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REGIONAL WATER PLAN FOR THE GUADALUPE RIVER BASIN

GBRA

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Guadalupe-Blanco River Authority

and

HDR

HDR Engineering, Inc.

REGIONAL WATER PLAN
FOR THE
GUADALUPE RIVER BASIN

PREPARED BY
GUADALUPE-BLANCO RIVER AUTHORITY
SEGUIN, TEXAS

AND

HDR ENGINEERING, INC.
AUSTIN, TEXAS

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PREFACE

This Regional Water Plan has been developed for the Guadalupe-Blanco River Authority's 10-county service area of the Guadalupe River Basin. The boundaries of the 10 counties however, are not coterminous with the boundaries of the River Basin. The tabulations of data presented herein are totals for the full 10 counties. This fact is noted in the footnotes of the tables.

During the early stages of the planning project, public meetings were held in each county of the service area by the Guadalupe-Blanco River Authority (GBRA). The purposes of the meetings were to obtain local review of preliminary projections and to receive public input and local area data. During this data gathering and public participation process, GBRA also surveyed cities, industries, and agricultural interests to obtain current water use information and plans for any changes in water use. This information together with projections and planning data from the Texas Water Development Board were used throughout the study. The draft planning report was provided to representatives of each county, and to the Texas Water Development Board for review. The review comments were considered in the preparation of the regional planning report.

This water planning report contains projections of growth and water requirements for all water using functions for each of the 10 counties of the Guadalupe-Blanco River Authority service area. Both low and high growth rates, with and without water conservation, are included in order to show the effects of these two factors upon future water needs of the planning area. The differences are identified and discussed in the report, and water conservation and drought contingency methods recommended by the Texas Water Development Board are included in the regional plan.

On the water supply side, information is presented about the quantities of both ground and surface water. Potential water supply projects are identified and estimates of project costs are presented. Emphasis is placed upon regional water supply projects that are needed in the immediate future to meet local area municipal and light industrial type needs. However, projects to meet needs in future years and decades are also included. Obviously, the effects of water conservation efforts, including those in irrigation agriculture, will play a major role in the determination of the timing and sizing of such projects.

The information contained within this regional water planning report will be useful to both GBRA and local officials of the service area for the development and management of water resources to meet the needs of the future. GBRA appreciates the assistance of the Texas Water Development Board, local government officials, business leaders and the citizens of the area who participated in this regional water planning effort.

REGIONAL WATER PLAN
FOR THE
GUADALUPE RIVER BASIN
SERVICE AREA

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1.0 INTRODUCTION

The Guadalupe-Blanco River Authority (GBRA) was created by Acts of the Texas Legislature in 1933 for the purpose of controlling, storing, preserving, and distributing the waters of the Guadalupe River Basin for all useful purposes. GBRA is responsible for planning, developing, and operating regional facilities to supply water for useful purposes within the 10-county boundary of the Guadalupe River Basin (Figure 1).

The Guadalupe River Basin is experiencing population and economic growth. Existing water supplies and water facilities are straining to meet present needs in several areas and new water use practices and facilities are necessary to meet future needs in many parts of the Basin. For example, the upper basin is experiencing increased growth due to the relocation of people from the City of San Antonio and other metropolitan areas. Ground water supplies of this area are limited and, within the area, surface water must be developed to meet the growing needs. Limitations of an adequate water supply in specific areas are caused by growth in some areas and declining supplies in others as a result of unmanaged pumping which reduces historic flows.

In the San Antonio-Austin Corridor Region of New Braunfels, Seguin, San Marcos, and Lockhart, high growth rates are placing strains upon available water supplies, including those from the Edwards-Balcones Aquifer and stream flows. Regional systems to supply water in this area are needed.

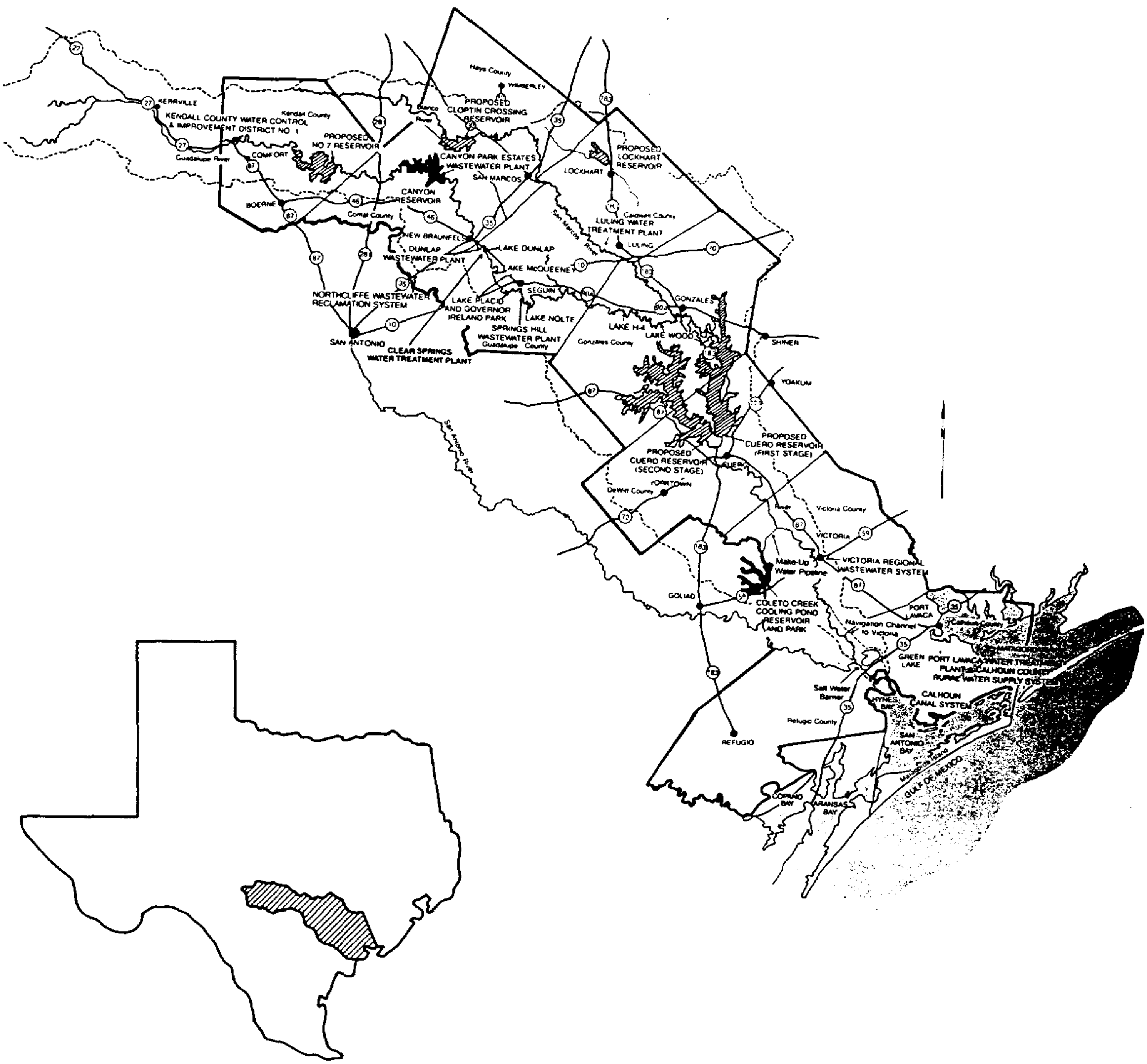
In the agricultural area of the central basin, water supplies must be protected from pollution by oil and gas exploration and production activities.

In the coastal region of Calhoun and Victoria Counties, population and industrial growth, along with irrigated agricultural water uses, are placing increasing demands upon both the ground and surface waters of the area. Pumping of water from the Gulf-Coast Aquifer within the area exceeds long-term annual recharge and contributes to the threat of land subsidence, which could contribute to increased flooding, and the threat of saline water intrusion into fresh water zones of the formation. Growth of coastal areas is placing higher demands upon both ground and surface water supplies.

Thus, regional water supply facilities and water conservation measures necessary to meet present and future needs in the coastal, corridor, and upper basin areas should be identified and evaluated.

Figure 1

Basin Map



1.1 The Study Area

The study area, which is shown in Figure 1, includes the 10 counties of the Guadalupe-Blanco River Authority district: Kendall, Comal, Hays, Caldwell, Guadalupe, Gonzales, DeWitt, Victoria, Calhoun, and Refugio. The 17 major cities of the area are Boerne, New Braunfels, San Marcos, Kyle, Schertz, Seguin, Lockhart, Luling, Gonzales, Nixon, Cuero, Yorktown, Victoria, Refugio, Woodsboro, Port Lavaca, and Seadrift. The 1980 census reported the population of the area to be 291,476. By 1985, the population had increased to 343,150.

The study area covers 7,306 square miles. The topography ranges from the steep rocky slopes of the Hill Country in Kendall, Comal, and Hays Counties through the gentle, rolling hills of the Piedmont (Guadalupe, Caldwell, Gonzales, and DeWitt Counties) to the flat coastal plains of Victoria, Calhoun, and Refugio Counties.

The Guadalupe River Basin is bounded on the north by the Colorado River Basin, on the east by the Lavaca River and Lavaca-Guadalupe Coastal Basins, on the west and south by the San Antonio River Basin, and on the south by the San Antonio-Nueces Coastal Basin. Headwaters of the Guadalupe River form in southwestern Kerr County, the county adjoining Kendall County to the west, at an elevation of approximately 2,360 feet. The river flows easterly to Gonzales and then southeasterly into Guadalupe Bay, part of the San Antonio Bay system. The Blanco and San Marcos Rivers are the principal tributaries of the Guadalupe River.[1]

The Blanco River originates in northern Kendall County at an elevation of approximately 1,900 feet and flows easterly, joining the San Marcos River 2 miles southeast of San Marcos at an elevation of 545 feet. The San Marcos River originates at San Marcos from the flow of the San Marcos Springs, and joins the Guadalupe River at Gonzales at an elevation of 252 feet.[2]

The South Fork of the Guadalupe River originates in southwestern Kerr County and joins the Guadalupe River near Hunt at an elevation of 1,735 feet. In New Braunfels, the Comal River originates from the flow of Comal Springs in Landa Park and joins the Guadalupe River on the east side of New Braunfels at an elevation of 583 feet. Coleto Creek, which forms the boundary separating Goliad and Victoria counties, joins the Guadalupe River at an elevation of approximately 20 feet, and the San Antonio River joins the Guadalupe about 5.9 miles north of Tivoli, near the coast. Both the quantity and quality of flows from the San Antonio Basin are important to water customers of the GBRA Calhoun Canal service area, since the canal diversions are downstream of the Guadalupe-San Antonio confluence.[3]

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[1]Unpublished, Texas Water Development Board, Austin, Texas, May, 1977.

[2]Ibid.

[3]Ibid.

The Guadalupe River Basin includes the Balcones Escarpment area of the Edwards Plateau Section in the Great Plains Province and the West Gulf Coast Section of the Coastal Plain Province. The land types include Edwards Plateau, Blackland Prairie, Claypan area, and Coast Prairie.[4]

The Edwards Plateau area is a deeply dissected, rapidly drained, brush and grass covered stony plain. Vegetation in the uplands consists of live oak, shin oak, cedar, mesquite, and short grasses. Hardwood species common in the bottomlands include oak and pecan. The thick upland soils are dark, calcareous clays and clayey loams. Bottomlands have dark, calcareous, clayey alluvial soils.[5]

The Blackland Prairies are nearly level to rolling, well dissected prairies with moderate to rapid surface drainage. Vegetation in the uplands includes tall bunch grasses with some mesquite and oak; whereas, hardwoods in the bottomlands consist mainly of oak, elm, cottonwood, and a few pecans. Upland soils are either dark, calcareous, clayey soils or neutral to slightly acid clays to sand loams, both of which change gradually with depth to marls or chalks. Bottomland soils are reddish brown to dark gray, slightly acid to calcareous, loamy to clayey alluvial soils.

The Claypan Area is a nearly level to gently rolling, moderately dissected region with moderate surface drainage. Vegetation consists of scattered stands of post oak and blackjack oak with tall bunch grasses, yaupon, and other underbrush. Upland soils are gray, slightly acid, sandy loams.[6]

The Coast Prairie is a nearly level, practically undissected plain with slow surface drainage. Upland vegetation consists of tall bunch grasses. Hardwoods, principally oak species, occur in the bottomlands. Upland soils are dark, neutral to slightly acid, clayey loams and clays which grade downward into light, calcareous clays.[7]

The upper reach of the Guadalupe Basin is underlain by Cretaceous age limestone which forms the Edwards Plateau. East and south of the Plateau are upper Cretaceous chalk, limestone, and clay. The extensive Balcones Fault Zone separates the Edwards Plateau from the Gulf Coastal Plain.

Cretaceous age strata are overlain by a sequence of southeasterly dipping sand, silt, clay, glauconite, volcanic ash, and lignite of Tertiary age. These strata, in turn, are overlain by clay, silt, and sand of the Pleistocene age Beaumont Formation in the coastal area of the

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[4]Ibid.

[5]Ibid.

[6]Ibid.

[7]Ibid.

basin.[8]

The Guadalupe River Basin lies in three climatic divisions in Texas, the Edwards Plateau division, the South Central division, and the Upper Coast division. The climate of the river basin is classified as subtropical-humid with hot summers. There is little change in the day-to-day summer weather except for occasional thunderstorms. Nights in the higher elevations are 6 to 7 degrees cooler than the more humid conditions typical of the coastal plain. During winter, polar air masses push southward through the basin, frequently bringing northerly winds and sharp drops in temperature for brief periods. Winter in the higher elevations is comparatively dry, with precipitation in the form of drizzle or light rain. Snowfall occurs rarely, and melts rapidly. In the coastal areas, winter is milder but typically wetter than in the higher elevations. The average annual net lake surface evaporation rate in the basin increases from approximately 25 inches in the southern tip to nearly 49 inches in the northwest corner. On the average, a difference of 7 to 8 percent in the relative humidity exists between the headwaters and the coastal areas.[9]

The Basin economy is diversified. Tourism, recreation, and retirement residential are important in the Hill Country and in coastal areas. Agriculture is important throughout the basin, with livestock production in practically every county, poultry production in the central basin counties, and rice production in coastal counties. Light manufacturing, textiles, and cement production are prevalent in the IH-35 corridor counties. Petrochemicals, plastics, and associated products production are major industries in Calhoun and Victoria counties. Oil, gas, sand, gravel, and clay are produced throughout the basin. Water resources are essential production inputs for many of the industries, electrical power generation, irrigation agriculture, livestock, poultry, and recreation businesses of the basin.

1.2 Study Objectives

The major purposes of this study are to (1) Identify and quantify existing municipal, industrial, agricultural, and other water uses throughout the study area; (2) Make projections of population growth and future water requirements for all purposes for the study area for each decade from 1990 through 2040; (3) Identify areas with potential water shortages; (4) Identify potential regional water supply systems and reservoir facilities to meet regional water needs; and (5) Prepare preliminary cost estimates to include capital cost, operation, and maintenance expenses for a 30 year period for proposed facility improvements, conservation, education, and institutional programs. The objectives will be accomplished through the use of water planning data from the Texas Water Development Board and the Texas Water Commission, surveys of cities, industries, and agriculture by the Guadalupe-Blanco River Authority, and engineering analyses and computations.

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[8] Ibid.

[9] Ibid.

1.3 Summary and Conclusions

1.3.1. Summary

The purposes of this study were to identify and quantify existing water use, make projections of future water needs for each decade from 1990 to 2040, identify potential areas of water shortage, identify potential regional water supply systems and reservoir sites, and prepare preliminary cost estimates for proposed facility improvements. The sources of information included surveys of cities, industries, and agricultural irrigation representatives throughout the area, Texas Water Development Board and Texas Water Commission files and studies, and GBRA files and studies.

The population of the 10-county service area of the Guadalupe-Blanco River Authority (GBRA) of the Guadalupe Basin increased from 228,000 in 1970 to approximately 380,000 in 1990. Population projections for the area in 2000 range between 453,000 and 483,000, in 2020 range between 578,000 and 669,000, and in 2040 range between 676,000 and 829,000.

Population growth rates of the area have averaged nearly 2.6 percent per year during the past 20 years, while state growth rates have been at a rate of 2.2 percent per year. For the next 50 years, population growth rates are projected to range between 1.56 and 1.85 percent annually, with projected state growth rates ranging between 1.45 and 1.66 percent annually. At these projected growth rates for the 50-year planning period, the population of the 10-county area will increase by a factor of 1.8 to 2.2 times the 1990 population.

Growth rates in the upper basin counties are the highest ranging from 2.0 to 2.37 percent per year. Rates in the mid-basin area range from 0.54 to 0.70 percent per year; rates in the lower basin counties of Victoria and Calhoun are in the 1.03 and 1.38 percent range, while Refugio County is projected to have a population decline. Both the upper basin (Kendall, Comal, Hays, and Guadalupe counties) and the lower basin (Victoria and Calhoun counties) area's growth are straining water supplies and water facilities.

Water conservation methods were identified and described. The major conservation techniques include public education and information, plumbing codes, water rates, metering, landscaping, recycling and reuse, and installation of more efficient irrigation water conveyance facilities.

Daily per capita water use was computed for each city and county of the study area for the period 1977 through 1986. Per capita water use varies from about 133 gallons per person per day in the coastal counties to about 165 gallons per person per day in the middle and upper basin counties. Under drought conditions, per capita water use in coastal areas was 156 gallons per person per day, and was 191 and 194 gallons per person per day in the middle and upper basin counties, respectively. These per capita water use statistics were adjusted for water conservation potentials of 15 percent phased in by 2020 and were used in making projections of future municipal water requirements of the Basin.

Water conservation potentials ranging from 10 percent to 15 percent were applied to industrial water requirements projections. Water conservation potentials ranging between 10 percent and 25 percent were used in making irrigation water requirements projections.

Water requirement projections were made for each city, and each county of the study area. The water requirements projections are for total quantities of water needed. In some cases the total supply needed can be obtained from aquifers, while in others, the supply will have to be obtained either from surface water or from a combination of surface and ground sources.

Projections were also made for each water using purpose--municipal, manufacturing, steam--electric power generation, agricultural irrigation, mining, livestock and poultry, and aquaculture. In 1980, total water use in the 10-county study area was 232,000 acre-feet, of which 21 percent was for municipal purposes, 25 percent was for manufacturing, 9 percent was for steam-electric power, 39 percent was for agriculture, 1 percent was for mining, and 5 percent was for livestock watering. Of the total water use in 1980, 21 percent was in the upper basin, 6 percent in the middle basin, and 73 percent in the lower basin.

Projected total water requirements for the study area for the year 2000 range from a low of 285,000 acre-feet to a high of 338,000. Of this total, 29 percent is for municipal purposes, 26 percent is for manufacturing purposes, 11 percent is for steam-electric power generation, 28 percent is for agriculture, one percent is for mining, and four percent is for livestock water. An additional 10,000 acre-feet is projected to be needed in 2000 for acquaculture.

Water requirements for the year 2040 range from a low of 364,000 acre-feet per year to a high of 486,000 acre-feet per year, with an additional 20,000 acre-feet needed for acquaculture. The distribution of water use among purposes is projected to change to a higher proportion of use in municipal and manufacturing purposes, with a lower proportion in irrigation. The proportion of use in the upper basin is projected to increase from 21 percent in 1980 to a range of 27 to 33 percent in 2040.

Public meetings were held in each of the 10 counties in order to obtain local input. The results included strong support for water conservation, protection of spring flows at Comal and San Marcos springs, and protection of water quality throughout the basin and particularly ground water quality in Gonzales and DeWitt counties from oil field pollution. The need for additional water supplies was voiced in each of the counties, with the strongest expressions being in Kendall, Comal, Hays, Guadalupe, and Calhoun counties. The participants focused upon water needed for population, industrial, and aquacultural growth. Regional types of water supply projects were conceptualized to meet the impending needs in these areas and are included in the following conclusions.

On the water supply side, the six aquifers of the basin were listed and described. In 1980, ground water use in the 10-county study area was 95,907 acre-feet (41 percent of total use). Ground water supplies of the 10-county area in 1980 were 180,153 acre-feet and are projected to be available at this level through about the year 2020, at which time supplies would decline to about 176,000 acre-feet annually if withdrawals are not increased to rates which result in aquifer mining (withdrawal exceeds recharge). Additional ground water supplies can be obtained from the Carrizo, Edwards-Trinity, Sparta, and Gulf-Coast aquifers for use in Caldwell, Guadalupe, Kendall, Gonzales, Refugio, and DeWitt counties, respectively. However, such development must be evaluated on a case by case basis, in order to appropriately consider availability of water rights which are held by private landowners, water quality, costs of wells, and transmission from potential well fields to points of use, and expected life of the aquifers.

Surface stream flow from below the Edwards Aquifer recharge zone to Victoria amounts to an average of 582,088 acre-feet, with a range of 25,300 acre-feet to 1,487,800 acre-feet per year. Approximately 376 "run-of-river" water rights permits have been issued by the Texas Water Commission for diversion and use of water from the streams of the Guadalupe Basin. Established rights for municipal, industrial, and agricultural uses make new diversions possible only during extreme high flow conditions. As a result, stored water (water which is legally stored under a permit with the Texas Water Commission, usually from high level flows which were previously unpermitted), is of substantial benefit to the Guadalupe River Basin. By properly utilizing stored water to fill in the low periods when natural flows are not available, or available only to senior water rights, water can be made available to more users in the Guadalupe River Basin.

Canyon Dam and Reservoir, which was constructed in the early 1960s, is the only conservation storage reservoir in the Guadalupe River Basin. The firm yield of Canyon Reservoir is approximately 40,000 acre-feet per annum. The current commitments from Canyon Reservoir are 32,628 acre-feet per annum. Some of these commitments are for firming up run-of-the-river rights.

An important issue which must be addressed in considering future water supplies is the harm caused to permitted surface water diverters by overpumping of the Edwards Aquifer. The Edwards Aquifer is recharged to the west through the Balcones Fault Zone and emerges naturally through the Comal and San Marcos Springs in New Braunfels and San Marcos, with annual discharges of approximately 208,500 and 111,800 acre-feet, respectively. As these flows emerge from the springs, they are considered surface water and have been permitted to users downstream. However, the definition of water in the Edwards Aquifer is clouded. As a result, increased ground water withdrawals are depleting the flows of the springs and interfering with the established rights of surface water users downstream. Presently upstream users are taking water in advance of water destined to downstream permitted users. As a result, the need to manage the withdrawals from the Edwards Aquifer becomes more imperative, as does the need to provide stored water to supplement the low flow periods which occur.

Total supplies of water within the 10-county study area include the long-term dependable yields of aquifers (180,000 acre-feet), firm yield of Canyon Reservoir (40,000 acre-feet) and stream flows (ranging from 25,300 to 1,487,800 acre-feet per year as measured at Victoria). Although run-of-the-river stream flows are not considered to be dependable supplies, these flows are the source of supplies for most of irrigated agriculture (80,000 to 90,000 acre-feet per year in recent years), manufacturing and steam-electric-power generation (about 80,000 acre-feet of consumptive use annually, with many times this quantity having been diverted, recycled, and returned to streams). As study area growth occurs and water requirements increase from present levels of about 245,000 acre-feet per year to a projected level of 285,000 to 338,000 acre-feet per year in 2000 and to a range of 364,000 to 486,000 acre-feet per year in 2040, it will be necessary to increase water conservation efforts, and to develop additional supplies of both ground and surface water. "Firming" run of river uses with stored water, subordination of hydroelectric water rights, ground water development in some aquifers as described above, and increased surface water development will be needed to meet future study area requirements.

Surface water development potentials within the Guadalupe Basin have been studied through the years. Potential reservoir sites include Cloptin Crossing on the Blanco near Wimberley in Hays County, Lockhart on Plum Creek near Lockhart in Caldwell County, Cuero I on the Guadalupe in DeWitt and Gonzales Counties, and Cuero II (Lindenau) on Sandies Creek, also in DeWitt and Gonzales Counties. GBRA, through its Long Range Planning Committee, will continue to review and evaluate the potential of the listed reservoir sites, and other sites, to supply water when it's needed. The selection and development of any site will be determined by the demand for water.

The Cloptin Crossing project would yield 35,000 acre-feet per year and in 1986 was estimated to cost about $68 million to construct. The Lockhart site had an estimated construction cost in 1986 of $30 million, with a yield of about 7,700 acre-feet. Cuero I had an estimated construction cost of $317.5 million in 1986, with a yield of 188,000 acre-feet per annum. The Cuero II site estimated construction cost in 1986 was $244.7 million, with a yield of 107,000 acre-feet per annum if diversions are made from the Guadalupe into the reservoir. Cuero I and II combined had an estimated construction cost in 1986 of $562.2 million with an estimated yield of 219,000 acre-feet.

Additional surface water supplies might be obtained from Lake Texana in the Lavaca-Navidad Basin which adjoins the Guadalupe Basin to the east of Victoria and Calhoun counties. To the extent that downstream needs are met from downstream reservoirs, including Lake Texana, the upstream basin supplies will be freed up for use in the upper and middle reaches of the Basin, and to meet some of the needs in the San Antonio Basin, particularly in the Bexar County area to supplement supplies from the Edwards Aquifer and thereby contribute to the maintenance of flows at Comal and San Marcos Springs.

Freshwater inflows to the Guadalupe Estuary must be maintained at satisfactory levels in order to protect the productive potentials of these estuaries. Previous studies have estimated that 1.57 million acre-feet of fresh water inflows to Guadalupe Estuary are needed annually for subsistence levels of fishery reproduction and growth, and that 2.02 million acre-feet are needed annually to maintain average historic levels of fishery productivities. The estimated 1986 business value of sport fishing, commercial fishing, and other recreational activity associated with the Guadalupe Estuary was $135 million, with $80 million occurring in the local area. The number of full-time job equivalents for commercial fishing attributed to the Guadaupe Estuary was 2,559 with an annual income of $29.6 million. Estimated local and state tax revenues from commercial and sport fishing in 1986 were $4.77 million. Each of the potential water storage projects mentioned above will need to be planned in a manner that meets the needs of the estuaries. When this is done, the reservoir yields may be affected, or a part of those yields may be reserved or assigned for release to the estuaries. Also, in future water development, the remaining, although rather small, quantities of hydroelectric power generation should be considered.

In the operation of surface water storage projects, GBRA prices stored water to customers at the cost of service for the storage (debt and operations and maintenance). As new projects are built, price will be adjusted to include the costs. In the management of stored water, GBRA, with Texas Water Commission approval via the water use permits, uses a "reservoir averaging" procedure, whereby the quantity of stored water sold per year to a water customer was held to a minimum by allowing diversions during a five-year period at the average quantity needed, with a special condition that the maximum diversion in any one of the five years cannot exceed three times the average. GBRA also makes stored water available to the irrigation customers of the Calhoun Canal System who have run-of-the-river permits. This is done in order to assure an adequate supply of irrigation water to bring a crop to maturity in case river flows decline during the irrigation season. The charge for this stored water is prorated among all irrigators, and is levied only upon the quantity of water actually used.

The flows of the Guadalupe River and its tributaries upstream of Canyon are fully appropriated under existing water rights, including the hydropower and Canyon Reservoir rights held by GBRA. Under an existing program operated by GBRA, and the Texas Water Commission upstream users in specific instances are allowed to divert and use the flows of the Guadalupe River upstream of Canyon Reservoir by subordinating GBRA's hydroelectric rights. The net result is a decrease in the flow of water utilized by the GBRA hydroelectric system in a given year; however, through the process, water is made available to users upstream who otherwise would be unable to divert water to meet their needs. To date, a total of 2,709 acre-feet and 27 users have been satisfied by this means of transferring water to areas which otherwise would be water short. It is anticipated that this program will be expanded in order to meet upstream needs and to increase the yield of Canyon Reservoir. The direct cost of this program is the net value of the hydroelectric power foregone.

In the study, local structural water supply alternatives are identified, with preliminary cost estimates, for Boerne, Canyon-Bulverde, San Marcos-IH-35 Corridor, rural areas in Guadalupe County (Clear Springs), Carbide-Seadrift, and Port O'Conner. The alternatives include water treatment plants, pipelines, and storage facilities. No additional reservoir storage projects are included at this time.

Boerne: The Boerne area is projected to need additional water supplies to meet population and business growth. Local area ground water and surface water sources are fully developed. Additional surface water could be obtained from the Guadalupe River through subordination of hydroelectric water rights downstream of Canyon Reservoir, and the construction of a diversion facility, pump station, and a pipeline from the river to Boerne Lake. Costs have been estimated for three different sizes of pipeline--six-inch, eight-inch, and 10-inch, which if operated at 75 percent of capacity could deliver 420, 840, and 1,512 acre-feet of water annually to Boerne Lake. Based upon the assumption that one-half the distance of the right-of-way would be alongside public roads, and, thus, would not require purchase of easements, the six-inch line would cost about $1.95 million, the eight-inch line would cost approximately $2.34 million, and the ten-inch line would cost approximately $2.96 million.

Canyon-Bulverde: The Canyon-Bulverde system would include a 1.0 million gallon per day (MGD) treatment plant, treated water pipelines, and storage tanks at a construction cost of approximately $2.9 million.

San Marcos - IH-35 Corridor: An alternative for supplying supplemental surface water along the IH-35 corridor and some parts of eastern Hays County would be by releasing Canyon Lake Water to the Guadalupe River and diverting the water at a point east of Interstate Highway 35.

In the first phase of the development of a supplemental surface water supply for San Marcos, a water treatment plant will be located along the San Marcos River east of IH-35, and raw water for the treatment plant will be obtained from the San Marcos River. In later phases, a raw water pipeline can be built from the Guadalupe River at New Braunfels, along IH-35, to San Marcos, in order to obtain more raw water for the San Marcos and neighboring areas along IH-35. The 1988 cost of such a line was estimated at $7.24 million. The 1988 cost estimate for a treated water pipeline from San Marcos to the Kyle area was $3.74 million.

Clear Springs Treatment Plant for Central Guadalupe County: The Green Valley Water Supply Corporation has a contract with GBRA for the delivery of treated water from a 2 mgd water treatment plant to be constructed on Lake Dunlap between New Braunfels and Seguin. The plant will have a firm water supply through a contract with GBRA for stored water from Canyon Reservoir to be treated at the plant. Recently, the Canyon Regional Water Authority (CRWA) was formed by four rural water supply corporations of central Guadalupe County. One purpose of the CRWA is to contract for common sources of water. One alternative is for each corporation to contract for water from the water treatment plant planned on Lake Dunlap. Cost of the treatment plant in 1986 was $3.1 million.

Carbide-Seadrift: In order to respond to the needs of Union Carbide Corporation and the City of Seadrift, three scenarios, each having two alternatives, have been identified and cost information has been developed for each. The apparent best alternative to serve Carbide, Seadrift, rural water customers, and GAF Corporation would have estimated construction costs of $1.15 million for Carbide and $681,000 for Seadrift (assuming Seadrift meets 100 percent of its need; if Seadrift chooses to meet only 70 percent of its need from this system, the cost would be $482,000). The construction costs to meet rural customer needs would be either $35,157 or $106,473, depending upon which alternatives are chosen by Carbide and Seadrift, since rural customers would be served from the same system. The construction cost to GAF Corporation would be approximately $80,280.

Port O'Connor: For Port O'Connor, two alternatives are presented; one being the construction of a new pipeline to provide more water, and secondly, a proposal to mix ground water with available surface water to meet peak weekend demands. The cost of the pipeline is estimated at $770,000 (1986). For the second alternative, water quality analyses were conducted to recommend a ratio of well and surface water which meets or exceeds the Texas Department of Health drinking water standards. Analyses of samples of water from four wells of the Port O'Connor area showed that well water quality is suitable for blending with presently available surface water. The resulting blended well and surface water would meet Texas Department of Health Drinking Water Standards. The estimated cost of a well, piping, pumps, transmission line, instruments, and storage tank modifications is $121,000.

1.3.2 Conclusions

Based on population projections and current and planned water use demands, the following recommendations are made for assuring an adequate supply of water to the Basin:

1. Regulation of withdrawals of water from the Edwards Aquifer is necessary to protect the flows of the Comal and San Marcos Springs and existing surface water rights. If regulation is not achieved, existing water users' rights will be impaired by upstream diversions by wells.

2. GBRA promote and encourage cities and water supply cooperatives of the Guadalupe Basin to adopt water conservation and drought contingency plans. The following procedures will be used to implement this objective:

    a) Provide recommended water conservation practices and drought contingency plans to cities and water supply cooperatives of the basin, such recommended plans for entities that obtain water from the Edwards Aquifer to be the water conservation and drought contingency plans developed by the Edwards Underground Water District;

    b) Provide water conservation and drought contingency planning technical assistance and information to cities, water supply cooperatives, industries, farmers, and ranchers;

    c) When applicable, include water conservation practices in water sales agreements; and

    d) Publicize and stress water conservation throughout the Basin through water conservation education and public information programs for public and private schools, the news media, and organizations.

3. Current practices of "firming" run-of-river uses (utilizing stored water to fill in low periods when natural flows are not available) to better utilize and extend resources should continue.

4. Continue to review the potential of reservoir sites currently identified, and other sites, to provide water to meet growth needs.

5. Subordination of downstream senior rights should continue, when possible, to allow for upstream diversion to supply the Boerne area of Kendall County.

6. Construction of a system to deliver treated water to the rural growth area from Canyon Lake to Bulverde should be considered.

7. Expanded facilities for treated water delivery should be considered for Port O'Conner and Seadrift.

8. Subordination of senior downstream water rights to increase the yield of Canyon Reservoir as a means of providing more stored water without new construction should be evaluated.

9. Periodic review of water quality standards in the rural areas of the middle Basin, and protection of groundwater sources should continue.

10. Monitoring of surface water flows of the Guadalupe River Basin should continue.

11. Flows of the San Antonio River should be monitored to prevent a degradation of the quality of flows in the lower Guadalupe River Basin.

12. Surface water should be used by the City of Victoria to supplement groundwater uses.

13. Coordination should continue with the Canyon Regional Water Authority and the Hays County Water Development Board.

2.0 PROJECTIONS OF FUTURE WATER REQUIREMENTS

Projections are made of the total quantities of water (ground water plus surface water) that will be needed in each city and each county of the study area at each of the projection years (1990, 2000, 2010, 2020, 2030, and 2040) for each major water using purpose -- municipal, manufacturing, steam-electric power generation, agricultural irrigation, mining, livestock and poultry, aquaculture, bays and estuaries, and recreation. In order to make these projections, it was necessary to make projections of population growth, growth of water using industries, growth of steam-electric power generation, agricultural irrigation, mining (petroleum, sand, gravel, and stone), livestock and poultry, aquaculture (fish farming), and recreation. Analyses were made of water use reports to state water agencies by cities, water supply corporations, industries, farmers and ranchers, agricultural agencies, and regional water authorities in order to develop the relevant and appropriate planning statistics and parameters for use in making water requirements projections. Explanations are presented below and in Appendix A for each projection.

2.1 Population Projections

High and low population projections were made for each county using the vital statistics (births and deaths) of each county, the age characteristics of each county, life expectancy of each age group, and two different migration rates (Appendix A).[1] **For the high population projection, the migration rates of the 1970's were used. For the low projection, the migration rates of the 1960's were used.** Migration is the number of people moving into or out of the county. During the 1970's the net increase in population of the counties, due to migration, was higher than that of the 1960's. Thus, the high population projection results when migration rates of the 1970's are incorporated into the population projections method. The migration rates of the 1960's results in the low population projection.

The individual city high and low population projections were obtained by allocating the high and low county projections among the cities and rural areas of each county, respectively. The allocation to each city was the percentage that city was of the county totals in the 1980 census.

Population projections are shown in Table 1. In 1980, the 10-county study area had a population of 290,347. By 1985 the area's population was estimated at 347,530. Projections to the year 2000 range between 454,000 and 483,000, to 2020 range between 578,000 and 669,000, and to 2040 range between 676,000 and 829,000. Population growth rate for the area ranges from a low of 1.56 percent per year to a high of 1.85 percent per year.

Growth rates in the upper basin counties are the highest ranging from 2.0 to 2.37 percent per year. Rates in the mid-basin area range from 0.54 to 0.70 percent per year; rates in the

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[1]Unpublished, Texas Water Development Board, Austin, Texas, October, 1989.

TABLE 1
GUADALUPE BASIN
POPULATION PROJECTIONS

COUNTY	POPULATION			POPULATION PROJECTIONS												GROWTH RATE	
				1990		2000		2010		2020		2030		2040		1970-2040	
	1970	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
																(percent)	
UPPER																	
1. KENDALL	6,964	10,635	14,029	16,823	16,881	18,898	20,800	21,282	23,931	22,788	26,462	24,301	29,287	25,095	30,816	1.85	2.15
Boerne	2,432	3,229	4,874	6,018	6,039	6,359	6,998	7,157	8,048	7,661	8,897	8,159	9,834	8,426	10,347	1.79	2.09
2. COMAL	24,165	36,446	46,159	53,740	54,332	69,567	75,215	81,896	90,445	92,555	103,272	100,252	117,904	104,345	126,010	2.11	2.38
New Braunfels	17,859	22,402	26,887	31,122	31,466	35,473	38,355	42,548	46,993	48,538	54,161	53,075	62,423	55,241	66,714	1.63	1.90
3. HAYS	27,642	40,594	61,488	73,580	73,886	98,267	104,893	116,803	141,852	140,883	178,053	161,673	211,119	173,233	229,972	2.65	3.07
San Marcos	18,860	23,420	32,800	36,364	36,864	42,748	48,700	54,473	66,156	65,929	83,324	75,821	99,011	81,242	107,852	2.10	2.52
Kyle	1,629	2,093	3,536	5,007	5,049	6,745	7,522	8,594	10,438	10,401	13,146	11,963	15,622	12,818	17,017	2.99	3.40
4. GUADALUPE	33,554	46,708	54,606	63,201	64,156	77,299	84,576	89,735	102,987	101,224	116,356	112,736	136,924	118,986	148,575	1.82	2.15
Seguin	15,934	17,854	19,647	22,247	22,584	23,953	26,209	25,812	29,625	29,132	33,487	31,165	37,852	32,892	41,072	1.04	1.36
Schertz	4,061	7,262	7,836	9,008	9,146	11,235	12,293	12,108	13,896	13,665	15,707	14,621	17,757	15,429	19,265	1.92	2.24
5. CALDWELL	21,178	23,637	27,388	30,302	30,490	32,857	36,725	34,724	38,818	36,686	42,749	39,752	47,564	41,379	50,175	0.96	1.24
Lockhart	6,489	7,953	9,628	11,296	11,367	12,155	13,587	13,425	15,008	13,633	15,887	14,056	16,819	14,631	17,742	1.17	1.44
Luling	4,719	5,039	5,408	5,386	5,420	5,045	5,640	5,340	5,970	5,422	6,319	5,590	6,689	5,819	7,057	0.29	0.58
Subtotal	113,503	158,020	203,670	237,646	239,745	296,888	322,209	344,440	398,033	394,136	466,892	438,714	542,798	463,038	585,548	2.02	2.37
MIDDLE																	
6. GONZALES	16,375	16,883	18,840	18,598	18,821	19,138	19,417	20,105	21,049	21,974	24,760	25,194	29,157	26,982	31,651	0.72	0.94
Gonzales	5,854	7,152	7,889	7,771	7,865	8,225	8,345	9,170	9,601	9,454	10,653	10,046	11,627	10,759	12,621	0.87	1.10
Nixon	1,925	2,008	2,283	2,356	2,385	2,465	2,501	2,747	2,877	2,831	3,191	3,007	3,480	3,219	3,777	0.73	0.96
7. DEWITT	18,660	18,903	20,200	18,888	18,961	19,950	20,442	21,100	22,006	22,388	23,509	23,561	24,823	24,171	25,506	0.37	0.45
Cuero	6,956	7,124	7,432	6,985	7,012	7,390	7,573	7,838	8,175	8,335	8,753	8,755	9,224	8,967	9,463	0.36	0.44
Yorktown	2,411	2,498	2,520	2,567	2,577	2,725	2,793	2,890	3,015	3,073	3,227	3,227	3,400	3,304	3,487	0.45	0.52
Subtotal	35,035	35,786	39,040	37,486	37,782	39,088	39,859	41,205	43,055	44,362	48,269	48,755	53,980	51,153	57,157	0.54	0.70
LOWER																	
8. VICTORIA	53,766	68,807	75,499	76,006	77,292	85,702	88,524	93,439	98,212	101,802	113,229	113,482	130,439	119,832	140,029	1.15	1.38
Victoria	41,349	50,695	55,980	56,772	57,733	66,372	68,558	74,095	77,880	78,488	87,299	83,829	96,356	88,520	103,440	1.09	1.31
9. REFUGIO	9,494	9,289	8,729	8,550	8,570	8,461	8,551	8,312	8,402	7,953	8,044	7,569	7,665	7,569	7,665	-0.32	-0.30
Refugio	4,340	3,898	3,464	3,347	3,355	3,310	3,346	3,251	3,287	3,108	3,144	2,954	2,992	2,954	2,992	-0.55	-0.53
Woodsboro	1,839	1,974	1,875	1,812	1,817	1,793	1,813	1,760	1,780	1,683	1,703	1,600	1,621	1,600	1,621	-0.20	-0.18
10. CALHOUN*	16,385	18,445	20,592	20,224	20,373	23,252	24,050	26,504	28,140	30,004	32,708	33,063	36,892	34,714	39,185	1.03	1.20
Port Lavaca	10,491	10,911	11,968	11,963	12,052	14,690	15,195	16,766	17,801	18,996	20,709	20,439	22,807	21,199	23,930	1.00	1.18
Seadrift	1,092	1,277	1,560	1,587	1,599	1,929	1,996	2,203	2,339	2,495	2,720	2,684	2,995	2,783	3,142	1.34	1.52
Subtotal	79,645	96,541	104,820	104,780	106,235	117,415	121,125	128,255	134,754	139,759	153,981	154,114	174,996	162,115	186,879	1.01	1.21
TOTAL	228,183	290,347	347,530	379,912	383,762	453,391	483,193	513,900	575,842	578,257	669,142	641,583	771,774	676,306	829,584	1.56	1.85

Source: Texas Water Development Board

* West of Lavaca Bay

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

lower basin counties of Victoria and Calhoun are in the 1.03 to 1.38 percent range, while Refugio county is projected to have a population decline due to an older population in the 1980's and a lack of in-migration of the younger, child bearing age groups. As will be shown later, the size of the populations of cities and counties determines the quantities of water that will be needed for municipal purposes.

2.2 Per Capita Water Use

Daily water use per person, referred to as per capita municipal water use was computed for each city and county of the study area for the period 1977 through 1986. The computations were made from the respective annual water use reports that are made to the Texas Water Development Board by each city and water supply corporation located within the study area. Computations were made of the 10-year average per capita municipal water use and of the per capita water use during the dry years within the 10-year period, since the latter reflects the demands upon municipal water supplies during droughts.[2] Both the average and the drought (High) per capita water use statistics are shown for counties and cities of the study area for both the without conservation and the 15 percent per capita conservation conditions (Table 2). These are the parameters that are used when computing the total quantities of municipal water that will be needed in future years for average and dry weather (High per capita) conditions, with and without municipal water conservation. **It should be noted that the per capita water use for each city is computed from the annual water use reports by that city. It should be further noted that if the city reports sales of water to an industry for purposes other than employee drinking water and sanitation, that quantity of water was deleted from the computations and was transferred to the manufacturing water use accounts of the county in which the industry is located.** In this way the per capita water use statistic is kept as nearly as possible to being the quantity of water used per person per day within each respective city for human living and comfort needs (drinking, bathing, sanitation, food preparation, dish washing, laundry, lawn watering, fire protection, swimming pools, hotels, motels, restaurants, commercial laundries, car washes, public fountains, and aesthetics).

The per capita municipal water use statistics for counties are computed from the municipal water use reports of the cities and public water supply corporations within each county. In cases where cities and water supply corporations service areas transcend county boundaries, their respective reports are divided among the affected counties on the basis of the number of connections located within each county. **For that portion of a county's population which is not served by a public water system (rural dwellers who have their own wells), per capita water use for domestic purposes is set at 110 gallons per person**

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[2]Data for dry years were adjusted upward in cases where municipal supply systems could not meet the needs and some form of mandatory conservation was in place. For cases where reported per capita use was less than 150 gallons per day and the extreme year use was less than four gallons difference, the extreme value plus 10 gallons was used. In cases were the reported use was less than 110 gallons per person per day, the 10-year average for that case was increased by 30 percent and used as the drought or high demand parameter.

Table 2
Guadalupe Basin per Capita Water Use

County/City	Without Conservation		With Conservation*	
	1977-1986 Average	Dry Years High	1977-1986 Average	Dry Years High
	- - - - - - - (gallons per person, per day) - - - - - - -			
Upper	**165**	**194**	**139**	**163**
1. Kendall	128	151	108	127
Boerne	162	182	138	155
2. Comal	194	228	162	190
New Braunfels	231	257	196	218
3. Hays	169	199	139	164
San Marcos	211	238	179	202
Kyle	143	175	122	149
4. Guadalupe	155	182	130	153
Seguin	168	200	143	170
Schertz	143	182	122	155
5. Caldwell	148	173	122	143
Lockhart	137	160	116	136
Luling	182	231	155	196
Middle	**162**	**191**	**139**	**163**
6. Gonzales	182	214	155	182
Gonzales	193	244	164	207
Nixon	173	182	122	155
7. DeWitt	144	169	122	144
Cuero	160	203	136	173
Yorktown	144	161	122	137
Lower	**133**	**156**	**113**	**133**
8. Victoria	134	157	114	134
Victoria	145	165	123	140
9. Refugio	131	154	111	131
Refugio	138	154	117	131
Woodsboro	161	180	137	151
10. Calhoun	132	156	111	131
Port Lavaca	127	141	108	120
Seadrift	110	133	94	113
Ten County Area	**156**	**183**	**133**	**156**
Statewide	**165**	**194**	**139**	**163**

*Based upon water conservation programs that would reduce per capita water use 15 percent by 2020.
Note: Climate can impact water use, as can tourism which can increase consumption within an area, yet is not included in the population count of the area.

per day. This value was chosen since it is the quantity which closely approximates per capita water use in cities during the winter months when lawn watering and other outdoor water use is at its lowest; i.e., this appears to be a good approximation of the per capita quantity of water that is needed to operate the home in a rural setting.

The 1977-1986 per capita water use statistics vary from about 133 gallons per person per day in the coastal counties to about 165 gallons per person per day in the middle and upper basin counties (Table 2, Column 1). Under drought conditions, per capita water use in coastal areas was 156 gallons per person per day, and was 191 and 194 gallons per person per day in the middle and upper basin counties, respectively (Table 2, Column 2). In San Marcos, and in New Braunfels, computed per capita water use is higher than in other cities of the basin. The large number of tourists who visit these areas contribute to water use in motels and commercial establishments, thus driving the per capita computations of water use upward. For example, the total water use data includes that of tourists and other visitors, but tourists and visitors are not included in the population used in computing per capita water use. Therefore, for areas having high tourism in relation to size of the resident population, higher per capita water use results from the computation method.

It is interesting to note that with a 15 percent reduction in per capita water use, the drought year per capita water use statistic is equal to the 1977-1986, average per capita water use or, to put it another way, during the 1977-1986, 10-year period, average annual per capita water use was 85 percent of the average annual per capita water use during the dry years of the period.

2.3 Water Conservation

In this discussion, "water conservation" refers to increasing the efficiency of water supply systems through stopping leaks in water pipes and plumbing, through changes in the practices of those who use water to reduce the quantities used in everyday living, and to improving the efficiency of water use in industry and agriculture. The objectives of a water conservation program are to implement water use efficiency practices which are permanent. This differs from drought contingency and drought management planning which means establishing methods and techniques to reduce water use during severe droughts and during emergencies when water system failure or other water supply impairments or interruptions may occur. Water conservation methods are identified in Section 5 of this report.

In the water requirements projections of this study, the effects of water conservation are taken into account. In the case of municipal water requirements, water conservation is phased in at a rate of reducing per capita water use by 2.5 percent by 1990, 5.0 percent per decade by 2010, and an additional 2.5 percent by 2020 for a total of 15 percent of the 1977-1986 reported municipal water use (Appendix A, Page 4).

The effects of water conservation in manufacturing water use were computed for each major manufacturing water using sector (See Appendix A, Page 5). The effects are projected to be phased in through technology, recycling, and reuse between 1990 and 2010, and for use in making manufacturing water requirements projections, are expressed as a percentage of water used by each respective industry in 1980. It is estimated that in some industries, by the year 2010, only 90 percent of the quantities used in 1980 would be needed to produce the same level of outputs.

During the past 15 years, the practice of "flow-through" irrigation for rice production has been discontinued, resulting in a reduction of irrigation water use per acre from about 7.5 feet to 5.0 feet per year. It is estimated that agricultural water conservation programs could further reduce the quantity of water needed per acre irrigated. The rates of conservation used in making agricultural water requirements projections for this study are as follows:

Agricultural Water Conservation		
Year	**Projection**	**Water Savings through Conservation**
1990	Low High	15% of 1980 Use Zero
2000	Low High	10% of Base Use 5% of Base Use
2010	Low High	20% of Base Use 10% of Base Use
2020	Low High	no change from 2010 no change from 2010
2030	Low High	no change from 2010 in Upper and Middle basin
2030 Victoria Calhoun	Low High	25% of Base Use 15% of Base Use

Where Base Use is the quantity of water used for irrigation in the year having the highest number of irrigated acres in each county, as reported in irrigation surveys for 1958, 1964, 1969, 1974, 1979, and 1984, since this is an indication of the irrigation potential within each county. **For the high projection, conservation effects are 10 percent by 2010 in the interior counties and 15 percent by 2030 in coastal counties (Calhoun and Victoria).** For the low projection, conservation effects are 20 percent by 2010 in the interior counties, and 25 percent by 2030 in coastal counties (Appendix A, Page 9). These conservation rates were chosen to reflect conservation potentials in the different parts of the basin, i.e., irrigation application rates in the upper basin counties are approximately 1.33 acre-feet per acre, in the middle basin counties are 1.0 acre-feet per acre, and in the coastal counties are 4.12 acre-feet per acre. The potential for conservation appears to be much greater in the coastal counties, thus the projected higher conservation parameters in those counties after 2030. (See Section 5.2 for a discussion of stored water for agricultural irrigation.)

2.4 Projected Water Requirements

In this section, the projections of water requirements for each of the major water using functions -- municipal, manufacturing, steam-electric power generation, agricultural irrigation, mining, livestock and poultry, agriculture, bays and estuaries, and recreation -- are presented for cities and counties for the years 1990, 2000, 2010, 2020, and 2030, and 2040. Projections are made with and without the effects of conservation. **The projections are for total water use -- ground water plus surface water.**

2.4.1 Municipal Water Requirements

In this study, water for municipal purposes includes water for use in and around homes and commercial establishments, and water for public health and safety, recreation and aesthetics in urban areas; i.e., water for drinking, bathing, sanitation, food preparation, dishwashing, laundry, lawn watering, fire protection, restaurants, car washes, swimming pools, hot tubs, saunas, fountains, golf courses, public parks, sports centers, aquariums, and perhaps other uses. Since municipal type water is supplied by public water supply utilities, it must meet safe drinking water standards. Water treatment technology exists such that water can normally be treated to meet drinking water standards. The question is, will there be enough raw water to treat?

Projections of municipal water requirements were made for each of eight combinations of population and per capita water use parameters. The eight different projection sets for counties are as follows:

Table Number	Population		Per Capita Water Use		Conservation	
	Low	High	Average	High	Without	With
Table 3a	X	X		X	X	
Table 3b	X	X		X		X
Table 3c	X	X	X		X	
Table 3d	X	X	X			X

Note that each of Tables 3a, 3b, 3c and 3d contain municipal water requirements projections for counties for both low and high population projections, as shown in Table 2. Table 3a contains projections for high and low population, and high per capita water use, without conservation. This projection set is the case of highest municipal water requirements, since it is based upon the high, or drought year per capita water use, without the effects of municipal water conservation. **Under these conditions, municipal water use within the 10-county study area would increase from 62,263 acre-feet in 1985 to between 91,681 and 98,617 acre-feet annually in 2000, and between 138,738 and 170,255 acre-feet annually in 2040.**

TABLE 3a
GUADALUPE BASIN
PROJECTED MUNICIPAL WATER REQUIREMENTS
(HIGH PER CAPITA WATER USE, WITHOUT CONSERVATION)

COUNTY	WATER USE 1980	WATER USE 1985	1990 LOW	1990 HIGH	2000 LOW	2000 HIGH	2010 LOW	2010 HIGH	2020 LOW	2020 HIGH	2030 LOW	2030 HIGH	2040 LOW	2040 HIGH
			(acre-feet of water)											
UPPER														
1. KENDALL	1,484	1,966	2,840	2,849	3,168	3,487	3,567	4,011	3,819	4,434	4,072	4,907	4,205	5,163
2. COMAL	8,862	11,439	13,730	13,878	17,347	18,746	20,465	22,590	23,152	25,819	25,108	29,509	26,128	31,530
3. HAYS	8,393	11,243	15,443	15,567	20,202	22,435	25,398	30,667	30,490	38,317	34,887	45,305	37,323	49,277
4. GUADALUPE	7,131	8,639	12,916	13,110	15,688	17,166	18,134	20,811	20,454	23,512	22,731	27,606	23,991	29,953
5. CALDWELL	4,033	4,430	5,882	5,917	6,255	6,946	6,607	7,338	6,918	7,994	7,411	8,788	7,698	9,248
Subtotal	29,903	37,717	50,811	51,321	62,660	68,780	74,171	85,417	84,833	100,076	94,209	116,115	99,345	125,171
MIDDLE														
6. GONZALES	3,342	3,420	4,460	4,510	4,600	4,670	4,860	5,080	5,270	5,930	5,990	6,920	6,410	7,510
7. DEWITT	2,838	3,509	3,569	3,582	3,769	3,862	3,987	4,160	4,232	4,445	4,454	4,690	4,567	4,818
Subtotal	6,180	6,929	8,029	8,092	8,369	8,532	8,847	9,240	9,502	10,375	10,444	11,610	10,977	12,328
LOWER														
8. VICTORIA	10,265	12,853	13,364	13,591	15,155	15,654	16,582	17,430	17,986	20,006	19,918	22,894	21,034	24,577
9. REFUGIO	1,444	1,287	1,473	1,477	1,459	1,474	1,432	1,448	1,370	1,385	1,305	1,320	1,305	1,320
10. CALHOUN*	2,623	3,477	3,565	3,591	4,038	4,177	4,600	4,885	5,208	5,679	5,771	6,440	6,077	6,859
Subtotal	14,332	17,617	18,402	18,659	20,652	21,305	22,614	23,763	24,564	27,070	26,994	30,654	28,416	32,756
TOTAL	50,415	62,263	77,242	78,072	91,681	98,617	105,632	118,420	118,899	137,521	131,647	158,379	138,738	170,255

Source: Texas Water Development Board
High per capita water use, without conservation.
*West of Lavaca Bay

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

TABLE 3b
GUADALUPE BASIN
PROJECTED MUNICIPAL WATER REQUIREMENTS
(HIGH PER CAPITA WATER USE, WITH CONSERVATION)

COUNTY	WATER USE		PROJECTED MUNICIPAL WATER REQUIREMENTS											
			1990		2000		2010		2020		2030		2040	
	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
					(acre-feet of water)									
UPPER														
1. KENDALL	1,484	1,966	2,769	2,779	2,931	3,225	3,122	3,510	3,247	3,770	3,461	4,171	3,574	4,390
2. COMAL	8,862	11,439	13,388	13,535	16,053	17,348	17,920	19,780	19,695	21,962	21,358	25,100	22,226	26,818
3. HAYS	8,393	11,243	15,878	15,997	19,748	21,014	22,326	26,937	26,039	32,693	29,777	38,632	31,848	42,009
4. GUADALUPE	7,131	8,639	12,593	12,784	14,514	15,878	15,867	18,209	17,387	19,987	19,322	23,466	20,392	25,463
5. CALDWELL	4,033	4,430	5,746	5,779	5,817	6,455	5,831	6,471	5,940	6,856	6,359	7,530	6,604	7,923
Subtotal	29,903	37,717	50,374	50,874	59,063	63,920	65,066	74,907	72,308	85,268	80,277	98,899	84,644	106,603
MIDDLE														
6. GONZALES	3,342	3,420	4,349	4,401	4,261	4,323	4,261	4,459	4,492	5,055	5,102	5,894	5,460	6,393
7. DEWITT	2,838	3,509	3,478	3,491	3,487	3,571	3,489	3,639	3,598	3,778	3,784	3,987	3,881	4,098
Subtotal	6,180	6,929	7,827	7,892	7,748	7,894	7,750	8,098	8,090	8,833	8,886	9,881	9,341	10,491
LOWER														
8. VICTORIA	10,265	12,853	13,031	13,252	14,018	14,479	14,510	15,252	15,291	17,004	16,930	19,461	17,880	20,891
9. REFUGIO	1,444	1,287	1,436	1,439	1,348	1,363	1,254	1,267	1,165	1,178	1,108	1,123	1,108	1,123
10. CALHOUN*	2,623	3,477	3,476	3,501	3,736	3,863	4,025	4,275	4,427	4,825	4,905	5,475	5,167	5,830
Subtotal	14,332	17,617	17,943	18,192	19,102	19,705	19,789	20,794	20,883	23,007	22,943	26,059	24,155	27,844
TOTAL	50,415	62,263	76,144	76,958	85,913	91,519	92,605	103,799	101,281	117,108	112,106	134,839	118,140	144,938

Source: Texas Water Development Board
High per capita water use, with conservation.
*West of Lavaca Bay

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

TABLE 3c
GUADALUPE BASIN
PROJECTED MUNICIPAL WATER REQUIREMENTS
(AVERAGE PER CAPITA WATER USE, WITHOUT CONSERVATION)

COUNTY	WATER USE		PROJECTED MUNICIPAL WATER REQUIREMENTS											
			1990		2000		2010		2020		2030		2040	
	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
					(acre-feet of water)									
UPPER														
1. KENDALL	1,484	1,966	2,449	2,458	2,730	3,003	3,073	3,454	3,290	3,820	3,509	4,227	3,623	4,448
2. COMAL	8,862	11,439	11,859	11,988	14,861	16,059	17,550	19,371	19,863	22,150	21,554	25,329	22,428	27,062
3. HAYS	8,393	11,243	13,922	14,032	18,187	20,189	22,840	27,562	27,400	34,412	31,338	40,670	33,519	44,228
4. GUADALUPE	7,131	8,639	10,436	10,592	12,639	13,828	14,586	16,739	16,454	18,912	18,268	22,187	19,282	24,073
5. CALDWELL	4,033	4,430	5,035	5,064	5,368	5,951	5,663	6,282	5,931	6,846	6,358	7,529	6,601	7,921
Subtotal	29,903	37,717	43,701	44,134	53,785	59,030	63,712	73,408	72,938	86,140	81,027	99,942	85,453	107,732
MIDDLE														
6. GONZALES	3,342	3,420	3,562	3,604	3,674	3,727	3,880	4,059	4,209	4,736	4,784	5,526	5,119	5,994
7. DEWITT	2,838	3,509	2,917	2,929	3,081	3,159	3,261	3,400	3,461	3,635	3,640	3,834	3,733	3,939
Subtotal	6,180	6,929	6,479	6,533	6,755	6,886	7,141	7,459	7,670	8,371	8,424	9,360	8,852	9,933
LOWER														
8. VICTORIA	10,265	12,853	11,767	11,965	13,334	13,774	14,589	15,332	15,829	17,605	17,539	20,161	18,522	21,641
9. REFUGIO	1,444	1,287	1,262	1,266	1,248	1,262	1,226	1,239	1,174	1,187	1,117	1,131	1,117	1,131
10. CALHOUN*	2,623	3,477	3,087	3,109	3,509	3,631	3,999	4,246	4,526	4,934	5,011	5,589	5,271	5,950
Subtotal	14,332	17,617	16,116	16,340	18,091	18,667	19,814	20,817	21,529	23,726	23,667	26,881	24,910	28,722
TOTAL	50,415	62,263	66,296	67,007	78,631	84,583	90,667	101,684	102,137	118,237	113,118	136,183	119,215	146,387

Source: Texas Water Development Board
Average per capita water use, without conservation.
*West of Lavaca Bay

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

TABLE 3d
GUADALUPE BASIN
PROJECTED MUNICIPAL WATER REQUIREMENTS
(AVERAGE PER CAPITA WATER USE, WITH CONSERVATION)

COUNTY	WATER USE		PROJECTED MUNICIPAL WATER REQUIREMENTS											
			1990		2000		2010		2020		2030		2040	
	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
					(acre-feet of water)									
UPPER														
1. KENDALL	1,484	1,966	2,389	2,396	2,525	2,779	2,689	3,024	2,797	3,247	2,981	3,594	3,080	3,780
2. COMAL	8,862	11,439	11,564	11,691	13,755	14,863	15,370	16,964	16,900	18,845	18,337	21,546	19,081	23,020
3. HAYS	8,393	11,243	13,595	13,702	16,886	18,737	20,089	24,219	23,414	29,374	26,760	34,693	28,614	37,717
4. GUADALUPE	7,131	8,639	10,174	10,328	11,691	12,790	12,763	14,648	13,986	16,075	15,529	18,859	16,389	20,465
5. CALDWELL	4,033	4,430	4,920	4,948	4,994	5,536	5,005	5,547	5,103	5,880	5,465	6,461	5,671	6,793
Subtotal	29,903	37,717	42,642	43,065	49,851	54,705	55,916	64,402	62,200	73,421	69,072	85,153	72,835	91,775
MIDDLE														
6. GONZALES	3,342	3,420	3,476	3,516	3,403	3,453	3,403	3,559	3,588	4,035	4,075	4,707	4,360	5,104
7. DEWITT	2,838	3,509	2,845	2,853	2,851	2,922	2,852	2,977	2,942	3,088	3,094	3,259	3,173	3,349
Subtotal	6,180	6,929	6,321	6,369	6,254	6,375	6,255	6,536	6,530	7,123	7,169	7,966	7,533	8,453
LOWER														
8. VICTORIA	10,265	12,853	11,471	11,665	12,335	12,740	12,764	13,417	13,455	14,963	14,908	17,136	15,742	18,396
9. REFUGIO	1,444	1,287	1,230	1,233	1,155	1,167	1,074	1,086	997	1,009	949	961	949	961
10. CALHOUN*	2,623	3,477	3,010	3,033	3,247	3,357	3,501	3,716	3,848	4,195	4,257	4,752	4,479	5,059
Subtotal	14,332	17,617	15,711	15,931	16,737	17,264	17,339	18,219	18,300	20,167	20,114	22,849	21,170	24,416
TOTAL	50,415	62,263	64,674	65,365	72,842	78,344	79,510	89,157	87,030	100,711	96,355	115,968	101,538	124,644

Source: Texas Water Development Board
Average per capita water use, with conservation.
*West of Lavaca Bay

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

Projections of municipal water requirements for the case of high per capita water use, with conservation, show municipal water requirements within the study area increasing from 62,263 acre-feet in 1985 to between 85,913 and 91,519 acre-feet in 2000, and to a range of 118,140 and 144,938 acre-feet annually in 2040 (Table 3b). Due to the fact that in these projections the conservation effect has been phased in between 1990 and 2020, the reduction in municipal water requirements due to conservation is less than 15 percent in these early years of the projections. **A comparison of Tables 3a and 3b shows the potential effects of a municipal water conservation program upon the municipal water requirements during dry years, for both the low and high population projections.**

In Tables 3c and 3d a parallel set of municipal water requirements projections are shown for the study area, using 1977-1986 average per capita water use as opposed to high or drought year per capita water use, as was used in Tables 3a and 3b. **Under conditions of average per capita water use, without water conservation, total municipal water requirements for the 10-county study area increase from 62,263 acre-feet to between 78,631 and 84,583 acre-feet in 2000, and to a range of 119,215 to 146,387 acre-feet in 2040 (Table 3c).** For the same conditions, with a water conservation program whose goal is to reduce per capita water use by 15 percent by 2020, total municipal water requirements in the study area would increase from 62,263 acre-feet in 1985 to between 72,842 and 78,344 in 2000 and to a range of 101,538 and 124,644 in 2040 (Table 3d).

2.4.2 Manufacturing Water Requirements

Fresh water is used in manufacturing for cooling manufacturing processes, cleaning and waste removal, internal transportation, and in some cases is a production factor integral to the process, such as in vegetable canning. In addition, water is also needed for employees for drinking, and sanitation and for grounds maintenance, landscaping, fire protection and aesthetics. In the study area, there are about 56 manufacturing establishments that report using fresh water in their respective production processes.

That is to say that these manufacturing establishments depend upon fresh water, in the quantities reported, in order to carry out their respective levels of operation. The quantities are expressed in terms of the number of acre-feet diverted from streams and canals plus the number of acre-feet pumped from wells for use within manufacturing plants. Much of this water is used several times within the plants, but for purposes of this study, all quantities are referred to only once, as measured at the diversion point, since these are the quantities that must be available in order for the respective manufacturing processes to operate. Thus, for purposes of this study, the terms "Manufacturing Water Use" mean the quantities of fresh water, as measured at the diversion points, including any pumped from wells. At the present time, there are 32 different types of water using industries located within the study area (Table 4). The major water users are food processing, fabric and textiles, chemicals, abrasives, metals, and equipment manufacturing (Table 4).

Table 4
Guadalupe Basin Water-Using Industries

Number	Industry
1.	Meat products
2.	Dairy products
3.	Grain mill products
4.	Bakery products
5.	Sugar and confectionery products
6.	Beverages
7.	Miscellaneous food preparations
8.	Broad-woven fabric mills - cotton
9.	Broad-woven fabric mills - man-made fiber
10.	Hats, caps, and millinery
11.	Household furniture
12.	Miscellaneous publishing and printing
13.	Industrial inorganic chemicals
14.	Plastic materials & synthetic resins, rubber, fiber
15.	Soap, detergents, and cleaning preparation
16.	Industrial organic chemicals
17.	Petroleum refining
18.	Miscellaneous products of petroleum & coal
19.	Fabricated rubber products
20.	Plastics products
21.	Cement, hydraulic
22.	Structural clay products
23.	Concrete, gypsum and plaster
24.	Abrasive, asbestos & misc. non-metallic mineral
25.	Steelworks, blast furnaces, and rolling and finishing mills
26.	Primary smelting and refining of nonferrous metals
27.	Rolling, drawing and extruding of nonferrous metals
28.	Fabricated structural metal products
29.	Farm and garden machinery and equipment
30.	Electric lighting and wiring equipment
31.	Household audio and video equipment and recording
32.	Dolls, toy, games and sporting and athletic equipment

In 1980, the quantity of water that was diverted from surface sources plus the quantity pumped from wells for use by manufacturing establishments of the study area was reported at 58,455 acre-feet per year (Table 5), with a decline to 49,508 acre-feet in 1985. The decline from 1980 to 1985 was due to economic recession in the mid 1980's at which time the chemicals industries, which are large users of water, were operating at approximately 75 percent of capacity. A survey of these industries in 1990 showed that significant economic recovery had occurred by 1988, and 1989, such that by 1990, water use is about 90 percent of the 1980 reported levels. The 1990 survey also identified planned growth of existing industries and planned expansions and additions of water using industries of the study area, together with estimates of the quantities of water that will be needed to operate the plants.

Projections of future water requirements were made for each manufacturing sector type, based upon projected low and high growth rates of the respective sectors. The projections also took into account the conservation effects of recycling and reuse and the expected improvements in water use technology (Appendix A, Page 6). The projections were then summarized and are tabulated for the counties in which the industries are located (Table 5).

Total manufacturing water use within the study area in 1980 was reported at 58,455 and in 1985 was reported at 49,508 acre-feet, of which 10 percent was in Hays and Comal counties, two percent was in the middle basin counties of Gonzales and DeWitt, and 85 percent was in Victoria and Calhoun counties (Table 5). Projected manufacturing water requirements for the study area range between 70,727 and 88,008 acre-feet year in 2000, and between 128,571 and 164,454 acre-feet per year in 2040. It is emphasized that a large proportion of water used for manufacturing purposes is cooling water which is recirculated many times and then is returned to the streams and river or is discharged into arms of the bays and estuaries. Thus, it is not consumed, and is available for downstream uses, including other diverters, fish and wildlife, and recreation.

2.4.3. Steam-Electric Power Water Requirements

Steam-electric power generation plants located in Victoria, Calhoun, and Goliad counties obtain water from the Guadalupe River for condenser cooling, boiler feed make-up, sanitation, grounds maintenance, and pollution control. Consumptive (evaporative) water requirements typically range from one-third to one-half gallon of water for each kilowatt-hour of electricity produced; however, from 20 to 60 gallons of water are circulated through the power plant condenser for each kilowatt-hour of electric power produced.

In the study area, one steam-electric plant (Coleto Creek) diverts water from a cooling lake (Coleto Creek Reservoir) and returns its cooling water to the same lake. Make-up water to replace that which is evaporated or consumed is diverted from the river. The other major power plant diverts water from the river, uses it once, and returns it to the river where it is available for downstream uses.

TABLE 5
GUADALUPE BASIN
PROJECTED MANUFACTURING WATER REQUIREMENTS, WITH CONSERVATION

COUNTY	WATER USE		PROJECTED MANUFACTURING WATER REQUIREMENTS											
			1990		2000		2010		2020		2030		2040	
	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
	(acre-feet of water)													
UPPER														
1. KENDALL	7	10	12	12	15	17	18	21	19	27	22	31	24	37
2. COMAL	4,960	3,627	3,678	3,824	3,873	4,546	4,062	5,264	4,370	6,348	4,642	7,644	4,940	8,779
3. HAYS	1,345	1,371	1,681	1,694	2,164	2,470	2,574	2,994	2,952	3,742	3,265	4,604	3,609	5,212
4. GUADALUPE	919	907	943	958	999	1,082	1,111	1,281	1,207	1,493	1,300	1,743	1,403	2,052
5. CALDWELL	219	224	248	248	290	307	327	368	364	441	398	522	439	629
Subtotal	7,450	6,139	6,562	6,736	7,341	8,422	8,092	9,928	8,912	12,051	9,627	14,544	10,415	16,709
MIDDLE														
6. GONZALES	776	863	983	988	1,181	1,285	1,350	1,543	1,516	1,876	1,666	2,260	1,834	2,672
7. DEWITT	105	81	83	84	97	103	109	124	122	148	133	176	148	212
Subtotal	881	944	1,066	1,072	1,278	1,388	1,459	1,667	1,638	2,024	1,799	2,436	1,982	2,884
LOWER														
8. VICTORIA	34,287	26,219	27,045	27,306	39,325	52,372	52,381	52,487	60,781	65,585	68,814	76,930	77,906	90,147
9. REFUGIO	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10. CALHOUN*	15,837	16,206	19,014	19,518	22,783	25,826	26,349	32,938	30,274	40,629	34,046	47,128	38,268	54,714
Subtotal	50,124	42,425	46,059	46,824	62,108	78,198	78,730	85,425	91,055	106,214	102,860	124,058	116,174	144,861
TOTAL	58,455	49,508	53,687	54,632	70,727	88,008	88,281	97,020	101,605	120,289	114,286	141,038	128,571	164,454

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

Source: Texas Water Development Board

*West of Lavaca Bay, thus does not include water needs of Formosa Plastics plant that is located north of Point Comfort.

Steam-electric power water requirements are expressed in terms of consumptive use (Table 6) as opposed to gross quantities diverted, as is the case for all other purposes. For power plants that use cooling lakes this is the quantity needed to keep the lakes satisfactorily supplied. However, for plants which divert from streams and use the once through cooling procedure, water planners and operators must be sure that stream flow is adequate to meet gross diversion needs.

Water consumption for steam-electric power generation in the study area in 1980 was 20,650 acre-feet, and in 1985 was 36,424 acre-feet. Since electric power generation capacity to supply the study area appears to be adequate for the next 20 years, the projected low and high quantities are equal and are held constant at 37,200 acre-feet per year to 2020 (Table 6). However, it is projected that additional electric power will be needed in the area after 2020. Therefore, electric power generation water requirements are increased by 7,000 acre-feet per year (the quantity of water that would be evaporated by a 520 megawatt unit) in 2020 and the low and high projections are held constant at 44,200 acre-feet per year from 2020 to 2040.

2.4.4 Agricultural Irrigation Water Requirements

In the study area, the major irrigated crop is rice, which is produced in Calhoun and Victoria counties. Irrigation is practiced in the other counties, where irrigated crops include grain, forage, and in recent years, some acreage of orchards in the upper basin. The source of water for irrigation in the upper and middle basin counties is about 50/50 between surface and ground water. In Victoria County, over 98 percent of irrigation is from wells drilled into the Gulf Coast aquifer. In Calhoun County, 91 percent of irrigation water is from surface sources, with nine percent from aquifers.

In 1980, irrigation water use in the study area was estimated at 89,718 acre-feet (Table 7). Acreage irrigated was estimated at 26,332, of which 18 percent was in the upper basin counties, seven percent was in the middle basin counties, and 75 percent was in the lower basin counties. However, over 90 percent of study area irrigation water use was in the coastal, rice producing area, where application rates per acre must be much higher -- about three times that for forage and grain crops elsewhere in the basin.

In 1985, due to the extremely poor farm economic conditions, and the general economic downturn, irrigation in the study area declined from 26,332 acres to approximately 20,000 acres, and used an estimated 64,710 acre-feet of water. Rice acreage in the coastal areas declined by about 72 percent between 1980 and 1985. In the late 1980s, there was some recovery in the farm economy and about one-third to one-half of the acreage that was idle to irrigation between 1980 and 1985 was returned to irrigation. Thus, it is expected that in future years, irrigated acreage and irrigation water use will vary between the 1985 level of 20,000 acres and the 35,864 acre maximum level that has been practiced within the study area (see Appendix A, Table A-2). The 1985 acreage was established in response to severe farm economic conditions; thus, it appears to be a lower bound established by economics.

TABLE 6
GUADALUPE BASIN
PROJECTED STEAM ELECTRIC WATER REQUIREMENTS
WITH CONSERVATION

COUNTY	WATER USE		PROJECTED STEAM ELECTRIC WATER REQUIREMENTS											
			1990		2000		2010		2020		2030		2040	
	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
					(acre-feet of water)									
UPPER														
1. KENDALL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. COMAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. HAYS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. GUADALUPE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. CALDWELL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MIDDLE														
6. GONZALES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. DEWITT	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOWER														
8. VICTORIA*	20,584	26,203	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000
9. REFUGIO	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10. CALHOUN	66	55	100	100	200	200	200	200	200	200	200	200	200	200
11. OTHER**	0	10,166	11,000	11,000	11,000	11,000	11,000	11,000	18,000	18,000	18,000	18,000	18,000	18,000
Subtotal	20,650	36,424	37,100	37,100	37,200	37,200	37,200	37,200	44,200	44,200	44,200	44,200	44,200	44,200
TOTAL	20,650	36,424	37,100	37,100	37,200	37,200	37,200	37,200	44,200	44,200	44,200	44,200	44,200	44,200

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

Source: Texas Water Development Board

*Consumptive use from once through cooling water. Gross diversions are on the order of 209,000 acre-feet per year with return to the River of 183,000 acre-feet.

**Coleto Creek in Goliad County. Diversions from the Guadalupe. Consumptive use from cooling lake (Coleto Creek).

upper range of 35,864 acres was established through economic conditions of the late 1970's and 1980's that were favorable to irrigation farming; i.e., fairly high grain prices and dry weather conditions in some years of the period.

Projections of future water requirements for agricultural irrigation, within the study area were made for "base year" acreage and two levels of water conservation. The base year acreage approach was used for projection purposes because of the fluctuations in irrigation that have occurred in the study area in response to both economic and weather conditions.

When farm prices are low and production costs are high, irrigation acreage has declined. When rainfall during the growing season is high, irrigation water use is low, but when rainfall is low, then irrigation water use is higher. Thus, there is a need to establish a "base" from which to make projections of adequate quantities of water to meet agricultural irrigation needs. The procedure and projections are presented below.

The base year acreage and quantities of water used were established from historic surveys of irrigation water use in Texas (see Appendix Table 1). The base year was selected as the year in which the most acres were irrigated during the historic period for which irrigation water use information is available (1958, 1964, 1969, 1974, 1979, 1984, and 1989 unpublished) since this is an indication of the potential acreage that could most easily be irrigated within each county; i.e., the acreage that was irrigated at some point in time during the past 30 years. This acreage is also an indication of lands to which irrigation water rights have been permitted.

Low and high irrigation water requirements projections show irrigation water requirements of the study area to range between 92,400 and 96,688 acre-feet annually in 2000 and to range between 77,346 and 87,523 acre-feet annually in 2040. The low projection is based upon a high rate of conservation which, if successfully phased-in between 1990 and 2030, is expected to reduce water requirements per acre by 20 percent in the upper basin and 25 percent in the lower basin, rice producing counties. (See Section 2.3 for explanation of agricultural water conservation estimation procedures.)

The high agricultural irrigation water requirements projections are based upon the same irrigated acreage base as the low projections, but have a lower rate of reduction in water use per acre through water conservation than in the low case projections. Whereas the low projections were based upon conservation savings of 20 percent per acre by 2010, the high projections were based on a savings of only 10 percent through conservation by 2010, and only 15 percent savings through conservation in the rice growing areas instead of 25 percent.

The agricultural irrigation projections are for a fairly stable upper level of irrigation water use throughout the study area for the projection period, with water use in the upper and middle basin holding at near its historic high of 13,000 to 14,000 acre-feet per year, and the middle basin counties at 4,000 to 4,500 acre-feet per year. However, the projections indicate that through water conservation programs, irrigation water use in the lower basin counties could perhaps be reduced from around 80,000 acre-feet per year to a range of 60,000 to

70,000 acre-feet per year (Table 7). All units are measured at the well head, in the case of ground water, and at the river bank diversion points, in the case of surface water.

2.4.5 Mining Water Requirements

Mining includes the production or recovery of building materials such as sand, gravel, clay, and stone, and crude petroleum. Water use for mining purposes in the study area in 1980 was reported at 2,073 acre-feet and had increased to 4,861 acre-feet in 1985, when construction activities were at a high level, just before the economic decline (Table 8). About 90 percent of water use within the study area is for sand and gravel recovery, with most of the remainder being for crude petroleum recovery. Use of water for crude petroleum recovery is located in the oil producing counties of Guadalupe, Caldwell, Gonzales, DeWitt, Refugio, and Victoria. Some sand, gravel, stone or lime mining is done in practically all of the counties of the study area, but is largest in Comal, Hays, DeWitt, Victoria, and Calhoun counties.

The 1980 level of mining water use was chosen as the low projection, since it represents mining of both building materials and crude petroleum. The 1985 levels occurred under "boom" time conditions in both the building and energy industries, and have not been sustained. Thus, the water requirements projections were based upon the 1980 level of activities in the mining sectors. The low projection for 1990, 2000, 2010, 2020, 2030, and 2040 is set at the 1980 reported level of water use for mining purposes within each county of the study area, with the exception of DeWitt and Calhoun counties. For these counties, where water use is for crude petroleum production, the low projections in some years were equated to the high projections, which took into account the expected decline in future water use for crude oil recovery as water flooding of oil fields declines due to exhaustion of recoverable reserves by this technique.

The high projections of water requirements are based upon projections of growth in the building materials and the energy industries (Appendix A, Page 9). It is emphasized, however, that the use of water for crude petroleum recovery is expected to rise as water flooding of oil fields is developed and expanded, but will decline after a period of time, as oil recovery is completed. This rise and then fall can be seen in the water requirements projections for Gonzales, DeWitt, and Refugio Counties (Table 8).

Projections of future water requirements for mining range from the low of 2,073 acre-feet in 1980 to a high of 3,661 acre-feet in 2000, and a high of 5,096 acre-feet in 2040 (Table 8).

2.4.6 Livestock and Poultry Water Requirements

Drinking water is needed for farm and ranch animals (beef cattle, dairy cattle, horses, swine, goats, sheep, chickens, and turkeys). In 1980, it was estimated that 10,814 acre-feet of water were used in this way in the study area (Table 9). The estimate for 1985 was 10,904 acre-feet.

TABLE 7
GUADALUPE BASIN
PROJECTED IRRIGATION WATER REQUIREMENTS
WITH CONSERVATION

COUNTY	WATER USE			PROJECTED LIVESTOCK WATER REQUIREMENTS											
				1990		2000		2010		2020		2030		2040	
	BASE*	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
						(acre-feet of water)									
UPPER															
1. KENDALL	610	536	150	455	536	549	580	488	549	488	549	488	549	488	549
2. COMAL	691	255	0	216	255	622	656	553	622	553	622	553	622	553	622
3. HAYS	2,993	1,082	1,099	919	1,082	2,693	2,843	2,394	2,693	2,394	2,693	2,394	2,693	2,394	2,693
4. GUADALUPE	8,425	3,124	2,360	2,655	3,124	7,582	8,003	6,740	7,582	6,740	7,582	6,740	7,582	6,740	7,582
5. CALDWELL	2,118	1,600	499	1,360	1,600	1,906	2,012	1,694	1,906	1,694	1,906	1,694	1,906	1,694	1,906
Subtotal	14,837	6,597	4,108	5,605	6,597	13,352	14,094	11,869	13,352	11,869	13,352	11,869	13,352	11,869	13,352
MIDDLE															
6. GONZALES	2,938	1,200	1,424	1,020	1,200	2,644	2,791	2,350	2,644	2,350	2,644	2,350	2,644	2,350	2,644
7. DEWITT	2,005	424	331	360	424	1,804	1,904	1,604	1,804	1,604	1,804	1,604	1,804	1,604	1,804
Subtotal	4,943	1,624	1,755	1,380	1,624	4,448	4,695	3,954	4,448	3,954	4,448	3,954	4,448	3,954	4,448
LOWER															
8. VICTORIA	26,099	26,099	11,876	23,357	26,019	24,291	24,794	20,879	23,489	20,879	23,489	19,574	22,184	19,574	22,184
9. REFUGIO	502	0	50	426	502	451	477	401	451	401	451	401	451	401	451
10. CALHOUN	55,398	55,398	46,921	47,088	55,398	49,858	52,628	44,318	49,858	44,318	49,858	41,548	47,088	41,548	47,088
Subtotal	81,999	81,497	58,847	70,871	81,919	74,600	77,899	65,598	73,798	65,598	73,798	61,523	69,723	61,523	69,723
TOTAL	101,779	89,718	64,710	77,856	90,140	92,400	96,688	81,421	91,598	81,421	91,598	77,346	87,523	77,346	87,523

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

Source: Texas Water Development Board

*The highest quantity of water reported to have been used during the historic series of irrigation surveys, as reported by the Texas Water Development Board, Report 294, "Surveys of Irrigation in Texas, 1958, 1964, 1969, 1974, 1979, and 1984," Unpublished 1989. See Appendix, Table1.

TABLE 8
GUADALUPE BASIN
PROJECTED MINING WATER REQUIREMENTS, WITH CONSERVATION

COUNTY	WATER USE		PROJECTED MINING WATER REQUIREMENTS											
			1990		2000		2010		2020		2030		2040	
	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
					(acre-feet of water)									
UPPER														
1. KENDALL	1	0	1	6	1	8	1	9	1	10	1	10	1	10
2. COMAL	889	961	889	1,128	889	1,368	889	1,596	889	1,824	889	2,052	889	2,308
3. HAYS	1	97	1	6	1	11	1	12	1	14	1	14	1	14
4. GUADALUPE	9	98	9	106	9	115	9	129	9	142	9	156	9	172
5. CALDWELL	1	27	1	12	1	23	1	17	1	10	1	4	1	1
Subtotal	901	1,183	901	1,258	901	1,525	901	1,763	901	2,000	901	2,236	901	2,505
MIDDLE														
6. GONZALES	9	18	9	19	9	22	9	26	9	24	9	21	9	22
7. DEWITT	115	125	115	125	115	135	107	107	81	81	53	53	38	38
Subtotal	124	143	124	144	124	157	116	133	90	105	62	74	47	60
LOWER														
8. VICTORIA	709	3,482	709	1,380	709	1,538	709	1,739	709	1,940	709	2,141	709	2,417
9. REFUGIO	316	53	53	292	53	268	53	224	53	180	53	136	53	102
10. CALHOUN	23	0	23	98	23	173	23	126	23	78	23	31	12	12
Subtotal	1,048	3,535	785	1,770	785	1,979	785	2,089	785	2,198	785	2,308	774	2,531
TOTAL	2,073	4,861	1,810	3,172	1,810	3,661	1,802	3,985	1,776	4,303	1,748	4,618	1,722	5,096

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

Source: Texas Water Development Board

The low projection of livestock and poultry water requirements was set at the 1980 estimated levels, since this was a recent point in time at which the livestock and poultry industries were operating at fairly thin profit levels. Thus, it appears that this is near a lower bound of livestock and poultry numbers within the study area. The high projection of livestock and poultry water requirements is based upon projections of maximum carrying capacities of range land, and projected trends of the numbers of poultry within the study area (Appendix A, Page 9). The projected water requirements for livestock and poultry reach their highest level of 14,653 acre-feet for the study area in 2000 and thereafter range between 10,814 and 14,653 acre-feet per year (Table 9).

2.4.7 Aquaculture Water Requirements

Aquaculture is the production of fish in a confined and managed environment. In the study area, aquaculture is not an established economic activity; thus, there are no records of fresh water use for these purposes. However, experience from neighboring states of Arkansas, Louisiana, and Mississippi indicates that fresh water needs for a moderate size catfish processing plant and an associated 4,000 surface acres of ponds are about 35,000 acre-feet per year.[3]

An aquaculture industry is beginning to develop in the Texas coastal area. Producers located within the study area are beginning efforts to obtain fresh water for aquaculture. For purposes of this study, it is projected that fresh water needs for aquaculture within the study area are as follows:

Year	Quantity
1995	5,000 acre-feet
2000	10,000 acre-feet
2010	15,000 acre-feet
2020	20,000 acre-feet
2030	20,000 acre-feet
2040	20,000 acre-feet

Of these totals, it is estimated that one-third would be from storage and two-thirds would be run-of-the-river flows. Obviously, the growth rate of this industry and the quantity of water that will be needed will depend upon profitability of aquacultural enterprises. More study and feasibility analyses are needed in order to assess the potentials and to make more realistic projections of fresh water needs.

[3] "Texas Aquaculture: Status of the Industry," Texas Agricultural Extension Service, College Station, Texas, 1989. (James T. Davis, Extension Fisheries Specialist).

TABLE 9
GUADALUPE BASIN
PROJECTED LIVESTOCK WATER REQUIREMENTS

COUNTY	WATER USE		PROJECTED LIVESTOCK WATER REQUIREMENTS												
			1990		2000		2010		2020		2030		2040	
	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
					(acre-feet of water)									
UPPER														
1. KENDALL	539	406	539	630	539	722	539	722	539	722	539	722	539	722
2. COMAL	343	276	343	405	343	468	343	468	343	468	343	468	343	468
3. HAYS	573	617	573	675	573	777	573	777	573	777	573	777	573	777
4. GUADALUPE	1,059	869	1,059	1,254	1,059	1,450	1,059	1,450	1,059	1,450	1,059	1,450	1,059	1,450
5. CALDWELL	1,036	747	1,036	1,226	1,036	1,416	1,036	1,416	1,036	1,416	1,036	1,416	1,036	1,416
Subtotal	3,550	2,915	3,550	4,190	3,550	4,833	3,550	4,833	3,550	4,833	3,550	4,833	3,550	4,833
MIDDLE														
6. GONZALES	3,352	3,825	3,352	3,897	3,352	4,443	3,352	4,443	3,352	4,443	3,352	4,443	3,352	4,443
7. DEWITT	1,772	2,073	1,772	2,101	1,772	2,432	1,772	2,432	1,772	2,432	1,772	2,432	1,772	2,432
Subtotal	5,124	5,898	5,124	5,998	5,124	6,875	5,124	6,875	5,124	6,875	5,124	6,875	5,124	6,875
LOWER														
8. VICTORIA	1,179	1,170	1,179	1,400	1,179	1,623	1,179	1,623	1,179	1,623	1,179	1,623	1,179	1,623
9. REFUGIO	491	535	491	581	491	673	491	673	491	673	491	673	491	673
10. CALHOUN	470	386	470	558	470	649	470	649	470	649	470	649	470	649
Subtotal	2,140	2,091	2,140	2,539	2,140	2,945	2,140	2,945	2,140	2,945	2,140	2,945	2,140	2,945
TOTAL	10,814	10,904	10,814	12,727	10,814	14,653	10,814	14,653	10,814	14,653	10,814	14,653	10,814	14,653

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

Source: Texas Water Development Board

2.4.8 Bays and Estuaries Water Inflows

Although the relationships between fresh water inflows and estuarine production are not fully understood, there is widespread agreement that fresh water is needed to maintain productive conditions in the estuaries, including the Guadalupe Bay (San Antonio Bay system) into which the Guadalupe River discharges. Fresh water inflows establish salinity gradients that are important to the reproduction, growth, and development of marine species. River flows also transport nutrients and sediments that are essential to organisms of the food chain for important finfish and shellfish species of the estuaries. Data have been collected and studies have been made by federal and state agencies and the GBRA of the relationships among fresh water inflows and estuarine conditions. The major data collection and study efforts are summarized briefly in the following paragraphs.

The Texas Parks and Wildlife Department has sampled the San Antonio Bay system for salinity and fisheries catch since the mid 1930's.[4] These data have been used by individual researchers and state agencies to compute correlations between fisheries catch and inflows. Although statistically significant correlations have been found between the volumes of inflow and fish catch, it is clear that the volume of fish catch depends upon many other factors, including severe weather events (freezes and hurricanes), price of fish, size and effort of the fishing fleet, and cost of labor and fuel.

In 1967, the Texas Water Development Board, in cooperation with universities and other state and federal agencies, initiated a Texas Bays and Estuaries program. The purpose of the program was to collect physical, chemical, and biological data with which to develop an understanding of the relationships among fresh water inflows, nutrients, sediments, and other factors affecting the ecology and fisheries of each of the Texas bays and estuaries in order to guide the planning and development of water resources.

Between 1975 and 1979, The Water Development Board and The Texas Department of Water Resources performed intensive data collection, laboratory studies, and hydrologic modelling studies, with publication of reports for each of the major Texas estuarine systems, including "Guadalupe Estuary: A Study of the Influence of Freshwater Inflows," LP-107, August 1980. The hydrology of the contributing drainage areas was calculated, water quality of inflows was tested, mathematical models of circulation and the salinity of Guadalupe Bay were calculated, production and transport of nutrients from the marshes into the estuary were estimated, and phytoplankton, zooplankton, and benthic organisms of the food chain were identified and related to salinity. Quantities of commercial and sport fish landings for the period 1962 through 1976 were statistically correlated to seasonal quantities of fresh water inflows.

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[4] Espey, Huston & Associates, Inc., "Water Availability Study for the Guadalupe and San Antonio River Systems", Volume I, Austin, Texas, February 1986, page 5-1.

The analyses showed that shrimp harvests were positively correlated with freshwater inflows in the spring months of April-June and negatively correlated with fresh water inflows in the winter months of November and December. Finfish (trout and drum) harvests were positively correlated with inflows in November, December, April, and June, and negatively correlated with inflows in other months. Thus, from these analyses, it appeared that the fresh water needs of some species, for example shrimp, could be adverse to the productivity of other species, for example, trout and drum, and vice versa.

Using the equations and computer models developed during the study, computations were made of the quantities of fresh water flows that might be needed to achieve: (1) upper and lower monthly salinity limits for metabolic activities of fisheries species; (2) marsh inundation needs for nutrient transport; and (3) the quantities of fresh water inflows correlated with average values of fisheries harvests for the 1962-1976 period for the major commercial and sport fisheries species of Guadalupe Bay -- red drum, sea trout, and white shrimp. Computations were also made of the maximum estimated total commercial harvests of shrimp (the highest commercial valued species) if the 1941-1976 average annual fresh water inflows were distributed in a seasonal pattern to meet salinity and marsh inundation needs; i.e., harvest enhancement of the major commercial species of the estuary.

Although the studies of 1975-1979 were the most comprehensive undertaken to that date, the mathematical expressions of the relationships, of necessity, had been estimated using only a few years, and in some cases, only a few months of data, since no more data were available. In 1985, the Texas Legislature authorized and funded joint Texas Water Development Board, Texas Parks and Wildlife Department, and Texas Water Commission studies with emphasis upon understanding the relationships among fresh water inflows and associated nutrients, sediments, and bay conditions necessary for a sound ecological environment. The schedule for these studies was 1985-1989, with publication of results in February, 1991. The 1985-1989 studies are built upon the earlier work described above, and in particular, are based upon longer time series of data.

In a 1984, 1985, and 1986 water supply study of the Guadalupe and San Antonio River Basins by Espey, Huston and Associates, Inc. (EH&A) for the Guadalupe-Blanco River Authority (GBRA), the City of San Antonio (CSA), and the San Antonio River Authority (SARA), an assessment was made of the needs of Guadalupe Bay and Estuary regarding fresh water inflow requirements.[5] This study considered: (1) salinity versus inflow, and (2) selection of highest desirable salinity levels. The study presented recommendations of monthly inflow requirements necessary to maintain viable habitat, and assessed the effects of recommended monthly inflow requirements upon estimates of fisheries catch and reservoir yields. The EH&A study showed that species viability requirements for fresh water inflow to Guadalupe Bay were 40 percent less, on an annual basis, than was computed in the Texas Department of Water Resources (TDWR) studies referenced above. In quantitative terms, this is 600,000 acre-feet per year versus 1.0 million acre-feet per year.

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[5]Ibid, page 5-2

However, the EH&A study concludes that this level of difference does not necessarily exist for the other inflow/fish catch alternatives studied by TDWR (subsistence, 1.57 million acre-feet annually; maintenance, 2.02 million acre-feet annually; and shrimp enhancement, 2.26 million acre-feet annually), and recommended further study.

In their analyses of reservoir yields, EH&A used the recommended inflow requirements to maintain variable habitat, and applied these requirements "to future reservoir operation for Cuero I, Cuero II (Lindenau), and Cibolo (Lower) in an attempt to develop an operating scenario which will take into account the needs of the estuary as a primary consideration."

"The flow requirements to the bays and estuaries necessary to maintain viable habitat were employed in the model runs to determine reservoir yield. If a monthly inflow was less than the recommended minimum, no water was stored and the total volume was passed through to the estuary. Where flow was available for storage, it was never reduced below the recommended minimum monthly flow for that particular month. All analyses were run against the future baseline inflow conditions. These conditions remove, from the available flows to the bay, all existing, but unused, water rights. The future use of existing water rights will substantially reduce flows to the estuary. However, until exercised, those flows would continue to the bay."

"The reservoirs, however, because of the pass-through of flow requirements to the bays and estuaries necessary to maintain viable habitat, do not substantially alter the low inflow years from the future baseline conditions, except for the full development scenario. During those low inflow years, very little inflow is available for storage because inflows are generally at or below recommended levels."

"Water rights, if they had been exercised historically, would have reduced the historic flow levels to those predicted by the future baseline condition. Thus, when compared to historic inflow conditions, the future baseline condition shows a substantial increase in the number of months during which the inflow falls below the recommended levels. The increase is greatest during July, August, and September, and begins to taper off during October. This is largely due to the bulk of the water rights being utilized for irrigation during those months. The number of events is the same for all reservoirs because the flow requirements to the bays and estuaries necessary to maintain viable habitat prevent storage if the inflow is at or below the recommended level. Therefore, the recommended inflow program to maintain viable habitat prevents further exacerbation of low-flow events beyond that caused by future water rights use. Fifty-three percent of the occurrences occur in the nine years with less than 600,000 ac-ft/year inflow, primarily during the droughts of the early and mid-1950s and early 1960s. Only 17% occurred in years of flows in excess of 1.5 million ac-ft/year. The remaining low-flow months (30%) occurred in the flow range from 0.6 to 1.5 million ac-ft/year. The minimum flow program prevented the low flows from becoming more frequent due to reservoir operation. This would be most critical during those flow periods of from 0.6 to 1.5 million ac-ft/year."

"The individual reservoirs appear to have far less effect on the estuary than the effect of the future water rights. However, since these are cumulative effects, the additional effects of the reservoirs need to be assessed. The full development scenario, while not increasing the number of times monthly inflows are reduced below that determined as necessary to maintain viable habitat over future baseline conditions, does influence the monthly and annual inflows to a noticeable extent. A noticeable downward shift in the distribution of annual average inflows is predicted under the full development scenario. These will include additional analyses of the temporal effect of the inflow reductions. The individual reservoirs appear to have an acceptable level of impact to the estuaries."

An August 1987 report by Texas A & M University estimated that the total business associated with sport fishing, other recreational activity, and commercial fishing in the Guadalupe estuary in 1986 amounted to $80 million in the local region and $135 million for the state.[6] Commercial fishing accounted for 88 percent of the regional business and 87 percent of the state business effect.

The estimated statewide employment effects of sport fishing were 308 full-time job equivalents, with total income of $4.7 million, annually. The number of full-time job equivalents for commercial fishing associated with the Guadalupe Estuary were 2,559, with annual income of $29.6 million.

The estimated state and local tax revenues from sport fishing were $670 thousand, annually; the tax effects for commercial fishing were $4.1 million annually.

The quantities of stream flows from the Guadalupe which enter San Antonio Bay each month during the 1978 through 1987 10-year period were calculated and are shown in Table 10. These quantities were calculated as follows: Monthly flows at the Victoria gage minus diversions downstream of Victoria plus return flows downstream of Victoria. During this 10-year period, the highest monthly inflow was 2,371,444 acre-feet in June of 1987. The lowest monthly inflow was 7,317 acre-feet in July of 1984. During the 1978-1987 10-year period, the lowest annual inflow was 596,936 in 1984. The highest annual inflow year of this period was 1987 with 5,173,257 acre-feet (Table 10).

[6]"Guadalupe Estuary: Economic Impact of Recreational Activity and Commercial Fishing," Departments of Recreation and Parks and Agricultural Economics, Texas A & M University, College Station, Texas, August 1987.

Table 10 Guadalupe Basin - Stream Flows to San Antonio Bay					
Year	Month	Quantity (acre-feet)	Year	Month	Quantity (acre-feet)
1978	1	88,453	1979	1	416,772
	2	89,924		2	291,605
	3	87,483		3	313,954
	4	93,309		4	489,672
	5	63,136		5	649,344
	6	133,600		6	531,904
	7	40,001		7	198,632
	8	327,874		8	156,645
	9	372,030		9	141,296
	10	131,992		10	75,227
	11	175,421		11	75,004
	12	98,643		12	81,275
Total		1,702,866	Total		3,421,330
1980	1	110,947	1981	1	77,217
	2	82,233		2	73,712
	3	64,383		3	103,171
	4	61,228		4	122,154
	5	238,388		5	207,757
	6	72,197		6	937,634
	7	34,407		7	326,550
	8	63,122		8	150,056
	9	124,310		9	825,472
	10	76,334		10	258,785
	11	72,419		11	342,780
	12	174,916		12	140,231
Total		1,075,884	Total		3,565,519

Source: Texas Water Development Board, Unpublished, 1990.

Table 10 (continued)
Guadalupe Basin - Stream Flows to San Antonio Bay

Year	Month	Quantity (acre-feet)	Year	Month	Quantity (acre-feet)
1982	1	110,327	1983	1	68,617
	2	163,099		2	117,986
	3	100,882		3	183,457
	4	81,308		4	98,199
	5	422,518		5	111,455
	6	95,209		6	90,690
	7	54,704		7	113,883
	8	41,602		8	58,523
	9	33,996		9	88,599
	10	68,026		10	74,879
	11	113,383		11	90,739
	12	69,936		12	51,030
Total		1,354,990	Total		1,148,057
1984	1	72,697	1985	1	167,225
	2	58,039		2	112,261
	3	85,729		3	210,516
	4	37,979		4	219,924
	5	30,975		5	120,580
	6	18,902		6	207,736
	7	7,317		7	210,954
	8	13,131		8	70,055
	9	9,757		9	65,450
	10	103,579		10	159,629
	11	77,717		11	288,099
	12	81,114		12	232,400
Total		596,936	Total		2,064,829

Source: Texas Water Development Board, Unpublished, 1990.

Table 10 (continued) Guadalupe Basin - Stream Flows to San Antonio Bay					
Year	**Month**	**Quantity (acre-feet)**	**Year**	**Month**	**Quantity (acre-feet)**
1986	1	135,825	1987	1	372,460
	2	123,105		2	273,459
	3	91,747		3	382,101
	4	66,614		4	169,166
	5	118,069		5	231,934
	6	360,805		6	2,371,444
	7	97,484		7	516,606
	8	49,728		8	320,565
	9	97,236		9	176,527
	10	215,988		10	127,899
	11	187,106		11	117,514
	12	490,999		12	113,582
Total		2,034,706	Total		5,173,257

Source: Texas Water Development Board, Unpublished, 1990.

2.4.9 Recreation Water Use

In the study area, water oriented recreation is quite popular and is an important business enterprise. Recreational activities include sport fishing in the lakes and streams, swimming, boating, water skiing, sailing, canoeing, rafting, tubing, water slides, camping, picnicking, hiking, and week-end visits to the area to enjoy water sports and the scenery of the springs, streams, and lakes. None of these activities are consumptive users of water, but each of them depends upon the springs, streams, and lakes. Since water oriented recreational needs can be met, at least in part, with natural flows of the springs, streams, and Blanco and Guadalupe Rivers, water for recreational purposes is not tabulated separately from other uses.

2.4.10 Basin Total Water Requirements

In this section, the low and high projections of total (ground plus surface water) future water requirements of the study area for all purposes -- municipal, manufacturing, steam-electric power generation, agricultural irrigation, mining, livestock and poultry, and aquaculture -- are presented. In order to obtain these totals, individual category projections presented earlier are summed at each projection point for all purposes for each county of the study area. The summations are made for both high and average per capita municipal water use, without and with municipal water conservation. Conservation and reuse is included in projections of manufacturing, steam-electric power generation, and agricultural water requirements. The resulting projections are shown in Tables 11a, 11b, 11c, and 11d.

In 1980, total water use in the 10-county study area was 232,000 acre-feet, of which 21 percent was for municipal purposes, 25 percent was for manufacturing, nine percent was for steam-electric power, 39 percent was for agriculture, one percent was for mining, and five percent was for livestock watering (Table 12). Of the total water use in 1980, 21 percent was in the upper basin, six percent in the middle basin, and 73 percent in the lower basin.

Projected total water requirements for the study area for the year 2000 range from a low of 285,000 acre-feet to a high of 338,000 (Table 12). The low projection is for the low population and economic growth rate and is based upon average per capita water use, with conservation effects included in all of the projections. The high projection is based upon the high population and economic growth rates, with the high per capita water use rate for municipal purposes, without municipal water conservation. However, in the high projection, water conservation effects are included in all uses except municipal.

For the year 2000 high projections mentioned above, 29 percent is for municipal purposes, 26 percent is for manufacturing purposes, 11 percent is for steam-electric power generation, 28 percent is for agricultural, one percent is for mining, and four percent is for livestock water (Table 12).

Projected water requirements for the year 2040 range from a low of 364,000 acre-feet per year to a high of 486,000 acre-feet per year (Table 12). The distribution of water use among purposes is projected to change to a higher proportion of use in municipal and manufacturing purposes, with a lower proportion in irrigation (Table 12). The proportion of use in the upper basin is projected to increase from 21 percent in 1980 to a range of 27 to 33 percent in 2040 (Table 12 and Appendix B, Figures B.1 - B.11).

2.5 Local Needs Identified Through Public Input

Public input has been encouraged through meetings conducted in each of the ten counties of the basin. Prior to each meeting, preliminary population and water use data were provided to certain elected officials and area civic representatives, and comments were solicited. Notice of each meeting was provided to elected officials and community representatives, and comments were solicited. Notice of each meeting was provided to elected officials and community representatives and through local news media.

A summary of comments received at each meeting follows.

TABLE 11a
GUADALUPE BASIN
PROJECTED TOTAL WATER REQUIREMENTS -- ALL USES

COUNTY	WATER USE		PROJECTED TOTAL WATER REQUIREMENTS											
			1990		2000		2010		2020		2030		2040	
	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
					(acre-feet of water)									
UPPER														
1. KENDALL	2,567	2,532	3,847	4,033	4,272	4,814	4,613	5,312	4,866	5,742	5,122	6,219	5,257	6,481
2. COMAL	15,309	16,303	18,856	19,490	23,074	25,784	26,312	30,540	29,307	35,081	31,535	40,295	32,853	43,707
3. HAYS	11,394	14,427	18,617	19,024	25,633	28,536	30,940	37,143	36,410	45,543	41,120	53,393	43,900	57,973
4. GUADALUPE	12,242	12,873	17,582	18,552	25,337	27,816	27,053	31,253	29,469	34,179	31,839	38,537	33,202	41,209
5. CALDWELL	6,889	5,927	8,527	9,003	9,488	10,704	9,665	11,045	10,013	11,767	10,540	12,636	10,868	13,200
Subtotal	48,401	52,062	67,429	70,102	87,804	97,654	98,583	115,293	110,065	132,312	120,156	151,080	126,080	162,570
MIDDLE														
6. GONZALES	8,679	9,550	9,824	10,614	11,786	13,211	11,921	13,736	12,497	14,917	13,367	16,288	13,955	17,291
7. DEWITT	5,254	6,119	5,899	6,316	7,557	8,436	7,579	8,627	7,811	8,910	8,016	9,155	8,129	9,304
Subtotal	13,933	15,669	15,723	16,930	19,343	21,647	19,500	22,363	20,308	23,827	21,383	25,443	22,084	26,595
LOWER														
8. VICTORIA	93,123	81,803	91,654	95,696	106,659	121,981	117,730	122,768	127,534	138,643	136,194	151,772	146,402	166,948
9. REFUGIO	2,251	1,925	2,443	2,852	2,454	2,892	2,377	2,796	2,315	2,689	2,250	2,580	2,250	2,546
10. CALHOUN*	74,417	67,045	70,260	79,263	77,372	83,653	75,960	88,656	80,493	97,093	82,058	101,536	86,575	109,522
11. OTHER**	0	10,166	11,000	11,000	11,000	11,000	11,000	11,000	18,000	18,000	18,000	18,000	18,000	18,000
Subtotal	169,791	160,939	175,357	188,811	197,485	219,526	207,067	225,220	228,342	256,425	238,502	273,888	253,227	297,016
TOTAL	232,125	228,670	258,509	275,843	304,632	338,827	325,150	362,876	358,715	412,564	380,041	450,411	401,391	486,181

Source: Texas Water Development Board
High per capita water use, without conservation.
*West of Lavaca Bay
**Coleto Creek in Goliad County. Diversions from the Guadalupe. Consumptive use from lake (Coleto Creek).

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

TABLE 11b
GUADALUPE BASIN
PROJECTED TOTAL WATER REQUIREMENTS -- ALL USES

COUNTY	WATER USE		PROJECTED TOTAL WATER REQUIREMENTS											
			1990		2000		2010		2020		2030		2040	
	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
					(acre-feet of water)									
UPPER														
1. KENDALL	2,567	2,532	3,776	3,963	4,035	4,552	4,168	4,811	4,294	5,078	4,511	5,483	4,626	5,708
2. COMAL	15,309	16,303	18,514	19,147	21,780	24,386	23,767	27,730	25,850	31,224	27,785	35,886	28,951	38,995
3. HAYS	11,394	14,427	19,052	19,454	25,179	27,115	27,868	33,413	31,959	39,919	36,010	46,720	38,425	50,705
4. GUADALUPE	12,242	12,873	17,259	18,226	24,163	26,528	24,786	28,651	26,402	30,654	28,430	34,397	29,603	36,719
5. CALDWELL	6,889	5,927	8,391	8,865	9,050	10,213	8,889	10,178	9,035	10,629	9,488	11,378	9,774	11,875
Subtotal	48,401	52,062	66,992	69,655	84,207	92,794	89,478	104,783	97,540	117,504	106,224	133,864	111,379	144,002
MIDDLE														
6. GONZALES	8,679	9,550	9,713	10,505	11,447	12,864	11,322	13,115	11,719	14,042	12,479	15,262	13,005	16,174
7. DEWITT	5,254	6,119	5,808	6,225	7,275	8,145	7,081	8,106	7,177	8,243	7,346	8,452	7,443	8,584
Subtotal	13,933	15,669	15,521	16,730	18,722	21,009	18,403	21,221	18,896	22,285	19,825	23,714	20,448	24,758
LOWER														
8. VICTORIA	93,123	81,803	91,321	95,357	105,522	120,806	115,658	120,590	124,839	135,641	133,206	148,339	143,248	163,262
9. REFUGIO	2,251	1,925	2,406	2,814	2,343	2,781	2,199	2,615	2,110	2,482	2,053	2,383	2,053	2,349
10. CALHOUN*	74,417	67,045	70,171	79,173	77,070	83,339	75,385	88,046	79,712	96,239	81,192	100,571	85,665	108,493
11. OTHER**	0	10,166	11,000	11,000	11,000	11,000	11,000	11,000	18,000	18,000	18,000	18,000	18,000	18,000
Subtotal	169,791	160,939	174,898	188,344	195,935	217,926	204,242	222,251	224,661	252,362	234,451	269,293	248,966	292,104
TOTAL	232,125	228,670	257,411	274,729	298,864	331,729	312,123	348,255	341,097	392,151	360,500	426,871	380,793	460,864

Source: Texas Water Development Board
High per capita water use, with conservation.
*West of Lavaca Bay
**Coleto Creek in Goliad County. Diversions from the Guadalupe. Consumptive use from lake (Coleto Creek).

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

TABLE 11c
GUADALUPE BASIN
PROJECTED TOTAL WATER REQUIREMENTS -- ALL USES

COUNTY	WATER USE		PROJECTED TOTAL WATER REQUIREMENTS											
			1990		2000		2010		2020		2030		2040	
	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
					(acre-feet of water)									
UPPER														
1. KENDALL	2,567	2,532	3,456	3,642	3,834	4,330	4,119	4,755	4,337	5,128	4,559	5,539	4,675	5,766
2. COMAL	15,309	16,303	16,985	17,600	20,588	23,097	23,397	27,321	26,018	31,412	27,981	36,115	29,153	39,239
3. HAYS	11,394	14,427	17,096	17,489	23,618	26,290	28,382	34,038	33,320	41,638	37,571	48,758	40,096	52,924
4. GUADALUPE	12,242	12,873	15,102	16,034	22,288	24,478	23,505	27,181	25,469	29,579	27,376	33,118	28,493	35,329
5. CALDWELL	6,889	5,927	7,680	8,150	8,601	9,709	8,721	9,989	9,026	10,619	9,487	11,377	9,771	11,873
Subtotal	48,401	52,062	60,319	62,915	78,929	87,904	88,124	103,284	98,170	118,376	106,974	134,907	112,188	145,131
MIDDLE														
6. GONZALES	8,679	9,550	8,926	9,708	10,860	12,268	10,941	12,715	11,436	13,723	12,161	14,894	12,664	15,775
7. DEWITT	5,254	6,119	5,247	5,663	6,869	7,733	6,853	7,867	7,040	8,100	7,202	8,299	7,295	8,425
Subtotal	13,933	15,669	14,173	15,371	17,729	20,001	17,794	20,582	18,476	21,823	19,363	23,193	19,959	24,200
LOWER														
8. VICTORIA	93,123	81,803	90,057	94,070	104,838	120,101	115,737	120,670	125,377	136,242	133,815	149,039	143,890	164,012
9. REFUGIO	2,251	1,925	2,232	2,641	2,243	2,680	2,171	2,587	2,119	2,491	2,062	2,391	2,062	2,357
10. CALHOUN*	74,417	67,045	69,782	78,781	76,843	83,107	75,359	88,017	79,811	96,348	81,298	100,685	85,769	108,613
11. OTHER**	0	10,166	11,000	11,000	11,000	11,000	11,000	11,000	18,000	18,000	18,000	18,000	18,000	18,000
Subtotal	169,791	160,939	173,071	186,492	194,924	216,888	204,267	222,274	225,307	253,081	235,175	270,115	249,721	292,982
TOTAL	232,125	228,670	247,563	264,778	291,582	324,793	310,185	346,140	341,953	393,280	361,512	428,215	381,868	462,313

Source: Texas Water Development Board
Average per capita water use, without conservation.
*West of Lavaca Bay
**Coleto Creek in Goliad County. Diversions from the Guadalupe. Consumptive use from lake (Coleto Creek).

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

TABLE 11d
GUADALUPE BASIN
PROJECTED TOTAL WATER REQUIREMENTS -- ALL USES

COUNTY	WATER USE		PROJECTED TOTAL WATER REQUIREMENTS											
			1990		2000		2010		2020		2030		2040	
	1980	1985	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
	(acre-feet of water)													
UPPER														
1. KENDALL	2,567	2,532	3,396	3,580	3,629	4,106	3,735	4,325	3,844	4,555	4,031	4,906	4,132	5,098
2. COMAL	15,309	16,303	16,690	17,303	19,482	21,901	21,217	24,914	23,055	28,107	24,764	32,332	25,806	35,197
3. HAYS	11,394	14,427	16,769	17,159	22,317	24,838	25,631	30,695	29,334	36,600	32,993	42,781	35,191	46,413
4. GUADALUPE	12,242	12,873	14,840	15,770	21,340	23,440	21,682	25,090	23,001	26,742	24,637	29,790	25,600	31,721
5. CALDWELL	6,889	5,927	7,565	8,034	8,227	9,294	8,063	9,254	8,198	9,653	8,594	10,309	8,841	10,745
Subtotal	48,401	52,062	59,260	61,846	74,995	83,579	80,328	94,278	87,432	105,657	95,019	120,118	99,570	129,174
MIDDLE														
6. GONZALES	8,679	9,550	8,840	9,620	10,589	11,994	10,464	12,215	10,815	13,022	11,452	14,075	11,905	14,885
7. DEWITT	5,254	6,119	5,175	5,587	6,639	7,496	6,444	7,444	6,521	7,553	6,656	7,724	6,735	7,835
Subtotal	13,933	15,669	14,015	15,207	17,228	19,490	16,908	19,659	17,336	20,575	18,108	21,799	18,640	22,720
LOWER														
8. VICTORIA	93,123	81,803	89,761	93,770	103,839	119,067	113,912	118,755	123,003	133,600	131,184	146,014	141,110	160,767
9. REFUGIO	2,251	1,925	2,200	2,608	2,150	2,585	2,019	2,434	1,942	2,313	1,894	2,221	1,894	2,187
10. CALHOUN*	74,417	67,045	69,705	78,705	76,581	82,833	74,861	87,487	79,133	95,609	80,544	99,848	84,977	107,722
11. OTHER**	0	10,166	11,000	11,000	11,000	11,000	11,000	11,000	18,000	18,000	18,000	18,000	18,000	18,000
Subtotal	169,791	160,939	172,666	186,083	193,570	215,485	201,792	219,676	222,078	249,522	231,622	266,083	245,981	288,676
TOTAL	232,125	228,670	245,941	263,136	285,793	318,554	299,028	333,613	326,846	375,754	344,749	408,000	364,191	440,570

Source: Texas Water Development Board
Average per capita water use, with conservation.
*West of Lavaca Bay
**Coleto Creek in Goliad County. Diversions from the Guadalupe. Consumptive use from lake (Coleto Creek).

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

Table 12
Guadalupe Basin Water Requirements Projections Summary*

Area/Use	Water Use 1980	Projected Water Requirements 2000 Low	2000 High	2040 Low	2040 High
UPPER					
1. Municipal	30 (64)	50 (67)	69 (70)	73 (73)	125 (77)
2. Manufacturing	7 (15)	7 (9)	8 (8)	10 (10)	17 (10)
3. Steam-Elect.	0 (0)	9 (9)	0 (0)	0 (0)	0 (0)
4. Irrigation	6 (13)	13 (18)	14 (14)	12 (12)	13 (18)
5. Mining	1 (2)	1 (1)	2 (2)	1 (1)	2 (1)
6. Livestock	3 (6)	3 (4)	5 (5)	3 (3)	5 (3)
7. TOTAL	48 (100)	75 (100)	98 (100)	100 (100)	163 (100)
MIDDLE					
1. Municipal	6 (43)	6 (37)	9 (41)	8 (42)	12 (46)
2. Manufacturing	1 (7)	1 (5)	1 (5)	2 (10)	3 (11)
3. Steam-Elect.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4. Irrigation	2 (14)	4 (25)	4 (19)	4 (21)	4 (15)
5. Mining	<1 (-)	<1 (-)	<1 (-)	<1 (-)	<1 (-)
6. Livestock	5 (36)	5 (31)	7 (33)	5 (26)	7 (27)
7. TOTAL	14 (100)	17 (100)	22 (100)	19 (100)	27 (100)
LOWER					
1. Municipal	14 (8)	17 (9)	21 (10)	21 (8)	33 (11)
2. Manufacturing	50 (30)	62 (32)	78 (35)	116 (47)	145 (49)
3. Steam-Elect.	21 (12)	37 (19)	37 (17)	44 (18)	44 (15)
4. Irrigation	81 (48)	75 (39)	78 (35)	61 (25)	70 (23)
5. Mining	1 (1)	1 (1)	2 (1)	1 (1)	3 (1)
6. Livestock	2 (1)	2 (1)	3 (1)	2 (1)	3 (1)
7. TOTAL	170 (100)	193 (100)	220 (100)	246 (100)	297 (100)
BASIN					
1. Municipal	50 (21)	73 (26)	99 (29)	102 (28)	170 (35)
2. Manufacturing	58 (25)	71 (25)	88 (26)	128 (35)	164 (34)
3. Steam-Elect.	21 (9)	37 (13)	37 (11)	44 (12)	44 (9)
4. Irrigation	90 (39)	92 (32)	96 (28)	77 (21)	87 (18)
5. Mining	2 (1)	2 (1)	4 (1)	2 (1)	5 (1)
6. Livestock	11 (5)	11 (4)	15 (4)	11 (3)	15 (3)
7. TOTAL	232 (100)	285 (100)	338 (100)	364 (100)	486 (100)

*Projections rounded to nearest thousand. Percentages of totals are in parentheses. Low projection is for average per capita water use, with conservation in all uses. High projection is for high per capita water use, without conservation in municipal use, with conservation in all other uses.

NOTE: Data are for entire counties of GBRA service area instead of just parts of counties located in the Guadalupe Basin.

Kendall County -

*Population projections are reasonable.
*A conservation plan is in place by the county.
*Residents object to a new water district.
*Boerne needs a commitment from GBRA for a water supply from the Guadalupe River (subordination).
*The city needs to analyze the current water supply in drought conditions (surface & groundwater).

Comal County -

*Population projections are reasonable except in the Canyon Lake area, which should indicate a greater growth potential.
*Basin-wide conservation is necessary.
*Consider recharge dams.
*Treated water is needed to the West of Canyon Lake.
*Stable industrial use.

Guadalupe County -

*Conservation plans are needed for the County and City. The City of Schertz has a conservation plan and believes others should also.
*Population projections are reasonable.
*Residents realize the need to protect springflow to protect Seguin's water right.
*The Canyon Regional Water Authority has a study plan which addresses some alternatives for rural areas obtaining alternative water sources.
*Storage from Canyon Reservoir is a good means of protecting water use by the City of Seguin.
*Growth will occur in Western Guadalupe County.

Hays County -

*Need to verify population projections with the City of San Marcos.
*Conservation plan is in place.
*Need for drinking water in Northern Hays Co.
*Need alternatives for water.
  *Shower Bath Cave (recharge).
  *Cloptin Crossing Reservoir.
  *Coordination with Hays Co. Water Development Board should continue.
  *Declining agricultural use is expected.

Caldwell County -

*A conservation plan is needed.
*Some potential growth is possible if the San Antonio-Austin beltway is built, or Bergstrom AFB becomes a new municipal airport for Austin.
*Potential growth and water needs exist in the northern area of the county.

Gonzales County -

*A conservation plan is needed.
*Population projections are reasonable.
*Growth will occur in poultry and swine industries - not large water users.
*Groundwater may be limited by activity from oil industry.
*Future supplies will be from surface water - must have firm yield. Need to protect quality in surface water. Need to protect springflow.
*Growth in Gonzales County rural water system.

DeWitt County -

*Need to provide water in-basin prior to diversion.
*Municipal conservation plans are needed.
*Water use would change if a large reservoir was built locally.
*Some increase in peach industry should be considered.
*Questions on per capita use of water in rural versus urban areas.
*Concerns about water quality being affected by oil industry.

Victoria County -

*Need "confidence" in water supply and water quality.
*Need to re-evaluate industrial water use projections.
*City of Victoria is going to explore surface water development.
*Agricultural use should be stable or average, but 15-20% savings in water would be good.
*Conservation plans are needed.
*The potential for aquaculture exists.

Calhoun County -

*An increased supply of treated water is needed in Port O'Connor, Point Comfort, and Seadrift.
*Agricultural use is stable. 15-25% less water use would be desirable.
*Good potential for aquaculture.
*Industrial conservation is in place.
*Municipal conservation is needed.

Refugio County -

*Agree with population projections.
*Believe the local water supply is adequate. Need information on the extent of the current supply under drought or for the year 2040.
*Conservation plans are needed.

2.6 Regional Needs/Out-Of-Basin

In addition to the in-basin water needs, as identified in Section 2.4, the eastern parts of Bexar County also need water from the Guadalupe River Basin. (All of Guadalupe County's needs have been included in the projections of Section 2.4.) These areas are growing rapidly (annual growth rates are between 2.6 and 2.7 percent) and presently depend upon the Edwards Aquifer for water. The Canyon Regional Water Authority of Guadalupe County and neighboring water supply entities of Bexar County are considering the acquisition of surface water supplies to supplement, and perhaps replace ground water as their major source of supply. Such a program would reduce demands upon the Edwards Aquifer and thereby contribute to maintaining flows at Comal and San Marcos Springs. (See Section 5.4.5). The quantities of water needed in the eastern Bexar County area are projected to increase from 3,100 acre-feet per year in the early 1990s to over 11,600 acre-feet per year in 2040.[7] The Texas Water Development Board projects that the Bexar County area will need to obtain approximately 46,000 acre-feet of water annually from the Guadalupe Basin by 2000, and approximately 134,000 acre-feet annually by 2040.[8] San Antonio is the largest water using entity of Bexar County. At the present time, San Antonio officials and leaders of other water utilities and water organizations of Bexar County and neighboring areas are making studies of potential sources of additional water supplies and ways to increase water supplies for the area. The types of projects being considered are aquifer recharge, reclamation and reuse of wastewater, Medina Lake, development of surface water from Applewhite, obtaining surface water from the Lavaca, Navidad, and Colorado Basins, and obtaining ground water from the Carrizo Aquifer within the San Antonio Basin.

[7] Unpublished water planning data, Texas Water Development Board, Austin, Texas, October 1989.

[8] "Water for Texas: Today and Tomorrow," Texas Water Development Board, Austin, Texas, November 1990. (Draft, Texas Water Plan).

3.0 EXISTING WATER RESOURCES

3.1 Ground Water

Ground water sources are currently used by some municipal, agricultural, and industrial users throughout the Guadalupe River Basin. In many instances the continued use of ground water is the most reasonable alternative. In all instances, efforts should be made to protect the quality of the ground water source and to realize the limitations imposed by certain aquifer characteristics.

Problems associated with ground water aquifers include poor quality of some aquifers, low recharge rates, and overpumping which limits their reliability. Ground water sources are illustrated on the attached Figure 2. A description of the characteristics of each ground water source follows:

The Edwards-Trinity (Plateau) Aquifer occurs in a small area in the northern part of the Guadalupe River Basin. Total thickness ranges up to about 500 feet. Most existing wells have low yields, but well yields of 250 to 500 gallons per minute (gpm) are possible where there is sufficient saturation in the limestones. The quality of water in the aquifer is good, generally containing less than 500 mg/l total dissolved solids.

The Trinity Group Aquifer also occurs in a small area in the northern part of the Guadalupe River Basin. Well yields range up to about 100 gpm. Water in the aquifer is generally fresh.

The Edwards (Balcones Fault Zone) Aquifer extends across Comal and Hays Counties in the north-central part of the Guadalupe River Basin. Thickness ranges from 400 to 500 feet. Yields of large-capacity wells average 1,500 gpm, but locally wells produce up to 3,000 gpm. Water in the aquifer generally contains less than 500 mg/l total dissolved solids.

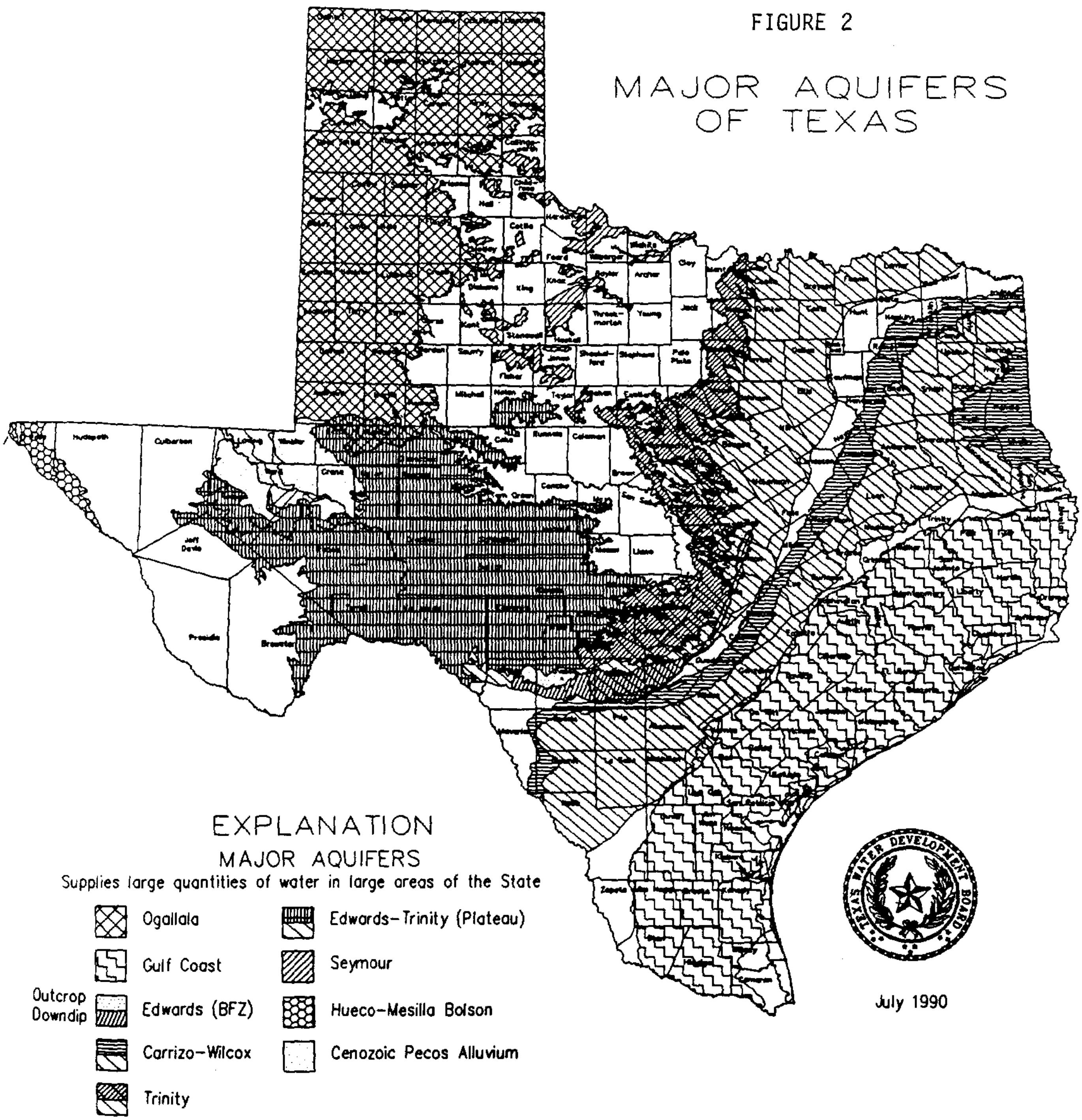
The Carrizo-Wilcox Aquifer occurs in the central part of the Guadalupe River Basin. Total thickness ranges up to more than 2,000 feet. Yields of high-capacity wells average 500 gpm, but locally reach 1,500 gpm. Water in the aquifer generally contains less than 1,000 mg/l total dissolved solids.

The Gulf Coast Aquifer occurs over the entire southern part of the basin. The aquifer extends to a maximum depth of about 1,600 feet. Yields of large-capacity wells average 500 gpm, but locally reach 1,500 gpm. The water generally contains less than 1,000 mg/l total dissolved solids.

The Hickory Sandstone Aquifer occurs in a small area along the northern edge of the upper part of the Guadalupe River Basin. Total thickness averages about 400 feet. Only the downdip part of the aquifer extends into the Guadalupe River Basin. Few wells penetrate the Hickory Sandstone Aquifer in the basin, but in adjacent basins, well yields

FIGURE 2

MAJOR AQUIFERS OF TEXAS



range from 200 to 1,500 gpm. Water in the aquifer varies widely, containing from less than 3,000 to 10,000 mg/l total dissolved solids.

The Ellenburger-San Saba Aquifer also occurs along the northern edge of the Guadalupe River Basin. Only the most downdip portion of the aquifer extends into the Guadalupe River Basin. No wells are known to penetrate the aquifer in the basin: however, in adjacent basins the total thickness ranges up to about 1,000 feet and yields of large-capacity wells range up to 1,000 gpm.

The Queen City Aquifer occurs in a narrow band across the middle part of the Guadalupe River Basin. The aquifer has a maximum thickness of about 400 feet. Yields of large-capacity wells are generally less than 200 gpm, but locally reach a maximum of about 400 gpm. Water in the aquifer varies widely, containing from less than 1,000 to as much as 3,000 mg/l total dissolved solids.

The Sparta Aquifer occurs in a narrow band across the middle part of the Guadalupe River Basin. Maximum thickness is approximately 100 feet. Yields of most wells are less than 100 gpm, but properly constructed wells could produce higher yields. Water in the aquifer contains from less than 1,000 to about 3,000 mg/l total dissolved solids.

It is anticipated that surface water must be made available to supplement ground water in many instances. Kendall County will require water in the Boerne area, and surface water must be made available in the Bulverde reach of Comal County.

The City of New Braunfels has converted in part to a surface water supply to reduce demands on the Edwards Aquifer. Through the combination of sources it will be well situated to meet future demands. The City of San Marcos, in Hays County, is in a similar situation, having contracted for stored water from Canyon Reservoir to supplement demands on the Edwards Aquifer.

The upper area of Hays County in the Wimberley reach, however, will continue to place a demand on ground water resources.

In the counties of Caldwell, Gonzales, and DeWitt, groundwater sources continue to be a reasonable means of supplying the existing and projected municipal growth and to meet agricultural uses. Use should be cautious, however, since ground water supplies are slow to recharge, can be depleted, and are subject to poor quality characteristics.

Monitoring of groundwater sources is necessary to determine any reduced quality. In some instances (as with uncapped flowing artesian wells from oil and gas exploration) water can be wasted, and quality of groundwater sources can be impacted from unnecessary withdrawals.

In the Victoria area, subsidence from pumping of the Gulf Coast Aquifer may cause problems and a supplemental supply of surface water is encouraged.

Refugio County has a sufficient supply of groundwater. As is true with DeWitt and Gonzales Counties, efforts must be made to protect the quality from problems imposed by present and future oil and gas exploration.

The Calhoun County water supply is primarily a surface water supply. Increased demands exist in some rural areas which require additional facilities. Improved delivery facilities are being considered for some areas, and interim measures such as blending treated surface water with ground water for peak use are being reviewed.

Table 13 lists the current use of ground water by aquifer, by county. Groundwater use in Calhoun County was 14,730 acre-feet in 1980 and far exceeded the 2,940 acre-feet of long-term available supply. Ground water use in Victoria County was 39,932 acre-feet, which is at 97 percent of the long-term available supply of 41,130 acre-feet. Ground water use in the other counties was less than the long-term supply available, with use in Gonzales County being only 10 percent of long-term supply, use in Caldwell being 29 percent of supply available, use in DeWitt and Refugio Counties being 23 percent of supply available, use in Kendall and Guadalupe Counties being 33 to 36 percent of supply available, use in Hays County being 50 percent of supply available, and use in Comal County being 63 percent of supply available. It should be noted that the aquifers from which additional ground water can be obtained within the study area are the Carrizo, Edwards-Trinity, Sparta, and the Gulf-Coast aquifer in Refugio, Gonzales, and DeWitt counties.

3.2 Surface Water

Under Texas Water Law, surface water is public water subject to use under an appropriate system managed by the Texas Water Commission. As such, the natural flows of the surface water streams of the state are subject to use by obtaining a permit from the Texas Water Commission. Therein, a priority of use (municipal, agricultural, industrial) and a priority in time (the first in time, being the first in right) has evolved. Through the adjudication of water rights in respective basins, water rights are confirmed or, in instances where water rights have not been utilized to their fullest extent, are canceled to make water available for new users. The system has developed into an orderly system which utilizes the resource to the greatest benefit without impeding the existing rights of other users.

The total number of water rights permits within the Guadalupe Basin, including contracts for stored water, is 376, of which 226 or 60 percent are in the 10-county service area (Table 14). The largest proportion of municipal water use permits are in Upper Basin in the Hill Country and along the I-35 Corridor with 29,417 acre-feet. Industrial water rights permits are concentrated in Comal, Victoria, and Calhoun Counties where total quantity permitted is 640,475 acre-feet, of which approximately 78 percent are non-consumptive (Table 14). Irrigation water rights are found throughout the basin, but the largest concentrations are in Calhoun County with 98,901 or 75.8 percent of the total 130,506 acre-feet. The hydroelectric rights are located in Comal, Hays, Guadalupe, Gonzales, and DeWitt Counties. GBRA Permit 21 is in the amount of 1,300 cfs (cubic feet per second) for a series of four

Table 13 Ground Water Use and Projected Ground Water Supply									
			Projected Supply Available						
County	Aquifer	Use 1980	1990	2000	2010	2020	2030	2040
		----------- (acre-feet) -----------							
Caldwell	Carrizo*	--	10,055	10,055	10,055	10,055	9,190	9,190
	Queen City	--	328	328	328	328	328	328
	TOTAL	2,982	10,383	10,383	10,383	10,383	9,518	9,518
Calhoun	Gulf Coast	--	2,940	2,940	2,940	2,940	2,940	2,940
	TOTAL	14,730	2,940	2,940	2,940	2,940	2,940	2,940
Comal	Edwards**	--	18,792	18,792	18,792	18,792	18,792	18,792
	TOTAL	11,890	18,792	18,792	18,792	18,792	18,792	18,792
DeWitt	Gulf Coast	--	15,866	15,866	15,866	15,866	15,866	15,866
	TOTAL	3,511	15,866	15,866	15,866	15,866	15,866	15,866
Gonzales	Gulf Coast	--	2,083	2,083	2,083	2,083	2,083	2,083
	Queen City	--	6,104	6,104	6,104	6,104	6,104	6,104
	Sparta	--	16,340	16,340	16,340	16,340	16,340	16,340
	Carrizo*	--	22,033	22,033	22,033	22,033	19,840	19,840
	TOTAL	4,226	44,560	44,560	44,560	44,560	44,367	44,367
Guadalupe	Carrizo*	--	12,583	12,583	12,583	12,583	9,947	9,947
	TOTAL	4,625	12,583	12,583	12,583	12,583	9,947	9,947
Hays	Edwards	--	20,767	20,767	20,767	20,767	20,767	20,767
	TOTAL	10,442	20,767	20,767	20,767	20,767	20,767	20,767
Kendall	E/T***	--	5,364	5,364	5,364	5,364	5,364	5,364
	TOTAL	1,748	5,364	5,364	5,364	5,364	5,364	5,364
Refugio	Gulf Coast	--	7,768	7,768	7,768	7,768	7,768	7,768
	TOTAL	1,821	7,768	7,768	7,768	7,768	7,768	7,768
Victoria	Gulf Coast	--	41,130	41,130	41,130	41,130	41,130	41,130
	TOTAL	39,932	41,130	41,130	41,130	41,130	41,130	41,130
	AREA	--						
	TOTAL	95,907	180,153	180,153	180,153	180,153	176,459	176,459

*Carrizo-Wilcox
**Edwards Balcones Fault Zone
***Edwards-Trinity

Table 14
Surface Water -- Number of Water Rights Permits and Quantity Permitted By Type of Use;July 1990

County	Municipal		Industrial		Irrigation			Mining		Hydroelectric		Recreation		Other		TOTAL	
	No.	Ac-Ft	No.	Ac-Ft.	No.	Ac.	Ac-Ft	No.	Ac-Ft.	No.	Ac-Ft	No.	Ac-Ft	No.	Ac-Ft	Permits*	Ac-Ft
HIGH																	
Kerr	11	3,899	3	417	102	3,400	4,622	2	153	0	0	20	1,107	0	0	138	10,198
Blanco	1	600	0	0	6	231	159	0	0	0	0	5	0	0	0	12	759
Subtotal	12	4,499	3	417	108	3,631	4,781	2	153	0	0	25	1,107	0	0	150	10,957
UPPER																	
1.Kendall	1	25	0	0	30	1,598	2,247	0	0	0	0	0	0	0	0	31	2,272
2.Comal**	13	8,198	5	146,445	16	1,450	1,535	1	3	1	124,870	9	6,475	0	0	45	287,526
3.Hays	2	5,593	3	10,614	11	1,003	1,802	0	0	1	64,370	10	0	2	700	29	83,079
4.Guadalupe	5	12,301	6	594	18	2,151	3,876	0	0	4	2,749,407	2	83	0	0	35	2,766,261
5.Caldwell	3	3,300	0	0	19	3,574	6,804	0	0	0	0	2	0	0	0	24	10,104
Subtotal	24	29,417	14	157,653	94	9,776	16,264	1	3	6	2,938,647	23	6,558	2	700	164	3,149,242
MIDDLE																	
6.Gonzales	2	3,040	2	6	10	2,650	4,179	0	0	3	1,956,794	2	0	0	0	19	1,964,019
7.DeWitt	0	0	0	0	9	466	801	0	0	1	538,560	2	0	0	0	12	539,361
Subtotal	2	3,040	2	6	19	3,116	4,980	0	0	4	2,495,354	4	0	0	0	31	2,503,380
LOWER																	
8.Victoria	1	10	6	423,381	9	3,539	5,580	0	0	0	0	1	0	0	0	17	428,971
9.Refugio	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.Calhoun***	3	12,660	5	70,649	6	33,002	98,901	0	0	0	0	0	0	0	0	14	182,210
11.Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal	4	12,670	11	494,030	15	36,541	104,481	0	0	0	0	1	0	0	0	31	611,181
Canyon Balance	-	17,372	-	2,700	-	-	-	-	-	-	-	-	-	-	-	-	20,072
SUBTOTAL(1-11)	30	62,499	27	654,389	128	49,433	125,725	1	3	10	5,434,001	28	6,558	2	700	226	6,283,875
TOTAL	42	66,998	30	654,806	236	53,064	130,506	3	156	10	5,434,001	53	7,665	2	700	376	6,294,832

Source: Texas Water Commission
*Includes contracts
**Does not include Canyon permit, which is 50,000 acre-feet
***Based upon Permit 1614E authorized usage of 106,000 acre-feet per year distributed at 10% municipal, 50% industrial, and 40% irrigation (GBRA, 1985).

power plants located on the Guadalupe River in Guadalupe and Gonzales counties.[1] (Note: a continuous flow of 1,300 cfs for one year is 941,200 acre-feet.)

It is important to note that as water flows downstream, it meets a multiplicity of nonconsumptive needs and permits, for example, hydroelectric power generation, industrial cooling needs, recreation uses, and freshwater flows to the estuaries. Because of increased flows below the confluence of the San Marcos and Guadalupe Rivers, more water is available in the lower reaches of the Guadalupe River Basin. Surface stream flow from below the Edwards Aquifer recharge zone to Victoria amounts to an average of 582,088 acre-feet, with a range of 25,300 acre-feet to 1,487,800 acre-feet per year.

The appropriation of the natural flows (or the run-of-the-river flows) of the Guadalupe River Basin, in normal conditions, are currently utilized to their fullest extent. Established rights for municipal uses, industrial uses, and agricultural uses make new diversions possible only during extreme high flow conditions. As a result, stored water (water which is legally stored under a permit with the Texas Water Commission, usually from high level flows which were previously unpermitted) is of substantial benefit to the Guadalupe River Basin. **By "firming" (utilizing stored water to fill in the low periods when natural flows are not available, or available only to senior water rights), water can be made available to more users in the Guadalupe River Basin.** For example, in Calhoun County in the lower basin, on the average, one acre-feet of stored water from Canyon Reservoir will firm up three acre-feet of run-of-the-river rights. Through the use of the remaining 7,372 acre-feet of uncommitted stored water in Canyon Reservoir, together with GBRA run-of-the-river rights, over 29,000 acre-feet of dependable supply could be made available immediately to existing or to new customers in the lower basin. Through subordination of hydroelectric rights held by GBRA (see Section 5.3) even larger quantities of dependable supply can be made available to present or new users.

In the middle basin counties (Gonzales and DeWitt), one acre-foot of stored water from Canyon, when combined with run-of-the river rights of 1.5 acre-feet can be leveraged into a dependable supply of 2.5 acre-feet. However, the closer to Canyon Reservoir, the lower the potential for "firming up" run-of-the-river rights through leveraging with stored water. For example, the ratio does not rise above one-to-one in the reach between Canyon and IH-35.

An important issue which must be addressed in considering future water supplies is the harm caused to permitted surface diverters by overpumping of the Edwards Aquifer. The Edwards Aquifer is a large, free-flowing conduit which recharges to the west through the Balcones Fault Zone and emerges naturally through the Comal and San Marcos Springs in New Braunfels and San Marcos, respectively. **(Figure 3)** These are the largest flowing springs in the State of Texas with annual discharges of approximately 208,500 and 111,800 acre-feet, respectively. As these flows emerge from the springs, they are considered surface

[1] EH&A Vol. 1, page 7-53.

Comal Springs and San Marcos Springs

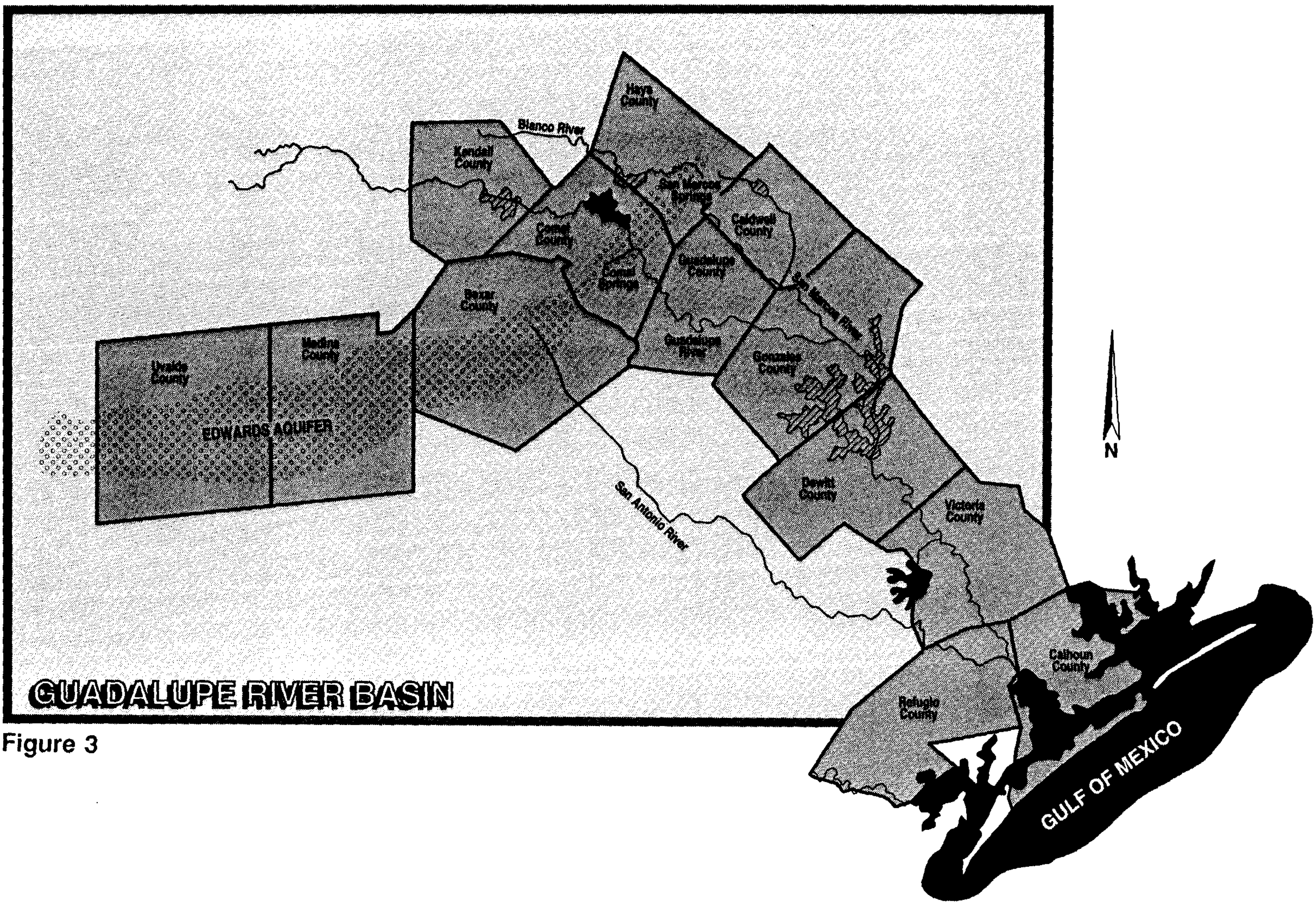


Figure 3

water and have been permitted to users downstream. However, the definition of water in the Edwards Aquifer is clouded; increased ground water withdrawals are depleting the flows of the springs and interfering with the established rights of surface water users downstream. The result is that existing uses are being impaired and endangered by upstream users taking water in advance of water destined to downstream permitted users. **As a result, the need to manage the withdrawals from the Edwards Aquifer becomes more imperative, as does the need to provide stored water to supplement the low flow periods which occur.**

Canyon Dam and Reservoir was constructed in the early 1960's to capture the flood flows of the Guadalupe River for use during drought, and to supplement low flow periods to provide water to the residents of the Guadalupe River Basin. It is the only conservation storage reservoir in the Guadalupe River Basin. The storage and use of the surface water is managed under Permit 1886 issued by the Texas Water Commission.

The "firm yield" of a reservoir is the measure of the benefit of the reservoir during a drought. **The "firm yield" is the number of acre-feet of lawfully stored water that can be diverted from the reservoir (or released for diversion downstream) annually, during a repeat of the drought of record.** The firm yield of Canyon Reservoir is approximately 40,000 acre-feet per annum. The current commitments from Canyon Reservoir are 32,628 acre-feet per annum.

The firm yield can be increased to an amount permitted by the Texas Water Commission (the use of an average of 50,000 acre-feet per annum) by GBRA partially subordinating to Canyon Reservoir, downstream hydroelectric, non-consumptive water rights, also in the name of GBRA.

4.0 AREAS OF WATER SHORTAGE (BY COUNTY)

Kendall County
Boerne, in Kendall County, needs to supplement its existing source. One alternative is through a subordination agreement whereby senior downstream permit holders allow upstream diversion of surface water for transmission and storage.

Comal County
The Bulverde area of Comal County has substantial ability to grow from the extending San Antonio population. A treated water supply was evaluated for providing service from Canyon Lake to near Bulverde. New Braunfels has contracted for storage rights and a water treatment plant is under construction to reduce demand on the Edwards Aquifer.

Hays County
The City of San Marcos also has a commitment for water from storage in Canyon Reservoir to provide a back-up supply of water to meet growth needs. A bond issue for construction of a water treatment plant has been approved.

An extension of water to the City of Kyle is also an alternative, once the San Marcos plant is complete. Additional growth will then be possible along the IH-35 Corridor, with both New Braunfels and San Marcos having adequate water supplies, and with water available along the transmission route to San Marcos.

Guadalupe County
Water will be needed in the Western part of Guadalupe County, and can be provided by existing rural cooperatives, although new facilities and increased supplies are needed. Planning for a treatment plant on the Guadalupe River between New Braunfels and Seguin has been studied and is a reasonable alternative. Initial sizing of the plant is 2 mgd with a 1.0 mgd average daily production. Treated water costs are estimated at .906/1000 gallons.

The City of Seguin diverts and treats water from the Guadalupe River under permit (Certified No. 803, dated June 30, 1914) with the Texas Water Commission. The withdrawal is 7,000 acre feet per annum. Current City use is approximately 5 mgd, or 4,200 acre feet per annum. Because of this early priority date, the City has sufficient rights during normal flow periods. In 1989 the City of Seguin contracted for 2,000 acre feet per annum of storage in Canyon Reservoir to supplement low flow conditions. The duration of this commitment was set by the City for three years, while comparisons were made with other alternative back up supplies.

A study for the City (Littlefield, July, 1990) recommended two alternatives: a commitment for storage from Canyon Reservoir in the amount of 4,301 acre feet per annum (or 2,967 acre feet per annum if conservation measures are adopted), or construction of wells and pipeline facilities to deliver approximately 10,000 gpm from the Carrizo-Wilcox Aquifer in northern Wilson County.

The cost of storage from Canyon Reservoir is $53.03 per acre foot per annum. No new capital costs are required for delivery. The capital cost of the well field option is $7,580,000, with an estimated annual cost of $860,000.

Caldwell County
The impact of potential growth through the construction of the San Antonio-Austin Beltway, or the relocation of the Austin Municipal Airport to the Lockhart side of Austin, could cause substantial growth in the area. Although there are some limitations to the use of ground water sources, surface water alternatives are currently limited by price. Alternatives include the construction of the Plumb Creek Reservoir, or an extension of a transmission line from San Marcos to provide treated or raw water to the Lockhart area.

Gonzales County
In Gonzales County the most reasonable means of assuring a reasonable water supply is to first protect ground water sources from potential degradation from oil or gas activity in the area. Gonzales is in a good geographic location to use surface water supplies to extend future municipal supplies.

Dewitt County
It appears that the most reasonable initiative is to protect the existing groundwater source in DeWitt County, although surface water can be made available for municipal uses when and if necessary.

Victoria County
The City of Victoria has seen cycles in growth and water use. Because of higher rainfall in the coastal area, the per capita use of water is less than in many other areas of the Basin. Supplementation of existing ground water use from the Gulf Coast Aquifer is recommended to provide the City with the assurance of an adequate supply to meet its future needs. The local economy is supported by a large industrial base which also relies on a firm water supply. Through the GBRA practice of firming run-of-the-river uses with stored water, additional water can be provided in the Lower Basin to support and expand on the industrial base.

Refugio County
The population of Refugio County is expected to decline from current levels. The existing ground water source is believed to be adequate, and the most reasonable initiative is to protect the source from degradation from oil or gas activity.

Calhoun County
The need for increased delivery facilities for treated water was identified in the outer areas of Calhoun County, particularly in the Port O'Connor, Point Comfort, and Seadrift areas. It was noted that the Point Comfort area has the potential to be supplied through an agreement with the local Formosa Plastics plant and the Lavaca-Navidad River Authority. Because of the distance to Port O'Connor and Seadrift from existing treatment facilities, alternatives for delivery of water appear expensive by municipal standards. Because of the

continued interest in an increased water supply to Port O'Connor, several alternatives have been developed to provide water to the area.

The City of Port Lavaca has a good municipal water supply. Treated surface water is delivered to the city from the Port Lavaca Water Treatment Plant, operated by GBRA. The plant is presently being expanded to a 6 million gallons per day (mgd) peak capacity to comply with recent Department of Public Health changes in regulations and to meet increased use in the area.

Calhoun County also has a large industrial base which is supported by the GBRA practice of firming run-of-the-river permits with stored water in Canyon Reservoir.

It is anticipated that the agricultural base in Calhoun County will be stable, with some water savings as agricultural practices change and new methods and varieties of crops are introduced. The potential for the development of aquaculture is good in Calhoun County, and provision should be made to provide water in support of the diversification of the agriculture base.

5.0 REGIONAL WATER SUPPLY ALTERNATIVES

5.1 Water Conservation and Return Flows

A water conservation program which emphasizes increased efficiency of water use on the water demand side, while at the same time giving commensurate attention to improved efficiency of water supply and water reuse on the supply side, can make significant contributions toward meeting the future water needs throughout the Guadalupe Basin. Such a program would need to focus upon both the management of water supply and water using systems and apparatus to control and eliminate waste and wasteful practices, as well as the encouragement of installation of more efficient plumbing fixtures and water using appliances and equipment in homes, businesses, factories, and on farms and ranches. In addition, a water conservation program would also consider the introduction of landscaping systems and practices which require less water than those in use now, new crops that take less water per acre, the return and reuse of treated waste water, and capital investments in water delivery facilities, such as unlined canals, to reduce losses.

The important point to understand about water conservation is that the objectives on the demand, or water using side of the ledger are to bring about change in behavior, management, and technical factors so as to reduce the quantity of water needed per person and per economic activity without adversely affecting either the person or the business. The idea is to phase in water conservation programs in a manner such that they are not disruptive to either life style or business activity, and that they become permanent, thereby having a lasting effect upon water use. The net result will be a lowering of the future water requirements, as has been projected in this study.

An equally important point to remember about water conservation on the supply side of the ledger is that the objective is to make permanent, long lasting changes to water supply facilities such that they perform efficiently from both the engineering and economic standpoints. Water supply conservation can also include the development of methods and systems to increase quantities of usable water, such as treatment, storage, conveyance, and delivery of wastewater effluent from one type of use to another (say municipal effluent for industrial cooling water or for irrigation of golf courses, parks and open spaces, and forage and grains for livestock feed). Some major methods whereby water conservation can be accomplished are:

(a) Public education and information to inform people how to save water in the home by turning off faucets while brushing teeth, shaving, and washing hands, to wash only full loads of clothes and dishes, to water lawns in the evening hours when evaporation is lowest, and when landscaping, to choose native shrubs and grasses that use less water;

(b) Plumbing codes which specify low-flush toilets and flow restricting showerheads, filtering and recycling of water for swimming pools, and require insulation of hot water pipes;

(c) Retrofit programs to phase in low-flow shower heads and low-flush toilets when plumbing repairs are made, and to install flow restrictors in high-flow shower heads;

(d) Water rate structures which increase as the quantity of water used increases;

(e) Universal metering or metering of each water customer so that the monthly water bill is computed on the basis of water used each month;

(f) Water conservation landscaping to encourage the reduction of lawn watering through reduced areas watered, the use of native plants that require less water, and xeriscaping;

(g) Leak detection and repair to reduce water waste through leaky pipes and plumbing from the treatment plant or the well all the way to the customers' sinks, commodes, bathtubs, and showers;

(h) Recycling and reuse of treated wastewater for landscape watering, industrial purposes, and agricultural irrigation;

(i) Recycling and reuse of industrial water, especially for industrial cooling purposes;

(j) Canal lining to reduce leakage of water being transferred from streams and wells to cities, industries, farms, and ranches;

(k) Irrigation canal lining, irrigation scheduling, installation of underground pipe, and the use of efficient irrigation application methods, such as drip, trickle, and low energy precision systems to replace furrow, flood, and high pressure sprinkler systems where possible; and

(l) Demineralization of brackish and saline water, blending of waters of different qualities, and storage, treatment, and conveyance of flood water.

As was stated earlier, the water requirements projections of this report are based upon the assumption that water conservation and reuse programs will be developed and phased in during the 1990's. At the present time, GBRA is participating in a basin wide water conservation education program through the public school system by supplying water conservation materials to science teachers.

Water conservation methods listed above, and particularly public education and information programs, along with the development and distribution of "generic" or example municipal water conservation plans to cities of the basin will be implemented in the near future. Other water conservation methods will be implemented in due course (see Appendix C and Section 1.3.2, page 1-12).

The return of properly treated wastewater is a beneficial means of supplying water to existing diverters, protecting reservoir yields for the Basin. Return flows by municipalities can play a dramatic role in determining the yield of any proposed reservoir, and in providing water to users downstream. Return flows by the City of San Antonio as an example, can provide substantial flows to the lower Guadalupe River Basin to satisfy demands of water right holders below the confluence of the San Antonio and Guadalupe Rivers, and to meet the demands of the basin estuaries. Future policy decisions by the City of San Antonio regarding these return flows will have a dramatic impact on decision-making regarding reservoir development.

Extensive reuse, while it will reduce the demands on other water supplies, may also reduce the yields and water of downstream reservoirs and of waters available to other permit holders downstream.

Stream conditions should be monitored to assure compliance with discharge requirements and to develop information on the ability of a stream to improve the quality of the water through the natural process.

While actual reuse is currently limited, certain applications are practical and in some areas can off-set the use of treated water for some purposes such as landscape watering.

Reuse by industry is more common as an economic consideration and can substantially reduce the demands on water supplies.

5.2 Storage and Management

Existing water rights play an extremely important role in the future availability of water for development. As existing water rights are used to their fullest extent, it can be expected that future flows of the streams of the Guadalupe basin will decline.

Reductions in springflows from the Comal and San Marcos Springs would have a severe impact on the ability of existing water right holders to obtain flows which they have historically used, and would also have a severe impact on the flows to the bays and estuaries. In considering the development of surface water reservoirs, caution must be given to the treatment of springflow for use in honoring existing downstream water rights prior to determining water available for storage.

Canyon Reservoir is currently the only water supply storage reservoir in the Basin. Based on recent analysis, the firm yield of the reservoir is approximately 40,000 acre feet per annum. Current commitments from storage amount to 32,628 acre feet per annum (Table 15).

In the past, Guadalupe Basin reservoir sites have been identified and studied. Information about those which have been studied in recent years--Cloptin Crossing, Lockhart, Cuero I and Cuero II is shown in Table 16, the location of each reservoir is shown on Figure 4, and a brief description is given below. It is important to note that reservoir development downstream of Canyon Reservoir can meet some if not all downstream needs that are now being met from Canyon. Thus, Canyon water can be freed up for uses in the upstream reaches of the Basin.

Table 15
Guadalupe-Blanco River Authority
Projected Water Supply Customers
As of January 1, 1991

Permittee	Purpose	Commitment AF/YR	Exp Dt	Ac Irr	Div Rate	County	Cont. Dt.
Murrell	Mun 010	10	051197	--	15 GPM	Comal	012577
SHWSC	Mun 010	1500	050827	--	500 GPM	Guad	062667
GCWSC	Mun 010	700	030139	--	600 GPM	Gonz	030289
WW Sports	Mun 010	1	123194	--	60 GPM	Comal	020990
PLWTP	Mun 010	1500	022008	--	2 MGD	Calhoun	022068
Comal ISD	Mun 010	11	123197	--	13 GPM	Comal	050787
GVWSC	Mun 010	4500	041805	--	2800 GPM	Guad	041885
Yacht Club	Mun 010	4	123195	--	6 GPM	Comal	061285
CCRWSC	Mun 010	560	071610	--	898 GPM	Calhoun	071670
New Braunfels	Mun 010	6720	012509	--	6000 GPM	Comal	012689
Seguin	Mun 010	2000	100192	--	10,327 GPM	Guad	100189
Crystal Clear	Mun 010	500	042320	--	600 GPM	Guad	042390
San Marcos	Mun 010	5000	101019	--	6000 GPM	Comal/Hay	101090
	Subtotal	**23006**					
Propst	Dom 011	1	123193	--	13 GPM	Comal	051288
Moehrig	Dom 011	1	123193	--	300 GPM	Guad	051288
Peters	Dom 011	1	Indef	--	25 GPM	Comal	031281
Mar Lodge	Dom 011	5	123193	--	15 GPM	Comal	020189
Salge	Dom 011	1	123109	--	20 GPM	Comal	082489
	Subtotal	**9**					
DuBose	Ind 020	5	102801	--	50 GPM	Gonz	102881
SMI	Ind 020	500	Yr to Yr	--	600 GPM	Guad	012281
GAF	Ind 020	40	123190	--	--	Calhoun	042280
Acme	Ind 020	25	012906	--	100 GPM	Guad	013081
Henk	Ind 020	1	123194	--	100 GPM	Comal	012290
BP Chemical	Ind 020	1100	021095	--	10250 GPM	Calhoun	021180
CP&L	Ind 020	6000	090125	--	16000 GPM	Calhoun	090175
Carbon Graphite	Ind 020	334	071497	--	1550 GPM	Calhoun	071582
UCC	Ind 020	1200	123191	--	32000 GPM	Calhoun	060185
Standard	Ind 020	120	123193	--	125 GPM	Guad	052987
Comal Fair	Ind 020	1	123129	--	200 GPM	Comal	083089
McRay Drilling	Ind 020	1	123190	--	80 GPM	Gonz	121989
Darst Creek Agg	Ind 020	10	123194	--	240 GPM	Guad	010990
90W Contractors	Ind 020	1	123190	--	416 GPM	Comal	041090
Krause	Ind 020	3	123190	--	300 GPM	Guad	040490
	Subtotal	**9341**					
Brelsford	Irr 030	20	123193	50	400 GPM	Guad	122188
Erben	Irr 030	5	123194	20	534 GPM	Comal	040882
Wuests	Irr 030	100	--	75	500 GPM	Guad	042472
Maples	Irr 030	6	123193	40	300 GPM	Guad	010989
Zurovec	Irr 030	4	123194	15	250 GPM	Guad	020190
Cooper	Irr 030	2	030900	11	--	Comal	031080
Southland	Irr 030	3	123190	8	20 GPM	Guad	021688
Goldbeck	Irr 030	1	123189	5	70 GPM	Comal	090988
Chaparral	Irr 030	120	123194	75	200 GPM	Guad	010490
Missildine	Irr 030	10	123190	10	350 GPM	Guad	011290
Bergstrom	Irr 030	1	123192	1	100 GPM	Guad	012290
	Subtotal	**272**					
TOTAL		**32628**					

Table 16
Summary of Potential Reservoir Yields

Reservoir	Firm Yield (AC/A)	Cost** (Year of Estimate)	Elevation	Capacity ac/ft	Surface Acres Top of Conservation Pool	Surface Acres Top of Spillway	Surface Acres Probable Maximum Flood
Canyon	40,000	21 million (1964 actual)	909.0	369,507	8,240	12,890	17,120
Cuero I*	188,000	318 million (1986)	242.0	1,149,675	41,500	44,080	51,200
Cuero II*	107,000	245 million (1986)	232.0	601,838	26,875	39,880	42,850
Cuero I & II combined	219,000	563 million (1986)	242.0(I) 232.0(II)	1,751,513	68,380	83,960	94,050
Lockhart	7,700	30 million (1986)	488.0	55,593	2,950	3,520	NA
Cloptin Crossing	35,000	68 million (1986)	980.5	283,400	6,007	NA	NA

* If each reservoir is constructed alone for water supply purposes.
** Rounded to next highest million dollars.
NA = Not Available

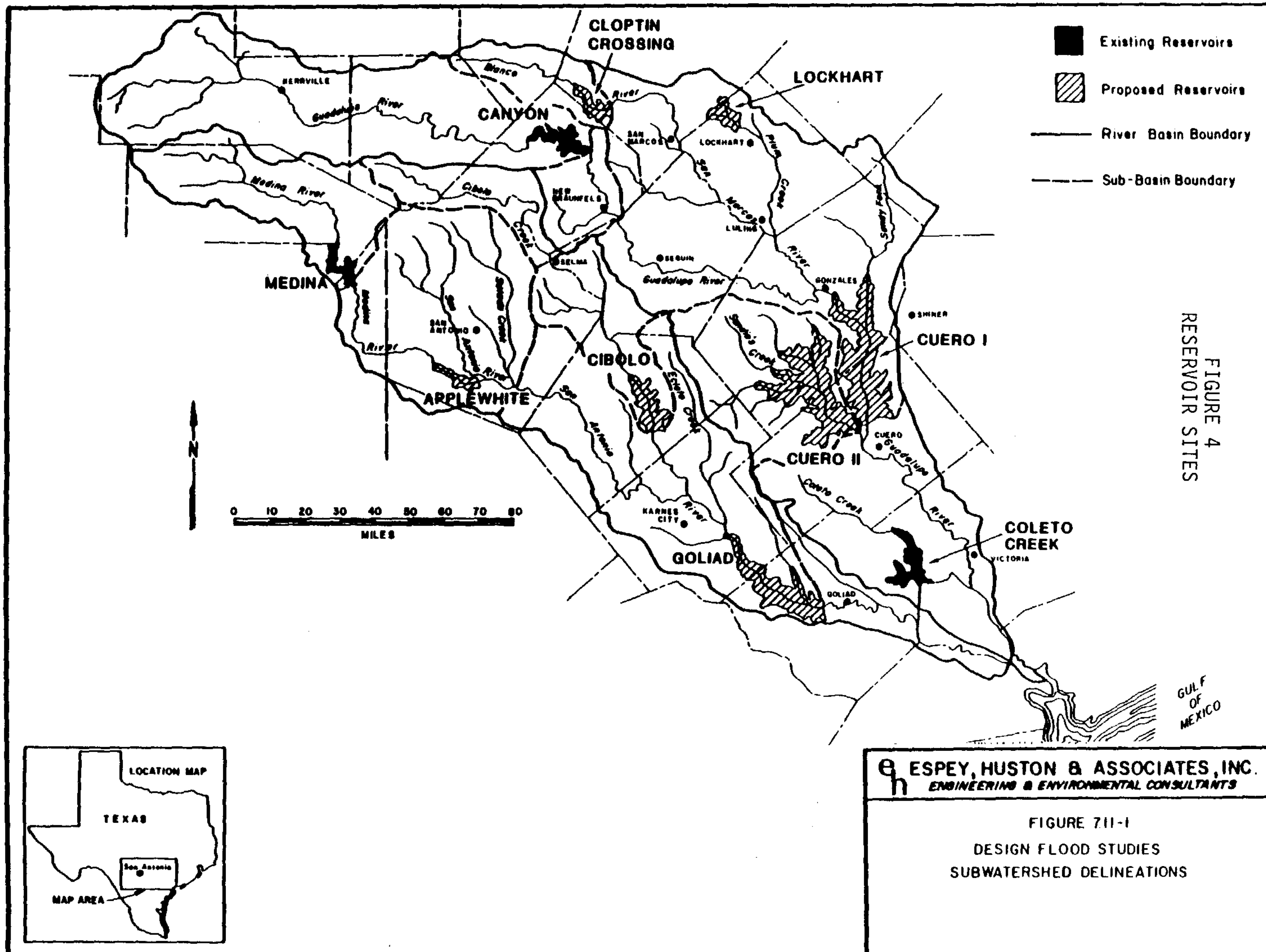


FIGURE 4
RESERVOIR SITES

Estimates of the costs for four potential reservoirs: (1) Cloptin Crossing Reservoir, (2) Lockhart Reservoir, (3) Cuero Reservoir I, and (4) Cuero Reservoir II, as shown on Figure 4, are:

Cloptin Crossing Reservoir: The reservoir has been studied at a site at mile 32.5 on the Blanco River in Hays County, about 2 miles above Wimberley. Drainage area above the dam is 307 square miles. The site was studied in 1986 by GBRA as a water supply reservoir without flood control storage ("Alternative Source Water Supply Study," GBRA, 1987). The normal water surface as proposed would be at elevation 980.5 and have a surface area of 6,007 acres. The site has the potential to develop a firm yield of 35,000 acre feet per annum. Cost estimates for construction of the project were $68 million in 1986 prices.

Lockhart Reservoir: The reservoir has been studied at a site on Plum Creek at stream mile 30.5 in Caldwell County, about 3 miles north of Lockhart. It controls a drainage area of 118 square miles. The project is considered a source of municipal water supply. Flood protection is not planned in the project. The normal water surface is planned at elevation 488.0 ft. above mean sea level and would have a surface area of 3,520 acres. The firm yield of the reservoir, studied by GBRA in 1986, was 7,700 acre feet per annum ("Alternative Source Water Supply Study," GBRA, 1987). The 1986 estimate was $30 million.

Cuero Reservoir I--alone: The Cuero Reservoir I has been studied for a location approximately 4 miles north of Cuero on the Guadalupe River. The drainage area above the dam is approximately 4,166 square miles. The reservoir has been studied for conservation storage only. The normal water surface as proposed would be at elevation 242.0 ft. above mean sea level and have a surface area of 41,500 acres. The top of the spillway would be at elevation 244.7 feet, with a surface area of 44,080 acres. Because of its location below the confluence of the Blanco and San Marcos Rivers with the Guadalupe River, the site has the potential to develop a firm yield of 188,000 acre feet per annum. Cost estimates for construction of the project in 1986 were $317,516,574 and annual operation and maintenance costs in 1986 prices were $1,682,773.[1]

Cuero Reservoir II--alone: The Cuero Reservoir II (also known as the Lindenau Reservoir or the Sandies Creek Reservoir) has been studied for a location on Sandies Creek, in DeWitt County, approximately 4.5 miles northwest of Cuero. Drainage area above the dam is 678 square miles. The reservoir has been studied for conservation use only. The normal water surface as proposed would be at elevation 232.0 and have a surface area of 26,880 acres. The site has the potential to develop a firm yield of 107,000 acre feet per annum if Cuero I is not built and diversions are made by pumping flood flows from the Guadalupe into the reservoir. Cost estimates for construction of the project in 1986 were $244,681,238, with annual operation and maintenance costs of $2,931,595 (1986 prices).[2]

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[1]EH&A Vol. 1, page 7-53

[2]Ibid.

Cuero I and II--combined: Cuero I and Cuero II, as standalone reservoirs, are described above. If both sites are constructed for water supply only, the firm yield of the two together would be 219,000 acre-feet, with a surface area at the top of the conservation pools of 68,380 acres, and a surface area of 83,960 acres at the top of the spillway elevations. It should be noted that the top of the conservation pool elevation for Cuero I would be 242.0 feet above sea level, and for Cuero II would be 232.0 feet above sea level. The top of the spillway elevation for Cuero I would be 244.7 feet above sea level; the top of the spillway elevation for Cuero II would be 240.5 feet above sea level. In 1986, the construction costs of the two reservoirs would have been $562,197,812, with annual operations and maintenance costs of $3,441,368.[3]

Out-of-Basin (Lake Texana): In addition to Guadalupe Basin projects, a potential source of surface water in the lower basin is from reservoirs of the Lavaca-Navidad Basin (Lake Texana). The Lake Texana service area includes the Lavaca-Navidad River Basin and the adjoining coastal basins (Colorado-Lavaca to the east and Lavaca-Guadalupe to the west). The eastern one-half of Victoria County and about 85 percent of Calhoun County are located within the Lavaca-Guadalupe Coastal Basin. At the present time, water use in Victoria and Calhoun counties is about 159,000 acre-feet per year, of which about 27 percent is obtained from local aquifers and 73 percent is obtained from the Guadalupe River. Projected requirements for these two counties range between 204,000 and 232,000 acre-feet in 2020 and range between 228,000 and 272,000 acre-feet in 2040. Some of the future water needs in both of these counties could be met from the existing Lake Texana and from Palmetto Bend Stage 2 if it is developed.

To the extent that lower Guadalupe Basin needs are met from the Lavaca-Navidad Basin, Guadalupe Basin surface water supplies would be freed up for use in the upper and middle reaches of the Basin, and to meet some of the needs in the San Antonio Basin, particularly in the Bexar County area to supplement supplies from the Edwards aquifer and thereby contribute to the maintenance of flows at Comal and San Marcos Springs.

Bays and Estuary Needs: Fresh water inflows to San Antonio and Matagorda Bays must be maintained at satisfactory levels in order to protect the productive potentials of these estuaries. As was explained in Section 2.4.8, studies of fresh water needs of Texas estuaries are in progress and are expected to provide information essential to the management of water resources commensurate with maintenance of a sound ecological environment of the bays and estuaries. Each of the potential water storage projects mentioned above will be planned in a manner such that the needs of the estuaries are taken into account. When this is done, the reservoir yield, as shown in Table 16, may be changed, or a part of those yields may be reserved or assigned for release to the estuaries.

Hydroelectric Power Development Potential: According to a study by GBRA in 1981, there is a potential for a small quantity (about 16 million kilowatt hours) of additional hydroelectric power development in the lower basin. This development would be a non-consumptive use of water, and would not have a priority call upon stored water. Thus, the

[3]Ibid.

projected water requirements do not include quantities of water for this purpose.

Reservoir Averaging: In the Guadalupe Basin, GBRA has developed an operating procedure whereby stored water from Canyon reservoir is used to "firm-up" run-of-the-river rights for water rights holders downstream of Canyon (see explanation of this procedure in Section 4.0).

By using stored water from Canyon, it has been possible to develop a "reservoir averaging" method whereby Coleto Creek Reservoir, an off-channel cooling lake for a steam-electric power plant in the lower basin, can be dependably operated with a run-of-the-river permit by water from the Guadalupe, backed by a minimum quantity of stored water. The run-of-the river permit for Coleto Creek Reservoir is 20,000 acre-feet per year. The agreement for stored water provides for a five year average of 6,000 acre-feet per year of stored water from Canyon, with a special condition that the maximum quantity of stored water that can be used during any one of the five years is 18,900 acre-feet. In this way, stored water for the electric utility is minimized, and the project has an adequate water supply to allow operations during short term droughts.

Pricing of Stored Water: GBRA has a philosophy of pricing stored water, so the rate includes the cost of the capital; operation, and maintenance of facilities; and other expenses required to store and deliver the water, at the cost of service to provide stored water. The basin price is calculated as the weighted average cost of service from all projects in the basin. Thus, the basin price is based upon debt service, operation, and maintenance costs for all projects involved in providing the service (stored water). The current cost of stored water is $53.03 per acre-foot per year. This cost could decrease as debt for current projects is paid off, but it could increase as new projects are financed and built.

Stored Water for Agricultural Irrigation: In the Guadalupe Basin, some irrigation farmers who use surface water have rights only to run-of-the river flows. Thus, they do not have a dependable water supply during times of drought. In any given year, if GBRA has uncommitted water in storage at the beginning of the year, GBRA provides stored water from Canyon Reservoir, under a special arrangement with the irrigation farmers. Under this policy, on a year-to-year basis, GBRA provides stored water to the irrigation distribution system to meet the needs of individual irrigators who need more water to finish an individual season than is available to them under the terms of their respective run-of-the-river water rights, when stream flows are below normal due to drought conditions. The charge for this water is the system price for stored water -- $53.03 per acre foot, and is prorated among all the irrigators who use the distribution system to which the stored water is available. In this way, individual irrigators can proceed with their respective farming operation, with assurance that there will be enough water available to complete the irrigation season and bring the crop to maturity. This method reduces the need to have to resort to various strategies during the irrigation season to perhaps over irrigate when stream flows are high, in an effort to store soil moisture for later months when stream flows are not expected to be adequate to meet irrigation needs. All who participate share the costs, and thereby benefit by having a limited amount of stored water available during times of drought. It is emphasized, however, that this policy is operated on a year-to-year basis as opposed to being a long-term irrigation water supply policy.

5.3 Subordination

Subordination is defined as an agreement whereby a senior (earlier in time) water right permit holder allows another water right permit holder to exercise diversion or storage rights first, thereby increasing the use by the junior right.

Subordination is considered in two areas: Subordination of existing hydroelectrical rights to provide water to users upstream of Canyon Reservoir who would otherwise be unable to divert water, and subordination of existing hydroelectric rights on a broader scale to increase the yield of Canyon Reservoir.

Subordination to Provide Some Water Upstream of Canyon Reservoir: Under an existing program operated by the Guadalupe-Blanco River Authority, upstream users in specific instances are allowed to divert and use the flows of the Guadalupe River upstream of Canyon Reservoir. The flows of the Guadalupe River and its tributaries upstream of Canyon are already appropriated virtually all of the time under hydropower rights held by GBRA under Certificates of Adjudication 18-5488 and 18-5172, other rights held by GBRA, including Certificate of Adjudication 18-2074 C authorizing Canyon Reservoir, and water rights held by others. In many instances, GBRA is able to subordinate its hydropower rights to make water available for use at times when the entire flow is required to be allowed to pass to honor the GBRA hydroelectric rights, but less than the entire flows required to be allowed to pass to honor all other water rights.

The net result is a decrease in the flow of water utilized by the GBRA hydroelectric system in a given year; however, through the program, water is made available to users upstream who otherwise would be unable to divert water to meet their needs. To date, a total of 27 users (permitted for a total of 2,709 ac/ft/yr) have been satisfied by this means of transferring water to areas which otherwise would be water short. It is anticipated that this program will continue (Table 17).

Subordination to Increase the Yield of Canyon Reservoir: On a broader scale, subordination of hydropower water rights in the name of GBRA can increase the current yield of Canyon Reservoir. Based on recent analysis, the current firm yield of Canyon Reservoir is estimated to be 40,000 acre feet per annum. Since this analysis indicates a yield less than the permitted diversions from Canyon Reservoir of 50,000 acre feet per annum as permitted by the Texas Water Commission, the potential for subordinating the downstream hydroelectric rights to increase the firm yield would allow GBRA to realize the full potential of the reservoir for water supply purposes. (See Section 3.2 for a discussion of the use of stored water to firm up run-of-the-river water rights.) Again, caution must be used in determining the effects of reduction in springflow on yield of the reservoir. It is also appropriate to consider that upstream subordination agreements in place will be included in the reservoir inflows used in these analyses. Preliminary indications are that the yield of Canyon Reservoir could be increased to approximately the permitted yield of 50,000 acre-feet per annum through subordination of GBRA's hydroelectric right to the next right which is the City of Seguin non consumptive right of 365 cfs. By honoring the City of Seguin's right, it is assumed that all other downstream water rights holders will be satisfied.

Table 17
Subordination Agreements

Permittee	Purpose	AF/YR	Exp Date	Ac Irr	Div Rate	County	Dt Filed	Permit No.	Act. No.	Remarks
River Inn	Mun 010	10	03-02-24	--	50 GPM	Kerr	03-02-84	18-1956A	041502	
Cypress	Mun 010	35	04-18-25	--	35 GPM	Comal	04-18-85	4163A	041505	Min. of 11.2 AF/yr evaporation
TPWD	Mun 010	25	11-14-23	--	50 GPM	Comal	11-14-83	4106	041504	
Subtotal		**70**								
SE Savings	Rec	42	11-12-25	--		Kerr	11-12-85	5029	041507	
Elmore	Rec	25	06-11-30	--	13 GPM	Kerr	06-11-90	--	041611	Min. of 25 AF/YR evaporation ** Pending
Subtotal		**67**								
Williams	Irr 030	50	03-04-25	--	400 GPM	Kendall	03-04-85	4255	041514	
Worth	Irr 030	518	02-07-25	200	2250 GPM	Kendall	02-07-85	5107	041512	
Miller	Irr 030	90	01-10-25	--	700 GPM	Kerr	01-10-85	--	041511	
Hutton	Irr 030	50	01-28-25	76	600 GPM	Comal	01-28-85	4291	041510	
Poth	Irr 030	70	03-06-24	35	180 GPM	Kerr	03-06-84	4181	041509	
Brundage	Irr 030	45	03-06-24	25	180 GPM	Kerr	03-06-84	18-0241	041508	
Mullins	Irr 030	10	08-11-23	6	250 GPM	Kerr	08-11-83	4096	041501	
Wright	Irr 030	80	03-20-25	80	1000 GPM	Kendall	03-20-85	4285	041513	
Harbison	Irr 030	10	03-10-26	12	400 GPM	Kerr	03-10-86	5060	041602	
Riverhill	Irr 030	215	09-05-26	160	1000 GPM	Kerr	09-05-86	3207	041603	Min. of 56.0 AF/Yr. evaporation
Shelton 1	Irr 030	20	03-17-23	14	200 GPM	Kerr	03-17-83	A4223	041503	No evaporation loss w/dom./livestock
Shelton 2	Irr 030	150	08-17-29	--	300 GPM	Kerr	08-17-89		041607	Pending
Storm	Irr 030	75	01-22-27	50	260 GPM	Kerr	01-22-87	5122	041604	
Schwarz	Irr 030	40	03-02-27	38.2	200 GPM	Kendall	03-02-87	5125	041605	
Hayes	Irr 030	40	10-24-28	40	250 GPM	Kerr	10-24-88	--	041606	Pending
Mobley	Irr 030	50	10-20-29	--	400 GPM	Kerr	10-20-89	--	041608	Pending
Casa Bonita	Irr 030	2	01-15-30	--	200 GPM	Kerr	01-15-90	--	041609	Pending
Camp Arrowhead	Irr 030	300	05-02-30	--	315 GPM	Kerr	05-02-90	--	041610	Pending **Minimum 100 AF/YR evaporation
Donzis	Irr 030	5	05-14-30	--	60 GPM	Kerr	05-14-90	--	041612	Pending
Shelton 3	Irr 030	600	05-23-30	--	3600 GPM	Kerr	05-23-90	--	041613	Pending
Langbein	Irr 030	150	08-03-30	--	750 GPM	Kendall	08-03-90	--	041614	Pending
Subtotal		**2570**								
Murphy	Dom Oil	2	07-08-25	--	8 GPM	Comal	07-08-85	--	041515	Pending
Subtotal		**2**								
TOTAL		**2709**								

Date: 8-23-90

Although some reduction in hydropower generation would result from the subordination, the increased yield to the reservoir would provide a means of improving storage ability and the delivery of water without additional structural requirements. As the Basin continues to grow, this appears to be a first step in providing increased water supplies to meet Basin demands.

Certification of Adjudication 18-2074C (Permit 1886 issued by the Texas Water Commission in 1956), allows the impoundment of waters in Canyon Reservoir after first satisfying prior downstream water rights. At times capacity is available in the reservoir for additional impoundment, however, inflows must be passed through the reservoir to honor senior water rights downstream. Since the current firm yield of the reservoir is based on storing only flows in excess of senior downstream rights, the reservoir yield could be increased through subordination of senior downstream water rights.

One major water right downstream is for hydroelectric generation under Certificate of Adjudication 18-5488 (Permit 21 issued in 1914) and Certifiocate of Adjudication 18-5172 (Permit 1096 issued in 1926). These are nonconsumptive rights owned by GBRA and are senior rights on the watershed. Permits 21 and 1096 provide for the nonconsumptive diversion of 1,300 cfs and 1,250 cfs respectively.

Through the subordination of Permits 21 and 1096 water which would otherwise be passed through the reservoir to honor these permits would be stored in the reservoir. Inflows committed to other downstream water rights senior to the Canyon Reservoir Permit 1886 and high level flows in excess of the storage capacity of the reservoir conservation pool would still pass through the reservoir.

An analysis of the potential for increasing the yield of the reservoir was conducted with several assumptions, among those:

1. Springflow from the Comal Springs would be maintained at the year 1956 level, effective when the Canyon Reservoir Permit was issued. A second alternative was developed using 1980-1986 springflow conditions. During this second period analysis springflow was reduced because of increased pumping of the Edwards Aquifer.

   (The Comal Springs provide a major portion of flows to downstream water rights holders. Any reduction in springflow will reduce the amount of water available downstream. If a greater amount of inflows are passed through Canyon Reservoir to compensate for reduced flows from the springs, then less water is available for storage.)

2. The Federal Energy Regulatory Commission requirements for minimum flows under FERC License 3865-003 for Canyon Dam Hydroelectric generation would be met.

3. Diversions would be made downstream from the reservoir.

Hydrologic modeling of the affect of subordination of Permits 21 and 1096 on the yield of Canyon Reservoir indicate that a firm yield of 66,000 acre-feet could be achieved from the reservoir under 1956 permit conditions. Under the 1980-1986 springflow conditions, the yield would be 52,000 acre-feet per annum.

Results of the study therefore indicate the yield of Canyon Reservoir can be increased to approximately the 1956 permitted diversion of 50,000 acre-feet per annum through partial subordination of GBRA's hydroelectric right.

5.4 Structural Alternatives

5.4.1 Canyon Bulverde

An analysis of the method and cost of meeting the needs of the area between Canyon Lake and Bulverde, in Comal County, was conducted. A plat of the area is attached **(Figure 5)** and the cost estimates are shown in Table 18. A survey of the area indicates 2,267 potential connections in the Canyon Lake area, and an additional capacity is provided for 530 new connections in the Smithson Valley area. A 1.0 mgd plant has been proposed to satisfy these users. The cost per thousand gallons would be $3.95 for service to the initial 2,267 customers, or $3.44 per thousand gallons if additional transmission were provided for service to the additional 530 customers in the Smithson Valley area.

A breakdown of the most reasonable costs for Phase I (construction of a 1 mgd plant and transmission facilities for service to 2,267 users), and Phase II (the addition of transmission facilities to service an additional 530 customers) is shown in Table 19.

5.4.2 Port O'Connor, Seadrift, and Union Carbide

The community of Port O'Connor, is currently served by the Calhoun County Water Supply Corporation, which purchases water from the Port Lavaca Water Treatment Plant, each operated by the Guadalupe-Blanco River Authority. Sources of ground water in the county are limited; however, some areas are still utilizing the Gulf Coast Aquifer as their primary source. The main impediment to providing water to some areas is the cost because of long distnaces to pump treated water with too few customers **(Figure 6).**

Although a system now exists in Port O'Connor, increased demand on peak weekends cause strains on the ability of the system to deliver water. Several alternatives have been considered; one is the construction of a new pipeline to provide an increased water supply to Port O'Connor and another is a proposal to mix groundwater with available surface water to satisfy peak weekend and holiday demands.

Total cost of the alternative for providing a new pipeline is $770,000 (Table 20). Past surveys of the Port O'Connor area indicate as many as 307 existing potential users (those who currently do not have service from the rural water system), and 474 potential development connections - a total of 781 potential new customers.

Improvements necessary to provide service to existing customers, existing unserved residents, and potential development include transmission, distribution, storage, and pump modifications.

Canyon – Bulverde Water Supply

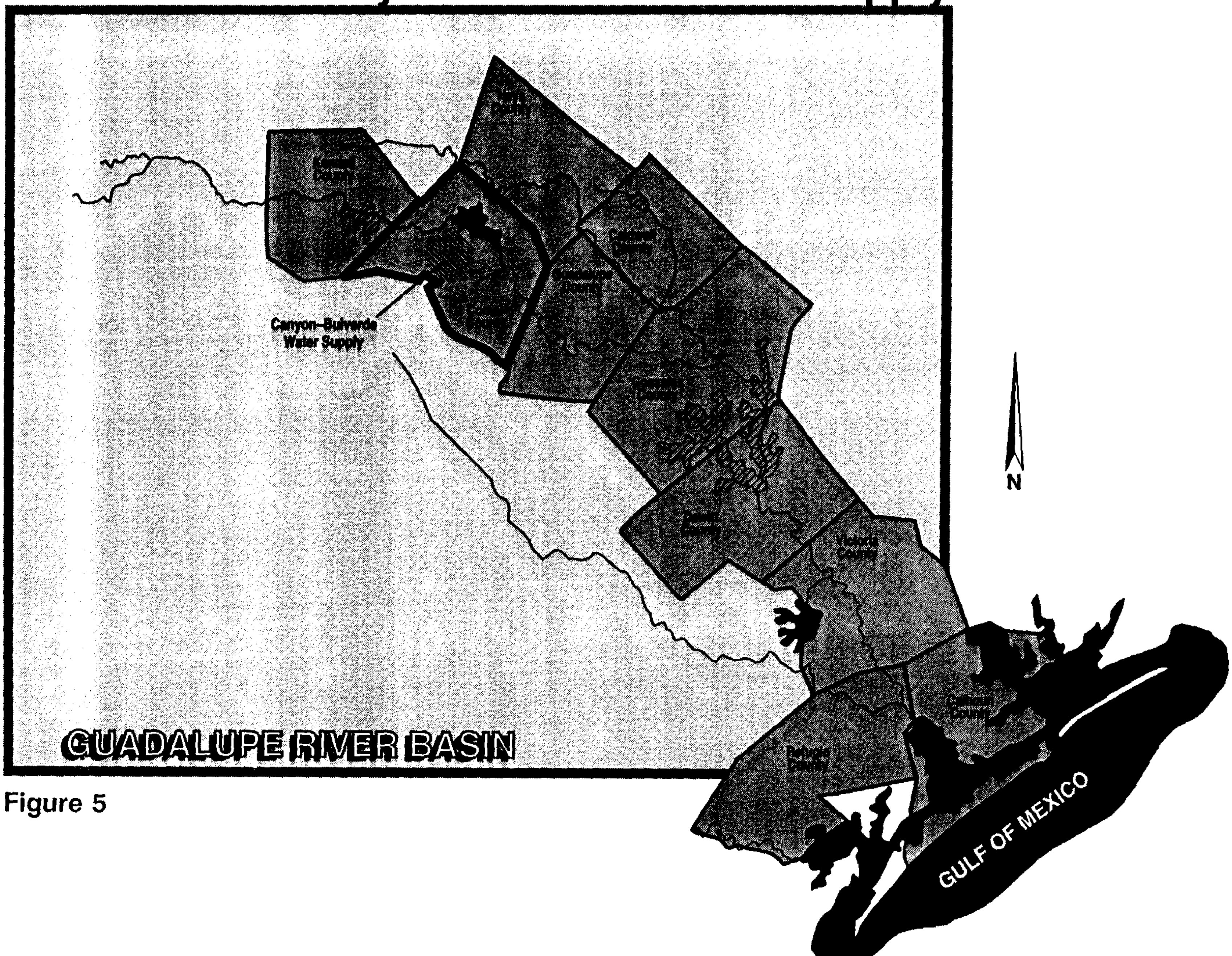


Figure 5

Table 18
Canyon Lake Area Water Treatment Plant
Preliminary Cost Estimate

8-8-90

Phase 1

	Option 1	Option 2	Option 3	Option 4A	Option 4B
EST. CONNECTIONS		Existing Meters ==150 gals/day=========			
C.L. Village West	440	440	440	440	440
The Oaks	161	161	161	161	161
Canyon Lake Forest	298	298	298	298	298
Astro Hills	132	132	132	132	132
Lakeview Park	189	189	189	189	189
Rolling Hills	202	202	202	202	202
Water Front Park	125	125	125	125	125
Canyon Lake Hills	229	229	229	229	229
Mobile Homes Estates	106	106	106	106	106
Canyon Lake Mobile	283	283	283	283	283
Westhaven	102	102	102	102	102
		Future Meters ====================			
Smithson-Valley	0	0	0	0	0
Total Connections	2267	2267	2267	2267	2267
SURFACE DEMAND					
Avg Day per con.(GPD	150	150	150	150	150
Avg Day (gallon/day)	340,050	340,050	340,050	340,050	340,050
Max. Day (gals/day)	680,100	680,100	680,100	680,100	680,100
Yearly Total (A-F)	381	381	381	381	381
CONSTRUCTION COST	1 MGD	1 MGD	1 MGD	1 MGD	1 MGD
Intake	$160,000	$160,000	$160,000	$160,000	$160,000
Treatment Plant	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000
Hi-Service Pump St.	$85,000	$85,000	$85,000	$85,000	$85,000
Telemetery	$35,000	$35,000	$35,000	$35,000	$35,000
Land	$45,000	$45,000	$45,000	$45,000	$45,000
Legal (Cont/Permit)	$23,000	$23,000	$23,000	$23,000	$23,000
Engineering	$151,100	$151,100	$151,100	$151,100	$151,100
Project Admin.	$131,000	$131,000	$131,000	$131,000	$131,000
Financing	$0	$0	$0	$0	$0
Contingency	$240,000	$240,000	$240,000	$240,000	$240,000
Transmission	$900,000	$900,000	$900,000	$900,000	$900,000
Intermediate Booster	$0	$0	$0	$0	$0
TOTAL	$2,870,100	$2,870,100	$2,870,100	$2,870,100	$2,870,100
	$1,870,100				
ANNUAL COST					
New Debt Plant	$139,135	$215,818	$143,126	$118,206	$154,114
New Debt Trans.	$65,728	$98,592	$65,384	$54,000	$70,404
Plant O&M	$206,657	$206,657	$206,657	$206,657	$206,657
Transmission O&M	$80,000	$80,000	$80,000	$80,000	$80,000
Canyon Water	$31,000	$31,000	$31,000	$31,000	$31,000
TOTAL	$522,520	$632,066	$526,166	$489,863	$542,175
COST PER 1000 GAL	$4.21	$5.09	$4.24	$3.95	$4.37
	9%,20y-1M$	9%,20y	6%,30y	5y-6% int	6%,25y

Table 18 (cont'd)
Canyon Lake Area Water Treatment Plant
Preliminary Cost Estimate 8-8-90

Phase 2

	Option 1	Option 2	Option 3	Option 4A	Option 4B
EST. CONNECTIONS		Existing Meters ==150 gals/day==========			
C.L. Village West	440	440	440	440	440
The Oaks	161	161	161	161	161
Canyon Lake Forest	298	298	298	298	298
Astro Hills	132	132	132	132	132
Lakeview Park	189	189	189	189	189
Rolling Hills	202	202	202	202	202
Water Front Park	125	125	125	125	125
Canyon Lake Hills	229	229	229	229	229
Mobile Homes Estates	106	106	106	106	106
Canyon Lake Mobile H	283	283	283	283	283
Westhaven	102	102	102	102	102
		Future Meters ===300 gal/day=========			
Smithson-Valley	530	530	530	530	530
Total Connections	2797	2797	2797	2797	2797
SURFACE DEMAND					
Avg Day per con.(GPD	150/300	150/300	150/300	150/300	150/300
Avg Day (gallon/day)	499,050	499,050	499,050	499,050	499,050
Max. Day (gals/day)	998,100	998,100	998,100	998,100	998,100
Yearly Total (A-F)	559	559	559	559	559
CONSTRUCTION COST	1 MGD	1 MGD	1 MGD	1 MGD	1 MGD
Intake					
Treatment Plant					
Hi-Service Pump St.					
Telemetery					
Land					
Legal (Cont/Permit)					
Engineering					
Project Admin.					
Financing					
Contingency					
Transmission	$592,590	$592,590	$592,590	$592,590	$592,590
Intermediate Booster	$275,000	$275,000	$275,000	$275,000	$275,000
TOTAL	$867,590	$867,590	$867,590	$867,590	$867,590
ANNUAL COST					
Old Debt	$204,863	$314,409	$208,510	$172,206	$224,519
New Debt (9% @ 30y)	$95,041	$95,041	$63,029	$52,055	$67,869
Plant O&M	$271,460	$271,460	$271,460	$271,460	$271,460
Transmission O&M	$100,000	$100,000	$100,000	$100,000	$100,000
Canyon Water	$31,000	$31,000	$31,000	$31,000	$31,000
TOTAL	$702,364	$811,911	$673,999	$626,721	$694,847
COST PER 1000 GAL	$3.86	$4.46	$3.70	$3.44	$3.81
	9%,20y	9%,20y	6%,30y	5y int.	6%,25y

Table 19
Canyon Lake Area Water Treatment Plant
Preliminary Cost Estimate Summary 8-8-90

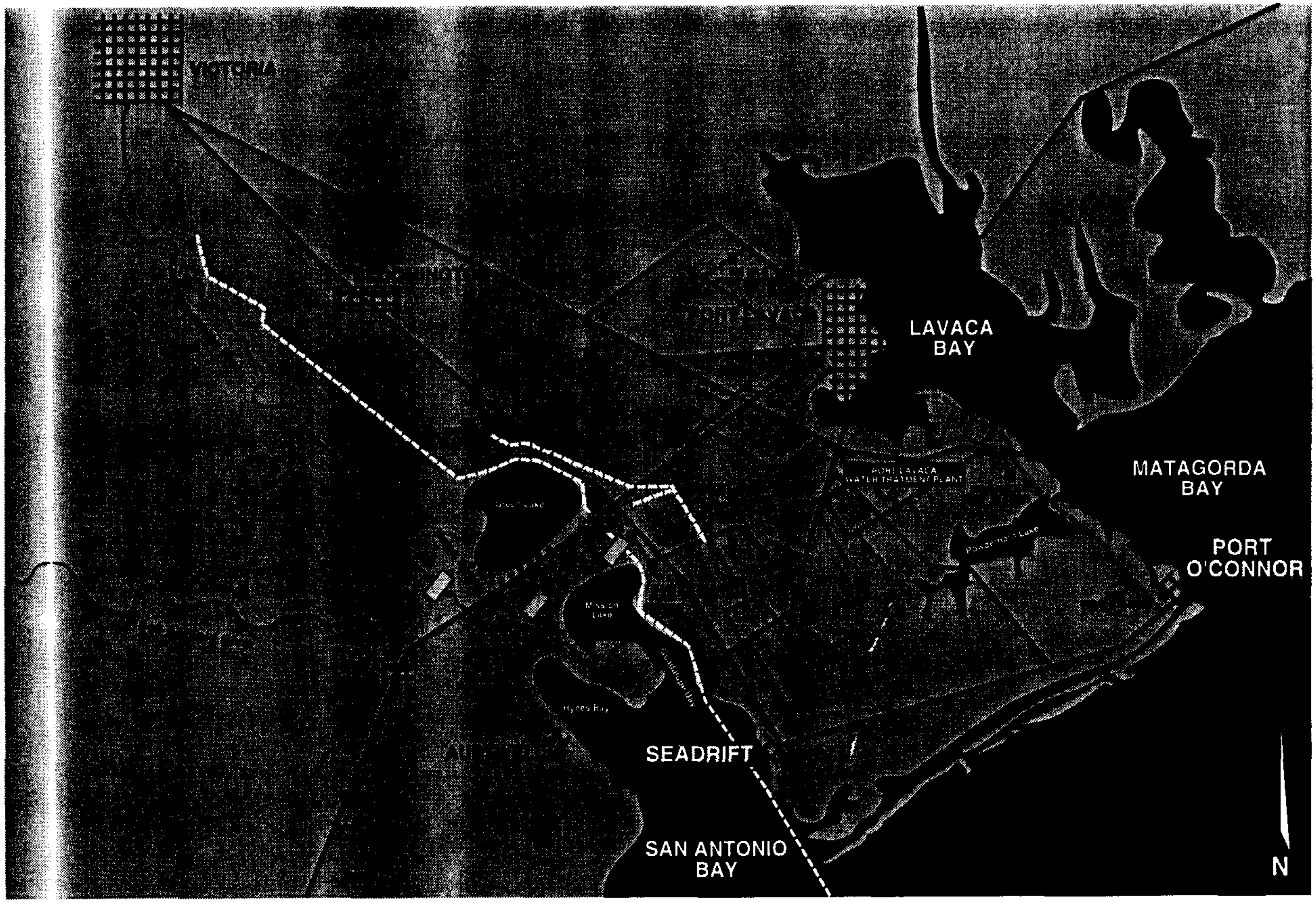
Phase 1

	Option 1	Option 2	Option 3	Option 4A	Option 4B
COST PER 1000 GAL					
New Debt Plant	1.12	1.74	1.15	0.95	1.24
New Debt Trans.	0.53	0.79	0.53	0.44	0.57
Plant O&M	1.67	1.67	1.67	1.67	1.67
Transmission O&M	0.64	0.64	0.64	0.64	0.64
Canyon Water	0.25	0.25	0.25	0.25	0.25
TOTAL	4.21	5.09	4.24	3.95	4.37

Canyon Lake Area Water Treatment Plant
Preliminary Cost Estimate Summary

Phase 2

	Option 1	Option 2	Option 3	Option 4-A	Option 4-B
COST PER 1000 GAL					
Old Debt Plant	$0.76	$1.18	$0.79	$0.65	$0.85
Old Debt Trans. Line	$0.36	$0.54	$0.36	$0.30	$0.39
New Debt (9% @ 30y)	$0.52	$0.52	$0.35	$0.29	$0.37
Plant O&M	$1.49	$1.49	$1.49	$1.49	$1.49
Transmission O&M	$0.55	$0.55	$0.55	$0.55	$0.55
Canyon Water	$0.17	$0.17	$0.17	$0.17	$0.17
TOTAL	$3.86	$4.46	$3.70	$3.44	$3.81



CALHOUN COUNTY OPERATIONS

Figure 6

- VICTORIA BARGE CANAL
- DELIVERY CANAL
- DELIVERY PIPELINE
- RURAL WATER SYSTEM
- SALT WATER BARRIER

Table 20
Port O'Connor Expansion Construction Costs

	Units	Unit Estimate	Unit Price	1986 Costs	1984 Costs
Distribution					
Pipe 8"	FT	8300	3.5	29050	42330
Pipe 6"	FT	15200	2.1	31920	68400
Road Bore	FT	100	60.0	6000	6000
Tie-in	EA	4	1000.0	4000	4000
Valve 8"	EA	3	500.0	1500	1500
Valve 6"	EA	3	300.0	900	900
Subtotal				73370	123130
Storage @ POC					
Pumps	EA	2	6000.0	12000	0
Install	EA	2	2000.0	4000	0
Piping	FT	150	15.0	2250	0
Subtotal				18250	0
Transmission					
Pump St.	LS	1	50000.0	50000	35000
Pipe 10"dry inst	FT	51500	5.1	262650	370800
Pipe 10"wet inst	FT	25000	7.4	185000	237500
Pipe 10" DI	FT	250	55.0	13750	13750
Pipe 10" 200psi	FT	25000	5.7	142500	206500
Road Bore	FT	240	70.0	16800	16800
Tie-in	EA	2	1000.0	2000	2000
Valves	EA	10	600.0	6000	6000
Subtotal				678700	888350
TOTAL				$770,320	$1,011,480

To evaluate the alternative proposal to blend groundwater from a well that might be drilled in the Port O'Connor area with surface water from the existing water system to meet peak weekend and holiday demands, of the present 240 Port O'Connor customers, a chemical analysis of the water from four wells of the area was conducted (Figure 7 and Table 21). Although the quality of the water from the four wells varies greatly, well water could be blended with the treated surface water, and thereby increase the total water supply available for Port O'Connor. The resulting blend of groundwater and surface water would have to meet or exceed the Texas Department of Health Drinking Water Standards.[4]

From the standpoint of water quality, water from a well located near sample well sites one and two could be blended in a ratio of four gallons of groundwater to one gallon of surface water. The blending ratio at sample well site three could be on a one-to-one ratio of well water to surface water, whereas the blending ratio at sample well site four could be only one gallon of well water to four gallons of surface water. In these ratios, the resulting blend of groundwater and surface water would meet the Texas Department of Health Drinking Water Standards.

The estimated cost of a well and pipeline needed for implementation of the ground water-surface water blending alternative depends upon the depth of the well and the distance the well is located from the present surface water storage tanks and booster station. The estimated cost of constructing a public water supply well with a capacity of 150 gallons per minute at a depth of 250 feet, together with equipment, instrumentation, and storage tank modifications is $121,000. This cost assumes that the well is located within 400 feet of the existing ground storage tank and booster station. The estimated cost of additional 6" water line from the well to the Port O'Connor Booster Station is $4.50 per linear foot. One well would produce enough water to allow blending with existing surface supplies to meet peak demands of Port O'Connor's present customers plus supply approximately 150-175 additional customers.

It should be noted that the quality of water from a well located in the area surveyed is expected to decline in future years as the well is pumped and the water table in the immediate vicinity is drawn down. However, if such a well is used only to meet peak demand needs, a ground water-surface water blending project, such as that described here would be expected to have a useful life in excess of 10 years.

Seadrift and Union Carbide, both located in western Calhoun County, are facing the effects of stricter drinking water standards and have asked the Guadalupe-Blanco River Authority (GBRA) to develop cost estimates for delivering treated water. GAF Corporation and the

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[4]"An Analysis of the Potential for Blending Ground Water and Surface Water for Public Water Supply for Port O'Connor, Texas," HDR Engineering, Inc., Austin, Texas, December, 1990.

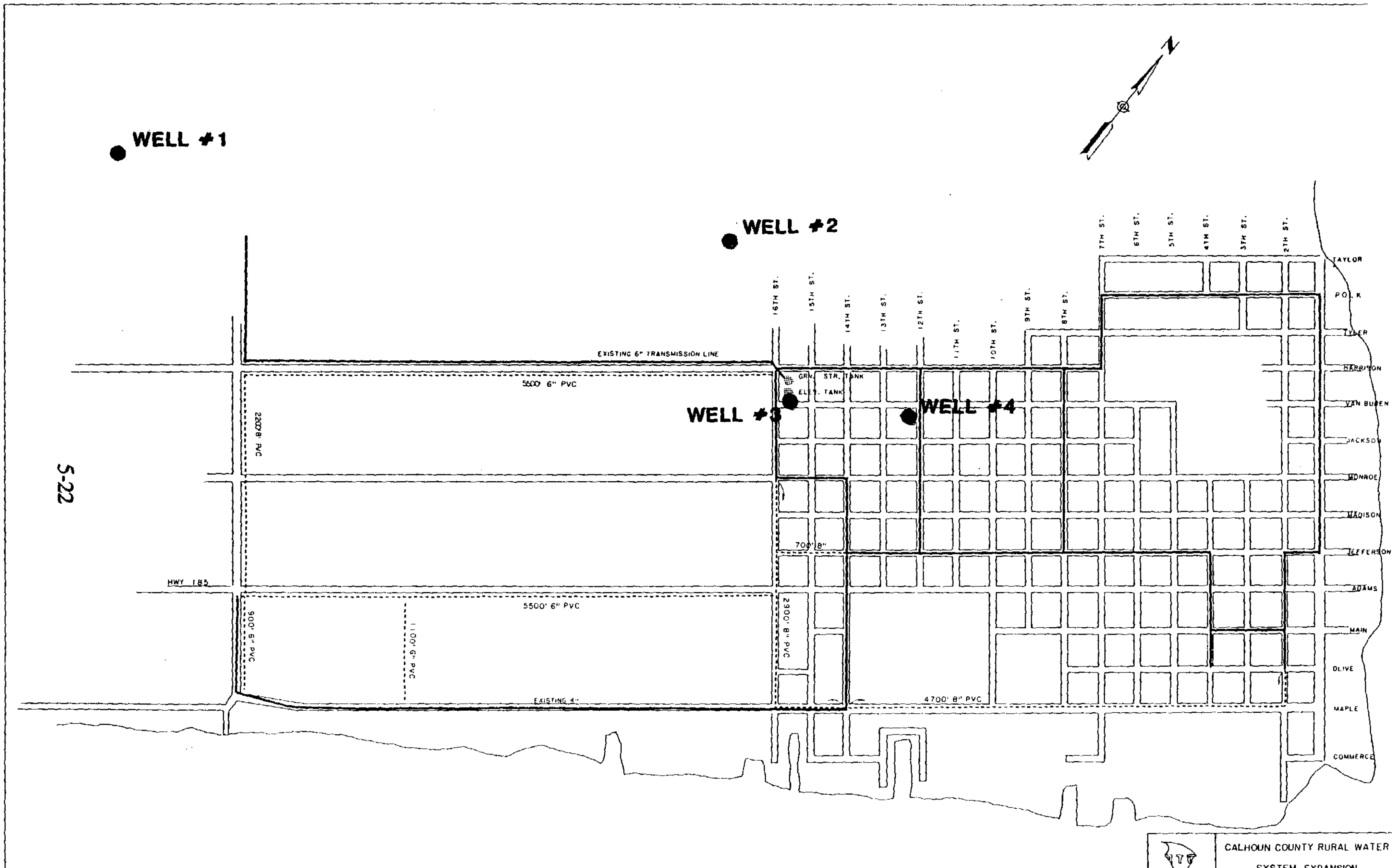

Figure 7
Port O'Connor Well Blending Sample Sites

Table 21
Port O'Connor Water Supply Study
Well Blending Alternative Chemical Summary

State Standards		Site #1	Site #2	Site #3	Site #4
TDS (mg/l)	1000	1150	1100	1160	1820
pH	7.0	8.3	8.2	8.2	8.0
NO_3 (mg/l as N)	10	1	1	1	1
Na (mg/l)	---	395	395	477	712
Ca (mg/l)	---	11	13	21	33
Cl (mg/l)	300	268	254	450	880
SO_4 (mg/l)	300	80	44	42	1
Conductivity	---	1920	1860	2390	3300
Well Depth (ft)	---	220	220	218	226

pH = expression of acidity or alkalinity
TDS = total dissolved solids
mg/l = milligrams per liter
NO_3 = nitrate
Na = sodium
Ca = calcium
Cl = chloride
SO_4 = sulphate

Rural Water Supply System could be customers of an expanded treated water system in the area.[5]

Union Carbide (Carbide) presently treats all of its own water. The raw water, which is treated in the Union Carbide water treatment plant, is from the Guadalupe River delivered by the GBRA through a series of canals. Carbide is considering having GBRA supply treated water for drinking purposes while the balance of Carbide's needs (process water) would be supplied by Carbide.

The City of Seadrift presently relies solely on groundwater for all of its potable water. The water is chlorinated, stored, and delivered by the city. Seadrift has studied having GBRA supply a portion or all of their present drinking water.

In order to respond to the Carbide and Seadrift needs, three scenarios, each having two alternatives, were identified and cost information was developed for each (Figure 6 and Table 22). The scenarios and alternatives are:

<u>Scenario #1</u>: (Carbide) Booster Station at GBRA's Port Lavaca Water Treatment Plant:

- Alternative #1 serves Carbide, GAF, and rural customers (Pipeline route begins at intersection of Highways 238 and 2433 and ends at Carbide's north property line).

- Alternative #2 serves Carbide only (Pipeline is south of Alternative #1 route).

<u>Scenario #2</u>: (Seadrift) Booster Station at GBRA's Port Lavaca Water Treatment Plant; Pipeline route follows Highway 238 to the southwest, turns south at Highway 185, and ends at the northern city limits:

- Alternative #1 provides Seadrift with 70 percent of its needs at a rate of 227 gallons per minute (gpm);

- Alternative #2 provides Seadrift with 100 percent of its needs at a rate of 324 gpm.

<u>Scenario #3</u>: (Carbide, Seadrift, and rural customers along Highway 185). The proposed pipeline route is the same for the alternatives contained within Scenario #2. The transmission line begins at a new booster station at the GBRA Port Lavaca Water Treatment Plant, follows Highway 238 to the southwest, and at the intersection of Highways 238 and 185, the pipeline turns to the north and south (Figure 6). The pipeline to the south of the intersection would follow Highway 185 to the City of Seadrift while the pipeline to the north of the intersection would serve Carbide and rural customers along Highway 185.

[5]"Union Carbide and City of Seadrift Potable Water Supply Study," GBRA Revised, Seguin, Texas, February 1990.

TABLE 22
COST ESTIMATE SUMMARY -- CARBIDE and SEADRIFT

Scenarios with Alternatives	Flows		POTENTIAL CUSTOMERS' FLOWS AND COSTS							
	Total Peak Flow	Total Ave. Flow	Carbide		Seadrift		RWSS*		GAF	
			Ave.Flow	Cost	Ave. Flow	Cost	Ave. Flow	Cost	Ave. Flow	Cost
SCENARIO #1										
Alt. #1	530	430	350	$1,014,012	0	0	50	$106,473	30	$80,281
Alt. #2	480	380	350	$1,094,706	0	0	0	0	30	$80,281
SCENARIO #2										
Alt. #1	250	227	0	0	227	$978,672	0	0	0	0
Alt. #2	356	324	0	0	324	$993,387	0	0	0	0
SCENARIO #3										
Alt. #1	745	622	350	$1,152,216	227	$481,703	15	$34,298	30	$79,905
Alt. #2	851	719	350	$1,156,667	324	$681,710	15	$35,157	30	$80,151

Notes: 1) All flows shown are in gallons per minute.
2) Scenario #1, Alternative #1 "Costs," when including present value of Port Lavaca transmission charges, are $1,465,512, $170, 973, and $111,587, respectively, for Carbide, RWSS, and GAF.
*RWSS, Rural Water Supply Customers

There are two alternatives given in Scenario #3:

- Alternative #1 provides Seadrift with 70 percent of its present needs or 227 gpm, Carbide with 350 gpm, GAF with 30 gpm and 15 gpm to rural customers.

- Alternative #2 provides Seadrift with 100 percent of its present needs or 324 gpm, Carbide with 350 gpm, GAF with 30 gpm, and 15 gpm to rural customers.

A discussion and summary of the estimated costs of the alternatives are presented below.

Providing Union Carbide with treated water exclusive of the City of Seadrift would be done in Scenario #1, Alternatives #1 and 2. If Carbide were to act exclusive of Seadrift, the lowest cost alternative would be Alternative #1 or the northern route (Table 21). Though this route is the lower cost of the two, these costs do not include transmission charges which will be made by the City of Port Lavaca. Also, if the northern route were selected, there is the possibility of Highway 35 being enlarged and the pipeline moved (if the pipeline were laid in highway ROW). An advantage of the northern route is that of all of the alternatives, this one has the potential of serving the most rural customers.

The southern route or Scenario #1, Alternative #2 has difference kinds of problems. By following the GBRA canal right-of-way, the pipeline could be placed in or near the canal levee. If the pipeline were to break, the levee may be washed out, causing a major portion of the canal system to be out of service. Also, if the pipeline were to have a minor leak, it may be hard to distinguish it from a canal leak or irrigation water. Maintenance of the pipeline would be more difficult and, therefore, more costly.

Choosing between the alternatives that provide the City of Seadrift with treated water exclusive of Carbide is simply a matter of whether Seadrift wants 70 percent or 100 percent of its present needs. There is only one feasible route--follow Highway 238 to 185 and then turn south to Seadrift. The route which would follow the Old Seadrift Highway is the same distance as the one proposed but has many difficulties. Constructing the proposed pipeline along the Old Seadrift Highway allows limited right-of-way and there are many fences to cross. Following Highway 238, the entire distance is unobstructed and the highway is not expected to be enlarged.

Scenario #3, Alternatives 1 and 2 provide treated water to both the City of Seadrift and Union Carbide. Choosing the best alternative depends on the amount of water Seadrift wants to take. Because both alternatives are proportional, the selection is strictly a matter of how much water is required. Either alternative will provide water to 25 potential rural customers.

Though the alternatives in Scenario #3 are proportional, it should be noted that Seadrift can be provided the same amount of water for less cost in Scenario #3 than in Scenario #2. This savings comes from sharing pipeline and booster station costs with Carbide from the

GBRA Port Lavaca Water Treatment Plant to the intersection of Highways 238 and 185. In essence, it is better for the City of Seadrift to join with Union Carbide than to act alone.

Comparing costs for Carbide between Scenario #1 and Scenario #3 shows that Carbide can have treated water supplied cheaper if it acts alone (Table 21). It is emphasized, however, that costs do not include transmission charges made by the City of Port Lavaca. Applying transmission charges (as shown in note 2 of Table 21) to the Scenario #1, Alternative #1 costs, combined with the uncertainty of what the charges may be in the future, make Scenario #3 the best alternative.

5.4.3 IH-35 Corridor

The residents of Hays County, along the IH-35 corridor, have historically depended upon ground water from the Edwards Aquifer. Increased pumping of the aquifer has caused declining spring flow and awareness of the need to seek management of withdrawals and other sources of water supply. Studies have shown that a reasonable alternative for supplying supplemental surface water along the IH-35 corridor and some parts of eastern Hays County would be by releasing Canyon Lake Water to the Guadalupe River and diverting the water at a point east of Interstate Highway 35.[6]

In September, 1990, the voters of San Marcos approved the issuance of bonds to construct a water treatment plant in order to supplement San Marcos existing water supplies through the use of surface water from Canyon Reservoir. The water treatment plant will be located along the San Marcos River east of IH 35.

In this first phase of the development of a supplemental surface water supply for San Marcos, raw water for the treatment plant will be obtained from the San Marcos River. In this manner, San Marcos is moving to implement the first phase of a plan to supplement its water supply and ultimately provide surface water along the IH-35 corridor. In later phases, a raw water pipeline can be built from the Guadalupe River at New Braunfels, along IH-35, to San Marcos, in order to obtain more raw water during drought conditions for the San Marcos and neighboring areas along IH-35. The 1988 cost of such a line was estimated at $7.24 million. The 1988 cost estimate for a treated water pipeline from San Marcos to the Kyle area was $3.74 million. Both the raw water and the treated water pipelines mentioned above would be adequate to meet the projected supplemental surface water needs of the IH-35 corridor area to about the year 2015.

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[6] "Hays County Water and Wastewater Study", Hay County Water Development Board, May 1989, San Marcos, Texas

5.4.4 Pipeline Alternatives to Boerne

The Boerne area is projected to need additional water supplies to meet population and business growth. Local area ground water and surface water sources are fully developed. Additional surface water could be obtained from the Guadalupe River through subordination of GBRA hydroelectric rights downstream of Canyon Reservoir, and the construction of a diversion facility, pump station, and pipeline from the river to Boerne Lake. Boerne obtains about 60 percent of its water supply from Boerne Lake. The yield of the lake is not adequate to meet growing needs. However, the lake's yield could be supplemented with raw water from the Guadalupe. The existing water treatment plant and treated water storage capacities would be expanded as needed.

Costs have been estimated for three different sizes of pipeline -- six-inch, eight-inch, and 10-inch, which if operated at 75 percent of capacity could deliver 420, 840, and 1,512 acre-feet of water to Boerne Lake annually. The diversion point on the Guadalupe would be near Ammons Crossing on Highway 474. The pipeline route would follow Highway 474 southward for approximately 5.2 miles (27,500 feet), at which point the route would turn westward, cross country and proceed to a point near the intersection of IH 10 and Highway 87. From this point, the route would follow IH 10 northwestward to a point near the intersection of IH 10 and Upper Cibola Road, where it would be necessary to bore under IH 10, and continue along Upper Cibola Road to a point at which the route would be directed into Boerne Lake. Estimated total length of the pipeline from the Guadalupe to Boerne Lake is about 55,000 feet (10.42 miles).

Elevation at the river diversion point is about 1,125 feet-msl, with two peaks along the route at 1,575 feet-msl and 1,618 feet-msl. Based upon the assumption that one-half the distance of the right-of-way would be alongside public roads, and, thus, would not require purchase of easements, the six-inch line would cost about $1.95 million, the eight-inch line would cost approximately $2.34 million, and the ten-inch line would cost approximately $2.96 million.

5.4.5 Clear Springs Treatment Plant Alternative

Rural areas in Guadalupe County are presently served by several rural water supply corporations including the Green Valley Water Supply Corporation, the Crystal Clear Water Supply Corporation, the East Central Water Supply Corporation, and the Spring Hills Water Supply Corporation.

Currently, the Green Valley Water Supply Corporation has a contract with the GBRA for the delivery of treated water from a 2 mgd surface water treatment plant to be constructed on Lake Dunlap, between New Braunfels and Seguin (Figure 8). The plant will have a firm water supply through a contract with GBRA for stored water from Canyon Reservoir to be treated at the plant.

More recently, the Canyon Regional Water Authority (CRWA) was formed by the same rural water supply corporations. One purpose of the CRWA is to contract for common sources of water.

One viable alternative is for each corporation to contract for water from the water treatment plant planned on Lake Dunlap at a plant construction cost of \$3.1 million in 1986 prices.[7] Cost of treated water at the plant is estimated at \$.906/thousand gallon.

[7]"Alternative Source Water Supply Study," Table 6.2.1, Page 15, Guadalupe-Blanco River Authority, February, 1987, Sequin, Texas

Lake Dunlap and Water Treatment Plant

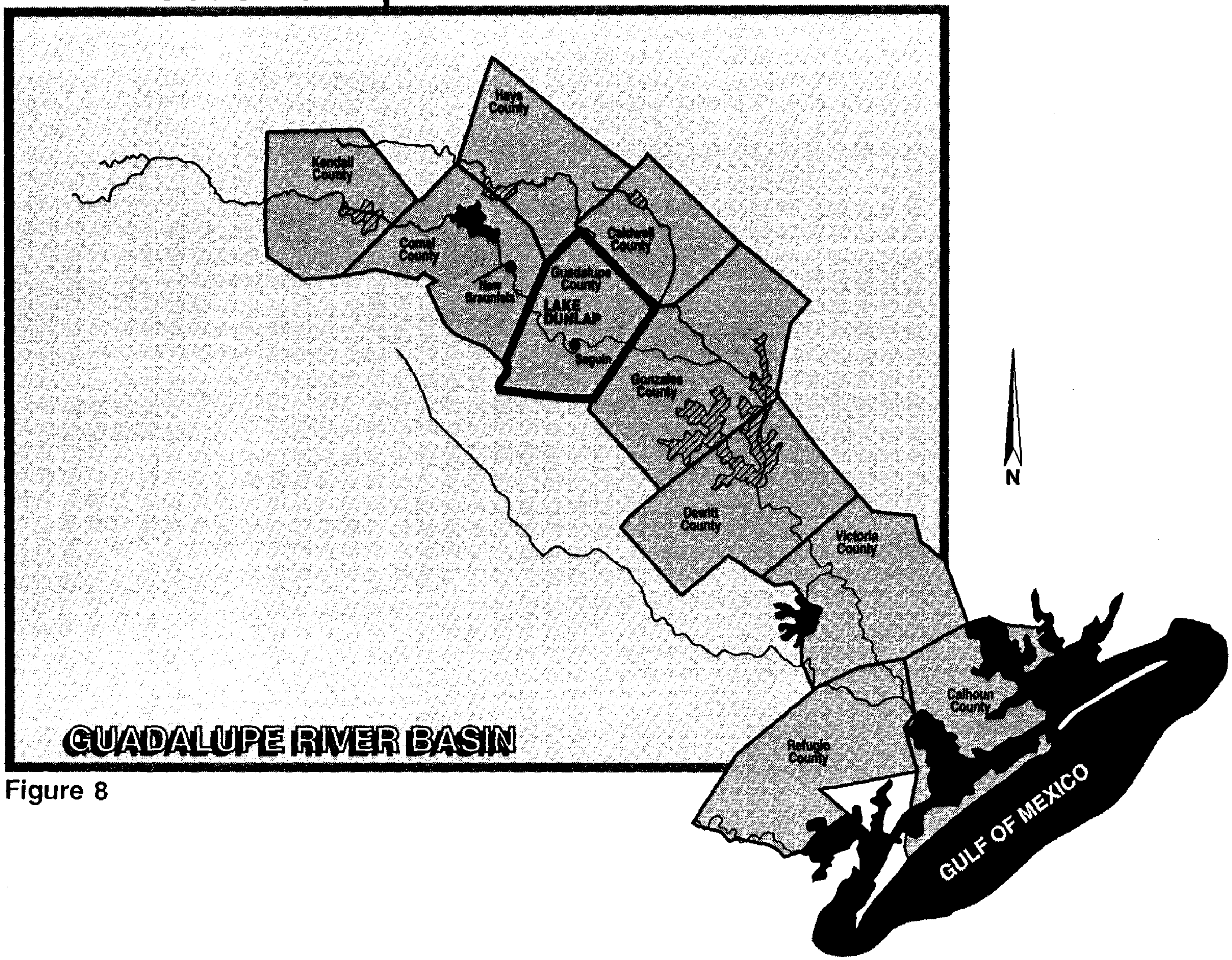

Figure 8

5.4.6 Regional Water Supply Study Implementation Chart

		1990	1995	2000	2005	2010	2015	2020	2040
1.	Encourage Water								
	Conservation Plans	---------							
	Adoption	X							
2.	Evaluate Regional								
	Water Needs		-------	-------	-------	-------			
3.	Implement								
	Subordination	--------X							
4.	Subordinate								
	Upstream	X							
5.	Study Irrigation	-----							
	Conduct Study	----							
	Implement Recommend.		X						
6.	Development Canyon/								
	Bulverde	-----							
	Implement		X-----X						
7.	Develop Port								
	O'Connor	----							
	Partial Implement.	X							
	Develop Seadrift	----							
	Implement			X					
8.	Develop I-35	--------------------------------							
	Implement			X					
9.	Boerne Pipeline	--------							
	Implement		X						
10.	Guadalupe County								
	Water For Co-Ops	--------							
	Implement		X						

APPENDIX A

Methods, Data, and Assuptions

utilizes a five-year interval. The population projection for the county in 1990 is the sum of the cohort populations after two estimation intervals of five years each. The projections for 2000, 2010, 2020, 2030, and 2040 are then made through a series of five-year interval projections from 1990.

The following equation was used to project the population of each cohort (age, race, and sex group) in each county:

$$P_{t+5} \quad = \quad P_t + B - D + M$$

where:

P_{t+5} = the population for a cohort five years after the initial date t (the initial date, t, is 1980);

P_t = the population for a cohort at the initial date, t=1980;

B = births into cohorts age 0-4 at time t+5 and is zero for all other cohorts;

D = deaths for a cohort between times t and t+5; and,

M = net migration for a cohort (the difference between the number of people moving into the county and the number moving out).

Data for use in making population projections were obtained form the Texas Department of Health; i.e.; births and deaths (vital statistics) of each county were used in making population projections for that county. The probability of death during the projection period for members of each cohort was taken from the most recent U.S. Life Table and adjusted to Texas death rates using historical differences between U.S. and Texas death rates. Finally, migration into and from counties was estimated. A low rate based upon net migration rates of the 1960s and a high rate based upon the net migration rates of the 1970s were used. The range of migration rates, when applied in the projections method, results in a low and a high population projection for each county for the projection points of 1990, 2000, 2010, 2020, 2030, and 2040.

Water Requirements Projections

The procedures for making projections of water requirements for the years 1990, 2000, 2010, 2020, 2030, and 2040 for the following water using purposes: (1) municipal, (2) manufacturing, (3) steam-electric power generation, (4) agricultural irrigation, (5) mining, (6) livestock and poultry, (7) aquaculture, (8) bays and estuaries, and (9) recreation, are described below.

Municipal Water Requirements

Projections of municipal water requirements are made as follows: (1) Using population projections, as described in Section 6.1, and (2) per capita municipal water use, as described below, (3) multiply the population projection times the per capita water use projection to obtain daily municipal water requirements for the service area, and (4) expand daily estimates to annual estimates and express in terms appropriate and useful for planning, such as million gallons per day and acre-feet per year.

Daily per capita water use for each basin was computed from the 1977 through 1986 annual reports of municipal and commercial water use that were collected by the Texas Water Development Board. The results for drought years within this ten-year period, as defined by the National Weather Service, were averaged in order to obtain a per capita water use statistic that is applicable to the drought periods of weather cycles[1]. This drought period per capita water use statistic was used as the "without conservation" per capital water use statistic for computing future municipal water requirements for the "without water conservation" high case. Thus, the effects of drought upon daily per capita water use are considered in the computation of water requirements.

For the "with water conversation" projections case, per capita water use was estimated to be reduced from level, as expressed in the paragraph above, on the following schedule.

Time Period	Water Conservation Reduction in Per Capita Water Use (percent)
1980-1990	2.5
1990-1995	2.5
1996-2000	2.5
2001-2005	2.5
2006-2010	2.5
2011-2020	2.5
2021-2040	0.0
Total	15.0

[1]Unpublished planning statistics, Texas Water Development Board, Austin, Texas. August, 1989.

The rates shown are the same rates of water conservation now being used in long-range water supply planning by the Texas Water Development Board. Note that the rate of reduction in water use for the 1980s is projected to be 2.5 percent, five percent per decade until 2010 and an additional 2.5 percent from 2011 to 2020 when the total reduction expected will have been achieved.

Manufacturing Water Requirements

In future years, water using industries of the study area will include those industries that exist there now and new plants that will be attracted to the area. The water requirements projections methods take these factors into account, as is explained below, first for industries that exist within the area in 1990, and for new plants after 1990.

Water using industries of the study area in 1990 include meat packing and beverages of the food processing group, plastics and resins, organic and inorganic chemicals, cyclic crudes and intermediates, agricultural chemicals, textiles, cement manufacturing, and metals.

Projections of future water requirements for manufacturing sectors are based upon: (1) annual water use levels of each sector as reported to the TWDB and the Texas Water Commission by the industries in the annual water use surveys of the 1980s, (2) projected annual growth rates of each industry, and (3) projected improvements in water use efficiency within each manufacturing sector through technology improvement and recirculation of water within plants.

Projected Annual Water Use: Projections of annual manufacturing water requirements are made by multiplying the three factors listed above, for the existing industries, in the following manner:

$$At = B1985 \cdot GRt \cdot RTt$$

Where:

At = projected annual water use by manufacturer A, in acre-feet per year, in year t;

B1985 = reported water use by manufacturer A in base year 1985

GRt = annual growth rate of manufacturer A for a given number of years (note: growth rate estimates were made for each decade from 1980-2040, and are presented below); and

RTt = annual coefficient of improvement in water use efficiency through improvement in water use technology and recirculation of water (note: estimates of RT factor for each decade from 1980-2040, and are presented below).

In addition to existing industries, plant expansions and new plants are projected for the study area by 2010. Once these new plants are established, then their respective water use levels are added into the time stream of projections and become subject to the projected growth rates and efficiency improvement coefficients for projections of water requirements from those dates forward.

The locations of the new plants mentioned above are projected on the basis of existing water supplies and facilities, transportation corridors, industrial sites, and port facilities in the Victoria and Calhoun Counties area.

Industrial Growth Rates: The growth rates used in this study are adapted from long-term projected national and Texas growth rates of these industries, as prepared by Chase Econometrics[2], U.S. Bureau of Economic Analysis[3], Data Resources, Inc.[4], and the Texas Water Development Board[5]. The long-term growth rate projections for the major water using industries of the study area are listed in Table A-1.[6]

These projected growth rates listed above were adjusted to take into account the economic downturn in Texas during the 1980s, including the effects of the recovery of the chemical industry of the Texas Coastal area in the late 1980s and the effects of the Formosa Plastics announced expansion in late 1988 upon local area industries.

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[2] Chase Econometrics, Inc., "Long-Term Regional Forecasts," Vol. III, Bala Cynwyd, Pa. 1981.

[3] U.S. Bureau of Economics Analysis, "Regional Projections of Employment, Income and Population, Unpublished, Washington, D.C. 1981.

[4] Data Resources, Inc., "U.S. Long-Term Review," Lexington, Mass., 1982.

[5] "Texas Manufacturing Water Use, Long-Term Projections," Texas Department of Water Resources, L-P 193, Austin, Texas, 1983.

[6] Ibid, page 99.

Table A-1

Projected Manufacturing Sector Growth Rates												
			1990-2000		2000-2010		2010-2020		2020-2030		2030-2040	
No.	SIC	Industry	Low	High	Low	High	Low	High	Low	High	Low	High
			percent									
1	201	Meat products	1.55	2.20	1.18	1.87	1.03	1.87	0.91	1.85	0.91	1.85
2	202	Dairy products	0.82	1.16	0.81	1.18	0.81	1.27	0.82	1.49	0.88	1.62
3	204	Grain mill products	1.66	1.71	1.39	1.53	1.32	1.50	1.32	1.50	1.32	1.50
4	205	Bakery products	1.71	2.44	1.46	2.05	0.89	2.06	0.94	2.02	0.94	2.02
5	206	Sugar and confectionary products	1.71	2.08	1.46	1.67	0.89	1.63	0.94	1.56	0.94	1.56
6	208	Beverages	1.78	2.39	1.39	1.81	1.18	1.51	1.04	1.43	0.52	0.72
7	209	Miscellaneous food preparations	1.88	1.92	1.47	1.92	1.47	1.53	1.41	1.53	1.00	1.53
8	221	Broad-woven fabric mills - cotton	0.00	0.65	0.00	0.72	0.16	1.40	0.17	1.44	0.17	1.51
9	222	Broad-woven fabric mills - man-made fiber	0.00	1.68	0.00	1.53	0.16	2.00	0.17	2.00	0.17	2.00
10	235	Hats, caps, and millinery	1.31	2.27	0.57	1.68	0.71	1.52	0.71	1.75	0.71	1.80
11	251	Household furniture	2.06	2.98	2.51	2.63	2.28	2.35	2.24	2.31	2.29	2.31
12	274	Miscellaneous publishing and printing	2.84	3.39	1.49	2.71	1.11	2.54	0.89	2.40	0.88	2.40
13	281	Industrial inorganic chemicals	2.17	3.76	1.74	2.99	1.41	2.72	1.19	2.61	1.18	1.37
14	282	Plastic materials & synthetic resins, rubber, fiber	2.18	3.78	1.75	3.01	1.41	2.73	1.19	1.99	1.18	1.98
15	284	Soap, detergents, and cleaning preparation	2.06	2.85	1.67	2.34	1.37	2.11	1.15	2.01	1.15	1.27
16	286	Industrial organic chemicals	2.38	3.18	1.87	2.92	1.51	2.25	1.26	1.57	1.25	1.57
17	291	Petroleum refining	0.30	0.63	0.30	0.61	0.00	0.00	0.00	0.00	0.00	0.00
18	299	Miscellaneous products of petroleum & coal	0.08	0.60	0.55	1.12	0.00	0.00	0.00	0.00	0.00	0.00
19	306	Fabricated rubber products	3.03	3.39	2.06	2.27	2.03	2.13	1.69	2.02	1.84	2.13
20	307	Plastics products	2.83	3.39	1.50	2.38	1.09	2.09	0.88	1.97	0.88	1.97
21	324	Cement, hydraulic	1.68	2.70	1.36	2.31	1.03	2.23	0.84	2.19	0.84	1.19
22	325	Structural clay products	2.30	3.65	1.77	2.89	1.30	2.66	1.04	2.53	1.02	1.33
23	327	Concrete, gypsum and plaster	2.07	3.30	1.62	2.69	1.22	2.52	0.97	2.42	0.96	1.29
24	329	Abrasive, asbestos & misc. nonmetallic mineral	2.75	4.15	1.85	1.85	1.45	2.27	1.03	2.09	1.03	1.20
25	331	Steelworks, blast furnaces, and rolling mills	0.65	0.85	0.65	0.85	0.00	0.00	0.00	0.00	0.00	0.00
26	333	Primary smelting and refining of nonferrous metals	0.65	0.85	0.65	0.85	0.00	0.00	0.00	0.00	0.00	0.00
27	335	Rolling, drawing and extruding of nonferrous metals	0.58	0.79	0.13	0.27	0.13	0.19	0.00	0.00	0.00	0.00
28	344	Fabricated structural metal products	3.16	3.77	1.59	2.54	1.22	2.23	1.04	1.73	1.04	1.63
29	352	Farm and garden machinery and equipment	3.80	4.11	2.92	3.16	1.78	2.43	1.42	2.19	1.42	1.43
30	364	Electric lighting and wiring equipment	2.03	2.27	1.54	2.01	1.15	1.97	1.01	1.96	1.01	1.96
31	365	Household audio and video equipment and recording	2.03	3.42	1.54	2.65	1.15	2.32	1.02	2.16	1.02	2.25
32	394	Dolls, toys, games and sporting and athletic equipment	2.98	4.10	2.25	2.98	1.88	2.67	1.76	2.45	1.35	2.45

Manufacturing Water Conservation: Improvements in water use efficiency by water using industries through technology and recirculation are expected to reduce the quantities of water required by industry. The estimated effects of these water conservation measures are expressed in the following coefficients shown below:

Conservation Coefficients (%)

Time Period	Food & Beverages	Textiles	Chemicals	Plastics	Cement
1981-1990	0.97	0.98	0.97	0.97	0.98
1991-2000	0.93	0.96	0.93	0.93	0.95
2001-2010	0.90	0.95	0.90	0.90	0.93
2011-2020	1.00	1.00	1.00	1.00	1.00
2021-2030	1.00	1.00	1.00	1.00	1.00

These estimates are from the Texas Water Development Board's study of water conservation potentials in water using industry[7]. The estimates indicate, for example, that during the decade of the 1990s, improvements in water use efficiency will result in water requirements being 93 percent of those of 1980 for the same level of operations. These coefficients were used in computing the projections of manufacturing water requirements, with conservation.

Steam Electric Power Water Requirements

Steam-electric power generation plants require water for condenser cooling, boiler feed make-up, sanitation, grounds maintenance, and pollution control. Consumptive (evaporative) water requirements typically range from one-third to one-half gallon of water for each kilowatt-hour of electricity produced. From 20 to 60 gallons of water are circulated through the power plant condenser for each kilowatt-hour of electric power produced. In the study area, at one power plant (Coleto Creek) the water is then returned to cooling reservoirs where it is allowed to cool, after which it is recirculated through the power plant. At the other major plant, cooling water is diverted from the river, used once, and returned to the river, used once, and returned to the river, where it is available for downstream uses. For the study area the quantities of water used for steam-electric power generation are a matter of record from the existing power plants. The quantities used in this study are the quantities evaporated, or consumed, as opposed to gross diversions. This is a deviation from procedures applied to other water using functions, and is used because steam-electric power consumptive water use is so low, only about 2 percent of total circulation.

[7]"Updated Projections of Future Changes in Manufacturing Water Use in Texas," Austin, Texas, 1982.

Agricultural Irrigation Water Requirements

The quantities of fresh water required for agricultural irrigation in each of the counties of the study area were projected as follows. The base year acreage and quantities of water used were established from historic surveys of irrigation water use in Texas.[8] The base year was selected as the year in which the most acres were irrigated during the historic period for which irrigation water use information is available (1958, 1964, 1969, 1974, 1979, 1984, and 1989 unpublished) since this is an indication of the potential acreages that could most easily be irrigated within each county; i.e., are the acreages that have been irrigated at some point in time during the past 30 years (Table A-2). These acreages are also an indication of lands that have used water to which irrigation water rights have been permitted. (Guadalupe Basin irrigation water rights in 1984 were 65,304 acres and 114, 789 acre-feet).

Mining Water Requirements

Water use for building materials (sand, gravel, clay, stone, and lime) recovery was projected on the basis of growth projections of these sectors as follows:

	1980 1990	1990 2000	2000 2010	2010 2020	2020 2030	2030 2040
			(percent)			
Upper Basin	1.25	2.00	1.50	1.35	1.20	1.20
Middle Basin	1.00	1.00	1.00	1.00	1.00	1.00
Lower Basin	2.00	1.10	1.10	1.10	1.10	1.10

Projections of water requirements for crude petroleum recovery were based upon an analysis of oil fields within the study area and upon reports to the Texas Railroad Commission of water use for these purposes. Projections were made of length of secondary recovery operations and of new secondary recovery projects within the study area.

Livestock and Poultry Water Requirements

Projections of the quantities of drinking water needed for livestock and poultry were made for each county of the study area. The method used was to proejct the numbers of

[8]"Surveys of Irrigation in Texas: 1958, 1964, 1969, 1974, 1979, and 1984," Report 294, Texas Water Development Board, Austin, Texas, 1986.

Appendix Table A-2
Guadalupe-Blanco River Basin
Base Year, Agricultural Irrigation
Water Use*

County	Base Year					
		Source of Water		Acreage	Quantity of Water**	Ac-Ft per Acre
	Year*	Ground	Surface			
Upper		(percent)			(acre-feet)	
Kendall	1974	40	60	734	610	0.83
Cornal	1984	78	22	523	691	1.32
Hays	1969	67	33	2,367	2,993	1.26
Guadalupe	1984	56	44	5,728	8,425	1.47
Caldwell	1974	8	92	1,755	2,118	1.21
Subtotal				11,107	14,837	1.33
Middle						
Gonzales	1969	60	40	2,839	2,938	1.03
DeWitt	1964	91	9	1,996	2,005	1.00
Subtotal				4,835	4,943	1.02
Lower						
Victoria	1980	98	2	7,908	26,099	3.30
Refugio	1964	97	3	890	502	0.56
Calhoun	1980	9	91	11,124	55,398	4.98
Subtotal				19,922	81,999	4.12
TOTAL				35,864	101,779	

*The year having the highest number of acres irrigated during the historic series of irrigation surveys, as reported by the Texas Water Development Board, Report 294, "Surveys of Irrigation in Texas, 1958, 1964, 1969, 1974, 1979, and 1984." Unpublished 1989.

**Adjusted from on-farm use, as reported, to quantify at point of diversion of surface water portion of use. Adjustment is 1.3.

each type of livestock within each county at each of the projection dates. Computations of water requirements were then made by multiplying each livestock population times the number of gallons of water needed per day by each livestock type, as reported in livestock and poultry would be on the farms and ranches year round. Since this may not be entirely accurate, the projections may be somewhat high. However, the projection method included only drinking water and did not include water for livestock sanitation.

Thus, these two factors are offsetting, to an extent.[9]

Aquaculture Water Requirements

Fresh water for aquaculture needs are based upon reports of fresh water use in catfish farming in the neighboring states of Arkansas, Louisiana, and Mississippi. For a moderate size processing plant and 4,000 surface acres of ponds, this is 35,000 acre-feet per year.[10] Projections for this study are based on these data, and an indication that the industry is developing in Texas coastal areas near the study area. Based on this information a judgemental projection of freshwater for aquaculture in the study area is as follows: 1995 - 5,000, acre-feet; 2000 - 10,000 acre-feet; 2010-15,000 acre-feet; and 2020, 2030, and 2040 -- 20,000 acre-feet.

Bays and Estuaries Water Requirements

Studies by the Texas Water Development Board, Texas Parks and Wildlife Department, and Texas Water Commission of fresh water inflow needs for Texas Bays and Estuaries, inculding San Antonio Bay into which the Guadalupe River discharges, are nearing publication as of the date of this study (August 1990). In this study, the fresh water flows from the Guadalupe into the bays are tabulated for each month for the 10-year period 1978 through 1987, the most recent year for which data are available with which to make calculations. The monthly quantities are calculated as follows: Monthly gaged flow at Victoria minus diversions downstream of Victoria plus return flows downstream of Victoria.

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[9] yet to be done.

[10] "Texas Aquaculture: Status of the Industry," Texas Agricultural Extension Service, College Station, Texas, 1989, James T. Davis, Extension Fisheries Specialist.

APPENDIX B

Projections Figures

APPENDIX A

Methods, Data, and Assumptions

Water resources planning methods, water use data, and the underlying assumptions that have been developed and are being used by the Texas Water Development Board are used in this study. Water use surveys by the Guadalupe-Blanco River Authority are used to adjust and refine the Water Development Board's most recent population and economic projections. The types of water uses are stated and explained below.

Municipal water uses include the quantities of fresh water that are used in homes of cities and unincorporated places for drinking, flushing toilets, bathing, food preparation, dishwashing, laundering, lawn watering, air conditioning, swimming pools, fire protection, public fountains, car washing, restaurants, public buildings, offices, street washing, and perhaps other sanitation and aesthetic purposes. The total of all of these uses is normally measured and expressed in gallons per person, per day, or as per capita water use per day. The quantities of water needed for municipal purposes within an area are directly related to the number of people that live and work in the area.

Manufacturing water use includes the quantities of fresh water used in the operation of a manufacturing plant for cooling the various processes, including electric power generation, and in the production processes for washing, coloring, canning, sanitation, and landscaping.

Water use in steam-electric power generation is the quantity of fresh water used to operate the boilers, cool the generation equipment, and for sanitation and landscaping.

Water use in agricultural irrigation is the quantity of fresh water that is artificially applied to the fields by farmers and ranchers to grow crops. In the study area, orchards, nurseries, forage, rice, and other grains are produced using irrigation water from aquifers and streams.

Fresh water used in sand and gravel washing and for the recovery of crude petroleum is classified as mining water use.

Drinking water and water for sanitation purposes in the production of livestock, poultry, and dairy is classified as livestock and poultry water requirements. However, water for food processing, meat packing, poultry slaughter, creameries, and canneries is included in manufacturing water requirements.

Fresh water used in fish farming, such as catfish, shrimp, oysters, and other fish production in managed ponds or waterways is referred to as water for aquaculture. Freshwater inflows to bays and estuaries is the quantities of freshwater needed to maintain the environments of the bays and estuaries in a condition satisfactory for the reproduction and growth of species native to these environments.

Freshwater is used for recreation in two major types of recreation activities: (1) swimming pools, saunas, hot tubs, spas, and commercial, water oriented recreation facilities, and (2) outdoor recreation activities such as fishing, boating, swimming, water skiing, canoeing, rafting, tubing, picnicking, and sightseeing.

The former type of recreation water uses are usually supplied by municipal systems and are accounted within municipal water uses. The later types are usually supplied as a joint service of streams and lakes, and occur along with stream flow or as a companion use of lakes.

For purposes of developing water supplies to meet needs at a future point or points in time, it is necessary to make projections of the quantities of water that will be needed for these purposes on a daily and an annual basis. The methods for making these projections for the study area are set forth below.

Population Projections

High and low population projections were prepared for each of the cities and counties in the study area. These are needed in order to make projections of municipal water requirements.

Individual-county population projections for 1990, 2000, 2010, 2020, 2030, and 2040 were calculated via a method in which the numbers for the separate groups or cohorts of the population are projected to a point in time, say 1985, and then summed to obtain county totals. A cohort is defined as a group of people having similar characteristics, such as the group of white females who are between the ages of five and nine years. For purposes of making population projections for water planning, 16 age groups, two ethnic groups, and two sex groups for each county, making a total of 64 cohorts, were used. Birth, death, and migration rates characteristic of each cohort, of each study area county, were used in making the projections.

The population projection method considers the differences in age characteristics of the population of each county, and the effects of these differences upon population in future years. For example, women 20-24 are more likely to have children than women 40-44. Thus, it is useful to know the number of women in each age group rather than just the total number of women when projecting births. Or, men 75-79 are less likely to survive another ten years than men 35-39, exemplifying that numbers of deaths are also better projected with age-detailed data. Thus, for projection purposes, the population of each county in 1980 was divided into an age/race/sex cohort table. Then to each cell of the county population table, characteristic birth, death, and migration rates were applied to determine the cohort populations for the next projection date, i.e; 1985. Because the cohort populations are divided into five-year intervals, the estimation technique also

FIGURE B.1
Kendall County Projected Water Requirements and Ground Water Supply

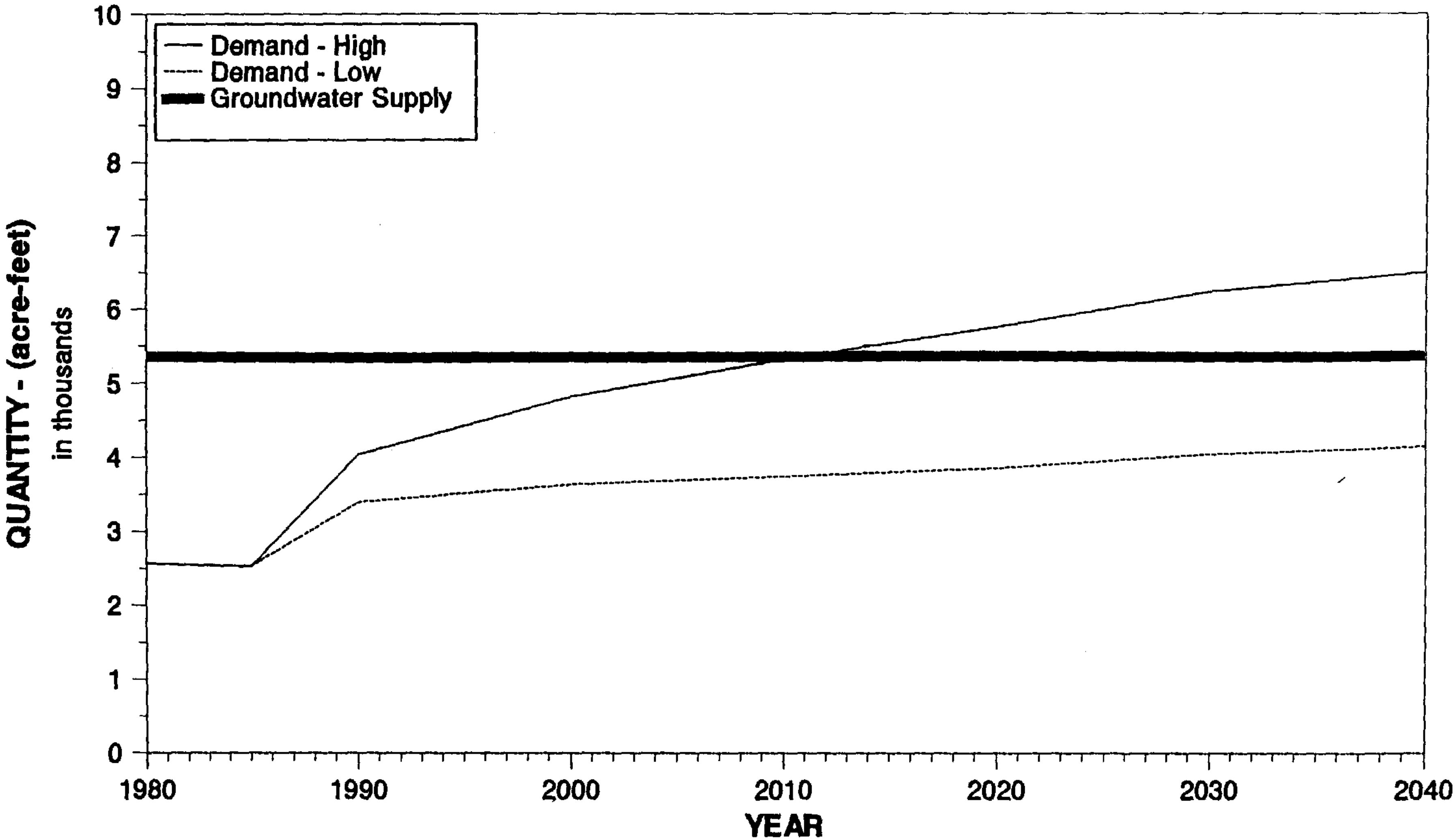


FIGURE B.2
Comal County Projected Water Requirements and Ground Water Supply

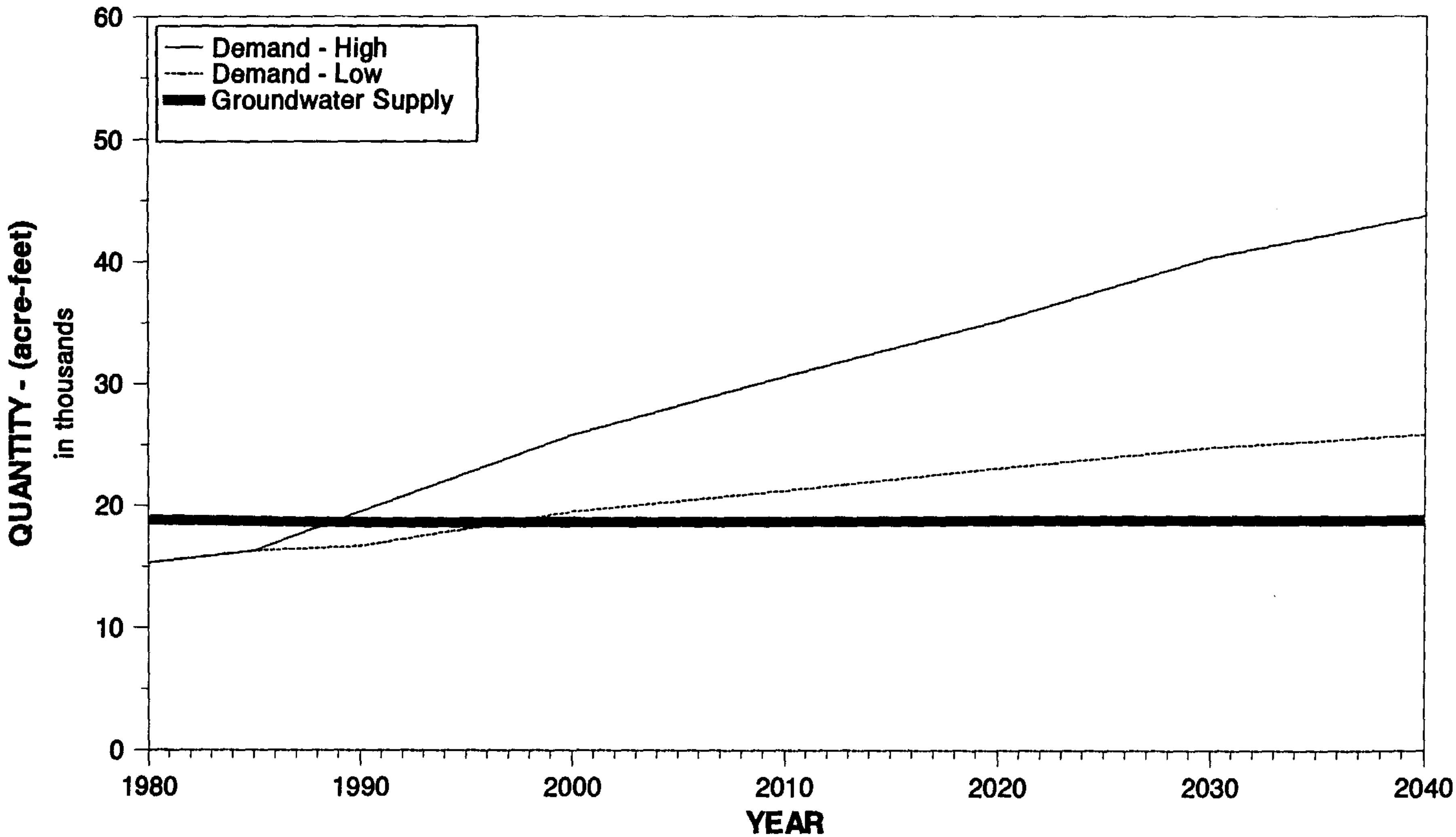


FIGURE B.3
Hays County Projected Water
Requirements and Ground Water Supply

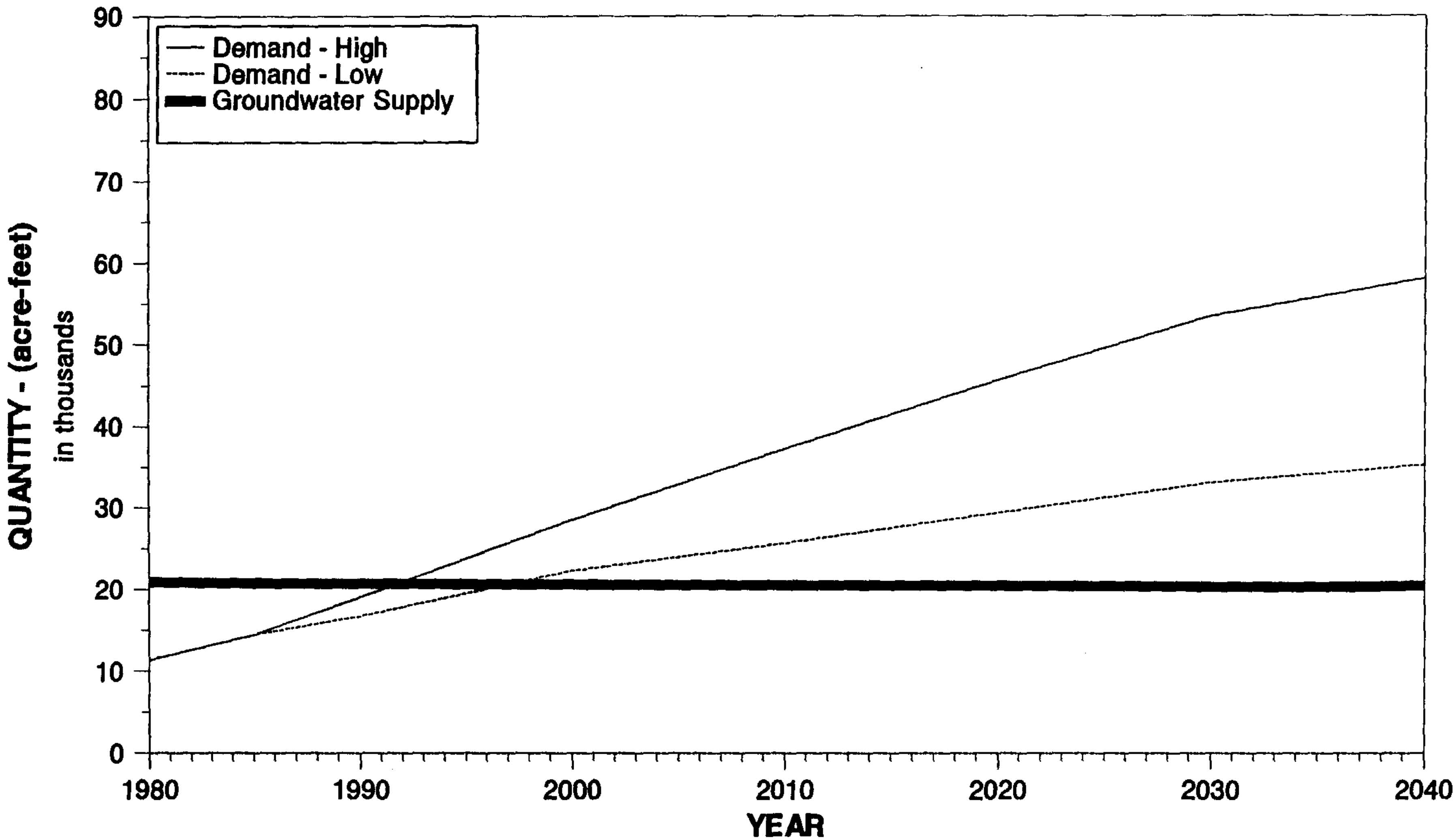
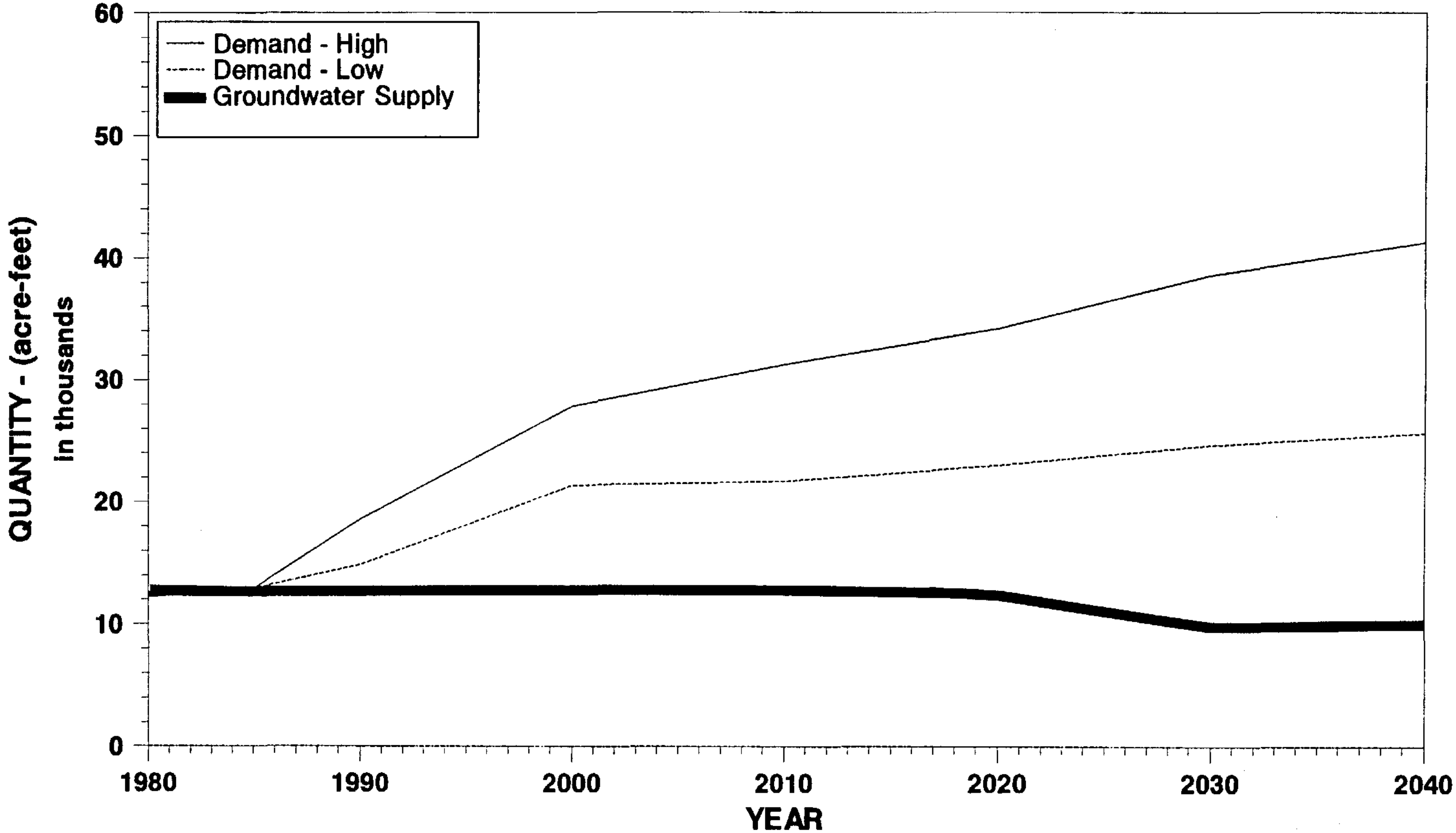


FIGURE B.4
Guadalupe County Projected Water



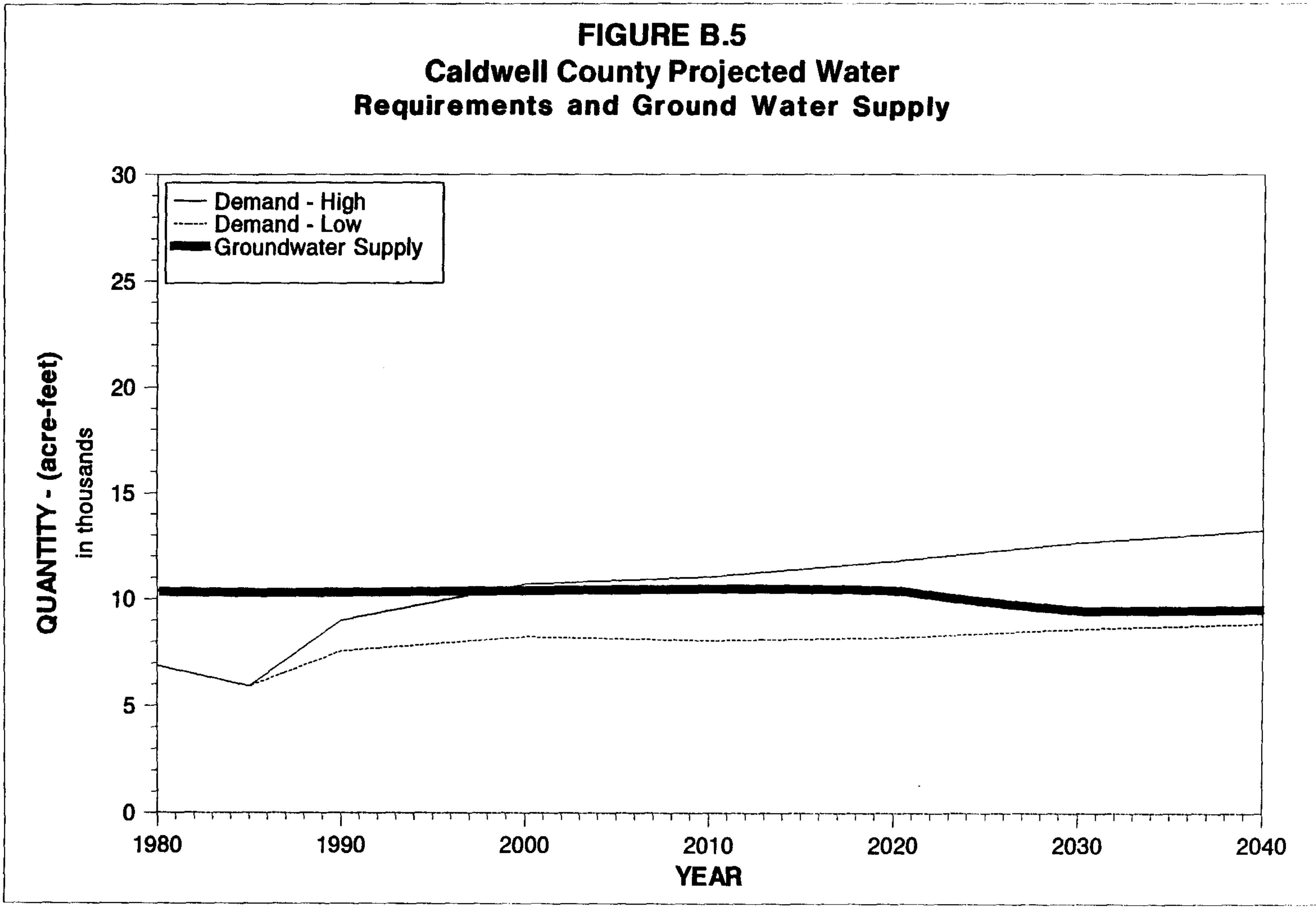


FIGURE B.5
Caldwell County Projected Water
Requirements and Ground Water Supply
Demand - High
Demand - Low
Groundwater Supply
30
25
20
15
10
5
0
QUANTITY - (acre-feet)
in thousands
1980
1990
2000
2010
2020
2030
2040
YEAR

5

FIGURE B.6
Gonzales County Projected Water
Requirements and Ground Water Supply

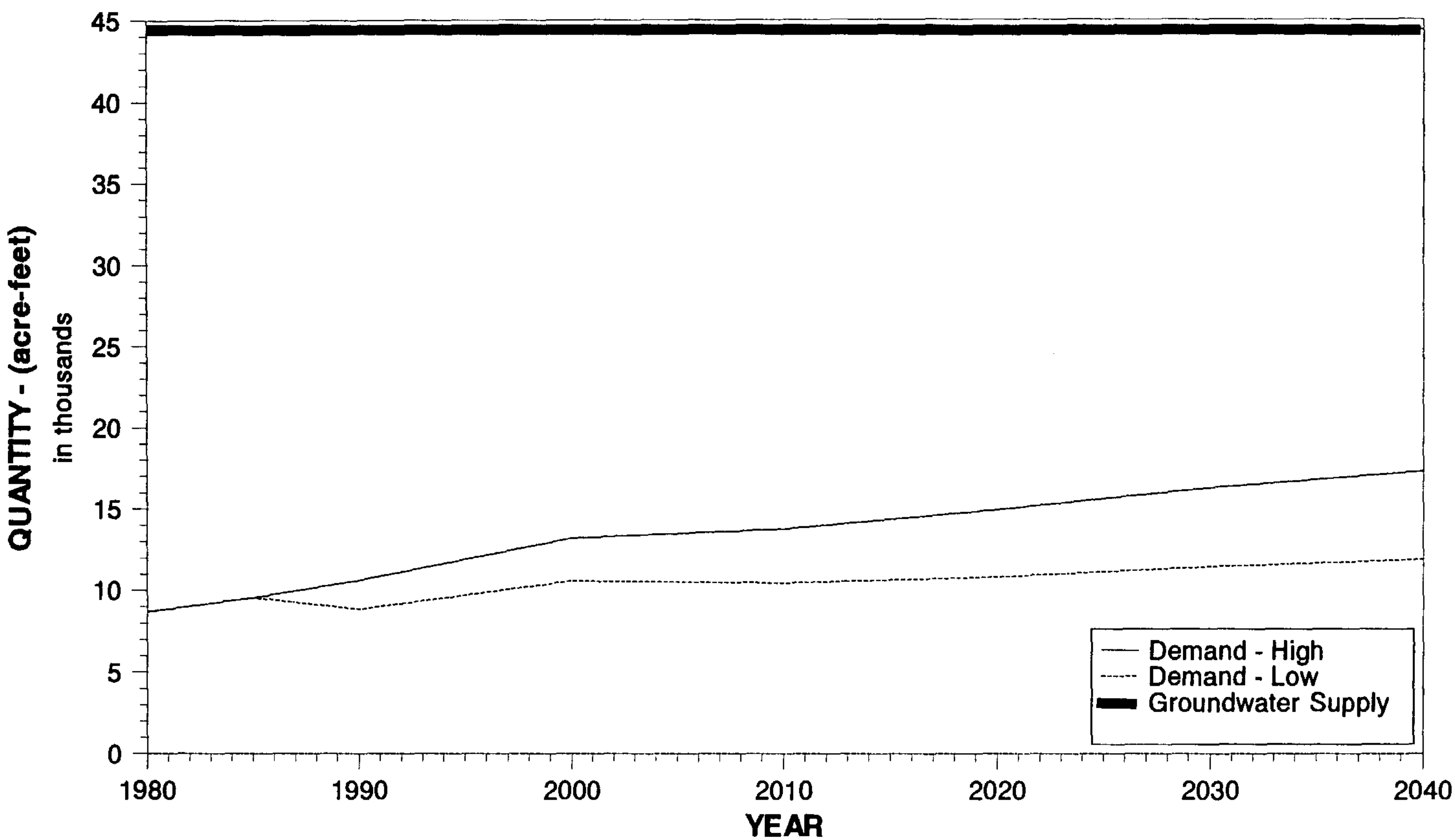


FIGURE B.7
Dewitt County Projected Water Requirements and Ground Water Supply

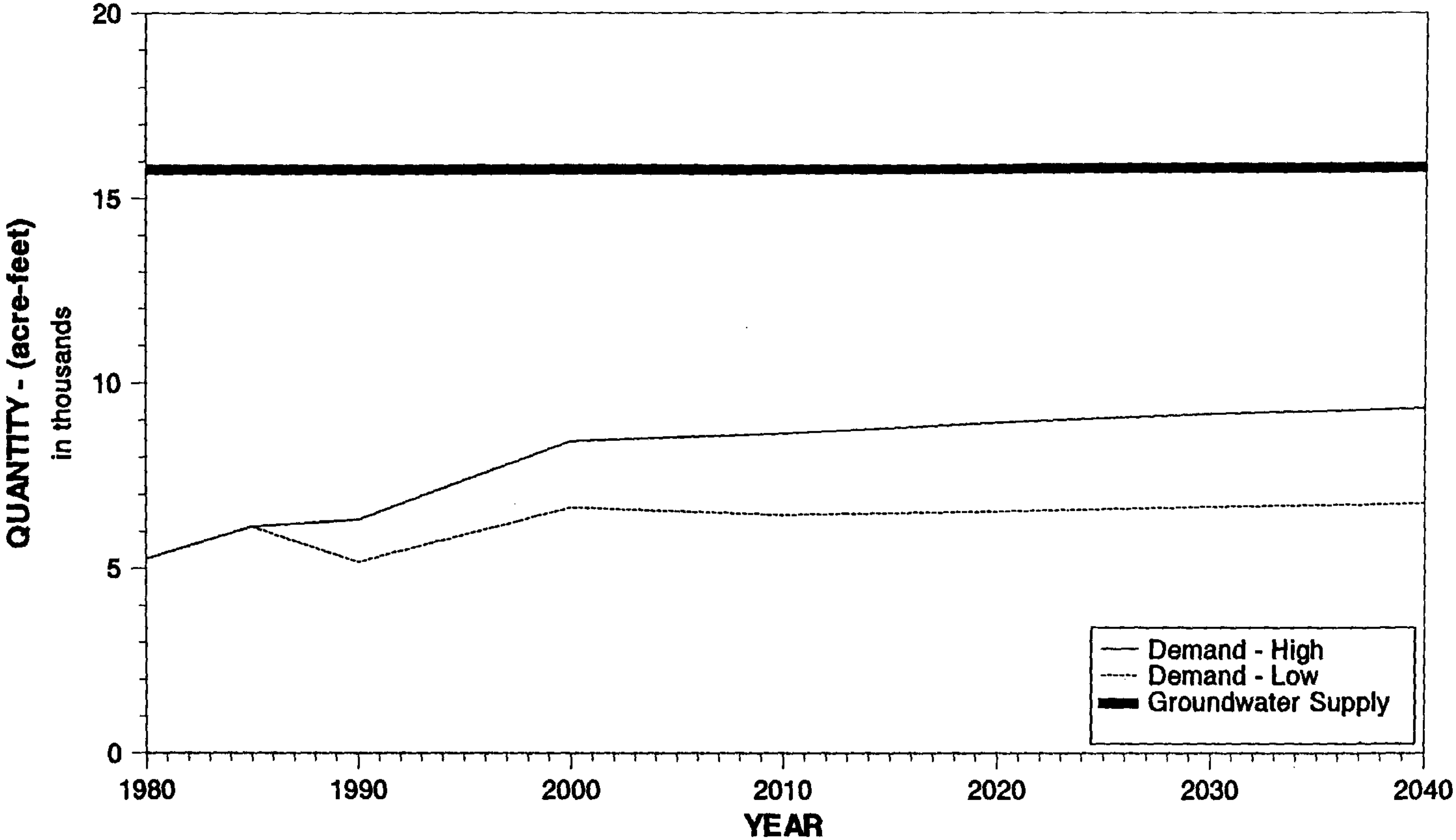


FIGURE B.8
Victoria County Projected Water Requirements and Ground Water Supply

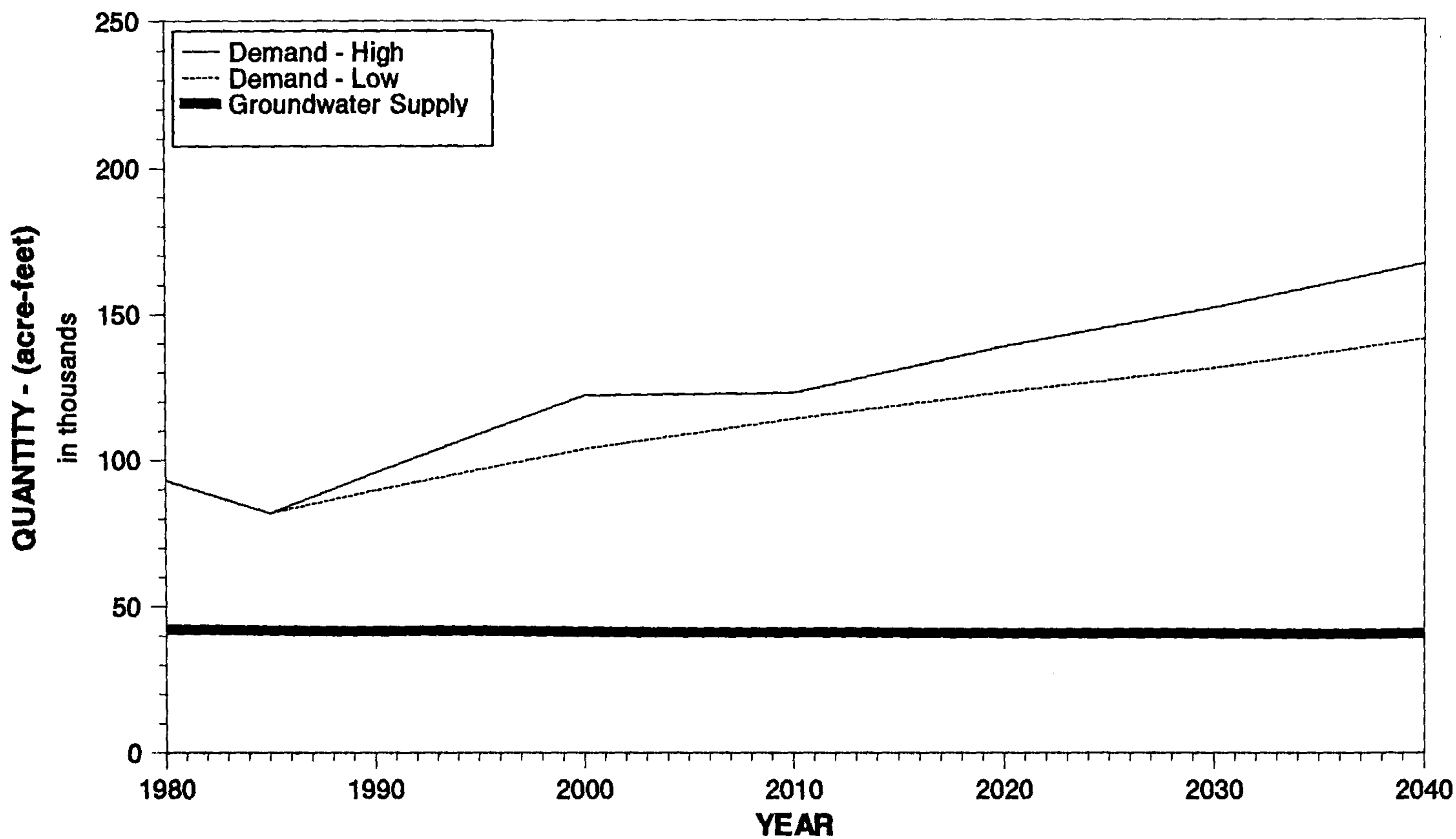


FIGURE B.9
Refugio County Projected Water Requirements and Ground Water Supply

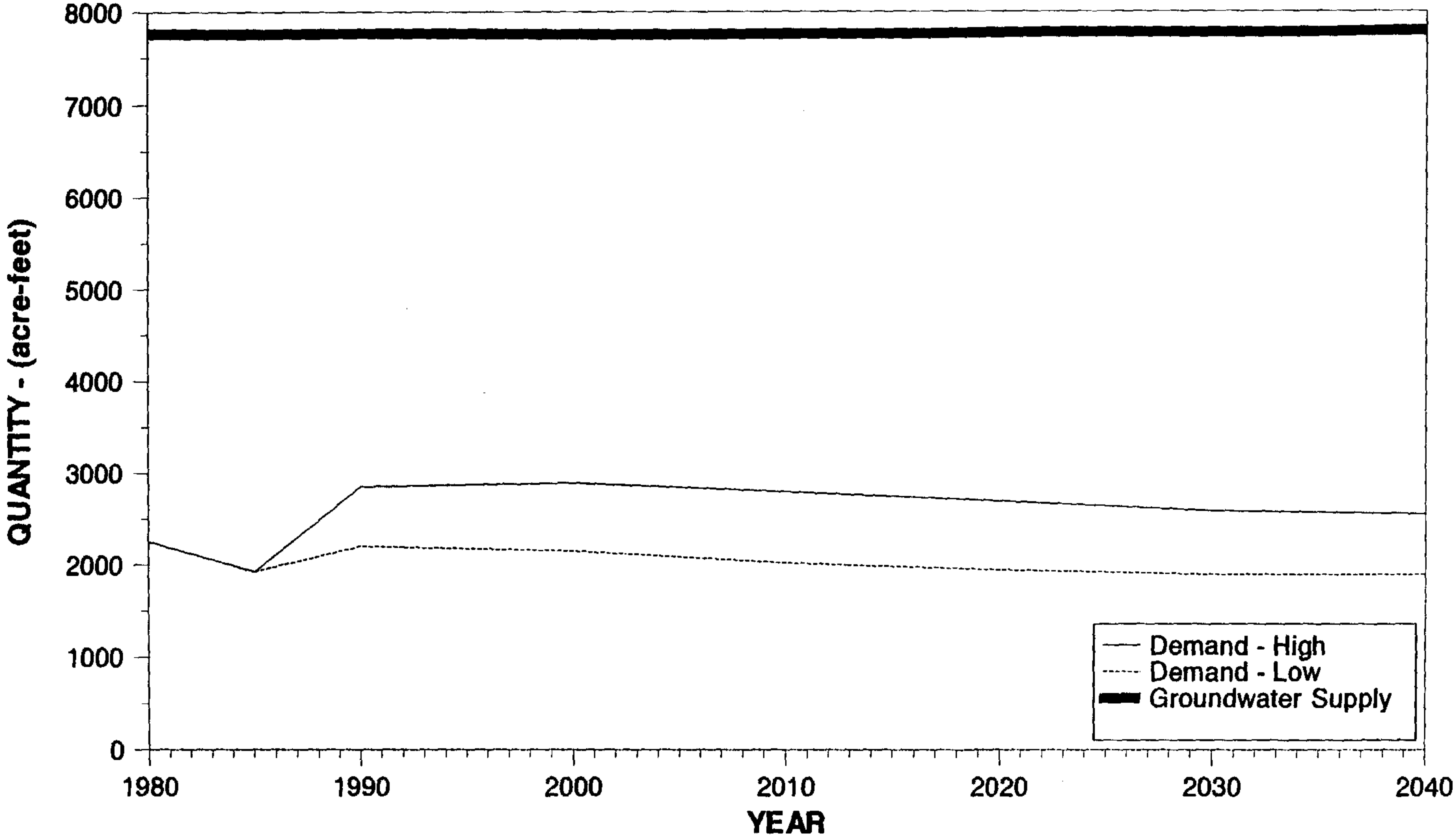
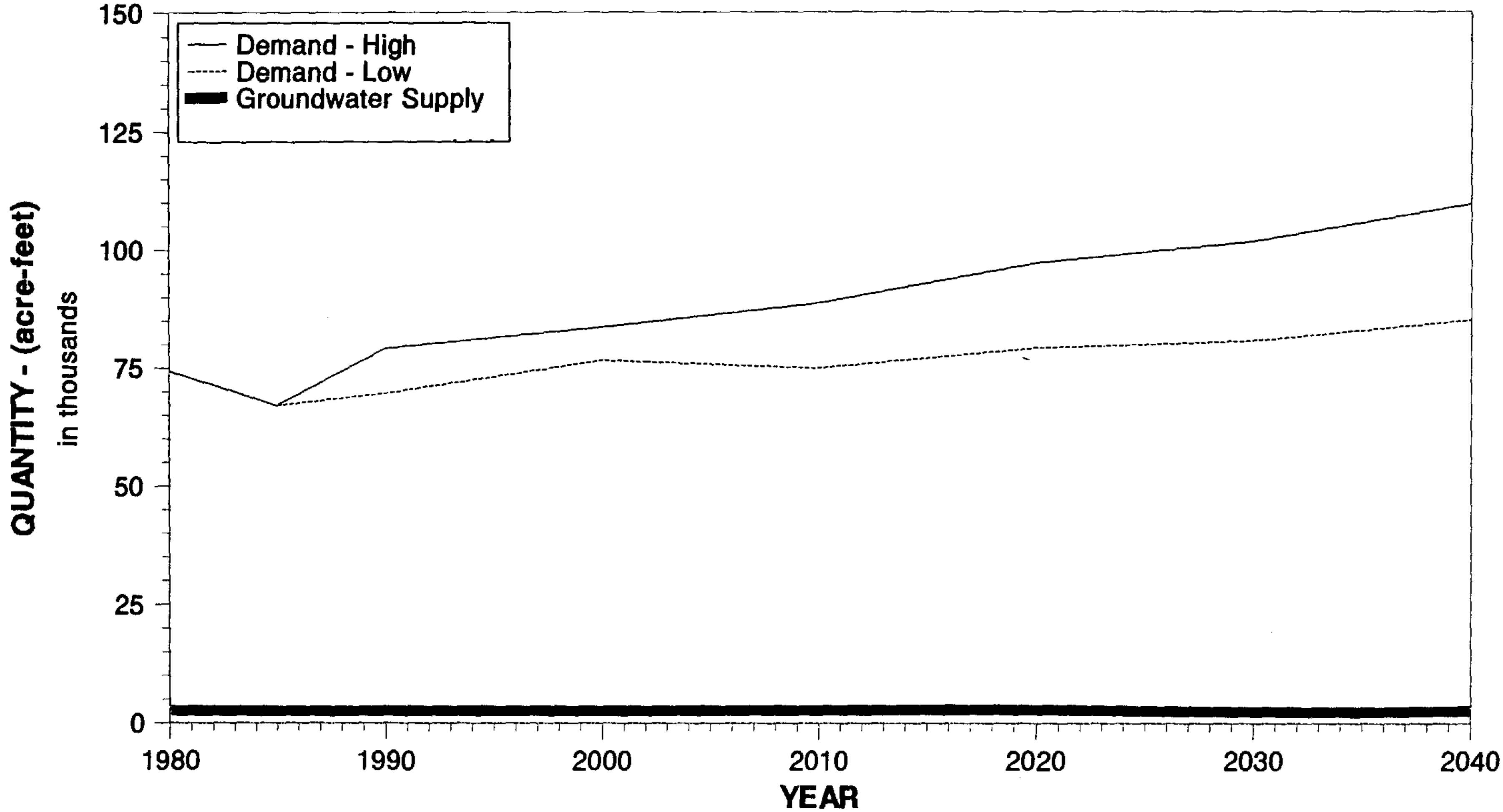
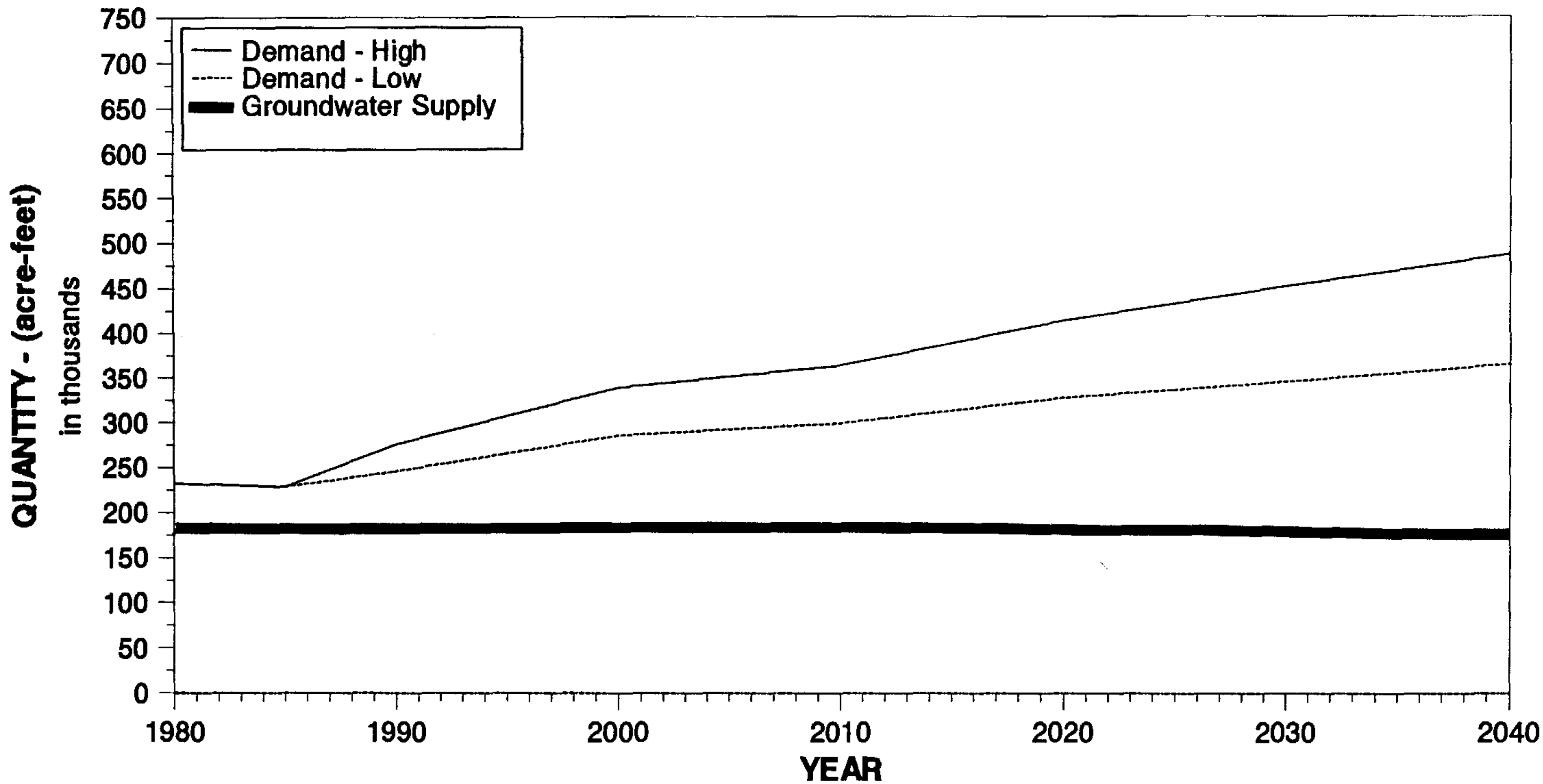


FIGURE B.10
Calhoun County* Projected Water Requirements and Ground Water Supply



*West of Lavaca Bay

FIGURE B.11
Total Projected Water Requirements and Ground Water Supplies for All Counties*



*Calhoun County - West of Lavaca Bay.
Also, includes Coleto Creek in Goliad
County & diversions from the Guadalupe.

APPENDIX C

Drought Contingency Plan

APPENDIX C

Drought Contingency Plan

Drought and other uncontrollable circumstances can disrupt the normal availability of both ground and surface water supplies, and during drought conditions water demands increase. For example, during dry periods of the 1980's municipal water use in the Guadalupe River Basin was 18 percent higher than under normal conditions. Limitations on supplies of ground and surface water or failure of any part of the facilities to pump, treat, store and distribute water can present a public water supply utility with an emergency situation.

It is important to distinguish drought contingency planning from water conservation planning. While water conservation planning involves implementing permanent water use efficiency or reuse practices, drought contingency planning establishes temporary methods or techniques designed to be used only as long as the emergency exists. The Guadalupe River Basin planning area water supply is obtained from an interrelated system of streams and aquifers. The drought contingency plan presented here is flexible in that it contains guidelines that can be used by public water supply systems that are: (A) supplied with water from streams of the Guadalupe River Basin; (B) supplied with water from the Edwards and Related Aquifers located in the Basin; and (C) supplied with water from the Carrizo and Gulf Coast Aquifers located in the Basin. The following drought contingency planning elements recommended by the Texas Water Development Board are presented for each of the water supply types listed below:

1. Trigger conditions signaling the start of an emergency period;
2. Drought contingency measures;
3. Information and education;
4. Initiation procedures;
5. Termination notification actions; and
6. Implementation procedures.

(A) Trigger Conditions and Measures for Surface Water Systems:

Trigger Conditions

1. Mild Conditions

   a. Daily water demand reaches the level of 90 percent of system capacity for three consecutive days; or

   b. Distribution pressure remains below normal for more than six consecutive hours.

2. Moderate Conditions

   a. Daily water demands reach 100 percent of system capacity for three consecutive days; or

   b. The supply of water is continually decreasing on a daily basis and the water supply utility is advised to conserve by the Guadalupe-Blanco River Authority or the Texas Water Commission; or

   c. Decrease in the water pressure in the distribution system as measured by the pressure gauges and customer complaints.

3. Severe Conditions

   a. The imminent or actual failure of a major component of the system which would cause an immediate health or safety hazard; or

   b. Water demand is exceeding 100 percent of system capacity for three consecutive days; or

   c. The full allotment of raw water is being pumped from the system's supply sources.

Drought Contingency Measures

The following actions will be taken by the water supply utility when trigger conditions are met for the utility's service area.

1. Mild Condition

   a. Inform public by giving notice of a mild drought to the customers served by the system; the posting of the notice, and notifying news media of the mild drought;

   b. Provide to the public a list of methods to conserve water (see Attachment); and

   c. Public will be advised of the trigger condition situation daily.

2. Moderate Condition

   a. Inform the public through the news media that a trigger condition has been reached, and they should look for ways to voluntarily reduce water use. Specific steps which can be taken will be provided through the news media;

b. Notify major commercial water users of the situation and request voluntary water use reductions;

c. The following mandatory lawn watering schedule shall be implemented: Customers with even numbered street addresses may water on even numbered days of the month. customers with odd numbered street addresses may water on odd numbered days of the month. Watering shall occur only between the hours of 6-10 a.m. and 8-10 p.m.;

d. Request water users to insulate pipes rather than running water to prevent freezing during winter months; and

e. Water utility staff will begin monitoring water pressure in the distribution system and water levels in the storage tanks.

3. Severe Condition

a. Continue implementation of all relevant actions in preceding phase;

b. Car washing, window washing, pavement washing are prohibited except when a bucket is used;

c. The following public water uses, not essential for public health or safety, are prohibited:

1). Street washing,
2). Water hydrant flushing,
3). Filling swimming pools,
4). Athletic field watering,
5). Park Watering, and
6). Golf course watering.

d. Certain industrial and commercial water use which are not essential to the health and safety of the community will be prohibited from water use; and

e. Through the news media the public will be advised daily of the trigger conditions.

Information and Education

Once trigger conditions and emergency measures have been approached, the public will be informed of the conditions, and measures to be taken. The process for notifying the public includes:

1. Posting the Notice of Drought conditions at City Hall, County Courthouse, Post Office, Public Library, Senior Citizens Center, and Major Supermarkets;

2. General Circulation to Newspapers.

3. Notifying Local Radio and Television Stations.

Termination Notification

Termination of the Drought measures will take place when the trigger conditions which initiated the drought measures have subsided, and an emergency situation no longer exists. The public will be informed of the termination of the drought measures in the same manner that they were informed of the initiation of the drought measures through the officials in charge.

(B) Trigger Conditions and Measures for areas served by the Edwards and Related Aquifers:

The Drought Contingency Plan developed by the Edwards Underground Water District (EUWD) in 1988, is the Drought Contingency Plan of this study for those areas in Comal, Hays, and Guadalupe counties that obtain water from the Edwards and Related Aquifers.[1] The EUWD Drought Contingency Plan will be modified from time to time, and those elements which pertain to parts of the Guadalupe Basin will be updated, as appropriate.

Trigger Conditions

1. Mild Condition

   Water level in Index Well AY-68-37-203 (J-17) in Bexar County declines to 660 feet.

2. Moderate Condition

   Water level in Index Well AY-68-37-203 (J-17) in Bexar County declines to 644 feet.

3. Severe Condition

   Water level in Index Well AY-68-37-203 (J-17) in Bexar County declines to 628 feet.

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[1]Draft Drought Management Plan, Edwards Underground Water District, San Antonio, Texas, March, 1988.

Drought Contingency Measures

The following actions shall be taken by the public water utilities when trigger conditions are met for the utilities' service areas:

1. Mild Condition

   (a) Inform the public through the news media condition has been reached and that they should look for ways to voluntarily reduce water use. Specific steps which can be taken will be provided through the news media. (See Attachment).

   (b) Publicize a voluntary lawn watering schedule.

   (c) Request water users to insulate pipes rather than running water to prevent freezing during winter months.

2. Moderate Condition

   (a) Continue implementation of all sections in preceding phase.

   (b) Car washing, window washing, and pavement washing is prohibited, except when a bucket is used.

   (c) The following mandatory lawn watering schedule will be implemented: Consumers with even numbered street addresses may water on even days of the month. Consumers with odd numbered street addresses may water on odd days of the month. Watering shall occur only between the hours of 6-10 a.m. and 8-10 p.m.

   (d) Public water uses, not essential to public health or safety, are prohibited.

3. Severe Condition

   (a) Continue implementation of all relevant actions in preceding phase.

   (b) All outdoor water use not essential to public health or safety is prohibited. Watering of livestock would not be prohibited.

Information and Education

The purpose and desired effects of the Drought Contingency Plan will be communicated to the public through articles in local newspapers and supplemented by pamphlets and notices. When trigger conditions appear to be approaching, the public will be notified through publications of articles in local newspapers, with information on water conserving methods (see Attachment).

Newspapers will publish notifications that drought contingency measures are abated for a given condition, and will outline measures necessary for the reduced condition.

Throughout the duration of drought contingency measure implementation, regular articles will appear to explain and educate the public on the purpose, cause, and methods, of conservation for that condition.

Initiation Procedure

Prior to formal notification of a drought condition, public water utilities will release a statement to all media sources warning that a potential drought condition is approaching. Once a trigger condition is reached, water utility officials will make formal notification that a particular drought condition is in effect.

Termination Notification

Water utility officials will acknowledge through the news media that the emergency condition has passed.

(C) Trigger Conditions and Measures for Areas Served by Carrizo and Gulf Coast Aquifers.

1. Mild Conditions

    a. Daily water demand reaches the level of 90 percent of system capacity for three consecutive days; or

    b. Distribution pressure remains below normal for more than six consecutive hours.

2. Moderate Conditions

    a. Daily water demands reach 100 percent of system capacity for three consecutive days;

    b. The storage in the water supply system is continually decreasing on a daily basis and the water supply utility is advised to conserve by the Texas Water Commission, or the Texas Department of Health; or

d. Request water users to insulate pipes rather than running water to prevent freezing during winter months; and

e. Water utility staff will begin monitoring water pressure in the distribution system and water levels in the storage tanks.

3. Severe Condition

a. Continue implementation of all relevant actions in preceding phase;

b. Car washing, window washing, pavement washing are prohibited except when a bucket is used;

c. The following public water uses, not essential for public health or safety, are prohibited:

1) Street washing,
2) Water hydrant flushing,
3) Filling swimming pools,
4) Athletic field watering,
5) Park watering, and
6) Golf course watering.

d. Certain industrial and commercial water use which are not essential to the health and safety of the community will be prohibited from water use; and

e. Through the news media the public will be advised daily of the trigger conditions.

Information and Education

Once trigger conditions have been reached, the public will be informed of the conditions, and measures to be taken. The process for notifying the public includes:

1. Posting the Notice of Drought conditions at City Hall, County Courthouse, Post Office, Public Library, Senior Citizens Center, and Major Supermarkets;

2. Copy of notice to Newspapers, and hold press conferences; and

3. Copy of notice to Local Radio and Television Stations.

Termination Notification

Termination of the Drought measures will take place when the trigger conditions which initiated the drought measures have subsided, and an emergency situation no longer exists. The public will be informed of the termination of the drought measures in the same manner that they were informed of the initiation of the drought measures through the officials in charge.

ATTACHMENT

WATER SAVING METHODS THAT CAN BE PRACTICED BY THE INDIVIDUAL WATER USER

In-home water use accounts for an average of 65 percent of total residential use, while the remaining 35 percent is used for exterior residential purposes such as lawn watering and car washing. Average residential in-home water use data indicate that about 40 percent is used for toilet flushing, 35 percent for bathing, 11 percent for kitchen uses, and 14 percent for clothes washing. Water saving methods that can be practiced by the individual water user are listed below.

A. BATHROOM

1. Take a shower instead of filling the tub and taking a bath. Showers usually use less water than tub baths.

2. Install a low-flow shower head which restricts the quantity of flow at 60 psi to no more than 3 .0 gallons per minute.

3. Take short showers and install a cutoff valve or turn the water off while soaping and back on again only to rinse.

4. Do not use hot water when cold will do. Water and energy can be saved by washing hands with soap and cold water, hot water should only be added when hands are especially dirty.

5. Reduce the level of the water being used in a bath tub by one or two inches if a shower is not available.

6. Turn water off when brushing teeth until it is time to rinse.

7. Do not let water run when washing hands. Instead, hands should be wet, and water should be turned off while soaping and scrubbing and turned on again to rinse. A cutoff valve may also be installed on the faucet.

8. Shampoo hair in the shower. Shampooing in the shower takes only a little more water than is used to shampoo hair during a bath and much less than shampooing and bathing separately.

9. Hold hot water in the basin when shaving instead of letting the faucet continue to run.

10. Test toilets for leaks. To test for a leak, a few drops of food coloring can be added to the water in the tank. The toilet should not be flushed. The customer can then watch to see if the coloring appears in the bowl within a few minutes. If it does, the fixture needs adjustment or repair.

11. Use a toilet tank displacement device. A one-gallon plastic milk bottle can be filled with stones or with water, recapped, and placed in the toilet tank. This will reduce the amount of water in the tank but still providing enough for flushing. (Bricks which some people use for this purpose are not

recommended since they crumble eventually and could damage the working mechanism, necessitating a call to the plumber).

12. Install faucet aerators to reduce water consumption.

13. Never use the toilet to dispose of cleaning tissues, cigarette butts, or other trash. This can waste a great deal of water and also places an unnecessary load the sewage treatment plant or septic tank.

14. Install a new low-volume flush toilet that uses 3.5 gallons or less per flush when building a new home or remodeling a bathroom.

B. KITCHEN

1. Use a pan of water (or place a stopper in the sink) for rinsing pots and pans and cooking implements when cooking rather than turning on the water faucet each time a rinse is needed.

2. Never run the dishwasher without a full load. In addition to saving water, expensive detergent will last longer and a significant energy saving will appear on the utility bill.

3. Use the sink disposal sparingly, and never use it for just a few scraps.

4. Keep a container of drinking water in the refrigerator. Running water from the tap until it is cool is wasteful. Better still, both water and energy can be saved by keeping cold water in a picnic jug on a kitchen counter to avoid opening the refrigerator door frequently.

5. Use a small pan of cold water when cleaning vegetables rather than letting the faucet run.

6. Use only a little water in the pot and put a lid on it for cooking most food. Not only does this method save water, but food is more nutritious since vitamins and minerals are not poured down the drain with the extra cooking water.

7. Use a pan of water for rinsing when hand washing dishes rather than a running faucet.

8. Always keep water conservation in mind, and think of other ways to save in the kitchen. Small kitchen savings from not making too much coffee or letting ice cubes melt in a sink can add up in a year's time.

C. LAUNDRY

1. Wash only a full load when using an automatic washing machine (32 to 59 gallons are required per load).

2. Use the lowest water level setting on the washing machine for light loads whenever possible.

3. Use cold water as often as possible to save energy and to conserve the hot water for uses which cold water cannot serve. (This is also better for clothing made of today's synthetic fabrics.)

D. APPLIANCES AND PLUMBING

1. Check water requirements of various models and brands when considering purchasing any new applicance that uses water. Some use less water than others.

2. Check all water line connections and faucets for leaks. If the cost of water is $1.00 per 1,000 gallons, one could be paying a large bill for water that simply goes down the drain because of leakage. A slow drip can waste as much as 170 gallons of water EACH DAY, or 5,000 gallons per month, and can add as much as $10.00 per month to the water bill.

3. Learn to replace faucet washers so that drips can be corrected promptly. It is easy to do, costs very little, and can represent a substantial amount saved in plumbing and water bills.

4. Check for water leakage that the customer may be entirely unaware of, such as a leak between the water meter and the house. To check, all indoor and outdoor faucets should be turned off, and the water meter should be checked. If it continues to run or turn, a leak probably exists and needs to be located.

5. Insulate all hot water pipes to avoid the delays (and wasted water) experience while waiting for the water to "run hot".

6. Be sure the hot water heater thermostat is not set too high. Extremely hot settings waste water and energy because the water often has to be cooled with cold water before it can be used.

7. Use a moisture meter to determine when house plants need water. More plants die from over-watering than from being too dry.

E. OUT-OF-DOOR USES

1. Water lawns early in the morning during the hotter summer months. Much of the water used on the lawn can simply evaporate between the sprinkler and the grass.

2. Use a sprinkler that produces large drops of water, rather than a fine mist, to avoid evaporation.

3. Turn soaker hoses so the holes are on the bottom to avoid evaporation.

4. Water slowly for better absorption, and never water on windy days.

5. Forget about watering the street or walks or driveways. They will never grow a thing.

6. Condition the soil with compost before planting grass or flow beds so that water will soak in rather than run off.

7. Fertilize lawns at least twice a year for root stimulation. Grass with a good root system makes better use of less water.

8. Learn to know when grass needs watering. If it has turned a dull grey-green or if footprints remain visible. It is time to water.

9. Not water too frequently. Too much water can overload the soil so that air cannot get to the roots and can encourage plant diseases.

10. Not over-water. Soil can absorb only so much moisture and the rest simply runs off. A timer will help, and either a kitchen timer or an alarm clock will do. An inch and one-half of water applied once a week will keep most Texas grasses alive and healthy.

11. Operate automatic sprinkler systems only when the demand on the town's water supply is lowest. Set the system to operate between four and six a.m.

12. Not scalp lawns when mowing during hot weather. Taller grass holds moisture better. Rather, grass should be cut fairly often, so that only 1/2 to 3/4 inch is trimmed off. A better looking lawn will result.

13. Use a watering can or hand water with the hose in small areas of the lawn that need more frequent watering (those near walks or driveways or in especially hot, sunny spots).

14. Learn what types of grass, shrubbery, and plants do best in the area and in which parts of the lawn, and then plant accordingly. If one has a heavily shaded yard, no amount of water will make roses bloom. In especially dry sections of the state, attractive arrangements of plants that are adapted to arid or semi-arid climates should be chosen.

15. Consider decorating areas of the lawn with rocks, gravel, wood chips, or other materials now available that require no water at all.

16. Not "sweep" walks and driveways with the hose. Use a broom or rake instead.

17. Use a bucket of soapy water and use the hose only for rinsing when washing the car.

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