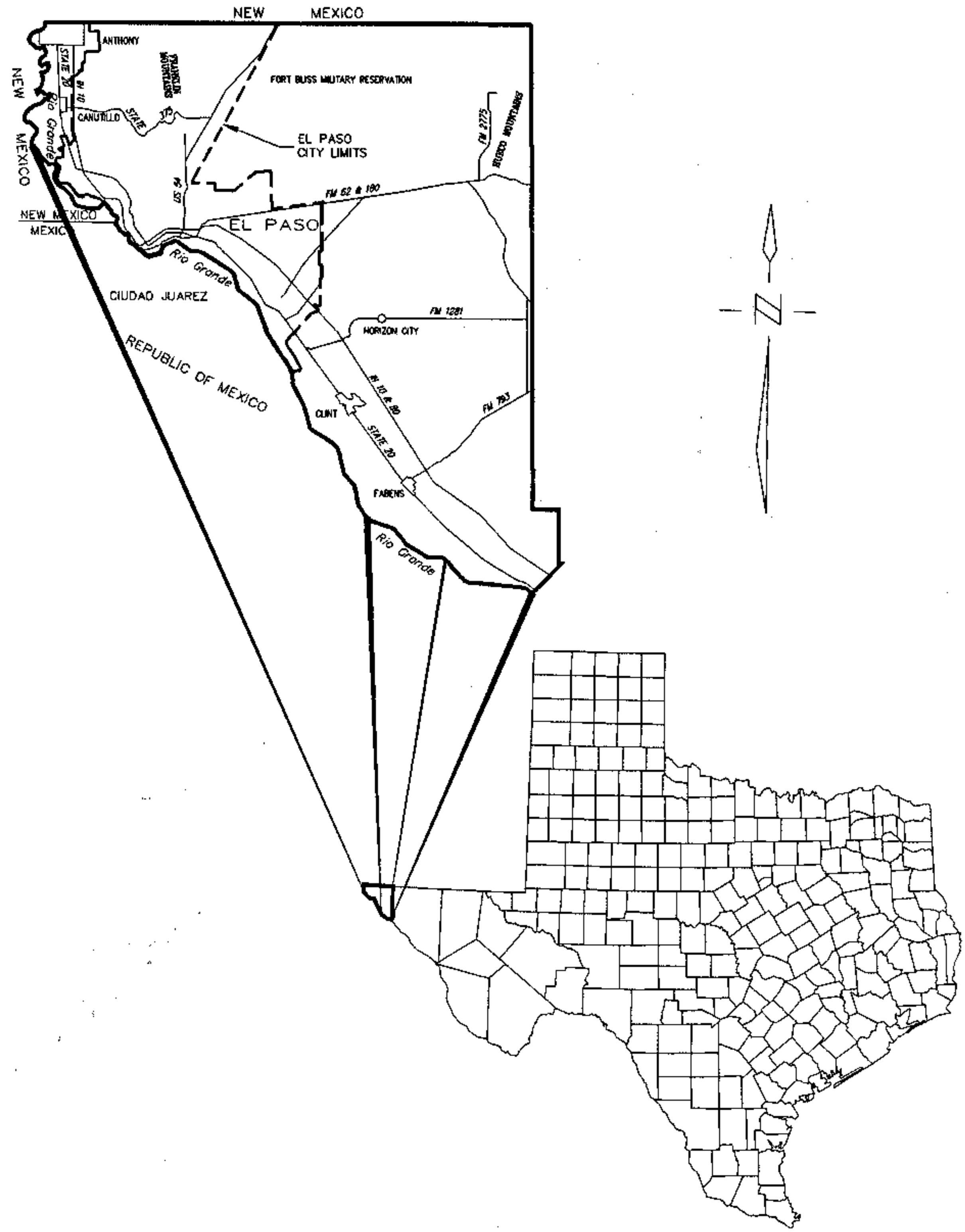


Figure 1

LOCATION OF STUDY AREA

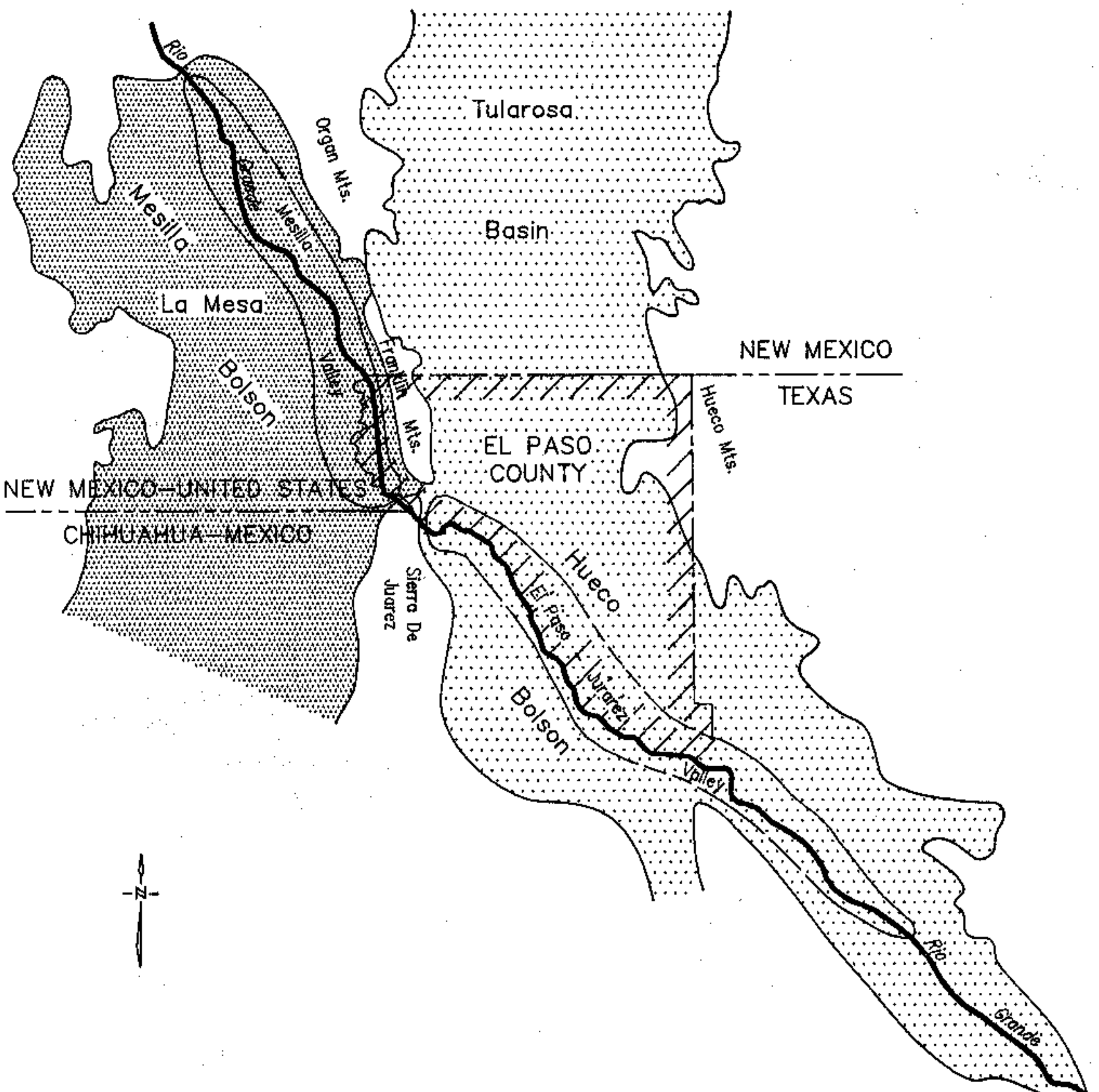


Figure 2

PHYSIOGRAPHIC MAP OF THE EL PASO AREA

# GEOHYDROLOGY

## Regional Structure

The geologic framework of the El Paso area, which lies within the Basin and Range Province, is primarily controlled by the Rio Grande Rift which resulted in a series of grabens, or down-dropped basins. The upland areas flanking the basins on the west and east in Texas are outcrops of rocks ranging in age from Precambrian to Tertiary, while west and southwest flanking uplands in Chihuahua, Mexico are outcrops of Cretaceous rocks. These rocks and those further north and northwest in New Mexico were the source materials for the Tertiary and Quaternary alluvial sediments which fill the basins and are referred to as bolson deposits.

Basins in El Paso County, formed by normal block faulting, include the Hueco and Mesilla bolsons. These block-faulted grabens are asymmetrical due to downward displacement being greater on one side of the basin than the other.

## Stratigraphy and Water-Bearing Properties

Fresh to slightly saline ground water in the El Paso area primarily occurs in deposits of the Hueco and Mesilla bolsons and the Rio Grande alluvium. Elsewhere, consolidated igneous and sedimentary bedrock units yield only small quantities of water to a few wells in the county.

### *Hueco Bolson*

The Hueco bolson, the principal aquifer in the El Paso area, consists of an upper fluvial zone of mostly stream-channel and flood-plain deposits composed of silt, sand, gravel, and caliche; and a lower lacustrine (lake deposits) zone containing mostly clay and silt. Strain (1966) assigned the name Camp Rice to the upper formation and Fort Hancock to the lower, both of which are probably equivalent to the Sante Fe Group deposits in the Mesilla bolson (Strain, 1969; and Hawley and others, 1969).

Maximum thickness, according to Mattick (1967) and Gates and others (1978), is about 9,000 feet and occurs within a deep structural trough paralleling the east side of the Franklin Mountains. Bolson thickness and sediment grain size generally decrease in an easterly direction across the basin.

Recharge of 5,640 acre-feet per year (Meyer, 1976) is principally from precipitation runoff along the base of the Organ and Franklin Mountains in New Mexico and Texas and the Sierra de Juarez in Mexico. In addition, Meyer stated that during the period 1968-73 the average annual ground-water leakage into the bolson from the alluvium was approximately 33,300 acre-feet. Discharge from the bolson occurs naturally as ground water seeps into the overlying Rio Grande alluvium and artificially by pumping wells, most of which are located in the vicinity of the City of El Paso (Alvarez and Buckner, 1980).

Ground water in the Hueco bolson aquifer outside of the valley is under water-table conditions, whereas in the valley, the aquifer is under leaky artesian conditions. Water levels in the aquifer have been affected by extensive historical withdrawals which have caused major water-level declines. Depth to water ranges from about 350 feet near pumping centers to less than 100 feet elsewhere. As a result of the water-level declines, ground-water movement is generally toward pumping centers.

The chemical quality of the ground water differs according to its location, both areally and with depth. Dissolved-solids concentrations range from less than 500 to over 1,500 milligrams per liter. A quality survey conducted by White (1983) indicated an average dissolved-solids concentration of 642 milligrams per liter in samples from wells in the United States and 736 milligrams per liter in samples from wells in Ciudad Juarez. Water-quality deterioration, due to large withdrawals and declining water levels, continues to be a problem in the El Paso area.

## *Mesilla Bolson*

The Mesilla bolson consists of alluvial basin-fill deposits composed of clay, silt, sand, and gravel of the Sante Fe Group. Recent alluvial sediments overlie bolson deposits along the Mesilla Valley of the Rio Grande on the eastern side of the basin. In the lower Mesilla Valley near the City of Canutillo, ground water is pumped for municipal, industrial, and irrigation supply from three water-bearing zones which are differentiated by their lithology, water levels, and chemical quality. These zones are locally referred to as the shallow, intermediate, and deep aquifers. The shallow aquifer includes the overlying Rio Grande alluvium.

Leggat and others (1962) estimated that about 18,000 acre-feet of water per year recharges the aquifers in the lower Mesilla Valley. Recharge occurs by precipitation in the valley and runoff from the Franklin Mountains; by seepage from canals, laterals, the Rio Grande, and applied irrigation water; and by ground-water underflow from uplands in New Mexico. Discharge of ground water occurs by evapotranspiration, drain flow at the lower end of the valley, and pumping wells (Alvarez and Buckner, 1980).

Depth to water in the shallow aquifer is generally 5 to 15 feet below land surface, although, during periods of heavy withdrawals for irrigation, water levels may decline as much as 10 to 15 feet. Water levels in wells completed in the deeper aquifers generally range from slightly higher than those in the shallow aquifer to several feet lower, and are especially lower in the more heavily pumped area between Anthony and Canutillo.

The chemical quality of the ground water in the lower Mesilla Valley ranges from very fresh to saline with salinity generally increasing to the south along the valley. The water is also generally freshest in the lower aquifer and contains progressively higher concentrations of dissolved solids in the shallower zones.

## *Rio Grande Alluvium*

The Rio Grande alluvium consists of stream-channel and floodplain deposits composed of poorly sorted clay, silt, sand, and gravel which are in part derived from the erosion and redeposition of underlying bolson deposits. These alluvial sediments, which reach an average maximum thickness of about 200 feet, are hydraulically connected to underlying bolson deposits, and form a part of the shallow aquifer. The alluvium is an important source of shallow ground water for supplemental irrigation when the surface-water flow in the Rio Grande is not sufficient to meet the total agricultural water needs of the valley farmers.

Recharge to the Rio Grande alluvium occurs from infiltration of precipitation which falls directly on the surface and runoff from the adjoining bolson surfaces; leakage from the Rio Grande and, to a lesser extent, from numerous canals which traverse the heavily cultivated and irrigated floodplain; and excess irrigation water applied to the cultivated land. Leakage from the Rio Grande to the alluvium has increased from 15,000 acre-feet in 1968 to 30,000 acre-feet during 1983 (Land and Armstrong, 1985). Discharge occurs largely by seepage into drainage canals, evaportranspiration, downward leakage into underlying bolson deposits, and pumpage (Alvarez and Buckner, 1980).

Ground water in the alluvium is under water-table conditions and is generally only a few feet below land surface except in areas where the water level has declined due to direct pumpage from the alluvium or due to downward leakage into underlying heavily pumped aquifers. The alluvium has been completely drained in parts of downtown El Paso and Ciudad Juarez.

Water in the Rio Grande alluvium mostly ranges from slightly to moderately saline (1,000 to 10,000 milligrams per liter dissolved-solids concentrations). The freshest water occurs near the river where the alluvium is being recharged. Poorer quality water occurs where irrigation practices bring leached minerals to the ground-water system. Downward leakage of poor quality water from the alluvium has caused problems in areas where the underlying bolson aquifers are being heavily pumped.

# GROUND-WATER PROBLEMS

Historical large-scale ground-water withdrawals, especially from well fields located in the downtown areas of El Paso and Ciudad Juarez, have caused major water-level declines which have significantly changed the direction and rate of flow, and the chemical quality, of ground water in the aquifers.

## Water-Level Decline

The most prominent water-level declines have occurred in municipal well fields that have been developed in the Hueco bolson aquifer. The rates of water-level decline in the City of El Paso metro area range from less than 0.5 foot per year near the eastern boundary to more than 5 feet per year near pumpage centers (White, 1983). Historically (1903-89), the greatest declines of as much as 150 feet are in the downtown areas of El Paso and Ciudad Juarez (Figure 3). Declines in excess of 50 feet have occurred in the same general area during the 10 year period prior to 1989 (Figure 4).

Meyer (1976) indicated that the Hueco bolson receives a large amount of induced recharge by vertical leakage of water from the Rio Grande alluvium. The water moves downward from the alluvium when pumpage of ground water from the bolson lowers its artesian head below the water table in the alluvium. Due to lining of part of the Rio Grande channel in 1968, the alluvium receives very little recharge from surface-water inflow in the El Paso metropolitan area and therefore is significantly drained by the leakage.

Declining water levels, primarily in the shallow water-table aquifer, have resulted in a minor amount of land-surface subsidence due to the dewatering of clay beds (Land and Armstrong, 1985). Releveling of bench marks in the metropolitan area has shown land-surface subsidence of about 0.2 foot. Local areas of subsidence coincide with areas that historically were swamps along the Rio Grande and are indicated by surface fractures and cracks in buildings. Subsidence is not expected to increase dramatically in the future.

Less severe water-level declines have occurred in the lower Mesilla Valley. Declines of 10 to 30 feet in the intermediate and deep aquifers of the Mesilla bolson have reversed the vertical flow of ground water thus causing leakage of inferior-quality water from the shallow zone. Water levels in shallow wells have not experienced any appreciable long-term change, thus suggesting that recharge to and discharge from the aquifer are in general equilibrium (White, 1983).

## Water-Quality Deterioration

Increasing dissolved-solids concentrations in fresh-water zones of both the Hueco and Mesilla bolsons are attributed mainly to downward leakage of brackish water from shallow zones and possibly upconing of brackish water from below. Analyses of water samples from wells completed in the Hueco bolson show an average annual increase in dissolved solids of about 10 milligrams per liter since the 1950's and 1960's in the United States and about 30 milligrams per liter since the 1970's in Ciudad Juarez. In parts of downtown El Paso and Ciudad Juarez, the dissolved-solids concentration in ground water has increased at rates of 40 to 100 milligrams per liter per year during these periods. Dissolved-solids concentrations have also increased in ground water produced from the intermediate zone of the Mesilla bolson at an average rate of about 9 milligrams per liter per year (White, 1983).

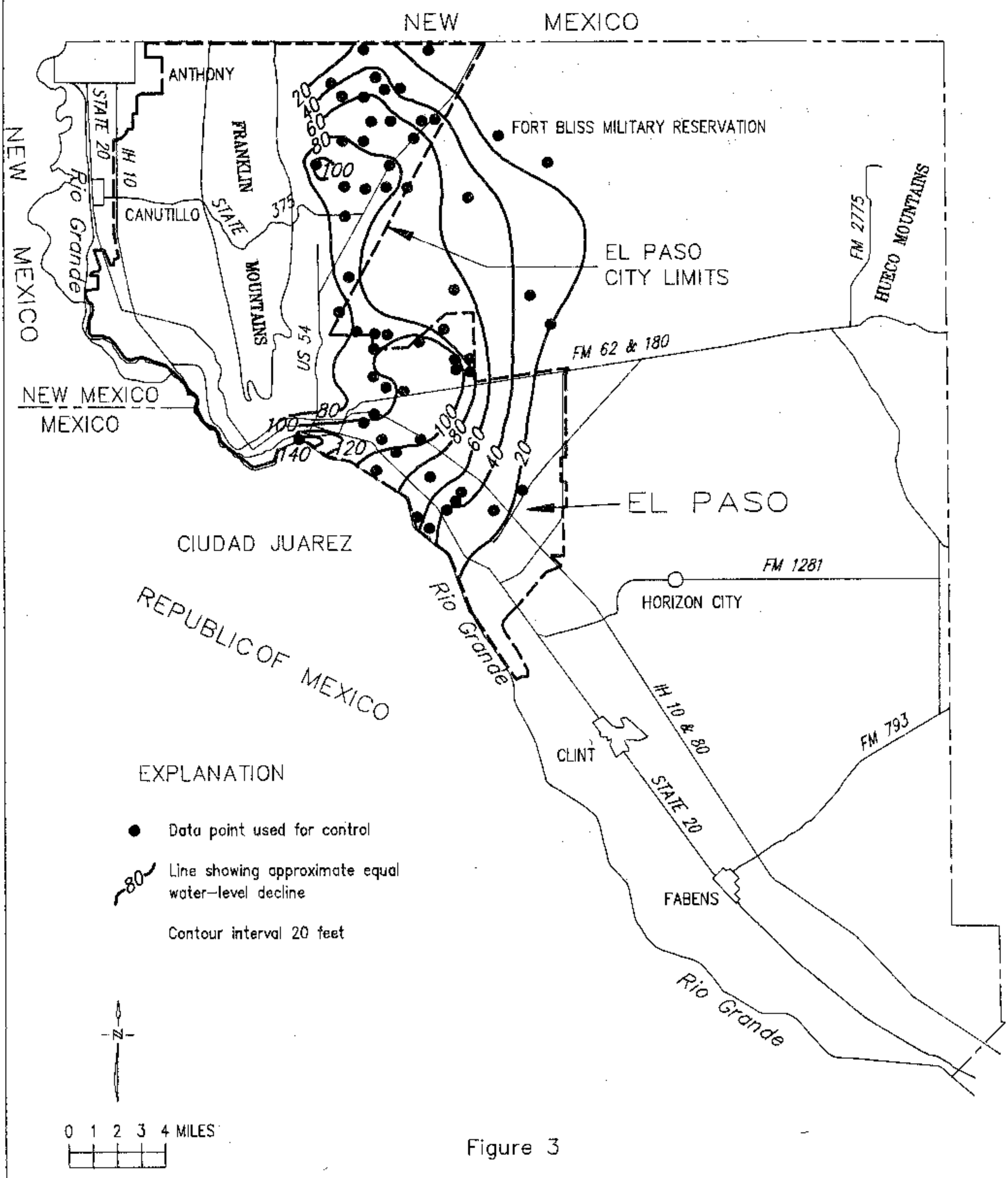


Figure 3

WATER—LEVEL DECLINE IN THE HUECO BOLSON AQUIFER FROM 1903 TO 1989

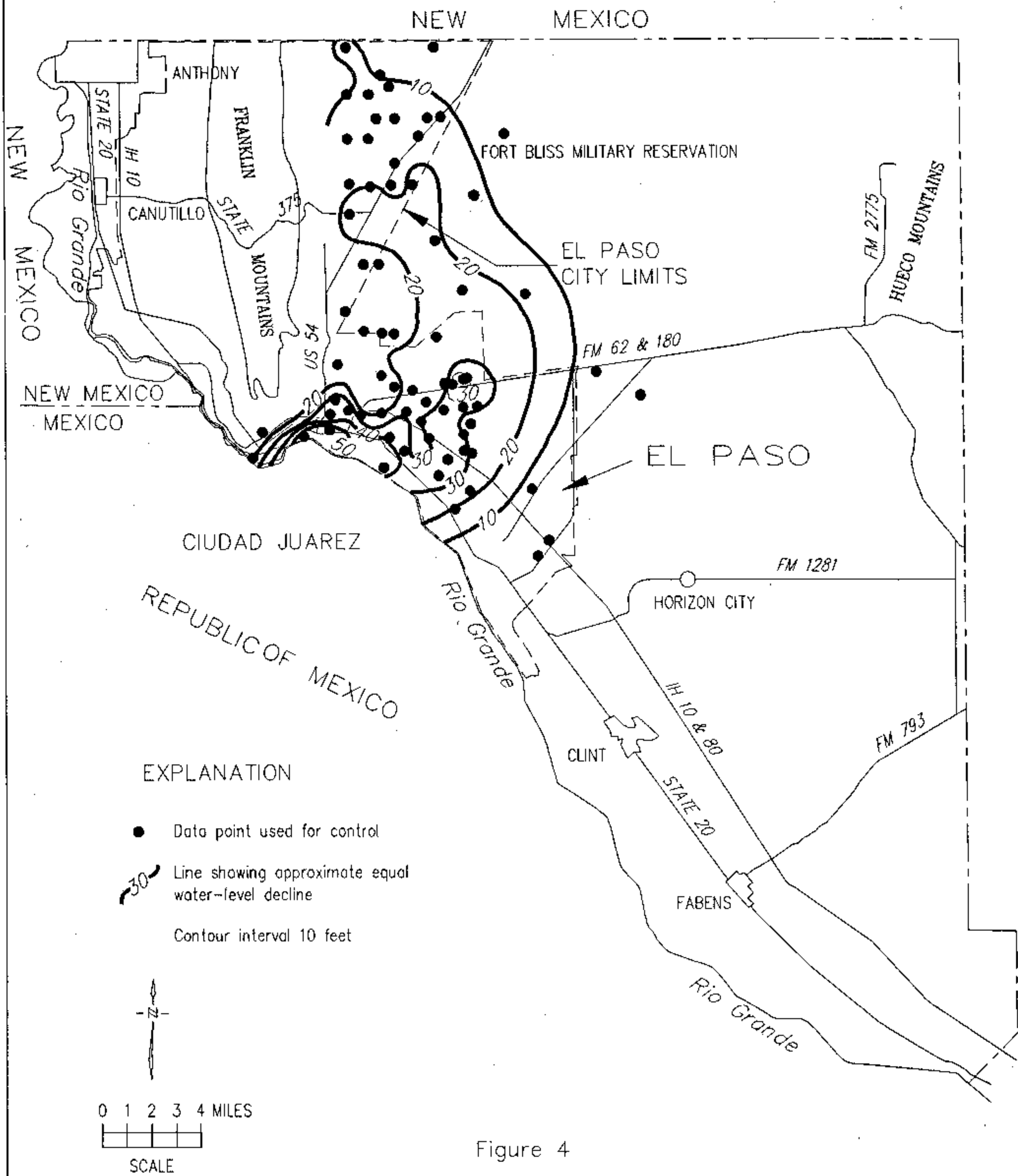


Figure 4

WATER-LEVEL DECLINE IN THE HUECO BOLSON AQUIFER FROM 1978-79 TO 1988-89

# PROJECTED WATER DEMAND

## Population

The population of El Paso County is primarily concentrated along the Rio Grande corridor and depends heavily on economic conditions associated with agriculture, industry, and tourism. In 1985, the total county population was 545,006, of which 94 percent resided in the Cities of Anthony, Canutillo, Clint, El Paso, Fabens, and the Fort Bliss military reservation. Across the Rio Grande, in Ciudad Juarez, the population is roughly estimated to be about 1.2 million by the West Texas Council of Governments.

With a 1985 population of 482,853, the City of El Paso has 89 percent of the total county population. The City population is expected to increase to 818,757, or by 70 percent, by the year 2010. The total county population is similarly projected to increase by 74 percent to 950,815 by the year 2010.

The 1980 and 1985 population for cities and rural areas, along with projected estimates for the years 1990, 2000, and 2010, are shown in the following table. Population projections for the study area were estimated by extending Bureau of Census statistics according to growth rates used in the 1988 Texas Water Development Board Revised Data Series population projection methodology.

| City | 1980 | 1985 | 1990 | 2000 | 2010 |
|---|---|---|---|---|---|
| Anthony | 2,640 | 3,254 | 3,872 | 5,207 | 6,353 |
| Canutillo | 3,866 | 4,423 | 5,085 | 7,000 | 8,540 |
| Clint | 1,314 | 1,823 | 2,154 | 2,694 | 3,286 |
| El Paso | 425,259 | 482,853 | 532,340 | 671,008 | 818,757 |
| Fabens | 4,219 | 4,621 | 5,202 | 6,323 | 7,714 |
| Fort Bliss | 12,622 | 12,901 | 12,901 | 12,901 | 12,901 |
| Rural | 29,979 | 35,131 | 49,965 | 68,093 | 93,264 |
| **County Total** | **479,899** | **545,006** | **611,519** | **773,226** | **950,815** |

**Source:** 1980 and 1985 population is based on Bureau of Census statistics. 1990, 2000, and 2010 population is based on 1988 Texas Water Development Board Revised High Series population projection. The term "Rural" includes smaller communities and all rural population.

## Water Use

The total amount of water used in 1985 in El Paso County was about 289,000 acre-feet, 37 percent of which was pumped from the local aquifers. This amount is a 6 percent reduction from the 1980 total use and is a result of a substantial decrease in

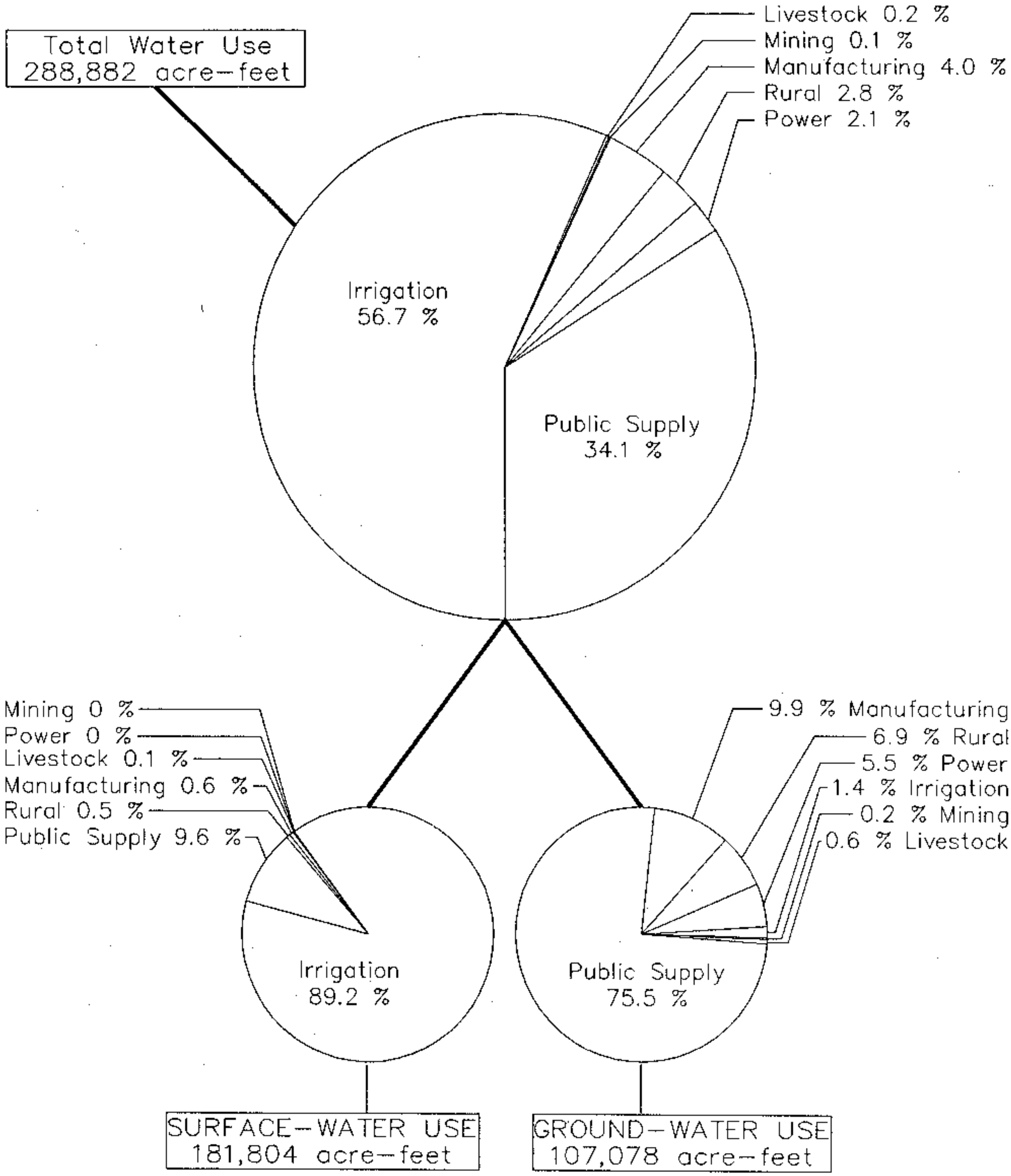


Figure 5

GROUND, SURFACE, AND TOTAL WATER USE
IN EL PASO COUNTY IN 1985

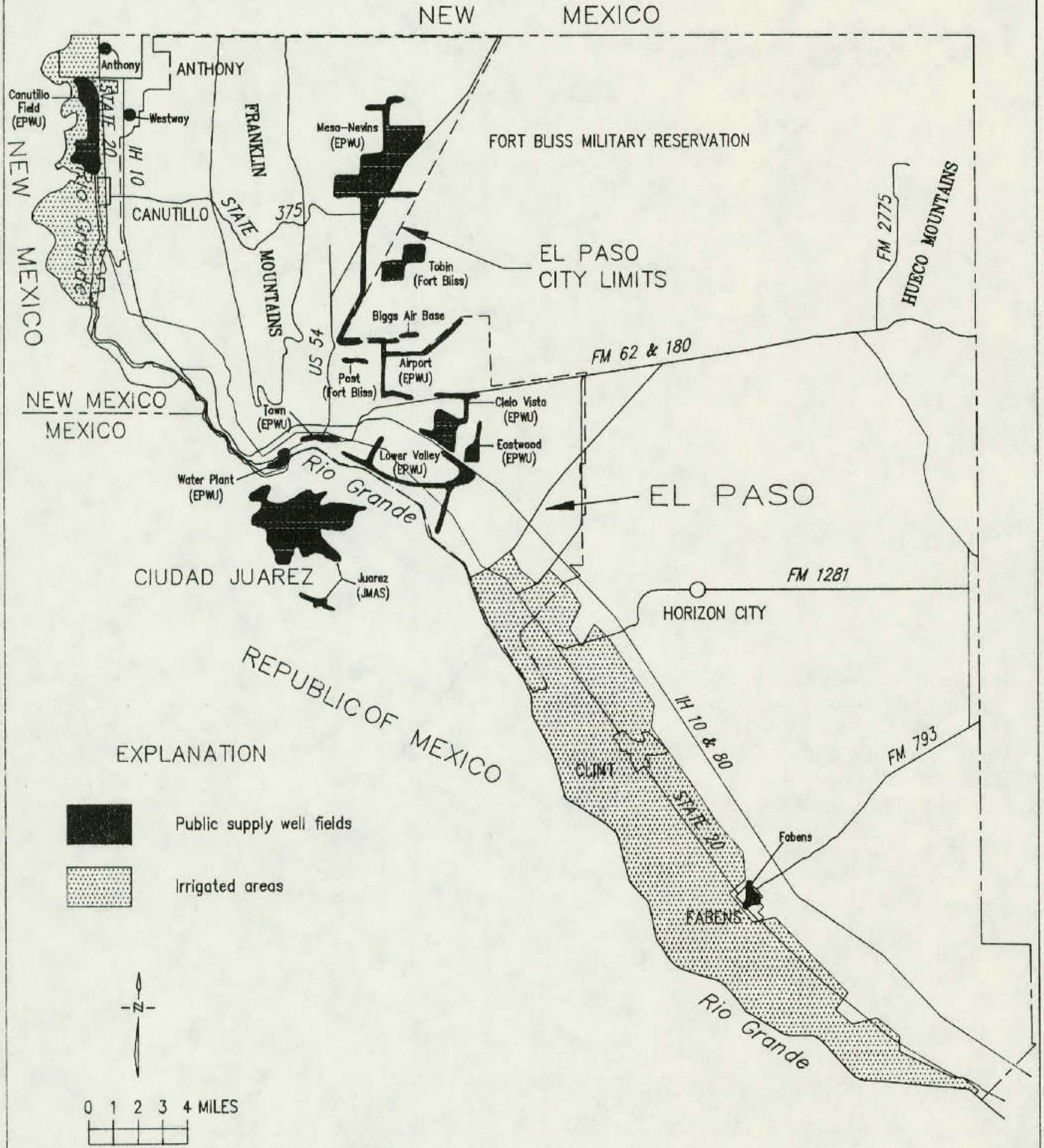


Figure 6

AREAS OF GREATEST PUBLIC SUPPLY AND IRRIGATION PUMPAGE irrigation use. The following table and Figure 5 show the quantity of water by type of use and source for the year 1985. Figure 6 shows the major areas of public supply pumpage and irrigation use in the area.

| Use | 1985 Ground Water (ac-ft) | 1985 Surface Water (ac-ft) | 1985 Total Water (ac-ft) |
|---|---|---|---|
| Public Supply | 80,845 | 17,572 | 98,417 |
| Rura7,367 | 875 | 8,242 | |
| Manufacturing | 10,657 | 1,054 | 11,711 |
| Power | 5,941 | 0 | 5,941 |
| Irrigation | 1,490 | 162,272 | 163,762 |
| Mining | 176 | 0 | 176 |
| Livestock | 602 | 31 | 633 |
| **Total** | **107,078** | **181,804** | **288,882** |

**Source:** Texas Water Development Board 1988 Revised Data Series.

As reported in this section, 1985 water use was compiled by the Texas Water Development Board and is documented in its 1988 Revised Data Series preliminary draft. Public supply and rural use is based on amounts reported by cities or other suppliers and apportioned by population where appropriate. Livestock use is based on the study area's rural geographical share apportioned to county total livestock use. All other use is based on site-specific computed use.

## *Public Supply*

The municipal water needs of the various cities and Fort Bliss military reservation in El Paso County are supplied from both the Rio Grande and ground-water sources. In 1985, over 98,000 acre-feet of water was supplied for municipal use, 82 percent of which was derived from local aquifers. Water supplied to the City of El Paso (89,073 acre-feet) represents 91 percent of the 1985 total public supply use. In that year, the City diverted nearly 17,000 acre-feet of water from the Rio Grande. This use by the City is permitted under contract with the El Paso County Water Improvement District No. 1 and the Rio Grande Project.

Public supply represents 76 percent of the 1985 ground-water use in El Paso County, but only 34 percent of the total combined surface- and ground-water use. The following table lists the major public-supply users in the county and the source and quantity of water used by each in 1985. Across the Rio Grande, ground-water pumpage for public supply and individual use in Ciudad Juarez, Mexico, as reported to the U.S. Geological Survey by the Governor's office of the State of Chihuahua, has increased from about 56,000 acre-feet in 1980 to about 79,000 acre-feet in 1987.

| Use | 1985 Ground Water (ac-ft) | 1985 Surface Water (ac-ft) |
|---|---|---|
| Anthony | 463 | 0 |
| Canutillo | 274 | 21 |
| Clint | 230 | 55 |
| El Paso | 72,149 | 16,924 |
| Fabens | 677 | 0 |
| Fort Bliss | 7,052 | 572 |
| **Total** | **80,845** | **17,572** |

**Source:** Texas Water Development Board 1988 Revised Data Series.

## *Rural*

The rural population in 1985 used 8,242 acre-feet of water which is approximately 3 percent of the total county use. Most of this water is pumped from private wells, although 875 acre-feet was purchased from the City of El Paso.

## *Manufacturing*

Manufacturing represents the primary industrial use of water in El Paso County. In 1985, manufacturing use amounted to 11,711 acre-feet which is an increase of 23 percent from the amount used in 1980 and represents 4 percent of the total county use. Approximately 46 percent of the water used for manufacturing in 1985 was supplied by the City of El Paso.

## *Power*

Water used for the generation of electrical power in 1985 amounted to 5,941 acre-feet, all of which was pumped from aquifers. Approximately 27 percent of the water supply was obtained from seven wells located in Dona Ana County, New Mexico. The balance was supplied by the City of El Paso.

## *Mining and Livestock*

Water used for mining in El Paso County in 1985 amounted to 176 acre-feet of ground water. Livestock use in 1985 amounted to 633 acre-feet, most of which was ground water. The 31 acre-feet of surface water used for livestock was supplied from local sources including creeks, stock tanks, pits, and the Rio Grande.

## Irrigation

El Paso County is one of the leading agricultural counties in Texas and virtually all of the production depends upon irrigation primarily from the Rio Grande, augmented by pumpage from the Rio Grande alluvium during periods of surface-water shortage.

The first irrigation practiced in the area was near a community that sprang up around the Spanish mission "Our Lady of Guadalupe of El Paso" which was founded in 1659 in what is now downtown Ciudad Juarez, Mexico. By 1851 about 40,000 acres of cultivated fields on both sides of the Rio Grande was irrigated with river water distributed by a system of acequias or irrigation ditches (Sayre and Livingston, 1945; and U.S. Bureau of Reclamation, 1973).

In the 1890's Mexico filed a claim against the United States for damages due to river water shortages primarily in the Mesilla and El Paso Valleys. The 1896 Embargo and subsequent Mexican Treaty of 1906 placed restrictions on the unlimited use of water from the upper reaches of the Rio Grande, and eventually resulted in the 1938 Rio Grande Compact. The compact provides for scheduled deliveries of water in the Rio Grande by the States of Colorado and New Mexico.

In order to deliver the required water downstream, the U.S. Reclamation Service constructed Elephant Butte Reservoir, diversion dams, canals, and open drains. This water delivery and recovery system, completed in 1925, was called the Rio Grande Project. Landowners on the Project are represented by the Elephant Butte Irrigation District of New Mexico and the El Paso County Water Improvement District No. 1 of Texas. In addition, the Hudspeth County Conservation and Reclamation District No. 1, consisting of approximately 20,000 acres of the El Paso Valley in Texas, organized below the Rio Grande Project.

Currently, almost all of the agricultural production in the county occurs within the irrigated area of the El Paso County Water Improvement District No. 1 and areas contiguous to the district that irrigate by pumping. The district has an irrigable area of 76,114 acres and the contiguous areas that irrigate solely by pumping amount to an additional 8,600 acres. The farms with surface-water rights apply approximately 3 acre-feet of water per acre during full water supply years (U.S. Bureau of Reclamation, 1973).

Water for irrigation use is obtained primarily by diversion from the Rio Grande because of the low cost and superior quality of the river water. However, during years of inadequate surface-water supply, shallow wells in the Rio Grande alluvium are pumped to augment the diversions. In 1985, 99 percent of the water used for irrigation was diverted from the Rio Grande. The following table shows the ratio between surface-water and ground-water irrigation use for specified years along with the number of acres irrigated and number of operable irrigation wells.

| Year | Ground Water (ac-ft) | Surface Water (ac-ft) | Acres Irrigated | Irrigation Wells |
|---|---|---|---|---|
| 1958 | 4,681 | 188,321 | 55,551 | 547 |
| 1964 | 4,828 | 135,853 | 55,000 | 550 |
| 1969 | 4,685 | 201,329 | 57,919 | 593 |
| 1974 | 4,055 | 175,255 | 56,375 | 601 |
| 1979 | 1,760 | 163,315 | 53,810 | 590 |
| 1984 | 833 | 158,876 | 47,526 | 590 |

**Source:** Texas Water Development Board, 1986.

In 1985, almost 164,000 acre-feet of water was used for irrigation in El Paso County which is 57 percent of all the water used in the county. Also, 89 percent of all the water diverted into El Paso County from the Rio Grande was used for irrigation (Texas Water Development Board, 1988).

## Projected Water Demand, 1990-2010

The total annual water requirement for El Paso County is expected to increase by about 63,000 acre-feet or 22 percent from 1985 to the year 2010. Public supply and rural use combined is projected to increase in response to the expected population growth by about 79,000 acre-feet or 74 percent during this period. Industrial manufacturing water use is also projected to increase by about 38 percent. Irrigation use, however, is projected to decline by about 19,000 acre-feet or 12 percent by the year 1990 and then remain at about that rate of use through the year 2010. Projected water demand for power, mining, and livestock use are all expected to remain about equal to the present rate of use through the year 2010. Projected water demand by use category is listed in Table 1. According to these projections, by the year 2010, water demand for public-supply use will have increased from 34 to 48 percent of the total county water demand, while irrigation use will decrease from 57 to 40 percent of total county demand.

Projections of future public supply and rural requirements are based upon 1988 Texas Water Development Board population projections and projected high per capita water use with conservation. All other water use projections are based upon 1988 Texas Water Development Board High Series (preliminary draft) projected demands and the apportioned share of total county demands. High Series projections take into account the demands that are likely to occur during drought conditions.

**Table 1**
**Projected Total Water Demand**
**by Use**
**in El Paso County[1]**
**(units in acre-feet)**

| Use | Year 1990 | Year 2000 | Year 2010 |
|---|---|---|---|
| Public Supply[2] | 125,234 | 147,895 | 169,136 |
| Rural[3] | 9,822 | 12,700 | 16,454 |
| Manufacturing | 12,645 | 14,504 | 16,186 |
| Power | 6,000 | 6,000 | 6,000 |
| Irrigation | 144,461 | 144,461 | 143,601 |
| Mining | 176 | 183 | 190 |
| Livestock | 544 | 625 | 625 |
| **Total** | **298,882** | **326,368** | **352,192** |

1 Projected water demand includes both surface and ground water and is based on Texas Water Development Board High Series (preliminary draft) projected demands, dated September 1988.

2 Public supply includes projected demands for the Cities of Anthony, Canutillo, Clint, El Paso, Fabens, and Fort Bliss Military Reservation.

3 Rural includes smaller communities and all rural population use.

# AVAILABILITY OF WATER

## Current Availability of Ground Water

The amount of fresh ground water (less than 1,000 milligrams per liter) available on a perennial basis from the Hueco and Mesilla bolson aquifers within El Paso County is approximately 6,000 acre-feet (Meyer, 1976) and 18,000 acre-feet (Leggat and others, 1962), respectively, which is the average annual effective recharge to the aquifers. Theoretically, this quantity can be developed without reducing the quantity of ground water in storage, although it should be recognized that a single well, or well field, cannot recover the total sustainable annual yield of the aquifer. Annual withdrawal by pumpage (107,078 acre-feet in 1985) exceeds this available quantity, thus resulting in areas of water-level decline as shown in Figures 3 and 4. The 6,000 acre-feet in the Hueco has been exceeded since the early 1900's, and the 18,000 acre-feet in the Mesilla has been exceeded since the 1950's (White, 1983).

Approximately 10.6 million acre-feet of theoretically recoverable fresh water was calculated to occur in Hueco bolson deposits in 1973 in the El Paso metro area by Meyer (1976). This volume was revised to 10.2 million acre-feet for the year 1980 by the continuing water resources planning function of the Texas Water Development Board. White (1983) estimated that in 1980, the recoverable fresh-water resource of the Hueco bolsom aquifer in the metro area was about 10 million acre-feet. More recently (Jan. 1989), White estimated that approximately 9.7 million acre-feet remains in the aquifer, 9.3 million acre-feet of which occurs in the metro area (Don White, 1989, personal communication).

The Mesilla bolson deposits and the Rio Grande alluvium together were estimated to contain about 560,000 acre-feet of fresh water in storage under the Texas part of the lower Mesilla Valley (Leggat and others, 1962). However, this estimate was revised by Gates and others (1978) to about 820,000 acre-feet. The Texas Water Development Board has assigned a volume of 560,000 acre-feet for the year 1980. A test-well drilling program will soon be initiated by the City of El Paso to determine the southern boundary of the aquifer system south of the Canutillo well field which is expected to show that an upward revision of estimates should be made for volumes in storage in the Mesilla bolson (Tom Cliett, 1989, personal communication).

Even though this fresh water in storage is considered theoretically recoverable, the proximity of poor quality ground water requires the constraint that only 50 to 75 percent of the fresh water be pumped to prevent the degradation of its chemical quality.

In addition to the fresh water resources, Meyer and Gordon (1972) estimated that about 3.4 million acre-feet (4 million estimated by White, 1983) of slightly saline (1,000 to 3,000 milligrams per liter) ground water in the Hueco bolson aquifer underlie and adjoin the fresh water zone. Also, about 300,000 acre-feet of slightly saline water is estimated to be stored in the Rio Grande alluvium in the lower Mesilla Valley (Gates and others, 1978). Although this water is unsuitable for drinking, it may be made potable if blended with fresher water or by desalination. The City of El Paso presently uses a blending procedure in a part of its water-supply production system.

A report by Wilson and others (1981) shows that the saturated section in the Mesilla Valley thickens to the north and west in New Mexico to as much as 2,400 feet. The study estimated that 20 million acre-feet of fresh water and 2.7 million acre-feet of slightly saline water are theoretically available to wells in the part of the valley north of Anthony. In the La Mesa area in New Mexico, the study estimated that, assuming a specific yield value of 8.9 percent, 34 million acre-feet of fresh water is theoretically available. Subsequent test-hole data indicate that about 22.5 to 33.8 million acre-feet of theoretically recoverable fresh water occurs assuming a specific yield of 10 to 15 percent (Don White, 1989, personal communication).

## Current Municipal Conservation Practices

The City of El Paso Water Utilities has instigated several conservation activities, some of which extend back as much as 15 years (Tom Cliett, 1989, personal communications). Some of the on-going activities include, but are not restricted to, the following:

1. A water-resources management plan.
2. Recharge of the Hueco bolson with treated effluent.
3. A plumbing code and well permit regulation.
4. An inverted pricing rate schedule (the more water used, the higher the rate).
5. Public conservation education.
6. Blending of fresh and brackish water.
7. Reduction in distribution losses by replacing old and leaking water lines and lining reservoirs.
8. Metering all users.

These activities together have been estimated to save at least 31,600 acre-feet of water per year.

## Potential for Conjunctive Use of Ground and Surface Water

The Rio Grande has from the very beginning played a key role in the development of the El Paso Community. In 1985, water from the river supplied 18 percent of public supply and 99 percent of irrigation use in El Paso County. All water rights to the Rio Grande in El Paso County are allocated and additional inflow is not expected in the future. Therefore, as water-use requirements change, water rights to the existing supply should likewise be transferred when available.

With the Rio Grande Project in place, very little through-flow of the river is available downstream for such projects as the Hudspeth County Conservation and Reclamation District No. 1 (U.S. Bureau of Reclamation, 1973). Water continuing down river from the Rio Grande Project, during years of normal runoff and supply, is primarily irrigation system waste water and drainage return flow, and municipal sewage effluent.

The following management practices have been carried out to some degree for years and their continuation should help increase the availability of the current surface-water supply:

1. Continued modernization of the Rio Grande Project conveyance system by lining of the canals and ditches with concrete and, where feasible, replacing with pipe, to reduce the amount of water lost to deep percolation. However, this does result in less recharge to the aquifer.

2. Eradication of phreatophytes along waterways to reduce water loss due to transpiration.

3. Continued reuse of sewage effluent for irrigation.

## Potential for Additional Ground-Water Development

Fresh ground water in El Paso County is currently being withdrawn at a rate in excess of recharge, and undeveloped sources of fresh ground water of significant quantity probably do not occur within the county. However, large amounts of slightly saline water occur in the Texas part of both the Hueco and Mesilla bolsons which may be available for blending with fresh water to provide water of acceptable quality for most uses (White, 1983).

The nearest potential supplies of import water in Texas occur in limited quantities in bolson deposits southeast of El Paso in Culberson, Hudspeth, and Jeff Davis Counties. As stated previously, as much as 54 million acre-feet of fresh ground water occurs in the Mesilla bolson north and west of El Paso County in New Mexico (Wilson and others, 1981). Use of this water by the City of El Paso will require changes in laws that presently prevent its exportation across the state line. Negotiations, however, are now being held to obtain water from New Mexico.

## Potential Methods of Increasing Aquifer Recharge

Recharge is the process by which water is absorbed and added to the zone of saturation. Any activity by man, either intentional or unintentional, that increases or supplements the rate of replenishment to the aquifer, is called artificial recharge.

As described previously, natural recharge to the bolson aquifers occurs primarily by the downward percolation of water derived from precipitation on the surface, runoff from the mountains, seepage from the Rio Grande and canals, infiltration of applied irrigation water, and leakage from the overlying alluvium. Probably very little practical enhancement of these processes can be made to increase recharge in the study area. In fact, the lining of a segment of the Rio Grande has resulted in a reduction of recharge as seepage from the river.

Probably the most practical method of producing additional recharge involves returning treated sewage effluent from the various municipal water systems to the aquifers by way of recharge wells. In 1985, the City of El Paso put into operation the Fred Hervey Water Reclamation Plant. This facility is currently restoring 5 to 6 million gallons of sewage a day to drinking water standards and injecting most of it back into the Hueco bolson through 10 recharge wells. The recharge water migrates through the aquifer and eventually will be reclaimed at the City's production wells. As of August 1989, over 16,000 acre-feet of water has been recharged to the aquifer through this process (Tom Cliett, 1989, personal communication).

The reclamation and recharge procedure appears to be operating quite successfully and additional facilities of this type may be beneficial. However, strict monitoring of the chemical quality of the injected water is absolutely essential.

## Projected Availability Through the Year 2010

The amount of ground water needed to supply projected demands in El Paso County through the year 2010 is in excess of the estimated annual effective recharge to the aquifers and, therefore, a large portion will continue to be drawn from storage. Only 50 to 75 percent of the approximately 10,260,000 acre-feet of fresh water in storage in the Hueco and Mesilla bolsons can be withdrawn without seriously affecting water quality.

Increasing water demands caused by a rapidly growing population will hasten the rate of withdrawal of this safe yield, resulting in a depleted fresh-water source in the early to middle 21st century, unless alternate sources can be acquired to supplement the current supply. Acquisition of additional water rights to the Rio Grande by the City of El Paso along with a continued aggressive conservation program will be beneficial, but will not prevent the eventual depletion of the aquifers. It is therefore essential that the City of El Paso, along with other major ground-water users, earnestly continue to evaluate alternative water sources, recharge and reuse projects, and conservation practices.

## SELECTED REFERENCES

Alvarez, H.J., and Buckner, A.W., 1980, Ground-water development in the El Paso region, Texas, with emphasis on the resources of the lower El Paso Valley: Texas Department of Water Resources Report 246, 346 p.

Ashworth, J.B., and Nordstrom, P.L., 1989, Public supply ground-water use in western Texas: Texas Water Devel. Board Report 311, 163 p.

Bluntzer, R.L., 1975, Selected water well and ground-water chemical analysisdata, Ciudad Juarez, Chihuahua, Mexico: Texas Water Devel. Board file report, 29 p.

Bureau of Economic Geology, 1983, Geologic atlas of Texas, Van Horn-El Paso sheet: Univ. of Texas, Bureau of Economic Geology map.

Cliett, T.E., 1969, Groundwater occurrence of the El Paso area and its relatedgeology: New Mexico Geologic Society, Border Region, Chihuahua Mexico and United States, Guidebook 20th Field Conference, 1969, p. 209-214.

Davis, M.E., and Leggat, E.R., 1965, Reconnaissance investigation of the ground-water resources of the upper Rio Grande basin, Texas, in Reconnaissance investigations of the ground-water resources of the Rio Grande basin, Texas: Texas Water Commission Bulletin 6502, p. U1-U99.

Garza, Sergio, Weeks, E.P., and White, D.E., 1980, Appraisal of potential for injection-well recharge of the Hueco bolson with treated sewage effluent--Preliminary study of the northeast El Paso area, Texas: U.S. Geological Survey open-file report 80-1106, 37 p.

Gates, J.S., and Stanley, W.D., 1976, Hydrogeologic interpretation of geophysical data from the southeastern Hueco bolson, El Paso and Hudspeth Counties, Texas: U.S. Geological Survey open-file report 76-650, 37 p.

Gates, J.S., White, D.E., Stanley, W.D., and Ackermann, H.D., 1978, Availability of fresh and slightly saline ground water in basins of westernmost Texas: U.S. Geological Survey open-file report 78-663, 115 p.; also published as Texas Department of Water Resources Report 256.

Hawley, J.W., Kottlowski, F.E., Seager, W.R., King, W.F., Strain, W.S., and Lemone, D.V., 1969, The Sante Fe Group in the south-central New Mexico border region, in Border Stratigraphy Symposium: New Mexico Bureau of Mines and Mineral Resources Circular 104, p. 52-67.

International Boundary and Water Commission, 1989, Ground-water conditions and resources in El Paso/Juarez valley: Prepared by Hydraulics Branch, Planning Division, U.S. Section, International Boundary and Water Commission, 41 p.

Kirby, J.W., 1968, Water resources--El Paso County, Texas--past, present, future: Univ. Texas at El Paso Master's Thesis, 181 p.

Knowles, T.R., and Alvarez, J.H., 1979, Simulated effects of ground-water pumping in portions of the Hueco bolson in Texas and Mexico during the period 1973 through 2029: Texas Department of Water Resources LP-104, 26 p.

Knowles, D.B., and Kennedy, R.A., 1956, Ground-water resources of the Hueco bolson, northeast of El Paso, Texas: Texas Board of Water Engineers Bulletin 5615, 265 p.; republished 1958, U.S. Geological Survey Water-Supply Paper 1426, 186 p.

Land, L.F., and Armstrong, C.A., 1985, A preliminary assessment of land-surface subsidence in the El Paso area, Texas: U.S. Geological Survey Water-Resources Investigations Report 85-4155, 96 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 Bulletin 6203, 195 p.; republished 1963, U.S. Geological Survey Water-Supply Paper 1669-AA, p. AA1-AA49.

Mattick, R.E., 1967, A seismic and gravity profile across the Hueco bolson, Texas: U.S. Geological Survey Professional Paper 575-D, p. D85-D91.

Meyer, W.R., 1976, Digital model for simulated effects of ground-water pumping in the Hueco bolson, El Paso area, Texas, New Mexico, and Mexico: U.S. Geological Survey Water-Resources Investigations Report 58-75, 31 p.

Meyer, W.R., and Gordon, J.D., 1972, Development of ground water in the El Paso district, Texas, 1963-70: Texas Water Devel. Board Report 153, 50 p.

Müller, D.A., and Price, R.D., 1979, Ground-water availability in Texas, estimates and projections through 2030: Texas Department of Water Resources Report 238, 77 p.

Sayre, A.N., and Livingston, Penn, 1937, The ground-water resources of the El Paso area: U.S. Geological Survey open-file report, 5 p.

____1945, Ground-water resources of the El Paso area, Texas: U.S. Geological Survey Water-Supply Paper 919, 190 p.

Strain, W.S., 1966, Blancan mammalian fauna and Pleistocene formations, Hudspeth County, Texas: Univ. of Texas at Austin, Memorial Museum Bulletin 10, 55 p.

____1969, Late Cenozoic strata of the El Paso area, in Border Stratigraphy Symposium: New Mexico Bureau of Mines and Mineral Resources Circular 104, p. 122-123.

Sundstrom, R.W., and Hood, J.W., 1952, Results of artificial recharge of the ground-water reservoir at El Paso, Texas: Texas Board of Water Engineers Bulletin 5206, 19 p.

Texas Water Development Board, 1986, Surveys of irrigation in Texas, 1958, 1964, 1969, 1974, 1979, and 1984: Texas Water Devel. Board Report 294, 243 p.

____1988, Revised data series, preliminary draft: unpublished.